Animal Diversity, Natural History and Conservation

— Vol. 5 —

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Dr. Vijay Kumar Gupta, Ph.D., FLS, London (born 1953-) Chief Scientist, CSIR- Indian Institute of Integrative Medicine, Jammu, India. He did his M.Sc. (1975) and Ph.D. (1979) in Zoology both from University of Jammu, Jammu-India. His research capabilities are substantiated by his excellent work on histopathology, ecology and reproductive biology of fishes, turtles, birds and mammals, which has already got recognition in India and abroad.

Dr. Gupta has to his credit more than 100 scientific publications and review articles which have appeared in internationally recognized Indian and foreign journals. Founder fellow, life member and office bearer of many national societies, academies and associations. He has successfully completed a number of research/consultancy projects funded by government, private and multinational agencies. His current areas of interest are histopathology, toxicology, pre-clinical safety pharmacology, reproductive efficacy studies of laboratory animals and biodiversity.

He is the Series Editor of the recently published multi-volume set of books, "**Comprehensive Bioactive Natural Products (Vols. 1-8)"**, published by M/S Studium Press, LLC, USA. He is also Editor-in-Chief of the books, "**Utilisation and Management of Medicinal Plants (Vols. 1-3)"**, "**Medicinal Plants: Phytochemistry, Pharmacology and Therapeutics (Vols.1-4)", "Traditional and Folk Herbal Medicine (Vols. 1-3)"**, **"Natural Products: Research Reviews (Vols. 1-4)", "Bioactive Phytochemicals: Perspectives for Modern Medicine (Vols. 1-3)", "Perspectives in Animal Ecology and Reproduction (Vols. 1-10**)" and **"Animal Diversity, Natural History & Conservation (Vols. 1-5)"**. The Editor-in-chief of the American Biographical Institute, USA, has appointed him as *Consulting Editor* of *The Contemporary Who's Who*. Dr. Gupta also appointed as Nominee for the *Committee for the Purpose of Control and Supervision of Experiments on Animals* (CPCSEA, Govt. of India). The *Linnaean Society of London, U.K*. has awarded fellowship to him in November 2009 in recognition of his contribution towards the cultivation of knowledge in Science of Natural History. Recently, Modern Scientific Press, USA has nominated Dr. Gupta as the Editor of the *International Journal of Traditional and Natural Medicine*.

Dr. Anil K. Verma, Ph.D., M.N.A.Sc., FLS, London (born 1963-) Prof. & Head, Department of Zoology, Govt. (P.G.) Degree College Rajouri, J&K State, did his M.Sc. in Zoology (1986) from University of Jammu, Jammu. He has undergone his M.Phil. (1988) and awarded first rank and Ph.D.(1993) in the field of animal reproduction at the same University. Dr. Verma has published about 60 research papers and review articles in reputed journals and books. He is also a member Editorial Board of the book series "Advances in Fish and Wildlife: Ecology and Biology" a Daya Publishing House, New Delhi. In recognition of his standing in greater scientific community, the Board of Directors of the American Association for the advancement of science (AAAS) New York, Washington, has awarded membership to him. The *Linnaean Society of London, U.K*. has awarded fellowship to him in October 2006 in recognition of his contribution towards the cultivation of knowledge of Science of Natural History.

Dr. Verma was also nominated as Nominee, CPCSEA by Ministry of Environment & Forests, Govt. of India, and also awarded "The Rashtriya Gourav Award" and "The Best Citizen of India" award by the India International Friendship Society in 2009-2010. He is also a nominated member of the Global Academy of Science, India.

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Foreword

The Indo-Malayan ecozone is one of the 17 most diverse on Earth, and India represents an extraordinary high species concentration; for instance about 12, 8, 14 and 9 per cent of respectively all fish, reptilian, bird and mammal species can be found in India, albeit the country only constitutes little over 2 per cent of the global land area. With a standing human population of in excess of 1.2 b, India also faces unprecedented challenges with respect to biodiversity conservation and protected areas management. As one of the globally fastest growing emerging megaeconomies India has the potential to integrate national development with biodiversity conservation objectives, and a huge research base within the management of wildlife and natural resources shows important trends in that direction. In such a huge biogeographcal region basic knowledge on animal diversity, their natural history and conservation requirements are a prerequisite for safeguarding this outstanding scenario of species, habitats and landscapes, which include the highest elevations on the planet, and ranges from arid deserts to humid tropical forests and alpine biomes.

This Volume 5 of "*Animal Diversity, Natural History and Conservation*" continues the accounts of the previous four volumes, and contains varied and up-to-date basic ecological knowledge on both invertebrates and vertebrates, from both the aquatic and terrestrial biomes, including a thematic focus on the interrelationships between on one hand wildlife and habitats contra human exploitation and anthropogenic disturbances.

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Preface

Today, one of the major areas of concern is the complete loss of some of the species, many of which are not known to us but are already threatened due to the destruction of their natural habitat. Conservation seeks to prevent complete elimination of a species for which there may be no alternatives. All organisms are linked in the food chain and interact with their abiotic environment in order to make the ecosystems self-sustaining units.

The disappearance of a link in the food chain upsets nature's balance, thereby creating problems and disrupting the overall ecological balance. It is, therefore, in our interest to conserve our resources. There is now a global realization about the urgent need to conserve the world's biological diversity.

Considering the immense values of biodiversity and subsequent rapid loss of the same, during the past couple of decades, enormous conservation efforts are being made for restoring the biodiversity of various habitats, through the on-site and off-site protection. The UNGA has decided to declare 2011-2020 as the "Decade on Biodiversity" which coincides with and also supports the implementation of the strategic plan for bio-diversity and there appears to be a basic need of humans to connect with nature and also with bio-diversity. It is in this back drop that it is felt that there should be a serious introspection for finding ways and means to suggest potential remedial measures to arrest the deterioration of the fragile ecological balance.

The earth has experienced and recovered from many natural distress in the past, but we now seem to be at a critical point, with humans facing responsibility for the future of the planet. All species, while evolving and adapting to the demands of their habitats, climatic and geological conditions, can change dramatically, subjecting environments and their ecologies to a dynamic swirl of physical forces.

Within the last 200 years, the human population has exploded, dominating many habitats at the cost of valuable natural systems, such as forests and wetlands, polluting air, water and land. At such, the resulting disruption of natural systems by

human activity has revealed the fragility of the system threatening to destroy entire ecologies and render many species extinct.

In the present volume of the book series, an attempt has been made to encapsulate the scientific information pertaining to the modern day research in the field of animal diversity, biology and conservation. This effort is likely to serve as a catalyst for the development of innovations and approaches for future studies in the fields. The chapters have been contributed by the experts with exhaustive, relevant and update information. We are greatly indebted to the contributors who have whole heartedly support us in this endeavour.

We hope, that the book shall be a landmark and useful for an array of biologists, ecologists, naturalists and conservationists to a considerable extent.

Dr. V.K.Gupta, ***FLS***

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Chapter 21

Ecological Crisis vis-à-vis Intraspecific Conflict: A Case Study with Rhinos in Jaldapara and Gorumara National Parks, West Bengal, India

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ABSTRACT

In West Bengal, population of the Great Indian one-horned rhinoceros (*Rhinoceros unicornis*) in the floodplains of Jaldapara (216.51 km²) and Gorumara (79.45 km²) National Parks in Jalpaiguri district, the hunting and poaching hotspots up to early 1980s, has gradually been recovered from the bottom of depression (14+8= 22) to the carrying capacity threshold (186+43= 229) during the last two and half decades, consequent upon strict protection and successful reproduction. The burgeoning population has now posed a heavily skewed sex-ratio (excessive number of adult males than that of reproductive females). This has resulted in frequent infighting- as well as forced mating-casualties and dispersal of the victims to the safe range-edge or even far beyond to establish new territories. The probable solutions of this crucial management problem are round-the-clock monitoring, seclusion of the identified more aggressive males, reintroduction of more wild females from the neighbouring rangelands, development of new grasslands and translocation of the excess population to those habitats in the region in phases.

Keywords*: Riparian grassland, Population boom, Skewed sex-ratio, Infighting-casualties.*

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Introduction

The Great Indian One-horned Rhinoceros, *Rhinoceros unicornis* Linnaeus, 1758, is now restricted to almost exclusively within and around protected areas in India (Assam, Uttar Pradesh and West Bengal) and Nepal (extinct from Bangladesh and Bhutan) and its population has turned around from approximately 200 individuals in the late 19th century to a range of 3300-3350 at the end of August 2013. The recovery of the species is one of the greatest conservation success stories in both the countries. Despite some serious threats in past few decades, the park managers have been able to reduce the poaching pressure successfully and the rhino population increased considerably. *R. unicornis* is the only Asian large mammal species in recent history whose IUCN Red List status has been down-listed from 'Endangered' to 'Vulnerable' in 2008. But due to the most impressive increase of rhino populations and other associated mega herbivores- *Elephas maximus* (elephant) and *Bos gaurus* (gaur) in the protected areas (rhino lands), followed by excessive cattle grazing, the carrying capacity of rhino has been exceeded there, which leads to an ecological crisis and increased risk of rhino-human conflict as the rhinos frequently move out of the parks to meet their biological needs.

The re-introduction programmes of the excess park population have now begun and the species is starting to repopulate the former habitats where not so long ago they had become extinct from. But the threat of poaching is still present, so also the dwindling habitats. Most of the rhino habitat is suffering from tremendous biotic pressure. As a result, intraspecific competition and conflict is often encountered resulting in increasing mortality or injury of the rhinos, particularly the bulls. Moreover, many rhinos are now frequently straying from the safety of the parks to the fringe areas as well as far-flung (ca. 50 km) habitats and some of them have been staying there either seasonally or even permanently.

Objective of the Study

Though a number of studies have been undertaken in the popular rhino lands of Assam (India) and Nepal, very little attempt has been made to project the third important conservation site in northern West Bengal. The present paper discusses the nature and impact of heavily skewed sex-ratio (male-biased) as a result of the burgeoning rhino population in Jaldapara and Gorumara, reaching the carrying capacity threshold and probable management solutions to this problem.

Study Areas

In erstwhile Bengal, *R. unicornis* was distributed extensively in both the Upper Gangetic Plains and Lower Gangetic Plains (Biographical Zones 7A and 7B) during the nineteenth century, but presently the species is restricted to only two fragmented (approximate linear distance of 45 km) protected areas (National Parks) in the former zone- Jaldapara spread over 216.51 km² (25°58´-27°45´N and 89°08´-89°55´E) under Wildlife Division-III and Gorumara covering 79.45 km² (26°43´–26°47´N and 89°47´–88°52´E) under Wildlife Division-II (Bahuguna and Mallick, 2004). Jaldapara is the second largest natural home and *in situ* conservatory of this Schedule-I species in India after Kaziranga of Assam (Ghosh and Das, 2007). Moreover, the Ministry of

Environment and Forests, Govt. of India, has declared Gorumara as one of the best-managed National Parks in the country for the year 2009 and for the first time in the history of Greater One-horned Rhino census, advanced genetic tools have been used in Gorumara and the same programme will also be undertaken in Jaldapara.

Jaldapara is demarcated by Bhutan and Totopara village on the north, Falakata-Cooch Behar Road on the south, Reserve Forests, 14 tea gardens and 32 revenue villages on the east and west. Gorumara is bounded by Batabari-Nagrakata Road on the north, reserve forests of Jalpaiguri Forest Division on the south, the River Jaldhaka and tea gardens on the east and National Highway 31 on the west. More than 50 human settlements are located within its zone of influence.

The altitude of these rhino lands varies from 25 m to 275 m asl. Here the highest temperature recorded in the summer is 37ºC with high humidity (75-95 per cent) and the lowest in the winter- 10ºC. The average annual rainfall is about 380 cm, mostly occurring between mid-May to mid-October. December is driest and July wettest.

