

Research Article

Food Habit and Feeding Patterns of Great Indian One-Horned Rhinoceros (*Rhinoceros unicornis*) in Rajiv Gandhi Orang National Park, Assam, India

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Food and feeding patterns of great Indian one-horned Rhinoceros (*Rhinoceros unicornis*) has been studied in Rajiv Gandhi Orang National Park. Altogether 75 species of grasses, 27 species of herbs-shrubs, 27 species of trees, and 9 species of aquatic plants species were identified as a food-plant species of Indian Rhino in the study area. Of the total 75 species of grasses, 48 species had a relative dominance of <1.0. The *Saccharum spontaneum* was ranked as the highest relative dominance food-plant among grasses (relative dominance value, 8.45%), while the *Cyperus pilosus* ranked the lowest (relative dominance value, 0.08%). Among 27 herbs-shrubs species, three had a relative dominance of <1.0. The *Diplazium esculentum* was ranked the highest relative dominance food plants among herbs-shrubs food plants (relative dominance value, 13.83%), while the *Solanum viarum* was ranked the lowest (relative dominance value, 0.66%). All tree species had a relative dominance of >1.0. The *Dalbergia sissoo* ranked the highest among all trees (relative dominance value, 7.94%), while the *Anthocephalus cadamba* ranked the lowest (value, 1.19%). Grasses constituted 86.66% of the total annual diet of Rhino, while the aquatic and woodland species constituted only 13.34% of the total annual diet. Altogether 71 plants species were identified as the Rhino food plants at Rajiv Gandhi Orang National Park. Of which, grasses constituted the highest (42 species), followed by woodland species (trees, herbs-shrubs), (20 species) and aquatic plants (9 species). The grass species *Hemarthria compressa* contributed a highest of 11.63%, while the aquatic plant *Polygonum hydropiper* was the least of 0.01% in total annual diet. Out of total 42 food-plant species, 20 grass species had no selectivity. The *Hemarthria compressa* was the top ranking grass species that has been 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. Thus, the grass species alone have enough to provide food for Indian Rhino in Rajiv Gandhi Orang National Park. Soil licking and crop depredation by the Indian Rhino were common in the fringe villages in study area.

1. Introduction

Food is the primary requirement of an animal to survive and maintain its good health. Hence, the animal must acquire food that contains enough nutrients to fulfill its physiological needs. Again, the distribution pattern of food resources over the habitat guides the distribution of male and female individuals. [1]. Hence, the availability of food resource and its distribution pattern do 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 reintroduction programme. Hence, a number of keystone and flagship species [2, 3] are subjected to study to

layout a holistic approach for conservation and 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 [4–13]. Apart from that, the studies on the chemical composition of food items [6, 14], feeding behaviour of Rhino [4, 5], analysis of Rhino dung, seed dispersal, germination of seed on Rhino dung [10, 15], and so forth 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 Rajiv Gandhi Orang National Park.

The present study aimed 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. The study emphasizes following objectives: (1) to investigate the food habitat of Indian Rhino in study area to find out the seasonal feeding pattern, (2) to identify the food plants species and its characteristics in different habitat of study area, (3) to identify the staple food of Indian Rhino, and (4) to find out the food selectivity and dietary spectrum of Indian Rhino in Rajiv Gandhi Orang National Park, based on gathered data.

2. Materials and Methods

2.1. Study Area. The Rajiv Gandhi Orang National Park (coordinates: 92°15′–92°27′E and 26°29′–26°40′N) is situated in the north bank of the river Brahmaputra and within the administrative boundary of Darrang, Udalguri and Sonitpur districts of Assam, India (Figure 1). The study area is located about 130 km apart from the state capital city Guwahati and included under the jurisdiction of Mangaldoi Wildlife Division, Department of Environment and Forests, Government of Assam, India. The area of the park is 78.81 sq.km. The park harbours 64 Rhinos (2009 Census).

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

The study area comprises of alluvial floodplains of the river Brahmaputra. In fact, the complete study area is an alluvial terrace, and the entire Rajiv Gandhi Orang National Park could be divided into two halves, that is, lower Orang and upper Orang. The lower Orang portion is more recent origin, whereas the upper portion to its north is separated by high bank, traversing the park from east to west. The terrain

is gently sloping from North to South. The altitude of the study area ranges between of 45–75 m MSL.

The entire protected area was a human habitat area till the last decade of the 19th century [16]. Prior to declaration of Orang as a “Game Reserve” in 1915, different ethnic groups occupied the entire study area. Two large tributaries of the river Brahmaputra, namely, Dhansiri and Panchnoi are associated with numbers of streams and *nullah* that criss-crosses the park and became the source of water for the entire habitat.

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

2.2.1. Vegetation Sampling. For vegetation sampling, a total of 80 quadrats (1 m × 1 m in size) for grasses, 20 quadrats (5 m × 5 m in size) for shrub and herbs, and 20 quadrats (10 m × 10 m in size) for trees were taken covering all the habitats in Rajiv Gandhi Orang National Park. Since the Rajiv Gandhi 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 was recorded to calculate the relative dominance [2, 17].

2.2.2. Sampling for Food Habits. Scan animal sampling and ad libitum sampling [18] methods were used to collect the data of food and feeding habit at Rajiv Gandhi Orang National Park. During study, the seasonal variation of time spent on feeding in different food plant species was recorded to identify the staple food, food selectivity, and dietary spectrum of Indian Rhino in Rajiv Gandhi Orang National Park from dawn to dusk. The staple food referred to 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 $R > 1$, 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 quadrat.

