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Structure and composition of a protected dry savanna in the northern Brahmaputra floodplains of Assam, Northeast India

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Abstract
We studied the plant species diversity, structure and composition of the dry savanna in Rajiv Gandhi Orang National Park, Assam, India. The plant species diversity of the area was found to be HÊ= 2.83. Edge area had a higher density of grass and herbaceous species followed by core and the river side areas. Four major type of associations could be seen among the grass species *viz*. i) *Apluda mutica-Neyraudia reynaudiana-Cissus quadrangularis*, ii) *Axonopus compressus-Cynodon dactylon-Dichanthium* sp., iii) *Arundo donax- Saccharum spontaneum- Imperata cylindrica,* and iv) *Cymbopogon flexuosus-Eulalia fastigiata*. The present study will contribute towards the better understanding of the important ecosystem and help in the management of biodiversity in the area.

Keywords: Assam, Composition, Diversity, Dry savanna, National Park, Structure

Introduction
Savannas are characterized by distinct biological communities like trees and shrubs mixed with dominant herbaceous vegetation cover. These are the sensitive and transitional ecosystems of the world vulnerable to change with biophysical properties of soil (Sankaran *et al.*, 2005). Sankaran *et al.* (2005) described annual precipitation as the most limiting factors in the African savanna followed by the disturbances like fire and grazing. The disturbances in the form of fire and grazing made the savanna diversified and without these factors, the area will become dominated by few species (Belsky, 1992). Events of high grazing and unmanaged conditions resulted in degradation of grasslands worldwide (Ghosh and Mahanta, 2014, Ratan and Singh, 2013). Most of the grassland ecosystems in India have evolved due to disturbances and abandoned cultivation (Yadava, 1990); they may also be considered as secondary savanna (Backéus, 1992).

Savanna represents a sub-climax stage which is maintained by herbivore and annual burning in North East India (Yadava, 1990). Among these, the grasslands occurring in the Brahmaputra flood plains are specially known for their dwellers that include the flagship species like greater one-horned rhino (*Rhinoceros unicornis*), pygmy hog (*Porcula salvania*) and Bengal florican (*Houbaropsis bengalensis*). With increasing anthropogenic pressure, most of these habitats are now converted to human habitation and arable lands, with a leftover of a few isolated patches, where the fauna lives under a constant threat of becoming a meta-population (Choudhury *et al.*, 2016). Very little works have been done on the community structure of grasslands in northeast India (Uma Shankar *et al.*, 1991; Lahkar, 2008; Khatri and Barua, 2011). In the present study, we tried to analyse the diversity, structure, and composition of a dry savanna in Rajiv Gandhi Orang National Park (RGONP), Assam, North-east India.

Materials and Methods
Study Area: Rajiv Gandhi Orang National Park (RGONP) (26°29' to 26°40' N and 92°16' to 92°27' E) is located in the northern floodplains of river Brahmaputra (Fig. 1). It covers an area of 78.8 km^2 comprising of grasslands intermixed with woodlands and water bodies. The area receives an average rainfall of 1200 mm during the monsoon with relative humidity varying from 67-85% during this period with an average minimum and maximum temperature of 10°-25° C in winter and 25°-36° C in summer (Sarma, 2010). The vegetation of the park can be broadly classified into Eastern Himalayan Moist Deciduous forest (3C/C3b), Eastern Seasonal Swamp forest (4D/SS1), Khair-Sisoo Forest (5/1S2), Eastern Wet Alluvial Grassland (4D/2S2) and Plantations (Champion and Seth, 1968). *Lagerstroemia parviflora* Roxb.*,Terminalia bellirica* (Gaertn.) Roxb.*, Sterculia villosa* Roxb.*, Bombax ceiba* L.*, Semecarpus anacardium* L.f.*, Schima wallichii* Choisy*, Syzygium cumini*(L.) Skeels,

