ECOLOGY, BEHAVIOUR AND MANAGEMENT PRACTICES OF GREAT INDIAN ONE HORNED RHINOCEROS (*Rhinoceros unicornis,* L.) AT GORUMARA, JALDAPARA AND KAZIRANGA NATIONAL PARKS, INDIA

A Thesis submitted to the Raiganj University
for the award of Doctor of Philosophy
In Zoology

By

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PREFACE

From the earliest human civilization man and animal have been interdependent in many respects. Some have become domesticated but many of them have remained in wild. The wildlife and forests with lush green vegetation completes the cycle of energy flow as well as ecosystem. India is having a vast forest coverage with one among the highest biodiversity zone of the world and the wild animals are the jewels of those forests. But illegal hunting, poaching, habitat destruction and human encroachment have created immense pressure on those wild animals.

Great Indian one horned rhinoceros is one of the victim for the above reasons. Rhinos are bearing a curse on their nose, i.e., their horn. It has got some mythological beliefs that these horns are the magic medicine for impotents, though this characteristic feature is yet to be proved. For this reason only they have been killed mercilessly during the past several hundred years. Many of them have been killed just for fun in the nineteenth and early twentieth century. Due to increase of human population and frequent man and animal conflict they have become cornered to such an extent that from some rhino habitat areas they have been wiped out permanently.

In this context it was felt necessary that this precious animal must be conserved in a better way,at least, are to be survived from this 'back to the wall' condition. For this purpose a thorough and extensive research work, especially on their food preference, demographic study, home range pattern, daily activity cycle and other behavioural patterns ,was permitted to do in Gorumara and Jaldapara Wildlife Sanctuaries (both are now National Parks) by the higher authorities in the early eighties. As there were no previous records of study on rhinoceros in those two places the works were done as pioneering works there. In the last year the study was concentrated in Kaziranga National Park in Assam which is still known to be the home land of rhinoceros.

It was a long way journey. After completion of a strainous field study my findings have been depicted and analysed in this thesis and some recommendations have been made for their better conservation in future. Finally, our whole heartedly endeavour and wish for the rhinos' welfare can only get back their glorious past to some extent.

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Dedication

The thesis is dedicated to my parents Late Bimal Prosad Bhattacharya and Late Chitra Bhattacharya who were the inspiration in every sphere of my life

ACKNOWLEDGEMENTS

I express my deepest gratitude to the Honourable Vice-Chancellor, Prof. Dr Anil Bhuimali who was always keen to my work and extended his helping hand whenever needed. I also express my sincere thanks to Dr. Kaushik Chakraborty, Associate Professor, Department of Zoology, Gour Banga University, Malda for his constant encouragement and guidance from time to time.

I am, especially grateful to retired Professor Bikash Chandra Pal, Department of Zoology, University of North Bengal, Darjeeling -734013, who first made me aquainted with the pros and cons of Animal Behaviour. A big thank is also due to the Registra, Dr. Durlav Sarkar and Assistant Registrar, Sri Biplab Chakraborty and other staffs of Raiganj University for their kind support in publishing this thesis. Thanks are also due to my groups of fellow researchers staffs and teachers of the Department of Zoology, Raiganj University.

I am thankful to the UGC for the fellowship provided, which almost made entire part of my field work possible. I am grateful to the faculty members of the Department of Zoology, University of North Bengal for their kindness and readiness to help me as and when it was necessary.

I tender my sincere thanks to the workers of Botanical Survey of India, Shibpur Howrah who did the laborious task in identifying the plant specimens and also to the zookeepers of Alipur zoo, Kolkata by providing me some valuable information. Thanks are also due to the authors whose works have been cited in my thesis and to a number of anonymous referees for their criticisms and insightful remarks that, at the end, considerably improved the quality of work presented here.

I wish to acknowledge indebtness to my daughter Dr. Amrita Bhattacharya, son-in law Tamal Ghosh and son Abhirup Bhattacharya for their constant support and encouragement. In addition, I acknowledge the mental support from my maternal uncle Late Debu Sanyal, Sri Shiba prosad Sanyal, Smt. Chanchali, Sanchali and Dipali Sanyal. I express my gratitude to my brother-in laws (Kamal, Tushar and Shyamal Kanti Nandi) and to my sister-in-law (Kaberi Nag) and to all other remaining members of my extended in-laws family for their understanding and support.

I wish I could ever fully express my special love and respect for my beloved wife. It is actually she from whom I got domestic support for my taxing job but she endured this lack and extended all conceivable support during my research work. She has always been the greatest source of inspiration to me.

And last but not the least, I tender my sincere love and respect, whichever appropriate, to all those relatives and friends, whom I could not specifically name here due to lack of space.

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December, 2018

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LAND USE PATTERN AND LAND USE CHANGES OF THE VILLAGES ADJACENT TO GORUMARA AND JALDAPARA NATIONAL PARKS AND POTENTIAL THREATS TO RHINO CONSERVATION DURING LAST 30 YEARS

CHAPTER – 1

LAND USE PATTERN AND LAND USE CHANGES OF THE VILLAGES ADJACENT TO GORUMARA AND JALDAPARA NATIONAL PARKS AND POTENTIAL THREATS TO RHINO CONSERVATION DURING LAST 30 YEARS

1.1 Introduction:

The population of Indian one horned rhino could never be increased to a satisfactory level during the last 100 years, because of habitat loss and poaching. These two above mentioned reasons have become the major threats for their survival. If we look at the chronological human population census of the surroundings of Gorumara and Jaldapara for the last 40 years or so it will be clear that how the human population pressure has tightened the rope on the natural habitats of Indian rhinoceros. The adverseness has been added by the annual floods particularly at Kaziranga National Park which is taking lives of the wild animals including rhinoceros almost in every year. Nevertheless, the population of rhino along with other animals have been increased (not satisfactorily) due to best possible management system, i.e., by regular tight vigilance, by taking stern actions against poachers, habitat improvement, by imposing restrictions against domestic herbivores , fighting against invasive plant species etc.

1.2 Major threats for decrease of rhino population:

1.2.1 ***Habitat loss due to anthropogenic causes:*** Habitat loss and wiping out of forest covers has been a regular and gradually increasing phenomenon during the last few decades. It has been estimated that between 1900 and 1990 a range of 450 km^2 to 580 km^2 of tall riverine grasslands have been lost in the foothills of northern West Bengal (Mallick, 2015) on account of change in land use patterns, namely, (a) tea garden extensions (200-250km^2), (b) extended agricultural fields (60-80 km^2), (c) encroachment for new establishments (20- 30 km^2) and (d) destructions of grasslands due to flood (20-30 km^2).

TABLE 1.1: *Loss of Rhino habitat and the range of loss in km^2(after Mallick,2015 and Bist,1994).*

REASONS FOR LOSS OF GRASSLAND	RANGE OF LOSS
I.TEA GARDEN EXTENSIONS	200-250 km^2
II. EXTENSIONS OF AGRICULTURE	60-80 km^2
III. ENCROACHMENT FOR NEW ESTABLISHMENTS	20-30 km^2
IV. DESTRUCTION OF GRASSLANDS DUE TO FLOOD	20-30 km^2
V. CONVERSION OF GRASSLANDS INTO COMMERCIAL PLANTATIONS	150-190 km^2
TOTAL	450- 580 km^2

Apart from this, conversion of alluvial grasslands into commercial plantations has been one of the major causes of habitat loss ranging from 150 -190 km^2 (Bist,1994). If we compare the habitat loss of only Jalpaiguri district of West Bengal from 1950 to till date almost 50% of the forest covers and grassland habitat have been lost (Fig.1) resulting into human animal conflict. After independence, a rapid immigration of large number of Bengali speaking population from the East Pakistan (now Bangladesh) occurred in Doors and Terai regions of Himalayan foothills where they settled permanently and gradually engulfed the buffer zones surrounding the core areas. A sudden increase of human population in those areas reveals the truth (West Bengal Census Report,2011).

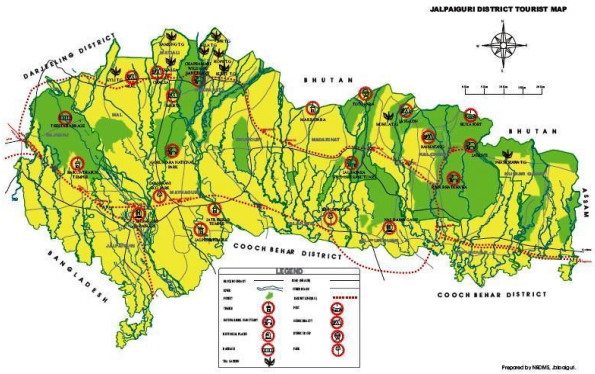


Fig.1.(a) Forest map of Jalpaiguri District before Formation of Alipurduar District in 2014

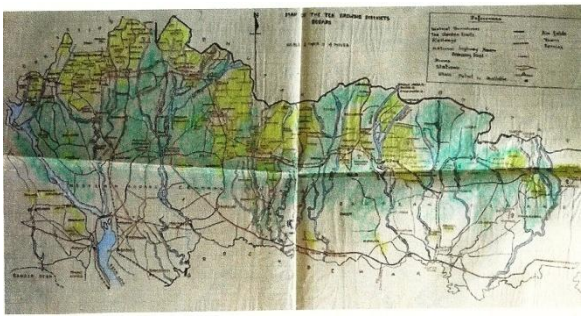


Fig1.1(b) Old map of Jalpaiguri District in early fifties, bottle green areas showing the previous forest areas

The total population of the study area adjacent Gorumara has increased from 3401173 to 3869675 and population density has also increased from 546 persons per sq km to 621 persons per sq km from 2001-2011. The decennial growth rate of population is 13.77% in between the period of 2001-2011, while in previous decade it was 17.84% (Mukherjee,2016 and Census, 2001, 2011). Land use change and transformation of forest areas into settlement

are done to meet the needs of growing population. A google satellite map shows the present settlements in the vicinity of Gorumara National Park (Fig1.5). This has given rise to human-wildlife conflict. There after the immigrant populations along with local populations have been increased in a geometrical progression destroying hectors of habitats until the Government Authority felt it necessary to give protection to the forest and wildlife habitats, but it was too late.

1.2.2 ***Fragmentation of natural habitats:*** Fragmentation of natural habitats of wild animals and forest cover is a continuous process due to conversion of forest land for tea plantation and other artificial plantations of sal and teak.It has been added by the encroachment of agricultural lands (Bhattacharyya and Padhi (2013) narrowing the important buffer zones. Unplanned human settlements at the southern border of the then Jaldapara Wildlife Sanctuary during partition of India and, thereafter, a steady approach of the settlements inside Sanctuary towards northern side made the two riverine habitats (flood plain of Char Torsa and Sil Torsa) fragmented. The steady increase of settlements again got acceleration after Bangladesh war in 1971. The dual pressure, i.e., rise of human population and their settlements along with agricultural fields from all the three sides made the habitats more fragmented. It is recorded that in all the protected areas in this region about 23.32 sq.km of forest degradation occurred in 2011-12 which is greater than 2006-07 statistics (Table-1).

Table 1.2: Degradation of forest lands in different years

YEAR	AREA in Sq.Km.	
2006-2007	13.43	
2011-2012	23.32	Increase $9.89km^2$

Source: SFR: 2006-07 and 2011-12

The irregular habitats also make the hindrance to spread forest covers over the regions (Times of India, Kolkata, 2013). But further degradation is to be avoided at any cost. There is also the need of establishment of corridors for migration of animals (especially rhinos and elephants) from one habitat to another. As for example, Laokhowa-Burachapori Sanctuary is today isolated from the mainland of Kaziranga National Park but once they were connected. In between lands should be recovered as a corridor to preserve the genetic heterozygosity of rhinos. Moreover, the existing corridors need to be improved expeditiously (Fig.2).

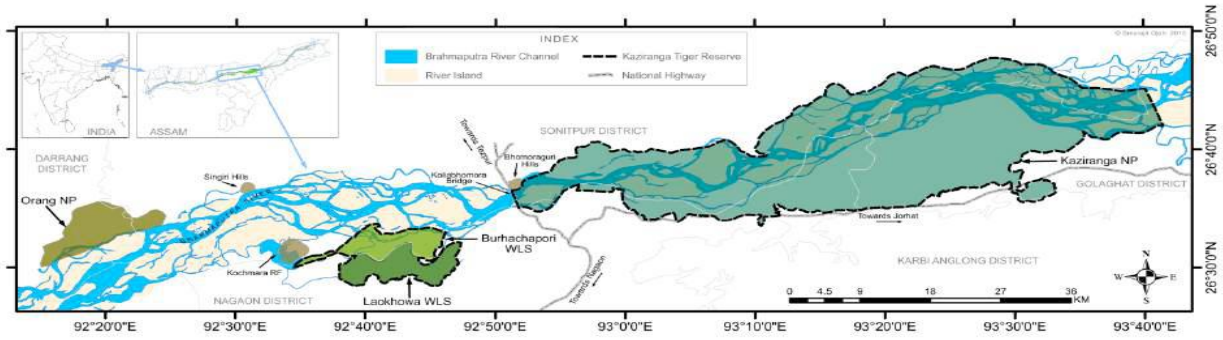


Fig.1.2: *Proposed corridor in between Kaziranga and Laokhowa-Burachapori in IRV-2020.*

To prevent forest fragmentation/degradation more emphasis should be put on 'conservation agriculture'. Afforestation should be carried out on massive scale on degraded habitats. However, some innovative solutions are to be found to procure funds for afforestation apart from the central and state governments. For example, in the article 'elephants, people and the battle for peaceful coexistence' the authors speak of innovative funding using carbon credits under climate change obligations by converting a part of the tea plantations linking Buxa and Jaldapara into mixed forest plantations for use by elephants as unhindered corridors (Sukumar and Murali,2010).

Habitat fragmentation is a process where large, continuous area of habitat is both reduced in area and divided into two or more fragments by roads, railway tracks, agricultural fields, settlements, canals, power lines (Sharma,2016). Habitat fragmentations lead to gene pool isolation among animals and which is again responsible for increase of undesirable homozygosity and decrease of desirable heterozygosity. The lack of genetic variability is caused by inbreeding (Frankham et.al.,2002) and moreover, a population's fitness is largely dependent on its heterozygosity (Reed and Frankham,2003). Since frequent inbreeding occur in fragmented small populations, there is every possibility to accumulate and chance mixings of lethal, deleterious, mutated genes resulting into high rate of mortality, loss of vigour and fertility.

1.2.3 ***Poaching for rhino horn:*** The second most unwanted threat to the survival of Indian rhino was the merciless and brutal poaching for their horns. Not only rhino, but the elephants for their tusks, the tigers for their skins, etc. have been slaughtered due to intense greed of the illicit traders followed by huge demand from the customers who are mostly the inhabitants of China, Vietnam and Yemen. At the back of the curtain a mythological belief of aphrodisiac quality of rhino horn and enhancing vigour plays an important role creating the demand for

rhino horn, Chinese traders are the biggest suppliers of the rhino horn products worldwide. One pound of Indian rhino horn is sold at 10000$ in the world market. The price has been rocketed like anything in recent years due to tight security.

In this context, an analysis of human population pressure surrounding the protected areas in Dooars and Terai regions of Northern districts of West Bengal (precisely, Jalpaiguri and Alipurduar Districts) was undertaken from the collected secondary data and the data obtained from West Bengal Population Census records. These areas are under rapid habitat destruction due to several anthropogenic pressures and developmental activities like development of roads and houses, establishment of tea gardens, encroachment of uninhabited lands by establishing agricultural fields anew, mining and quarrying in the up hills resulting into siltation in the rivers, exotic plants, forest fires etc. In a nut shell, a rapid change in the ecosystems are being made through the last few decades.

In the last two decades or more Human Wildlife Conflicts (HWC) have been risen many folds in the Jalpaiguri and newly formed Alipurduar Districts because of increasing human population causing habitat shrinkage in one hand, on the other hand, increase of population of wildlife in the protected areas. The big herbivore animals, like elephant, rhino, gaur, sambar, cheetal etc. consume in total a great amount of food per day per kilogram of body weight (Bhattacharya and Chakraborty, 2017) to meet their daily needs. It has been observed that the squeezed habitats may not be able to supply sufficient food to them in near future, as a result of which, frequency of invading in croplands around may be increased causing both the loss of human lives and the lives of wild animals. As for instance, only the rhino population in Jaldapara has been increased from 14 in 1983 to 200 in 2017 (Census of rhino in March,2017) but the rhino habitat has been decreased to about 30% (Source: Range Office of Jaldapara,2017). Forest Department is thinking about translocation of some active breeding bulls and cows in the adjacent Patlakhawa zone which was previously a rhino inhabited area in fifties and sixties decades. The second habitat has been selected at Buxa Tiger Reserve.

According to proper available rhino habitat area and to check the excess number of greater one-horned rhinoceros in Gorumara and Jaldapara National Parks, the ministry of Forest and Wildlife Department has come forward for inclusion of two new places in West Bengal. Currently, there are 251 rhinos in these two regions – 200 in Jaldapara, and 51 in Gorumara, which is quite a high number in comparison to the parks' capacity (although AWLW of Jaldapara NP Mr. Bimal Debnath thinks that still some more rhinos can be added with the

present number (Bimal Debnath, Pers. Comm. Nov.2018).The two new areas that have been identified to absorb the excess rhinos are Buxa Tiger Reserve and a small adjacent reserve in Patlakhawa which are not far away in respect of translocation from the existing populations.

"It's like keeping all your eggs in one basket. If something happens to your population, it's gone. Moreover, if you have a small and closed population, its genetic quality is likely to go down. So it is best if you spread out your rhino population, give them enough space or connectivity, so they can also have a healthy gene pool." – Amit Sharma, Senior coordinator for rhino conservation, WWF India.

In a meeting last year at Jaldapara National Park, Asian Rhino Specialist Group under the IUCN, discussed the need for increasing the genetic diversity of the rhino populations in Jaldapara and Gorumara National Parks by allowing the exchange of healthy and breeding adult rhinos.

As per the survey held in 2015, there has been a sudden increase of rhino population in West Bengal. It's a good sign that the rhino population is increasing but the poaching continues to be a major threat in West Bengal. Over the past few months, at least 2 rhinos have been killed in northern West Bengal, according to local media.

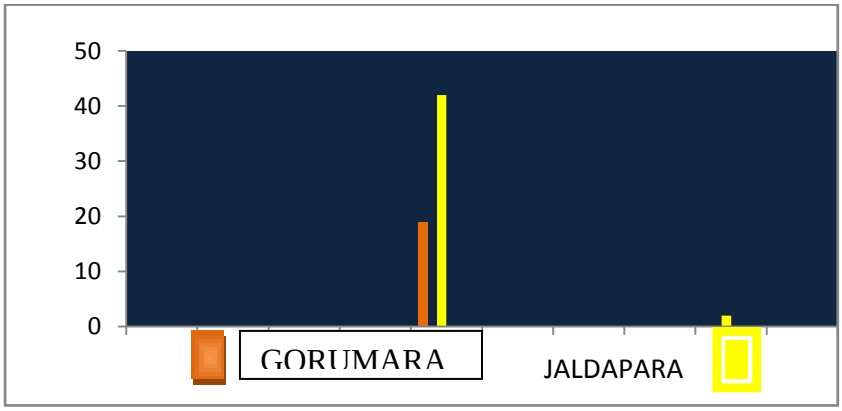


Fig.1.3 *No of villages in the fringe areas of Gorumara and Jaldapara N.P. Only 2 villages are still lying within protected areas of Jaldapara*

According to the State Forest Report (Data Source: SFR, 2011-12) there are 19 and 42 villages in the fringe areas of Gorumara and Jaldapara National Parks respectively which are very near to the core zones. Surprisingly, two villages within the protected area of Jaldapara still remain. The decadal population growth from 2001 to 2011 (birth-death + immigrants – emigrants) has been recorded 468,502 and is still growing. By this time area under encroachment of forest area has been 141.2 hectares (2005-06) and 103.38 hectares (2011-12), totalling 244.58 hectares of land only in Jalpaiguri Division (State Forest Report, 2011-

12). Fig.1.4. depicts the present birds' eye view image through a satellite image of forest map of dooars which shows the scattered remnants of glorious past of forest covers.

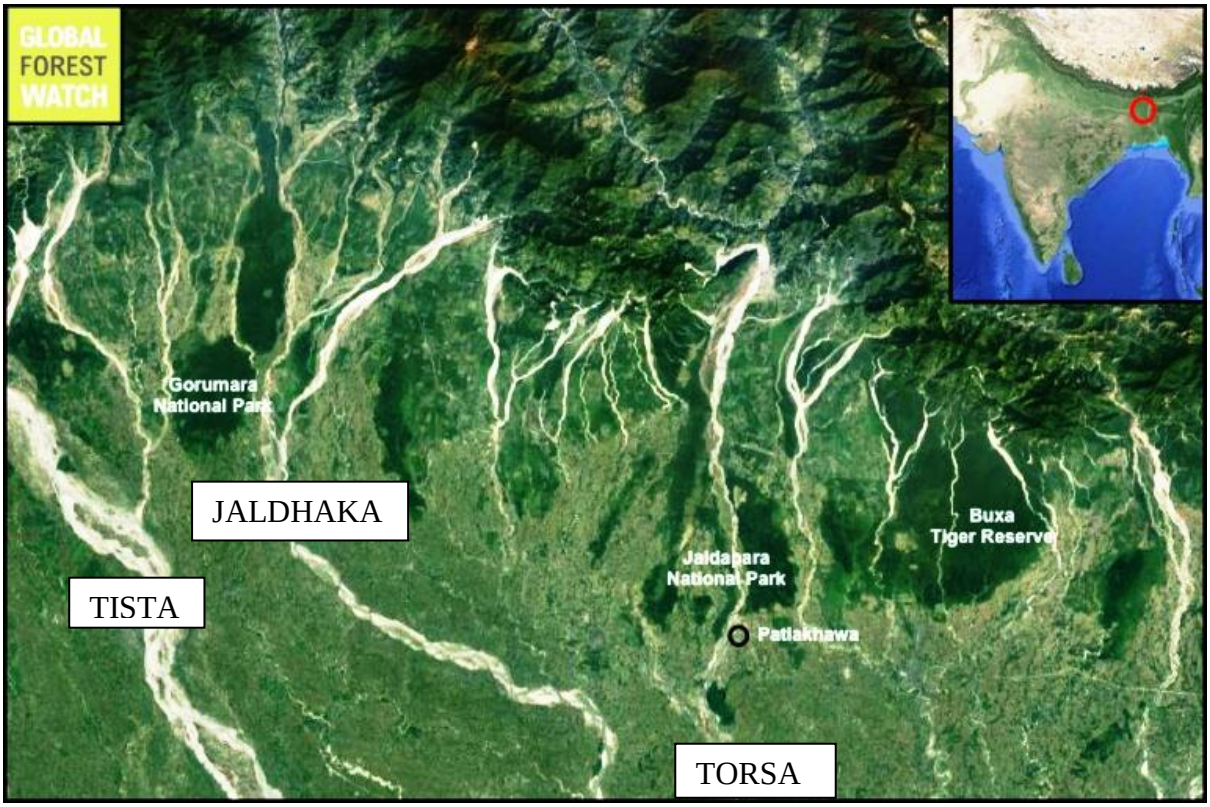


Fig.1.4: *Present overview satellite imgae of Gorumara and Jaldapara N.P. in the North Bengal Forest map. In inset the locations in India map.*

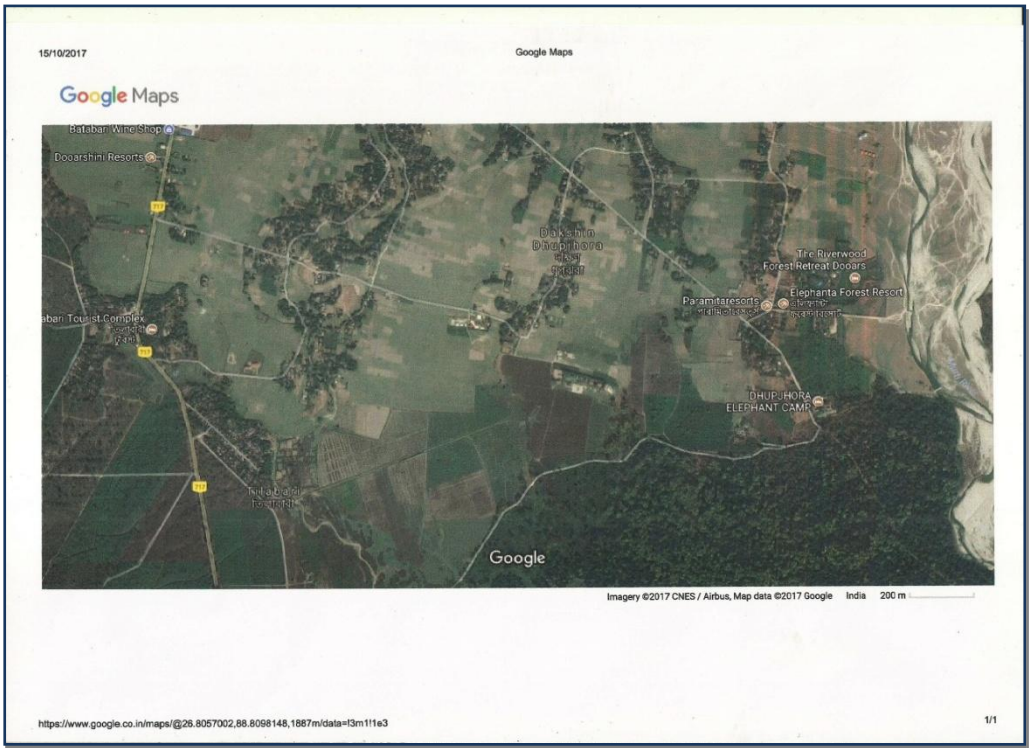


Fig.1.5:*A close view Google Satellite Image of Gorumara showing human settlements around*

1.2.4 Encroachment of woodland by natural process at Jaldapara: Most of the grasslands of actual rhino habitat in Duars and Terai regions, consisting of Sachharum spontaneum, Saccharum narenga, S. arundinaceum, Phragmites karka, Arundo donax, Narenga porphyrocoma, Themada villosa, etc, and the grasslands sparsely mixed with khoir-sissoo or simul-siris trees are gradually being succumbed to the woodland encroachment. Among those tall grass species one or two species, such as, Sachharum spontaneum and S.narega grows vigorously in the parks suppressing all other species of rhino fodders and thereby losing diversity (Ghosh and Das, 2007). The natural vegetation is gradually changing due to recurring floods and succession of vegetations (Bhattacharya, 2012). In 1968, a devastating flood in Jaldapara, shifted the course of River Torsa from west to east over a width of 20 km, creating Mara Torsa (dead), Buri Torsa (old) and Char Torsa (deserted), leaving only a perennial river Shil Torsa flowing through the eastern leg. Torsa and the small Malangi have merged with each other during the previous floods. Most of the area of earlier course of the Torsa is covered by grasslands. However, the emerging trees are invading the grasslands in succession extensively. Healthy habitat has also been dwindled considerably by weeds and climber infestation, among those Michania scandens is one amongst the most harmful climbers.

Fig.1.6: *Invasive plant species Michania scandens is a major threat to rhino fodders*

1.2.5 *Changes of Land Use Pattern in Jaldapara*: It has been known from the previous records of Jaldapara that the rhinos once used to graze the whole Park area (the then Sanctuary) up to the mid twentieth Century (Spillet, 1966), but subsequently the use-area has been reduced to about 160 km² (including the new additional area of 101 km^2 in the north of NH31 up to Bhutan border) due to various anthropogenic reasons (Ghosh, 1991). The core habitat was roughly estimated to be about 100 km² (46.29 per cent) (Syangden *et al.,* 2007).

During the present study, 96.04 km² (45 per cent of the total area) were found to be most suitable habitat of the rhinos, of which the pure grasslands cover 30.55 km² (14.11 per cent), grasslands with *Acacia-Dalbergia* succession 42.90 km² (19.81 per cent) and grassland with *Bombax-Albizia* succession 22.59 km² (10.3 per cent), whereas the secondary habitat was estimated to be about 50 km² and the seasonal (monsoon) upland habitat to be approximately 10 km². The rhinos are not presently known to visit Titi (39.19km²), Jaigaon (17.56 km²) and Dalsingpara (14.78 km²) blocks, north of National Highway 31A as well as Salkumar (5.02 km²) in between the two legs because those are less preferred habitats.

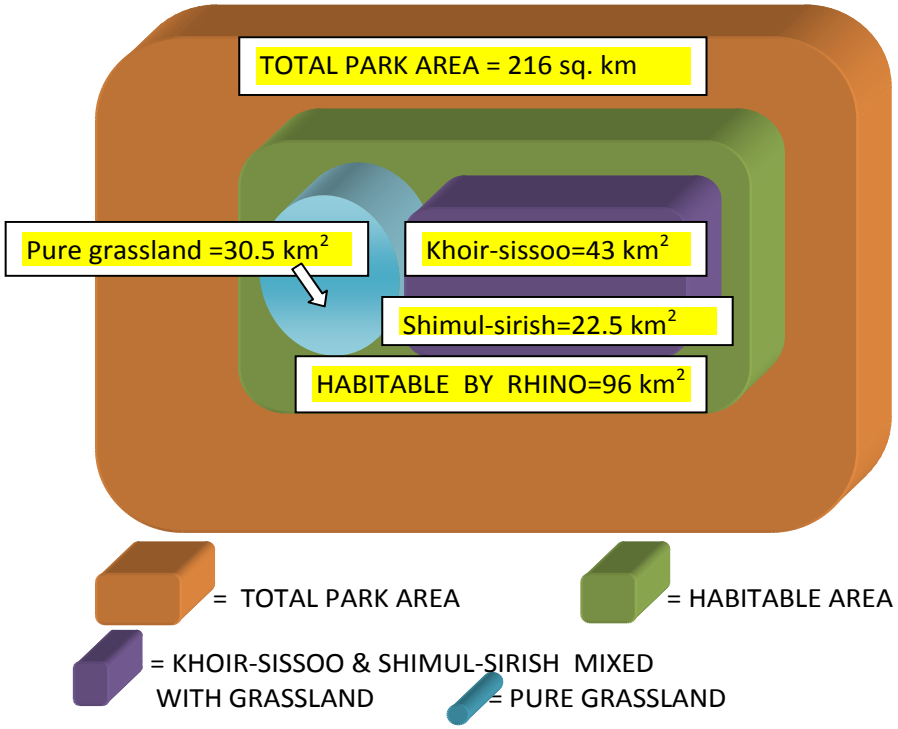


Fig. 1.7: *Schematic representation of Jaldapara habitats (after Mallick,2015) [drawn not to the scale]*

Fig1.8 (a) and 1.8(b) shows the block wise compartments of Jaldapara N.P. from 1993 and before 1993 respectively. Onwards 1993 extra 101 km² area comprising of Joygaon, Dalsinghpara and Titi blocks at the north side of NH31A up to Bhutan border and two blocks namely, Mendabari and Bania have been added. Among these, Joygaon, Dalsinghpara and Titi blocks are entirely uninhabitable for rhinos and there is no record of visit of rhinos in those blocks. On the other hand, Mendabari and Bania blocks along with CC lines have good rhino fodder, in spite of that, rhinos are less frequent visitor over there and do not stay for a long time crossing the river Shil Torsa. Fig.1.8(c) represents a working map of early research days, where the encircled areas depict the known rhino habitats.

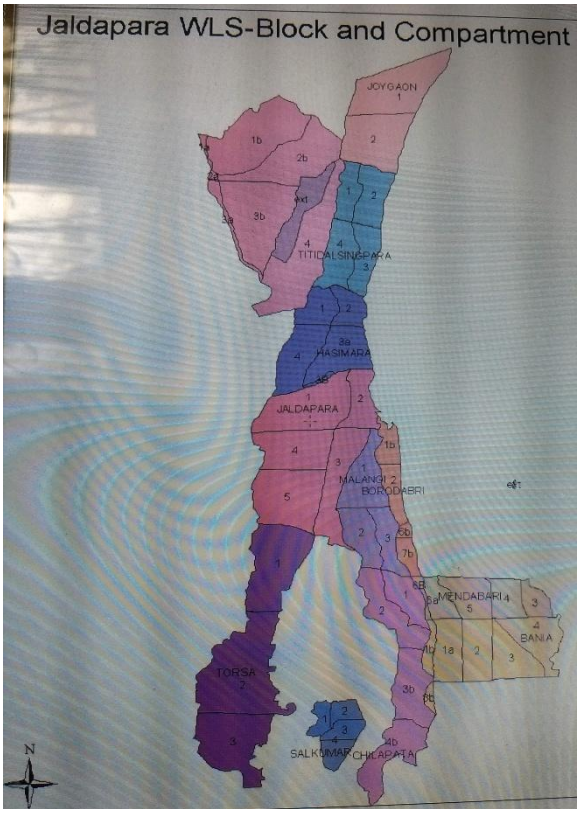


Fig.1.8(a):*Block wise map of Jaldapara after 1993 101 km^2 area has been added in the north of NH31*

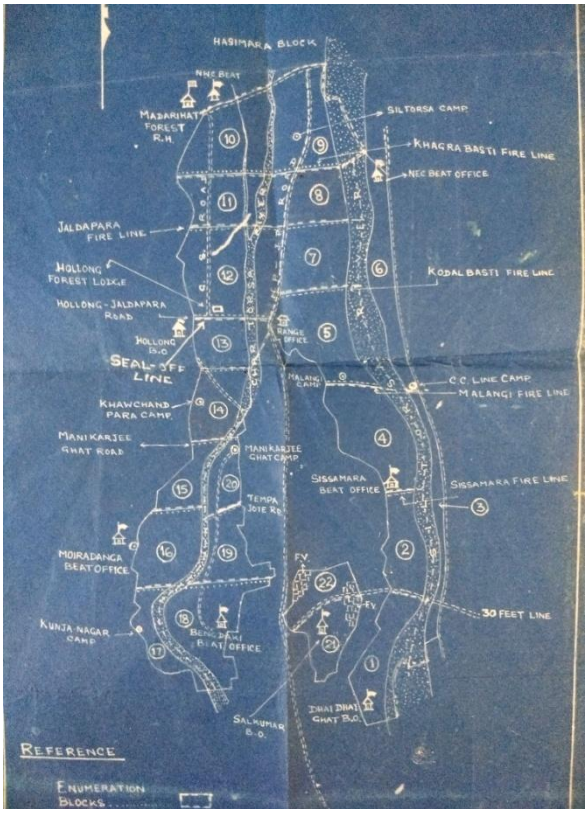


Fig 1.8(b): *Block wise map of Jaldapara in 1982 Mendabari, Bania, Titi,Dalsinghpara and Joygaon Blocks were absent at that time.*

It is quite obvious that in normal course the rhino concentration is higher in those blocks where the quantity and quality rhino fodders are mostly available. According to Banerjee (1993), Chilapata, Jaldapara and Torsa blocks are much productive in terms of biomass in ton/ hactor than Hollong, Bengdaki, Daidaighat, Borodabri, NWCC Line blocks. Thatswhy, the density of rhino populations are mostly found in the southern and central parts of the park and considered as prime grassland habitat. Table 1.3 projects about a comparative statement of productions in terms of biomass in ton/ hector and the percent coverage of pure grassland habitat at Jaldapara.

Table 1.3: *A comparative statement of biomass in ton/ hector and percent grass coverat Jaldapara (Banerjee,1993)*

Blocks	**Biomass in ton/hector**	**% grassland coverage**
Chilapata, Jaldapara, Torsa	19.50 – 22.05 tons/ hector	65 – 75%
Hollong, Bengdaki, Dhaidhaighat, Borodabri, New CC Lines	12.50 – 15.08 tons/ hector	31 – 41%

Overall, we have observed that the two ranges, i.e., Jaldapara East comprising of Jaldapara, Sissamara, Dhaidhaighat and Malangi beats and West range comprising of Hollong, Kujanagar, Bengdaki and TEC beats are high rhino concentration areas which corresponds the study of Das et.al.(2003).

1.2.6 ***Other problems relating to conservation at Jaldapara:*** The Southern part of Jaldapara,where the habitat is favourable for rhinos, has got a peculiar shape like a trouser and for this reason, naturally it has got a very long boundary. Longer the boundary greater the pressure on its safety and security. Because of its linear shape with two trouser's leg like projections and size, Jaldapara is facing severe problems of livestock grazing and human pressure. Commonly thousands of cattle were seen grazing inside the park every day. It is a serious threat in terms of spreading infectious diseases like foot and mouth disease, reindeer pest disease etc. which has every possibility of contaminating those diseases via the domestic cattle. Moreover, practically, buffer zone is almost absent and human settlements reside in the fringe areas, that too is a serious concern about the protection of the park. Illicit poachers can manage to get an easy entry into the park and becomes the cause of headache to the management authority.

1.3 ***Conservation success story:*** In recent years, rhinos along with other large and medium to smaller sized herbivores have been successfully conserved due to a tireless effort like intensive patrolling on elephant back, on foot and by vehicles from the part of forest management (Mallick,2015). Besides this, eco-development activities and an intense intelligence network in and around these protected areas (Martin, 2006; Martin and Vigne, 2012) also brought success to them for which there was only one case of poaching during the twenty first century.

It is a good approach from the part of the forest authorities that they are now installing many modern anti-poaching devices like installation of spy cameras in some hidden places, particularly, along the rhino and elephant corridors; modern weapons and binoculars to combat with the poachers; wireless system for quick communication and to get information in advance; good network among the forest guards, as well as, spreading network among the surrounding villagers, tighter vigilance and taking stern actions against the illegal intruders etc. Due to these reasons, there was a single case of poaching during 21st century at Jaldapara up till 2015 and no poaching at Gorumara so far, and so Gorumara was declared as the best among the National Parks in India by Ministry of Environment and Forest in 2009. Although

a few incidents of poaching have recently been occurred at Jaldapara in July,2015 which was seventh in a row and in February,2018 (Bhattacharya,P.,2015) where the horns were removed but due to a strong network the total gang of six poachers including a "sharp shooter" from Arunachal Pradesh have been arrested on 8th February,2018 soon after the last incident occurred (Bhattacharya, P.,2018).

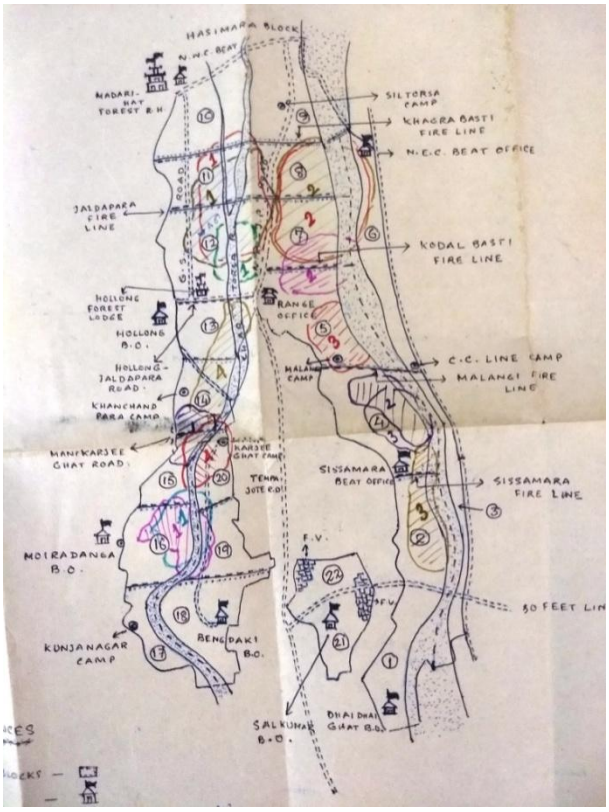


Fig.1.8 (c): *Working map of Jaldapara in 1982*

The locations and ranges of different known rhinos are expressed in the working map in left [Fig.1.8(c)].Some of these areas' width in the west and east legs are so narrow that the lives of rhinos remain at stake. Moiradanga and Bengdaki in western leg and Sissamara, Dhaidhaighat and partly Malangi beats, in particular, are very vulnerable in respect of safety and security of rhinos along with other animals of commercial value. Although, pure grassland habitat in Jaldapara is confined only within 30 km^2 (prime rhino habitat) (Nandi,1991) but they are also observed in the riverine forests of khoir-sisso and shimul- sirish mix grassland zones.

Jaldapara Forest Management Authorities, in recent years, have managed to check rhino habitat loss moderately through many habitat improvement programmes and the processes are still in progress which are as below:

- Plantation of quality indigenous tall, medium and short fodder grasses, so that no shortage arisen in the driest months.
- Removal of invasive plant species such as climbers (*Michenia sp.* Fig.1.6) and weeds, both in grasslands and riverine forest areas.
- To regenerate nutritive shoots a process of selective burning of grasslands in alternate areas has been undertaken.
- Sowing of seedlings of indigenous tree species in selected areas to compensate the loss of forest cover.

- A number of concrete water recharging structure was constructed at Harindangar char (Jaldapara- 5) for maintaining the water-level of the stream Chirakhawa (preferred rhino-bathingsite), which have yielded excellent results.

1.4 ***Present scenario at Gorumara:*** The combined Jaldhaka-Murti-Indong-Diana floodplains have formed Gorumara,which consists of 11 forest blocks (29 compartments). The blocka are arranged according to larger to smaller areas, which are as below:

Table: 1.4: *Block and compartment wise area of Gorumara National Park*

Blocks	Compartments	Area
South Indong	1,2.3	12.73 km^2
Tondu	1,2a,2b,3,4a,4b	11.31 km^2
Barahati	1,2,3	9.31 km^2
Medlajhora	1,2,3	8.50 km^2
Bhokolmardi	1,2,3	8.35 km^2
Selkapara	1,2	7.67 km^2
Gorumara	1,2	6.59 km^2
Kakurjhora	1,2	5.65 km^2
Dhupjhora	1a,1b,c	4.24 km^2
Jaldhaka	1b	2.62 km^2
Central	1	2.48 km^2
11Blocks	29 compartments	Total area 79.45 km^2

Gorumara has suffered less anthropogenic threats compared to Jaldapara regarding human pressure and livestock grazing. The main core area has been better protected by thick forest on north and south sides, west by vast stretch of tea garden and east side by Jaldhaka river.

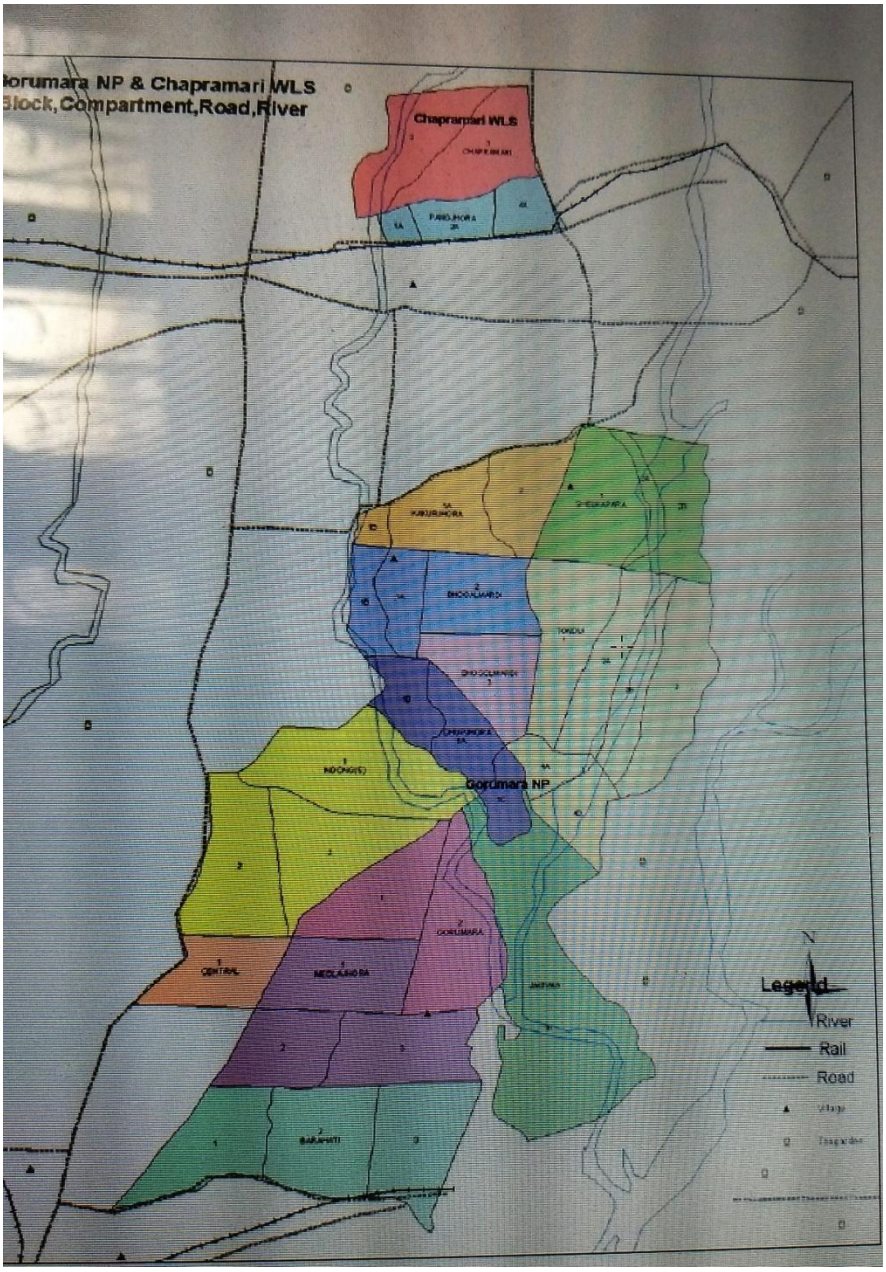


Fig.1.9: *Present Block and Compartment wise map of Gorumara N.P*.

The eastern Jaldhaka side is its weaker point also. Easy entry of poachers is possible from that side; but strict vigilance from the part of authority has prevented creating disturbances from the poachers.

In Gorumara, too the resident rhinos do not use the whole park area. In fact they mostly use the core habitat zone of 8 km^2 area which comprises only 10.08 percent of the total park area (Bhutia,2008). During our present study the rhinos were mostly found to use (grazing, resting, wallowing, roaming and other activities) riverine grasslands of Dhupjhora (4.24 km^2) Jaldhaka (2.62 km^2) and a small part of the south Indong I (1.5 km^2 out of 12.73 km^2) blocks which corresponds to the study of Mallick (2015).

There are four major vegetation types in Gorumara. Most of the area is occupied by woody canopy forest comprising of sal (*Shorea robusta*) and segun (*Tectona grandis*), followed by *Acacia- Dalbergia* mixed riverine forest and*Albizia- Bombax* mixed grassland (both make 30 percent of total park area (Mandal,2007) and riverine grassland (10.08 percent). Of course, the major vegetation types include swampy areas, muddy wallowing pools, perennial water reserves and other minor ecosystems.

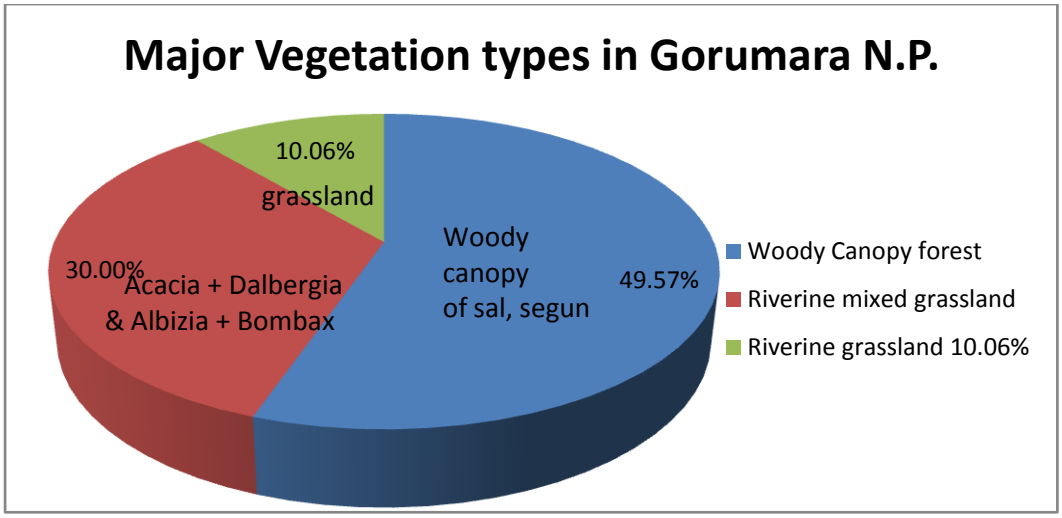


Fig.1.10: Graphical representation of major vegetation types in Gorumara

Like Jaldapara, several copies of working maps of Gorumara were also made to locate rhinos on spot, their droppings, vegetation types, home range patterns etc. readily and latter on the location spots were analysed which were correlated with time of the day, seasons, temperature and other climatic factors. Fig 1.11(b) shows the working map of Gorumara for ready references.

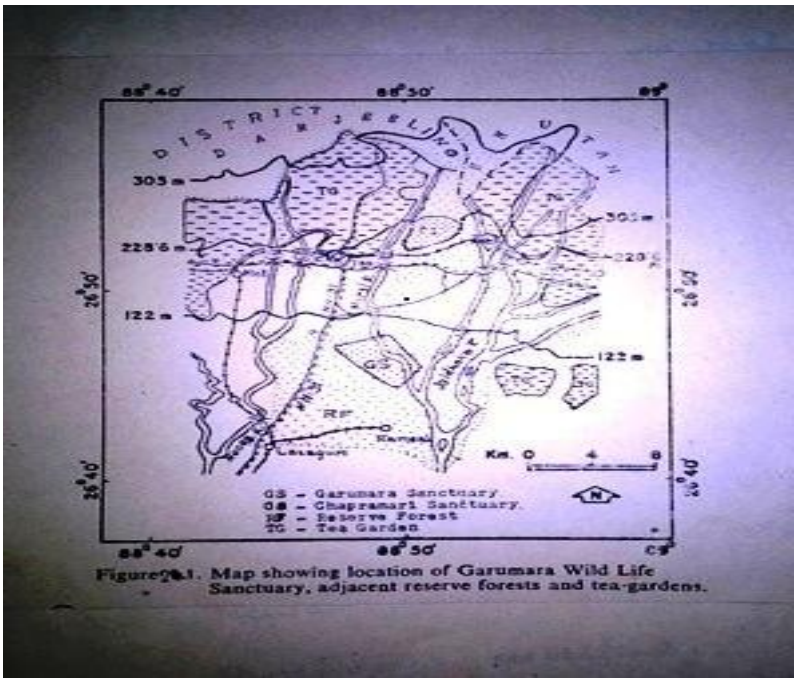


Fig.1.11(a): *A 1981 map of Gorumara and adjacent areas*

Fig.1.11 (a) A map showing the location of Gorumara Wildlife Sanctuary (the then), adjacent reserve forests and tea-gardens in 1981.