The formulae of food selectivity could be represented as

$$\text{Selectivity} = R = \% \text{ of feeding records of } A^1, \\ A^1 \text{ relative dominance,} \quad (1) \\ A^1 = \text{Species 1.}$$

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

The study was carried out from April 2000 to March 2003 covering random sampling points of the whole study area of 78.81 sq.km. in Rajiv Gandhi Orang National Park (92°15′–92°27′E; 26°29′–26°40′N). A total of 10 days per

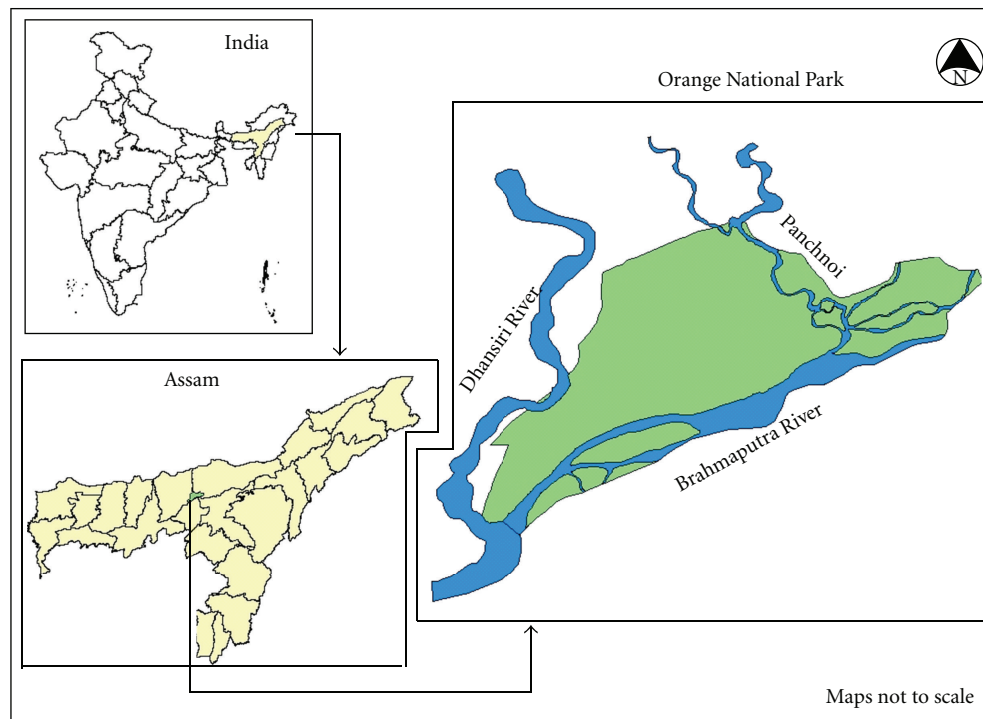


FIGURE 1: Location map of Rajiv Gandhi Orang National Park.

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. The data were further analyzed to find out the daily range, home range, and habitat utilization pattern. 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 and every visit.

The foraging tract was followed at the time of scan sampling, the grasses were identified if possible, and samples were collected to make herbarium sheet for identification of food plants. The plucked eaten food plants were confirmed by

- (a) direct observation of foraging rhino;
- (b) following the rhino food tracks;
- (c) by fresh Rhino dung analysis, that is, comparing undigested parts of food plants with herbarium sheet.

3. Results

3.1. Relative Dominance and Frequency

3.1.1. Grasses. The study revealed the presence of 75 grass species under Poaceae and Cyperaceae family in Rajiv Gandhi Orang National Park during sampling. Of the total 75 grass species, 48 had a relative frequency <1, 13 had relative

TABLE 1: Frequency occurrence of grasses, shrubs, herbs, and tree species in Rajiv Gandhi Orang National Park.

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

frequency 1-2, and 14 had >2 (Table 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 a dominance value of 0.08%.

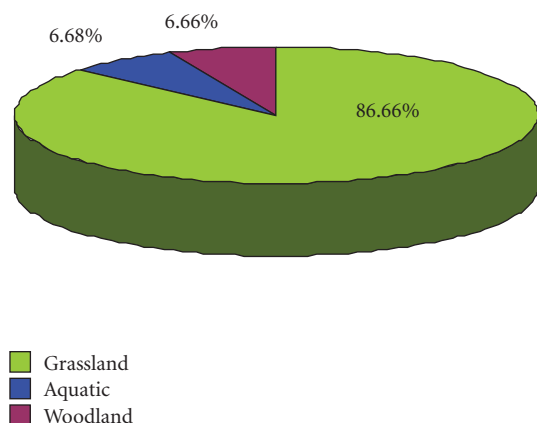


FIGURE 2: Annual uses of food items by Indian Rhino at Rajiv Gandhi Orang National Park.

3.1.2. Herbs and Shrubs. A total of 27 herbs and shrubs species belonging to 16 families (see Appendix 6.2) were recorded during sampling in Rajiv Gandhi Orang National Park of which 3 species had a relative frequency <1, and 24 species had a relative frequency >1 (Table 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%.

