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Phytosociological Status of a Monotypic Genus *Indopiptadenia*: A Near Threatened Tree from the Terai-Bhabar Region of Central Himalaya

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ABSTRACT

A phytosociological assessment was done in Terai-Bhabar region of the central Himalaya to understand the current status of a monotypic genus *Indopiptadenia*. Identification of different forest communities within the region was also accomplished. Cluster analysis and PCA revealed five forest communities (i.e., sal miscellaneous forest, sal dominant forest, lowland miscellaneous forest, teak plantation and *Indopiptadenia* population) on the basis of their species composition. Out of these 5 communities, *Indopiptadenia* population attracted more attention due to its small and declining population. The unique habitat of this small population found chiefly on gravely-sandy soil along the water streams edges places it before the natural threats of floods and cutting of river banks. The lowest tree density (440.00 stem ha^{-1}) and basal cover (19.35 m^2 ha^{-1}) values were exhibited by this plant community. This suggests that the population of *Indopiptadenia* is more exposed forest community in comparison to others and faces higher degree of anthropogenic pressures for their fodder and timber values.

Key words: *Indopiptadenia oudhensis*, tropical moist deciduous forest, central himalaya, PCA

INTRODUCTION

The phytosociological study deals with the structure and function of the plant communities and exposes the relationship between different species growing together in it. Without the basic understanding about the structure of a community, it is impossible to know its functioning. Thus a lot of phytosociological studies have been conducted throughout the world to understand the structure of different forest communities (Campbell *et al*., 1986; Timilsina *et al*., 2007; Top *et al*., 2009; Sambare *et al*., 2011; Erenso *et al*., 2014). In Indian scenario, several phytosociological studies have also been performed in different tropical forests: Western India (Sharma and Upadhyaya, 2002; Panchal and Pandey, 2004; Krishna *et al*., 2014), Peninsular India (Parthasarathy *et al*., 1992; Visalakshi, 1995; Parthasarathy, 1999; Mani and Parthasarathy, 2005; Gunaga *et al*., 2013), North East India (Bhuyan *et al*., 2003; Kumar *et al*., 2006; Kibria and Saha, 2011; Sarkar and Devi, 2014) and Northern India (Singh and Singh, 1991; Sagar *et al*., 2003; Pandey and Shukla, 2003; Chauhan *et al*., 2008; Tripathi and Singh, 2009; Behera *et al*., 2012). In Northern Indian forests, furthermost studies have been executed in the tropical dry deciduous forests of Vindhyan region (Jha and Singh, 1990; Sagar and Singh, 2006; Sagar *et al*., 2008) and tropical moist deciduous forests of the Terai region (Pandey and Shukla, 1999; Shukla, 2009;

Bajpai *et al*., 2012a), while a lesser information is available about the forests of Terai-Bhabar region. The Terai-Bhabar region lies along the Himalayan foothills and represented by few protected areas (Singh *et al*., 1995; Singh and Anand, 2002; Tripathi and Singh, 2009). As far as biodiversity is concerned, it is one of the highly divers region of the country (Johnsingh *et al*., 2004), due to edge effect and moreover facing diverse anthropogenic pressure (Bajpai *et al*., 2012a, b).

The Terai-Bhabar region of the Central Himalaya bears a monotypic genus *Indopiptadenia* Brenan, represented by *I. oudhensis* (Brandis) Brenan. It is endemic to Terai-Bhabar region of the Himalaya along Indo-Nepal border. In India it has so far been reported from Suhelwa wildlife sanctuary in Balrampur district of Uttar Pradesh and Sarda Valley in Champawat district of Uttarakhand (Bajpai *et al*., 2014). In the central Himalayan Terai-Bhabar region (i.e., Suhelwa wildlife sanctuary), it grows in the sideways of the water streams on gravelly sandy soil. The habitat destruction and over exploitation of this species for hard wood and leaves for fodder since more than a century restrict its distribution to a few countable patches in scattered populations. Previously, it was supposed to be common (Brandis, 1874; Duthie, 1903, 1906), while further studies have been considered it as critically endangered (Biswas and Chandra, 1997; Prakash *et al*., 2009; Singh, 2010). Recently Bajpai *et al*. (2014), have conducted an exhaustive taxonomic study of the genus and also provided preliminary information on phenology and conservation status based on EOO and AOO values by using Geo-Cat tool (Bachman *et al*., 2011). In this study, the species has been assessed as 'near threatened' as per IUCN criteria. However, in the lack of previous data on decline and fluctuation in the population size of the species, the requirements of a, b or c conditions of criteria B of IUCN have not been used in the study. All these information can be generated by conducting phytosociological studies which include frequency, density, dominance and Importance Value Index (IVI) of the candidate species with all other associate species to utilize them for proper conservation assessment. Hence, the present study was conducted in Suhelwa Wildlife Sanctuary (SWS) to generate the phytosociological information on the candidate species and their associate trees from the region. This base line information about the tree population can be further utilized to quantify the decline as well as the fluctuation of the population. The present study also helps in the identification of different forest communities and association pattern of those communities.