The Torsa-Malangi floodplains have formed the trouser-shaped rhino-habitat in Jaldapara. It consists of twelve forest blocks (46 compartments)- Bania (Compartments 1-4, 8b): 16.48 km², Barodabri (1b, 2, 6b, 7b): 6.09 km², Chilapata (1-2, 3b, 4b): 18.54 km², Dalsingpara (1-4): 14.78 km², Hasimara (1-4): 16.43 km², Jaldapara (1-5): 34.51 km², Jaigaon (1-2): 17.56 km², Malangi (1-3): 12.42 km², Mendabari (3-6): 10.22 km², Salkumar (1-4): 5.03 km², Titi (1-4 part): 38.19 km² and Torsa (1-3): 26.26 km² (Figure 21.1).

The combined Jaldhaka-Murti-Indong-Diana floodplains have formed Gorumara, which consists of 11 forest blocks (25 compartments)- Barahati (1–3): 9.31 km^2, Bhokolmardi (1–3): 8.35 km^2, Central (1): 2.48 km^2, Dhupjhora (1a, b, c): 4.24 km^2, Gorumara (1–2): 6.59 km^2, Jaldhaka (1b): 2.62 km^2, Kakurjhora (1–2): 5.65 km^2, Medlajhora (1–3): 8.50 km^2, Selkapara (1–2): 7.67 km^2, South Indong (1–3): 12.73 km^2 and Tondu (1; 2a, b; 3; 4a, b): 11.31 km^2 (Figure 21.2).

Next to Kaziranga (Assam, India) and Royal Chitwan (Nepal), Jaldapara is the third prime conservation area of this endemic megaharbivore of the floodplains (Vigne and Martin, 2012), a genetic isolate from Nepal and Assam for centuries (Groves, 1993, 2003; Ali *et al.*, 1999). Jaldapara (Sanctuary) has been upgraded to National Park in May 2012 for better management, whereas Ministry of Environment and Forests, Government of India, declared Gorumara as the best-managed National Park in the country for the year 2009.

Materials and Methods

A database was prepared by collating the published and unpublished records (census, monitoring, birth/casualty, rescue, chemical immobilization, treatment and release) of *R. unicornis* in the study area. Ground surveys were undertaken separately for Jaldapara and Gorumara during 1st January-31st December 2012 with the help of frontline forest department staff. A questionnaire survey was also conducted among the stakeholders including forest and fringe villagers, members of local Eco-development/Forest Protection Committees living in and around these two protected areas.

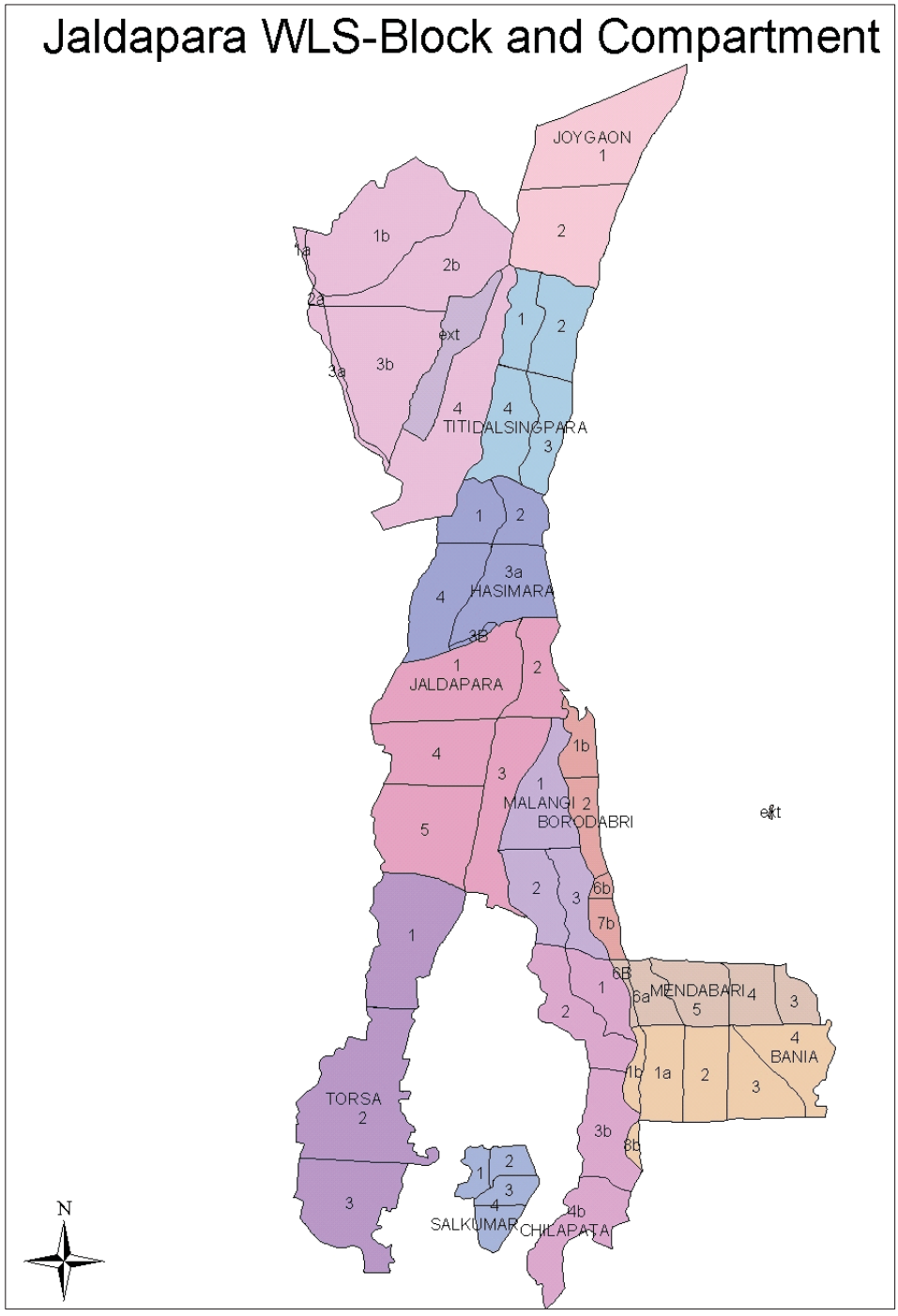

Figure 21.1: Jaldapara National Park.

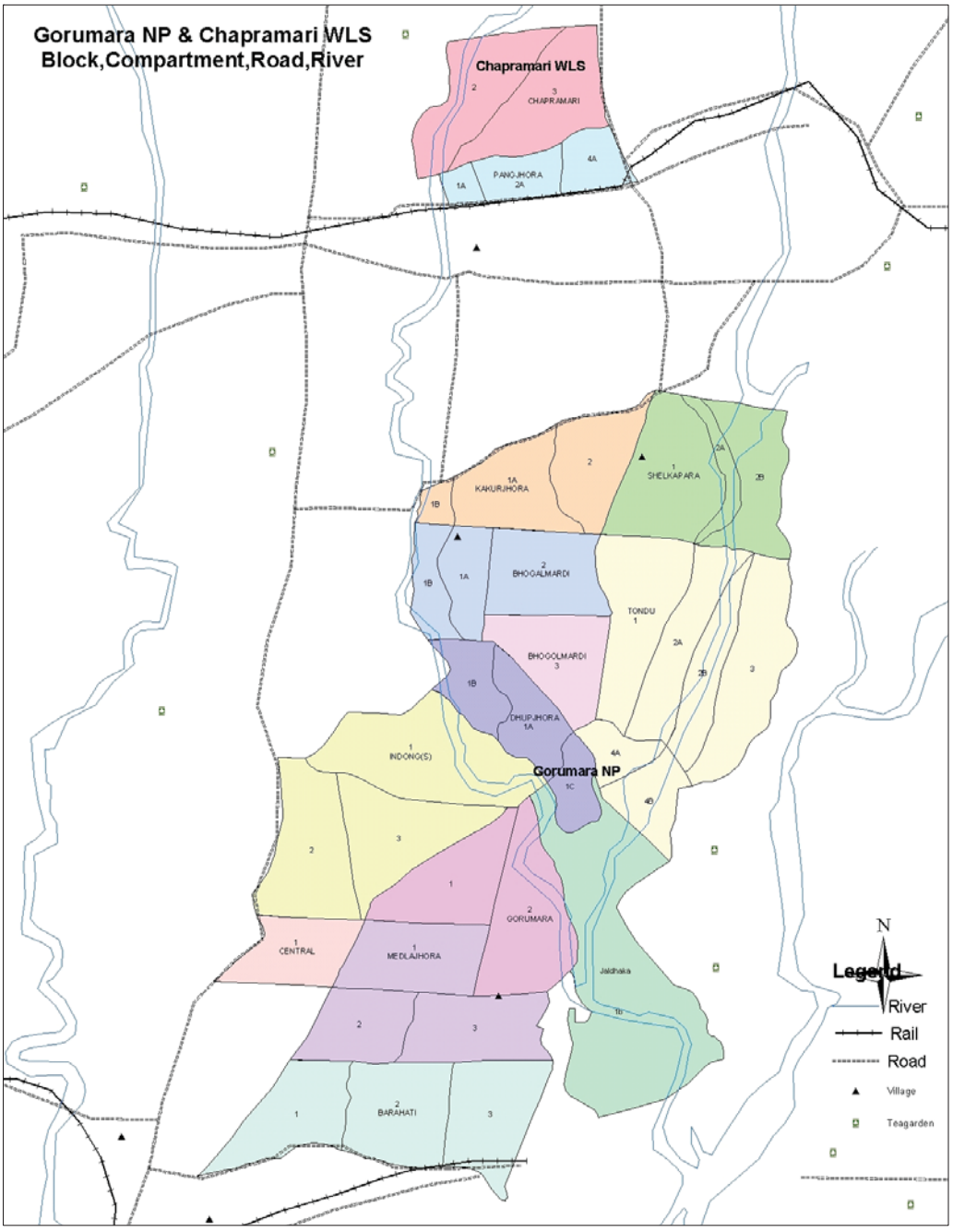

Figure 21.2: Gorumara National Park.

The rhinos were recorded in the thick and open grasslands, savannah woodlands, saltlicks and wallowing pools by direct sighting in the morning (06-10 h), late afternoon and evening (16-21 h) from elephant back, vehicle, watch tower and also indirect evidences like 'middens' or high community dung heaps, tracks and wallowing signs.

An attempt was made to classify the rhinos as to sex and age class (*i.e.* adults, subadults and calves including the juveniles). If there was any doubt as to the sex of an adult animal, it was classified as 'non-sexed'. The age/sex of the rhinos was determined in the field on the following basis:

1. *Adult*: Shoulder height above 160 cm and horn base above 18 cm with prominent neck folds;
   (a) *Male*: Penis either visible from the side or the rear (urination indicating the location); deeply folded skin around the neck; large horn with wider base;
   (b) *Female*: Genitalia visible from the rear (urination indicating the location); the folds around the neck and the horn comparatively smaller; often accompanied by calf.
2. *Sub-adult*: Shoulder height 135-160 cm and horn base 8-18 cm and neck fold small but visible and growing, the individuals moving without mother;
3. *Juvenile*: Shoulder height 120-135 cm and horn base up to 8 cm and moving without mother;
4. *Calf*: Shoulder height below 120 cm and horn base absent or just growing and neck fold small but visible and growing, practically without formation of the horn; moving with the mother.