Syzygium fruticosum DC., *Ziziphus mauritiana* Lam. are the major tree species and among the grasses, *Cymbopogon flexuosus* (Nees ex Steud.) W. Watson, *Phragmites karka* (Retz.) Trin. ex Steud., *Saccharum arundinaceum* Retz., *Saccharum narenga* (Nees ex Steud.) Hack., *Saccharum spontaneum* L., *Imperata cylindrica* (L.) Raeusch, are the most prominent (Sarma 2010). Among the tree species *Bombax ceiba* L., *Lagerstroemia parviflora* Roxb., *Syzygium cumini* (L.) Skeels are some of the climax species for the grassland which ultimately results in conversion of savanna to woodland. Among the grass species, *Imperata cylindrica* (L.) Raeusch and *Cynodon dactylon* (L.) Pers. are some of the pioneer species, while species like *Cymbopogon flexuosus* (Nees ex Steud.) W. Watson, *Saccharum narenga* (Nees ex Steud.) Hack., and *Saccharum arundinaceum* Retz. represent the sub-climax species. The grassland can be further subdivided into two distinct types *viz*., i) dry savanna ii) wet alluvial (Sarma, 2010). The park provides suitable habitat to *Rhinoceros unicornis*, *Panthera tigris*, *Elephas maximus*, *Axis porcinus*, *Porcula salvania*, *Sus scrofa* and the critically endangered bird *Houbarospsis bengalensis*.

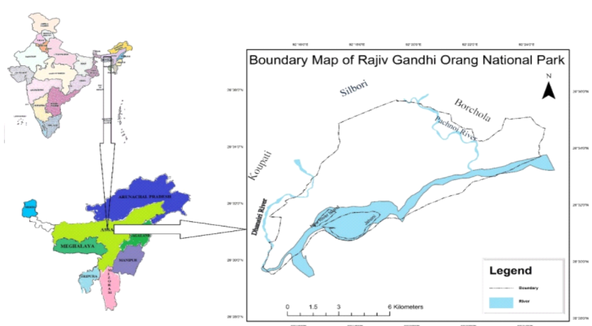

Fig. 1. Location map of Rajiv Gandhi Orang National Park, Assam, India

Study design: The entire park was divided into 367 grids, each of the grids being 0.25 km^2. A total of 112 grids were identified as dry savanna dominant area. Based on its location in the National Park, the dry savanna area was divided into core area, edge area, and riverside area. Out of the 112 grids, 27 grids (25%) were selected randomly for vegetation sampling. Vegetation sampling was done following quadrat method (Misra, 1968). Quadrat sized 1 m × 1 m areas were used to sample the grassland vegetation (Kent, 2011). The basal cover was determined by measuring the basal diameter of each species using a slide caliper (Uma Shankar *et al.,* 1991). The plants were later identified by consulting the herbaria of Botanical Survey of India, Eastern Regional Centre, Shillong and regional flora (Kanjilal *et al*.,1934-1940).

Data analysis: Raunkiaer's life form was followed to categorise the plants into the grass, herb, shrub, and forb. Data were analysed to estimate density, frequency, basal area and Importance Value Index (IVI) (Misra, 1968). Shannon-Wiener diversity index (Shannon-Wiever, 1949) and Simpsons index of Dominance (Cd) (Simpson, 1949) was used to assess species diversity in the three different zones *viz*. core area, edge area, and riverside area (alpha diversity) as well as for the overall dry savanna area of the park (Gamma diversity). Whittaker's measure of Beta diversity (âw) was used to study beta diversity among the three savanna areas of the park (Magurann, 2004). Association among the grass species were analysed by using cluster analysis; Bray-Curtis index was used to see the grassland association (Magurann, 2004).Chi-square, One-way ANOVA, and Post hoc analysis (Tukey's -HSD) was performed to compare the significance of the findings. Biodiversity pro software (McAleece *et al*., 1997) and Past (Hammer *et al*., 2001) were used to perform the statistical tests.

Results and Discussion

Grasslands in the Indian subcontinent are mostly of successional nature and would reach climax stage of tropical forest without human interventions. They are influenced by various factors like altitude, soil characteristics and biotic factors (Uma Shankar *et al*., 1991). As grasslands are dominated by grasses and forbs, species diversity in the grassland is generally less (Karki *et al*., 2000; Singh *et al*., 2005; Astapati and Das, 2012). The present study provides detailed information about the diversity of a dry savanna in the unique Brahmaputra floodplains of Northeast India which is a part of the famed Indo-Burma Hotspot of Biodiversity (www.conservation.org/How/Pages/Hotspots.aspx, accessed on 29 June 2016).