MATERIAL AND METHODS

Study area: The study area Suhelwa Wildlife Sanctuary (SWS) is located at Balrampur (Tulsipur, Barahwa, Bankatwa, East and West Suhelwa forest ranges) and Shrawasti (Rampur and Bhabhar forest ranges) districts of Uttar Pradesh in India (Fig. 1). It is a good representative of the Terai-Bhabar region of Central Himalaya. It is about 127 km long and 7 km wide strip along Indo-Nepal international border between 27°33'-27°55'N and 81°55'-82°45'E covering an area of 452 km^2 with 120-200 m elevation (Anonymous, 2005; Jaiswal and Bhattacharya, 2013). It was declared a wildlife sanctuary in 1988.

The sanctuary comes under the tropical moist deciduous forest of the Himalayan Terai-Bhabar bio-geographical subdivision (Champion and Seth, 1968; Rodgers and Panwar, 1988). It represents the monsoon type climate with three distinct seasons: winter (November-February), summer (April-June) and rainy (July - September). The average temperature ranges from 12.5°C in January to 28°C in May and June while the average rainfall ranges from 9 mm in winter to 71 mm in rainy season (Fig. 2).

Data collection and analysis: The random stratified sampling method was adopted to collect the ecological data from different land use type (Krebs, 1989). Total number of tree species individuals

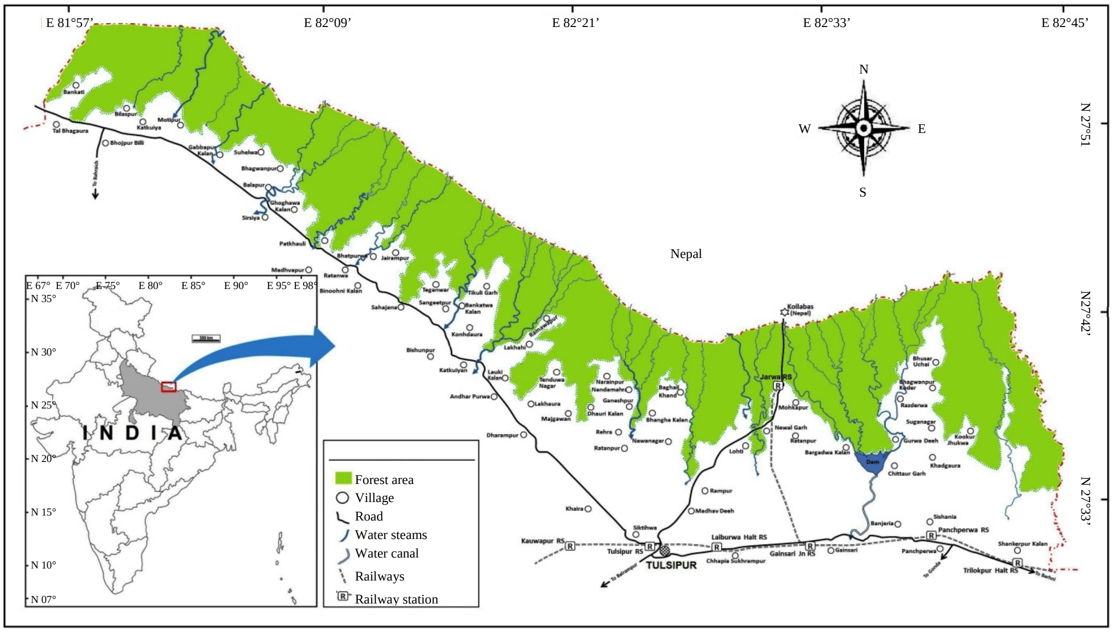

Fig. 1: Location map of study site (Suhelwa wildlife sanctuary)