Results and Discussion

Ecological History

(a) Fragmention of Habitat

During the nineteenth century, the rhinos were distributed from the *terai* of Darjeeling district, west of the River Tista, through the western *duars* in Jalpaiguri and Cooch Behar (upper region) districts, east of the River Torsa up to the eastern *duars* (Assam). Up to the early twentieth century, the jungles of Cooch Behar Raj (eastern and western *duars*) were linked with the Darjeeling *terai* or foothills, when the rhinos could travel from east to west and *vice versa* for hundreds of kilometres without crossing a single man-made path. The ecological boundary of Jaldapara was then extended up to Titi Block in the north bordering Bhutan, Chilapata Block (Bania-5, Mendabari-1 and Barodabri-8) up to Buxa (89º20'-89º55' E, 26º30'-26º55' N) in the east, Garodhat-Patlakhawa-Pundibari of Cooch Behar in the south and Khairbari in the west. The rhinos of Bholka Range (Buxa) moved freely between Assam and West Bengal across the Sankosh. The populations of Jaldapara and Gorumara are isolated by physical barriers and ecological boundaries. There is no record of rhino-movement in between Jaldapara and Gorumara. The ecological boundary of Gorumara was

extended up to the River Tista in the west and surrounding forests of Jalpaiguri Forest Division in the north, east and south.

As a sequel to fragmentation of the habitat, no biological corridor is left linking the protected areas in northern Bengal- Buxa-Jaldapara, Jaldapara-Gorumara, Gorumara-Chapramari and Gorumara-Mahananda (Figure 21.3). So, the surviving subpopulations in Jaldapara and Gorumara have become isolated, which has restricted the potential gene-flow.

(b) Loss of Habitat

It is estimated that the extent of tall riparian grassland lost in three sectors of northern Bengal between 1900 and 1990 was 450-580 km^2 on account of-

1. Extension of tea gardens (200-250 km^2),
2. Extension of agriculture (60-80 km^2),
3. Encroachments or establishment of leasehold *Khasmahals* (20-30 km^2),
4. Annual flood-erosions (20-30 km^2), and
5. Forestry practices (conversion of grassland by commercial plantation): 150-190 km^2 [30-40 km^2 in the Sankosh-Rydak sector (89°44'-89°47' E, 26°34'-26°40' N) of Buxa and Garodhat, 70-90 km^2 in the Torsa-Hasimara sector of present Jaldapara including Patlakhawa of Cooch Behar and 50-60 km^2 in Jaldhaka-Diana sector of present Gorumara] (Bist, 1994).

(c) Population Decline

Whereas rhino populations in the floodplains of Ganges river system, *i.e.* Malda, Murshidabad and 24-Parganas (the Sundarbans) districts of southern Bengal were wiped out during the late nineteenth century (Mukherjee, 1963; Agrawal *et al.*, 1992; Das, 2008), at least 240 rhinos [120+ in Sakosh-Rydak, 100+ in Torsa and 20+ in Jaldhaka-Diana sectors] existed in northern Bengal during 1890s (Bist, 1994). Consequent upon large-scale hunting and poaching as well as extensive habitat loss, their range has been reduced to less than one-eighth (Banerjee, 1966) followed by extinction of most of the subpopulations in this region during the last two centuries (Maharaja of Cooch Behar, 1908; Menon, 1996; Martin, 1996a, 1996b, 1999; Pandit and Yadav, 1996; Bahuguna and Mallick, 2010). The rhino population of Jaldapara-Gorumara was shot down to 22 (14+eight respectively) in 1985 (Bhutia, 2008).

Even during three enumerations in Jaldapara between 1964 and 1966, out of a population range of 50-60 as a sequel to the sharp decline in 1966, Spillet (1966) observed, "36 per cent of the sexed adults were males and 52 per cent of the adult females were accompanied by young. In comparison, 54 per cent of the adults observed during the enumeration were males and only 31 per cent of the adult females were accompanied by young. In either case, the relatively high percentage of young would probably indicate that the population is thriving". But after thirty years, Wildlife Institute of India (1997) recorded a negative growth rate of rhinos in Jaldapara and Gorumara up to 1996. The annual growth rate of Jaldapara population was -0.0222 (95 per cent CL±0.039) per year between 1930 and 1996, whereas the figure was 0.0079 (95 per cent CL±0.012) for Gorumara between 1968 and 1996. The sex ratio for

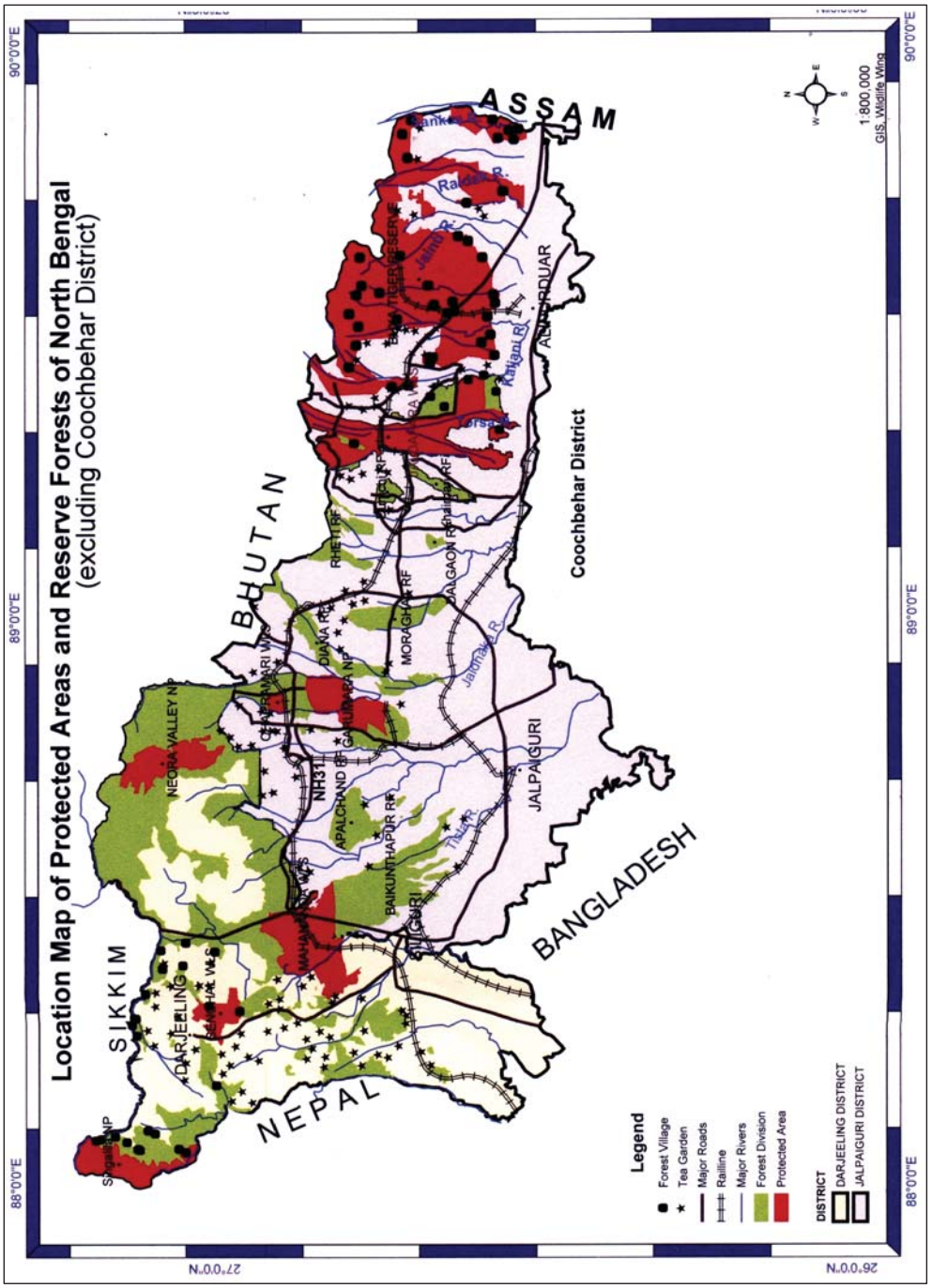

Figure 21.3: Protected Areas in North Bengal.

adult male to adult female in Jaldapara was 0.694:1.000 (95 per cent CL±0.133) during 1975-1996, while in Gorumara, it was 0.395:1.000 (95 per cent CL±0.077) during 1968-1996. The ideal ratio is considered to be 0.25:1.00 to 0.30:1.00. The calf-adult female ratio for Jaldapara was 0.509:1.000 (95 per cent CL±0.078) and in Gorumara it was 0.349:1.000 (95 per cent CL±0.111).

(d) Population Revival (Boom)

During early 1990s, the carrying capacity of Jaldapara and Gorumara was assessed to be 100 and 20 respectively (Molur et al., 1995). But during the last two and half decades, the rhino population had reached an all-time record of 229 (Jaldapara and surroundings: 186, an increase of 48.8 per cent between 2009 and 2013, *i.e.* 9.76 per cent per year + Gorumara and surroundings: 43, a rise of 22.85 per cent between 2010-2012, *i.e*. 7.61 per cent per year), as per direct counts by the park authorites (Tables 21.1 and 21.2). Aaranyak, Assam, also conducted a field survey in Gorumara for dung collection in April 2011 by using elephants. Laboratory work was carried out in the Wildlife Genetics Laboratory of Aaranyak at Guwahati. The unique "genetic profiles" of individual rhinos, popularly known as DNA fingerprints were determined from dung DNA extracts using a set of polymorphic microsatellite markers. In this process, candidate markers were tested on rhino samples of known individual identity, in order to determine the minimum number of such markers needed for identifying individuals from unknown samples. Through this process, the total number of individuals present (43) in the collected dung samples was determined (Barthakur *et al*., 2012; Talukdar, 2012).

Table 21.1: Rhino population in Jaldapara

Year	*AM*	*AF*	*Nonsexed*	*SAM*	*SAF*	*Nonsexed*	*MC*	*FC*	*Nonsexed*	*Total*
1975	7	7	4	–	–	–	5			23
1978	5	7	4	–	–	–	3			19
1980	5	7	6	–	–	–	4			22
1988	9	11	–	–	–	–	4			24
1989	9	13	–	–	–	–	5			27
1992	8	12	–	–	–	–	13			33
1993	4	7	2	–	–	–	11			26
1996	9	18	2	–	–	–	8			42
2002	17	11	2	6	2	2	16	4	14	74
2004	32	28	3	5	3	2	1	1	21	96
2006	35	33	2	4	3	5	3	3	20	108
2009	42	33	1	14	6	1	0	2	26	125
2013	62	55	4	8	6	9	42			186

AM: Adult Male; AF: Adult Female; SAM: Sub Adult Male; SAF: Sub Adult Female; MC: Male Calf; FC: Female Calf.

Table 21.2: Rhino Population in Gorumara

Year	AM	AF	Unsexed	SAM	SAF	Unsexed	Calf	Total
1978	1	3	3				1	8
1989	4	7	–				1	12
1993	4	7	–				4	15
1996	2	6	–				7	15
2002	6	11	–	–	–	–	5	22
2004	9	11	–	–	–	–	5	25
2005	13	9	2	–	–	–	3	27
2006	12	9	–	2	–	–	8	31
2009	17	12	–	1	–	–	5	35
2013	14	11	–	7	3	1	–	43

AM: Adult Male; AF: Adult Female; SAM: Sub Adult Male; SAF: Sub Adult Female.

The conservation success of rhinos in the study area could be achieved due to exemplary conservation efforts like intensive (24 h) patrolling (05-09 h on elephant back, 09-15 h on foot, 15-19 h on elephant back, 19-22 h by vehicle and 22-05 h by vehicle or on foot/elephant back), intelligence gathering and eco-development activities in and around these protected areas (Martin, 2006; Martin and Vigne, 2012), for which there was only one case of poaching during the twenty first century.

Habitat Use Patterns

Habitat utilisation pattern of rhinos (Figures 21.4–21.6) is dependent upon food, grass cover and water (Sarma, 2012). The rhinos used to exploit all the forest seral stages in Jaldapara and Gorumara to meet its year-round food and cover requirements (Rawat, 2005). The habitat types and extent in Jaldapara and Gorumara are shown in Tables 21.3 and 21.4.