3.1.3. Trees. The study found altogether 27 tree species belonging to 8 families in Rajiv Gandhi Orang National Park with a relative frequency >1.0 (see Table 1). The *Dalbergia sissoo* was the highest ranked species with a relative dominance value of 7.94%, whereas the *Anthocephalus cadamba* ranked the lowest was species with a relative dominance value of 1.19%.

3.1.4. Food Items and Food Selection. The study showed that, grass constituted the highest of 86.66% total annual food of Indian Rhino in Rajiv Gandhi Orang National Park, but the nongrass aquatic plants and tree species constituted only 13.34% of total annual diet, indicated the high selection of grasses by Indian Rhino in Rajiv Gandhi Orang National Park during foraging (Figure 2).

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 (Figure 3). Of the total 42 grass species, 20 species had no selectivity but eaten during foraging time owing to availability in the grassland habitat of study area.

3.1.5. Food Items. Study showed that altogether 71 plant species have used by Indian Rhino as food items throughout the year in study area, of which 42 species were grasses, 20 species trees, herbs, and shrubs, and 9 species were other aquatic plant. Again, among all the 71 food plant species, the Indian Rhino consumed a total of 63 plant species as food during premonsoon, 49 species during monsoon, 57 species

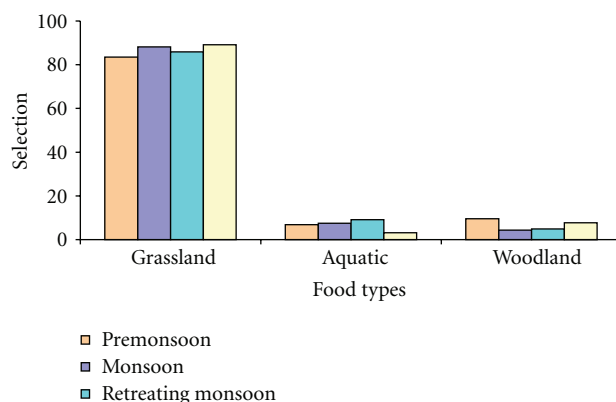


FIGURE 3: Seasonal use of food plant species by *Rhinoceros unicornis* in Rajiv Gandhi Orang National Park.

TABLE 2: Seasonal use of food-plant species by Indian Rhino in Rajiv Gandhi Orang National Park.

Species	Premonsoon	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

during retreating monsoon, and 58 species were used during winter season. Again, the Indian Rhino had consumed 36 grass species, 19 trees and aquatic plant species during premonsoon season, whereas consumed 32 grasses, 11 trees, and 6 aquatic plants species during monsoon season. During retreating monsoon, they consumed altogether 33 grass species, 17 trees species, and 7 other aquatic plants, whereas during winter season they consumed a total of 39 grass species, 15 trees species, and 4 other aquatic plants species (see Table 2).

3.1.6. Categories of Consumed Food Plant Species. Study revealed that there were altogether 12 different categories of food plants, that have been based on plant characteristics under three major habitat types, namely, grasslands, aquatic and woodland habitats in Rajiv Gandhi Orang National Park (Table 3). The Rhino consumed dissimilar categories of food items in various seasons of the year. The analysis of proportional use of food plant types by Indian Rhino showed that the plant types, namely, dry short grass (dsg), wet creeping short grass (wcsg), and wet tall grass (wtg) were consumed in maximum proportion during premonsoon compared to other types (Figure 4). 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 (see Figure 5). Whereas, the wet creeping

TABLE 3: The food plant species, in which habitat it occurs, feeding percentage, and major categories of food-plants of *Rhinoceros unicornis* in Rajiv Gandhi Orang National Park (PM: premonsoon; M: monsoon; RTM: retreating 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 shrubs; EAB: emergent aquatic bed; CAB: creeping aquatic bed; FFAB: free-floating aquatic bed; SM: submerged; SV: swampy vegetation; GL: grassland; Aq: aquatic; WL: woodland).

