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SEASONAL VARIATIONS IN FOOD PLANT PREFERENCES OF REINTRODUCED RHINOS *RHINOCEROS UNICORNIS* (MAMMALIA: PERRISSODACTYLA: RHINOCEROTIDAE) IN MANAS NATIONAL PARK, ASSAM, INDIA

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Abstract: The food preferences of translocated Rhinos in Manas National Park were studied to find out variations in seasonal and annual preferences. A total of 139 plants species belonging to 39 families were observed to be consumed as food. On an average, grasses (n=33) contributed 24% of Rhino food, aquatic plants (n=23) 16.5%, shrubs (n=11) 7.5%, herbs (n = 31) 22.3% trees (n=26) 18.7%, creepers (n=3) 2.1% and agricultural crops (n=12) 8.6%. Among the grasses, throughout the year *Arundo donax*, *Cynodon dactylon*, *Imperata cylindrica*, *Saccharum elephantinus* and *Saccharum spontaneum* were the maximum preferred species. Rhinos were observed to browse shrubs and tree twigs during the winter season and browsing was found to be very limited during the monsoon due to the abundance of young grass. Various anthropogenic pressures such as unregulated grassland burning, cattle grazing, invasions of *Bombax ceiba* and shrubs like *Chromolaena odorata*, *Leea asiatica* and herbs like *Ageratum conyzoides* have degraded some of the important grasslands. So, a proper grassland management protocol including the burning of grasslands during the dry season, keeping grazing animals away and control of weeds is suggested in the areas extensively used by the Rhinos.

Keywords: Food preferences, grassland management, reintroduction, *Rhinoceros unicornis*, translocation.

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Authors Contribution: DKD has contributed to field studies, scientific analysis and write up. PJB has given the guidance for plant identification. AMS, ANS, and RM have critically analyzed the findings.

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INTRODUCTION

Reintroduction is a process of releasing animals into an unfamiliar novel environment where they must explore their surroundings to acquaint themselves in order to survive. It is an attempt to reintroduce species to an area which were earlier part of their historical range but were locally exterminated due to poaching or became extinct. It is a complex and risky endeavor and corresponding success rates are low (IUCN 2012). Therefore, it is highly imperative to monitor newly released species based on scientific principles and methodology to make future endeavors more successful (Emslie et al. 2009).

There are multiple factors responsible for the success of a reintroduction program in recipient sites, and food preferences is one of the primary requirements. Food plants diversity, distribution, and available seasonal preferences give a proper insight into animal adaptation in new locations.

Globally, there are ample studies on Greater One-horned Rhinoceros (GoH) food plant preferences but very limited studies were done on post-release food preferences. Brahmachary et al. (1971), Laurie (1982), Jnawali (1986), Dinerstein & Wemmer (1988), Dinerstein & Price (1991), Dutta (1991), Patar (2004), Konwar et al. (2009) and Hazarika & Saikia (2012) studied food plant preferences in respective protected areas of India and Nepal. Jnawali (1995), Dinerstein (2003), Steinheim et al. (2005), Pradhan et al. (2008) did some studies on reintroduced Rhinos food plant preferences in Bardia National Park of Nepal. All these studies indicated that Rhinos are essentially grazers with the majority of the diet comprising *Cynodon dactylon*, *Imperata cylindrica*, *Narenga prophyracoma*, *Saccharum elephantinus*, and *Saccharum spontaneum*. This study was carried out to emphasize identification and profiling of preferred food plants of Rhinos and its characteristics in relation to season.

STUDY AREA

The study was carried out in Manas National Park (MNP) that is globally recognized as a UNESCO World Heritage Site. MNP is situated between 26°30'–27°00'N & 91°51'–92°00'E (Fig. 1). It is located in the foothills of the Himalaya on the northern bank of the Brahmaputra Valley of Assam and falls within the districts of Chirang and Baksa along the international boundary of India and Bhutan. MNP is famous for its rich floral and faunal

biodiversity including species such as the Indian Tiger *Panthera tigris*, Pygmy Hog *Sus salvanius*, Golden Langur *Trachypithecus geei*, Hispid Hare *Caprolagus hispidus*, Bengal Florican *Houbaropsis bangalensis* and White-winged Wood Duck *Cairina scutulata*.

The management history of MNP dates back to 1905 when the area was declared as North Kamrup Reserved Forests, and later in 1928, the area was named as 'Manas Game Sanctuary'. During 1951 and 1955, the area was increased to 391km². The Manas Tiger Reserve (2,837km²) was included as one of the first eight tiger reserves declared in the country under Project Tiger in 1973. The sanctuary area was also inscribed in the list of World Heritage Site in 1985. The entire Manas Tiger Reserve was also declared a biosphere reserve in 1989. Manas Sanctuary was finally declared as a national park in the year 1990 by encompassing an area of 500km².

MNP has a good Rhino habitat and presumably had more than 100 Rhinos until the mid-1990s (Vigne & Martin 1994). The entire population of MNP was wiped out due to poaching in the early nineties (Dutta et al. 2015; Barman et al. 2014). Therefore, a new Rhino population was established in MNP under the program of Indian Rhino Vision 2020 (IRV2020). IRV2020 is a joint program of the Assam Forest Department, World Wide Fund for Nature (WWF) and International Rhino Foundation (IRF) formulated by the "Task Force for Translocation of Rhinos within Assam" in November 2005. The program aims to work for the long-term conservation of Rhinos in Assam through enhanced protection and range expansion (Ghose & Dutta 2014).

METHODS

This study was carried out in Manas National Park within a period of six years (2008–2013). Rhinos were radio-collared with very high frequency (VHF) radio collars (African Wildlife Tracking) at the capture sites (Kaziranga NP and Pobitora WS). Tracking of the Rhinos was carried out by using directional antennae (Telonics RA-14K antennae, 148-152 MHz, rubber duct, heavy duty), VHF radio receiver (Communication Specialists, R-1000 receiver, 148/152 MHz). Direction compass was used to triangulate Rhino location in dense and tall vegetation and Locate windows version 7 software was used to find out spatial information.

