Phytosociological studies, biodiversity conservation in a sub tropical moist deciduous forest of Rajaji Tiger reserve; Uttarakhand, India

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ABSTRACT *The Indian Himalayan region spreads across Jammu & Kashmir, Himachal Pradesh, Uttarakhand, West Bengal and Arunachal Pradesh. It support approximately 18,440 species of plants, 241 mammalian species and 979 birds species The study assessed vegetation composition, pattern of plant diversity and conservation strategies in Rajaji Tiger Reserve, Haridwar-Pauri forest divison (29°15' to 30°31' N, 77°52' to 78°22' E, altitude 250–1100 m) in a tropical moist deciduous forest of Shivalik Hills. The site represents the different combination of dominants and co-dominant species. In trees, most of the species showed contagious pattern of distribution only few showed random pattern of distribution. On the other hand maximum shrubs species showed contagious pattern but only one species showed regular pattern of distribution. In herbs most of the species showed contagious distribution while four species showed the random pattern of distribution but none of the species showed regular pattern of distribution. The Shannon diversity index for trees was 1.887 and for shrubs and herb it was 1.893 and 2.987 respectively. The Simpson index for trees was 0.193 and 0.330, for shrubs and herbs it was 0.058. The Pielou evenness index was 0.68 for trees, 0.86 for shrubs and 0.88 for herbs. The species richness index (Margalef index) was 2.60 for trees, 1.21 for shrubs, and 4.82 for herbs. Further the study also assessed the different conservation strategies in the tiger reserve which are greatly providing protection to flora and fauna and helping in the restoration of ecosystem.*

Keywords: *Biodiversity, Herbs, Shrubs, Trees, Rajaji tiger reserve*

Introduction

Tropical forests are regarded one of the most diversity rich ecosystem in the world (Sanders, 2006; Sayer and Whitmore, 1991). These forests represent the most common heritage with livehood portfolios by majority of peoples in developing country especially in India. In India, these tropical forests account for approximately 86% of the total forest land (Singh and Singh 1988). These forests are strongly affected by anthropogenic activities (Champion and Seth 1968; Singh et al. 1991). Due to the high anthropogenic pressures in the past several years, the dry as well as the deciduous forest cover in most parts of India is being converted into dry deciduous scrub, dry grasslands and dry savannah which are progressively poor in species. This type of situation calls for in-depth study of these tropical forests with respect to structure, regeneration of species and diversity. The tropical deciduous forests are the most widespread forests in India and also known as monsoon forests. They spread over regions which receive rainfall range between70-200 cm. On the basis of the availability of water, these deciduous forests are further categories into moist and dry deciduous. The moist deciduous forest receives a rainfall range between 100-200 cm and mainly comprise *Dalbergia sissoo, Shorea robusta, Mallotus phillipensis* etc. On the other hand the dry deciduous forest covers a vast area of the India and receives a rainfall range between 70-100 cm. These forest are mainly comprises *of Butea monosperma, Cassia fistula, acacia catatue* etc. Tropical forest area the drivers of many ecosystem and helps in maintaining the sustainability of the forest. Large area of these tropical forest are lost or ruined every year with dramatic consequences for biodiversity. The main regions for biodiversity loss in forest are fragmentation, invasive species, deforestation, over-exploitation, and climate change. (Gardner et al., 2009; Morris, 2010; Anonymous, 2013). The destruction of these tropical forest is likely to continue in the future, causing an extinction crisis among the species (Bradshaw et al., 2009). Though in recent time the rate has declined, the net forest loss in many humid tropics such as Brazil and Indonesia is still alarming (FAO, 2010). In India, the native forests are claimed to be reducing at an alarming rate of 3.5% annually (Puyravaud and Davidar, 2010) not withstanding a total forest cover increase, on account of reforestation. The resource from these forests however are getting eroded not due to rural consumption in underdeveloped economy, but also now driven by industrial growth and globalisation (Butler and Lawrence, 2008).