(a) Jaldapara

The rhinos appear to be confined to the moist habitats supporting the semi-evergreen to evergreen forests, almost always in association with the alluvial plains and tall grassland. This largest tract of tropical grasslands (savannah) in the state consists of *Saccharum sponaneum, S. arundinaceum, Phragmites karka, Arundo donax, Narenga porphyrocoma, Themada villosa,* etc, dotted with associations of Khair-Sissoo (*Acacia catechu-Dalbergia sissoo*) and Simul-Siris (*Bombax ceiba-Albizia procera*) woodlands. Most of these grasslands have been lost to the woodland encroachment. Moreover, due to the use of mostly one particular species *i.e.*, *Saccharum narenga* (Dhadda), which grows vigorously and, naturally, it suppresses the growth of other species of rhino fodder in the vegetation (Ghosh and Das, 2007).

The natural vegetation is in a state of flux due to recurring floods and succession (Bhattacharya, 2012). In Jaldapara, the River Torsa shifted its course in 1968 from west to east over a width of 20 km, creating *Mara* (dead), *Buri* (old) and *Char* (deserted)

Table 21.3: Habitat Types and Extent in Jaldapara

Habitat Type	*Forest Block and Compartments*	*Area in km²*	*Percentage Cover*
Dry mixed	Titi 1-4; Jaldapara 3-5; Torsa 1-3; Chilapata 4B; Hasimara 4	46.17	21.33
Wet mixed (Semi-evergreen)	Jaldapara 2; Hasimara 4; Mendabari 6; Bania 3, 4; Barodabri 1-2; Chilapata 2, 3B	12.41	05.73
Mixed Sal	Barodabri 1-2, 6B, 7B; Mendabari 6; Bania 1; Titi 1-3; Salkumar 1, 3	17.61	08.13
Grassland	Hasimara 3; Jaldapara 3-5; Malangi 1-3; Chilapata 1, 3B; Bania 8B; Barodabri 7B; Torsa 2	30.55	14.11
Grassland and Khair-Sissoo succession	Hasimara 1-4; Dalsingpara 1-4; Joigaon 1-2; Titi 4; Jaldapara 1-5; Malangi 1-2; Chilapata-3B	42.90	19.81
Grassland with Simul-Siris succession	Dalsingpara 1-4; Joigaon 1-2; Titi 1-4; Torsa-1	22.59	10.43
Bamboo brakes	Titi 1; Jaldapara 3; Bania 1	1.23	00.56
Plantations	Mendabari 3-6; Bania 1-4; Titi 2-4; Joigaon 1; Hasimara 2; Dalsingpara 3	26.40	12.20
Sandy riverbed, degraded patch, forest villages	Barodabri 6(a), 7b; Hasimara 2; Malangi 2-3; Chilapata 2	16.65	07.70
Total		216.51	100.00

Table 21.4: Habitat Types and Extent in Gorumara

Habitat Type	*Forest Block and Compartments*	*Area in km²*	*Percentage Cover*
Riverine forest	Tondu 1, 2a, 2b, 3, 4a, 4b; Selkapara 1-2	18.99	23.91
Sal forest	Gorumara 1-2; South Indong 1-3; Bhogolmardi 1-3	27.67	34.82
Wet and dry mixed forest	Barahati 1-3; Central 1; Medlajhora 1-3; Kakurjhora 1-2	25.93	32.63
Savannah forest	Jaldhaka 1b; Dhupjhora 1a, 1b, 1c	6.86	08.64
Total		79.45	100.00

Figure 21.4: Foraging Rhinos in Jaldapara.
(Photo Credit Sourav Basu).

Figure 21.5: Rhino Feeding on Grass in Jaldapara.
(Photo Credit Sourav Basu).

Figure 21.6: Statue in Gorumara.

Torsa and the small Malangi merged with it during the previous floods. Most of the area of earlier course of the Torsa is covered by grassland. However, the emerging trees have invaded the grassland extensively. Weeds and climber infestation has also degraded the habitat.

Many habitat improvement programmes have been undertaken like overwood removal in colonized areas, plantation of indigenous tall and short fodder grasses, eradication of weeds and climbers, selective burning of the grassland for regeneration of nutritive fodder, cutting back of tree species, control of wild fire, etc. A number of concrete water recharging structure was constructed at Harindangar char (Jaldapara-5) for maintaining the water-level of the stream Chirakhawa (preferred rhino-bathing site), which have yielded excellent results.

Spillet (1966) observed that wherever domestic livestock grazing is evident there are few, if any, rhino present. The rhinos used the whole park area up to mid-twentieth century, but subsequently the use-area has been reduced to about 160 km² due to various anthropogenic disturbances (Ghosh, 1991). The core habitat was roughly estimated to be about 100 km² (46.29 per cent) (Syangden *et al.*, 2007). During the present study, 96.04 km² (45 per cent of the total area) were found to be most suitable habitat of the rhinos, of which the pure grasslands cover 30.55 km² (14.11 per cent), grasslands with *Acacia-Dalbergia* succession 42.90 km² (19.81 per cent) and grassland with *Bombax-Albizia* succession 22.59 km² (10.3 per cent), whereas the secondary

habitat was estimated to be about 50 km² and the seasonal (monsoon) upland habitat to be approximately 10 km². The rhinos are not presently known to visit Titi (39.19 km²), Jaigaon (17.56 km²) and Dalsingpara (14.78 km²) blocks, north of National Highway 31A as well as Salkumar (5.02 km²) in between the two legs.

Bhattacharya (1982) described the home range and daily movement pattern of the rhino at Jaldapara and Gorumara. Banerjee (1993) also observed that the rhinos ramble in maximum numbers in most of the seasons within those forest blocks because their preferred food plants (quality as well as quantity) are available there. According to him, the grasslands (dominant species being *Saccharum narenga, S. arundinaceum* and *S. longisetosum* var. *hookeri*) in Chilapata, Torsa and Jaldapara are quite productive (coverage 65-75 per cent and biomass 19.50-22.05 ton/ha) as compared to other areas (Hollong, Bengdaki, Daidaighat, Borodabri, NWCC Line) of the park (coverage 31-41 per cent and biomass 12.5-15.08 ton/ha). Hence, the rhinos are mainly concentrated in the central and southern parts of the park (prime grassland habitat).

Das *et al.* (2003) also analysed nine vegetation types in Jaldapara: (i) Riverine, (ii) Wet Mixed Forest (iii) Sal Forest (iv) Semi-evergreen Forest (v) Low Grassland, (vi) Tall Grassland, (vii) Savannah, (viii) Open Herbland and (ix) Hydrophytic vegetation. But they did not survey all the vegetation types in Chilapata and Nilpara Ranges, as the rhinos rarely or never visit these places. Some places of Mendabari and Bania (Compartments 6 and 7) Beats of Chilapata Range are visited by Rhinos to graze on *Imperata cylindrica, Digitaria ciliaris, Oplismenus compositus, Axonopus compressus* and *Saccharum narenga* for a very brief period before returning to Jaldapara, but never stay at Bania areas for a considerable duration. They observed that two ranges - Jaldapara East (Jaldapara, Sissamara, Daidaighat and Malangi Beats) and West (Hollong, Kunjanagar, Bengdaki and TEC Beats) are high rhino concentration areas. The rhinos visit the CC Line Camp area, across the river, less frequently and they generally graze on *Oplismenus compositus* in the open herbland and on *Saccharum spontaneum* and *S. narenga* (restricted in distribution) in the riverine vegetation. The gross total of rhino-fodder and with specieswise yield, separately for monsoon and post-monsoon, in Jaldapara was also determined (Tables 21.5–21.7). The Beat-wise highest amount of fodder is produced (total of two seasons' production) in Sissamara Beat area (34953.408 qt) which is followed by Jaldapara Beat (29026.037qt), Harindanga (29008.826 qt), Moiradanga Beat (20544.492 qt) and Malangi Beat (17508.463 qt). Range-wise Jaldapara East Range is the highest producer (85730.18 qt) of rhino-fodder followed by Jaldapara West Range (79738.15 qt). The Siltorsa Beat of Jaldapara North Range also produce good amount of fodder (11466.455 qt) and is also a good area for the rhinos to graze. But the yield recorded from Bania and C.C. Line is quite low and it is not possible for the rhinos to live there continuously. While the total recorded yield of fodder during monsoon is 88378.78 qt, it is 89026.21 qt and the total yield of two seasons is 1,77,404.986 qt.

Approximately 30 km² of Jaldapara have good quality grassland (Nandi, 1991). The present study has revealed that the pure grasslands occur in small patches at Jaldapara 3-5, Malangi 1-3, Chilapata 1 and 3b, Bania 8b, Barodabri 7b and Torsa 2 compartments. The grasslands with *Acacia-Dalbergia* succession are found as small islands in the riverbeds and along the old course of Torsa (western leg). During the

study, the rhinos were most frequently found in their prime habitat at Jaldapara 3-5, Torsa 1-2 and Chilapata 1-2. They were also sighted at Malangi 1-3 and Torsa 3. Occasionally, a few rhinos used to visit some parts of the Bania [29.04 km^2 (89°22' E 26°38' N)] and Mendabari [17.38 km^2 (89°23' E 26°38' N)] blocks. Maximum number of rhinos was spotted in the East range (97), followed by West Range (36) and North range (34) (89°15'-89°23' E, 26°32'-26°42' N). In the secondary habitat of the eastern part, 15 rhinos were sighted in Kodalbusty Range and two in Chilapata Range.

Jaldapara 2 (3.03 km^2) and Hasimara 3a (5.24 km^2), 3b (0.05 km^2) and 4 (5.24 km^2) have good grassland with *Dalbergia sissoo*, *Bombax ceiba* and *Acacia catechu*, but suffer from water scarcity, especially during the dry season. The rhinos visit these areas for grazing only. During the rainy season, their concentration increases here, but, during the summer, their number decreases.

A number of wallow pools, artificial glades and salt licks used by the rhinos were located at Jaldapara-3 and 5, Malangi-2 and Chilapata-2 and 3. Regular visibility of the rhinos was recorded from all these sites, particularly during the hot hours of the summer. The rhinos were mostly seen between 6-8.30 am and 5-8.30 pm.

(b) Gorumara

Out of four major forest types in Gorumara, the riverine grassland and savannah woodland with *Acacia-Albizia-Bombax* succession occupy about 30 per cent of the total plant cover (Mandal, 2007). In Gorumara too, the resident rhinos do not use the whole park area. In fact, the core habitat used by them is only 8 km^2 (10.06 per cent)(Bhutia, 2008). Ghosh (2012) mentioned two distinct ecotones for the rhinos-Riverain Rolling Flood Land Forests (RFF), Riverine Riparian Forests (RRF). This habitat offers the best grazing ground for the rhinos. During the present study, the rhinos were found to graze mostly in the riverine grasslands of Dhupjhora and Jaldhaka blocks (6.86 km^2). The rhinos usually avoided the wet mixed forests, but, in the dry season (summer), when there is threat of fire in the grassland, the rhinos frequently used this type of forests at Barahati 1, 3; Central 1; Medlajhora 1; Dhupjhora 1b, 2 and Kakurjhora 2 as resting place and browsed on the lower canopy. The rhinos were mostly seen in the wallow pools and saltlicks located at Tondu 4, Old Khunia, Jaldhaka 1b, Medla doba, Medla 3, South Indong 1, Dhupjhora 1b and Barahati 3.

Abundance of rhino-dung in various habitats of Jaldapara and Gorumara, as recorded during the field survey, is tabulated in Table 21.8. It appears that the rhinos usually prefer the savannah and natural grasslands for grazing than the plantations and riverine forests. In the tropical moist deciduous forest, the dung-heaps were found in Gorumara only, but not in Jaldapara.