Immediately after release, Rhinos were tracked and located three times daily in the morning, afternoon and evening (i.e., from 6–10 hr, 10–14 hr and 14–18 hr). Sometimes, Rhinos were also located at night (i.e., 18–6

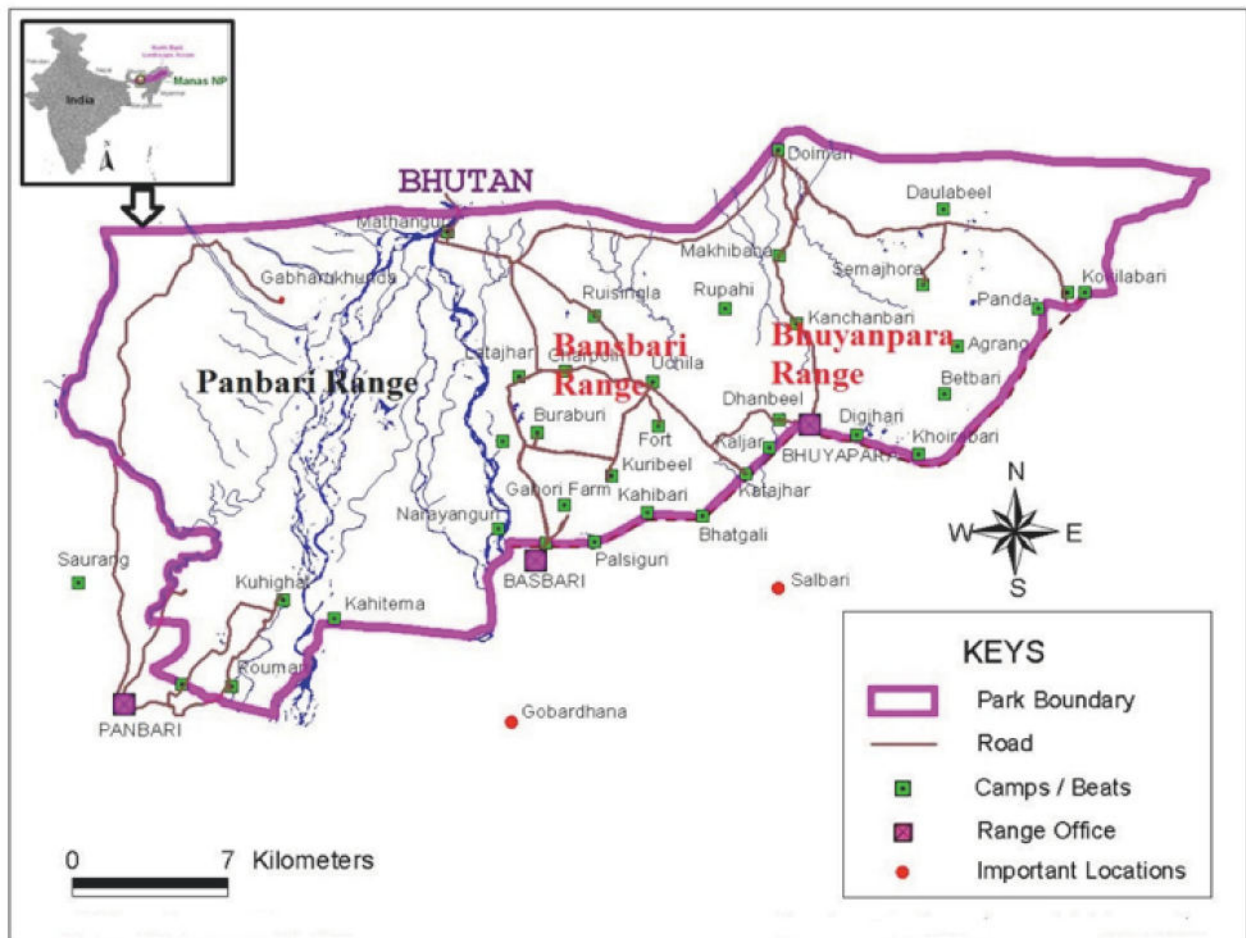


Figure 1. Manas National Park

hr) which was largely dependent on accessibility.

Patrolling elephants, four wheelers, motorbikes and bicycles were used during the monitoring process and sometimes trackers went on foot to track the collared Rhinos. The monitoring data was collected by homing in technique and when the terrain was not negotiable; GPS coordinates and Rhino locations were obtained by triangulation techniques (Freegard 2009). IRS P6 LISS satellite data for 2013 (November) were used to derive habitat information of MNP through Standard Image Analysis Technique. The habitat that could be distinguished both visually and from satellite images were broadly categorized into woodland, grassland, swamp and water bodies (Dutta et al. 2015).

Food plant preferences were recorded using direct focal observation methods (Wallmo & Jeff 1970; Laurie 1978, 1982; Inawali 1986, 1995; Dinerstein & Wemmer 1988; Dinerstein & Price 1991; Dinerstein 2003; Kandel et al. 2008; Bhattacharya 2011). Riding on captive elephants using binoculars Rhinos were observed at very

close quarters (5–10 m) (Kandel et al. 2008). Whenever there was a doubt in identification of a forage species, direct observation was followed by onsite inspection, taking photographs/video and later identifying the plant with a published checklist and by a plant taxonomist (Kandel et al. 2008). Depending on the temperature, rainfall, humidity, there are four distinct seasons seen in MNP (Barthakur 1984): pre-monsoon (March, April), monsoon (May to September), retreating monsoon (October, November), and winter or dry season (December to February).

