CHAPTER-VI: FOOD AND FEEDING ECOLOGY

6.1 Introduction

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

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

A number of studies on feeding ecology of Indian Rhino were conducted by several authors in India and Nepal, such as (Laurie, 1978, 82; Deka *et al.*, 2003; Bairagee, 2004; Patar, 1977; Brahmachary *et al.*, 1969, 1971; Bhattacharyya, 1991; Ghosh, 1991; Hazarika and Saikia, 2006). Apart from that, the studies on the chemical composition of food items (Deka *et al.*, 2003; Banerjee, 2001), feeding behaviour of Rhino (Laurie, 1978, 82), analysis of Rhino dung, seed dispersal and germination of seed on Rhino dung (Dinerstein, 1991; Brahmachary

et al., 1971) etc. were carried out in India and Nepal conditions. Among those, most studies were conducted in Terai grassland and on natural and introduced Rhino population. Although, few studies were carried out in the Brahmaputra floodplain area, most of them were qualitative in nature. Hence, the present study was aimed to quantify the data on feeding ecology of Rhino, to analyze the food and feeding habits, food preference and food selectivity of Rhino in Orang National Park.

6.2 Aim and objectives

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

Objectives

(1) To investigate the food habits of Indian Rhino to find out the seasonal feeding pattern in Orang National Park.

(2) To identify the food plants species and its characteristics in different habitat of Orang National Park.

(3) To identify the staple food of Indian Rhino in Orang National Park.

(4) To find out the food selectivity and dietary spectrum of Indian Rhino in Orang National Park, based on gathered data.

6.3 Methodology

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

(a) Vegetation sampling

For vegetation sampling, a total of 80 quadrats (1m × 1m in size) for grasses, 20 quadrats (5m × 5m in size) for shrub and herbs, and 20 quadrats (10m × 10m in size) for

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

(b) Sampling for Food & Feeding

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

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

A^1 = Species 1.

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

6.4. Results

6.4.1 Relative dominance and frequency of food plant species

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

(b) Shrubs and herbs: A total of 27 shrubs and herb species belonging to 16 families (Appendix: 6.2) were recorded during sampling in Orang National Park of which 3 species had a relative frequency <1 and 24 species had a relative frequency >1 (Table: 6.1). The species *Diplazium esculentum* was the highest ranked species among shrubs and herbs with a relative dominance value of 13.83%, while the *Solanum viarum* was the lowest ranked species with a relative dominance value of 0.66% (Appendix: 6.2).

(c) Trees : The study found altogether 27 tree species belonging to 8 families (Appendix: 6.3) in Orang National Park with a relative frequency >1 (Table: 6.1). The *Dalbergia sisso* was the highest ranked species with a relative dominance value of 7.94%, whereas the *Anthochephalus cadamba* ranked the lowest was species with a relative dominance value of 1.19% (Appendix: 6.3.).

Table 6.1. Frequency of occurrence of Grasses, Shrubs, Herbs & Tree species in Orang National Park during study.

Frequency class	Frequency of Grass species	Frequency of shrub and herb species	Frequency of Tree
0—1	48	3	0
1—2	13	8	7
2—3	5	6	5
3—4	1	2	4
4—5	6	3	4
5—6	1	0	1
6—7	1	1	4
7—8	0	0	2
8—9	0	2	0
9—10	0	0	0
10—11	0	0	0
11—12	0	1	0
12—13	0	0	0
13—14	0	1	27
Total	75	27	

6.4.2 Food items and food selection

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

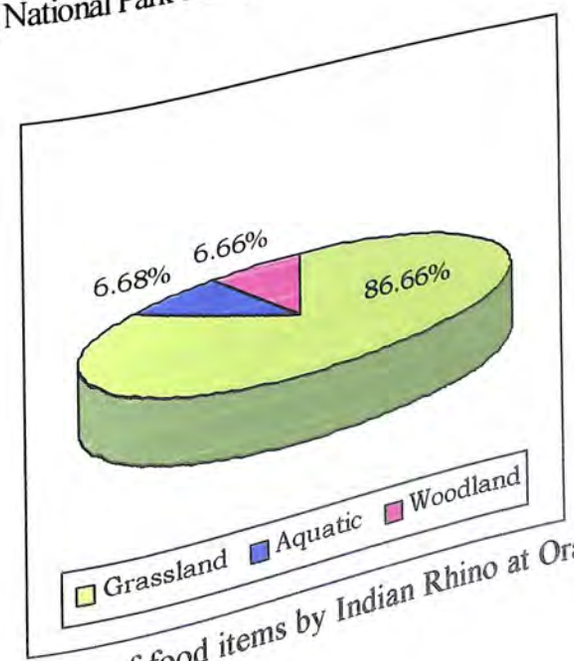

Fig. 6.1 Annual uses of food items by Indian Rhino at Orang National Park (data in yearly basis)

The study also revealed that, the Indian Rhino selected 89.13 % grass species as food items during winter season and 83.50% during monsoon season (Fig: 6.2). Out of total 42 grass species, 20 species had no selectivity but were still eaten, owing to availability of that species in the grassland habitat.

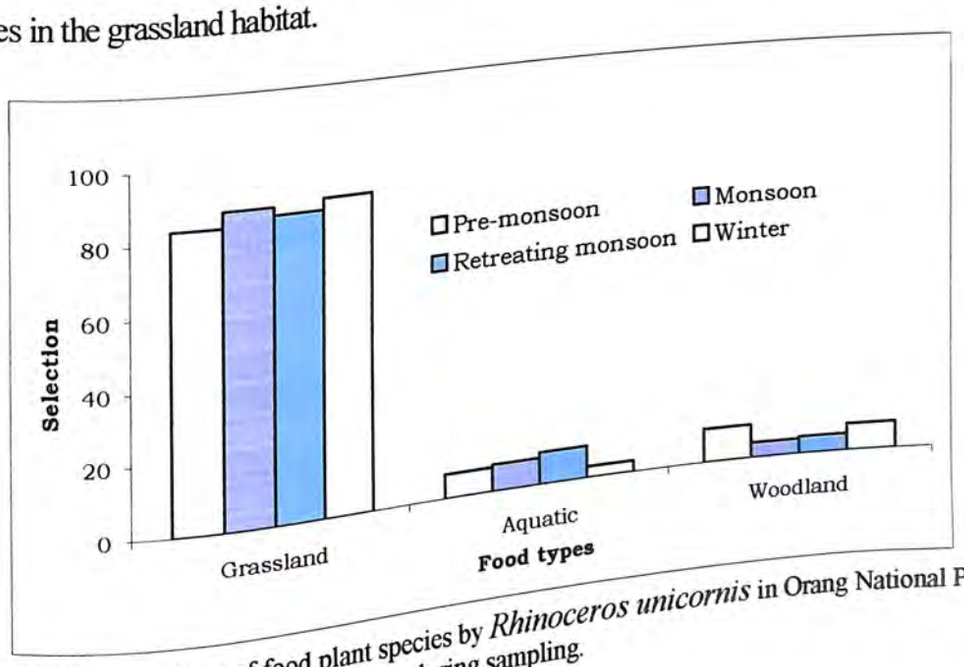

Fig: 6.2 Seasonal use of food plant species by *Rhinoceros unicornis* in Orang National Park during sampling.

6.4.3 Food items

Study showed that, altogether 71 plant species were used by Indian Rhino as food items throughout the year in Orang National Park, of which 42 species were from grasses, 20 species from trees, shrubs and herbs and 9 species were from aquatic food plant species (Appendix 6.4). Again, among all the 71 food plant species, the Indian Rhino consumed a total of 63 plant species as food during pre-monsoon, 49 species during monsoon, 57 species during retreating monsoon and 58 species were used during winter season. The study also revealed that the Indian Rhino consumed 36 grass species, 19 trees and aquatic plant species during pre-monsoon season, 32 grasses, 11 trees and 6 aquatic plants during monsoon season. During retreating monsoon, they consumed total of 33 grass species, 17 trees species and 7 aquatic plants species, whereas, during winter season they consumed total of 39 grass species, 15 trees species and 4 aquatic plants species (Table: 6.2).

Table – 6.2: Seasonal use of food plant species by Indian Rhino in Orang National Park

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

6.4.4. Categories of consumed food plant species

Study showed that, there were altogether 12 different categories, based on plant chracteristics, belonging to three major habitat types, such as Grasslannd, Aquatic and Woodland habitats in Orang National Park (Table:6.3). The Rhino consumed different categories of foood items in various seasons of the year. The analysis of proportional use of food plant types by Indian Rhino showed that, the plant types such as, dry short grass (dsg), wet creeping short grass (wcsg) and wet tall grass (wtg) were consumed in maximum proportion during pre-monsoon season, compared to other types (Fig:6.3). Again, the proportional use of wet creeping short grass (wcsg), dry short grass (dsg), wet tall grass (wtg) and creeping aquatic beds (cab) were higher during monsoon season than other types of food plant species (Fig:6.4). Whereas, the wet creeping short grass(wcsg), wet tall grass (wtg), dry short grass(dsg), submerged (sm) and creeping aquatic beds (cab) types of food plants were consumed in higher proportion during re-treating monsoon season (Fig:6.5). During winter season, the Indian Rhino consumed higher proportion of wet creeping short grass(wcsg), wet tall grass(wtg), dry short grass(dsg), wet short grass(wsg), dry tall tree(dtt) and creeping aquatic beds (cab) types of food plants than other types of species (Fig:6.6).

Table: 6.3. Food plants species, habitat it occurs, feeding percentage and major categories of food plant species of *Rhinoceros unicornis* in Orang National Park.

Food plant species	Families	Types of food Plants	Habitat Category	% of feeding			
				PM	M	RTM	WIN
Grasses							
Agrostis zenkeri	Poaceae	WSG	GL	1.0	0.0	0.0	0.89
Apluda mutica	Poaceae	DSG	GL	2.2	0.5	0.0	1.7
Arundinella begalensis	Poaceae	WCSG	GL	1.8	2.3	1.06	0.9
Arundinella nepalensis	Poaceae	WCSG	GL	1.9	0.7	0.49	1.84
Arundo donax	Poaceae	WTG	GL	7.8	5.6	6.8	5.3
Axonopus compressus	Poaceae	WSG	GL	1.4	0.0	0.0	0.58
Bracharia ramosa	Poaceae	WCSG	GL	2.4	6.8	3.45	2.66
Chrysopogon aciculatus	Poaceae	DSG	GL	4.0	5.8	4.46	4.13
Cynodon dactylon	Poaceae	WSG	GL	3.0	1.5	2.3	1.63
Cyperus cyperoides	Cyperaceae	WSG	GL	0.0	0.1	0.4	0.0
Cyperus rotundus	Cyperaceae	WSG	GL	0.0	2.4	1.6	1.53
Cyperus brevifolius	Cyperaceae	WSG	GL	0.0	0.4	1.8	0
Cyperus globosus	Cyperaceae	WSG	GL	0.0	0.2	0.47	0.23
Cyperus kyllingia	Cyperaceae	WSG	GL	0.0	0.9	0.4	0
Cyrtococcum accrescens	Poaceae	DSG	GL	1.7	0.0	0.0	0.94
Dichantium caricosum	Poaceae	WSG	GL	1.7	0.0	0.0	1.89
Digitaria ciliaris	Poaceae	WSG	GL	0.8	0	0.8	2.4
Echinochloa crusgalli	Poaceae	WSG	GL	0.0	0.0	0.0	0.89
Eleusine indica	Poaceae	DSG	GL	1.8	0.3	1.75	1.92
Eragrostis japonica	Poaceae	WTG	GL	1.2	0.0	0.9	0.56
Eragrostis unioloides	Poaceae	WSG	GL	0.8	0.1	0.0	1.84
Erichola procera	Poaceae	WSG	GL	1.7	0.5	0.6	0.32
Hemarthria compressa	Poaceae	WSG	GL	7.9	13.0	14.3	11.8
Hemarthria protesna	Poaceae	WSG	GL	1.0	1.6	1.86	0.82
Hygroryza aristata	Poaceae	WSG	GL	1.8	2.3	2.48	1.34
Hymenachne pseudointerrupta	Poaceae	WSG	GL	7.9	14	12.6	8.57
Sacciolepis interrupta	Poaceae	WCSG	GL	2.2	1.0	0.74	2.06
Leersia hexadra	Poaceae	DSG	GL	3.5	14	9.23	8.7
Leptochloa panicea	Poaceae	WCSG	GL	1.8	1.0	1.7	1.56
Panicum walense	Poaceae	WSG	GL	1.3	0.0	0.0	0.84
Oplismenus burmannii	Poaceae	DSG	GL	1.3	1.0	1.6	0.87
Paspalidium flavidum	Poaceae	DSG	GL	0.6	0.0	0.56	1.61
Paspalum conjugatum	Poaceae	WCSG	GL	0.7	1.3	1.33	0.89
Paspalum dilatatum	Poaceae	WSG	GL	0.9	1.1	1.5	0.6
Phragmites karka	Poaceae	WSG	GL	5.8	3.3	3.88	4.67
Saccharum procerum	Poaceae	WTG	GL	1.1	1.8	0.93	1.83
Saccharum ravanae	Poaceae	WTG	GL	2.6	1.8	0.8	2.31
Saccharum spontaneum	Poaceae	WTG	GL	3.7	1.0	0.68	2.89