The map shown left side was collected from the Gorumara Beat Office, which proved to be much helpful during the course of our study. Latter we prepared working maps for our convenience after being familiar with the sites within the Sanctuary(Fig.1.11(b)

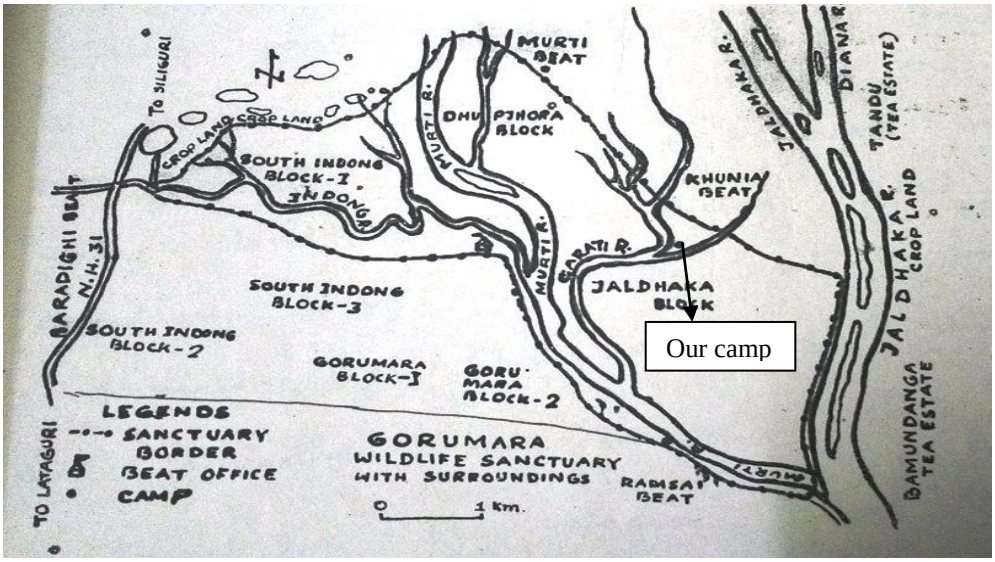


Fig.1.11(b):*Working map of Gorumara in 1981. The black spot located at the junction of the bifurcation of Garati river indicates ourcamp*.

Rhinos were the continuous and regular visitors mostly in the Dhupjhora and Jaldhaka blocks and partially in the south Indong I blocks (present study) but during summer months (last part of March, entire April and May) they frequently invaded the adjacent wet mixed forests where they usually disliked to stay for a long time. It was because of the rotational firings in grasslands in those months and the rhinos were seen browsing the leaves of lower branches going against their habit. In summer months either the dominant bulls used to show much territoriality (though they are not actually territorial) not by leaving the best areas of grasslands containing muddy wallowing pools or if they retreated, after a deadly fight with the other bulls, they used to take shelters in the adjacent wet mixed forests. In many occasions, the subordinate bulls and immature have been found roaming and resting or found grazing or browsing with a greater home range in Medlajhora 1, Kakurjhora 2, Central 1 and Barahati 1,3. For wallowing and saltlicking they used to preferSouth Indong 1, Jaldhaka 1b, Tondu 4, Medla 3, Dhupjhora 1b, Old Khunia, and Barahati 3.

1.4.1 *Constraints about the rhinos of Gorumara*: Gorumara was awarded best managed and protected National Park in India in 2009 by Ministry of Environment and Forest, Government of India based on the following facts:

- Having a very good buffer zone giving a secured inner core zone.
- Undisturbed habitats
- Increasing the population of Rhino and other animals
- Overall nicely managed Park
- No incidence of poaching during the last six years.

But this increasing rhino population has been creating much pressure on the tiny grassland habitat of Gorumara and this population boom with skewed sex ratio (adult male population outnumbers the adult female population considerably) led much intra-specific male to male aggressions which ended in the deaths of weaker individuals in many occasions. If not death occurred the weaker ones got severe injury or driven out of the park. These incidences kept busy the Park Officials and forest guards because the driven rhinos outside the park area turned vulnerable to the poachers. Over population within a small area becomes sometimes bad as it happens in case of Gorumara.

1.4.2 ***Over population as well as skewed sex ratio of rhino causing much intra specific conflict at Gorumara:*** The present status of rhinoceros and their future status of population density depends on the demographic ratio of male: female and their age structure which reflects the reproductive ability of rhinoceros (Spillet, 1966). Generally ungulates are promiscuous in case of mating and a single healthy adult bull has the capacity to inseminate three or four females one after another. So the sex ratio of 1 male: 3 or 4 females should be the ideal. For that reason, in a population where there is higher percentage of female, that population is likely to be sustained and a higher reproductive potential is noticed. With this data one can predict the future population status by a simple calculation and can calculate its average net loss or gain annually subject to the carrying capacity limit of that Sanctuary.

Let there be a population of rhino in Sanctuary A containing 5 adult males and 8 adult females and there are 8 adult males and 5 adult females in Sanctuary B and all are within their reproductive age limit. The preconditions are that all the female rhinos are get inseminated and fertilized, no natural death or death due to agonistic interactions occur and also there are no incidence of poaching and emigration. After 16 months (gestation period of Indian rhinos) one can expect maximum 5+ 8+ 8 (calves) = 21 individuals from Sanctuary A and maximum 8+5+5(calves)= 18 individuals from Sanctuary B. Sanctuary A gets a clear cut gain of three rhinos over Sanctuary B. So skewed sex ratio has a direct effect on the population strength of rhino or other ungulates as in the latter case.

But in Gorumara, the average sex ratio has completely overturned from the early nineties when the sex ratio was 1:2 (Bist,1994). Currently, Gorumara is having 51 rhinos, out of which there are 21 adult males, 1 sub adult male, 16 adult females, 1 sub adult female, 10 calves (whose sexes are yet to be identified), 1 non sexed (Basu,2017) and one adult male probably died (?).

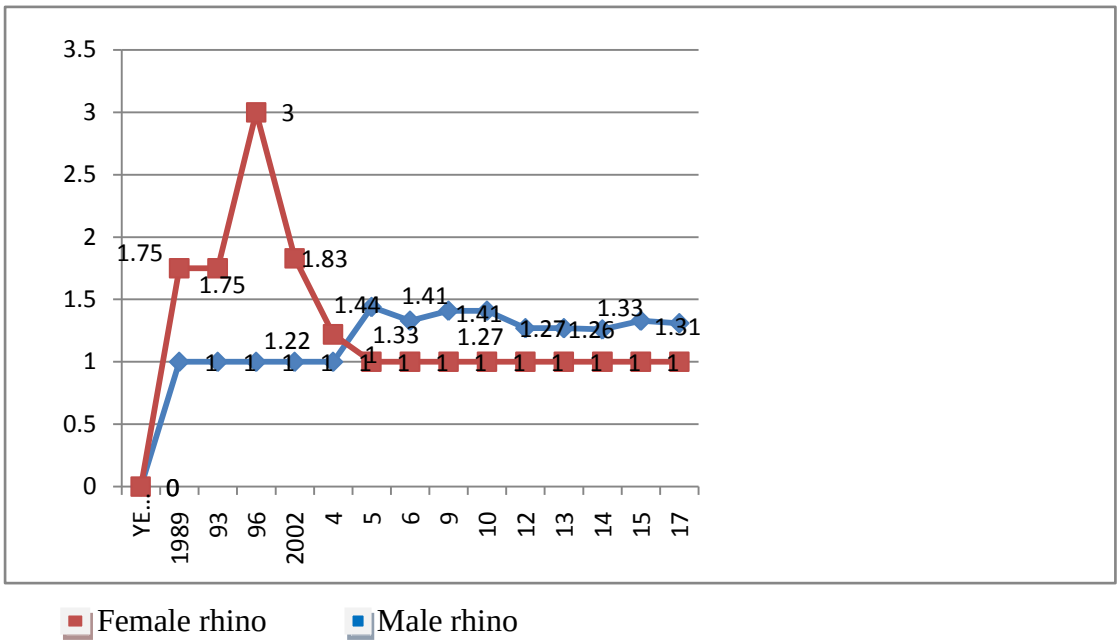
This heavily skewed sex ratio (Borthakur,et.al. 2012) can be traced back from the official records since 2005 and since then agonistic interactions in Gorumara gradually took place. The ideal ratio should be 1:3 (Borthakur,et.al,2012) but in Gorumara presently it is 1.31:1. How the sex ratio has been changed chronologicallyis shown in the Table- 1.5

Table 1.5: *Chronological changes in the sex ratio in Gorumara*

Year	No. of males	No. of females	Total population	Sex ratio
1989	4	7	12	1:1.75
1993	4	7	15	1:1.75
1996	2	6	15	1:3.00
2002	6	11	22	1:1.83
2004	9	11	25	1:1.22
2005	13	9	27	1.44:1
2006	12	9	31	1.33:1
2009	17	12	35	1.41:1
2010	17	12	35	1.41:1
2012	14	11	43	1.27:1
2013	14	11	43	1.27:1
2014	19	15	47	1.26:1
2015	20	15	50	1.33:1
2017	21	16	51	1.31:1

The above table shows two distinct phases of sex ratio in Gorumara, i.e., before 2005 and after 2005. The altered sex ratio after 2005 has led many intra specific infightings causing severe injuries and even deaths in a few occasions. Besides this driven out males have invaded nearby croplands for food creating human-rhino conflicts. The bull to bull fights are either mainly centred on the possession of breeding females in oestrous condition or possession of best areas of the park during dry months. Fig.1.12 shows the graph representing the skewed sex ratio in Gorumara.

Fig.1.12: *Skewed sex ratio from 2005 in Gorumara where male population exceeds female population*



From the above graph it is quite evident that despite its overall growth, the sex ratio of the park's rhino population is severely imbalanced, with more reproductive-aged males than females (Fig.1.14).

A male-heavy population threatens the long-term reproductive and genetic viability of the population, as well as leading to increased conflict over mates.

Gorumara, a tiny National Park, has been remained isolated from the neighbouring Jaldapara since the last decade of the 19th century. This gene pool isolation along with high rate of inbreeding has deviated the population towards unwanted homozygosity from the desirable heterozygosity.

The population boom in the small habitat of Gorumara is not healthy for the current residents of the park as the carrying capacity of this small habitat is not sufficient for so many large voracious herbivores, so some adjacent areas are under consideration for relocation of some adult rhinos namely, Buxa Tiger Reserve and Patlakhawa of Coochbehar.

Frequent infightings or intra-specific aggressions have been recorded in recent years (Table 1.6) due to skewed sex ratio in favour of males and these agonistic interactions are the root cause of straying out of some weaker bulls in the forest area outside the park which is vulnerable to poaching

In near future continuous inbreeding may cause low genetic diversity in Gorumara's rhino population, as compared to those found in Kaziranga or at least in Jaldapara. The Gorumara rhinos are in confinement for 125 years or so. In this situation, a male heavy population implies that a smaller and smaller proportion of the reproductive-age population actually contributes to breeding. Hence, the loss of genetic diversity in the generations to come is inevitable.

Table 1.6: *Intra specific aggressions in recent years in Gorumara (Basu,2017)*

Year	Number of fights	Injury	Death
2017	6	6(2major)	-
2016	8	7	-
2015	1	1	1
2014	1	1	1

1.4.3 ***Effects of breeding ages of females influencing skewed sex ratio****:* It is proved that the age of the mother is an influencing factor to procure the natal sex ratio. In case of Indian rhinoceros the age categories at birth of calf are less than or equal to 12years, between 12 and 19 years and greater than 19 years (Mallick,2015).

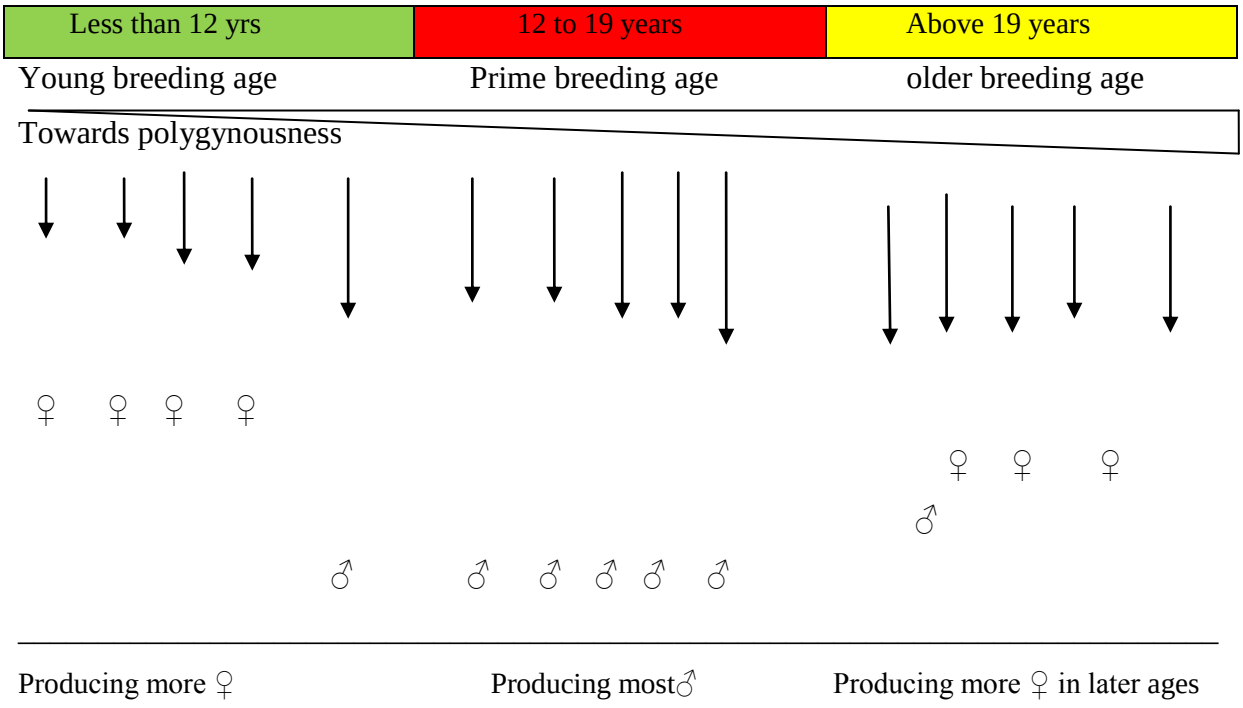


Fig.1.13:*Breeding ages in female individuals*

Rhino females are known to be polygynous in nature, at least under pressure imposed by breeding males, and throughout their lives the average body condition do not remain same . It has been observed that usually the male offspring are born when their mothers are in good biological and physiological condition. On the other hand, females in poor condition tend to produce female offspring. The sex ratio of male calves to female calves is expected to be low in too young females (because the body is not fully mature at that age) and aging breeding females (when the reproductive ability diminishes). But it becomes high in females of prime breeding age (Fig.1.13). As they reach the end of their reproductive life, their body condition is degraded.

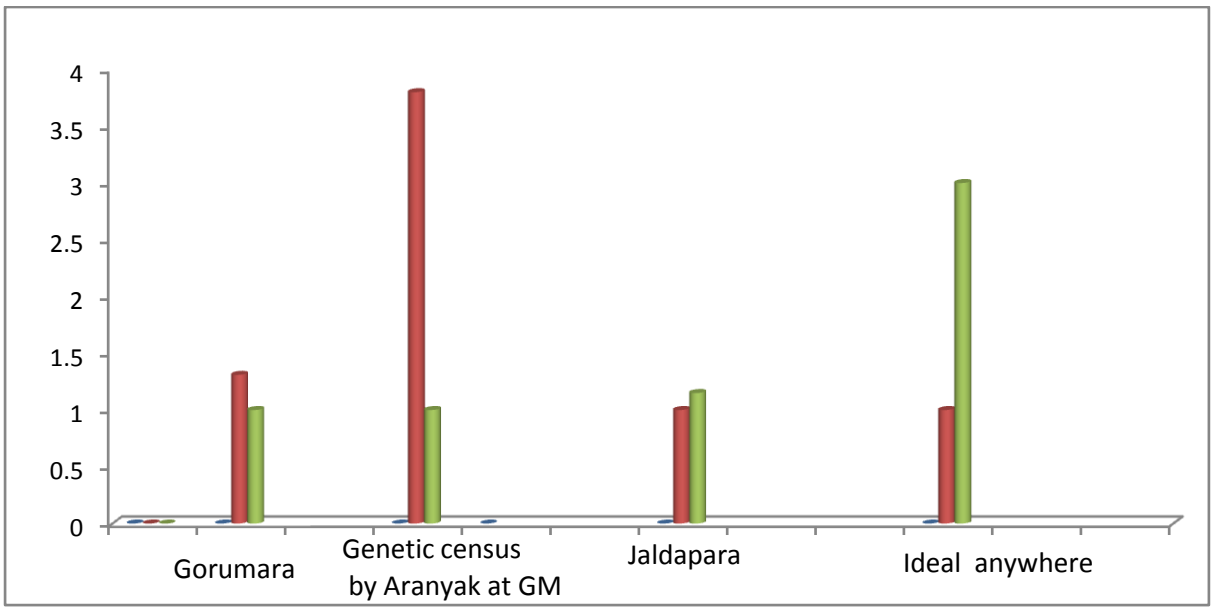


Fig.1.14: *Sex Ratios at Gorumara, Genetic census by Aranyak at Gorumara, Jaldapara and Ideal situation*

Now the question is this why the sex ratio in Gorumara is becoming more and more skewed in favour of males when there is equal opportunity to inseminate the younger and older females by the breeding bulls apart from prime breeding aged females. The answer may be that the fighting amongst dominant males is centring upon the prime breeding aged females who are less in number. The conceived prime breeding aged females usually give birth to male offspring since their body conditions are better. Thus, a severe aggression is noticed among adult males and also with the females who refuse to accept dominant males. In many occasions adult females are attacked and chased by males and lastly get severe injury. Better adult condition affects the reproductive success of the male more than the female. Often the powerful male, who is obviously in better condition, drive other males out from the breeding

sites and sire many offspring himself, whereas a male in poor condition is not likely to sire any offspring because he is driven away from the females by the better conditioned males.

From the evolutionary standpoint one kind of Darwinian fitness plays a role over here. The offspring are mostly the descendants of the genetically superior parents and a large section of them are latter identified as males. So a genetically fit population is gradually replacing an unfit population but at the same time repeated inbreeding by same dominant breeding bulls each and every time is inviting a rhino population of lower genetic diversity.

1.5 ***Immediate remedies:*** Immediately a number of female rhinos must be translocated from the neighbouring population, i.e., from Jaldapara, but the D.F.O. of Jaldapara Sumita Ghatak explains that the sex ratio of Jaldapara is just managed there and Jaldapara is not in a position to share a portion of female rhino population right now, so the matter is hanging at present (Basu, May 2017).

1.5.1 *Practical problems relating to the reintroduction of rhinos in two new sites in West Bengal:*

Buxa Tiger Reserve Area and Patlakhawa Forest near Jaldapara.: If the rhinos are to relocate in the two new proposed above mentioned sites from the existing rhino population the first and foremost difficulties are to face is that to maintain the sex ratio in the new sites. The ideal sex ratio is 1 male: 3 female rhinos to avoid male to male and sometimes male to female aggression (if the female refuses to accept courtship initiated by the male). Already in the existing sites (Gorumara and Jaldapara) the female population is severely low. So, if the 1:3 ratio in the two new sites is to maintain and the breeding bulls and cows are brought from the present sites, the sex ratio in the existing population will be more skewed which may lead to extinction of local populations.

It would be more realistic if some strong females are introduced from other areas (preferably from Kaziranga, because a large population usually possess high heterozygosity) and a few breeder males are taken to those sites where there is a shortage of male population. As for example, except Assam and West Bengal the only rhino population exists in Dudhwa National Park in Uttar Pradesh, India. There out of 30 rhinos, confined in a small area, it is assumed that just one male probably affecting the genetic health of the population (Dasgupta,2016). In that case Dudhwa can be the new home of some Gorumara male rhinos.

Gorumara and Jaldapara have been remained isolated for some 125 years or so. That means, these two patchy rhino populations did not have the chance of genetic mixing for more than a century. By this time, they have passed through tremendous turmoil and in a few occasions almost knocked the door of extinction due to poaching, habitat shrinkage, natural calamities like flood etc. In those bad days there genetic quality likely went down because of living in such a small and closed area. Though population has been increased considerably, still there is no other option beyond inbreeding. To overcome this peculiar situation and to increase heterozygosity, interchange of some breeding males and females with Jaldapara may be the only solution for checking homozygosity.

Let us hope for the best in future.

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CHAPTER : 2

The Study on the population status, demographic changes, age-sex proportion, Social Association, group size and group composition

Eight rhinos have been captured in a single frame

2 Population Studies

2.1 Identification:

2.1.1 Identification by Direct Observation:

Much works have been done on the population studies, demographic patterns and social associations of Indian rhinoceros (Ulrich,1964; Lahan and Sonowal,1973; Laurie,1978; Bhattacharya,1991; Foose et.al.,1993; Bhattacharya,1993; Jnawali,1995; Mukherjee and SenGupta,1999; Hazarika,2007). Animals containing social groups have some advantages over the non-social animals like rhinos in relation to the intra specific communication systems such as responses to any visual, auditory and other signals; interdependency on each other, alertness to danger with a prior estimation etc. All these may increase the fitness level for survival. As the rhinos have no strong bondage among the individuals they are somewhat reluctant about the dangers to come.

In our initial days of staying at Gorumara and Jaldapara we needed to identify individual rhinos in order to estimate their actual number, age-sex ratio, density of population etc. I myself, along with other four Forest Guards and watchers (Plate 2.1) consumed much of our time in searching of the rhinos and let them familiar to me. Firstly, we had to depend on their morphological appearances and their individual recognising features such as arrangement and irregularities in skin folds, horn length and shape, tail length, structural fold of bibs, body scars (if any) etc. which were noted down in our field diary. Photographs were taken, as many snaps we could take from different angles so as to be sure about slightest morphological differences. Since these two areas were never studied before concerning with rhinos' behavioural aspects, we had no ready references of works with earlier photographs or written descriptions of rhinos. We followed the above mentioned recognisable features which were used by Laurie in 1978 at Royal Chitawan National Park in Nepal. Close observations on the above features could enable us to identify the rhinos individually in a gradual process.

Plate 2.1: *My team mates at Gorumara; standing left is the author*

2.1.1.1 Identification of age-class :

The sexually mature adults were easier to identify than the immature ones due to presence of prominent genitalia in the former ones. The height and length of the immature and weaning calves were not considered because those were changeable in course of time. For convenience, I classified three age sexual maturity classes which are as follows :

Adult : Sexually mature but not necessarily full grown (about 4 yrs. Old or older). They may attain but full body size grows up to 6 and half years. The body folds are prominent, horn grows considerably. Commonly developed bumps, folding of bibs, irregularities of the skin folds, tubercles and scars (when present) are the identifying features as the animals grow older.

Immature : Not sexually mature but leave their mothers and are shorter than the adults but may be nearly full grown (about 2 to 4 yrs. Old). The body surface is overall smooth. Body folds are not distinct. Horns do not grow up to full length.

Calf : Still with their mothers (Plate 2.2)

***2.1.1.2 Sex determination* :**

Simultaneously with age-class identification we also paid our attention to the determination of sexes. The adult dominant breeding bulls were easily recognisable by means of their

Plate 2.2: *Mother with calf at Kaziranga*

external genitalia or penis, which were visible from lateral and rear sides. Besides, they were generally recognised by their wider girth at the shoulder region and massively built body. A female in oestrous was recognised by the dribbled urine resulting in a large, dry, whitish stain leaving on the hind legs and surrounding the vulva. The other females' (non-oestrous) genitalia were needed closure observation from the rear side. Apart from observing genitalia the other sexual dimorphic features such as comparative body size and shape, shape of the head, neck and bib folds, shape and size of the horns etc. were taken into consideration when the rhinos, particularly the adults could not be observed from the rear side. The sexual dimorphic features in adult rhinos have been presented in the tabular form below :

Male	Female
1.<u>External Genitalia :</u> Penis is visible in between hind legs from behind or sides.	1(a). In oestrous condition a dry white stain is noticed between hind legs and surrounding the vulva. 1(b). In other females vaginas are visible from rear side under careful observation
2.<u>Body size :</u> Larger in bulk and structure	2. Smaller in body size.
3.<u>Shape of head :</u> Wider at the neck region.	3. Narrower at the neck region but also tapering towards the snout.

4. Horn : Broader at the base and usually longer.	4. Narrower at the base and smaller.
5. Neck folds and bibs :Deeply folded skin around the neck and rump ; bigger bib beneath the chin.	5. Shallow folding of skin around the shoulder and rump, smaller bib. shoulder and rump ; smaller bib.
6. Accompaniment of calves : Calves are never accompanied	6. Accompanied calves clearly indicates the adults as the mothers and females

Sex determination of the immature, in general, was often difficult to conclude from a distance since they had not developed above mentioned strong sexual dimorphisms. In older immature, however, the tendency of formation of would be distinctive sexual dimorphic features started to begin which could prove something about their sexual status. The younger immature rhinos have no clear development of the skin folds on their bodies. However, it took several days observation to come to a definite conclusion about their sexual status if they were not too young.

Sex determination of the calves were nearly impossible. The younger calves required prolonged observation for sex determination, but the slightest disturbances made by any sound either from the part of the observer or by any sound audible to the calves from other sources led them to take entry underneath the abdomen or other side of their mothers, thereby, often the visions were interrupted. Apart from the calves' timidity the mothers seemed to be very aggressive. Lower the age of the calf higher the aggressiveness of the mother as well as higher the limit of safe distance from the mothers and vice versa.

The mothers often could be able to detect our presence and depending on safe distance either they chased or tended to chase or ran away taking the baby front. In several occasions we were chased by the mothers at Gorumara, Jaldapara and even at Kaziranga (where they are believed to be much sociable due to higher tourist encounter and greater population density)[Plate 2.2].

But, we were able to register the calves (Sec.2.2) at Gorumara and Jaldapara by the individual characters seen with their respective accompanied mothers' appearance. The new born babies always remained close to their mothers. Later, during the age of weaning and gradual transformation from calf to immature category they were tried for sexual registration.

2.1.1.3 Individual Identification:

For spot identification we used to record at least one or two identifying features for each rhino. It was important since it could reduce the chance of findings two rhinos with the same recorded features and thereby avoiding the confusion in their registration process.

In the dense thick vegetation intermingled with tall reeds at Jaldapara and Gorumara it was not always possible to observe the animals for a longer duration but when a brief glimpse of a rhino caught our eyes we became able to identify that by our previous experiences unless we knew their minute characteristic differences such as ears, rump, skin folds, horns, tails and their two flanks. For ears the acquired nicks along the edges, shape, size and positions over their heads (distance between two ears) etc. were considered as the distinctive features. The last part with tuft of hairs at the end of tails were sometimes found to be lost in some rhinos. we could readily identify one adult female at Gorumara (GF02) whose amputated tail could identify herself (Plate 2.3). For horns, the degree of curvature, rings and grooves at the bases, length etc.were the prominent recognising features. In addition to those individual fold characteristics, swellings on the folds, distance between the ears and direction, general shapes of the heads were also considered as reliable identifying features (see section 2.2).

Although we tried to take photographs of each individual but, in many occasions photography was often proved to be impractical particularly at night and in dense tall grasses. So these photographs were supplemented by line drawings and description of each individual's identifying marks. Latter, at the time of registration these drawings with brief description were recorded besides respective registered individuals. Identity cards with brief descriptions were also made for quick reference.

2.1.2 Identification by Indirect Observation:

From the early eighties (beginning of our research study) while tracking the trails of rhinos tirelessly hours after hours the fact became gradually clear to us that the foot prints of the individuals would never be alike (Fig.2.8). Thick vegetation and low density of rhino population both at Gorumara and Jaldapara often made our observations difficult. So, simultaneously, along with direct observation we inclined to collect the life sized foot prints of rhinos from normal surface condition following a simpler modification of S.R.Choudhury's technique (Panwar,1980). Besides study of foot prints for individual identification we also learned to estimate the age classes by viewing the size of the dung balls. However, in no case the sex could be identified.

2.1.2.1 Individual Identification by foot print analyses:

The method adopted here consists of a colourless rectangular plate measuring 35 cm x 32 cm x0.3 cm, a free flowing sketch pen, some papers, a couple of rubber bands, a piece of soaked cotton and a metre steel tape. The impressions might look bigger on a slushy soil while looked compact and perfect on a harder surface. Even in such situations, however, as far as practicable, perfectly normal rear foot prints were taken for keeping records and further analysis. Rear left or right foot prints were taken into account since the fore foot prints were partially or completely superimposed by hind foot prints while walking.

The glass plate was placed lightly above the well formed rear foot impressions and the cares were taken that the eyes remain perpendicularly straight over the impressions in order to avoid errors due to parallax while tracing the outlines. The tracings on the glass plate were transferred immediately to the paper sheets by holding the glass plate along with the overlaid sheet of paper against sunlight and tracing was done. After transferring the impression to the paper the previous impression was removed by soaked cotton to get it ready for taking next impression.

A lot of tracing practice and experience in analytical comparison enabled us to visualise the intricate differences which helped us to identify one rhino from another. We always used to look for the special features in the morphology of the foot prints. Rhinos being the perissodactyle mammal the limb structure developed the mesaxonic condition where the digits arranged on both sides of the third digit which is the main weight bearing digit (Young, 1988). In other words, the main axes of the limbs pass down on to the third digits. In case of rhinos only three digits along with the sole leaves an impression on the soil. The impressions revealed that the middle digit is somewhat horizontal guarded on both sides by two lateral vertically placed digits. The other two digits are reduced and non-functional. The sole is broader at the top and narrows down at the base. Individuality remains in the shape and angular orientations of the digits from the centre point, length and width of the toes and soles, shape of the soles and some other minute differences (Fig.2.2). However, we found no identical impression among the rhinos resembling the finger prints of human beings.

In the latter part of our study we could identify all the rhinos of Gorumara and almost half of the total population of Jaldapara by their foot prints. But it took time to recognise them by their foot prints as we had to know first which foot print belonged to which one. For example, the more aggressive bull GB02 (Bhattacharya, 1992) who had long pointed horn

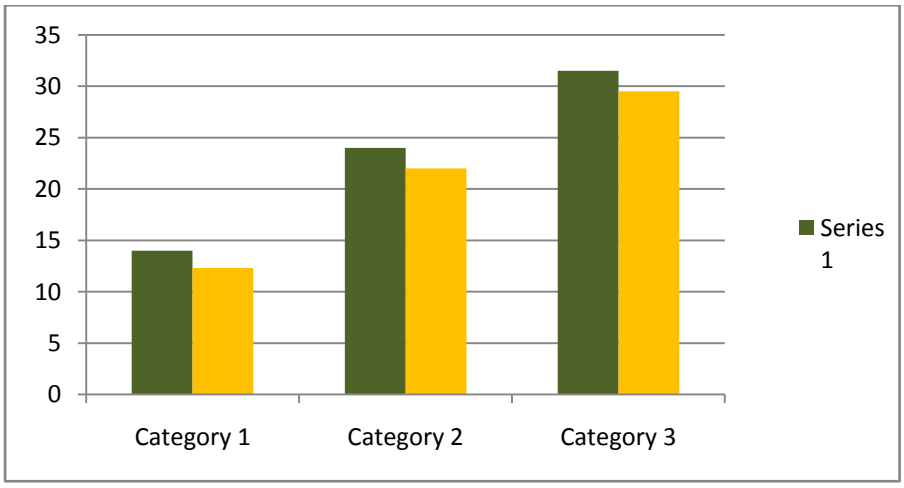
and a tubercle on the left shoulder skin fold possessed a deep notch between 2nd and 3rd toe. Another adult female of Gorumara (GF03) who had an amputated tail had comparatively smaller third toe (Table 2.1).

The beautiful aspect of this method is that one can get necessary valuable data on them and can continue his /her study particularly on home range, habitat use pattern, daily activity cycle, population study and so on by following their tracks and trails without viewing them. When the visibility of rhinos was often obscured by the dense tall reeds and riverine mixed forest in addition to the low density of population this method of recognition by their foot prints alone proved effective during the study.

2.1.2.2 Age class identification:

2.1.2.2 (a) By foot print:

In the new study areas where the rhinos were yet to be familiar to us, even then, we were able to predict the age class instantaneously though the individual identification was not possible. The age class was predicted by measuring or viewing at a glance (through experience gained in the latter years) of the respective size, area, length and breadth of the foot impressions. The average length and breadth of the foot print of an adult rhino is slightly more than double to that of the calf. The sub adults lie in between these two. Corresponding average length and breadth of the impressions in cm for three age classes have been shown in Fig. 2.3 and in the table 2.2.



Calf Sub adult Adult

Legend : series 1 = length in cm ; series 2 = breadth in cm

Fig.2.3 *: Length and breadth of the foot impressions are almost double to that of the calves. The sub adults lie in between these two.*

Age class	length in cm	breadth in cm
Adult	31.5	29.5
Immature	24.0	22.0
Calf	14.0	12.3

Table.2.2: *The data represents average length and breadth of the foot impressions in three age classes.*

2.1.2.2 (b) By measuring dung ball size and weight:

We found dung balls of varying diameter and weight scattered in different dung hills (Bhattacharya, 1993) which suggested that they commonly shared the same defecation spots in many occasions. The dung balls of different size and weight gave us conclusive informations about the home ranges, territorial and defecation behaviour along with scent marking pattern (discussed in section 5.2). The table below (Table 2.3) shows the comprehensive data on diameter of dung balls (in cm) and weight (in gms) available in fresh conditions for the three age classes.

Age clas	Diameter of dung balls (in gms)	Weight of dung (in cm)
Adult	520(±)	13.8 ($\pm$ 0.8)
Immature	365(±)	9.9 ($\pm$ 0.4)
Calf	180(±)	5.2 ($\pm$ 0.5)

Table 2.3 : *Data representing diameter (in cm) and weight (in gms) of dung balls in three age classes.*

2.2 Registration:

After confirmation of individuals' identifying characters either by direct or indirect observations the rhinos were registered accordingly (Annex.II). The registration number included at first the abbreviation of the name of the place where the particular rhino belonged. Then came hierarchically the age class which was again followed by the sex class.

In case of adults the single initial letter 'B' or 'F' indicated both age and sex classes. For example, 'GB' or 'JF' signifies Gorumara Bull or Jaldapara Female.

In case of immature or sub adult the sex class was put within parenthesis after age class if the sex was detected. Then the individual numbers were given to each individual as 01, 02 and so on. The calves were represented by the letter 'C'. No sex class was inferred then. Examples, GI(M)01, JI(F)02 & GC01.

By the end of November, 1981 all the rhinos were registered at Gorumara. Unfortunately, on 9th April,1981 the only calf (GC01) of the eldest mother (GF01) was reported to death by tiger predation (Nandi, pers.comm.). This death was compensated by a birth (GC02) in November in the same year. The calf was registered at the end of that month. In April,1981 the largest bull (GB01) was poached by the horn hunters. In addition to this the same ruthless incidence occurred in the last part of May,1982, the younger female(GF02) was killed just few days before I left Gorumara permanently.

So, at the time of my leaving from Gorumara, 9 rhinos including a calf was surviving till 31st May,1982. After that I regularly kept contact with Gorumara Forest and Wildlife Department Officials. No major decline in the population was happened till April,1984 when I finished all my field works lastly at Kaziranga, Assam.

Jaldapara, on the other hand, being much bigger in area (Sec.2.2.2) contained only 28 rhinos. But unfortunately during my one year field study (1982-'83) seven rhinos were killed in quick succession. We could not register many of the poached rhinos within that short period of time since they were killed within two and half month time just after my entry over there. Actually they died before they became sufficiently familiar to us for correct registration. So, the population came down to only 21 by October,1982.

Out of those twenty one rhinos nine were registered. Majority of them were from Moiradanga beat located in the western leg of the sanctuary. A few were registered from Sissamara beat of eastern leg. The registered individuals were divided into three adult males (JB01, JB02 & JB03). Three adult females (JF01,JF02, JF03), one immature male [JI(M)01] and two immature females [JI(F)01, JI(F)02].

Besides those registered individuals, five other rhinos were also encountered occasionally by me but due to lack of proper investigation and being afraid of duplication I did not consider them for registration. Among those five four of them were immature and I failed to identify their sex because only brief glimpses of them caught my eyes.

The other non registered individuals were also encountered by me several times. I, along with my team mates, felt their presence on the other side of the tall reeds, or inside the bushes, or away from us on the other side of the river, or by emitting sounds by themselves. If they were not met their foot impressions were taken after their departure. I collected many of those foot impressions from wallowing sites, but those impressions were not preserved for future records permanently as most of those foot prints became distorted because of thick soft mud of wallowing pools. The identifying features from morphological appearance and foot prints of registered individuals are shown in the form of Identity Cards in Fig. 2.4 which shows the intricate differences among themselves.

2.3. Results:

2.3.1 Density:

From the above discussions (Sec.2.2) it is clear that at the end of May,1982 Gorumara possessed only 9 rhinos (own observation) while Jaldapara had 21 rhinos (own observation and Wildlife Warden's report,1983). During my study period at Kaziranga (1983-84) there were 1080 rhinos [CCF(WL),1984] up to the end of April.1984. The areas of the sanctuaries and national park covered 8.63 km^2, 115 km^2 (latter in 1993, 101km^2 more area was added from northern Titi forest up to the border of Bhutan making it 216 km^2), and 430 km^2 respectively. The following table (2.3.1) shows the actual density of the counted rhinos in the above mentioned three study areas.

Sanctuary/N.P.	Area in km^2	No. of rhinos	Actual density
Gorumara	8.63(core area)	9	1.04
Jaldapara	115	21	0.18
Kaziranga	430	1080	2.51

Table 2.3.1 : *Actual density (crude density) of rhinos in three study areas*

2.3.2 Searching hours and actual observation hours:

Due to low population density at Gorumara and lowest at Jaldapara (Table 2.3.1) we had to spend a considerable time in searching in those two places. The actual observation hours which we congregated by accumulating minutes by minutes observation were much less in those two areas. In the first five months of the first year of our study at Gorumara (1980-'81) we spent approximately 300 hrs for searching rhinos but actual observation happened to be

only 3.5 hours! It happened partly due to our less experience and partly due to the hostile monsoon which made many parts of the sanctuary inaccessible. In the latter months we became familiar with the rhino habitats and overcame that helpless situation. Altogether we spent 2002 hours for searching rhinos over there but could able to observe them directly for 33.40 hours (Table 2.3.2).

we had to face the same situation at Jaldapara. It was more difficult to find a rhino there at will. Some parts and blocks , particularly drier northern blocks, were completely devoid of rhino population due to unfavourable habitat conditions. A decade ago, when the rhino density was higher to that of the present day density, a few of them used to live in those blocks at least temporarily (Roy, pers. Comm..). The situation turned grave when seven rhinos were poached in quick succession (Sec. 2.2) from June to September of that year (1982-'83). The density dropped down to 0.18/km^2 from 0.24/km^2 of previous year. Chances of observations became more and more difficult. However, from October,1982 we managed to stay at two rhino habitat localities, i.e., Moiradanga beat in the western leg and Sissamara beat in the eastern leg. Bulk of our data was collected from those two blocks. Altogether, we spent 970 hrs for field study, of which only 20 hrs were considered to be successful !

Kaziranga was the only exception where continuous observation was possible without interruption. The excellent habitat consisting of shallow water bodies surrounded by short grasses particularly in Baguri block proved to be much effective in connection to rhino observation. Considering the density of rhinos over there I spent only 600 hrs.(approx.) for searching (including those areas which were not supposed to be rhino habitats) and I obtained 153 hours of actual observation. The ratio between searching hours and actual observation hours in the three study areas with respective density of population in four consecutive years have been represented in the table 2.3.2 below :

Year	Place	Density	Obs. Hours	Search hours	Ratio
1980-'82	Gorumara	1.04	33.40	2002.00	1:59.9
1982-'83	Jaldapara	0.18>0.2	20.00	970.00	1:48.5
1983-'84	Kaziranga	2.51>2.5	153.00	600.00	1:3.92
1980-'84	TOTAL		206.40	3572.00	1 :17.3

Table 2.3.2 : *Chronological representation of the ratio between actual observation hours and searching hours with respective population density in three study areas.*

2.3.3 Sighting records and number of sighted individuals:

After a strainous two years searching at Gorumara and one year at Jaldapara, the number of sightings were recorded as 234 and 156 respectively. Of the 234 sightings at Gorumara, 1980-'81 alone claimed 140 sightings, on the other hand, only 94 sightings were recorded in 1981-'82. This might be due to the poaching incidences occurred at Gorumara in April,1981 taking the lives of two adult rhinos. At Jaldapara during 1882-'83 156 sightings were recorded. Highest sightings were recorded at Kaziranga where we found 489 sightings according to our field records. The number of rhinos sighted 433 at Gorumara (in two years), 260 at Jaldapara and 1065 at Kaziranga (Fig.2.3.1).

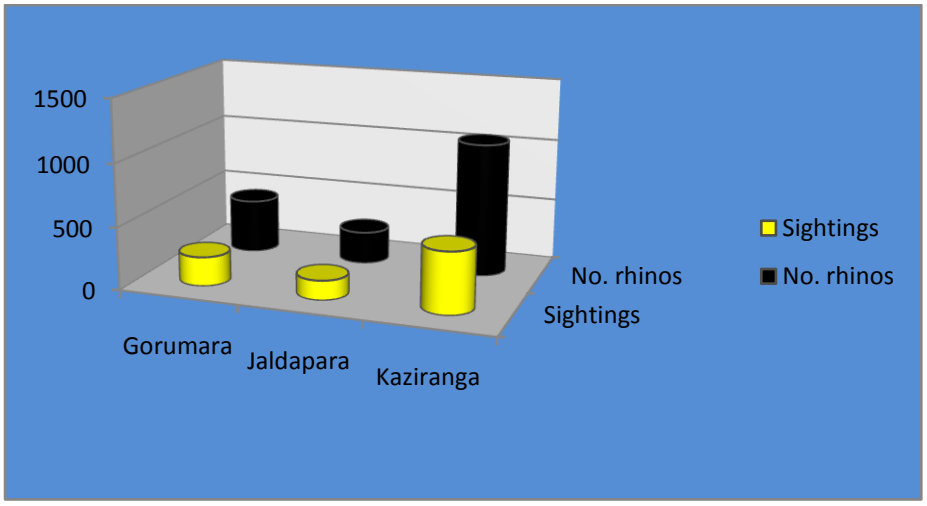


Fig.4.3.1 *The number of sightings (lemon yellow) and number of rhinos sighted (black) in three study areas*

2.3.4 Average duration of observation per sighting:

We had the better opportunity to observe the rhinos' behaviour patterns at Kaziranga for longer durations. It was calculated that average observation period per sighting at Kaziranga was more than double than those of Gorumara and Jaldapara. Average observation durations were 8.9 min, 7.8 min. and 17.5 min. at Gorumara, Jaldapara and Kaziranga respectively (Fig.2.3.2 and Table 2.3.3). At Kaziranga many of the rhino habitats were consisting of open beels and surrounding short grasslands which enabled us to continue behavioural study with uninterrupted viewing.

Place	Year	Density	Observationperiod/sighting(inminutes)
Gorumara	1980-'82	1.04	8.9
Jaldpara	1982-'83	0.18	7.8
Kazirang	1983-'84	2.51	17.5

Table 2.3.3: *Average observation period (in minutes) per sighting in three study areas*

2.3.5 Sightings in different parts of the day:

Bulk of the sightings I recorded in the morning and afternoon session. Midday sightings were recorded in the close vicinity of wallowing sites (Sec.3.2). In many occasions we found the fresh foot prints and body impressions on the mud of the wallowing sites. However, midday sightings, all we recorded in the three study areas, were comparatively feeble (Table 2.3.4). Sightings in the afternoon and evenning sessions were slightly higher than the morning sesssion at Gorumara, where as, at jaldapara and at kaziranga opposite pattern we noticed. But we do not consider this to be much conclusive since our searching hours were not always evenly distributed in the morning and afternoon sessions in all the study areas.

Table 2.3.4 depicts that starting from June 1980 to the end of May 1984, i.e., in four consecutive years'study, we encountered the rhinos in 879 occassions and sighted 1758 individuals in all the 879 sightings. Of the 879 sightings we recorded 356, 128 and 395 sightings in morning, midday and afternoon sessions respectively including many brief glimpses. Besides this total 1758 individual sightings of rhinos, it was divided into 745, 188 and 825 individuals in those three sessions accordingly.

Considering the low population density and thick tall vegetations at Gorumara and jaldapara, we think that above sighting records are good enough for further study regarding their general behaviour patterns. Of course, a fairly well analysis based on indirect observations proved to be an assisting factor.

Palce	Year	Sample size*	Morning	Noon	Afternoon/Evenning
Gorumara	1980-'81	140(262)	47(89)	8(14)	85(159)
Gorumara	1981-'82	94(171)	34(53)	7(19)	53 (99)
Jaldapara	1982-'83	156(260)	70(122)	25(45)	61 (93)
Kaziranga	1983-'84	489(1065)	205(481)	88(110)	196(474)
TOTAL	1980-'84	879(1758)	356(745)	128(188)	395(825)

*Sample size includes no. of sightings and sighted no. of rhinos within parentheses.

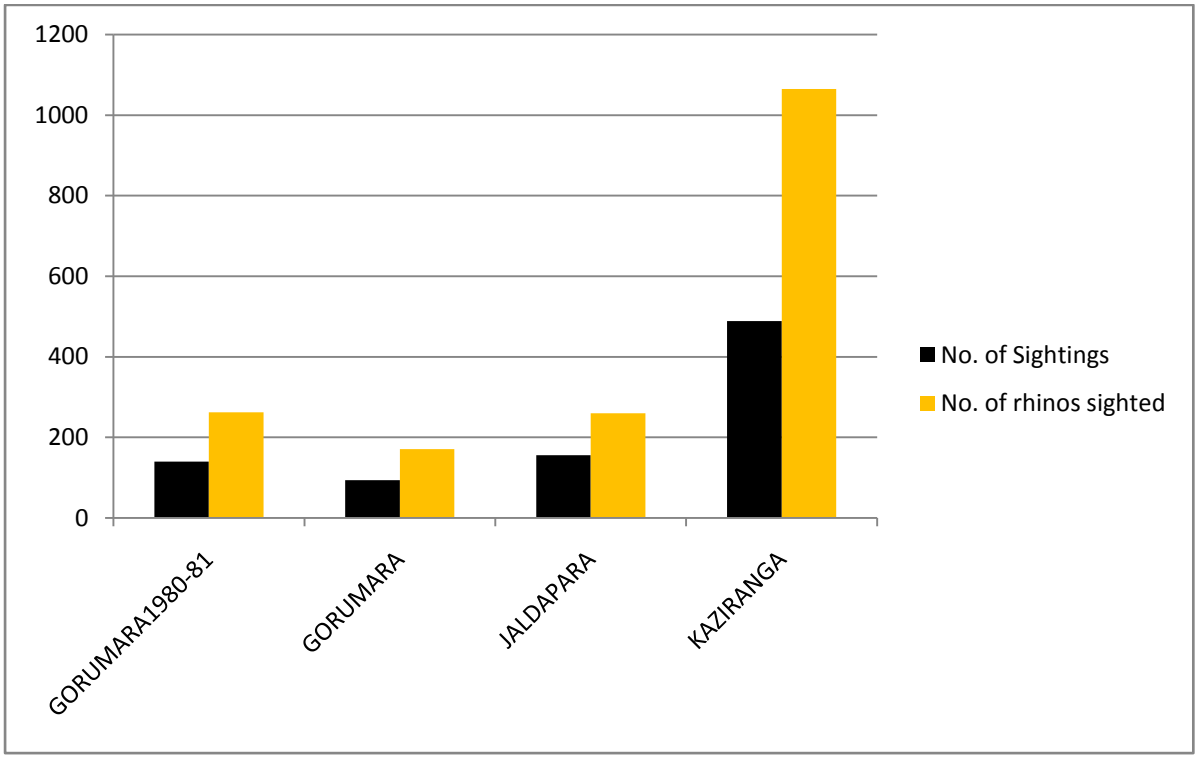
Table 2.3.4 : *Chronological representation of no. of sightings and sighted no. of individual rhinos in different times of the day*

2.3.6 Ratio between sightings sighted individuals and group size:

Table 2.3.4 reveals that in the three consecutive years at Gorumara and Jaldapara the average ration between no. of sightings and no. of sighted individuals remains below 2. It does occur due to low population density in those two places. The ratio at Kaziranga only exceeds the

level of 2. In the former cases the dyads consisted of mostly by the mother – calf association and the breeding pairs. On the other hand, the Kaziranga dyads, apart from the above two combinations, found composed of various types of combinations such as, adult female + sub adult female, two sub adults, adult female + sub adult male (probably the older calf) etc.

At Kaziranga due to higher rhino density we found much accommodativeness among them and they were found using the same habitat irrespective of age and sex. A tendency of avoiding major agonistic interactions with other herbivores or with fellow individuals was noticed also. It might be due to the fact that they were habituated to live gregariously at least in superficial level. However, various combinations of dyads, triplets and quadruples increased the sighted number of rhinos per sighting. Table 2.3.5(a) and Fig. 2.5 shows the ratio between sighted individuals and sightings and 2.3.5(b) shows the group composition analysis in reference to the years and places



= 1:1.87 [GORUMAR1980-81]

= 1:1.81[GORUMARA 1981-82]

= 1:1.66 [JALDAPARA 1982-83]

= 1:2.17 [KAZIRANGA 1983-84]

Fig. 2.5 : *The figure shows striking difference in no. of sightings and rhinos sighted, Kaziranga lies far ahead than those of Gorumara and Jaldapara. The data below shows the ratio between the above parameters in three study areas*

Table : 2.3.5 (a) *Comparative study on the ratio between number of sightings and sighted rhinos in the three study areas*.

Place	Year	No. of sightings	No. of individuals	Ratio
Gorumara	1980-81	140	262	1.87
Gorumara	1981-82	94	171	1.81
Jaldapara	1982-83	156	260	1.66
Kaziranga	1983-84	489	1065	2.17
		879	1758	2.0 (Avg.)

In the first year (1980-'81) the frequency of sighting of dyads exceeded the 2nd year's (1981-'82) sighted dyads. In the first year the dyads were mostly composed of a known breeding pair and a mother-calf association. But in the following year, observations on dyads were decreased due to two consecutive poaching [Table 2.3.5 (b)]. Triplets usually formed by an adult female, one juvenile and another sub adult female. Formation of quadrates could not be inferred strictly as their social compositions but they might be congregated together for enjoying the best areas. Congregation and segregation usually did not happen systematically, but they used to come close together while searching for food and wallowing sites not disturbing each other.

A single case of observation on a penta-group (five rhinos together) was recorded in April, 1981 at Gorumara. Quadruplet formations at Gorumara were seen to be variable ; sometimes by a breeding pair combining with a mother-calf association, sometimes by a mother-calf and two juveniles and so on.

In initial months at Jaldapara and Bardabri block (1982-83) we observed mostly the lone bulls and lone cows. One large bull and a smaller cow were frequent visitors in the vicinity of our camp particularly at night. Their presence were felt by the cracking sounds of chewing short and tall grasses. Northern Jaldapara blocks do not have good rhino habitats, so it was true in case of Bardabri block. But when we shifted our study centre at Moiradanga block (located in south western leg) we started viewing dyads and occasionally triplets. Our frequent visits at Sissamara block (eastern leg of Jaldapara Sanctuary) also appeared to be fruitful.

We observed 23 dyads over there at Sissamara, mostly comprising of a breeding pair, and a mother-calf unit. A couple of immature (non-sexed) in three occasions also came to our notice. Like Gorumara we observed a group consisting of five members at Moiradanga. We were confirmed that it was a chance occurrence by union of a lone cow, a mother – calf unit and a breeding pair since the same mother with her calf were found roaming isolately in my latter visits. The calf was known by its mother who could be instantly identified by a cut mark on her left ear.