Study site

The state Uttarakhand is situated in northern India and has about 34,651 km^2 of forests. The protected forests constitute about 28.52% of the total forested area (Forest Survey of India, 2011). The present study

area i.e., Rajaji tiger reserve lies in the upper Gangetic plains has a rich floristic as well as faunistic diversity assemblage. One of the most important parts of the Indo-Gangetic Plains biogeographic zone is Shivalik landscape which has special significance in India due to intermingling of taxa from the Indo-Malayanand Palaearctic regions (Sivakumar et al. 2010). Rajaji tiger reserve (earlier named as Rajaji National park) was established in 1983 with the aim of maintaining the population especially Asian Elephants and is designated as a protected area for 'Project Elephant' by the Ministry of Environment, Forest and Climate Change, Government of India.

The tiger reserve spread in an area of 820.42 Km^2. The River Ganga flows 24 km through the park dividing the Tiger reserve into two unequal halves. The three important seasons of the park area summer (March-June), winter (November – February) and monsoon (June –September). In summer the temperature raises 40-45^{0}C and in winter 20-25^{0}C. The annual rainfall ranges from 1200-1500 mm. Generally the soil is poor and infertile but in some places accumulation of humus occurs. The Chilla forest range of the tiger reserve lies in the east of the river Ganges and attached to the Garhwal forest Division. The elevation lies between 302 and 1000 meter above sea level. This range of the reserve is one of the great centre attractions for tourists and approximately 90% tourist visit in Chillla range every year to enjoy the wildlife and scenic beauty. The dominant plant species area *Shorea robusta, mallotus phillipensis, Dalbergia sissoo, Acatia catatue.* Some of the faunal species of the reserve are *Elephus maximus, Panthera pardus, P.tigris, Axis axis*, *Axis peroconius, Cervus unicolor, Naemohaedus goral etc.*

Material and Methods:

The study was carried out in Chilla Range of Rajaji Tiger Reserve, Uttarakhand which comes under the Shivalik range in tropical moist deciduous forest in the foothills of Himalayas during 2015-2017. The objectives of the study were to assess the status of the different layers of the plants by Nested quadrate sampling method. Quadrate size of 20×20 m^2 for tree species and 5×5 m^2 for shrub layer. 1×1 m^2 size of quadrate (A total of 12 Quadrat for tress, 24 for shrubs and 72 for herbs) was laid down randomly to collect the information of the floral species. The diameter at breast height (dbh) of all individuals in each quadrate was measured for all trees, shrubs and herbs.

Data analysis

The quantitative analysed for frequency, density, and abundance was done (Curtis and MacIntosh, 1950) and after that Relative frequency, relative density, relative dominance were calculated by following (Phillips, 1959). The importance value index (IVI) at species level was calculated from the sum of relative frequency, relative density, and relative dominance (Curtis, 1959). The following formulas were used to calculate the quantitative parameters:

$$\text{Frequency (\%)} = \frac{\text{Number of the quadrates in which the species occurred}}{\text{Total number of quadrates studied}} \times 100$$

$$\text{Density} = \frac{\text{Number of individuals of a species in all quadrates}}{\text{Total number of quadrates taken}}$$

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates in which the species occurred}}$$

$$\text{Relative Frequency (RFR)} = \frac{\text{Frequency of individual species}}{\text{Frequency of all species}} \times 100$$

$$\text{Relative Density (RD)} = \frac{\text{Density of individual species}}{\text{Density of all species}} \times 100$$

$$\text{Relative Dominance (RDo)} = \frac{\text{Basal area of a species}}{\text{Basal area of all species}} \times 100$$

Finally the Importance value index was calculated on the basis of the following formulas:

Importance value index (IVI) = Relative Frequency + Relative density+ Relative dominance

The ratio of abundance to frequency is generally used to interpret the distribution pattern of species (Whitford, 1949). The ratio of abundance to frequency indicates regular distribution if below 0.025, random distribution between 0.025-0.05 and contagious if it is >0.05 (Curtis and Cottam, 1956).

Shannon's diversity index

The diversity indices reflect the manner in which abundance is distributed among the different species constituting the community. The species diversity index (H') was determined by the following formula:

$$H' = -\Sigma\, p_i \ln p_i \qquad \text{(Shannon and Wiever, 1963)}$$

Where, pi = ni/N, which denotes the importance probability of each species in a population; ni = importance value for species "i", N = total of importance values. Concentration of dominance (Cd), known as Simpson index (Simpson, 1949).

$$Cd = \Sigma p_i^2$$

The evenness index was determined by:

$$J' = H'/\ln s$$

(Pielou, 1966)