In Jaldapara, the rhinos and many other sympatric species such as wild elephant, gaur, hog deer, wild pig and spotted deer partially share the habitat, whereas the rhino habitat in Gorumara is mainly shared by the gaur, the seasonally ranging wild elephants and hog deer existing in low density. Whereas the deer are selective feeders, the rhinos and elephants are bulk feeders, feeding on a variety of grass species. In Jaldapara, particularly in the forest block of Jaldapara, Chilapata, Torsa and Malangi it is the abundance of dung sites of rhino, elephant, gaur, spotted deer and wild pig

Table 21.5: Gross-Total of Palatable Biomass Available in Jaldapara (Das *et al.*, 2003)

Ranges	*Beats*	*Monsoon*		*Post-monsoon*		*Two Seasons' Totalin qt*
		Yield/sqmin g	*Total Yieldin qt*	*Yield/sqmin g*	*Total Yieldin qt*	
Jaldapara East	Jaldapara	248.361	14134.71	261.655	14891.33	29026.037
	Sissamara	358.767	20080.19	265.736	14873.22	34953.408
	Dhai Dhai Ghat	85.331	1987.94	72.857	1620.489	3608.429
	Valuka River	–	–	666.5	633.841	633.841
	Malangi	258.849	8552.378	271.068	8956.085	17508.463
Range Total:			44755.21		40974.97	85730.18
Jaldapara West	Hollong: JP 5 (Harindanga)	148.841	11492.49	226.857	17516.34	29008.826
	Hollong: Torsa 1	44.8	393.656	35.3	310.18	703.836
	Moiradanga	453.402	12241.86	307.505	8302.633	20544.492
	Kunjanagar	288.938	5656.826	293.264	5741.531	11398.357
	Bengdaki	231.655	4816.112	337.051	7007.291	11823.403
	T.E.C.	296.241	2843.914	325.762	3415.319	6259.233
Range Total:			37444.85		42293.29	79738.15
Jaldapara North	Siltorsa	279.953	12351.948	277.761	12255.23	24607.178
	50 ft Camp	32.741	596.546	21.143	385.236	981.782
Range Total:			12948.494		12640.466	25588.96
Chilapata	Bania	72.034	89.682	239.896	298.67	388.352
Kodalbasti	C.C. Line Camp	80.93	20.501	242.2	61.353	81.854
GRAND TOTAL:			95258.737		96268.749	1,91,527.496

Table 6: Species-wise yield of fodder in different parts of Jaldapara Wildlife Sanctuary in monsoon vegetation (Das *et al.*, 2003)

Sl.No. Fodder Species	Ranges and Beats														
	Jaldapara East Range				Jaldapara West Range						Jaldapara North Range		Chiap-ata	Kodal-basti	Total Yield
	Jal.	Sissa.	DD Ghat	Mala.	Hollo.	Harind.	Moirad.	Kunja.	Bengd.	TEC	50 ft	Siltorsa	Bania	CC Line	
1. *Alpinia nigra*	50.415	300.457	*	105.97	*	201.339	*	39.809	*	*	15.639	*	7.679	*	721.308
2. *Arundinella bengalensis*	118.13	170.39	*	57.309	*	120.002	25.955	130.52	112.014	50.88	12.147	197.636	2.219	0.651	997.853
3. *Arundo donax*	633.279	991.75	*	485.417	19.331	827.846	70.519	97.564	54.18	23.36	16.064	160.686	3.221	1.008	3384.225
4. *Axonopus compressus*	1158.06	916.509	*	790.39	115.55	665.553	681.3	178.943	194.09	66.88	27.938	961.359	8.569	3.052	5768.187
5. *Cymbopogon jwarancusa*	114.64	38.479	*	36.263	*	324.646	90	618.665	418.509	153	52.93	56.868	*	*	1903.96
6. *Imperata cylindrica*	1695.3	2233.521	476.39	782.833	60.63	1234.53	1978.14	1537.852	891.563	448.6	59.185	2617.778	13.729	3.051	14033.15
7. *Mikania micrantha*	1644.63	4100.184	939.57	960.346	91.385	1342.629	2533.47	403.959	66.213	71.68	35.924	1621.304	22.533	4.135	13837.969
8. *Saccharum arundinaceum*	174.53	1151.201	*	36.263	*	*	117.058	*	*	*	*	*	*	*	1479.052
9. *Saccharum bengalense*	78.918	519.631	*	*	*	226.813	75.339	*	107.831	*	*	36.572	*	*	1045.104
10. *Saccharum longisetosum var. hookeri*	*	*	*	*	*	*	29.613	*	*	*	*	*	*	*	29.613
11. *Saccharum longisetosum var. longisetosum*	*	1232.294	*	19.485	*	*	233.419	291.06	*	*	*	*	*	*	1776.258
12. *Saccharum narenga*	2753.17	4615.046	*	1763.355	*	1772.068	2669.95	1100.023	1304.65	877.8	129.971	3638.679	13.782	4.298	20642.753
13. *Saccharum spontaneum*	3428.37	1366.177	*	2037.084	*	2375.645	16.113	*	216.783	380.8	107.013	818.699	9.235	3.384	10759.302
14. *Saccharum spontaneum* (Ikra)	400.433	485.285	*	264.093	*	*	632.323	*	32.571	*	*	*	*	*	1814.705
15. *Themeda arundinacea*	166.562	1289.536	*	377.346	*	*	1543.36	117.468	218.61	81.6	*	1451.387	*	*	5245.864
16. *Thysanolena latifolia*	65.411	*	67.214	59.325	15.377	49.867	*	*	*	*	*	*	4.439	*	261.633
17. *Typha angustifolia*	430.947	111.622	*	75.058	*	1065.861	*	*	*	*	70.3	168.082	*	*	1921.87

Table 21.7: Species-wise Yield of Fodder in different Parts of Jaldapara Wildlife Sanctuary in Post-monsoon Vegetation (Das *et al.*, 2003)

Sl.No.	Fodder Species	Ranges and Beats														
		Jaldapara East Range				Jaldapara West Range						Jaldapara North Range		Chiap-ata	Kodal-basti	Total Yield
		Jal.	Sissa.	DD Ghat	Mala.	Hollo.	Harind.	Moirad.	Kunja.	Bengd.	TEC	50 ft	Siltorsa	Bania	CC Line	
1.	*Alpinia nigra*	391.101	34.345	*	32.352	*	526.83	173.452	30.066	*	*	19.344	*	67.048	*	1274.538
2.	*Arundinella bengalensis*	28.93	*	*	110.776	*	38.607	89.659	17.48	80.85	3.52	2.429	48.24	*	3.479	423.97
3.	*Arundo donax*	765.771	909.767	*	179.38	19.331	117.601	225.552	28.604	261.03	82.4	16.034	220.65	*	1.452	2827.572
4.	*Axonopus compressus*	1162.631	1484.223	*	357.566	82.158	347.063	412.728	183.181	439.593	81.68	24.962	1211.892	*	1.469	5789.146
5.	*Cymbopogon jwarancusa*	78.254	*	*	45.43	*	2582.28	442.353	801.363	*	2.88	29.547	890.099	*	*	4872.206
6.	*Imperata cylindrica*	1552.207	2748.89	347.928	775.706	52.283	3186.917	1410.015	1487.229	840.147	403.04	23.261	2622.467	4.564	2.364	15457.018
7.	*Mikania micrantha*	2535.057	2465.987	853.14	3154.448	87.431	518.911	373.419	345.628	1011.78	868.24	28.575	1022.05	97.292	27.055	13389.013
8.	*Saccharum arundinaceum*	*	805.205	*	*	*		110.328	*	*	*	*	*	*	*	915.533
9.	*Saccharum bengalense*	94.853	27.985	*	125.185	*	1435.37	*	76.214	53.13	19.52	*	540.947	*	*	2373.204
10.	*Saccharum longisetosum var. hookeri*	*	*	*	*	*	*	50.741	*	*	*	*	*	*	*	50.741
11.	*Saccharum longisetosum var. longisetosum*	*	1943.686	*	*	*	*	482.835	*	*	*	*	*	*	*	2426.521
12.	*Saccharum narenga*	2110.724	1722.349	*	1263.918	*	5060.223	1888.361	1490.28	1647.03	1052.5	106.892	3279.791	111.09	14.777	19747.915
13.	*Saccharum spontaneum* (Kasia)	2532.415	488.466	*	1633.599	*	51.673	1083.259	*	132.825	63.04	56.27	657.312	7.003	7.481	6713.343
14.	*Saccharum spontaneum* (Ikra)	189.707	961.666	*	110.133	*	*	266.276	174.804	102.795	182.4	*	*	*	*	1987.781
15.	*Themeda arundinacea*	658.045	300.203	*	460.22	*	*	423.621	*	542.85	177.76	*	259.827	*	*	2822.526
16.	*Thysanolena latifolia*	*	*	73.081	*	7.908	*	9.31	*	*	*	*	*	*	*	90.299
17.	*Typha angustifolia*	675.83	122.116	*	392.35	*	2177.209	408.631	*	762.3	*	38.414	112.648	*	*	4689.498

were much higher as compared to other species like sambar and barking deer which favour the woodland and the savannah woodland areas. It was found that the plantation of grasses were mainly preferred by the rhino, elephant, gaur, wild pig, less by hog deer and spotted deer. Moreover, because of its linear shape with two trouser leg like projections and size, Jaldapara is facing severe problem of livestock grazing and human pressure. Thousands of cattle graze inside the forests every day. Contradictorily, Gorumara does not suffer from such acute anthropogenic threats. Due to inadequate availability of fodder during the summer months, it is a period of stress for the resident herbivores. This raises high possibility of the pachyderms straying in the neighbouring areas and causes a serious management problem.

Table 21.8: Abundance of Rhino-Dung in Various Habitats of Jaldapara and Gorumara during Field Survey

Habitat Type	*Jaldapara*	*Gorumara*
Natural grassland	104	19
Plantation	61	17
Tropical moist deciduous forest	–	15
Riverine forest	14	10
Savannah forest	261	10
Total	440	71

Skewed Sex-Ratio

Age composition generally reflects the status of rhinos in terms of its reproductive potential (Spillet, 1966). A high percentage of young animals generally indicates that a population is growing or thriving, whereas a relatively small proportion of young indicates a low producing or senile population. Sex ratios likewise are an indication of reproductive potential. Most mammals, particularly ungulates, are promiscuous in their mating and a single adult male is generally sufficient to cover three or more females. Therefore, within reasonable limits, a predominantly female population has a higher reproductive potential than one with more males. With reliable age composition and sex ratio data, it is possible to calculate the average annual rate of net increase or loss, as well as determine the population status.

The average sex-ratio in Jaldapara and Gorumara was 1:2 during early 1990s (Bist, 1994). But, the ideal or balanced sex-ratio (male:female) of the breeding rhinos is 1:3. Now, there are 61 adult males, 55 adult females, three unsexed, 23 sub-adults and 42 calves in Jaldapara. The figures for Gorumara were 21 adult males, 14 adult females, 7 calves and 1 unsexed including the dispersed rhinos in Chapramari (88º49'-88º51' E, 26º53'-26º54' N) in Wildlife II and Swaraswatipur (west) in Baikunthapur Divisions. So, the population figures for Jaldapara and Gorumara are heavily skewed or male-biased. Further, sex identity of all the individuals in Gorumara was determined using genetic markers developed by Wildlife Genetics Laboratory of Aaranyak and Centre for Conservation and Research of Endangered Wildlife, Cincinnati Zoo and Botanical Garden, USA. Dung provides the source of DNA sample of every individual

and also helps identify its sex. This is achieved through selecting and using a panel of highly polymorphic microsatellite markers for individual identification and sex chromosome linked markers for sex identification. However, the conventional method of head counting by the forest department almost matches with the figure of genetic study, *i.e.* a skewed male to female sex-ratio of 4:1. This study exemplifies how genetic analysis of dung can successfully be used for identification of individual rhinos and their sex, which can be used for long term monitoring of the natural populations. But the animal's age vis-à-vis reproductive capability could not be ascertained from this study. The most serious observation is that the genetic diversity in the Gorumara rhino population is low. Aaranyak is working further in generating genetic information from the rhino population in Jaldapara and to understand spatial distribution of genetic diversity to assist genetic management of the species in future.

