Studies on the Eco-behavioural Aspects of Great Indian One-horned Rhinoceros (*Rhinoceros unicornis* Linn.) in the Orang National Park, Assam, India

A Thesis submitted to the Gauhati University for the degree of Doctor of Philosophy (Science)

2007

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Declaration

I hereby declare that, this thesis is the result of my own research work, which has been carried out under guidance and supervision of Dr. P.K Saikia, Reader, Department of Zoology, Animal Ecology and Wildlife Biology Lab., Gauhati University. Also I would like to declare that, neither the thesis nor any part thereof was submitted to any other University/ Institution for any Degree or Diploma.

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This is to certify that **Mr. Buddhin Ch. Hazarika** carried out this research work entitled **"Studies on the Eco-behavioural Aspects of Great Indian One-horned Rhinoceros (*Rhinoceros unicornis* Linn.) in the Orang National Park, Assam, India"** under my guidance and supervision which is being submitted to the Gauhati University, for the Degree of Doctor of Philosophy.

This thesis is the result of his own investigation on the subject. He has fulfilled all the requirements under Ph. D. regulation of Gauhati University. This thesis or any part of it has not been submitted by the candidate to any other University for any other degree.

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CHAPTER-I: INTRODUCTION

1.1 Background

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 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, Pabitara Wildlife Sanctuary, Burachhapori Wildlife Sanctuary and Laokhowa Wildlife Sanctuary of the Brahmaputra Valley of Assam (Prater, 1971; Laurie, 1978; Dutta, 1991; Ghosh, 1991). Presently, 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 1649 (as per 1999 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) survive 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)

Table: 1.1– The present distribution status, habitat occurences and population size of Indian Rhino. (Data Source : IUCN/SSC Asian Rhino Specialist Group Report, 1999).

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

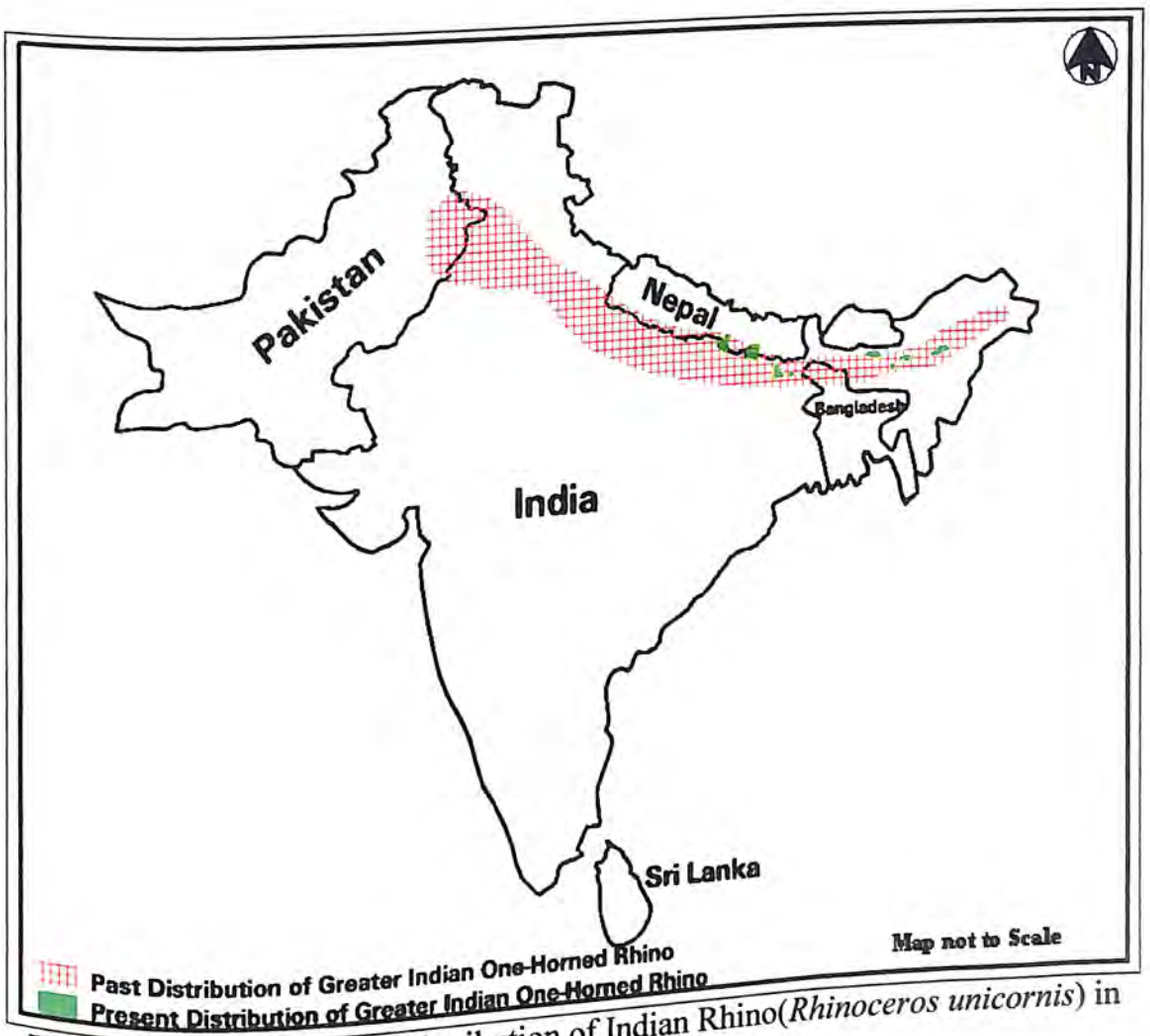

Fig- 1.1: Past and present distribution of Indian Rhino(*Rhinoceros unicornis*) in South Asia

The Indian Rhino is severely threatened by hunting, owing to its superstitious belief and high demand and value of its horn in the national and international markets. Therefore, a very small population (above 2500 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 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.

1.2. Grassland Habitat

Grasslands, the prime habitat of Indian Rhino, is composed of approximately 24% of the global vegetation structures (Smith, 1996) and covering almost 20% of

the total land surface (Murthy and Sanjappa, 2002), is now in declining trend. Apart from Rhino, this grassland habitat supports a wide varieties 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 shola-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 of *Phragmites-Saccharum-Imperata* and *Themeda-Arundinella* type grasslands, are 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.

1.3. Studies on Rhino

A number of studies have been carried out for 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 plains 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), was also studied in details. The various aspects of conservation issue of Indian Rhinoceros were studied by Bhattacharya and Pal (1982) in Brahmaputra floodplains.

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

1.4. Objectives of the study

The present study emphasizes 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.

Objectives

1. To find out the habitat selectivity, habitat utilization 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 behavioral 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.

1.5. 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. Firstly, the Orang National Park is the representative type of the Brahmaputra floodplain 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 floodplain grassland the Orang National Park receives regular annual flood, 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.

1.6. 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 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 the 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 has become successful for conservation, similar with that of Indian Rhino. The northern sub-species of White Rhinos are one

of the three most critically endangered taxa of Rhino with less than 28 individuals of surviving population size.

Table – 1.2: Shows the 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 during 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 Rhinos is slightly in increasing trend (Table –1.3).

Table –1.3: The population status of African Black (*Diceros bicornis)* and White Rhino (*Ceratotherium simum*) as on 1998 census. (**Source**: Asian Rhino Specialist Group Report; Strien & Foose, 1999).

Sub-species	Scientific Name	Population
Northern Simum	*Ceratotherium simum simum*	28
Southern White Cottoni	*Ceratotherium simum cottoni*	>8440
Southern Black Minor	*Diceros bicornis minor*	1363
South Western Bicornis	*Diceros bicornis bicornis*	741
Eastern Michaeli	*Diceros bicornis michaeli*	485
Northern Longipes	*Diceros bicornis longipes*	>10

(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 60 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 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 –1.4 Status of Sumatran Rhino (*Dicerorhinus sumatransis*) as on 1999 census.

Country	Population size
Indonesia	110-200
Malayasia	120-160
Laos	?
Thailand	?
Myanmar	10*
Borneo	?

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

The Indian Rhino had a population size of only 366 individuals in Kaziranga National Park during 1966, but now its population size has been increased up to 1649 individuals. Out of total 2600 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 the conservation of Indian Rhino.

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CHAPTER-II: REVIEW OF LITERATURE

2.1. Background

A large numbers of information on Indian Rhinoceros were available since historical times and most of them were depicted 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 Indian Rhino (Asian Rhino Specialist Group Report, 1999).

2.2 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 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 battlefield. Ali (1927) and Guggisberg (1966) documented the killing of the Indian Rhinos near the border of Kashmir by the invader Taimur during 1398, hunting by Babur near Peshwar during 1519 and by Jahangir and other Moghul Kings during the period from 1605-1627.

2.3 Past distribution

The first detailed scientific description of the Indian Rhino was written by Person during 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 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 was enumerated by Lwin (1998). Choudhury (1996) described the past distribution of the Indian Rhinos in different locality 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 Rhinos were exported from India to Portugal during the year 1513, which was the first record of the Indian Rhino exported to the European country.

2.4 Morphometric study

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

2.5 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 detailed 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 smuggling techniques, crime and trade related laws of the Indian Rhino and other wildlife species of India.

2.6 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) provided 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 Pobitora Wildlife Sanctuary. The brief description of the census report of Indian Rhino in Jaldapara Wildlife Sanctuary was written by Mukherjee and Sengupta (1999).

2.7 Disease and health

Arora (1986), Bhattacharjee and Halder (1971), Bhattacharya *et al.*,(1992), Bordoloi *et al.*, (1990), Islam (1994) and Chakravorty *et al.*, (1993) described about the diseases, genetic aspects and various other health problems of the free ranging and captive population of the Indian Rhinos in different Zoos of India. Nandi (1972) described about 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.

2.8 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 about the home range and daily movement pattern of 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 Pobitora Wildlife sanctuary. The diet and habitat used by the Indian Rhinos during dry season was 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 was done by Kushwaha *et al.* (2000). Again, the brief description on the behaviour of the Indian Rhino was 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, India.

Although, various researchers studied the Indian Rhino in different aspects, the detailed information regarding the ecology and behaviour of Indian Rhino is very scanty. The remarkable study on the ecology of 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 at Brahmaputra flood plain habitat. Bhattacharyya (1991), in his doctoral research emphasized only biological aspects, but provided less information on the ecological aspects, in Kaziranga National Park. Again, Bhattacharya (1983) in his Dissertation (during wildlife management Diploma course) suggested a brief description on the habitat types of the Indian Rhino in Orang National Park. Patar (1977) in his M.Sc. dissertation emphasized on the food habit of the Indian Rhino in Kaziranga National Park. Banerjee (2001) in her M.Sc. dissertation works 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 Pobitora Wildlife Sanctuary and Assam State Zoo cum Botanical Garden.

2.9 Captive population

Buechner and Mackler (1975), Mackler and Buechner (1978), Buechner *et al.*(1978) has 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.

2.10 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) has 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.

2.11 Present scenario at Brahmaputra Valley

The Brahmaputra floodplain 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 plain habitat till today. Hence, the present study tried to cover the ecology and behaviour of Indian Rhino with reference to the conservation perspectives of the Indian Rhino in the Brahmaputra floodplain habitat. Very recently, the Wildlife Trust of India has initiated the rescue operation and rehabilitation programme of Rhino, and one three years 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, U.S. Fish and Wildlife Service and the Department of Environment and Forests, Government of Assam, are planning to translocate the Indian Rhino in to Manas National Park, which was an excellent habitat for the Indian Rhino since its disappearance during 1993.

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CHAPTER- III: GENERAL STUDY AREA AND METHODS

3.1 Introduction

The chapter deals with the detailed description of 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.

3.2. Study area

3.2.1 Location

The Orang National Park (co-ordinates, $92^0 15'$-$92^0 27'$E and $26^0 29'$-$26^0 40'$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.

3.2.2 Physiography

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

The study area comprises of alluvial floodplains 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 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 of 45- 75m MSL.

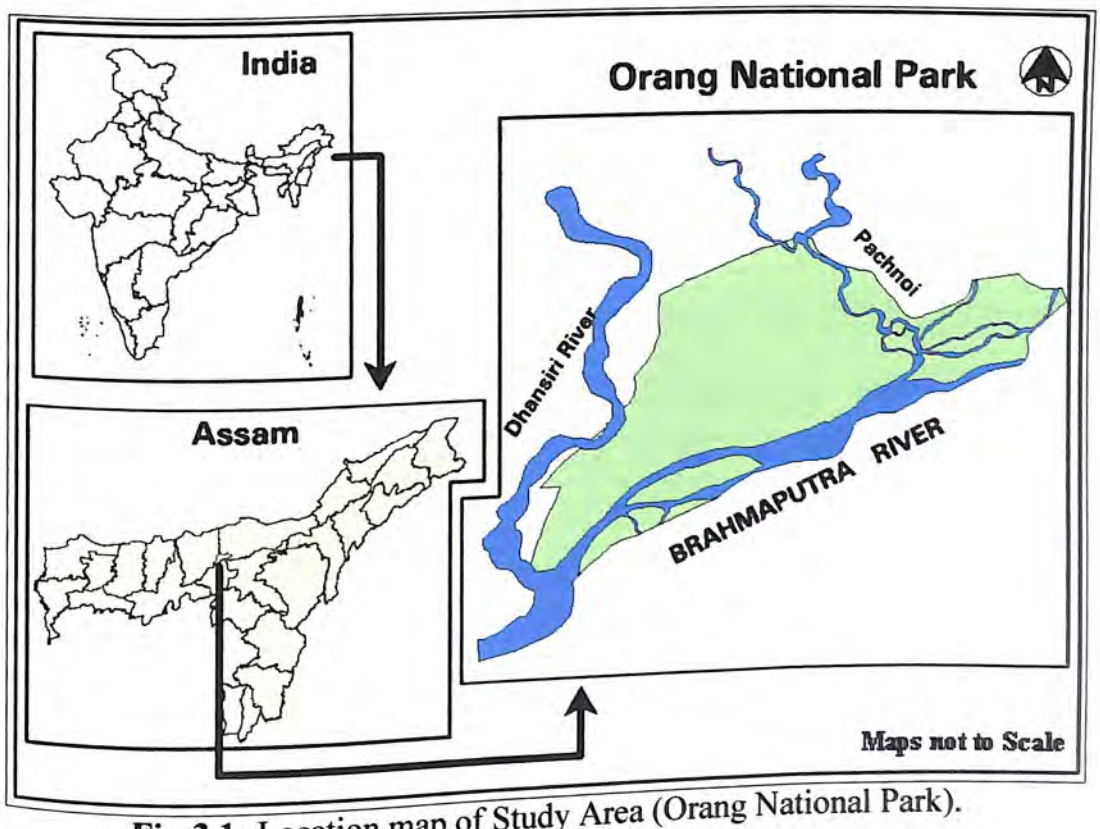

Fig-3.1: Location map of Study Area (Orang National Park).

3.2.3 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 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 at the outskirts of the Orang National Park. The entire protected

area was a human habitat area till the last decade of 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, namely Dhansiri and Panchnoi are associated with numbers of streams and *nullah* that criss-crosses the park and 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.

3.2.4 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 km^2 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 km^2 had been 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 respectively. This process continued till 1962 through Afforestation Division of Hojai (Nagoan, Assam). During 1972, the planted area was handed over to 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 km^2. During the year 1991, an area of 3.21 km^2 was added to it by evicting encroachers from government land and ultimately, total area became 78.81 km^2. Finally, the sanctuary was upgraded to a National Park during 1999 (Plate – 1).

3.2.5 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 was 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 1160mm. 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 falls and moving mist and fog appears. 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).

3.2.6 Vegetation

The vegetation of the study area is basically composed of four different types (Champion and Seth, 1968) such as (i) Eastern Himalayas Moist-deciduous forests (3C/C3b), (ii) Eastern seasonal swamp-forest (4D/SS1), (iii) Khair-Sisso forests (5/1S2) and (iv) Eastern 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 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* etc. are available in these areas.

(b) Woodland habitats

The Woodlands are mainly found in northern part of the park, which consists of indigenous tress, 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 consists 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.

