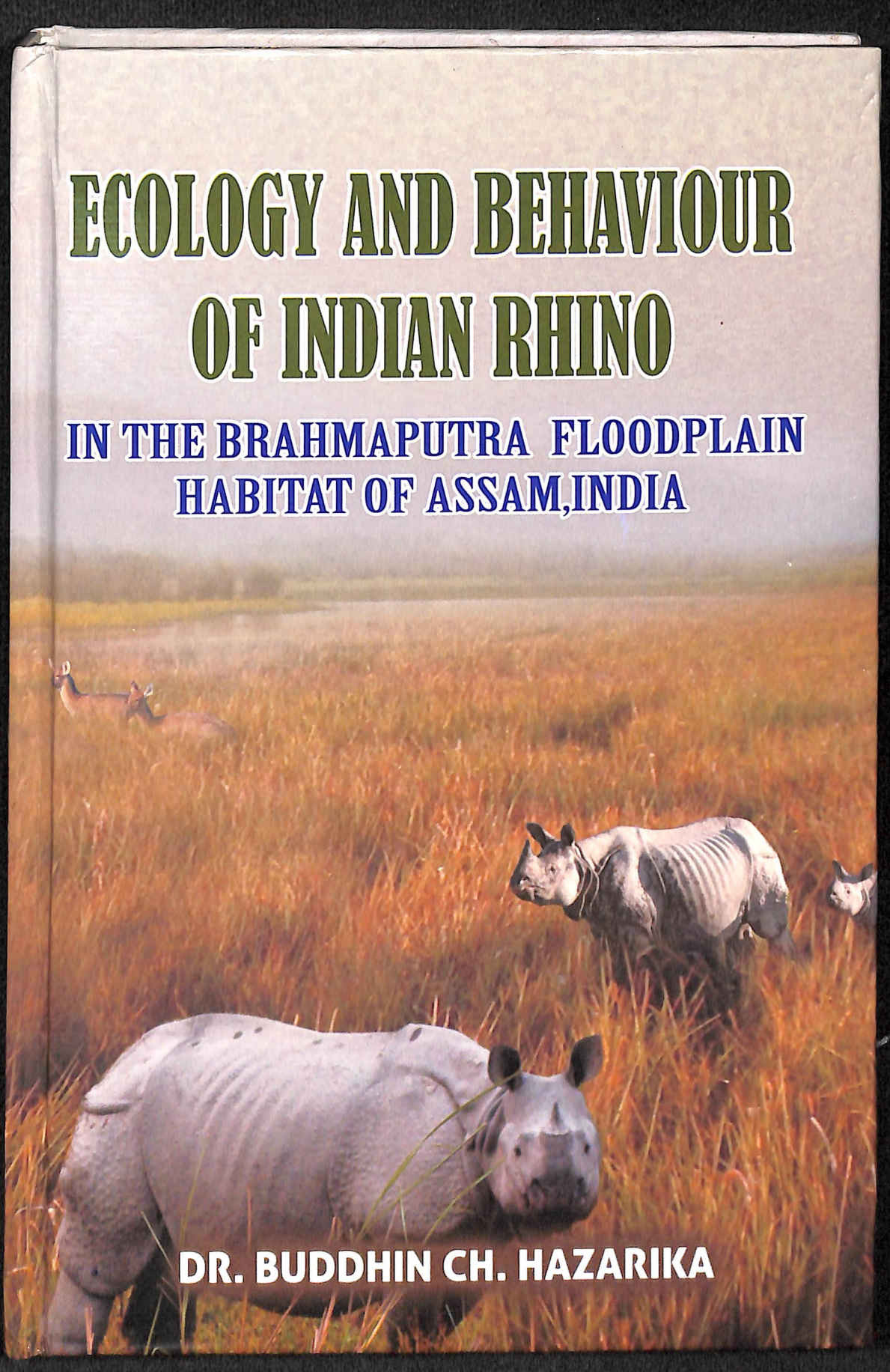
ECOLOGY AND BEHAVIOUR OF INDIAN RHINO

IN THE BRAHMAPUTRA FLOODPLAIN HABITAT OF ASSAM,INDIA



DR. BUDDHIN CH. HAZARIKA

ECOLOGY AND BEHAVIOUR OF
INDIAN RHINO
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Dr. Buddhin Ch. Hazarika

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PREFACE

The Indian Rhino, which is the state animal of Assam is one of the vulnerable (IUCN), Schedule-I [Wildlife (P) Act, 1972], animals in the world. The animal, which has been related with both the life and lore of the people of Assam is associated both with respect and superstition. Although, the animal has been known to people since time immemorial, but very less actual scientific studies have been conducted on this majestic animal in modern times.

Assam, which is proud to host the largest population of Indian Rhinos in the world has seen few, if any detailed studies being undertaken on the natural life of the animal and its behaviour. Although, a few books are available to the public on the Indian Rhino in Assam, most of them tend to be a general introduction to the species and not a detailed information source on the Indian Rhino in Assam itself. However, a few wonderful pieces of work are available for the student in the form of research papers and dissertations, but they are limited to the University libraries and students of the subject only.

The idea for this compilation came, through a discussion among family members and friends about the need for a detailed guide to the behaviour of the Indian Rhino during one of my discussion session with my friends. When, this idea was shared with renowned publisher Mr. Nabin Baruah, he immediately accepted the idea and stated his full support for the plan. The idea was for the book to be a compilation of abridged research papers on various domains of the Indian Rhino in the form that it is useful both as a ready reckoner as well as a source of research material for students of the subject.

Mr. Baruah moved immediately to put the plan into action. Mr. Mahesh Deka and Mr. Madhab Bordoloi started the work of typesetting and compiling research papers into the book format. It is largely due to the hardwork put in by Mr. Baruah, Mr. Deka and Mr. Bordoloi that this compilation has been possible. My guide during my Doctoral research Dr. Prasanta Kr. Saikia and my friends Mr. Abhijit Rabha IFS, Dr. Abhijit Bora and Mr. Bhrigu Prasad Saikia who contributed with their valuable suggestions and support both during my research work and during the compilation of this book.

I hope that this compilation would be accepted by the people who have special interest in the Indian Rhino and the research fraternity inspite of its inherent shortcomings. I would consider my work more than successful if the wildlife lovers consider studying more on this magnificent animal and if I am able to bring more students into the field of research on this precious animal. Suggestions and comments are always welcome both about the book and my research in general as it is with my readers' support that I would be able to plug my shortcomings and continue my work in the future.

Guwahati,
22 December, 2011

Buddhin Ch. Hazarika

ACKNOWLEDGEMENT

Writing a few words of acknowledgement cannot justify the immense support of all the people involved in this venture, still as a matter of custom, I would like to put on record their support as a minor sign of gratitude.

At the outset, I would like to put on record the immense support of Mr. Prasanta Kr. Saikia, Professor, Gauhati University, my research guide for my Doctoral thesis as well as my friend. In addition to this, I would like to acknowledge the support of my educators of Dept. of Zoology, Gauhati University especially Prof. P.C. Bhattacharyya who were always there for support and guidance whenever I needed them.

The youth of the present generation exhibit exceptional talent as well as dedication and it is due to the support of a few dedicated energetic youths namely Dr. Abhijit Bora, Bhrigu Prasad Saikia, Sandeepan Das, Dr. Bhaskar Saud and Pranjit Sarma that this effort has been possible.

Friends, as true to their nature are always present to support when needed and it is due to the support of my few close friends namely Mr. Abhijit Rabha, IFS, Dr. Prabal Sarkar who put in their time and effort in supporting me in every step of this venture.

The support of Mr. C.R. Bhobora IFS, Mr. S.P. Vashistha IFS, S. Momin AFS, DFO, Wildlife Division, Mangaldai and Mr. P. Deka, J. Deka, Ranger and staff of Orang National Park is gratefully acknowledged.

I would also like to acknowledge the support of the Staff of my parent institution Mangaldai College for their immense support and help in all my ventures.

Mr. Nabin Baruah, publisher and proprietor of Purbanchal Prakash deserves a special mention for his personal efforts which he put into this compilation. The support of Mr. Mahesh Deka and Mr. Bordoloi who put in their time and effort for the compilation and formatting of the book is immense and deeply acknowledged.

I would like to acknowledge the support of my parents, my wife Chandrama and my two sons Angshuman and Pratyushman who were a part of every hurdle and success in this venture.

Finally, I would like to ask for the forgiveness of all those who could not be personally mentioned but it is with the support of all the non-mentioned people that this work has been printed on paper for presentation to the people.

Buddhin Ch. Hazarika

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Chapter – I

INTRODUCTION

The Great Indian One-horned Rhinoceros (*Rhinoceros unicornis* Linn. 1758), the most primitive mega herbivore species, represents the vanishing group of ungulate, is confined to a few protected areas of India and Nepal. Earlier, the Great Indian One-horned Rhinoceros (hereafter, written as Indian Rhino) was widely distributed throughout the Indo-Gangetic plains and its neighbouring countries. The past distribution range of the species was extended from Sind Province, Peshawar (Pakistan) in the west to North India, Nepal and extending up to Assam and Myitkina (now Myanmar) in the east. It includes the areas of alluvial floodplains as well as the nearby foothills (Terai regions) of South Asia from Indus to the Ganges and the Brahmaputra River Valley (Prater, 1971; Laurie, 1978, 82; Choudhury, 1985; Dutta, 1991; Ghosh, 1991). At the end of the seventeenth century, it had completely disappeared from most of its distribution ranges except Nepal, West Bengal and Assam. The present distribution of Indian Rhino is limited to certain pockets of the Himalayan Terai region (Chitwan-Rapti Valley) in eastern Nepal, Jaldapara Wildlife Sanctuary and Gorumara National Park of Ganga and Teesta Valley and Kaziranga National Park, Orang National Park, Manas National Park, Pabitora Wildlife Sanctuary, Burachhapori Wildlife Sanctuary and Laokhowa Wildlife Sanctuary of the Brahmaputra Valley of Assam (Prater, 1971; Laurie, 1978; Dutta, 1991; Ghosh, 1991). At present, almost 71% of the total global population of Indian Rhino is distributed in the Brahmaputra Valley alone, where Kaziranga National Park itself harbours more than 2201 (as per 2009 Census, Government of Assam) individuals

of Indian Rhino. The Royal Chitwan National Park of Nepal has the second largest global population (about 600 individuals) of the Indian Rhino (Foose and Emslie, 1999) surviving at present. However, the present existence of the Indian Rhino in Manas National Park is doubtful and the population of the Indian Rhino from Laokhowa and Burachhapori Wildlife Sanctuaries were completely wiped out in recent times (*Table : 1.1*). The sightings of Indian Rhino from Bhutan Manas were also sporadically reported (Choudhury, 1985), but no such authentic records of any viable population of Indian Rhinos are available from Bhutan Manas. (*Fig. 1.1*)

Location			Existance of Rhino	Habitat Characteristics		Population sizes
Country	State	Protected area		Flood plain	Grassland types	
Nepal		Chitwan NP	Y	Y	Terai	600 (1999)
India	UP	Bardia NP	Y	Y	Terai	52 (1999)
		Dudhwa WLS	Y	N	Terai	21 (1999)
	WB	Jaldapara WLS	Y	Y	Terai & Riverine	53 (1999)
		Garumara NP	?	?	Terai & Riverine	19 (1999)
	Assam	Manas NP	Y	Y	Terai & Riverine	Unknown
		Kaziranga NP	Y	Y	Riverine	1649 (1999)
		Orang NP	Y	Y	Riverine	46 (1999)
		Pabitora WLS	N	Y	Riverine	76 (1999)
		Laokhowa WLS	N	Y	Riverine	Locally extinct during 1983
		Burachhapari WLS	N	Y	Riverine	Locally extinct
		Sunai-Rupai WLS	N	Y	Terai & Riverine	Locally extinct (long back)

Abbreviations : NP=National Park, WLS=Wildlife Sanctuary, Y=Yes and N=No. UP=Uttar Pradesh, WB=West Bengal, ?=No present record of existence.

Table : 1.1– The present distribution status, habitat occurences and population size of Indian Rhino.

The Indian Rhino is severely threatened by hunting, owing to superstitious belief and the high demand and value of its horn in the national and international markets. Therefore, only a very small population (above 2899 individuals) of the Indian Rhino is presently surviving in the world. If this process of hunting and trading continues, the Indian Rhino will become extinct from its natural habitat within a very short period of time. Hence, the Indian Rhino has been

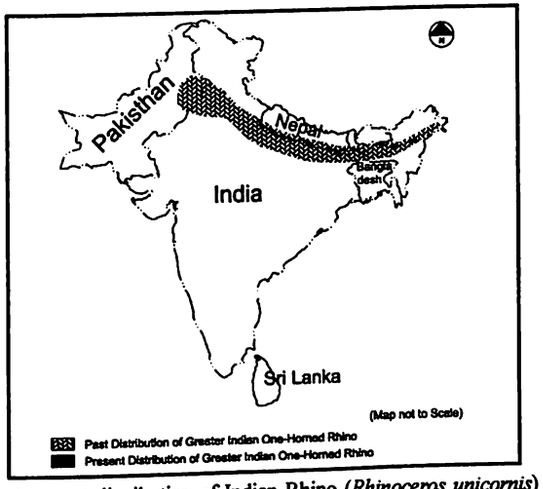

Fig-1.1 : Past and present distribution of Indian Rhino (*Rhinoceros unicornis*) in South Asia

enlisted in the Appendix-I of the IUCN Red Data Book and Schedule-I of the Indian Wildlife (Protection) Act, 1972 to conserve this precious endangered species.

Grassland Habitat

Grasslands, the prime habitat of Indian Rhino, are composed of approximately 24% of the global vegetation structures (Smith, 1996) and covering almost 20% of the total land surface (Murthy and Sanjappa, 2002) are now in declining trend. Apart from rhino, this grassland habitat supports a wide variety of animal species occupying at different habitat strata, of which, the Indian Rhino, the Asiatic Wild Elephant, Wild Buffalo, Deer and Royal Bengal Tiger are the most important mega-herbivore and carnivorous species respectively and identified as the flagship species of grassland community. In India, about 3.9% of the total land surface is occupied by grassland habitats, which are mainly seral in nature and has a great diversity. Those grassland habitats of Indian sub-continent are distributed in the semi-arid and arid grasslands of Deccan peninsula and Rajasthan, waterlogged grasslands of Terai belt, the rolling shoal grasslands of hill tops of Western Ghats and the high-altitude temperate-alpine grasslands of Himalayas (Murthy and Sanjappa, 2002). The Terai grassland zones of India are located at the foothill zones of the Himalaya (Uttaranchal, Uttar Pradesh and Bihar), whereas the Indo-Gangetic and Brahmaputra floodplain grassland

that comprises *Phragmites-Saccharum-Imperata* and *Themeda-Arundinella* type grasslands is located in alluvial soils of the river valley of Ganga and Brahmaputra (Dabadghao and Sankhanarayan, 1973). Owing to unambiguous habitat characteristic and climatic condition, each grassland habitat supports wide varieties of wildlife fauna, of which, the wild buffalo, tiger and deer are the most commonly found wildlife species in the grassland habitats of India. But due to large-scale destruction of grassland habitat and habitat alteration, the species inhabited in grassland habitats are threatened to population decline.

Studies on Rhino

A number of studies have been carried out on Indian Rhino covering different aspects of population status and ecology in Terai grassland of Nepal (Laurie, 1978, 1982; Patar,1980; Jnawali, 1986; Moe, 1993; Stracey, 1957; Gee 1959; Pelinck and Upreti, 1972; Dinerstein and Price, 1991), West Bengal (Bist, 1994), flood-prone plain grasslands of Kaziranga National Park (Lahan and Sonowal, 1973; Choudhury, 1985; Mukherjee and Sengupta, 1999; Gee, 1953a & b; Patar,1977, 2005) and Orang National Park (Bhattacharya, 1983) of Assam. Apart from that, the study of *Rhinoceros unicornis* was also done in captivity to know its biology and behaviour (Mackler, 1975; Mackler and Buechner, 1978; Lang *et al.*, 1977; Bhattacharyya and Goswami, 1987; Chowdhury, 1966; Buechner *et al.*, 1975; Bhatia, 1971; Bhattacharyya, 1991; Ripley, 1967; Venugopal *et al.*, 1994). The historical evidence of its distribution patterns (Rookmaaker, 1983, 2002; Choudhury, 1985), the aspects of seed dispersal caused by rhinoceros (Dinerstein and Wemmer, 1988; Dinerstein, 1991) were also studied in details. The various aspects of conservation issue of Indian Rhinoceros were studied by Bhattacharya and Pal (1982) in Brahmaputra flood-prone plains.

However, majority of the studies were confined either in captivity or at the Terai grassland habitat of Nepal and India. But very little attempt was made to study the ecology and behaviour of the Indian Rhino in Brahmaputra flood-prone plain habitats. Recently, an attempt was made to translocate the Indian Rhino from Kaziranga National Park to Manas National Park during July, 2005 to June, 2008 as a part of conservation programme of Indian Rhino in Assam,

with the support of the World Wide Fund for Nature and the International Rhino Foundation. But, for the successful translocation and rehabilitation programme, a comprehensive knowledge of its biology, ecology and behaviour is very much essential.

The present study was carried out to evaluate the basic knowledge of biology, ecology and behaviour of the Indian Rhino in Brahmaputra Valley, particularly in Orang National Park for future conservation perspectives of the Indian Rhino in its present distribution ranges.

Objectives of the study

The present study emphasises the ecology and behaviour of Great Indian One-horned Rhinoceros in Orang National Park. The knowledge of the ecology and behaviour of *Rhinoceros unicornis* is very much essential for the filling up of its lacunae of conservation implication of the species throughout its distribution range. The following objectives were taken for the present study:

1. To find out the habitat selectivity, habitat utilisation pattern, home range area and activity budgeting of the *Rhinoceros unicornis* in Orang National Park in different seasons of the year.
2. To find out the food habit and feeding behaviour of *Rhinoceros unicornis* in the Orang National Park.
3. To investigate the behavioural activities of the *Rhinoceros unicornis* during breeding and non-breeding periods of the year.
4. To find out the threat factors of the *Rhinoceros unicornis* to draw the habitat specific conservation strategies for this endangered species.

Selection of Orang National Park as study site

The study of the ecology and behaviour of Indian Rhino in Orang National Park was selected for various reasons. At first, the Orang National Park is the representative type of the Brahmaputra flood-prone plain grassland habitat and the only protected area of the northern bank of the river Brahmaputra, where a viable population of Indian Rhino still survive. Secondly, like other flood-prone plain

grassland the Orang National Park is affected by flood every year, which has an ecological significance in maintaining the grassland habitat, coupled with existing enormous number of water bodies such as wetlands, rivers and streams etc.

Species account of the family Rhinocerotidae

The family Rhinocerotidae is one of the oldest groups of land mammal in the world. They have survived over 50 million years. In the past, there were several species of Rhinoceros in different parts of the world. At present, only five species of rhinos are representing the family Rhinocerotidae in the world (Table-1.2). These are namely, the Indian Rhino (*Rhinoceros unicornis*), Sumatran Rhino (*Dicerorhinus sumatransis*) and Javan Rhino (*Rhinoceros sondicus*) found in Asia, while the Black Rhino (*Diceros bicornis*) and White Rhino (*Ceratotherium simum*) are found in Africa. The African Rhino could easily be differentiated as they bear two sharp long horns, while the Asian Rhino has single horn. Although Sumatran Rhino (*Dicerorhinus sumatransis*) has one more fold like horn rear and near to the first horn, it is blunt and the body size of the rhino is also quite smaller as compared to that of the African Rhino. Moreover, the body size of Black Rhino is almost equal to that of the Indian Rhino and the White Rhino is the biggest of all and the shape of its mouth is also quite different.

(a) African species

There are two sub-species of African White Rhino, namely Northern White (*Ceratotherium simum simum*) and Southern White (*Ceratotherium simum cottoni*), while the African Black Rhino has four sub-species viz. Southern minor (*Diceros bicornis minor*), South West bicornis (*Diceros bicornis bicornis*), Eastern michaeli (*Diceros bicornis michaeli*) and Northern longipes (*Diceros bicornis longipes*).

The Southern White Rhino represents over 60% of the surviving rhinos of the world (Table–1.3). This species is lucky enough as successful efforts have been made for its conservation, similar with that of the Indian Rhino. The northern sub-species of White Rhinos are one of the three most critically endangered species of rhino with less than 28 individuals of surviving population size.

Table – 1.2: Variations of the world Rhinoceros species

Group	English Name	Species
African Rhinoceros	Northern White	*Ceratotherium simum simum*
	Southern White	*Ceratotherium simum cottoni*
	Southern Minor	*Diceros bicornis minor*
	South West Bicornis	*Diceros bicornis bicornis*
	Eastern Michaeli	*Diceros bicornis michaeli*
	Northern Longipes	*Diceros bicornis longipes*
Asian Rhinoceros	Javan Rhino	*Rhinoceros sondaicus sondaicus*
		Rhinoceros sondaicus annamiticus
	Sumatran Rhino	*Dicerorhinus sumatransis sumatransis*
		Dicerorhinus sumatransis harrisoni
	Great Indian One-horned Rhino	*Rhinoceros unicornis*

The Black Rhinos had a population size of about 70,000 in 1970. Since then, it declined rapidly and ultimately attained a population size of 2300 individuals during early 1990 (Foose & Emslie, 1999). At present, the population size of Black Rhino is slightly in increasing trend (Table –1.3).

b) Asian Rhino

The Indian species have no sub-species variation (Table – 1.2). The most critically endangered of all species of the Asian Rhino is the Javan Rhino with a population size of only 29-47 as on June-2009, Hariyadi et.al (2011) individuals. At present, there are two populations of Javan Rhino, one is Indonesian (*Rhinoceros sondaicus sondaicus*) population and other one is Vietnamese (*Rhinoceros sondaicus annamiticus*) population. The other Asian Rhino is Sumatran Rhino, also known as Asiatic Two-horned Rhino (*Dicerorhinus sumatransis*). Though the population size (Table – 1.4) of the Sumatran Rhino is greater than that of Javan Rhino, its population is highly fragmented and less secured. There are also two populations of Sumatran Rhino, one is *Dicerorhinus sumatransis sumatransis* and the other is *Dicerorhinus sumatransis harrisoni*, distributed in Malayasia, Sumatra, Sabah and Borneo, with a population size of about 300 individuals.

Table-1.3 : Population status of African White Rhino (*Ceratotherium Simum*) and Black Rhino (*Diceros bicornis*) as of 2010. (*Source:* The IUCN Red list of threatened Species).

Species	White rhino				Black rhino					Total
Subspecies	C.s.cottoni (northern)	C.s.simum (southern)	Total WR	Trend	D.b.bicornis (south-northern)	D.b.michaeli (eastern)	D.b.minor (southern-central)	Total WR	Trend	Total B&W
South Africa		18,796	18,796	Up	171	60	1,684	1,915	Up	20,711
Namibia		469	469	Up	1,750			1,750	Up	2,219
Kenya	4	361	365	Up		594		594	Up	959
Zimbabwe		290	290	Down			431	431	Down	721
Botswana		135	135	Up			7	7	Stable	142
Tanzania						88	25	113	Up/Down?	113
Swazilan		88	88	Up			17	17	Stable	105
Zambia		7	7	Enhanced			27	27	Stable + In	34
Malawi							24	24	Up	24
Uganda		9	9	Up						9
Mozambique		6	6	Down			1	1	Min	7
Angola					1			1	Min	1
Totals	4	20,161	20165		1,922	742	2,216	4,880		25,045
Rounded	4	20,160	20170		1,920	740	2,220	4,880		25,050

Table –1.4 Status of Sumatran Rhino (*Dicerorhinus sumatransis*) as per 2009 census

Country	Population size
Indonesia	170 – 230
Malayasia	100 +
Laos	?
Thailand	?
India, Myanmar Bangladesh	10*
Borneo	> 50 Sabah

? = No proper survey; * Present population size is doubtful

The Indian Rhino had a population size of only 366 individuals in Kaziranga National Park in 1966, but now its population size has increased up to 2201 individuals. Out of total 2899 individuals of Indian Rhino, Assam harbours about 1850 individuals. Hence, Assam is also called as the 'The Land of Rhino' and the only stronghold for conservation of Indian Rhino.

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Chapter – II

REVIEW OF LITERATURE

Background

A large number of information on Indian Rhinoceros were available since historical times and most of them were available in various journals, magazines, mythological dialogue and in epics. Being an old civilization, the Indian customs and beliefs are also associated with a few of the most important wildlife species, especially, the Asiatic elephant, Asiatic lion, Royal Bengal Tiger, Indian Rhino and deer species. Apart from that, the Indian Rhino has been accepted by the people of Assam as the State animal. Thereafter, it has got a definite aesthetic, economic and conservation value. However, very little information are available on the ecology and behaviour of this species, although, the State of Assam itself harbours almost two third (about 71%) of the global population size of the Indian Rhino (Asian Rhino Specialist Group Report, 1999).

Past history of the Indian Rhino

The earliest historical document of the Indian Rhino is the old Carved Seal from the Indus Valley civilization (Mohan-Jo-Daro and Harrapa civilization), way back in 3000 B.C. (Dutta, A.K. 1991; Gee, 1964). The fifth pillar Edict of the Emperor Ashoka, built during 300 B.C., also indicated about the Indian Rhino. In the *Chandogya Upnishad* (900 BC), the Indian Rhino was described as an animal like elephant and buffalo, lived in marshes and grazed on river banks of India (Rao, 1957). According to Prater (1971) and Van Strien (1974), the people believe that the rhino horn bears poison detecting property and hence, the poison detecting cups

were made from rhino horn by the ancient kings. Even today, many people believe on such superstitions, which might have been the primary cause of rhino poaching activity. Stracey (1949, 57) described that the Indian Rhino was domesticated in Assam and was used for ploughing as well as in battle field. Ali (1927) and Guggisberg (1966) documented the killing of the Indian Rhinos near the border of Kashmir by the invader, Taimur in 1398, hunting by Babur near Peshwar in 1519 and by Jahangir and other Moghul kings during the period from 1605 to 1627.

Past distribution

The first detailed scientific description of the Indian Rhino was made by Person in 1743 about the second Indian Rhino brought to London during 1739 (Laurie, 1978, 82). Gee (1951, 1953a, 1953b, 1959, 1963), Rookmaaker (1980, 1982) and Choudhury (1985) described about the past and present distribution of Indian Rhino within the Indian sub-continent, including Nepal and Pakistan, and also about the abundance of Indian Rhino in West Bengal, Assam, Bihar (India) and Nepal. Bist (1994) described the historical distribution of the Indian Rhino in North Bengal. In Myanmar, the past distribution records of the Indian Rhino were enumerated by Lwin (1998). Choudhury (1996) described the past distribution of the Indian Rhinos in different localities of the Brahmaputra Valley and also enlisted stray records of the species outside the protected areas of Assam. Stracey (1949, 57) described about the vanishing status of the Indian Rhinos from the wildlife sanctuaries of Assam during his period. Dutta (1991) has documented that the live specimens of Indian Rhino were exported from India to Portugal during the year 1513, which was the first record of the Indian Rhino exported to the European country.

Morphometric study

Gee (1953a & 1953b) studied the biology as well as the comparative account of the body measurements of the Indian Rhinoceros, the height, weight and length of calves, collected from Calcutta, Nepal and Assam (Kaziranga National Park). Dinerstein (1991) made a description of the sexual dimorphism and variation in body measurements of the adult rhino with respect to age and sex class.

Trading and poaching

Talukdar (1995) reported the poaching trend of the Indian Rhino in Orang National Park while Vigne and Martin (1991, 1994) have reported the information of poaching intensities of Indian Rhino throughout the State of Assam. Martin (1996) reported the details of smuggling and trade routes of the rhino horn from West Bengal. Martin *et al.*, (1987) reported the overall poaching and trade of rhino horn in India. Menon (1996) briefly described the poaching, trade route and the use of the rhino horn in traditional medicine. Menon and Kumar (1998) summarized the details of smuggling techniques, crime and trade related laws of the Indian Rhino and other wildlife species in India.

Population and distribution

Gee (1953, 64), Lahan (1973, 74), Choudhury (1985), Dinerstein (1991), Hussain (2001) and Talukdar (1995, 2000, 2002) gave an account of the population status, demography and conservation threats of the Indian Rhino in Assam and West Bengal. Shebbeare (1953) made a brief description of the status of the three species of Asian Rhino. Bairagee (2004) described the population status and mortality rate of the Indian Rhino in Pabitora Wildlife Sanctuary. The census report of Indian Rhino in Jaldapara Wildlife Sanctuary was briefly described by Mukherjee and Sengupta (1999).

Disease and health

Arora (1986), Bhattacharjee and Halder (1971), Bhattacharya *et al.*,(1992), Bordoloi *et al.*, (1990), Islam (1994) and Chakravorty *et al.*, (1993) made a description of the diseases, genetic aspects and various other health problems of the free ranging and captive population of the Indian Rhino in different zoos of India. Nandi (1972) described the horn cancer of the Indian Rhino, whereas Islam (1994) studied about the gastro-intestinal parasites like *Strongyle sp.* in the free ranging Indian Rhinos in Orang National Park.

Ecology and behaviour

The information regarding the biology of Indian Rhino is very limited. The lone study on this aspect was carried out by Bhattacharyya (1991) in Assam. Bhattacharya (1982) described the home range and daily movement pattern of the Indian Rhino at

Jaldapara Wildlife Sanctuary and Gorumara National Park of West Bengal. Choudhury (1966), Brahmachary (1969), Dinerstein and Wemmer, (1988) and Dinerstein (1991) studied the food habits and seed dispersal pattern of the Indian Rhino in India and Nepal. Bairagee (2004) descried the food preferences of the Indian Rhino in the grasslands of the Pabitora Wildlife Sanctuary. The diet and habitat, used by the Indian Rhinos during dry season, were studied by Fjellstad and Steinheim (1996) in Royal Bardia National Park, Nepal. Dinerstein and Price (1991) studied the demography and habitat use pattern of the Indian Rhino in Terai grassland habitat. The effect of the changes of land use pattern and the habitat suitability index of the Indian Rhino at Kaziranga National Park were studied by Kushwaha *et al.* (2000). Again, the behaviour of the Indian Rhino was briefly described by Gee (1953a & b). Mary *et al.* (1998) studied the feeding and territorial behaviour of the Indian Rhino in Kaziranga National Park of Assam.

Although various researchers studied the Indian Rhino in different aspects, the detailed information regarding the ecology and behaviour of the Indian Rhino is very scanty. The remarkable study on the ecology of the Indian Rhino was conducted by Laurie (1978, 82) in Nepal. He covered all the aspects of ecology and behaviour, such as population dynamics, diurnal time budgeting, food and feeding, reproductive and social behaviour of the Indian Rhino in Chitwan National Park of Nepal. Similar study was also conducted by Ghosh (1991) at Jaldapara Wildlife Sanctuary of West Bengal in his doctoral research. Jnawali (1995) has studied the population ecology, dietary composition, variation of the home ranges of male and female Indian Rhino in Royal Bardia National Park of Nepal and compared the food plants with the Chitwan National Park for his doctoral research. All those studies were done at Terai grassland habitat. However, no such in-depth studies on ecological works were conducted in Brahmaputra flood-prone plain habitat. Bhattacharyya (1991) in his doctoral research emphasised only biological aspects, but provided less information on the ecological aspects in Kaziranga National Park. In the dissertation by Bhattacharya (1983) (during wildlife management diploma course) there is a brief description on the habitat types of the Indian Rhino in Orang National Park. Patar (1977) in his

M.Sc dissertation emphasised on the food habit of the Indian Rhino in Kaziranga National Park. Banerjee (2001) in her M.Sc dissertation worked on chemical composition of the selected food plant species of Indian Rhino in Kaziranga National Park. Deka (2003) has evaluated the nutritional contents of prime forage items of the Indian Rhino in Pabitora Wildlife Sanctuary and Assam State Zoo-cum-Botanical Garden.

Captive population

Buechner and Mackler (1975), Mackler and Buechner (1978), Buechner *et al.*(1978) described the breeding behaviour of the captive Indian Rhino and Cow-calf relationship in captivity. Bhattacharyya *et al.*, (1987) has provided some information on parturition process, neonate and maternal behaviour of captive rhino. Ali (1927, 1958), Tong (1962), Chowdhury (1966), Bhatia and Desai (1971), Krishne (1969), Lang (1977), Reed (1974), Rookmaaker (1979), Sabharwal (1989) and Misra (1993) described the calf birth and breeding behaviour of captive Indian Rhino in various zoos. Venugopal (1994) gave an account of the activity pattern of the Indian Rhino of the Mysore zoo. The record of birth in captivity in Kathmandu was first described by Hodgson (1834). In Assam, Kakati (1972) and Rajkonwar (1985) described their observation on the reproduction of the captive population of the Indian Rhino. Report on hand rearing of the Indian Rhino at Hamburg zoo was described by Hegenbeck (1969) in Washington. Dixon (1981) described the social interactions and development of the sexual behaviour of the Indaian Rhino in captivity.

Re-introduced population

A number of studies were conducted on the reintroduced population of the Indian Rhino in the Royal Bardia National Park of Nepal and in Dudhwa National Park of India. Schenkel (1983) analysed the habitat suitability index, while Hajra & Shukla (1982) studied the botanical aspects of the Dudhwa National Park for re-introduction of the Indian Rhino. Singh & Rao (1984), Sale & Singh (1987), Singh (1985), Sinha (1991, 94), Sinha & Sawarkar (1991a & b, 94) and Sinha *et al.*, (2001) studied on the success of re-introduction and management of the Indian Rhino in Dudhwa National Park. Jnawali & Weggee (1993) studied the space and habitat use, while Bauer

(1988) studied the successes of the re-introduction of the Indian Rhino in Royal Bardia National Park of Nepal.

Present scenario in Brahmaputra Valley

The Brahmaputra flood-prone plain habitat supports two-third of the total population of the Indian Rhino. But, no such major ecology and behavioural study was conducted on Indian Rhino in the Brahmaputra flood-prone plain habitat till date. Hence, the present study tried to cover the ecology and behaviour of the Indian Rhino with reference to the conservation perspectives of the Indian Rhino in the Brahmaputra flood-prone plain habitat. Very recently, the Wildlife Trust of India initiated the rescue operation and rehabilitation programme of rhino, and one three-year-old hand rearing female rhino was translocated to Manas National Park in collaboration with the Department of the Environment and Forests, Government of Assam. The WWF-India, in collaboration with the International Rhino Foundation, US Fish and Wildlife Service and the Department of Environment and Forests, Government of Assam, is planning to translocate the Indian Rhino in Manas National Park, which was an excellent habitat for the Indian Rhino since its disappearance in 1993.

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Chapter – III

GENERAL STUDY AREA AND METHODS

Introduction :

The chapter deals with the detailed description of the study area, physiography and location, climate, vegetation structure and the status of Indian Rhino population in Orang National Park. The various standard methods, used for the study of ecology and behaviour of the Indian Rhino in Orang National Park, are also included in this chapter.

Study area :

Location :

The Orang National Park (co-ordinates, 92°15′-92°27′E and 26°29′-26°40′N) is situated in the north bank of the river Brahmaputra and within the administrative boundary of Udalguri and Sonitpur districts of Assam, India (*Fig.3.1*). The study area is located about 130 km apart from the State capital city, Guwahati and included under the jurisdiction of Mangaldoi Wildlife Division, Department of Environment and Forests, Government of Assam, India.