Sateria pumila	Poaceae	WSG	GL	0.0	0.0	0.0	1.7
Themda villosa	Poaceae	WTG	GL	2.4	0.8	1.06	2.62
Vetiveria ziganoides	Poaceae	WTG	GL	0.0	0.0	0.8	0.07
Imperata cylindrica	Poaceae	DSG	GL	1.6	2.5	2.6	1.2
Aquatic Plants							
Ipomea aquatica	Convolvulaceae	CAB	Aq	1.0	1.5	1.9	1.26
Pistia stratiotes	Araceae	FFAB	Aq	1.7	1.6	0.74	0.89
Eichhornia cressipes	Pontideriaceae	FFAB	Aq	0.9	1.1	0.84	0.0
Vallisneria spiralis	Hydrocharitiaceae	SM	Aq	0.7	0.0	1.66	0.0
Hydrilla verticillata	Hydrocharitiaceae	SM	Aq	1.6	0.0	1.8	0.3
Nymphaea nouchali	Nymphaeaceae	EAB	Aq	0.0	1.0	0.87	0.0
Trapa bispinosa	Trapaceae	EAB	Aq	0.3	0.0	0.0	0.0
Enhydra fluctuans	Asteraceae	CAB	Aq	0.5	2.1	1.35	0.7
Alpinia allughas	Zingiberaceae	SV	Aq	0.1	0.2	0.0	0.0
Herbs and Shrubs							
Ageratum conyzoides	Asteraceae	DS	WL	0.5	0.0	0.02	0.4
Mikenia micranth	Asteraceae	DH	WL	0.5	0.0	0.47	0.55
Melastoma malabathricum	Melastomaceae	DS	WL	0.6	0.0	0	0
Lantana camera	Verbenaceae	DS	WL	0.7	0.0	0.55	0
Xanthium strumarium	Asteraceae	DS	WL	0.7	0.0	0.53	0.16
Grewia sapida	Tilliaceae	DS	WL	0.9	0.7	0.61	0.53
Polygonum hydropiper	Polygonaceae	DH	WL	0.0	0.0	0.0	0.01
Diplazium esculantum	Dryopteridaceae	DH	WL	0.9	0.0	0.2	0.67
Amaranthus spinosus	Amaranthaceae	DH	WL	1.0	0.0	0.6	0.0
Trees							
Bombax ceiba	Bombaceae	DTT	WL	0.9	0.0	0	0.78
Trewia nudiflora	Euphorbiaceae	DTT	WL	0.5	0.6	0.66	0.76
Dalbergia sisso	Papilionaceae	DTT	WL	0.7	0.9	0.12	0.87
Cassia fistula	Cesalpiniaceae	DTT	WL	0.5	0.4	0.05	0.81
Mangifera indica	Anacardiaceae	DTT	WL	0.0	0.4	0.03	0.0
Ficus glomerata	Moraceae	DTT	WL	0.6	0.4	0.01	0.63
Streblus asper	Moraceae	DST	WL	0.0	0.0	0.01	0.0
Ficus rumphii	Moraceae	DTT	WL	0.1	0.4	1.03	0.9
Artocarpus lakoosha	Rhamnaceae	DTT	WL	0.0	0.5	0.01	0.04
Ziziphus zuzuba	Liguminoceae	DST	WL	0.5	0.3	0.02	0.26
Bauhinia purpurea		DTT	WL	0.0	0.0	0.02	0.35

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

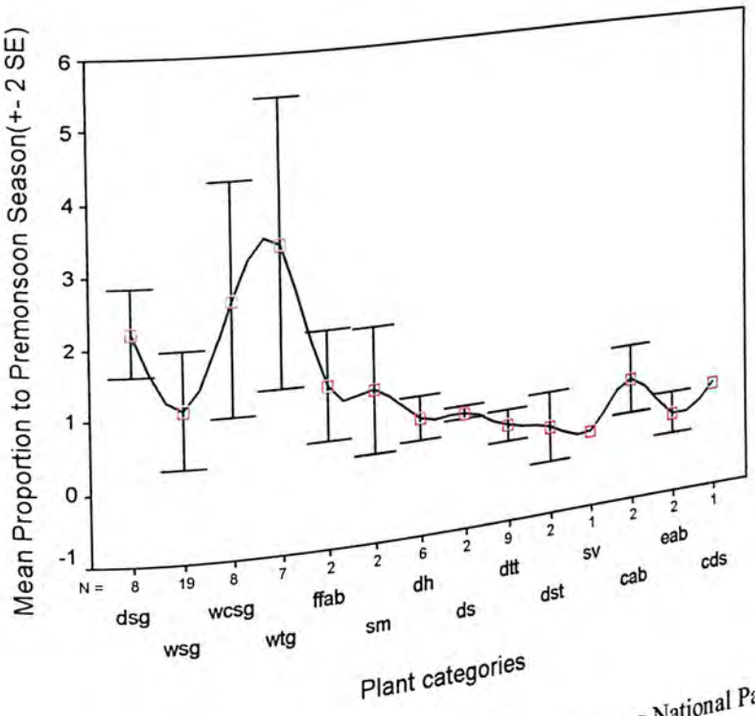

Fig: 6.3: Proportional use of food plants species by Indian Rhino in Orang National Park during Pre-monsoon season (data was represented, Mean ± 2SE; **wsg:** Wet Short Grass; **wcsg:** Wet Creeping Short Grass; **dsg:** Dry Short Grass; **dst:** Dry short tree; **dtt:** Dry tall Tree; **dh:** Dry herbs; **ds**: Dry shurbs; **eab**: Emergent aquatic bed; **cab**: Creping aquatic bed; **ffab**: Free-floating aquatic bed; SM: Submerged; **sv:** Swampy Vegetation)

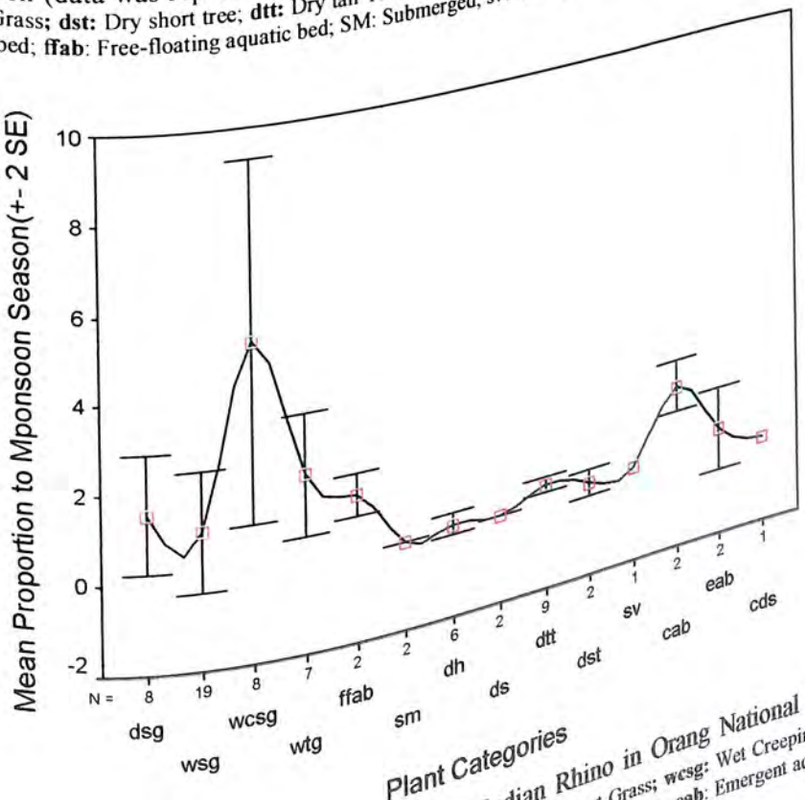

Fig: 6.4: Proportional use of food plants species by Indian Rhino in Orang National Park during Monsoon season (data was represented, Mean ± 2SE; **wsg:** Wet Short Grass; **wcsg:** Wet Creeping Short Grass; **dsg:** Dry Short Grass; **dst:** Dry short tree; **dtt:** Dry tall Tree; **dh:** Dry herbs; **ds**: Dry shurbs; **eab**: Emergent aquatic bed; **cab**: Creping aquatic bed; **ffab**: Free-floating aquatic bed; SM: Submerged; **sv:** Swampy Vegetation)

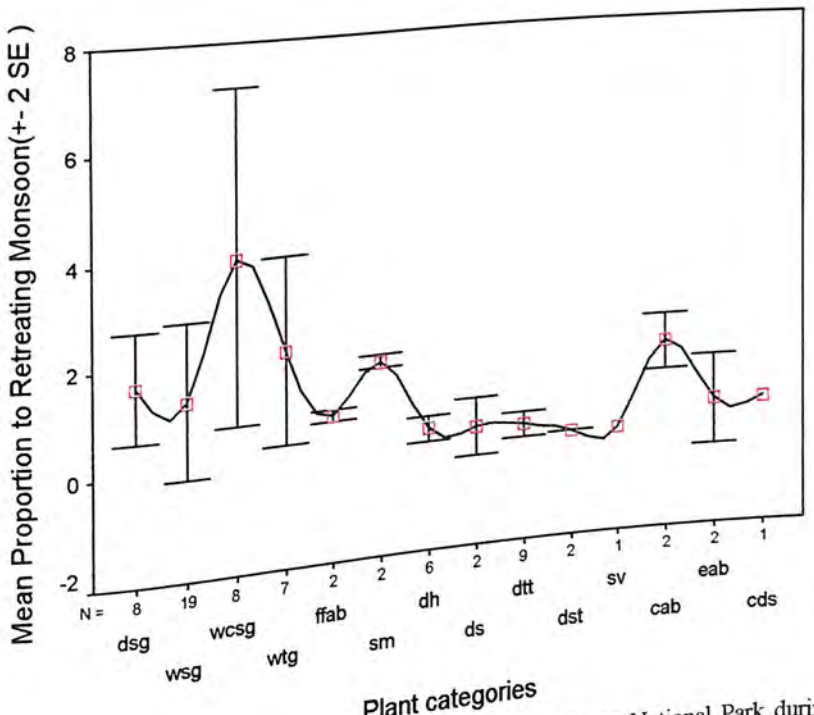

Fig: 6.5: Proportional use of food plants species by Indian Rhino in Orang National Park during Retreating monsoon (data was represented, Mean ± 2SE; **wsg:** Wet Short Grass; **wcsg:** Wet Creeping Short Grass; **dsg:** Dry Short Grass; **dst:** Dry short tree; **dtt:** Dry tall Tree; **dh:** Dry herbs; **ds**: Dry shurbs; **eab**: Emergent aquatic bed; **cab**: Creping aquatic bed; **ffab**: Free-floating aquatic bed; SM: Submerged; **sv:** Swampy Vegetation).

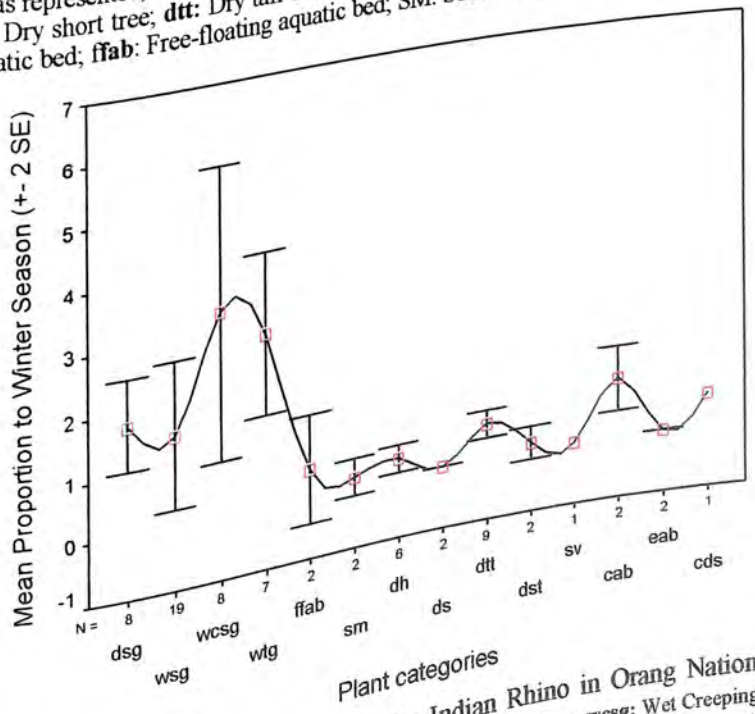

Fig: 6.6: Proportional use of food plants species by Indian Rhino in Orang National Park during Winter season (data was represented, Mean ± 2SE; **wsg:** Wet Short Grass; **wcsg:** Wet Creeping Short Grass; **dsg:** Dry Short Grass; **dst:** Dry short tree; **dtt:** Dry tall Tree; **dh:** Dry herbs; **ds**: Dry shurbs; **eab**: Emergent aquatic bed; **cab**: Creping aquatic bed; **ffab**: Free-floating aquatic bed; SM: Submerged; **sv:** Swampy Vegetation).

6.4.5 Feeding frequency

The study revealed that, the grass species *Hemarthria compressa* contributed the highest consumed (11.63%) food plant species of Rhino, while the marshyland plant species *Polygonum hydropiper* was the lowest consumed (0.01%) food plant species, in their total annual diet. The annual feeding frequency of the ten top ranking plant species of Indian Rhino in their total annual diets were the *Hemarthria compressa, Hymenachne pseudointerrupta, Leersia hexandra, Arundo donax, Chrysopogon aciculatus, Phragmites karka, Bracharia ramosa, Cynodon dactylon, Saccharum spontaneum* and *Imperata cylindrica* (Table: 6.4).

Table- 6.4: Shows the ten top ranking annual food plants of Indian Rhino in Orang National Park during study period.

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

6.4.6 Staple food

The analysis showed that, altogather 36 plant species (Table: 6.5) were selected by Indian Rhino as their regular food item. This 36 numbers constituted 83.64% of the total annual diet budget of Indian Rhino in Orang National Park. Among all the 36 plant species, 24 plant species were grasses that constituted 75.97% of the total selected annual food plant species; hence, it referred as staple food of Indian Rhino. But, among non-grass species, only

9 trees species and 3 aquatic plant species were also selected as annual food, which constituted only 7.67% of the total annual diet, that were also referred as staple food (Table : 6.6).