The entarance to the study area

The old Shiv temple inside the study area

A man-made pond of the study area

The researcher in study area

A Rhino near anti-poaching forest camp

A forest road in study area

Plate 1 : A view of the Study Area

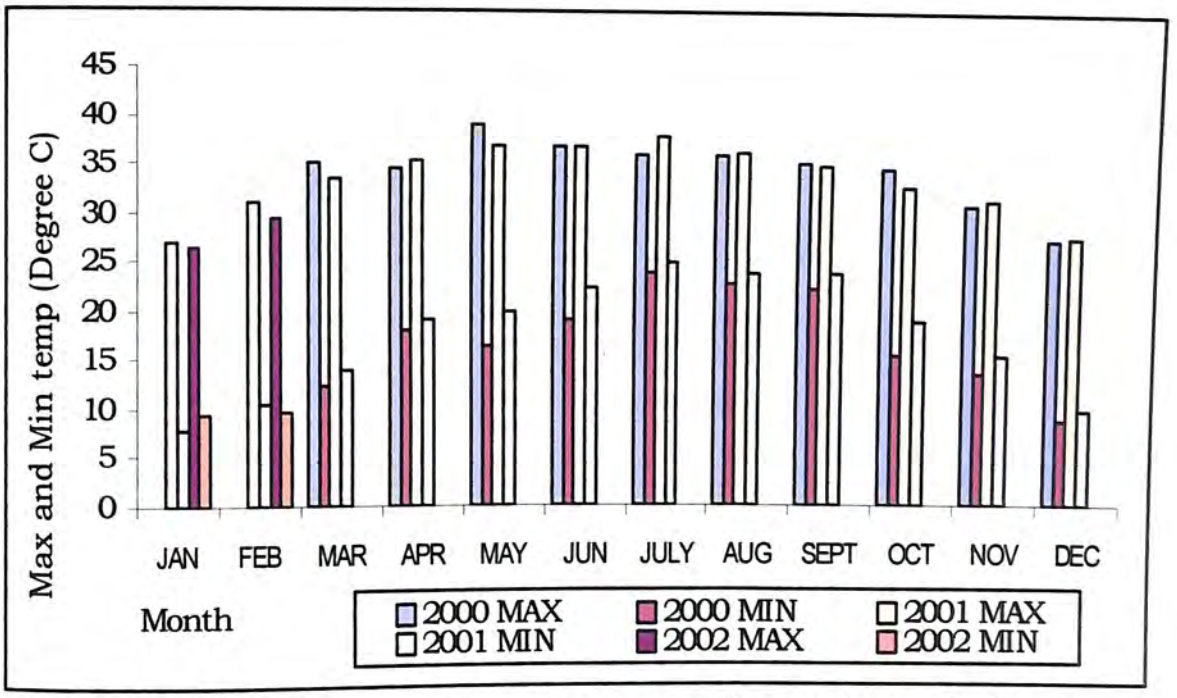

Figure: 3.2: Maximum and minimum temperature of the study area during the period of 2000-2002.

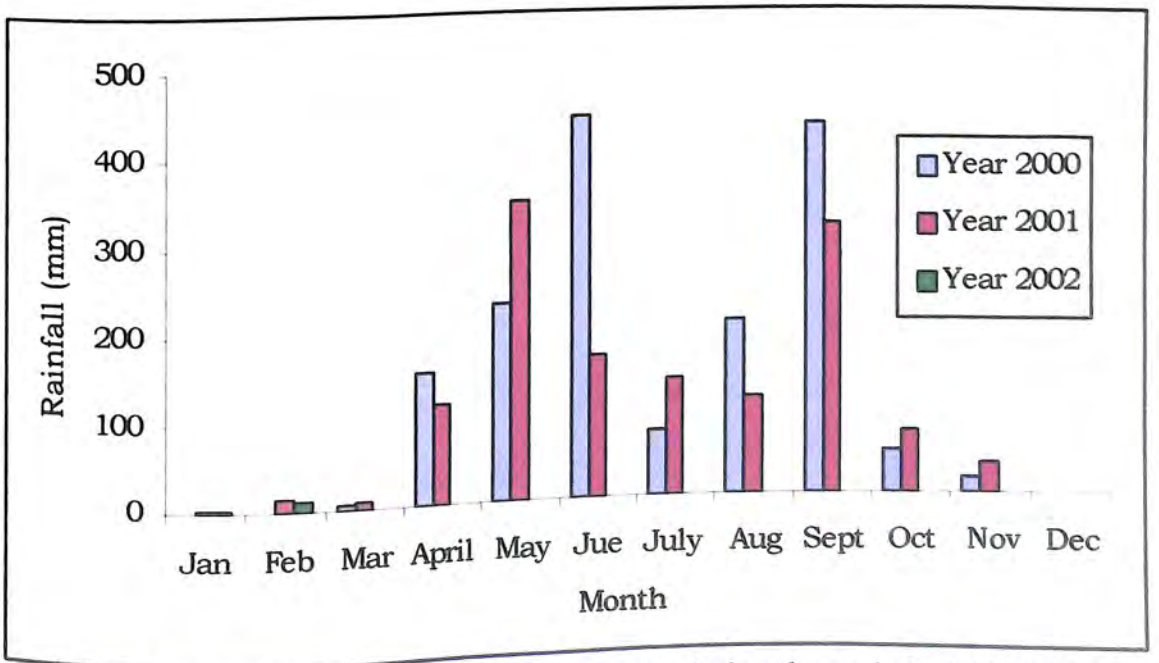

Figure: 3.3: Relative humidity of the study area during the period of 2000-2002.

3.2.7 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 the year 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 has sharply dropped down to 46 individuals in the year 1999. Since then, the poaching trend was decreased and now it is quite negligible. However, the existing rhino population has showed the imbalance of sex ratio, in which the numbers of males are higher in numbers than the female (Census report, Govt. of Assam, 1999). Further more, the population of the Indian rhino in Orang National Park is slightly in increasing trend during the study period.

Table-3.1 Population census data of India Rhino in Orang National Park from 1985-2006

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	46
2006	28	27	-	-	-	9	-	4	68

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

3.3 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 behavioral, 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 quadrate sampling method was used (as per Krebs, 1985; Southwoods and Henderson 2000). The size of the quadrate 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. Detailed methods were described in concerned chapters.

3.3.1 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). Again, the existing methods were standardized and the whole study was divided into two parts - (i) Pilot study and (ii) Final field study.

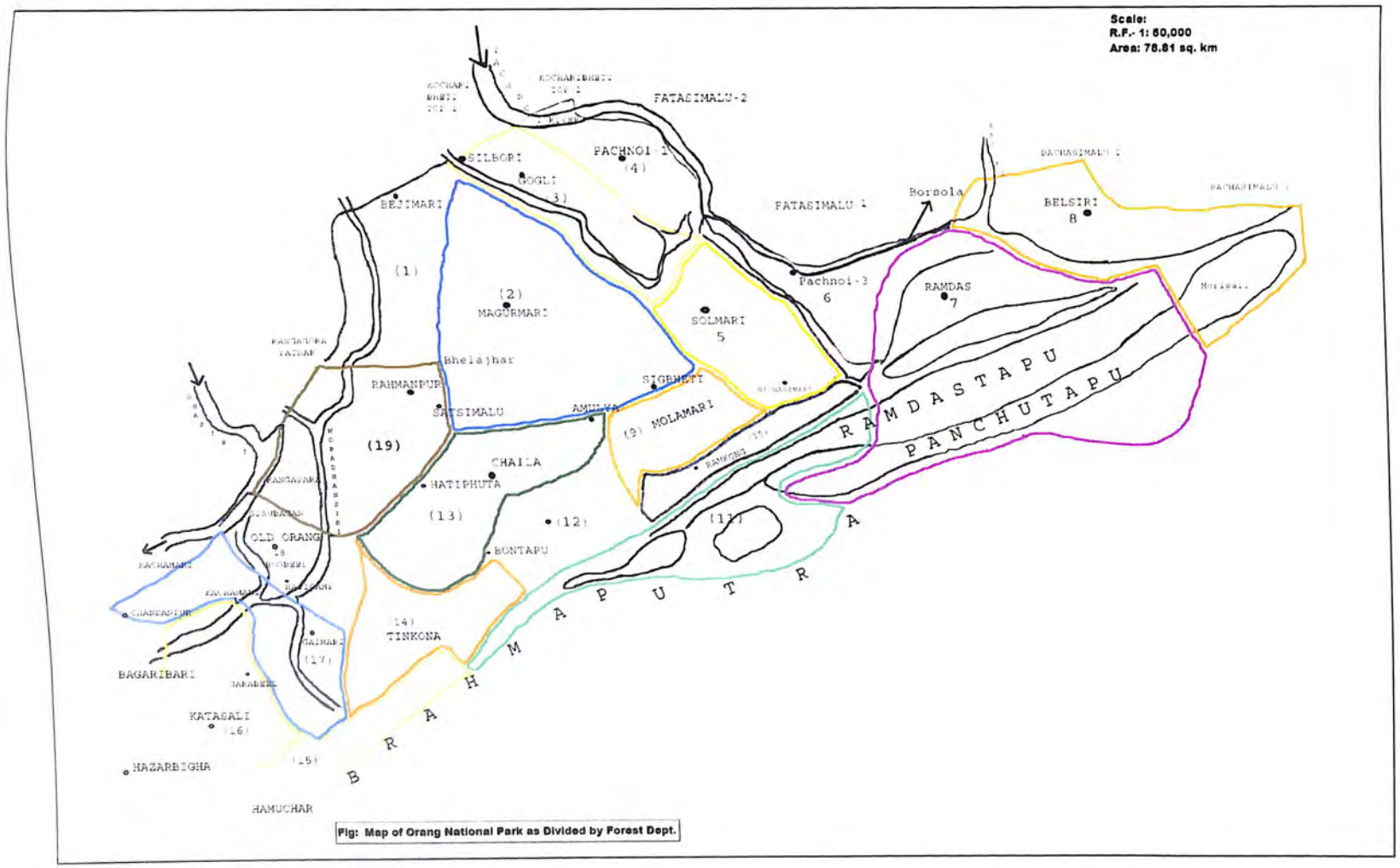

Fig: Map of Orang National Park as Divided by Forest Dept.

Fig – 3.4 : Block map of the study area

Pilot Study: The Pilot study in Orang National Park was conducted from vember, 1999 to March, 2000 and the behavioral categories, sampling methods, dy block design and sampling sites selection were finalized.

Final Field Study: The Final field study of *Rhinoceros unicornis* was carried from April, 2000 to March, 2003 in the study area to collect the appropriate field a.

.2.Instrument Used: The instruments used for field data collection were Zenith 8×50 Binocular, (ii) Thermo-Hygrometer with Clock, (iii)Nikon SLR N-60 h 300 mm Tele Zoom Lens and (iv) One set of GPS (Garmin, 72)

.3. Identification of plant species

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

.4 Data collection

To collect the behavioral and ecological data of Rhino at Orang National Park, a al of 10 days per month period were spent and data were collected using vehicles, cycles, departmental elephants and on foot. During rainy season, when the odwater rises to a maximum level, the country boats were also used for field data llection. All data of rhino sightings were noted down in the field notebook and ta sheets. The numbers of age-sex groups and the sighting locations of the rhinos re noted down using GPS and compass bearings.

To collect the data of '*Scan Animal Sampling*', one observer follows the dividual rhino and all activity bouts within 5 minutes time intervals from dawn to sk were recorded in a datasheet prepared for the purpose (Appendix- 3a, 3b).

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

b) Vegetation Data collection

During vegetation data collection, the quadrate sampling were used and the nidentified plant species were collected for the herbarium sheets preparation. The hino food plant species were recorded and collected for laboratory identification. he specimens were identified at the Department of Botany, Gauhati University by omparing with museum specimens and available books and literatures.

.3.5. Data Analysis

The methods of data analysis are described in concerned chapters.

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CHAPTER– IV: HOME RANGE AND TERRITORIALITY

.1 Introduction

Majority of wild animals possess well-defined home range area for their xclusive use. Those well-defined areas provide food, shelter and protection (Odum, 971) and are a primary need for the survival of the wild animal species. Again, the nimal species protect certain well-defended area for their vital activities of life ycle, is known as its territory. The studies on the home range in various wildlife pecies suggest that, the sizes of the home ranges are directly related to its body size nd 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 ehavioural pattern of the animal species have also some affect on the home range ze (Gittleman and Harvey, 1982; Lindstedt *et al.*, 1986). Apart from that, the arious factors such as, availability of food, forage quality and metabolic equirements also influence the home range sizes in various animal species (Laurie, 978, 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.

.2 Methods of Study

The study of home range and territoriality of Indian Rhino was done in rang National park from April 2000 to March 2002 for gathering the suitable data f the species.

Although, the satellite and radio tracking techniques were widely used for ie study of home range and territoriality of wild animals, those methods were not

effective and needs enormous safety measure and thus risks. Therefore, all the
tracking activities for home range and territoriality studies in Orang National
were followed as per the previously used well-established and cost effective
ods (Bhattacharyya, 1991; Lehner, 1996; Laurie, 1978, 82). For this purpose,
ndividuals of various age-sex classes were identified and marked with the help
isting morphological differences from other individual.

Study Design

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

.1 Individual ID and marking of Rhino

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

Individual Identification

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

To conduct the study of Home range and Territoriality of Indian Rhino at rang National Park, the following age-sex classes were made, based on external aracters.

) **Age Classes**

(i) Adult Rhino: When height of the individual at shoulder was above 5 feet inches and the horn base was above 7 inches with prominent neck folds, the dividual is considered as an adult. In case of male, the penis was generally visible om either sides or rear and the urination pattern of male was towards backwards or ar either side and squirt urination was frequent. In case of female, the urination ttern was generally originated from upper rear portion and continuous flow of ine, which helps to identification of sex. If an individual was found along with lf, it was considered as an Adult female.

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

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

) **Identification of Sex**

The sex identification was made as follows: -

) **Adult Male:** The Rhino was considered as adult male, when the penis visible om the side or the rear. The urination pattern of the Rhino also indicated the cation of the genitalia. Generally the urination pattern of adult male had squirt ttern in both static and moving condition. Apart from that, the male individuals

posses 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 falls 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 regards to the above mentioned marks and characters, was considered as unsexed (unidentified sex).

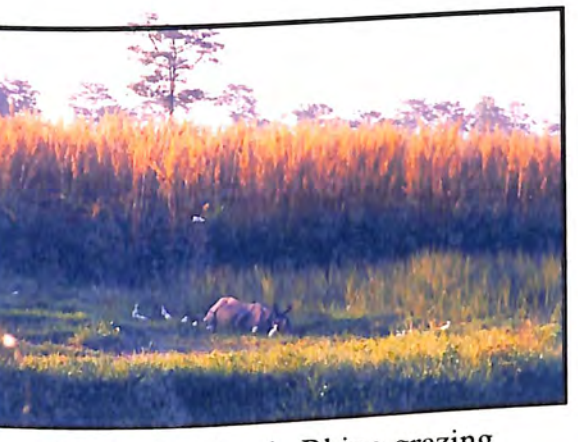
The marking of individual Rhino for both the sex and age classes were made as per Laurie (1978, 82), Bhattacharyya (1991) and Lehner (1996). The identification keys used for the study were such as (i) Arrangement and irregularities of the skin folds, (ii) Scars on body, (iii) Arrangement of tubercles on the rump, (iv) Ear nick (cut mark, ear fold etc.), (v) Tail length, and (vii) 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 based on their physical and morphological characters (as per Laurie, 1978, 82; Lehner, 1996; Bhattacharyya, 1991) (Table-4.1; Plate -2).

The marked old female Rhino

Marked old female Rhino in marshyland



Marked old male Rhino grazing marshyland

Marked adult male Rhino while grazing

Marked adult female Rhino in marshy land

The marked old male Indian Rhino

Plate 2 : Some marked Rhinos of the study area

able: 4.1: Marked Rhinos for home range and territoriality study, based on Individual ID arks of animal at Orang National Park.

SL No.	Marked Individuals	Identification marks
1	Old Female ($O_{♀}$)	1. Cut mark in left Ear. 2. Horn was relatively small. 3. Old age.
2	Old Male ($O_{♂}$)	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 ($A_{♂}$)	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 ($A_{♀}$)	1. Horn was sharp but very short. 2. Right Ear had cut mark (torned).
5	Adult Female with Calf ($A_{♀}$ C)	1. Horn was big and very sharp. 2. The cow was slightly lame. 3. Quite big size of the body.
6	Sub-adult Female ($SA_{♀}$)	1. Horn was very small. 2. Slim body.
7	Sub-adult male ($SA_{♂}$)	1. Horn was very small 2. Slightly folded Ear 3. Stout body.

.2.2. Study Parameters

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

The home range was defined as the total area covered by an individual rhino a specific time period. Whereas, the well-defended area of rhino within its home nge either during foraging movement, shelter or during breeding display, was nsidered as territoriality of the species. Again, the territorial defence mechanisms ere considered, when they posses aggressive behaviour in the form of threat,

snorting, chasing, attack and escaping (avoiding) from direct conflict with others within its territory.

4.2.3 Data collection and analysis

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 were measured with the help of GPS coordinates of the same individual, at least minimum of five positions within the study period. 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 (Mohr,1947; 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 & connecting all the outer edges of GPS points to find out the home range area in regards to the different marked individuals.