Food plant species	Families	Types of food plants	Habitat category	Percent of feeding			
				PM	M	RTM	WIN
(a) Grasses							
<i>Agrostis zenkeri</i>	Poaceae	WSG	GL	1.0	0.0	0.0	0.89
<i>Apluda mutica</i>	Poaceae	DSG	GL	2.2	0.5	0.0	1.7
<i>Arundinella bengalensis</i>	Poaceae	WCSG	GL	1.8	2.3	1.06	0.9
<i>Arundinella nepalensis</i>	Poaceae	WCSG	GL	1.9	0.7	0.49	1.84
<i>Arundo donax</i>	Poaceae	WTG	GL	7.8	5.6	6.8	5.3
<i>Axonopus compressus</i>	Poaceae	WSG	GL	1.4	0.0	0.0	0.58
<i>Brachiaria ramosa</i>	Poaceae	WCSG	GL	2.4	6.8	3.45	2.66
<i>Chrysopogon aciculatus</i>	Poaceae	DSG	GL	4.0	5.8	4.46	4.13
<i>Cynodon dactylon</i>	Poaceae	WSG	GL	3.0	1.5	2.3	1.63
<i>Cyperus cyperoides</i>	Cyperaceae	WSG	GL	0.0	0.1	0.4	0.0
<i>Cyperus rotundus</i>	Cyperaceae	WSG	GL	0.0	2.4	1.6	1.53
<i>Cyperus brevifolius</i>	Cyperaceae	WSG	GL	0.0	0.4	1.8	0
<i>Cyperus globosus</i>	Cyperaceae	WSG	GL	0.0	0.2	0.47	0.23
<i>Cyperus kyllingia</i>	Cyperaceae	WSG	GL	0.0	0.9	0.4	0
<i>Cyrtococcum accrescens</i>	Cyperaceae	DSG	GL	1.7	0.0	0.0	0.94
<i>Dichanthium caricosum</i>	Poaceae	WSG	GL	1.7	0.0	0.0	1.89
<i>Digitaria ciliaris</i>	Poaceae	WSG	GL	0.8	0	0.8	2.4
<i>Echinochloa crus-galli</i>	Poaceae	WSG	GL	0.0	0.0	0.0	0.89
<i>Eleusine indica</i>	Poaceae	DSG	GL	1.8	0.3	1.75	1.92
<i>Eragrostis japonica</i>	Poaceae	WTG	GL	1.2	0.0	0.9	0.56
<i>Eragrostis unioides</i>	Poaceae	WSG	GL	0.8	0.1	0.0	1.84
<i>Eriochloa procera</i>	Poaceae	WSG	GL	1.7	0.5	0.6	0.32
<i>Hemarthria compressa</i>	Poaceae	WSG	GL	7.9	13.0	14.3	11.8
<i>Hemarthria protesna</i>	Poaceae	WSG	GL	1.0	1.6	1.86	0.82
<i>Hygroryza aristata</i>	Poaceae	WSG	GL	1.8	2.3	2.48	1.34
<i>Hymenachne pseudointerrupta</i>	Poaceae	WCSG	GL	7.9	14	12.6	8.57
<i>Sacciolepis interrupta</i>	Poaceae	DSG	GL	2.2	1.0	0.74	2.06
<i>Leersia hexandra</i>	Poaceae	WCSG	GL	3.5	14	9.23	8.7
<i>Leptochloa panicea</i>	Poaceae	WSG	GL	1.8	1.0	1.7	1.56
<i>Panicum walense</i>	Poaceae	DSG	GL	1.3	0.0	0.0	0.84
<i>Oplismenus burmannii</i>	Poaceae	DSG	GL	1.3	1.0	1.6	0.87
<i>Paspalidiumflavidum</i>	Poaceae	WCSG	GL	0.6	0.0	0.56	1.61
<i>Paspalum conjugatum</i>	Poaceae	WSG	GL	0.7	1.3	1.33	0.89
<i>Paspalum dilatatum</i>	Poaceae	WSG	GL	0.9	1.1	1.5	0.6
<i>Phragmites karka</i>	Poaceae	WTG	GL	5.8	3.3	3.88	4.67
<i>Saccharum procerum</i>	Poaceae	WTG	GL	1.1	1.8	0.93	1.83
<i>Saccharum ravennae</i>	Poaceae	WTG	GL	2.6	1.8	0.8	2.31
<i>Saccharum spontaneum</i>	Poaceae	WTG	GL	3.7	1.0	0.68	2.89
<i>Setaria pumila</i>	Poaceae	WSG	GL	0.0	0.0	0.0	1.7
<i>Themeda villosa</i>	Poaceae	WTG	GL	2.4	0.8	1.06	2.62
<i>Vetiveria zizanioides</i>	Poaceae	WTG	GL	0.0	0.0	0.8	0.07
<i>Imperata cylindrica</i>	Poaceae	DSG	GL	1.6	2.5	2.6	1.2

TABLE 3: Continued.

Food plant species	Families	Types of food plants	Habitat category	Percent of feeding			
				PM	M	RTM	WIN
(b) Aquatic plants							
<i>Ipomea aquatica</i>	Convolvulaceae	CAB	Aq	1.0	1.5	1.9	1.26
<i>Pistia stratiotes</i>	Araceae	FFAB	Aq	1.7	1.6	0.74	0.89
<i>Eichhornia crassipes</i>	Pontederiaceae	FFAB	Aq	0.9	1.1	0.84	0.0
<i>Vallisneria spiralis</i>	Hydrocharitaceae	SM	Aq	0.7	0.0	1.66	0.0
<i>Hydrilla verticillata</i>	Hydrocharitaceae	SM	Aq	1.6	0.0	1.8	0.3
<i>Nymphaea nouchali</i>	Nymphaeaceae	EAB	Aq	0.0	1.0	0.87	0.0
<i>Trapa bispinosa</i>	Trapaceae	EAB	Aq	0.3	0.0	0.0	0.0
<i>Enhydra fluctuans</i>	Asteraceae	CAB	Aq	0.5	2.1	1.35	0.7
<i>Alpinia allughas</i>	Zingiberaceae	SV	Aq	0.1	0.2	0.0	0.0
(c) Herbs and shrubs							
<i>Ageratum conyzoides</i>	Asteraceae	DS	WL	0.5	0.0	0.02	0.4
<i>Mikania micrantha</i>	Asteraceae	DH	WL	0.5	0.0	0.47	0.55
<i>Melastoma malabathricum</i>	Melastomataceae	DS	WL	0.6	0.0	0	0
<i>Lantana camera</i>	Verbenaceae	DS	WL	0.7	0.0	0.55	0
<i>Xanthium strumarium</i>	Asteraceae	DS	WL	0.7	0.0	0.53	0.16
<i>Grewia sapida</i>	Tiliaceae	DS	WL	0.9	0.7	0.61	0.53
<i>Polygonum hydropiper</i>	Polygonaceae	DH	WL	0.0	0.0	0.0	0.01
<i>Diplazium esculentum</i>	Dryopteridaceae	DH	WL	0.9	0.0	0.2	0.67
<i>Amaranthus spinosus</i>	Amaranthaceae	DH	WL	1.0	0.0	0.6	0.0
(d) Trees							
<i>Bombax ceiba</i>	Bombacaceae	DTT	WL	0.9	0.0	0	0.78
<i>Trewia nudiflora</i>	Euphorbiaceae	DTT	WL	0.5	0.6	0.66	0.76
<i>Dalbergia sissoo</i>	Papilionaceae	DTT	WL	0.7	0.9	0.12	0.87
<i>Cassia fistula</i>	Caesalpinaceae	DTT	WL	0.5	0.4	0.05	0.81
<i>Mangifera indica</i>	Anacardiaceae	DTT	WL	0.0	0.4	0.03	0.0
<i>Ficus glomerata</i>	Moraceae	DTT	WL	0.6	0.4	0.01	0.63
<i>Streblus asper</i>	Moraceae	DST	WL	0.0	0.0	0.01	0.0
<i>Ficus rumphii</i>	Moraceae	DTT	WL	0.1	0.4	1.03	0.9
<i>Artocarpus heterophyllus</i>	Moraceae	DTT	WL	0.0	0.5	0.01	0.04
<i>Ziziphus zuzuba</i>	Rhamnaceae	DST	WL	0.5	0.3	0.02	0.26
<i>Bauhinia purpurea</i>	Leguminoseae	DTT	WL	0.0	0.0	0.02	0.35