Table-6.5: **Staple food** of Rhino in Orang National Park (a) Grasses (b) Trees, (c) Aquatic plants.

a. Grasses

Name of the Food plant	Seasons			
	PM	M	RM	W
Arundinella begalensis (Spreng.) Druce.	1.8	2.3	1.06	0.9
Arundinella nepalensis Trin.	1.9	0.7	0.49	1.84
Arundo donax Linn.	7.8	5.6	6.8	5.3
Bracharia ramosa (L.) Stapf.	2.4	6.8	3.45	2.66
Chrysopogon aciculatus (Retz.) Trin.	4.01	5.8	4.46	4.13
Cynodon dactylon (L.) Pers	3.02	1.5	2.3	1.63
Eleusine indica (L.) Gaertn.	1.84	0.25	1.75	1.92
Erichola procera (Retz.) C.E.Hubb.	1.71	0.5	0.6	0.32
Hemarthria compressa (L.f.) R.Br.	7.9	12.5	14.3	11.83
Hemarthria protesna Steud.	0.96	1.56	1.86	0.82
Hygroryza aristata (Retz.) Nees ex Wight&Arn.	1.81	2.26	2.48	1.34
Hymenachne pseudointerrupta	7.93	13.5	12.57	8.57
Imperata cylindrica (L.) Beauv.	1.6	2.5	2.6	1.2
Leersia hexandra Sw.	3.54	13.72	9.23	8.7
Leptochloa panicea (Retz.) Ohwi	1.8	1.03	1.7	1.56
Oplismenus burmannii (Retz.) P.Beauv.	1.3	1.01	1.6	0.87
Paspalum conjugatum Berg.	0.7	1.3	1.33	0.89
Paspalum dilatatum Poir.	0.86	1.08	1.5	0.6
Phragmites karka (Retz.) Trin.ex.Steud.	5.83	3.3	3.88	4.67
Saccharum procerum Roxb.	1.08	1.81	0.93	1.83
Saccharum ravanae (L.) Beauv.	2.61	1.8	0.8	2.31
Saccharum spontaneum Linn.	3.68	0.96	0.68	2.89
Sacciolepis interrupta (Willd.) Stapl.	2.2	0.95	0.74	2.06
Themeda villosa(Poir.) A.Camus.	2.4	0.83	1.06	2.62

b. Trees	Seasons			
	PM	M	RM	W
Artocarpus lakoosha Roxb.	0.02	0.45	0.01	0.04
Bauhinia purpurea L.	0.02	0.01	0.02	0.35
Cassia fistula L.	0.49	0.37	0.05	0.81
Dalbergia sisso Roxb.	0.67	0.85	0.12	0.87
Ficus glomerata Roxb.	0.57	0.36	0.01	0.63
Ficus rumphii Bl.	0.05	0.35	1.03	0.9
Grewia sapida Roxb.	0.94	0.66	0.61	0.53
Trewia nudiflora L.	0.52	0.62	0.66	0.76
Ziziphus zuzuba Lamk.	0.46	0.29	0.02	0.26
c. Aquatic plants				
Enhydra fluctuans Lour.	0.5	2.1	1.35	0.7
Ipomea aquatica Forssk.	1.03	1.48	1.9	1.26
Pistia stratiotes Linn.	1.73	1.6	0.74	0.89

Table –6.6: Percent use of Staple food by Indian Rhino in Orang National Park

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

PM= Pre monsoon; M=Monsoon; RM= Reteating monsoon; W=Winter

6.4.7 Dietary spectrum

The food selection pattern of the Indian Rhino showed a distinct dietary spectrum during present study. The study showed that up to 10 top ranking food plants species of Rhino constituted almost 56.44% of the total annual diet, but it was 72.19% up to 20 top ranking food plants species, whereas, the rest 41 food plants constituted only 28% of the total annual diet of the Rhinos in Orang National Park (Fig: 6.7). Again, among the 20 top ranking food plant species, 19 species were grasses and only one species was aquatic plant species (*Ipomea aquatica*). This clearly indicated that, the grass alone was the sufficient food items, of Rhino, necessary for survival in Orang National Park.

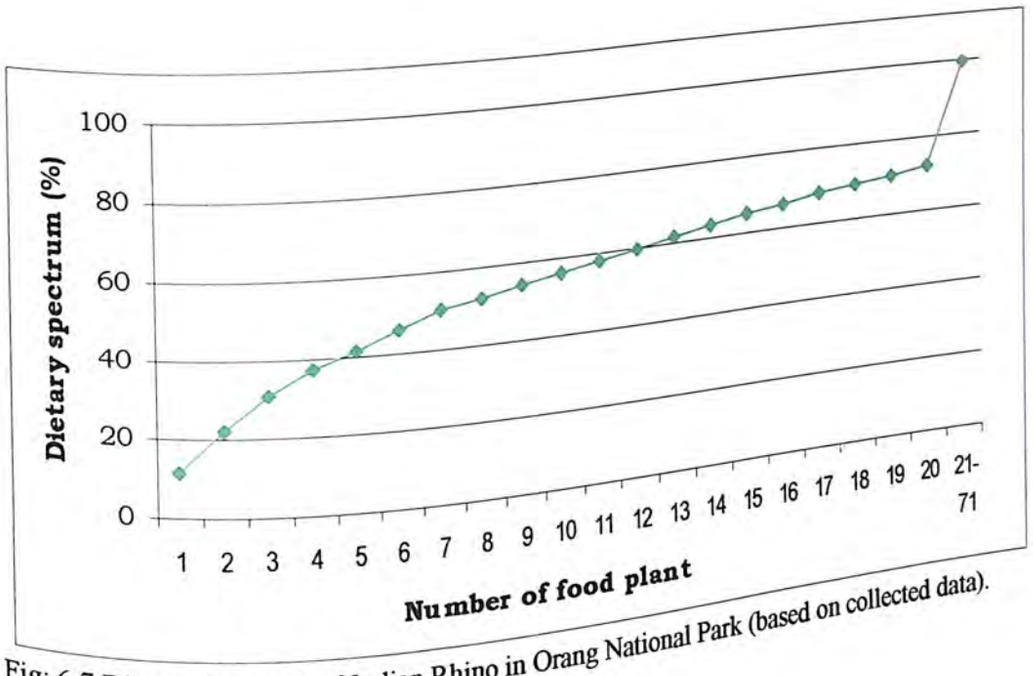

Fig: 6.7 Dietary spectrum of Indian Rhino in Orang National Park (based on collected data).

6.4.8 Cultivated crop as food

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

Table– 6.6: Cultivated crop and vegetable species eaten by Indian Rhino as food along with natural food item.

Crop	Vegetable and other plants
Zea mays (Zea)	*Cucurbita pepo* (Summer Squash)
Oryza sativa (Paddy)	*Cucurbita maxima* (Red Pumpkin)
Cicer arietianum (Gram)	*Luffa acutangula* (Ridged gourd)
Pisum sativum (Peas)	*Cucumis sativus* (Cucumber)
Cajanus cajan (Pigeon Pea)	*Capsicum annum* (Chilli)
Phaseolus mungo (Black Gram)	*Abelmoschus esculentus* (Lady's finger)
Phaseolus lunatus (Lima bean)	*Cucurbita maxima* (Sweet gourd)
Phaseolus aureus (Green Gram)	*Solanum melongena* (Brinjal)
Triticum aestivum (Wheat)	*Ipomea batatus* (Sweet potato)
Lathyrus sativus (*Khesari dal*)	*Carica papaya* (Papaya)

6.4.9 Geophagy (Soil eating)

Seven soil eating (soil licking) sites of Indian Rhinos were located in Orang National Park, during study period (Table- 6.8). The Rhino frequently visited the soil eating sites during night hours. It was also reported by the forest personnel that, the Rhino occasionally consumed soil near the forest camps.

Table - 6.8: Soil eating locations in Orang National Park

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

6.5 Discussion

In the present study, the consumption of 86.66% grass species followed by 6.68% aquatic plants and 6.66% woodland species (browse) by Indian Rhino indicates that, grass is the main food plant species of Rhino in Orang National Park. This is also evident from the seasonal diet pattern, where 89.13% grass was

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

Again, the number of food plant species of Indian Rhino varies from habitat to habitat which was suggested by other studies. Laurie (1978, 82) stated that, Indian Rhino fed on 183 food plant species belongs to 57 families in Chitwan National Park. Ghosh (1991) stated that Rhino consumed 82 plant species belonging to 34 families in Jaldapara Wildlife Sanctuary. So, it ~~is~~ varies in varying occasion. The

present study indicates that, the Indian Rhino of Orang National Park confined to 71 plant species of which 42 are grasses, 20 are woodland and 9 are aquatic species. This type of food composition is almost also almost same in various seasons of the year, hence, grasses play a major role in diet composition of Indian Rhino.

The most preferred 10 top ranking food plants are namely, *Hemarthria compressa* (11.63%), *Hymenachne pseudointerrupta* (10.64%), *Leersia hexandra* (8.80%), *Arundo donax* (6.38%), *Chrysopogon aciculatus* (4.60%), *Phragmites karka* (4.42%), *Bracharia ramose* (3.83%), *Cynodon dactylon* (2.11%), *Saccharum spontaneum* (2.05%), *Imperata cylindrica* (1.98%).

All these 10 species are from grasses and are growing in wet grassland habitat. These findings of top ranking species are contradictory with the findings of Laurie (1978, 82) and Ghosh (1991) in Chitwan National Park of Nepal and Jaldapara Wildlife Sanctuary of West Bengal respectively. But the study conducted by Bhattacharyya (1991) in Karziranga National Park of Assam, is almost similar to the present study. This clearly indicates that, the wet grassland habitat plays a vital role in the food selection by Indian Rhino in the Brahmaputra floodplain habitat of Orang National Park and other protected areas of Assam (India) in comparison to other Rhino habitats of South-East Asia.

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

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

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

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

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CHAPTER: VII : BEHAVIOURAL ECOLOGY

7.1 Introduction

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

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

comprehensive conservation strategy for Indian Rhino in Orang National Park as well as in Assam.

7.2 Aim and objectives

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

Objectives

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

7.3 Methodology

(a) Sampling methods

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

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

of Indian Rhino from the park area was collected and the GPS locations of visiting sites and the status of the Rhino after stray out were also recorded.

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

7.3.1 Data analysis

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

7.4 Results

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

7.4.1 Behavioural Cataloguing

Altogether 14 major behavioural patterns were categorized for Indian Rhino in Orang National Park, those were such as (1) Feeding, (2) Locomotion, (3) Comfort, (4) Vigilance, (5) Non- breeding agonistic behaviour, (6) Non-breeding play behaviour (7) Local migration (8) Crop raiding behaviours (9) Vocalization (10) Courtship behaviour (11) Mating behaviour (12) Breeding play behaviour (13) Breeding Vocalization and (14) Breeding agonistic behaviours. Apart from these major types, certain subtypes were also categorized, such as under locomotion behaviour, three subtypes were identified (i) Walking (ii) Galloping and

(iii) Running, under feeding behaviour, six subtypes, such as (i) Browsing (ii) Grazing (iii) Drinking and (iv) Dive-feeding (v) Breast feeding and (vi) Geophagy. Under non-breeding agonistic and breeding agonistic behaviour, five subtypes were categorized such as (i) Snorting (ii) Threat Display (iii) Chasing (iv) Attack and (v) Escaping behaviour. Under comfort behaviour, three sub-types were categorized, such as (i) Resting (ii) Sleeping and (iii) Wallowing and under wallowing behaviour, two subdivisions such as (a) Mud wallowing and (b) Water wallowing. In case of breeding behaviour, two major types of behaviours were found such as (1) Courtship behaviour and (2) Mating behaviour and under courtship three subtypes such as (i) Touching (ii) Licking and (iii) Chasing behaviour, whereas mating behaviour was also categorized into two subtypes (i) Mounting and (ii) Dragging behaviour (Plate -4).

7.4.2 Description of behavioural patterns

A. Non- breeding behaviour

1. Feeding behaviour

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

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

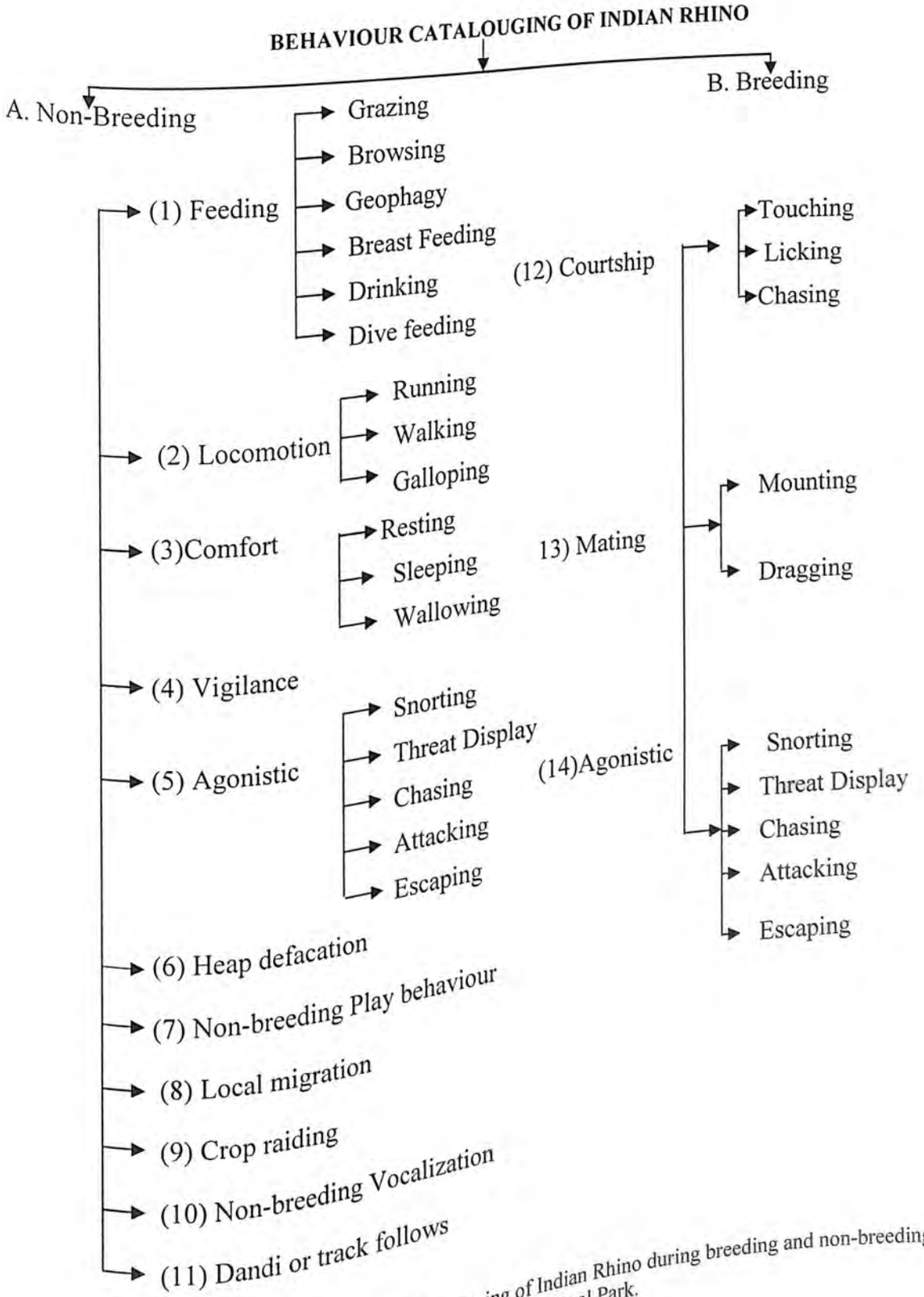


Fig. - 7.1: Flow chart of Behavioural Cataloguing of Indian Rhino during breeding and non-breeding period at Orang National Park.