(b) Territory size

The identified individual of Indian Rhino confined to a specific area indicated the territoriality of the species during foraging & feeding, wallowing,

shelter, breeding etc. The area, where the individual Rhinos were aggregated mostly, was measured as the defended area of territory.

4.3 Results

4.3.1. (a) Home Range

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

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 suitable habitat with covering more area and visited even outside the park boundary (Figure-4.3 and 4.4). Whereas, the proportional use of home range size of old male was highest during pre-monsoon season and gradually declined, and ultimately 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 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 uses 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, no significant relationship between the individuals of Indian rhino at Orang National Park.

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)
	Pre Monsoon	Monsoon	Re teating Monsoon	Winter	
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.

b. 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 $km^2 \pm 0.41$SD, followed by old male, 15 localities and covered a mean home range size of 6.05 $km^2 \pm 0.36$SD, sub-adult male, 13 localities and covered a home range sizes of 6.38 $km^2 \pm 0.49$SD, Old female, 12 localities and covered an home range area of 5.9 $km^2 \pm 0.49$ SD, adult male, 11 localities and home range area of 6.84 $km^2 \pm 0.64$ 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).

Study also showed that, all the marked rhino 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 Seoratali, Amulya and Satsimalu area during pre-monsoon, Amulya during monsoon and Tinkona, Rahmanpur and Seoratali 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.

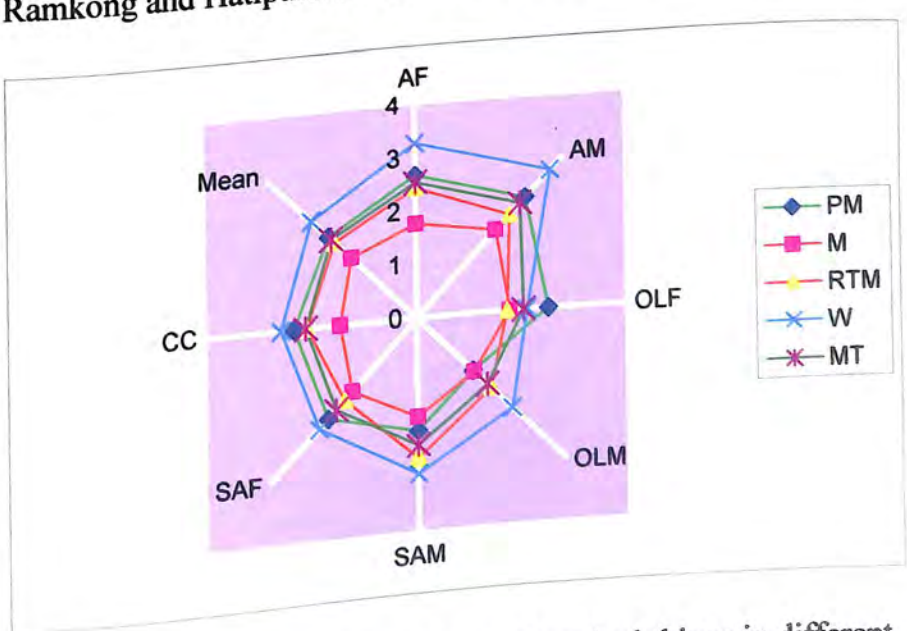
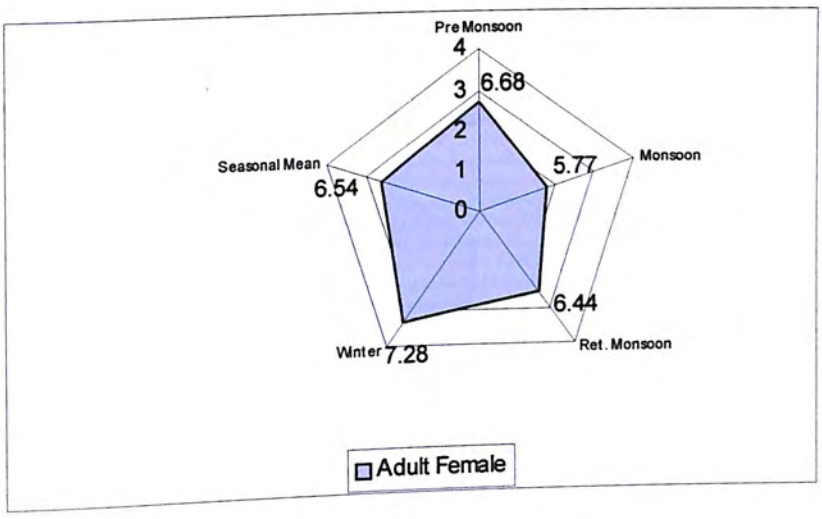
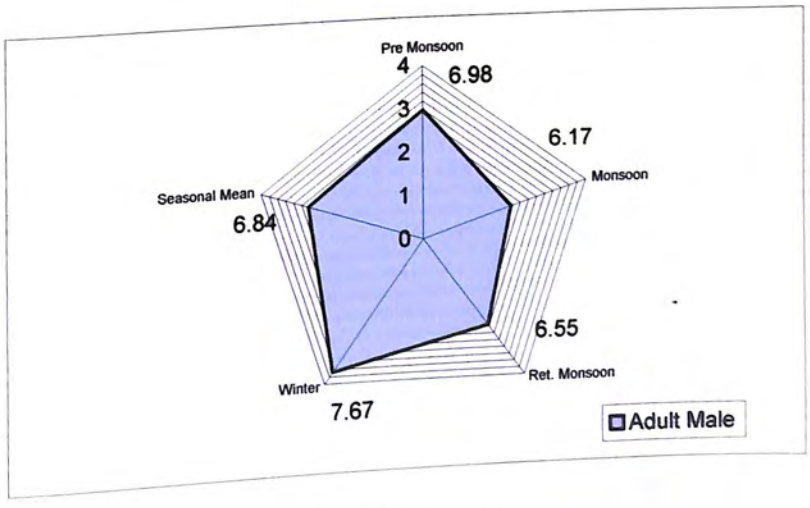


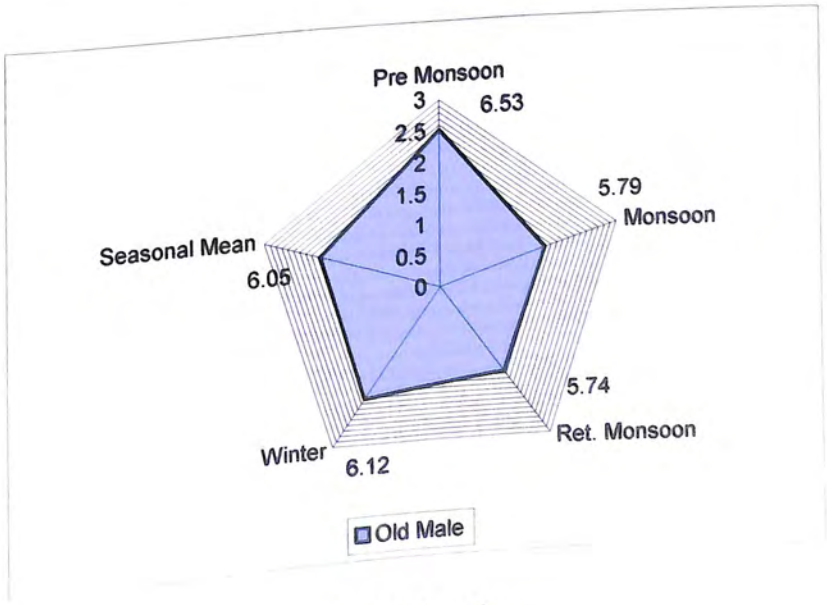
Fig-4.1: Variation of Home range sizes of marked rhinos in different Age-sex groups at Orang National Park (CC= Cow Calf; SAF= Sub-Adult Female; SAM=. Sub Adult Male;OLM= Old Male; OLf= Old Female;AM= Adult Male; AF= Adult Female)



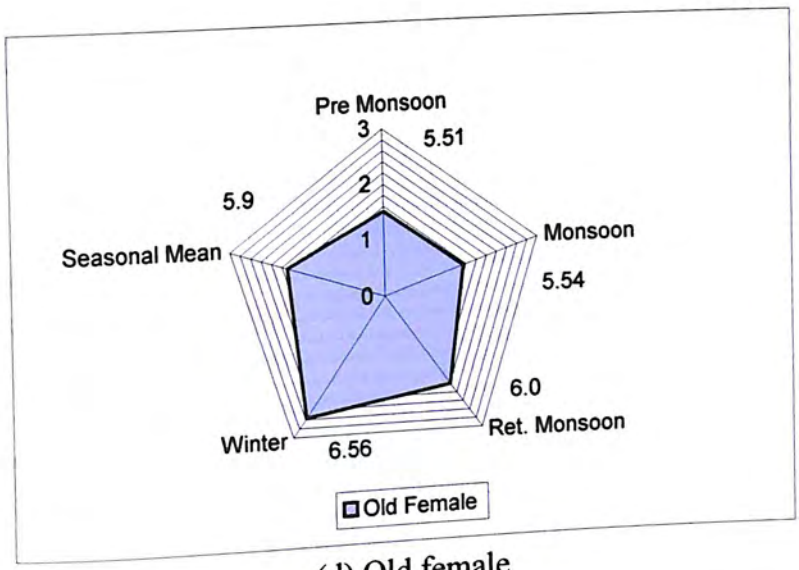
(a) Adult female



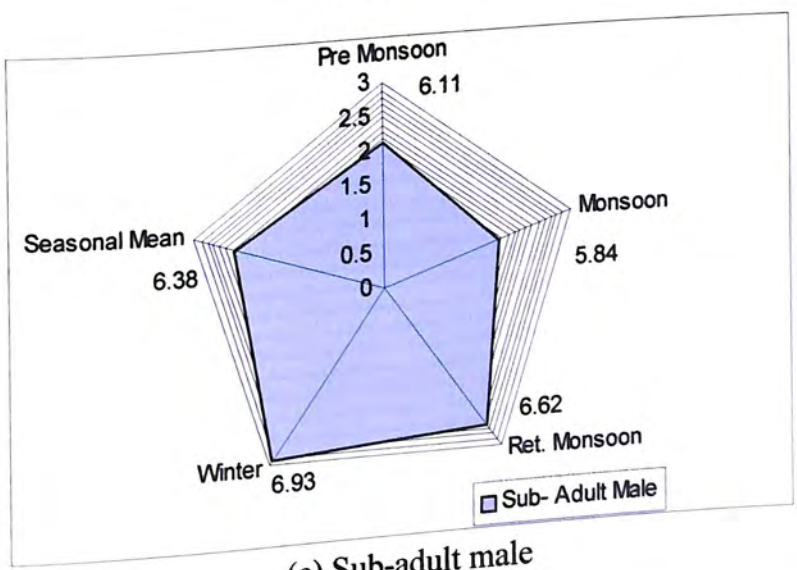
(b) Adult male



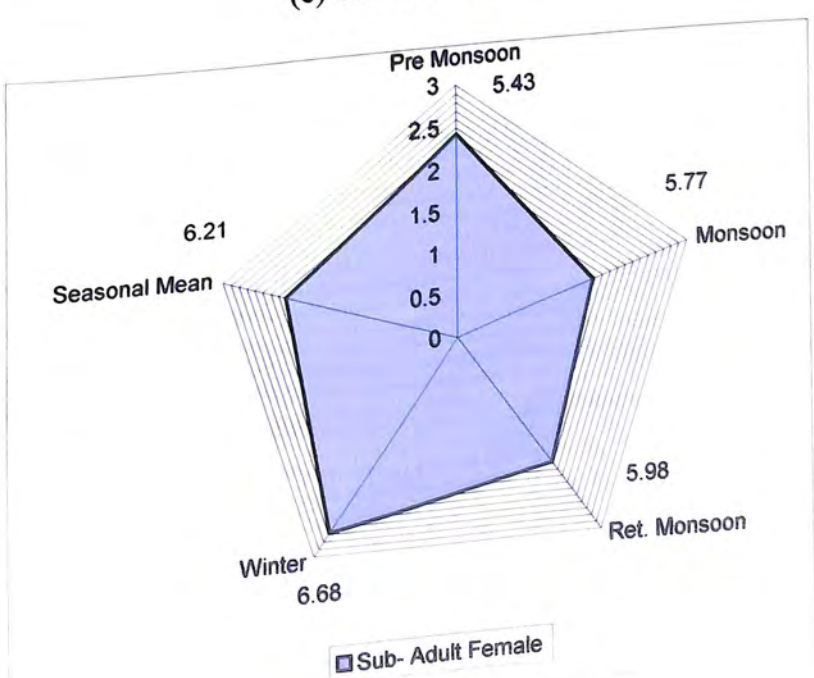
(c) Old male



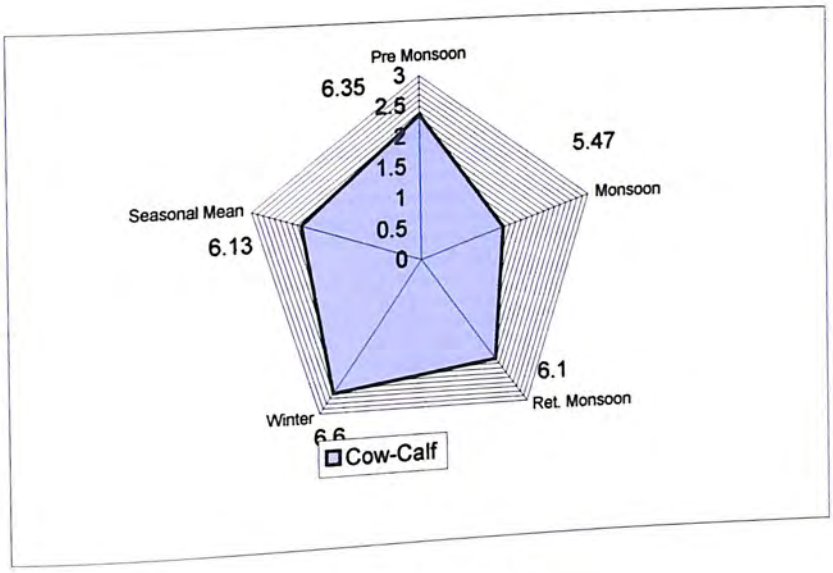
(d) Old female



(e) Sub-adult male



(f) Sub-adult female



(g) Cow-calf

Figure-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.

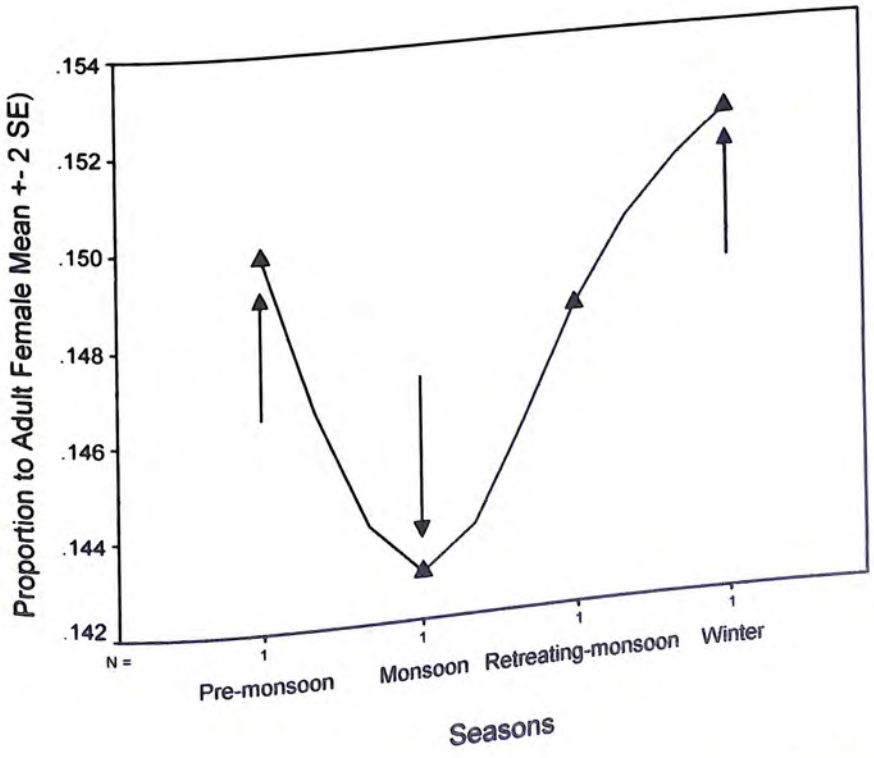


Fig.-4.3. Proportional use of home range sizes by the marked adult female rhino during pre-monsoon, monsoon, retreating monsoon and winter seasons in the study area.