Eighteen Rhinos were released at MNP (10 from Pobitora WS and 8 from Kaziranga NP) during the ensuing period (Appendix 1). After release at Buraburijhar and Rhino camp release sites (Fig. 2), the Rhinos moved to different locations of MNP. Some of these areas were very difficult to access and logistically, it was not possible to go there for regular study. Out of the total 18 Rhinos released in the wild, eight Rhinos moved to difficult to access parts of the park and that is why only 10 Rhinos

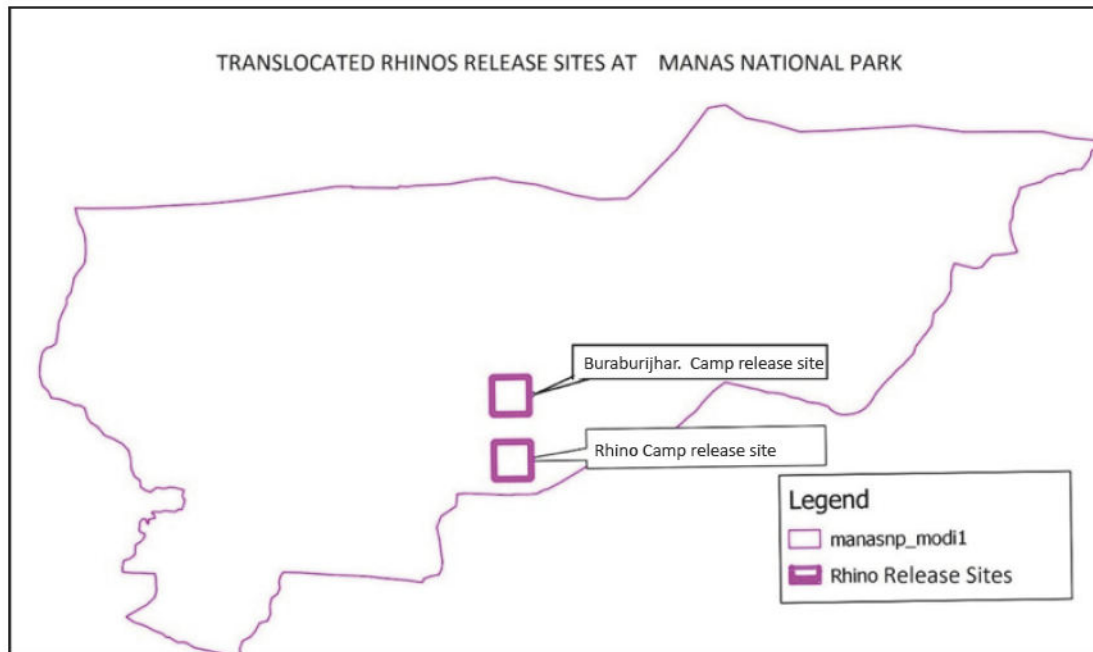


Figure 2. Buraburijhar and Rhino camp Rhino's release sites

could be accessed regularly for the study. Among the 10 Rhinos, there were three adult males, four adult females and three calves (Images 1–8).

RESULTS

Rhinos fed on 139 plant species in different seasons. Out of 139 species, 23 species were short grass species, 11 species were tall grass species, 23 species were aquatic plants, 11 species shrubs, 30 species herbs, three species creepers, 26 species were trees and 12 species were crops (Tables 1–8). As per preference and availability of plants, 49 species were observed to be preferred throughout the year with 1,969 feeding records (Table 9). Almost equal feeding proportion was observed among all groups of Rhinos for 34 plant species in pre-monsoon, monsoon, retreating monsoon seasons and 220 feeding proportion was recorded for the same (Table 10).

Apart from these plant species, some plants were preferred particularly in respect of season. In the pre-monsoon, eight species were recorded with 22 feeding observations among all groups of Rhinos. During the monsoon season, six plant species were exclusively recorded with 24 feeding observations among adult males only. In the retreating monsoon season, four plant species were recorded with 34 feeding records. During

the winter, 13 particular plant species were recorded with 46 feeding observations among all groups of Rhinos. Just after the release, some Rhinos strayed outside the park and raided crops in agriculture fields. There were 12 agriculture crop species preferences recorded with 70 feeding records during the settling phase of Rhinos. Adult male R1 and R2 raided agriculture crops during the settling phase for a maximum number of times. But rice were observed to be preferred inside the encroached areas of Bhuyanpara range of MNP. Rice preferences observation was also recorded even after the settling phase of Rhinos.

During this period, the only single observation was recorded for herbs *Amphineuron opulentum*, *Brassica campestris*, *Cassia tora*, *Diplazium esculentum*, *Hydrocotyle rotundifolia*, *Hydrocotyle sibthropioides*, *Spilanthes paniculata*, *Xanthium indicum*. Among creepers, *Mikania scandens* and shrubs, only *Flemingia bracteata* and among the trees *Bauhinia variegata*, *Emblia officinalis*, *Careya arborea* were observed.

Preferred Plant Species Round the Year

As mentioned earlier, 49 types of species were preferred by Rhinos all round the year. Among the 49 species, 45% (n=22) species were grasses, 16% (n=8) species were herbs, 12% (n=6) species were aquatic plants, 4% (n=2) species were creepers and 22% (n=11) species belonged to tree species were observed to be

Table 1. List of short grasses preferred by Rhinos in Manas National Park

	Scientific name	Family
1	<i>Axonopus compressus</i> L.	Poaceae
2	<i>Cynodon dactylon</i> (L.) Pers	Poaceae
3	<i>Cenchrus ciliaris</i> L.	Poaceae
4	<i>Cyperus compressus</i> L.	Cyperaceae
5	<i>Cyperus digitatus</i> Roxb.	Cyperaceae
6	<i>Cyperus rotundus</i> L.	Cyperaceae
7	<i>Cyperus pilosus</i> Vahl.	Cyperaceae
8	<i>Cyperus auricomus</i> Roxb.	Cyperaceae
9	<i>Cyperus iria</i> L.	Cyperaceae
10	<i>Dactyloctenium aegyptium</i> L.	Poaceae
11	<i>Eleusine indica</i> (L.) Gaertn.	Poaceae
12	<i>Eragrostis</i> sp.	Poaceae
13	<i>Fimbristylis aestivalis</i> (Retz.)	Cyperaceae
14	<i>Hemarthria compressa</i> (L.f.)R.Br.	Poaceae
15	<i>Imperata cylindrica</i> L.	Poaceae
16	<i>Kyllinga brevifolia</i> Rottb.	Cyperaceae
17	<i>Leersia hexandra</i> Sw.	Poaceae
18	<i>Mariscus compactus</i> (Retz)	Cyperaceae
19	<i>Paspalum conjugatum</i> Bergius.	Poaceae
20	<i>Paspalum orbiculare</i> L.	Poaceae
21	<i>Pogonatherum crinitum</i> (Thunb) Kunth.	Poaceae
22	<i>Scirpus articulatus</i> L.	Cyperaceae
23	<i>Seteria glauca</i> L.	Poaceae