Physiography

The eastern side of the study area is bounded by Borsola area and the river Brahmaputra of Sonitpur district, th southern side by the river Brahmaputra, th western side by the tributary Dhansiri and Bogoribari village and the northern side is bounded by Nalbari and Rongagora villages of Darrang district.

The study area comprises alluvial flood-prone plains of the river Brahmaputra. In fact, the complete study area is an alluvial terrace and the entire Orang National Park could be divided into two halves i.e. lower Orang and upper Orang. The lower Orang

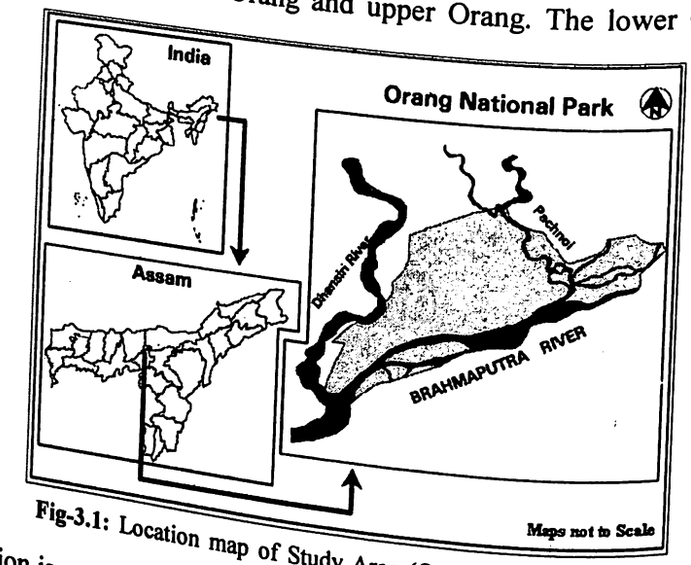

Fig-3.1: Location map of Study Area (Orang National Park).

portion is more recent origin, whereas, the upper portion to its north is separated by high bank, traversing the park from east to west. The terrain is gently sloping from North to South. The altitude of the study area ranges between 45-75 m MSL.

Historical background

The name *'Orang'* owes its origin from the Assamese word 'OOR' which means 'the end' (Saikia, 2005). Historically, it was the end of the eastern boundary (demarcated by river *Panchnoi*) of the King "*Arimatta or Vaidyadeva*" , who reigned after the Pal Dynasty during 12th century A.D. in former Kamrup district, whose capital was 'Rangiya' (Gait, 1967; Choudhury, 1987). According to some local people of the study area, the name 'Orang' came from the ethnic group of 'tea labour' brought from Orissa by the British tea planters, whose ancestors are still residing in the outskirts of the Orang National Park. The entire protected area was a human habitat till the last decade of the 19th century (Talukdar and Sharma, 1995). Prior to declaration of Orang as a 'Game Reserve' in 1915,

different ethnic groups occupied the entire study area. (Plate – 1) The existence of 26 man-made ponds and the Shiva temple inside the park are the evidences of the past human settlements within the present study area. The prevalence of water-borne epidemic type of disease forced them to abandon the area prior to 1900 A.D. (Talukdar & Sharma, 1995). As the inhabitants abandoned the villages, the whole area was converted into an excellent habitat for various wildlife species. Two large tributaries of the river Brahmaputra - Dhansiri and Panchnoi, associated with a number of streams and *nullah* that criss-cross the park, became the source of water for the entire habitat.

The Orang National Park is the last refuge of the Indian Rhino *(Rhinoceros unicornis* Linn. 1758*)* in the northern bank of the river Brahmaputra, Assam, India. The area harbours 68 numbers (as per, Census Department of Environment & Forest, Government of Assam, 2006) of Indian Rhino.

Present scenario as protected area

The present protected area (Orang National Park) was first declared as a 'Game Reserve' covering an area of 80.54 km² in the year 1915, and was a part of Mazbat Forest Range under Darrang Forest Division, Assam. In the year 1931, an area of 17.29 km² was de-reserved from the northern boundary of the reserve to settle some immigrants from Mymensingh district of East Pakistan (now Bangladesh) under the scheme of '*Grow more food.*' From that year onward (i.e. from 1931), the Bor's working plan (*Taungya system*) was started (Saikia, 2005). As per the norms of the system, an area was allotted to each family for plantation purpose in exchange of fodder and grazing facilities for their cattle. Subsequently, softwood tree plantations were started from 1942-52 and 1952-62. This process continued till 1962 through Afforestation Division of Hojai (Nagoan, Assam). During 1972, the planted area was handed over to the wildlife wing of the State Forest Department and ultimately, the area was included as an 'Auxiliary area' of the Project Tiger. During 1985, the Game Reserve was upgraded to a status of Wildlife Sanctuary covering an area of 75.60 km². During the year 1991, an area of 3.21 km² was added to it by evicting encroachers from Government land and ultimately, the total area became 78.81 km².

Finally, the sanctuary was upgraded to a National Park during 1999. (Plate – 1)

Climate

The climate of the study area is meso-thermal humid climate of Brahmaputra Valley type. On the basis of the seasonal variation of temperature, rainfall and humidity, the climate could be divided into four distinct seasons, such as pre-monsoon, monsoon, re-treating monsoon and winter (Borthakur, 1986).

a) **Pre-monsoon** (March- May): It is a transitional period between relatively dry winter and hot summer and is characterized by a rapid rise and fall of temperature. The minimum and maximum temperature during this season ranged between 20° and 32°C. The average relative humidity was 67-85% and the average rainfall was 390 mm during the study period.

(b) **Monsoon** (June-September) : The monsoon season is the characteristic type of rainy season of the year with an average rainfall of 1160 mm. The minimum and maximum temperature ranged between 25° and 36°C. The average relative humidity was 81% during this season.

(c) **Retreating monsoon** (October-November): In retreating monsoon, the temperature gradually fell and moving mist and fog appeared. The minimum and maximum temperature ranged between 20° and 30°C. Rainfall slightly lowered in this season and attained up to 106.4 mm and average relative humidity was 80% during the study period.

(d) **Winter** (December-February): The winter season is characterized by cool weather and fog. Average minimum and maximum temperature dropped down to 12° and 25°C respectively. The average relative humidity ranged between 77% and 65%. The average rainfall was 21 mm only during the study period (Figure-3.2 & 3.3).

Vegetation

The vegetation of the study area is basically of four different types (Champion and Seth, 1968), such as (i) Eastern Himalaya's moist-deciduous forests (3C/C3b), (ii) Eastern seasonal swamp-forest (4D/SS1), (iii) Khair-Sisso forests (5/1S2) and (iv) Eastern

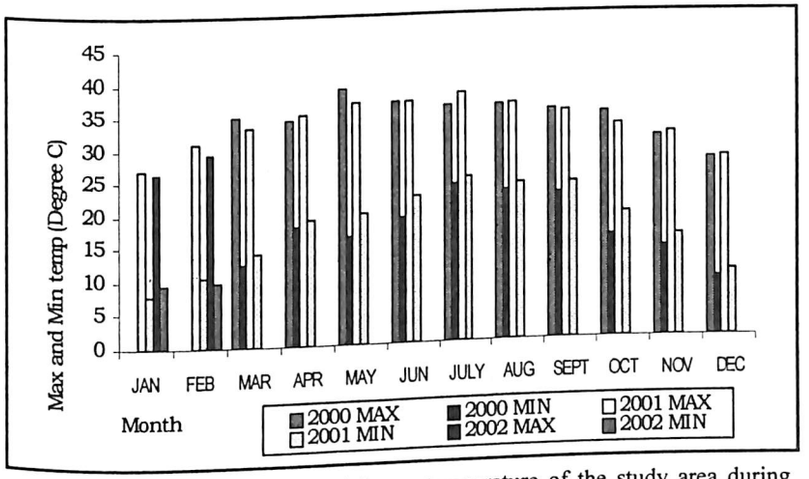

Figure - 3.2 : Maximum and minimum temperature of the study area during the period of 2000-2002

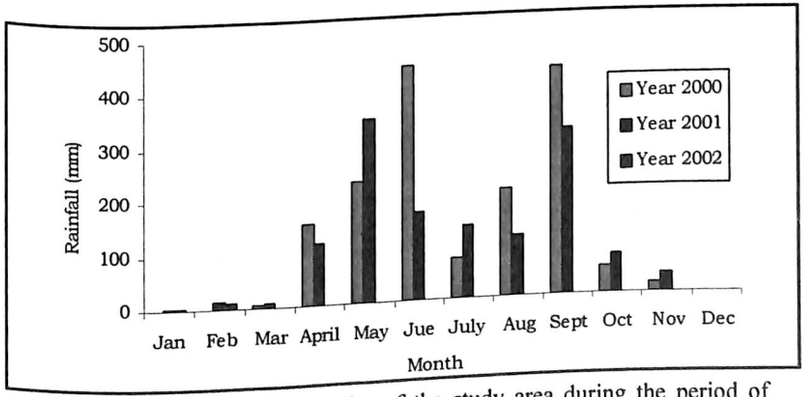

Figure - 3.3 : Relative humidity of the study area during the period of 2000-2002

wet-alluvial grasslands (4D/2S2). Apart from that, the vegetation composition of the study area is unique within North Bank, which comprises short and tall grasslands dotted with natural and planted woodland habitat and water bodies.

(a) Grassland habitats

Depending on the height of the grasses, the grasslands may be divided into - (i) Tall grassland, (ii) Short grassland and (iii) Marshy grassland.

(i) **Tall Grassland**: The tall grassland consists of *Saccharum ravanae, Arundo donax, Phargmytis karka, Themda arundinaceum, Saccharum spontaneum, Saccharum elephantinum, Andropogon squarrosus, Pollinia ciliata, Cenchurus ciliaris,* etc.

(ii) **Short grassland**: The short grassland consists of *Imperata cylindrica, Cynodon dactylon, Hemerthria compressa, Chrysopogon aciculatus, Vetivaria ziganoides, Leersia hexandra, Brachiarea ramosa, Hymenachne pseudoimperata,* etc.

(iii) **Marshyland**: The marshylands are mostly covered with *Enhydra fluctuans, Ipomoea raptans, Ipomoea aquatica, Vallisnaria sp, Hydrilla verticillata, Eichornia crassipes, Trapa bispinosa, Trapa natans, Lemna perpusilla, Nymphea species, Nelumbu nucifera, Tinospora cordifolia, Brachiaria pseudoimperata, Alpinia allughas, Pistia stratiotes, Lemma pancicostata,* etc. Grasses like *Leersia hexandra, Hymenachne pseudointerrupta, Hygroryza aristata* are available in these areas.

(b) Woodland habitats

The woodlands are mainly found in the northern part of the park, which consist of indigenous trees, found in the form of both man-made and natural conditions. Many softwood trees and exotic trees are also found in the man-made forest patches. The woodlands may be divided into (i) Natural and (ii) Plantation forests.

(i) **Natural forest:** It consists of *Bombax ceiba, Acacia catechu, Albizzia procera, Sterculia villosa, Ziziphus mauriciana, Trewia nudiflora, Syzygium fruticosum, S. cumini, Bauhinia purpurea, Tamarix dioca, Lagerstroemia speciosa, Ficus bengamina, Ficus religiosa, Biscofia javanica, Alstonia scholaris,* etc.

(ii) **Plantation forest**: The plantation forests consist of *Anthocephalus cadamba, Dalbergia sisoo, Acacia catechu, Albizzia procera, A. lebek, Samania saman, Tectona grandis, Tona ciliata, Trewia nudiflora, Michaelia champaka, Bombax ceiba, Alstonia scholaris, Biscofia javanica, Lagerstroemia speciosa,* etc.

Rhino population in Orang National Park

The first government census of Indian Rhino was conducted at Orang during 1985, when it was upgraded to a wildlife sanctuary. Subsequently, three more censuses were conducted in 1991, 1999

and 2006 (*Table-3.1*). The population of rhino varies from time to time and reached its highest peak of 97 individuals in the year 1991. But, owing to large-scale poaching activities and natural death, the rhino population sharply dropped down to 46 individuals in the year 1999. Since then, the poaching trend decreased and now it is quite negligible. However, the existing rhino population has showed imbalance of sex ratio, in which the number of males is higher than the females (Census report, Govt. of Assam, 1999). Further more, the population of the Indian Rhino in Orang National Park was slightly in increasing trend during the study period.

Table-3.1 Population census data of India Rhino in Orang National Park from 1985-2009

Census Year	Adult			Sub-adult			Calves		Grand Total
	Male	Female	SUI	Male	Female	SUI	Male	SUI	
1985	23	23	0	7	2	0	10	0	65
1991	28	41	5	0	1	0	22	0	97
1999	17	17	1	3	2	0	6	0	45
2006	28	27	-	-	-	9	-	4	68
2009	16	22	-	1	2	7	-	11>1yr. 5<1yr.	64

SUI : Sex Unidentified

Table: 3.2. Blockwise area of Orang National Park (*Source:* Forest Department, Govt. of Assam)

Block number	Name of the area	Block area (ha)
1	Bezimari, Rangagora	356.25
2	Magurmari, Bhelajhar	776.75
3	Silbori, Googli	325.0
4	Pachnoi-1, Fatasimalu	325.0
5	Solmari, Nichalamari	437.5
6	Pachnoi-3, Borchola	328.75
7	Ramdas, Morisali	1162.5
8	Bachasimalu, Belsiri, Morisali	619.75
9	Molamari	313.5
10	Ramkong	120.0
11	Ramdastapu, Panchatapu	408.75
12	Bontapu	259.25
13	Hatiputa, Chila beel	440.0

14	Tinkona	178.0
15	Hamuchar	303.75
16	Katasali, Hazarbigha, Baghmora	443.75
17	Gaimari, Gara beel, Kachamari	284.75
18	Old Orang, Bog beel, Sisu Bagan	304.0
19	Satsimalu, Rahmanpur	493.75

Methodology

The study was carried out from November 1999 to October 2003 in Orang National Park. Various methods, such as the Scan Animal Sampling, Ad. Libitum Sampling (Altmann, 1974) and the methods of Lehner (1996) were used to collect the behavioural, activity budgeting and ecological data of Orang National Park. The methods of Laurie (1978, 82), Copperrider (1956), Petrides (1975), Cook and Stubbendieck (1986), Martin (1970), Pieper (1978), Neff (1974), Wallmo *et al.* (1973), Riney, (1982) and Holechek *et al.* (1982, 1984, Bhattacharyya, 1991) were also used to collect the feeding ecology data. For vegetation sampling, the quadrat sampling method was used (as per Krebs, 1985; Southwoods and Henderson 2000). The size of the quadrat was taken 1m´1m, for grasses 5m´5m for herbs and shrubs and 10m´10m for woodland habitat. All samplings were made randomly in a stratified way.

Study design

For convenient data collection, the study has been designed and the study area was divided into 19 different blocks (*Table-3.2, Fig.3.4*). The existing methods were standardized and the whole study was divided into two parts - (i) Pilot study and (ii) Final field study.

(i) Pilot study: The pilot study in Orang National Park was conducted from November, 1999 to March, 2000 and the behavioural categories, sampling methods, study block design and sampling sites selection were finalised.

(ii) Final field study: The final field study of *Rhinoceros unicornis* was carried out from April, 2000 to March, 2003 in the study area to collect the appropriate field data.

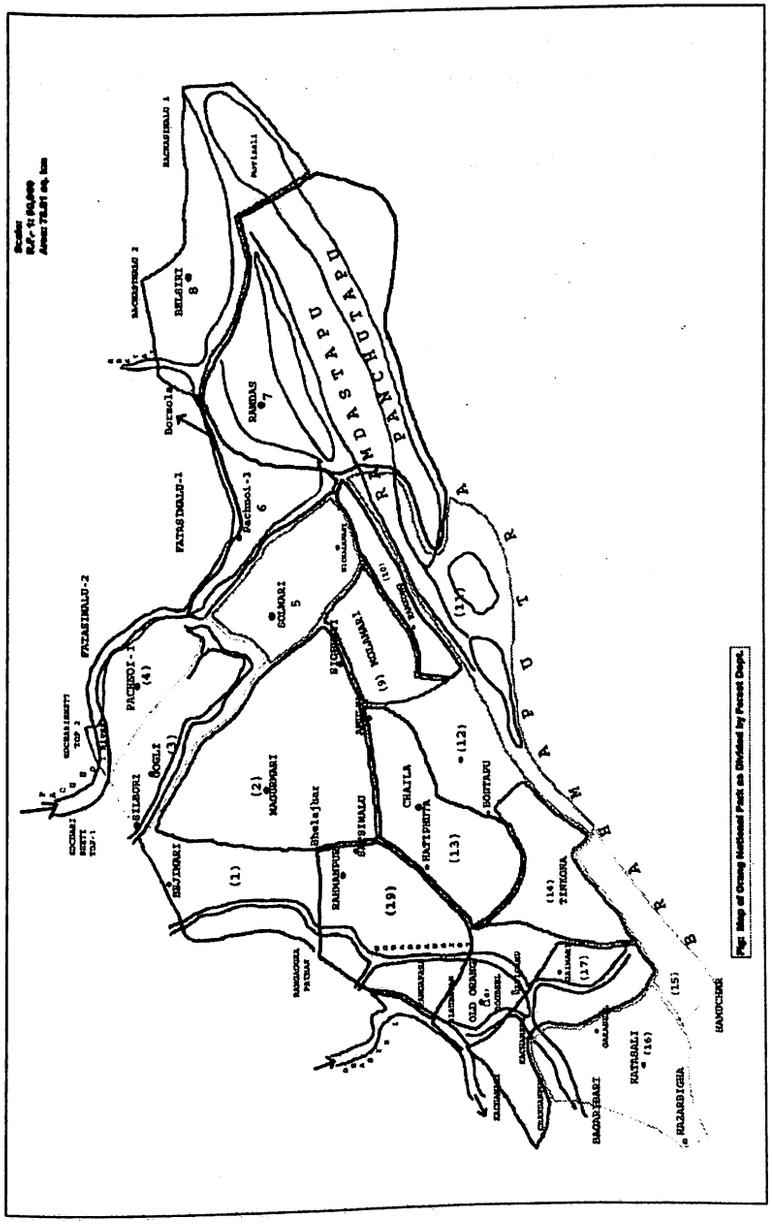

Fig: Map of Orang National Park as Divided by Forest Dept.

Figure - 3.4 : Block map of the study area

Instruments used:

The instruments used for field data collection were (i) Zenith 8×50 binocular, (ii) Thermo-hygrometer with clock, (iii) Nikon SLR N-60 with 300 mm tele zoom lens and (iv) One set of GPS (Garmin, 72)

Identification of plant species

The plant species were identified using the books of Kanjilal and Bor (1940), Mitra (1958), Shukla (1996), Nath (1999), Dutta (2002) and Bora (2003). Field notebook, data sheets and cardboards were used during data recording.

Data collection

(a)To collect the behavioural and ecological data of rhino at Orang National Park, a total of 10 days per month period were spent and data were collected using vehicles, bicycles, departmental elephants and on foot. During rainy season, when the floodwater rose to a maximum level, the country boats were also used for field data collection. All data of rhino sightings were noted down in the field notebook and data sheets. The numbers of age-sex groups and the sighting locations of the rhinos were noted down using GPS and compass bearings.

To collect the data of '*Scan Animal Sampling*', one observer followed the individual rhino and all activity bouted within an interval of 5 minutes from dawn to dusk were recorded in a datasheet prepared for the purpose (Appendix- 3a, 3b).

The non-systematic sampling of behavioural events such as sexual behaviour, agonistic behaviours (both intra and inter specific), movements, soil-eating (Geophagy) behaviour, drinking behaviour were also recorded using *Ad. Libitum Sampling* (Altmann, 1974). The data of human-rhino conflict, including crop damage, death or injury of rhino and human were also recorded during observation outside study area or at fringe villages.

(b) Vegetation data collection

During vegetation data collection, the quadrat sampling was used and the unidentified plant species were collected for the herbarium sheets preparation. The rhino food plant species were

recorded and collected for laboratory identification. The specimens were identified at the Department of Botany, Gauhati University by comparing with museum specimens and available books and literatures.

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Chapter – IV

HOME RANGE AND TERRITORIALITY

Majority of wild animals possess well-defined home range area for their exclusive use. Those well-defined areas provide food, shelter and protection (Odum, 1971) and are a primary need for the survival of the wild animal species. The animal species protect certain well-defended area for their vital activities of life cycle, which is known as its territory. The studies on the home range in various wildlife species suggest that the sizes of the home ranges are directly related to its body size and weight of mammals (Lindstedt *et al.*, 1986; Swihart *et al.*, 1988), birds (Schoener, 1968) and Lizards (Turner *et al.*, 1969). Again, the social structures and behavioural pattern of the animal species have also some effect on the home range size (Gittleman and Harvey, 1982; Lindstedt *et al.*, 1986). Apart from that, the various factors, such as availability of food, forage quality and metabolic requirements also influence the home range sizes in various animal species (Laurie, 1978, 82).

Objectives

1. To find out the home range, territoriality and seasonal use of habitat types of Indian Rhino in Orang Natonal Park.
2. To examine the fact whether the Indian Rhino possesses any territoriality and that have any specific defence mechanism in natural condition.

Methods of Study

The study of home range and territoriality of Indian Rhino was

done in Orang National Park from April 2000 to March 2002 for gathering the suitable data of the species.

Although the satellite and radio tracking techniques were widely used for the study of home range and territoriality of wild animals, those methods were not cost-effective and needed enormous safety measures and risks. Therefore, all the rhino tracking activities for home range and territoriality studies in Orang National Park were followed as per the previously used well-established and cost-effective methods (Bhattacharyya, 1991; Lehner, 1996; Laurie, 1978, 82). For this purpose, the individuals of various age-sex classes were identified and marked with the help of existing morphological differences from other individual.

Prior to initiation of field investigation, the study has been designed to collect the suitable data. The designed of the studies were such as the identification and marking of individual rhino, selection of parameters, sampling design and selection of the study locations for data collection.

To study the home range and territoriality, the individual marking of rhino has been done, based on the existing identification marks as it was the foremost and necessary task for this aspect. In present study, the individual marking techniques (Individual ID) were followed as per the methods used by Bhattacharyya (1991), Lehner (1996) and Laurie (1978, 82).

A. Individual Identification

The first criterion for proper identification of individual rhino was the sex differences. Since the study was planned to select all the representative types of age-sex class compositions, the sex identification has become an important task. The following criteria were used for age-sex determination (as per Laurie, 1978, 82; Bhattacharyya, 1991; Mukharjee and Sengupta, 1999), such as (i) External genitalia, (ii) Body size and shape of the head, (iii) Horn and neck fold, (iv) Urination pattern, (v) Accompanying calf and (vi) Developed and under-developed mammary gland.

For territoriality of Indian Rhino at Orang National Park, the following age-sex classes were made, based on external characters.

(a) Age Classes

(i) Adult rhino: When height of the individual at shoulder was above 5 feet 4 inches and the horn base was above 7 inches with prominent neck folds, the individual was considered as an adult. In case of male, the penis was generally visible from either sides or rear and the urination pattern of male was towards backwards or rear either side and squirt urination was frequent. In case of female, the urination pattern was generally originated from upper rear portion and continuous flow of urine, which helped identifying the sex. If an individual was found along with calf, it was considered as an adult female.

(ii) Sub-adult rhino: If the shoulder height of the rhino was above 4 feet 6 inches and the horn base was below 3 inches and the neck folds were smaller, but visible and generally found along with adult female, then it was considered as a sub-adult rhino.

(iii) Rhino calf: If the shoulder height of the rhino was below 4 feet 6 inches and the horn was below 3 inches or just started to grow or always attached with their mother, then it was considered as rhino calf.

(b) Identification of sex

The sex identification was made as follows:

(i) Adult male: The rhino was considered as adult male when its penis was visible from the side or the rear. The urination pattern of the rhino also indicated the location of the genitalia. Generally, the urination pattern of adult male had squirt pattern in both static and moving conditions. Apart from that, the male individuals possess deeply folded skin around the neck, characterized by large body size and big horn with wider base.

(ii) Adult female: An individual rhino was considered as adult female when the location of genitalia was observed from back. The urination pattern also indicated the location of the genitalia, whether it was situated at rear or side. The urination pattern of the adult female was found to be continuous flow of urine, which fell on ground just few inches away from the hind leg of the animal. The skin folds around the neck and the horn base were comparatively smaller than the male. The female was mostly attached with calf.

(iii) Sex unidentified: Any individual rhino, whose sex could not be determined in regard to the above mentioned marks and characters, was considered as unsexed (unidentified sex).

The marking of individual rhino for both the sex and age classes were made as per Laurie (1978, 82), Bhattacharyya (1991) and Lehner (1996). The identification keys used for the study were such as (i) Arrangement and irregularities of the skin folds, (ii) Scars on body, (iii) Arrangement of tubercles on the rump, (iv) Ear nick (cut mark, ear fold), (v) Tail length and (vi) The length, shape and size of the horn and its anomalies.

B. Selected individuals for study

Altogether seven rhinoceros in different age and sex classes were selected for the study. Those selections were done on the basis of their physical and morphological characters (as per Laurie, 1978, 82; Lehner, 1996; Bhattacharyya, 1991) (Table-4.1; Plate-2).

Table: 4.1: Marked rhinos for home range and territoriality study, based on Individual ID marks of animal at Orang National Park

SL No.	Marked Individuals	Identification marks
1	Old Female	1. Cut mark in left ear 2. Horn was relatively small 3. Old age
2	Old Male	1. Sharp long horn and tip of the horn was forked 2. Cut mark in right ear 3. Ribs were distinctly visible from a visual distance
3	Adult Male	1. Horn was very much blunt and looks wave like 2. Disintegrated horn 3. An injury mark on right thigh 4. Aggressive in nature
4	Adult Female	1. Horn was sharp but very short 2. Right ear had cut mark (torn)
5	Adult Female with Calf	1. Horn was big and very sharp 2. The cow was slightly lame 3. Quite big size of the body
6	Sub-adult Female	1. Horn was very small 2. Slim body
7	Sub-adult male	1. Horn was very small 2. Slightly folded ear 3. Stout body

Study Parameters

Altogether four parameters were selected for home range and territoriality study of Indian Rhino, such as (1) Home range pattern, (2) Seasonal variation of home range, (3) Territoriality and (4) Territorial defence mechanisms.

The home range was defined as the total area covered by an individual rhino in a specific time period. Whereas, the well-defended area of rhino within its home range, either during foraging movement, shelter or during breeding display, was considered as territoriality of the species. Again, the territorial defence mechanisms were considered, when they possessed aggressive behaviour in the form of threat, snorting, chasing, attack and escaping (avoiding) from direct conflict with others within its territory.

For the collection of home range and territoriality data, each and every corner of the study area was visited using elephant back, vehicles and on foot and the marked rhinos sighted were recorded using 'Garmin GPS-72'. The behavioural patterns of both the marked and unmarked rhinoceros were recorded in field notebook for territorial defence and avoidance.

(a) Home range

To collect the home range pattern used by the marked individual rhino between two successive periods were collected. The distance covered by the marked rhinos (at least minimum of five positions within the study period) was measured with the help of GPS coordinates of the same individual. A total of five to six samples of each identified individual were recorded to find out the seasonal variation of home range pattern. For analysis of home range pattern, the marked individuals were located using GPS coordinates and plotted on the base map using GPSU 4.10 software and converted into the final polygon to determine the seasonal variation of home range pattern. The home ranges were estimated using the minimum convex polygon (MCP) method (Clutton-Brock, *et al.* 1982). Readings of all GPS coordinates taken for confirmation of home

range size in different seasons were plotted on the base map and connecting all the outer edges of GPS points to find out the home range area in regard to the different marked individuals.

The study revealed that the Indian Rhino showed a distinct home range pattern in both age-sex class groups. The Indian Rhino covered an average total area of 6.29 $km^2 \pm 0.32$ SD /individual (N = 28; Table-4.1) throughout the year in Orang National Park. Again, there was a distinct seasonal variation of home range pattern in different age-sex groups (Figure- 4.1; 4.2a-g; Table-4.2), in which the adult male covered a highest of 7.67 $km^2 \pm 0.50$ SD / individual

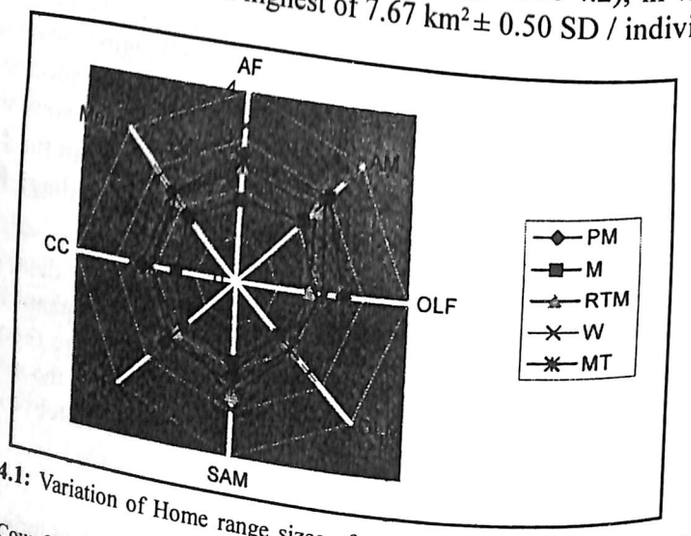
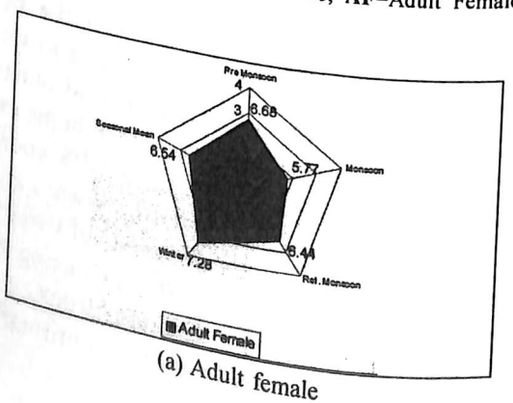
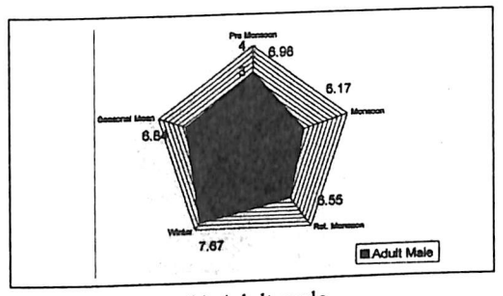


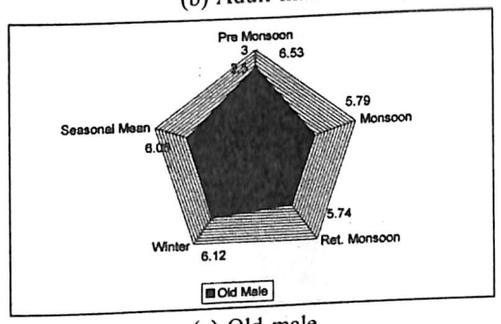
Fig.- 4.1: Variation of Home range sizes of marked rhinos in different Age-sex groups at Orang National Park
(**CC**=Cow Calf, **SAF**=Sub-Adult Female, **SAM**=Sub Adult Male, **OLM**=Old Male, **OLF**=Old Female, **AM**=Adult Male, **AF**=Adult Female)



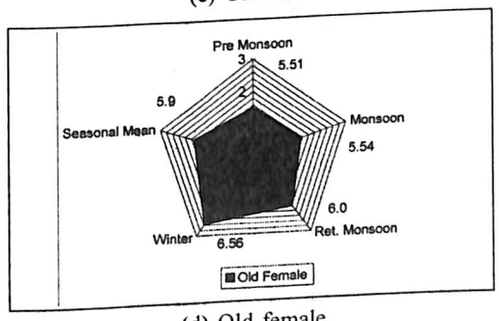
(a) Adult female



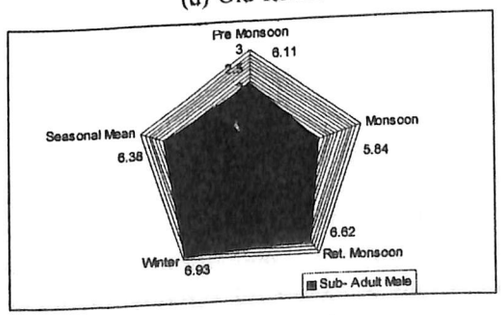
(b) Adult male



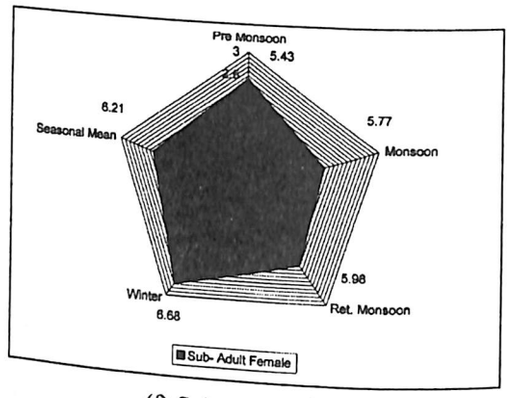
(c) Old male



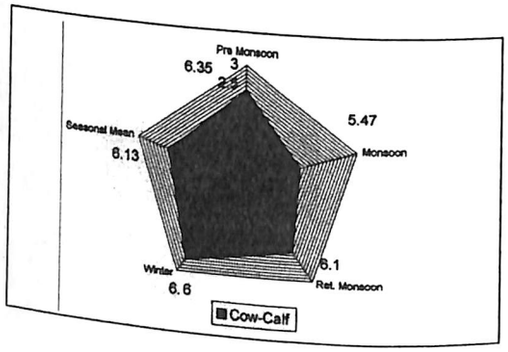
(d) Old female



(e) Sub-adult male



(f) Sub-adult female



(g) Cow-calf

Fig.- 4.2 : Radar Diagram showed the home range sizes of different marked *Rhino* in various seasons of the year in Orang National Park (a) Adult female; (b) Adult male; (c) Old male; (d) Old female; (e) Sub-adult male; (f) Adult Female; (g) Cow calf.

(N = 4) compared to others, during winter season. Whereas, the smallest total home range size was found to be 5.59 $km^2 \pm 0.49SD$ / individual (N = 4) in case of old female rhino in a year and 5.51 km^2 / individual, only during pre-monsoon season.

Home range size

The analysis of home range area showed that the proportional use of home range sizes of adult male and adult female was higher during winter and pre-monsoon season than retreating monsoon and monsoon season. During winter and pre-monsoon season, both adult male and adult female searched for suitable habitat covering more area and visited even outside the park boundary (Figure-4.3 and

Table- 4.2: Home range sizes of different marked age-sex group rhinos in Orang National Park

Marked Individuals (Age-sex groups)	Observed Samples				Mean Total home range sizes (km^2) (X ± SD)
	PM	M	RTM	WIN	
AF	6.68	5.77	6.44	7.28	6.54±.62
AM	6.98	6.17	6.55	7.67	6.84±.64
OLM	6.53	5.79	5.74	6.12	6.05±.36
OLF	5.51	5.54	6.0	6.56	5.9±.49
SAM	6.11	5.84	6.62	6.93	6.38±.49
SAF	6.43	5.77	5.98	6.68	6.21±.41
CC	6.35	5.47	6.1	6.6	6.13±.49
Group Mean± SD	6.37±.47	5.76±.23	6.20±.33	6.83±.51	6.29±.32

N=145, (**AF** : Adult Female, **AM**: Adult Male, **OLM**: Old Male, **OLF** : Old Female, **SAM** : Sub-adult Male, **SAF** : Sub-adult Female, **CC**: Cow Calf.)