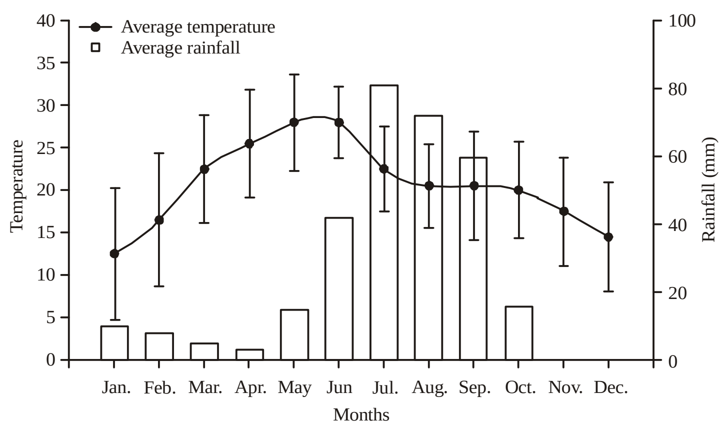

Fig. 2: Average annual variation of climate at Suhelwa wildlife sanctuary

and their diameter were measured in 73 quadrates of 20×20 m size during 2013-2014. This basic data was used to compute the frequency, density and dominance and finally Importance Value Index (IVI) for each tree (CBH ≥20 cm) (Curtis and McIntosh, 1950; Krebs, 1989). Species wise IVI of each quadrates were used to congregate the trees in different forest communities on the behalf of their association by using cluster analysis, employing Bray-Curtis similarity measure and UPGMA algorithm (Ludwig and Reynolds, 1988; Jongman *et al*., 1995; Rai *et al*., 2012; Bajpai *et al*., 2012a). The Principal Component Analysis (PCA) was also performed to verify the results of cluster analysis and to find out the different communities of the forest area. After congregation, different diversity indexes were computed with the help of IVI values for each community (Simpson, 1949; Cottam and Curtis, 1956; Magurran, 1988). The multivariate options of PAST version 2.12 were used to execute cluster analyses, PCA and calculate diversity indexes (Hammer *et al*., 2001; Hall, 2005; Rai *et al*., 2012; Bajpai *et al*., 2012a).

RESULTS

The cluster analysis and PCA reveal the existence of five forest communities within the study area (Fig. 3, 4). On the behalf of dominant trees and their habitat they were named as,