The frequency of sighting records of dyads, triplets, quadruplets and to some extent penta groups were found to be much high at Kaziranga (1983-'84) due to its highest density of rhino population. Sighting records of dyads finished well ahead of the recorded sightings on lone individuals over there. But it was hard to believe that the groups consisting of 5,6,7 and 8 members were all belonging to the specific groups rather those large groups might have the compositions of some smaller subgroups. It is known that rhinos are not gregarious animals rather they lead solitary lives, so a large group of 8 rhinos consisting of some singles or a few dyads or triplets used to come close together very often during grazing or wallowing because of high density. In the driest months from March to May they used to form larger groups in the best habitat zones, congregated knowingly or unknowingly for better food, water and above all for enjoying cooler muddy wallowing sites.

2.3.7 Percent observations of group size:

The percent wise calculation of the group composition it is revealed that out of total 879 sighting records the lone individuals, dyads, triplets and quadruplets comprise of 36.17%, 40.95%, 14.44% and 5.23% respectively totalling to 96.97%. The data observed for the groups of 5, 6, 7 or 8 members were negligible. The percentages of group compositions of dyads, triplets and quadruplets achieved this represent able shape due to higher sighting records of above said groups at Kaziranga. Of the total 489 sightings at Kaziranga, singles, dyads, triplets, quadruplets and penta group comprised 30.26%, 40.23 %, 14.72%, 7.15% and 3,27%. But if we calculate the result in all the three study areas Kaziranga alone claims 57.77 %, 56.69%, 76.08% and 88.88% sighting records respectively (Table 2.3.6).

Table 2.3.5(b) : *The comparative group composition analysis of observed rhinos in reference to years and place*

Place	Year	GROUP COMPOSITION							
		1	2	3	4	5	6	7	8
Gorumara	1980-81	53	59	22	5	1	-	-	-
Gorumara	1981-82	43	28	20	3	-	-	-	-
Jaldapara	1982-83	74	65	13	3	1	-	-	-
Kaziranga	1983-84	148	208	72	35	16	6	3	1
Total sightings		318	360	127	46	18	6	3	1
no of rhino		318	720	381	184	90	36	21	8

Total sightings = 879 and total no. of rhinos sighted = 1758 ; in the three study areas,

Table 2.3.6 : *Chronological percent observations of group size in three study areas*

Group size	Total sightings	Kaziranga	Jaldapara	Gorumara
1	36.17	16.83	8.41	10.92
2	40.95	23.66	7.39	9.89
3	14.44	8.19	1.47	4.77
4	5.23	3.98	0.34	0.91
5	2.04	1.82	0.11	0.11
6	0.68	0.68	-	-
7	0.34	0.34	-	-
8	0.11	0.11	-	-
Total	99.96	55.61	17.72	26.60

2.3.8 Are the Kaziranga rhinos a bit social than their West Bengal representatives ?

From the above percentage records it appears that the social bondage to some extent is present in Kaziranga rhinos unlike Sumatran (Borner,1979) and Javan rhinos (Santiapillai et.al.1990) and Malayan tapirs (William and Petridges,1980). This does not mean that they have made themselves gregarious like wild buffaloes (Divekar et.al.,1988) and gaurs (Guin

and Pal,1982). If they would be gregarious the existing total population at Gorumara and Jaldapara would not exceed one or two groups. But the fact was that the Kaziranga rhinos were compelled to make a superficial social habit under pressure due to high population density in some places, and thereby, shifted a little from their original solitary behaviour. While feeding on the succulent green grasses in the choice able pastures, or during sharing the large shallow water bodies for wallowing the rhinos of Kaziranga used to come close together forming larger and larger groups. A peaceful coexistence without much aggression was noticed in their daily activities, most probably, due to a rich and spacious habitat.

The rhinos of Kaziranga have learnt to live with their con-specifics along with other large herbivores without involving much in agonistic interactions. Though we observed aggressions in a few occasions and, we were also reported about some aggressive interactions between themselves and, in two cases with elephants happened elsewhere at Kaziranga [Sharma,(R.O.), pers.com. and Pal, (B.O.), pers. Com.]. In case of African Black rhinoceros, who are known not to be much social, group size reached it s maximum level up to six consisting of A♀ - c + A♀ - c + A♂ + Im.♀. Otherwise, maximum group size ranged from 1 to 4 (Frame, 1980).

Rhinos of Jaldapara and Gorumara were not that much fortunate. Low population density led them to live a more or less solitary life. In addition to that, limited favourable green pastures and wallowing pools, in many occasions, they were seen in aggressive mood particularly in the driest months.

2.3.9: Age Sex Composition:

The group compositions containing various individuals in different group sizes were also analysed during my study period. In the initial months of my study period, in all the study areas, the sexual identification of many sub adults could not be possible. However, in the latter months their sexual dimorphic characters (sec. 2.1.1.2) made possible to differentiate them considerably either in male or female which helped me to identify their sex. Mother and her calf were always treated as a unit.

Among the lone individuals most of them were lone bulls or lone cows. In many occasions lone bulls were followed by lone cows with some distance or vice versa. The frequency of sightings of lone sexed sub adults or non sexed sub adults were less than that of the adults except in my second year's observation at Gorumara. This might be due to the poaching

incidences of two adults at Gorumara in 1981-'82, Thereby, decreased the frequency of sightings of lone adult individuals.

The dyads were mostly composed of breeding pairs and mother-calf associations at Gorumara and Jaldapara (Table 2.3.7). The compositions of dyads were much diversified though the sightings of breeding pairs and mother-calf associations were predominant. Two non sexed sub adults (f = 30) were seen frequently near the borbeel at Kaziranga but I was not sure whether they were same individuals or not sighted in all the thirty occasions.

A combination of one adult female, one sub adult male and another sub adult female forming a triplet (f=10) was a common group of visitor near my camp at Garati (Gorumara) in 1980-'81. At Jaldapara none of the combinations were dominant over each other. However, a mother and her calf in association with an adult female recorded highest among all the associations.

Altogether 9 types of triplets were seen at Kaziranga. There the combinations of 1) 1A♂ + 2A♀, 2) A♀-c + 1A♀, and 3) A♀ - c + 1A♂ remained prevalent among the triplets.

I had been able to record only two (f=5) and three (f=3) types of tetra lets at Gorumara in 1981 and 1982 respectively (Fig. 2.3.7 a and b). The chance of viewing a tetra let at Jaldapara was very poor. In spite of that I was fortunate enough to view tetra lets there in three occasions in three separate sightings.

Kaziranga claimed the highest types of combinations in tetralet formations. Altogether, I was able to observe eight (f=35) types of groups consisting of four rhinos in each group over there. Most of those groups were consisting of two mothers and their two calves (1A♀ - c + 1A♀ - c) or a mother- calf unit with other adults and sub adults. (Table 2.3.7 d)

Only in two occasions I remained successful in viewing the groups containing five rhinos, one at Gorumara (1980-81) and another at Jaldapara (1982-83). Gorumara rhinos were congregated near a large wallowing pool at Garati in the last quarter of March, 1981 probably in search of water or for wallowing forming a temporary association. On the other hand, in full monsoon, in mid August one adult male and two adult female rhinos of Jaldapara at Moiradanga beat had to move forcibly from the lower flooded area to the drier upper area on the other side of the river just to avoid excess water. On the other side of the criss-crossed rivulets of Torsa they united temporarily with a mother calf association. I found no other such group containing five rhinos in my second year staying at Gorumara

In every case Kaziranga was the exception in population group studies. Six types of penta let combinations in sixteen occasions came to my notice there in different seasons. Out of these six types, one type consisting of one adult male, one adult female, one sub adult male and two sub adult females were alone seen in six occasions.

The groups consisting of 6,7 or 8 members were found to be absent entirely at Gorumara and Jaldapara. The chances of viewing those groups at Kaziranga also happened occasionally. However, I saw four, three and one kind of group combinations in 6,7 or 8 member group sizes respectively. In larger groups the presence of M-c units were usually common (Table 2.3.7 d).

Table: 2.3.7 (a): *Age- sex combinations in the observed groups at Gorumara in 1980-81*

Group size	Age-sex compositions	Total number of sightings	Total rhinos sighted
1	A♂ A♀ SA♂ SA♀ NSA NSSA 20 15 5 6 2 5	53 x 1	= 53
2	A♂ + A♀ M-c A♀ + SA♂ 18 21 3 SA♀+SA♀ NSSA +SA♀ 6 3 A♂ +NSSA NSSA +NSSA 1 7	59 x 2	=118
3	A♀+SA♂+SA♀ M-c +SA♂ 10 8 SA♂ + SA♀ +NSSA 3 A♂+NSSA+NSSA 1	22 x 3	= 66
4	A♂ + A♀ + M-c M-c +SA♀ +SA♂ 3 2	5 x 4	= 20
5	M-c + A♀ + SA♂ + SA♀ 1	1 x 5	= 5

Total sightings = 140

Total rhinos sighted = 262

Table 2.3.7(b) : *Age-sex combinations in the observed groups at Gorumara in 1981-82*

Group size	**Age-sex compositions**	**Total number of sightings**	**Total rhinos sighted**
1	A♂ A♀ SA♂ SA♀ NSA NSSA 13 11 9 8 0 2	43 x 1	= 43
2	A♂ + A♀ M-c A♀ + SA♂ SA♀+SA♀ 7 12 4 3 A♂ + SA♀ SA♂ + SA♀ 1 1	28 x 2	= 56
3	M-c + A♀ A♀ + SA♂ + SA♀ 6 7 M-c+SA♂ M-c + A♂ A♂ +SA♀ + SA♀ 3 2 2	20 x 3	= 60
4	A♂ +A♀ + M-c M-c + SA♂ + SA♀ 1 1 A♂+ A♀ +2 NSSA 1	3 x 4	= 12

Total sightings = 94

Total rhinos sighted = 171

Table 2.3.7(c) : *Age-sex combinations in the observed groups at Jaldapara in 1982-83*

Group size	Age-sex compositions	Total number of sightings	Total rhinos sighted
1	A♂ A♀ SA♂ SA♀ NSA NSSA 38 18 4 3 3 8	74 x 1	= 74
2	A♂ + A♀ M-c A♀ + SA♂ 22 28 4 SA♂+SA♀ A♂ +NSSA NSSA+NSSA 5 2 3 A♀ + NSSA 1	65 x 2	=130
3	A♀ + SA♂ + SA♀ M-c + A♀ M-c+SA♀ 3 5 3 M-c + NSSA A♂ + A♀ + NSSA 1 1	13 x 3	= 39
4	M-c + M-c M-c +A♀ + SA♂ 1 1 A♂ + A♀ + NSSA + NSSA 1	3 x 4	= 12
5	A♂ + A♀ + M-c + A♀ 1	1 x 5	= 05

Total sightings = 156

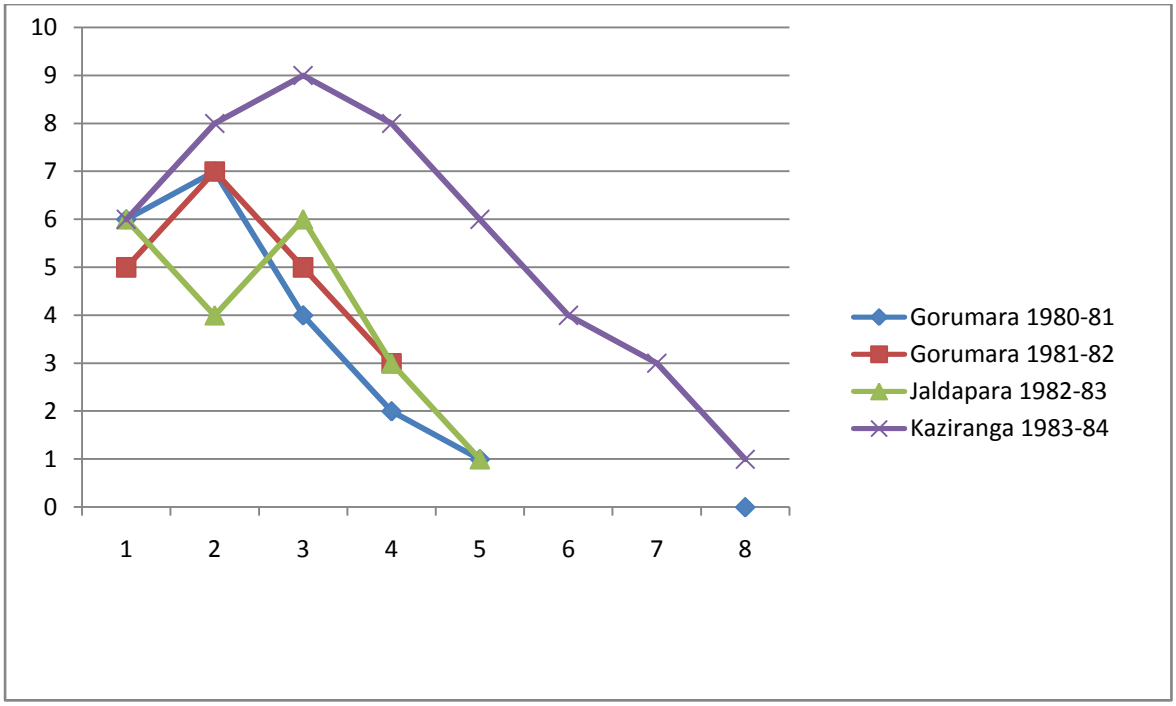
Total rhinos sighted = 260

Table 2.3.7 (d). *Age- sex compositions in the observed groups at Kaziranga 1983-84*

Group Size	Age – sex compositions	Total number of sightings	Total rhinos sighted
1	A♂ A♀ SA♂ SA♀ NSA NSSA 43 29 17 11 14 34	148 x 1	= 148
2	A♂ + A♀ M-c SA♂ + SA♀ 45 38 23 SA♀+SA♂ A♀+NSSA A♀+SA♂ 16 26 23 A♂+NSSA NSSA + NSSA 7 30	208 x 2	= 416
3	A♂+A♀+A♀ M-c+A♀ M-c+A♂ 15 13 18 A♂+SA♀+NSSA M-c+SA♀ M-c+SA♂ 4 9 3 A♂+NSSA+NSSA SA♀+SA♀+SA♂ 5 3 A♂+NSA+SA♀ 2	72 x 3	=216
4	M-c+M-c M-c+SA♂+SA♀ A♂+A♀+M-c 6 8 4 A♂+A♀+SA♂+SA♀ 2A♂+2A♀ 3 8 2A♀+2NSSA 2SA♂+2SA♀ SA♀+3NSSA 2 3 1	35 x 4	= 140
5	M-c + M-c +A♀ A♂+A♀+SA♂+2SA♀ M-c+2A♀+SA♂ SA♂+2NSSA+M-c 2A♂+3A♀ A♂+NSA+SA♀+2SA♂	16 x 5	= 80
6	2M-c+A♂+A♀ 2M-c +M-c(SA♂) 2 2 2A♀+2SA♀ +2SA♂ 2A♀+A♂+2NSSA+SA 1	6 x 6	= 36
7	A♂+A♀+M-c+SA♂+SA♀+NSA 1 2A♂+2A♀+NSSA+M-c 1 2A♀+A♂+2SA♀+SA♂+NSSA 1	3 x 7	= 21
8	M-c+M-c+A♀+SA♂+SA♂+SA♀+NSA 1	1 x 8	= 08

Total sightings = 489

Total rhinos sighted = 1065



Vertical Left side Y-axis represents the types of age-sex combinations

Fig.2.6: *Comparative study on age sex compositions in three study areas*

2.3.10 Comparative study on the types of Age-sex combinations:

Fig.2.6 shows picturesque differences in the types of age sex compositions in the three study areas. Kaziranga places itself in a markedly higher position than the other two study areas. As much as nine types of compositions were found at Kaziranga in the formation of triplets including non-sexed adults and sub adults. On the other hand, maximum seven types of age-sex compositions were found in the formation of dyads at Gorumara (1980-81). Jaldapara remained remarkably in the lesser category in the formation of four dyad types only.

A bird's eye view on the fig. 2.6 and an analysis on it suggests that the Kaziranga rhinos are much reluctant in their habits by making superficial combinations among themselves due to higher population density. But, however, in all the cases, the breeding pairs and the mother-calf combinations remained constant, at least, for a considerable period of time. Those dyads did not dissolve easily for making another composition or enrolled themselves to be the members of some other groups as the immature and recessive bulls as well as subordinate cows did frequently.

2.3.11 Sighting records under various ecological conditions:

For final calculation of sighting records and sighted rhinos we divided the whole year into four distinctive seasons. Having characteristic climatic features, each season was marked by two parameters, temperature and rainfall and to trace out the degree of differences the sighting records were tallied with actual observation hours and searching hours.

The seasons were divided into four different categories each having the duration of three months. These were namely i) HOT WET consisting of June, July and August ; ii) COOL WET comprised September, October and November ; COOL DRY consisting of December, January and February and lastly, iv) HOT DRY comprised March, April and May.

For measurement of rainfall, a rain gauge was used to measure it in mm. we used to place it near our camp where we stayed permanently, at least for a few months. For measurement of daily temperature a maximum – minimum hygrometer was used to measure the daily temperature in Celsius and some- times relative humidity was measured when needed.

In all the three study areas the temperature of hot seasons ranged between 27^{o} C to 35^{o} C and of the cool seasons between average 18.5^{o} C to 25^{o} C. Almost similar ecological conditions prevail in those three areas regarding temperature and rainfall, since those areas are all located on the same latitudinal plane. The months of June, July and august are considered to be the hot – moist period containing high relative humidity, touching the point of about 100%. The highest rainfall was recorded at Jaldapara as high as 695 mm at that period and lowest at Gorumara in 1981-82 being 585 mm. The lowest rainfall was recorded in the dry seasons, especially in the coolest months (December, January and February) ranged within 15 mm and 34 mm (Table 2.3.8).

Number of sightings, as well as, total rhinos sighted in relation to actual observation remained lowest in the hot-wet season than the usual average.

Table : 2.3.8 *Seasonal variation of sightings and observation hours with respective average temperature and rainfall according to the rears and places*.

Place	Season(months)	No. of sightings	Obs. Hrs.	Temp^{o} C	Rainfall (mm)
Gorumara	Hot Wet (J.J.A)	20 (34)*	2.45 (180)ʌ	27	612
(1980-81)	Cool Wet (S.O.N)	35 (62)	3.00 (220)	24	395
	Cool Dry (D.J.F)	44 (93)	5.15 (260)	18.5	28
	Hot Dry (M.A.M.)	41 (73)	5.40 (260)	34	71
Gorumara	Hot Wet(J.J.A.)	15 (30)	2.30 (215)	27	585
(1981-82)	Cool Wet (S.O.N.)	21 (39)	3.30 (225)	23.5	330
	Cool Dry (D.J.F.)	17 (30)	4.20 (330)	19	15
	Hot Dry (M.A.M.)	41 (72)	6.40 (312)	35	52
Jaldapara	Hot Wet (J.J.A.)	12 (29)	2.45 (209)	27.5	695
(1982-83)	Cool Wet (S.O.N.)	32 (58)	5.20 (225)	25	418
	Cool Dry (D.J.F.)	62 (101)	6.25 (276)	19	26
	Hot Dry (M.A.M.)	50 (72)	5.30 (260)	33	74
Kaziranga	Hot Wet (J.J.A.)	49 (130)	15.00 (120)	28	660
(1983-84)	Cool Wet (S.O.N.)	120 (239)	35.30 (144)	24	305
	Cool Dry (D.J.F.)	219 (405)	62.30 (174)	20	34
	Hot Dry (M.A.M.)	101 (291)	39.00 (162)	34	88

*Figures in the parentheses indicate total number of sighted rhinos

ʌFigures in the parentheses indicate total searching hours

although the actual observation in that season at Kaziranga exceed well ahead than other two sanctuaries.

Actual observation hours were recorded highest in the dry months, i.e., both in cool season (Dec., Jan., & Feb.) and in hot months (Mar., April &May). Bulk of the sightings and observation hours were recorded in those two seasons. Of the total 206 hours of actual observations 66% (135 hrs) alone were noted in the dry months and 34% were recorded in the wet months(June, July, Aug., Sept., Oct. & Nov.). In the dry months the percentage of rainfall remained within only 9% of the total rainfall (Fig. 2.7).

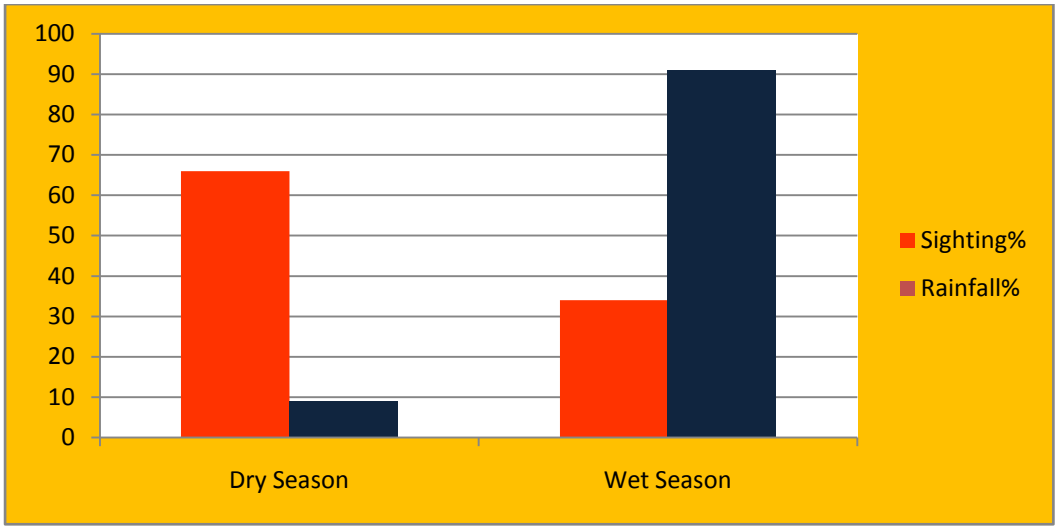


Fig.2.7 : *Histogram shows an interrelationship between percentage of sighting and percentage of rainfall.*

2.4 Population estimation by foot impressions:

A colourless rectangular plate of 35 cm x 32 cm x 0.3 cm, a free flowing fibre micro-tip pen, some papers, a couple of rubber bands and a metre steel tape were used to take individual foot impressions. It was much more simpler than the technique adopted by S.R.Choudhury [quoted by Panwar (1980)] for the identification of tiger at Simlipal National Park in Orissa. A lot of tracing practice and experience in analytical comparison enabled us to visualise the intricate differences which helped much in identifying one rhino from another. The special features hidden in the morphology of the foot impressions were studied. The impressions of either right or left hind feet were taken into account for comparative study as the fore footprints were partially or completely superimposed by hind footprints while walking.

The impressions might look bigger and distorted in slushy soil and compact and smaller on a hard surface. Even in such situations, as far as practicable, perfectly normal rear footprints were selected for keeping records. The glass plate was placed lightly above the well formed rear foot impressions and cares were taken to avoid errors owing to parallax while tracing the outlines of footprints by pacing eyes vertically above the impressions. The tracings done on the glass plate were readily transferred on the paper sheets just to make the glass plate reusable for taking the impression of next footprint. During transfer of tracings from glass plate to paper sheet the glass plate along with the tied paper sheet were held against the sunlight and copied thereafter.

Rhinos being the perissodactyle animal and having the mesaxonic type of foot, only three digits along with the sole gets an impression on the soil. The imprints reveal that the middle digits are somewhat horizontal guarded on both sides by two lateral vertically placed digits. Individuality remains in the shape and angular orientations of the digits from the centre point, shape of the sole (Fig. 2.8) etc. No identical impressions of different individuals were recorded during our field study. The sex could, however, not be identified which is possible in case of tiger (Panwar, 1980). The sole is broader at the top and narrows down at the base (Fig.2.9).

Since the animals lead almost a solitary mode of life, more or less, undistorted footprints could be transferrable from soil to paper. But in a few occasions the confusing multiple tracks were seen. The multiple tracks were sometimes created only when the rhinos formed the breeding pair or a mother associated with her calf. Rearing of the calves is entirely the responsibility of the mothers, therefore, the mother-calf associations were quite usual to see. The track analyses suggest that sometimes the subordinate bulls were allowed to get included with superficial relationship in the family groups consisting of adult females and juveniles. In such cases many good footprints of front movers were destroyed by the followers

$^{1}/_{16}{}^{th}$ graphical reduction of life sized foot impressions (Fig 2.8) were carefully transferred on graph papers having 0.25 cm^2 as the smallest unit. The first capital letter 'G', 'J' or 'K' signify the places Gorumara, Jaldapara and Kaziranga. The first letter is followed by second capital letter 'B', 'F', 'J','M' and 'C' ; which stand for bull (dominant adult male), female, juvenile, mother and calf respectively. Here 'GB01'signifies the number one dominant adult male of Gorumara.

According to individual foot impression characteristics GB01 carried almost a flat middle toe, whereas, GB02 possessed a notch at the junction of 2^{nd} and middle (3^{rd}) toe. In GB02 the third toe is placed at much higher level in comparison to that of the third toe of GB01. Similar spectacular differences are observed among the three Gorumara female rhinos as illustrated in Fig. 2.8. GF02 had almost spherical toes corresponding to the sole having

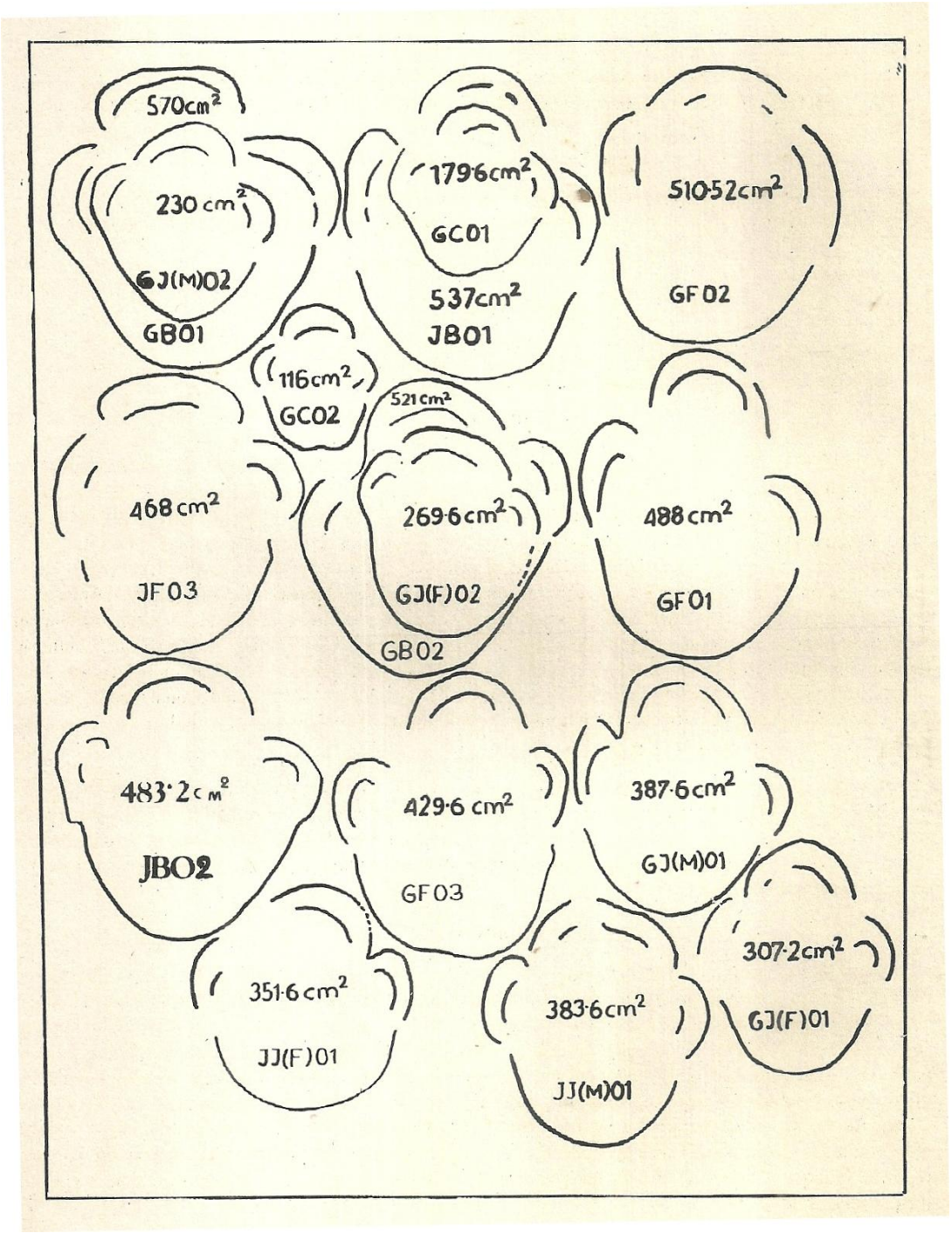


Fig.2.8: *1/16th graphical life sized foot impression of Gorumara and Jaldapara rhinos.*

slight depressions at the junction of the toes. JB02 had an extra outgrowth at the posterior portion of the 2nd toe. JF03 bore an inward crevice at the junction of the 4th toe and the sole. In GJ(F)02 the toes were comparatively shorter than the other rhinos. JJ(M)01 had an inward depression at the posterior tip while GC02 had a depression at the posterior tip.

The maximum narrowness (δ) as evident from Table 2.4.1 are found in three adults : GB01,GB02 and JF03 ; three juveniles JJ(M)01, GJ(F)01 and GJ(M)02 and in only one calf (Table 2.4.1). The value of δ is found to be the least for '___C03' which is purely a hypothetical case obtained from the regression technique as shown in Table.2.4.1.

Table 2.4.1: *Ratio (δ) between maximum breadth of sole (B_m) and breadth of the posterior region (B_p) of the sole (1/4th position from the posterior tip) showing the narrowness of the posterior region [$\delta \alpha 1/B_p$] or [$\delta \alpha B_m$]*

Individual Nos. of rhinoceros	Maximum breadth (B_m) of sole (in cm)	Breadth of the posterior region of sole (B_p) (in cm)	Ratio (δ) between B_m/B_p	Angular orientation (°) of toes from centre point: 2nd	4th
GB01	31.6	21.6	1.463*	39	58
GB02	28.8	20.4	1.412*	21	45
GF01	25.6	20.8	1.231	47	25
GF02	26.4	21.2	1.245	43	38
GF03	25.6	20.0	1.280	43	45
JB01	28.0	22.4	1.250	47	35
JB02	27.6	20.0	1.380	36	27
JF01	31.2	24.4	1.279	34	33
JF02	28.4	21.6	1.315	18	33
JF03	26.4	18.4	1.435*	43	45
GJ(M)01	24.0	18.4	1.304	36	12
JJ(M)01	24.8	17.2	1.442*	35	22
JJ(F)01	23.6	19.2	1.229	37	32
GJ(F)01	21.6	15.2	1.421*	39	30
GJ(F)02	20.0	15.2	1.316	42	40
GJ(M)02	19.2	13.6	1.412*	30	30
GC01	18.0	12.8	1.406*	40	32
GC02	13.6	10.0	1.360	30	30
$-CO_3^h$	10.0	8.94	1.119h	—	—

* = Maximum Narrowness found
h = Hypothetical Case (New Born Baby)

In respect to the angular orientation of the toes from the centre point of the area of foot impression GB01 shows 39^o and 58^o angular orientation for 2nd and 3rd toes respectively. On the other hand, GB02 shows only 21^0 and 45^0 which is interestingly a spectacular difference too (Fig.2.9). Similar remarkable differences are noticed in other rhinos as shown in Table 2.4.1.

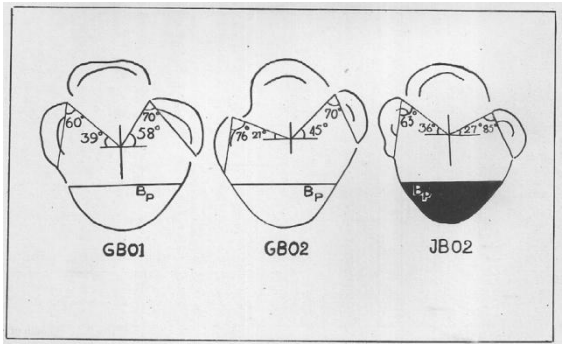


Fig. 2.9 *Comparative representation of three sole impressions of same age class showing the angular orientation of toes.*

2.4.1 Explanation:

The areas were, however, estimated by counting the unit blocks as well as the fractional segments of the blocks at the periphery of the foot impressions. On multiplication of the total number of blocks by 0.25 cm^2 x 16 (since the original impressions were reduced to $^1/_{16}$ th graphically for convenience), nearly accurate actual areas (S) were obtained. The measured actual area (S) for sixteen samples out of eighteen (Fig. 2.8) were analysed to give a well fitted theoretical equation :

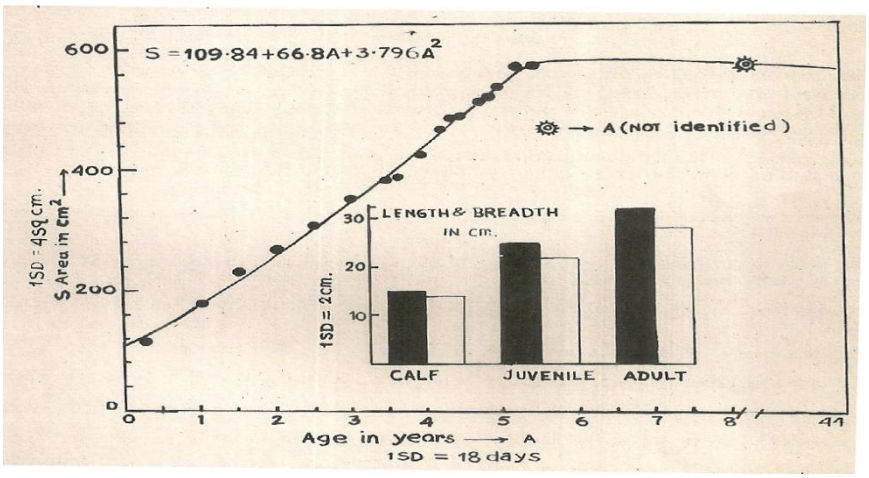


Fig.2.10: *A regression Analysis based on the relationship between the age and size of the footprints.*

$$S = 109.84 + 66.8A + 3.796\ A^2 \quad \text{..... (1)}$$

As shown in Fig.2.10 in terms of the age parameters A with only ± 2.28% error in the regression technique. This is the reason why the observed data were found to lie excellently at per to the theoretical curve (Fig.2.10). From the age of 5½ years onwards the theoretical curve (eq. 1) is made to be flat horizontal with the experimental points parallel to the age axis. The beautiful aspect of Fig. 2.10 is that when A=0 the new born baby is likely to have its hind sole area in the close vicinity of 109.84 cm^2 ± 2.28 cm^2 which is marked as '__CO_3' in the Table 2.4.1. The age (A) excepting those for the calves as observed by me were supplied by the respective forest department authorities.

For the lower value of A the contribution of the second term in eq.(1) will be more. But, that due to third term it will be larger as A increases. This indicates that just after first year there is a rapid growth up to 5½ years followed by a kink on the verge of adult hood. After attaining the flat horizontal plane for the maximum area of 572 cm^2 the S-A curve has a tendency to reach a slight lower value of 564 cm^2 probably due to aging which is a biological law.

The similar study in terms of histogram is shown (Fig 2.10) for the corresponding maximum length and breadth of the foot impressions in cm in three age classes. It indicates that the

maximum length and breadth of the footprint of an adult rhino is slightly more than double to that of the calf. The juveniles and sub adults lie in between these two.

During a recent census in Ujong Kulon National Park on Javan rhinoceros population, the largest measured foot print was 31.0 cm (in width) for adult and 24.0 cm for sub adult (Santiapillai et.al. 1990). However, in a previous census the calves and juveniles were not recorded since their foot prints were less deeply imprinted on the soil due to lesser weight, secondly, their smaller foot prints were easily overlooked (Amman,1985). So, often the young age classes are not properly represented.

From the above results and discussions, we, therefore, conclude that the Great Indian one horned rhinoceros bears individual recognition characteristics in the soles apart from identifying their age-classes. So, by following their tracks and trails one can get valuable data about their home range, habitat use pattern, daily activity cycle, population and demographic study and so on without viewing them. Of course, it is important to mention here that one must recognise the sole impression for which individual it belongs to - that may require some days' experience.

2.5 The status of Kaziranga rhino population:

2.5.1. Kaziranga in recent past:

Kaziranga (93^{o} 30'E, 26^{o}30'N has been considered to be the safest homeland of Great Indian one horned rhinoceros for many years. The story of the Kaziranga rhinos is a landmark in India's conservation history.

In the late nineteenth century Assam's rhinos had been hunted almost to extinction when the alluvial plains were cleared for tea plantations. By 1908, when the hunting of rhinos was declared illegal, only a dozen rhino was left there. But the first effective measures were taken by declaring it as "Kaziranga Wildlife Sanctuary" in 1932. The executive committee of the Indian Board for Wildlife first recommended to make it a National Park by creating a buffer zone surrounding the area at Mysore conference (IBWL,1952). According to that recommendation Assam State Government by a Gazette Notification, soon after, duly created such a buffer zone surrounding the core area which enabled lowering the poaching incidences significantly (Gee, 1955). The rest of the years have been glorified bearing a magnificent record of successful management implication with a sincere effort credited to the forest officials and staff. The excellent rhino habitat had been declared a National Park w.e.f. 1st January, 1974.

The National Park extends in an east-west direction lengthwise and spreads over two neighbouring districts, Nawgong and Shibsagar. The southern boundary is guarded by the Assam Trunk Road where frequent patrolling is done by the Kaziranga Forest Department. The Northern boundary is limited by the frequent course changing and branched (making many islands by its tributaries) Brahmaputra river. Every year from June to October a considerable area of the northern part of the park goes under water causing flood added with heavy monsoon. The animals are pushed to the higher southern part and death due to flood is common here. During the dry season the tall grassland is burnt by the Park staff to enable the growth of young sprouts of lush green grasses. Both fire and floods have managed to maintain the Park's primitiveness (Spillet,1966).

The management of the Park is the entire responsibility of the Kaziranga Forest Department. The National Park occupies an area of 434 km^2. Up till early nineties there was a good communication network between the camps (guard posts), beats and range offices. During that period there were 104 camps, 400 forest guards, 40 elephants and a few four wheel drive vehicles (Bhattacharya, 1993), compared to 34 camps, 183 forest guards, 20 elephants and a few jeeps in 1994 (Laurie,1978). Two speedboats were the new inclusions in the Park for use in the rainy season. Most areas could be visited by four wheel drive jeep during the dry season.

The forest officials reported that in spite of the above listed facilities available to them, Kaziranga still required at least the double of forest guards and elephants for better protection and management in that large area (Bhowmick,1992).

The illegal poaching considerably decreased at Kaziranga in those years. It was known from the official census report that, 1129 rhinos were surviving in that area which was forty nine more than that of the last census report of 1984 [Govt. of Assam, CCF(WL),1992]. The great threats to the rhino survival are flood and unscrupulous poaching (Sharma, 1984[pers. Communication] ; Lahan, 1984). In 1988, severe flood in Brahmaputra river took the lives of 33 rhinos ; on the other hand, illicit poaching caused the death of 55 rhinos. In most of the cases the horns were removed by the poachers (Bhowmick,1992).

In spite of these disastrous events the magical survival of the rhinos prevailed there. It happened partly because of the ULFA (United Liberation Front of Assam) militants, who in the latter years of eighties decade emerged as a new threatening power inside Assam. The ULFA activists began to take stern action against the illicit poachers from the early months of

1990. In the last part of 1990 the ULFA authorities declared that whoever will destroy the nature of Assam they would be convicted and severely punished. After this declaration poachers and illegal traders became panic stricken. This courageous attitude also spread into the minds of forest guards and officials. The forest guards killed 9 and 2 poachers in 1991 and in January, 1992 respectively with their less sophisticated weapons (Bhowmick, 1992).

The other side of the coin is brighter. People around the world were gradually realizing the need of bringing a halt to the trade of rhino products. Since 1982, WWF had set up a campaign against big game animals poaching. From 1985, a scheme for conservation was projected by that organisation to exert a pressure on the Governments of East and South-East Asia to ban the sale of rhino horn (Vigne and Martin, 1986). Doctors and Pharmacists were urged to introduce their patients to substitutes like bovine horn,

The neat results had been encouraging to the wildlife lovers. Many South and South-East Asian countries have banned the trades of rhino products (Vigne and Martin,1986). The sale of rhino horn in South-East Asia had been dropped over the past decades creating a hope that Great Indian rhinos may, overall, be able to survive in some of their natural habitats like Kaziranga.

2.5.2. Explanation on the basis of rhino population:

Fig. 2.11 shows graphical representation of an initial six yearly and scientifically studied census report on rhino population which started from 1966. Before that, in 1957, 1961 and in 1963 the estimated population varied from 250-300 although the applied method was very crude (Source: Copyright Kaziranga N.P., Bokakhat, Golaghat Dist., Assam, 785612, India).

A steady increase in their number is noticed up to 1978. From 1978 onwards their rate of increase lowered down and during early nineties, the population growth curve had been almost parallel to the year axis. The annual rate of increase in rhino numbers came down from 45 and 48 (1966-’72 & 1972-’78 respectively) to only 6.4 (1983-’93) in spite of addition of new members by birth.

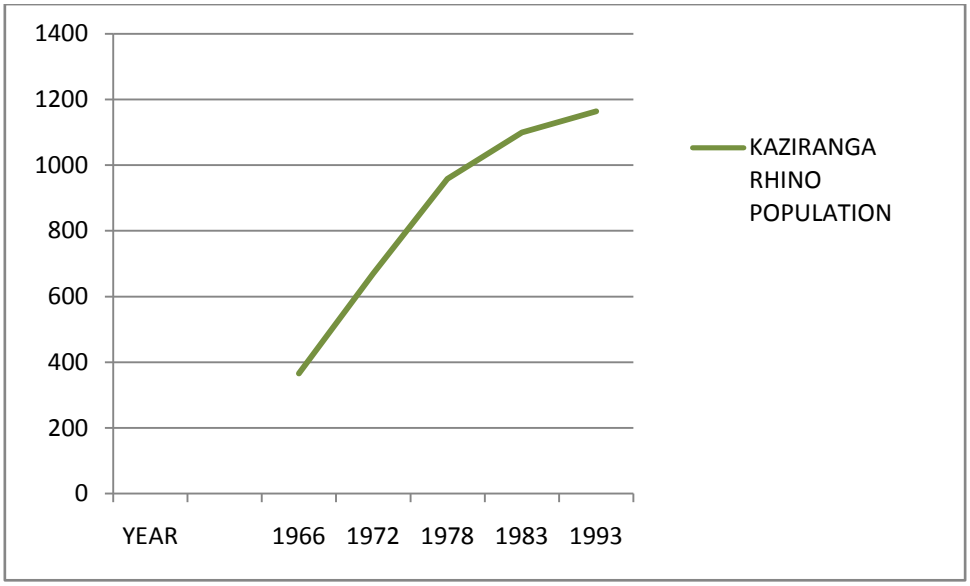


Fig.2.11: *Rhino census report of Kazirang from 1966 (Source: Kaziranga N.P.,Bokakhat, Golaghat Dist., Assam, 785612, India)*

It is revealed from the Table 2.5.1. that during mid seventies, i.e., from 1972 – 1978 (in between 2nd and 3rd census) altogether 212 rhinos lost their lives due to various reasons. Although, almost half (109) of the deaths were natural, but, despite this disaster the annual rate of increase was highest ever recorded. (Table2.5.2). A steady increase in their population was noticed during that period. In contrast, during the four years from 1988-1991, lives of altogether 102 rhinos had so far been taken by floods and poachers apart from deaths due to other reasons, such as, disease, fight, tiger predation etc. (Table 2.5.3).

Year	Poaching	Fighting	Disease	Natural	Accident	Unknown	Tiger Predation	Flood	Total
1972	**-**	**1**	**1**	**15**	**-**	**-**	**4**	**-**	**20**
1973	**3**	**1**	**10**	**21**	**-**	**7**	**16**	**4**	**62**
1974	**3**	**-**	**-**	**11**	**1**	**1**	**6**	**1**	**23**
1975	**5**	**2**	**-**	**27**	**-**	**-**	**5**	**-**	**39**
1976	**1**	**1**	**-**	**12**	**1**	**-**	**7**	**-**	**22**
1977	**-**	**1**	**-**	**20**	**1**	**1**	**12**	**1**	**37**
1978 (up to March)	**-**	**-**	**-**	**3**	**-**	**2**	**4**	**-**	**9**
	12	**6**	**11**	**109**	**3**	**11**	**54**	**6**	**212**

Table 2.5.1: *Loss of rhino lives due to various reasons during the period 1972-'78 at Kaziranga(Source: Kaziranga National Park's Official records).*

Year Range	Actual number Increased/yr.
1966-1972	**45**
1972-1978	**48**
1978-1983	**8.4**
1983-1993	**6.4**

Table 2.5.2: *Annual rate of population increase of rhinoceros from 1966-1993.It is interesting to note that despite heavy loss of lives of rhinos (212 nos.) highest rate of increase occurred (Source: Bhattacharya,1993).*

Table 2.5.3: *Deaths of rhino due to only flood and poaching apart from other reasons at Kaziranga from 1988-1991*

Year	Poaching	Flood	Total
1988	**10**	**33**	**43**
1989	**12**	**-**	**12**
1990	**28**	**-**	**28**
1991	**19**	**-**	**19**
	69	**33**	**102**

Thus it seemed that despite an almost constant death rate during 1984-1991 compared to that of previous years (1972-'78), the rate of increase of rhino population had reached its lowest limit. Was it due to a decrease in fertility in the adult female rhinos or had the population reached rapidly to the carrying capacity limit? Both these assumptions proved wrong in the latter years (Sec. 2.5.3).

The Indian rhinos give birth to a single calf at 3 to 4 years intervals after a gestation period of 16 months. The age of first reproduction is 6 year. So, hypothetically, an adult female can give birth to a maximum of 7 or 8 calves during her life time, taking a maximum 44 years as the expected life span. But in reality, in the old ages the females lose the capacity of fertility and may not conceive in the older ages. Data received from the chronological census reports (1966-'91) showed that the age composition was consisting of nearly 70% adults, 12% juveniles and 18% calves [Govt. of Assam, CCF(WL),1984]. This indicated that during those

years a stable population including a balanced recruitment prevailed there. A similar stable recruitment rate was found among the African black rhinoceros (*Diceros bicornis*, L.) population in Masai Mara Game Reserve (Mukinya,1973). Out of the 70% adult population, almost half were females. The annual birth rate was about 15% of the total adult female population, which remained steady up to 1978, then fell to 5.3% in 1984 and further dropped to 1.8% in 1991 due to civil war, mass habitat destruction and relentlessly hunting and poaching (Emslie,2012) and similar niche competition with elephants (Rookmaaker,2004).

The exponential growth curve of the rhino population prevailed up to the late 1970s and then became almost horizontal in the latter years. It appears that up to 1978-'79 there were no limiting factors, but then an overcrowding effect became predominant due to overuse of pasture, limited resting and moving places, competition for food and cover etc. The population increased at a slower rate at first (lag phase), then more rapidly (approaching a positive acceleration phase or logarithmic phase); but soon slowed down gradually as the environmental resistance increased (negative acceleration phase), until, a more or less, equilibrium level is reached and maintained (Odum,1983). Here at Kaziranga, it took 58 years to reach the population level of 400 from the original 12 rhinos in 1905 (firstly lag phase latter attained positive acceleration phase) In the next 12 years (1966-'78) it doubled the population (exponential logarithmic phase) and the period from 1978 onwards considered as the negative acceleration phase (Fig.2.12)

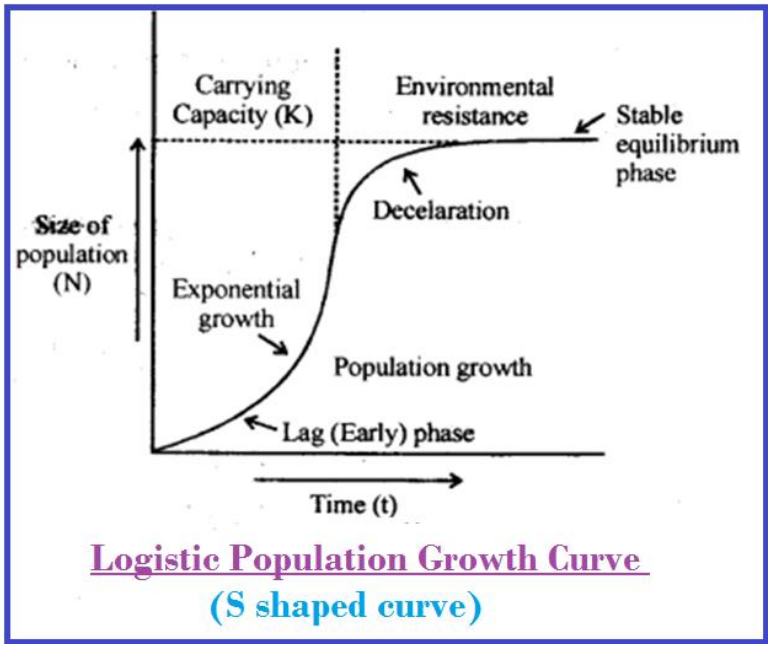


Fig.2.12: *The population growth curve of Kaziranga rhino followed the rule of logistic growth curve up to late 80's.*

At that time it was presumed that the nature of the growth curve showed that the number of rhinos at Kaziranga should have been around 1200 in the 430 km^2 area consisting of 66% grassland, 28% forest cover and 6% beels and marsh land [Govt. of Assam, CCF (WL), 1984] unless there occurred heavy setbacks like epidemics, floods, poaching, tiger predation etc. in Kaziranga in the coming years.

It is to be mentioned here specially about the tiger predation on rhino calves. The census report of 1991 showed that the tiger's natural prey, i.e., hog deer, were decreasing in number at an alarming rate. During the last 7 years (1984-1991) the hog deer population had dropped down to only 2,400 in 1991 from 10,000 in 1984. It might be due to that the big carnivores were increasing in number. It could be apprehended that this sudden drop of deer population might cause frequent tiger predation on rhino calves in the years to come.

2.5.3: Kaziranga in recent times:

Our prediction about the future trend of rhino population during 1991-'93 proved totally wrong (Bhattacharya,1993). In the later years, after a short period of stable situation, the rhino population started increasing almost exponentially and today more than 70% of wild Indian rhino population lives in Kaziranga (Table 2.5.4)

Table 2.5.4: *Present situation of Kaziranga rhino population*

KAZIRANGA RHINO POPULATION

1957,1961 and 1963 : Varied from **250-300,** the method used were very crude	
1966 : 366 [first scientific census method applied]	
1972 : 658	+ 292
1978 : 939	+ 281
1984 : 946 (Population growth is very negligible)	+ 07
1991 : 1120	+ 174
1993 : 1164 (Population growth is negligible)	+ 44
1999 : 1552	+ 388
2006 : 1855	+ 303
2009 : 2048	+ 193
2012 : 2290	+ 242
2013 : 2390 [special census]	+ 100
2015 : 2401*[663♂,802♀,186(unsexed), 90 SA♂, 114 SA♀, 90 SA(unsexed), 251 juvenile (1-3 yrs.), 205 Calf (less than one year) = total 2401]	+ 11
2018: 2413 (up to March) [642 ♂ were male, 793♀, 206 unsexed; 387 sub-adult rhinos between the ages of four and six, of which 116♂, 149♀,122 unsexed; 385 calves (less than one year) = total 2413]**	+ 12

*Copyright Kaziranga N.P., Bokakhat, Golaghat Dist., Assam, 785612, India

** Dutta,A.(2018): Kazitranga National Park's rhino population rises by 12 in 3 years, Hindustan Times, New Delhi,24th April,2018.