Diversity: A total of 67 plant species has been recorded from the dry savanna area of the park (Table 1). Among them, the most important species was *Imperata cylindrica* (L.) Raeusch (IVI = 73.14) followed by *Saccharum narenga* (Nees ex Steud) Hack. (IVI= 72.09) and *Saccharum spontaneum* (IVI= 18.73). The most frequently occurring species was *Imperata cylindrica* (L.) Raeusch (43.3%). Diversity index (HÊ) of the dry savanna area was found to be 2.83. The grassland diversity in RGONP (H2 = 2.83) was found to be similar with the diversity of humid grasslands of Meghalaya (H2 = 2.31) (Uma Shankar *et al*., 1991), but was comparatively higher than that recorded by Karki *et al*. (2000) (H2 =0.97), Singh *et al*. (2005), (H2 =1.9-1.5) and Astapati and Das (2012), (H2 =1.4). Sankaran (2009) found higher species richness and diversity at lower elevation grassland in Kalakad-Mundanthurai Tiger Reserve, Western Ghat.

Table 1. Frequency, density, basal cover and importance value index of different plant species in the savanna area of Rajiv Gandhi Orang National Park, Assam (2012-2014)

Scientific name of plants	Core area			Edge area			Riverside area		
	Frequency (%)	Density (ha^{-1})	IVI	Frequency (%)	Density (ha^{-1})	IVI	Frequency (%)	Density (ha^{-1})	IVI
Ageratum conyzoides (L.) L.	18	21667	4.8	0	0	0.0	0	0	0.0
Alpinia nigra (Gaertn.) Burtt	2	3611	2.6	0	0	0.0	0	0	0.0
Alternanthera sessilis (L.) R.Br. ex DC.	12	123056	7.2	6	6920	2.5	20	32500	9.4
Apluda mutica L.	0	0	0.0	6	17301	1.3	0	0	0.0
Arundo donax L.	2	556	0.4	41	283737	10.5	15	65000	9.0
Axonopus compressus (Sw.) P. Beauv.	0	0	0.0	18	1262976	10.0	0	0	0.0
Bombax ceiba L.	7	2222	2.0	12	13841	2.5	10	10000	3.4
Chromolaena odorata (L.) R.M. King & H. Rob.	37	54444	11.6	6	6920	1.3	5	27500	2.1
Cissus quadrangularis L.	15	15000	3.9	0	0	0.0	0	0	0.0
Commelina diffusa Burm.f.	0	0	0.0	6	76125	1.6	0	0	0.0
Convolvulus arvensis L.	2	278	0.4	0	0	0.0	0	0	0.0
Costus speciosus (J. Koenig) Sm.	2	278	0.4	0	0	0.0	0	0	0.0
Chrysopogon aciculatus (Retz.) Trin.	0	0	0.0	12	1598616	44.7	0	0	0.0
Curcuma sp.	3	5833	1.1	0	0	0.0	0	0	0.0
Cymbopogon flexuosus (Nees ex Steud.) W. Watson	10	51667	6.3	0	0	0.0	0	0	0.0
Cynodon dactylon (L.) Pers.	0	0	0.0	41	6757785	40.1	0	0	0.0
Cynodon arcuatus J.Presl	0	0	0.0	12	1629758	10.5	0	0	0.0
Cyperus corymbosus Rottb.	2	1111	0.4	0	0	0.0	0	0	0.0
Cyperus rotundus L.	0	0	0.0	6	3460	1.2	0	0	0.0
Cyperus brevifolius (Rottb.) Hassk.	0	0	0.0	6	404844	2.8	0	0	0.0
Cyperus digitatus Roxb.	2	1944	0.4	6	76125	1.5	0	0	0.0
Desmodium gangeticum (L.) DC.	25	41111	7.1	12	38062	2.6	25	107500	21.7
Desmodium triflorum (L.) DC.	3	38056	2.2	18	508651	5.9	0	0	0.0
Dichanthiumannulatum (Forssk.) Stapf	2	8333	0.7	12	1871972	12.2	0	0	0.0
*Eleusine indica (*L.) Gaertn.	0	0	0.0	12	148789	3.5	0	0	0.0
Eragrostis unioloides (Retz.) Nees ex Steud.	0	0	0.0	6	190311	2.1	0	0	0.0
Eulalia fastigiata (Nees ex Steud.) Haines	22	145556	13.5	12	384083	3.9	0	0	0.0
Flemingia macrophylla (Willd.) Merr.	13	9444	3.2	6	3460	1.3	0	0	0.0
Floscopa scandens Lour.	2	833	0.4	0	0	0.0	0	0	0.0
Grewia sapidaRoxb. ex DC.	12	5833	2.8	0	0	0.0	0	0	0.0
Hemarthria compressa (L.f) R.Br	0	0	0.0	6	34602	1.4	0	0	0.0
Hydrocotyle sibthorpioides Lamk.	0	0	0.0	18	197232	4.5	0	0	0.0
Imperata cylindrica (L.) Raeusch	50	1110000	59.2	65	8339100	59.8	80	10515000	144.8
Ipomoea aquatica Forssk.	3	556	0.7	0	0	0.0	0	0	0.0
Lantana camara L.	2	833	0.4	0	0	0.0	0	0	0.0
Leea crispa L.	28	12778	9.2	0	0	0.0	5	2500	1.7