Table 2. List of tall grasses preferred by Rhinos in Manas National Park

	Scientific name	Family
1	<i>Andropogon</i> sp	Poaceae
2	<i>Arundo donax</i> L.	Poaceae
3	<i>Carex</i> sp.	Cyperaceae
4	<i>Erianthas</i> sp.	Poaceae
5	<i>Narenga porphyracoma</i> (Hance) Bor.	Poaceae
6	<i>Pollinia ciliata</i> Trin.	Poaceae
7	<i>Phragmites karka</i> (Retz.) Trin ex Steud.	Poaceae
8	<i>Saccharum spontaneum</i> L.	Poaceae
9	<i>Saccharum elephantinus</i> Robx.	Poaceae
10	<i>Themeda villosa</i> Poiret.	Poaceae
11	<i>Vetiveria zizanioides</i> (L.) Nash	Poaceae

Table 3. List of herbs preferred by Rhinos in Manas National Park

	Scientific name	Family
1	<i>Ageratum conyzoides</i> L.	Asteraceae
2	<i>Alternanthera sessilis</i> L.	Amaranthaceae
3	<i>Amaranthus spinosus</i> L.	Amaranthaceae
4	<i>Amaranthus viridis</i> L.	Amaranthaceae
5	<i>Amphineuron opulentum</i> (Kaulf.) Holttum.	Thelypteridaceae
6	<i>Astraceae</i> sp.	Asteraceae
7	<i>Brassica campestris</i> L.	Brassicaceae
8	<i>Cassia tora</i> L.	Caesalpiniaceae
9	<i>Centrella asiatica</i> L.	Apiaceae
10	<i>Chenopodium album</i> L.	Chenopodiaceae
11	<i>Commelina longifolia</i> Lam.	Commelinaceae
12	<i>Commelina benghalensis</i> L.	Commelinaceae
13	<i>Commelina</i> sp.	Commelinaceae
14	<i>Drymaria diandra</i> L.	Caryophyllaceae
15	<i>Diplazium esculentum</i> Retz.	Athyriaceae
16	<i>Eclipta alba</i> , L.	Asteraceae
17	<i>Eclipta prostate</i> L.	Asteraceae
18	<i>Euphorbia hirta</i> , L.	Euphorbiaceae
19	<i>Floscopa scandens</i> L.	Commelinaceae
20	<i>Fragaria indica</i> . Andr.	Rosaceae
21	<i>Grangea maderaspatana</i> L. Poir.	Asteraceae
22	<i>Houttuynia cordata</i> , Thunb.	Saururaceae
23	<i>Hydrocotyle rotundifolia</i> , Lam.	Apiaceae
24	<i>Leucas linifolia</i> Roth.	Lamiaceae
25	<i>Oxalis corniculata</i> , L.	Oxalidaceae
26	<i>Premna herbaceae</i> Roxb.	Verbenaceae
27	<i>Polygonum chinense</i> L.	Polygonaceae
28	<i>Pouzolzia</i> sp.	Urticaceae
29	<i>Pteridium aquilinum</i> L. Kuhn	Pteridaceae
30	<i>Spilanthes paniculata</i> Wall. ex D.C.	Asteraceae

eaten all round the year. There were 1993 feeding observations recorded for these species during the entire period of the study. Preferences for grasses was found to be more than for plants. As per observation, *Arundo donax* (19%), *Cynodon dactylon* (17%), *Imperata cylindrica* (13%), *Saccharum spontaneum* (9%) and *Saccharum elephantinus* (9%), grasses were preferred more than other aquatic plants and herbs (Table 9).

Astraceae sps, *Centrella asiatica*, *Eclipta alba*, *Eclipta prostrata*, *Floscopa scandens*, *Houttuynia cordata*, *Oxalis corniculata*, *Pteridium aquilinum* were common herbs that were preferred. *Enhydra fluctuans*, *Jussiaea repens*, *Pistia stratiotes*, *Boerhavia diffusa*, *Lemna panicostate*,

Table 4. List of aquatic plants preferred by Rhinos in Manas National Park

	Scientific name	Family
1	<i>Azolla pinnata</i> R.Br.	Azollaceae
2	<i>Blyxa aubertii</i> Rich.	Hydrocharitaceae
3	<i>Boerhavia diffusa</i> L. nom.com	Nyctaginaceae
4	<i>Blumea laciniata</i> (Roxb.) DC	Asteraceae
5	<i>Cuphea balsamona</i> Browne	Lythraceae
6	<i>Enhydra fluctuans</i> Lour.	Asteraceae
7	<i>Eichhornia crassipes</i> (Mort) Solms.	Pontederiaceae
8	<i>Eleocharis fistulosa</i> (Roxb) Schult.	Cyperaceae
9	<i>Hydrilla verticillata</i> (L. f) Royale.	Hydrocharitaceae
10	<i>Hydrocotyle sibthorpioides</i> L.	Apiaceae
11	<i>Ipomoea reptans</i> Frossk.	Convolvulaceae
12	<i>Jussiaea repens</i> Ktze.	Onagraceae
13	<i>Lemna panicostate</i> L.	Lemnaceae
14	<i>Monochoria vaginalis</i> (Burm. f) C. Presl. Ex. Kunth.	Pontederiaceae
15	<i>Najas graminea</i> Del.	Najadaceae
16	<i>Nymphaea nouchali</i> Burm.	Nymphaeaceae
17	<i>Pistia stratiotes</i> L.	Araceae
18	<i>Potamogeton crispus</i> L.	Potamogetonaceae
19	<i>Polygonum barbatum</i> L.	Polygonaceae
20	<i>Polygonum hydropiper</i> L.	Polygonaceae
21	<i>Sagittaria sagitifolia</i> L.	Alismataceae
22	<i>Trapa bispinosa</i> Roxb.	Trapaceae
23	<i>Vallisneria spiralis</i> L.	Hydrocharitaceae

and *Polygonum barbatum* were common aquatic plants preferred by Rhinos all-round the year. The Common creeper in Manas NP *Paederia foetida* was observed to be preferred for 1% than other plants species.