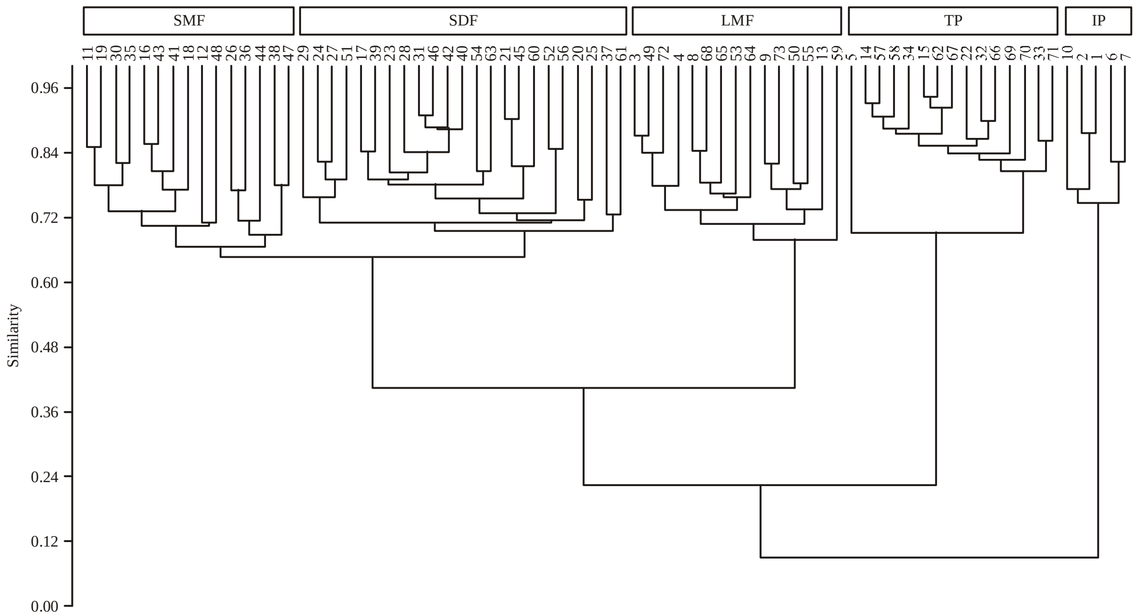

Fig. 3: Cluster showing different forest communities of Suhelwa wildlife sanctuary (SMF-Sal miscellaneous forest, SDF: Sal dominant forest, LMF: Low-land miscellaneous forest, TP: Teak plantation and IP: *Indopiptadenia* population)

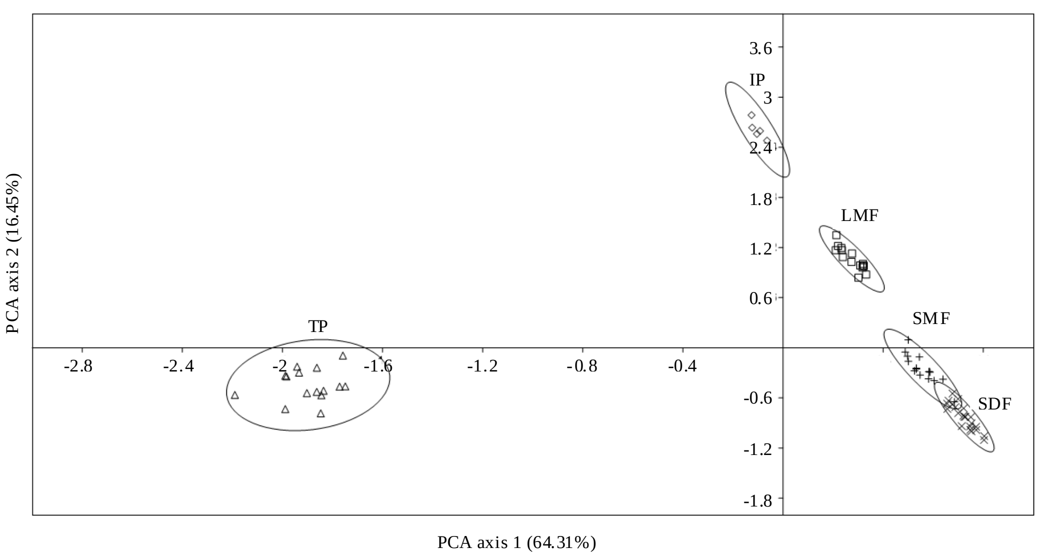

Fig. 4: Principal component analysis showing different forest communities of Suhelwa wildlife sanctuary (SMF-Sal miscellaneous forest, SDF: Sal dominant forest, LMF: Low-land miscellaneous forest, TP: Teak plantation and IP: *Indopiptadenia* population

Sal Miscellaneous Forest (SMF), Sal Dominant Forest (SDF), Lowland Miscellaneous Forest (LMF), Teak Plantation (TP) and *Indopiptadenia* Population (IP). In SMF *Shorea robusta* Gaertn.f. was recorded as the dominant and *Mallotus philippensis* (Lamk.) Muell. Arg. as co-dominant tree with IVI values 107.55 and 66.10, respectively. Sal Dominant Forest resulted *Shorea robusta* as dominant tree with highest IVI (138.00) among all the communities and *Mallotus philippensis* as co-dominant with 62.94 IVI. Moist affectionate LMF was dominated by *Mallotus philippensis* with maximum IVI (89.34) in contrast to other communities and co-dominated by *Shorea robusta* and *Mallotus nudiflorus* (L.) Kulju and Welzen with IVI values 48.82 and 44.57, respectively. Teak plantation was prominently dominated by *Tectona grandis* L. f. with 185.73 IVI and co-dominated by *Mallotus philippensis* with IVI 44.63. The smallest and diminishing community i.e., *Indopiptadenia* population was dominated by *Indopiptadenia oudhensis* (Brandis) Brenan with 66.60 IVI and co-dominated by *Wendlandia heynei* (Schult) Santapau and Merch, *Woodfordia fruticosa* (L.) Kurz, *Holoptelea integrifolia* (Roxb.) Planch. and *Acacia catechu* (L. f.) Willd. with IVI values 44.73, 42.99, 42.40 and 39.14, respectively (Table 1).