short grasses (wcsg), wet tall grasses (wtg), dry short grasses (dsg), submerged (sm), and creeping aquatic beds (cab) types of food-plants were consumed in higher proportion during retreating monsoon season (Figure 6). 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 (dt), and creeping aquatic beds (cab) types of food plants than other types of species (Figure 7).

3.1.7. 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 *Hemarthria compressa*, *Hymenachne pseudointerrupta*, *Leersia hexandra*, *Arundo donax*, *Chrysopogon aciculatus*, *Phragmites karka*, *Brachiaria ramosa*, *Cynodon dactylon*, *Saccharum spontaneum*, and *Imperata cylindrica* (Table 4).

3.1.8. Staple Food. The analysis showed that altogether 36 plant species (Table 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 Rajiv Gandhi Orang National Park. Among all the 36 plant species, 24 plant species were grasses that constituted 75.97% of the total selected annual food plant species; hence, it is referred to as staple food of Indian Rhino. But, among nongrass species, only 9 trees species and 3 aquatic plant species were also

TABLE 4: Shows the ten top ranking annual food plants of Indian Rhino in Rajiv Gandhi Orang National Park.

SL number	Species	Annual feeding frequency (%)
1	<i>Hemarthria compressa</i>	11.63
2	<i>Hymenachne pseudointerrupta</i>	10.64
3	<i>Leersia hexandra</i>	8.80
4	<i>Arundo donax</i>	6.38
5	<i>Chrysopogon aciculatus</i>	4.60
6	<i>Phragmites karka</i>	4.42
7	<i>Brachiaria ramosa</i>	3.83
8	<i>Cynodon dactylon</i>	2.11
9	<i>Saccharum spontaneum</i>	2.05
10	<i>Imperata cylindrica</i>	1.98

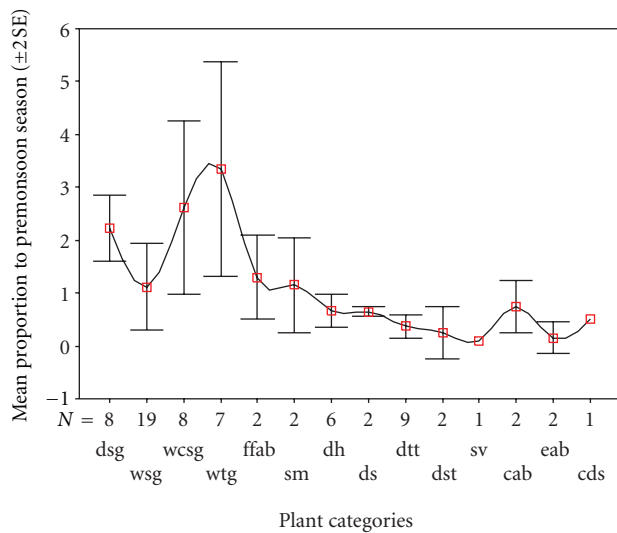


FIGURE 4: Proportional use of food plants species by Indian Rhino in Rajiv Gandhi Orang National Park during premonsoon season (data was represented, Mean \pm 2SE; wsg: wet short grass; wscg: wet creeping short grass; dsgr: dry short grass; dst: dry short tree; dtt: dry tall tree; dh: dry herbs; ds: dry shrubs; eab: emergent aquatic bed; cab: creping aquatic bed; ffab: free-floating aquatic bed; SM: submerged; sv: swampy vegetation).

selected as annual food, which constituted only 7.67% of the total annual diet, that were also referred as staple food (Table 6).