The Richness index (Margalef, 1958) was determined by

$$R = S-1/\ln(N)$$

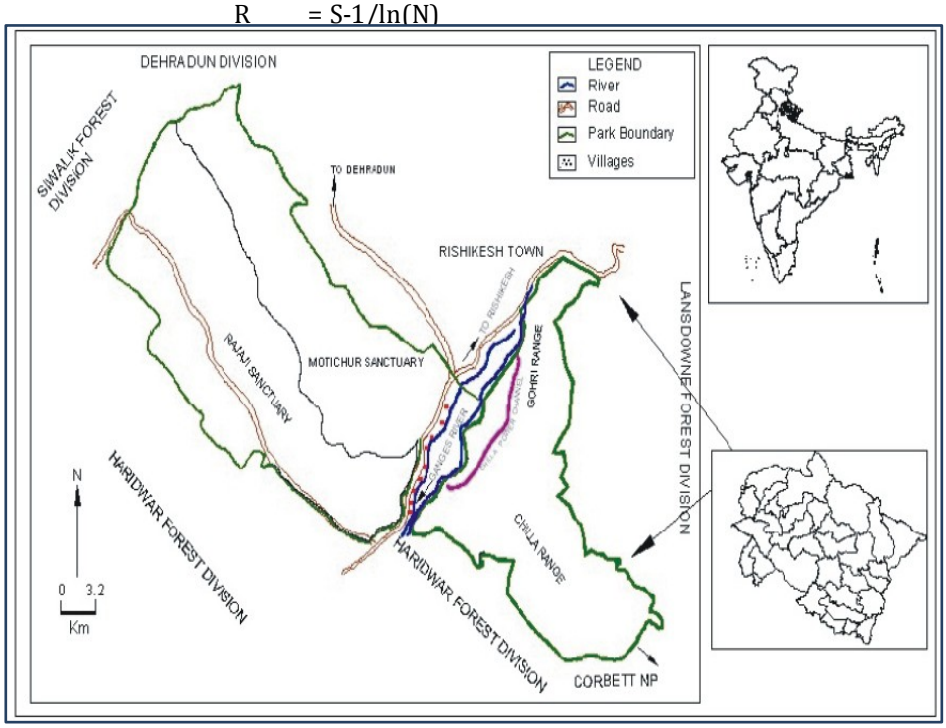

Fig. 1: Map of Rajaji tiger reserve showing the Study area (Chilla range)

Table 1. Frequency %, Density (D/hectare), TBC ($m^2 hac^{-1}$), A/F, Importance value index of trees in the study area

Species	Family	F %	Density/hectare	TBA ($m^2 hac^{-1}$)	A/F	IVI
Holoptelia integrifolia	Ulmaceae	100	216.6665	11.74758	0.08667	117.291
Ehertia laevis	Ehretiaceae	50	43.75	0.16056	0.07	15.942
Crateva religiosa	Capparidaceae	58.3333	60.4166	0.12446	0.07102	19.642
Ficus palmata	Moraceae	8.3333	2.0825	0.01035	0.12	1.781
Celtis australis	Cannabaceae	8.3333	2	0.01432	0.12	1.791
Morus alba	Moraceae	8.3333	12.5	0.0895	0.36	3.8
Cedrella toona	Meliaceae	8.3333	2.08325	0.186645	0.12	2.8
Orozylum indicum	Bignoniaceae	16.6666	4.1665	0.05991	0.06	3.788
Ficus religiosa	Moraceae	16.6666	4.1665	0.08789	0.06	3.95
Adina cordifolia	Rubiaceae	8.3333	2.08325	2.65381	0.12	17.057
Listea chinensis	Lauraceae	91.6666	95.8325	0.17921	0.02975	30.906
Terminalia	Combretaceae	8.3333	4.1665	1.22233	0.24	9.097

bellerica						
Alstonia Scholaris	Apocynaceae	8.3333	2.08325	0.13435	0.12	2.497
Naringi crenulata	Rutaceae	75	139.58325	0.19542	0.09926	34.745
Cassia fistula	Fabaceae	33.3333	12.5	0.3195	0.045	9.355
Mallotus phillipensis	Euphorbiaceae	91.6666	62.5	0.11813	0.02975	25.552
Total			666.57	17.304		299.994

Table 2. Frequency %, Density (D/hectare), TBC (m^2 hac^{-1}), A/F, Importance value index of shrubs in the study area