The latest headcount of the famous key stone species at Kaziranga estimates that presently the number is 2413. This is an increase of only a dozen over the 2015 figure. But according to the State Wildlife Officials fewer rhinos may have been sighted this time due to the incomplete burning of tall grasses and reeds (Karmakar, 2018). This could be due to high moisture content actually prevails in the month of March, so the burning on entire rhino habitat was not possible which is necessary for regeneration of low-lying vegetation in the 434 sq. km. park, a UNESCO World Heritage Site that also faces annual floods.

> *"We estimated the rhino population to be 2,413 after a two-day exercise that ended on Tuesday. This estimate, as with the census of the past, is plus or minus 100," N.K. Vasu, the State's Chief Wildlife Warden, said.*

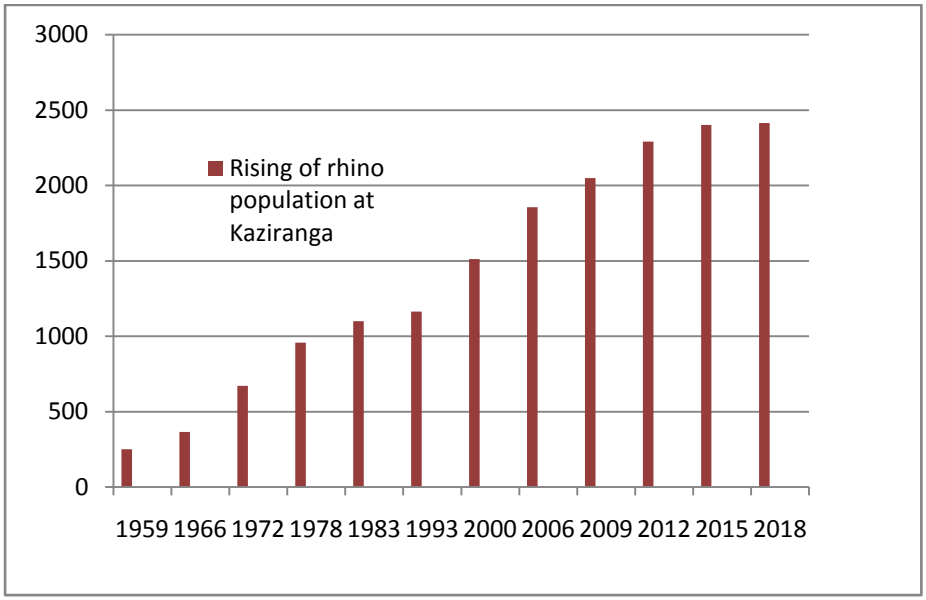


Fig.2.13: *Recent rhino population trend in Kaziranga, population has been more than double after 1993.*

As it was thought earlier that the rhino population would reach the carrying capacity limit within 1993 but the rhino population trend in Kaziranga shows that after 1993 the population has been more than double and it may further increase despite natural calamities like flood and poaching (Fig.2.13). The following conservation measures have been played as key role from mid nineties.

1. Kaziranga National Park has been granted maximum protection under the Indian law for wildlife conservation. Various laws, which range in dates from the *Assam Forest Regulation of 1891* and the *Biodiversity Conservation Act of 2002* have been enacted for protection of wildlife in the park (State of Conservation of the

World Heritage Properties in the Asia-Pacific Region- Kaziranga National Park,2003)

2. Preventive measures such as construction of anti-poaching camps and maintenance of existing ones, patrolling, intelligence gathering, and control over the use of firearms around the park have reduced the number of casualties.[40][41] (Kaziranga National Park Bulletin, 2008) and (The Telegraph,23rd August,2008)
3. Since 2013, the park used cameras on drones which are monitored by security guards to protect the rhino from armed poachers.
4. To mitigate the losses due to flood, human-animal conflict with villagers for damaging the crops, avoiding collisions with speeding vehicles, the authorities have increased patrols, purchased additional speedboats for patrol, and created artificial highlands for shelter.
5. Several corridors have been set up for the safe passage of animals across National Highway–37 which skirts around the southern boundary of the park (Bonal and Chowdhury,2004).
6. To prevent the spread of diseases and to maintain the genetic distinctness of the wild species, systematic steps such as immunization of livestock in surrounding villages and fencing of sensitive areas of the park, which are susceptible to encroachment by local cattle, are undertaken periodically.
7. To control the growth and irradication of invasive species, research on biological methods for controlling weeds, manual uprooting and weeding before seed settling are carried out at regular intervals.
8. Grassland management techniques, such as controlled burning, are effected annually to avoid forest fires (UN Kaziranga Factsheets,2008).

According to the Indian Rhino Vision 2020 programme (IRV2020), a collaborative effort between various organisations, including the International Rhino Foundation, Assam's forest department, Bodoland Territorial Council, WWF-India, and the US Fish and Wildlife Service has been taken. IRV2020 hopes to raise the number of rhinos in Assam to 3,000 by 2020 and spread them over seven of the state's protected areas: Kaziranga, Pobitora, Orang national park, Manas national park, Laokhowa wildlife sanctuary, Burachapori wildlife sanctuary and Dibru Saikhowa wildlife sanctuary (Patil,2016).

"The present population trend shows that the population growth is healthy, and achieving the target of 3000 rhinos in wild is very much possible" – says Amit Sharma, the Senior Coordinator of the Rhino Conservation Programme at WWF-India.

Kaziranga is to face two major threats in the point of survival of rhinos, these are: 1. Flood, which occurs almost in every year and takes lives of many animals (Fig.2.2), and 2: Poaching, As undemarkated and frequently changed map of northern Brahmaputra side becomes vulnerable to rhinos and because of highest concentration of rhino population, poachers and their masterminds concentrate their efforts over this area. The major transportation route to Myanmar for illegal traders is also very close to Kaziranga (Plate.2.3).

Plate.2.2: *Rhinos are in flood in Kaziranga*

Although in recent years Kaziranga has achieved great success to a halt in poaching practices, many poachers have been shot dead due to strict vigilance, some of the sharp shooters are in custody and huge amount of arms have been seized. Administration is trying to hit back to the poaching network. Still a large section of people mainly in China and Vietnam are the illicit buyers of rhino horn products so there is always a hidden demand for rhino horn in the underground market. Vietnam and China are the highest consumers of rhino horns. The major route is through Myanmar via Imphal and Morah (Plate 2.3).

Apart from flood and poaching health issues and diseases need further study. Habitat loss is not an issue at present since rhinos live in well guarded isolated pockets. But the invasive plant species may create a stress on the availability of fodders, climate change is also a concern of it.

Under IRV2000 programme 18 rhinos have so far been translocated from 2008 to 2012. But in 2016, due to some poaching incidences in Manas and death of a mother and a calf in

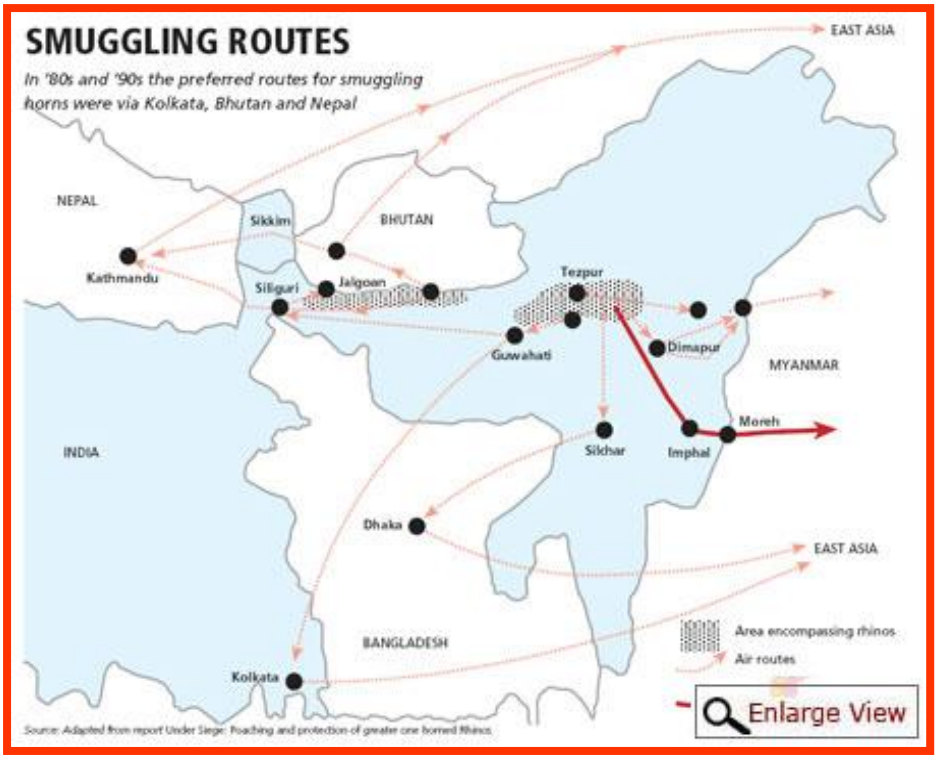


Plate.2.3: *Major routes of trading of poached rhino horn*

Burachapori the translocation programme is remained stop temporarily. In that year 22 rhinos have died due to monsoon flooding.

Inspite of this loss the Kaziranga rhino population has got a momentum. The record shows that from early sixties the rhino population has never been dropped from the previous census. It is true that Assam's 91.4% rhino population remains in Kaziranga and over 80% of total wild population (Patil,2016) which is not good for a meta-population but still importance of Kaziranga can never be ignored as it possesses the bulk of wild population and it is the only hope for rhinos maintaining the genetic heterozygosity.

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Chapter: 3

Daily Activity Cycle, Wallowing and Resting Behaviour, Intra specific and Inter specific Agonistic Inter actions

Chapter:3

3.1 Daily activity cycle

3.1.1 Introduction:

The 24 hour cycle is governed by the primary circadian clock in mammals through a pair of supra-chiasmatic nuclei (SCN).These are the distinct groups of cells located in the hypothalamus. In case of normal visual stimulation the light passes through the retina via some photoreceptor cells, such as 'rods' and 'cones', but, apart from this, retina is also equipped with some specialized ganglionic cells, and being photosensitive, these cells can send impulses directly to the SCN, as a result of which synchronization of different activities are performed in different parts of the day (Hughes,2015). If cells from the SCN, which contain the photo-pigments melanopsin, are removed, the animals maintain their own rhythm in the absence of external stimulations (Welsh, et.al.2010).

Many of the workers have concentrated their studies on the daily activity patterns of Greater one horned rhinoceros while doing their research in a broader field on this animal. Each and every animal has its own circadian rhythm based on their active and resting period which is also changeable according to season (circum-annual). Indian rhino showed distinct variation of activity patterns throughout the year (Hazarika et.al.,2013). An extensive study on daily activity cycle on Great Indian one horned rhinoceros was done at Gorumara and Jaldapara National Parks (erstwhile sanctuaries) by Bhattacharya and Pal (1982). To avoid the heat of the day Indian rhinos feed usually at night, early morning and late afternoon (Fahey,2018) and Deka and Sharma (2015) reported that the rhinoceros spent most of the time on grazing both on grassland and wetland which was also compared with the zoo inhabitants. Being the most aquatic rhino among all the five species (Burnie and Wilson, 2001) they spend a considerable time in 24 hours duration in wallowing or wading/swimming through the water pools either for resting or for feeding on aquatic plants almost entirely keeping itself submerged (Bhattacharya, unpubl.data). The study revealed that the midday is mainly allocated for resting either in shade or in wallows. Slight alteration of this pattern occurs in monsoon and cool season when rhinos feed at midday (www.animalinfo.org,2018).

Indian rhinos are known to have no reproductive season, breeding may occur in any time of the year. Circum-annual movements may usually vary according to season, as well as according to age and sex if they are not confined in a very small habitat. More or less time budget for feeding, wallowing, resting, drinking, salt licking, movements etc. remain fixed

and usually in fixed times in a 24 hour cycle. But as the season changes the duration and time of the above mentioned behaviours also change. The ecological factors like temperature, rainfall, sunlight and the availability of fodders, which they like, have great impacts on the duration and timings of those behaviours. As for example, in the hot dry season the midday part of the 24 hour cycle is used for wallowing (Bhattacharya and Pal, 1982) and resting to get rid of the heat and Tabanid fly, while during winter that midday part is utilised for feeding. It has been observed that the Indian rhinos spent more time in grazing during post monsoon season than the pre monsoon (Deka and Sharma,2015).

Some information are available regarding daily activity cycle in wild (Bhattacharya and Pal,1982), (Yadav,2000), activity pattern in zoo (Venugopal,et.al 1994), feeding and wallowing behaviour (Bhattacharya,1991; Ghosh,1991; Patar,2005), diurnal and nocturnal aggressive, feeding and drinking behaviour (Laurie,1978). Goddard (1967) and Laurie (1978) extensively worked on Indian and African black rhinoceros respectively.

3.1.2 Study schedule and technique:

An ecological and ethological study on Great Indian one horned rhinoceros was started from May 1980 at Gorumara and Jaldapara National Parks (erstwhile Sanctuaries). Four consecutive days in the first week of each month were selected for observation on the daily activity pattern of this animal. On each of the four days, observations were taken for a period of six hours; so that data were obtained for 24 hours in each month covering the daily cycle. Longer times were spent in the places where the probability of observations were better. Brief glimpses were also recorded and considered as the number of sightings. Duration of observations varied from brief glimpses of a few seconds up to over an hour. Observations were aided by the use of a 8x30 binoculars and the pictures were taken by an Asahi Pentax ME (lens 1:1.4) camera. Most observations were made from tree top platforms or from elephant back. Apart from these, many observations were made ‘on foot’. In case of wallowing the fresh mud cover on the body, foot prints and body impressions on the mud, besides direct observations were considered as an index of wallowing. The number of animals sighted and times spent by the animals in various activities at the four 6 hour periods of a day were collected. All the observation sites were recorded on working maps with date time and duration, as well as the types of behaviours were also noted in a field note book. The ecological parameters, such as temperature, rainfall, depth and area of wallowing pools were also noted relating to the above mentioned behaviours.

All the behaviours of Indian rhino could be divided into two broad categories:

Active behaviours: Feeding, walking, chasing, fighting, agonistic interactions, reproduction etc.

Inactive behaviours: Wallowing, resting, sleeping, lying on the ground.

No animal can be active throughout the day and night. So the animals must consume the stored energy judiciously, i.e., consumption of synthesized ATP by combining the both active and inactive behaviours. The rhinos, being one of the heaviest animals on the earth, consumed their time alternately by active and inactive behaviours. As for example, often the feeding and walking were followed by wallowing or resting; or the agonistic interactions like chasing and fighting, which require more energy, were followed by resting or lying on the ground.

3.1.3 Outcomes of the findings:

Altogether 2281 minutes (38 rhino hours) of actual observation were recorded over a period of about 300 hours. Seven hundred four individuals were sighted during this period. For convenience four general categories of activities such as feeding, wallowing, resting and others were considered. Activities included in the 4^{th} category were standing, moving, salt licking, drinking, alert, chasing, fighting and interactions with conspecifics and other animals. These activities were observed less frequently. The patterns of behaviours are described below:

Feeding: It includes a very short period of investigation for selection of fodder followed by cracking (in case of tall reedy grasses) and actual plucking and subsequently chewing. This process is repeated along with irregular movements for searching of fodders.

Wallowing: Resting in muddy wallows in sitting or lying postures or in submerged condition in standing or in slow swimming postures when the water level is high particularly during monsoon.

Resting: Lying on chest or flanks on short grassland, on muddy or dry soil etc. The eyes may be open with raised ears (alert posture) or closed (sleeping or drowsing)

Others:

Moving: It includes walking, trotting, running, galloping and wading through water.

Alert posture: It involves raising the head and ears and orienting towardsany stimulus

Interaction with con-specifics and other mammals: Rhinos behaviour towards any con-specific and other mammals which may be as below:

Agonistic display from a distance.

Attacking by the dominant to the subordinate or to each other and lastly infighting.

Chasing by the dominant and retreating of the subordinate to a safe distance.

Pre mating display and mounting (only between con-specifics).

Investigation – standing motionless orienting towards the direction of its movement in a raised head posture.

Defecation and urination with foot dragging and dung scrapping.

A total of 653, 473, 447 and 708 minutes of observation were done in the 1^{st}, 2^{nd} , 3^{rd} , and 4^{th} six hourly periods of the day respectively. Fig.3.1 shows percent time spent in different activities in each of the four 6 hourly periods of the day. Feeding appeared to be mostly a nocturnal activity with more feeding in the early than in the late part of the night. Laurie (1978) obtained maximum feeding in the early morning, i.e., 4-8 hours. In the late part (i.e. 0-6) of the night the frequency of resting increased. Wallowing increased from 35% in 6-12 hour to 70% in the 12-18 hour period. Almost similar observations were found in southern white rhinoceros in captivity (O'Connor, 1986). Other activities were higher in the early morning and late afternoon mostly due to higher frequency of movement during those periods. In contrast to our observations Goddard (1967) obtained maximum activity during 14 to 19 hours in African Black Rhinoceros. White rhinoceroses feed and rest alternately during day and night. In hot, dry weather they routinely rest during the hottest part of the day (www.savetherhino.org, 2017). Rhinos are mostly inactive during the day and spent a major portion of their time in wallowing and resting particularly in hot hours (Gee, 1964).

The seasonal variation in percent time spent on major activities has also been done during the field study. Table 1 shows that the percent time spent on feeding and resting were higher in the cool season (considered from the late October to early part of March.) Wallowing was recorded highest in the hot season (March-May) and lowest in the cool season. It appears to be directly correlated with temperature. Other activities reached to its maximum level in the wet season due to higher percentage of movement, probably as a consequence of availability of preferred food plants over large areas.

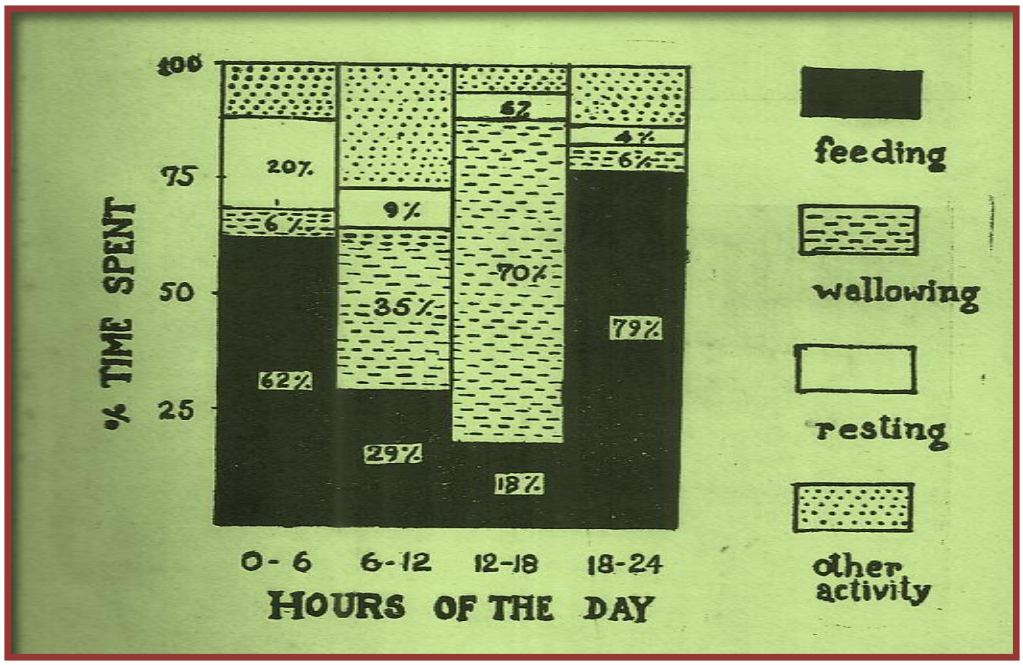

Fig.3.1.1: *24 hour activity pattern as shown by percent time spent by rhinos*

Table 3.1.1 shows that the percent time spent on feeding and resting were higher in the cool season. Wallowing was highest in the hot and lowest in the cool season and appears to be directly correlated with temperature. Other activities were maximum in the wet season due to higher percentage of movements, probably as a consequence of availability of preferred food plants over larger areas.

Table 3.1.1: *Seasonal variation in percent time spent on major activities*

Seasons	Observation in minutes	Feeding	Wallowing	Resting	Others
Hot	911	47.20	37.10	5.81	9.87
Wet	620	47.58	21.45	9.51	21.46
Cool	750	59.73	11.33	15.86	13.08

3.1.4 Discussions:

The time budgeting and the pattern of distribution of time for different activities throughout the day, as well as adjustment of time distribution according to the change of season (temperature, moisture, availability of light etc.), is an important aspect of survivavilty for an animal. They do it naturally by the influence of some intrinsic factors. The physiological adaptations also play some role for active and inactive periods. As for example, during hot

season the rhinos pay more attention in wallowing than other seasons (Table 3.1.1) and during midday (12-18 hours) 70% time is spent in wallowing (Fig.3.1.1). It clearly indicates that temperature is a prime ecological guiding factor for which the heavy body needs to cool itself quickly to adjust with the intrinsic enzymatic actions when the temperature rises considerably, either in hot season or in the hot part of a day. In Orang National Park (Assam) the Indian rhinos spent more time in feeding during winter season followed by pre monsoon time (in this study it is hot season) (Hazarika et.al., 2013).

Two decades back, just after the breakout of civil war in Eastern and Central Africa the population strength of Northern white rhinoceros dwindled to only 10 in the wild (IRF,2005); and before that, when the situation was not so vulnerable, possibly to assist in thermoregulation, during dry season in the decade of 80s' they grazed under the tree shade for up to 30 minutes and then took rest alternately (van Gyseghem,1984). This Northern white rhino sub species (*Ceratotherium simum cottoni*) became active in grazing around 4 pm and continued up to the end of the evening. Usually the activity level comes down to its lowest level during the hottest time of the day and increases when the environment is moderately cool, possibly to assist in thermoregulation in black rhinoceros(Goddard,1967) and in Javan rhinoceros (Schenkel and Schenkel- Hullinger,1969b).

It has been observed in black rhinoceros that in too cold nights they become less active (Mehradadfar,1999). So range of temperature plays an important factor in their daily activity patterns. Apart from temperature and humidity, relative abundance and distribution of food, water and mates also have great influence on their activity patterns. But, usually the free ranging large mammals like rhinoceros remain engaged in feeding, movement and other active works in both day and night (Goddard,1967; Schenkel and Schenkel-Hullinger,1969a,b; Owen-Smith,2004).

3.2 Wallows and wallowing behaviour

3.2.1 Introduction:

Wallows and wallowing pools are the must use habitat of the rhinos, the Indian rhinos are in particular, who are the most aquatic among all the rhinos. Wallows are often the water logged mud pools where the soils remain wet almost throughout the year even in the driest months and usually located in the low lands of the National Parks. Wallowing is an important event in the daily activity cycle of the rhinos and they spent a considerable time in wallowing particularly in the summer season. Wallowing pits may exist singly within the grassland

meadows or may be congregated consisting of five or six pits. Apart from greater one horned rhinoceros, Sumatran rhinoceros are also known to have the habit of wallowing (Julia, et.al.,2001).

Wallows are usually located beside or near the well frequented rhino routes and mostly inside the core area of grassland habitats. The slushy soil gets more slushy as it gets near to the mud pools and the rhinos of all age and sex classes are often seen sharing the same wallowing pool in groups except mother-calf association. In Kaziranga, as 70% of the total wild population lives there, moderately large groups consisting of 8 – 10 rhinos are often seen wallowing together in close quarters. Obviously, these are superficial associations (Bhattacharya and Chakraborty, 2016) and after completion of wallowing they generally depart and divides in small groups or goes solitarily. The mother – calf bondage usually look for separate wallowing sites just to avoid other conspecifics. The mud covering on the body gives them some relief from heat of midday, keeps the skin moist and protect them from biting insects (tabanid fly).

Similar activities have been reported in a few other large mammals such as bison (McHugh,1958), water buffalo (Prater,1971), sambar (Brander,1923; Schaller,1967), pigs (Deborah,2011). Not only protection from sun, but the pigs seems to wallow for temperature regulation, even, they are seen wallowing in the mud in cold weather. According to Marc Bracke of Wageningen University (in the report of Deborah,2011) the pigs lost sweat gland in the evolutionary process and as they did not evolve functional sweat glands they developed the habit of wallowing as a part of their daily activities. Moreover, it is believable that wet mud all over the body is better way to regulate body temperature as the cool water evaporation through the mud is slower than dipping in cold water.

The similar affinity to roll over on mud like pig (though rhinos have never seen rolling over completely), also might be due to fewer sweat glands in the epidermis which drive them for wallowing to decapitate heat from the body (Deka, 2015).

Two types of wallowing are common in case of Indian rhinoceros, these are: mud wallowing and pool wallowing. Indian rhinos are very much fond of mud wallowing, the reasons have been depicted above. This behaviour is quite similar with those of wart hog (Anonymous,2013), pigs (Bracke,2011) and domestic pigs (Vestergaard and Bjerg,1996). On the other hand, they are often seen pool wallowing (as they are most aquatic among all the rhinos) by submerging its body only keeping the nose, ears and eyes above the surface water

and remain busy either chewing or searching aquatic plants (Bhattacharya, unpubl. Data) or During water wallowing, the Rhino immersed its entire body into the water by keeping only head portion above the water surface (Hazarika and Saikia, 2010). This behaviour corresponds with the behaviour of Hippopotamous of Africa. It can be stated that Indian rhinos feel comfort with the behaviour of both types of wallowing which have been evolved to match with the moist humid monsoonal local conditions.

3.2.2 Techniques and study schedules adopted for this study:

Wallowing behaviour of rhinos attracted us very much because they spent a major portion of the day by wallowing either in mud or in water. In our earlier work (Bhattacharya and Pal, 1982) we quantified that wallowing frequency increases as the diurnal temperature rises. Apart from direct view some indirect signs, such as a portion of the body or whole body covered with fresh mud or wet under part of the body, fresh foot prints or body impressions on the mud pools indicated us that they just emerged out from the wallowing sites. Longer times were spent in midday near the wallows for observations on wallowing behaviour. Most of the observations were made from tree-top platforms (some of the platforms were permanently made to observe rhinos near the well frequented 'rhino paths' or near the wallowing sites). For easy access to climb on the platforms the trunk of the trees were nailed alternately. Occasionally rope ladder was also used for this purpose. Some of the observations were made from elephant back at Jaldapara and Gorumara, particularly in the wet season. Besides, early morning and late afternoon hours were regularly spent on walking along the 'firelines' and 'Rhino-routes' Duration of observations varied from brief glimpses of a few seconds to over half an hour. The rhinos were sighted with the aid of a pair of 8x30 binoculars. Pictures were taken with an Asahi Pentax ME camera (lens 1:1.4 with a tele 80-200 zoom attachment). The time and durations of the observations were recorded by a stop watch and then those were noted down in the field work book. The wallowing spots were spotted on a field map. The depth and the area of wallowing pools were measured by a steel tape. One tally counter machine was of use to find out the frequency of each behaviour At Gorumara, intensive observations were made in the eastern part of the core area of the National Park. At Jaldapara, most observations were done in the Moiradanga beat of Western leg and Sissamara beat of the Eastern leg as the rhino concentrations were most in those two areas.

Data were taken on wallowing behaviour at different types of wallows. The size and total number of foot prints and body impressions on or close to the wallows were recorded and rubbed off afterwards to avoid repeated countings. Besides fresh mud cover on the body of the individuals of known age and sex were also considered as an index of wallowing in three different seasons. The frequency of wallowing at different times of the day were also recorded. Data were also taken on total area, the area of watery portion and other parameters of 42 perenial wallows in three different seasons were noted in the work book.

3.2.3 Results and Discussion:

3.2.3.1 Selection of wallowing sites and wallowing postures:

A typical perennial wallow contains a pool of water, either in the centre or at one end and the rest of the area is covered with fine grain soft mud. When a rhino approached a wallow without water it always selected the softest part of the mud. Some wallows dried up in the hot season. Usually the rhinos had a choice to wallow in the wallows where at least a remnant of water pool was still present. The differences in wallowing behaviour at wallows with different depth of water is shown in Table 3.2.1.

While wallowing in narrow streams rhinos lied on the sternum with most of the body submerged and from time to time dipped the head down into the water. The rhinos changed the orientation of the body at irregular intervals. Sometimes they changed position in the water pool, possibly to select the better places. Occasionally rhinos were seen to roll over on to their backs with legs of one side in the air, and in so doing coated one flank with mud. Rhinos never rolled completely over.

Wallowing rhinos frequently disclosed their presence by characteristic deep breathing sound. During wallowing their eyes were usually closed and ear movements were less frequent, and in a prolonged one, the rhinos the rhinos seemed to be in a state of slight drowsiness and the

Table 3.2.1*: Wallowing of the Great Indian One-horned Rhinoceros at different types of wallows at Gorumara and Jaldapara National Parks.*

Nature of wallows	Average depth of water (in cm)	Average area/width	Orientation of the body during wallowing
Wallows with Shallow water	20	$25m^2$	Lied on sternum with the chin and throat touching and throat touching the mud or body lied on either side of the body
Narrow stream	65	5m	Lied on the sternum on the knees, raising the nostril, horn, eyes, ears dorsal spine above the water level
Bigger pool sto Nost level.	Above 100	$120m^2$	Mostly float and swam and stpod up from time to time. Nostril kept above water Level. Head submerged Occasionally under water

latency to interaction was considerably high. As such one could get close to them on tip toes. They, however, came to alertness by any noise.

Absence of shade did not appear to affect the rhinos adversely. Rhinos had been observed wallowing under direct sun less than 25 metres away from cool shade of sissoo (*Dalbergia sissoo* Roxb.) and shimul (*Bombax ceiba* L.) trees. It may be assumed that rhinos preferred wallows more than cover. Goddard (1967) made similar observations on resting black rhinoceros in Northern Tanzania, E. Africa.

3.2.3.2 Wallowing frequency in different seasons:

Wallowing was most frequent in summer and least in winter (Fig. 3.2.1). Most rhinos encountered during the months from March to May had a fresh mud cover on the body (Plate 3.2.1), whereas, rhinos encountered during cooler months hardly had any such cover. Laurie (1978), however, found that wallowing was most frequent during monsoon.

Plate 3.2.1: *An old photograph of Gorumara rhino showing mud cover at rump and belly region diagonally (Photo by author)*

The frequency of wallowing in percent observation (Fig.3.2.1) suggests that Wallowing and temperature have a positive correlation ship. Rising of temperature leads them to spend more time in wallows and fall of temperature refrain them (not entirely) from wallowing, although in Royal Chitawan National Park, Nepal, Rhinos have been found wallowing throughout the year, particularly in monsoon (Laurie,1978).

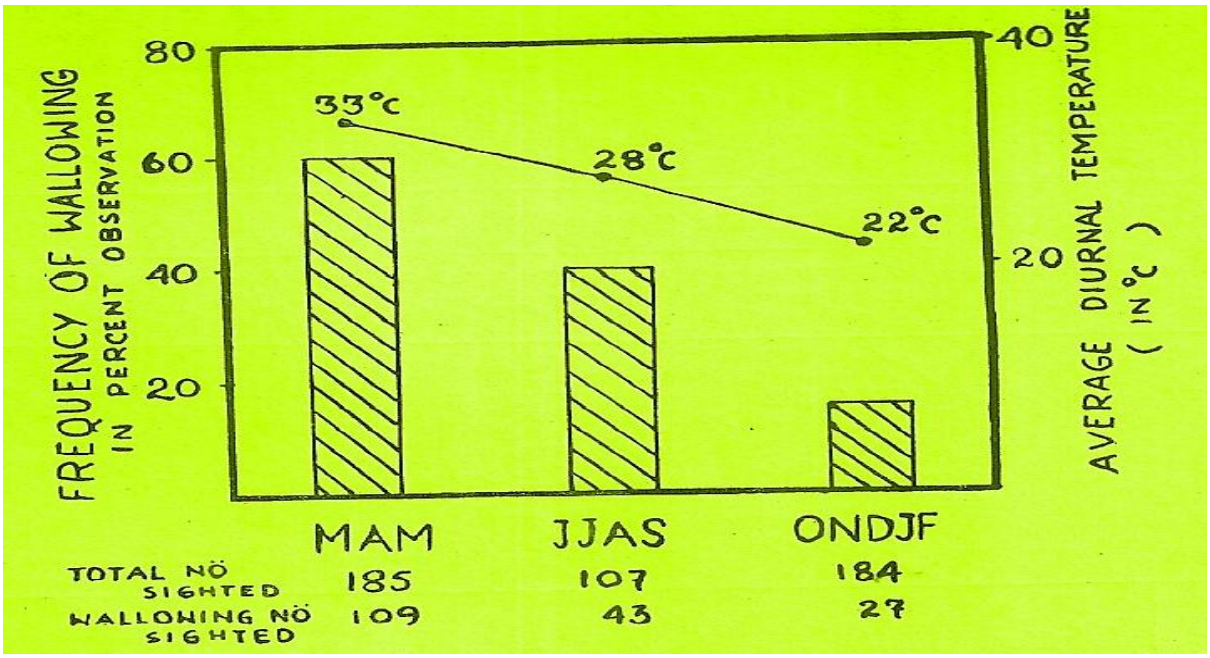

Fig. 3.2.1: *Frequency of wallowing of Great Indian one-horned Rhinoceros in three different seasons (Source: Pal and Bhattacharya,1986)*

3.2.3.3 Wallowing at different hours of the day:

It is clear that rhinos wallowed most in the hot hours of the midday and least during the night. The frequency of wallowing was lower on cool, overcast days during the summer and monsoon. Most observations on wallowing were recorded between 8:30 and 17:00 hours when the animals were rather inactive, particularly, between 9:30 and 15: 00 hours, the peak hours considered for wallowing. Laurie (1978), on the contrary, found that the Indian rhinos wallowed most in the early morning. In case of black rhinoceros, Goddard (1967) recorded 90% of the observations on wallowing between 16:00 and 18:00 hours in Northern Tanzania, E. Africa. A wounded rhino was, however, observed to wallow at night. The fresh mud cover on their bodies was seen most frequently in late afternoon. This indicated that at midday the rhinos were engaged in wallowing. Besides, at afternoon the vegetation along the 'rhino path' leading out from the wallows were found typically smeared with wet mud which probably dripped down from the rhinos' skin.

3.2.3.4 Effect of age and sex on wallowing:

Larger animals tended to visit the wallows more often than smaller ones. At Jaldapara and Gorumara the large bulls and cows were observed to visit the wallows more frequently than the juveniles of either sex and weaned calves. The juvenile males and females never visited the wallowing sites during the cool season. The calves, however, were observed to visit the wallows more frequently than the juveniles in the dry season. This probably was due to the fact that the calves during that time always accompanied the mother.

3.2.3.5 Average area and depth of wallows:

The total area of the wallows and its watery portion, the depth of water and soft mud of 42 perennial wallows were measured in dry, wet and cool seasons (Table 3.2.2). The area and depth of wallows increased considerably in the wet season. Talbot (1960) reported that a wallow used by Sumatran rhino (*Didermocerus sumatrensis*) measured 1.83 metre to 3 metre or 3.5 m long and 92 cm to 1.5 m wide while the Javan species (*R. Sondaicus*) used slightly bigger wallows measuring 3.5 m by 1.8 m. But the wallows used by Indian rhinos are much bigger than the wallows used by Sumatran and Javan species. It may also be mentioned here that Indian rhinos are also bigger in size. In the hot months of the year the average area of watery portion of the total area of wallowing sites are much less (15 m^2 : 22 m^2, i.e., 1: 1.46), on the other hand, the wet months bear higher watery portion (25 m^2 : 28 m^2 or 1 : 1.12) (Table 3.2.2). More or less similar ratio between depth of soft mud and depth of water is

found in those two seasons. Vertically two ratios are 9cm (water) : 10 cm (soft mud), i.e., 0.9: 1.0 and 15 cm : 20 cm, i.e. 1: 1.33 in hot and wet seasons respectively (Table 3.2.2) (Pal and Bhattacharya,1986).

Table 3.2.2 *Average area and depth of 42 perennial wallows in Gorumara and Jaldapara National Parks*

	Area (in M^2)		Depth (in cm)	
Seasons	Average total area	Average area of watery portion	Average depth of mud	Average depth of water
HOT March to May	22 ± 3.2	15 ± 2.6	10 ± 1.0	9 ± 0.8
WET June to Sept.	28 ± 3.4	25 ± 3.0	20 ± 1.1	15 ±0.6
COOL Oct. To Feb.	23 ± 2.9	17 ± 2.7	14 ± 0.9	11 ± 0.6

3.2.3.6 Do all the five species of rhinos have similar affinities for wallowing?

In a behavioural study on black rhinoceros Joubert and Eloff (1971) have shown that South West African black rhino subspecies wallow less frequently than its East African siblings, this is because of the dry rocky terrain of South West Africa which is unsuitable for wallowing. The wallowing activities only gets its momentum during rainy season and regular visits to water holes take place both for drinking and wallowing. This behaviour helps them cooling down body temperature and it is recorded that till dusk they continue wallow.

Indian rhinos are blessed with the suitable ecological condition compared to that of African black rhinoceros. The regional differences of ecological conditions play a great role on their wallowing activities.

The large herbivores like elephants, rhinos, hippopotamus, etc., adopt various ways to cool down their body temperature. For dissipating body heat elephants use their huge thin ears for fanning purpose and during day time hippos remain submerged. According to Bill Konstant (2013) the following comment made by him may be most appropriate:

"Rhinos also risk overheating under the hot tropical sun, and they lack sweat glands that would help them cool off. So, whether they live out on the plains, in marshes or in dense jungles, they routinely seek out water to get rid themselves of excess heat. When they bathe in mud, we call this wallowing. By coating its body in cool wet mud, the rhino provides the path for internal heat to radiate from its body and evaporate into thin air. Wallowing also helps the rhino protect its skin from insect pests like mosquitoes and flies, as well as from sunburn."

The White rhinos of South Africa spent much of their resting time in wallows to keep cool and to get rid of skin parasites. They need water for drinking every 2-4 days. If there is no wallowing place available, they roll in dry dust (www.savetherhinos.org). So behaviourally all the rhinos are fond of wallowing.

The Javan rhinoceros is the rarest among all rhino species, and possibly the rarest large mammal on the earth and is considered as the critically endangered animal. Not much behavioural study has been done on this animal. According to some titbit reports from the study by Hutchins and Kregger (2006), Javan rhinos are solitary animal with the exception of breeding pairs and mothers with calves. They sometimes congregate in small groups at salt licks and mud wallows. Wallowing in mud is a common behaviour for them; the wallowing activity allows them to maintain cool body temperature and helps to prevent disease and parasite infestation. The Javan rhinoceros does not generally dig its own mud wallows, but prefer to use other animals' wallows or naturally occurring pits.

3.3 Intra specific and Inter specific Agonistic Behaviour

3.3.1: Introduction:

Indian rhinos are not known to be very much aggressive in captivity or in wild like other large animals (eg., elephant seal, mountain sheep, American bison etc.) but some severe aggressions are recorded from the past studies by Lahan (1974), Laurie (1978) and Hazarika and Saikia (1999). In general, aggressive or agonistic behaviours are not always ended with a severe injury or death, but most of these types of interactions are confined within threat displays or anger which actually causes no physical harm. Such types of displays usually include snorting (one kind of vocalization that makes the opponent scared) , displaying teeth or claws, body size, enlarging spines on the neck (frill necked agamid lizard), facial expressions, release of chemicals for defensive purpose and changes in colouration (Staaden, et.al., 2011). Many of the large herbivores become aggressive to defend their territories, as

for example Hippos of Africa, who, actually, are considered to be most dangerous and symbol of aggression on earth (Harris, 2009).

It has been discovered that glucocorticoid hormones play a key role in promoting the agonistic behaviour. Similarly, acute reduction of corticosterone hormones diminishes aggression (Kiran et.al.,2008). The hormonal effects on the aggressive behaviour on the animals have been studied intensively, particularly the sex hormones, which plays a great role leading to displaying more aggression in males. Due to having bigger bodies and having the ability to defend the group and territories the aggressiveness has automatically evolved in males rather than females.

3.3.2 Agonistic interactions in rhinocereos:

Agonistic interactions in Indian rhinoceros ranges from mild snorting to direct attack associated with a long chase. The aggression shown by a rhino from mild to severe may be categorized as below:

Erection of head and pinnae → Snorting → Threat display → Chasing → Attack
with mild sound (vigilance) ↓

Fleeting or escaping

Apart from the above behaviours rhinos are also seen standing motionless in the alert posture.

Intra specific aggression in Indian rhinos is commonly found but they have been found to be involved in inter specific aggression also in some occasions. Although Indian rhinos are not much territorial but during dry and hotter months they are seen in alert posture with head keeping horizontal to the ground, pinnae in erect or directed forward and occasional movement of pinnae to locate the origin of sound source.

Fighting between males is very common in Gorumara and Jaldapara due to skewed sex ratio (Gorumara in particular) in favour of males (Section 1.4.2). The infighting may continue until death of weaker competitor or until the weaker male departs that area after receiving severe injury. Dominant adult males are the primary initiators in fights. According to the rhino mortality records at Gorumara, fights between dominant males are the most common cause of rhino mortality. During pre mating or courtship males become also very aggressive toward females if she refuses the male. In that case usually a male chases his partner over long two kilometres either attacking from behind or attack her face-to-face. The main weapon of Indian rhinoceros is their lower incisor, and by a up thrust it can make a deep scar of 2 inches

deep and 18 inches long (Talbot,1960 and Gee, 1964), unlike African rhinos who actually use their horns (Dinerstein, 2003). Probably, this may be due to the blunt horns of Indian rhinos which are of no use during fight. Hazarika and Saikia (2010), though, observed in Orang National Park that the Indian rhinos also use horns during attack.

3.3.2.1. Vigilance:

The agonistic interaction always initiates with vigilance. During vigilance no other activities, such as feeding, movement, courtship, running wallowing, resting, sleeping etc. do occur and a rhino may remain motionless for an hour with keeping its head horizontal to the ground to slight upward (Plate 3.3.1), simultaneously pinnae are erected upward or move forward to backward direction to realise the source of sound. The vigilance may be associated with mild sound, almost inaudible from a distance, but not continuous. In general, the rhinos are very alert in presence of other animals and specially the cows are much alert when they are accompanied by the calves and always keep an watchful eye on the surrounding situation. Time to time the mother cow may be very aggressive if she smells slightest danger to her calf. If it happens the cow instantly takes guard keeping her calf in safest position and drives away the intruder beyond a safe distance. The cows try their best to tackle any unwanted situation which they feel to be detrimental to their calves. Lesser the age of the calves higher the vigilance and alertness rendered to the calves from the part of their mothers.

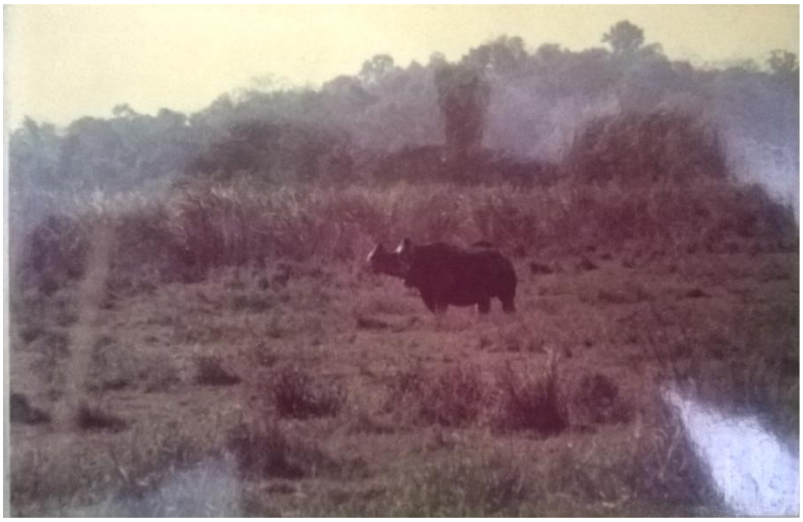

Plate 3.3.1*: A massively built Kaziranga dominant bull in vigilance mood (photo by author).*

3.3.2.2. Snorting and Threat display:

Snorting and threat display are the two next phases of agonistic interaction performed by the adult rhinos. Usually the snorting and threat display can't be separated and go on

simultaneously. It is one kind of threat display by making a louder sound like FRRAAA.....FRRAAA.... at regular intervals. In case of bulls this type of emission of sounds may be for protecting their own temporary territories (as such no marked territoriality is found in them) just to keep away the intruders. Sometimes they pretend to attack the other individual, and shows a physical aggression bodily. The pinnae moves forward and backward and body language shows a sheer excitement. The emission of sound gets intensified and turns into a louder hunk. In many cases the excitement subsides and the two individuals gets away from each other or the weaker one gradually retreats out of the sight of the dominant bull. If it is not occurred the individuals get engaged in next step of agonistic interaction, i.e., attacking each other and fighting.

3.3.2.3. Chasing:

Chasing is done mostly by the dominant adult bull. To some extent territoriality is noticed in the bulls. Usually it tries to displace the opponent male and chasing is done up to 2 km from the initiation point. During pre-mating time the cow is chased by the bull up to a long distance and finally both of them may have the risk of receiving injury. During chasing honk and grunt sound is emitted from the chaser. This type of aggressiveness is also noticed in mother-cow who always remain alert and chase the intruder up to a short distance and drives it away at any cost if the intruder tries to invade into her safe distance boundary.

3.3.2.4. Attack:

Attacking is the last phase of agonistic interaction and it causes physical injury. If the two individuals are equally strong and no sign of retreating of any one is noticed, the fight continues until death of any one. Sometimes the smaller or weaker individual gets severe injuries which latter can bring death. The attack from dominant bull can be minimized if the other bull remains submissive from the beginning. Usually they use lower incisor during attack but horn may also be used. When the opponent is fleeting the attack may, usually, done on the back or flank region. Most of the deaths of adult males are reported from Gorumara due to infighting (1.4.2).

3.3.2.5: Fleeting or escaping:

This happens in case of subordinate or weak or sub-adult males. These males, usually, do not want to take part in fighting. They leave the dominant bull's area by quick running or galloping. They are also scared about larger elephants or even humans and always try to keep off beyond a safe distance.

3.3.3: A case study of inter-specific aggression at Gorumara:

It was a cool afternoon of January 1981. A faint grazing sound was nearing to our camp, the source of that we could be able to locate from the left side of the fire line which went straight to the Jaldhaka river some 2 km away. Due to tall elephant grass and reeds the animal could not be viewed but the nature of sound of tearing and chewing grass was felt like rhino. Suddenly one medium sized elephant, some 100 metres away from us, appeared from the right side of the fire line and entered the left side leisurely.

Within half a minute we heard a loud threatening sound and a male rhino came out from the left side of tall grass hide and chased the elephant along the fire line. Readily we could identify the rhino as GB02 (Gorumara Bull No.2) who had a reputation of being bad tempered and about one month ago he ousted the bull GB01 after an intense fight. The sound emitted was very loud and repetitive divisible into four syllables like below:

FAA – FAA – FAA - FAA

All the syllables were forcibly emitted and of equal strength. We realized that when even the last syllable had a force like first one then it proved to be the sign of anger and hostility. The rhino could not tolerate the presence of that elephant which was slightly bigger as per our eye estimation. Latter when we studied the pre-mating call in the next month, i.e., in February,1981(Bhattacharya,1993),we were able to distinguish clearly the difference between pre-mating call with that of aggressive call. The pre-mating call was as below:

FAA – FAA- FAA – FAA-FAA-FAA-FAA and

FAA- FAA – FAA - **FAA-** FAA – FAA- **FAA-** FAA – FAA - **FAA-** FAA – FAA

Here, (i) divisible into seven syllables, gradually the sounds diminished and last one or two segments almost inaudible, it means when the partner is not near but his or her presence is felt and after emission of the sound long pause is sustained. (ii) it indicates when the male and female is very close, courtship play is about to start, repetitive 3 to 5 syllables and nonstop emission of sound. But in aggressive call all the syllables are distinctively clear and are of equal force and suddenly stops.

The elephant did not take any risk of fight and quickly ran out of our sight. After some time the rhino again returned to its original place showing the winning sign in its body language. He did not bother about the size of the competitor thinking himself as the king of his domain.

3.3.4: Agonistic interactions performed by other rhinos:

African black rhinoceros (*Diceros bicornis*) is one of the reputed bad tempered animal among all the large herbivores. Due to poor vision (myopia) often they charge tree trunks, or termite mounds or safari cars and they are often engaged in infightings. Highest rate of mortality is recorded for any mammal and data reveals that about 50% of males and 30% of females die mostly because of combat related injuries (Berger and Cunningham,1998). They attack out of fear, confusion and panic. Though they possess high sense of smell and hearing but due to very poor eyesight they charge if they sense a threat. Black rhinoceros are not very aggressive towards others of their species, usually only bluffing aggression occurs when they come close to each other (WWF Global, 2018).

Black rhinos are also very unpredictable. For nothing they can attack a moving jeep or a stationary tree trunk out of confusion and also because of poor eye sight. The same individuals have been observed walked into camp sites at night and then walked away peacefully (Conniff, 2011). In the point of aggression Indian rhinos are somewhat predictable, usually they try to avoid human or moving cars excepting the mothers who are very much attentive to her new born calves.

White rhinos are considered to be less aggressive in comparison to black rhinoceros and also Indian rhinos. This may be partly due to the savannah grassland where the live in and it becomes easy to locate them at a great distance, so without their knowledge, the chances of getting too close to them are very low. On the other hand, the low height grassland makes them easier to see people coming and so they get ample time to move away if they want. But it has been reported that the white rhinos sometimes can attack (www.savetherhino.org. 2018). They are also most social among all the rhino species. As many as a herd of fourteen rhinos can be seen grazing together which indicates they are more sociable than the other species of rhinoceros and obviously indicates their lesser aggression towards others(wiki.safariltd.com,2018).

During courtship the male Sumatran rhinos often become too aggressive with female. At that time the males can injure the females and even can kill them. In wild, the female could run away from an aggressive male, but in captivity they are unable to escape. This inability to escape from the aggressive males is one of the causes of low success rate of captive breeding programs in Sumatran rhinoceros (Zahari, et.al., 2002. 2005; Roth, et.al. 2006).

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CHAPTER-4

FEEDING AND DEFECATION BEHAVIOUR, COMPOSITRION OF FODDERS, SELECTION OF FODDERS BY RHINO POPULATION UNDER ALTERNATIVE SITUATION AND FOOD ASSIMILLATION

CHAPTER-4

FEEDING AND DEFECATION BEHAVIOUR COMPOSITRION OF FODDER, SELECTION OF FODDER BY RHINO POPULATION UNDER ALTERNATIVE SITUATION AND FOOD ASSIMILLATION,

4.1 FEEDING PROCESS AND SEASONAL VARIATION IN FOOD PREFERENCES

4.1.1 Introduction:

Rhinos being the caecum animal and having large size enjoy diversified fodders than the ruminants (Kleiber,1961). Caecum animals require a greater amount of food due to their anatomical characteristics (Bell,1971), but at the same time their relative requirement per unit weight of the body tissue, i.e., intake in gm/kg/day is fairly low (Bhattacharya and Chakraborty,2017). As Indian rhino is having an increased surface area because of its heavy body weight the proportion of relatively inert or non-metabolizing tissue is higher than smaller herbivores. It results in decreasing requirement of food on per kilogram body weight (Warrington,2001). Being a perissodactyle and hind gut fermenter (Sinclair et.al.,2006), Indian rhino has the capacity of digesting less nutritious food items (Bell,1971; Jarman,1974), such as tall elephant grasses which have much amount of cellulose, hemi-cellulose and lignin content but less amount of nutritious plant material. Indian rhino is a large herbivore and average weight is being nearly 2000 kg, their basal metabolic rate is lower than smaller animals (Clutton-Brock and Harvey,1983) because greater the surface area lower the rate of metabolism and thatswhy, Indian rhinos can manage on roughage fodders. It has been estimated that the nutritional requirements usually vary inversely according to body size and weight. It is again dependent on the seasonal food availability with a fluctuation of their general biology.