It is well known that maternal age influences the natal sex ratio. For the wild dams of *R. unicornis*, the age categories at birth of calf are less than or equal to 12 years, between 12 and 19 years and greater than 19 years. Since the species is polygynous and the average body condition varies among them, it appears that the females in good condition tend to produce male offspring, whereas females in poor condition tend to produce female offspring. The sex ratio of male calves to female calves is expected to be low in young and aging breeding females and high in females of prime breeding age. As they reach the end of their reproductive life, their body condition diminishes. The young or nulliparous dams are in superior body condition compared with middle-aged or multiparous females. Thus, the younger dams would be more likely to produce male offspring. On the other hand, better adult condition affects the reproductive success of the male more than the female. The male in better condition exclude other males from breeding and sire many offspring himself, whereas a male in poor condition is not likely to sire any offspring because he is driven away from the females by the better conditioned males. This tendency is explained below.

Agonistic Interactions and Intraspecific Fighting

In ethology, the term 'agonistic behaviour', coined by Scott and Fredericson in 1951 (Barrows, 2001), in practice, a broader term than 'aggressive behaviour', is any social behaviour related to fighting between contestants who are competing over limited resources including food, shelter and mates. Although agonistic behaviour varies among different species, agonistic interaction includes not only actual aggression between two animals to gain the targeted resource in spite of the high cost involved, such as severe injury or fatality due to the inflicted wounds, but also two more functionally and physiologically interrelated, much safer, ritualistic behaviours, normally occurring in sequence (McGlone, 1986; Manning, 1998).

1. Prelude warming up-cum-threat displays of strength before the final round of battle takes place so that the opponent moves back, and
2. Ultimate submission and/or retreat.

Intraspecific fighting of the resident rhinos is the major mortality factor affecting all sex and age groups in the study area. The adult male rhinos are usually solitary in nature and form temporary associations with the females during sexual encounters.

Since home ranges of the Indian Rhinos show much overlap between different individuals of each sex, the concept of exclusive territory is absent in this species. For example, the breeding bulls have loosely defined territories, which are well defended but can overlap with those of both "weak" males, and with known, neighbouring "strong" males. As a result, the types and outcome of interactions between different sex and age classes are varied because their aggressive or submissive interactions depend on the probability of winning, *i.e.* adult male over adult female or subadult male and the prime-aged bull over the old-aged.

The dominant adult male tries to establish its supremacy by showing off its strength with other adult males for mating with females in oestrus. Hence, fights between males are quite common and whenever two or more adult or subadult rhinos approach each other, either at wallows or foraging grounds, there is every possibility of reaction by at least one of them. Most interactions are short and one individual normally retreats or moves aside. But if both of them are stubborn, one of them starts chasing the opponent over a short distance at the primary stage, failing which a prolonged chase is made by the stronger rhino till the intruder crosses the safe limit. The most prolonged interactions may also take place between an adult male and an adult female and sometimes result in the death of one opponent (Dinerstein and Price, 1991).

Laurie (1978, 1982) also studied the aggressive behaviour in Royal Chitwan of Nepal. High levels of fighting mortality in translocated populations have also been recorded in Chitawan, which accounted for 28.6 per cent of the deaths due to causes other than poaching (Laurie, 1978). The various components of agonistic interactions between the rhinos are sudden turn, prolonged stare, curling back the lips to show the lower tusks, advancing slowly towards the antagonist, charging with head down, horn-to-horn stare, horn clash + lunge, submissive lying, tail curling, immediate fight after initial displays and prolonged chase. In Chitawan, 37 per cent of agonistic interactions escalated to some kind of horn-to-horn confrontation, resulting, in extreme cases, in horn clashes and lunges with the lower tusks to the neck, flanks, and rump of the opponent (Laurie, 1982).

In southern African populations, such incidents accounted for 41 per cent of natural deaths since 1989 (Brett, 1998). Intolerance between the breeding bulls is most frequent in the study area. Ghosh (1991) described in brief about male dominance relationship in Jaldapara. Hazarika and Saikia (2010) also described the non-breeding agonistic behaviour of the male rhinos in Rajib Gandhi Orang National Park in Assam. They have categorised five subtypes of performing threat and threat displays against competitor to chase other intruder from his territory or to defend from unwanted competitor in its own territory. These are:

1. Snorting: A vocal threat by producing a "*khaawk…-khaawk…*" sound at regular interval;
2. Physical threat display or aggression of the dominant individual by expression (erect head, ear pinna, making a mild sound) for pretending to attack the other individual approaching or being approached.
3. Aggressive chasing to displace the weak Rhino or adult Rhino or sub-

adult Rhino by the dominant rhino for a very longer distance.

4. Attacking the opponent and having a horn-to-horn fight and also to inflict deep wounds by using the "tushes", the outer pair of long lower incisors (up to 8 cm of the males and shorter in case of the females), from backside, when the weaker of the opponent fled when charged.
5. Escaping behaviour: Generally, the weak animals does not take part in fights or attack the dominant male, but runs away with a galloping motion.

Recently, Tripathy (2013) highlighted this feature in Dudhwa in the *terai* of Uttar Pradesh.

The rhino males are generally territorial and they mark this area by defecation and/or urine scent markings and compete for estrous females. In fact, it is a predominant feature of rhino sociology. Mostly, the bulls do not associate with one another. Territorial bulls trespassing into the territory of an adjacent bull normally take avoidance action and serious fights are usually averted. Encounters may take the form of short charges with much dust raising or, at closer quarters, horn clashing. Subtle displays may involve pulling the ears back as a sign to the others to keep off; advancing steps often accompanied by a snarl are used as a threat; charges; prodding with the horn or staring at each other, horn against horn, as intimidatory gestures. Horn against horn clashing is a more intense ritual attack, which may develop into horn-wrestling and finally jabbing with the horn. Where a territorial bull is accompanied by a female in oestrus, however, serious fighting may ensue. Wounding may be caused by the horn or by heavy shoulder battering and may lead to internal injury. A deposed territorial bull may be allowed to remain in the territory providing he clearly demonstrates his submissiveness. Subordinate bulls respond to territorial bulls with snorting, snarling or shrieking, but seldom actually engage in fighting, although they have been killed in such encounters. Under the circumstances, when a young bull does try to establish himself in a territory, he either has to do so in an unoccupied area, or fight another bull to win some turf. Such 'upstarts' have little hope of winning a territory off a prime-aged bull (ca 17-30 years old), but can drive out or kill older bulls, who are on the decline physically. Old bulls, if not killed, will move out to a quiet part of their former range or live a fringe existence until they die. But a marked tension always looms large as they are short tempered and become hostile, if encountered. There is a lot of 'scrapping' going on all the time between the dominant and the subordinate rhinos and there are a great number of rhino with scars, torn ears and gashes, particularly the bulls.

Infighting among the adult males is a common site in the study area during the mating season. Avari (1957) doubted if Jaldapara can support a larger population because of the cantankerous nature of the bull and the numerous fights which develop as a result cause quite a number of deaths. These fights usually start over the favours of a female during the breeding season. In some infights, the horns are split or broken off (Ghosh, 1991). Till the first decade of twenty first century, such infighting-casualties were low (1-4 per annum) in the study area. Spillet (1966) described such an encounter in Jaldapara: "On April 2 at 05.45, just after crossing the River Torsa north-west of the Jaldapara Forest Rest House, we heard the roar, followed by two honking snorts, of

rhino somewhere along the river north of us. We started towards the noise, but within a short time encountered an adult rhino. We observed it until we were able to determine its sex and ensure that there were no other rhino present in the tall grass nearby. After leaving the solitary male we sighted a large male at 06.00 coming directly towards us across an open island of sand in the river bed. On the distant bank were two more rhino. The male approaching us had a large bleeding gash, about 24 inches (60 cm) long, which extended across the top of his neck and down onto the left shoulder. The courting male was noticeably smaller than the ousted one and had a much shorter horn".

During the post-independence period, there were very few records of infighting-casualty up to early 1990s and all the reported cases (n= 7) occurred in Jaldapara (Bist, 1994). Thereafter, when the male-female sex-ratio was almost 1: 2, a few recurring incidents of male-male aggression leading to death of the old bulls and subordinate males in both Jaldapara and Gorumara were reported by Yadav (2000a, 2000b). An old bull was severely injured by a dominant male at Jaldapara-5 in December 1992 and again at Torsa-2 in the last week of January 1993, even if the former moved almost 10 km away from the first site. Similar incidents of repeated attacks on an older bull of Jaldapara took place in February 1993, April and September 1994, leading to its death in December.

Yadav (2000a, 2000b) also observed: "Antagonistic behaviour of Rhinos was typical before and during the fight. The dominant male was observed to keep both its ears erect and forward and occasionally move its head upwards before approaching the old male Rhino from a distance of nearly 100 m. As the dominant male approached nearer the old male, it perfumed squirt-urination and rubbed the horn on a medium girth *Dalbergia síssoo* tree. This display was followed by dragging of the hind legs one by one making marks on the earth. Soon after, the dominant male ran towards the older male in full speed with lowered head and making typical sound. Older male Rhino was chased for a distance and was charged by the dominant male by pointed horn in the rump's flanks. During the fight dominant male also opened the mouth wide and displayed tusks. The older male Rhino once turned suddenly to face the other but again ran after a brief pause. Dominant male Rhino chased the opponent for more than 300 m with accompanying typical loud vocalízations. The weak old male Rhino ran in full speed with curled tail. In another incident of clash similar behaviour was observed with additional head to head confrontation. The dominant male Rhino attacked with the horn and the tusks on the head of the weak male Rhino. Attacks were also made from side to side with aim at the head region. However, due to the movement injuries were also received on the neck and side of front folds. Both the male Rhinos frequently performed squirt-urination during the ñght. At the end of every fight the dominant male Rhino totally overpowered the o1d weak Rhino."