Species	Family	F %	Density/hac	TBA (m^2 hac^-	A/F	IVI
Murraya koenigii	Rutaceae	70.833	2300	26.313	0.1146	58.429
Lantana camara	Verbenaceae	100	2500	38.525	0.0625	77.543
Adhatoda vesica	Acanthaceae	87.5	2666.64	16.7465	0.08707	55.866
Helictres isora	Sterculaceae	16.667	350	0.14	0.31499	6.447
Cassia occidentalis	Fabaceae	37.5	483.332	0.70083	0.08593	12.327
Clerodendrum viscosum	Verbenaceae	70.833	22883.33	22.51363	0.11377	54.709
Calotropis procera	Apocynaceae	20.833	533.32	0.85331	0.3072	9.498
Colebrookia oppositifolia	Lemiaceae	16.667	416.6685	0.21667	0.37499	7.076
Indigofera spp	Fabaceae	70.833	433.332	0.08233	0.00353	18.808
Total		491.66	11966.62	106.09		300.00

Table 3. Frequency %, Density (D/m^2), TBC, A/F, Importance value index of herbs in the study area

Species	Family	F %	Density/m^2	A/F	IVI
Kallinga monochephala	Cyperaceae	3.889	56.944	1.05426	20.526
Adiantum spp	Pteridaceae	29.167	29.167	0.03429	17.278
Ageratum conyziodes	Asteraceae	40.278	40.278	0.045	35.156
Achyranthus aspera	Amaranthaceae	16.667	16.667	0.060.08	13.452
Cyanodon dactylon	Poaceae	12.5	12.5	0.08	6.968
Sida spinosa	Malvaceae	8.333	36.11	0.52002	14.85
Mucuna pruriens	Fabaceae	1.389	1.389	0.71994	0.8
Centella asiatica	Apiaceae	2.778	16.667	2.15983	4.013
Oxallis corniculata	Oxallidaceae	5.56	19.444	0.6295	5.238
Abutilon indicum	Malvaceae	12.5	177.778	0.14222	72.487
Cayratia trifolia	Vitaceae	2.77778	16.667	0.36	4.013
Xanthium strumarium	Asteraceae	5.556	9.722	0.31497	4.725
Parthenium hysterophorus	Asteraceae	13.889	26.389	0.1368	25.926
Cissampelos prariara	Menispermaceae	16.667	22.222	0.08	11.184
Borhavia diffusa	Nyctaginaceae	1.389	4.167	2.15983	1.196
Commelina benghalensis	Commelinaceae	5.556	11.111	0.35997	4.206
Perilla frutscense	Lamiaceae	4.167	6.944	0.23998	2.903
Euphorbia hirta	Eophorbiaceae	2.778	9.722	1.2599	2.62
Pogostemon benghalensis	Lamiaceae	4.167	6.944	0.47996	2.903
Cyprus rotundus	Cyperaceae	12.5	26.389	0.16889	9.652

Evolvulus nummularius	Convolvulaceae	2.778	9.722	0.35997	2.62
Oplimensus burmanii	Poaceae	1.389	1.389	0.71994	0.791
Ichnocarpus frutescense	Apocynaceae	20.833	29.167	0.0672	15.932
Asparagus racemosus	Asparagaceae	4.167	4.167	0.23988	2.35
Cheilanthes spp	Pteridaceae	11.111	33.333	0.27	10.489
Vitis latifolia	Vitaceae	1.389	9.722	0.71994	2.073
Aerva sanguinolenta	Amaranthaceae	4.167	4.167	0.23998	2.371
Bahunia vahlii	Fabaceae	1.38888	1.388	0.72	0.909
Launea procummbens	Asteraceae	4.01074	4.167	0.02493	2.31
Total		253.897	644.44		299.941

Table 4: Phytosociological attributes in the study area

Parameter	Tree	Shrub	Herb
Richness index	2.60	1.21	4.82
Pielou Eveness Index	0.68	0.86	0.88
Shannon's diversity index	1.887	1.893	2.987
Simpson Index(cd)	0.193	0.330	0.058