Scientific name of plants	Core area			Edge area			Riverside area		
	Frequency (%)	Density (ha^{-1})	IVI	Frequency (%)	Density (ha^{-1})	IVI	Frequency (%)	Density (ha^{-1})	IVI
Leersia hexandra Sw.	2	2222	0.4	0	0	0.0	0	0	0.0
Mikania micrantha Kunth	13	5000	3.1	12	13841	2.6	25	35000	8.7
Mimosa diplotricha Sauvalle	7	1389	1.9	0	0	0.0	15	30000	5.6
Mucuna prurita (L.) Hook.	2	278	0.4	0	0	0.0	5	17500	1.8
Murdania nudiflora (L.) Brenan	0	0	0.0	6	141869	1.9	0	0	0.0
Neyraudia reynaudiana (Kunth) Keng	13	28611	5.1	0	0	0.0	0	0	0.0
Ophiuros megaphyllus Stapf ex Haines	2	2778	0.6	0	0	0.0	0	0	0.0
Osbeckia nepalensis Hook. f.	7	1389	1.5	0	0	0.0	0	0	0.0
Oxalis corniculata L.	3	2222	0.8	0	0	0.0	0	0	0.0
Paederia foetida L.	0	0	0.0	6	3460	1.4	0	0	0.0
Paspalum conjugatum P.J. Bergius	0	0	0.0	6	41522	1.6	0	0	0.0
Polygala scandens Vell.	8	8611	2.2	0	0	0.0	0	0	0.0
Polygonum barbatum L.	2	7778	0.7	0	0	0.0	0	0	0.0
Pygmaeopremna herbacea (Roxb.) Moldenke	2	2222	0.5	0	0	0.0	0	0	0.0
Rotala indica (Willd.) Koehne	0	0	0.0	6	34602	1.4	0	0	0.0
Saccharum narenga (Nees ex Steud.) Hack.	68	863889	112.7	6	86505	3.9	0	0	0.0
Saccharum ravennae L.	10	55833	11.1	6	3460	1.4	10	165000	21.4
Saccharum spontaneum L.	7	37500	3.6	47	1145329	35.5	85	1170000	67.0
Sacciolepis interrupta (Willd.) Stapf	2	1944	0.4	0	0	0.0	0	0	0.0
Sterculia villosa Roxb.	3	833	0.8	0	0	0.0	0	0	0.0
Syzygium fruticosum DC.	2	278	0.4	0	0	0.0	0	0	0.0
Tamarix dioica Roxb. ex Roth	0	0	0.0	24	141869	14.4	0	0	0.0
Vetiveria zizanioides (L.) Nash	3	31667	2.0	0	0	0.0	0	0	0.0
Ziziphus mauritiana Lam.	0	0	0.0	6	10381	1.3	5	5000	1.7
UN Climber sp. 1	5	1667	1.2	0	0	0.0	0	0	0.0
UN Climber sp. 2	2	278	0.4	0	0	0.0	0	0	0.0
UN Grass sp.	15	32222	4.6	6	58824	1.7	0	0	0.0
UN Herb sp. 1	7	7222	1.7	12	525952	5.0	5	2500	1.6
UN Herb sp. 2	7	18333	2.2	0	0	0.0	0	0	0.0
UN Herb sp. 3	2	1667	0.4	0	0	0.0	0	0	0.0
UN Shrub sp.	2	278	0.4	0	0	0.0	0	0	0.0

Table 2. An account of plant species in three different zones of dry savanna area of Rajiv Gandhi Orang National Park (2012-14)