Repeated chase and aggressive fighting between one fully grown adult male Rhino and a sub-adult Rhino (5-7 years old) was observed in Gorumara (Yadav, 2000a, 2000b). This particular sub-adult male Rhino was very timid and used to flee immediately on the approach of stronger bull. This sub-adult male Rhino was repeatedly chased by the stronger bull and forced to move out of the prime Rhino habitat. The sub-adult male changed its range use after confrontation with stronger

adult male and shifted to central Diana block after crossing the river Jaldaka in the last week of August 1995. Central Diana block is fragmented patch of forest surrounded by tea garden and human habitation and was not considered safe from protection point of view. It was decided to drive this sub-adult Rhino towards Gorumara using departmental Elephants. However, every time it went up to the River Jaldhaka it again ran back to a small *Dalbergia sissoo* plantation patch on the bank of the river Jaldhaka outside forest area. Since all attempts to drive back the Rhino failed, a team of staff along with one departmental Elephant were stationed in that area to ensure safety of the animal, with the hope that the Rhino may, on its own, enter Gorumara. However, the Rhino was reluctant to cross the river and confined its territory across Jaldhaka river near zero-bundh. The attempts for chemical capture failed in January, 1996 and the operation was ultimately abandoned apprehending that shock and trauma caused by chemically induced capture may have fatal result. In the night of 29.2.1996 the sub-adult Rhino was attacked by the dominant bull Rhino which crossed the river Jaldhaka and fiercely charged the weak rhino. The staff camping nearby burst crackers and drove away the adult male Rhino using departmental Elephant. The fight lasted for around half an hour. During the night, the sub-adult Rhino recieved severe injuries in the right thighs, under portion of the belly and on the left part of the face. Blood was also oozing from these injuries. It was evident from the injuries that the sub-adult male Rhino was completely overpowered by the adult bull and felled to the ground. The dominant bull used its horn ñercely to attack and injure the weak Rhino. Again after a week the dominant bull crossed the river Jaldhaka and entered the patch forest where sub adult male Rhino had taken shelter. It chased the sub-adult male Rhino for around 4 km towards Gommara National Park and forced it to cross the Jaldhaka river. The chase continued upto the Garati Camp where adult bull overpowered the weaker one and again injured it in the right and left thighs. The injured Rhino took shelter in a secluded area of Medla-3 Compartment where Rhinos generally do not visit. The movement of the Rhino was tracked and it was observed that wounds were quite severe. It was decided to keep the injured Rhino within the electric fence to give proper medication. The sub-adult Rhino was guided with the help of departmental Elephant towards the electric fence area. The electric fence was switched off and part of it dismantled when it approached near the fence. When the injured Rhino entered that area the electric fence was made operational. Firstly for some days long acting antibiotics mixed with turpentine oil were sprayed on the wounds from a distance on Elephant back. The movement of the injured sub-adult Rhino was regularly monitored and it was observed grazing, wallowìng and drinking water. After three days the injured Rhino was seen in the resting position when staff went to spray medicine. It was able to move very slowly and again it went near a tree and took resting position. The veterinary doctors administered intramuscular antibiotic and antipyritic injections including a life saving drug. The condition of the Rhino deteriorated fast and it was unable to move and died on 12th March 1996. According to the veterinary doctors the injuries were quite severe and Rhino immovable. It also became anaemic due to heavy blood loss.

Male undergoes a period of heat as does the females and these periods must coincide before mating takes place. Males come into heat when they are in rut. In

females, the period of estrous cycle is about 46-48 days. In the study area, the rhinos prefer to breed between the months of March and September. But the urge for mating of the males and females do not synchronize all the times. When the estrous female refuses the approaching male, she was observed to attack the male (Hazarika and Saikia, 2010). The bulls become equally aggressive during the pre-mating phase when fights were also observed in the study area between an aggressive bull and a cow not in oestrus or accompanied by a calf. In fact, a female reluctant to mate is not tolerated by the approaching male. In the extreme case, the male rhinos often attack and kill the breeding females to ensure that the other male contender does not get possession over it. Such incidents also took place when the breeding females refused to respond to an approaching male and go to another one. In Gorumara, some females (particularly the immature, pregnant and lactating females) died due to struggle during forced mounting, when they often got stuck into the mud (Martin and Vigne, 2012). Old female rhinos incapable to mate are also prone to sustaining injuries. This seems to indicate that they are not being tolerated. Calves generally remain with their mothers for three to four years and are quite protected by mothers. Often the calves were also killed opportunistically to force the reluctant mother to breeding again. In Jaldapara, a lactating male calf was also brutally killed (torn into pieces) by an adult male in September 2011, when the mother did not allow it to mate. Male infanticide was also observed in the study area. After weaning from mothers, the juvenile males are attacked frequently.

The male-male and male-female encounters, resultant injuries and casualties have now become a crucial management issue in Jaldapara and Gorumara. If the injured animals are detected in the forests during regular monitoring, they are captured through chemical immobilization, treated and released after recovery. But sometimes the animals, already under excessive stress, died in spite of taking all possible measured to save them.

Since the sex-ratio has now become heavily imbalanced, 12 rhinos died of suspected infighting in 2012 and another one in January 2013. In the past three years, four males and one female have died in Gorumara because of infighting and two males lost their fight with a stronger one and strayed out of Gorumara permanently. A forty years old male was killed by a young bull in an infight over a female at Siltorsa riverbed of Jaldapara in September 2012. Three male rhinos died in the park within one month. Such incidents took place mostly at Jaldapara 1, 3, 5, Malangi1 1-3, Torsa 1-3, Chilapata 1-2, Barodabri 1, 6, Bania 1, 3, 4, and Torsa riverbed in Jaldapara and Dhupjhora and zero bundh (River Jaldhaka) in Gorumara. On 9th January 2013, a 40-year old male rhino was killed by a young one in Jaldapara. The carcass was found on the Holong River banks in the west range near Sibnathpur village.

Dispersal

Temporary or seasonal local migration for food and shelter is a common phenomenon among the adult rhinos, particularly the males. In the past, the rhinos confined to the grassland habitat between the Rivers Sankosh and Rydak moved freely between Assam and West Bengal. Similarly, the rhinos of Jaldapara and Chilapata travelled to the neighbouring Bhutri forests on the east and also to Cooch

Behar on the south. The Patlakhawa subpopulation also ranged further up to Pundibari near Cooch Behar. The rhinos were distributed across the forest of upper Tondu, lower Tondu and in the floodplains of the Rivers Diana and Jaldhaka on the north-east or Hiljhora forest on the north-west of Gorumara. They further moved up to Indo-Bhutan border on the north and Mynaguri (now non-forest civil area) on the south. In March 1989, one female rhino strayed up to the Bangladesh border and was later brought back. In 1992, another female strayed out to Mahananda Sanctuary by crossing the River Tista and died due to exertion of such longest journey.

Sometimes some of the comparatively weaker individuals (young or old) migrate from the core habitat to distant areas permanently, which may be associated with the competition for reproductive resources. After the deadly infighting between two males over a breeding female, the defeated or chased out rhino was often reported to stray out of the prime rhino habitat to the range-edge or new habitat far away, which is an indicator of the skewed male-female ratio in Jaldapara and Gorumara. Whereas there are contiguous reserve forests in the eastern side of Jaldapara, some older or subordinate male rhinos, after being chased out of the prime habitat by the dominant male, used to move towards the secondary habitat at their range-edge and settle in Bania-Mendabari-Chilapata or southern Patlakhawa forests of Cooch Behar. But they were not reported to go to the disturbed and degraded forests in the north beyond Madarihat or towards the west. The rhinos of Gorumara are known to travel about 8.5 km north up to Chapramari, a sanctuary in between the Jaldhaka and Murti floodplains spread over 9.15 km^2, which has limited area under grass. They also used to stray into the forests of Central Diana or often towards Sipchu-Khumani forests of Jalpaiguri Division.

In the study area, tendency of the rhinos to stray out of the protected areas due to increased biotic and abiotic pressure was observed more during the fall and winter than other seasons. The lists highlighting straying incidents (Table 21.9) and chemically immobilised rhinos (Table 21.10) in the study area will reveal that in most of the cases, bulls were involved and the majority strayed from Jaldapara. Traditionally these animals are tried to retrieve back to the respective protected area with the help of manpower and *kunkis* (trained captive elephants). But driving through the fragmented thickly populated disturbed areas is very difficult and risky too. Besides, such efforts consume lot of resources as well as time. When such an effort fails, chemical restraining and translocation of the disoriented animal becomes the only viable option left to save the life of the individual.

The Apalchand forest (around 80 km^2) of Baikunthapur Division, west of Gorumara at a distance of about 50 km, is close to the River Tista, where a suitable grassland has been developed. In June 1992, a highly vagile female strayed out into the forests of Apalchand range and moved as far west across the River Teesta into Mahananda (88°19'-88°31' E, 26°46'-26°55' N), following the route through Apalchand (88°38' E, 26°47' N) and Salugarah (88°27' E, 26°45' N) Reserve Forests. The rhino was, however, poached. On 15 September 2008, an adult male had strayed out of the core area of Gorumara and went marauding through five villages in Mynaguri block. After one week, a ten-year old female and a calf had strayed out from Gorumara. All of them were driven back to the forests. On 12 November 2009, a seven-year old adult

Table 21.9: Straying of Rhino in Jaldapara and Gorumara

Date	*Loation*	*Sex*	*Extent of Damage*	*Management action*	*Remarks*
15.11.2009	Senpara, Baradighi from Gorumara	Adult male	None	Driven back to forest	–
22.11.2009	Mongpong from Gorumara	Adult male	None	Driven back to forest	–
25.11.2009	Near Tista river beside Saraswatipur, Baikunthapur from Gorumara	Adult male	None	Driven back to forest	–
28.11.2009	Mahananda Wildlife Sanctuary from Gorumara via Baikunthapur	Adult male	None	Driven back to forest	–
02.12.2009	Mongpong from Gorumara	Adult male	None	Driven back to forest	–
11.12.2009	Kathambari, Phuljhora from Gorumara	Adult male	None	Driven back to forest	–
03.01.2011	Moiradanga, Jaldapara	Adult male	None	Tranquillised and released back to forest	–
19.01.2011	Uttar Majabari near Kranti, Baikunthapur from Gorumara	Adult male	None	Driven back to forest	–
20.01.2011	Gazoldoba, 10 no., Baikunthapur from Gorumara	Adult male	None	Driven back to forest	–
23.01.2011	Mongpong from Gorumara	Adult male	None	Driven back to forest	–
28.02.2011	Battala, Belacoba, from Baikunthapur	Adult male	Human injury	Driven back to forest	Prasanta Yadav, DR/Fr. injured

Table 21.10: Chemical Immobilisation of Injured Rhinos in Jaldapara and Gorumara

Sl.No.	Date	Location	Sex/Age	Drug Applied	Remarks
1.	23.10.2003	Torsa-1, Jaldapara	Adult male	Immobilon- 2.5 ml	Treated
2.	12.05.2004	Chilapata-2, Sissamara, Jaldapara	Adult female	Immobilon- 1.7 ml	Inventory of injury
3.	12.05.2004	Chilapata-2, Sissamara, Jaldapara	Calf	Immobilon- 1.7 ml	Inventory of injury
4.	25.05.2005	Dhupjhora, Gorumara	Calf	Immobilon- 0.3 ml	Treated
5.	30.09.2005	Malangi-1, Jaldapara	Adult male	HBM- 2.5 ml	Treated, died
6.	24.11.2005	Torsa-2, Jaldapara	Adult male	Immobilon- 4.7 ml	Treated
7.	10.12.2005	Barodabri-6, Kodalbasti, Jaldapara	Adult male	Immobilon- 2.5 ml	Treated
8.	10.01.2006	Bania-1, Chilapata, Jaldapara	Adult male	Immobilon- 7.6 ml	Treated (Dart missed)
9.	14.01.2006	Bania-3, Chilapata, Jaldapara	Adult male	Immobilon- 2.5 ml	Treated
10.	16.02.2006	Bania-4, Chilapata, Jaldapara	Adult male	Immobilon- 1.3 ml	Treated
11.	19.08.2006	Torsa riverbed, Jaldapara	Adult male	Immobilon- 2.5 ml	Treated
12.	28.09.2006	Barodabri-1, Kodalbasti, Jaldapara	Adult male	Immobilon- 3.0 ml	Treated
13.	29.09.2006	Barodabri-6, Kodalbasti, Jaldapara	Adult male	Immobilon- 3.0 ml	Treated
14.	24.02.2007	Jaldapara-5	Adult male	Immobilon- 2.5 ml	Treated, died
15.	18.03.2007	Malangi-3, Jaldapara	Adult male	Immobilon- 2.6 ml	Treated
16.	02.12.2008	Dhupjhora- 1b, Gorumara	Male, 7 years	Immobilon- 1.25 ml	Treated
17.	14.01.2009	Dhupjhora- 1b, Gorumara	Male, 7 years	Immobilon- 1.00 ml	Treated
18.	03.01.2011	Moiradanga, Jaldapara	Adult male	Xylazine- 2.25 ml	Treated
19.	20.09.2011	Jaldapara-3	Adult male	Immobilon- 1.90 ml, Revivon-1.90 ml	Treated
20.	30.11.2011	Jaldapara-2b	Adult male	Immobilon- 1.50 ml, Revivon-2.00 ml	Treated
21.	09.12.2011	Jaldapara-3	Adult male	Immobilon- 1.70 ml, Revivon-1.70 ml	Treated
22.	05.01.2012	Dhupjhora-1b, Gorumara	Adult male	Immobilon-2.00 ml, Revivon-2.50 ml	Treated

male left Gorumara after losing a fight with its rival, travelled to enter Apalchand forests, then reached Bodaganj under Belakoba range by crossing the Tista and finally entered the Eighth Mile forests of Mahananda. The reluctant rhino could not be driven back from Baikunthapur to Gorumara. In December 2010, another male rhino from Gorumara settled in the Apalchand forest. Ever since the grasslands in Gajoldoba area along the Tista serve as the third natural habitat for the dispersed rhinos. These rhinos occasionally visit the neighbouring forest areas of Saraswatipur and Targhera. Since these are not protected areas, regular patrolling on elephant back is required to monitor their movement.