4.1.2 Physiological aspects:

4.1.2.1 .Dentition pattern:A constant rate of intake and nutrient absorption through the gut can be maintained in this animal despite an inferior quality diet containing high fibre content that are largely indigestible. The adaptability starts form its dentition type. Indian rhinos have gradually evolved from browsing to grazing habit. Hypsodont type of dentition (Fig.4.1.) has

Fig.4.1.1: *The teeth of rhinoceros showing hypsodont type of dentition*

been gradually developed for chewing coarse grasses. Premolars have been molarified with high crowns embedded in thick enamel content and a facial extension has been occurred for giving room to the large chewing teeth. Such dentition type is the characteristic of grazers. The cheek teeth of Indian rhinos fall under the category of "sidewall hypsodonty" which are, actually the coverings of thick enamel on the side walls of the cheek teeth (Koeningswald,2011).

4.1.2.2. Selection of food plants*:*Despite rhinos being grazers, in particular, in absence of nutritious succulent food plants, they are forced to take taller plants which provide them a bulk diet though intrusion of high amount of cellulose and lignin cannot be avoided. As for example, cellulose percentage is found highest in *Imperata cylindrical* (61.01 ± 4.61), followed by *Phragmites karka* (57.30 ± 4.61), and *Saccharum spontaneum* (57.24 ± 4.28) respectively which are very well known rhino fodders (Thakur *et.al.*2014). On the other hand, in the low level plants which are more nutritious and low in cellulose and lignin content, the rate of hourly intake is very low and does not provide much energy. So the rhinos usually like to feed on tall and intermediate sized plants, preferably grasses.

4.1.2.3.The process of digestion: Rhinoceros being a hind gut fermenter evolved a much longer small intestine with a side pocket, known as caecum at the distal end of the small intestine just to ferment a fairly large amount of cellulose, hemi cellulose and lignin or other undigested food residues. The small intestine is associated with an increased retention time (Sinclair,*et.al.*,2006) which holds a very complicated process in the hind gut. In fact, Mean Retention Time (MRT) of digesta in the GI tract is highest in Indian rhinos (67 hrs.) among all the hind gut fermenters (Clauss, *et.al.,* 2009). For this mechanism they have also been adapted using microorganisms such as bacteria, protozoa and fungi to digest non digestible matters by fermentation (Chivers, *et.al.*,1994). Food materials must be retained in a fermentation chamber long enough for the microorganisms to cause fermentation before

movibg into the large intestine. The small intestine plays a major role in breaking down of food staffs by enzymatic actions followed by absorption into the blood stream.

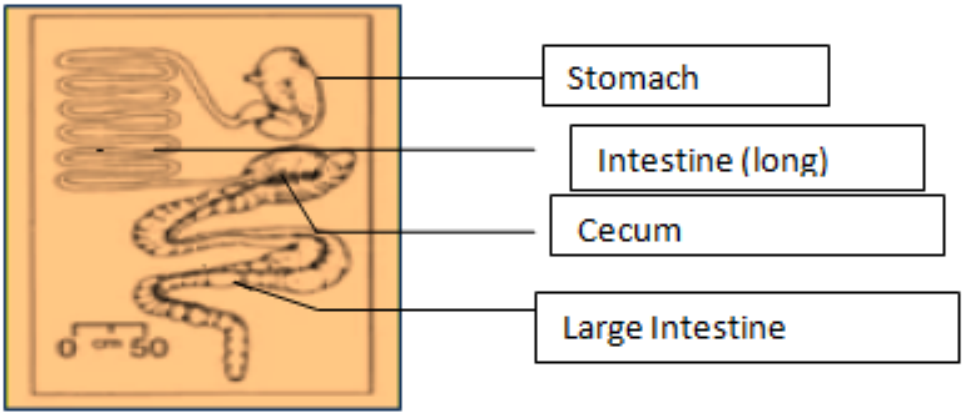


Fig.4.1.2: *The alimentary canal of Indian rhinoceros (Redrawn after Edward and Hume,1998)*

The large intestine plays two main roles, (1) absorb most of the remaining water into the body again to get rid of dehydration and (2) at the end of the fermentation in caecum the short chain fatty acids produced are absorbed and utilized and thereby providing energy. In an anatomical case study of southern sub species of African white rhinoceros (*Ceratotherium simum*, *simum*), who are also grazers, have shown that the caecum may be functionally replaced by the well developed colon which may act as the main fermentation tank in this animal (Endo, *et.al.*,2000). The same feature has also been observed by Stevens and Hume (1995).The absorption of microbial protein is little known. However, the hindgut fermenters like rhinos are to some extent less efficient than the ruminants who can digest high fibrous foods, but since indigestible parts are fermented in the caecum of rhinos they do not experience the loss of energy. Indian rhino do not need to ingest high energy and protein per unit of body weight. Since food material can be retained in the gut for longer periods in them, the rate of passage may be slow enough for fermentation and absortption of fatty acids to take place.

***4.1.2.4.The foraging time and selection of food*:** Indian rhinos being a perissodactyle, need a huge quantity of food per day, as a result of which, they can pay very little attention in selective foraging. They eat any kind of low quality elephant grasses which come on their way, as they require more nutrients in each day than the smaller mammals need, such as hog deer. Relative requirement is low, so they can adjust with the nutritional needs with relatively lower quality food. The dry dry mature elephant grasses in the dry season, i.e., in March, April, May and early part of June, possess proportionately high fibre and low nutrient. Despite relative dryness the rhinos do not hesitate foraging on those plants.

4.1.2.5. Food Intake Capacity in relation to Body Weight: Food requirement directly varies with the increasing body weight due to increasing cost for maintenance of the body (Moen,1973) although Clauss, et.al (2009) advocated that digestible food intake is independent of body mass, but dependent on food intake, digesta retention, and particle size.

Animal	Body wt. (in kg)	food intake in kg/day	%Food intake gm/kg/day	Digesta retention (in hr.)	Particle size (In mm)
Rhino (Indian)	2000(avg.)	19	0.95/9.5	67*	5.227**
Elephant (Indian)	2665(avg.)	25	0.93/ 9.3	50*	7.020**

Table:4.1.1: *Showing a correlation of body wt., Food intake, % food intake, Digesta retention time and Particle size * courtesy from Foose et.al (1982) and ** courtesy from Fritz et.al. (2009)*

Table 4.1.1 shows a comparative correlation of body weight with food intake digesta retention time and particle size in two largest herbivores of Asian origin, i.e., Indian rhino and Indian elephant. The Table shows the direct relationship between food intake and body weight in both these large herbivores, 19 kg and 25 kg respectively but the mean digesta retention time largely differs which is again negatively correlated with the particle size.

According to an estimation done by Kleiber (1961), it is found that the basal metabolic rate (kcal/day) of mammals is approximately seventy times the three fourth power of their body weight (in kg). So it is quite evident that the Indian rhinos require more nutrients per day than the smaller mammals.

Where forage quantity is limiting but consists of higher nutritive value, smaller body size is advantageous; on the contrary, where forage quality is limiting large body size fits to that environment (Bell,1969 and 1971). So the habitat of tall elephant grasses has become a blessing on the unicornis.

4.1.3. Food Preferences:

4.1.3.1. Literature Cited: A considerable number of field workers studied the food preferences of the large sized herbivores which were based on direct field observations (Goddard,1968; Laurie,1978; William and Petrides,1980). Food preferences without direct

observation could also be inferred by rumen content (Martinka,1968; Allen,1968; Cablentz,1970; Nixon *et.al.*,1977; Boeker *et.al*.,1972; McCaffery, *et.al.*,1974 and Karusmen,1978) and Tracer sample (Wilson *et.al.*,1977) analysis respectively. Rumen content analysis is hardly possible for large wild animals, especially, which are threatened to be extinct. The tracer sample analysis is a specialized but expensive technique and very often involved with certain operational hazards. While, faecal sample analysis is inexpensive, simple and effective. The undigested plant particles in the faeces mainly contain almost unchanged cell wall structures made up of cellulose and lignin and each plant species possesses some unique identifiable specific cell structures (Storr,1961). For this reason the faecal sample analysis can be of greater help in identifying plant specimens and food preferences accurately. So, this method has been widely applied by many wildlife biologists (Baumgartner and Martin,1939; Scott,1941; Dusi,1949; Adams,1957; Storr,1961; Adams, *et.al.*,1962; Lay,1965; Kiley,1966; Stewart,1967; Zyzner and Urness,1970; Robins *et.al.*,1975 and Chattopadhayay,1982) on different ungulates but except on Indian rhinos.

4.1.3.2 Methodology:Food analyses were done mostly by the examinations of cuticular plant cell structures obtained from the faecal samples collected seasonally(Plate 4.1) along with an assistance of direct observations. In initial stages, direct observations were much helpful in confirming the results derived from faecal sample analyses. Gradually direct observation method lost its importance in the latter stages since the intake food plants could be readily identifiable by examining the cell structures obtained from the faecal samples.

Plate 4.1: *Faecal sample analysis by the author in the Laboratory*

The faecal sample analysis required the preparation of reference slides. The plant specimens were collected from specific rhino habitats which were evidently supposed to be the rhino fodders and were observed eating by rhinos. Those plant specimens were identified from the Botanical Survey of India, Shibpur, Kolkata. Then the reference slides for cuticular structures were prepared from those identified plant specimens (Annexure-I).

Cell structures are frequently obscured by the abundance of cell contents, cell walls and presence of colouring matters etc. (Trease and Evans,1973). So the leaf fragments (cut into 5 to 10 mm pieces) were processed in the laboratory through a few chemical analyses, i.e., defatting, bleaching and clearing (Trease and Evans,1973). Reference slides were also made from many other plant species, particularly, those prevailing in the feeding areas. The measurements of the cell structures were taken by an ocular micrometer. The identification works from the known plant specimens were made under a microscope having 6.3 x 20 lenses (Annexure-I).

The faecal samples were collected from the National Parks for three different age classes, i.e., adult, immature and calf. The seasons were divided into i) hot-dry (March to May), ii) wet-humid (June to September) and iii) cool (October to February). For each season at least four faecal samples were collected for each age class.

Lastly, the slides from the faecal samples for plant cell structures were prepared following the same procedure adopted in preparation of reference slides. After clearing the temporary slides were prepared and the camera lucida drawings were done for the cuticular structure of each plant species to keep permanent records (Fig.5.3). For each sample 5 slides were prepared. Thus for each season and age class 4 x 5 = 20 slides were analysed. The total faecal matters of each sample were randomly taken on the slides for further identification and the countings were done to find out their food preferences systematically. For convenience, 5 gm of faecal sample were diluted in 20 ml distilled water for each season and age class to make an emulsification and then that emulsified matter was distributed evenly over five slides for examination.

4.1.3.3.Results and discussions: Maximum preference is observed in the adults in wet-humid season (Fig.4.3.1). The food preference or simply the preference (P) of a rhino of a given age-class is the total variety of plants in number taken in a particular area. The P is the function of age-class as well as season as evidenced by the following equations of P in terms of A, where A is the age of the animals.

$P = 29.059 + 3.040A + 1.175A^2$ ……..(1) for hot-dry se

$P = 46.190 – 1.873A + 2.159A^2$ ……..(2) for wet-humid season

$P = 26.982 + 8.393A + 1.286A^2$ ……..(3) for cool season

The above equations are illustrated graphically in Fig.4.3.1. The very nature of the curves in Fig.4.1.3. indicates the marked increase in intake of variety of fodders by the adults in any season while the calves consumed the least variety of food plants. The juveniles lie in between these two. In the dry and cool seasons the adults consumed almost twice the variety of food plants taken by the calves, n= 32 and 34 respectively as shown in the table 5.2. The slopes P vs A curves at all the ages are evidently straight lines establishing the fact that, the rates of preference per day are linear in all the seasons. It is seen that in wet-humid season the varieties of fodder consumption is maximum in comparison to other two seasons, i.e., dP/dA = 3.04 + 2.350A and dP/dA = 8.393 + 2.572A for hot-dry and cool seasons respectively, hence, dP/dA = -1.873 + 4.318A in wet-humid season. The slope is rather steep in wet-humid season because the availability of food reaches at maximal level during that time.

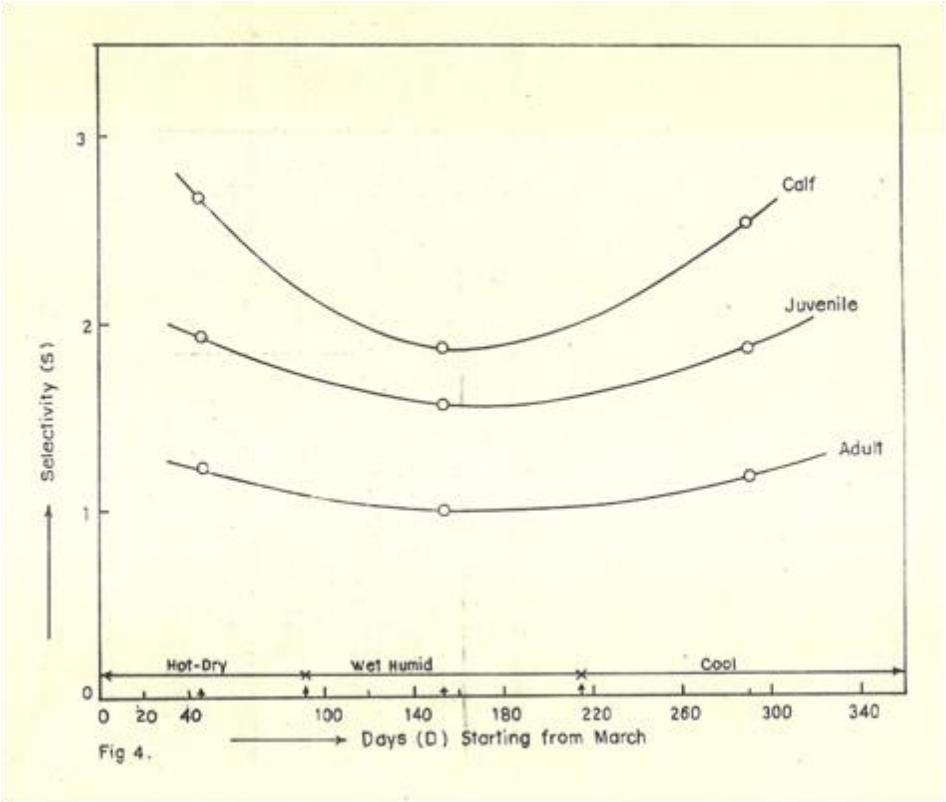


Fig 4.

4.1.3

In the dry season, particularly after burning, acute condition of food shortage reappears there. The shortage of food, water and drying up of wallowing pools at that time forcibly creates a stress on them, the large dominant adult bulls in particular, which leads to develop a territorial behaviour temporarily. Marked territoriality was shown by the dominant adult bulls and breeding pairs who usually stuck to the best areas during the dry months (Bhattacharya and Pal, 1982). A little overlapping home ranges were also noticed among themselves. This observation corresponds with the study done by Mukinya (1973) in case of African Black rhinoceros.

The curves in Fig. 4.1.3. also represent the selectivity (S) which was found to be highest among the calves. S is referred to the ratio of the maximum preference occurring in the adults in the wet-humid season to the preference of that animal of a particular age class in that season. Here the selectivity means that all the preferred plants may not be eaten by any particular age class since some time is involved for selection for the best chosen plants.

If P_{max} is thr maximum food preference for an adult Indian rhinoceros in the wet-humid sdeason and P is the preference by any rhino of any age class in any season then the selectivity of that animal may be defined as:

$$S = \frac{P_{max}}{P} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Indicating that S of the adult rhino in the wet-humid season is evidently a unity. The best fitted equation of S as a function of A, however, arrived at with the data as presented in Table 4.1.2 :

$S = 3.055 – 0.506A + 0.026A^2$ ……. (5) for hot-dry season

$S = 1.960 – 0.105A - 0.021A^2$ ……... (6) for wet-humid season and

$S = 2.846 – 0.435A + 0.018A^2$ …….. (7) for cool season

These are also illustrated graphically in Fig, 4.1.3.

The selectivity for each age class was also computed as a function of seasons (T) with the help of the following equations by adopting the regressive analysis technique from the observed data as presented in Table 4.1.2.

$S = 3.40 – 0.018T + 5.12 \times 10^{-5}T^2$ …… (8) for calves

$S = 2.42 – 0.012T + 4.33 \times 10^{-5}T^2$ …… (9) for immature and

$S = 1.42 – 0.005T + 1.42 \times 10^{-5}T^2$ …… (10) for adults

which have been represented graphically in Fig.4.3.2. The equations show that thedS/dT or the rate of selection becomes 0 and the selectivity were found to be least, i.e., 1.82, 1.59 and 1.01 on 176th, 139th and 125th days for calves, immatures and adults respectively (starting of the year is considered from 1st March). The very nature of the curves in Fig 4.5 shows that within this predicted period of 52 day time (from 125th day to 176th day the National Parks' natural supply of food has a tendency to remain in its peak form resulting a very low selectivity period for the rhinos. Thus due to monsoon the abundance of food supply facilitates greater consumption of biomass making low selectivity value.

Table 4.1.2: *Total variety types of plants eaten or the food preferences (P) in relation to its degree of selectivity (S) by different age classes of rhinoceros in three seasons.*

Age-class	S E A S O N S		
	HOT-DRY	WET-HUMID	COOL
	MAM	JJASO	NDJF
Adult	70(1.23)*	86(1.00)	73(1.18)
Immature	44(1.95)	55(1.57)	46(1.87)
Calf	32(2.69)	46(1.87)	34(2.53)

*The figures in the perentheses indicate selectivity

Table 4.1.3 shows the seasonal percentage of fodder intake in each of four categories of feeding types by all the age classes. For convenience the feeding types were divided into 1) grazing (intake of both tall and short grasses); 2) browsing (taking of foliages, twigs, fruits and seeds) 3) aquatic plant feeding (floating and submerged weeds) and 4) others (intake of sedges, herbs, creepers, shrubs, ferns etc.). The percentage of grazing as shown in Table 4.1.3 was the highest among the calves. The adults were less selective. As for example, the adults

grazed 52% and browsed 18%, while, on the other hand, the calves grazed 70% and browsed 11% only. The percent seasonal intake of other food plants such as herbs, shrubs, creepers and aquatic plants were more or less equal in all age classes. In the wet season the grazing percentage increased in all the age classes, i.e., 61.3%, 68.1% and 72.9% for adults, immatures and calves respectively as presented in Table 4.1.3.

Three or four most preferred fodders for all the age classes in all the seasons have been listed in Table 4.1.3. The figures in the perentheses indicate the frequency found on the slides. However, frequency below 60 were not taken into consideration as the most preferred fodders. Calves preferred to take short grasses like *Cynodon dactylon, Paspallum conjugatum, Digitaria sp. etc.* which are less fibrous in nature. The adults and immatures selected both the short and tall grasses with other types of plants irrespectively containing bhigh and low structural elements. Tall grasses like *Saccharum spontaneum, Arundo donax, Themeda sp.* etc. were the selected fodders taken by the adults while *Narenga porphyrocoma, Panicum sp.* etc. were selected by the immatures. The tough and coarse grasses like *Typha elephantine* and *Hymenachne pseudointerrupta* were usually avoided even by the adults. But it is interesting to note that that the resting and grazing areas were mostly covered by those coarse grasses. A steady and standard frequency of napier grass (*Panicum sp.*) was found in the faecal samples of all the age classes. Recently relative dominance of fodder species have been analysed in Rajiv Gandhi National Park, Assam and there *Saccharum spontaneum* has been found to have highest relative dominance among grass species <1.0 (Hazarika and Saikia, 2012). In an another study Rawat,G.S.(2005) has tried to prove that grasses become less palatable and coarse during dry season hence herbivores including rhinoceros shift their diet and grazing percentage become less in the dry season which corresponds our present study. The changing nature of grasses and poor regeneration of prime fodders, such as, *Saccharum sp.*and *Themeda sp.* may be due to change in moisture content and heavy grazing pressure

It is evidenced that the calves of the horses and bovines require better quality diet than the adults which contain more dietary protein (Hintz *et.al.*,1969; Hatfield,1970). This may be due

Table 4.1.3: *Percentage of different categories of fodders taken by different age-classes in three seasons*

Types of Fodder	Age Classes	S E A S O N S		
		Hot-Dry	Wet-Humid	Cool
		M-A-M	J-J-A-S	O-N-D-J-F
Grazing	A	52.5	61.3	53.5
	I	67.5	68.1	60.0
	C	70.0	72.9	64.5
Browsing	A	28.4	17.8	23.5
	I	12.5	17.6	18.3
	C	14.2	14.5	18.0
Aquatic plant feed.	A	6.0	7.3	7.2
	I	10.0	7.4	7.6
	C	7.2	2.3	5.3
Others (sedge,herb Creeper etc)	A	13.4	14.5	17.2
	I	10.0	7.7	15.3
	C	9.6	11.2	12.2

to an incompletely developed fermentation system and lighter body weight of the offsprings (Hatfield,1970). Body weight is an important factor and inversely varies with the protein per unit weight as the metabolic rate increases only as a function of body weight to the power of 2/3 (Kleiber,1961). For this reason the adult animals can survive better on low quality diet and require less energy and protein per unit body weight than the smaller ones (Jarman,1974 ; Janis,1976). The smaller animals, i.e., calves and immatures, on the other hand, require better quality diet enriched with protein per unit body weight since they remain within their growing periods. In this study we found that that the adult rhinos used to take a wider variety of food plants (Fig.4.1.4 & Table 4.1.2) many of which were consisting of lower protein to higher fibre ratio. The immatures were a bit selective and the selectivity was highest among the calves (Fig.4.1.4 & Table 4.1.2)

As the dietary diversity increases a wider varieties of amino acids are taken by the perissodactyles which is quite important for themselves. The amino acids are absorbed in the small intestine where the bacterial fermentation takes place and the essential amino acid varieties must come either from dietary diversity (Janis,1976) or form coprophagy (Eden,1940). The coprophagy nature is best reported in case of African black rhinoceros (Klingel and Klingel, 1966). The ruminants, however, can maintain their amino acid requirement on a relatively unvaried diet (Loosli, et.al.,1949).

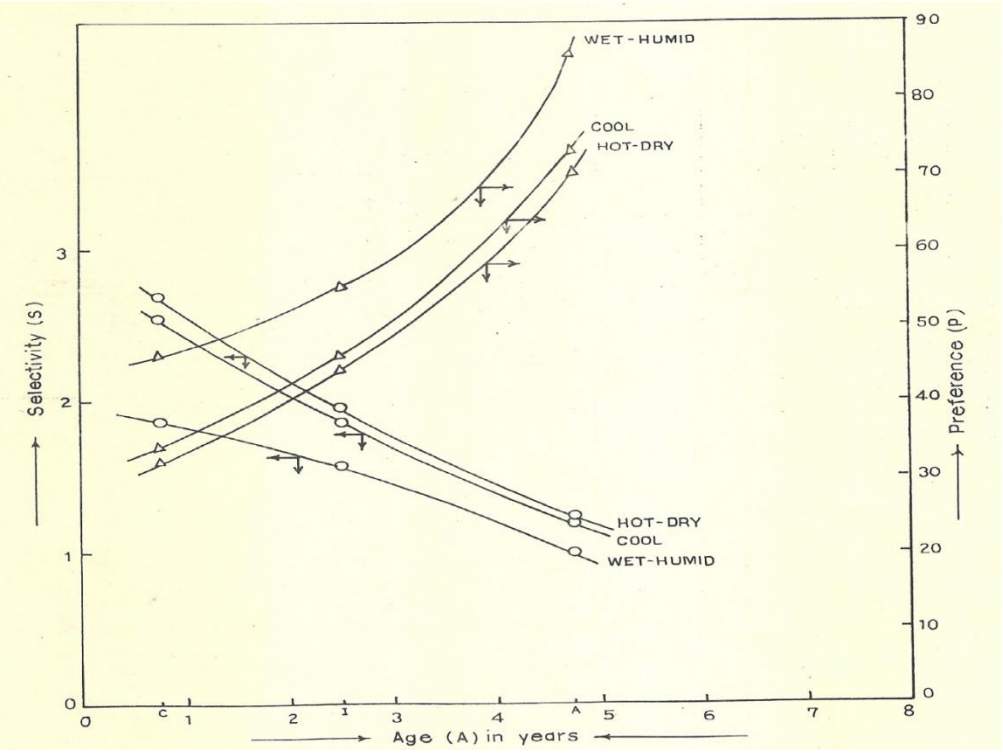


Fig.4.1.4*: A correlation between selectivity and food preference according to season and age class*

The results shown in Table 4.1.3 indicate that the main part of the diet of Indian rhinos are the variety of grasses. The common secondary compounds like alkaloids and pyrethrins are rare in grasses (Janzen,1975), though these compounds are exchanged by a high silica content. The tough fibres in the grasses are difficult to be chewed without suitable dentition. Indian rhinos having the hypsodont type of dentition (Simpson, 1950; Koeningswald, 2011) are used to deal with the silicates and tough fibres found in grasses. It also indicates that the Indian species are primarily grazer while African black rhinos have got the adaptability for browsing primarily, since their upper lips have been transformed into short proboscis like structure for catching the small twigs. Upper lip structure of black rhino is strikingly different from that of the South African species who are flat lipped and have got grazing adaptation.

4.1.4. Management implications:

To have the better general biology and reproduction capacity of Indian rhinoceros the following measures may be adopted:

Formation of glades: A number of glades from large to moderate size according to the density of rhinoceros/km^2 may be made at random inside the clearings of the core areas of the National Parks. These should preferably be made beside the perennial water sources like streams, lakes, ponds, rivulets, bogs, wallowing pools etc. The glades should be planted with preferable fodders of high nutritive value as suggested in this thesis. The glades should be maintained properly and plantations should be done in a rotational way so that the unwanted crisis of nutritious plants are avoided. In the dry months water should be sprayed on the grasses to have a healthy stock of fodder plants.

The above mentioned endeavour has another applicability in dispersing the rhinos as well as the large herbivores from the so called best areas, at least temporarily, where the animals congregate for competition for food, cover and water in the dry season. It may lead to the less conspecific infightings for limited resources in the hot months.

Formation of salt licks: Many more concrete salt licks should be made in the core areas to fulfil the basic demand of mineral salt requirements. Salt licks may be built near side the glades or near the well frequented rhino route, but must be inside the rhino habitat zones. The salt licks are to be provided the mineral salts at a regular intervals.

Yearly burnings: Rotational burnings should be made once or twice in a year. The peak period is from last week of February to first week of April because of dryness. To control the fires in large grassland zones and forest understories, they should be cut into a number of transects. After one burning the next one at the adjacent places may be done after one month to achieve the knee-high, fresh, lush green, soft grasses in the former area. The acute shortage of food can be minimized by this method.

Wallowing mud-pools: Soft, sticky, wallowing mud-pools should be left undisturbed as far as practicable. The sticky, thick film of mud over their body surface after wallowing helps them in heat regulation and also gives them a pleasant sensation.

These mud-pools also are recognised as their resting places. It is desirable to have shady places near the wallowing pools to get rid of scorchy sun.

Table 4.1.4: Most preferable fodders in each age-class in three different seasons

Age-class	HOT-DRY	WET-HUMID	COOL
	March-May	June-September	October-February
Adult	*Saccharum spontaneum(126)**	*Arundo donax (120)*	*Setaria sp.(110)*
	Eleusine indica (94)	*Panicum sp. (86)*	*Polygonium amphibious(80)*
	Panicum sp. (100)	*Phragmites karka (82)*	*Macaranga indica (65)*
	Themeda sp. (82)	*Dalbergia sissoo (75)*	*Themedasp. (64)*
	Panicum sp. (112)	*S.spontaneum (110)*	*A. donax (84)*
Immature	*Axonopus compressus(88)*	*Narenga porphyrocoma(96)*	*Chryspogon aciculatus(79)*
	A.donax (92)	*Nerandina reynaudiana(81)*	*Cyperus siberianus (62)*
	N. porphyrocoma (85)	*Setaria glauca (68)*	*Digitaria complex (64)*
	Cynodon dactylon (112)	*Digitaria granularia (98)*	*C. dactylon (86)*
Calf	*Paspallum conjugatum(108)*	*Panicum sp. (98)*	*Pogonethrum critinum(74)*
	N. porphyrocoma (102)	*E. indica (76)*	*P. conjugatum (70)*
	Imperata cylindrica (9	*C, dactylon (78)*	

*Figures in the perentheses indicate frequencies found on the slides. Frequencies below 60 were not taken into consideration.

4.2. DEFECATION BEHAVIOUR

4.2.1. Introduction:

It is reported that rhinos consume daily about 1% of their body weight, so if, the average weight of an adult rhino be 2000 kg, it must consume almost 20 kg per day for its activities (Houwald,2016) and, at the same time, a considerable amount of undigested part must be defecated away from the body.

A spectacular and an interesting eventful behaviour occurs in rhinoceros that they use some common latrines during the course of their movements in their familiar areas where they inhabit. This animal is of special interest for their defecation and scent marking behaviour

which are also common in some mega herbivores like equids, tapirs, elephants, antelopes and south American camelids (Lucas, E. Fiorelli et. al., 2013).

It is assumed that the sight (Ullrich, 1964), scent (Srivastava, 2015) or both of the previously deposited dung and dung piles stimulate them to defecate. Sometimes the released odour of the fresh dung leads them to move towards those dunging areas following the right tracks and direction. This uncommon behaviour, i.e., the common sharing of the same dung pile with selection of defecation spots is thought to have some deep relations for exhibiting the self-existence to other individuals.

Indian rhino has a tendency to defecate in some selected locations (for some days or even months), and as a result of continuous deposition of dung at the same spots, leads to a heap like structures (Bhattacharya, A., 1994 and Hazarika B.C. & Saikia P.K., 2010). Besides scent marking of territories dung and dung piles are reported to indicate the reproductive state of the individuals also. The displays of bulls during defecation and urination depend on their social rank (Owen-Smith, 1975).

Here, this study was divided in to two phases. The first phase was concentrated on the clustering patterns of dung piles and selection of defecation spots according to their choice which might have some scent marking relationships among the individuals. Besides, some physical parameters like, measurements of dung heaps, wet and dry weight, dry weight of undigested plant materials according to their age classes (Bhattacharya and Chakraborty, 2016) were also studied.

The second phase of the study was mainly concentrated on the sequential and chronological successive depositions (Bhattacharya,1994) done by the individuals to find out if they used any kind of remote sensing technique or if, at all, they were involved in any kind of intimate scent marking relationships.

4.2.2: Methodology:

During the years 1981 and ’82 and latter in 1994-95 an extensive study was undertaken on different aspects of defecation behaviour of Indian rhinoceros at Gorumara (26°40´ N, 89°00´ E) and Jaldapara (25°68´ N, 89°55´ E) National Parks (the then Wildlife Sanctuaries). The repeated use of the same spot for defecation and continuing the process by several individuals for over a month attracted our attention very much. We started keeping records the sequential depositions made by the individuals who could be recognised by their foot prints (Bhattacharya and Acharya,1993). Since little direct observation on defecating posture was

possible and which was a chance factor also, mainly the tracks and other traces (like dung scrapings and foot dragging with dung particles etc.) of rhinos near the dung piles were taken into consideration and were noted. Day, time, month, seasons were also recorded to analyse the seasonal variation. The individual identifications were mostly based on the size and peculiarities of their hind foot prints (Bhattacharya and Acharya, 1993). Those foot prints, which one was whose foot print, that gradually became familiar to us during the previous few months effort. A ready reference of life sized known foot prints were carried together with other instruments. After recording those foot prints, close to the freshly deposited dung, were rubbed off afterwards to avoid repetition. Sometimes, the rhinos present near fresh depositions were considered as the depositions made by those same individuals. All the middens (dung heaps) were recorded on a number of working maps differentiating it into chronological depositions with a citation of date, time, season etc. Frequent visits to different defecation sites, either near the mud pools, or in their grazing areas or at the sides of their routes made us possible to get acquainted with on spot identifications of those places on a map.

At first all kinds of depositions were noted and were classified either as dung piles or single defecations. Dung piles were specifically defined as groups of single defecations attached with one another end to end or overlapped considerably, or the single defecations not more than 5 meters away from one another at their nearest ends. Latter on those gaps might have a chance to be filled up by a number of single defecations. Besides this, the measurement and weight of the dung balls were also taken into account as the identifying characters of the different age classes. However, individual identifications were not possible by measuring the dung balls. The freshness and the number of depositions were noted just to find out how many weeks or months were taken actually to form a complete midden. The number of dung balls per deposition and the total weight of single fresh depositions were also recorded to find out the gross assimilation efficiency (Section in this article). The dry weight of each 50 gm dung sample of twenty different single defecations /dung piles were measured to examine the actual content exhaled from the body. Each defecation spot was marked, numbered and labelled with twigs and photographs were taken by an Ashahi Pentax ME camera (lens 1:1.4) for further analysis while away from the field.

Almost simultaneously we started working on the successive depositions made by the different depositors possibly who were supposed to be close mates in most of the cases. It also proved to be very useful in estimation of the actual home ranges (Bhattacharya and

Pal,1982) and habitat use pattern enjoyed by them. For convenience we used to visit some selected rhino dunging areas on each day in the vicinity of our camp to see any further fresh deposition added during last 24 hours. We could easily identify the age classes by examining the size of the dung balls whether adult, calf or of intermediate age classes.

4.2.3: Results and Discussions

4.2.3.1: Clustering patterns and locations

Altogether 276 depositions were recorded in the study areas in three years duration (from August, 1980 to July, 1983) to know about the cluster patterns as well the locations of defecations. The recorded defecations were either single or in the form of dung piles (Table 4.2.1). The large dung piles were found to be located beside well frequented rhino routes both at Gorumara and Jaldapara (Table4.2.2). The further analysis reveals that the rhinos tended to defecate more at dung piles than on new spots. Ullrich (1964) reported that sights of dung piles stimulate them to defecate. Odour of the dung piles is also one of the principal cause to provoke other rhinos to defecate on or near the spots (Srivastava, 2015). Single defecation sites were mostly developed into dung piles if they were deposited on or beside well frequented rhino routes. Single defecation sites comprised of only 17% (Table4.2.1), while, on the other hand, the cluster occurrence of deposits comprising of two and three defecations were more than 50% of all the defecations recorded. Very large and scattered dung piles consisting of seven or eight defecations were rarely seen during that period. It might be due to the low population densities in those areas. Approximately 2/3rd of the single defecations were deposited on or beside less frequented rhino routes where they visited occasionally. However, very large dung piles were frequently observed latter on at Kaziranga because of higher rhino density/km2 over there.

Table 4.2.1: Single or cluster occurrence of depositions in the study areas (sample size = 276)

Single/cluster of dungs	*Occurrence*	*Percent of occurrence*
1 single	47	17.0
2 cluster	80	28.9
3 cluster	74	26.8
4 cluster	43	15.6
5 cluster	21	7.6
6 cluster	7	2.5
7 cluster	2	0.7
8 cluster	2	0.7

The successive depositions on the dung piles varied according to the frequency of visits to those areas made by the rhinos. Many sites consisting of single and double defecations left unused for several months but had been observed to be of use again when some rhinos moved into those areas in search of food and water. So the clustering patterns of defecations largely depended on the availability of food, water and mud pools whose existences were variable throughout the season. In April and May (peak dry, hot season), 1982 at Gorumara, 34 dung heaps (among 60 dung heaps) comprising of 3, 4 and 5 defecations were found to be concentrated near the marshes, narrow streams, water and mud pools. Many of those piles were newly formed. At Gorumara and Jaldapara, the unburnt areas of grassland in October-November, 1981-1982 and 1982-1983, rarely had fresh depositions added to the dung piles. But in the following seasons, i.e., after 3-4 months, most of the old dung piles began to be added again by fresh depositions. Some were newly created during or just after the period of burning and re-growth of grasses. Burnings were usually followed by the rains and thunderstorms which simultaneously added nutrients to the soil in the form of burnt ash for facilitating re-growth of young green succulent grasses. This biological change of fodder drew attraction to the rhinos of all age and sex classes.

It is obvious from the above observations that during hot months rhinos had a tendency to concentrate in those temporary best areas making overlapping home ranges (Bhattacharya and Pal,1982). The dominant ones often engaged themselves in intra and inter specific battle for keeping supremacy over those best comfortable areas, having watery mud pools, which underwent gradual shrinkage both in volume and area. These all behaviours led them to defecate more frequently in those, so called, “best areas”.

Rhinos tended to select particular spots to defecate either in presence or in the absence of dung piles. The locations are shown in Table4.2.2. Dung piles were concentrated mostly on or beside the main rhino routes. A considerable number of defecations were found at the ecotonal zones like, at the junction between grassland and woody mixed forest; and at the base of the tree trunks (Table 4.2.2).

Table 4.2.2: Details of the locations of the dung piles (Sample size:276)

Locations	Preferred places	Occurrence	% of occurrence
A.On or close to the main tracks	1.Deposited on or beside rhino path	128	46.4
	2. Beside water pool and marshes	65	23.6
	3. At the base of the tree trunks	31	11.2
	4. On small herbs dry litters and grasses(under open sky)	7	2.5
	5. On small grass/dry and wet litters(under canopy)	5	1.8
	6. On coarse gravels (under open sky)	2	0.7
		238	86.2
B.Away from main tracks	1.On clear soil, sand, grass in grassland	38	13.8
TOTAL		276	100.0

Buechner et.al., (1975) reported that a captive male Indian rhino had a tendency to squirt urinate at the junction of his shade and outer enclosure. Sumatran rhinos had a preference for depositing their faeces on main tracks or close to the streams (Borner, 1979) which is similar to the present observation. For convenience, the locations were divided into two major divisions, i) On or close to the main tracks and ii) away from the main tracks. Dung piles deposited away from the main tracks were found to be comprised of only 13.8% among all the defecations (Fig. 4.2.1). It has been reported by certain workers that in captive conditions rhinos preferred to defecate on certain locations (Skafte, 1961).

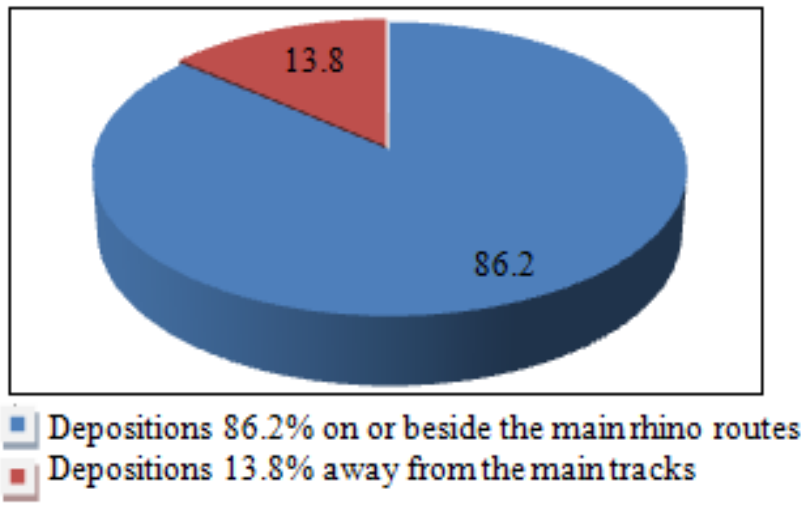


Fig.4.2.1: Locations of defecations

4.2.3.2: Physical Characteristics of dung

Altogether 36 single defecations and 21 dung piles were taken into consideration to have a knowledge on the dunging area, its height, no of droppings taken to form a dung pile, and the span of period of its formation (Table 4.2.3). However, it was difficult to know about the dropping numbers and the duration of formation for the deserted as well as the disintegrated dung piles since the entire dung piles became brittle and individual droppings became intermingled with one another. These were all found in an area of 3 km^2 at Gorumara consisting of tall grasses, ecotones, short and medium grasses, sal and mixed forest. The result reveals that a complete dung pile occupied nearly 255 cm in diameter and 55 cm in height in average which were much more wider and higher than those of the deserted dung piles, i.e., 170 cm in diameter and 30 cm in height. The dung piles varied in the degree of piling up and some were scattered over a wide area. In those cases dung scrapings might be the cause of scattering. The maximum height of one dung pile recorded was 70 cm but many piles were under 40 cm at their highest peaks. A dung pile, usually, took about 55 days to give its complete shape and on average took 7 droppings to build up before using another defecation spot elsewhere (Table 4.2.3a). A fresh single defecation occupied 55cm in diameter and 16 cm in height, whereas, old lone defecation took only 45 cm and 13 cm in diameter and height respectively (Table 4.2.3b).

Table 4.2.3a: *Physical characteristics of defecation and span of formation of dung pile*.

Types of dung pile	No.of samples	Diameter (in cm.)	Height (in cm)	No.of droppings taken	Span of use (days)
Complete dung pile	21	295.3	54.6	7	55
Deserted dung pile (going to be disintegrated)	16	170.0	26.0	?	?

In general the fresh defecations had a range of greenish black to deep greenish brown in colour. The texture seemed to have more or less spongy and moist. As the fresh defecations grew older the texture would become soft and brittle, dry and the colour gradually turned into

straw colour. In many cases the size of the dung balls appeared to remain same, at least externally, for up to four months. Then gradually the dung balls broke up into pieces and ultimately the entire dung turned into a brittle fibrous mass which finally disintegrated.

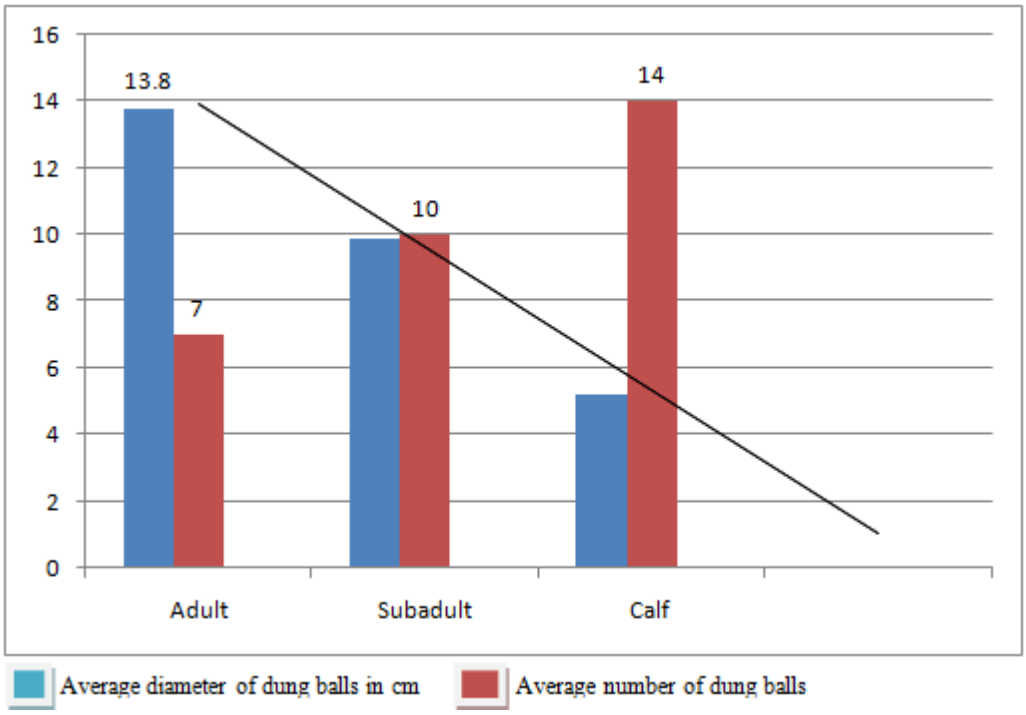
Table 4.2.3b: Physical characteristics of a single defecation

Type of dung (adult)	No. of samples	Diameter (in cm)	Height (in cm)	Texture	Colour
Fresh	58	55	20	spongy & moist	greenish black to deep greenish brown
Old	35	45	13	soft, brittle and dry	straw coloured

The Indian Rhino is categorized under 'bulk and roughage feeder' as it has the capacity of extensive lower tract fermentation and with its typical setting of teeth pattern, mouth anatomy and volume of intake (Lahan et.al.,1993). With additional rumen/reticulum volume of 53% and 22% more than other ruminants, it requires a microbial synthesis of food intake for almost 20 hours and a caecum digestion for around 3 hours. Thatswhy, a fresh adult dung does not look like a ruminant dung but contains fibrous material from digested leaves, grasses, remains of reeds, small branches and twigs of maximum up to 5 cm in length which gave the dung its typical rough texture and appearance. The dung of adult Sumatran rhinos appeared to be coarser than those of the immature (Hubback,1939). . The Indian Rhino is basically a grazer, the short grassland being its prominent food habitat. Due to adverse shrinking in habitat, the animal is forced to take a considerable amount of browse material (Lahan et.al.,1993)

The dung of adult, sub adult and calf consisted the diameter of the dung balls of 13.8 cm (±1.1 cm), 9.9 cm (±0.6 cm) and 5.2 cm (±0.5 cm) respectively (sketch.2). The adult animals deposited 5 to 10 dung balls at a time and the calves deposited as many as 14 dung balls on average at a time (Fig.4.2.2).

Fig.4.2.2: Bar diagram showing a correlation between diameter and number of dung balls in different age classes.



The range of the number of dung balls noted was 5-10, 9-12 and 12-16 respectively. It is to be concluded that the dung balls varied inversely with the age of the rhinos, i.e.

NDB α 1/a

Where 'NDB' is number of dung balls and 'a' is the age. Sex found to have no effect on the number and size of the dung balls

4.2.3.3: Weight analysis, dry weight and moisture content of dung:

Seventy eight fresh single droppings were considered for weight analysis in that study period. The average weight of a single defecation in a bout by adults, sub adults and calves were 10.953 kg, 4.946 kg and 1.689 kg respectively (Table 4.2.4). The dry weight and the weight of dry undigested part From 50 gm dung samples of each of 20 individuals' defecations for all the age classes were measured in the laboratory in 1981-1982. All the fresh dung samples were collected from Gorumara and they were kept in airtight polythene packets so that the moisture content would remain intact. Afterwards 50 gm dung samples were transferred in to

Table 4.2.4: Weight analysis of 78 fresh single defecations according to age class

Age Class	Sample Size	Average wt. of total single Defecation
Adult	40	10.953 kg
Sub adult	20	4.946 kg
Calf	18	1.689 kg

the packets made up of blotting paper for each age class. The packets were labelled with proper age class, time and place. Then all the blotting paper packets were kept inside a hot oven at a fixed temperature of 39 ^{0}C and left in the oven for 48 hrs. After proper drying the packets were taken out and the dry weights of the dung samples were measured. After that the dry materials were meshed in a 2 mm perforated mesh and the materials remained left on the mesh were considered as the dry undigested part. The Table 4.2.5 shows that the dry weight from each 50 gm dung sample for adult, sub adult and calf comprises 19.3%, 18.7% and 17.6% respectively; on the other hand, the moisture content comprises 80.7%, 81.3% and 82.32% respectively. A gentle gradual decrease of moisture content is observed as the age increases. The above data correspond with that of the general appearance of dung where the usual texture of the dung balls of the calves are comparatively smoother due to absence of coarse and larger undigested particles.

4.2.3.4: Measurement of dry weight, dry weight of undigested part and moisture content of 50 gm fresh dung sample of each age class

Out of seventy eight fresh single droppings the average wet weight of a single defecation in a bout by adults, sub adults and calves were 10.953 kg, 4.946 kg and 1.689 kg respectively (Table 4.2.4). The dry weight and the weight of dry undigested part showing the gradual decrease of weight in dry undigested part from adult to calf is also taken into account which has been shown in Table 4.2.5. The average dry undigested part is 7.14 gm (14.3%, approx.), 6.5 gm (13.0%) and 5.79 gm (11.6%) from each 50 gm dung sample for adult, sub adult and calf respectively.

Table 4.2.5: Measurement of dry weight, dry weight of undigested part and moisture content from 50 gm fresh dung sample for each age class (Sample no. 20 from each age class).

ADULT		SUB ADULT		CALF	
Dry weight in gm	Dry undigested part in gm	Dry weight in gm	Dry undigested part in gm	Dry weight in gm	Dry undigested in gm
$\Sigma X = 193.3$ $\bar{X} = 9.7$ $\bar{X}\% = 19.3$	$\Sigma Y = 142.8$ $\bar{Y} = 7.14$ $\bar{Y}\% = 14.28$	$\Sigma X = 186.9$ $\bar{X} = 9.34$ $\bar{X}\% = 18.69$	$\Sigma Y = 131.0$ $\bar{Y} = 6.5$ $\bar{Y}\% = 13.0$	$\Sigma X = 176.2$ $\bar{X} = 8.81$ $\bar{X}\% = 17.62$	$\Sigma Y = 115.8$ $\bar{Y} = 5.79$ $\bar{Y}\% = 11.6$
$\bar{X} - \bar{Y} = 2.525$ gm		$\bar{X} - \bar{Y} = 2.84$ gm		$\bar{X} - \bar{Y} = 3.02$ gm	
Moisture content		Moisture content		Moisture content	
$C - \bar{X} = 40.33$ gm i.e., $50 - 9.7 = 40.33$ gm $(C - \bar{X})\% = 80.7\%$		$C - \bar{X} = 40.65$ gm i.e., $50 - 9.34 = 40.65$ gm $(C - \bar{X})\% = 81.31\%$		$C - \bar{X} = 41.19$ gm i.e., $50 - 8.81 = 41.19$ gm $(C - \bar{X})\% = 82.32\%$	

The above results reveal that the adults can consume all kinds of grasses irrespective of their nutrient contents. For this reason the appearance of their dung is rough textured; on the other hand, the calves were highly selective in taking their fodders (Bhattacharya, 1993). The calves took mostly soft tip portions of lush green grasses or juicy food plants of higher nutrient contents. The food selection of sub adults (not reached to reproductive state) lie in between these two age classes and they are not such selective as the calves do. It was observed that the milking calves sometimes used to take coarse grasses just to imitate their accompanied mothers, but in quick succession they used to reject those coarse grasses and started searching for softer ones.

4.2.3.5: Associated Pre and Post Defecating Behaviours:

4.2.3.5.1: Change of tracks: Analysis of the trails revealed that in most cases rhinos just stopped on their path and dropped dung. Usually the rhinos stopped near the old dung or dung piles and defecated either close to the previous one or a few metres away or over the old dung/dung piles. In five occasions at Gorumara and four occasions at Jaldapara changing of tracks for defecation were noticed mostly by the adults (Table 5.2.6). Probably they might be influenced by the scent of previously deposited dung piles lying on widely separated parallel tracks.

Table 5.2.6: Some associated Pre and Post Defecating behaviours exhibited by rhinos in two National Parks (Bhattacharya,1994).