3.1.9. 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 Rajiv Gandhi Orang National Park (see Figure 8). Again, among the 20 top ranking food-plant species, 19 species were grasses, and only one species was aquatic plant species

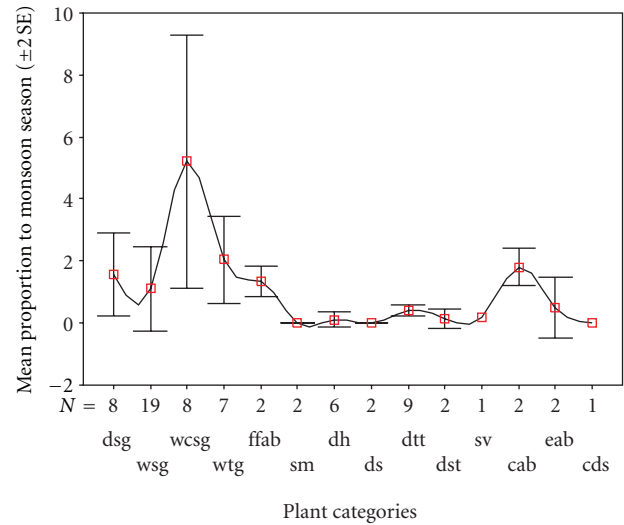


FIGURE 5: Proportional use of food plants species by Indian Rhino in Rajiv Gandhi Orang National Park during monsoon season (data was represented, Mean \pm 2SE; wsg: wet short grass; wscg: wet creeping short grass; dsgr: dry short grass; dst: dry short tree; dtt: dry tall tree; dh: dry herbs; ds: dry shrubs; eab: emergent aquatic bed; cab: creeping aquatic bed; ffab: free-floating aquatic bed; SM: submerged; sv: swampy vegetation).

(*Ipomea aquatica*). This clearly indicated that the grass alone was the sufficient food items, of Rhino, necessary for survival in Rajiv Gandhi Orang National Park.

3.1.10. Cultivated Crop. The study revealed that the Indian Rhinos in Rajiv Gandhi Orang National Park had often visited in fringe villages for depredation of cultivated crops. There were altogether 10 cultivated crops and 10 vegetables eaten by Rhino as their food. No quantitative analysis of the cultivated crops were made, that have consumed in dark hours of the day (Table 7).

3.1.11. Geophagy (or Soil Eating). There were altogether seven soil eating (soil licking) sites of Indian Rhinos in Rajiv Gandhi Orang National Park during study period (Table 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.

4. Discussion

In 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, the grasses are the key food-plant species of Rhino in Rajiv Gandhi Orang National Park. This is also evident from the seasonal diet pattern, where 89.13% grasses were consumed during winter and 83.50% during premonsoon season. Laurie [4, 5] also reported that Indian Rhino at Nepal also consumed 86.4% grasses, 5.2% aquatic plants, and 3.4% browse from February–May (spring season), while 88.7% grasses, 5.7%

TABLE 5: Staple food of Rhino in Rajiv Gandhi Orang National Park (a) grasses, (b) trees and (c) aquatic plants.

Name of the food plant	Seasons			
	PM	M	RM	W
(a) Grasses				
<i>Arundinella begalensis</i> (Spreng.) Druce.	1.8	2.3	1.06	0.9
<i>Arundinella nepalensis</i> Trin.	1.9	0.7	0.49	1.84
<i>Arundo donax</i> Linn.	7.8	5.6	6.8	5.3
<i>Brachiaria ramosa</i> (L.) Stapf.	2.4	6.8	3.45	2.66
<i>Chrysopogon aciculatus</i> (Retz.) Trin.	4.01	5.8	4.46	4.13
<i>Cynodon dactylon</i> (L.) Pers	3.02	1.5	2.3	1.63
<i>Eleusine indica</i> (L.) Gaertn.	1.84	0.25	1.75	1.92
<i>Eriochloa procera</i> (Retz.) C.E.Hubb.	1.71	0.5	0.6	0.32
<i>Hemarthria compressa</i> (L.f.) R.Br.	7.9	12.5	14.3	11.83
<i>Hemarthria protesna</i> Steud.	0.96	1.56	1.86	0.82
<i>Hygroryza aristata</i> (Retz.) Nees ex Wight and Arn.	1.81	2.26	2.48	1.34
<i>Hymenachne pseudointerrupta</i>	7.93	13.5	12.57	8.57
<i>Imperata cylindrica</i> (L.) Beauv.	1.6	2.5	2.6	1.2
<i>Leersia hexandra</i> Sw.	3.54	13.72	9.23	8.7
<i>Leptochloa panicea</i> (Retz.) Ohwi	1.8	1.03	1.7	1.56
<i>Oplismenus burmannii</i> (Retz.) P.Beauv.	1.3	1.01	1.6	0.87
<i>Paspalum conjugatum</i> Berg.	0.7	1.3	1.33	0.89
<i>Paspalum dilatatum</i> Poir.	0.86	1.08	1.5	0.6
<i>Phragmites karka</i> (Retz.) Trin.ex.Steud.	5.83	3.3	3.88	4.67
<i>Saccharum procerum</i> Roxb.	1.08	1.81	0.93	1.83
<i>Saccharum ravennae</i> (L.) Beauv.	2.61	1.8	0.8	2.31
<i>Saccharum spontaneum</i> Linn.	3.68	0.96	0.68	2.89
<i>Sacciolepis interrupta</i> (Willd.) Stapl.	2.2	0.95	0.74	2.06
<i>Themeda villosa</i> (Poir.) A.Camus.	2.4	0.83	1.06	2.62
(b) Trees				
<i>Artocarpus heterophyllus</i> Lamk.	0.02	0.45	0.01	0.04
<i>Bauhinia purpurea</i> L.	0.02	0.01	0.02	0.35
<i>Cassia fistula</i> L.	0.49	0.37	0.05	0.81
<i>Dalbergia sissoo</i> Roxb.	0.67	0.85	0.12	0.87
<i>Ficus glomerata</i> Roxb.	0.57	0.36	0.01	0.63
<i>Ficus rumphii</i> Bl.	0.05	0.35	1.03	0.9
<i>Grewia sapida</i> Roxb.	0.94	0.66	0.61	0.53
<i>Trewia nudiflora</i> L.	0.52	0.62	0.66	0.76
<i>Ziziphus zuzuba</i> Lamk.	0.46	0.29	0.02	0.26
(c) Aquatic plants				
<i>Enhydra fluctuans</i> Lour.	0.5	2.1	1.35	0.7
<i>Ipomea aquatica</i> Forssk.	1.03	1.48	1.9	1.26
<i>Pistia stratiotes</i> Linn.	1.73	1.6	0.74	0.89