4.4). Whereas, the proportional use of home range size of old male was the highest during pre-monsoon season and gradually declined, and ultimately it was the lowest during winter season (Fig-4.5), indicating that the old male confined within the core National Park area and utilized existing resources during winter season and travelled more area during pre-monsoon and monsoon season, owing to avoid conflict with strong adult male. But in case of old female, the proportional use of home range sizes were found to be higher and

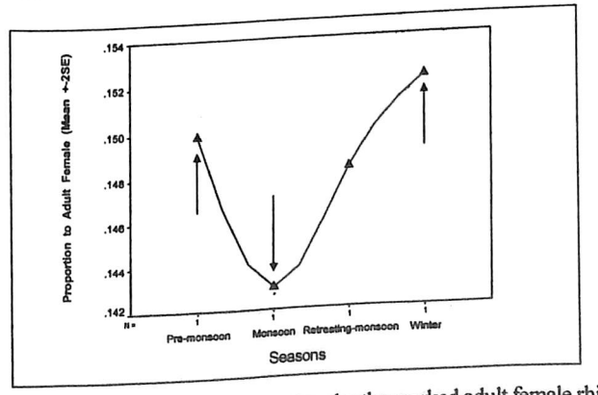


Fig.- 4.3 : Proportional use of home range sizes by the marked adult female rhino during pre-monsoon, monsoon, retreating monsoon and winter seasons in the study area.

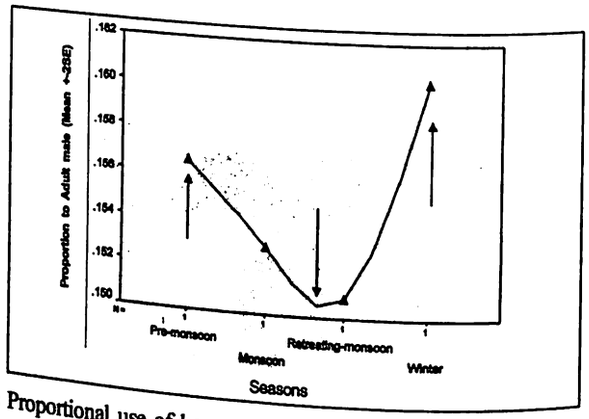


Fig.- 4.4 : Proportional use of home range sizes by marked adult male rhino during pre-monsoon, monsoon, retreating monsoon and the winter seasons in study area.

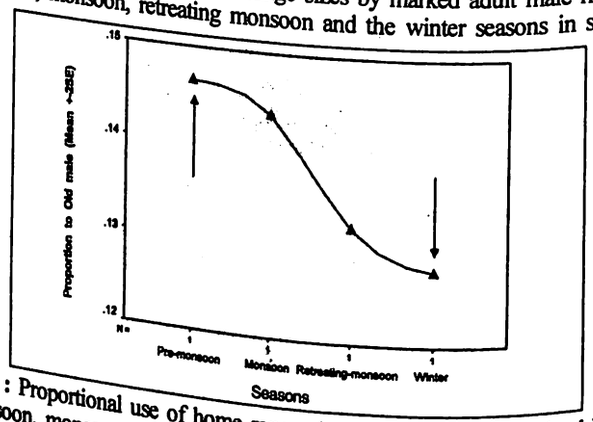


Fig.- 4.5 : Proportional use of home range sizes by marked old male rhino during pre-monsoon, monsoon, retreating monsoon and the winter seasons in study area.

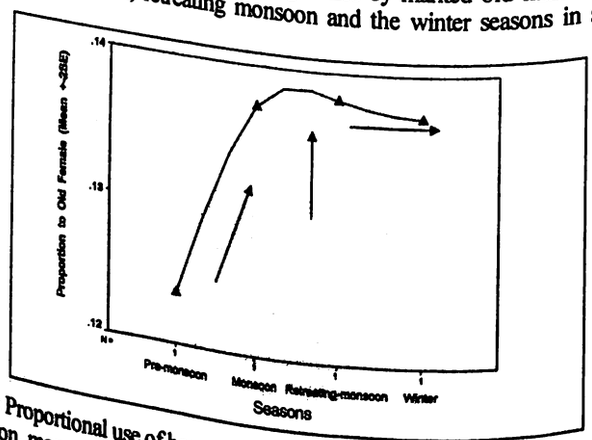


Fig.- 4.6 : Proportional use of home range sizes by marked old female rhino during pre-monsoon, monsoon, retreating monsoon and the winter seasons in the study area.

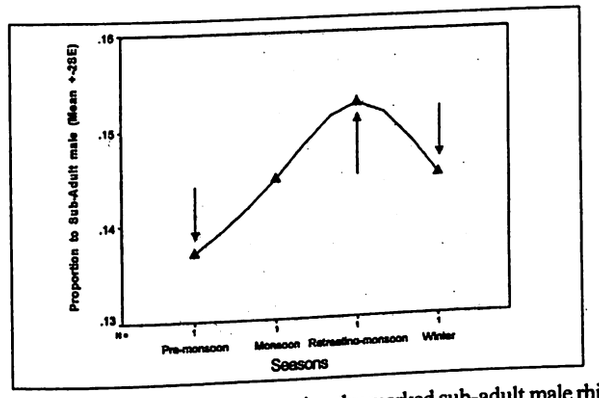


Fig.- 4.7 : Proportional use of home range sizes by marked sub-adult male rhino during pre-monsoon, monsoon, retreating monsoon and the winter seasons in the study area.

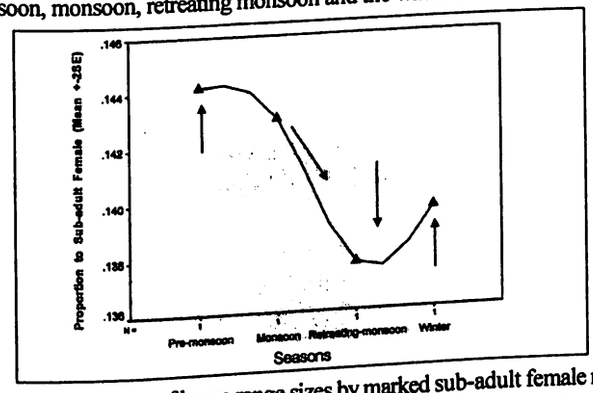


Fig.- 4.8 : Proportional use of home range sizes by marked sub-adult female rhino during pre-monsoon, monsoon, retreating monsoon and the winter seasons in the study area.

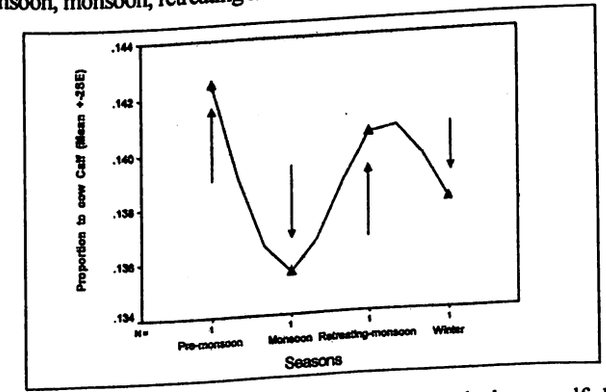


Fig.- 4.9 : Proportional use of home range sizes by marked cow-calf during pre-monsoon, monsoon, retreating monsoon and the winter seasons in the study area.

almost equal in size during monsoon, retreating monsoon and winter season, but reduced during pre-monsoon season (Fig-4.6).

The analysis of Spearman's Rank correlation between proportional use of home range sizes by marked rhinos showed significant but negative correlation between sub-adult male and sub-adult female (r^s=-1.0; $p< 0.001$), whereas there was no significant relationship between the individuals of Indian Rhino at Orang National Park.

Range locality, overlaps and polygonal area

The home ranges were estimated using the minimum convex polygon methods (Mohr, 1947). The analysis of home range area in seven marked individuals of different age-sex groups showed that the sub-adult female travelled altogether 16 different habitat patches to complete their annual cycle and covered a mean home range area of 6.21 km^2 ± 0.41SD, followed by old male, 15 localities and covered a mean home range size of 6.05 km^2 ± 0.36SD; sub-adult male, 13 localities and covered a home range sizes of 6.38 km^2 ±0.49SD; old female, 12 localities and covered an home range area of 5.9 km^2 ±. 0.49 SD; adult male, 11 localities and home range area of 6.84 km^2 ± .0.64 SD; adult female, 11 localities and home range area of 6.54 km^2 ±. 0.62 SD and cow calf, 11 localities and home range area of 6.13 km^2 ±. 0.49SD (Table 4.3-4.9).

The study also showed that all the marked rhinos had a tendency to range overlapped in various locations with other marked individuals during their annual cycles. The polygonal area of marked old female was overlapped with marked old male in Seuratoli and Satsimalu habitat patches during pre-monsoon and monsoon season and Satsimalu *beel* during monsoon season (Table-4.3 and 4.4 and Fig-4.10 and Fig-4.11. The polygonal area of marked adult male was found to overlap with polygonal area of marked old female in the Seuratali, Amulya and Satsimalu area during pre-monsoon, Amulya during monsoon and Tinkona, Rahmanpur and Seuratali during winter season. Likewise, the polygonal area of marked adult male was overlapped with marked adult female in Amulya camp area during monsoon, Amulya, Ramkong and Hatiputa area during re-treating monsoon season.

Table-4.3: Site locality, geographic locations and total home range area of marked old female rhino in four different seasons of the year in Orang National Park

Site Locality	Lasmbert Conformal Conic Everest		Total Area (km^2)	Geographic WS 84	
Pre-monsoon					
Seuratali	1170971	528611.18	5.51	92D20´15.21"E	26D32´32.03"N
Satsimalu	1168777.8	528876.52		92D18´53.21"	26D33´47.16"
Ramkong	1167745.5	528652.64		92D18´13.54"	26D33´42.44"
Satsim *beel*	1167679.2	527690.79		92D18´08.05"	26D33´09.96"
Bhutiali	1168085.5	527363.26		92D18´22.38"	26D32´57.71"
Amulya	1171422.9	526836.73		92D20´26.76"	26D32´30.51"
Monsoon					
Seuratali	1171056.7	528649.85	5.54	92D20´18.57"	26D33´33.11"
Satsimalu	1168765.5	528786.76		92D18´52.47"	26D33´44.15"
Ramkong	1167859.5	528488.78		92D18´17.34"	26D33´36.56"
Satsim beel	1167791.1	527373.38		92D18´11.30"	26D32´58.87"
Bhutiaali	1168544.1	527035.14		92D18´38.68"	26D32´45.29"
Amulya	1171254.1	526902.26		—	—
Retreating Monsoon					
Seuratali	1170480.9	527735.78	6.0	92D19´53.98"	26D33´03.68"
Tinkona	1168588.4	529394.79		92D18´47.67"	26D34´05.29"
Hatiputa	1167581.7	528025.71		92D18´05.41"	26D32´21.61"
Rahmanpur	1166816.6	525649.95		92D17´29.17"	26D32´03.06"
Magurmari	1168813.9	526608.31		—	—
Winter					
Rahmanpur	1171535.1	529696.68	6.56	92D20´39.88"	26D34´07.32"
Magurmari	1170700.9	529761.23		92D20´08.58"	26D34´11.84"
Kanchanbagan	1168104.2	529264.71		92D18´28.98"	26D34´02.22"
Singhbheti	1167761.6	527551.73		92D18´10.73"	26D33´05.01"
Satsim beel	1167990	527134.65		92D18´18.07"	26D32´50.21"
Seuratali	1169568.9	526926.12		92D19´17.04"	26D32´38.73"

Table-4.4: Site locality, geographic locations and total home range area of marked old male rhino in four different seasons of the year in Orang National Park

Site Locality	Lasmbert Conformal Conic Everest		Total Area (km^2)	Geographic WS 84	
Pre-monsoon					
Satsimalu	1171268.6749	529867.0942	6.53	92D20´30.35"E	26D34´13.85"N
Amulya/Barkhe	1169060.6060	528620.5135		92D19´03.10"	26D33´37.68"
Seuratali	1167802.8452	528424.8618		92D18´15.00"	26D33´34.54"
Kansan Bagan	1167517.7528	527563.9945		92D18´01.57"	26D33´06.11"
Silbori	1171223.9546	526736.6674		92D20´18.94"	26D32´27.67"

Monsoon					
Satsimalu	1169457.4994	526138.5322	5.79	92D19′10.39"	26D32′12.29"
Naorsisa	1166612.1650	527133.5608		92D17′26.04"	26D32′54.01"
Seuratali	1167853.1556	528654.0538		92D18′17.61"	26D33′42.19"
Hatiputa	1169345.6984	528860.8856		92D19′14.61"	26D33′45.05"
Tinkona	1169848.8028	528586.9732		92D19′32.76"	26D33′34.34"
Satsim *beel*	1170027.6843	528195.6699		92D19′38.30"	26D33′20.56"
Retreating monsoon					
Hatiputa *beel*	1168921.0715	528887.3096	5.74	92D18′58.66"	26D33′47.13"
Naorasisa	1170717.4547	527471.5555		92D20′02.09"	26D32′54.04"
Satsimalu	1170132.5857	526571.0430		92D19′37.22"	26D32′25.10"
Seuratali	1168883.9370	526960.9556		92D18′51.28"	26D32′41.82"
Near Barkhe C	1165407.2162	525057.8107		92D16′34.13"	26D31′46.87"
Winter					
Satsim *beel*	1168292.8706	527673.3524	6.12	92D18′31.17"	26D33′07.66"
Amulya	1168780.0766	529150.1958		92D18′54.15"	26D33′56.45"
Satnearib	1170881.1528	528571.6386		92D20′11.69"	26D33′30.94"
Barkhe	1169414.4595	526526.3882		92D19′09.97"	26D32′25.58"
Kachamari C	1168648.1250	526693.8652		92D18′41.55"	26D32′33.41"
Hatip *beel*	1165186.9319	524415.1619		92D16′23.83"	26D31′25.66"

Table-4.5: Site locality, geographic locations and total home range area of marked adult male rhino in four different seasons of the year in Orang National Park

Site Locality	Lasmbert Conformal Conic Everest		Total Area (km^2)	Geographic WS 84	
Pre-monsoon					
Seuratali	1170987.16756	528419.98014		92D20′15.22"E	26D33′25.50"N
Hatipota	1169877.00356	528585.78385		92D19′33.82"	26D33′34.23"
Amulya	1168622.66242	530186.15013		92D18′51.42"	26D34′32.07"
Ramkong	1168435.23213	528210.92328		92D18′38.21"	26D33′25.52"
Amulya	1167714.34642	527490.03757		92D18′08.76"	26D33′03.05"
Satsimalu	1168557.78270	526214.06986		92D18′36.65"	26D32′17.37"
Rahmanpur	1171585.50270	527360.27814		92D20′34.52"	26D32′47.84"

Monsoon					
Satsim *beel*	1171131.34470	529378.75814		92D20′23.65"	26D33′57.65"
Sila *beel*	1168081.99813	528592.99271		92D18′26.06"	26D33′39.48"
Tinkona	1167397.15671	525731.07643		92D17′51.34"	26D32′04.20"
Hatiputa	1168456.85870	526459.17100		92D18′33.60"	26D32′25.97"
Amulya	1170237.44642	527259.35414		92D19′43.31"	26D32′48.18"
Retreating Monsoon					
Tinkona	1170150.94013	528470.44214		92D19′43.80"	26D33′29.54"
RamkongG	1169502.14299	527677.46785		92D19′16.85"	26D33′04.43"
Nislamari	1168089.20699	527504.45528		92D18′22.96"	26D33′02.49"
Amulya	1167152.05556	525968.96871		92D17′42.82"	26D32′12.96"
Chailla *beel*	1171152.97127	527007.04414		92D20′17.10"	26D32′37.05"
Hatipota	1172998.43870	528996.68871		92D21′32.96"	26D33′39.46"
Winter					
Satsimalu	1168544.31996	530018.64611	7.67	92D18′47.94"	26D34′26.60"
Old Orang	1165792.46977	527043.12336		92D16′54.81"	26D32′53.22"
Rahmanpur	1169384.78652	526087.43155		92D19′07.48"	26D32′10.76"
Hatiputa	1169195.00375	527415.91095		92D19′04.44"	26D32′56.40"
Seuratali	1169608.45907	528168.26408		92D19′22.38"	26D33′20.80"

Table:4.6: Site locality, geographic locations and total home range area of marked adult female rhino in four different seasons of the year in Orang National Park

Site Locality	Lasmbert Conformal Conic Everest		Total Area (km^2)	Geographic WS 84	
Pre-monsoon					
Nisalmari	1168718.259712	526109.043844	6.68	92D18′42.39"E	26D32′13.35"N
Mola	1168224.125392	528154.708721		92D18′30.07"	26D33′24.20"
Gaspara	1170469.492223	528997.041317		92D19′57.47"	26D33′46.54"
Hati Camp Q	1171770.115198	528272.481667		92D20′44.33"	26D33′18.30"
Roumari	1171393.753825	526897.610530		92D20′25.85"	26D32′32.66"
Monsoon					
Singhbheti	1169898.400558	529051.555872	5.77	92D19′36.07"	26D33′49.98"
Roumari	1170193.474029	530166.730093		92D19′50.68"	26D34′27.03"
Amulaya	1169000.970208	527897.716851		92D18′58.61"	26D33′13.30"
RamkongG	1171119.394231	526839.522335		92D20′15.31"	26D32′31.46"
Singhbheti	1172391.262640	528900.966652		92D21′09.74"	26D33′37.90"
Retreating Monsoon					
Hatiputa	1170493.281563	529818.109113	6.44	92D20′00.92"	26D34′14.35"
Bantapu	1169732.754389	528322.539803		92D19′27.56"	26D33′25.69"
Amulaya	1167903.196955	527059.018467		92D18′14.56"	26D32′47.88
RamkongG	1169538.575348	526321.683739		92D19′14.02"	26D32′18.28"
Singhbheti	1172333.560871	527935.477534		92D21′04.56"	26D33′05.28"

		Winter			
Nislamari	1171138.811016	530293.218047	7.28	92D20′26.77"	26D34′28.68"
Magurmari	1173080.193690	528648.837946		92D21′34.97"	26D33′27.41"
Singhbheti	1170573.781731	526526.356142		92D19′53.74"	26D32′22.35"
Roumari	1168567.203370	527801.294017		92D18′41.93"	26D33′11.24"
RamkongG	1170718.661035	529126.939649		92D20′07.28"	26D33′50.25"

Table-4.7: Site locality, geographic locations and total home range area of marked sub-adult male rhino in four different seasons of the year in Orang National Park

Site Locality	Lasmbert Conformal Conic Everest		Total Area (km²)	Geographic WS 84	
		Pre-monsoon			
Katsali beel	1167176.33845	527564.13725	6.11	92D17′48.68"E	26D33′07.06"N
GasparaA	1168147.51426	526664.29074		92D18′22.56"	26D32′33.80"
Bagaribari	1167176.33845	527564.13725		92D17′48.68"	26D33′07.06"
KachamariC	1163379.42512	524496.97749		92D15′15.84"	26D31′33.45"
Haticamp Q	1163955.54636	523855.01382		92D15′35.61"	26D31′10.05"
		Monsoon			
Satsimalu	1169134.73235	529187.49164	5.84	92D19′07.66"	26D33′56.73"
Tinkona	1168510.84422	529081.54837		92D18′43.77"	26D33′54.87"
Hatipota	1166068.26332	526132.79408		92D17′02.41"	26D32′21.54"
Seoratali	1167992.89935	525856.16444		92D18′14.22"	26D32′06.79"
KachamariC	1169617.36279	527663.08573		92D19′21.15"	26D33′03.62"
		Retreating Monsoon			
Barkhe	1169660.62041	529164.80657	6.62	92D19′27.44"	26D33′54.49"
Hatiputa	1166638.76133	528053.82897		92D17′29.89"	26D33′25.19"
Seoratali	1165826.16057	526333.40079		92D16′53.89"	26D32′29.02"
Tinkona	1166746.68487	525590.63291		92D17′26.35"	26D32′01.24"
KachamariC	1168752.79300	526834.92783		92D18′45.94"	26D32′37.91"
		Winter			
Hatiputa	1171406.44236	529583.80384	6.93	92D20′34.67"	26D34′03.84"
Seoratali	1170873.17311	529552.06162		92D20′14.44"	26D34′04.26"
RamkongG	1167724.34516	527761.80057		92D18′09.98	26D33′12.25"
Singhbheti	1168003.67667	526403.23367		92D18′16.32"	26D32′25.33"
Kanchan Bagan	1171203.29217	527184.09222		92D20′19.55"	26D32′42.29"

Table-4.8: Site locality, geographic locations and total home range area of marked sub-adult female rhino in four different seasons of the year in Orang National Park

Site Locality	Lasmbert Conformal Conic Everest		Total Area (km²)	Geographic WS 84	
		Pre-monsoon			
HaticampQ	1168296.9336	526886.3158	6.43	92D18′28.89"E	26D32′40.92N
GasparaA	1166118.3905	526366.0667		92D17′05.02"	26D32′29.32
Tinkona	1164748.0915	525581.0479		92D16′10.86"	26D32′06.47"
KachamariC	1163447.4687	523249.2171		92D15′14.56"	26D30′50.89"
Katsali *beel*	1165031.4414	523346.7638		92D16′14.66"	26D30′49.81"
		Monsoon			
Haticamp	1170016.8750	527773.2802	5.77	92D19′36.58"	26D33′06.24"
Naorsisa	1168793.7728	528367.3584		92D18′52.24"	26D33′29.83"
Barkhe	1167465.8332	527786.3849		92D18′00.29"	26D33′13.80"
Satsimtowe	1165255.5128	525178.5562		92D16′28.77"	26D31′51.39"
Seoratali	1166478.6150	525130.5058			
		Retreating Monsoon			
Hatiputa	1170547.4403	527937.9910	5.98	92D19′57.12"	26D33′10.36"
Satsimalu	1168800.5476	529221.0195		92D18′55.14"	26D33′58.80"
Magormari	1166713.1589	527291.5420		92D17′30.34"	26D32′59.09
Satsim *beel*	1167339.8690	526743.7875		92D17′52.31"	26D32′38.75"
Seuratali	1167542.1927	525756.8425		92D17′56.89"	26D32′04.67"
		Winter			
Ramkong G	1171583.1117	529376.3490	6.68	92D20′40.70"	26D33′56.31"
Rahmanpur	1171101.8943	528003.6130		92D20′18.26"	26D33′11.04"
Samsim *beel*	1171481.8027	526975.3274		92D20′29.41"	26D32′35.06"
Amulya	1168174.0663	526742.3169		92D18′23.80"	26D32′36.37"
Seuratali	1167383.8567	528023.8748		92D17′57.93"	26D33′22.09"

Table-4.9 Site locality, geographic locations and total home range area of marked cow calf rhino in four different seasons of the year in Orang National Park

Site Locality	Lasmbert Conformal Conic Everest		Total Area (km²)	Geographic WS 84	
		Pre-monsoon			
Tinkona	1166872.31812	528711.11709	6.35	92D17′40.75"E	26D33′46.86"N
Kachamari C	1168359.85183	528415.72032		92D18′36.00"	26D33′32.68"
Rangarah	1168908.44582	527872.40127		92D18′55.03"	26D33′12.70"
Hatiputa	1169045.59431	526585.31537		92D18′56.22"	26D32′28.61"
Sasim *beel*	1167679.38428	525830.99864		92D18′02.30"	26D32′06.80"
Seuratali	1165959.75312	525778.24922		92D16′57.22"	26D32′09.80"

Monsoon					
Seuratali	1169461.10806	526220.62035	5.47	92D19′10.78"	26D32′15.07"
Gandrmari *beel*	1169946.19589	528341.14712		92D19′35.67"	26D33′25.73"
Naorsisa	1168842.04360	528793.89575		92D18′55.38"	26D33′44.18"
Hatiputa	1167178.88535	527722.08266		92D17′49.26"	26D33′12.42
Satsim *beel*	1165913.03713	527047.57959		92D16′59.38	26D32′53.03"
Retreating monsoon					
Satnearib	1168087.56453	528814.79231	6.10	92D18′26.96"	26D33′46.99"
Hatiputa	1167271.28303	528178.65570		92D17′54.16"	26D33′27.66"
Amulya	1167817.34721	527536.88956		92D18′12.79"	26D33′04.35"
Satsim *beel*	1168098.82358	525819.88365		92D18′18.10	26D32′05.26"
Seuratali	1171600.38972	529349.59743		92D20′41.27"	26D33′55.35"
Winter					
Seuratali	1169446.48029	529512.55548	6.60	92D19′20.44"	26D34′06.90"
Satsim *beel*	1170146.57355	527430.22679		92D19′40.41"	26D32′54.23"
Seuratali	1169195.16476	527017.35127		92D19′03.21"	26D32′41.87"
Gandrmari *beel*	1168626.71296	526107.82840		92D18′38.93"	26D32′13.57"
Rahmanpur	1165916.09544	526772.01944		92D16′58.64"	26D32′43.67"

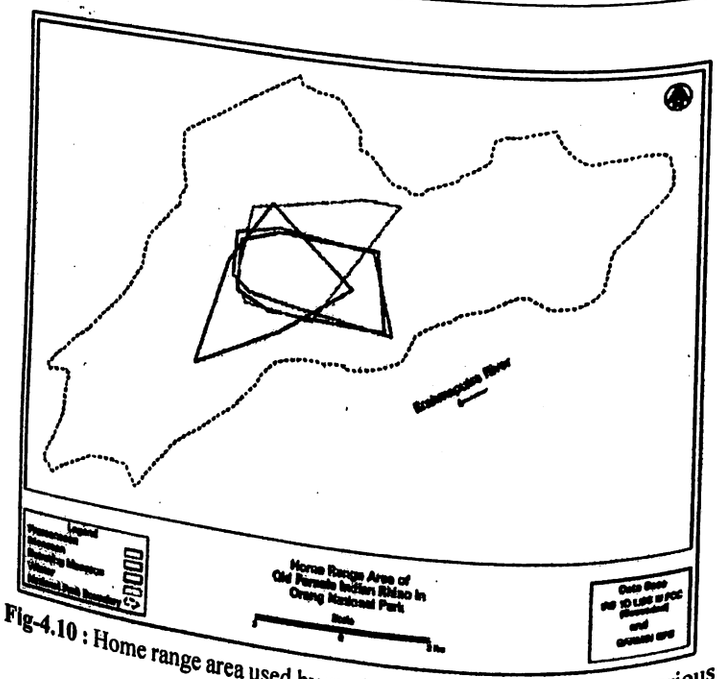


Fig-4.10 : Home range area used by marked old female rhino during various seasons of the year

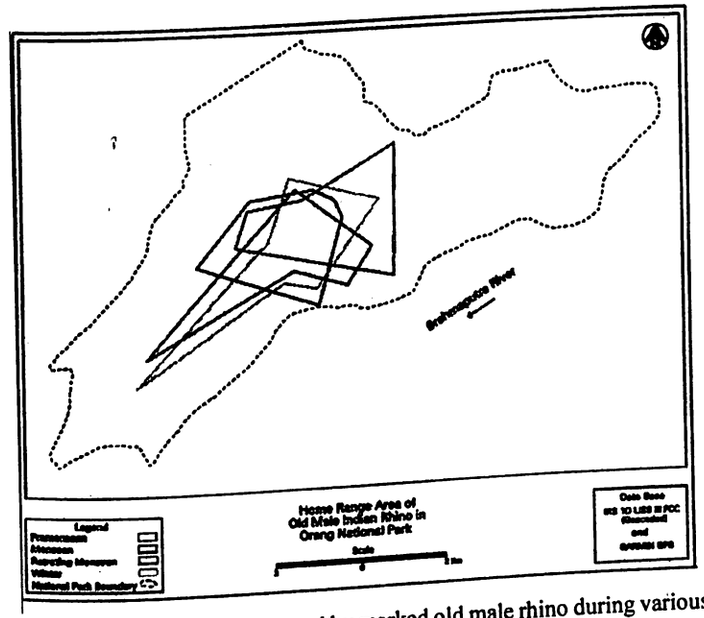


Fig-4.11 : Home range area used by marked old male rhino during various seasons of the year

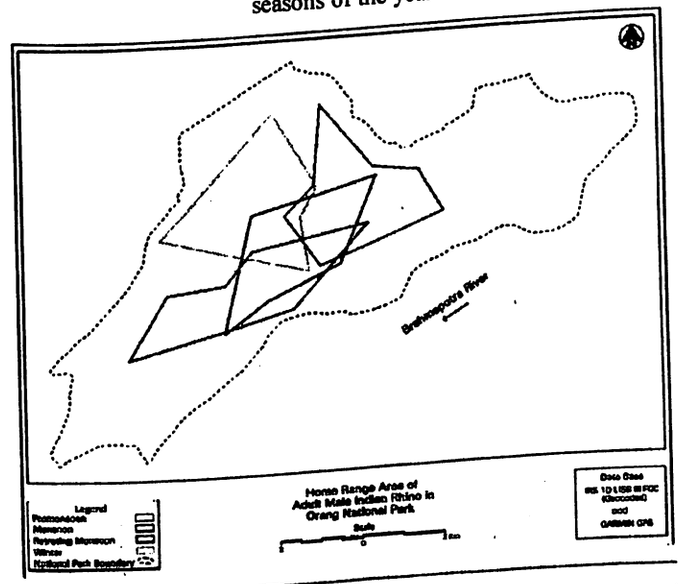


Fig-4.12 : Home range area used by marked adult male rhino during various seasons of the year

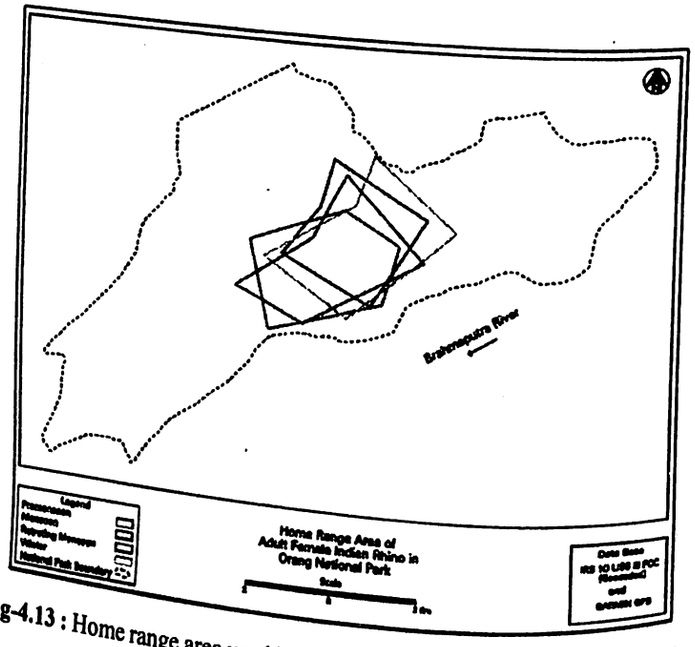


Fig-4.13 : Home range area used by marked adult female rhino during various seasons of the year

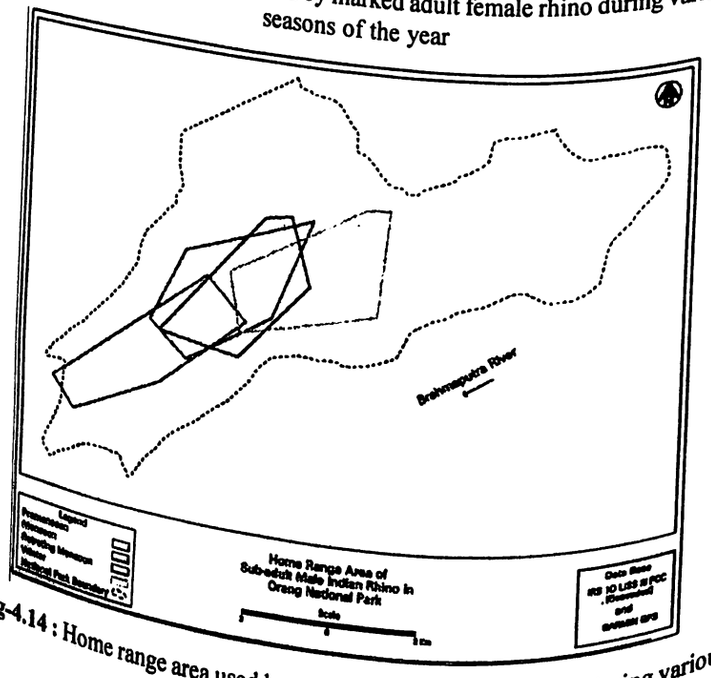


Fig-4.14 : Home range area used by marked sub-adult male rhino during various seasons of the year

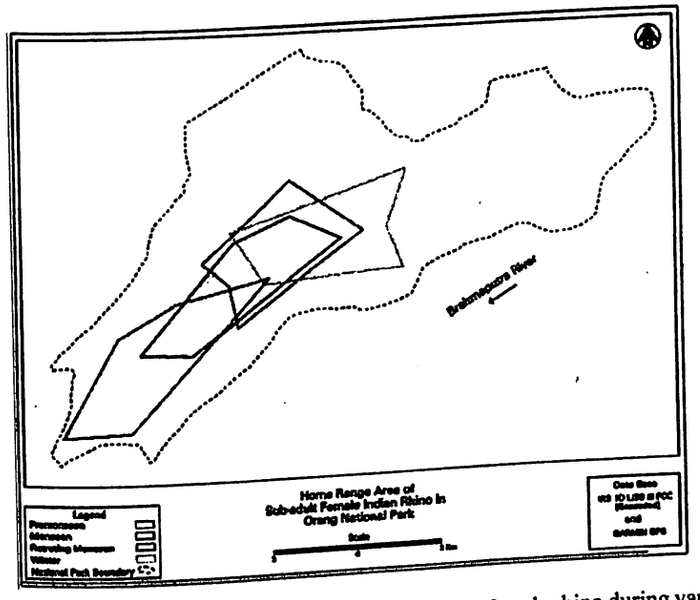


Fig-4.15 : Home range area used by marked sub-adult female rhino during various seasons of the year

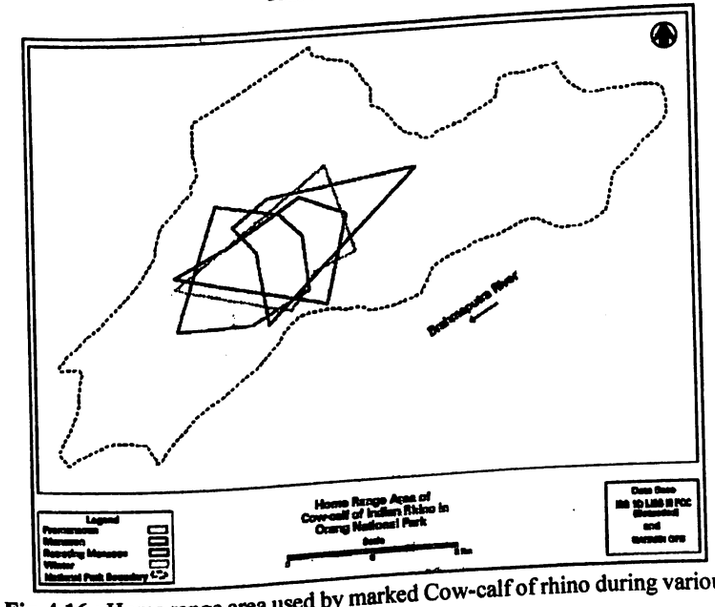
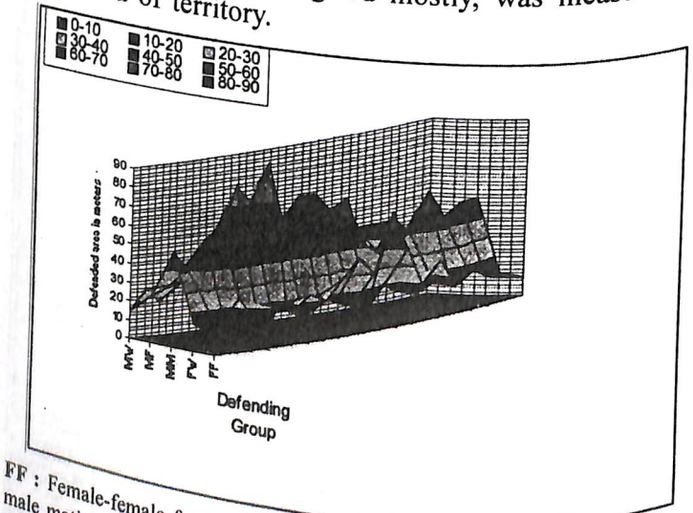


Fig-4.16 : Home range area used by marked Cow-calf of rhino during various seasons of the year

(b) Territoriality

The Indian Rhino showed distinct territoriality during breeding and foraging period, but possesses very less territoriality during wallowing period. Again, the territoriality was found to be strong between same sex groups than others. Apart from that, they maintained a distinct spatial distances between two rhinos in their daily activities. The study also showed that the spatial distance between male-male individual was higher than that of female-female individuals (Table-4.10). To avoid territorial conflict, the rhino maintained definite distance between male-male individuals and it was higher during mating display, followed by feeding and wallowing activities (Table 4.10). In case of female, no such territorial defence was observed during mating, as no two females were observed during mating display. But, female-female territorial defence was higher only during feeding and wallowing activity (Table 4.10).