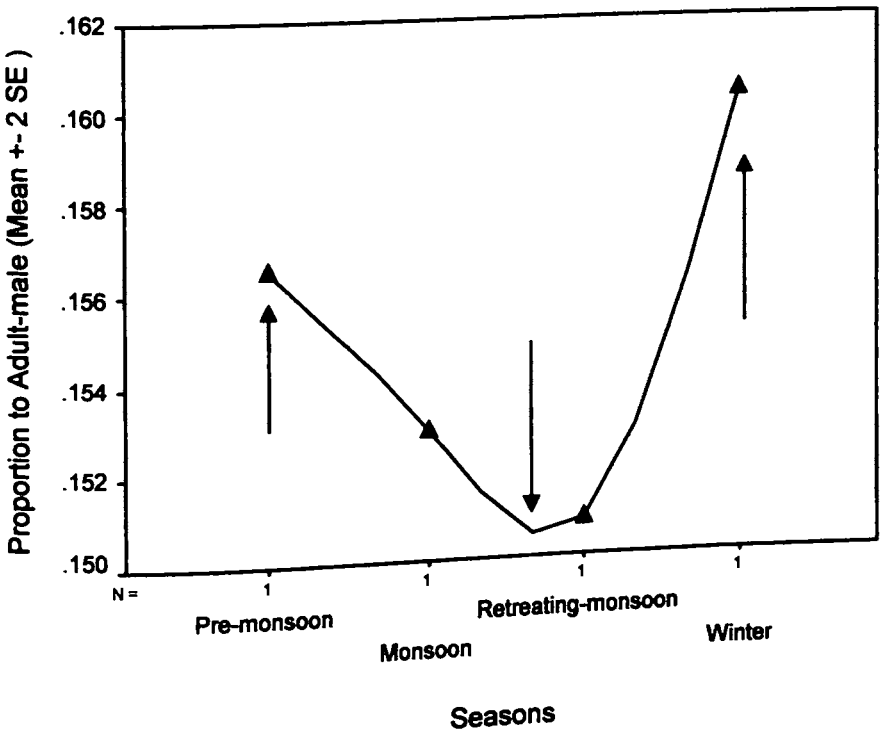


Fig.-4.4. Proportional use of home range sizes by marked adult male rhino during pre-monsoon, monsoon, retreating monsoon and the winter seasons in study area.

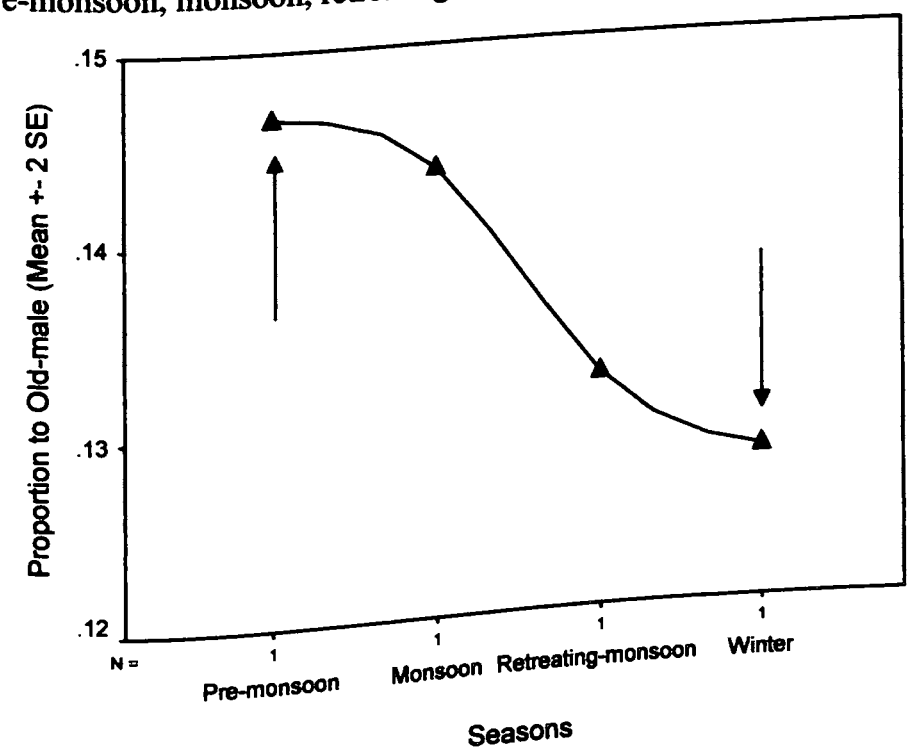


Fig.-4.5. Proportional use of home range sizes by marked old male rhino during pre-monsoon, monsoon, retreating monsoon and the winter seasons in study area.

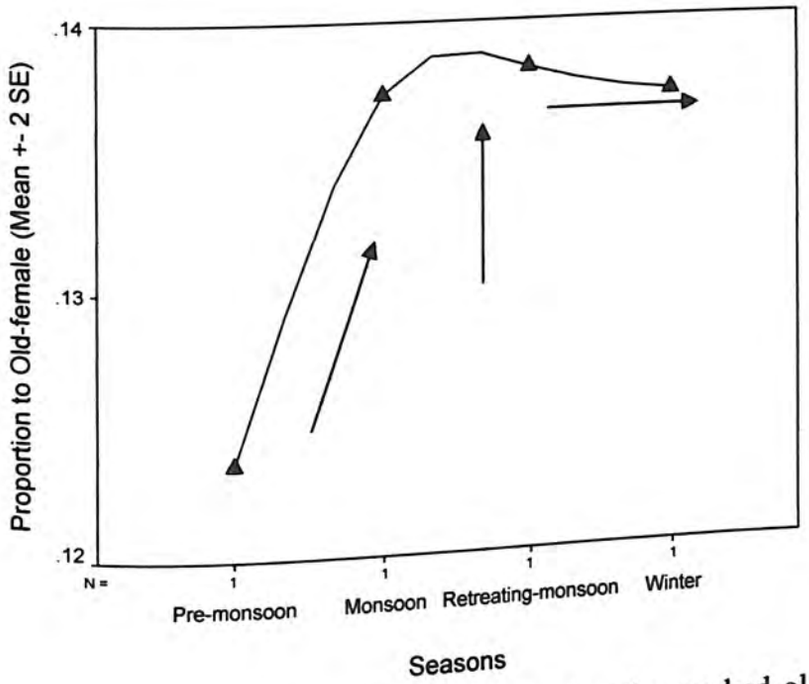


Fig.-4.6. Proportional use of home range sizes by marked old female rhino during pre-monsoon, monsoon, retreating monsoon and the winter seasons in the study area.

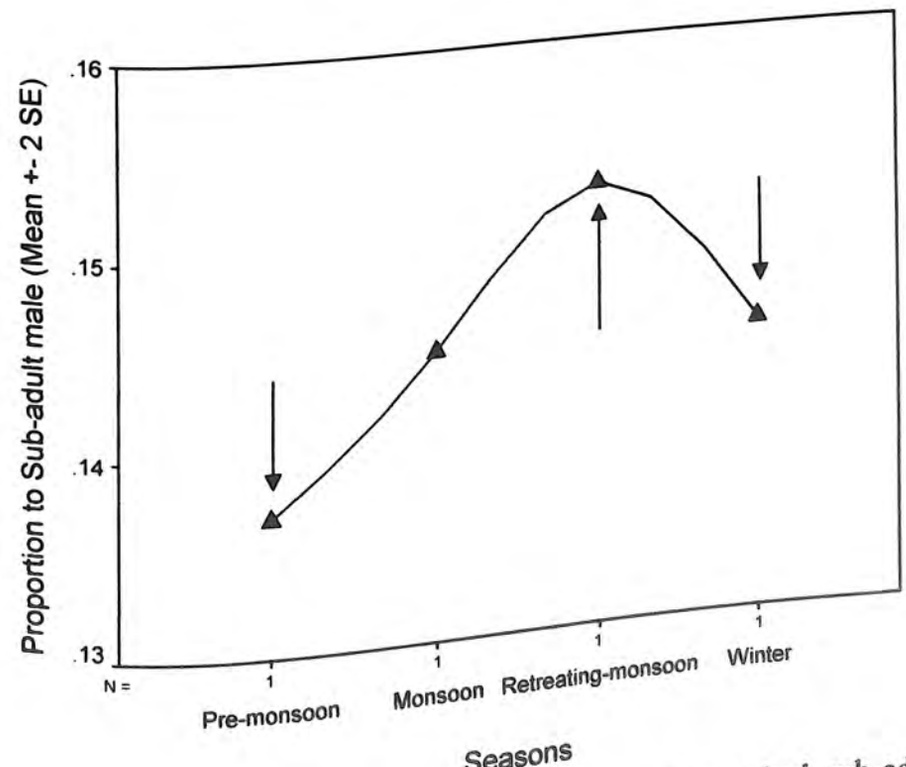


Fig.-4.7. Proportional use of home range sizes by marked sub-adult male rhino during pre-monsoon, monsoon, retreating monsoon and the winter seasons in the study area.

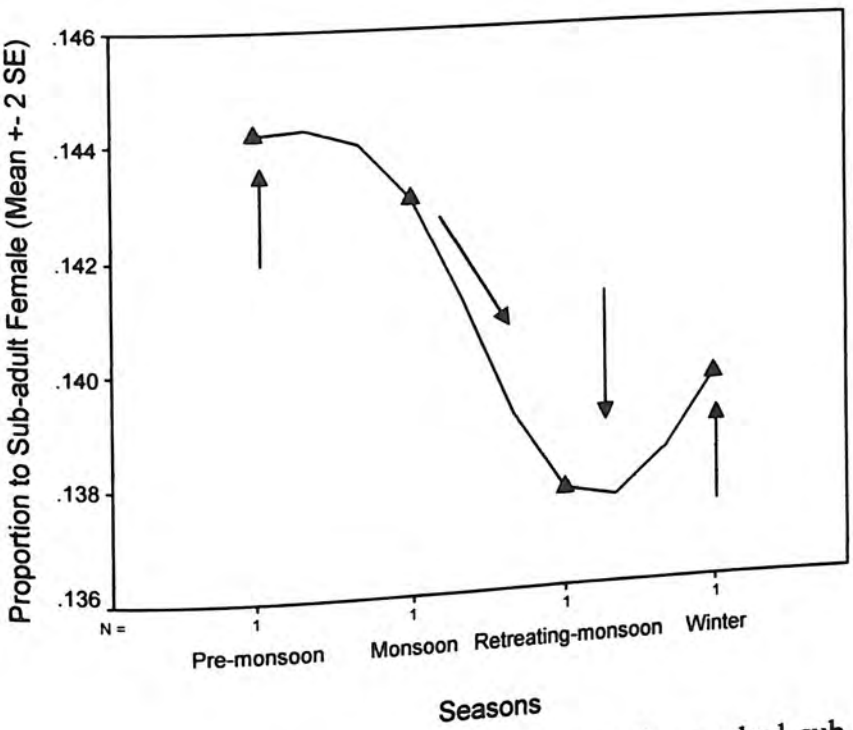


Fig.-4.8. Proportional use of home range sizes by marked sub-adult female rhino during pre-monsoon, monsoon, retreating monsoon and the winter seasons in the study area.

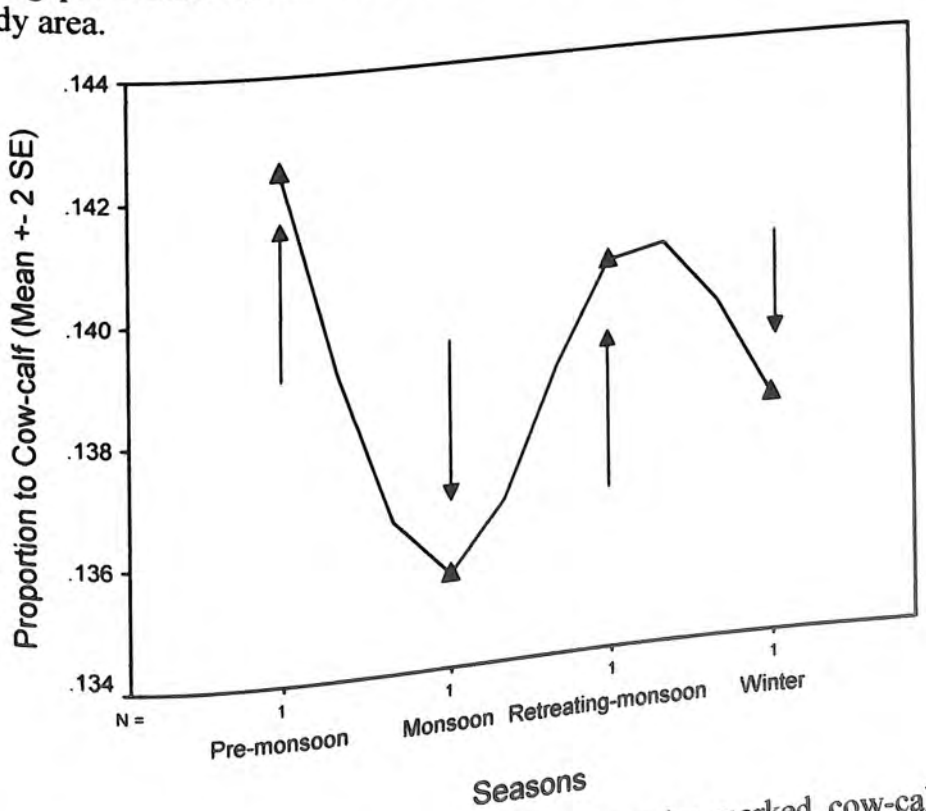


Fig.-4.9. Proportional use of home range sizes by marked cow-calf during pre-monsoon, monsoon, retreating monsoon and the winter seasons in study area.

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					
Seoratali	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					
Seoratali	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
Bhutia ali	1168544.1	527035.14		92D18'38.68"	26D32'45.29
Amulya	1171254.1	526902.26		---	------
Retreating Monsoon					
Seoratali	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	26D32D21.61
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"
Seoratali	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.

Sighting Location	Lambert 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"
Seoratali	1167802.8452	528424.8618		92D18'15.00"	26D33'34.54"
Kansanbagan	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"
Seoratali	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"	26D32'2510"
Seoratali	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"
HatipBeel	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.

Siting location	Lambert Conformal Conic Everest		Total area (km^2)	Geographic WS 84	
Pre-monsoon					
Seoratali	1170987.16756	528419.98014	6.98	92D20'15.22"E	26D33'25.50"N
Hatipota	1169877.00356	528585.78385		92D19'33.82"	26D33'34.23"
Amulya b	1168622.66242	530186.15013		92D18'51.42"	26D34'32.07"
RamkongG	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					
SatsimBeel	1171131.34470	529378.75814	6.17	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	6.55	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"
ChaillaBeel	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"
Seoratali	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 locations	Lambert 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 location	Lambert 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"	26'32"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"
Kansanbagan	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 Location	Lambert Conformal Conic Everest		Total Area (km^2)	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
Satsimbeel	1167339.8690	526743.7875		92D17'52.31"	26D32'38.75"
Seoratali	1167542.1927	525756.8425		92D17'56.89"	26D32'04.67"
Winter					
RamkongG	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"
Seoratali	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 Location	Lambert Conformal Conic Everest		Total Area (km^2)	Geographic WS 84	
Pre-monsoon					
Tinkona	1166872.31812	528711.11709	6.35	92D17'40.75"E	26D33'46.86"N
KachamariC	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"
Seoratali	1165959.75312	525778.24922		92D16'57.22"	26D32'09.80"
Monsoon					
Seoratali	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"
Seoratali	1171600.38972	529349.59743		92D20'41.27"	26D33'55.35"
Winter					
Seoratali	1169446.48029	529512.55548	6.60	92D19'20.44"	26D34'06.90"
Satsim beel	1170146.57355	527430.22679		92D19'40.41"	26D32'54.23"
Seoratali	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"

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 Location	Lambert Conformal Conic Everest		Total Area (km^2)	Geographic WS 84	
Pre-monsoon					
Tinkona	1166872.31812	528711.11709		92D17'40.75"E	26D33'46.86"N
KachamariC	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"
Seoratali	1165959.75312	525778.24922	6.35	92D16'57.22"	26D32'09.80"
Monsoon					
Seoratali	1169461.10806	526220.62035		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	5.47	92D16'59.38	26D32'53.03"
Retreating monsoon					
Satnearib	1168087.56453	528814.79231		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"
Seoratali	1171600.38972	529349.59743	6.10	92D20'41.27"	26D33'55.35"
Winter					
Seoratali	1169446.48029	529512.55548		92D19'20.44"	26D34'06.90"
Satsim beel	1170146.57355	527430.22679		92D19'40.41"	26D32'54.23"
Seoratali	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	6.60	92D16'58.64"	26D32'43.67"

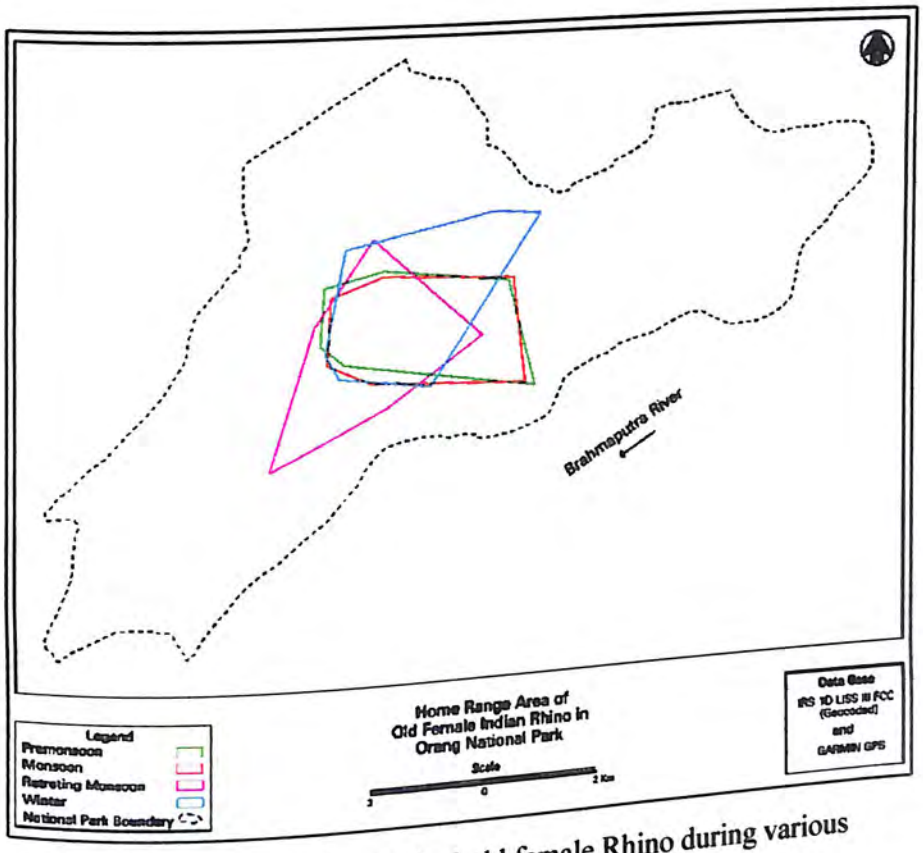


Fig-4.10: Home Range area used by marked old female Rhino during various seasons of the year.