Table 1: Importance value index of tree species in different forest communities from Suhelwa wildlife sanctuary

	Forest communities				
Name of species	SMF	SDF	LMF	TP	IP
Acacia catechu (L. f.) Willd.	7.48	1.66	4.69	0.00	39.14
Aegle marmelos (L.) Correa	1.26	0.89	0.00	0.00	0.00
Azadirachta indica A. Juss.	0.00	0.00	0.00	0.00	11.08
Barringtonia acutangula (L.) Gaertn.	0.00	0.00	24.41	0.00	0.00
Bauhinia purpurea L.	0.00	0.00	0.00	1.61	0.00
Bauhinia racemosa Lamk.	1.57	0.00	0.00	0.00	0.00
Bischofia javanica Bl.	0.00	0.58	0.00	0.00	0.00
Bridelia retusa (L.) A. Juss.	13.33	5.09	0.00	11.69	0.00
Careya arborea Roxb.	0.00	1.55	1.42	1.89	0.00
Wendlandia heynei (Schult) Santapau and Merch	0.00	0.00	0.00	0.00	44.73
Cordia dichotoma G. Forst.	3.05	1.21	0.00	2.03	0.00
Dalbergia sissoo Roxb. ex DC.	0.00	0.00	9.54	0.00	0.00
Desmodium oojeinense (Roxb.) H. Ohashi	11.25	1.42	0.00	0.00	0.00
Dillenia indica L.	0.00	1.96	0.00	0.00	0.00
Dillenia pentagyna Roxb.	0.00	1.71	1.47	0.00	0.00
Diospyros exsculpta Buch.-Ham.	4.03	3.05	0.00	0.00	0.00
Ehretia laevis Roxb.	0.98	6.10	0.00	0.00	0.00
Ficus benghalensis L.	0.00	0.57	0.00	0.00	0.00
Ficus hispida L. f.	0.00	0.00	7.94	0.00	0.00
Ficus palmata Forssk. subsp. *virgata* (Roxb.) Browicz	0.00	0.00	1.81	0.00	0.00
Ficus racemosa L.	0.00	0.00	3.84	0.00	0.00
Ficus religiosa L.	1.63	0.00	0.00	0.00	0.00
Ficus semicordata Buch.-Ham. ex Sm.	0.00	0.00	0.00	0.00	11.81
Garuga pinnata Roxb.	0.00	0.00	0.00	1.15	0.00
Gmelina arborea Roxb. ex Sm.	0.00	1.23	0.00	0.00	0.00
Grewia asiatica L.	0.00	0.00	6.00	0.00	0.00
Grewia tiliifolia Vahl.	0.93	0.60	1.41	0.00	0.00
Haldina cordifolia (Roxb.) Ridsdale	4.76	3.20	0.00	4.09	0.00
Holarrhena pubescens (Buch.-Ham.) Wall. ex G. Don	0.54	0.32	0.00	6.13	0.00
Holoptelea integrifolia (Roxb.) Planch.	17.42	3.16	4.53	2.32	42.40
Hymenodictyon orixense (Roxb.) Mabberley	1.20	0.00	0.00	0.00	0.00
Indopiptadenia oudhensis (Brandis) Brenan	0.00	0.00	0.00	0.00	66.60
Kydia calycina Roxb.	0.00	1.19	4.38	0.00	0.00
Lagerstroemia parviflora Roxb.	22.09	16.40	0.00	0.00	0.00
Lannea coromandelica (Houtt.) Merr.	8.41	0.95	3.84	0.00	0.00
Litsea glutinosa (Lour.) Rob.	0.48	0.56	0.00	0.00	0.00
Madhuca longifolia var. *latifolia* (Roxb.) Chev.	1.35	2.12	1.81	0.00	0.00
Mallotus nudiflorus (L.) Kulju and Welzen	0.00	0.00	44.57	0.00	0.00