The identified individual of Indian Rhino confined to a specific area indicated the territoriality of the species during foraging and feeding, wallowing, shelter and breeding. The area, where the individual rhinos were aggregated mostly, was measured as the defended area of territory.



FF : Female-female feeding; **FW** : Female-female Wallowing, **MM** : Male-male mating; **MF** : Male-male feeding; **MW** : Male-male Wallowing

Fig-4.17 : Spatial distance (m) maintained by adult-male and adult-female Rhinoceros that indicating the terrirorial defended area for wallowing, feeding and mating activities.

Table 4.10: The spatial distances (in meter) maintained for territory defence by adult male-male and adult female-female rhino

Defending animals	Territorial defended area in activity			N
	Wallowing (Mean ± SD)	Feeding (Mean ± SD)	Mating (Mean ± SD)	
Male*Male	16.35 ± 6.1	33.15 ± 8.98	57±14.36	60
Female*Female	15.8±4.07	22.6±12.76	—	40

Territorial defence

The territorial defence mechanism was always evident during courtship and feeding activities. But, the defence mechanism was not distinct during wallowing activities. However, the rhino maintained a clear-cut distance between two active wallowing sites.

Territory defence mechanism

Although rhinos were sometimes seen in group structure, in their natural habitat of two or more individuals (other than cow-calf, sub-adults and male-female pair), they did not form group, except courtship. However, sub-adult rhinos were observed grazing together as they formed group irrespective of sex. Study revealed that while grazing, adult males and adult females (without calf) other than courtship period, used to protect their territory by making snorting sound at regular intervals. Sneezing-like sound was also common while grazing. The individual rhino first stood still with its head up, erecting ear pinna and making snorts (n=27), whenever they observed any other individual. In some cases (n =7), it expressed attacking mood by advancing towards the intruder. In all cases except two, it was observed that, the intruder goes away after this behaviour of the first. It was observed that, during grazing, the first one raised its head, made a snort, curled its lip and the incisor teeth were visible in three cases.

In wallowing, it was observed that especially, the adult male rhino maintained a definite distance of at least 5-10 metres from other rhinos who shared the same water body for wallowing, depending on the size of water bodies. Another special feature of wallowing was that rhinos were always found facing towards the bank of the water body. Although several rhinoceros shared the same water body, but they came and departed by different tracks.

During courtship, the other rhinos maintained an average distance of more than 50 metre radius from the mating pairs. The male rhino frequently snorted and in three cases it was observed that by making both snorting and honking, the male chased and attacked the opponent.

Altogether 71 events of aggressive threat displays were observed during the process of territorial defence activities of which 11 were mating-territory defence activities in which maintaining of a distance of 40 meters between defender and offender rhinoceros was observed. Altogether 46 events of feeding-territory defence threat display were also observed. Those were performed by producing snorting resulting in maintaining a distance of 17.5m (range, 15-20 m, N=46) between two adults of same sex, which indicated the territorial defence activities during feeding. It was also found that in the feeding territory between two sub-adult rhinos no specific distance was maintained, which indicated the less territory during feeding. Altogether 14 events of wallowing-territory defence threats were observed. It was also observed that the male-male distance was always higher than that of male-female or male-sub-adult spatial distance.

The home range size of Indian Rhino in Orang National Park ranges between 5.94-6.84 km² in the present study. The findings indicate that the distribution pattern of food resource over the habitat has an effect on the movement pattern of Indian Rhino, which ultimately determines the size of the home range area. The present findings of home range of Indian Rhino also support the earlier study of Hutchins(1971). He has found 5.8-7.77 km² home range size of rhinoceros at Hluhluwe. But Laurie (1978-82) mentioned about the home range size of Indian Rhino ranges between 0.44-8.86 km² at Royal Chitwan National Park of Nepal. Such a low home range size of 0.44 km² area has not been observed in our present study. However, several variations of home range size and variability among age and sex classes have been reported in the present study sites at Orang National Park. This variation of home range pattern of Indian Rhino in Nepal and Indian condition might be due to variation of habitat qualities. Goddard (1967a and 1967b) revealed a wide variation of home range sizes in different habitats

qualities in Olduvai. He recorded a home range size of 2.5 km² in forest habitat and maximum of 8.8 km² in drying thorn-scrub habitat. In another separate study of Hutchinns (1969) recorded 3 km² home range size of Black Rhino in thicket habitat and 5 km² in Savanna habitat. Hence it could be opined that, the home range size is determined by the habitat factors as well as feeding behaviour of the species. As a grassland inhibitor, the Great Indian one-horned rhinoceros shows variation of home range sizes in different feeding habitats of different geographical locations.

Age-sex-class effect on home range size

The wide variation of home range size in different age-sex classes is evident in present study. A larger home range area may be due to excessive exploitation of food and mate resources and avoidance of territorial conflict, while a smaller home range occurs owing to some physical problems of the individual concerned and as well as the presence of smaller calf. Past studies also indicated a variation home range size among different age-sex classes of rhino (Laurie (1978, 1982). The former opined that the adult males are distributed over the habitat of females. So the home range sizes vary.

Territorial overlap

In the present study also the home range overlap amongst adult male and female is a common phenomenon, and 24 km² area is vigorously used by most individuals of rhino in Orang National Park. This is an indication of territorial overlapping among rhinos. Laurie (1978, 1982) also reported that the territory overlap up to 6 km² is a common occurrence in Nepalese rhino. He also indicated that the size of the territory overlap varies from individual to individual. In the present study, the adult male and old male rhino territory has overlapped with the adult female and old female during pre-monsoon and winter season. These two seasons are associated with the high mating frequency. The frequency of direct attack or charges to other individuals for defending territories are very low, but for avoidance of territorial conflict escaping behaviour by weaker male is very common among the rhinos in Orang National Park.

The study of the home range and territory of Indian Rhino in

Orang National Park indicates that the variation of home range size is a cause of strong positive selection of certain habitat pattern and food resources. This selectivity leads to territory over-lapping among different individuals. Laurie's (1978, 1982) findings of male-female territory overlap for accessing estrous females also supported our findings of territorial overlapping in Orang National Park. Again, the improved habitat quality might be supporting higher population size than it was earlier in the same habitat size.

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Chapter - V

HABITAT ECOLOGY

The individuals or a group of wild animals never use the entire habitat homogenously, but utilise selected zones of the habitat. This habitat selection may be determined by the availability of food resources, mate distribution as well as safety from predators (Fjellstad & Steinheim, 1996). There is a species-specific variation of habitat use pattern owing to distinct food choice of individual species, which may or may not be available in each habitat patches and home range area (Bell, 1971). The differences of food choice lead to a variation of habitat utilisation pattern in different species. It is widely applicable among herbivorous animals. The seasonal variation of food availability, such as burning of grassland and annual flood also affects the variation of habitat utilisation pattern of herbivorous animals (Lahan and Sonowal, 1973; Debroy, 1986). Again, the differences of age and sex ratios of animals are also found to determine the habitat use types. For example, the distribution of female Indian Rhino depends on the distribution pattern and quality of food resources over the habitat and the distribution of male Indian Rhino depends on the spatial distribution of females. The study of the species-specific habitat selection and its utilisation pattern are important to draw a comprehensive conservation strategy of the species. (Dinerstein & Price, 1991; Jnawali & Wegge, 1991)

The studies on the habitat use and utilisation pattern of *Rhinoceros unicornis* were conducted by Laurie (1978, 82), Rookmaaker (1982) and Dinerstein & Price (1991) in Terai grasslands of Chitwan National Park and Royal Bardia Wildlife Sanctuary of Nepal. However, very

little information is available regarding the study of habitat ecology and food habits of Indian Rhino in the Brahmaputra flood-prone plain habitat (Hazarika & Saikia, 2006). So, the present study on habitat use, its utilisation pattern and the selectivity of Indian Rhinos were carried out in the Brahmaputra flood-prone plain grassland of Orang National Park.

The prime aim of the present study was to find out the habitat preference and its utilisation pattern of Indian Rhinos in Brahmaputra flood-prone plain grasslands of Orang National Park. The objectives of the study were as follows -

(i) To identify the different habitat types of Indian Rhino in Orang National Park,

(ii) To find out the habitat utilisation pattern of *Rhinoceros unicornis* in Orang National Park in different months and seasons of the year,

(iii) To find out the habitat selectivity of Indian Rhino in Orang National Park.

The study of habitat ecology of *Rhinoceros unicornis was* carried out in the Orang National Park from April, 2000 to March, 2002. To find out the habitat use, habitat utilisation pattern and selectivity of different habitats were observed through direct field investigation. The available habitat types of Orang National Park were identified using satellite imagery, direct field observation and ground truth of habitat data. The methods adopted for the collection of habitat data in Orang National Park were described in the following sub-sections.

(a) Categorisation of habitat

To collect the habitat use data of Indian Rhino, a base map was prepared, using (1:50,000 scale) Survey of India (No. 83B/6) topographical map year (1967-1968) and it several copies. The location of existing anti-poaching camps and other relevant information were superimposed on the prepared topographical maps. The filled-up draft topographical maps during field investigation were again superimposed on the IRS IB LISS II Geo-coded F.C.C. (Satellite images) of 7, December 1996. To rectify the false colour composition and to standardise the colour specification of the satellite imagery, several

field visits were made covering all the study sites, representing all major habitats. While passing through different habitats, the GPS readings (latitude and longitude) were taken in respect to habitat types and then incorporated into the working satellite imagery to determine the variation of habitat types, based on colorations. Total area in different landscape areas was calculated by using a Digital Planimetre based on the specific area of different colours in the satellite imagery. The habitats were categorised on the basis of the different vegetation structures and landscape characters.

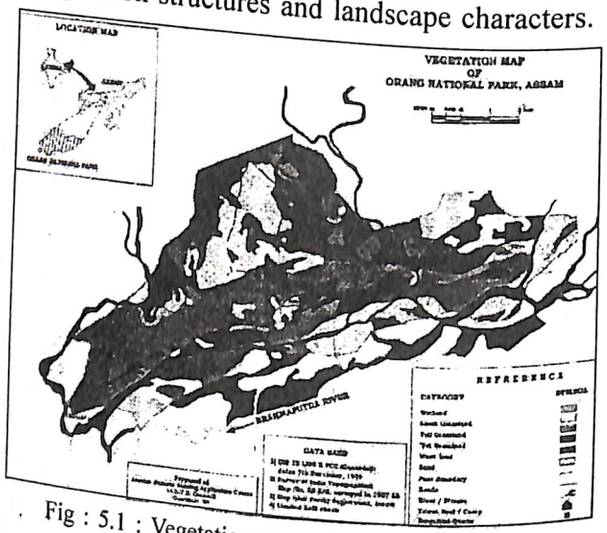


Fig : 5.1 : Vegetation map of Orang National Park

(b) Habitat utilisation pattern

To investigate the habitat utilisation pattern of Indian Rhino in Orang National Park, each and every area of the park was visited and the sightings of rhino was recorded and then plotted separately in the base map, in respect to age-sex class and the habitat types. The activities at the time of first sighting of Indian Rhinos were also noted down. The GPS readings at the site (nearest 50 metre accuracy) and the time of animal sightings were also recorded.

(c) Habitat selectivity

The selectivity of the different habitats by rhino was calculated to find out the habitat preference of the species. To determine the habitat selectivity, the ratios of available areas of different habitats were compared to the ratios of rhinos sighted in different habitats.

$$\text{Habitat Selectivity} = \frac{\text{Total no. of rhino sighted in a particular habitat}}{\text{Total no. of sighting record of rhino in all habitats}} \times 100$$

Landscape matrix

The analysis of Satellite Imagery of Orang National Park revealed that out of total of 78.81 km² area of the park, 25.93 km² (32.9%) area was occupied by dry tall-grassland, followed by wet grassland (both marshy and wet) 17.13 km² (21.7%), short grassland 14.05 km² (17.8%), 10.75 km² (13.6%) wetland, woodland 6.88 km² (7.7%) and water bodies and sand bars 4.86 km² (5.5%). Of all the water bodies, the area of 0.5 km², (0.6%) was covered by stagnant water bodies and an area of 4.36 km² (5.5%) was covered by flowing rivers and streams

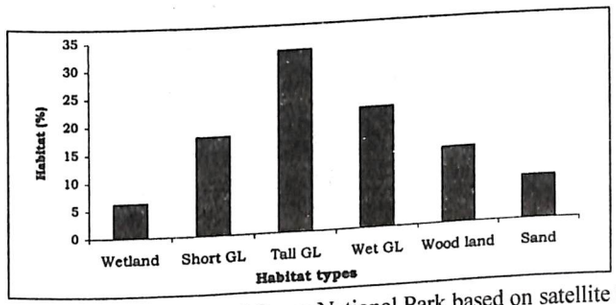


Fig : 5.2 Landscape classification of Orang National Park based on satellite imagery and field survey

Rhino habitats

Study revealed that the Indian Rhino utilised altogether five major habitat types in Orang National Park, such as (i) Water bodies, (ii) Short grassland, (iii) Tall grassland, (iv) Wet grassland and (v) Woodland habitat. (Plate-3)

(i) Wetland or water bodies

The water bodies included all the landscapes with at least minimum water exists up to above ground. The basic types of water bodies were such as open water wetland, stagnant water bodies, marshy land, rivers and streams. The ditches and low lying wallowing sites, which generally dried up during the winter season, were also included under water bodies.

(ii) Short grassland

The landscape area, which covered below five feet tall grasses, was categorised as short grassland habitat. The vegetation composition of this habitat was - *Hemarthria compressa*, *Cyandon dactylon*, *Andropogon aciculatus*, *Digitaria ciliaris*, *Oplismenus burmanni*, *Laptochloa panacea*, *Eleusine indica*,*Imperata cylindrica*, etc. The roadside area's ground cover and different camp premises with grass heights of below five feets were also included under short grassland habitats. In certain occasions, the tall grass species like *Arundo donax*, *Phragmatis karka*, *Saccharum ravanae*, etc. were grown very dwarf, owing to edaphic conditions. Hence, those vegetation types were also considered as short grassland habitat. Again, the small patches of tall grasses, existed within continuous patches of short grassland, were also considered as short grassland.

(iii) Tall grasslands

The landscape area with a grass height of above 5 feet was categorised as tall grassland habitat. The characteristic vegetation types of tall grasslands composed of *Saccharum ravanae*, *Phragmites karka*, *Saccharum spontaneum*, *Arundo donax*, *Impareta cylindrica*, etc. The small patches of short grassland within the vast area of tall grassland were considered as tall grassland during landscape classification.

(iv) Wet grassland

The landscape area composed of marshy and wet grasses were categorised as wet grassland habitat. In marshyland habitat, the soil was saturated with water content and the ground zones become muddy. The edges of *beels*, found to be almost dry during winter seasons, were categorised as marshy habitat. The grass species composed of marshy habitat, mainly, *Hymenachne pseudointerrupta*, *Leersia hexandra*, *Hygroryza aristata*, etc. and the dominant grass species in wet grassland, such as *Hymenachne pseudointerrupta*, *Leersia hexandra*, *Oplismenus burmanni*, *Hygroryza aristata*, etc.

(v) Woodland

The landscape area, which was covered by woody trees with a height of above 15 feet with undergrowth vegetations, was categorised as woodland habitat. Although there were many sandy

areas (or sand bars) in the study area, but the Indian Rhino was never seen utilising these zones.

Habitat utilisation pattern

Study revealed that the Indian Rhino used a maximum of 41.41% wet grassland habitat, followed by 27.88% tall grassland, 18.99% water bodies, 8.08% short grassland and only of 3.64% woodland habitat in Orang National Park throughout the year (Fig: 5.3). The Indian Rhino was never found using sandy areas in Orang National Park, but the hoof marks were seen on the sandy river banks and river beds.

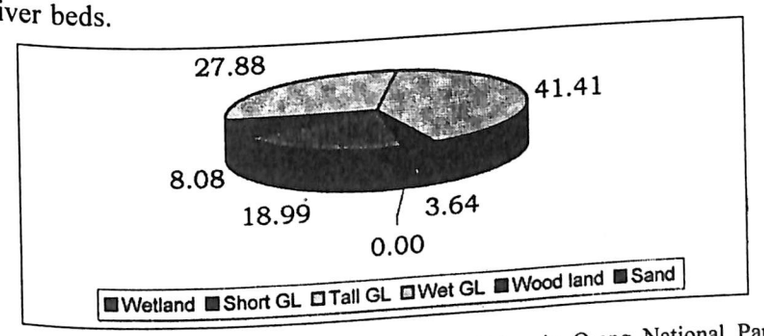


Fig: 5.3. Habitat utilisation pattern of Indian Rhino in Orang National Park throughout the year (Data in % basis)

A. Seasonal use of habitat

(i) Pre-monsoon

Study showed that the Indian Rhino used highest of 45.7% wet grassland, followed by 38.3% tall grassland, 7.4% water bodies, 5% short grassland and minimum of 3.7% woodland habitats during pre-monsoon season (Fig.-5.4).

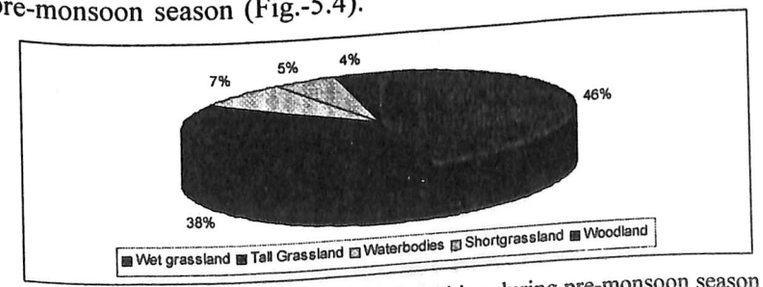


Fig: 5.4: Habitat utilisation pattern of Indian Rhino during pre-monsoon season in Orang National Park (Data in % basis)

(ii) Monsoon

Study showed that Indian Rhinos utilised highest 42% of wet grassland, followed by 35.5% water bodies, 9.7% tall grassland and 6.5% each in short grasslands and woodland habitat during monsoon season (Fig. 5.5)

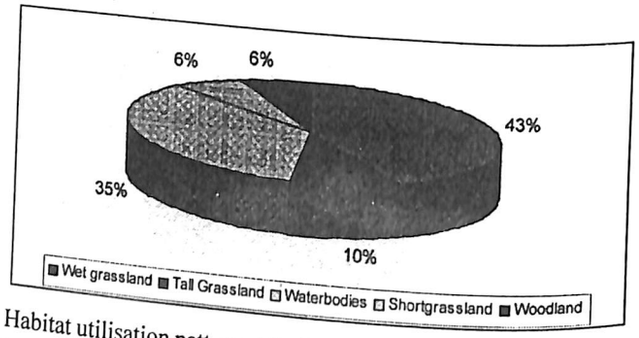


Fig: 5.5: Habitat utilisation pattern of Indian Rhinoceros during Monsoon season in Orang National Park (Data in % basis)

(iii) Retreating monsoon

Study revealed that the Indian Rhino utilised highest 42% of wet grassland habitat, followed by 26% each in tall grasslands and water bodies (wetland habitat), 6% woodland habitat and minimum 4% of short grassland habitat in Orang National Park during retreating monsoon season (Fig. 5.6).

(iv) Winter

Study revealed that the Indian Rhino utilised highest 37% of wet grassland, followed by 29% tall grassland, 16% water bodies (wetland), 14% short grassland and minimum 4% of woodland habitat in Orang National Park during winter season (Fig.5.7).

The analysis of proportional use of habitat types by Indian Rhino in Orang National Park showed that during monsoon season, proportional use of wetland and woodland habitat was higher than the other habitats (Fig.5.8a), whereas it was tall grassland, wet grassland and woodland habitat during pre-monsoon season (Fig.5.8b). During winter season, the proportional use of short grassland and woodland habitat was higher than the other habitats (Fig:5.8c), whereas the proportional use of wetland habitat was higher during retreating monsoon season (Fig.5.8d). The analysis of Spearman Rank

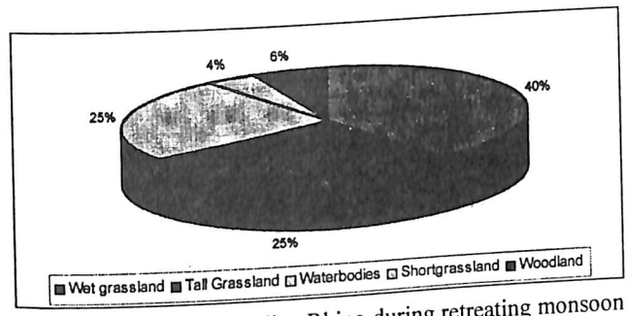


Fig: 5.6 : Habitat utilisation by Indian Rhino during retreating monsoon in Orang National Park (Data in % basis)

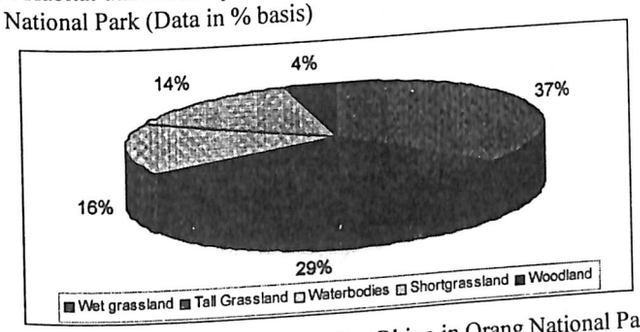


Fig: 5.7 : Habitat utilisation pattern of Indian Rhino in Orang National Park during winter season (Data in % basis)

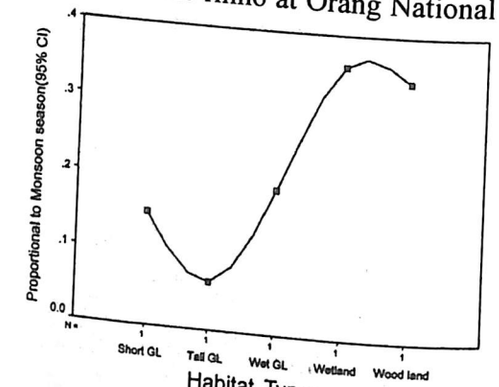
correlation between the seasonal use of habitat types showed that, there was a significant negative correlation between habitat use type of Indian Rhino during retreating monsoon and winter season (Spearman Rank Correlation : $r^s = -.037$; $p = 0.05$).

Habitat preferences of adult male and female rhino

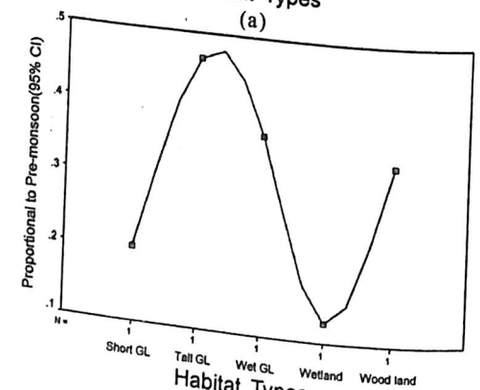
Again the analysis of dry and wet season preferences of habitat types by adult male and female rhino showed that the proportional use of wetland habitat was higher for both male and female rhino during wet than dry season (Fig.5.9a and Fig.5.10a). Whereas the proportional use of woodland, short grassland, tall grassland and marshyland habitat was different for both adult male and adult female during dry season (Fig. 9b and Fig.10b).

The analysis of Spearman Rank correlation between male and female habitat use types during dry and wet season showed that for both the male and female, dry and wet season habitat use was significant but there was negative correlation between each other

(For female - **Dry and Wet**: Spearman Rank correlation = $r^s = -0.613$, P =0.0001; For male - **Dry and Wet**: = $r^s = -0.842$; P = 0.0001), indicating the different types of habitat during dry and wet season by both adult male and female rhino at Orang National Park.



(a)



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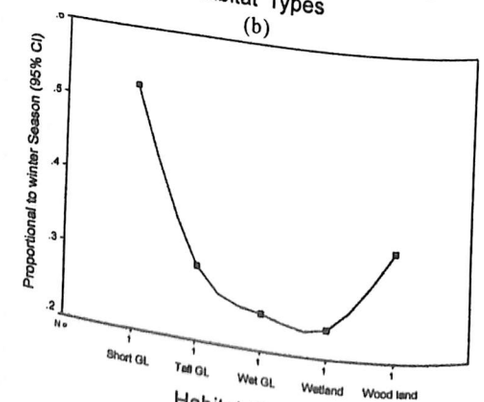
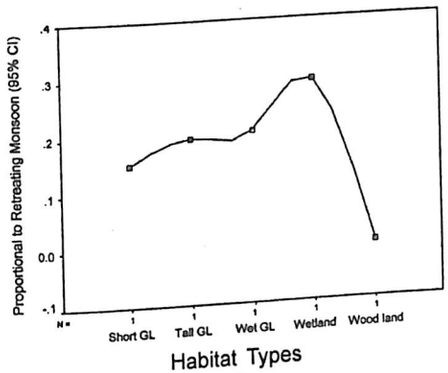
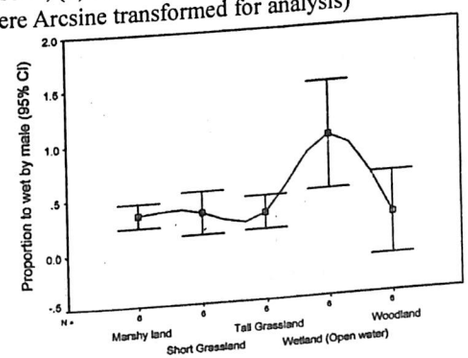


(c)



(d)

Fig. 5.8 Proportional use of habitat types by Indian Rhino in Orang National Park (a) Monsoon, (b) Pre-monsoon, (c) Retreating monsoon, (d) Winter season (Data were Arcsine transformed for analysis)



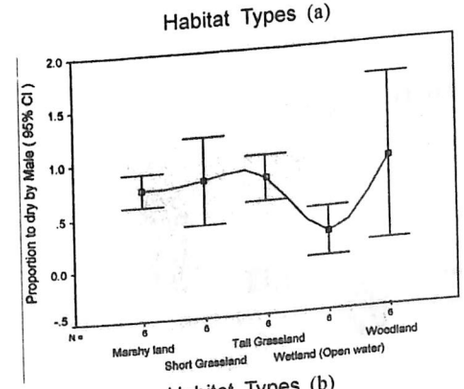
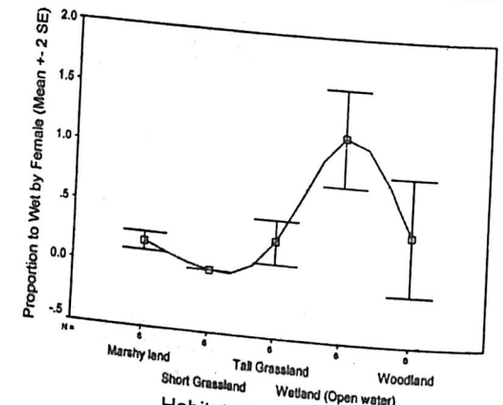


Fig. 5.9 Dry and wet season habitat preference by adult male Rhino in Orang National Park (a) During wet season, (b) During dry season (Data were Arcsine transformed for analysis)



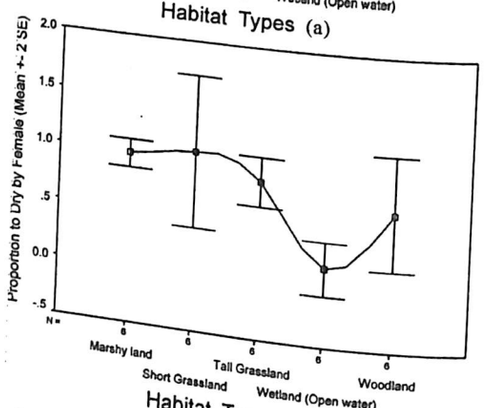


Fig. 5.10 Dry and wet season habitat preference by adult female Rhino in Orang National Park (a) During wet season, (b) During dry season (Data were Arcsine transformed for analysis)

Habitat Selectivity :

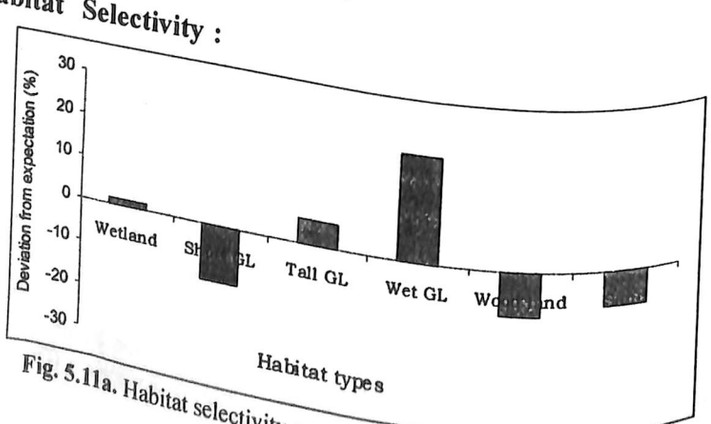


Fig. 5.11a. Habitat selectivity expectation level Pre-monsoon season.

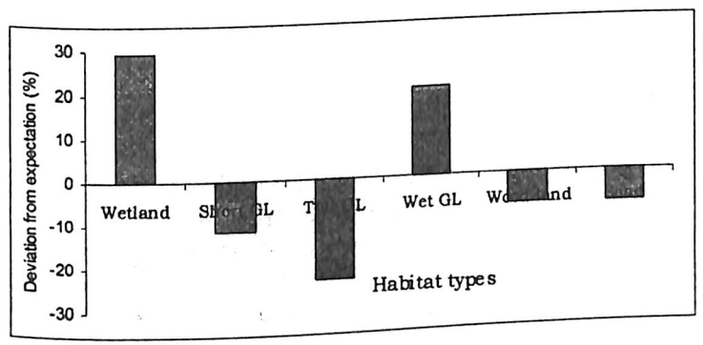


Fig. 5.11b. Habitat selectivity expectation level Monsoon season.

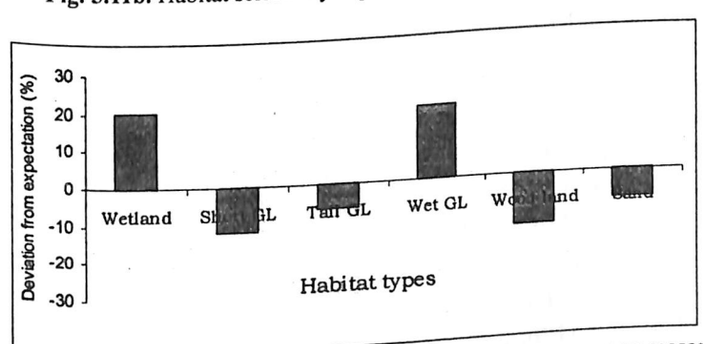


Fig. 5.11c. Habitat selectivity expectation level re-treating moonsoon season.

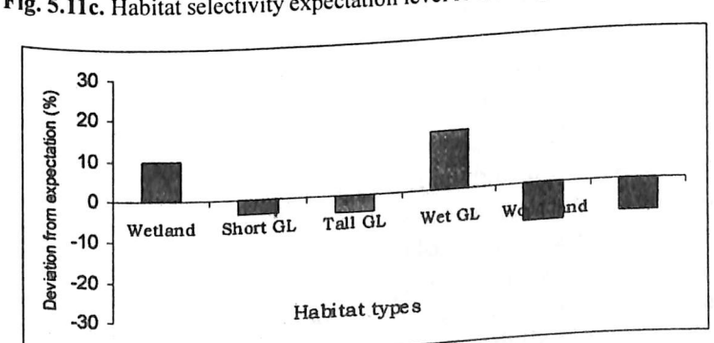


Fig. 5.11d. Habitat selectivity expectation level winter season.

The variation of habitat utilisation pattern of Indian Rhino in Orang National Park showed that the wet grassland and water bodies (wetland) were the highly selected habitat, while the short grassland,

tall grassland and woodlands habitats were less selected habitats during pre-monsoon season. The wet grassland habitat was highly selected (24%) by Indian Rhino in Orang National Park, followed by tall grassland (5%) and wetland habitat (only 1%) (Fig.5.11a). During monsoon season, the wetland habitat was highly selected by the Indian Rhino (29%) for feeding, (above expected level), followed by wet grassland (20%), whereas the tall grassland, short grassland and woodland habitat were less selected (23%, 11% and 7% respectively) (Fig.5.11b). During retreating monsoon season, the wetland habitat was highly selected by Indian Rhino in study area (20%, above the level of expectation), followed by wet grassland (19%), while the woodland, short grassland and tall grassland habitats were less selected (14%, 12% and 6% respectively) than others (Fig.5.11c). During winter season, the wet grassland habitat was highly selected (14%, above the level of expectation), followed by wetland (10%), whereas the woodland, tall grassland and short grassland habitats were less selected for Indian Rhino (9%, 4% and 3% respectively) in Orang National Park (Fig.5.11d).