TABLE 6: Percent use of Staple food by Indian Rhino in Rajiv Gandhi Orang National Park (PM: premonsoon; M: monsoon; RM: retreating monsoon; W: winter).

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

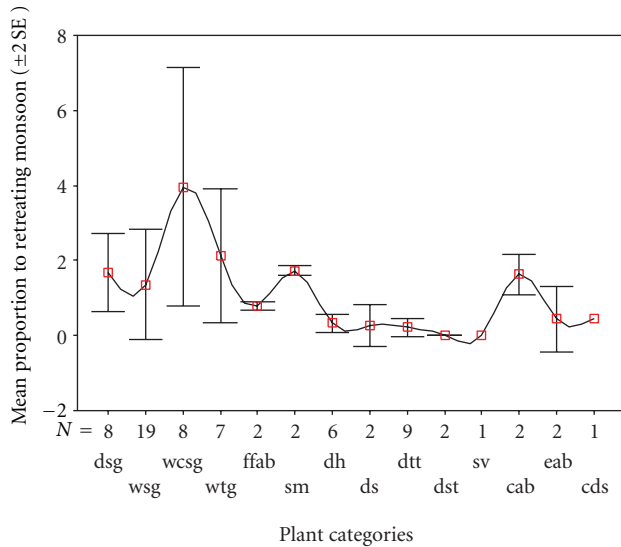


FIGURE 6: Proportional use of food plants species by Indian Rhino in Rajiv Gandhi Orang National Park during retreating monsoon (data was represented, Mean \pm 2SE; wsg: wet short grass; wscg: wet creeping short grass; dsg: dry short grass; dst: dry short tree; dtt: dry tall tree; dh: dry herbs; ds: dry shrubs; eab: emergent aquatic bed; cab: creeping aquatic bed; ffab: free-floating aquatic bed; SM: submerged; sv: swampy vegetation).

TABLE 7: Cultivated crop and vegetable species eaten by Indian Rhino as food in association with natural food items (name written in parentheses are in local vernacular names).

Crops	Vegetables and others
<i>Zea mays</i> (zea)	<i>Cucurbita pepo</i> (summer Squash)
<i>Oryza sativa</i> (paddy)	<i>Cucurbita maxima</i> (red Pumpkin)
<i>Cicer arietinum</i> (gram)	<i>Luffa acutangula</i> (ridged gourd)
<i>Pisum sativum</i> (peas)	<i>Cucumis sativus</i> (cucumber)
<i>Cajanus cajan</i> (pigeon pea)	<i>Capsicum annum</i> (chilli)
<i>Phaseolus mungo</i> (black gram)	<i>Abelmoschus esculentus</i> (lady's finger)
<i>Phaseolus lunatus</i> (lima bean)	<i>Cucurbita maxima</i> (sweet gourd)
<i>Phaseolus aureus</i> (green gram)	<i>Solanum melongena</i> (brinjal)
<i>Triticum aestivum</i> (wheat)	<i>Ipomea batatas</i> (sweet potato)
<i>Lathyrus sativus</i> (khesari dal)	<i>Carica papaya</i> (papaya)

aquatic plants and 5.6% browse from June–September (monsoon season) and 70.4% grasses, 8.0% aquatic plants and 21.6% browse from October–January (winter season). Those results supported the present findings of grass as the most preferred food items of Indian Rhino. Similar types of findings were also observed by Jnawali [19] in Bardia National Park and Chitwan National Park in Nepal. He suggested that a highest proportion of 92% grass species has used as the diet of Indian Rhino during monsoon in Bardia National Park and 86% in Chitwan National Park during hot season and lowest of 42–57% during winter season. Fjellstad and Steinheim [20] also suggested that the diet of Indian Rhino has consisted of 63% grass and 28% browse.