Parameters	Core area (n =60)	Edge area (n = 17)	Riverside area (n = 20)
Species richness	49	35	14
Range of individuals/m^2	58-873	108-999	33-639
Stand density (m^2) ± SE at 95 % confidence limit	163.3 ± 38.85	443.06 ± 118.6	243.7 ± 89.51
Dominant plant species	*Saccharum narenga* (112.7), *Imperata cylindrica* (59.2), *Eulalia fastigiata* (13.5)	*Imperata cylindrica* (59.2), *Chrysopogon aciculatus* (4.7), *Cynodon dactylon* (40.1)	*Imperata cylindrica* (144.8), *Saccharum spontaneum* (67.0),*Desmodium gangeticum* (L.) DC. (21.7)
Shannon diversity index (Hý)	2.46	2.73	1.66
Simpsons index of Dominance (Cd)	0.26	0.19	0.75

Structure and composition: In the present study, *Imperata cylindrica* and *Saccharum narenga* were found to be the most dominant grass species in RGONP. *Saccharum narenga* was found to be the most dominant grass species in the core area (IVI= 112.7), while, *Imperata cylindrica* was the dominant species at both the edge area of the park (IVI= 59.8) and in the riverside area (IVI= 144.8) (Table 1). Karki *et al*. (2000) and Tandon *et al.* (2013) also recorded *Imperata cylindrica* as the dominant species of grass in Royal Bardia National Park, Nepal. In the present study, *Saccharum narenga* was found to be the most dominant species in the undisturbed core area, while it was *Imperata cylindrica* in the disturbed areas. However, *I. cylindrica* was the second most dominant grass species in the core area; thus this grass species was the dominant species in all three savanna areas of the park. The core area had no disturbance except for the controlled burning for grassland management by the park authorities, while the edge area of the park had anthropogenic pressure in the form of thatch collection and grazing, and the riverside area had disturbance in the form of annual flooding and soil erosion. *I. cylindrica* is an early successional grass species with good growth and is more tolerant to disturbance (Khatri and Barua, 2011). It can thrive at the edge of the park. However, the larger grass species, such as *S. narenga* grew more in the undisturbed areas with good density and were bigger in size (Khatri and Barua, 2011).

The core area had significantly high species accumulation (49 spp.) followed by the edge area of the park (35 spp.) and the riverside area (14 spp.) (Table 2; $F_{2, 94}$ = 6.93, P <0.01). Number of species belonging to different plant types in different zones of dry savanna area has been depicted in Fig 2. However, the edge area had more number of individuals per hectare area (4430588 ha^{-1}) followed by riverside area (2437000 ha^{-1}) and the core area (1662667 ha^{-1}) (Murica, 1995). Grass species was found to be significantly more at the park edge (χ^2_{2} = 7.09, P < 0.05; Fig 2). Significantly more herbaceous species were found in the core areas as compared to the edge and the riverside area (χ^2_{2} = 12.25, P < 0.01; Fig. 2). Though significantly more number of species were recorded from the core areas (Table 2; $F_{2, 94}$ = 16.09, P < 0.001), the species diversity index, however, was significantly more at the edge than the other two zones (Table 2; $F_{2, 94}$ = 5.15, P <0.01). Tukey test confirms that this difference among the three zones was due to the difference in the plant diversity of core area and riverside area, and the difference between edge and riverside area. With higher species diversity in edge area, the dominance was found to be low in edge areas (Cd =0.19) (Table 2). Again, dominance was found to be more in the riverside area (Cd=0.75) where the diversity (H' = 1.66) was comparatively lower than the other two areas. This is due to the increase in plant species with higher individuals which resulted in higher species diversity with lower dominance (Magurran, 2004). Among different plant types, the grass had the highest density in all the areas compared to other plant types (Fig 3). The density of grass and herbs was found more in the edge areas. Significantly, higher number of herbs and climbers were recorded from the core area, while more grass species were recorded from the edge area. This may be attributed to the edge effect and disturbance because disturbance was low in the core area and higher at the edge and riverside area (Murica, 1995). Disturbance in the form of human interference and livestock grazing at the edges might be the reason for the higher species diversity in those areas (Uma Shankar *et al.,* 1991; Sundriyal, 1992; Karki *et al.,* 2000). In the riverside area, erosion and regular siltation formed the major disturbance regime, which might have promoted grasses to grow more. Thus, only the grass species with early successional stage were found to occur in these areas. This might be the probable reason for lower species richness in riverside area. Though the species richness of grass is found to be low in edge area yet due to the presence of disturbance in the form of biotic pressure there is a comparatively higher diversity (Sundriyal, 1992). Grazing reduces competition and promotes species richness and diversity within a community (Karki *et al*., 2000). They observed that in comparison to the neighbouring grassland, in the grazing areas different community grew, forming grazing-adapted forms. Grass species like *Chrysopogon aciculatus* are tolerant to high biotic and grazing pressure. Species like *Chrysopogon aciculatus* and *Cynodon dactylon* form dense mat near the surface of the soil. Sundriyal (1992) also found that under high grazing and biotic pressure, the tussock habit of grass had a decisive advantage and results in the growth of more individuals. Thus, disturbance in the form of erosion and deposition by river and human as well as grazing pressure may be the main reason for this difference in vegetation composition and density (Uma Shankar *et al*., 1991; Sundriyal, 1992). Grass density was found to be more than other plant types in all the study sites. The density of grass species was higher at the edge, while grass species had higher IVI in the riverside area. Among the grass species recorded in riverside areas, only a few grass species were found to be dominant; *viz*., *Imperata* *cylindrica, Saccharum spontaneum* and *Desmodium gangeticum.* Therefore, IVI of these species were higher than that of the other study sites. Because of more number, *Imperata cylindrica* had high cover in the edge and riverside area. Again, when the beta diversity among the three areas were calculated the core area and riverside area together had higher diversity (βw=0.6) followed by core and edge area (βw=0.59) and edge and riverside area (βw=0.55).