All individual Rhinos were seen to browse some of the tree twigs, leaves, and fruits in this period but browsing was observed at a maximum among adult males and calves. Preferably, Rhinos browse dwarf plants like *Bombax ceiba*, *Butea monosperma*, *Careya arborea*, *Cassia fistula*, *Dillenia pentagyna*, *Gmelina arborea* and *Macaranga denticulata*.

Plant Species Preferred during the Pre-monsoon, Monsoon and Retreating Monsoon Seasons

During the pre-monsoon, monsoon and retreating monsoons Rhinos were observed to give equal preferences to 34 plants species. Throughout this period, Rhinos preferred 41% (n=14) grasses, 44% (n=15) aquatic plants, 9% (n=3) herbs and 6% (n=2) shrubs respectively. Among the grasses, *Cyperus auricomus*

Table 5. List of creepers preferred by Rhinos in Manas National Park

	Scientific name	Family
1	<i>Mikania scandens</i> B.L. Rob	Asteraceae
2	<i>Paederia foetida</i> L.	Rubiaceae
3	<i>Paederia hirsute</i> L.	Rubiaceae

Table 6. List of shrubs preferred by Rhinos in Manas National Park

	Scientific name	Family
1	<i>Alpinia allughas</i> (Gaertn.) B.N.	Zingiberaceae
2	<i>Blastus cochinchinensis</i> (Benth.) Triana	Malastomaceae
3	<i>Clerodendron infortunatum</i> L.	Verbenaceae
4	<i>Flemingia bracteata</i> (L.) W.T. Aiton	Papilionaceae
5	<i>Ganaphalium indicum</i> L.	Asteraceae
6	<i>Leea indica</i> (Burm.f) Merry.	Leeaceae
7	<i>Lannea grandis</i> Engler.	Anacardiaceae
8	<i>Malastoma malabatricum</i> L.	Malastomaceae
9	<i>Malastoma</i> sp.	Malastomaceae
10	<i>Solanum torvum</i> Sw.	Solanaceae
11	<i>Xanthium indicum</i> L.	Asteraceae

(5.5%), *Cyperus pilosus* (5.0%), *Cyperus digitatus* (3.6%), *Vetiveria zizanioides* (10.5%) were preferred maximally. But for tall grasses like *Erianthas* spp. (4.5%), *Phragmites karka* (4.1%), fewer preferences were observed among all groups of Rhinos. Among the aquatic plants, *Azolla pinnata* (3.6%), *Cuphea balsamona* (2.7%), *Eichhornia crassipes* (2.7%), *Eleocharis fistulosa* (5.9%) *Monochoria vaginalis* (6.4%) and *Vallisneria spiralis* (10%) were preferred among all age groups of Rhinos (Table 10).

Among the shrubs, Rhinos preferred *Alpinia allughas*, *Malastoma malabatricum* during this period. *Chenopodium album*, *Commelina benghalensis*, *Leucas linifolia* were herbs mostly preferred by Rhinos during these seasons. Apart from these preferable plant species, some species were observed to be unique in particular seasons. In the pre-monsoon season, eight additional plant species preference was observed and *Malastoma* spp. *Leea indica* was preferred among the shrubs and *Amaranthus spinosus*, *Amaranthus viridis* were preferred among the herbs. Adult males and calves were observed browsing tree twigs of *Alstonia scholaris*, *Ficus religiosa* *Largerstroemia parviflora*, and *Lannea grandis*.

During the monsoon season, preference for four tree species and one herb was observed among adult males and calves. These were *Anthocephalus cadamba*, *Bischofia javanica*, *Eugenia jambolana*, and *Trewia*



Images 1. Rhino-1 (Sat hazar), adult male Rhino, Date of release at Manas: 12 April 2008 Approximate age: 12½ Years. Place of origin: Pobitora Wildlife Sanctuary



Images 2. Rhino-2 (Iragdao), adult male Rhino. Date of release at Manas 12 April 2008. Approximate age: 10½ Years. Place of origin: Pobitora Wildlife Sanctuary



Images 3. Rhino-3 (Laisri), adult female Rhino. Date of release at Manas: 27 December 2010. Approximate age 12½ Years. Place of origin: Pobitora Wildlife Sanctuary



Images 4. Rhino-5 (Manas), adult male Rhino. Date of release: 17 January 2011. Approximate age 10 years. Place of origin: Pobitora Wildlife Sanctuary



Images 5. Rhino-6 (Xavira), adult female (Cow) & Rhino-7 (Syria) male calf. Date of release: 17 January 2011. Approximate age of mother 13 years and calf 2½ years. Place of origin: Pobitora Wildlife Sanctuary



Images 6. Rhino-8 (Giribala), adult female. Date of release: 17 January 2011. Approximate age: 12 years. Place of origin: Pobitora Wildlife Sanctuary

nudiflora. Rhinos mainly preferred leaf and fruits of these tree species. *Ageratum conyzoides* was the only herb unique in the monsoon period. During the retreating monsoon, four additional species preferences were observed among Rhinos. *Albizia procera* and *Sida aquata* were two tree species the leaves of which were preferred by all three groups of Rhinos. *Commelina longifolia* and *Clerodendrum infortunatum* were the other two herbs observed specifically during this period.