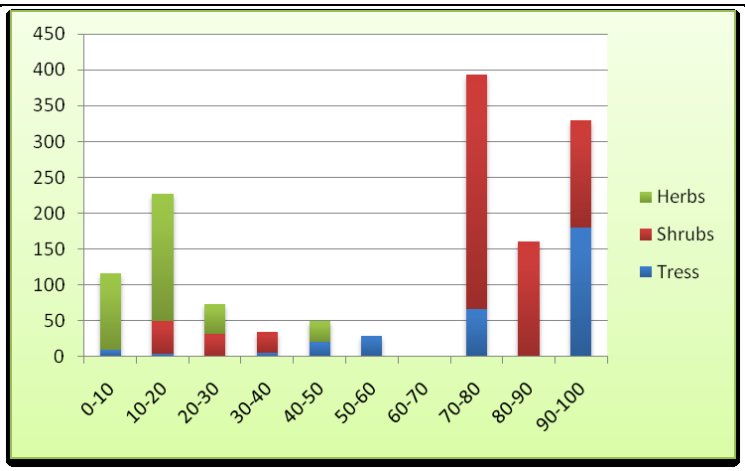

Fig 2: Total number of individuals of different Frequency classes

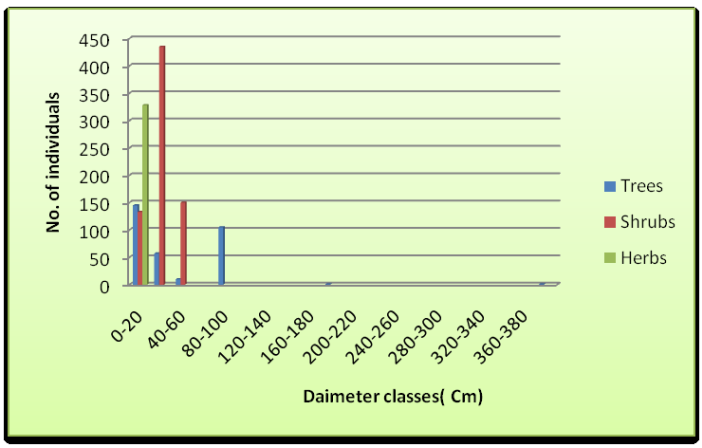

Fig 3: Total number of individuals of different diameter classes

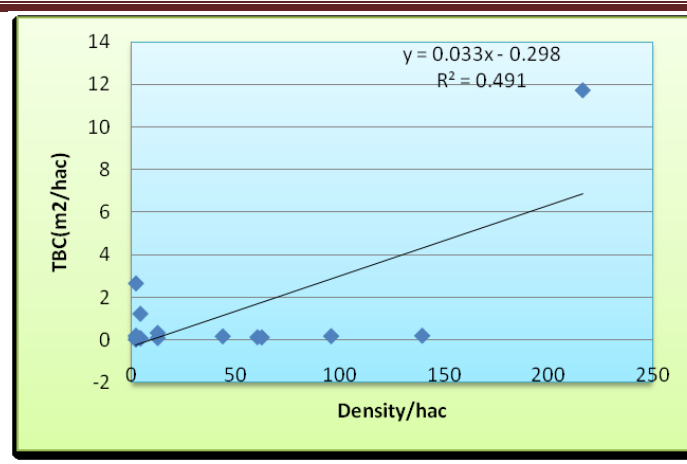

Fig 4: Correlation between density/hac and total basal area in tree layer

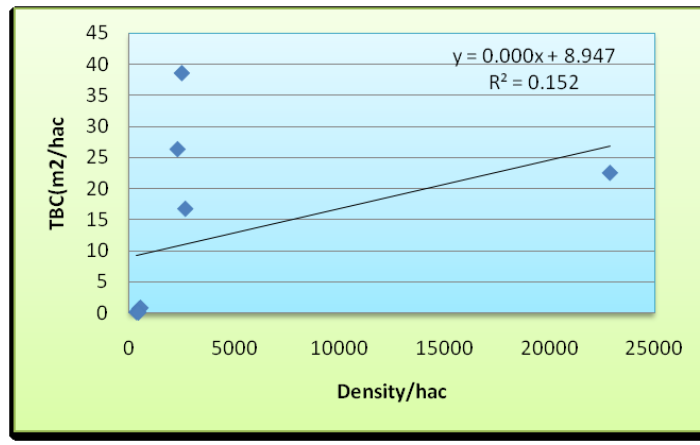

Fig 5: Correlation between density/hac and total basal area in shrub layer

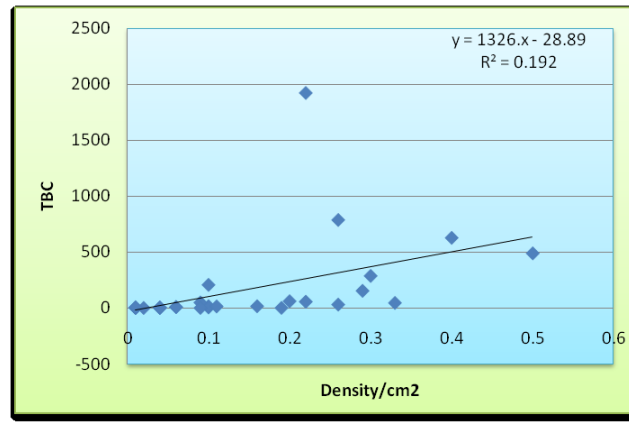

Fig 6: Correlation between density/hac and total basal area in herb layer

Results

Species richness and diversity

In trees strata, 16 species belonging to 15 genera under 14 families were recorded in the study area **(Table 1).** In trees, most of the species belongs to family Moraceae (3) followed by the Rutaceae, Fabaceae, Euphorbiaceae, Ulmaceae, Ehretiaceae**,** Apocynaceae, Bignoniaceae, Lauraceae, Cannabaceae, Capparadiaceae, Rubiaceae, Combretaceae (1 species each for other family). In tree strata, the total stem density was varies from 2.08325 - 666.5797 individuals hac^{-1}. On the other hand the total basal area varies from 0.01035-11.74758 m^2 hac^{-1}. The importance value index (IVI) in tree strata ranged from 1.781 **-** 117.291. All the phytosociological parameter like density, basal area and IVI was highest for *Holoptlia integrifolea* indicating that this one is the most dominant species in the tree strata. The least dominant species of tree layer are *ficus*

palmata , *Celtis australis.* The abundance frequency ratio (A/F) indicates the maximum of the tree showed contagious distribution pattern of the species and only four species showed the random pattern of distribution but none of the species showed regular pattern of the distribution in tree strata.