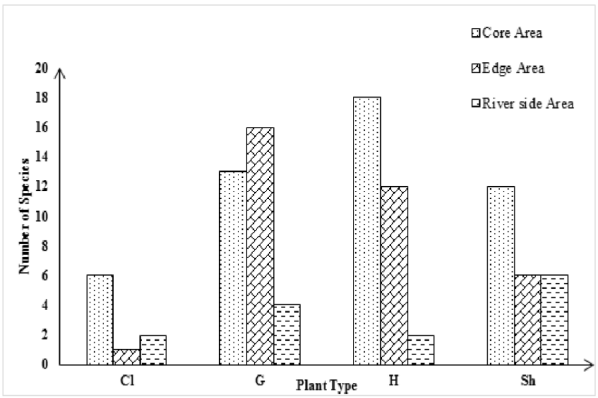

Fig 2. Status of plant species found in the three different zones of dry savanna in Rajiv Gandhi Orang National Park, Assam during 2012-2014. (Cl= Climber, G= Grass, H= Herb, Sh= Shrub)

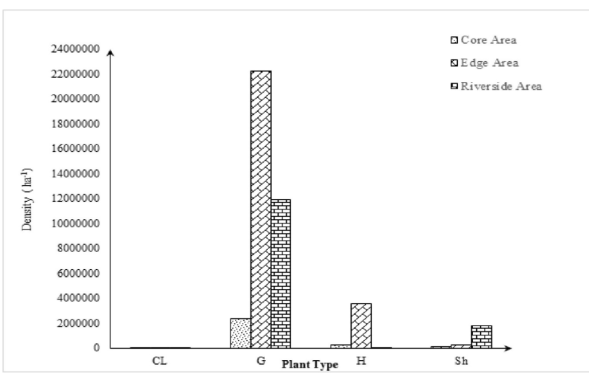

Fig 3. Density (ha^{-1}) of different plant types in the three different zones of dry savanna in the Rajiv Gandhi Orang National Park, Assam during 2012-2014. (Cl= Climber, G= Grass, H= Herb, Sh= Shrub)

Species association: In the present study, four distinct associations in the dry savanna grasslands of the park were observed. Cluster analysis indicated four major types of associations among the grass species of Rajiv Gandhi Orang National Park (Fig 4). The associations observed were: i) *Apluda mutica-Neyraudia reynaudiana-Cissus quadrangularis*, ii) *Axonopus compressus-Cynodon dactylon-Dichanthium* sp., iii) *Arundo donax-Saccharum spontaneum-Imperata cylindrica,* and iv) *Cymbopogon flexuosus-Eulalia fastigiata*. These associations can be seen prominently in the dry savanna areas of the park.