Plant Species Preferred during the Winter Season

During the winter season, Rhinos were observed to prefer species which are available throughout the year. Besides, 13 additional species preferences were observed among Rhinos. Rhinos were recorded 46 times to prefer such species. Grassland burning, livestock grazing, and scarcity of water affect distribution patterns of Rhinos. Apart from commonly available plants, Rhinos preferred some specific herbs like *Drymaria diandra*, *Euphorbia hirta*, *Fragaria indica*, *Grangea maderaspatana*, *Polygonum chinense*, *Premna herbacea*, *Pouzolzia spp.* *Solanum torvum* was the only shrub unique in the winter season. *Polygonum barbatum* and *Polygonum hydropiper* were two aquatic plants preferred during winter. Adult female and Rhino calves occasionally preferred fruits of two tree species viz. *Terminalia chebula* and *T. bellirica*.

DISCUSSION

Altogether, 139 plants species from 39 families were recorded as food plants during the period of this study. Earlier workers, Laurie (1982) mentioned that Rhinos in Chitwan NP Nepal preferred 183 species of plants from 57 families, Jnawali (1995) recorded 283 plant species available to Rhinos in Chitwan NP and 179 species in Bardia NP of Nepal and all recorded species were eaten by Rhinos. Bhattacharya (2011) recorded 163 species of plants preferred by Rhinos belonging to 50 families in Pobitora WS. Hazarika & Saikia (2012) recorded 138 species of Rhino food plants in Rajiv Gandhi Orang NP of which 54.34% were grasses, 19.5% herbs- shrubs, 19.5% trees, and 6.52% aquatic plants. So, there are variations in the food plants eaten by different Rhino populations.

Rhinos preferred tall grassland areas of Buraburijhar, Rhino camp, Kuribeel and Forte in the study area just after release. Soon they came out of cover and started using the short grassland areas. As per observation, it was witnessed that Rhinos eat grass, herbs, shrubs, tree sapling along with aquatic plants and their home ranges were determined by places with abundant grasslands.

Table 7. List of tree species preferred by Rhinos in Manas National Park

	Scientific name	Family
1	<i>Albizia procera</i> Benth.	Mimosaceae
2	<i>Alstonia scholaris</i> , L.R. Br.	Apocynaceae
3	<i>Anthocephalus cadamba</i> (Roxb.) Bosser	Rubiaceae
4	<i>Bauhinia variegata</i> (L.) Benth	Caesalpiniaeeae
5	<i>Bischofia javanica</i> Blume	Euphorbiaceae
6	<i>Bombax ceiba</i> L.	Bombacaceae
7	<i>Butea monosperma</i> (Lam.) Taub.	Fabaceae
8	<i>Careya arborea</i> Roxb.	Lacnythedaceae
9	<i>Cassia fistula</i> . L.	Caesalpiniaeeae
10	<i>Dillenia indica</i> , L.	Dilaneaceae
11	<i>Dillenia pentagyna</i> ,Roxb.	Dilaneaceae
12	<i>Emblca officinalis</i> L.	Euphorbiaceae
13	<i>Eugenia jambolana</i> Lam.	Myrtaceae
14	<i>Ficus glomerata</i> Roxb.	Moraceae
15	<i>Ficus religiosa</i> L.	Moraceae
16	<i>Gmelina arborea</i> Roxb.	Verbenaceae
17	<i>Largerstroemia parviflora</i> L.	Lythraceae
18	<i>Morus</i> sp.	Moraceae
19	<i>Macaranga denticulata</i> (Blume) Muller Ar.	Euphorbiaceae
20	<i>Spondias magnifera</i> L.	Anacardiaceae
21	<i>Sterculia villosa</i> L.	Sterculiaceae
22	<i>Sida aquata</i> L.	Malvaceae
23	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Combretaceae
24	<i>Terminalia chebula</i> Retz.	Combretaceae
25	<i>Trewia nudiflora</i> , L.	Euphorbiaceae
26	<i>Zizyphus jujuba</i> Mill.	Rhamnaceae

Table 8. List of agricultural crops preferred by Rhinos

	Scientific name	Family
1	<i>Brassica oleracea</i> L.	Brassicaceae
2	<i>Capsicum annum</i> ,L.	Solanaceae
3	<i>Cicer arietinum</i> , L.	Fabaceae
4	<i>Cucurbita maxima</i> Duchesne	Cucurbitaceae
5	<i>Cucumis sativas</i> , L.	Cucurbitaceae
6	<i>Hibiscus subdarifa</i> L.	Malvaceae
7	<i>Luffa acutangula</i> (L.) Roxb	Cucurbitaceae
8	<i>Oryza sativa</i> L.	Poaceae
9	<i>Pisum sativum</i> L.	Papilionaceae
10	<i>Phaseolus aureus</i> (L.) R. Wilezek	Papilionaceae
11	<i>Solanum tuberosum</i> L.	Solanaceae
12	<i>Triticum aestivum</i> L.	Poaceae

It was observed that *Arundo donax*, *Saccharum* sp., *Imperata cylindrica* assemblage were commonly occurring in Kuribeel, Buraburijhar, Rhino camp, Forte camp, Chorfuli areas' grassland in Bansbari range and Rupahi, Kanchanbari, Aboidara and Kaljhar areas' grasslands of Bhuyanpara range. These were common Rhino ranging areas for grazing. Similar findings were indicated by previous workers Bezbaruah (2008) and Lahkar (2008) too.

Cynodon dactylon-*Cyperus rotundus*-*Vetiveria zizanioides* association was observed in Pulsiguri, Katajhar, Tinmile areas of Bansbari range and Kaljhar, Dhonbeel and some parts of Digjhari areas Bhuyanpara range. Lahkar (2008) indicated that *Cynodon dactylon* formed 10–75 % in this association. These grassland areas found along the southern boundary of the Park were highly preferred both by Rhinos and cattle.