It is evident from the present study that the Indian Rhino in Orang National Park prefers wet grassland habitat throughout the year. The Indian Rhino selects this habitat not only for food availability, but it is the positive selection of foraging ground. Most of the rhinos prefer food items, which are available in the wetland habitat (marshy land) of the study area. There are several advantages to use this wet grassland habitat. Firstly, the grasses of the wet grassland habitats are relatively softer than the grasses found in dry zones of the habitat. Secondly, while the Indian Rhino forages on marshy habitat, the animals confronted with less disturbances from annoying flies. Thirdly, the body temperature is regulated by water content available in the marshy habitat while grazing, standing and wallowing in the waterlogged area. Again the edible grasses are available in wet and marshy habitat in all the seasons. When the tall grasses get matured during late October, the soft grasses become coarse, hard and unpalatable. Hence, the Indian Rhino seldom uses tall grassland after October. This type of grazing situation on unpalatable grasses of tall grassland from October onward to new sprouting stage was reported by Ghosh, (1991) in his studies.

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Chapter – VI

ACTIVITY BUDGETING

Activity budgeting of an animal denotes the allocation of time in various diurnal (or nocturnal for certain animals) activities in a specific time period. The study of activity budgeting is very essential for a species to understand its lifestyle characteristics and is a foundation stone for interrelating the ecology and behaviour of animal species (Struhsaker and Leland, 1979). The allocation of time in different behavioural activities and its distribution pattern in each day is very important aspect to understand the time adjustment of an animal in various feeding habitats to optimise its resource use for growth and development. This is primarily because "time" is a hidden constraint that affects all other behaviours (Dunbar, 1992). Again, the activity budgeting also varies depending on the numbers of ecological and biological factors, such as body size (Clutton-Brock & Harvey, 1977; Gaulin, 1979; Struhsaker & Leland, 1979), diet availability (Clutton-Brock, 1977; Zielinski *et al.*, 1983), distribution and abundance of food resources (Milton, 1980; Bhattacharya & Pal, 1982; Harvey, 1985; Mendes, 1989; Srivastava, 1989; Sarkar, 2000) and climatic factors (Bernstein, 1972; Bernstein & Mason, 1963; Chivers, 1969) of an animal.

Again, the activity is the behavioural output of an individual or group of animals of a species in response to resource availability and the other responses to climate, competition for resource, mate availability, etc. It is also an important indicator of the health of a habitat which reflects the status and distribution patterns of the resources.

Since the activity budgeting helps understand the species-specific and site-specific time allocation, it is used as a tool to lay out comprehensive conservation strategy for a species in a particular area. Most of the studies on activity budgeting of large herbivores have been done by several authors, such as Indian Rhino by Laurie (1978) & Ghosh (1991) and wild elephant by Sukumar (1989), etc. Again, Laurie (1978, 82) and Bhattacharya & Pal (1982) studied the diurnal cycle of activity budgeting of Indian Rhino in Nepal and West Bengal, but very little attempt was made to study the activity budgeting of Indian Rhino in the Brahmaputra flood-prone plain.

The present study of activity budgeting of Indian Rhino was an attempt to find out the daily time allocation in different behavioural settings of the species in Orang National Park. This will help lay out the site-specific conservation strategy for the Indian Rhino, especially in Orang National Park or other similar rhino habitats of the flood-prone plain area on the bank of river Brahmaputra.

The main objectives of the activity budgeting of Indian Rhino were, such as:

1. To investigate the activity pattern of Indian Rhino in Orang National Park in different seasons of the year,
2. To identify the major behavioural activities that play a vital role in time allocation of Indian Rhino.

For convenience of study, field surveys for activity budgeting of Indian Rhinos were done during day light hours in Orang National Park. The night surveys were not possible owing to lack of sufficient infrastructure and security arrangements. Again, the night survey was also not possible due to less visibility for dense habitat condition (thick tall grasses). The following methods were adopted for the study of activity budgeting of Indian Rhino in Orang National Park.

(a) Scan sampling

The continuous follow up action of Indian Rhino, using *Focal Animal Sampling* (Altman, 1974) was not possible, owing to excessive tall grasslands (where the tall grasses overshoot the rhino height). Hence, Scan Animal Sampling (Altman, 1974) was found to be suitable for sampling the activity budgeting of Indian Rhino in Orang National Park. The Ad. Libitum Sampling method (Altmann, 1974) was also

used to record the important activities between two scans.

(b) Data collection

During the study of Indian Rhino in Orang National Park the "dawn to dusk" investigation methods were followed and the observed behavioural activities were recorded and the time spent in various activities by all individuals sighted in each 5 minutes time period was also recorded. For these purposes, data sheets were prepared and carried to the field for instant data recording (Appendix: 6.1). The activity patterns, such as feeding, locomotion, comfort, wallowing, vigilance, non-breeding play, breeding play, agnostic and all other behaviours related to its breeding and non-breeding purposes, etc. were recorded in the data sheet. Apart from that, the less frequent activities sighted between two scans were also recorded in the data sheets (*Ad. Libitum Sampling*, Altman, 1974). During data collection, the uniformity was maintained to represent all age and sex compositions of Rhino.

Selectivity of time allocation for behavioural settings

The time allocation for various behavioural activities by an animal may be determined either by availability of time or habitat condition, as well as other ecological factors. To find out this selectivity, the seasonal variation of time spent in different behaviours were compared with the overall time allocation in different activities.

Activity budget

The present study revealed that the Indian Rhino showed distinct variation of activity pattern in different seasons of the year. The Indian Rhino in Orang National Park spent a maximum of 46.2%

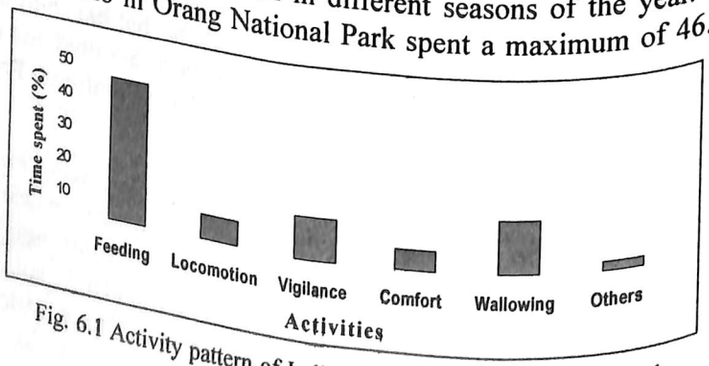

Fig. 6.1 Activity pattern of Indian Rhino in Orang National Park throughout the year.

time on feeding activities, followed by wallowing 18.4%, vigilance 15.1%, locomotion 9.1%, comfort 8.01% and minimum of 5.6% in other miscellaneous activities (Fig-6.1). The results indicated that feeding was the guiding factor, which affect time allocation in various activities, possesses by Indian Rhino.

a) **Seasonal variation of feeding activity**

The study showed that the Indian Rhino in Orang National Park allocated maximum time on feeding activities (55.29%) during winter season, followed by pre-monsoon (48.75%) and retreating monsoon (47.34%) season, whereas it was lowest (36.96 %) during monsoon season (Fig: 6.2a).

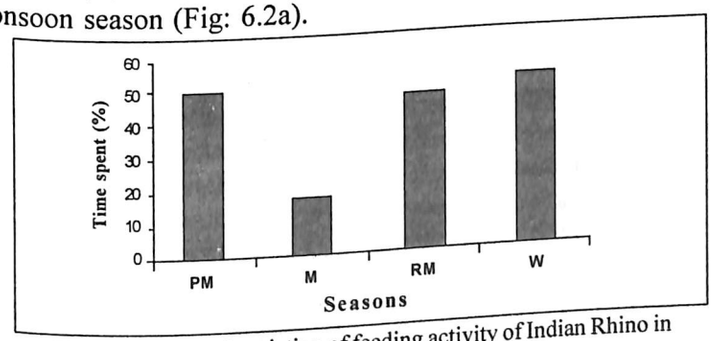

Fig: 62a : Seasonal variation of feeding activity of Indian Rhino in Orang National Park

(b) Locomotion

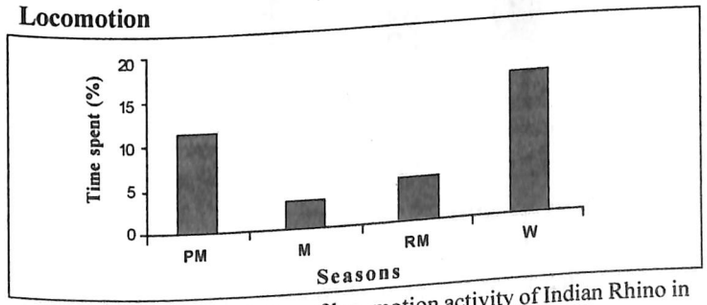

Fig: 6.2b : Seasonal variation of locomotion activity of Indian Rhino in Orang National Park

There was also a distinct seasonal variation of time allocation in locomotion activity of the Indian Rhino. The highest percentage of locomotion activity was observed during winter season (16.5%), locomotion activity was observed during pre-monsoon (11.32%), retreating monsoon (5.07%) and followed by monsoon season (3.3%) (Fig: 6.2b).

(c) Wallowing

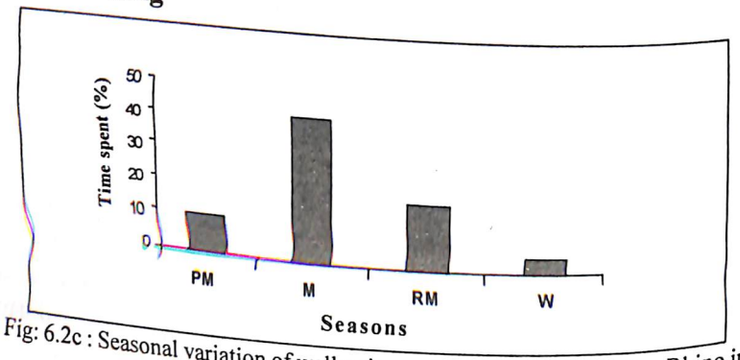

Fig: 6.2c : Seasonal variation of wallowing activity showed by Indian Rhino in Orang National Park

The study showed that, the variations of time allocation in wallowing activity by Indian Rhino were varies in different seasons of the year. The highest time allocation on wallowing activity was found during monsoon season (41.3%), followed by retreating monsoon (17.4%) and pre monsoon (9.1%), whereas lowest (2.2%) time was allocated during winter season in Orang.

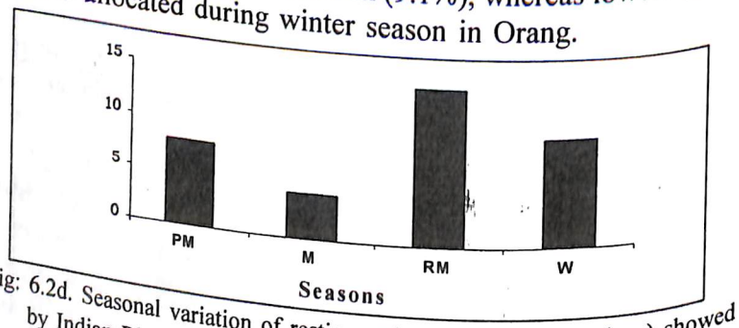

Fig: 6.2d. Seasonal variation of resting activity (comfort behaviour) showed by Indian Rhino in Orang National Park.National Park (Fig :6.2c).

(d) Comfort behaviour

Study showed that the time allocation of Indian Rhino for comfort activities were varies in different seasons of the year. The highest time was allocated during retreating monsoon (14.7%), followed by winter (10.1%), pre monsoon (7.9%) and monsoon season (4.2%)(Fig:6.2.d).

(e) Vigilance

Study revealed that the Indian Rhino spent almost equal time on vigilance behaviour in all four seasons of the year. However, the

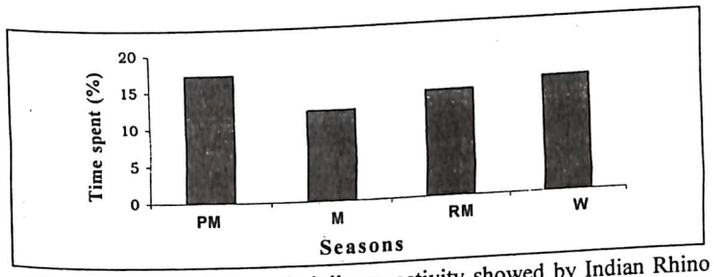

Fig: 6.2e. Seasonal variation of vigilance activity showed by Indian Rhino in Orang National Park

trend of vigilance activity increased during winter and it continued till pre-monsoon season (Fig:6.2e).

(f) Miscellaneous activities

Study showed that the Indian Rhinos spent 5.6% of time in various other miscellaneous activities. During pre-monsoon season, they spent 1.9% of time on miscellaneous activities, followed by retreating monsoon (1.8%), monsoon (1.2%) and winter season (0.7%).

Selectivity of time allocation in behavioural activity

The analysis of selectivity for time allocation in different behavioural activities of Indian Rhino showed that except wallowing activity, there was no selectivity in behavioural settings during pre-monsoon season. The wallowing activity was negatively selected during pre-monsoon season, in which the species spent comparatively less time in wallowing than the level of expectation (Fig: 6.3a).

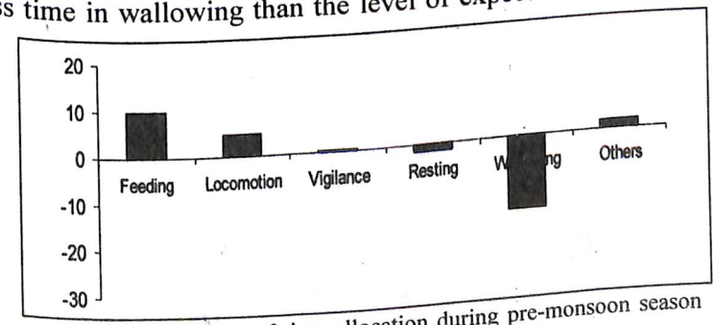

Fig: 6.3.a. Selectivity of time allocation during pre-monsoon season (Deviation from expectation).

Again, during monsoon season, the time allocation for feeding, locomotion, vigilance (monitoring) and comfort activities were negatively selected, while in wallowing, it was positive during

monsoon season (Fig.8.3b).

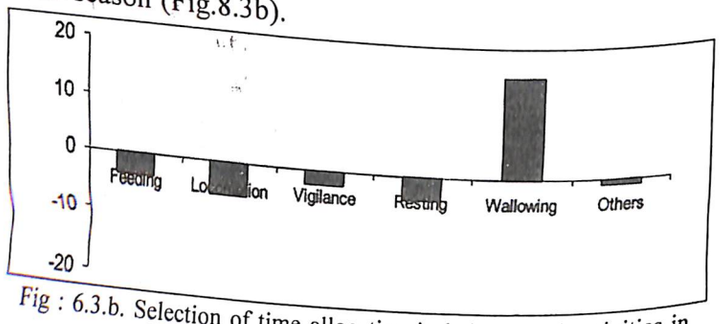

Fig : 6.3.b. Selection of time allocation in behavioural activities in monsoon season (Deviation from expectation).

There was no major selection trend of time allocation in feeding, locomotion, vigilance and wallowing activities, during re-treating monsoon observed, whereas it was positive for comfort behaviour. (Fig.6.3c).

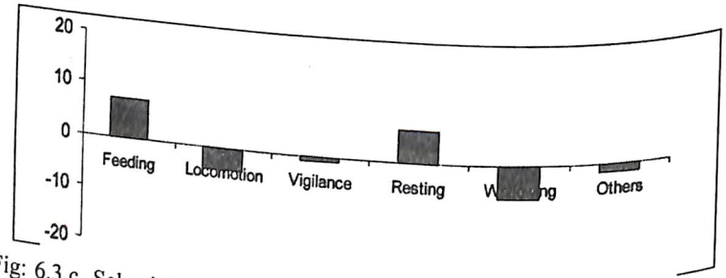

Fig: 6.3.c. Selectivity of time allocation during Retreating-monsoon season (Deviation from expectation).

(d) Winter

Study showed that, there was a distinct positive selection (10%) of time allocation in feeding and locomotion activity during winter season. But the highest of 16.2% negative selection of time allocation was observed in wallowing activity during winter. (Fig.6.3d).

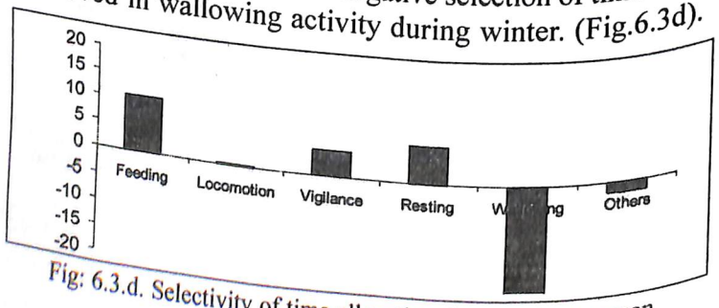

Fig: 6.3.d. Selectivity of time allocation during winter season (Deviation from expectation)

Activities during dark

Although no systematic night surveys of Indian Rhino were done during study period occasional observation revealed that the rhinos remained active during night hours also. It was found that the rhino frequently moved from one place to other for foraging and mating activity during darkness. Grazing was observed till midnight and in early hours of the day. Study also showed that the frequency of mating display was higher during night hours than morning hours, which could be easily recognised from their special vocalisation of *"thet-thet... thet-thet"* and metallic whistling sound. The geophagy (the soil eating activity) and crop raiding (in fringe villages) normally took place during night hours. But, they were never found wallowing during night hours, although they frequently crossed the river, canals and *beels* (wetlands).

The present findings of higher time spent on feeding activity by Indian Rhino across the season indicate that the feeding activity is the guiding factor responsible for variation in time allocation in different behavioural patterns. The time surplus after feeding activity is thus shared in all other activities like locomotion, comfort behaviour and social interactions, etc. The earlier studies on activity budgeting of Indian Rhino by Laurie (1978, 82) also suggested that activity budgeting of Indian Rhino mainly depends on the factors like diet quality and distribution and abundance of food resources. Again, the present findings in less time spent on feeding activity during monsoon and maximum in other three seasons are the results of comparatively higher food availability in habitat during monsoon season. So, Indian Rhino in the Orang National Park lives on forage during the season of the scatteredly distributed food or less available. The individual rhino has to forage more time to locate the food, resulting in higher time spent on foraging. But, when food is uniformly distributed or comparatively high in the habitat, the individual of Indian Rhino spends less time in foraging, leading to less time allocation. However, when time spent on feeding is high, the individuals of Indian Rhino again readjust their time in various other activities, as diurnal hours are fixed. Since "time" is a limiting factor, the Indian Rhino has to determine the cost benefit to the spent time in various activities throughout the day. For the survivability and reproduction needs, proper quantity of energy and therefore, an individual never

compromises with time in feeding activity.

Since most of the time an individual has to spend on foraging and locomotion activities, the individuals of Indian Rhino have to spend a lot of energy. To balance this loss, a rhino has to spend a lot of time on comfort activity. A least time spent during monsoon must have relationship with the availability of food resource, which is reflected in the study. The time saved for comfort was spent 8.01% on resting, 18.4% on wallowing, 15.1% on vigilance and 3.1% on other social behaviour. Laurie (1978) has found that Indian Rhino spent 36.4% of their total time on resting activity in Chitwan National Park, Nepal. Vigilance (monitoring) behaviour is equally necessary for Indian Rhino in different seasons of the year to protect themselves from enemy and hence no significant seasonal variation was observed.

Again, the wallowing activity increases more than two folds during monsoon, as compared to other two seasons. These results indicate that the time spent on wallowing activity mainly depends on the availability of water resources. Since water resource is available during monsoon, the individuals of Indian Rhino select more time on wallowing during monsoon and less time during winter season. The wallowing activity during monsoon may be related to thermo regulation of the body of Indian Rhino. It is also evident from the present study that the rhinos also wallow during heavy showers of monsoon in Orang National Park and hence, contradict the reasons of thermoregulation alone. Again, the distribution of wallowing activity throughout the seasons in Orang National Park indicates that exo-parasites like flies, ticks, etc. disturbed the body of Indian Rhino and to avoid disturbances they go for wallowing. Ghosh(1991) stated that the functions of wallowing behaviour is a part of reducing disturbing factors of ectoparasites and annoying flies. So, wallowing activity is one of the most essential behaviours of Indian Rhino for their survival.

However, the foraging costs in terms of searching, processing and nutritional benefits differ among different food items. Hence, an individual or a group of individuals manage the time allocation in feeding, moving and other activities in order to balance the foraging costs in different food items. Therefore, the time allocation in different activities, especially in foraging activity is greatly influenced by the nature of food (Clutton-Brock, 1975) and their spatial distribution in the habitat.

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Chapter – VII

FOOD AND FEEDING ECOLOGY

Food is the primary requirement of an animal to survive and maintain their good health. Hence, the animal must acquire food that contains enough nutrients to fulfil their physiological needs. Again, the distribution pattern of food resources over the habitat guides the distribution of male and female individuals. (Mary *et al.*, 1998). Hence, the availability of food resource and its distribution pattern not only affect the physiology of a species, but also affect the activity (or time budget) and the habitat utilisation pattern of the wildlife species.

The study of species-specific food choice and the distribution pattern of food resources over the habitat is important prerequisite to improve the habitat quality and has a great value for in situ conservation of a species. It also helps in evaluating the habitat quality before initiating the species re-introduction programme. Hence, a number of keystone and flagship species (Krebs, 1985; Riclkefs, 2001) are subjected to study to lay out a holistic approach for conservation and management action plan. During the conservation and management process, the feeding ecology is one of the best tools for understanding the food choice of a species, which further helps in understanding the reasons of habitat selectivity and variation in time allocation in different activities.

A number of studies on feeding ecology of Indian Rhino were conducted by several authors in India and Nepal (Laurie, 1978, 82; Deka *et al.*, 2003; Bairagee, 2004; Patar, 1977; Brahmachary *et al.*, 1969, 1971; Bhattacharyya, 1991; Ghosh, 1991; Hazarika and Saikia, 2006). Apart from that, the studies on the chemical composition of

food items (Deka *et al.*, 2003; Banerjee, 2001), feeding behaviour of rhino (Laurie, 1978, 82), analysis of rhino dung, seed dispersal and germination of seed on rhino dung (Dinerstein, 1991; Brahmachary *et al.*, 1971) were also carried out in India and Nepal conditions. Among those, most studies were conducted in Terai grassland and on rhino population. Although, few studies were carried out in the Brahmaputra flood-prone plain area, most of them were qualitative in nature. Hence, the present study was aimed at quantifying the data on feeding ecology of rhino and analysing the food and feeding habits, food preference and food selectivity of rhino in Orang National Park.

The main aim of the present study was to find out the food and feeding habit and food selectivity of Indian Rhinos in order to lay out a comprehensive conservation strategy in the Brahmaputra flood-prone plain habitats. For this purpose, the following objectives were selected for the study.

1) To investigate the food habitat of Indian Rhino to find out the seasonal feeding pattern in Orang National Park,
2) To identify the food plants species and its characteristics in different habitat of Orang National Park,
3) To identify the staple food of Indian Rhino in Orang National Park,
4) To find out the food selectivity and dietary spectrum of Indian Rhino in Orang National Park, based on gathered data.

For the study of food and feeding ecology of Indian Rhino, the following methodologies were used for data collection.

(a) Vegetation sampling

For vegetation sampling, a total of 80 quadrats (1m×1m in size) for grasses, 20 quadrats (5m×5m in size) for shrub and herbs, and 20 quadrats (10m×10m in size) for trees were taken covering all the habitats in Orang National Park. Since the Orang National Park is primarily a grassland habitat dotted with scattered forests and shrub land, more quadrats were placed on grasslands, compared to other habitats. During sampling, the number of each individual plant species found on the quadrats were recorded to calculate the relative dominance (Krebs, 1985; Southwood & Henderson; 2000).

(b) Sampling for food and feeding

During 'dawn to dusk' sampling of Indian Rhino, the scan animal sampling (Altmann, 1974) and Ad. Libitum Sampling (Altmann, 1974) methods were used to collect the data of food and feeding habit at Orang National Park. During the study, the seasonal variation of time spent on feeding in different food plant species was recorded to identify the staple food, food selectivity and dietary spectrum of Indian Rhino in Orang National Park. The staple food referred here is the food items eaten by Indian Rhino throughout the year, irrespective of seasons. The food selectivity is the ratio of the per cent of time spent and per cent of dominance of each plant species.The ratio 'R' indicated whether the consumed plant species had an effect on availability in the habitat or outcome of the food selection. If the $R > 1$, then it suggested strong selection of feeding activity and when $R < 1$, then it suggested that the feeding occurred due to availability of particular food items. Again, if $R = 1$, then it indicated that the particular plant species was consumed as per its distribution and dominance in the sampling quadrat. The formulae of food selectivity could be represented as –

$$\text{Selectivity} = R = \frac{\%\text{ of feeding records of } A^1}{A^1 \text{ relative dominance}}$$

A^1 = Species 1.

The dietary spectrum was determined by quantifying the food dependency of Indian Rhino in the study area.

Relative dominance and frequency of food plant species

(a) Grasses :

The study revealed the presence of 75 grass species under Poaceae and Cyperacae family (Appendix: 6.1) in Orang National Park during sampling. Of the total 75 grass species, 48 had a relative frequency <1 and 13 had relative frequency 1-2 and 14 had >2 (Table: 7.1). The *Saccharum spontaneum* was the highest ranked relative dominant species whose dominance value was 8.45%, while the *Cyperus pilosus* was the lowest ranked grass species with an dominance value of 0.08%. (Appendix: 6.1).

(b) Shrubs and herbs :

A total of 27 shrubs and herb species belonging to 16 families

(Appendix: 6.2) were recorded during sampling in Orang National Park of which 3 species had a relative frequency <1 and 24 species had a relative frequency >1 (Table: 7.1). The species *Diplazium esculentum* was the highest ranked species among shrubs and herbs with a relative dominance value of 13.83%, while the *Solanum viarum* was the lowest ranked species with a relative dominance value of 0.66% (Appendix: 6.2).

(c) Trees :

The study found altogether 27 tree species belonging to 8 families (Appendix: 6.3) in Orang National Park with a relative frequency >1 (Table: 7.1). The *Dalbergia sisso* was the highest ranked species with a relative dominance value of 7.94%, whereas the *Anthochephalus cadamba* ranked the lowest was species with a relative dominance value of 1.19% (Appendix: 6.3.).

Table 7.1. Frequency of occurrence of grasses, shrubs, herbs and tree species in Orang National Park during the study

Frequency class	Frequency of grass species	Frequency of shrub and herb species	Frequency of tree
0 – 1	48	3	0
1 – 2	13	8	7
2 – 3	5	6	5
3 – 4	1	2	4
4 – 5	6	3	4
5 – 6	1	0	1
6 – 7	1	1	4
7 – 8	0	0	2
8 – 9	0	2	0
9 – 10	0	0	0
10 – 11	0	0	0
11 – 12	0	1	0
12 – 13	0	0	0
13 – 14	0	1	0
Total	**75**	**27**	**27**

Food items and food selection

The study showed that grass constituted the highest 86.66% of the total annual food of Indian Rhino in Orang National Park, but the non-grass aquatic plants and tree species constituted only 13.34 % of total annual diet indicating the high selection of grasses by Indian Rhino in Orang National Park during foraging.

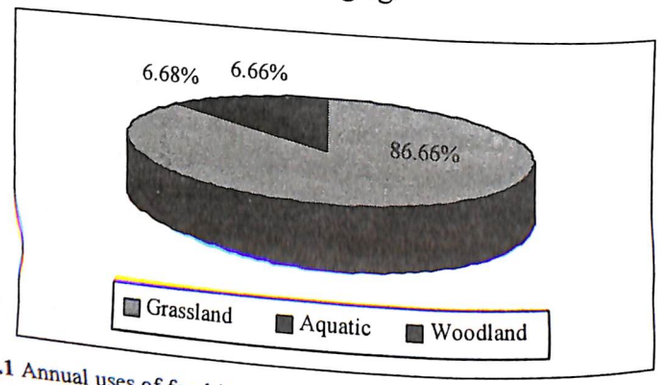

Fig: 7.1 Annual uses of food items by Indian Rhino at Orang National Park (data in yearly basis)

The study also revealed that the Indian Rhino selected 89.13 % grass species as food items during winter season and 83.50% during monsoon season (Fig: 7.2). Out of total 42 grass species, 20 species had no selectivity, but were still eaten, owing to availability of that species in the grassland habitat.

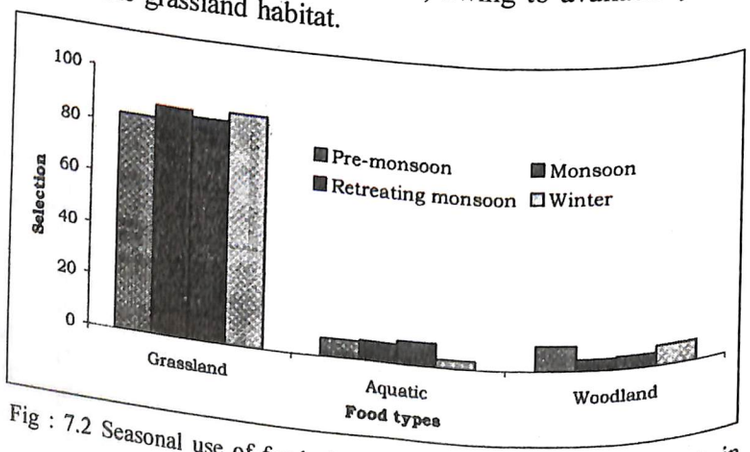

Fig : 7.2 Seasonal use of food plant species by *Rhinoceros unicornis* in Orang National Park during sampling

Food items

Study showed that, altogether 71 plant species were used by Indian Rhino as food items throughout the year in Orang National Park, of which 42 species were from grasses, 20 species from trees, shrubs and herbs and 9 species were from aquatic food plant species (Appendix 6.4). Again, out of all the 71 food plant species, the Indian Rhino consumed a total of 63 plant species as food during pre-monsoon, 49 species during monsoon, 57 species during retreating monsoon and consumed 58 species during winter season. The study also revealed that the Indian Rhino consumed 36 grass species, 19 trees and aquatic plant species during pre-monsoon season, 32 grasses, 11 trees and 6 aquatic plants during monsoon season. During retreating monsoon, they consumed total of 33 grass species, 17 trees species and 7 aquatic plants species, whereas, during winter season they consumed a total of 39 grass species, 15 trees species and 4 aquatic plants species (Table: 7.2).

Table – 7.2: Seasonal use of food plant species by Indian Rhino in Orang National Park

Species	Pre-monsoon	Monsoon	Retreating Monsoon	Winter
Grasses	36	32	33	39
Tree species	19	11	17	15
Aquatic plant species	8	6	7	4
Total	63	49	57	58

Categories of consumed food plant species

Study showed that there were altogether 12 different categories, based on plant chracteristics, belonging to three major habitat types, such as grasslannd, aquatic and woodland habitats in Orang National Park (Table:7.3). The rhino consumed different categories of foood items in various seasons of the year. The analysis of proportional use of food plant types by Indian Rhino showed that the plant types such as dry short grass (dsg), wet creeping short grass (wcsg) and wet tall grass (wtg) were consumed in maximum proportion during pre-monsoon season, compared to other types (Fig:7.3). Again, the proportional use of wet creeping short grass (wcsg), dry short grass (dsg), wet tall grass (wtg) and creeping aquatic beds (cab) were higher during monsoon

season than other types of food plant species (Fig:6.4). Whereas, the wet creeping short grass (wcsg), wet tall grass (wtg), dry short grass (dsg), submerged (sm) and creeping aquatic beds (cab) types of food plants were consumed in higher proportion during retreating monsoon season (Fig:7.5). During winter season, the Indian Rhino consumed higher proportion of wet creeping short grass (wcsg), wet tall grass (wtg), dry short grass (dsg), wet short grass (wsg), dry tall tree (dtt) and creeping aquatic bed (cab) types of food plants than other types of species (Fig:7.6).

Table 7.3: Food plant species, habitat it occurs, feeding percentage and major categories of food plant species of *Rhinoceros unicornis* in Orang National Park.