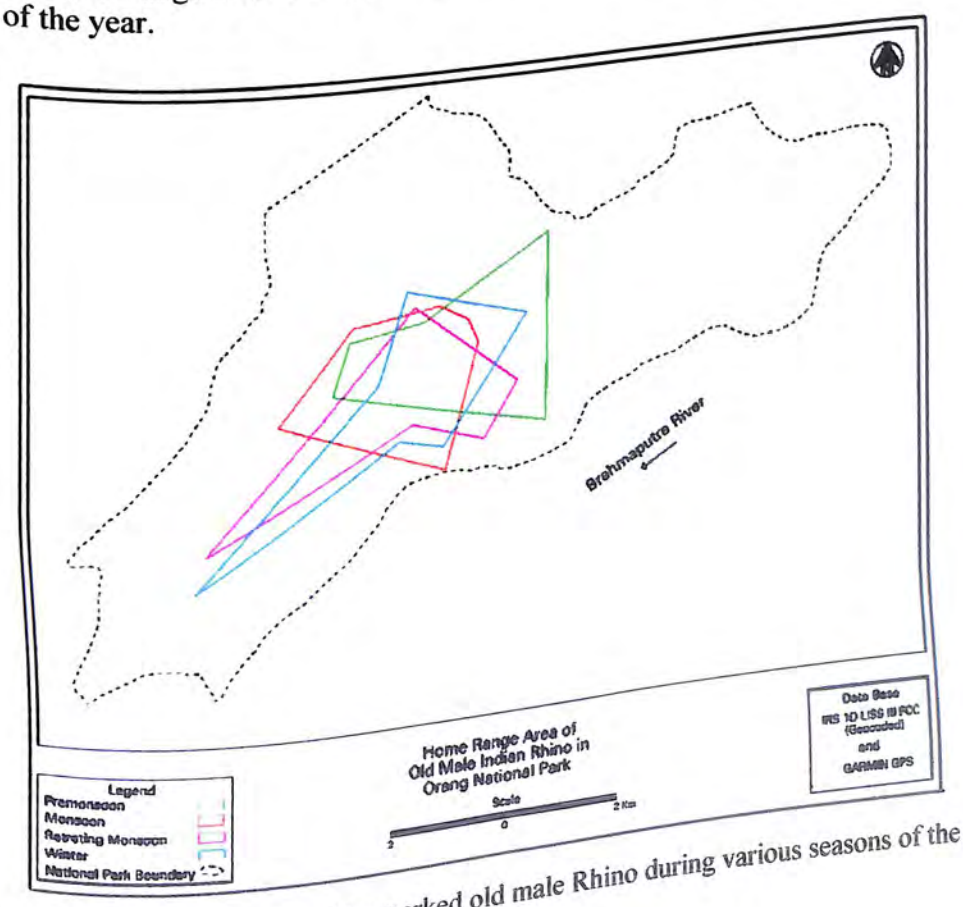


Fig-4.11: Home Range area used by marked old male Rhino during various seasons of the year.

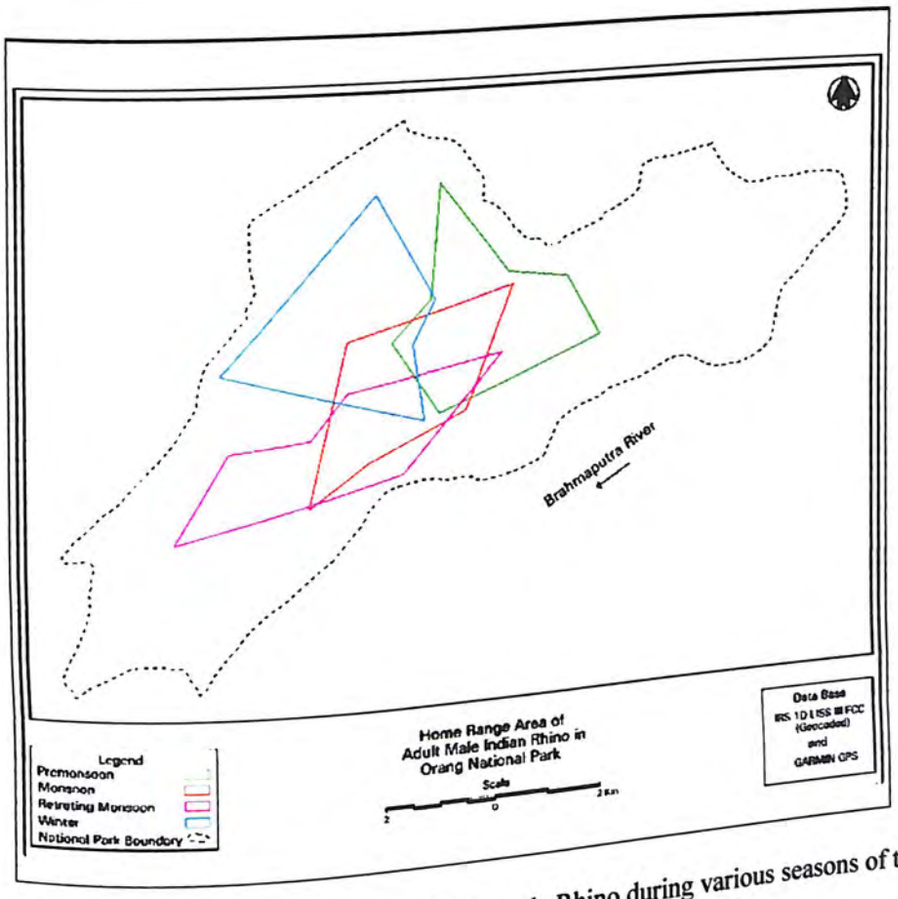


Fig-4.12: Home Range area used by marked adult male Rhino during various seasons of the year.

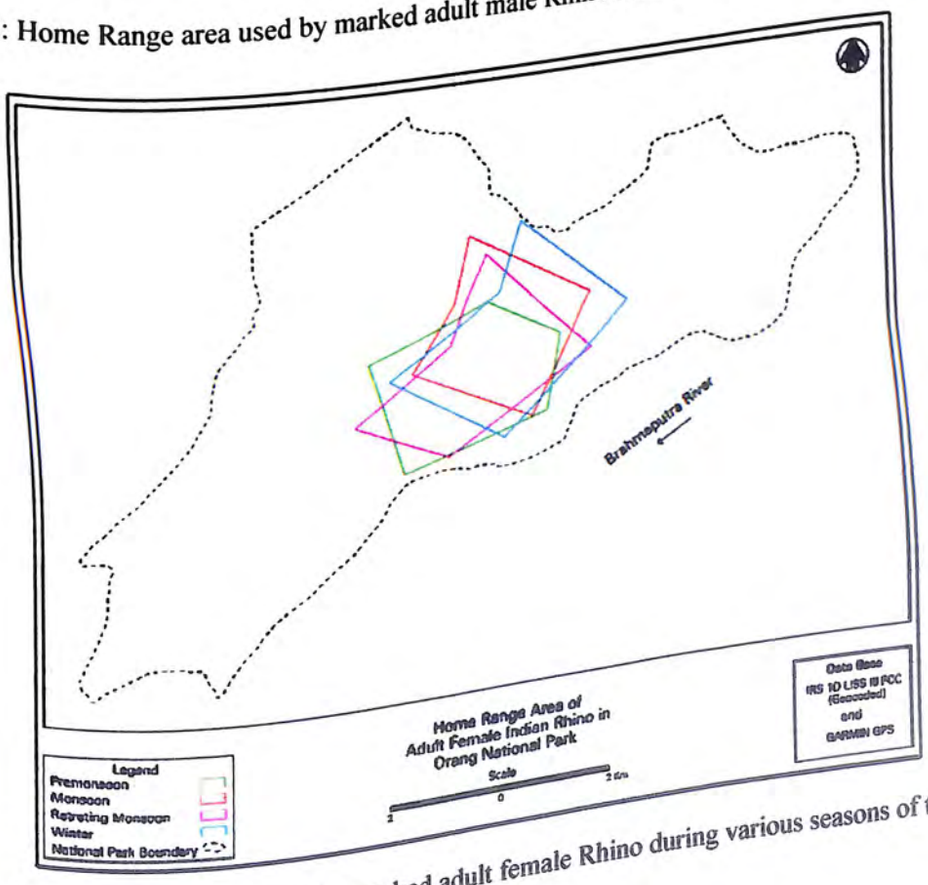


Fig-4.13: Home Range area used by marked adult female Rhino during various seasons of the year.

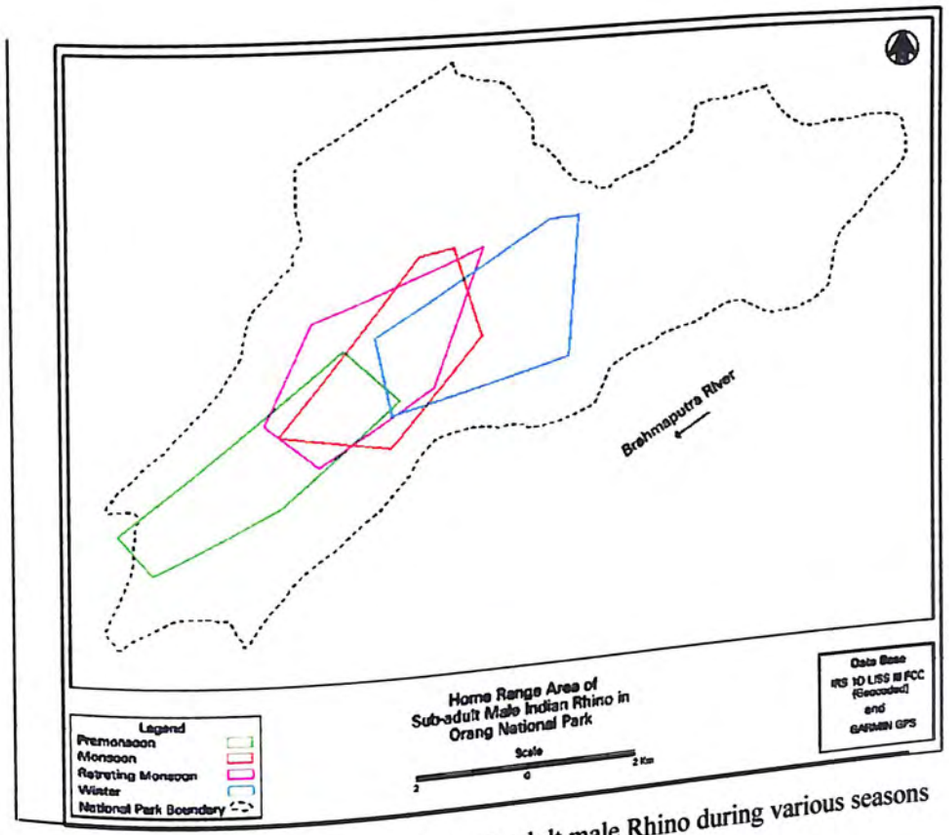


Fig-4.14: Home Range area used by marked sub-adult male Rhino during various seasons of the year.

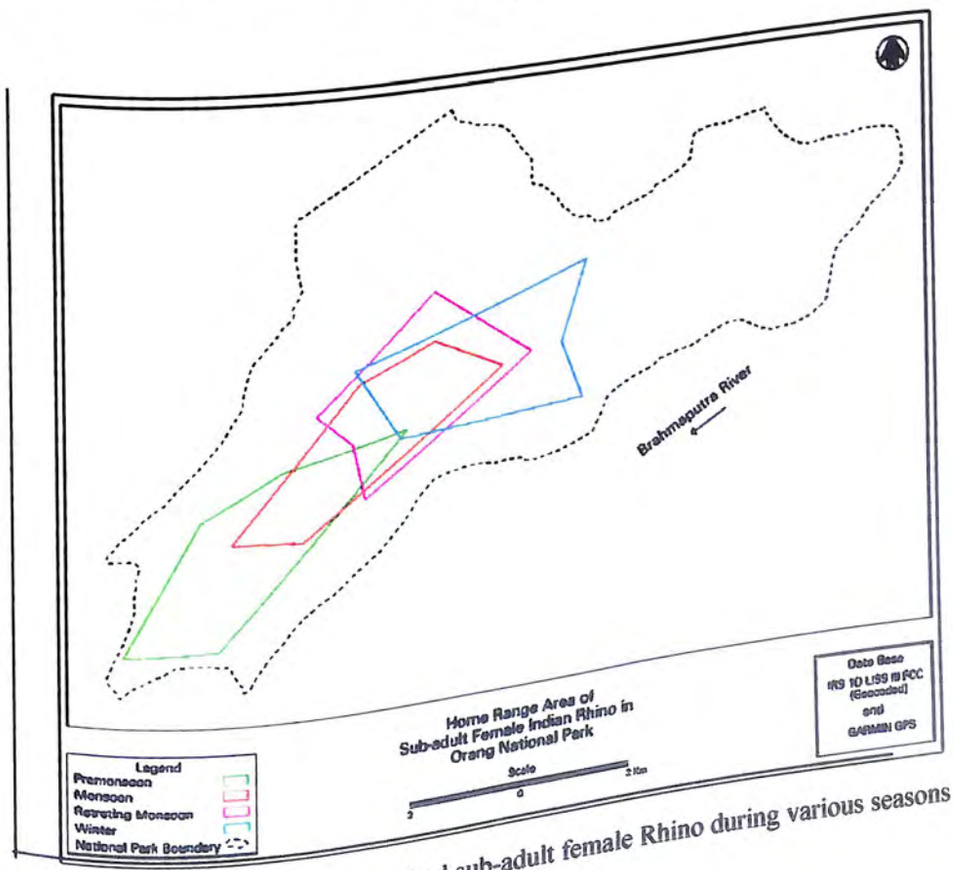


Fig-4.15: Home Range area used by marked sub-adult female Rhino during various seasons of the year.