Associated behaviours	Gorumara	Jaldapara
Change of tracks for defecation	A♀ (GF02)-1 A♀ (GF03)-2 A♂ (JB02)-2	A♂ (JB01)-1 A♀ (JF03)-1 Imm. (NS)-2
Earth scrapping over own dung	A♂ (GB01)-4	A?-4 Imm.♂(JJM02)-2
Dung Scrappig	A♂ (GB02)-3 A♀ (GF01)-1 C (GC01)-1 Imm. (NS)-1	A♂ (JB02)-2 A♀ (JF03)-1 Imm. (NS)-1
Foot dragging	A♂ (GB01)-2 Imm.♀ (GJF02)-2	A (NS) - 3
Coprophagy	Nil	Probably by an immature

NS = Non sexed, Imm. = Immature, GF = Gorumara Female, GB = Gorumara Bull, GC = Gorumara calf. GJF = Gorumara Juvenile Female, JF = Jaldapara Female, JB = Jaldapara Bull, JJM = Jaldapara Juvenile Male.

4.2.3.5.2: Earth scrapping over the own dung: Rhinos normally walked off immediately after defecation. But on eight occasions, two adults, one at Gorumara (the largest and oldest bull, GB01) and another at Jaldapara; and in two cases one known immature male at Jaldapara left the mark of scrapping the earth backwards over their own dung by both the hind feet alternately (Table 4.2.6). With those scrapping, the earth usually covered their droppings partially. In case of the largest bull (GB01) at Gorumara it was observed that this earth scrapping behaviour developed at the onset of the dry season only after a fight with his close rival GB02 for occupying the best area for water, cover and green grass. In that fight the former (GB01) was the loser. It might be a fact that the particular bull tried to hide the odour emitted from his freshly deposited dung as well as hiding himself from that of his dominant rival. Although the Indian rhinos have pedal scent gland, the dusting over their dung might have partial success for hiding themselves. Part of their dung balls were damaged with those scrapings. Mud and leaves were cast off about one and half metre away behind the dung piles.

4.2.3.5.3: Dung scrapping: An opposite dung scrapping behaviour was also noticed from the signs left by them. In both the National Parks two dominant adult bulls, GB02 and JB02 were mainly the dung scrappers (Table 4.2.6). It was probably meant to exhibit themselves to their close rivals and subordinates. One mother and her calf were evidenced to scrap their own dung at Gorumara due to some unknown reason, possibly the calf imitated its mother

Dung scrapping behaviour is somewhat rare in Javan (Hoogerwerf,1970) and Sumatran (Borner,1979) rhinoceros. It was, however, reported that though dung scrapping behaviour is rare in Greater one horned rhinoceros at Royal Chitawan National Park in Nepal, all the age and sex classes were involved in dung scrapping (Laurie,1978). This behaviour is known to be frequent in African black (Klingel and Klingel,1966) and white rhinoceros (Sperka,2013).

4.2.3.5.4: Foot dragging: The foot dragging marks made after defecation is also an important behaviour to be mentioned here. In both the National Parks, two adults and two immature were involved in foot dragging behaviour after defecation. The oldest bull (GB01) of Gorumara left the mark of foot dragging on two occasions. In both the cases small fresh dung fragments were found up to a certain distance along the foot dragging marks (Table 4.2.6). The probable cause of foot dragging might be due to the fact that, the bull was trying to clean his dung laden feet just to get rid of the releasing odour from his hind feet because he was trying to avoid his close rival GB02 after losing a battle few days back (Bhattacharya,1994). In other cases foot dragging marks were devoid of dung fragments. Why the immature drag their feet for any reason requires further investigation. Male white rhinos are often seen dragging their feet after defecation. Usually they do it to mark their territory either by destroying plants or by dragging feet (White rhino facts,2018).

4.2.3.5.5: Coprophagy: The coprophagy nature is found to be very insignificant in Indian rhinos but it s best reported in African black rhinoceros (Klingel and Klingel,1966). During the two years of our study at Gorumara no case of coprophagy was noticed. At Jaldapara, it was done probably by an immature since the foot impressions of that individual were distorted owing to muddy soil and it was difficult to prove its exact recognition, but, the overall size, at a glance, was favourable for its inclusion in the younger age class. This behaviour was confirmed since no signs of adding fresh defecation and other post defecating behaviours like, earth scrapping, dung scrapping, foot dragging etc. left there and the dung fragments remained scattered close by. The rhinoceros may be stimulated for this kind of behaviour due to shortage of minerals in their body.

4.2.3.6: Sequential depositions by different individuals and scent marking relationship: Judging from the varying diameters of dung balls of different defecations in one midden (dung pile) it was clear that the dung piles were not made by a single animal or by the animals of a particular age class, but by different individuals of different age groups. Of the

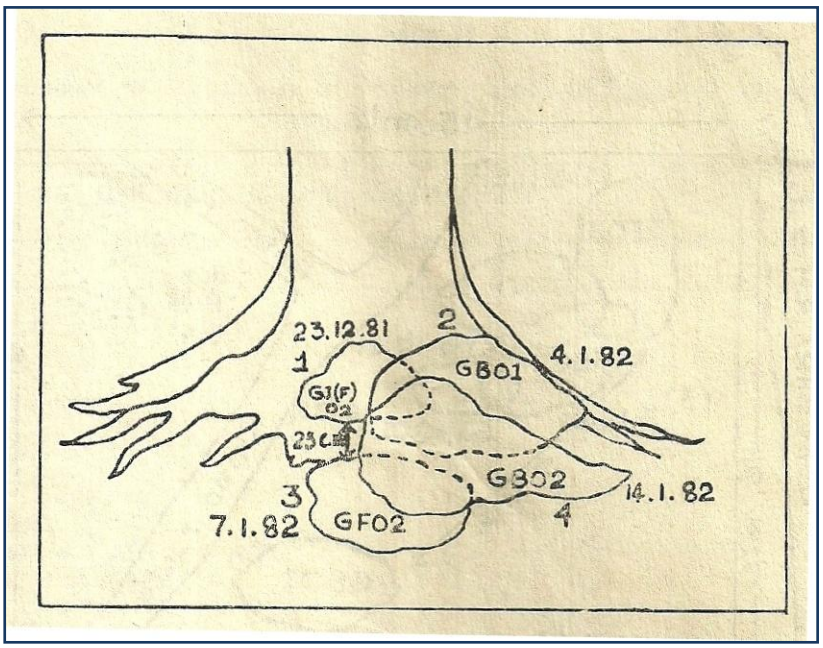
Table 4.2.7: Sequence of depositions by different individuals forming dung piles (Sample size = 104) [Bhattacharya,1994]

SEQUENCE OF DEPOSITIONS BY INDIVIDUALS							
Number of dung piles							
1	2	3	4	5	6	7	
A♀ ← A♂							40
A♂ ← A♀							19
A♀ ← A♂	← A♀	← A					12
A♀ ← A♂	← I♀	♂					11
I♀ ← I♀					← I♂		
							7
M-C ← M-C	← M-C						
						5	
A♂				← I♂	← A♀		
							3
I♀				← A♂	← A♀	← A♂	
						(fig.5.2.3)	2
I♀				← A♀	← A♂	← I♀	
2 A♂	← A♀	← I♀			← I♂		
						2	
A♀	← A♂	← A♀	← A♀	← A♂	← A♀	← I♂ (Fig.5.2.4)	1

104 dung piles at Gorumara, track and footprint analysis clearly indicated that in 40 cases two breeding pairs used to defecate in different parts of the park in October- November-December, where cows were the first defecators. In 19 cases the bulls first defecated and latter the cows defecated over the dung of the bulls. In five occasions, one mother-calf

association was seen to defecate over their own dung (Table: 4.2.7). Fig. 4.2.3 and Fig. 5.2.4show the duration and sequential formation of dung piles by individuals known by their footprints. Dung piles were used by Indian rhinos of all age and sex classes at Chitawan National Park, Nepal (Laurie, 1978) and similar findings have been reported in case of white rhinos where the dung piles appeared to have a territorial marking function (Owen-Smith,1971).

Fig. 4.2.3: A sketch done on the work book during field study at Gorumara showing the sequential depositions of known individuals over the base of the buttress of a shimul (*Bombax ceiba)* tree



4.2.3.7: Pedal scent gland: The rhinos followed each other by sniffing along the tracks, since pedal scent gland occur in them. Pedal scent glands, common in Artiodactyla, are shown to be confined to the genus Rhinoceros among Perissodactyla (Cave,2009). It is likely that olfactory signals include odours left on the trails from those glands in addition to those of urine and dung. The pedal scent gland in rhinoceros may have been evolved because of the scent of dung on the feet quickly disappears in a wet environment. So, there may have been a selection pressure for scent marking by evolving the pedal scent gland as an alternative form. It was proved to be an easier way to locate and communicate with the fellow individuals despite living a solitary nature. The Sumatran (Strickland,1967) and Javan (Sody,1959) rhinos are also reported to communicate among themselves with this method.

4.2.3.8: Scent marking behaviour: Great one horned rhinos have the habit to maintain, in males particular, somewhat loosely defined territories and in doing so, they take the help of their own defecated dung or spraying urine. They are frequently seen dung scrapping, foot

dragging, earth scrapping over their own dung etc. and each of these kind of behaviours has its specific meaning. Obviously, when any rhino scrap earth over its own freshly deposited dung, that does mean that he or she wants to conceal himself/herself from the nearest rival. On the contrary, dung scrapping behaviour is a type of exhibition of the presence of an individual, so that the scent of dung is sprayed in the air, thereby, exhibiting the vigour of the dung scrapper. The foot dragging behaviour is also associated with the getting rid of dung which are sticked to their hind feet while kicking dung backwards after defecation adds scent to their path.

Comparatively, females are less territorial and can accommodate other rhinos irrespective of age and sex in their areas, or in other words, they often have overlapping territories which they frequently change with the change of season and that also depends on the availability of food and water. Females, particularly in oestrous condition, are also equally capable to communicate with the males and they are also to send signals by spraying urine or by

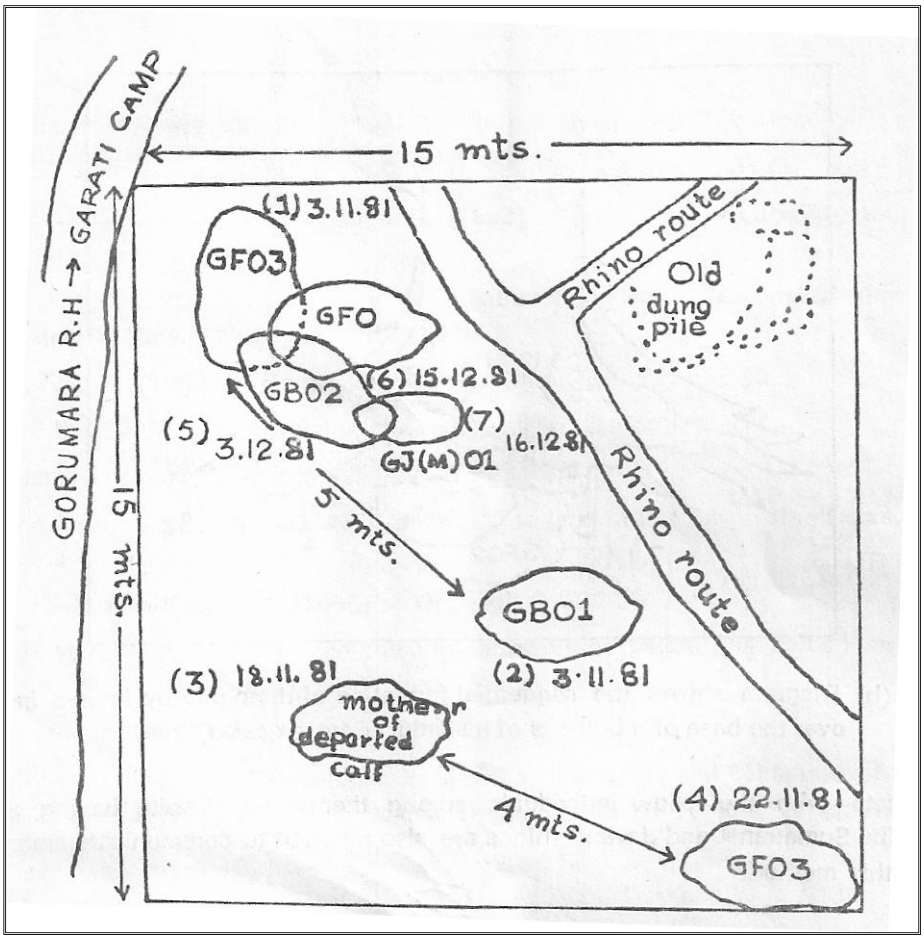


Fig. 4.2.4: Another sketch during field study showing the sequential depositions made by rhinos of different age and sex classes beside well frequented rhino route at Gorumara.

scrapping dung or by dragging feet so that the fellow individuals can feel their presence. Though they possess pedal scent gland under their feet, but in wet environment that become less effective and they rely more on their urination and dung deposition.

Actually the dung piles are the centres of one kind of information passing centres. If someone thinks that the rhinos are just scrapping and kicking its own dung around he or she is mistaken, rather, the rhinos, particularly the adult bulls, are adding important information to the dung heap. The adult white rhino bulls often show dominance by dung scrapping photo 4.2.1(Sperka,2013). In case of South African white rhino Sperka(2013) wrote his observation-

"Females in the area by will leave their droppings, but they will not scrape. They leave a scent message for the dominant bull in case they are ready to mate. If that is the case he will pick up the info at his next visit and look for the lady. Any young bull pathing through the territory will also leave his message (a distance away from the big guys' stuff) without scraping to tell the dominant bull that he does not want to challenge him. If another bull puts his dung on top or near the dominant bull's droppings and scrapes them around then he declares his intention to challenge the territory holder. As soon as they meet they will fight!

So, if you see dung in the bush, it is not always just waste"

Photo 4.2.1: *A white rhino bull is scrapping and kicking its dung (Courtesy: Christian Sperka,2013) and* **Photo 4.2.2:** *An Indian rhino is in the action of dung scrapping (Courtesy: Rhino Facts, 2017).*

Apart from strong odour of fresh dung the Indian rhinos are able to smell the remote faint ones since they have a very high power of sensing smell rather than vision. Often the males are observed walking with their heads to the ground as if sniffing, presumably following the scent of females (Dinerstein,2003).

4.3. GROSS ASSIMILLATION EFFICIENCY

The amount of food consumption and amount of voiding dung in 24 hrs. is a measuring index of smooth maintenance of general physiology of animals. Though it is quite manageable in zoos but it proves to be tough measuring in the wild, where the animals are living in a vast stretch of grassland or in a mixed forest. It is a time consuming process and is also associated with a lot of risk while making a close observation. So some indirect methods are applied which has already been discussed in section 4.2.1. and 4.2.2.

A lot of these type of works have been undertaken on elephants (Rees,2008), herbivorous lizards and non-ruminants (Karasov et.al.,1986), damsel fishes (Cleveland, 2003) etc. and all the authors have given stress on the amount of nutrients absorbed by the animals. Net growth efficiency is negatively correlated with assimilation efficiency and may range from 20% to 90%. It is calculated that gross growth efficiencies normally fluctuate between 15% to 35% and demonstrate a nonlinear correlation with assimilation efficiency (Welch,1968). Carnivores, in general, tend to have high assimilation efficiencies and low net growth efficiencies, while the herbivores have lower assimilation efficiencies and higher net growth efficiencies (Welch,1968). The large herbivores like rhinoceros fall in the latter category. Winberg (1956) has brought together much of what is known about the bioenergetics and growth of animals. The energy budget of an animal may be represented (Winberg, 1956 and Richman, 1958) as below:

$I = G + R + E$ ..... (1)

Where I = Ingestion, G = Growth, R = Respiration and E = Egestion

Further: $A = G + R$ = Assimilation and A/I = Assimilation efficiency..... (2)

G/I = Gross Growth Efficiency ..... (3)

(K_1 of Ivlev,1939)

and

G/A = Net Growth Efficiency .....(4)

In continuation of our earlier works the second phase of the study includes the gross assimilation efficiency by the rhinos in different areas of the National Parks, namely Gorumara and Jaldapara and a distinct regional variation in the gross assimilation was recorded. The rhinos permanently inhabiting the Malangi, Sissamara, Jaldapara 3 and Torsa blocks of Jaldapara National Park had shown higher rate of efficiency than the other

surrounding blocks like Bengdaki, Hollong, Dhaidhaighat, Bardabri and new CC Lines. The former blocks consist of a stretch of high quality grasslands and the estimated average of daily consumption by adults confined within 18.5 kg. The quality fodders in those blocks could fulfil their hunger by providing sufficient energy to them. Although a considerable amount of roughage fodders were also a part of their diet in those blocks and the total ingested fodders underwent a long retention and bacterial fermentation processes as by the law of large ceacum animals' digestive mechanism. The amount of average weight of defecation per adult per day was estimated 10.446 kg, which means that the rate of gross assimilation amounted to be 18.5 – 10.446 = 8.054 kg which they managed to burnt daily through various activities. On the other hand, the blocks containing a bulk of low quality vegetations, the daily consumption most often exceeded 19.5 kg and sometimes reached 20 kg and estimated defecation per day per adult was recorded 10.953 kg., that does mean that 20-10.953 = 9.047 kg assimilation proved to be equivalent or might be to some extent less than 8.054 kg in terms of energy input. The Juveniles and calves were not considered for this study. It is also to be taken into consideration that most of the adult rhinos were not the permanent residents of the best areas. Many of them had wider home ranges during their daily activity cycles. Only one or two dominant adult bulls and three adult cows remained constantly in the best blocks.

The same situation happened at Gorumara. The rhinos inhabiting Dhupjhora, Jaldhaka and a small part of South Indong blocks are considered to be best habitat zones for rhinos. And the gross assimilation recorded there was 8 kg ± 0.235kg. Whereas the other 8 blocks consisting of 24 compartments are considered to be very poor in respect of the rhino habitat zone. Not a single rhino was a permanent resident over those blocks. Not much data could be possible to collect from those blocks and compartments for statistical analysis.

Our findings were latter compared with the resident rhinos of Kolkata zoo. As per verbal communication with the rhino caretakers they reported that they allowed to take them nutritious fodder consisting of green grass, hay, some leaves amounting maximum up to 18 kg per day per adult which corresponds to our study. Defecations per day per adult were also calculated during 36 to 48 hours duration after assimilation and was estimated to be 10.02 kg ± 0.3 kg. So the assimilation was calculated to be 18.0 kg – 10.02 kg = 8 kg (approx.).

Table 4.3.1*Gross Assimilation Efficiency at Jaldapa*

Ingestion	grassland	18.5 kg
Egestion	grassland	10.446 kg
Assimilation effic.		8.054 kg
Ingestion	in other areas	20 kg (aprx.
Egestion	In other areas	10.953 kg
Assimilation Effic.		9.047 kg
	Gross assimilation efficiency in Zoo	8.0 kg(apx

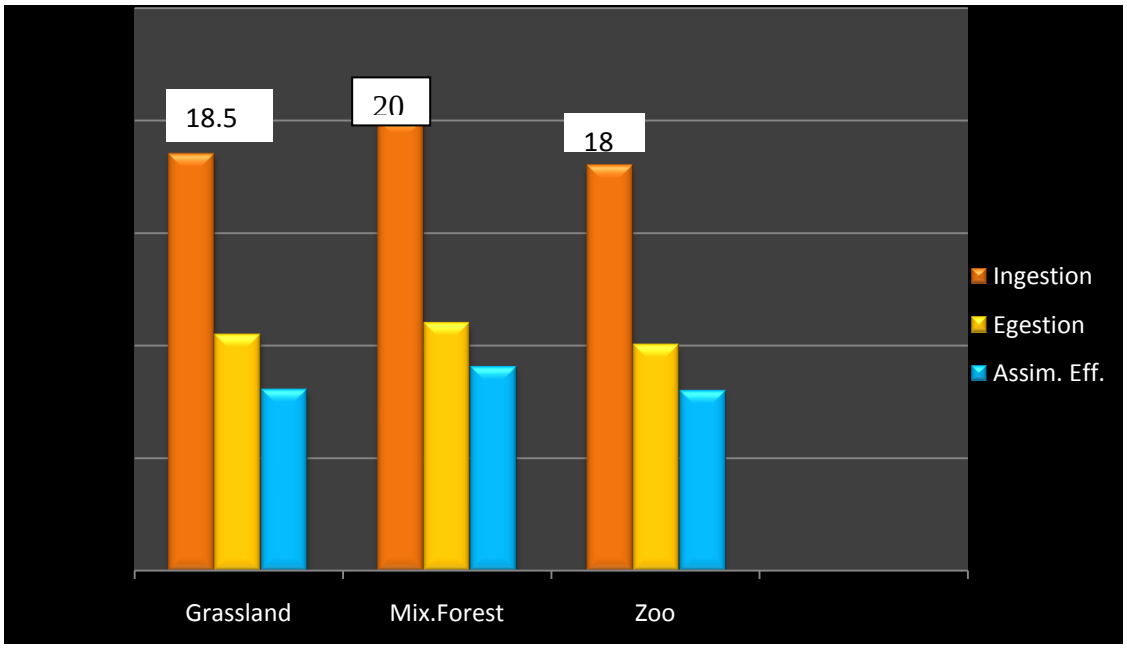


Fig.4.3.1: *Gross assimilation efficiency at Jaldapara corresponded with zoo.*

Now the point is that the rhinos are to ingest more (in this case 1.5 kg approx.) in the areas other than grasslands to fulfil their nutritional requirements, on the other hand, the nutritious grasslands provide them more nutrients with less consumption. This 1.5 kg difference per day is, presumably equivalent to the nutritional requirement compensation per day (Table 4.3.1)

Regarding egestion or defecation the average difference is nearly 500 gms per day in two habitats (10.953 kg – 10.446 kg = 0.507 kg). More fibrous materials are seen in their dung in the mixed forests or the habitats which are not very desirable to them.

The gross assimilation is slightly higher (approximately 1 kg per day per adult) in the habitats other than grassland (9.047 kg – 8.054 kg = 0.993 kg), but, since very few adult rhinos were the permanent residents in those areas it proved difficult to collect sufficient data. Many of the subordinate adults could manage to stay in the fringe areas adjacent to grasslands or ecotonal zones, where they fed on grasses but used to move through the mixed forest zones bordering the grasslands.

The daily intake of southern species of white rhino has been estimated 35 kg (Anonymous 2009), which means if a white rhino bull weighs 2400 kg (average) it consumes 1.45% of its body weight. It seems to be much high in comparison to Indian bull rhino. The consumption depends entirely on the metabolic activity, growth rate, quality of fodder and so on. The data from different sources (Silberman and Fulton,2016) reveals that a new born calf of Indian rhino weighs only 55-60 kg, but within six weeks the calf attains up to 158 kg, i.e., per day increase of weight is 3.4 kg (approx) ! So during growing period the metabolic activity remains too high and until attaining full maturity (6-7 years for cow and 7-9 years for bull) the food consumption level, whatever it is, gets absorbed its most part and helps to grow the animal. After attaining full maturity the food consumption becomes lower and roughage fodder gets included in their diet but during young stages nutritious fodder is required to keep up the assimilation efficiency high.

As the percentage of dry undigested part found in dung is lowest in calf and highest in adult (section 4.2.3.3) it is obvious that assimilation efficiency is highest in calf and lowest in adult. The assimilation must be high in young ages because the growth is an important factor associated with the assimilation in the individuals. When the individuals attain full maturity, i.e., no growth occurs, the assimilation or absorption of nutrients are only necessary to maintain the metabolic activities and daily normal functions of the huge body. So the adults are able to survive on roughage fodders, no extra nutrient for growth is needed.

If an Indian male rhino weighs 2000 kg and consumes 20 kg (approx) per day, i.e., 1% of its body weight and a new born weighs 55 kg it does not mean that it will consume only 0.5 kg per day. As the growth is concerned it may need either 2 to 3% consumption of its body

weight or high quality diet with high nutrient content. According to Silberman and Fultor (2016) the weight range matrix of black, white and Indian rhinos are as below (Table 5.2.9) :

Table 4.3.2: *Average weight range matrix of black, white and Indian rhino (Silberman and Fultor (2016)*

Species	New born (in kg)	Adult (in kg)
Diceros bicornis (black)	30 -35	1000-1050
Ceratotherium simum (white)	55-65	2000-3200
Rhinoceros unicornis (Indian)	50-60	1600-2800

From the above table it is evident that a new born Indian rhino calf, whose average weight is 55 kg, gains weight 2200 kg within 7 – 9 years (average 8 years) in case of bull and in case of cow, it gains 1600 kg within 6 – 7 years. This means that net gain of weight in case of bull is 2200 kg – 55 kg = 2145 kg in 8 years, i.e., 2145 ÷ 8 = 268.13 kg per year. In case of cow it becomes 1600 kg ÷ 6 = 266.66 kg per year. The heaviest rhinoceros ever recorded up to 4,000 kg (Indian rhinoceros facts,2017).

This enormous increase of weight within the short period of time is obviously related with huge consumption of food, as well as quality food, per day. So the national parks consisting of over population of rhinoceros, as it happens in Gorumara, Jaldapara and also in Kaziranga, surely have to face nutritional crisis sooner or later.

There is an ample scope of study on the aspect of assimilation according to age and body weight of the individuals relating to the consumption of food and voiding of dung in every stage of life which can throw light on the carrying capacity of the park and that can be compared with the zoo animals.

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Chapter 5.
Metapopulation Management

A tranquilized rhino is being surgically operated

"*Most national and regional rhino conservation plans call for rhinos to be managed as part of a metapopulation. In effect, the various individual populations of a specific subspecies in a country or region are managed as part of the overall national or regional herd with interchange of animals (genetic material) between the constituent sub-populations. A subspecies metapopulation is not simply a set of separate rhino breeding groups within a region – there has to be some form of managed gene flow between the individual populations that make it up. Rhinos are managed aspart of a metapopulation to avoid losing genetic diversity through inbreeding or genetic drift, andin so doing maintain sufficient genetic diversity for rhinos in future to be able to adapt to changingenvironments. Translocations within a metapopulation are likely to be necessary to maintain good population growth rates in both donor and recipient areas within a metapopulation.*"

------ IUCN Guidelines for In-situ Re-introduction and Translocation for African & Asian Rhinoceros

Chapter: 5

Metapopulation Management

5.1: Introduction:

Based on Richard Levins' (1969) idea meta-population is widely applied to the species occur in naturally or artificially fragmented habitats, though it was initiated by him through a model of population dynamics of insect pests in agricultural fields. It can be considered as the populations within a population. A meta-population actually consists of a group of isolated populations of same species which can interact at some level.

Some of the species of rhinos, like many of the mega-vertebrates, that actually may vanish well before their habitat disappears (Foose,2005). Due to rapid influx of human population in the rhino habitat zones, particularly after independence, caused mass destruction of habitat resulting into fragmentations of habitat as well as rhino populations. The last two resorts are Gorumara and Jaldapara in Bengal , three in Nepal, i.e., Royal Chitawan national Park. Bardia and Suklapantha (although presently the last two rhino areas consist of entirely translocated rhinos from RCNP) (Thapa et.al. 2013), and 5 in Assam, namely, Kaziranga, Pobitora, Orang, Manas and Laokhowa. Apart from these places Dudwa in UP (adjacent to Nepal border) also consists of a number of rhino population. The rhinos living in those isolated habitats are gradually developing homozygosity, particularly, where the number of individuals are too small. As for example Gorumara and Jaldapara have been remain isolated for some 125 years or so (Chapter 1).

5.2: Problems of management of small populations:

Small populations are vulnerable to stochastic problems that are difficult to predict.(Foose,2005) Stochastic problems may be demographic (as for example, Gorumara is suffering from skewed sex ratio tilted towards male), environmental or genetic in nature. Smaller populations are mostly succumbed to the environmental issues, such as droughts, floods, epidemics or other catastrophes which can directly create pressure by retarding population growth, survivality and fertility of individuals. These environmental factors are increasingly recognised as severe threats to the fragmented small population (Thorne,1991). Demographically, small populations may generate demographic problems, such as skewed sex ratio, unstability in age distribution, or random failures in survival and fertility that can fatally disrupt self perpetuation and self propagation. Genetically, small populations may

generate stagnancy by losing heritable diversity which is very much essential to keep itself fit under existing environmental conditions and self adaptability in changed situation. So, in a nutshell, there will be more stochastic risk in the small fragmented populations.

The meta-population management of rhinoceros is concerned with the following constraints which can be categorically divided into two heads:

5.2.1(i)Anthropogenic Cause:

(a)Habitat encroachment, loss of habitats and vanishing of corridors:

High birth rate, low death rate and cumulative influx of immigrants in the surrounding human population of rhino reserves and dependency on the forest products, such as collecting of dry leaves, twigs, grasses even small logs, etc. for fuel wood purpose are the common cause of habitat destruction. The new human settlements in between two habitats along with extension of agricultural fields wiping out the animal corridors and is considered as one of the added problem.

(b)Grazing by domestic cattle:

It is a common practice by the surrounding villagers that they allow their cattle to graze in the fringe areas of protected parks and during grazing the cattle unknowingly enter into the park area in day time. The diseases such as, foot and mouth disease can be spread by those cattle which may be very fatal to the wild animals including rhinoceros.

(c) Cutting of trees:

Many illegal (legal on papers) saw mills have been established during last 30-35 years within 5-10 km distance range of forest areas. Unauthorized persons, who are employed by the saw mill owners, entering illegally into the forest and valuable trees are cut by them after dusk which are not replaced. So, the forest areas are being squeezed day by day. By this way a section of people are getting easy black money.

(d) Poaching:

It is the most serious threat of all. The illegal trade of animal body parts are run mostly by illicit Chinese and Vietnamese traders. This underground business has a good network and is very lucrative to the underworld people. A large section of Asian people believe the magical properties of rhino horn and as the rhino population

(except Indian one horned rhino) has come down globally but the belief remains same, the price of rhino horn has gone up to its highest level in comparison to gold value. The illicit traders employ professional sharp shooters to kill the rhinos. In the point of view of meta-population management the poaching is one of the toughest challenge to the wildlife authorities.

(e) Rituals of the tribal people surrounding the forest areas:

Some rituals, particularly in the beginning of Bengal year tribal people en mass enter into the park and kill the smaller animals, such as, wild boar, rabbits, deers etc. From time immemorial these rituals are going on and the poor animals are being killed every year for nothing, thus creating sheer disturbance of the wildlife. Though in recent years this trend has been minimized.

(f) Hunting:

Hunting is totally prohibited. If someone does this he or she is convicted.

5.2.1.(ii)Natural cause:

(a) Change of the characteristics of core area:

Tall and medium sized grassland is the prime rhino habitat in the core area of the parks. The seeds of the surrounding forest trees are being blown by wind and are replanted in the grassland zones. So there is a tendency of the grasslands being encroached by the trees nearby and gradual transformation of grasslands to the mixed vegetations which must be avoided, otherwise, acute shortage of food plants may occur and carrying capacity may be decreased.

(b)Genetical threat:

Small, fragmented wild animal populations face the risk of continuous inbreeding which may lead to genetic degradation. It has been estimated that a population consisting of less than 100 breeding individuals, sustained for a number of generations, as is the case of most surviving rhino populations, may loss genetic variation. In this case lethal, mutated, non adaptable, weaker genes have greater chances to come close to each other in the genetic loci and those are phenotypically expressed in the population. It can be compared with the small stagnant water bodies where the quality of water is degraded through time. This can result in decreased immunity to diseases and reproductive capability. Apart from this, small populations

are like all eggs in a basket where unpredictable natural calamities, like floods, wildfire, epidemics etc. may also lead to a reduction in the number of breeding individuals. Loss of reproductive capacity in the rhino populations will lead to shrinkage in the population size, and will continue to lose genetic variability until it becomes demographically unstable. By then, such a population is virtually doomed because it enters an "extinction vortex" as is in the case of Javan rhinoceros. Small population size results into increased inbreeding which may cause lower birth rates and decreased survival in an unstoppable event until the population is entirely vanished

(c) Natural calamities and environmental degradation:

Natural calamities like floods in the Brahmaputra valley and floods due to frequent course changing rivers like Torsa, Jaldhaka, Murti and other rivers during monsoon is one of the major causes of depletion of a percentage of rhino population. Every year the situation is getting worse particularly in the Brahmaputra flood plain. The opposite picture is seen in the dry months when the streams, rivulets and other water bodies dry up which results into considerable infightings occur among themselves to occupy the best areas of the park. It is because of global warming and other cofactors that the natural hydrological cycle is disrupted. A gradual change in environment during the last 40 to 50 years caused slow and gradual minute changes in the vegetation patterns that may not be adaptive for the large herbivores who are very much orthodox in their lifestyle. Obviously these environmental degradations are the results of the long term effects caused by humans.

A comprehensive meta-population management programme was undertaken through P.H.V.A. Workshop for Great Indian one horned rhinoceros at Jaldapara in 1993 and the Report was published in August 1995. It was the first comprehensive and scientific approach to check the diminishing of small fragmented Indian rhino populations. The severity of bad effects on the rhino populations were of deep concern and implementation of actual positive steps were started to check the rhino mortality and uplifting the individuals' population.

5.3: Viable Meta-population Management Strategies:

Because of the above constraints the meta-population management strategies should be based on the priority basis. The rhino populations which are sufficiently large, such as Kaziranga or Royal Chitawan National Park in Nepal, the self propagating population has no immediate

threat of extinction but the viability must be maintained. It is somewhat true also in case of Jaldapara. In all the three areas the population range is over 100, the number which is considered to be the minimum viable range (Mace and Lande, 1991). But problem lies with the smaller isolated populations who are having population size below 100. The following management strategies may be adopted although some of these are already adopted by the Park authorities.

5.3.1: Re-establisment of corridors:

Many of the rhino reserves are located closely but isolated. For example, Laokhowa and Burachapori Sanctuaries are very adjacent to Kaziranga N.P. but in between two reserved areas human settlements prevail (Chapter 1.2.2). Once upon a time Burachapori- Laokhowa complex was an extended part of Kaziranga but in due course these areas have been isolated and the gap between these two is widening. Kaziranga is not affected due to this isolation but the small populations in the satellite region is suffering from genetic stagnancy.

To check this unhealthy situation a corridor must be re-established so that the homozygosity in Burachapori-Laokhowa region is avoided. Re-establishment of corridors in between Jaldapara and Gorumara in West Bengal part is very difficult but possible. The 44.27 km wide gap in between these two rhino areas is full of human settlements, agricultural fields or other manmade structures, but side by side there are open fields, inaccessible areas to mankind, rivulets, forests tea gardens. A proposed corridor can be made if supportive machineries from all concerns are available. A satellite map with imprinted line of corridor is shown below (Plate. 5.1) by keeping in mind that the least possible obstacles are faced by the animals during migration from Gorumara to Jaldapara and vice versa.

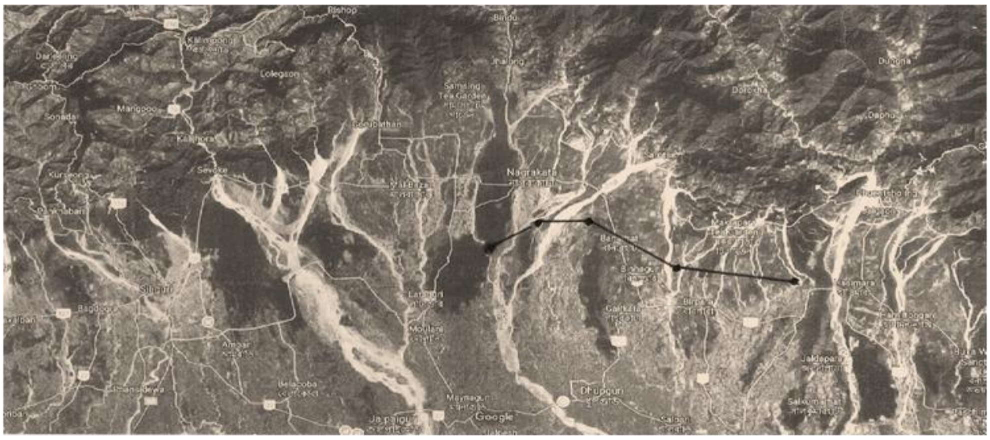


Plate. 5.1: *proposed corridor in between Gorumara and Jaldapara. (black) line*

5.3.2 Translocation programmes:

5.3.2.1 Translocation according to IUCN Guidelines:

An attempt has been made to establish a species in an area which once upon a time was a part of its historical range, but from which it has been forcefully driven out or has become extinct (IUCN, 1995). Successful re-introduction in a previous inhabited place is considered as Re-establishment. Re-introduction or translocation from one place to another means that a species or subspecies is being released anywhere inside its historical range with an aim to establish a viable, free ranging population in the wild.

The correct definition of translocation is the movement of wild individuals or populations from one part of their range to another (IUCN, 1995) according to a definite plan. On the other hand, re-enforcement or supplementation is the addition of individuals to an existing population of con-specifics (IUCN, 1995), for example, to improve genetic strength or to modify skewed sex ratios. This type of action may add some risk factors to existing wild population, such as disease and fighting in between supplementary and existing resident rhinos (Emslie, et.al. 2009).

In a re-introduced population, supplementation or addition is usually undertaken either to increase the effective founder number in a re-introduced population when it is not possible to re-introduce all founders at the same time, or to introduce new blood as a part of managing the genetic health of a meta-population (Emslie, et.al,2009).

When there is no remaining secured area left Benign Introduction is undertaken as an attempt to establish a species for the purpose of conservation, outside its recorded distribution but within appropriate habitat and eco-geographical area (IUCN, 1995). This is an effective conservation tool, particularly, when a species is on the verge of extinction.

5.3.2.2 History of Translocation in India and Nepal's perspective:

In Indian perspective the translocation programme was started lately, actually the first successful translocation programme was undertaken in 1984 when the first batch of founder rhinos were translocated from Kaziranga to Dudhwa, Uttar Pradesh. Since then there has been 8–10 translocations of rhino from Assam to Dudhwa. So far the translocations have remained successful excepting one mortality involving a pregnant female, and one evidence of fracture case. There are some records of calf mortality, which includes premature parturition and aggression related incidents. In Nepal in 1990s, altogether 87 greater one-horned rhino were successfully translocated from Chitwan National Park in Nepal to establish two new populations in Bardia and Suklaphanta protected areas.

5.3.2.3 The constraints during translocation in Asian perspective:

In India and Nepal the improved protocols still remain largely absent due to lack of previous experience. Due to uneven terrain and soft muddy soil the domesticated trained elephants (known as "koonkie") are generally used as a darting platform during capture and this method differs from the methods adapted in Africa. This darting operations can only be undertaken during dry months of the year as devastating flood is the common occurrence during rainy season. It is a hazardous procedure because darting can only be successful when a group of koonkie elephants effectively corner a rhino. From the inception of this type of operation, "etorphine" (using the "Immobilon" preparation with "Acepromazine" tranquiliser in combination) has long been used as the drug of choice because of its availability (Emslie, et.al,2009). After tranquilizing, a greater one horned rhino is loaded into a previously built wooden crate with the help of sled and rope techniques and awakening of the animal is done in the crate by injecting "Diprenorphine" injection. This process needs a huge amount of man power and total time by approximately 1 hour after immobilisation compared to African rhinos, which are partially revived and itself walks into the crate.. Partial recovery/walking techniques using chemical agonist antagonist combinations used in Africa are not generally used with greater one-horned rhino in India and Nepal.

5.3.2.3.1 Translocation without "boma" phase:

A long journey in the small crates during transportation may be shocking to the rhinos' mental and physical ability as expensive helicopters are not used in Indian subcontinent for quick transportation. Moreover, after strainous journey the rhinos are released in the recipient reserves without passing through any "boma phase" (It is a timber lined or without timber a large circular pit consisting of wallowing pool). Here the translocated animal is kept for some weeks to adapt to artificial feeding and human presence just to recover from the trauma. This moist, muddy pool helps the animals to wallow and remaining cool effectively. It has been found that in Nepal that, when boma has been used the programme has been highly successful, could be tamed easily and general health is recovered. Usually very young (2-3 years old) rhinos are caught for transportation in European zoos and occasionally in Nepal and are placed in a pit boma. In India, it is a common practice that the Greater one horned rhinos are usually moved by roads using crates.

5.3.2.3.2 Use of alternate drug combinations:

As many translocation programmes are being taken in India for expansion of rhino range Kaziranga in Assam is playing a leading role to make it successful. For this purpose an extensive Research programme has been undertaken to find the alternate appropriate drug combinations, for example "ketamine" (for tranquilizing) and "meditomidine" (for reviving). After application of this drug combination an encouraging result has been obtained. It has been effective with captive and tamed rhino and apparently effective with the young free ranging rhinos in the wild. It has been proved to be an effective alternative drug to etorphine but may not be appropriate to immobilize the adults and healthy animals in the wild.

5.3.2.3.3 Selection of founder population for Re-establishment:

If the establishment of corridors are not viable the second effective step is the translocation of few bulls and cows to the nearest rhino reserves and vice versa. Anyway, a mixing of gene pool is necessary to avoid the homozygosity, particularly in the smaller populations. Jaldapara can somehow manage to keep its heterozygosity but for smaller Gorumara it is almost impossible. Not only due to its population size but also due to its skewed sex ratio heavily tilted towards male at Gorumara, is one of the major hindrances to keep maintaining a healthy and riskless population size (section 1.4.2).

As new translocated population or reintroduced population is an important part of the total population, it has an effect as founders on the future generations to come. Founders are those animals (here rhinos) who carry the genes from source and that are transmitted into the existing population. So an intensive care must be taken to ensure that the founders represent a viable gene pool from the source population. According to Foose (1987) and Lacy (1989) at least 20 to 30 effective founders should be selected to start a new population.

Dominant males are the prime breeders in stable or nearly stable small populations. They tend to have a monopoly of breeding to multiple females in oestrous condition and thereby random mating is prevented. It causes distortion of sex ratio and finally becomes detrimental to genetic quality, since same genes are transmitted through generations. If it continues for generations, after 30 to 40 years the rhinos belonging to close relatives will breed to each other and the total number of genes present in a population will be low. The non dominant males, who are debarred from mating and who could not migrate naturally, translocation of those doomed and dispersing young rhinos in new habitats can prevent reproduction in close relatives thus improving genetic quality.

5.3.3: Effective population size vs total population size.

The exact population size of rhinos for its viability may vary depending on several genetic, demographic and biological characteristics of the population. It is also applicable in other mega herbivores who are restricted to their specific habitats. Mace and Lande (1991) proposed a general scheme of guidelines which provided quantitative idea about distribution and size of a population, its trends and stochasticity.

Mace and Lande (1991) formulated the survival capacity of a population depending on its effective size (which they termed as N_e) and total population size (termed as N). The effective size of a population is considered that how much that smaller population within a larger population contribute their genes to the future generations by reproducing with one another, in other words, the effective size of a population is genetically active and plays a key role by transmitting good genes in the next generations maintaining a healthy population and usually is much less than the actual number of animals. If the effective size is destroyed by means of stochastic problems the total population may loss genetic diversity.

Normally in smaller populations some animals fail to reproduce either due to skewed sex ratio (as in case of Gorumara rhinos) or due to lack of sufficient breeding pairs making disparities in life time production of offspring that can depress total population (N). In some cases N_e may be as low as 10% to 25%. Mace and Lande recommended a general N_e/N ratio of .2, by which an effective conservation programme may be continued. They advocated N_e as much as 500 for each distinct type of rhino to have the hetero genetic quality and demographic viability under the total population size 2500. More effective size along with total population size is always better and safer. The minimum 20% effective size should always be maintained for long term survival.

According to Mace-Lande hypothesis all the Indian rhino subpopulations except Kaziranga are in a category of critical or endangered. Kaziranga only possess 2501 rhinos incuding calves (Kaziranga Rhino Census, 2017). The next two subpopulations, i.e., Royal Chitawan and Jaldapara National Parks may have viable populations since they exceed minimum number of 100, as the preliminary analyses suggest that a viable number for each separate subpopulation of rhino should perhaps be at least 100 animals (Foose 1987; Seal and Foose, 1989: Khan 1989). But all other Indian Rhino subpopulations need much attention in the point of view of conservation.

Actually Rhino population need to be expanded to a range of 5000 to 10,000 individuals (Foose, 2005) for self propagation and perpetuation. Presently, among the world rhino

population only Southern White Rhinoceros gets the pass mark exceeding 5000 individuals surviving in the wild. Indian rhinoceros is fast approaching to that mark.

5.3.4: Improvement of rhino habitat (a case study in Gorumara N.P.):

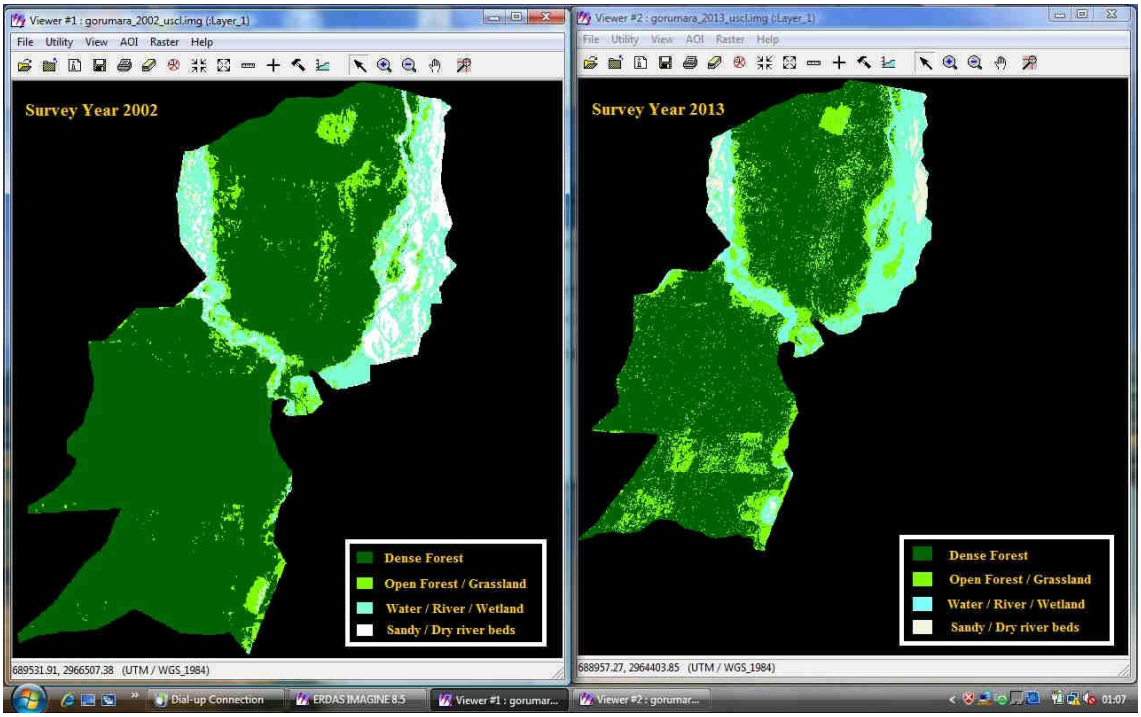
5.3.4.1: Development of grassland and wetland habitats:

The rhino population at Gorumara started increasing slowly during 1994-1997 which directly correlates with the rhino habitat development programme (mainly grasslands and wetlands) which was taken as a part of habitat manipulation practice (Raha et.al, 1993). Before 1993 the population increase was almost stagnant. The satellite images of Gorumara National Park of 2002 and 2013 (Fig. 5.2) clearly indicates the development of grassland habitats (Ghatak, et.al, 2016). This satellite image shows that preferred rhino habitat has been increased 5% (20% to 25%) during the period of 15 years from 1998 to 2013 and the population had risen to 35 and in the last census in 2015 it has been estimated to be 51 indicating the rate of growth to be 0.04 (Ghatak et.al.2016).

Table 5.1: *Expansion of Rhino habitat in sq. Km in correlation with year (After Ghatak,et.al.,2016)*

Year of mapping	Grassland (sq.km)	Wetland (sq. Km)	Grassland + Wetland Rhino habitat (sq.km)
1998	6.37	10.25	16.62
2002	8.41	10.46	18.87
2006	12.49	12.15	24.64
2010	13.45	11.01	24.46
2013	11.91	13.94	25.85
2017	Data not recorded	Data not recorded	Data not recorded

Table 5.1 shows that a net rhino habitat area of 9.23 sq.km has been added during the years between 1998 and 2013; in which 5,54 sq.km grassland and 3.69 sq.km wet land are included. The data of population increase and the tabular representation of habitat increase are the results of proactive management of the grassland and eradication of unwanted canopy forming trees as well as wetland preservation in that area. So the increase of rhino population is directly linked to the additional foraging area and compatible habitat of Rhino.



Plater.5.2: *Comparative classified satellite imageries for 2002 and 2013 (after Ghatak e.al.,2016)*

The above report tells about the success story of Gorumara where initially the Rhino habitat area was too small to survive a good number of rhinoceros. However, at present, Gorumara possesses more than 51 rhinoceros and still it is unknown what would be the actual carrying capacity of Gorumara. Since it has a very good buffer zone comprising of sal forest intermingled with other canopy trees the core area is protected and safe.

5.3.4.2: Eradication of weeds and climbers:

There is a tendency of covering the tall grasses by some climbers, specifically by *Michania scandens* which becomes detrimental to the health of tall grasses by restricting the rate of photosynthesis. A comprehensive and regular weeds and climber eradication programme must be continued throughout the year. A slightest relaxation about eradication programme may lead to the destruction of rhino fodders to a large extent. Of course, applications of herbicide or weedicide must be avoided because these toxic chemicals have direct hazardous effects on Rhino health. So, the National Park Officials should think about manual eradication of climbers and weeds those who are considered as non fodders. Gradual succession of weeds, climbers. tree etc. must be arrested so as to fecilitate the maintenance of grasslands which is the main part of the rhino habitat (Dey and Singh,2000).

Followings are some of the most destructive shrubs, weeds, herbs and climbers which are considered as invasive species and eradication programmes must be concentrated on these plants, namely

a) *Michania scandens* and *M. Macrantha*: These are also termed as "mile-a-minute" due to the speed of its growth. These are highly branched climbers and can cover the trees and fodders very quickly and their growth is arrested.

b) *Lantana camera*- These are all season shrub, spread rapidly, height ranges from 2-5 metre, semi woody, commonly known as Putus (Nature, Environment & Wildlife Society, 2017).

c) *Parthenium hysterophorus*- It is also an all season herb, it can propagate millions of seeds within a very short period of time, broad leaved, commonly known as Parthenium weed or Gajar weed.

5.3.4.3 Restoration of grasslands:

The faunal variety of Gorumara and Jaldapara can face some hindrances if the tree saplings gradually acquire the areas covered by grasslands. It is a natural phenomenon that the seeds of adjacent sal, teak, jarul, shimul, sirish trees etc. may be germinated in the nearby grasslands and a gradual, silent, natural encroachment of forests may occur through succession. Herbivores' natural habitat is the grassland and this habitat is the only nutrient supplier for grazers, in particular. As the Indian rhinos are primarily grazer acute shortage of food supply in the long run may be inevitable. So, like weed and climber eradication programme the grasslands must be restored by eradicating the unwanted saplings of those trees manually.

5.3.4.4 Prevention of monoculture of plants:

Aforestation is always desirable because it provides plentiful fodders and fruits for forest dwelling animals and thereby it may be an excellent home for the carnivores tp live based on the prey population. But in Gorumara and Jaldapara a chronological loss of diversified tree species is occurring and they have been limited in few pockets. Before these areas had established as Protected areas one kind of monoculture plantations of teak and jarul trees have been encouraged looking to its commercial benefits and conversion of natural diversified forest has been done regularly. Teak and Jarul plantations occupy almost 34% of the total plantations in the Protected areas, thus being an uncongenial factor for the wild animals (NEWS,2017). Due to this natural carrying capacity is hindered considerably.