Food plant species	Families	Types of food plants	Habitat Category	% of feeding			
				PM	M	RTM	WIN
Grasses							
Agrostis zenkeri	Poaceae	WSG	GL	1.0	0.0	0.0	0.89
Apluda mutica	Poaceae	DSG	GL	2.2	0.5	0.0	1.7
Arundinella begalensis	Poaceae	WCSG	GL	1.8	2.3	1.06	0.9
Arundinella nepalensis	Poaceae	WCSG	GL	1.9	0.7	0.49	1.84
Arundo donax	Poaceae	WTG	GL	7.8	5.6	6.8	5.3
Axonopus compressus	Poaceae	WSG	GL	1.4	0.0	0.0	0.58
Bracharia ramosa	Poaceae	WCSG	GL	2.4	6.8	3.45	2.66
Chrysopogon aciculatus	Poaceae	DSG	GL	4.0	5.8	4.46	4.13
Cynodon dactylon	Poaceae	WSG	GL	3.0	1.5	2.3	1.63
Cyperus cyperoides	Cyperaceae	WSG	GL	0.0	0.1	0.4	0.0
Cyperus rotundus	Cyperaceae	WSG	GL	0.0	2.4	1.6	1.53
Cyperus brevifolius	Cyperaceae	WSG	GL	0.0	0.4	1.8	0
Cyperus globosus	Cyperaceae	WSG	GL	0.0	0.2	0.47	0.23
Cyperus kyllingia	Cyperaceae	WSG	GL	0.0	0.9	0.4	0
Cyrtococcum accrescens	Cyperaceae	DSG	GL	1.7	0.0	0.0	0.94
Dichantium caricosum	Poaceae	WSG	GL	1.7	0.0	0.0	1.89
Digitaria ciliaris	Poaceae	WSG	GL	0.8	0	0.8	2.4
Echinochloa crusgalli	Poaceae	WSG	GL	0.0	0.0	0.0	0.89
Eleusine indica	Poaceae	DSG	GL	1.8	0.3	1.75	1.92
Eragrostis japonica	Poaceae	WTG	GL	1.2	0.0	0.9	0.56
Eragrostis unioloides	Poaceae	WSG	GL	0.8	0.1	0.0	1.84
Erichola procera	Poaceae	WSG	GL	1.7	0.5	0.6	0.32
Hemarthria compressa	Poaceae	WSG	GL	7.9	13.0	14.3	11.8

Hemarthria protesna	Poaceae	WSG	GL	1.0	1.6	1.86	0.82
Hygroryza aristata	Poaceae	WSG	GL	1.8	2.3	2.48	1.34
Hymenachne pseudointerrupta	Poaceae	WCSG	GL	7.9	14	12.6	8.57
Sacciolepis interrupta	Poaceae	DSG	GL	2.2	1.0	0.74	2.06
Leersia hexadra	Poaceae	WCSG	GL	3.5	14	9.23	8.7
Leptochloa panicea	Poaceae	WSG	GL	1.8	1.0	1.7	1.56
Panicum walense	Poaceae	DSG	GL	1.3	0.0	0.0	0.84
Oplismenus burmannii	Poaceae	DSG	GL	1.3	1.0	1.6	0.87
Paspalidium flavidum	Poaceae	WCSG	GL	0.6	0.0	0.56	1.61
Paspalum conjugatum	Poaceae	WSG	GL	0.7	1.3	1.33	0.89
Paspalum dilatatum	Poaceae	WSG	GL	0.9	1.1	1.5	0.6
Phragmites karka	Poaceae	WTG	GL	5.8	3.3	3.88	4.67
Saccharum procerum	Poaceae	WTG	GL	1.1	1.8	0.93	1.83
Saccharum ravanae	Poaceae	WTG	GL	2.6	1.8	0.8	2.31
Saccharum spontaneum	Poaceae	WTG	GL	3.7	1.0	0.68	2.89
Sateria pumila	Poaceae	WSG	GL	0.0	0.0	0.0	1.7
Themda villosa	Poaceae	WTG	GL	2.4	0.8	1.06	2.62
Vetiveria ziganoides	Poaceae	WTG	GL	0.0	0.0	0.8	0.07
Imperata cylindrica	Poaceae	DSG	GL	1.6	2.5	2.6	1.2
Aquatic plants							
Ipomea aquatica	Convolvulaceae	CAB	Aq	1.0	1.5	1.9	1.26
Pistia stratiotes	Araceae	FFAB	Aq	1.7	1.6	0.74	0.89
Eichhornia cressipes	Pontideriaceae	FFAB	Aq	0.9	1.1	0.84	0.0
Vallisneria spiralis	Hydro-charitiaceae	SM	Aq	0.7	0.0	1.66	0.0
Hydrilla verticillata	Hydro-charitiaceae	SM	Aq	1.6	0.0	1.8	0.3
Nymphaea nouchali	Nymphaeaceae	EAB	Aq	0.0	1.0	0.87	0.0
Trapa bispinosa	Trapaceae	EAB	Aq	0.3	0.0	0.0	0.0
Enhydra fluctuans	Asteraceae	CAB	Aq	0.5	2.1	1.35	0.7
Alpinia allughas	Zingiberaceae	SV	Aq	0.1	0.2	0.0	0.0
Herbs and shrubs							
Ageratum conyzoides	Asteraceae	DS	WL	0.5	0.0	0.02	0.4
Mikenia micranth	Asteraceae	DH	WL	0.5	0.0	0.47	0.55
Melastoma malabathricum	Melastomaceae	DS	WL	0.6	0.0	0	0
Lantana camera	Verbenaceae	DS	WL	0.7	0.0	0.55	0
Xanthium strumarium	Asteraceae	DS	WL	0.7	0.0	0.53	0.16

Grewia sapida	Tilliaceae	DS	WL	0.9	0.7	0.61	0.53
Polygonum hydropiper	Polygonaceae	DH	WL	0.0	0.0	0.0	0.01
Diplazium esculantum	Dryopteridaceae	DH	WL	0.9	0.0	0.2	0.67
Amaranthus spinosus	Amaranthaceae	DH	WL	1.0	0.0	0.6	0.0
Trees							
Bombax ceiba	Bombaceae	DTT	WL	0.9	0.0	0	0.78
Trewia nudiflora	Euphorbiaceae	DTT	WL	0.5	0.6	0.66	0.76
Dalbergia sisso	Papilionaceae	DTT	WL	0.7	0.9	0.12	0.87
Cassia fistula	Cesalpiniaceae	DTT	WL	0.5	0.4	0.05	0.81
Mangifera indica	Anacardiaceae	DTT	WL	0.0	0.4	0.03	0.0
Ficus glomerata	Moraceae	DTT	WL	0.6	0.4	0.01	0.63
Streblus asper	Moraceae	DST	WL	0.0	0.0	0.01	0.0
Ficus rumphii	Moraceae	DTT	WL	0.1	0.4	1.03	0.9
Artocarpus heterophyllus	Moraceae	DTT	WL	0.0	0.5	0.01	0.04
Ziziphus zuzuba	Rhamnaceae	DST	WL	0.5	0.3	0.02	0.26
Bauhinia purpurea	Liguminoceae	DTT	WL	0.0	0.0	0.02	0.35

Abbreviation: PM: Pre-monsoon, **M:** Monsoon, **RTM:** Re-treating monsoon, **WIN:** Winter, **WSG:** Wet short grass, **WCSG:** Wet creeping short grass, **DSG:** Dry short grass, **DST:** Dry short tree, **DTT:** Dry tall tree, **DH:** Dry herbs, **DS**: Dry shurbs, **EAB**: Emergent aquatic bed, **CAB**: Creping aquatic bed, **FFAB**: Free-floating aquatic bed, SM: Submerged, **SV:** Swampy Vegetation, **GL**: Grassland, **Aq**: Aquatic, **WL**: Woodland.

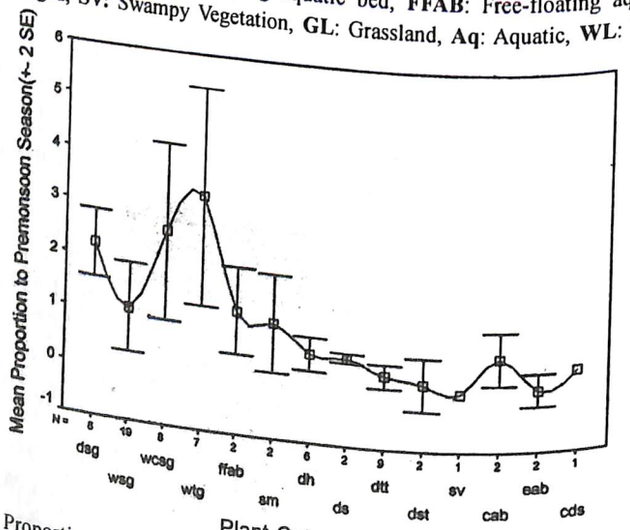

Fig: 7.3: Proportional use of food plants species by Indian Rhino in Orang National Park during pre-monsoon season (data was represented, Mean ± 2SE, **wsg:** Wet short grass, **wcsg:** Wet creeping short grass, **dsg:** Dry short gass, **dst:** Dry short tree, **dtt:** Dry tall tree, **dh:** Dry herbs, **ds**: Dry shurbs, **eab**: Emergent aquatic bed, **cab**: Creeping aquatic bed, **ffab**: Free-floating aquatic bed, SM: Submerged, **sv:** Swampy Vegetation)

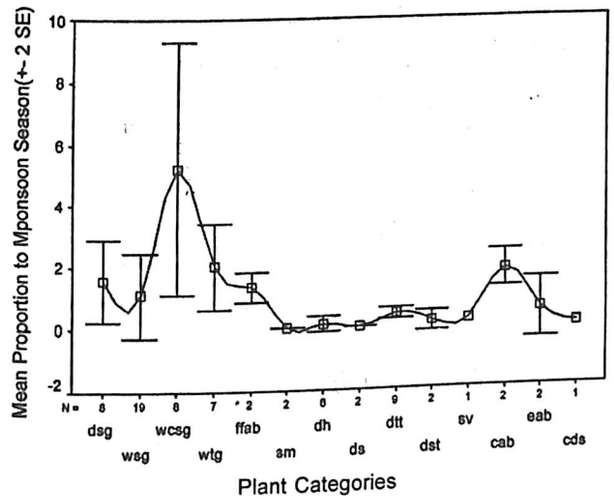

Fig: 7.4: Proportional use of food plants species by Indian Rhino in Orang National Park during Monsoon season (data was represented, Mean ± 2SE, **wsg:** Wet short grass, **wcsg:** Wet creeping short grass, **dsg:** Dry short grass, **dst:** Dry short tree, **dtt:** Dry tall Tree, **dh:** Dry herbs, **ds**: Dry shurbs, **eab**: Emergent aquatic bed, **cab**: Creping aquatic bed, **ffab**: Free-floating aquatic bed, **SM**: Submerged, **sv:** Swampy vegetation)

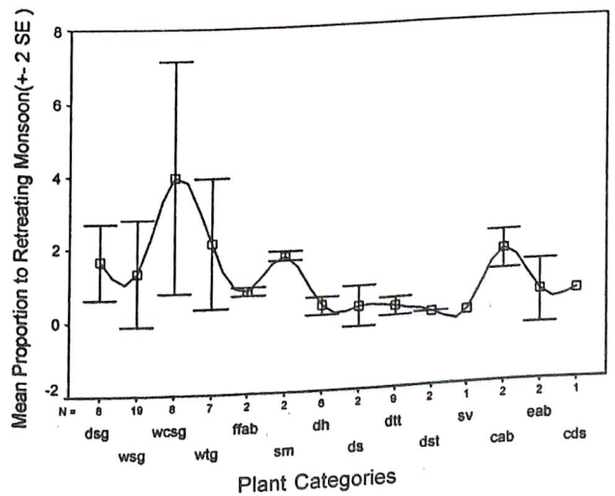

Fig: 7.5: Proportional use of food plants species by Indian Rhino in Orang National Park during retreating monsoon (data was represented, Mean ± 2SE, **wsg:** Wet short grass, **wcsg:** Wet creeping short grass, **dsg:** Dry short grass, **dst:** Dry short tree, **dtt:** Dry tall tree, **dh:** Dry herbs, **ds**: Dry shurbs, **eab**: Emergent aquatic bed; **cab**: Creping aquatic bed; **ffab**: Free-floating aquatic bed; SM: Submerged; **sv:** Swampy Vegetation).

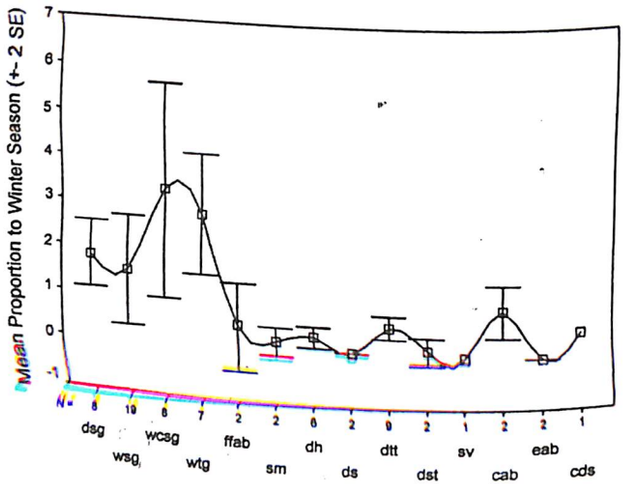

Fig: 7.6: Proportional use of food plants species by Indian Rhino in Orang National Park during Winter season (data was represented, Mean ± 2SE; **wsg:** Wet short grass, **wcsg:** Wet creeping short grass, **dsg:** Dry short grass, **dst:** Dry short tree, **dtt:** Dry tall tree, **dh:** Dry herbs, **ds**: Dry shurbs, **eab**: Emergent aquatic bed, **cab**: Creeping aquatic bed, **ffab**: Free-floating aquatic bed, SM: Submerged, **sv:** Swampy vegetation).

Feeding frequency

The study revealed that the grass species *Hemarthria compressa* contributed to the highest (11.63%) food plant species consumed by the rhino, while the marshyland plant species *Polygonum hydropiper* was the lowest consumed (0.01%) food plant species, in their total annual diet. The annual feeding frequency of the ten top ranking plant species of Indian Rhino in their total annual diets were the *Hemarthria compressa, Hymenachne pseudointerrupta, Leersia hexandra, Arundo donax, Chrysopogon aciculatus, Phragmites karka, Bracharia ramosa, Cynodon dactylon, Saccharum spontaneum* and *Imperata cylindrica* (Table: 7.4).

Table- 7.4: Shows the ten top ranking annual food plants of Indian Rhino in Orang National Park during study period

SL No.	Species	Annual feeding frequency (%)
1	*Hemarthria compressa*	11.63
2	*Hymenachne pseudointerrupta*	10.64
3	*Leersia hexandra*	8.80
4	*Arundo donax*	6.38
5	*Chrysopogon aciculatus*	4.60
6	*Phragmites karka*	4.42
7	*Bracharia ramosa*	3.83
8	*Cynodon dactylon*	2.11
9	*Saccharum spontaneum*	2.05
10	*Imperata cylindrica*	1.98

Staple food

The analysis showed that altogether 36 plant species (Table: 7.5) were selected by the Indian Rhino as their regular food item. These 36 plant species constituted 83.64% of the total annual diet budget of Indian Rhino in Orang National Park. Among all the 36 plant species, 24 plant species were grasses that constituted 75.97% of the total selected annual food plant species; hence, it is referred as staple food of Indian Rhino. But, among non-grass species, only 9 tree species and 3 aquatic plant species were also selected as annual food, which constituted only 7.67% of the total annual diet that were also referred as staple food (Table : 7.6).

Table-7.5: Staple food of rhino in Orang National Park (a) Grasses, (b) Trees, (c) Aquatic plants

a. Grasses	Seasons			
Name of the food plant	**PM**	**M**	**RM**	**W**
Arundinella begalensis (Spreng.) Druce.	1.8	2.3	1.06	0.9
Arundinella nepalensis Trin.	1.9	0.7	0.49	1.84
Arundo donax Linn.	7.8	5.6	6.8	5.3
Bracharia ramosa (L.) Stapf.	2.4	6.8	3.45	2.66
Chrysopogon aciculatus (Retz.) Trin.	4.01	5.8	4.46	4.13
Cynodon dactylon (L.) Pers	3.02	1.5	2.3	1.63
Eleusine indica (L.) Gaertn.	1.84	0.25	1.75	1.92
Erichola procera (Retz.) C.E.Hubb.	1.71	0.5	0.6	0.32
Hemarthria compressa (L.f.) R.Br.	7.9	12.5	14.3	11.83
Hemarthria protesna Steud.	0.96	1.56	1.86	0.82
Hygroryza aristata (Retz.) Nees ex. Wight & Arn.	1.81	2.26	2.48	1.34
Hymenachne pseudointerrupta	7.93	13.5	12.57	8.57
Imperata cylindrica (L.) Beauv.	1.6	2.5	2.6	1.2
Leersia hexandra Sw.	3.54	13.72	9.23	8.7
Leptochloa panicea (Retz.) Ohwi	1.8	1.03	1.7	1.56
Oplismenus burmannii (Retz.) P.Beauv.	1.3	1.01	1.6	0.87

Paspalum conjugatum Berg.	0.7	1.3	1.33	0.89
Paspalum dilatatum Poir.	0.86	1.08	1.5	0.6
Phragmites karka (Retz.) Trin. ex. Steud.	5.83	3.3	3.88	4.67
Saccharum procerum Roxb.	1.08	1.81	0.93	1.83
Saccharum ravanae (L.) Beauv.	2.61	1.8	0.8	2.31
Saccharum spontaneum Linn.	3.68	0.96	0.68	2.89
Sacciolepis interrupta (Willd.) Stapl.	2.2	0.95	0.74	2.06
Themeda villosa(Poir.) A.Camus.	2.4	0.83	1.06	2.62

b. Trees

Artocarpus heterophyllus Lamk.	0.02	0.45	0.01	0.04
Bauhinia purpurea L.	0.02	0.01	0.02	0.35
Cassia fistula L.	0.49	0.37	0.05	0.81
Dalbergia sisso Roxb.	0.67	0.85	0.12	0.87
Ficus glomerata Roxb.	0.57	0.36	0.01	0.63
Ficus rumphii Bl.	0.05	0.35	1.03	0.9
Grewia sapida Roxb.	0.94	0.66	0.61	0.53
Trewia nudiflora L.	0.52	0.62	0.66	0.76
Ziziphus zuzuba Lamk.	0.46	0.29	0.02	0.26

c. Aquatic plants

Enhydra fluctuans Lour.	0.5	2.1	1.35	0.7
Ipomea aquatica Forssk.	1.03	1.48	1.9	1.26
Pistia stratiotes Linn.	1.73	1.6	0.74	0.89

Table-7.6: Percent use of Staple food used in percentage by Indian Rhino in Orang National Park

Groups of plants	Staple food plants species		Proportional use of the staple food			
	Number	Proportional use	PM	M	RM	W
Grasses	24	75.97	70.68	83.56	78.17	71.46
Woodland	9	3.85	3.74	3.96	2.53	5.15
Aquatic	3	3.82	3.26	5.18	3.99	2.85
Total	36	83.64	77.68	92.70	84.69	74.46

PM=Pre-monsoon, M=Monsoon, RM=Reteating monsoon, W=Winter

Dietary spectrum

The food selection pattern of the Indian Rhino showed a distinct dietary spectrum during present study. The study showed that up to 10 top ranking food plants species of rhino constituted almost 56.44% of

the total annual diet, but it was 72.19% up to 20 top ranking food plants species, whereas the rest 41 food plants constituted only 28% of the total annual diet of the rhinos in Orang National Park (Fig: 7.7). Again, among the 20 top ranking food plant species, 19 species were grasses and only one species was aquatic plant species (*Ipomea aquatica*). This clearly indicated that the grass alone was the sufficient food item of rhino, necessary for survival in Orang National Park.

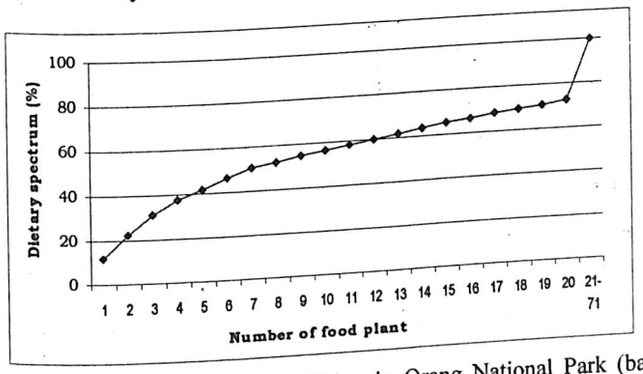

Fig: 7.7 Dietary spectrum of Indian Rhino in Orang National Park (based on collected data)

Cultivated crop as food

The study revealed that the Indian Rhinos of Orang National Park often visited in fringe village area for consumption of cultivated crops. There were altogether 10 cultivated crops and 10 vegetables crops. There were altogether 10 cultivated crops and 10 vegetables eaten by rhino as their food during the study period. No quantitative analysis of the cultivated crops were made, as they consumed it during night hours.

Table 7.6: Cultivated crop and vegetable species eaten by Indian Rhino as food along with natural food item

Crop	Vegetable and other plants
Zea mays (Zea)	*Cucurbita pepo* (Summer Squash)
Oryza sativa (Paddy)	*Cucurbita maxima* (Red Pumpkin)
Cicer arietianum (Gram)	*Luffa acutangula* (Ridged gourd)
Pisum sativum (Peas)	*Cucumis sativus* (Cucumber)
Cajanus cajan (Pigeon Pea)	*Capsicum annum* (Chilli)
Phaseolus mungo (Black Gram)	*Abelmoschus esculentus* (Lady's finger)

Phaseolus lunatus (Lima bean)	*Cucurbita maxima* (Sweet gourd)
Phaseolus aureus (Green Gram)	*Solanum melongena* (Brinjal)
Triticum aestivum (Wheat)	*Ipomea batatus* (Sweet potato)
Lathyrus sativus (*Khesari dal*)	*Carica papaya* (Papaya)

Geophagy (Soil eating)

Seven soil eating (soil licking) sites of Indian Rhinos were located in Orang National Park during the study period (Table- 7.8). The rhino frequently visited the soil eating sites during night hours. It was also reported by the forest personnel that the rhino occasionally consumed soil near the forest camps.

Table7.8: Soil eating locations in Orang National Park

Location		GPS location	Remark
Camp/Beat	Location	Latitude and Longitude	
Katasali Beat	1) In front of the Beat	92°15′13.43″E 26°31′02.54″N	Located under *Acacia catechu* tree
	2) North of the Katasali beel	92°15′32.24″E 26°31′02.73″N	Located under *Acacia catechu* tree
	3) North-west of the Katasali Beat	92°15′05.59″E 26°31′13.64″N	Located under *Acacia catechu* tree
	4) West of the Katasali Beat	92°15′01.21″E 26°31′57.47″N	Located under Palm tree
Chandanpur Camp	5) Near camp approaching point	92°15′13.43″E 26°31′15.37″N	Located under *Acacia catechu* tree
Satsimalu Beat	6) South of the Guest house	92°18′34.02″E 26°33′14.84″N	Located under *Lagerstoremia speciosa* tree
Bantapu Camp	7) In between Bantapu & Hatiputa camps	92°18′35.69″E 26°32′21.87″N	Located under *Acacia catechu* tree

In the present study, the consumption of 86.66% grass species followed by 6.68% aquatic plants and 6.66% woodland species (browse) by Indian Rhino indicates that grass is the main food plant species of rhino in Orang National Park. This is also evident from the

seasonal diet pattern that 89.13% grass was consumed during winter and 83.50% during pre-monsoon season. Laurie (1978, 82) also reported that the Indian Rhino in Nepal also consumed 86.4% grasses, 5.2% aquatic plants and 3.4% browse from the month of February to May (spring season), while 88.7% grasses, 5.7% aquatic plants and 5.6% browse from June to September (monsoon season) and 70.4% grasses, 8.0% aquatic plants and 21.6% browse from October to January (winter season). These results supported the present findings of grass as the most preferred food of the Indian Rhino. A similar type of result was also found by Jnawali (1995) in Bardia National Park and Chitwan National Park of Nepal. He reported that the highest proportion of 92% grass species used as the diet of Indian Rhino during monsoon in Bardia National Park and 86% in Chitwan National Park during hot season and lowest of 42-57% during winter season. Fjellstad and Steinheim (1996) also suggested that the diet of Indian Rhino consists of 63% grass and 28% browse. This clearly indicates that the Indian Rhino mostly depends on grasses rather than browse or other aquatic plants. Hence, it could be opined that the Indian Rhino is more habitat-specific than any other large herbivore mammal. Fjellstad and Steinheim (1996) also found in their study that rhino depends on quality food rather than quantity of food. They also found that the Indian Rhino spent 85% of total feeding time on 3 vegetation types, while it was 6 vegetation types for Asian Elephant to reach the same habitat occupancy. Hence, the numbers of habitat types are limited for Indian Rhino.

Again, the number of food plant species of Indian Rhino varies from habitat to habitat which was observed in other studies. Laurie (1978, 82) stated that Indian, Rhino, fed on 183 food plant species, belongs to 57 families in Chitwan National Park. Ghosh (1991) stated that rhino, that consumed 82 plant species, belonged to 34 families in Jaldapara Wildlife Sanctuary. So, it varies in all occasions. The present study indicates that the Indian Rhino of Orang National Park confined to 71 plant species of which 42 are grasses, 20 are woodlands and 9 are aquatic species. This type of food composition is almost the same in various seasons of the year, hence, grasses play a major role in diet composition of Indian Rhino.

The most preferred 10 top ranking food plants are *Hemarthria*

compressa (11.63%), *Hymenachne pseudointerrupta* (10.64%), *Leersia hexandra* (8.80%), *Arundo donax* (6.38%), *Chrysopogon aciculatus* (4.60%), *Phragmites karka* (4.42%), *Bracharia ramose* (3.83%), *Cynodon dactylon* (2.11%), *Saccharum spontaneum* (2.05%), *Imperata cylindrica* (1.98%), of which 6 species were positively selected for feeding. All these 10 species are from grasses and are growing in wet grassland habitat. These findings of top ranking species are contradictory with the findings of Laurie (1978, 82) and Ghosh (1991) in Chitwan National Park of Nepal and Jaldapara Wildlife Sanctuary of West Bengal respectively. But the study, conducted by Bhattacharyya (1991) in Karziranga National Park of Assam, is almost similar to the present study. This clearly indicates that the wet grassland habitat plays a vital role in the food selection by Indian Rhino in the Brahmaputra flood-prone plain habitat of Orang National Park and other protected areas of Assam (India) in comparison to other rhino habitats of South-East Asia.

The present findings of 83.64% annual diet of Indian Rhino's staple food in Orang National Park indicates that the Indian Rhino has a strong preference on certain food choice. Again the dietary spectrum of Indian Rhino further supports the strong selection of definite food plant species and the only 20 top ranking preferred food items constitutes 72.19% of the total annual diet of Indian Rhino in Orang National Park.

Crop depredation by wild elephant (Sukumar, 1989; Dey, 1991) is a common phenomenon in India. But, the crop depredation caused by Indian Rhino in fringe village around the study areas is a new dimension of this aspect. Laurie (1978, 82), Jnawali (1988) and Bhattacharyya (1991) have mentioned about the crop depredation behaviour of Indian Rhino in India and Nepal.

Like other large mammals, Indian Rhino in Orang National Park is also found licking (eat) soil occasionally in some specific locations. This is mainly due to compensation of mineral deficit of Indian Rhino in their regular diets. Gee (1964), Laurie (1978, 82), Ghosh (1991), Dutta (1991) and Bhattacharyya (1991) also observed that soil licking behaviour of rhino is mainly related to mineral deficiency of Indian Rhino in its feeding habitat. However, chemical analysis is suggested for finding out the physical need.

These results are indication of limitation and requirements of different food items to fulfil the daily requirements of nutritional and energy supplement. The limited plant species in the diet of Indian Rhino, though a variety of plant species available to feed on, suggest that they obtain certain preferred food to fulfil the nutritional and energy requirements for survival and reproducion. In order to survive and reproduce, an animal depends on diet that should contain adequate and balanced essential nutrients. Larger species like elephant, rhino tend to feed more because they need more energy. The age and sex variation also have some relationship with food intake. Females of some species tend to feed more on foliage than males because of greater protein requirement. Pregnant and lactating females tend to feed more on foliage because of an increase in metabolic rate.

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Chapter – VIII

BEHAVIOURAL ECOLOGY

Behaviour is the response of extrinsic factors guided by intrinsic factors (gene) of an individual of a species. Hence, the behavioural pattern of one species is quite different from the other. Again, the individuals or a group of same species show the variation of behavioural pattern in response to habitat conditions (e.g. availability and distribution of food resources), environmental factors (climatic factors) as well as the social factors. Being a solitary and primitive herbivorous mammal, Indian Rhino shows distinct behavioural characteristics. Laurie (1978, 82) has done remarkable studies on behavioural activities (both diurnal and nocturnal), which covered feeding behaviour, drinking behaviour, aggressive behaviour, non-breeding play behaviour and reproductive behaviour, etc.

Various scattered information are also available regarding the behavioural pattern of *Rhinoceros unicornis*, such as aggressive behaviour (Lahan, 1974), daily activity (Bhattacharya & Pal, 1982; Venugopal *et al.*, 1994; Yadav, 2000), feeding and wallowing behaviour (Bhattacharyya, 1991; Ghosh 1991; Patar, 2005), breeding behaviour (Buechner & Mackler, 1975; Buechner *et al.* 1975; Kakati & Rajkonwar, 1972), sexual behaviour (Ripley 1967), social interaction (Dixon & Macnamara, 1981), play behaviour (Mackler & Buechner, 1978), food and feeding behaviour (Patar, 1977; Laurie 1978,82; Ghosh 1991; Bhattacharyya, 1991), territorial behaviour (Ripley, 1967) and also human-rhino conflict (Jnawali, 1988; Hazarika & Saikia, 2005). However, those studies were not related to any conservation strategy. Therefore, the present study aimed at finding

out the definite conclusion for comprehensive conservation strategy for Indian Rhino in Orang National Park as well as in Assam.

The present behavioural study emphasises the behavioural peculiarities that have a significant value to lay out conservation strategies for Indian Rhino. To achieve this goal, the following objectives were taken into consideration.

1. To investigate the behavioural patterns of Indian Rhino in breeding and non-breeding periods of the year,
2. Behavioural cataloguing of Indian Rhino in Orang National Park,
3. To analyse the seasonal variations of behavioural pattern in Orang National Park,

(a) Sampling methods

During 'dawn to dusk' follow-up action of Indian Rhino, the occurrences of reproductive display, feeding behaviour, wallowing, locomotion and aggressive behaviour, etc. were recorded (Laurie, 1978, 82), using *Scan Animal Sampling* and *Ad. Libitum Sampling* methods (Altman 1974).

During field survey in Orang National Park, the presence of newborn calf and dung heaps were recorded with their frequency of occurrences. The GPS locations of dung heap sighted and patterns of tracks *(Dandis)* were also recorded. Apart from that the monthly visits of each fringe villages were made to record the crop depredation. The information of crop damage and destruction of other cultivated plant species were investigated at the fringe village sites and recorded in the notebook. If there were any information of human injury or causality of both the human and Indian Rhino, it was recorded after interview. The stray out information of Indian Rhino from the park area was collected and the GPS locations of visiting sites and the status of the rhino after stray out were also recorded.

For the observation of behaviour, the terms and nomenclature of the behaviour were used from the published literature (Laurie, 1978, 82; Ghosh, 1991; Bhattacharyya, 1991) and few behaviours like soil licking, local migration, dive feeding, and dragging, etc. were newly coined for the study.

Data analysis

The collected data on different behavioural patterns, habitat utilisation patterns, etc. were analysed graphically, using Microsoft Excel software and the percentage of each behaviour was computed to get the actual time allocation for different activities of Indian Rhino.

All the observed behavioural patterns of Indian Rhino were divided into two basic types, such as (a) Breeding behaviour and (b) Non-breeding behaviour. The breeding behaviours were related to breeding activities or associated with breeding purposes. The other behaviours, which were not associated with breeding purposes, were grouped together as non-breeding behaviour.

Behavioural cataloguing

Altogether 14 major behavioural patterns were categorised for Indian Rhino in Orang National Park, those were (1) Feeding, (2) Locomotion, (3) Comfort, (4) Vigilance, (5) Non-breeding agonistic behaviour, (6) Non-breeding play behaviour, (7) Local migration, (8) Crop raiding behaviours, (9) Vocalisation, (10) Courtship behaviour, (11) Mating behaviour, (12) Breeding play behaviour, (13) Breeding vocalisation and (14) Breeding agonistic behaviours. Apart from these major types, certain sub-types were also categorised. Under locomotion behaviour three sub-types were identified, such as (i) Walking, (ii) Galloping and (iii) Running. Under feeding behaviour six sub-types were identified, such as (i) Browsing, (ii) Grazing, (iii) Drinking, (iv) Dive-feeding, (v) Breast feeding and (vi) Geophagy. Under non-breeding agonistic and breeding agonistic behaviour, five sub-types were categorised, such as (i) Snorting, (ii) Threat display, (iii) Chasing, (iv) Attack and (v) Escaping behaviour. Under comfort behaviour, three sub-types were categorised, such as (i) Resting, (ii) Sleeping and (iii) Wallowing, and under wallowing behaviour, there were two sub-divisions, such as (a) Mud wallowing and (b) Water wallowing. In case of breeding behaviour, two major types of behaviours were found, such as (1) Courtship behaviour and (2) Mating behaviour and under courtship three sub-types were identified, such as (i) Touching, (ii) Licking and (iii) Chasing behaviour, whereas mating behaviour was categorised into two sub-types, such as (i) Mounting and (ii) Dragging behaviour. (Plate -4)

Behavioural patterns

A. Non-breeding behaviour

1. Feeding behaviour

The feeding or foraging behaviour was associated with the foraging movement for searching food items, consumption of food in the habitat and also techniques used for food intake in different habitat types and breast feeding by calf, etc. It also included all the feeding types, such as feeding on grasses, consumption of leaves or branches of trees, consuming soil as well as drinking of water, etc. On the basis of different feeding activities, the feeding behaviours were again categorised into six sub-types, such as:

i) Grazing: Grazing included the behaviour of rhino during grass intake using prehensile upper lip during the collection of short grasses and herbs from the ground zone. If roots come along with the grasses it also gets immediately separated from it and discarded into the ground.

ii) Browsing : Rhino occasionally intakes leaves, tender twigs by raising its head at a horizontal position with ground. In this posture, Rhino performed inward jerk of the head and mouth. Incisor teeths were also used during browsing process. Rhino occasionally intakes bark, fruits and seeds of edible shrubs and trees.

iii) Geophagy : (Soil licking/ eating): Rhino frequently consumes soil from some particular location of the habitat. The soil licking behaviour was performed by using tongue. During the process, rhino forwarded its tongue tip, licked the soil and consume it apart from that incisor teeths were also used to dig the selected soil and occasionally consumed a bulk of soil itself. During soil licking, they created a deep and wide den like structure. The same soil licking spots, used by several rhinos, were also observed at different times.

iv) Breast feeding : Rhino calves performed breastfeeding activity by sucking the mother's nipple, which was found almost the same in other herbivorous animals. But, rhino calves were observed sucking mother's nipple from the either side and occasionally from back side of the mother. The sucking activity found to have continued for a period of 20-30 minutes. Occasionally, the process continued when the mother started moving from one place to another.

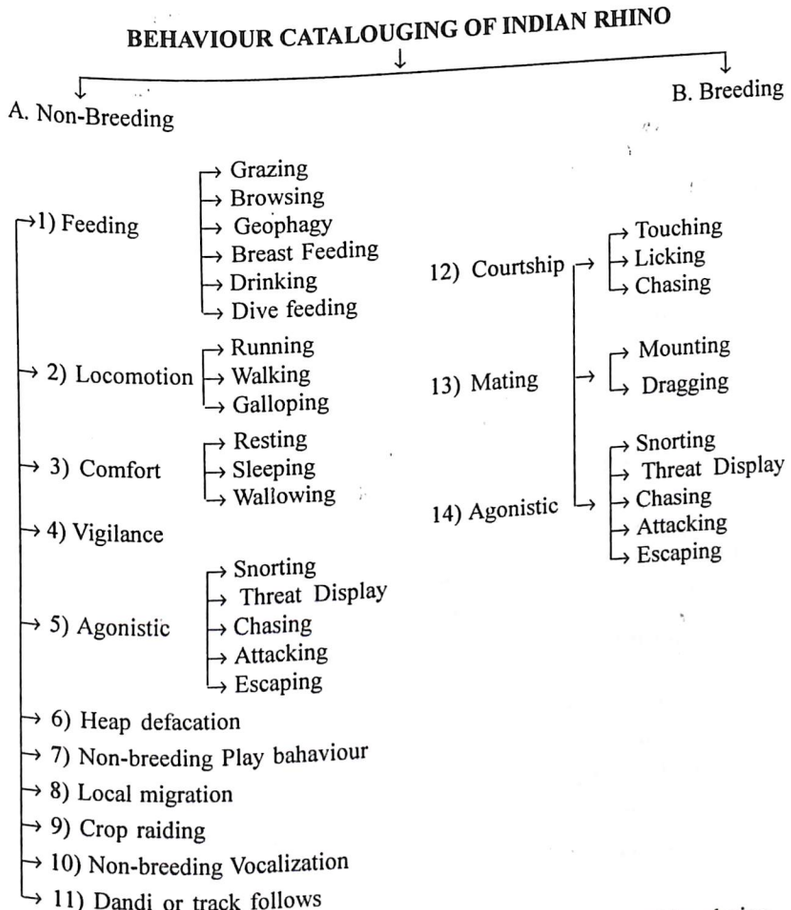

Fig. – 8.1 : Flow chart of Behavioural Cataloguing of Indian Rhino during breeding and non-breeding period at Orang National Park.

v) Drinking : Rhinos were found drinking water from *beels*, streams, ponds and wallowed sites, irrespective of water conditions. During drinking process, the rhino immersed its mouth into the water body and sucked it and engulfed the water. The drinking activities were normally observed during morning and evening time.

vi) Dive feeding : Dive feeding is a technique of feeding under water or submerged food plant like *Hydrilla, Vallisneria,* etc. Rhino immerses their heads into water and very often dive into

deep water, bite and collect mouthful of grasses and resurface again. The grasses collected were chewed and engulfed above water surface only. The individual remained in water for more than two minutes for collecting food plants. The dive feeding behaviour was very common in mid-day, when Indian Rhino in Orang National Park was generally found in comfort behaviour. In Orang National Park, dive feeding behaviour was observed, especially during retreating monsoon and monsoon season.