Table 1: Continue

Name of species	Forest communities SMF	SDF	LMF	TP	IP
Mallotus philippensis (Lamk.) Muell. Arg.	66.10	62.94	89.34	44.63	17.56
Melia azedarach L.	1.09	0.00	0.00	0.00	0.00
Miliusa tomentosa (Roxb.) Sinclair	0.97	2.03	1.39	1.84	0.00
Mitragyna parvifolia (Roxb.) Korth.	6.84	11.83	6.45	8.17	0.00
Murraya koenigii (L.) Spreng.	0.90	0.00	0.00	0.00	23.69
Oroxylum indicum (L.) Vent.	0.00	0.99	0.00	0.00	0.00
Pongamia pinnata (L.) Pierre	0.00	0.92	0.00	0.00	0.00
Pterocarpus marsupium Roxb.	0.00	1.70	0.00	0.00	0.00
Pterospermum acerifolium (L.) Willd.	0.00	1.37	0.00	0.00	0.00
Putranjiva roxburghii Wall.	1.05	0.00	0.00	0.00	0.00
Schleichera oleosa (Lour.) Oken.	0.00	5.07	0.00	0.00	0.00
Semecarpus anacardium L. f.	0.00	6.12	0.00	0.00	0.00
Shorea robusta Gaertn. f.	107.55	138.00	48.82	10.86	0.00
Stereospermum chelonoides (L.f.) DC.	0.00	1.45	0.00	0.00	0.00
Streblus asper Lour.	10.04	2.23	0.00	0.00	0.00
Syzygium cumini (L.) Skeels	0.00	0.74	15.92	3.11	0.00
Syzygium nervosum A. Cunn. ex DC.	0.00	0.00	0.00	2.32	0.00
Syzygium salicifolium (Wight) J.Graham	0.00	0.00	3.69	0.00	0.00
Tectona grandis L. f.	0.00	0.00	0.00	185.73	0.00
Terminalia arjuna (Roxb. ex DC.) Wight and Arn.	0.00	0.00	12.73	0.00	0.00
Terminalia bellirica (Gaertn.) Roxb.	0.00	0.97	0.00	0.00	0.00
Terminalia chebula Retz.	0.00	1.37	0.00	0.00	0.00
Terminalia elliptica Willd.	2.10	5.74	0.00	0.00	0.00
Toona ciliata M. Roem.	1.61	1.01	0.00	12.43	0.00
Woodfordia fruticosa (L.) Kurz	0.00	0.00	0.00	0.00	42.99
Total	300.00	300.00	300.00	300.00	300.00

SMF: Sal miscellaneous forest, SDF: Sal dominated forest, LMF: Lowland miscellaneous forest, TP: Teak population and IP: *Indopiptadenia* population

Sums of 28 tree species were represented by SMF community with 5 site specific species (species represented by this community exclusively). The average tree density and basal cover were calculated 818.75 stem ha^{-1} and 54.40 m^2 ha^{-1}, respectively. Amongst different indexes, dominance index was computed 0.193 while Simpson as 0.858 and Shannon diversity index as 2.205 for the community. Sal dominated forest reported the maximum representative (39) and site specific (13) tree species. It also reported the second highest values of tree density (903.41 stem ha^{-1}) and basal cover (47.11 m^2 ha^{-1}). Dominance, Simpson and Shannon indexes were calculated as 0.263, 0.737 and 2.087, respectively for the community. Lowland miscellaneous forest contributed a sum of 22 trees with second largest number of site specific tree species i.e., nine. Tree density and basal cover was calculated 891.67 stem ha^{-1} and 46.18 m^2 ha^{-1}, respectively. Dominance and Simpson indexes were calculated as 0.152 and 0.848, respectively while the Shannon diversity index was recorded maximum (2.319) for LMF. Teak plantation community reported 16 trees with minimum 4 site specific species. This monoculture plantation reported the highest values of tree density (936.67 stem ha^{-1}) and basal cover (47.95 m^2 ha^{-1}). It also contributed the highest dominance index (0.412), while minimum Simpson (0.588) and Shannon (1.464) indexes. *Indopiptadenia* population (IP) contributed total 9 with 5 site specific trees to the region. This smallest community reported the lowest value of tree density (936.67 stem ha^{-1}) and basal cover (19.35 m^2 ha^{-1}). It also showed the lowest dominance index (0.142) and highest simpson indexes (0.858). The Shannon diversity index was calculated as 2.054 for IP (Table 2).