Monoculture plantations should never be encouraged as it does not permit bushy understory and middle story to provide sufficient cover. Thus it is not favourable for wild animals to live in. For the growth of understory, infiltration of a considerable amount of light is needed to increase the browse value for ungulates but the dense canopy does not allow sufficient sunlight to pass in.

It is suggested that artificial restoration of grasslands be promoted to restore the carrying capacity of the parks by removing the old teak plantations.

5.3.5 Veterinary care:

Much of the veterinary care techniques have been learnt and experienced from the handling of the zoo animals, because they can be observed from a close quarter and intensive care can be taken specially when they become familiar with the zookeepers. Basel Zoo Garden of Switzerland, in particular, has contributed much knowledge about veterinary care and from their tireless continuous effort for almost more than 60 years much of the clinical diagnosis and their remedies have been known (Guldenschuh and Houwald,2002) which are applicable both in the wild and in the zoos. Further important inputs came from many other European and American zoos currently keeping Indian rhinos.

In general Indian rhinos living worldwide in the zoo gardens are considered to be healthy. However, chronic foot disease is becoming increasingly common in Indian rhinoceros both in the zoos and in the wild. Rhinoceros Husbandry Resource Manual (Fouraker and Wagener,1996) has become the guideline about various diseases and their treatment.

5.3.5.1: Foot Disease:

The wild Indian rhinos naturally have very strong pads, elevated soles and long horn walls. They are ‘sole walkers’ as their main weight is carried by the strong horn structures of the soles and hoof walls. Almost no weight is borne by the front part of the pad but the soles are concave and expand during locomotion (Plate 3b).

When comparing those with captive animals it becomes evident that in captive animals the situation looks different. Their footing surface is more or less flat and abrade. They have turned under the current captive situation into ‘pad-walkers’ and the main body weight is carried on the pad. The front part of the pad is not protected by an elevated structure of the soles and has to bear the massive weight of the animal.

Once the pad and sole structures become abraded they are prone to any further impact,such as the massive weight, sudden sharp turns, lack of moisture, etc. Those factors finally lead to the development of cracks in those predisposed regions (Plate 3a).

Plate 3a. *Cracks developed in captive Rhinos*

Plate 3b. *Sole of the wild rhino showing less number of cracks*

Therapy:

Severely affected animals are very difficult to treat and treatment schemes remained so far from recovery. However, the cracks need to be cleaned and care should be taken in such a way that most strain is taken off from that area. Attempts should be made that the fresh tissues are allowed to be regenerated. The problem can be managed to keep under control by regular cutting (every three weeks) of the small cracks and granulation tissue away. The healing up may not be completely cured but may be delayed. Atkinson (2001) reported that in a long term treatment scheme the healing process may not be 100% curable. In severe cases frequent anaesthesia is needed and it may be the only way to adequately control the problem (Atkinson.2001).

5.3.5.2: Other diseases:

Apart from foot diseases the Indian rhinos are very much prone to Dermatitis (skin problem), bacterial infections caused by *Salmonella sp.* Tetanus, Tuberculosis, caused by *Mycobacterium sp.* Viral infections, and various endoparasitic infections. But these can all be treated by taking preventive measures and by applying appropriate medicines ((Guldenschuh and Houwald,2002).

5.3.6: Orphanage:

On August 28, 2002, with the collaboration of the Assam Government, the Wildlife Trust of India, and International Fund for Animal Welfare, CWRC was inaugurated. Although there are other wildlife rescue centres in India, CWRC is the only one that takes in practically any wild creature, from tiger to eagle to snake. Its most unique residents, however, are the ones found only in Kaziranga, the rhinos(The Hindu, September,1,2018).

The centre got its first baby rhino in 2002. The building was still under construction. The baby was less than 15 days old. It quickly adapted for sucking milk bottle. In 2016, devastating flood in Brahmaputra river occurred and many animals including rhinos were rescued by the CWRC staffs (Plate 4 & 5).

CWRC is now home to seven rhinos. They are all rescued orphans. They share the centre's grounds with four baby elephants, orphans like the rhinos, and four leopards with similar personal histories who, owing to their carnivorous nature, are kept in wire-mesh enclosures closed on all sides.

Plate 4: A rhino calf being rescued from Kazirang
National Park during flood in 2016. Photo courtesyA rhino calf being rescued from Kaziranga National Park it--Subhamoy Bhattacharya

Plate 5: Rescued from Kaziranga floods, 8 rhinos in an enclosure

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CHAPTER – 6

A socio-economic database of the adjacent villages and spatial representation of the potential 'ecotourism spots' in order to restrict human activity along the '*Rhino corridor'* with proper recommendation for Rhino conservation with modern amenities

(Top left) Awareness programme is going on in an adjacent village of Gorumara (Below left) Cottages for ecotourism (below right) A gathering of villagers near forest camp

CHAPTER – 6

A socio-economic database of the adjacent villages and spatial representation of the potential 'ecotourism spots' in order to restrict human activity along the '*Rhino corridor'* with proper recommendation for Rhino conservation with modern amenities

6.1 Introduction:

As in all protected areas in India there is a strong relation between the people and the forests because the people living in and around the forests are considerably dependent on the forest resources for subsistence, commercial and cultural purposes. NTFPs collection is another important source of income for the villagers of 28 mile. They use small timber for house construction; thatch for roof; edible roots and tubers, mushrooms, leaf litter and leaves, flowers and fruits as substitute of staple foods especially during lean seasons; medicinal herbs for healing etc [8].

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There is a strong relationship between the villagers and forest because the people living in and surrounding the forest are heavily dependent on the forest resources for their daily livelihood, commercial and cultural purposes. This is a common scenario in India, as we observe in West Bengal forests. If their socio-economic condition is uplifted their dependency on the forest resources can be minimized. They use fallen timbers for house construction, thatch for roof casting, Mushrooms, leaves, fruits, tubers, edible roots are used as substitute or staple food particularly in the lean season. They also use medicinal herbs for treatment as modern medical facilities are very poor in those areas (Das, 2005).

6.2 Encroachment of Forest land by the surrounding population:

The gradual increase in population went on building pressure on the forest land for agriculture and other purposes. Consequently, the forest land faced a constant menace, due to encroachment during sixties and seventies. After the Forest (Conservation) Act, 1980 came into force the problem was, however, greatly checked. For diversion of forest land for any developmental purpose, compulsory afforestation on the land made available in lieu, has been made binding. The Hon'ble Supreme Court of India also expressed great concern with the state of affairs relating to illegal encroachment on forest lands in various States/Union Territories and in their order of 23.11.2001 in I.A. No. 703 in W.P. (Civil) No. 202 of 1995 restrained the Central Govt. from regularisation of encroachments in the country and in W.P.(Civil) No. 202 of 1995 in I.A.No. 502 of 2000 and I.A. No. 703 of 2001 in the case T.N. Godavarman Thiru Mulkpad Vs. U.O.I. & others directed the Chief Secretaries of the different States on 18.02.2002 to file a reply in relation to "the steps required to be taken by them to prevent further encroachment of forest land and in particular to the land in hilly terrains, national parks and sanctuaries etc." The apex court also directed to indicate as to what steps had been taken to clear the encroachments from the forests, which had taken place at an earlier point of time. In response to the observation and direction of the Hon'ble Apex Court, the Ministry of Environment and Forests suggested a time bound action plan for eviction of illegal encroachments on forest lands. The Chief Secretaries, Forest Secretaries and Principal Chief Conservators of all States/U.T.s were requested to prepare the baseline information containing a comprehensive list of encroachments in the State/U.T.s with current th status of eviction and to send the same to the ministry preferably by June 30, 2002. The Principal Chief Conservator of Forests were directed to provide detailed progress report of

the action taken, area evicted and area reclaimed/planted etc. every quarter commencing from July, 2002 onwards. The process of eviction is presently not being implemented without finalization of user right as per the Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights Act, 2006).

6.3 Past scenario:

During the last few decades the Park Managers' attitudes to the Protected Areas' surrounding population have been changed considerably. In the past, the illegal poachers or informers were given shelters in the surrounding villages and often the villagers were offered a lucrative amount for assisting them during poaching and smooth operation up to their successful retreat. A hot and cold combat between the Park authorities and the villagers were a common phenomenon in those days. The situation was not at all healthy in the point of view of Parks' management. The present author faced a horrible experience on 15th April, 1981 which was rediscovered from the pages of author,s old field diary-

"Gorumara: 15th April.1981: It was a cloudy pleasant morning. Suddenly an audible feeble noise from a distance was coming closer. The noise turned louder; some distinct clearly audible words such as ' catch, catch , kill it, kill it' we heard and we realised that hundreds of people were closing towards our camp. Ultimately the people with roaring sounds dispersed after reaching near our camp and started chasing, wild boars, deer, rabbits etc. In that very morning they crossed the Jaldhaka river on the eastern side of the Park and entered into the protected area. They were all equipped with bows and arrows and belonged to the 'modesia', (a tribal) ethnicity. I became scared and I had no previous experience of this type of hulliganism. But my fellow forest guards had experience with this type of activity. One of the forest guards dictated me to keep calm so that I did not raise any voice. 'It is their ritual and they maintain this ritual very sincerely on this Newyear's (Bengali) day'- told that forest guard.

During that one hour time they ransacked the forest and grassland, killed many poor frightened animals. And after one hour we observed that those people were returning back with dead bodies of animals hanging from their shoulders The park became all quiet on the eastern front within 8:30 A.M."

It was the picture of those days. No law and order, no rules, no ethics, no sympathy for the animals. The forests and habitats in West Bengal were gradually dwindling. All were waiting for hearing its last death bell.

6.4. Present scenario:

The situation gradually started changing from the late eighties and from early nineties the Park Officers started taking stern actions against the illegal intruders. Cattle grazing became minimized. More and more Forest Guards got employed. Strict law and order re-established and overall a good management techniques began to operate. Side by side frequent visits by the Park Officials or their representatives to the surrounding local villages resumed to make them realize that if the forests and wildlife survive they will also survive, so the villagers should protect the habitats and animals.

Actually this campaign started in early eighties but the local people did not bother much about those campaigns which included slide show, poster presentation, talk to the people in local gatherings, house to house campaign etc. These types of activities from the part of the Forest Departments were new to them and imposed a very little effect on the villagers. But Forest Department authorities never gave up hope and their continuous effort at last started giving result from the late eighties. Lastly, in the first decade of this century, situation became favourable in such a way that apart from 40 to 50 pairs of eyes of forest guards thousands pairs of eyes of villagers started keeping vigilance on the illegal intruders and miscreants. In Gorumara during last 7 years no poaching incidence occurred due to this vigilance by the local people and tightened security from the part of the Forest Department.

In general, the villagers surrounding the parks are poor and their economy is based on tea industry and agricultural products which are not sufficient to earn their livelihood throughout the year (Bhattacharya *et.al.*, 2016). It was a duty from the part of the West Bengal Government to eradicate the extreme poverty of the surrounding villagers so that their dependency on the forests are decreased considerably. To fulfil this programme the Ministry of Forest Department began various eco development programmes, such as, eco-tourism, home stay, entertainment programmes to the tourists, transporting, organized picnic spots, hotels for fooding and lodging, etc. all involving the local people. This kind of endeavour gave result very quickly and an upliftment from the below poverty level gradually occurred.

In West Bengal the density of the population around fragmented forests is the highest. So, there is an immense pressure on forests. The various socio-economic problems, such as,

poverty, underemployment and unemployment in the forest fringe areas, the major threat to forest comes from illicit collection of fuel wood, fodder and small timber from the forests by the villagers to sustain their livelihood (State Forest Report, 2011-12).

6.5 Actions taken by the Forest Department:

The vulnerable areas, where the problem still exists in the field of timber operation and poaching of wildlife, protection is provided through intensified patrolling by protective personnel. Otherwise, the other problems,(eg. Cattle grazing), have, however, been tackled by and large over a major part of forested tract in the State by formation of Forest Protection Committees and through the process of consolidation of Joint Forest Management. Vigilance by departmental protective staff has been strengthened in such areas through organization of mobile squads being assisted by 200 men specially constituted battalion of State Armed Police(State Forest Report, 2011-12). Action has been taken to stop illegal activities by wood-based industries operating in regions vulnerable to operation of gangsters. A post of Inspector General rank of Police Department, has been created in the Department of Forests for the forest protection purpose and to have the required communication with the Police Administration to extend their support over district and state level to combat organized gangsters in illicit operation of timber (State Forest Report,2011-12).

6.6 Socio-economic condition of the adjacent villagers:

6.6.1: As tea growers:

Most of the local inhabitants surrounding Jaldapara and Gorumara National Parks belong to the tea gardens. Economic infrastructure of this area still stands upon the production of tea where a considerable portion of the population belongs to the tribal community and is directly dependent on the tea industry (www.dooarsonline.com/economy).

Actually the tribal labourers of the tea estates were brought from the present day Chhotonagpur, Santhal Parghana and Chaibasa districts of Jharkhand and Chhattisgarh (previously Madhaypradesh) by the britishers, so they are not native to this zone but, their huge influx from time to time have changed the ethnic composition apart from economy, as well as, employement, culture, rituals, lifestyles etc in the Districts Jalpaiguri and Alipurduar (FAO, in Sodhganga. Inflibnet.ac.in, 2011). So far, this community has maintained their social systems, cultural identity and ethnicity (District Magistrate, ref. In Sodhganga.inflibnet.ac.in 2010).

West Bengal Government gives the land to the financially sound Tea Planters on lease which is renewable after 30 years but subject to the condition that the land will only be used for tea plantation (Bhowmik,2002). But still then a continuous slow encroachment of forest and grassland by the marginal tea bushes is in the process, and thereby, the forests and grasslands are losing their lands on every day. The decision of extension of tea cultivation area is again inviting two possibilities, i.e., more area under tea plantation needs more labourers – either immigrants or local people which follows more extension of built up area and crop cultivation for supplying growing demand of food supply.

Therefore extension of tea cultivation changes the Land Use pattern. Tea estates are usually large and to maintain these huge plantations a large amount of man power is needed. So they provide residential quarters for their employees along with some community facilities like school, hospital and other socio-cultural institutes, which cover a significant portion of total area. Apart from this most of the tea estates still occupy some extra land (between 10 and 35% of the total area) where no activity is performed. This area can be brought under tea cultivation. Of course play grounds should be excluded from this plan.

The tea industry received a severe blow from the early nineties when the biggest buyer of Indian tea, Russia, after 'Perestroika', refused to buy or partially lost the buying capacity of Indian tea. It then underwent through several fundamental changes and a severe crisis continued that got its peak during the first decade of this century. This resulted as many of sick, locked out and closed tea gardens and labourers and other official staff started getting irregular payments from the owners and a gloomy economy overwhelmed in the tea garden belt. As for example, Red Bank, Dharanipur, Surendranagar, Chamurchi and Bamandanga tea gardens remained closed for long periods leaving many workers on the verge of hunger. After a period of great hardship the gardens became operational, though issues of low productivity remained. The Red Bank Group (Red Bank, Dharanipur and Surendranagar) tea estates again closed down on October 19, 2013.

To overcome this gloomy situation some small farmers, who have financial potentiality and land, have started their own small tea gardens. Although an uneven competition from large tea companies is always there, nevertheless, a few Self Help Groups (SHGs) have come forward to help the small producers, so that they can get higher profits as it is a lucrative cash crop. Many of the independent producers participate in Self Help Groups that collect the tea, sell it, and distribute the profits to the farmers. The second category are the 'outgrowers' who sell their land to a tea company, continue producing tea on the same plot, and the company

purchases all of the products. Manures they use are the purchased fertilizers and cow dung along with heavily used pesticides (Mikhail et.al, 2010).

6.6.2 As Agricultural farmers:

As the population is considerably low in this region the average household in the Duars owns 5 bigha (0.8 hectares) of land each. The soil fertility is in general high and the crop production is more or less good having three crop cycles per year and no fallow period is observed in between. Inspite of three cropping cycles the stochastic environmental issues, such as flood, and raiding by large herbivores (elephants, gaurs and rhinos) in the harvesting seasons (the croplands which are in the close vicinity of the protected areas) hinder the crop production in a large scale, so the smaller agricultural farmers are not benefited much out of agriculture. The mazor cropping patterns are jute-rice-winter crop (potatoes, and/or vegetables) and jute-rice-tobacco. Additional crops include maize (in the upper tea garden areas) banana, bamboo, watermelon, and groundnut. Among these rice is the staple crop predominantly for consumption. As the very small part of Dooars fall under the planned irrigation project, the farmers use regularly underground water for irrigation and in the southern part of Dooars production of off-season rice is noticed as a crash crop. Dense plantations of betel nut trees are also one among the seasonal crops from which they earn money. In recent decades, small land holders have a general tendency of applying hybrid seeds, chemical fertilizers and a significant amount of pesticides but many of them still use local seeds and cow dung as manures. Cows are the most important livestock animal to them apart from poultry, as they provide financial stability not only by selling of milk but also provide labour for ploughing (Mikhail, et.al,2010). Next economic animal is goat by which the local meat supply is done.

Gorumara and Jaldapara are located on the flood plains of river Jaldhaka and Torsa which are known as the major rivers. For agricultural purpose the banks of these rivers are not appropriate due to their course changing nature. But along the other smaller rivers, farmers use canals, and follow an old method of river lift irrigation. The agricultural lands which are located away from the rivers, there the farmers generally use diesel or electric pumps most of which are taken as rent. But during proper irrigation time the rental of pumps become much expensive due to high demand and that may not be always affordable by the poor farmers. However, the tea growers largely use flood irrigation by pumping groundwater with a diesel or electric pump (Mikhail et.al., 2010).

6.6.3 Off-farm economy:

When the farmers pass through difficult times they rent out some of their lands for ready one time income or mortgage it to buy the essential commodities. Many households depend largely on off-farm income for their daily living, because meagre farm production is insufficient to run their families or entire earning program may come from off-farm activities. Most households in this category cultivate crops on their own land or on leased land, using off-farm income to supplement food supply; others buy all their food. Many unskilled villagers work as seasonal labourers on others' fields or in nearby factories. For off-farm income tea plantations provide works for some, whereas, service sectors, such as, providing school lunches as part of Self Help Group (SHG) programs, government construction programs or engage themselves driving their own toto-rickshaws/cycle-rickshaws in the nearby towns. Among these, many temporary Government Construction Projects provide major off-farm employements. Nevertheless, their rice and cows are considered to be most important to them though they receive the most income from off-farm labour. If they are given priority to select their desirable jobs they will preferably select categorically as follows:

1. Owning own farm is the highest preference.
2. Leasing land is the next preference and
3. Labouring or off-farm income is the last preference.

In this region community efforts relating to farming or to make big projects is entirely absent, rather, individualistic approach towards managing own resources, as for example, land trees and groundwater, is predominant and it is the characteristics of the people of this region. This makes those people vulnerable who are living without land (Mikhail, et.al,2010), or lying much below poverty line.

6.7 A rising hope:

So, in a nut shell, the socio-economic conditions in the villages surrounding Gorumara and Jaldapara has not been very much improved and still there is a low level dependency on the forest products by the villagers, particularly who are landless. This is not to say that who are having land properties do not extract forest products like thatch, timbers, grass for domestic animals etc., but in recent decades this tendency has been minimized due to strict vigilance and strict applications of law and order from the part of the Forest Department. It is one aspect, another aspect is that during the last 30 years or so, one kind of general consciousness and responsibility has been developed in the society about the forest and wild animals. The

credit largely goes to the Forest Department Personnels whose continuous whole hearted approach to the villagers and publicity about saving wildlife and habitats and providing them many new job opportunities (ecotourism, homestay, entertainment to the tourists, guiding jobs, etc.) which were not thought before, all collectively started giving much desired results about the safety and security of the wild animals. In addition, the school education which started from early eighties depicting the importance of forest and wildlife in the syllabus, they are now adults ,who learnt those ideals in their early boyhood and girlhood, are refraining others to be abstain from this type of destruction. These collective efforts are pushing the poachers and miscreants back to the wall and for that reason Gorumara National Park received the best protected National Park in India in 2009.

6.7.1 Ecotourism spots:

To save the natural wealth and for sustainable maintenance of this, West Bengal Forest Directorate has created many Eco- tourism centres in different parts of West Bengal. The alternative goal was to generate responsibility and awareness among the common people about our nature. So far 20 eco-tourism centres have been brought under online booking system in order to make these centres more accessible to general public. This system or portal has been developed by WBSFDA, a collaboration with NIC, to provide a single window online booking/cancellation facility to all interested tourists. This network has become fully functional on and from May 2015 (www.westbengalforest.gov.in,2017). For operating this scheme a current account has been opened opened in Yes Bank, Dalhousie branch, Kolkata. The payment collected from the visitors are credited to Yes bank through the payment gateway system viz. "PayU" (www.westbengalforest.gov.in) The status report of Online Booking for the year 2015-16 & 2016-17 is given below :-

Table 6.1: *Division and camp wise Eco-tourism centres and their net receipt in 2015-16 and 2016-17 at Gorumara and Jaldapara (Source: WBSFDA)*

Division	Eco-tourism Centres	Net receipt during 2015-16 (in INR)	Net receipt during 2016-17 (in INR)
Gorumara	1. Mouchaki Camp	195146.16	426600.00
	2. Hornbill Nest	57598.21	86400.00
	3. Murti Tents	166283.75	252500.00
Jaldapara	1. Kunjanagar	26424.32	8400.00
	2. South Khairbari	51996.83	150700.00
	3. Mendabari Jungle Camp	368468.63	764250.00

Net receipt = Gross receipt – statutory tax

These above named ecotourism centres have been able to give employment to many local villagers to generate their economy and it is a good approach to the villagers by involving them in a huge framework in terms of protection and better management of the parks.

6.7.1.1: Ecotourism Advisory Board;

Ecotourism Advisory Board comprises the following members including Chairperson:

1. Honourable Chief Minister – Chairperson
2. Chief Secretary to the Govt. of West Bengal – Ex-officio Vice Chairperson
3. Principal Secretary, Forest Department – Member
4. Principal Secretary, Tourism Department – Member
5. Dr. A.K.Raha, IFS (Retd.),Expert – Member
6. Shri Ujjwal Bhattacharya, IFS (Retd.), Expert – Member
7. Shri Raju Das, IFS – Chief Executive Officer

The above Eco-tourism Advisory Board is acting presently for taking any decision regarding alteration, addition of eco-tourism spots and seeking for new places to establish ecotourism zones. Jaldapara and Gorumara currently falls under Forest Zones which comprise ecotourism in Forests & Wildlife areas, Eco-sensitive areas, Wild animal corridors etc. [Government of West Bengal vide Gazetted Notification Registered No. WB/SC-247 No. WB(Part-1)/2015/SAR-426 dated 4th September, 2015] with a desire that special emphasis will be given on Jaldapara, Gorumara Chapramari, Sunderbans and other forests of North Bengal.

6.7.1.2 Why ecotourism is important?

Gorumara is encircled by many ethnic villages. More than 10,000 resident forest villagers derive their income from sources including employment in forest department activities, ecotourism, etc. Some of the villages are Saraswati, Budhuram, Bichabhanga, Chatua, Kalipur and Murti Forest Village. On an average more than 40000 inhabitants including children are dependent on the income of those 10000 resident villagers. So a good amount of money is circulated centering the ecotourism and other works in Gorumara and thereby uplifting the villagers from poverty.

6.8 Benefits to the local communities:

A considerably dense human population in comparison to other states surrounding the protected areas lives in West Bengal and this may be to a scale of more than 1,50,000 people who are the inhabitants of forest villages, fringe villages and tea gardens (Martin and Vigne,2012). The Forest Department is doing a trustworthy job that in any case of human injury, death or destruction of property and crops, specially by elephants, a good amount of compensation is given by the Park authorities which keeps maintaining good relations and trust with the villagers (Martin and Vigne,2012).

6.8.1: Financial support to the local communities of Jaldapara and Gorumara

Since Jaldapara has got a very long boundary for its peculiar trouser shape (Fig.1.8a) a large number of human settlements are there at the border regions which is vulnerable to the safety and security both to the wild animals and villagers. For that reason, just to avoid heavy influx of tourists, in the peak season, the Forest Department has built two main eco-parks (nature parks) at Kunjanagar and South Khoirbari , at the border region for the visitors to have picnics and night stay, if required. These eco-parks are reducing human pressure in the core area as well as fetching money for the local people.

All the employed staff of Kunjanagar and South Khoirbari are from local communities (Guha, 2007). The community also benefits from work in the Sanctuary, as for eg. Employed as guide from local community (25 nos.), casual workers (average 230 employees, but the requirement of casual workers depends on the pressure of works). 25% of the entry fees are received by the villagers from the Forest Department. This 25% along with funds from the State Government provides them a good financial support. Many zeeps are provided by the villagers which are green and an emblem of wildlife is displayed on it.

Forest Department has also done and doing many eco-developmental projects. The goal is how to engage the local people in different types of developmental activities, so that they can earn their livelihood. For this purpose, as the ecotourism is flourishing, more and more villagers are being employed like cook staffs for eco cottages, repair and maintenance work on the roads, making culverts, carrying out foot patrols, helping mahouts to cut grass for their elephants, and carrying out habitat management jobs in the surrounding forest plantations and load logs into lorries etc. Thus the Forest Department is providing extra income and keeping good relations with the local people. In return the Officials are informed by the villagers on illegal intruders and timber smuggling, and pay them accordingly.

Photo.6.1: *A meeting with the villagers at Gorumara- Dhupjhora beat (Source: Lucy Vigne)*

Officers also obtain data from informers working in tea stalls and tea gardens and for this purpose, regular meeting and discussions are arranged in fringe areas of the Park and the villagers also eagerly take part in the discussions. The best way to educate the people is to educate their school going children (Photo 6.1) and what they learn in their childhood that is imprinted in their minds. Forest Department is also trying to do some social works by implementing gas connection to the local people so that the use of fuel wood is minimized and encroachment of forest land is checked (Martin and Vigne,2012).

Actually the need of the poor villagers around the park is endless and their population around the park has been increased up to 900/km^2 near the fringe areas of Gorumara. Apart from protection and habitat improvement another important duty of Park's staff is to achieve trust and cooperation of the local villagers and which has been increasing from the early 90's. The National Park is also being increasingly benefited by this. A good understanding has become the backbone of the Park's management. The outcome of this cooperation is that since 1990s the livelihood of the villagers has been improved much in comparison to Jaldapara.

The following Table 6.2 will speak about how the families residing at the periphery of Gorumara have been benefitted due to establishing only five ecotourist places by the Forest

Department up to 2012 (Source Martin and Vigne,2012). Government is planning to open many more eco-tourist places, at least two in this year.

Table 6.2:*No of benefitted local people and families after establishing only 5 eco-tourist places*

cottages	cottage staff	Cultural dancers	Families making souvenirs	Families providing buffalo carts	Privately owned zeep	Guides	Boatmen
19	70	108	78	7	77	74	4

Since 1997 local communities are receiving 25% of the total earning from the tourism. The money is distributed to nine eco-development committees consisting of 52 members. They are representing 1600 families around the park and the estimated members of that 1600 families are nearly 8000 individuals. A monthly meeting is organised in the Park by the Forest Department Staff with the committee members and there they decide how to spend the money by implementing new projects. In some way these huge number of villagers are financially benefitted by the year round developmental works go on in the Park organized by the Forest department. Before 2000 ecotourism activities were very insignificant at Lataguri (presently a well known ecotourism spot) because there was no revenue generation there because on that period the matter of ecotourism was not very popular (Karmakar,2011) But. after resuming the ecotourism activity revenues began to accumulate in that area. Some developmental works which go all the year round in the nearby villages of the Park may be stated as below:

1. Making irrigation channels
2. Mushroom culture
3. Making ring wells and culverts
4. Providing torches and batteries to scare elephants
5. Producing non-palatable crops that elephants and other large herbivores do not eat. Such as black pepper and ginger.
6. Providing agricultural tools to the villagers
7. Providing funds to educate the children
8. Other alternative income generating works which is felt important.

6.8.2: Compensation paid by the Government due to Human-wildlife conflict:

In recent years, at Gorumara ,due to increase of animals and complete absence of poaching, Human-wildlife conflict has come to the limelight as a major issue. The large animals, particularly the elephants, are very much fond of palatable crops whichever come to their migratory routes in the harvesting seasons. Due to attack of animals if any human death occur West Bengal Government pay the compensation to that family in the tune of INR 100000 which is soon to be doubled. Treatment of injured persons by the attack of wild animals is entirely free of cost in Government hospitals. Damaged huts, live stocks and crops of affected persons are readily compensated by the Government.

Like Gorumara, Jaldapara also face the same problems, i,e., death, human injury, live stock death, destruction of crops and huts, specially by elephants. Rhinos may also damage as elephants do, but in a lesser frequency, because rhinos seldom go beyond half a kilometre from the Park's area. This may be partly due to high human density outside the Park or partly due to their solitary nature just to avoid the troubled areas. The rate of compensation is same, but WB Government is thinking to enhance the compensation amount categorically from the minor injury to death. This forward stepping helps to maintain trust and good relations with the villagers (Budhu Barman, villager, pers. Comm., 2018).

6.9: Rising of ethical views of the villagers:

The villagers living around Gorumara and Jaldapara have realised gradually during the last 30 years or so that, the forest and wildlife are the two revenue generating things for ever provided they are protected honestly by heart. It is just like a hen who lays golden eggs and if the hen is killed all will come to an end. The villagers are now quite aware of the importance of the parks and they know it very well that the benefits they receive from the parks will drastically be deducted if rhino poaching occurs or forest and grassland habitats are destroyed. The local people have been turned into the eyes and ears of the parks'staff, instead of the eyes and ears of the only handful of forest guards. This invisible human fencing is the toughest one which is hard to penetrate by the poachers and the timber smugglers. The attitude to the villagers by the Park staff has also been changed considerably from the attitude of seventies and early eighties when the park staff did all the vigilance work by themselves, there was no sympathy to the poverty of the fringe villagers, no understanding with them and ruthless policing was thought to be the only way of control (Guha,2007).

It was a long way to achieve this friendly situation and to win the trust and confidence of the local people. Initially the villagers were suspicious on the changed activities performed by the Park officials and staff but as the time passed by, the villagers inclined to the Park Officials' generous activities. In doing so the selected park personnel's continuous campaign, such as film show, slide show, meetings in public places, door to door contact etc. started giving result in the latter years.

6.10: Proper recommendations for rhino conservation with modern amenities:

6.10.1: The Positive sides:

In recent two and half decades time the success in rhino conservation programme in the two National Parks, Gorumara and Jaldapara, of Northern West Bengal has achieved satisfactorily due to the following reasons:

1. Amount of budget allocated for Gorumara (USD 4305/km^2) and Jaldapara (3171/km^2) both from Central and State Government is considered to be the highest in the world (Martin,2005).
2. A good trustworthy and understandable situation between the Park staff and the fringe villagers which are jointly helping to reach to a manageable situation in protecting the rhinos.
3. Development of habitats, i.e., grassland habitats, in both the National Parks to give room to more rhinos.
4. Heavy compensation to the nearest relatives of death victims due to human-wildlife conflicts or to the injured persons.
5. Minimal poaching incidences due to installation of tight vigilance system with the help of local people.
6. A good communication network either by mobile phone or by wireless system along with the local people's good wishes so that prior information about suspected poachers or tree smugglers is reached to the Park staff.
7. More or less sufficient motivated Park staff (158 in Gorumara and 418 in Jaldapara; excluding casual staff in both the Parks), whose continuous effort made the Parks safe places for rhinos.
8. Necessary vehicles are there for quick movement and 'kunki' elephants are there for reaching to inaccessible areas in shortest period of time.

The above eight point positive sides depict that the success story of the conservation efforts of both these two sites is mainly based on a strong bondage of cooperation between the Park staff and the surrounding local people. It has been the master stroke from the part of the West Bengal Forest and Wildlife Department who took the initiative to make this friendly environment and with this action the handful of local people who were still inclined to the outside poachers were pushed back to the wall. It can be a very good model of wildlife conservation to the National Parks and Sanctuaries not only in India but also in other parts of the world.

6.10.2: The other sides of conservation still to be achieved properly (some recommendations):

Despite brilliant success in conservation history, the time has now come for Gorumara and Jaldapara to adopt some procedures of conservation techniques with modern amenities which have been mentioned below:

1. Tranquilization procedure for translocation and reintroduction or for veterinary care still follow the old techniques which may bring lots of hazards to the animal itself (Section 5.3.2.3).
2. In India and Nepal still road transport of animals is the protocol. The transportation should be quick and hazardless. For this purpose air lifting by luggage carrier helicopter service is to be adopted which is frequently used in African continent.
3. After transportation the rhinos should pass through a 'boma phase' (section 5.3.2.3.1) just to recover from trauma.
4. Rhinos may be fitted with Satellite-GPS Collar to get actual data about their home range pattern, use of habitats and corridors if they are there. Recently in Nepal's Bardia National Park three female and one male rhino have been collared who actually use Khata corridor in between Bardia National Park (Nepal) and India's Katarniaghat Wildlife Sanctuary(www.wwfnepal.org, 2016).
5. Veterinary care should be taken more professionally. For this purpose regular monitoring by patrolling on foot or on elephant back should be done and if any injured or ill rhino is noticed (foot disease is common in particular) that must bring to the notice to the expert person.
6. An orphanage with utmost careful monitoring system and facilities must be there in the rhino parks, because in every year some juveniles are detached from their mothers during flood. In this case Kaziranga orphanage may be an ideal model to the other

parks and sanctuaries, where not only rhinos, elephants and other animals are also brought up there after successful rescue operation.

7. Besides check up of general health, genetic health of a rhino population is also to be studied just to find out how much heterozygosity is there in the population. Usually in a small population one or two dominant bulls remain active as breeders. So, in future, all the offspring become the descendants of a smaller section of that population and lesser number of genes are circulated in the population which may cause undesirable homozygosity. To overcome this, the other male rhinos, who are not supposed to be the active breeders, are to be brought in situ smaller enclosures with some females to make them prospective breeders. The aim should be that all the adult individuals can get chance for breeding.
8. Adequate supply of tranquilizing drugs, i.e., 'etorphine' and 'diprenorphine' are to be preserved in stock. The sole supplier of these two drugs is South Africa. But, recently irregular supply of these drugs has become the headache of the Park officials. Kaziranga is playing the leading role in translocation programme in India and they have invented two new drugs, 'ketamine' for tranquilizing and 'meditomidine' for awakening, are being improvised and fetching good results. In consultation with Kaziranga National Park officials those drugs can be purchased in Government level.
9. Though in-situ conservation is the best way of conservation but some time ex-situ conservation techniques may also play important role, particularly cryopreservation techniques in sperm bank, gene bank for future artificial insemination process. Similarly in laboratories the nutritional values of the preferred fodder plants are to be estimated, so that, best fodder plants are cultivated by making artificial grasslands (glades).
10. Foreign tourists (who are wildlife lovers) are not much aware about the West Bengal Rhino Parks. The success story of rhino conservation must reach to the international level by strong continuous campaign through websites, Newsletters, Wildlife Bulletins etc. For this purpose a good rail and road communication is necessary.
11. In peak tourist season more elephant riding and other communication system should be enhanced which is directly correlated with the revenue income so that the local people are benefitted.
12. The Park officials and other executive bodies must think about building up of some highland areas, so that during flood situation the rhinos and other animals are given shelters on those highlands and thereby rescued.

13. Animal corridor is the another point which is to be given great emphasis. The prospective animal corridors are to be identified and without disturbing those corridors either underpass or over bridges are to be built. As for example, Eight animal corridor points have been identified in between northern Kaziranga and adjacent southern Karbi-Anglong upland. During flood in Brahmaputra river the animals move to the upland through those eight points by crossing NH 37. Assam Government is considering to built elevated roads and over bridges in those areas(Fig.6.2).

Fig.6.2: *The animal corridors in between KazirangaN.P and Karbi Anglong* (*Red markings*)

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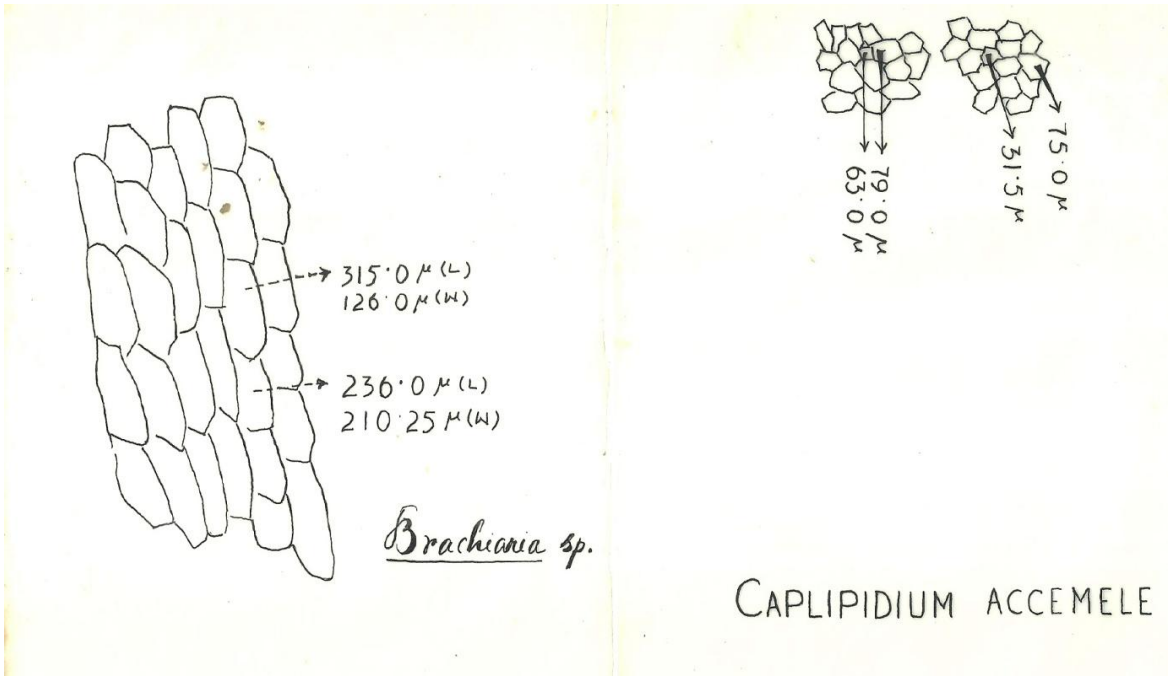
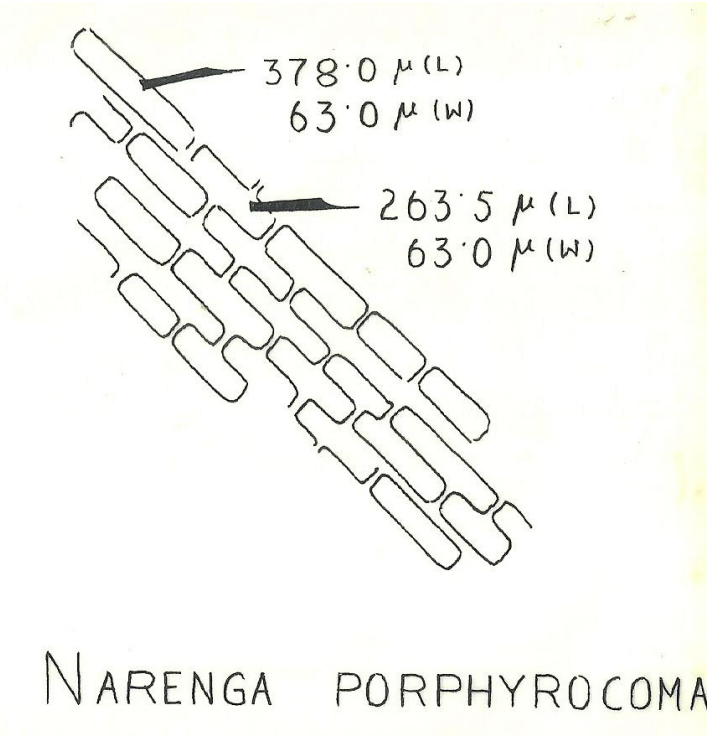
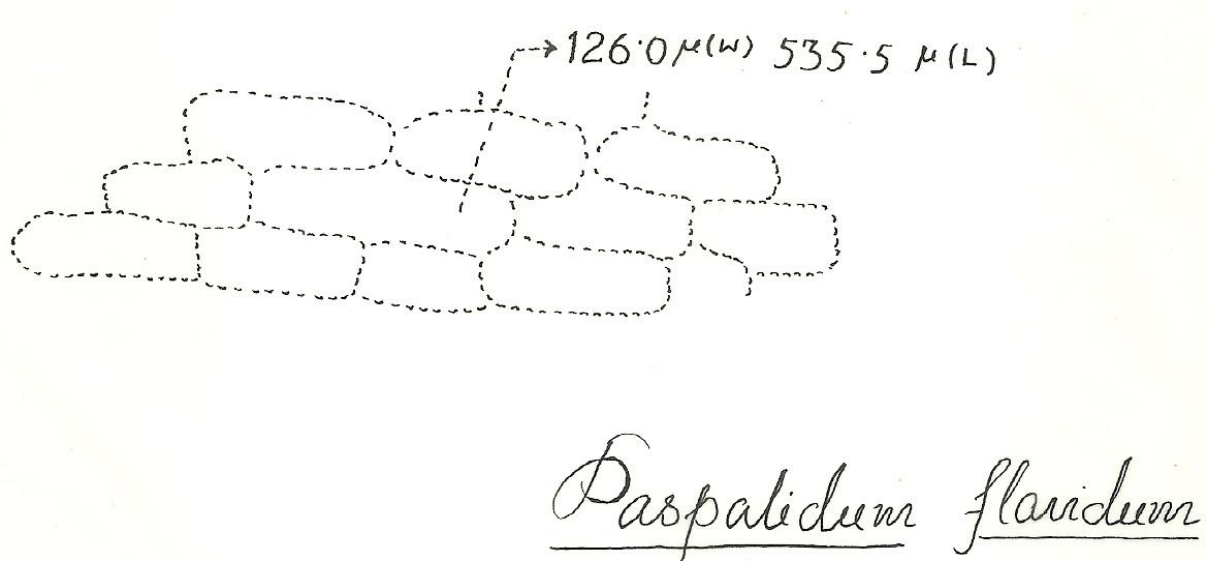
THE END

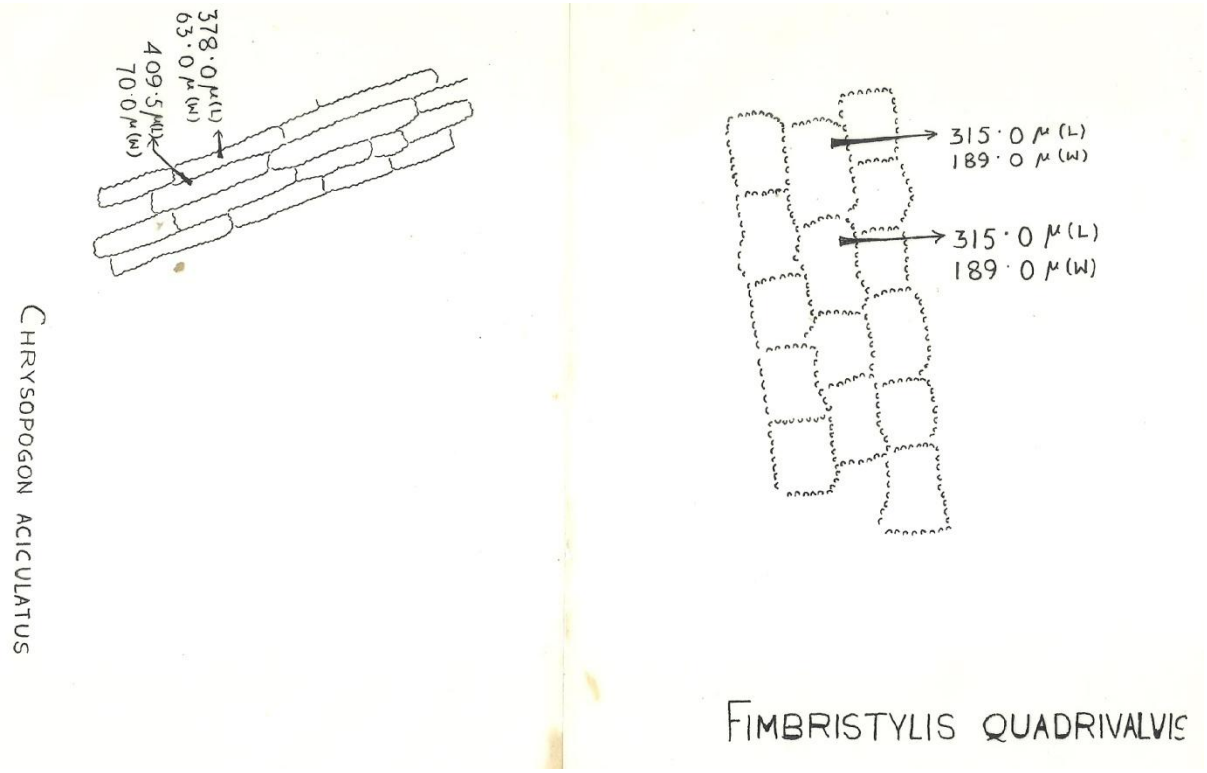
ANNEXURE-I

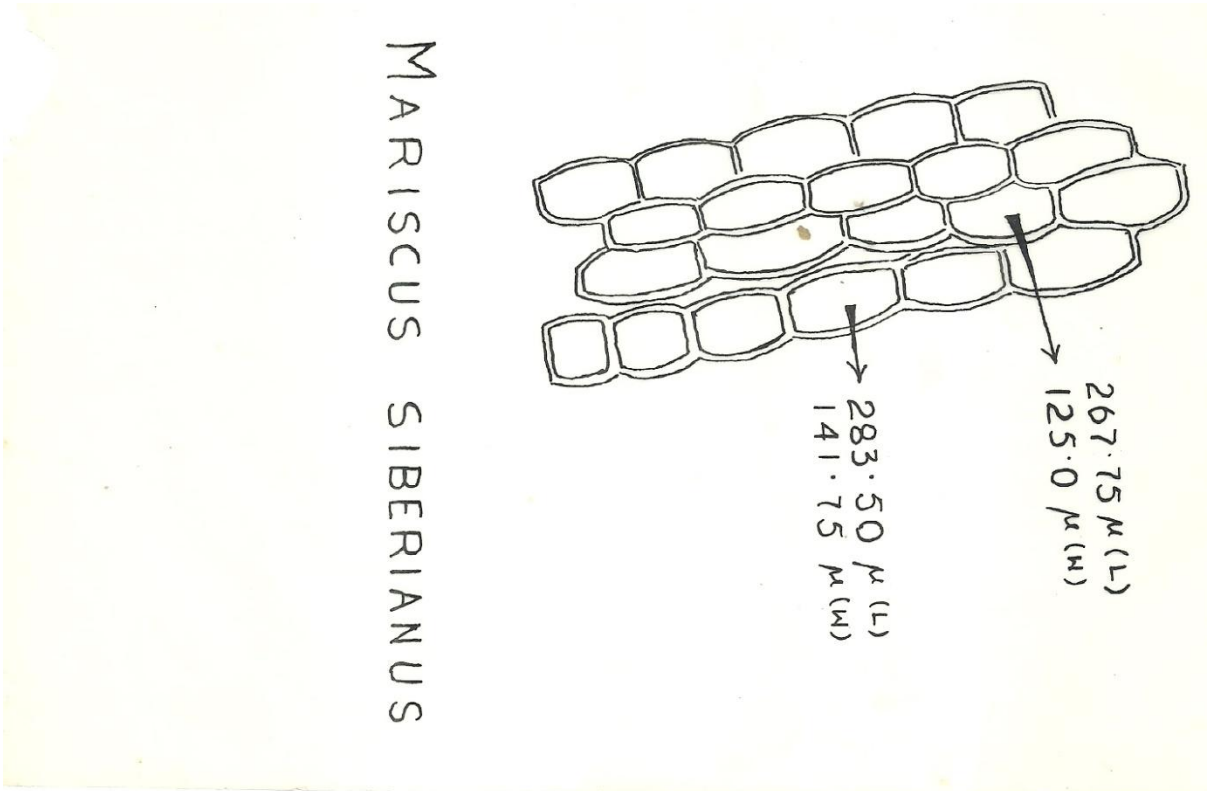
Cell wall structures of some selected fodders of Great Indian one horned rhinoceros

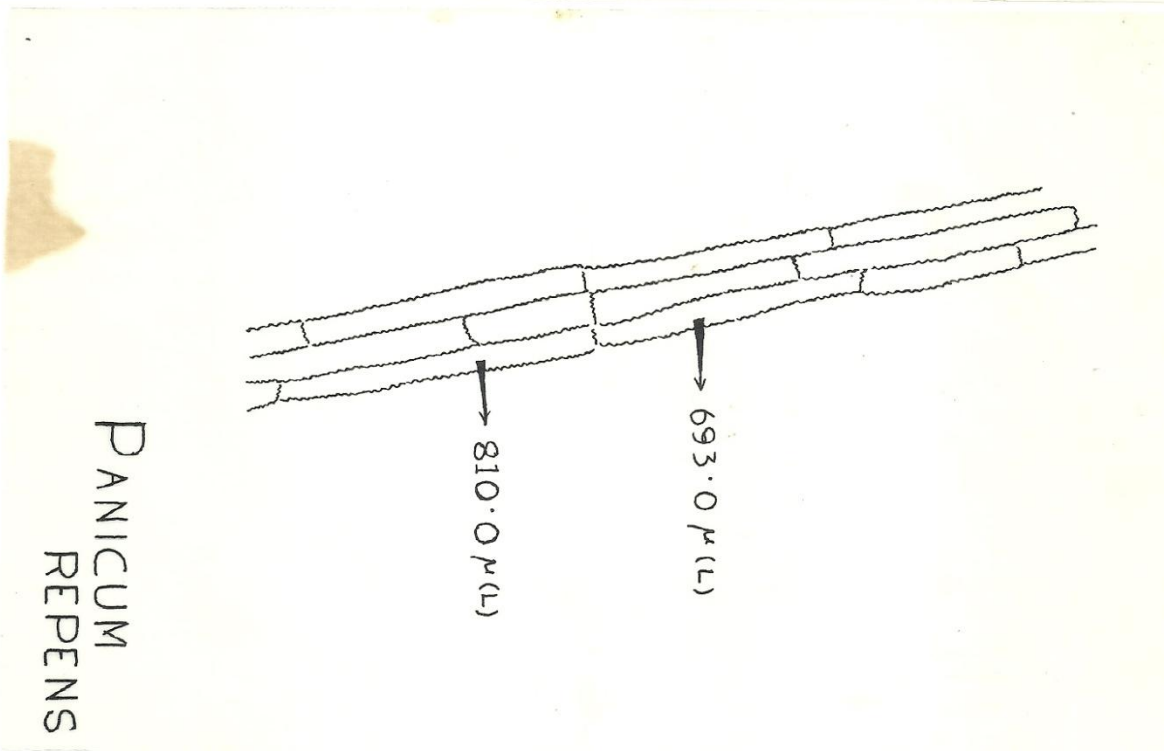


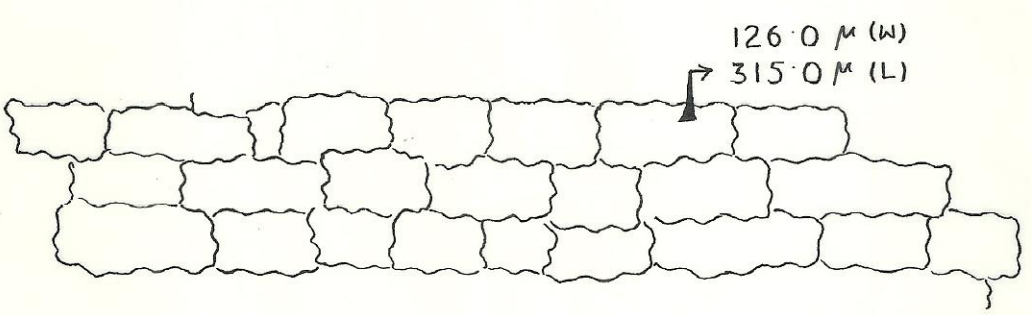



126·0 M (W) 535·5 M (L)
Paspalidum flavidum

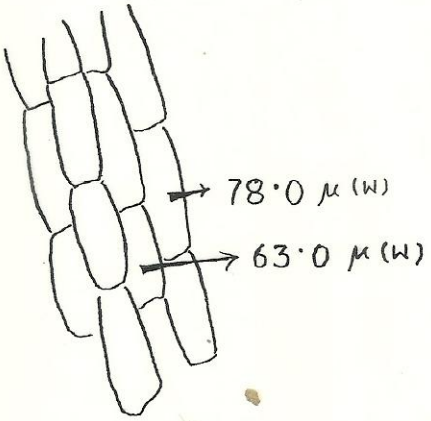

378·0 M (L)
63·0 M (W)
409·5 M (L)
70·0 M (W)
CHRYSOPOGON ACICULATUS
315·0 M (L)
189·0 M (W)
315·0 M (L)
189·0 M (W)
FIMBRISTYLIS QUADRIVALVIS