In shrubs strata, 9 species belonging to 9 genera under 7 families were recorded (**Table. 2**). In shrubs, most of the species belongs to the family Verbenaceae (2) followed by Fabaceae (2), Rutaceae, Apocynaceae, Leminacea, Acanthaceae, (1 species each). In shrubs strata, the total density was varies from 350 to 22883.33 hac^{-1} . On the other hand the total basal area varies from 0.14-22.51363 m^2 hac^{-1}. The highest density was recorded for *Clerodendrum viscosum* whereas lowest for *Helictres isora* and highest basal area was recorded for *Clerodendrum viscosum* and lowest was that of *Helictres isora.* The importance value index (IVI) in shrubs strata varies from 6.447- 77.543 in which highest was recorded for *Lantana camara* whereas lowest for *Helictres isora* indication that *Lantana camara* is one of the most dominant species whereas *Helictres isora is* least dominant species in the shrub layer. The abundance frequency ratio (A/F) indicates that maximum shrubs showed contagious distribution pattern of the species and only one species showed the regular pattern of distribution but none of the species in the shrubs layer showed random pattern of the distribution in shrubs strata.

In herbs strata, 29 species belonging 29 genera under 23 families were recorded (**Table 3**). In herbs, most of the species belonging to the family Asteraceae (4) followed by Fabaceae (2species each) Poaceae (2species each), Cyperaceae, Amaranthaceae, Malvaceae, Apiaceae, Oxallidaceae, Lamiaceae, Pteridaceae, Commelinaceae, Memispermaceae, Vitaceae, Nyctaginaceae, Euphorbiaceae, Apocynaceae, Asparagaceae, Convulvulaceae, (1 species each). The stem density of herbal species varies from 1.389- 177.778 cm^2 whereas the importance value index varies from 0.791-72.487. Maximum of density and was recorded for *Abutilon indicum* but lowest was for *Oplimensus burmanii and Mucuna pruriens*., *Abutilon indicum* was the dominant species in the herb strata because of its highest importance value index whereas lowest was recorded for *Oplimensus burmanii* indicating that it as least dominant species in the herb layer. The abundance frequency ratio (A/F) of maximum herb species showed contagious pattern of distribution, 4 species of herb showed the random pattern of distribution but none of the species showed regular pattern of the distribution.