Arundo donax, *Cynodon dactylon*, *Imperata cylindrica*, *Saccharum* sp. grasses were the most preferred species throughout the year. Asteraceae spp., *Centella asiatica*, *Eclipta alba*, *Eclipta prostrata*, *Floscopa scandens*, *Houttuynia cordata*, *Oxalis corniculata*, *Pteridium aquilinum* were common herbs and *Boerhavia diffusa*, *Enhydra fluctuans*, *Jussiaea repens*, *Lemna panicostate*, *Polygonum barbatum* and *Pistia stratiotes* were the aquatic plants preferred by Rhinos throughout the year. *Bombax ceiba*, *Butea monosperma*, *Careya arborea*, *Cassia fistula*, *Dillenia pentagyna* *Macaranga denticulata*, *Gmelina arborea* were tree species preferred by Rhinos all-round the year (Table 9). Browsing of trees was much more in winter and at a minimum during the monsoon season.

Dinerstein (2003) mentioned that *Cynodon dactylon*, *Coffea benghalensis*, *Litsea monopetala*, *Murraya paniculata*, *Narenga prophyracoma* *Saccharum spontaneum* and *Saccharum benghalensis* constituted maximum annual diet in Chitwan NP in Nepal. While in Bardia NP, *Arundo donax*, *Cynodon dactylon*, *Erianthus* species, *Saccharum spontaneum*, *Saccharum benghalensis* with *Callicarpa marcophylla*, *Calamus tenuis*, *Dalbergia sissoo*, and *Mallotus philippinensis* constituted the maximum annual diet. In Kaziranga NP, *Arundo donax*, *Cynodon dactylon*, *Erianthus* species and *Hemarthria compressa* constituted 77% of Rhino annual diet as observed by Patar (2004). So variations were observed in food plant preferences of Rhinos and seasonal variations in different places.

During the pre-monsoon, monsoon and retreating monsoons, Rhinos fed on grasses which formed 41% of the total food plants eaten, aquatic plants 44%, herbs 9% and shrubs 6% shrubs (Table 10). During

Table 9. Plants species preferred all round the year

	Name of the Plant	% of Observation
1	<i>Axonopus compressus</i> (L.) Pers.	3.8
2	<i>Arundo donax</i> , L.	18.7
3	<i>Andropogon</i> sp.	8.2
4	<i>Cenchrus ciliaris</i> , L.	5.2
5	<i>Cynodon dactylon</i> (L) Pers.	17.3
6	<i>Cyperus rotundus</i> L.	0.6
7	<i>Cyperus compressus</i> L.	1.2
8	<i>Cyperus</i> sp.	0.3
9	<i>Eleusine indica</i> (L.) Gaertn.	0.4
10	<i>Eragrostis</i> sp.	0.7
11	<i>Hemarthria compressa</i> (L.f) R Br.	0.5
12	<i>Imperata cylindrica</i> L.	13.5
13	<i>Kyllinga brevifolia</i> Rottb.	2.4
14	<i>Narenga pophyracoma</i> (Hance) Bor.	0.7
15	<i>Paspalum conjugatum</i> Bergius	0.5
16	<i>Paspalum orbiculare</i> L.	0.4
17	<i>Pogonatherum crinitum</i> (Thunb.) Kunth.	1.9
18	<i>Saccharum spontaneum</i> L.	8.9
19	<i>Saccharum elephantinus</i> L.	8.5
20	<i>Scirpus articulatus</i> L.	0.2
21	<i>Seteria glauca</i> L.	0.5
22	<i>Themeda villosa</i> (Poir.)	1.0
23	Asteraceae sp.	0.3
24	<i>Centrella asiatica</i> L.	0.2
25	<i>Eclipta alba</i> L.	0.3
26	<i>Eclipta prostrata</i> L.	0.4
27	<i>Floscopa scandens</i> L.	0.2
28	<i>Houttuynia cordata</i> Thunb.	0.2
29	<i>Oxalis corniculata</i> L.	0.3
30	<i>Pteridium aquilinum</i> L. Kuhn	0.3
31	<i>Jussiaea repens</i>	0.2
32	<i>Pistia stratiotes</i>	0.2
33	<i>Boerhavia diffusa</i>	0.1
34	<i>Lemna panicostate</i>	0.1
35	<i>Polygonum barbatum</i>	0.1
36	<i>Enhydra fluctuans</i> Lour	0.1
37	<i>Paederia foetida</i> L.	0.2
38	<i>Paederia hirsuta</i> L.	0.1
39	<i>Bombax ceiba</i> L.	0.3
40	<i>Butea monosperma</i> (Lam.) Taub.	0.2
41	<i>Careya arborea</i> Roxb.	0.2
42	<i>Cassia fistula</i> L.	0.2
43	<i>Macaranga denticulata</i> (Blume) Muller Ar.	0.4
44	<i>Gmelina arborea</i> Roxb.	0.1
45	<i>Dillenia pentagyna</i> Roxb.	0.2
46	<i>Morus</i> sp.	0.1
47	<i>Dillenia indica</i> L.	0.0
48	Papilionaceae sp.	0.2
49	<i>Spondias magnifera</i> L.	0.1

Table 10. Plant species preferred during the pre-monsoon, monsoon and retreating monsoons