MARISCUS SIBERIANUS
267·75 μ (L)
125·0 μ (W)
283·50 μ (L)
141·75 μ (W)

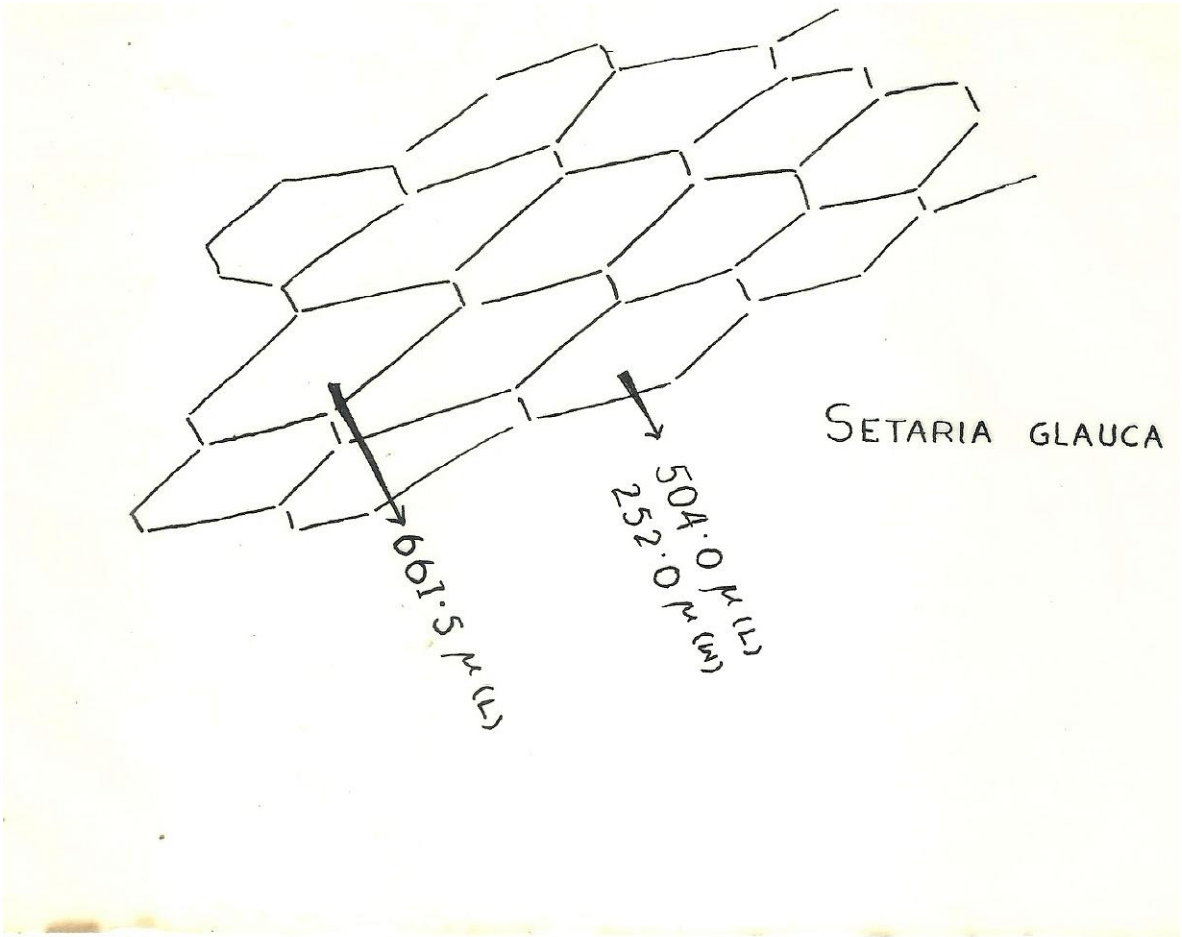

PANICUM
REPENS
810·0 μ (L)
693·0 μ (L)

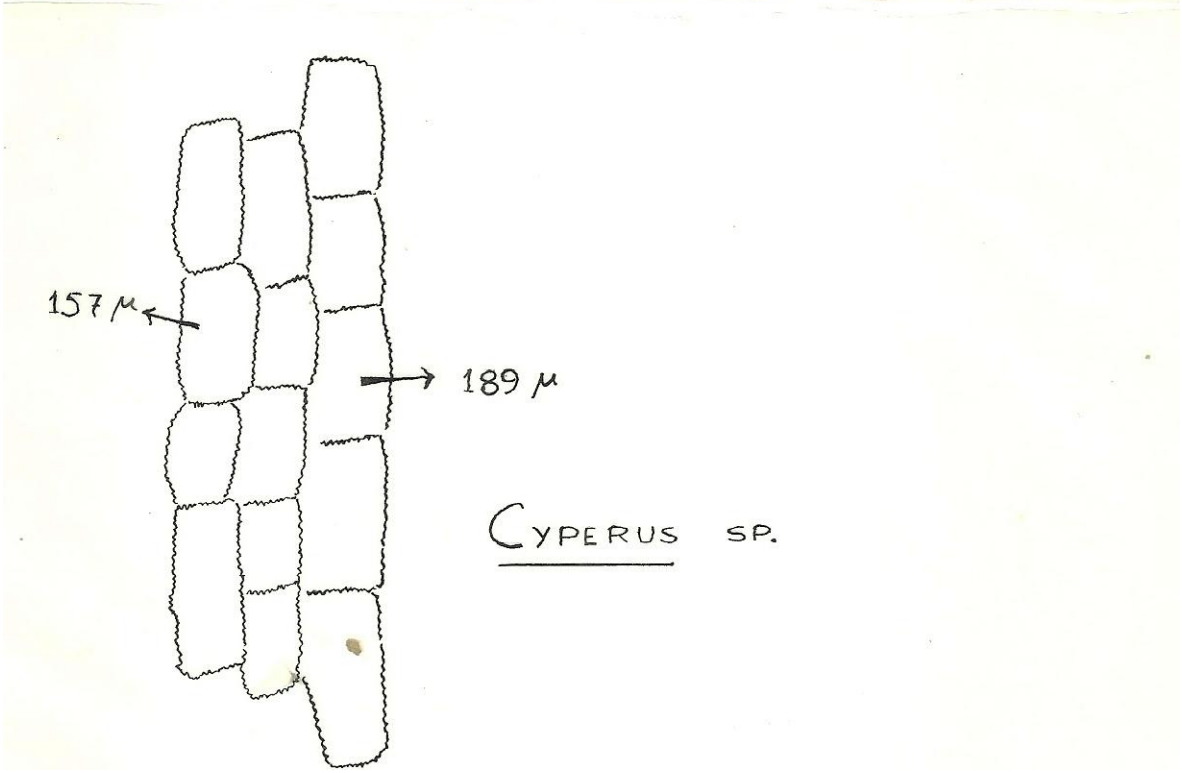


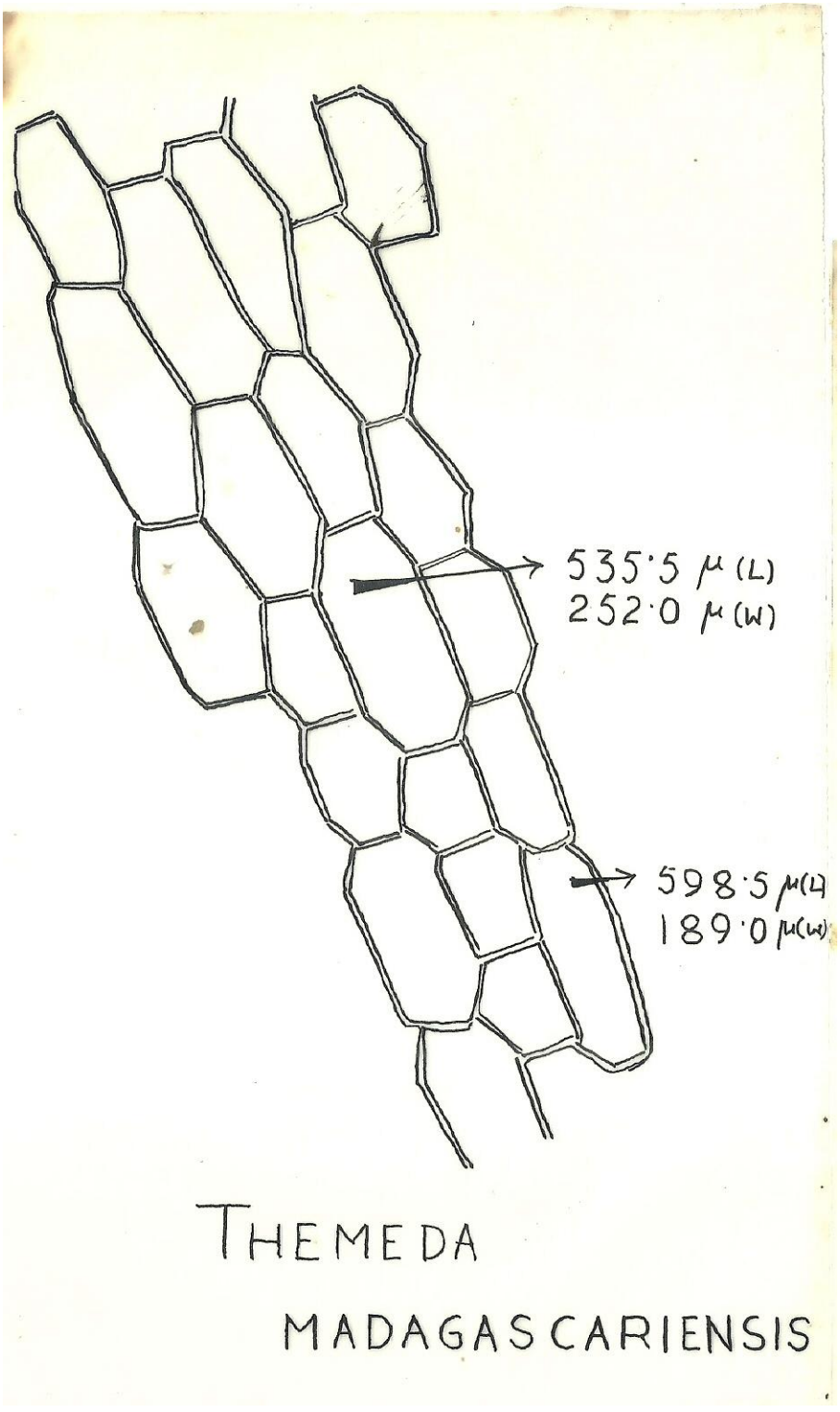
ISCHAEMUM RUGOSUM

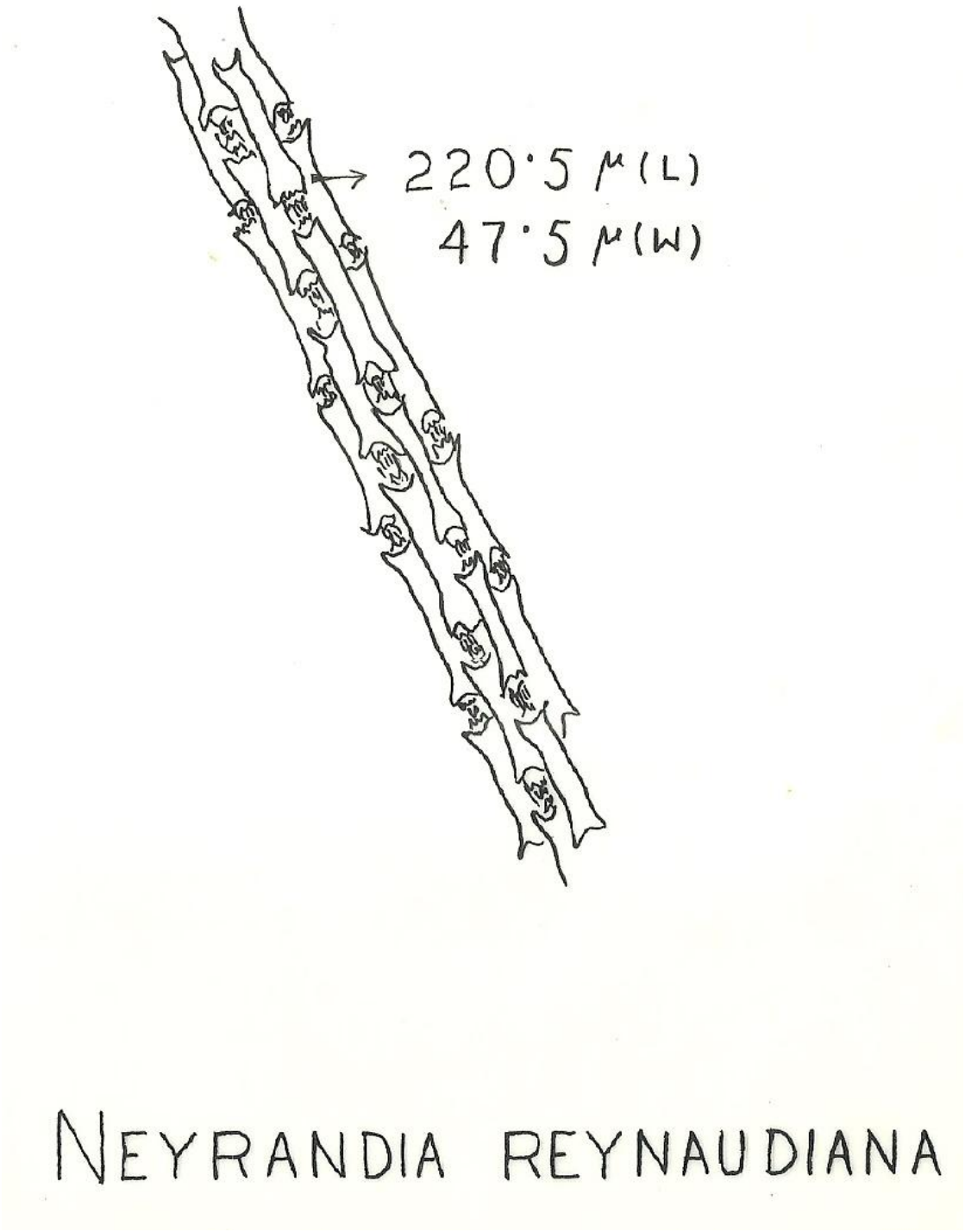


CYPERUS SIBERIANUS


SETARIA GLAUCA
504·0 μ (L)
252·0 μ (W)
661·5 μ (L)


157 μ
189 μ
CYPERUS SP.


535·5 μ (L)
252·0 μ (W)
598·5 μ(L)
189·0 μ(W)
THEMEDA
MADAGASCARIENSIS


220·5 μ (L)
47·5 μ (W)
NEYRANDIA REYNAUDIANA

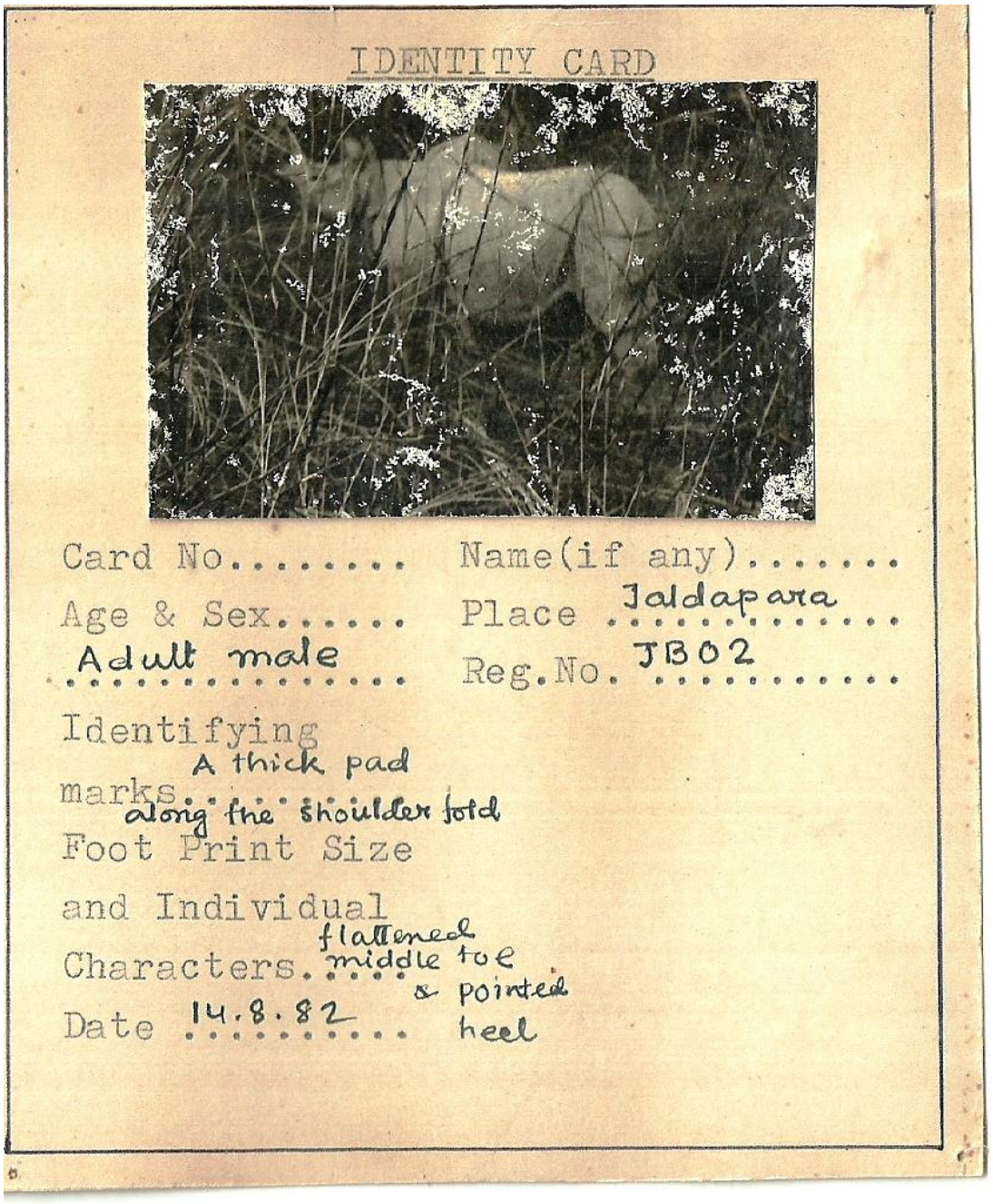
ANNEXURE-II

A few samples of identity cards of rhinoceros

IDENTITY CARD

CARD NO. .....
NAME (if any) .....
AGE & SEX Adult male
PLACE Gorumara
REGISTRATION NO. .....
IDENTIFYING MARKS High frontal bone & deep scars on the left rump.
FOOT PRINT SIZE & INDIVIDUALITIES (with figures) A deep notch at the junction of 2nd and 3rd toe
Date. .....

This adult male could be readily identified by a deep scar on the left rump


IDENTITY CARD

Card No..... Name(if any).....

Age & Sex..... Place Jaldapara.....

Adult male..... Reg.No. JB02.....

Identifying marks A thick pad along the shoulder fold

Foot Print Size and Individual Characters. flattened middle toe & pointed heel

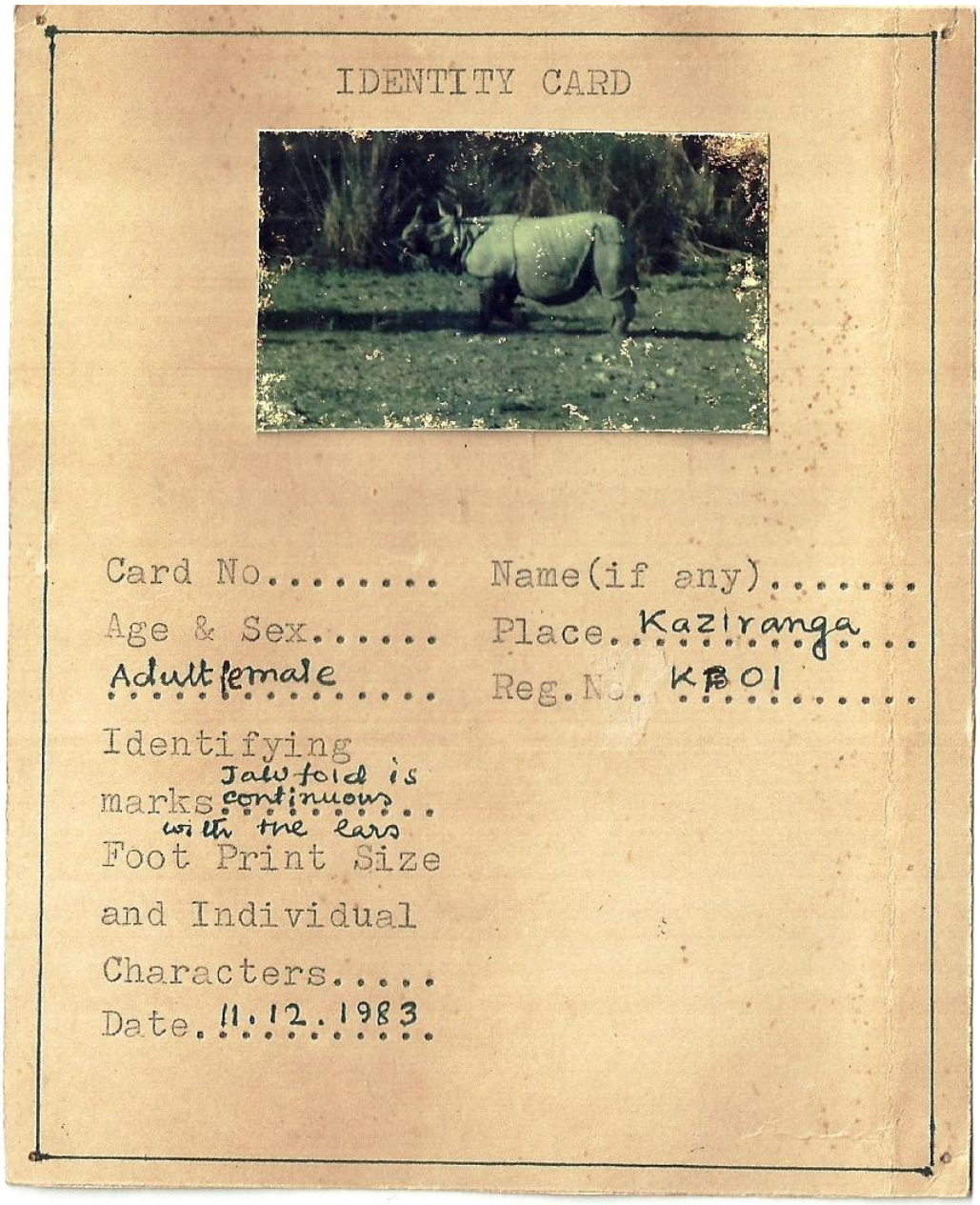
Date 14.8.82.....

An enormous thick pad on the shoulder was the characteristic of this Jaldapara adult male


IDENTITY CARD

Card No..... Name(if any).....
Age & Sex..... Place..Kaziranga.....
Adult male..... Reg.No. KB03.....
Identifying
marks..Cut ear (left).....
Foot Print Size
and Individual
Characters.....
Date..15.3.84.....

This Kaziranga male had left cut ear


IDENTITY CARD

Card No..... Name(if any).....

Age & Sex..... Place..Kaziranga...

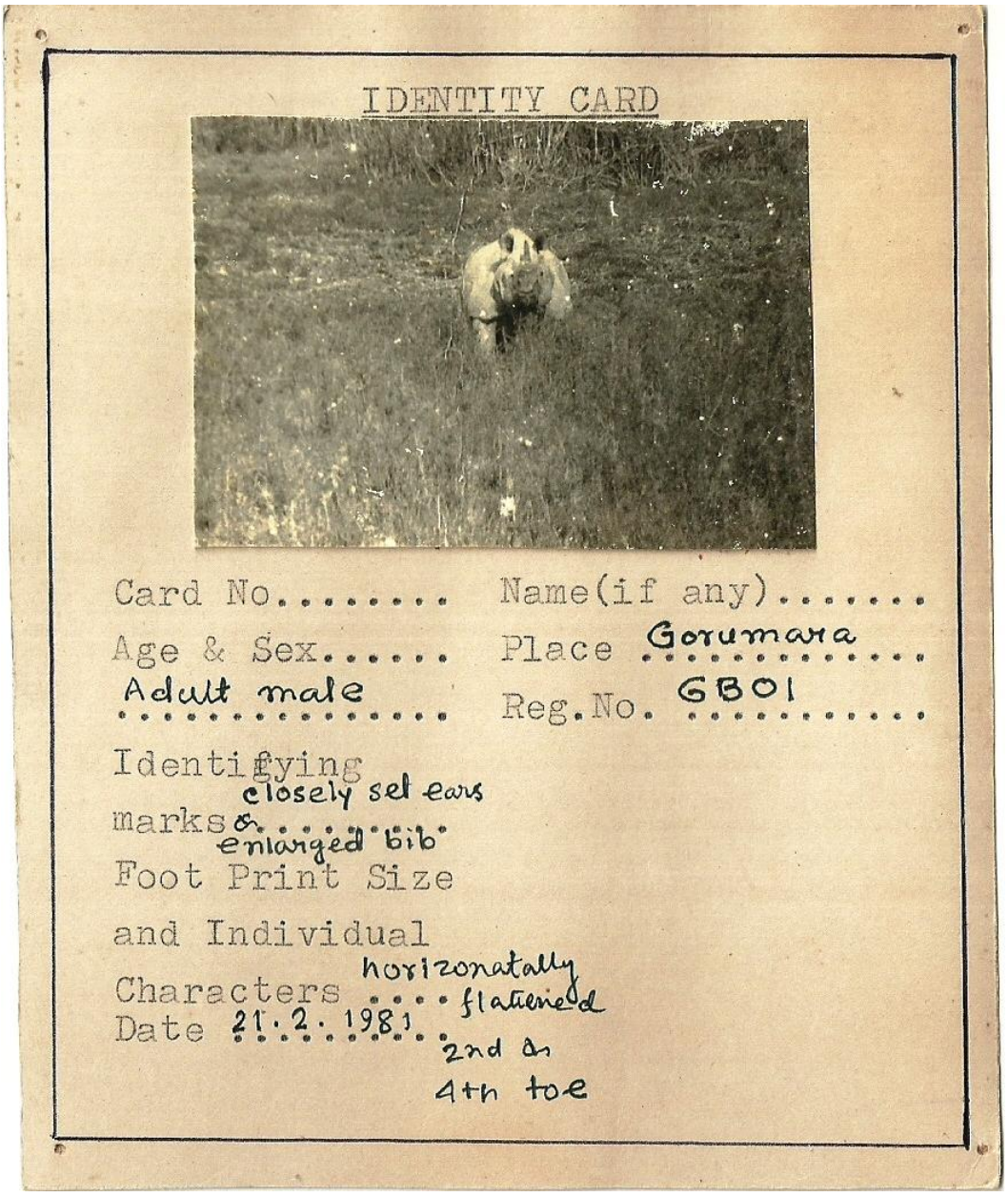
Adult female Reg.No. KB01

Identifying marks Jaw fold is continuous with the ears

Foot Print Size and Individual Characters.....

Date. 11.12.1983

This pregnant Kaziranga female had jaw folds continuous with ears



IDENTITY CARD

Card No..... Name(if any).....

Age & Sex..... Place Gorumara

Adult male Reg.No. GB01

Identifying marks closely set ears & enlarged bib

Foot Print Size and Individual Characters horizonatally flattened 2nd & 4th toe

Date 21.2.1981

This adult male of Gorumara had enlarged bib and closely set ears

ANNEXURE-III

Some published articles in National and International Journals

International Journal of Trend in Research and Development, Volume 5(4), ISSN: 2394-9333
www.ijtrd.com

Over Population, Skewed Sex Ratio and High Homozygosity are the Major Constraints for Better Survival of Indian Rhinos at Gorumara National Park, India

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[2]Associate Professor, Department of Zoology, Gourbanga University, P.O. + P.S. Malada, West Bengal India

Abstract: Over population of Indian rhino in a tiny grassland habitat and skewed sex ratio in favour of male population are posing serious threat to the future survival of rhino population in Gorumara National Park. In addition to that high homozygosity, because of heavy inbreeding during the last 125 years or so in this patchy isolated rhino habitat, is leading to a kind of genetic stagnancy which is not a very good sign for their genetical health. The sex ratio of rhino population at Gorumara is severely imbalanced outnumbering females of reproductive age by the males causing severe infightings among the males to take charge over the fewer females during breeding period. The prime reproductive aged females between 12 to 19 years have the tendency to give birth male offsprings possibly due to better physiological condition. As it has been observed that the females in poor reproductive condition, i.e., in pre prime and post prime breeding ages tend to give birth female offsprings. A male heavy population implies that a smaller and smaller proportion of the reproductive-age population actually contributes to breeding inviting the loss of genetic diversity in the generations to come. A steady solution may be the importing of some healthy strong females from Kaziranga N.P., where high heterozygosity prevails and exporting some adult bulls to Dudwa National Park (U.P.) where practically a single individual is capable of breeding and interchanging three or four male and female rhinos between Gorumara and Jaldapara N.P. to check the genetic stagnancy.

Keywords: *Skewed Sex Ratio, Prime Breeding Age, Homozygosity, Heterozygosity*

I. INTRODUCTION

Constraints about the rhinos of Gorumara: Gorumara was awarded best managed and protected National Park in India in 2009 by Ministry of Environment and Forest, Government of India based on the following facts:

1. Having a very good buffer zone giving a secured inner core zone.
2. Undisturbed habitats
3. Increasing the population of Rhino and other animals
4. Overall nicely managed Park
5. No incidence of poaching during the last six years.

But this increasing rhino population has been creating much pressure on the tiny grassland habitat of Gorumara and this population boom with skewed sex ratio (adult male population outnumbers the adult female population considerably) led much intra-specific male to male aggressions which ended in the deaths of weaker individuals in many occasions. If not death occurred the weaker ones got severe injury or driven out of the park. These incidences kept busy the Park Officials and forest guards because the driven rhinos outside the park area turned vulnerable to the poachers. Over population within a small area becomes sometimes bad as it happens in case of Gorumara.

Observations and Analytical Discussions:

Over population as well as skewed sex ratio of rhino causing much intra specific conflict at Gorumara: The present status of rhinoceros and their future status of population density depends on the demographic ratio of male : female and their age structure which reflects the reproductive ability of rhinoceros (Spillet, 1966). Generally ungulates are promiscuous in case of mating and a single healthy adult bull has the capacity to inseminate three or four females one after another. So the sex ratio of 1 male: 3 or 4 females should be the ideal. For that reason, in a population where there is higher percentage of female, that population is likely to be sustained and a higher reproductive potential is noticed. With this data one can predict the future population status by a simple calculation and can calculate its average net loss or gain annually subject to the carrying capacity limit of that Sanctuary.

Let there be a population of rhino in Sanctuary A containing 5 adult males and 8 adult females and there are 8 adult males and 5 adult females in Sanctuary B and all are within their reproductive age limit. The preconditions are that all the female rhinos are get inseminated and fertilized, no natural death or death due to agonistic interactions occur and also there are no incidence of poaching and emigration. After 16 months (gestation period of Indian rhinos) one can expect maximum 5+ 8+ 8 (calves) = 21 individuals from Sanctuary A and maximum 8+5+5(calves)= 18 individuals from Sanctuary B. Sanctuary A gets a clear cut gain of three rhinos over Sanctuary B. So skewed sex ratio has a direct effect on the population strength of rhino or other ungulates as in the latter case.

But in Gorumara, the average sex ratio has completely overturned from the early nineties when the sex ratio was 1:2 (Bist,1994). Currently, Gorumara is having 51 rhinos, out of which there are 21 adult males, 1 sub adult male, 16 adult females, 1 sub adult female, 10 calves (whose sexes are yet to be identified), 1 non sexed (Basu,2017) and one adult male probably died (?).

This heavily skewed sex ratio (Borthakur,et.al, 2012) can be traced back from the official records since 2005 and since then agonistic interactions in Gorumara gradually took place. The ideal ratio should be 1:3 (Borthakur,et.al,2012) but in Gorumara presently it is 1.31:1. How the sex ratio has been changed chronologically is shown in the Table- 1.1.

Table 1.1: Chronological changes in the sex ratio in Gorumara

Year	No. of males	No. of females	Total population	Sex ratio
1989	4	7	12	01:01.8
1993	4	7	15	01:01.8
1996	2	6	15	01:03.0

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Defecation Behaviour of Great Indian One Horned Rhinoceros (*Rhinoceros unicornis,* Linn.)

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Abstract: ***Great Indian one horned rhinoceros, a large perissodactlyle herbivore, has a peculiar habit of sharing common latrines and thereby, making large dung heaps. This behaviour may have some scent marking relationships among the individuals. Almost 83% initially deposited single defecations latter turned into dung heaps. Preferable locations of dunging areas were usually on or beside the well frequented rhino routes which were more than 86% of all the dunging areas. Among the physical parameters the average size of the complete dung heap is nearly 3 meters and height attains 55 cm (approx.). The span of formation of a complete dung hill is usually 55 days and takes on average 7 droppings. Interestingly, the number of dung balls decreases as the age increases. The estimated dry undigested parts are also less in calves measuring 11.6% but adults were found to contain as high as 14.28% as they are to take less nutritious coarse grasses. On the other hand moisture content is high in calves, almost 82%. In both these cases the sub adults lie in between these two age classes.***

Keywords: defecation, dung hill, dung pile, dung heap, midden, depositions, dunging area, rhino route

1. Introduction

Greater one horned rhinoceros (*Rhinoceros unicornis* L.*)* is a grotesque looking, semi-aquatic, large perissodactyle herbivore, now only confined in Nepal and sub Himalayan northern and north-eastern states of India. Their main home land is tall reeds and grass lands and often they are seen to spend times in swamps and riversides. In adult condition they weigh between 1800 kg to 2700 kg. And they consume 1% on average of their body weight daily (F.V.Houwald, 2016). This animal is of special interest for their defecation and scent marking behaviour which are also common in some mega herbivores like equids, tapirs, elephants, antelopes and south American camelids (Lucas, E. Fiorelli et. al., 2013). Indian rhino has a tendency to defecate in some selected locations (for some days or even months), and as a result of continuous deposition of dung at the same spots, leads to a heap like structures (Bhattacharya, A., 1994 and Hazarika B.C. & Saikia P.K., 2010). Besides scent marking of territories dung and dung piles are reported to indicate the reproductive state of the individuals also. The displays of bulls during defecation and urination depend on their social rank (Owen-Smith, 1975). It is assumed that the sight (Ullrich, 1964), scent (Srivastava, 2015) or both of the previously deposited dung and dung piles stimulate them to defecate. Sometimes the released odour of the fresh dung leads them to move towards those dunging areas following the right tracks and direction. This uncommon behaviour, i.e., the common sharing of the same dung pile with selection of defecation spots is thought to have some deep relations for exhibiting the self-existence to other individuals.

Here, this study mainly concentrates on the clustering patterns of dung piles and selection of defecation spots according to their choice which may have some scent marking relationships among the individuals. Besides, some physical parameters like, measurements of dung heaps, wet and dry weight, dry weight of undigested plant materials according to their age classes were also studied.

2. Study Areas

During the years 1981 and '82 an extensive study was undertaken on different aspects of defecation behaviour of Indian rhinoceros at Gorumara (26°40′ N, 89°00′ E) and Jaldapara (25°68′ N, 89°55′ E) National Parks (the then Wildlife Sanctuaries) under the foot hills of eastern sub-Himalayan region. It was a part of a broader field study on the ecology and behaviour of this animal. They are located in the northern part of the state West Bengal in the district Jalpaiguri (Jaldapara is now located in the district Alipurduar). Gorumara lies at the confluence of Murti and Jaldhaka rivers, on the other hand, Jaldapara is situated on the flood plain of river Torsa. Gorumara is supported by a good buffer zone, whereas, southern part of Jaldapara has got a shape like a trouser owing to the rapid encroachment by the villagers and outsiders (most of them are refugees, displaced from the erstwhile East Pakistan, latter from Bangladesh), resulting a very long boundary, leaving almost no buffer zone.

Apart from core zone Gorumara is predominated by sal (*Shorea robusta*) forest in the buffer zone. Most of the areas of Jaldapara are occupied by mixed riverine forest consisting of sissoo (*Dalbergia sissoo*), sirish (*Albizzia lebbek*), khoir (*Acacia catechu*) etc. intermingled by grassland meadows. Nearest Airport is Bagdogra for Gorumara and Coochbehar for Jaldapara. Nearest rail stations are Chalsa and Hasimara for Gorumara and Jaldapara respectively

3. Methods

Since little direct observation on defecating posture was possible and which was a chance factor also, mainly the tracks and other traces (like dung scrapings and foot dragging with dung particles etc.) of rhinos near the dung

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Study on Group Size and Group Composition of Great Indian one Horned Rhinoceros (*R.Unicornis,*Linn.) at Gorumara, Jaldapara and Kaziranga National Parks, India

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Abstract: ***Greater one horned rhinos are to some extent solitary in nature and they do not maintain any particular group size and age-sex composition in the groups. The group sizes are very much flexible, only excepting mother-calf association. Over all rhino groups consisting of five, six, seven and eight members were rarely seen in all the three study areas in comparison to single, dyads, triplets and quadruple groups. However, Kaziranga rhinos are comparatively a bit pseudo-social because of higher population density. Most probably they form superficial temporary associations during grazing or wallowing. Group size consisting of six, seven and eight members are totally absent at Gorumara and Jaldapara. The bulk of the group sizes observed at Gorumara and Jaldapara were single, dyads and triplets which attained almost 96% and 97% respectively. On the other hand, Kaziranga rhinos were seen in four, five, six, seven and eight groups comprising of more than 12% sighting records. The age-sex composition in larger groups were seen changing frequently. The all male groups sometimes formed temporary associations usually roamed at the periphery with a greater home range particularly at Gorumara and Jaldapara.***

Keywords: Group size, Group composition, dyads, triplets, quadruples, social association. Social groupings

1. Introduction

Indian rhinoceros is generally solitary in nature. But they are seen forming a variety of social groupings which are not at all steady. Basically, adult females are solitary when they are not accompanied by their calves. Sometimes an adult female allows her older calf to give her accompaniment until a newborn takes birth. On the other hand, the adult males are generally solitary but they form dyad during mating or during showing agonistic attitude to their fellow individuals or make triplets, quadruples or more during wallowing or grazing. But they sometimes occur in temporary associations of up to nine rhinos of various sex and age classes. Groups of up to 10 rhinos have been reported sharing a wallowing pool composed of females with their calves encircling a dominant adult male but without any sub adult male (Dinerstein,2003). The adult or sub adult males often feed or rest together but move independently of each other (Laurie et.al.,1983). In one study in Chitwan, Nepal, only 15% of the sightings of Indian rhinos were groups other than cow-calf pairs. Only seven groups consisted of more than three individuals and the most common type of group was comprised of two or three sub adults, usually sub adult males, which had recently left their mothers. The largest group recorded in Chitwan was of six sub adults (Laurie et al. 1983).

Much works have been done on the population studies, demographic patterns and social associations of Indian rhinoceros (Ulrich,1964; Lahan and Sonowal,1973; Laurie,1978; ; Bhattacharya,1991; Foose et.al.,1993; Bhattacharya,1993; Jnawali,1995; Mukherjee and SenGupta,1999; Hazarika,2007). Animals containing social groups have some advantages over the non-social animals like rhinos in relation to the intra specific communication systems such as responses to any visual, auditory and other signals; interdependency on each other, alertness to danger with a prior estimation etc. All these may increase the fitness level for survival. As the rhinos have no strong bondage among the individuals they are somewhat reluctant about the dangers to come.

2. Study Areas

During the years 1981 to 1984 an extensive study was undertaken on different aspects of population and demographic study and social groupings along with other behavioural studies on Indian rhinoceros at Gorumara (26°40′ N, 89°00′ E) and Jaldapara (25°68′ N, 89°55′ E) National Parks (the then Wildlife Sanctuaries) and Kaziranga National Park (26°30′ N, 93°30′ E) under the foot hills of eastern sub- Himalayan region. It was a part of a broader field study on the ecology and behavioural study of this animal. Gorumara and Jaldapara (Plate 1a and 1b) are located in the northern part of the state West Bengal in the district Jalpaiguri (Jaldapara is now located in the district Alipurduar). Gorumara lies at the confluence of Murti and Jaldhaka rivers, occupies an area of about 80 km^2 on the other hand, Jaldapara is situated on the flood plain of river Torsa. Gorumara is supported by a good buffer zone, whereas, southern part of Jaldapara has got a shape like a trouser owing to the rapid encroachment by the villagers and outsiders (most of them are refugees, displaced from the erstwhile East Pakistan, latter from Bangladesh), resulting a very long boundary, leaving almost no buffer zone. Jaldapara embraces an area of 216 km^2 area. Apart from core zone Gorumara is predominated by sal (*Shorea robusta*) forest in the buffer zone. Most of the areas of

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Why Do Indian Rhinos Eat Elephant Grasses

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Abstract: Indian rhinos can live on less nutritious fibrous tall elephant grasses due to their massive body size and heavy weight along with extended surface area resulting lower rate of metabolism. It results in decreasing requirement of food per kilogram body weight. Their hypsodont type of dentition has also been adapted for chewing coarse grasses. These grasses provide them bulk diet but contain much, nearly indigestible, cellulose, hemi cellulose and lignin. Rhino is basically a hind gut fermenter with a much longer small intestine associated with a caecum where the tough fibrous indigestible parts of the elephant grasses are fermented. Increased retention time of food in long small intestine for a complicated fermentation process is the characteristic feature. The large intestine plays the role of absorbing fatty acid and remaining water. Overall, the rate of passing of food is slow. They require huge amount of food per day so they pay very little attention in selective foraging. The ratio of surface area to volume is low in rhino necessitating a smaller caloric intake.

Keywords: *Elephant Grasses, Hind Gut Fermenter, Fermentation, Small Intestine*

I. INTRODUCTION

Being a perissodactyle and hind gut fermenter (Sinclair *et.al*.,2006), Indian rhino has the capability of digesting less nutritious food items (Bell.1971; Jarman,1974), such as, tall elephant grasses which have much amount of cellulose, hemi cellulose and lignin content but less nutritious plant material. Since Indian rhino is a large herbivore, average weight is about 2000 kg, their basal metabolic rate is lower than smaller animals (Clutton-Brock and Harvey,1983). Greater the surface area lower the rate of metabolism, thatswhy, they can manageon roughage fodders. It has been estimated that the nutritional requirements often vary disproportionately with body size. It is again dependent on the seasonal food availability with a fluctuation of their general biology.

Dentition type:

Fig.1 The teeth of rhinoceros showing hypsodont type of dentition

During the course of evolution, Indian rhinos have gradually evolved from browsing to grazing habit. Hypsodont type of dentition (Fig.1) has been gradually developed for chewing coarse grasses. Premolars have been molarified with high crowns embedded in thick enamel content and a facial extension has been occurred. Such dentition type is the characteristic of grazers. The cheek teeth of Indian rhinos fall under the category of "sidewall hypsodonty", which are, actually, dominated by high side walls that are covered with enamel (Koeningswald,2011).

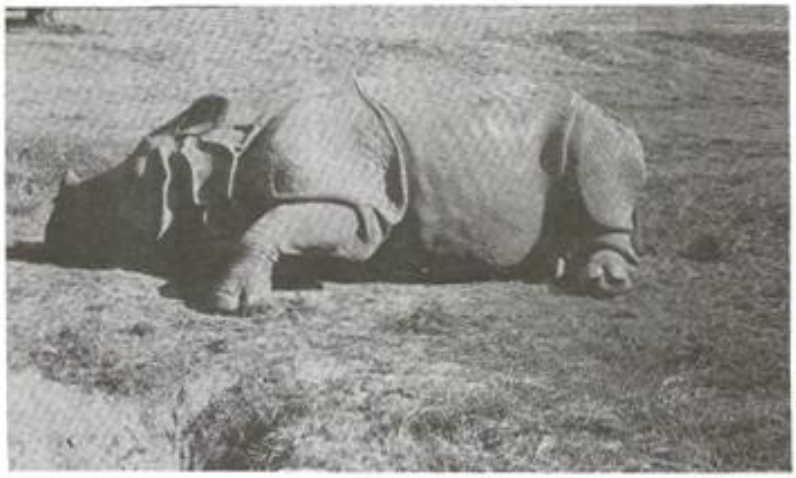
Selection of food plants:

Inspite of that, large herbivores like rhinos who are grazers in particular, in absence of nutritious, succulent food plants are forced to take taller plants. The taller plants provide a bulk diet, giving a support for their height and weight though those plants possess much cellulose and lignin. As for example, cellulose percentage is found highest in *Imperata cylindrica* (61.01 ± 4.61), followed by *Phragmites karka* (57.30 ± 4.61) and *Saccharum spontaneum* (57.24 ± 4.28) respectively which are very well known rhino fodders (Thakur *et.al.* 2014). On the other hand, in the low level plants, which are more nutritious and low in lignin and cellulose content, the rate of hourly intake is very low and does not provide much energy. So the large herbivores usually like feeding on the intermediate sized plants.

The process of digestion:

The large herbivores like rhinoceros evolved a much longer small intestine with a side pocket, known as cecum at the distal end of the small intestine just to ferment a fairly large amount of cellulose, hemi cellulose and lignin or other undigested food residues.The small intestineis associated with an increased retention time (Sinclair,*et.al*.,2006) which takes a complicated fermentation process in the hind gut. For doing this they have also been adapted using microorganisms such as bacteria, protozoa and fungi to digest non digestible matters by fermentation (Chivers, *et.al.,*1994). Food materials must be retained in a fermentation chamber long enough for the microorganism to cause fermentation before moving into the large intestine.The calculated mean retention times of fluids and particles in the whole gastrointestinal tract averaged 42 and 61 h, respectively, and were the longest ever recorded in a monogastric ungulate (Clauss,*et.al*.(2005). The small intestine plays a major role in breaking down of foods by enzymatic actions followed by absorption into the bloodstream.

The large intestine plays two main roles,1) absorb most of the remaining water into the body again to get rid of dehydration and 2) at the end of the fermentation in cecum the short-chain fatty acids produced are absorbed and utilized, thereby providing energy. Endo,*et.al*.(2000), in an anatomical case study of African white rhinoceros (who are also grazers), have shown that the cecum may be functionallyreplaced by the well developed colon which may act as themain fermentation tank in this animal. The same feature has also been observed by Stevens and Hume (1995).The absorption of microbial protein is little known.However, the hindgut fermenters like rhinos are to some extent less efficient than the ruminants who can digest high fibrous foods, but since only indigestible parts are



Subadult male rhino (Photo: Bhattacharya)

THE STATUS OF THE KAZIRANGA RHINO POPULATION

by Amal Bhattacharya

Introduction

Kaziranga (93° 30'E, 26° 30'N) has been considered to be the safest homeland of the Great Indian one horned rhinoceros (*R. unicornis* L) for many years. The story of the Kaziranga rhinos is a landmark in India's conservation history.

In the nineteenth century, Assam's rhinos had been hunted almost to extinction when the plains were cleared for tea plantations. By 1908, when the hunting of rhinos was declared illegal, only a dozen rhinos were left there. But the first effective measures were taken by declaring it as "Kaziranga Wildlife Sanctuary" in 1932. At the Mysore Conference (Indian Board for Wildlife, 1952), the executive committee of the Indian Board for Wildlife first recommended to make it a National Park by creating a buffer zone surrounding the area. According to that recommendation, the Assam State Government, by a gazette notification, soon after duly created such a buffer zone surrounding Kaziranga, which lowered the poaching incidences significantly (Gee, 1955). The years that followed recorded the successful management efforts of the forest officials and staffs. This excellent rhino habitat was declared a National Park w.e.f. 1st January, 1974.

Study Area

Kaziranga enjoys a great natural boundary, the river Brahmaputra, along its north side which becomes furious from June to October every year. During my first visit in 1984, I saw much of the lower lying grounds under water even in late November. Numerous tributaries of the river Brahmaputra flow through the Park, creating many permanent 'bheels' or lakes. The soils are all alluvial deposits of the Brahmaputra and its branches. The vegetation is mixed grasslands and riverine woodlands, with grasslands predominating in the west. Tall grasses are common on higher grounds and short grasses grow on the lower grounds surrounding the

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SOME NEW ASPECTS OF PRE AND POST DEFECATING BEHAVIOUR ASSOCIATED WITH SCENT MARKING RELATIONSHIP IN GREAT INDIAN ONE HORNED RHINOCEROS

By

Amal Bhattacharya

Summary

Indian rhinos are used, occasionally, to do some unusual pre and post defecating behaviour iike change of tracks, earth and dung scraping, foot dragging etc. apart from normal behaviour. Each such behaviour is expected to have some related reasonsl i.e. either hiding or exhibiting themselves. The dung piles are usually made by the defecations deposited by different individuals of different age classes. The rhinos possibly do communicate among themselves by dispersing scent in air either from pedal scent gland or from deposited dung and urine.

Introduction

The Great Indian rhinoceros *(R. unicornis* L.*)* has a peculiar defecation behaviour by making large dung piles in some selected spots and using the same defecation places over and over again. It is assumed that the sight[18], scent or both, of the previously deposited dung or dung piles stimulates them to defecate. Sometimes, the released odour of the dung leads them to move towards the dung piles. This uncommon behaviour, i.e., common sharing of the same dung pile with selection of defecation spots, is thought to have some deep relation for exhibiting self existance to other individuals. Defecation habit is known to have been reported on Indian [6,10,17], Sumatran[4], Javan[13] and African black[7,9,12] and white[11] rhinoceros. In the present study, some new interesting pre and post dropping behaviour patterns of Indian rhinoceros which were paid little attention before have been reported. Selection patterns of new and previous dunging areas for defecation according to their

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