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

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

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

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

vi) Dive feeding: Dive feeding is a technique of feeding on under-water or submerged food plant like *Hydrilla, Vallisneria* etc. Rhino immerse their head in to water and very often dive into deep water, bite and collect mouthful of grasses and

resurface again. The grasses collected were chewed and engulfed above water surface only. The individual remains in water for more than 2 min to collect food plants. The dive feeding behaviour was very common at mid-day period also, when Indian Rhino in Orang National Park was generally found in comfort behaviour. In Orang National Park, dive feeding behaviour was observed especially during Retreating monsoon and monsoon season.

2. Locomotion

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

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

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

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

3. Comfort behaviour

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

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

ii) Sleeping behaviour: The sleeping behaviour is the motionless state of animal like the resting behaviour, but the eyes of the animal always remained closed. In this state, the animal occasionally spread out all its legs on the ground and become flat, so it looks like a dead Rhino. The alertness of the animal in this posture has completely absent, here one person could approach the Rhino very near and could touch the body.

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

a) Mud wallowing: It is the process in which the Indian Rhino lies in mud or rolls their body in mud.

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

The duration of both types of wallowing varies from few minutes to several hours with or without interval. Most often the wallowing activities found to be solitary, but

occasionally up to 11 individuals in a same place were also observed. However, no age-sex specific social bonding was found during wallowing. When other rhinos approached the wallowed site, they shared the same site without conflict. When other animals like elephant approached the site, rhinos stand up and kept vigilance of the situation and go away without interaction when found uncomfortable.

Observation showed that, the Indian Rhino preferred open water or wetland with grasses for wallowing. They generally found to wallow in shallow water wetlands up to the water level below half of the body. The wallowing posture was same with sleeping and resting posture while the lower portion of the body was remained stuck into the mud and upper portion of the body was remained partially movable. Rhino was also found to use only in muddy place for wallowing.

4. Vigilance

Vigilance was the solitary behaviour of Rhino, without performing almost any other activities like feeding, running, walking, sleeping etc., nor they performed any social interactions. But carefully looked around and continuously watched the intruder or locate the sound. During vigilance, the Rhino erected their head and moves in and around for watching the situation. The ear pinna became erected either vertical or horizontal direction. Sometimes it moved both the direction and tries to locate the sources of sound or object. The eyes and ears were used during the process of vigilance behaviour. During vigilance, the Indian rhino occasionally produced mild sound. The Rhinoceros has found to be very much-alert animal in presence of other animals, especially, the large predators. The vigilance of cow with calf was found to be very active during wallowing than other age sex class. The cow always found to keep an eye on her calf for predators or any other uncomfortable situation. In wallowing posture, the cow was found to vigil and watched for a longer period (upto 90 minutes) without moving.

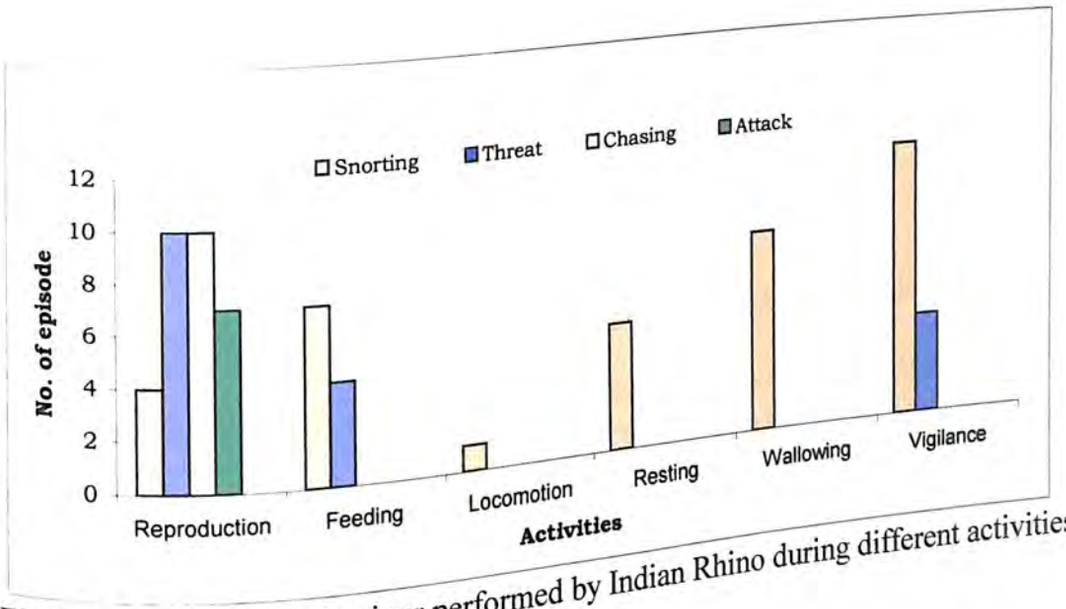


Fig.7.2: Aggressive behaviour performed by Indian Rhino during different activities in Orang National Park.

5. Non-breeding agonistic behaviour:

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

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

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

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

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

v) Escaping behaviour: Generally, weak animal never took part in fight attack. The weak animal goes away from nearby animal, either run away or galloping behaviour. It was a common phenomenon observed for Rhino during non-breeding season.

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

6. Heap defecation behaviour

The Indian Rhino had a tendency to defecate in a particular location, and as a result of continuous deposition of dung at the same spot, leads to form a heap like structure. This type of defecation behaviour was possessed by Indian Rhino alone. In all study blocks the rhino was to defecate only in the form of heap structure.

Altogether 76 number of rhino dung heaps were observed in different blocks of Orang National Park .The highest number of dung heap was found in block-2 (Fig: 7.3).

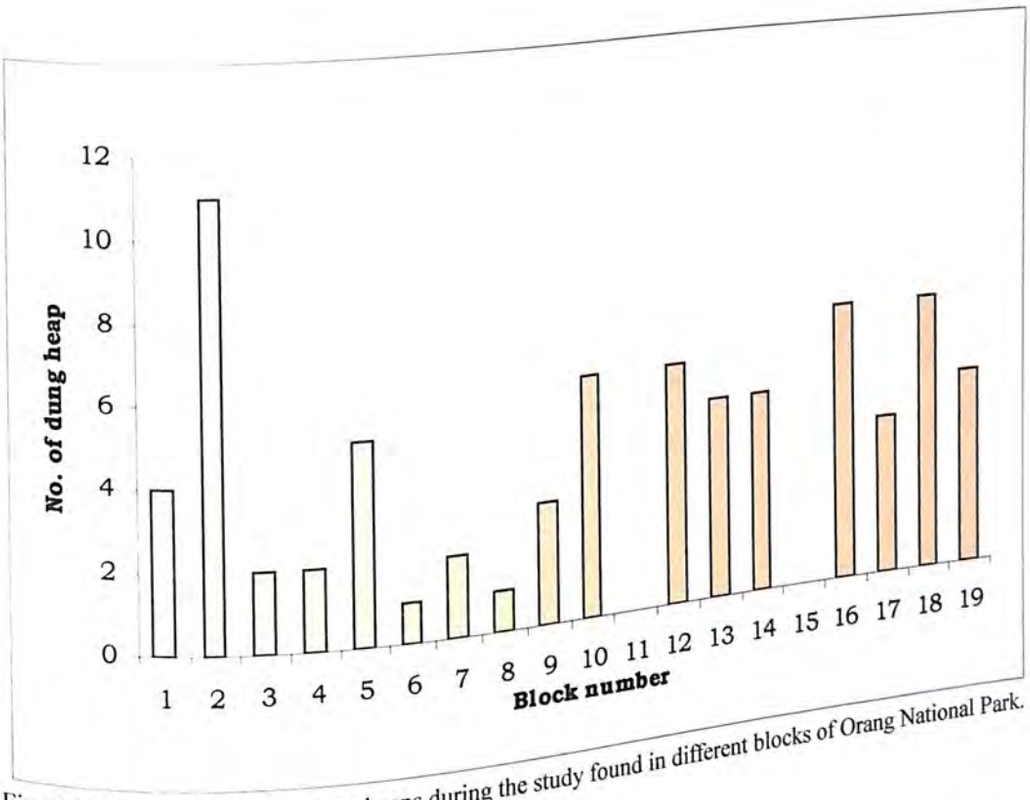


Fig: 7.3: Numbers of Rhino dung heaps during the study found in different blocks of Orang National Park.

7. Non- Breeding Play behaviour

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

8. Local migration

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

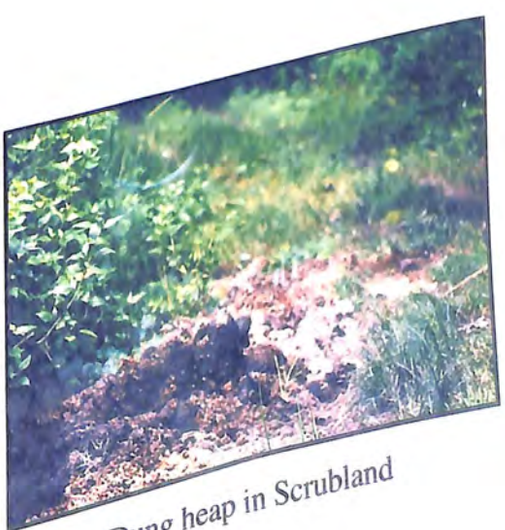
Vigilance behaviour in scrubland

Vigilance during feeding on grassland

Soil eating site (a)

Soil eating site (b)

Dung heap on forest road



Dung heap in Scrubland

Plate 4 : Some behavioural patterns of Indian Rhino in study area

Table-7.1: Records of local migration behaviour of Indian Rhino in Orang National Park

Date	Age-sex	Distances of stray out		Final	Remark
		Location	Aerial distance (approx.)		
August, 1988	AM	Mangaldai Town (Sericultural Farm)	35 km	Sent back by the forest official of ONP	
May, 2001	AM	Dalgaon then to south of Kharupetia	10 km	Died due to human atrocities	
October, 2003	AM	Bhuragaon crossing Brahmaputra river	8 km	Sent back by the forest official of ONP	
July, 2004	AM	Chereng Chapori/ Garubandha area	45 km	Stayed there for two months; then sent back	Rhino killed one and injured two people
September, 2005	AM	Kharupetia crossing Dalgaon	10 km	Sent back by the forest official of ONP	

The study found that, the local migration of Indian Rhino was a common phenomenon, they suddenly go out from the population to other destination but never completed their journey or to part of which also returned back to park area. A total of 4 individuals were found to stray out from the park and all of them were adult male. Majority of them were observed during the monsoon season and only one has observed in the Re-treating monsoon season. It was also found that, most of these incidents were taken place during flood season and a few in the winter season. It may be associated with the competition for reproductive resource that resulted straying out some of the weaker (low ranking) individuals or they intentionally move out of the population in search of mate. This needs further study to find out the reason behind stray out of some of the individuals of rhino from the population. However, most of them who strayed out of the population were fall victim from poaching.

9. Crop-raiding behaviour

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

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

10. Non-breeding Vocalization

Indian Rhino produces several types of sounds for auditory communication (Laurie 1978, 82). During study, it was observed that, when Rhino fled away after receiving any threat from intruder they produce a moo grunt like sound (*yaeeh…yaeeh…*). The vocalization was also heard, when mother responded to calf. During that, vocalization produces a honk like sound (*beyh…beyh…*). Again, during breeding display, Rhino produces a whistle like prolonged sounds (*fleet…fleet…*). The intensity and duration of vocalization during non-breeding period was shorter than the breeding display. The sounds produced during non-breeding occasions persist not more than 20 seconds. But, it was continued in an average of 1 minute (Range = 40-70 seconds) during breeding season.

11. *Dandi* or Track follow behaviour

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

B. Breeding behaviour

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

12. Courtship display

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

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

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

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

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

A total of 31 events of mating display were recorded during the study period, of which 87.9% of mate selection were initiated the adult male, whereas only 12.1 % (Fig. 7.4) was initiated by adult female. But the successful mating was performed only when the female accepted the adult male for mating.

It was observed that during courtship and mating, the female often run away or walk fast with male on her back, leading to severe injury of male on his hind legs. Occasionally female rhino was also got injured during this process. Females were occasionally become aggressive during courtship, resulted to physical attack by females to her male mate. Again it was observed that, the male and the female rhino get minor injury, while approached to each other during courtship.

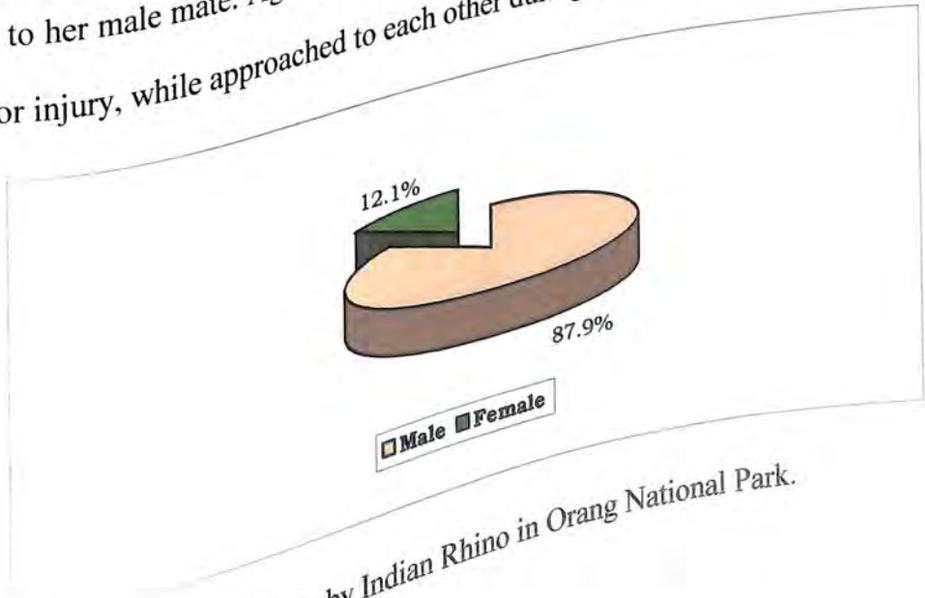


Fig. 7.4. Mate initiatives by Indian Rhino in Orang National Park.