2. Locomotion

The locomotion behaviour is the movement pattern of Indian Rhino from one place to another for their daily activities. During locomotion, the movement patterns may be performed in a normal way (0.5-20 m/mins) or by running from one place to another (100 m/min). Those were such as walking fast to cover a distance from one place to another (Galloping), walking normally, running, etc. On the basis of their movement patterns, the locomotion can be divided into three sub-types, such as:

i) Running: Running was the very fast movement of rhino in one particular direction, keeping the head downward. While in action both the fore legs as well as hind legs were kept in such a way as if they were in air at the same time. This behaviour was observed during the time of both breeding and non-breeding agonistic behaviour possession and also in escaping and fleeing behaviour.

ii) Walking: Walking was the movement of the body of rhino in a slow and steady manner by moving the alternate legs of fore and hind legs, simultaneously.

iii) Galloping: Galloping is a particular type of faster movement than walking, but slower running locomotion rather than fast running, which has a definite rhythm when the rhino goes away due to disturbance from intruders suddenly.

3. Comfort behaviour

The comfort behaviour includes the body postures with cessation of almost all physical activities or it is a state of motionless body posture or comfortabe staying. The comfort behaviour was divided into three sub-types, such as resting, sleeping and wallowing.

i) Resting behaviour: The resting behaviour includes the posture of the body either in standing or lying condition on ground, but eyes were kept open all the time. During resting state, the Indian Rhino remained alert and kept vigil with their erected ear pinnae.

ii) Sleeping behaviour: The sleeping behaviour was the motionless state of animal like the resting behaviour, but the eyes of the animal always remained closed. In this state, the animal occasionally spread out all its legs on the ground and became flat, so it looked like a dead rhino. The alertness of the animal in this posture was completely absent. When the rhino remained in this posture, a person could approach it very near and even could touch the body.

iii) Wallowing: Wallowing is a particular behavioural posture of Indian Rhino in which the rhino lied on the water holes (mud or water bodies), especially during day hours. Wallowing behaviour was also divided into two types : (a) Mud wallowing and (b) Water wallowing, based on the substratum used.

a) **Mud wallowing:** It is the process in which the Indian Rhino lied in mud or rolled their body in mud.

b) **Water wallowing:** During water wallowing, the rhino immersed its entire body into the water by keeping only the portion of the head above water surface.

The duration of both the types of wallowing varies from few minutes to several hours with or without interval. Most often the wallowing activities were found to be solitary, but occasionally, up to 11 individuals were also observed in the same place. However, no age-sex specific social bonding was found during wallowing. When other rhinos approached the wallowed site, they shared the same site without conflict. When other animals like elephant approached the site, rhinos stood up and kept vigil over the situation and went away without interaction when found uncomfortable.

Observation showed that the Indian Rhino preferred open water or wetland with grasses for wallowing. They generally found wallowing in shallow water wetlands up to the water level below half of the body. The wallowing posture was same with sleeping

deep water, bite and collect mouthful of grasses and resurface again. The grasses collected were chewed and engulfed above water surface only. The individual remained in water for more than two minutes for collecting food plants. The dive feeding behaviour was very common in mid-day, when Indian Rhino in Orang National Park was generally found in comfort behaviour. In Orang National Park, dive feeding behaviour was observed, especially during retreating monsoon and monsoon season.

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and resting posture while the lower portion of the body remained stuck into the mud and the upper portion of the body remained partially movable. The rhino was also found using only the muddy place for wallowing.

4. Vigilance

Vigilance was the solitary behaviour of rhino, neither performing almost any other activities like feeding, running, walking, sleeping, etc., nor any social interactions. But it carefully looked around and continuously watched the intruder or tried to locate the sound. During vigilance, the rhino erected their head and moved in and around for watching the situation. The ear pinna became erected either in vertical or horizontal direction. Sometimes it moved in both the directions and tried to locate the sources of sound or object. The eyes and ears were used during the process of vigilance behaviour. During vigilance, the Indian Rhino occasionally produced mild sound. The rhinoceros was found to be a very much alert animal in presence of other animals, especially, the large predators. The vigilance of cow with calf was found to be very active during wallowing than other age-sex class. The cow was always found keeping an eye on her calf for predators or in any other uncomfortable situation. In wallowing posture, the cow was found keeping vigil and watching for a longer period (up to 90 minutes) without moving.

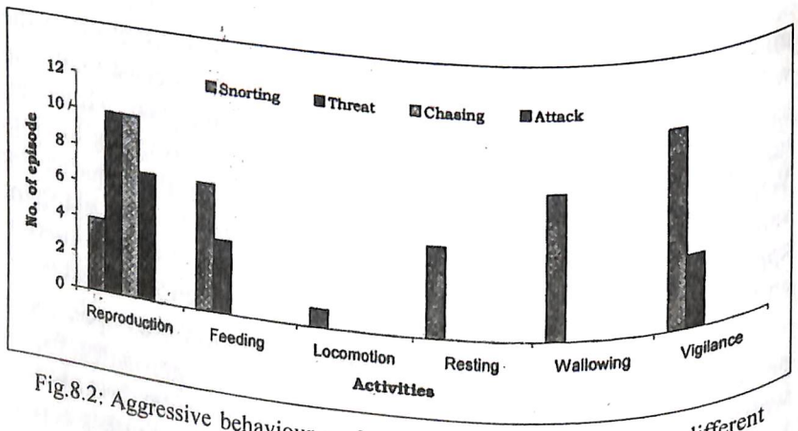

Fig.8.2: Aggressive behaviour performed by Indian Rhino during different activities in Orang National Park

5. Non-breeding agonistic behaviour

Non-breeding agonistic behaviours were those behaviours which the Indian Rhino possessed for performing threat and threat displays against competitor to chase other intruders from his territory or to defend from unwanted competitor in its own territory. Both male and female rhino performed agonistic behaviours. The non-breeding agonistic behaviour was categorised into five different sub-types, such as:

i) **Snorting:** Snorting was a kind of agonostic threat performing with sound by producing *khaawk...khaawk...* sound at regular intervals for protecting its own territory. It was a vocal dominance by adult female or male.

ii) Threat display: A kind of physical aggression expressed by the dominant individual (erects its head, ear pinna, making a mild sound) for pretending to attack the other individual approaching or being approached.

iii) Chasing: The chasing was a type of aggressive behaviour which helped displace one rhino by another. The strong individual of rhino generally chased the weak rhino or adult rhino or sub-adult rhino to a distance longer than its body length.

iv) Attack: The agonistic behaviour of rhino, which is physical attack on the opponent leading to injury of the body. During attack, they generally used incisor teeth and its horn. The attack may be performed from backside of the animal, when weak animal fled, during charging.

v) Escaping behaviour: Generally, weak animal never took part in fight. The weak animal went away from nearby animal, either ran away or showed galloping behaviour. It was a common phenomenon observed among rhinos during non-breeding season.

The characteristic features of both non-breeding and breeding agonistic behaviour are almost similar. The differences were observed in case of opposite sex aggression. When the estrous female refused the male, she was also seen attcking the male at the same time.

6. Heap defecation behaviour

The Indian Rhino had a tendency to defecate in a particular location, and as a result of continuous deposition of dung at the

same spot, led to form a heap-like structure. This type of defecation behaviour was possessed by Indian Rhino alone. In all study blocks the rhino was to defecate only in the form of heap structure.

Altogether 76 numbers of rhino dung heaps were observed in different blocks of Orang National Park. The highest number of dung heap was found in block-2 (Fig: 8.3).

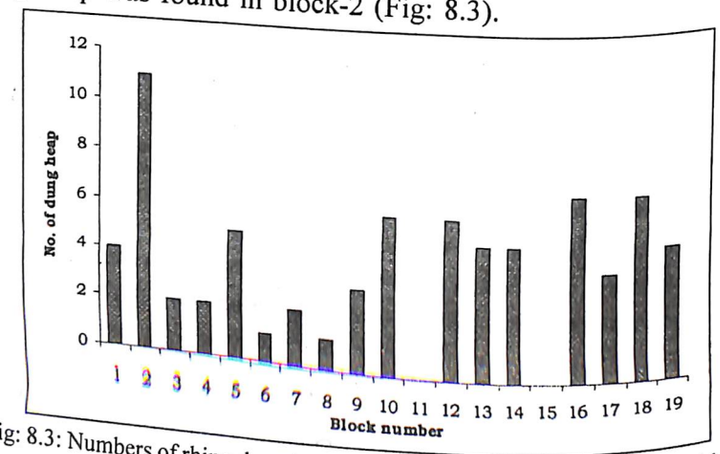

Fig: 8.3: Numbers of rhino dung heaps during the study found in different blocks of Orang National Park

7. Non-breeding play behaviour

The rhino calf performed the non-breeding play behaviour with their mother, when she was engaged in grazing, wallowing or resting posture. In this process, the calf ran to a short distance away from the mother and returned back to its mother and touched the mother's body. This play behaviour continued for several minutes.

8. Local migration

Movement or migration behaviour of rhino from one natural habitat or protected area to other natural areas outside its boundary was categorised as local migration. Indian Rhino in Assam has a common behaviour of travelling from one habitat patch to another and occasionally, the animal covered more than 100 km distance. It was evident that Indian Rhino migrated from Orang National Park to other fringe areas especially at night times or travelled to long distance in different seasons. During this behaviour, they normally raided the domestic or cultivated crops.

Table–8.1 : Records of local migration behabiour of Indian Rhino in Orang National Park.

Date	Age-sex	Distances of stray out		Final	Remarks
		Location	Aerial distance (approx.)		
August, 1988	AM	Mangaldai Town (Sericultural Farm)	35 km	Sent back by the forest official of ONP	
May, 2001	AM	Dalgaon then to South of Kharupetia	10 km	Died due to Human atrocities	
Oct., 2003	AM	Bhuragaon crossing Brahmaputra river	08 km	Sent back by the forest official of ONP	
July, 2004	AM	Chereng Chapori/ Garubandha area	45 km	Stayed there for two months; then sent back	Rhino killed one and injured two people
Sept., 2005	AM	Kharupetia crossing Dalgaon	10 km	Sent back by the forest official of ONP	

The study found that the local migration of Indian Rhino was a common phenomenon. They suddenly went out from the population to other destination but never completed their journey and returned back to the park area. A total of four individuals were found straying out from the park and all of them were adult male. Majority of them were observed during the monsoon season and only one was observed in the re-treating monsoon season. It was also found that most of these incidents took place during flood season and a few in the winter season. It may be associated with the competition for reproductive resource that resulted in straying out some of the weaker (low ranking) individuals or they intentionally moved out of the population in search of mate. This needs further study to find out the reason behind stray out of some of the individuals of rhino from the population. However, most of them, who strayed out of the population, became victims of poaching.

9. Crop-raiding behaviour

During field survey, it was found that the crops of neighbouring villages, namely Borsala, Kachari Toop, Phata-Simalu, Gariapathar, Bezimari, Rangagara, Bhabapur, Chandanpur and Bagoribari, located about 0.5 to 2 km aerial distance on the northeastern side of the park, were raided by Indian Rhino each year. This type of behaviour of Indian Rhino was categorised as crop-raiding behaviour. Most of the damage was done during fruiting or riping season of paddy crop while the raiding of vegetables and plants took place during vegetative stage.

No structural construction (eg. building) was damaged by Indian Rhino during study period. In 90% cases, the adult males visited the areas for crop raiding activity which was performed during night period. Occasionally, females with calf were found moving around the village areas for crop raiding. However, no injury or death of both rhino and human being was recorded from any fringe village during the study period.

10. Non-breeding vocalisation

Indian Rhino produces several types of sounds for auditory communication (Laurie 1978, 82). During the study, it was observed that when rhino fled away after receiving any threat from intruder they produced a moo grunt like sound (*yaeeh…yaeeh…*). The vocalisation was also heard when the mother responded to the calf and a honk like sound (*beyh…beyh…*) was produced. Again, during breeding display, rhino produced a whistle like prolonged sounds (*fleet…fleet…*). The intensity and duration of vocalisation during non-breeding period was shorter than the breeding display. The sounds produced during non-breeding occasions persisted for not more than 20 seconds. But, it continued in an average of one minute (Range = 40-70 seconds) during breeding season.

11. *Dandi* or track follow behaviour

The Indian Rhino had a behaviour of creating path in the habitat and that path was followed every time when they travelled from place to other. This behaviour of rhino was categorised as *dandi* or track follow behaviour. Study revealed that the Indian Rhino followed definite *dandi* in all habitats of Orang National Park. These were quite distinct at habitat, not in wetland. Similar characteristics of *dandi* or rhino track was also observed in scrubland marshyland habitat, but, *dandis* were zigzag and criss-crossed mannered in marshyland.

Breeding behaviour

The behavioural postures performed by Indian Rhino during breeding season or only during breeding purposes were categorised as breeding behaviour. Two major types of breeding behaviour were categorised, such as (1) Mating and (2) Courtship behaviour.

12. Courtship display

Courtship took place between adult male and adult female before mating. The courtship behaviour was divided into five subdivisions, such as:

(i) **Touching**: Touching behaviour was found to be performed by two partners by rubbing the body parts (by adult male and female) of Indian Rhino during pair formation. This activity continued several minutes. Flehmen (smelling of female genital) and curling of lips. The bull kept its chin on the rump and shoulder of the female after acceptance of the female in all observed cases.

After touching, the next behaviour observed was licking the body of each other.

(ii) **Licking**: Licking behaviour was observed as an post effect of touching behaviour of adult male rhino or female rhino with their prehensile tongue. The licking of body parts was performed rapidly by the opposite sex.

(iii) **Chasing**: The chasing behaviour was a part of courtship behaviour when it was performed during breeding display. During this process, the adult male chased the adult female and the male was running after female with very high speed. During this process, both the animals covered sometimes more than 500 metres of distance. This was an act to achieve the accessibility of an adult female for potential mating by an adult male rhino.

A total of 31 events of mating display were recorded during the study period, of which 87.9% of mate selection were initiated by the adult male, whereas only 12.1 % (Fig. 8.4) was initiated by

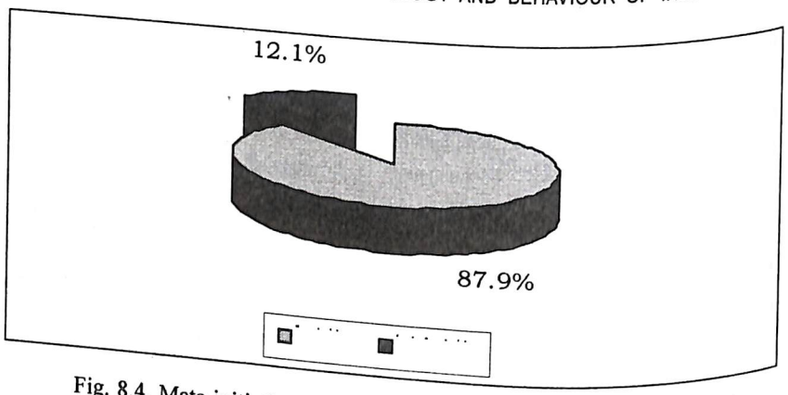

Fig. 8.4. Mate initiatives by Indian Rhino in Orang National Park

adult female. But the successful mating was performed only when the female accepted the adult male for mating.

It was observed that during courtship and mating, the female often ran away or walked fast with the male on her back, leading to severe injury of male on his hind legs. Occasionally female rhino also got injured during this process. Females occasionally became aggressive during courtship, resulting in physical attack by females on her male mate. Again, it was observed that the male and the female rhinos received minor injury, while approaching each other during courtship.

13. Mating display behaviour

When courtship display was successful, the female became submissive and agreed for mating or copulation. Mating behaviour was found to be completed with two sub-types of behaviour, such as (i) Mounting and (ii) Dragging.

(i) **Mounting:** Mounting was the process of riding of male on the female back keeping forelegs on her flank (or rump) for copulation purpose. Mounting continued for more than hours until it broke down.

(ii) **Dragging:** Dragging behaviour was found to be the act of copulating male and female Indian Rhino, in which the female carried the male on her back to a distance more than 60-150 m. (n=4) and formed a track in the dense grassland, scrubland, woodland or marshyland. During this process, the male generally could not walk

properly with their two hind legs being dragged above the substratum. This behaviour indicated that the female must be strong enough to drag the huge male body for a long distance of 150 metres on the rough surface of the tracks in the habitat.

After completion of mating the male dismounted immediately and the female slowly walked away and entered into the tall grassland, and disappeared. But, occasionally the female started to graze at a distance of about 50-60 metres from the dismounted male immediately after mating. But, after completion of mating, the males stood there for at least 3 minutes and started to graze slowly. No further association was observed after completion of mating.

Although the sightings of mating behaviour were very less, it was observed throughout the year and more in numbers during February, October and December (Fig : 8.5). This indicated that the Indian Rhino has no definite breeding season.

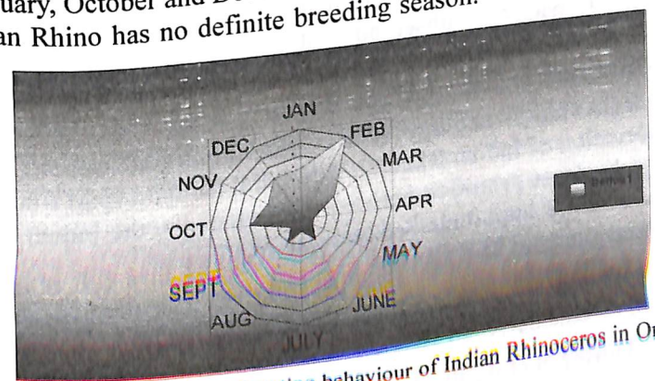

Fig.8.5: Monthly variation of mating behaviour of Indian Rhinoceros in Orang National Park

14. Breeding agonistic behaviour

Like the non-breeding agonistic behaviour, Indian Rhino displays agonistic behaviour, which can be termed as breeding agonistic behaviour. This type of agonistic behaviour was displayed by both male and female individuals. The characteristic features of non-breeding agonistic behaviour and breeding agonistic behaviour were almost the same.

Very less number of agonistic interactions among Indian Rhino was observed in Orang National Park. Of the total 71 episodes of aggressive behaviour, recorded during study period, 31 agonistic

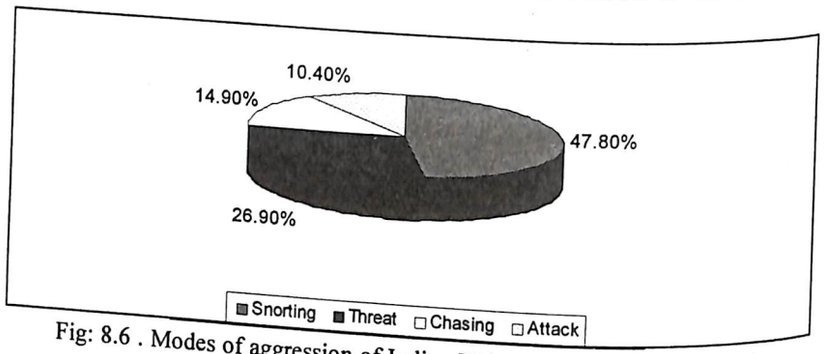

Fig: 8.6 . Modes of aggression of Indian Rhino in Orang National Park

interactions followed by 15 vigilance, 11 feeding, 8 wallowing, 5 resting and lowest, one aggressive behaviour were observed during locomotion (Fig: 8.6). Snorting was the most common (47.8%) type of agonistic behaviour to express aggression by Indian Rhino followed by threat (26.9%), chasing (14.9%) and attack (10.4) (Fig : 8.6). It was also observed that among agonistic behaviours, snorting was the common mode of aggression during all major activities pattern (Fig : 8.2).

Behavioural ecology is the most important aspect for the conservation of Indian Rhino in its natural habitat. Apart from that, being the most primitive herbivorous mammals, the Indian Rhino possess some important behavioural features that are directly or indirectly related to its survival perspectives measure. Again, some of the behaviours of Indian Rhino are itself responsible for becoming victim of poachers.

During mating display, female normally runs up to a higher distance of 2-3 kms or even more. In doing this, both the individuals often receive severe injury. Since mating takes place throughout the year, physical injury is a common phenomenon of Indian Rhino, which occasionally results in death. Again, the predation of rhino cub by tiger is a common phenomenon in Orang National Park as the rhino cubs are found throughout the year. This predation effect on rhino cub by tiger was also reported by Talukdar (2002) in Kaziranga National Park of Assam. Again, the mortality of Indian Rhino cubs is common during seasonal flood in each year. Therefore, the protection of rhino cubs during seasonal flood is very much essential in lower Orang habitat by constructing highlands or platform.

The presence of very less sweat glands in rhino skin leads to rigorous wallowing activity of Indian Rhino during warm days. This wallowing activity regulates the body temperature as well as exoparasites of their habitats. In the present study, the Indian Rhino found wallowing in a solitary manner and occasionally, up to 11 individuals wallowed in the same wetland within a minimum distance of 5-10 metres. This community wallowing activity of Indian Rhino was also reported by Laurie (1978, 82) and Ghosh (1991). Ghosh (1991) states that under very stressful condition more than one rhino can occupy wallow pool or they wallow in solitarily cow calf pair wallow together. As the duration of wallowing activity varies from few minutes to more than a hour without any break, hence the poachers take the advantage and go for hunting. Again, while in vigilance, the Indian Rhino keep watching any intruder for a long duration without moving, so, poachers are successful to kill the rhino. The occurance of wallowing behaviour of Indian Rhino especially during day hours indicates that the rhino avoids darkness for its own protection from large pretadors and poachers. Dutta (1991) also reported in his study that rhino seldom wallows during night hours. The wallowing is highest during the summer and almost absent during winter. During monsoon, Indian Rhino wallows from dawn to dusk. The posture of wallowing is similar to that of sleeping or resting i.e. the lower portion of their body remains stacked into the mud while other upper portions of the body remains free, hence it is a part of comfort behaviour. It also rolls in the mud by touching the mud with its backbone portions and mud stacked into their whole body. The stucked muddy cover over the whole body of the rhinos dries up and helps protect disturbance from flies. Apart from that, the Indian Rhino travelled from one place to another place within their habitat using same track and this track follow behaviour opens up a door for Indian Rhino poaching. The poachers take the advantage of track follow behaviour of rhino and set up a pitfall trap in fresh track to kill the animal very easily. Again, if the poachers identified a very fresh *dandi* (track) they monitored it for easy shooting. Similarly, the Indian Rhino has a tendency to defecate in a particular point. This peculiar nature of Indian Rhino also helped them becoming victims of poachers.

The local migration of Indian Rhino is also frequently found in

Orang National Park as reported by Laurie (1978, 82) in Nepal. This is a very common behaviour of Indian Rhino that they search for suitable habitat in order to re-establish a separate population. Laurie (1978,82) also reported the local movement behaviour of Indian Rhino in Nepal. This local migration may be a cause of inter-individual competition for mate resources or dominancy of one strong male over adult females during mating. Although, a large number of Indian Rhino go out of the protected area for searching habitat, they often fall prey to poachers.

The finding of crop depredation behaviour of rhino is a new dimension of threat for its conservation perspective. This crop depredation leading to human-rhino conflict, although it is not very serious. The fringe villagers are often stressed for such crop depredation behaviour of rhinos that may lead to killing of Indian Rhino in near future. Therefore, the park authority should provide special attention towards crop depredation of rhino within fringe village.

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Chapter – IX

CONSERVATION PERSPECTIVES OF INDIAN RHINO

For sustenance and survivability of a species, certain requirements are essential and it varies from species to species and habitat to habitat. Even the population of the same species living in the same habitat may have different requirement in different seasons. Therefore, it is important to know certain basic information about the species and their requirement for a comprehensive conservation strategy. The present study on the ecology and behaviour of the Indian Rhino in the Brahmaputra flood-prone plain habitat has revealed several aspects of the conservation and management. The study on the home range pattern has revealed that the Indian Rhino may use an area of up to 7.67 km^2 as their home range, indicating the need of a wide range area for their daily activities. The study of the habitat utilisation pattern revealed the utilisation of specific area within the home range by Indian Rhino. The wet grassland (including the marshy and wet grassland) selected by the Indian Rhino is more than the other habitat for feeding and other activities. This clearly indicates that the wet grassland plays a vital role for the survival of Indian Rhino in the Brahmaputra flood-prone plain habitat. The study on the activity budgeting shows that the Indian Rhino allocates more time on feeding compared to other activities. Since food is the primary requirement for survival of a population or species, the Indian Rhino allocates higher time on foraging and wallowing activities than other activities. Therefore, the selection of a specific area as their home range areas may be determined by the availability and distribution of food and other welfare resources.

Hence, the conservation and management of grassland habitat are the prime tasks for the conservation of the Indian Rhino in the Brahmaputra valley.

Besides these habitat factors, the number of species level issues also plays a major role in conservation of the Indian Rhino. Study on the behavioural ecology of the Indian Rhino indicated that the Indian Rhino itself is partially responsible for the poaching instances, owing to their inherent behaviour, like communal defecation in a same point and track (*dandi*) follow behaviour. Moreover, Indian Rhino has a tendency to stand on the same spot for a longer duration of time, while they undergo vigilance and wallowing activities. As a result, rhino often falls prey to poachers. Apart from that the individuals of Indian Rhino have a tendency to go out from the protected area, which also increase the poaching threat. There are several behavioural peculiarities of Indian Rhino that have a negative impact on its conservation. Among them, the most remarkable behaviour is the characteristic mating behaviour. A large number of male rhinos often get injured during mating, and occasionally lose their life. Since the mating takes place round the year, this type of physical injury is very common phenomenon. Similarly, the crop depredation by rhino has reached its peak nowadays in the fringe villages of Orang National Park. This type of behaviour leads to a negative impact on the people of the fringe villages and hampers the conservation initiation of Indian Rhino. Therefore, the park management must give emphasis on the species level issues for its conservation.

A. Rhino at risk

A number of factors are responsible for the habitat degradation of Indian Rhino. Lack of proper planning and facilities for conservation of Indian Rhino leads to the increase of poaching.

(a) Risk at habitat level

A number of factors are responsible for the shrinkage and degradation of grassland and wetland habitats, such as:

(i) Grassland habitat : The succession of grsssland habitat and the occurance of invasive weed species on the grassland habitat are the prime risks for grassland habitat in Orang National Park. As the controlled burning is not regularly practised by the Forest

Department, owing to financial crisis, the natural succession has become very fast and the woody plant and shrubs are invading the grassland habitat of Orang National Park. As a result of this, the grassland habitat has been shrinking, leading to declination of food resources. Since Orang National Park of Assam is situated on the bank of the river Brahmaputra, it receives annual flood each year. The flood water carries huge amount of silt that gets deposited on the grassland habitat, leading to a conversion of marshyland habitat into unfertile dryland. This dryland ultimately turns into a woodland habitat. As the Indian Rhino is purely a grassland dependent species, the conversion of grassland habitat into a woodland habitat is a major threat to the Indian Rhino in Orang National Park.

Again, the large-scale invasion of grassland habitat by invasive species weed species is the second largest threat to Indian Rhino habitat in Orang National Park as well as in the Brrahmaputra valley. The prime invasive weed species are *Mimosa sp.*, *Mikenia sp.*, *Leea sp.* etc. These weeds are not only posing threat to the food availability but also hindering the growth of grasses.

(ii) Loss of wetland habitat : The siltation and aquatic weed menace are the prime risk factors for wetland habitat.

Due to regular annual flood, most of the wetlands of Orang National Park become silted and reduce rhino habitats. The excessive growth of water hyacinth (*Eichornia crassipes*) in most of the wetlands of the Orang National Park leads to a decline of available habitat for feeding and wallowing.

(b) Risk at species level

(i) Lack of highland/ artificial raised platforms: Since the Orang National Park receives an annual flood each year, the large number of wild animals, including rhino stray out of the protected area. Apart from that the lack of highland or artificially built raised platform inside the low-lying areas of the park, leads to loss of wildlife population. Again, as there are no rescue facilities in Orang National Park, the park authority often fails to save a large number of wild animals, including rhino calves during heavy flood.

(ii) Spreading of diseases to wild animals: Domestic cattle from fringe villages enter into the Orang National Park very frequently, which leads to the spreading of certain contagious diseases among wild animals. Besides, cattle vaccination in the fringe villages

is very poor, owing to lack of proper financial assistance by the Forest authorities. Hence, there is a higher instance of disease contamination from the domestic cattle.

(iii) Insufficient manpower and infrastructure: The numbers of field staff to protect the park is very less. Again, the lack of proper infrastructure, such as sufficient forest camps, vehicle with adequate fuel supply, wireless sets for communication, arms and ammunition, etc. leads to reduce in patrolling efficiency.

(iv) Lack of proper conservation education : A group of wealthy people from several Asian countries has superstitious belief that the rhino horn has some magical and medicinal value. Hence, the demand of rhino horn is very high which leads to a higher poaching activity for horn.

(v) Law enforcement : Proper enforcement of law has never been taken up to control the poaching and illegal trade of wildlife and their trophies.

B. Conservation recommendations

(a) Habitat improvement

(a) The rhino habitat can easily be improved by regular controlled burning of grassland and uprooting of weeds like *Mimosa* and other invasive trees from the grassland habitat.

(b) The manual clearing of water hyacinth from the wetland habitat will help increase the open water space.

(c) Lantana camera, Mimosa sp., Leea sp., Mikenia sp. and other unwanted plant species that grow on the bank of wetland should be removed by uprooting it before fruiting stage.

(b) Habitat recovery

(i) De-siltation of the degraded and eutrified wetlands by manual removal of the bottom mud depositions, using bulldozer, may be useful to recover losing suitable habitat.

(c) Species recovery

1) Construction of highland or raised platform in the low-lying area in Orang National Park to check the animal

mortality during heavy flood.

2) The translocation or exchange of some of male-female rhinos with other protected areas of Assam may increase the genetic diversity among rhino population.

3) Regular vaccination programme of the domestic cattle, present in the fringe villages also reduce to spreading of contagious diseases.

4) Continuous rescue operation should be initiated to check the rhino mortality during heavy flood and also to take care of orphan calf rhino for increasing rhino population in Orang National Park.

(d) Formation of Anti-poaching Network

1) Formation of special task force who can actively take part in anti-poaching operation.

2) A comprehensive conservation network and pressure-building cell may be built up among the villagers to check illegal hunting during flood season. For this purpose, police authority, district administration, *Village Panchayat* (Local Body) and State Legislative Assembly Members (MLAs) may be involved.

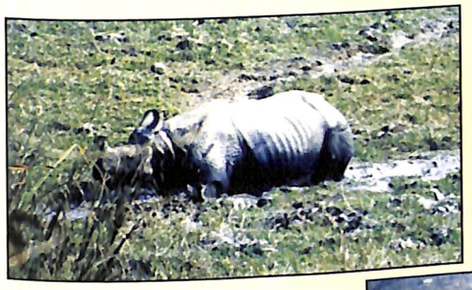
3) To maintain a proper rhino mortality data, to know the methods of poaching at different protected areas.

4) A regular dissemination of the conservation message to the grassroots level of the society by supplying education material (poster, leaflet, conservation charts, etc.), group discussion, popular lecture at the school level and religious sites (temple, mosque, church, etc.).

There is an urgent need to initiate some activities related to species, habitat, health and enforcement, to save the Indian Rhino and their habitats. Unfortunately, most of the conservation funds get diverted to infrastructure development and protection measure. Very negligible amount of quantity of the conservation funds was spent for habitat and species management. Hence, the park authorities must give more emphasis on mitigating the habitat level and species level crisis to conserve the Indian Rhino – the pride of Assam.