Table 2: Inventory details of tree species in different forest communities from Suhelwa wildlife sanctuary

	Forest communities				
Variables	SMF	SDF	LMF	TP	IP
Number of species	28.00	39.00	22.00	16.00	9.00
Site specific species	5.00	13.00	9.00	4.00	5.00
Tree density (stem ha^{-1})	818.75	903.41	891.67	936.67	440.00
Basal cover (m^2 ha^{-1})	54.40	47.11	46.18	47.95	19.35
Different indexes					
Dominance_D	0.193	0.263	0.152	0.412	0.142
Simpson_1-D	0.807	0.737	0.848	0.588	0.858
Shannon_H	2.205	2.087	2.319	1.464	2.054

SMF: Sal miscellaneous forest, SDF: Sal dominated forest, LMF: Lowland miscellaneous forest, TP: Teak population and IP: *Indopiptadenia* population

DISCUSSION

The results of the cluster analysis and PCA disclosed five forest communities from the study area: Sal Miscellaneous Forest (SMF), Sal Dominant Forest (SDF), Lowland Miscellaneous Forest (LMF), Teak Population (TP) and *Indopiptadenia* Population (IP). All the communities are congregated on the basis of their dominant, co-dominant and associated trees. Cluster as well as the PCA graph placed TP distinctly from the other communities due to its plantation nature and higher dominance of a single species i.e. *Tectona grandis*. *Indopiptadenia* population was also placed distinctly, due to the absence of a clear-cut major dominant tree and also for the more evenly distribution of the associated species. Sal miscellaneous forest and sal dominant forest communities are placed very close to each other due to the similar dominant (*Shorea robusta*) and co-dominant (*Mallotus philippensis*) species, while differ on the basis of their association with other tree species. LMF community is placed separately in the cluster and PCA but towards the sal communities (SDF and SMF) due to the presence of *Shorea robusta* as co-dominant species. Its differentiation from the sal communities is based on the presence of more moisture loving trees (*Barringtonia acutangula* (L.) Gaertn., *Dalbergia sissoo* Roxb. ex DC., *Ficus hispida* L. f., *Ficus palmata* Forssk. subsp. *virgata* (Roxb.) Browicz, *Ficus racemosa* L., *Grewia asiatica* L., *Mallotus nudiflorus* (L.) Kulju and Welzen, *Syzygium salicifoium* (Wight) J. Graham and *Terminalia arjuna* (Roxb. ex DC.) Wight and Arn.) in this community.

The overall tree density of SWS has been reported 798.10 stem ha^{-1} with maximum (936.67) from TP and minimum (440.00) from IP. The tree density of the forest has been found within the range of previously reports (276-935 stem ha^{-1}) from the tropics (Murali *et al*., 1996; Sundarapandian and Swamy, 1997; Ghate *et al*., 1998; Mani and Parthasarathy, 2005). Here the tree density has been reported higher than the several tropical evergreen forests (419-716) (Singh *et al*., 1984; Ganesh *et al*., 1996; Ghate *et al*., 1998; Parthasarathy, 1999; Chittibabu and Parthasarathy, 2000), tropical deciduous forests (150-810) (Jha and Singh, 1990; Shrestha and Jha, 1997; Rautiainen, 1999; Pandey and Shukla, 2003; Reddy *et al*., 2007; Bajpai *et al*., 2012a), Tropical moist forest (604) (Swan, 1988) and tropical rain forest (391-617) (Heaney and Proctor, 1990). The similar range (750-935 stem ha^{-1}) of tree density has been reported by some evergreen forests of North-East India and Eastern Ghats (Visalakshi, 1995; Mani and Parthasarathy, 2005; Devi and Yadava, 2006), while lower than the range (1054-1420) from the tropical rain forest of Amazon and Malaysia (Campbell *et al*., 1986; Proctor *et al*., 1988).