The correlation between different vegetational parameter of trees, shrubs and herbs are given in **(Fig 4,5,6).** The density was positively correlated with the total basal area in trees (r=0.244), shrubs (r=0.075) and herbs (r = 0.096).

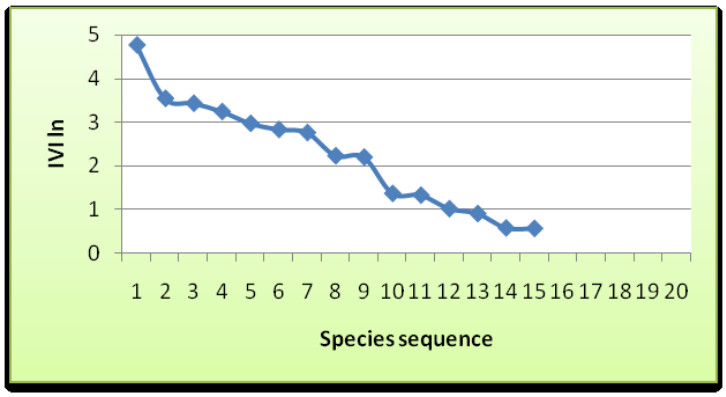

Fig 7: Dominance-diversity curve for trees

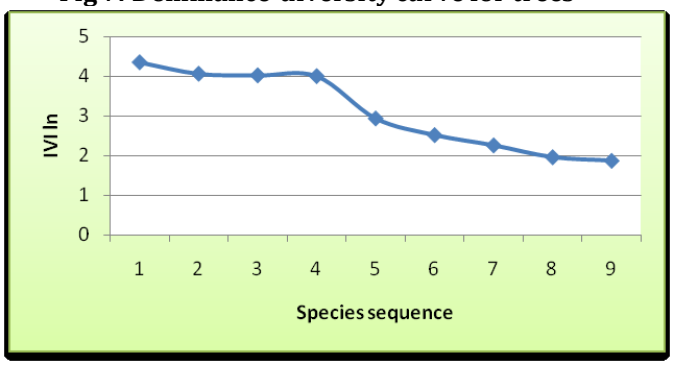

Fig 8: Dominance-diversity curve for shrubs

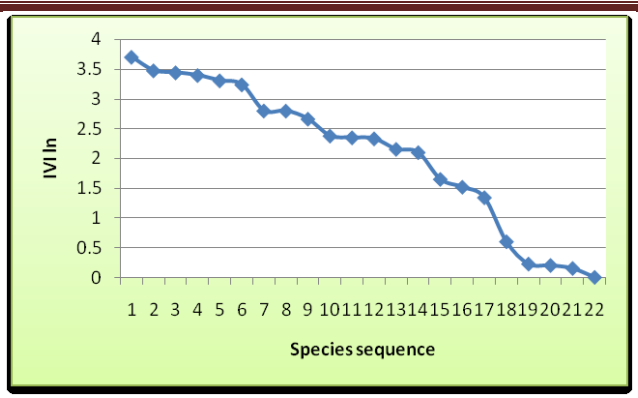

Fig 9: Dominance-diversity curve for herb

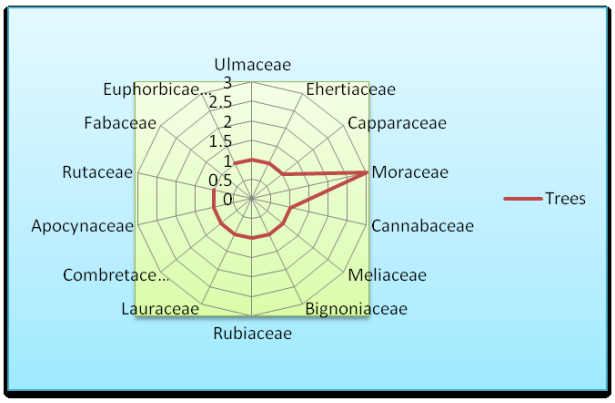

Fig 10: Num of individuals in different family of trees

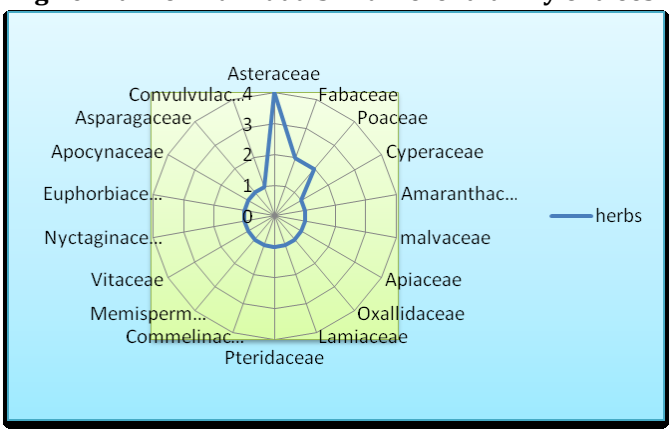

Fig 11: Num of individuals in different family of herb

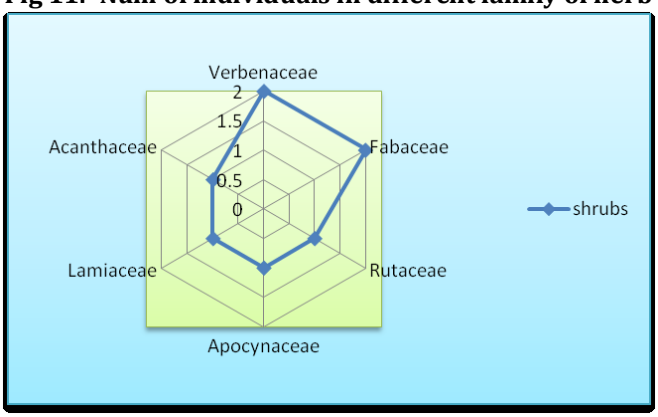

Fig 12: Num of individuals in different family of shrub

Biodiversity conservation strategies in a tropical moist deciduous forest of Rajaji tiger reserve

Protected areas are one of the most effective tools available for conserving biodiversity. Protection of the reserved area is the major issue for conservation of wildlife. A single-species approaches to protection, management as well as monitoring is insufficient to combat the threat to the overall biological diversity of any of the area. The multi-species-based monitoring and protection approaches are believed to be more reliable, timely, and informative in measuring the major changes in populations, communities as well as biological diversity (Manley et al. 2005). The tiger reserve is biologically rich in floral as well as faunal wealth but in Rajaji tiger reserve many tribal communities (Locally known as Gujjars) and villager are still residing. Due to the wildlife protection act of 1972, they were resettled for the tiger reserve but their number are abundant in Motichur, Chilla and some area of Mohand range of the reserve. Various anthropogenic activities were recorded in