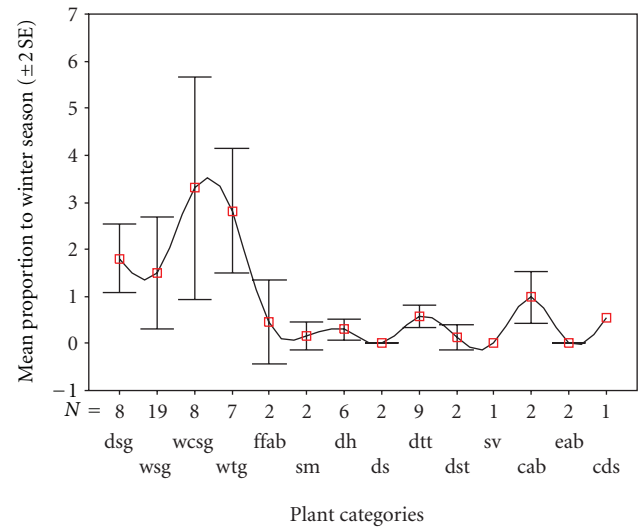


FIGURE 7: Proportional use of food plants species by Indian Rhino in Rajiv Gandhi Orang National Park during winter season (data was represented, Mean \pm 2SE; wsg: wet short grass; wscg: wet creeping short grass; dsg: dry short grass; dst: dry short tree; dtt: dry tall tree; dh: Dry herbs; ds: dry shrubs; eab: emergent aquatic bed; cab: creeping aquatic bed; ffab: free-floating aquatic bed; SM: submerged; sv: swampy vegetation).

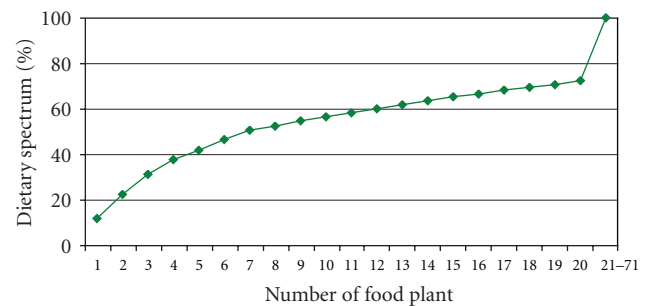


FIGURE 8: Dietary spectrum of Indian Rhino in Rajiv Gandhi Orang National Park (based on actual collected data).

This clearly indicates that, the Indian Rhino has mostly depended on grasses rather than browse or other aquatic plants. Hence, it could be opined that the Indian Rhino is more habitat specialized than any other large herbivore mammals. Fjellstad and Steinheim [20] also found in their study that Rhino depends on quality of food rather than quantity. They also found that Indian Rhino spent 85% total feeding time on three vegetation types, while there were six 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 [4, 5] has stated that Indian Rhino fed on 183 food-plants species under 57 families in Chitwan National Park. Ghosh [12] has stated that the Rhino consumed 82 plant species belonging to 34 families in Jaldapara Wildlife Sanctuary. So, it is varied in all occasions. The present study

TABLE 8: Shows the soil eating sites in Rajiv Gandhi Orang National Park with GPS locations.

Camp/Beat	Location	GPS location Latitude and Longitude	Remark
Katasali Beat	(1) In front of the beat	92° 15' 13.43'' E 26° 31' 02.54'' N	Located under <i>Acacia catechu</i> tree
	(2) North of the Katasali Beat	92° 15' 32.24'' E 26° 31' 02.73'' N	Located under <i>Acacia catechu</i> tree
	(3) North-west of the Katasali Beat	92° 15' 05.59'' E 26° 31' 13.64'' N	Located under <i>Acacia catechu</i> 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 <i>Acacia catechu</i> tree
Satsimalu Beat	(6) South of the Guest house	92° 18' 34.02'' E 26° 33' 14.84'' N	Located under <i>Lagerstroemia speciosa</i> tree
Bantapu Camp	(7) In between Bantapu and Hatiputa camps	92° 18' 35.69'' E 26° 32' 21.87'' N	Located under <i>Acacia catechu</i> tree

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

The mostly preferred 10 top ranking food plants are such as *Hemarthria compressa* (11.63%), *Hymenachne pseudointerrupta* (10.64%), *Leersia hexandra* (8.80%), *Arundo donax* (6.38%), *Chrysopogon aciculatus* (4.60%), *Phragmites karka* (4.42%), *Brachiaria ramosa* (3.83%), *Cynodon dactylon* (2.11%), *Saccharum spontaneum* (2.05%), and *Imperata cylindrica* (1.98%), of which six species were positively selected for feeding. All these 10 species are confined to grasses and growing in wet grassland habitat. These findings of top ranking species are contradictory with the findings of Laurie [4, 5] and Ghosh [12] in Chitwan National Park of Nepal and Jaldapara Wildlife Sanctuary, West Bengal, respectively. But the study conducted by Bhattacharyya [11] in Kaziranga National Park of Assam is almost similar to our 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 Rajiv Gandhi Orang National Park and as well as 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 Rajiv Gandhi Orang National Park indicate 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 Rajiv Gandhi Orang National Park.

Crop depredation by wild elephant [21, 22] 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 [4, 5] Jnawali [23] and Bhattacharyya [11] has mentioned the crop depredation behaviour of Indian Rhino in India and Nepal. Like other large mammals, Indian Rhino in Rajiv Gandhi 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 [24], Laurie [4, 5], Ghosh [12], Dutta, [25] and Bhattacharyya [11] 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 and Rhino tend to feed more because they need more energy. The age and sex variation also have some relationship with food intake. Females of some species tend to feed more on foliage than males because of greater protein requirement. Pregnant and lactating females tend to feed more on foliage because of an increase in metabolic rate.

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