13. Mating display behaviour:

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

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

(ii) **Dragging:** Dragging behaviour was found to be the act of copulating male and female Indian Rhino, in which female carried the male on her back to a distance more than 60-150 m. (n=4) and formed a track in the dense grassland, scrubland ,woodland or marshyland. During this process male generally could not walk properly with their two hind legs, but being dragged above the substratum. This behaviour indicated that, female must be strong enough to drag the huge male body for a long distance of 150 meters on the rough surface of the tracks in the habitat.

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

Although the sightings of mating behaviour were very less, it was observed throughout the year and more in numbers during February, October and December (Fig: 7.5). This indicated that, the Indian Rhino has no definite breeding season.

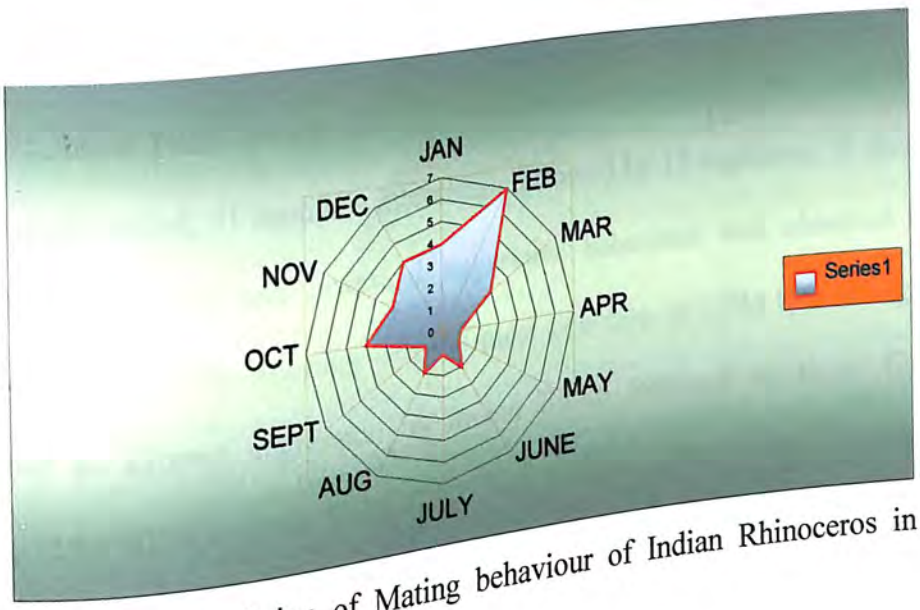


Fig.7.5: Monthly variation of Mating behaviour of Indian Rhinoceros in Orang National Park

14. Breeding Agonistic behaviour

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

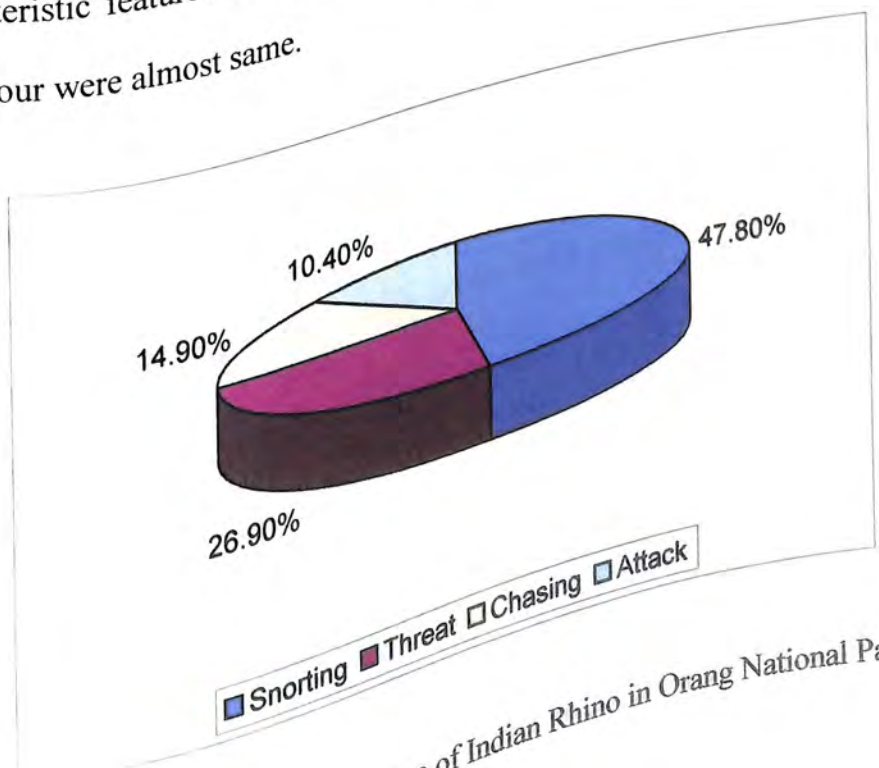


Fig: 7.6 . Modes of Aggression of Indian Rhino in Orang National Park.

Very less number of agonistic interactions was observed for Indian Rhino in Orang National Park. Of the total 71 episodes of aggressive behaviour, recorded during study period, 31 agonistic interaction followed by 15 vigilance, 11 feeding, 8 wallowing, 5 resting and lowest, 1 aggressive behaviour was observed during locomotion (Fig: 7.6). Snorting was the most common (47.8%) type of agonistic behaviour to express aggression by Indian Rhino followed by threat (26.9%), chasing (14.9%) and attack (10.4) (Fig: 7.6). Again, it was also observed that, among agonistic behaviour, snorting was the common mode of aggression during all major activities pattern (Fig: 7.2).

7.5 Discussion

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

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

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

poaching. The poachers take the advantage of track follow behaviour of Rhino and set up a pitfall trap in fresh track to kill the animal very easily. Again, if the poachers identified a very fresh *dandi* (track) they monitor it for easy shooting. Similarly, the Indian Rhino has a tendency to defecate in a particular point. This peculiar nature of Indian Rhino also threatened for being victim of poacher.

The local migration of Indian rhino is also frequently found in Orang National park reported by Laurie (1978, 82) in Nepal. This is a very common behaviour of Indian Rhino for searching suitable habitat for re-establishing a separate population Laurie (1978,82) also reported the local movement behaviour of Indian Rhino in Nepal. This local migration may be a cause of inter-individual competition for mate resources or dominancy of one strong male over adult females during mates. Although, a large numbers of Indian rhino go out from the protected area, for searching around habitat often fall into victim of poachers.

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

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CHAPTER -VIII : ACTIVITY BUDGETING

8.1. Introduction

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

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

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

Therefore, the present study of activity budgeting of Indian Rhino was an attempt to find out the daily time allocation in different behavioural settings of the species in Orang National Park. This will help to layout the site-specific conservation strategy for the Indian Rhino, especially in Orang National Park or other similar Rhino habitats of the Brahmaputra floodplain area.

8.2. Objectives

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

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

8.3. Methodology

For convenience of study, field surveys for activity budgeting of Indian Rhinos were done during day light hours in Orang National Park. The night surveys were not possible owing to lack of sufficient infrastructure and security arrangements. Again, the night survey was also not possible due to less visibility for

dense habitat condition (thick tall grasses). The following methods were adopted for the study of activity budgeting of Indian Rhino in Orang National Park.

(a) Scan sampling

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

(b) Data collection

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

8.3.1. Selectivity of time allocation for behavioural settings

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

different behaviours were compared with the overall time allocation in different activities.

8.4. Results

8.4.1. Activity budget

The present study revealed that, the Indian Rhino showed distinct variation of activity pattern in different seasons of the year. The Indian Rhino in Orang National Park spent a maximum of 46.2% time on feeding activities, followed by wallowing 18.4%, vigilance 15.1%, locomotion 9.1%, comfort 8.01% and minimum of 5.6% in other miscellaneous activities (Fig-8.1). The results indicated that, feeding was the guiding factor, which effect on time allocation in various activities, possesses by Indian Rhino.

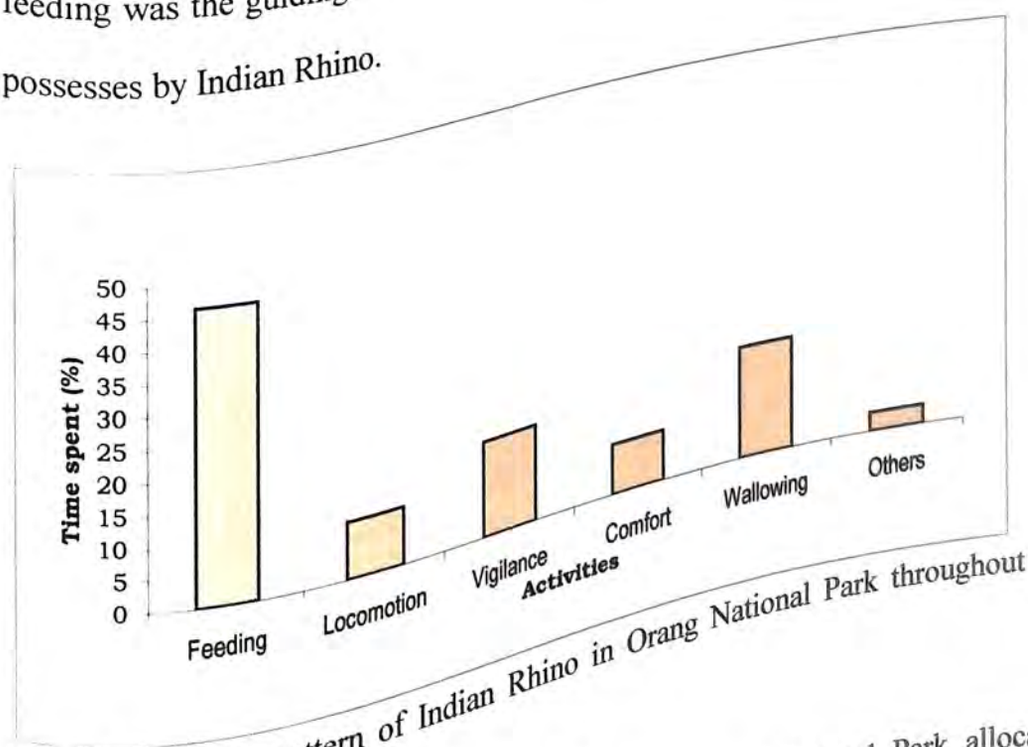

Fig. 8.1 Activity pattern of Indian Rhino in Orang National Park throughout the year.

a) Seasonal Variation of Feeding Activity

Study showed that, the Indian Rhino in Orang National Park allocated maximum time on feeding activities (55.29%) during winter season, followed by pre-monsoon (48.75%) and retreating monsoon (47.34%) season, whereas, it was lowest (36.96 %) during monsoon season (Fig: 8.2a).

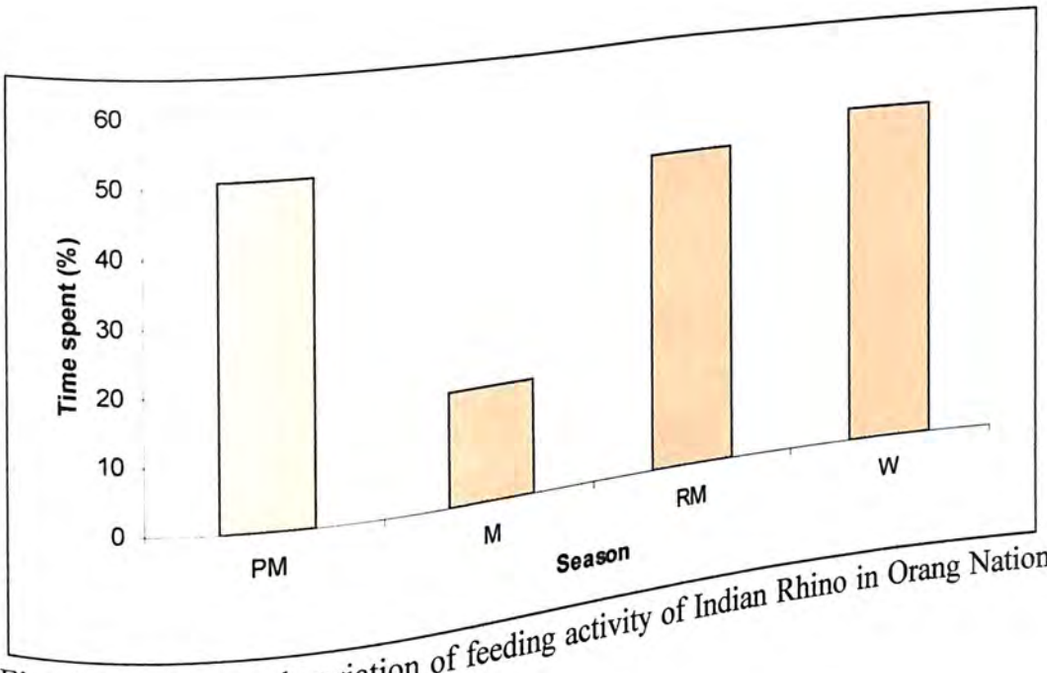

Fig: 8.2.a: Seasonal variation of feeding activity of Indian Rhino in Orang National Park

(b) Locomotion

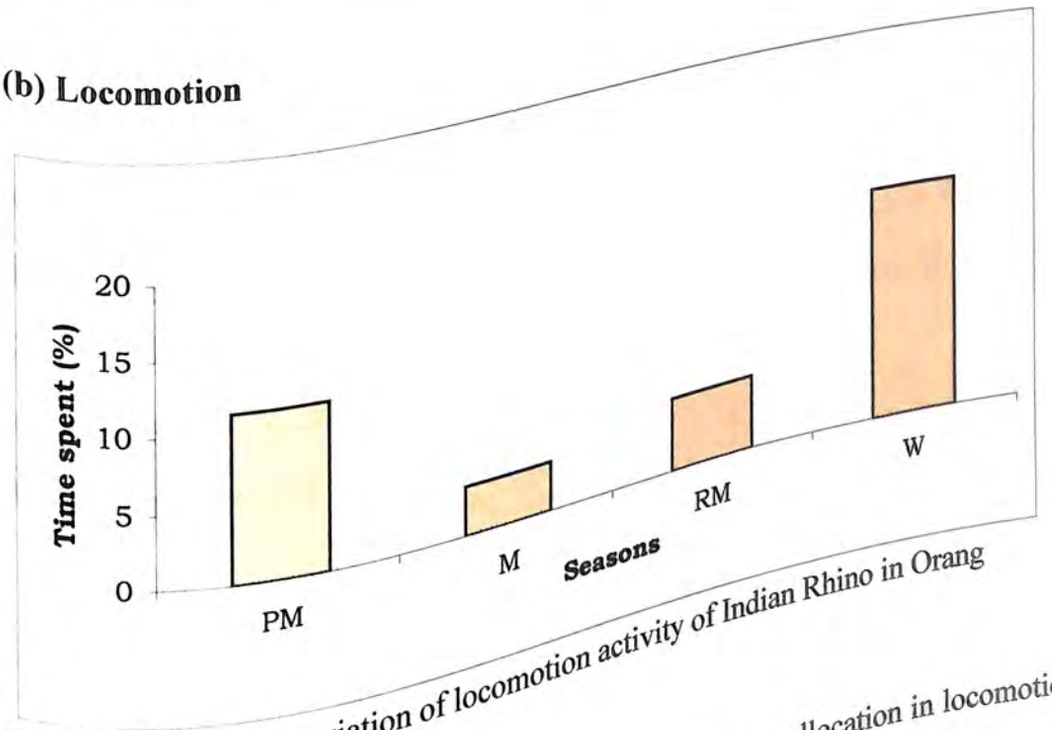

Fig: 8.2b. Seasonal variation of locomotion activity of Indian Rhino in Orang National Park.