Conclusions

The probable solutions to counter the problem of high infighting-casualties vis-à-vis skewed sex-ratio of the rhinos in Jaldapara and Gorumara are round-the-clock monitoring, seclusion of the identified more aggressive males in a separate large enclosure for promotion of eco-tourism, reintroduction of more wild females from the neighbouring rangelands, development of new grasslands and translocation of the excess population to other suitable habitats like Apalchand (Baikunthapur) in Jalpaiguri and Rasamati (Patlakahawa) forests in Cooch Behar in phases.

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References

Agrawal, V.C., Das, P.K., Chakraborty, S., Ghose, R.K., Mandal, A.K., Chakraborty, T.K., Poddar, A.K., Lal, J.P., Bhattacharya, T.P., and Ghosh, M.K., 1992. Mammalia . In *Fauna of West Bengal, Part I,* State Fauna Series 3 (Director, Zoological Survey of India, ed.), Zoological Survey of India, Calcutta, India, pp. 113-114.

Ali, S., Azfer, M.A., Basamboo, A., Mathur, P.K., Malik, P.K., Mathur, V.B., Raha, A.K., and Ansari, S., 1999. Characterization of a species-specific repetitive DNA from a highly endangered wild animal, *Rhinoceros unicornis*, and assessment of genetic polymorphism by microsatellite associated sequence amplification (MASA). *Gene,* **228(1-2)**: 33-42.

Avari, E.D., 1957. The Jaldapara Game Sanctuary, West Bengal. *Jour. Bengal Nat. Hist. Soc.,* **29 (3)**: 65-68.

Bahauguna N.C., and Mallick J.K., 2004. Ungulates of West Bengal and its adjoining areas including Sikkim, Bhutan and Bangladesh. In: *Ungulates of India* (Sankar K., Goyal S.P. eds.), ENVIS Bulletin: Wildlife and Protected Areas, **7(1)**: 219-238.

Bahauguna N.C., and Mallick J.K., 2010. *Handbook of the mammals of South Asia.* Natraj Publishers, Dehra Dun.

Banerjee, A.K., 1966. Rhinoceros- a historical treatment. In: *West Bengal Forests, Centenary Commemoration Volume.* Forest Directorate, Government of West Bengal, Calcutta, pp. 241–243.

Banerjee, L.K., 1993. *Plant resources of Jaldapara Rhino Sanctuary*. Botanical Survey of India, Calcutta.

Barrows, E., 2001. *Animal Behavior Desk Reference.* Florida: CRC Press LLC.

Bhattacharya, A., and Pal, B.C., 1982. Daily activity cycle of Great Indian one horned rhinoceros at Gorumara and Jaldapara WLS, West Bengal, India. *J. Bengal Nat. Hist. Soc.*, **1(2)**: 53-58.

Bhattacharya, M., 2012. Unwanted ground vegetation? *Current Science,* **102(5)**: 660.

Bhutia, P.T., 2008. Status of rhino and horn stockpiles in Jaldapara Wildlife Sanctuary and Gorumara National Park. In: *Report on the regional meeting for India and Nepal, IUCN/SSC Asian Rhino Species Group (AsRSG)* (Syangden B. *et al.,* eds.); March 5–7, 2007. Kaziranga National Park, Assam, India. pp. i–ii, 1–28.

Bist, S.S., 1994. Population history of Great Indian Rhino in North Bengal. *Zoo Print*, **9(3–4)**: 42-51.

Borthakur, S., Das, P.K., and Talukdar B.K., 2012. Genetic census of Greater One-horned Rhino in Gorumara National Park, West Bengal, India. *The Rhino Print* (Newsletter of the Asian Rhino Project), Winter: 13.

Brahmachary, R.L., Mallik, B., and Rakshit, B., 1971. An attempt to determine the food habits of the Indian Rhinoceros. *Jour. Bombay Nat. Hist. Soc.*, **67 (3)**:558-560.

Bret, R.A., 1998. Mortality factors and breeding performance of translocated black rhinos in Kenya: 1984-1995. *Pachyderm,* **26**: 69-82.

Das, A.P., Ghosh, C., and Bhowmick, D., 2003. *Project Report on estimation of Palatable Biomass in Jaldapara Wildlife Sanctuary with special reference to Rhinoceros unicornis L*. Department of Botany, University of North Bengal, India.

Das C., 2008. Further discovery of a plaque representing *Rhinoceros unicornis* from Dum Dum excavation, West Bengal: An observation. In: *Recent Researches in Indian Art and Iconography* (Sahai B., ed), Kaveri Books, Delhi, India, pp. 93–95.

Dinerstein, E., and Price, L., 1991. Demography and habitat use by greater one-horned rhinoceros in Nepal. *J. Wildl. Manage*. **55**: 401–411.

Ghosh, C., and Das, A.P., 2007. Rhino-Fodders in Jaldapara Wildlife Sanctuary in Duars of West Bengal, India. *Our Nature,* **5**: 14-20.

Ghosh D.K., 1991. Studies on the ecostatus of the Indian Rhinoceros (*Rhinoceros unicornis*) with special reference to the altered habitat due to the human interference in Jaldapara Wildlife Sanctuary, West Bengal. *Ph.D. Disseratation,* Ranchi University, Bihar, India.

Ghosh, S.B., 2012. Biodiversity and Wild Fodder of Gorumara National Park in West Bengal, India: Fodder Plants and Habitat of Gorumara National Park. *Journal of Environment and Ecology,* **3(1)**: 18-35.

Groves C.P., 1993. Testing rhinoceros subspecies by multivariate analysis. In *Proceedings of an International Conference: Rhinoceros Biology and Conservation* (Ryder O.A., ed), International Rhino Conference, May 9-11, 1991, Zoological Society of San Diego, California, USA, pp. 92-100.

Groves C.P., 2003. Taxonomy of ungulates of the Indian subcontinent. *Journal of the Bombay Natural History Society,* **100(2/3)**: 341-362.

Gupta, A.C., 1958. Gorumara Game Sanctuary. *Journal of Bengal Natural History Society*, **24(4)**: 133-139.

Hazarika, B.C., and Saikia, P.K., 2010. A study on the behaviour of great Indian one-horned rhinoceros (*Rhinoceros unicornis*) in the Rajiv Gandhi National Park, Assam, India. *NeBio.*, **1 (2)**: 62-74.

Laurie, W.A., 1978. The ecology and behavior of the greater one-horned rhinoceros. *Ph.D. Dissertation,* University of Cambridge, Cambridge, 449 pp.

Laurie, W. A., 1982. Behavioural ecology of the Greater One-Horned Rhinoceros (*Rhinoceros unicornis*). *Journal of Zoological Society of London,* **196**: 307-341.

Maharaja of Cooch Behar (Nripendra Narayan Bhupa), 1908. *Thirty-seven years of big game shooting in Cooch Behar, the Duars and Assam: A rough diary.* The Times Press, Bombay, 461 pp.

Mandal S., 2007. Wild fauna of Gorumara National Park, Jalpaiguri, West Bengal. *Intas Polivet,* **8(1)**: 257-261.

Manning, A., 1998. *An Introduction to Animal Behavior*. Cambridge University Press.

Martin E.B., 1996a. Smuggling routes for West Bengal's rhino horn and recent successes in curbing poaching. *Pachyderm,* **21**: 28-34.

Martin E.B., 1996b. The importance of park budgets, intelligence networks and competent management for successful conservation of the Greater One-horned Rhinoceros. *Pachyderm,* **22**: 10-17.

Martin E.B., 1999. West Bengal – Committed to rhino conservation yet a major entrepot for endangered wildlife products. *Pachyderm.,* **27**: 105-112.

Martin E.B., 2006. Policies that work for rhino conservation in West Bengal. *Pachyderm,* 41: 74-84.

Martin E., and Vigne, L., 2012. Successful rhino conservation continues in West Bengal, India. *Pachyderm*, **51**: 27-37.

Menon, V., 1996. *Under siege: poaching and protection of Greater One-horned Rhinoceroses in India.* TRAFFIC International, Cambridge, UK, 55 pp.

Molur S., Sukumar, R., Seal, U., and Walker, S. (eds.), 1995 *Report: Population and Habitat Viability Assessment (P.H.V.A) Workshop: Great Indian One-horned Rhinoceros*: *Jaldapara, 1993.* CBSG, Coimbatore, India, 85 pp.

Mukherjee, A.K., 1963. The extinct, rare and threatened game of the Himalayas and the Siwalik ranges. *Journal of the Bengal Natural History Society,* **32(1)**: 36-67.

Mukherjee, S., and Sengupta, S, 1998. Rhino poaching in Jaldapara Wildlife Sanctuary, North Bengal, India. *Tiger Paper,* **25 (1)**: 20-21.

Nandi, M., 1991. Is Terai grassland in West Bengal safe for Rhinos. *West Bengal*, 33(17): 518-521.

Pandit, P.K., and Yadav, V.K., 1996. Management of Jaldapara Wildlife Sanctuary, West Bengal, India. *Tigerpaper,* **23(4)**: 1-5.

Rawat, G.S., 2005. Vegetation dynamics and management of Rhinoceros habitat in *Duars* of West Bengal: An ecological review. *National Academy Science Letters,* **28(5 and 6)**: 179-186.

Sarma, P.K., 2012. Assessment of habitat utilization pattern of rhinos (*Rhinoceros unicornis*) in Orang National Park, Assam, India. *Pachyderm,* **51**: 38-44.

Spillet, J.J., 1966. The Jaldapara Wildlife Sanctuary, West Bengal. *Journal of Bombay Natural History Society,* **63(3)**: 534-556.

Syangden, B., Sectionov, S.E., Williams, A.C., Van Strien, N.,and Talukdar, B.K. (eds.), 2007. *Report on the Regional Meeting for India and Nepal IUCN/SSC Asian Rhino Specialist Group (AsRSG),* March 5-7, 2007, Kaziranga National Park, Assam, India, 28 pp.

Talukdar, B.K., 2012. Asian Rhino Specialist Group report. *Pachyderm*, **51**: 22-26.

Tripathy, A.K., 2013. Social and Reproductive Behaviour of Great Indian One-horned Rhino*, Rhinoceros unicornis* in Dudhwa National Park, U.P., India. *International Journal of Pharmacy and Life Sciences,* **4(11)**: 3016-3021.

Vigne, L., and Martin, E.B., 2012. A rhino success story in West Bengal, India*. Oryx,* **46(3)**: 327-328.

Wildlife Institute of India, 1997. *Study on the management of rhinoceros in West Bengal: Final Report.* West Bengal World Bank aided forestry project. Dehra Dun, India. pp. 201.

Yadav, V.K., 2000a. Male-male aggression in *Rhinoceros unicornis* – case study from North Bengal, India. *Indian Forester,* **126(10)**: 1030-1034.

Yadav, V.K., 2000b. Male-male aggression in *Rhinoceros unicornis*- An observation from North Bengal, India. *Zoos' Print Journal,* **15(9)**: 328-330.