ASIAN ONE HORNED RHINOCEROS

Solitary in Grassland : Live and let live



STUDY AREA

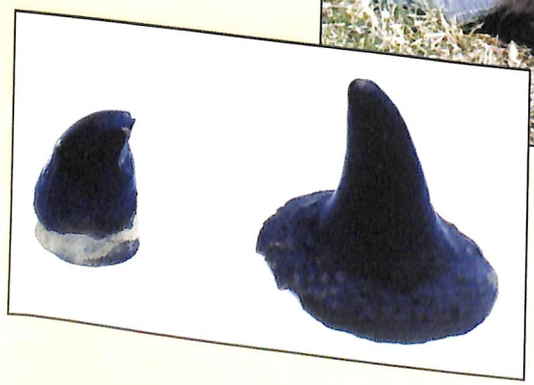
Rajiv Gandhi Orang National Park

NATURAL HABITAT

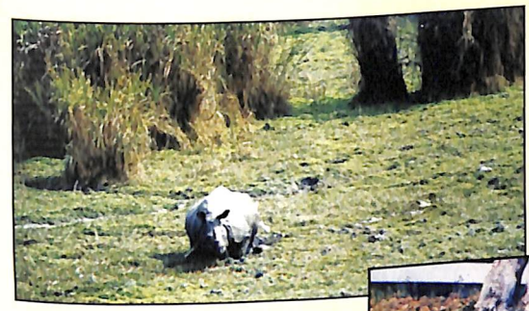
Riverine Grassland/Swampy-marshyland

THREATS AND PRESSURE

Habitat Degradation and Poaching for Horn



BEHAVIOUR



Grazing

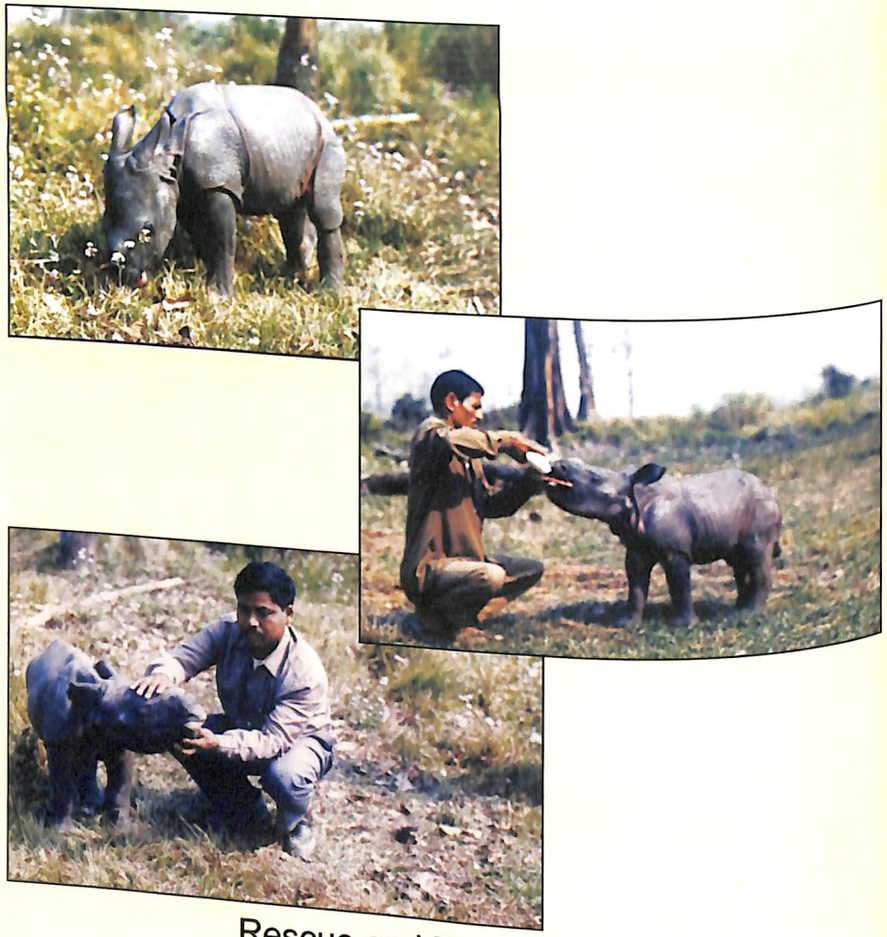
Soil Salt Licking Point

Soil Salt Licking Point

Wallowing
for parasite and heat

Dung heap due to defecation at some particular places in the habitat

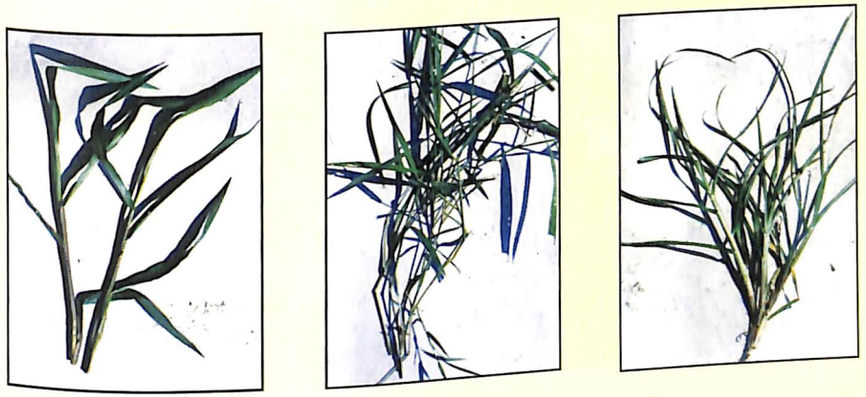
CONSERVATION



Rescue and Rehabilitation

Habitat management, Annual Burning

FOOD AND FEEDING



VIGILANCE

SUMMARY

The Great Indian One-horned Rhinoceros (*Rhinoceros unicornis* Linn. 1758) is one of the most primitive mega herbivore species, confined to a few protected areas of India and Nepal. At present, the distribution of Indian Rhino is confined to Himalayan Tarai habitats (Chitwan-Rapti Valley) of Eastern Nepal, Jaldapara and Gorumara Wildlife Sanctuary in Ganga-Teesta Valley and Brahmaputra Valley (Kaziranga Nationl Park, Orang Nationl Park, Pabitora Wildlife Sanctuary and Manas Nationl Park), Assam. The aim of the present study was to cover the ecology and behaviour of the Indian Rhino in Orang Nationl Park. To achieve this goal, the following objectives were taken, such as (1) to find out the habitat selectivity, habitat utilisation pattern, home range and activity budgeting of *Rhinoceros unicornis* in study area in different seasons of the year, (2) to find out the food habit and feeding behaviour of *Rhinoceros unicornis* in the study area, (3) to investigate the behavioral activities of the species during breeding and non-breeding periods of the year, (4) to find out the threat factors of the *Rhinoceros unicornis* to draw the habitat specific conservation strategies for this endangered species.

The study was carried out during the period from April, 2000 to March, 2003 in Orang NP (92°15′-92°27′E, 26°29′-26°40′N). A total of minimum 10 days per month were spent to visit each and every corner of the park. The field study was conducted using motor vehicles, bicycles, country boats, elephant back as well as on foot. During field visits, the sightings of Indian Rhinos were recorded

with their numbers, age-sex, GPS locations and habitat types, whenever sighted. The data were further analysed to find out the daily range, home range, and habitat utilisation pattern. During field visits, the vegetation samplings were done covering all the habitats on seasonal basis. Again, the sightings of rhino dung piles and occurrences of any less frequent opportunistic behaviour (e.g. aggressive, reproductive, etc.) were also recorded in each visit. Various standard methods were used during survey and analysis.

Chapter-IV emphasises on the home range and territoriality of Indian Rhino in Orang National Park. The study found that the adult male had a larger home range area compared to other age and sex classes. There was a distinct seasonal variation of home range pattern, which was highest in winter and lowest in monsoon. The adult male had a larger home range size (7.67 km^2) compared to other age-sex classes. There was a distinct seasonal variation in home range size in different age-sex classes and it was also overlapped among different age-sex classes in all the seasons. The Indian Rhino showed distinct territoriality during breeding and foraging period, but possessed very less territoriality during wallowing period. The territoriality was found to be strong between same sex groups than others. The species maintained a distinct spatial distances between two individuals in their daily activities. The spatial distance between "male-male" individual was higher than that of "female-female" individuals. In case of female, no such territorial defence was observed during mating period, as no such two females were observed during mating display. But, the "female-female" territorial defence was higher only during feeding and wallowing activities.

Chapter-V includes the study of habitat ecology of the Indian Rhino in Orang National Park. The analysis of Satellite Imagery of Orang National Park revealed that of the total 78.81 km^2 area of the study area, 25.93 km^2 (32.9%) area was occupied by dry tall-grassland, followed by wet grassland (both marshy and wet) 17.13 km^2 (21.7%), short grassland 14.05 km^2 (17.8%), 10.75 km^2 (13.6%) wetland, woodland 6.88 km^2 (7.7%) and water bodies and sand bars 4.86 km^2 (5.5%). Among all the water bodies, the area of 0.5 km^2 (0.6%) was covered by stagnant water bodies. and 4.36 km^2 (5.5%) by flowing rivers and streams. The study revealed that the

Indian Rhino utilised altogether five major habitat types in the study area, those were: (i) Water-bodies, (ii) Short grassland, (iii) Tall-grassland, (iv) Wet grassland and (v) Woodland habitat.

Chapter-VI deals with the food and feeding ecology of Indian Rhino at Orang National Park. Indian Rhino used maximum of 41.41% wet grassland habitat, followed by 27.88% tall grassland, 18.99% water bodies, 8.08% short grassland and only 3.64% woodland habitat. Seasonal variation of habitat utilisation was observed in both male and female.

A total of 75 species of grasses, 27 species of shrubs-herbs, 27 species of trees and 9 aquatic plant species were identified as a food plant species of Indian Rhino in study area. Of the 75 species of grasses, 48 species had a relative dominance less than 1. The *Saccharum spontaneum* ranked the highest relative dominance among grasses with a value of 8.45% while the *Cyperus pilosus* ranked the lowest with a value of 0.08%. Among 27 shrubs and herbs, species, 3 species had a relative dominance less than 1. The *Diplazium esculentum* ranked the highest relative dominance among the shrubs and herbs with a value of 13.83% while the *Solanum viarum* ranked the lowest with a value of 0.66%. All tree species had a relative dominance above 1. The *Dalbergia sisso* ranked the highest among all trees with a value of 7.94%, while the *Anthochephalus cadamba* ranked the lowest with a value of 1.19%. Grasses constituted 86.66% of the total annual diet, while aquatic and woodland species constituted only 13.34% of the total diet.

Altogether 71 plants species were identified as the food of Orang National Park. Of which, grasses constituted highest of 42 numbers, followed by woodland species (trees, shrubs and herbs), 20 numbers and aquatic species with 9 numbers. The grass species - *Hemarthria compressa* contributed a highest of 11.63% while the aquatic species - *Polygonum hydropiper* the least of 0.01% of the total annual diet. Out of total 42 species, 20 species of grasses had no selectivity. The *Hemarthria compressa* was the top ranking grass selected as food by the Indian Rhino. Altogether 36 food plants (24 grasses, 9 woodland species and 3 aquatic species) were identified as the staple food that constituted 83.64% of the total

annual diet. Study showed that, ten top ranking food plants constituted 56.44% and 20 top ranking food plants constituted 72.19% of the total annual diet. Grasses itself is enough to provide food for Indian Rhino in Orang National Park. Soil licking and crop depredation by Indian Rhino was common in the fringe villages of the Orang National Park.

Chapter-VII deals with behavioural ecology of Indian Rhino in Orang National Park. The present study categorised two basic types of behaviour, such as (a) Breeding and (b) Non-breeding behaviour. Altogether 14 major behavioural patterns were categorized for Indian Rhino under two basic types, such as (1) Feeding, (2) Locomotion, (3) Comfort, (4) Vigilance, (5) Non-breeding agonistic behaviour, (6) Non- breeding play behaviour, (7) Local migration, (8) Crop raiding behaviours, (9) Vocalization, (10) Courtship behaviour, (11) Mating behaviour, (12) Breeding play behaviour, (13) Breeding Vocalisation and (14) Breeding agonistic behaviours. Apart from those major types, certain subtypes were also categorized, such as under locomotion behaviour, three sub-types (i) Walking, (ii) Galloping and (iii) Running, under feeding behaviour, six subtypes, such as (i) Browsing, (ii) Grazing, (iii) Drinking, (iv) Dive-feeding, (v) Breast feeding and (vi) Geophagy. Under non-breeding agonistic and breeding agonistic behaviour, five sub-types, such as (i) Snorting, (ii) Threat Display, (iii) Chasing, (iv) Attack and (v) Escaping behaviour. Under comfort behaviour, three sub-types, such as (i) Resting, (ii) Sleeping and (iii) Wallowing, and under wallowing behaviour two sub-divisions, such as (a) Mud wallowing and (b) Water wallowing. In case of breeding behaviour, two major types of behaviours were found, such as (1) Courtship behaviour and (2) Mating behaviour and under courtship, three sub-types, such as (i) Touching, (ii) Licking and (iii) Chasing behaviour, whereas mating behaviour was categoried into two sub-types, such as (i) Mounting and (ii) Dragging behaviour.

Chapter-VIII deals with the time and activity budgeting of the species. The present study revealed that the Indian Rhino showed distinct variation of activity pattern in different seasons of the year. The Indian Rhino of Orang National Park spent a maximum of 46.2% time on feeding activities, followed by wallowing 18.4%,

vigilance 15.1%, locomotion 9.1%, comfort 8.01% and minimum of 5.6% in other miscellaneous activities. The results indicated that feeding was the guiding factor, which has effect on time allocation in various activities of Indian Rhino. The Indian Rhino of Orang National Park allocated maximum time on feeding activities (55.29%) during winter season, followed by pre-monsoon (48.75%) and retreating monsoon (47.34%) season, whereas it was lowest (36.96 %) during monsoon season. Again, the highest percentage of locomotion activity was observed during winter season (16.5%), followed by pre-monsoon (11.32%), retreating monsoon (5.07%) and monsoon season (3.3%). The study showed that the variations of time allocation in wallowing activity by Indian Rhino varied in different seasons of the year. The highest time allocation on wallowing activity was found during monsoon season (41.3%), followed by retreating monsoon (17.4%) and pre monsoon (9.1%), whereas lowest (2.2%) time was allocated during winter season in Orang National Park. The time allocation of Indian Rhino for comfort activities varied in different seasons of the year. The highest time was allocated during retreating monsoon (14.7%), followed by winter (10.1%), pre-monsoon (7.9%) and monsoon season (4.2%). They spent almost equal time on vigilance behaviour in all four seasons of the year. However, the trend of vigilance activity increased during winter and it continued till pre-monsoon season. The Indian Rhinos spent 5.6% time in various other miscellaneous activities. During pre-monsoon season, they spent 1.9% time on miscellaneous activities, followed by retreating monsoon (1.8 %), monsoon (1.2%), and winter season (0.7%).

Chapter-IX deals with the conservation perspectives of Indian Rhino in Orang National Park as well as in Brahmaputra Valley of Assam. For conservation purpose, the present study highlighted the importance of habitat and species level conservation effort for the conservation of the Indian Rhino in the Brahmaputra flood-prone plain habitat. Those were summarised as:

(1) Burning and uprooting of the *Mimosa, Mikenia* and other weeds species in the grassland habitat.
(2) Manual clearing of water hyacinth from the wetland habitat.
(3) Cutting of *Lantana, Leea* and other species of plant that grow

on the banks and edges of the wetland.

(4) Control burning of the grassland habitat to check excessive growth of weed and to check succession of the grassland habitat.

(5) De-siltation of the degraded wetlands by manual cutting of the mud. If possible, dozer may be used.

(6) Construction of upland/ raised areas to check mortality during flood.

(7) Translocation of certain individuals of Indian Rhino of both sexes to other protected area to reduce genetic threats.

(8) Providing of medical facility to take care of the injured and diseased individuals. Also to facilitate vaccination programme in the fringe villages.

(9) Providing of rescue facility to check mortality during flood and to take care of the orphan individuals of rhino.

(10) Formation of special task force who can actively take part in operation.

(11) A comprehensive network and pressure-building cell may be built up among the villagers to check hunting during flood season.

(12) Proper maintenance of the mortality data base to know the protected area specific method of poaching and

(13) Conveying the conservation message to the grassroots level of the society by providing education material.

(14) Setting up of Eco-Tourism facilities will be an attraction for the visitors of the park.

Hence, there is an urgent need of conservation initiation through different activities like habitat manipulation, species level issues, stringent law enforcement and health care of domestic cattle, etc. in order to save the Indian Rhino and their habitats.

❑❑❑

APPENDIX

Appendix – 3 (a)

Data sheet

Habitat utilization pattern of Rhinoceros Unicornis

Date : Site Location :

Temperature : Humidity :

Light condition :

Date :	Time
Habitat Type: Wet grassland, tall grassland, woodland, scrubland Marshy land, wetland (beel, pond, nullah), highland	No. of Rhino sighted :
Sex :	Age : I.D. Mark : (if any)
Name of the site :	Weather condition : Cloudy, Sunny, Rainy, Foggy

Remarks:

Appendix – 3 (b)

Data Sheet for behavioural studies / activity budgeting

Date : Locality : Sheet No.

Time : Individual / Gròup

Habitat type Water source distance : Slope : Other animal in association: (within 20m)	Group Spread : m Gr./ Individual : Distance : Block :	Temp : Light : Humidity : Rain : Cloud cover : %

Min	Focal/ Scan Animal Sampling	Ad Libitum
	5 Min. instance	
5		
10		
15		
20		
25		
30		

Appendix – 6.1: Relative dominance of grass species in Orang National Park.

Sl No.	Scientific name	Family	Relative dominance	
			%	Rank
1	*Agrostis zenkeri* Sensu Bor.	Poaceae	0.36	43
2	*Andopogan squrrosus* Hooker.	Poaceae	0.80	30
3	*Andopogan aciculatus* Retz.	Poaceae	0.94	25
4	*Andropogon citratus* D.C.	Poaceae	0.35	44
5	*Anthraxon hispidus* (Retz.) Trin.	Poaceae	0.64	33
6	*Anthraxon nudus* (Steud.) Hochst.	Poaceae	0.94	25
7	*Apluda mutica* L.	Poaceae	1.19	15
8	*Apocopsis paleacea* (Trin.) Hochr.	Poaceae	0.13	50
9	*Arundinella bengalensis* (Spreng.) Druce	Poaceae	0.95	24
10	*Arundinella nepalensis* Trin.	Poaceae	1.11	17
11	*Arundo donax* Linn.	Poaceae	2.87	9
12	*Axonopus compressus* (Sw.) P. Beauv.	Poaceae	0.29	47
13	*Brachiaria ramose* (L.) Stapf	Poaceae	1.50	13
14	*Brachiaria mutica* (Forssk.) Stapf	Poaceae	0.50	38
15	*Carex prealonga* Cl.	Cyperaceace	1.04	21
16	*Coelorhachis striatab* (Nees. Ex Steud) A. Camus.	Poaceae	0.54	37
17	*Crytococcum accrescens* (Trin.) Stapf	Poaceae	0.43	40
18	*Cyndon dactylon* (L.) Pers.	Poaceae	4.31	8
19	*Cyperus niveus* Retz.	Cyperaceace	0.94	25
20	*Cyperus brevifolius* (Rottb.) Hasak	Cyperaceace	0.54	37
21	*Cyperus cyperoides* (L.) Kuntz.	Cyperaceace	0.55	36
22	*Cyperus diffornis* L	Cyperaceace	0.32	45
23	*Cyperus globusus* All	Cyperaceace	0.15	49
24	*Cyperus imbricatus* Retz.	Cyperaceace	1.77	11
25	*Cyperus kyllingia* Endl.	Cyperaceace	0.56	35
26	*Cyperus pilosus* Vahl.	Cyperaceace	0.08	51
27	*Cyperus radiatus* Vahl.	Cyperaceace	0.31	46
28	*Cyperus rotundus* L.	Cyperaceace	1.07	19
29	*Cyperus siletensis* Nees.	Poaceae	0.76	31
30	*Cyrtococcum accrescens* (Trin.) Stapf	Poaceae	1.04	21
31	*Dactyloctenium aegyptium* (L.) Willd	Poaceae	0.13	50
32	*Desmostachya bipinnata* (L.) Stapf	Poaceae	0.27	48
33	*Dichanthium caricosum* (L.) A. Camus.	Poaceae	0.86	28
34	*Digitaria ciliaris* (Retz.) Koel	Poaceae	0.76	31
35	*Echionchola crusgalli* (L.) P. Beauv.	Poaceae	0.42	41
36	*Eleusine indica* (L.) Gaertn.	Poaceae	1.70	12

37	*Eragrostis japonica* (Thunb.) Trin.	Poaceae	0.80	30
38	*Eragrostis unioloides* (Retz.) Nees ex Steud.	Poaceae	0.70	32
39	*Saccharum ravennae* (L.) Murray	Poaceae	5.73	4
40	*Erichola procera* (Retz.) C.E.Hubb.	Poaceae	0.70	32
41	*Rottboellia cochinchinensis (Lour.) W.D.Clayton*	Poaceae	0.42	41
42	*Hemarthria compressa* (L.f.) R.Br.	Poaceae	4.34	7
43	*Hemarthria protesna* Steud.	Poaceae	1.17	16
44	*Hygroryza aristata* (Retz.) Nees ex Wight&Arn.	Poaceae	1.29	14
45	*Hymenachne pseudointerrupta* C. Muell.	Poaceae	5.81	3
46	*Imperata cylindrical* (L.) Beauv.	Poaceae	4.84	5
47	*Leersia hexandra* Swartz.	Poaceae	6.47	2
48	*Leptochloa panicea* (Retz.) Ohwi	Poaceae	1.04	21
49	*Narenga porphyrocoma* (Hance) Bor.	Poaceae	0.35	44
50	*Ophiuros megaphyllus* Stapf ex Haines	Poaceae	0.91	26
51	*Oplismenus burmannii* (Retz.) P. Beauv.	Poaceae	0.63	34
52	*Ottochloa nodosa* (Kunth) Dandy.	Poaceae	0.91	26
53	*Panicum accrescens* Trin.	Poaceae	1.08	18
54	*Panicum crusgalii* L.	Poaceae	0.55	36
55	*Panicum palusodosum* Roxb. Hort. Beng.	Poaceae	0.38	42
56	*Panicum brevifolium* Linn. Sp. Pl.	Poaceae	0.54	37
57	*Panicum walense* Mez.	Poaceae	0.86	28
58	*Paspalidium flavidum* (Retz.) A. Camus	Poaceae	0.90	27
59	*Paspalum conjugatum* Betz.	Poaceae	1.11	17
60	*Paspalum dilatatum* Poir.	Poaceae	0.99	22
61	*Paspalum longifolium* Roxb. Hort. Beng.	Poaceae	0.80	30
62	*Phalaris hispida* Thunb.	Poaceae	0.96	23
63	*Phragmites karka* (Retz.) Trin ex Steud	Poaceae	4.50	6
64	*Pogonatherum crinitum* (Thunb.) Kunth	Poaceae	0.44	39
65	*Pollina ciliate* Trin.	Poaceae	1.06	20
66	*Saccharum munja* Roxb.	Poaceae	0.54	37
67	*Saccharum pumilllo* Reichb.	Poaceae	0.35	44
68	*Saccharum procerum* Roxb.	Poaceae	1.29	14
69	*Saccharum spontaneum* L.	Poaceae	8.45	1
70	*Sacciolepis interrupta* (Willd.) Stapf	Poaceae	0.86	28
71	*Setaria pumila* (Poir.) Roem.& Schult.	Poaceae	0.70	32
72	*Themeda caudate* (Nees) A. Camus.	Poaceae	0.90	27
73	*Themeda villosa* (Poir.) A. Camus.	Poaceae	2.87	9
74	*Themeda arundinacea* (Nees) A. Camus.	Poaceae	0.84	29
75	*Vetiveria zizanoides* (L.) Nash.	Poaceae	1.82	10

Appendix – 6.2: Relative dominance of shrubs and herb species in Orang National Park.

Sl No	Scientific name	Family	Relative dominance %	Rank
1	*Ageratum conyzoides* L.	Asteraceae	4.19	7
2	*Alpinia allughas* (Retz.) Rosc.	Zingiberaceae	8.13	4
3	*Amaranthus spinosus* L.	Amaranthaceae	4.85	6
4	*Centella asiatica* (L.) Urban	Apiaceae	1.64	16
5	*Chenopodium album* L.	Chenopodiaceae	2.62	12
6	*Clerodendum kaempferi* (Jacq.) Sieb. Ex Steud	Verbinaceae	1.18	20
7	*Christella parasitica* (L.) Lev.Fl.Kouy. Tcheou	Thelypteridacea	6.75	5
8	*Curcuma aromatica* L.	Zingiberaceae	1.97	15
9	*Datura stramonium* L.	Solanaceae	0.72	22
10	*Diplazium esculentum (Retz.)* wartz	Athyriaceae	13.83	1
11	*Solanum viarum* Dunal.	Solanaceae	0.66	23
12	*Solanum torvum* Sw. Prodr.	Solanaceae	2.10	13
13	*Eupatorium odoratum* L.	Asteraceae	4.00	8
14	*Grewia sapida* Roxb.	Tiliaceae	2.62	12
15	*Lantana camera* L.	Verbinaceae	1.51	17
16	*Leea indica* (Burm. F.) Merr.	Vitaceae	2.75	11
17	*Leucas aspera* Link.	Lemiaceae	1.97	15
18	*Melastoma malabathrium* L.	Melastomaceae	0.79	21
19	*Mikenia micrantha* HBK	Asteraceae	4.19	7
20	*Mikenia scandens* Willd.	Asteraceae	11.66	2
21	*Mimosa pudica* L.	Mimosaceae	1.44	18
22	*Mimosa rubricaulis* Lamk.	Mimosaceae	2.82	10
23	*Oenanthe benghalansis* D.C	Apiaceae	2.03	14
24	*Polygonum chinensis* L	Polygonaceae	1.97	15
25	*Polygonum hydropiper* L.	Polygonaceae	3.47	9
26	*Tinospora cordifolia.* (Willd.) Hook. F.& Th.	Menispermaceae	1.38	19
27	*Xanthium strumarium* L.	Asteraceae	8.78	3

Appendix –6.3: Relative dominance of tree species in Orang National Park.

Sl No	Scientific name	Family	Relative dominance %	Rank
1	*Acacia catechu* Willd.	Mimosaceae	4.17	8
2	*Albizzia lebeek* (L.) Benth.	Mimosaceae	1.98	21
3	*Albizzia procera* (Roxb.) Benth.	Mimosaceae	6.65	3
4	*Alstonia scholaris* (L.) R.Br.	Apocynaceae	2.08	20
5	*Anthochephalus cadamba* Miq.	Rubiaceae	1.19	27
6	*Artocarpus heterophyllus* Lamk.	Moraceae	6.25	4
7	*Bauhinia purpurea* L.	Caesalpiniçeae	3.97	12
8	*Bisofica javanica* Bl.	Euphorbiaceae	2.28	18
9	*Bombax ceiba* L.	Bombacaceae	4.17	9
10	*Cassia fistula* L.	Caesalpiniceae	3.17	13
11	*Dalbergia sisso* Roxb.	Papilionaceae	7.94	1
12	*Delonix rigia* (bojr.) Raf.	Caesalpiniceae	1.39	25
13	*Dillenia indica* L.	Dilleniaceae	1.98	22
14	*Dysoxylum binecteriferum* Hk.F.et.Bedd.	Meliaceae	2.28	19
15	*Embilica officilnalis* L.	Euphorbiaceae	1.29	26
16	*Ficus glomerata* Roxb.	Moraceae	2.88	17
17	*Ficus religiosa* L.	Moraceae	6.15	6
18	*Ficus rumphii* Bl.	Moraceae	2.98	16
19	*Gmelina arborea* Roxb.	Verbenaceae	4.17	10
20	*Lagerstomeia speciosa* (L.) Pers.	Lythraceae	4.07	11
21	*Mangifera indica* L	Anacardiaceae	1.98	23
22	*Michelia champaca* L.	Magnoliaceae	1.59	24
23	*Streblus asper* Lour.	Moraceae	3.17	14
24	*Tamarix dioica* Roxb. Ex Roth.	Tamericaceae	6.25	5
25	*Tectona grandis* L.f.	Verbenaceae	3.17	15
26	*Trewia nudiflora* L.	Euphorbiaceae	7.14	2
27	*Ziziphus zuzuba* Lamk.	Rhamnaceae	5.65	7

Appendix : 6.4

Feeding frequency of food plants in different habitats of Orang National Park.

Sl No.	Food Plants	Species category	Feeding frequency	Rank
1	*Hemarthria compressa*	GL	10.63	1
2	*Leersia hexadra*	GL	8.8	2
3	*Hymenachne acutigluma*	GL	7.64	3
4	*Arundo donax*	GL	6.13	4
5	*Hygroryza aristata*	GL	5.72	5
6	*Cynodon dactylon*	GL	4.6	6
7	*Phragmites karka*	GL	4.2	7
8	*Bracharia ramosa*	GL	3.83	8
9	*Saccharum spontaneum*	GL	2.3	9
10	*Chrysopogon aciculatus*	GL	2.11	10
11	*Imperata cylindrica*	GL	1.98	11
12	*Oplismenus burmannii*	GL	1.95	12
13	*Saccharum ravanae*	GL	1.88	13
14	*Arundinella begalensis*	GL	1.52	14
15	*Themda villosa*	GL	1.48	15
16	*Eleusine indica*	Aq	1.44	16
17	*Ipomea aquatica*	GL	1.42	17
18	*Sacciolepis interrupta*	GL	1.39	18
19	*Cyperus rotundus*	GL	1.38	19
20	*Hemarthria protesna*	Aq	1.3	20
21	*Pistia stratiotes*	GL	1.24	21
22	*Arundinella nepalensis*	Aq	1.23	22
23	*Enhydra fluctuans*	GL	1.16	23
24	*Apluda mutica* Linn.	GL	1.1	24
25	*Cyperus globosus*	GL	1.08	25
26	*Paspalum conjugatum*	GL	1.06	26
27	*Leptochloa panicea*	GL	1.02	27
28	*Digitaria ciliaris*	GL	1	28
29	*Saccharum procerum*	GL	0.97	29
30	*Paspalum dilatatum*	Aq	0.94	30
31	*Hydrilla verticillata*	GL	0.93	31
32	*Dichantium caricosum*	GL	0.91	32
33	*Erichola procera*	Aq	0.78	33
34	*Eichhornia cressipes*		0.72	34

35	*Grewia sapida*	WL	0.69	35
36	*Paspalidium flavidum*	GL	0.68	36
37	*Eragrostis unioloides*	GL	0.68	- do -
38	*Cyrtococcum accrescens*	GL	0.67	37
39	*Eragrostis japonica*	GL	0.67	- do -
40	*Trewia nudiflora*	WL	0.64	38
41	*Dalbergia sisso*	WL	0.63	39
42	*Vallisneria spiralis*	Aq	0.60	40
43	*Ficus rumphii*	WL	0.58	41
44	*Cyperus brevifolius*	GL	0.56	42
45	*Panicum walense*	GL	0.54	43
46	*Axonopus compressus*	GL	0.50	44
47	*Agrostis zenkeri*	GL	0.48	45
48	*Vetiveria ziganoides*	GL	0.47	46
49	*Nymphaea nouchali*	Aq	0.47	- do -
50	*Diplazium esculentum*	WL	0.44	47
51	*Sateria pumila*	GL	0.43	48
52	*Cassia fistula*	WL	0.43	- do -
53	*Bombax ceiba*	WL	0.42	49
54	*Amaranthus spinosus*	WL	0.41	50
55	*Ficus glomerata*	WL	0.39	51
56	*Mikenia micranth*	WL	0.38	52
57	*Xanthium strumarium*	WL	0.34	53
58	*Lantana camera*	WL	0.32	54
59	*Cyperus kyllingia*	GL	0.32	- do -
60	*Ziziphus zuzuba*	WL	0.26	55
61	*Ageratum conyzoides*	WL	0.23	56
62	*Echinochloa crusgalli*	GL	0.22	57
63	*Melastoma malabathricum*	WL	0.16	58
64	*Artocarpus heterophyllus*	WL	0.13	59
65	*Cyperus cyperoides*	GL	0.12	60
66	*Mangifera indica*	WL	0.11	61
67	*Bauhinia purpurea*	WL	0.10	62
68	*Trapa bispinosa*	Aq	0.08	63
69	*Alpinia allughas*	WL	0.07	64
70	*Streblus asper*	WL	0.01	65
71	*Polygonum hydropiper*	WL	0.01	- do -

Appendix : 6.5

Selectivity of different groups of food Plant species in Orang National Park: (a) Grasses (b) Shrubs and herbs (c) Trees (d) Aquatic plants

(a) Grasses

Sl. No.	Food Plants	Dominance (%)	Feeding (%)	Selectivity
1	*Agrostis zenkeri*	0.36	0.55	1.53
2	*Apluda mutica/A. aristata*	1.19	1.27	1.06
3	*Arundinella bengalensis*	0.95	1.75	1.84
4	*Arundinella nepalensis*	1.11	1.42	1.28
5	*Arundo donax*	2.87	7.07	2.47
6	*Axonopus compressus*	0.29	0.58	1.96
7	*Brachiaria ramose*	1.50	4.42	2.94
8	*Chrysopogon (Andropogon) aciculatus*	0.94	2.44	2.60
9	*Cyndon dactylon*	4.31	5.31	1.23
10	*Cyperus cyperoides*	0.55	0.13	0.24
11	*Cyperus rotundus*	1.07	1.60	1.49
12	*Cyperus brevifolius*	0.54	0.64	1.20
13	*Cyperus globusus*	0.15	1.24	8.42
14	*Cyperus kyllingia*	0.56	0.37	0.65
15	*Cyrtococcum accrescens*	1.04	0.77	0.74
16	*Dichantium caricosum*	0.86	1.04	1.22
17	*Digitaria ciliaris*	0.76	1.15	1.50
18	*Echionchola crusgalli*	0.42	0.26	0.62
19	*Eleusine indica*	1.70	1.66	0.98
20	*Eragrostis japonica*	0.80	0.77	0.96
21	*Eragrostis unioloides*	0.70	0.78	1.12
22	*Saccharum ravanae*	5.73	2.17	0.38
23	*Erichola procera*	0.70	0.90	1.30
24	*Hemarthria compressa*	4.34	12.27	2.83
25	*Hemarthria protesna*	1.17	1.50	1.29
26	*Hygroryza aristata*	1.29	6.60	5.13
27	*Hymenachne pseudointerrupta*	5.81	2.66	0.46
28	*Imperata cylindrica*	4.84	2.28	0.47
29	*Leersia hexandra*	6.47	10.15	1.57
30	*Leptochloa panicea*	1.04	1.18	1.13
31	*Oplismenus burmannii*	0.63	2.24	3.57
32	*Panicum walense*	0.86	0.63	0.73
33	*Paspalidium flavidum*	0.90	0.79	0.88
34	*Paspalum conjugatum*	1.11	1.22	1.10
35	*Paspalum dilatatum*	0.99	1.08	1.09
36	*Phragmites karka*	4.50	4.84	1.08
37	*Saccharum procerum*	1.29	1.11	0.87
38	*Saccharum spontaneum*	8.45	8.82	1.04

Sl. No.	Food Plants	Dominance (%)	Feeding (%)	Selectivity
39	*Sacciolepis interrupta*	0.86	1.60	1.87
40	*Sateria pumila*	0.70	0.50	0.71
41	*Themda villosa*	2.87	1.70	0.59
42	*Vetiveria zizanoides*	1.82	0.55	0.30

(b) Shrub and herbs

1	*Ageratum conyzoides*	4.19	7.77	1.85
2	*Amaranthus spinosus*	4.85	13.77	2.84
3	*Diplazium esculentum*	13.83	14.86	1.08
4	*Grewia sapida*	2.62	23.14	8.83
5	*Lantana camera*	1.51	10.81	7.17
6	*Melastoma malabathrium*	0.79	5.32	6.77
7	*Mikenia micranth*	4.19	12.75	3.04
8	*Polygonum hydropiper*	1.97	0.25	0.13
9	*Xanthium strumarium*	8.78	11.32	1.29

(c) Trees

1	*Artocarpus heterophyllus*	6.25	3.51	0.56
2	*Bauhinia purpurea*	3.97	2.70	0.68
3	*Bombax ceiba*	4.17	11.35	2.72
4	*Cassia fistula*	3.17	11.62	3.66
5	*Dalbergia sisso*	7.94	16.96	2.14
6	*Ficus glomerata*	2.88	10.61	3.69
7	*Ficus rumphii*	2.98	15.74	5.29
8	*Mangifera indica*	1.98	2.91	1.46
9	*Streblus asper*	3.17	0.34	0.11
10	*Trewia nudiflora*	7.14	17.30	2.42
11	*Ziziphus zuzuba*	5.65	6.96	1.23

(d) Aquatic Plants

Sl. No.	Food Plants	Dominance (%)*	Feeding (%)	Selectivity *
1	*Ipomea aquatica* Frossk.	Data not available	1.42	Data not available
2	*Pistia stratiotes* L.	,,	1.24	,,
3	*Enhydra fluctuans* Lour.	,,	1.16	,,
4	*Hydrilla verticillata* (L.f.) Royle	,,	0.93	,,
5	*Eichhornia cressipes* (Mart.) Solms.	,,	0.72	,,
6	*Vallisneria spiralis* L.	,,	0.60	,,
7	*Nymphaea nouchali* Burn. f.	,,	0.47	,,
8	*Trapa bispinosa* (Roxb.) Makino	,,	0.08	,,

* Sampling was not done in aquatic habitat for aquatic vegetation.

The primitive mammal, Indian Rhino which is widely recognised to be the state Animal of Assam has returned from the brink of extinction over the last century owing to a number of conservation success stories in Assam and Nepal.

The majestic animal which is widely recognised as a symbol of power and strength across the world has inspired popular imagination since time immemorial. However, in recent times the survival of the animal is under renewed threat due to continued poaching, habitat destruction and other anthropological pressure. The available literature on this species for the common man is limited to coffee table books and there is limited literature available to provide detailed information in simple yet lucid language.

This book is an effort to present findings about the ecology and behaviour of the Indian Rhino in the flood plain habitat of Assam in a crisp but detailed package. We hope that the book would be useful for Students, Researchers, Conservationists and the layman alike who are interested to know about this majestic animal.

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