The basal cover of the trees of SWS ranges from 19.35-47.95 m^2 ha^{-1} by IP and TP, respectively with an average value of 43.00 m^2 ha^{-1}. It has been found within the range (7-104) for tropical forests (Singh *et al*., 1984; Jha and Singh, 1990; Mishra *et al*., 2008). It has been found lower than the tropical evergreen forests with basal cover 11-82.76 m^2 ha^{-1} (Campbell *et al.*, 1992; Visalakshi, 1995; Strasberg, 1996; Chittibabu and Parthasarathy, 2000; Mani and Parthasarathy, 2005; Devi and Yadava, 2006) and tropical deciduous forests with basal cover 7-61 m^2 ha^{-1} (Jha and Singh, 1990; Singh and Singh, 1991; Singh *et al.*, 1995; Varghese and Menon, 1998; Singh *et al.*, 2005) of the country. This range of basal cover has been found higher than the tropical rain forests of Malaysia viz. 26-46 m^2 ha^{-1} (Proctor *et al.*, 1988) and lower than the tropical rain forests of Amazonia i.e., 28-68 m^2 ha^{-1} (Campbell *et al.*, 1986). It is also found lower than the values (16-61) reported from adjacent tropical moist deciduous forests (Shrestha and Jha, 1997; Singh *et al.*, 2005; Tripathi and Singh, 2009; Bajpai *et al.*, 2012a).

The present study from SWS, documented the higher values of tree density, but lower values of basal cover in comparison with the similar kind of the forest from the country. It clearly indicates the presence of relatively young strains of trees in all the forest communities of SWS.

The average dominance index is recorded as 0.232 from SWS, ranging from 0.142 (IP) to 0.412 (TP) and has been found within the range (0.210-0.970) for tropical forests of India (Parthasarathy *et al.*, 1992; Visalakshi, 1995; Devi and Yadava, 2006). Its value has been reported lower than the tropical semi-evergreen forests of North-East India (Devi and Yadava, 2006), tropical moist deciduous forests of Northern India (Bajpai *et al.*, 2012a) and tropical dry deciduous forests of Central India (Prasad and Pandey, 1992). The lowest value of dominance (0.142) and highest value of Simpson (0.858) indexes from IP indicates the presence of maximum number of dominant trees with a highest heterogeneity within this community; while the highest value of dominance (0.412) and lowest value of Simpson (0.588) indexes from TP specified its plantation nature, presence of very few or one dominant tree species with lowest heterogeneity.

The average Shannon diversity index from SWS is reported as 2.026 with minimum (1.464) from TP and maximum (2.319) from LMF which are within the range (0.83-4.15) reported for Indian tropical forests (Singh *et al.*, 1984; Parthasarathy *et al.*, 1992; Visalakshi, 1995). It has been found lesser than the most of the tropical forests from peninsular India (Parthasarathy *et al.*, 1992; Sundarapandian and Swamy, 2000), central India (Prasad and Pandey, 1992), North-East India (Kumar *et al.*, 2006) and Northern India (Bajpai *et al.*, 2012a) as well as Panama (Knight, 1975). This lower diversity index values from the Terai-Bhabar forests of SWS indicates its low species diversity pool. This may be due to the pressure of higher natural and anthropogenic disturbances (Foster, 1990).

Outstandingly the smallest *Indopiptadenia* population attracts our attention as it is one of the few habitats of *Indopiptadenia oudhensis* and declining due to natural as well as anthropogenic activities. All the *Indopiptadenia* population quadrates are reported from the gravelly-sandy soil along the banks of water streams and the preference of such type of habitat forced this population to encounter the natural hazards such as floods and cutting of water streams banks. It not only reduces the post germination success of seedlings, but also reduces the number of matured trees by destroying them. The lowest tree density and basal cover represent that it is a comparatively open forest community which provide evidence to consider it a prone area for anthropogenic disturbances especially grazing and lopping for fodder and timber.

CONCLUSION

The present study concludes that both the sal communities (SMF and SDF) are the residue of old natural sal forest of Terai-Bhabar region. Both have the significant plant diversity as they jointly contributes ~71% (45) trees of the total encountered (63) and ~57% (26) site specific trees from the region. Although, TP is the monoculture plantation, however due to the presence of 4 site specific species, highest dominance index and lowest Simpson, Shannon and equitability indexes, it shows potential to be naturalised. By using the present base line information regarding the composition of *Indopiptadenia* population. A comparative study can be conducted after a sufficient time interval which will be helpful to find out the more accurate place of the species in the IUCN categories. To protect this monotypic genus, there should be a management plan to make aware the local people about the threat the species is facing and to protect the banks of streams from cutting in the rainy season through constructing some mechanical support or by other approaches.

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