There was also a distinct seasonal variation of time allocation in locomotion activity by the Indian Rhino. The highest percentage of locomotion activity was observed during winter season (16.5%), followed by pre-monsoon (11.32%), retreating monsoon (5.07%) and monsoon season (3.3%) (Fig: 8.2b).

(c) Wallowing

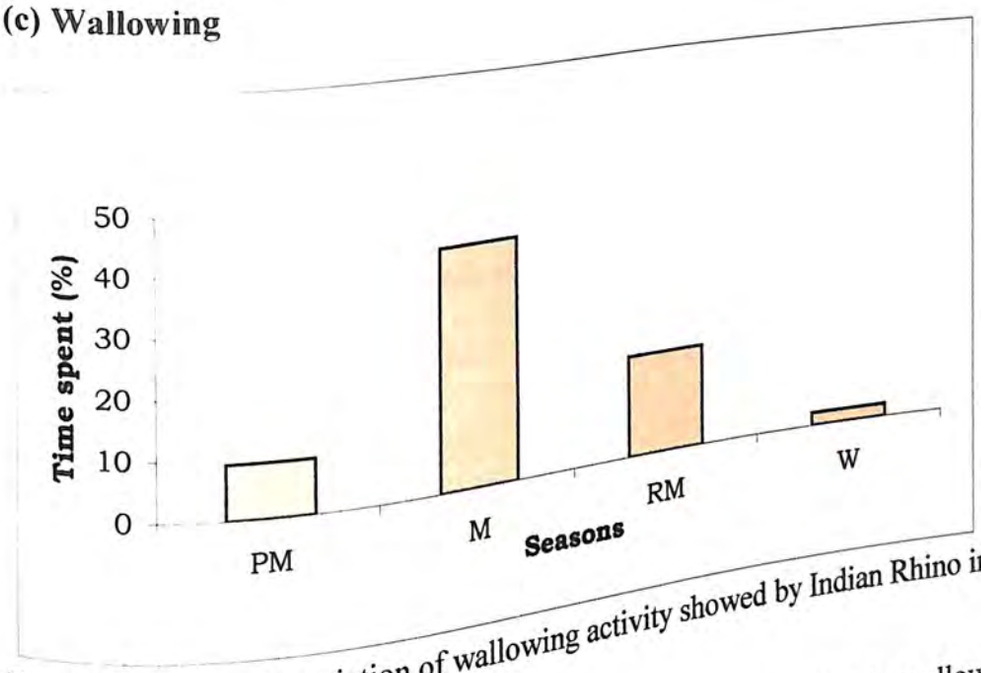

Fig: 8.2c. Seasonal variation of wallowing activity showed by Indian Rhino in Orang National Park

The study showed that, the variations of time allocation in wallowing activity by Indian Rhino were varies in different seasons of the year. The highest time allocation on wallowing activity was found during monsoon season (41.3%), followed by retreating monsoon (17.4%) and pre monsoon (9.1%), whereas lowest (2.2%) time was allocated during winter season in Orang National Park (Fig :8.2c).

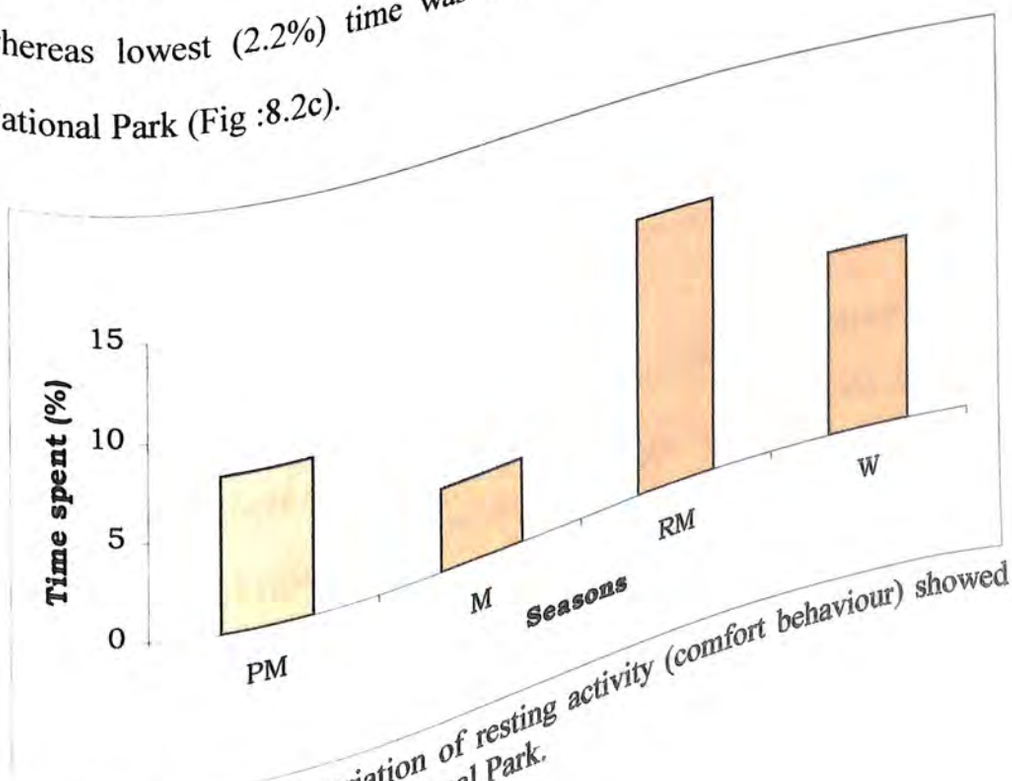

Fig: 8.2d. Seasonal variation of resting activity (comfort behaviour) showed by Indian Rhino in Orang National Park.

(d) Comfort behaviour

Study showed that, the time allocation of Indian Rhino for comfort activities were varies in different seasons of the year. The highest time was allocated during retreating monsoon (14.7%), followed by winter (10.1%), pre monsoon (7.9%) and monsoon season (4.2%)(Fig:8.2.d).

(e)Vigilance

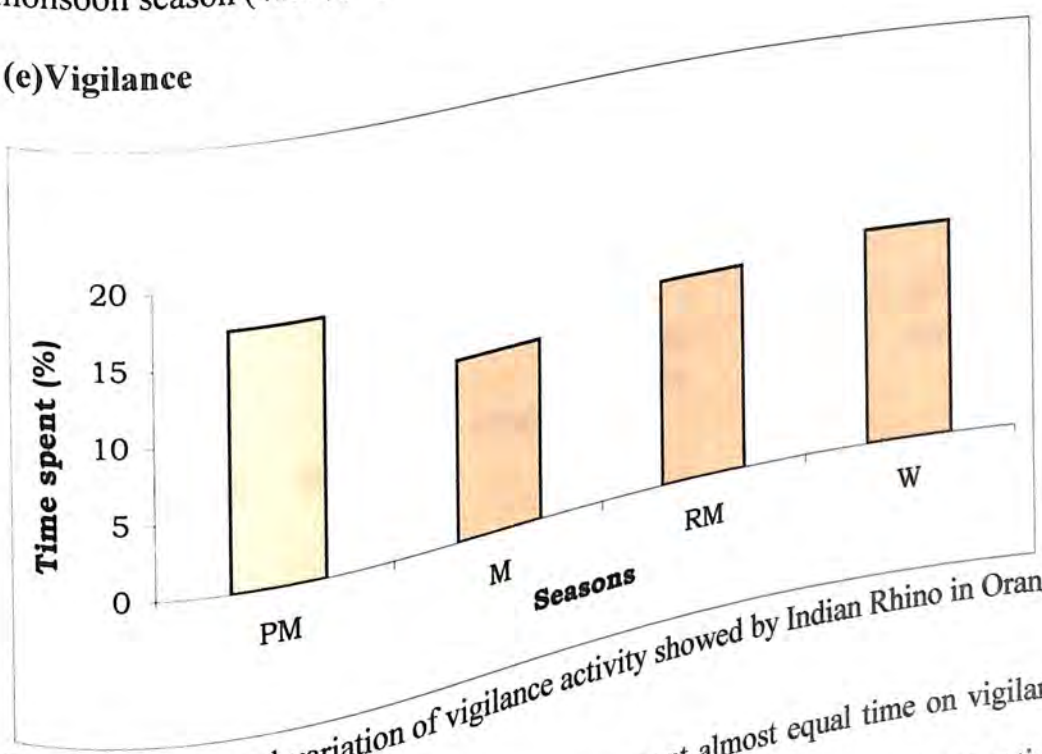

Fig: 8.2e. Seasonal variation of vigilance activity showed by Indian Rhino in Orang National Park.

Study revealed that, the Indian Rhino spent almost equal time on vigilance behaviour in all four seasons of the year. However, the trend of vigilance activity was increased during winter and it continued till pre-monsoon season (Fig:8.2e).

(f) Miscellaneous activities

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

8.4.2. Selectivity of time allocation in behavioural activity

The analysis of selectivity for time allocation in different behavioural activities of Indian Rhino showed that, except wallowing activity, there was no selectivity in behavioural settings during pre-monsoon season. The wallowing activity was negatively selected during pre-monsoon season, in which the species spent comparatively less time in wallowing than the level of expectation (Fig: 8.3a).

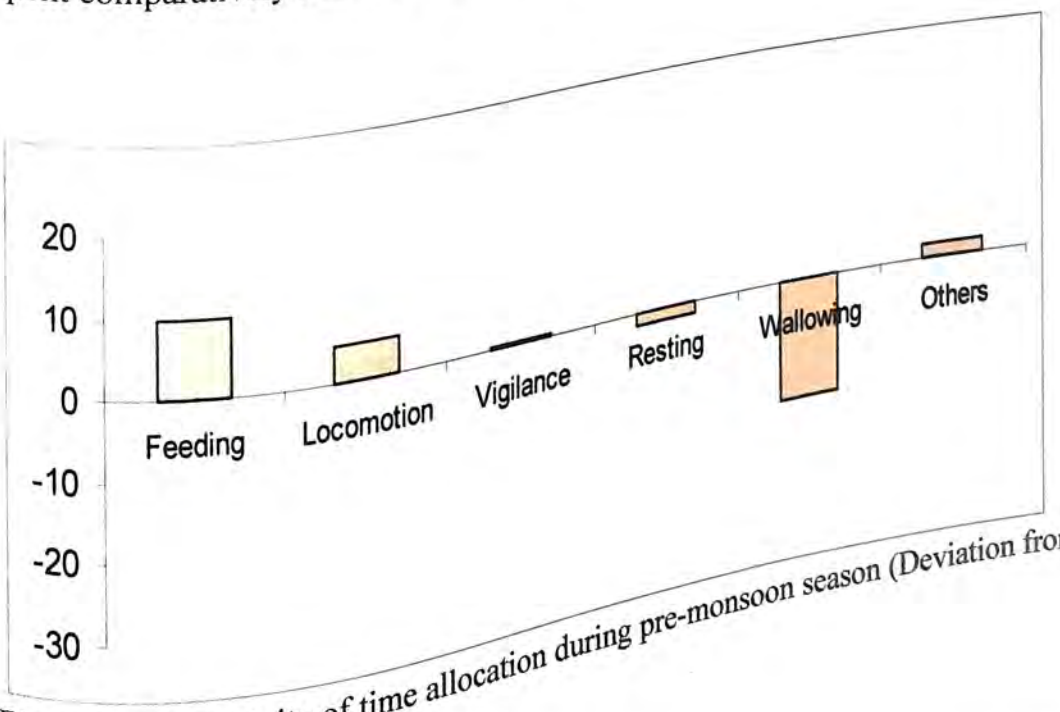

Fig: 8.3.a. Selectivity of time allocation during pre-monsoon season (Deviation from expectation).

Again, during monsoon season, the time allocation for feeding, locomotion, vigilance (monitoring) and comfort activities were negatively selected, while in wallowing, it was positive during monsoon season (Fig.8.3b).