	Name of the plants	% of Observation
1	<i>Cyperus digitalis</i> Roxb.	3.6
2	<i>Cyperus iria</i> L.	2.3
3	<i>Cyperus auricomus</i> Roxb.	5.5
4	<i>Cyperus pilosus</i> Vahl.	5.0
5	<i>Carex</i> sp.	3.6
6	<i>Dactyloctenium aegyptium</i> , L.	2.3
7	<i>Erianthas</i> sp.	4.5
8	<i>Fimbristylis aestivalis</i> (Retz.)	1.8
9	<i>Leersia hexandra</i> Sw.	2.3
10	<i>Mariscus compactus</i> (Retz.)	1.8
11	<i>Oryza sativa</i> L.	4.5
12	<i>Pollinia ciliata</i> Trin.	0.9
13	<i>Phragmites karka</i> (Retz.) Trin ex Steud	4.1
14	<i>Vetiveria zizanioides</i> (L.) Nash	10.5
15	<i>Azolla pinnata</i> R.Br.	3.6
16	<i>Blyxa aubertii</i> Rich.	2.3
17	<i>Blumea laciniata</i> (Roxb.) DC	1.4
18	<i>Cuphea balsamona</i> Browne	2.7
19	<i>Eichhornia crassipes</i> (Mort) Solms.	2.7
20	<i>Eleocharis fistulosa</i> (Roxb) Schult.	5.9
21	<i>Hydrilla verticillata</i> (L.f) Royale.	0.9
22	<i>Ipomoea reptans</i> , Frossk.	0.9
23	<i>Monochoria vaginalis</i> (Burm.f) C.Presl. Ex. Kunth.	6.4
24	<i>Najas graminea</i> Del.	1.8
25	<i>Nymphaea nouchali</i> Burm.	1.4
26	<i>Pistia stratiotes</i> L.	1.4
27	<i>Sagittaria sagitifolia</i> L.	0.5
28	<i>Trapa bispinosa</i> Roxb.	0.9
29	<i>Vallisneria spiralis</i> L.	10.0
30	<i>Chenopodium album</i> L.	0.9
31	<i>Commelina benghalensis</i> L.	1.4
32	<i>Leucas linifolia</i> L.	0.9
33	<i>Malastoma malabatricum</i> L.	0.5
34	<i>Blastus cochinchinensis</i> (Benth.) Triana	0.9

winter, some grasslands with species such as *Cyperus auricomum*, *Cyperus digitatus* and *Vetiveria zizanioides* dried up influenced the ranging patterns of the Rhinos. In winter, tall grasses (e.g., *Erianthus* sp.) were not preferred by Rhinos. Aquatic plants like *Eichhornia crassipes*, *Eleocharis fistulosa*, *Monochoria vaginalis* and *Vallisneria spiralis* were preferred during pre-monsoon, monsoon and retreating monsoon but not

in winter. *Vallisneria spiralis* is one of most preferred aquatic plants of the Rhinos and as a result, sometimes the Rhinos move out of the Park to feed on these plants. Crop raiding gradually declined after the home ranges were established but in Bhuyanpara range rice paddies in encroached areas were often raided.

During winter, anthropogenic pressure increased in the Rhino habitats on the periphery of MNP. Unregulated grassland burning, livestock grazing, collection of reeds and thatch, fishing in swampy areas and other water bodies caused major disturbances. Hence, these activities influence directly the food preferences and ranging pattern of Rhinos and other animals. Habitat condition in Bhuyanpara was considered as much suitable for Rhinos in earlier studies and official records (Patar et al. 2007; Bezbarua 2008). A maximum of Rhinos, however, utilize the central locations of Bansbari range (Image 9). A portion of Bhuyanpara range is encroached for paddy cultivation and protection level is comparatively weaker than that of Bansbari. So better protection is urged in entire MNP for future conservation of Rhinoceros species.

CONCLUSION

Reintroduced Rhinos have adapted well since release at MNP. Rhinos established their core home ranges where plenty of food plants and other suitable habitat prevails (Laurie 1982). Buraburijhar, Chorfuli, Forte camp, Kuribeel, Rhino camp of Bansbari range and Rupahi, Kanchanbari, Aboidara and Kaljhar areas of Bhuyanpara range are in the core home range of all Rhinos where plenty of preferable food plants and wetlands are present. Patar et al. (2007) and Bezbarua (2008) have also mentioned the abundance of preferable grass species of Rhinos as well as suitable habitat components in these areas. This study also indicated the dependency of Rhinos on aquatic plants which are found in abundance in numerous water bodies inside the park. Therefore, it is essential for park authorities to maintain hydrology of the park that supports aquatic flora. Desiltation should also be carried out to maintain wetlands dynamics (Sarma et al. 2012). It is observed that some of these grasslands have degraded with the invasion of *Bombax ceiba* and under shrubs like *Leuca asiatica*, *Chromolaena odorata* herbs like *Ageratum conyzoides* (Lahkar 2008). Proper management of grasslands, control of livestock grazing, improved protection along the southern boundary and regular awareness in the fringe villages instilling a pride of Rhino



Images 7. Rhino-11 (Maidangsri), female (calf). Date of release: 19 February 2012. Approximate age: 2½ years. Place of origin: Kaziranga National Park



Images 8. Rhino-13 (Swamli), adult female. Approximate age: 12 year & Rhino-14 (Adidiga), male calf. Approximate Age: 2½ years. Date of release: 19 February 2012.



Images 9. A grassland areas of Bansbari range of Manas National Park

conservation in Manas as in Kaziranga Tiger Reserve will be helpful to maintain a population of Rhinos in Manas National Park. Our objective is to have a viable population of Rhinos for which a healthy habitat is vital.

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Appendix 1. Details of Rhino translocation to Manas under IRV2020

	Name of the translocation/batches	No. of Rhino translocated /sex	Rhino-code	Place of Origin	Date of Release
1	Training-cum-translocation	2 adult males	Rhino 1, 2	Pobitora Wildlife Sanctuary	12.iv.2008
2	2 nd Phase of Translocation	Cow and a female calf	Rhino 3,4	Pobitora Wildlife Sanctuary	28.xii.2010
3	3 rd Phase of Translocation	Cow and male calf, 1 adult male, 1 adult female	Rhino 5,6,7,8	Pobitora Wildlife Sanctuary	18.i.2011
4	4 th Phase of Translocation	2 adult females	Rhino 9,10	Pobitora Wildlife Sanctuary	9.i.2012
5	5 th Phase of Translocation	2 pairs of cow and calves. 1 female and 1 male calf	Rhino 11,12,13,14	Kaziranga National Park	20.ii.2012
6	6 th Phase of Translocation	2 pairs of cow and calves. 2 male calves	Rhino 15,16,17,18	Kaziranga National Park	12.iii.2012

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