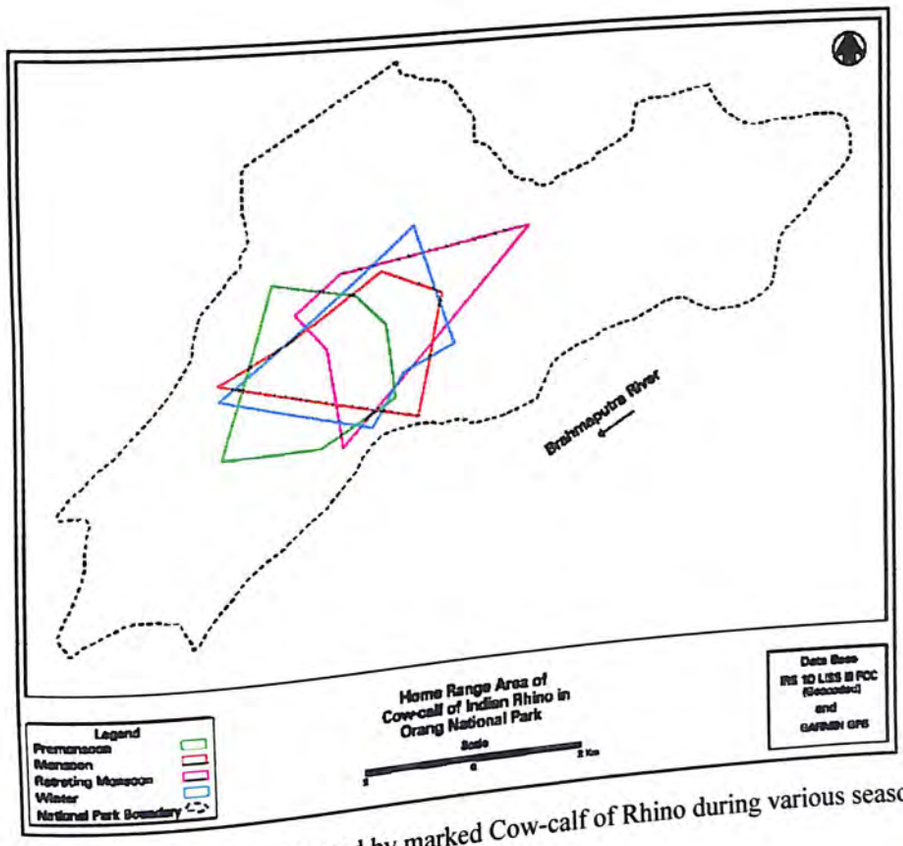
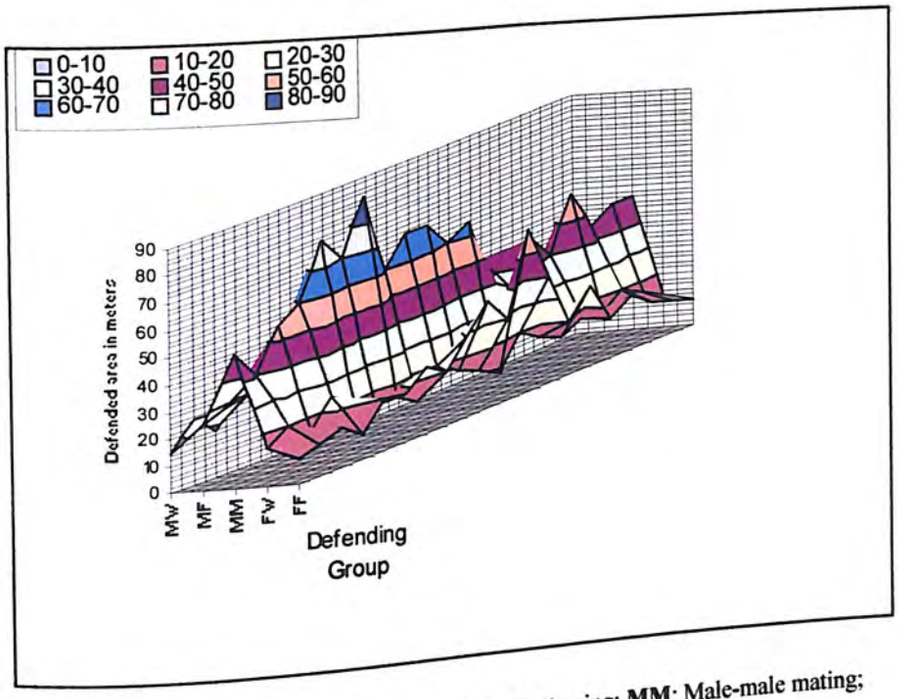


Fig-4.16: Home Range area used by marked Cow-calf of Rhino during various seasons of the year

(b) Territoriality

The Indian Rhino showed distinct territoriality during breeding and foraging period, but possess 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 Rhino 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 individual and 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).



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 territorial defended area for wallowing, feeding and mating activities.

Table4.10: The spatial distances (in meter) maintained for Territory defence by adult male-male & adult female-female Rhino.

Defending animals	Territorial defended Area in activity			
	Wallowing (Mean ± SD)	Feeding (Mean ± SD)	Mating (Mean ± SD)	N
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

4.3.2. 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.

4.3.3 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 observed to graze together as they form 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 adult male Rhino maintained a definite distance of at least 5-10 meters 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, Rhino always found to face 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 meter 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, which leads to maintain a distance of 40 meters between defender and offender rhinoceros. Again, there were altogether 46 events of feeding-territory defence threat display observed. Those were performed by producing snorting and resulted to maintain a distance of 17.5m (range, 15-20 m, N=46) between two adults of same sex, indicated the territorial defence activities during feeding. It was also found that, the feeding territory between two sub-adult Rhino did not maintained any specific distance, 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.

4.4 Discussion

The home range size of Indian Rhino in Orang National Park ranges between 5.94-6.84 km^2 in 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 determine 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 km^2 home range size of rhinoceros at Hluhluwe. But the, Laurie, (1978-82) had mentioned about the home range size of Indian Rhino ranges between 0.44-8.86 km^2 at Royal Chitwan National park of Nepal. Such a low home range size of 0.44 km^2 area was not been observed in our present study. However, several variations of home range size and variability among age and sex classes was reported from the present study sites in 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)

had revealed a wide variation of home range sizes in different habitats qualities in Olduvai. He recorded a home range size of 2.5 km^2 in forest habitat and maximum of 8.8 km^2 in drying thorn-scrub habitat. Again, in another separate study of Hutchinns (1969) recorded 3 km^2 home range size of Black Rhino in thicket habitat and 5 km^2 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 concern 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.

Home range overlap

In the present study also, the home range overlap amongst adult male and female is a common phenomenon, and the 24 km^2 area are vigorously used by most individuals of Rhino in Orang National Park. This is an indication of home range overlapping among Rhino. Laurie (1978, 82) also had reported that, the home range overlap up to 6 km^2 is a common occurrence in Nepalese Rhino. He also indicated that, the size of the home range overlap varies from individual to individual. In the present study, the adult male and old male Rhino home range overlapped with the

adult female and old female during pre-monsoon and the 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 home range over-lapping among different individuals. The Laurie's (1978, 1982) findings of male-female home range overlap for accessing estrous females also supported our findings of home range 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

5.1 Introduction

The individuals or a group of wild animal never use the entire habitat homogenously, but utilizes 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 utilization 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 utilization 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 utilization 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 utilization 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 floodplain habitat (Hazarika& Saikia, 2006). So, the present study on habitat use, its utilization pattern and the selectivity of Indian Rhinos were carried out in the Brahmaputra floodplain grassland of Orang national Park.

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

Objectives

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

(ii) To find out the habitat utilization 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.

5.2 Methodology

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 utilization pattern, and selectivity of different habitats were done by direct field investigation. The available habitat types of Orang National Park were identified using satellite imagery, direct field observation and ground truthing of habitat data. The methods adopted for the collection of habitat data in Orang National Park was described in the following sub- sections.

(a) Categorization 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 its 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 standardize 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 were calculated by using a Digital Planimetre based on the specific area of different colour in the satellite imagery. The habitats were categorized, based on the different vegetation structures and landscape characters. (Fig: 5.1).

Fig-5'1: **VEGETATION MAP OF ORANG NATIONAL PARK, ASSAM**

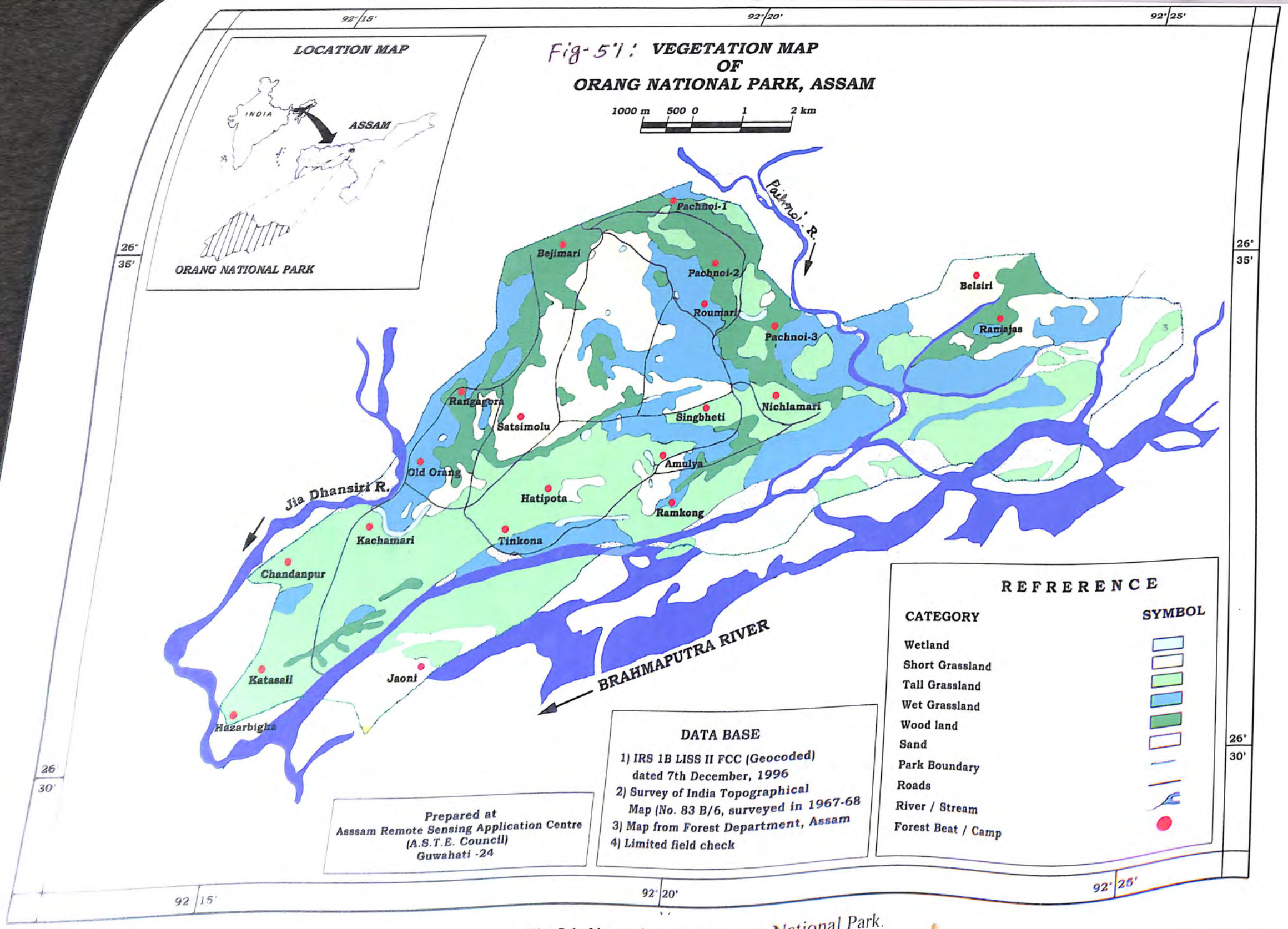


Fig:5.1: Vegetation map of Orang National Park.

(b) Habitat utilization pattern

To investigate the habitat utilization 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.

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

5.3. Results

5.3.1. Landscape matrix

The analysis of Satellite Imagery of Orang National Park revealed that, out of total of 78.81 km^2 area of the park, 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 (Fig: 5.2).

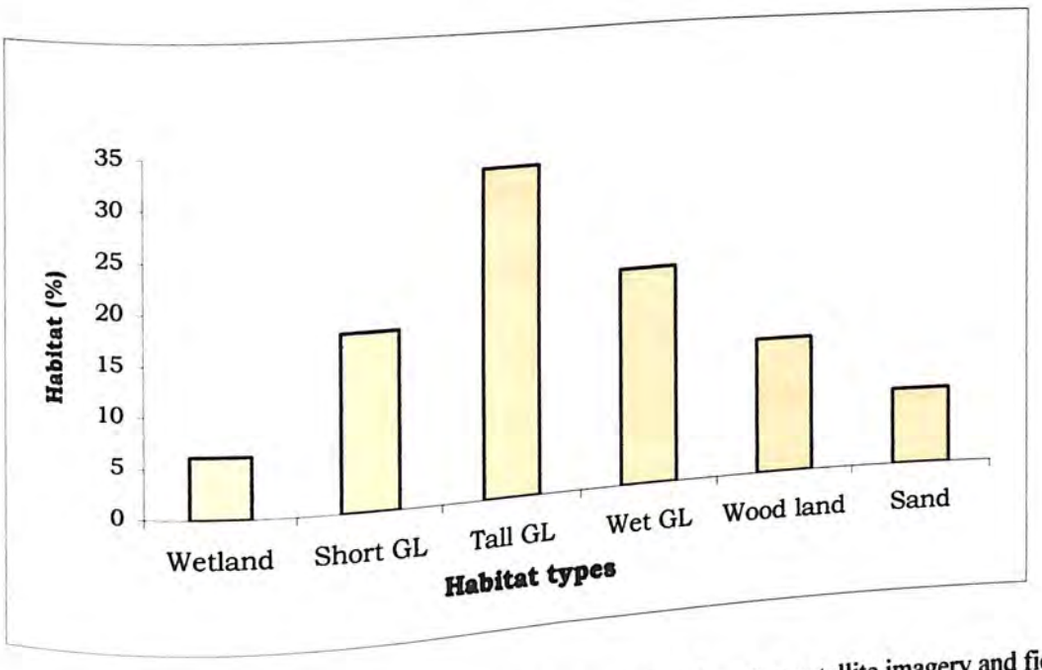


Fig: 5.2 Landscape classification of Orang National Park based on satellite imagery and field survey.

5.3.2 Rhino Habitats

Study revealed that, the Indian Rhino utilized altogether five major habitat types in Orang National park, those were 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 were included all the landscape coverage with atleast 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 categorized as short-grassland habitat. The vegetation composition of this habitats were - *Hemarthria compressa*, *Cyandon dactylon*, *Andropogon aciculatus*, *Digitaria ciliaris*, *Oplismenus burmanni*, *Laptochloa panacea*, *Eleusine indica*,*Imperata cylindrica* etc. The roadside areas 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 vegetations 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

All landscape area with a grass height of above 5 feet was categorized as tall grassland habitat. The characteristic vegetation types of tall grasslands composed of *Saccharum ravanae*, *Phragmites karka*, *Saccharum spontaneum*, *Arundo donax*, *Impareta cylindrica* etc. Again, the small patches of short grassland within 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 categorized as wet grassland habitat. In marshyland habitat, the soil was saturated with water content and the ground zones become muddy. The edges of *beels*, which found to be almost dry during winter seasons was 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 categorized as woodland habitat. Although, there were many sandy areas (or sand bars) in the study area, but the Indian Rhino never seen to utilized these zones.

5.3.3. Habitat utilization 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 to use sandy areas in Orang National Park, but the hoof marks were seen on the sandy river banks and river beds.

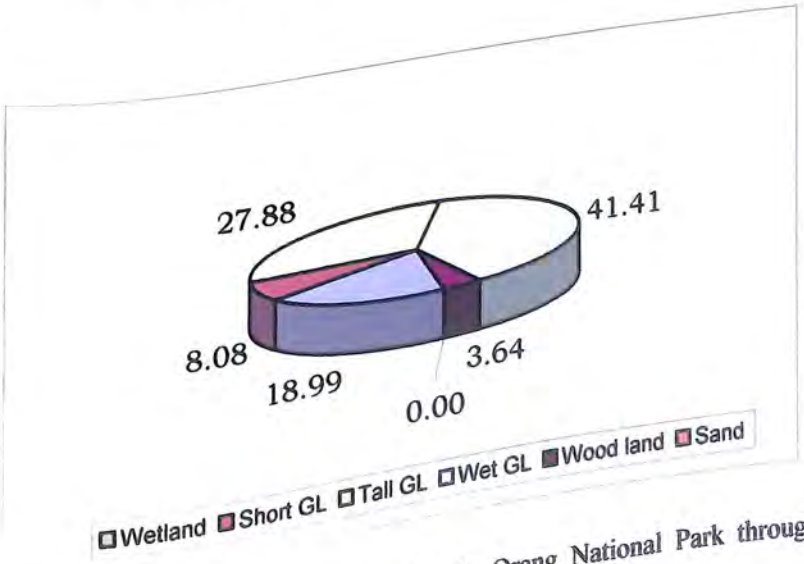


Fig: 5.3.Habitat utilization pattern of Indian Rhino in Orang National Park throughout the year (Data in % basis).