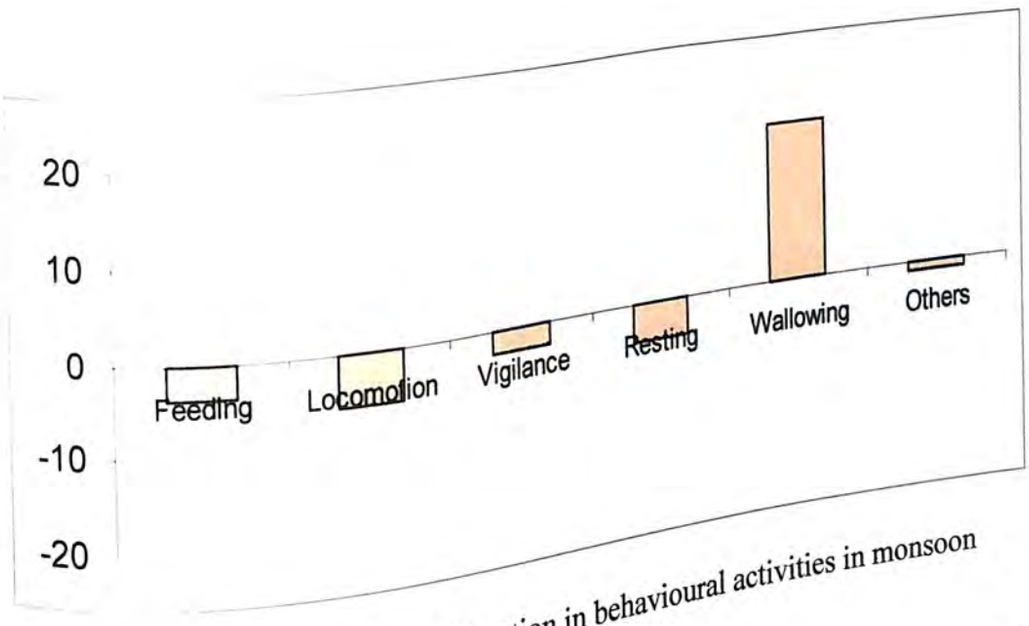

Fig: 8.3.b. Selection of time allocation in behavioural activities in monsoon season (Deviation from expectation).

There was no major selection trend of time allocation in feeding, locomotion, vigilance and wallowing activities, during re-treating monsoon observed, whereas it was positive for comfort behaviour (Fig: 8.3.c).

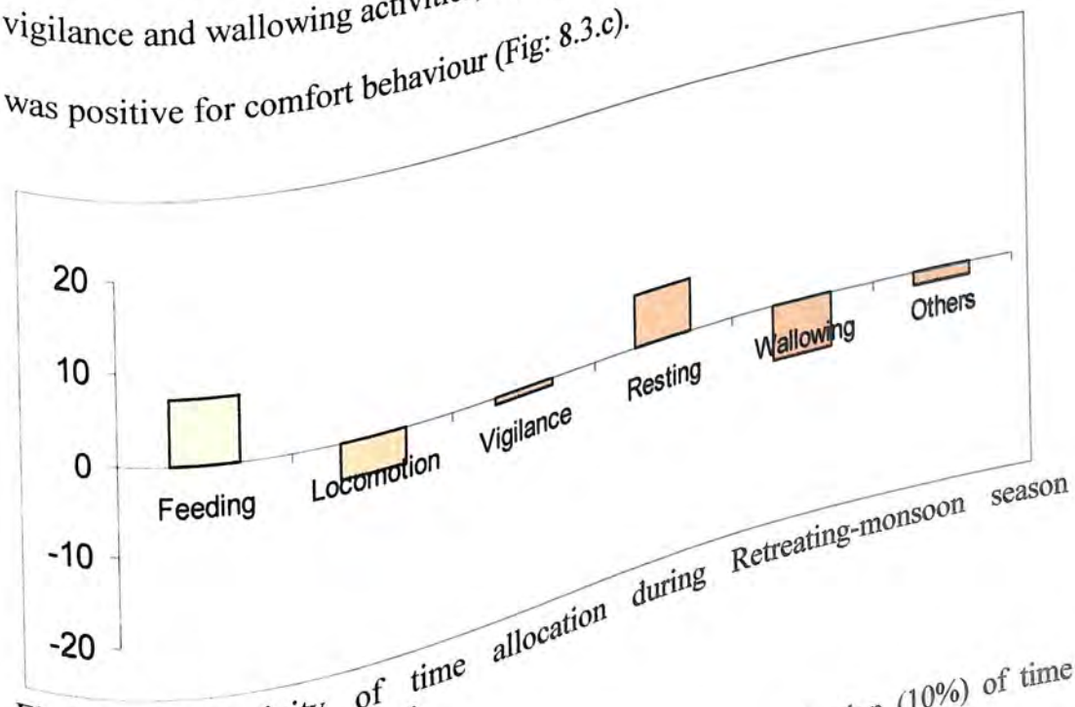

Fig.8.3.c Selectivity of time allocation during Retreating-monsoon season (Deviation from expectation).

(d) Winter

Study showed that, there was a distinct positive selection (10%) of time allocation in feeding and locomotion activity during winter season. But the highest of 16.2% negative selection of time allocation was observed in wallowing activity during winter (Fig: 8.3.d).

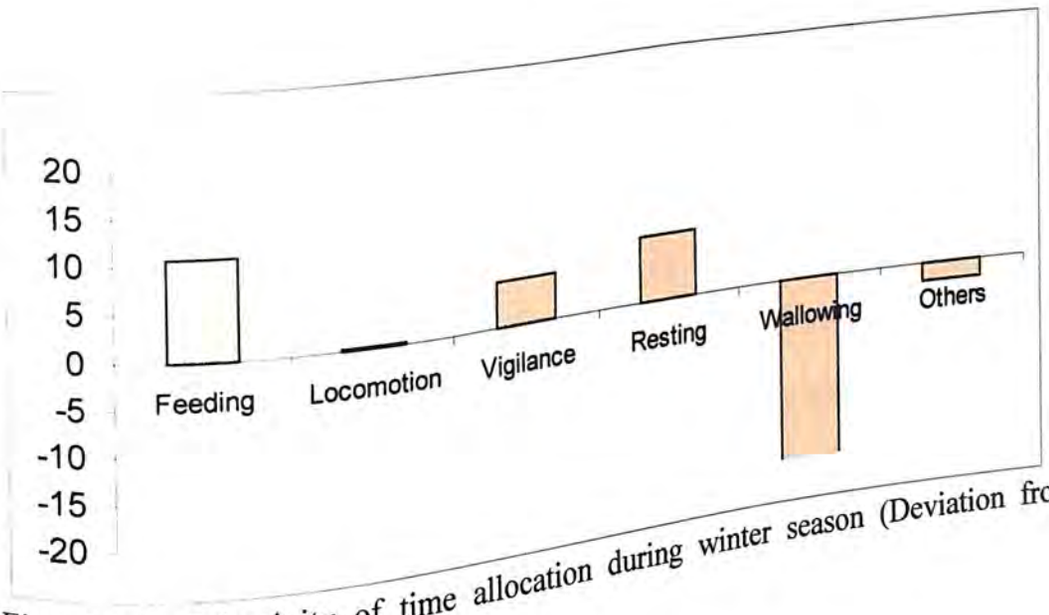

Fig: 8.3.d. Selectivity of time allocation during winter season (Deviation from expectation).

8.4.3 Activities during dark

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

8.5. Discussion

The present findings of higher time spent on feeding activity by Indian Rhino across the season indicates that the feeding activity is the guiding factor responsible for variation in time allocation in different behavioural patterns. The time surplus after feeding activity is thus, sharing in all other activities like locomotion, comfort

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

Since, most of the time has to spend on foraging and locomotion activities, the individuals of Indian rhino have to spend a lot of energy. To balance this loss, a rhino has to spend a lot of time on comfort activity. A least time spent during monsoon must have relationship with the availability of food resource, which is reflected in the study. The time saved for comfort was spent 8.01% on resting, 18.4% on wallowing, 15.1% on vigilance and 3.1% on other social behaviour. Laurie (1978) has found that, Indian rhino spent 36.4% of their total time on resting activity in Chitwan National Park, Nepal. Vigilance (monitoring) behaviour is

equally necessary for Indian Rhino in different seasons of the year to protect themselves from enemy and hence no significant seasonal variation was observed.

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

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

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CHAPTER – IX : CONSERVATION PERSPECTIVES OF INDIAN RHINO

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

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

A. Rhino at risk

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

(a) Risk at habitat level

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

(i) Grassland habitat: The succession of grsssland habitat and the occurance of invasive weed species on the grassland habitat is the prime risk for grassland habitat in Orang National Park. As the controlled burning is not regularly practiced by the forest department, owing to financial crisis, the natural succession has become very fast and the woody plant and shrubs are invading the grassland habitat of Orang National Park. As a result of this, the grassland habitat has been shrinking, leading to declination of food resources. Since, Orang National Park of Assam is situated on the bank of the river Brahmaputra, it receives annual flood each year. The floodwater carries huge amount of silt that gets deposited on the grassland habitat, leading to a conversion of marshyland habitat into unfertile dryland. This dryland ultimately turned into a woodland habitat. Since, the Indian Rhino is purely a grassland dependent species, the conversion of grassland habitat into a woodland habitat is a major threat to the Indian Rhino in Orang National Park.

Again, the large scale invasion of grassland habitat by invasive species weed species is the second largest threat of Indian Rhino habitat in Orang National Park as well as in the Brrahmaputra valley. The prime invasive weed species are *Mimosa sp.*, *Mikenia sp.*, *Leea sp.* etc. (Plate – 5). These weeds are not only posing threat to the food availability but also hindering the growth of grasses.

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

Due to regular annual flood, most of the wetlands of Orang National Park become silted and reduce Rhino habitats. The excessive growth of water hyacinth (*Eichornia crassipes*) in most of the wetlands of the Orang National Park leads to a decline of available habitat for feeding and wallowing (Plate – 5).

Eichornia invasion (Degraded wetland)

Mikenia invasion

An orphan Rhino calf after flood

A dead Rhino calf due to post flood effect

Blooming of *Eichornia crassipes* in water bodies

Lantana invasion

Plate 5 : Conservation threats of Rhino in study area

(b) Risk at species level

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

(ii) Spreading of diseases to wild animals: Domestic cattle from fringe villages enters into the Orang National Park very frequently, which leads to the spreading of certain contagious diseases among wild animals. Apart from that, cattle vaccination in the fringe villages is very poor, owing to lack of proper financial assistance by the Forest Authority. Hence, there is a higher instance of disease contamination from the domestic cattle.

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

(iv) Lack of proper conservation education

A group of wealthy people from several Asian countries has superstitious belief that, the Rhino horn has got some magical and medicinal value. Hence, the demand of Rhino horn is very high which leads to a higher poaching activity for horn.

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

B. Conservation Recommendations

(a) Habitat improvement

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

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

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

(b) Habitat recovery

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

(c) Species recovery

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

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

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

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

(d) Formation of Anti –poaching Network

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

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

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

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

There is an urgent need to initiate some activities related to species, habitat, health and enforcement, to save the Indian rhino and their habitats. Unfortunately, most of the conservation funds gets diverted to infrastructure development and protection measure. Very negligible amounts of quantity of the conservation funds were spent for habitat and species management. Hence, the park authorities must be given more emphasis to mitigate the habitat level and species level crisis to conserve the Indian Rhino – **the pride of Assam.**

CONCLUSION

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 present distribution of Indian Rhino is limited to certain pockets of the Himalayan Terai region of Eastern Nepal, Jaldapara Wildlife Sanctuary and Gorumara National Park of Ganga and Teesta Valley, and also Brahmaputra Valley of Assam. But, very little attempt was made to study the ecology and behaviour of the Indian Rhino in Brahmaputra flood plain habitat. Therefore, the present study was carried out to find out the 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.

The present study emphasizes the "Studies on the Eco-behavioural aspects of Great Indian One- horned Rhinoceros(*Rhinoceros unicornis*) in the Orang National Park, Assam India". The study was dived into nine chapters such as, Introduction, Review of literature, General study area and methods, Home range and territoriality, Habitat ecology, Food and feeding ecology, Behavioural ecology, Activity budgeting, and Conservation perspectives. The main objectives of the studies were such as, (1) to find out the habitat selectivity, habitat utilization pattern, home range and activity budgeting of *Rhinoceros unicornis* in study area in different seasons of the year, (2) to find out the food habit and feeding behaviour of *Rhinoceros unicornis* in the study area, (3) to investigate the behavioral activities of the species

during breeding and non-breeding periods of the year and (4) to find out the threat factors of the *Rhinoceros unicornis* to draw the habitat specific conservation strategies for this endangered species.

Chapter-I

This chapter describes the status and distribution of Indian Rhino and its relatives across the globe. Again, the chapter is also emphasizes on the conservation threats and the work done for the species across its distribution ranges.

Chapter-II

The chapter-II describes the literature review of the species in various aspects, across the golebe.

Chapter-III

This chapter describes the physiography and location of the study area and also different methods adopted for the data collection and analysis, period of study in Orang national park etc. The major methods of the data collections and data analysis are described in details in concering chapters.

Chapter-IV

This chapter emphasizes on the Home range and territoriality of Indian Rhino in Orang National Park. The study found that, the Adult male had a larger home range compared to other age and sex classes. There was a distinct seasonal variation of home range pattern, which was highest in winter and lowest in monsoon. The adult male had a larger home range size compared to other age-sex classes. There was a distinct seasonal variation in home range size in different age-sex classes and it was also overlapped among different age-sex classes in all the seasons. The Indian Rhino showed distinct territoriality during breeding and

foraging period, but possess very less territoriality during wallowing period. The territoriality was found to be strong between same sex groups than others. The species maintained a distinct spatial distances between two individuals in their daily activities. The spatial distance between "male-male" individual was higher than that of "female-female" individuals.

Chapter-V

This chapter includs the study of habitat ecology of the Indian rhino in Orang National park. The study revealed that, of the total 78.81 km^2 area of the study area, 25.93 km^2 area was occupied by dry tall-grassland, followed by wet grassland (both marshy and wet) 17.13 km^2, short grassland 14.05 km^2, 10.75 km^2 wetland, woodland 6.88 km^2 and water bodies and sand bars 4.86 km^2. The Indian Rhino utilized altogether five major habitat types in the study area, those were such as, (i) Water-bodies, (ii) Short grassland, (iii) Tall-grassland, (iv) Wet grassland and (v) Woodland habitat.

Indian Rhino used maximum of 41.41% wet grassland habitat, followed by 27.88% tall grassland, 18.99% water bodies, 8.08% short grassland and only 3.64% woodland habitat. The Seasonal variation of habitat utilization pattern was observed for both male and female Rhino.