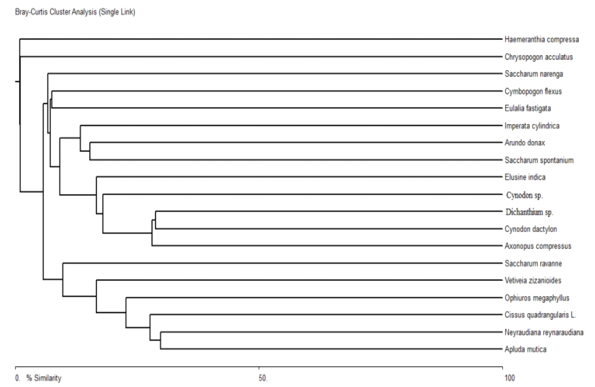

Fig 4. Cluster analysis (Bray-Curtis index) of grass species recorded in dry savanna of Rajiv Gandhi Orang National Park, Assam.

Peet *et al*. (1999) described that the spatial and temporal distribution of grassland assemblages as primarily influenced not only by disturbances like fluvial processes but also by fire, cutting and grazing. Various workers have described different associations in the terai grasslands. Lehmkuhl (1994) described eight grass association types at Chitwan National Park, Nepal while Peet *et al*. (1999) described nine types of grass assemblages from the protected grasslands of Nepal; Lahkar (2008) found seven type of grass association from Manas National Park in Assam, while Shukla (2009) reported eleven types of associations from the terai grasslands of Uttar Pradesh, India. Four distinct types of associations were observed in the savanna of the park in the present study:

i) *Apluda mutica-Neyraudia reynaudiana-Cissus quadrangularis* type: this association was seen in the core area of dry savanna where *S. narenga* was the dominant grass. These species were always found to be associated with dominant grass species in low number. Among the three species, *Neyraudia reynaudiana* had the highest density compared to the other two.

ii) *Cymbopogon flexuosus-Eulalia fastigiata* type: This type of associations was seen in the core area of dry savanna. Between the grasses, *Eulalia* sp. had comparatively higher density and importance value than the former one. Both the grasses closely associated with *S. narenga* dominated grasslands of the park.

iii) *Axonopus compressus-Cynodon dactylon-Dichanthium* sp. type: This association was seen mostly at the edge and riverside areas. All the areas had sparse tall grass cover and suffered from temporary inundation, grazing, and other anthropogenic disturbances. Associat-

-ed grass species were mostly creeping type plants and had a higher cover over the ground.

iv) *Arundo donax- Saccharum spontaneum- Imperata cylindrica* type: This association was found exclusively in the riverside areas. Among the associated species, *S. spontaneum* had higher density and cover as compared to the other two species. Most of the habitat for these associations were of new origin with recent soil deposition from the nearby rivers and most likely would have evolved due to change in river course.

The associations described in our investigation find similarity with observations by Shukla (2009). Among the associations, *Apluda mutica-Neyraudia reynaudiana-Cissus quadrangularis* and *Cymbopogon flexuosus-Eulalia fastigiata* type of association are mostly seen in the core areas of the park and they are closely associated with *S. narenga.* Both the associations can be seen widely throughout the dry savanna grasslands of RGONP. The *Axonopus compressus-Cynodon dactylon-Dichanthium* type of association can be seen in both the riverside area and near human habitation area of the park. While *Arundo donax- Saccharum spontaneum- Imperata cylindrica* type of associations can be seen mostly along the riverside areas. These associations of grass species also create specialized habitats for their dwellers like hog deer, swamp francolin, Bengal florican, (Peet *et al*., 1999, Rahmani, 2016). As the grasslands are transitional ecosystem, thus without management they cannot be kept unchanged for a long period. While the associations also reflect successional process within a system. The proper scientific knowledge of the plant associations will help the park managers to understand the grassland ecosystem in a better way and maintain the critical habitats for the specialised dwellers.

Conclusion

Grasslands are one of the most beautiful ecosystems in the world which are further enhanced by the enchanting dwellers it hosts, yet they are one of most neglected and mismanaged ecosystems in India. Though some of the grasslands are now protected, yet most of the grasslands are now vanishing at an alarming pace and the remnants exist only as isolated islands. Due to the dearth of knowledge and documentation on grasslands, there is no specialized management plan for any grassland in the region. Thus, the present study on grassland structure and composition of this very important protected savanna in the unique Brahmaputra floodplains of North East India will contribute greatly towards a better understanding and management of this savanna in particular and grassland ecosystems in general.

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