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).

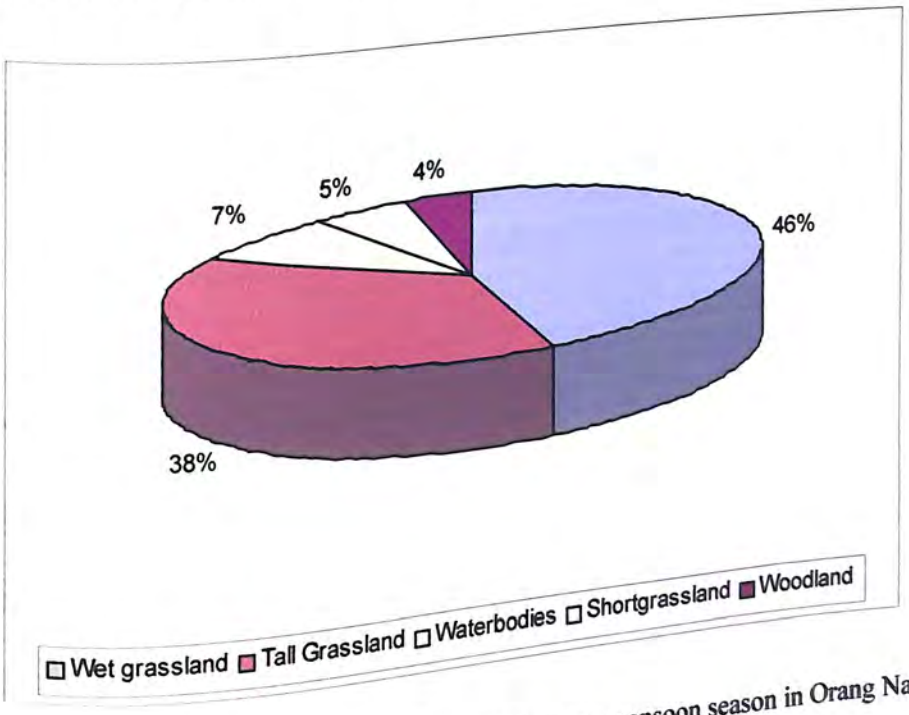


Fig: 5.4: Habitat Utilization pattern of Indian Rhino during pre-monsoon season in Orang National Park (Data in % basis).

(ii) Monsoon

Study showed that, Indian Rhinos utilized highest of 42% 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)

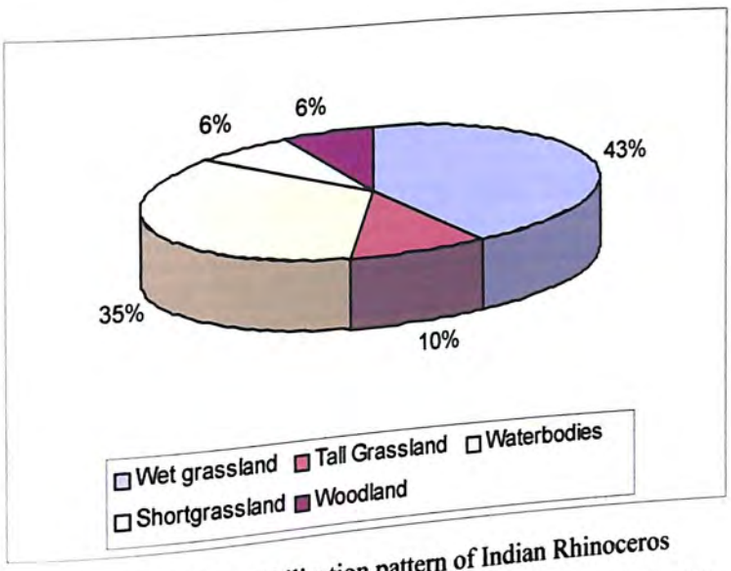


Fig: 5.5. Habitat Utilization pattern of Indian Rhinoceros during Monsoon season in Orang National Park (Data in % basis).

(iii) Re-treating monsoon

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

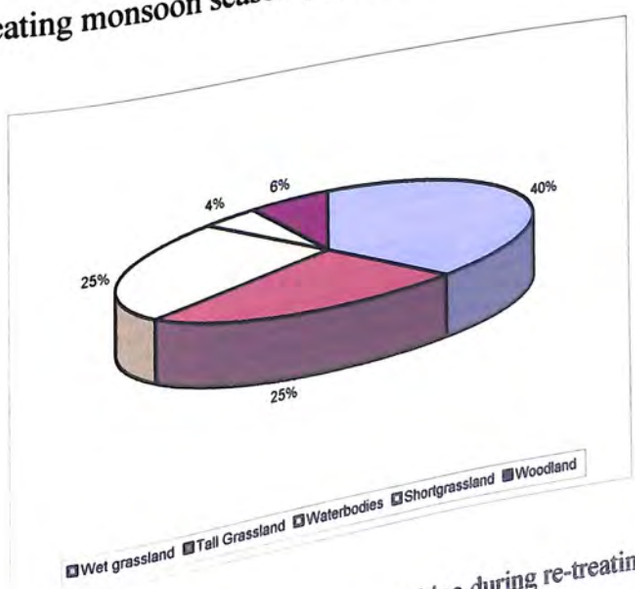


Fig.5.6. Habitat Utilization by Indian Rhino during re-treating monsoon in Orang National Park (Data in % basis).

(iv) Winter

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

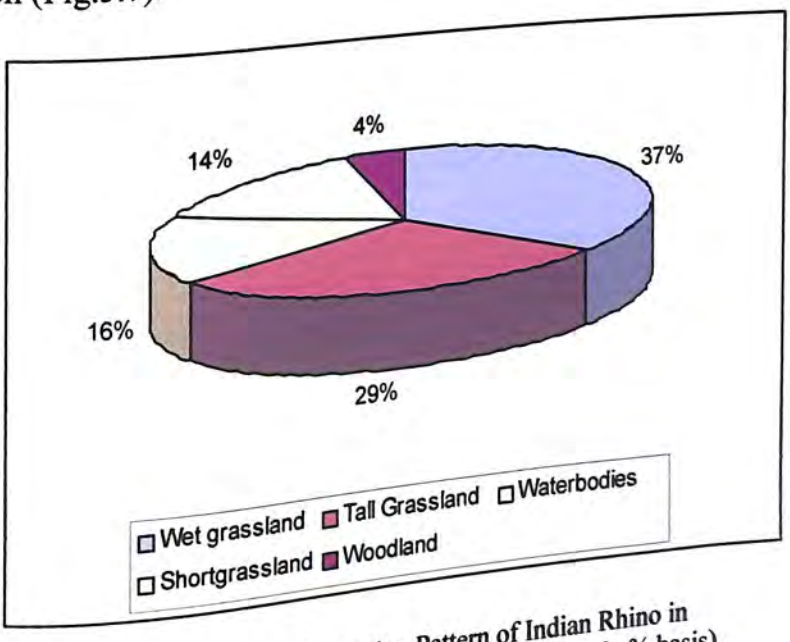


Fig.5.7: Habitat Utilization Pattern of Indian Rhino in Orang National Park during winter season (Data in % basis).

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

Tall grassland after annual control burning

New sprouting after control burning

A wallowing site

A wallowing site within tall grassland

A Rhino in water body

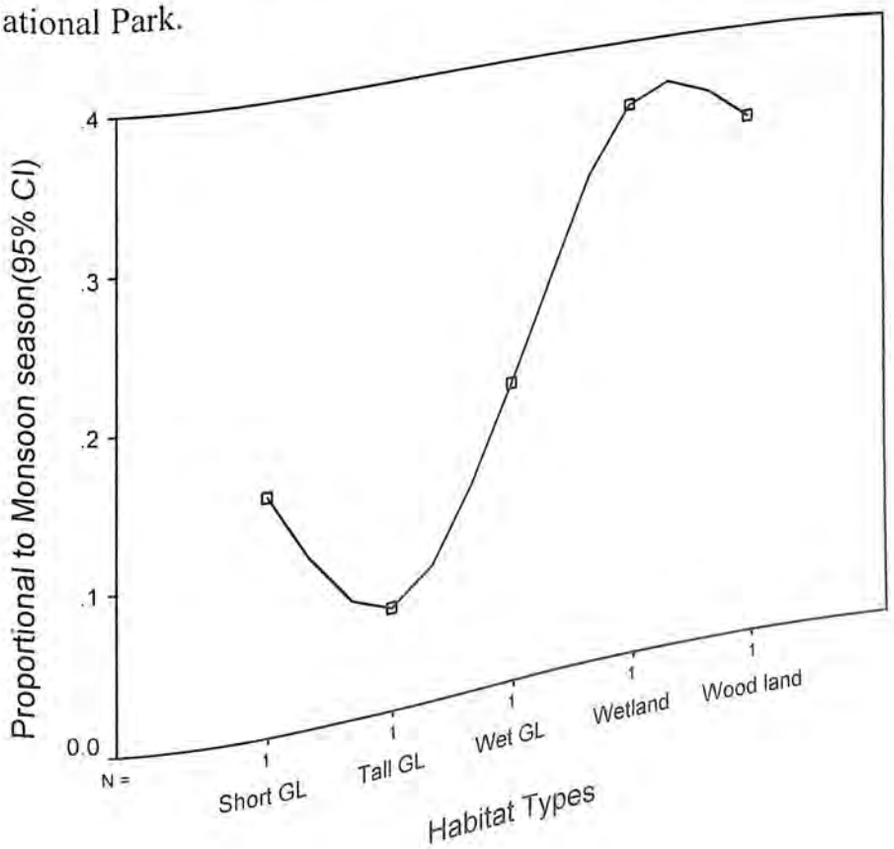
Marshy land, tall grassland and woodland

Plate 3 : Habitat diversity for Indian Rhino in study area

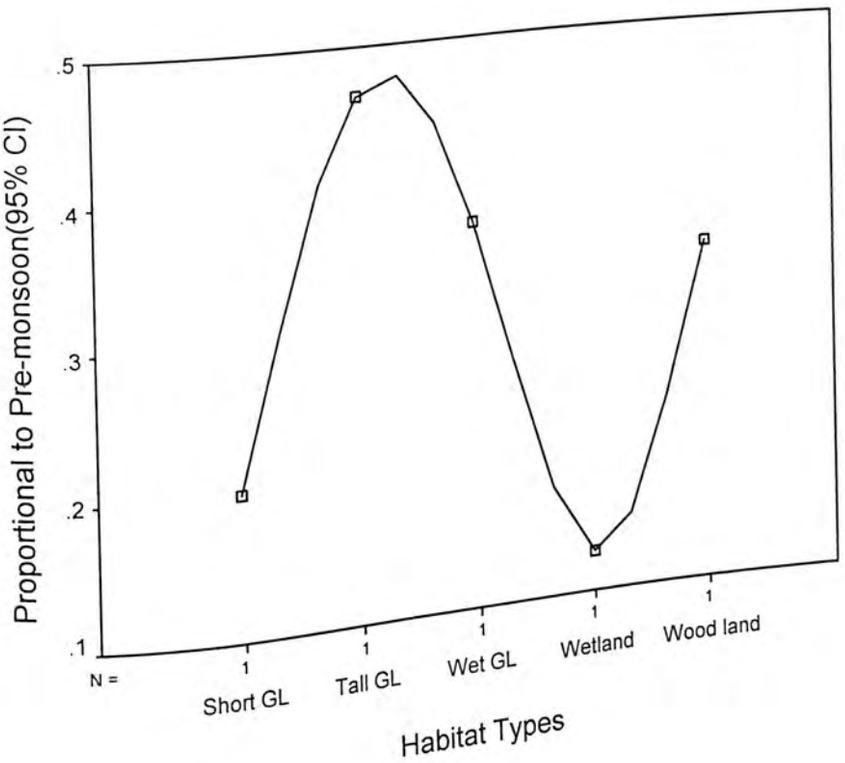
5.3.4 Habitat preferences of Adult Male and Female Rhino

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).

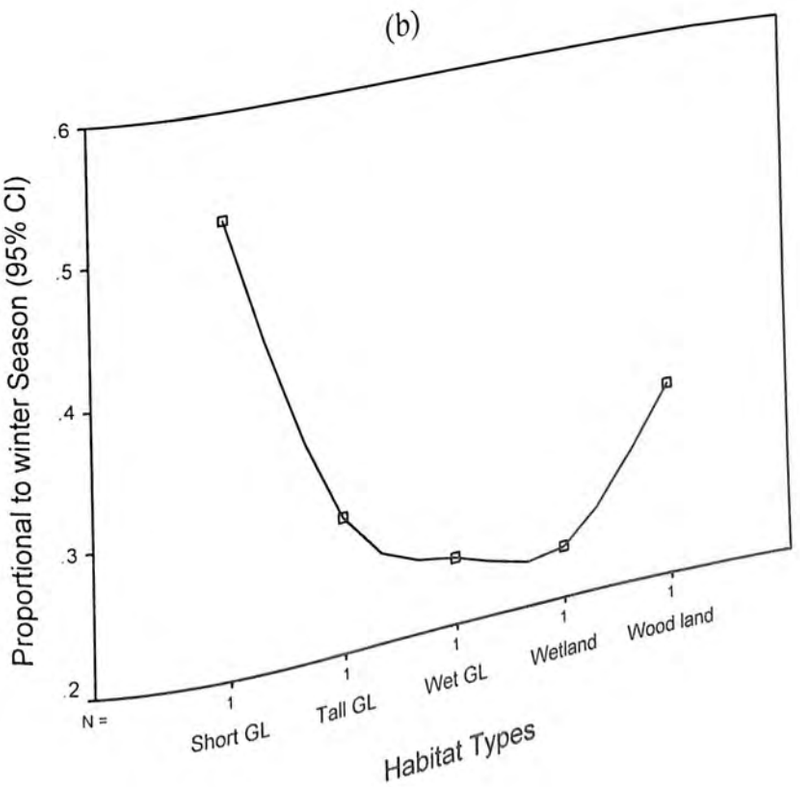
The analysis of Spearman Rank corelation between male and female habitat use types during dry and wet season showed that, both the male and female dry and wet season habitat use was significantly but negatively corelation between each other (For Female; **Dry and Wet**: Spearman Rank correlation = r^s = -0.613, P =0.0001; For Male; **Dry and Wet**: = r^s = -0.842; P = 0.0001), indicating the different types of habitat during dryand wet season by both adult male and female Rhino at Orang National Park.