Chapter-VI

This chapters deals with the food and feeding ecology of Indian Rhino at Orang national park. A total of 75 species of grasses, 27 species of shrubs-herbs, 27 species of trees and 9 aquatic plant species were identified as a food plant species of Indian Rhino in study area. Altogether 71 plants species were identified as the food plant of Rhino in Orang National Park. Of which, grasses constituted highest of 42 species, followed by 20 woodland

species, including herbs and shrubs, and 9 aquatic plant species. The grass species - *Hemarthria compressa* contributed a highest of 11.63% while the aquatic species - *Polygonum hydropiper* the least of 0.01% of the total annual diet. Out of total 42 species, 20 species of grasses had no selectivity. The *Hemarthria compressa* was the top ranking grass selected as food by the Indian rhino. Altogether, 36 food plants were identified as the staple food that constituted 83.64% of the total annual diet. Study showed that, ten top ranking food plants constituted 56.44% and 20 top ranking food plants constituted 72.19% of the total annual diet. Grasses itself is enough to provide food for Indian Rhino in Orang National Park.

Chapter-VII

This chapter deals with behavioural ecology of Indian Rhino in Orang national park. The present study categorized two basic types of behaviour such as (a) Breeding and (b) Non breeding behaviour. Altogether 14 major behavioural patterns were categorized. Apart from those major types, certain subtypes were also categorized on Major behavioural types. Study also found that, the behavioural patterns of Rhinoceros Unicornis has relationships with their conservation measures.

Chapter-VIII

This chapter is deals with the time and activity budgeting of the species. The study revealed that, the Indian Rhino showed distinct variation of activity pattern in different seasons of the year. The Indian Rhino of Orang National Park spent a maximum of 46.2% time on feeding activities, followed by wallowing 18.4%, vigilance 15.1%, locomotion 9.1%, comfort 8.01% and minimum of 5.6% in other miscellaneous activities. The results indicated that, feeding was the guiding factor, which had effect on time allocation in various activities, possesses by Indian Rhino. The Indian Rhino of Orang National Park allocated maximum time on feeding

activities during winter season, followed by pre-monsoon and retreating monsoon season, whereas, it was lowest during monsoon season. Again, the highest percentage of locomotion activity was observed during winter season, followed by pre-monsoon , retreating monsoon and monsoon season. The study showed that, the variations of time allocation in wallowing activity by Indian Rhino were varies in different seasons of the year. The highest time allocation on wallowing activity was found during monsoon season, followed by retreating monsoon and pre monsoon, whereas lowest time was allocated during winter season in Orang National Park. The time allocation of Indian Rhino for comfort activities were varies in different seasons of the year.

Chapter-IX

This chapter deals with the conservation perspectives of Indian Rhino in Orang national park as well as in Brahmaputra valley of Assam. The chapter highlighted the importance of habitat and species level conservation effort for the conservation of the Indian Rhino in the Brahmaputra floodplain habitat and also forwarded some conservation recommendations.

SUMMARY

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

The study was carried out from April, 2000 to March, 2003 in Orang NP ($92^0 15'$-$92^0 27'$E, $26^0 29'$-$26^0 40'$N). A total of 10 days per month was spent to visit each and every corner of the park. The field study was conducted using motor vehicles, bicycles, country boats, elephant back as well as on foot. During field visits, the sightings of Indian rhinos were recorded with their numbers, age-sex, GPS locations and habitat types, whenever sighted. The data were further analyzed to find out the daily range, home range, and habitat utilization pattern. During field visits, the vegetation samplings were done covering all the habitats on seasonal basis. Again, the sightings of Rhino dung piles and occurrences of any less frequent

opportunistic behaviour (e.g. aggressive, reproductive etc.) were also recorded in each visit. Various standard methods were used during survey and analysis.

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

The analysis of Satellite Imagery of Orang National Park revealed that, of the total 78.81 km^2 area of the study area, 25.93 km^2 (32.9%) area was occupied by dry tall-grassland, followed by wet grassland (both marshy and wet) 17.13 km^2 (21.7%), short grassland 14.05 km^2 (17.8%), 10.75 km^2 (13.6%) wetland, woodland 6.88 km^2 (7.7%) and water bodies and sand bars 4.86 km^2 (5.5%). Among all the water bodies, the area of 0.5 km^2 (0.6%) was covered by stagnant water bodies. and 4.36 km^2 (5.5%) by flowing rivers and streams. Study revealed that, the Indian Rhino utilized altogether five major habitat types in the study area, those were such as, (i) Water-bodies, (ii) Short grassland, (iii) Tall-grassland, (iv) Wet grassland and (v) Woodland habitat.

Indian Rhino used maximum of 41.41% wet grassland habitat, followed by 27.88% tall grassland, 18.99% water bodies, 8.08% short grassland and only 3.64% woodland habitat. Seasonal variation of habitat utilization was observed in both male and female.

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

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

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

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

The present study revealed that, the Indian Rhino showed distinct variation of activity pattern in different seasons of the year. The Indian Rhino of Orang National Park spent a maximum of 46.2% time on feeding activities, followed by wallowing 18.4%, vigilance 15.1%, locomotion 9.1%, comfort 8.01% and minimum of 5.6% in other miscellaneous activities. The results indicated that, feeding was the guiding factor, which effect on time allocation in various activities, possesses by Indian Rhino. The Indian Rhino of Orang National Park allocated maximum time on feeding activities (55.29%) during winter season, followed by pre-monsoon (48.75%) and retreating monsoon (47.34%) season, whereas, it was lowest (36.96 %) during monsoon season. Again, the highest percentage of locomotion activity was observed during winter season (16.5%), followed by pre-monsoon (11.32%), retreating monsoon (5.07%) and monsoon season (3.3%). The study showed that, the variations of time allocation in wallowing activity by Indian Rhino were varies in different seasons of the year. The highest time allocation on wallowing activity was found during monsoon season (41.3%), followed by retreating monsoon (17.4%) and pre monsoon (9.1%), whereas lowest (2.2%) time was allocated during winter season in Orang National Park. The time allocation of Indian Rhino for comfort activities were varies in different seasons of the year. The highest time was allocated during retreating monsoon (14.7%), followed by winter (10.1%), pre monsoon (7.9%) and monsoon season (4.2%). They spent almost equal time on vigilance behaviour in all four seasons of the year. However, the trend of vigilance activity was increased during winter and it continued till pre-monsoon season. The Indian Rhinos spent 5.6% time in various other miscellaneous activities. During pre-monsoon season, they spent 1.9% time on miscellaneous activities, followed by retreating monsoon (1.8 %), monsoon (1.2%), and winter season (0.7%).

For conservation purpose, the present study highlighted the importance of habitat and species level conservation effort for the conservation of the Indian Rhino in the Brahmaputra floodplain habitat. Those were summarized such as, (1) Burning and up rooting of the *Mimosa, Mikenia* and other weeds species in the grassland habitat, (2) Manual clearing of water hyacinth from the wetland habitat, (3) Cutting of *Lantana, Leea* and other species of plant that grow on the banks and edges of the wetland, (4) Control burning of the grassland habitat to check excessive growth of weed and to check succession of the grassland habitat, (5) De-siltation of the degraded wetlands by manual cutting of the mud. If possible, dozer may be used, (6) Construction of upland/ raised areas to check mortality during flood, (7) Translocation of certain individuals of Indian Rhino of both sexes to other protected area to reduce genetic threats, (8) Providing of medical facility to take care of the injured and disease individuals. Also to facilitate vaccination programme in the fringe villages, (9) Providing of rescue facility to check mortality during flood and to take care of the orphan individuals of Rhino, (10) Formation of special task force who can actively take part in operation, (11) A comprehensive network and pressure-building cell may be built up among the villagers to check hunting during flood season, (12) Proper maintenance of the mortality data base to know the protected area specific method of poaching and (13) Conveying the conservation message to the grass root level of the society by providing education material.

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

Appendix – 3 (a)

Data sheet

Habitat utilization pattern of Rhinoceros unicornis

Site Location :

Date :

Humidity :

Temperature :

Light condition :

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

Remarks:

Appendix – 3 (b)

Data Sheet for behavioural studies / activity budgeting

Sheet No.

Date : Locality :

Time : Individual / Group

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

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

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

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

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

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

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

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

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

Appendix: 6.4 – Feeding frequency of food plants in different habitats of Orang National Park.

SL No.	Food plants	Species category	Feeding frequency	Rank
1	*Hemarthria compressa*	GL	10.63	1
2	*Leersia hexadra*	GL	8.8	2
3	*Hymenachne acutigluma*	GL	7.64	3
4	*Arundo donax*	GL	6.13	4
5	*Hygroryza aristata*	GL	5.72	5
6	*Cynodon dactylon*	GL	4.6	6
7	*Phragmites karka*	GL	4.2	7
8	*Bracharia ramosa*	GL	3.83	8
9	*Saccharum spontaneum*	GL	2.3	9
10	*Chrysopogon aciculatus*	GL	2.11	10
11	*Imperata cylindrica*	GL	1.98	11
12	*Oplismenus burmannii*	GL	1.95	12
13	*Saccharum ravanae*	GL	1.88	13
14	*Arundinella begalensis*	GL	1.52	14
15	*Themda villosa*	GL	1.48	15
16	*Eleusine indica*	GL	1.44	16
17	*Ipomea aquatica*	Aq	1.42	17
18	*Sacciolepis interrupta*	GL	1.39	18
19	*Cyperus rotundus*	GL	1.38	19
20	*Hemarthria protesna*	GL	1.3	20
21	*Pistia stratiotes*	Aq	1.24	21
22	*Arundinella nepalensis*	GL	1.23	22
23	*Enhydra fluctuans*	Aq	1.16	23
24	*Apluda mutica* Linn.	GL	1.1	24
25	*Cyperus globosus*	GL	1.08	25
26	*Paspalum conjugatum*	GL	1.06	26
27	*Leptochloa panicea*	GL	1.02	27
28	*Digitaria ciliaris*	GL	1	28
29	*Saccharum procerum*	GL	0.97	29
30	*Paspalum dilatatum*	GL	0.94	30
31	*Hydrilla verticillata*	GL	0.93	31
32	*Dichantium caricosum*	Aq	0.91	32
33	*Erichola procera*	GL	0.78	33
34	*Eichhornia cressipes*	GL	0.72	34
35	*Grewia sapida*	Aq	0.69	35
36	*Paspalidium flavidum*	WL	0.68	36
		GL		

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

Appendix: 6.5 Selectivity of different groups of food Plant species in Orang National Park: (a) Grasses (b) Shrubs and herbs (c) Trees (d) Aquatic plants

(a) Grasses

SL No.	Food plants	Dominance (%)	Feeding (%)	Selectivity
1	*Agrostis zenkeri*	0.36	0.55	1.53
2	*Apluda mutica/A. aristata*	1.19	1.27	1.06
3	*Arundinella bengalensis*	0.95	1.75	1.84
4	*Arundinella nepalensis*	1.11	1.42	1.28
5	*Arundo donax*	2.87	7.07	2.47
6	*Axonopus compressus*	0.29	0.58	1.96
7	*Brachiaria ramose*	1.50	4.42	2.94
8	*Chrysopogon (Andropogon) aciculatus*	0.94	2.44	2.60
9	*Cyndon dactylon*	4.31	5.31	1.23
10	*Cyperus cyperoides*	0.55	0.13	0.24
11	*Cyperus rotundus*	1.07	1.60	1.49
12	*Cyperus brevifolius*	0.54	0.64	1.20
13	*Cyperus globusus*	0.15	1.24	8.42
14	*Cyperus kyllingia*	0.56	0.37	0.65
15	*Cyrtococcum accrescens*	1.04	0.77	0.74
16	*Dichantium caricosum*	0.86	1.04	1.22
17	*Digitaria ciliaris*	0.76	1.15	1.50
18	*Echionchola crusgalli*	0.42	0.26	0.62
19	*Eleusine indica*	1.70	1.66	0.98
20	*Eragrostis japonica*	0.80	0.77	0.96
21	*Eragrostis unioloides*	0.70	0.78	1.12
22	*Saccharum ravanae*	5.73	2.17	0.38
23	*Erichola procera*	0.70	0.90	1.30
24	*Hemarthria compressa*	4.34	12.27	2.83
25	*Hemarthria protesna*	1.17	1.50	1.29
26	*Hygroryza aristata*	1.29	6.60	5.13
27	*Hymenachne pseudointerrupta*	5.81	2.66	0.46
28	*Imperata cylindrica*	4.84	2.28	0.47
29	*Leersia hexandra*	6.47	10.15	1.57
30	*Leptochloa panicea*	1.04	1.18	1.13
31	*Oplismenus burmannii*	0.63	2.24	3.57
32	*Panicum walense*	0.86	0.63	0.73
33	*Paspalidium flavidum*	0.90	0.79	0.88
34	*Paspalum conjugatum*	1.11	1.22	1.10
35	*Paspalum dilatatum*	0.99	1.08	1.09
36	*Phragmites karka*	4.50	4.84	1.08
37	*Saccharum procerum*	1.29	1.11	0.87
38	*Saccharum spontaneum*	8.45	8.82	1.04
39	*Sacciolepis interrupta*	0.86	1.60	1.87
40	*Sateria pumila*	0.70	0.50	0.71
41	*Themda villosa*	2.87	1.70	0.59
42	*Vetiveria zizanoides*	1.82	0.55	0.30

(b) Shrub and herbs

SL No.	Food plants	Dominance (%)	Feeding (%)	Selectivity
1	*Ageratum conyzoides*	4.19	7.77	1.85
2	*Amaranthus spinosus*	4.85	13.77	2.84
3	*Diplazium esculentum*	13.83	14.86	1.08
4	*Grewia sapida*	2.62	23.14	8.83
5	*Lantana camera*	1.51	10.81	7.17
6	*Melastoma malabathrium*	0.79	5.32	6.77
7	*Mikenia micranth*	4.19	12.75	3.04
8	*Polygonum hydropiper*	1.97	0.25	0.13
9	*Xanthium strumarium*	8.78	11.32	1.29

(c) Trees

SL No.	Food plants	Dominance(%)	Feeding (%)	Selectivity
1	*Artocarpus heterophyllus*	6.25	3.51	0.56
2	*Bauhinia purpurea*	3.97	2.70	0.68
3	*Bombax ceiba*	4.17	11.35	2.72
4	*Cassia fistula*	3.17	11.62	3.66
5	*Dalbergia sisso*	7.94	16.96	2.14
6	*Ficus glomerata*	2.88	10.61	3.69
7	*Ficus rumphii*	2.98	15.74	5.29
8	*Mangifera indica*	1.98	2.91	1.46
9	*Streblus asper*	3.17	0.34	0.11
10	*Trewia nudiflora*	7.14	17.30	2.42
11	*Ziziphus zuzuba*	5.65	6.96	1.23

(d) Aquatic Plants

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

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