(a)


Proportional to Pre-monsoon(95% CI)
.5
.4
.3
.2
.1
N =
1
1
1
1
1
Short GL
Tall GL
Wet GL
Wetland
Wood land
Habitat Types

(b)


Proportional to winter Season (95% CI)
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.5
.4
.3
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N =
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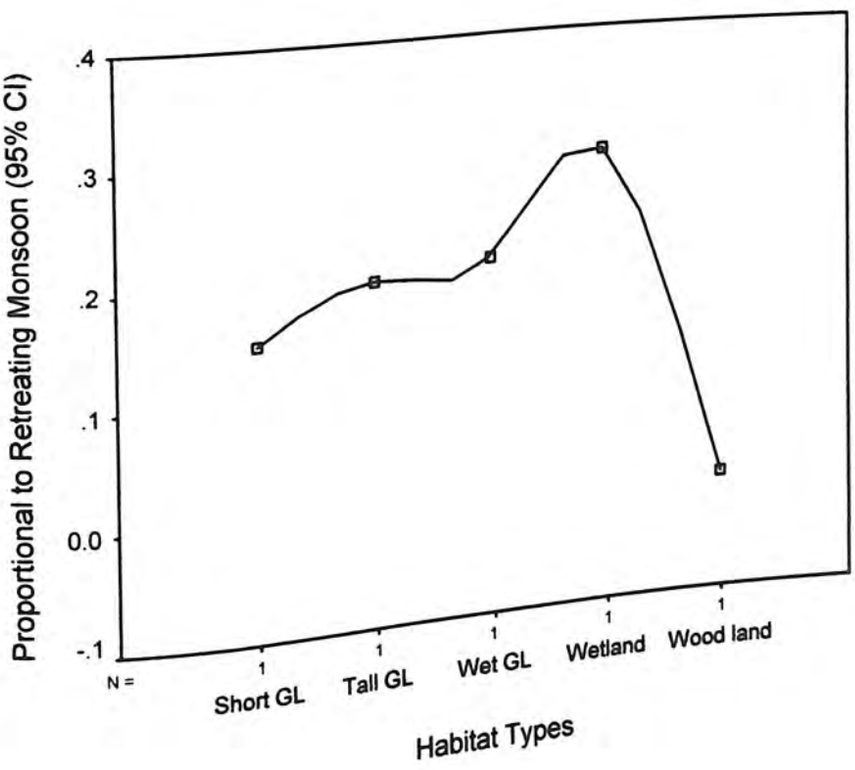
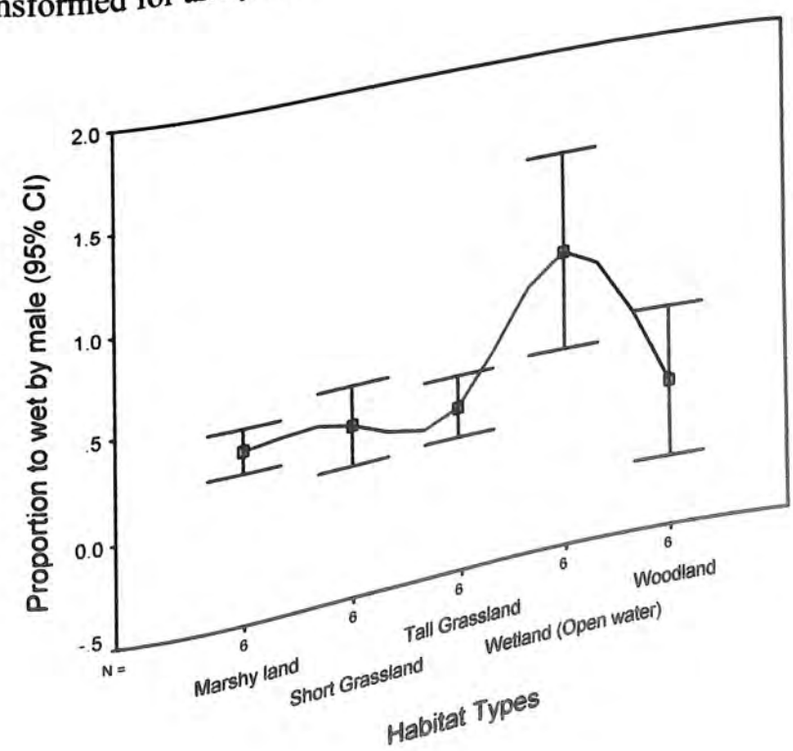
1
Short GL
Tall GL
Wet GL
Wetland
Wood land
Habitat Types

(c)

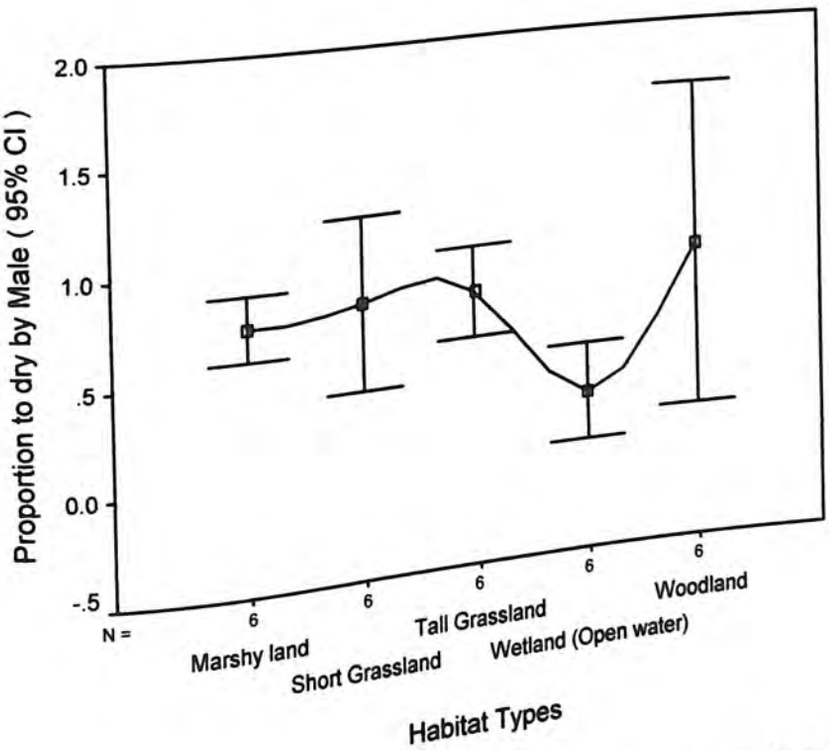


(d)

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

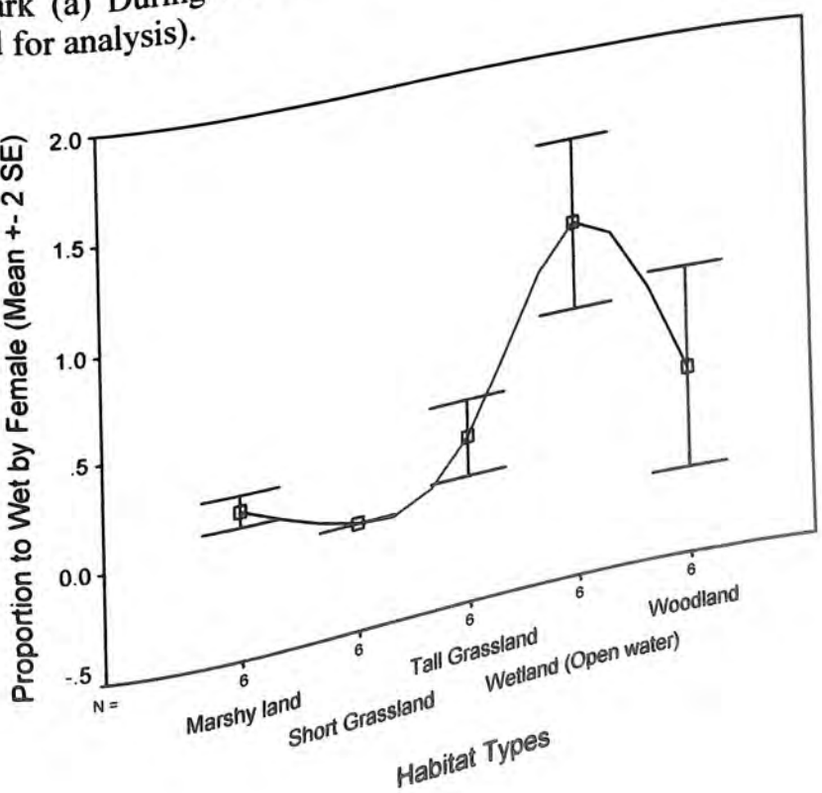


(a)

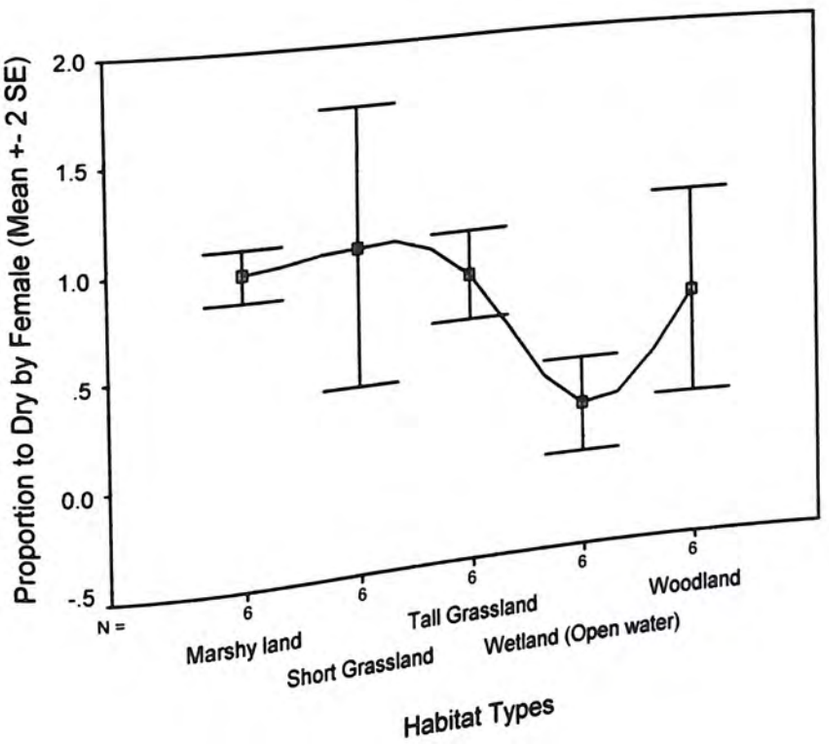


(b)

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).



(a)



(b)

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).

5.3.5 Habitat selectivity

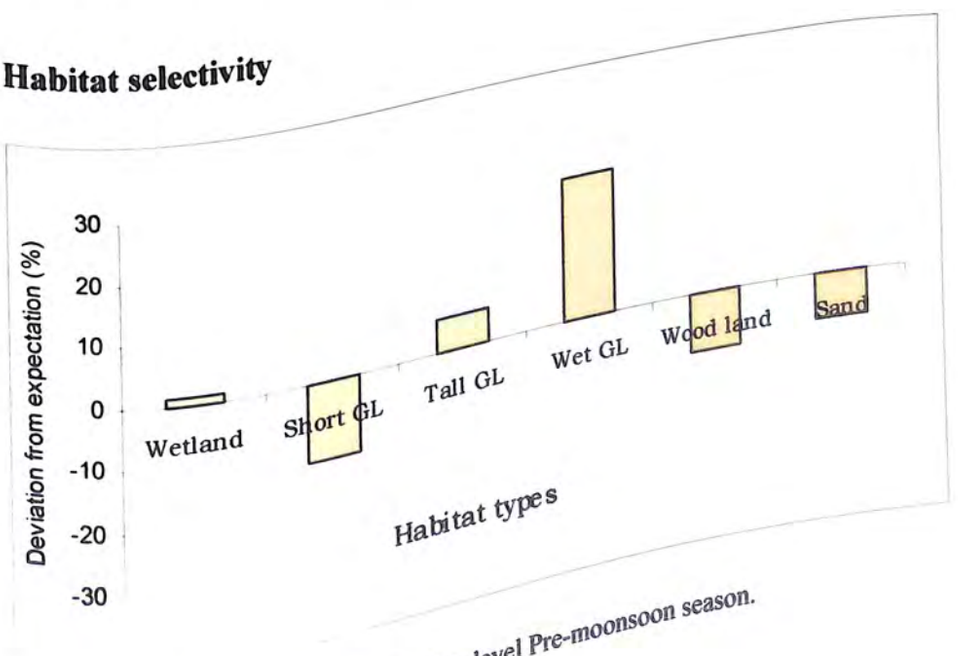


Fig 5.11a. Habitat selectivity expectation level Pre-moonsoon season.

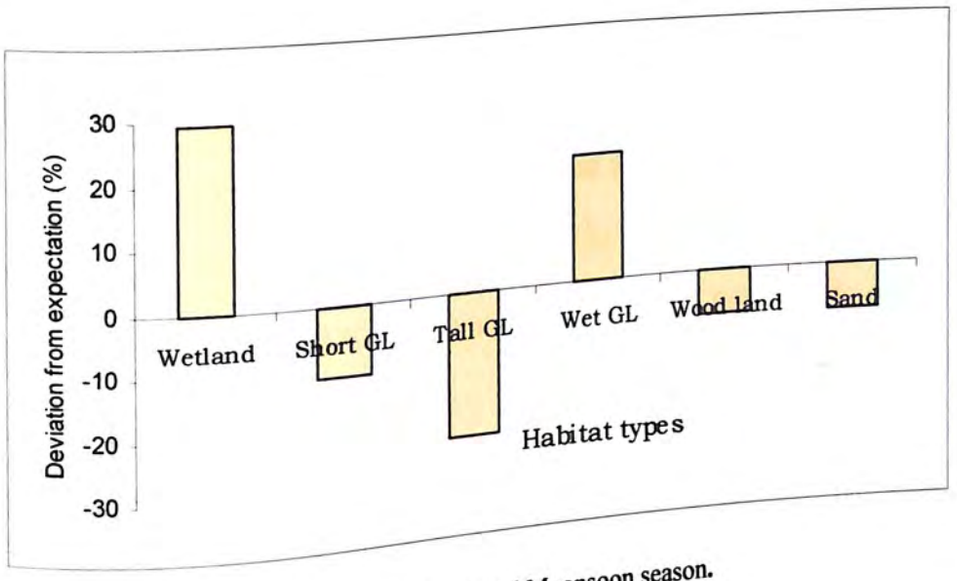


Fig . 5.11b Habitat selectivity expectation level Moonsoon season.

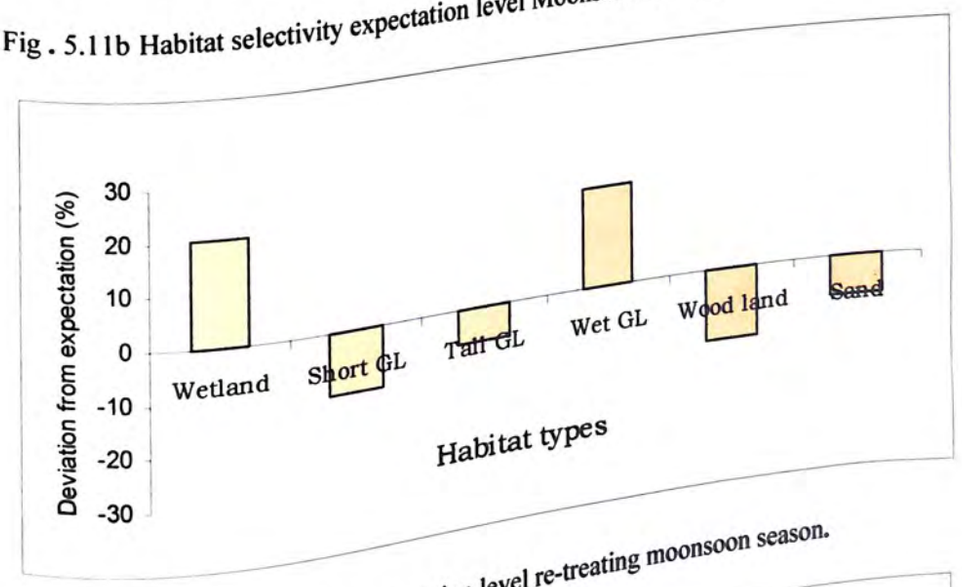


Fig . 5.11c Habitat selectivity expectation level re-treating moonsoon season.

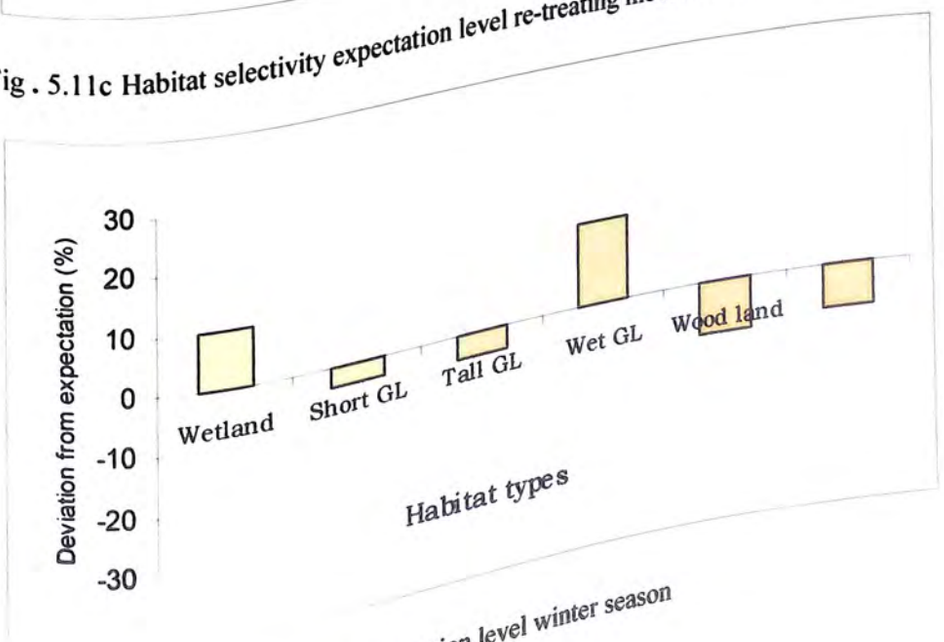


Fig . 5.11d Habitat selectivity expectation level winter season

The variation of habitat utilization pattern of Indian Rhino in Orang National Park showed that, the wet grassland and water bodies (wetland) were 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).

5.4 Discussion

It is evident from the present study that, the Indian Rhino in Orang National Park prefers wet grassland habitat throughout the year. This habitat selection of Indian rhino is not because of food availability, but also positive selection of foraging ground. Since, most of the Rhino prefers 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 forage 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 waterlogged area. Again the edible grasses are available in wet and marshy habitat in all the seasons. Since, the tall grasses become mature during late October when the soft grasses are converted to coarse, hard and unpalatable. Hence, the Indian rhino seldom use 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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