the tiger reserve which has affected the flora and fauna. Approximately 20 villagers are located in the south western, 20 villages along with the eastern boundary and 15 villages in northern axis of the area. This villager totally depends on the forest resources for their livehood like collection of fuel and fodder. Some of the invasive species like *Trewia nudiflora, Lantana camara, Parthenium hysterophorus* etc. affecting adversely to other ground flora and harm the regeneration pattern of the species. Exotic weeds like *Lantana camara* and *Parthenium hysterophorus* and some of the native weeds like *Adhatoda vasica*, *Cannabis sativa* are problems throughout the Rajaji-Corbett Tiger Conservation Unit, which affecting severely the suitability of the habitat for ungulates (Johnsingh and Negi, 2003). Therefore, the following strategies have been applied by the government and park officials to protect the floral as well faunal wealth:

- Construction of fire-line
- Eradication of harmful plant species
- Gujjar (Tribal community) Rehabilitation programme
- Stoppage of illegal lopping and grazing.
- Anti- poaching camps

Construction of fire-line

Forest fire is a major problem in the Rajaji tiger reserve as it severely harm the ground flora and animals. If natural disasters are excluded from the forest fire then the forest fire come close to being the worst kind of all disaster (Heikkilla et al., 1993). Fire-lines are crucial for preventing the forest fire. The fire-lines are of 100 feet, 50 feet, 20 feet, 10 feet and 4 feet. These fire lines are constructed in all the nine range of the tiger reserve. Burning of grasses and other inflammable materials are collected on the fire line in controlled manner before the beginning of fire season. Regular maintenance is kept so that L*antana camara* cannot overtake the fire-line. Maintenance of fire- lines is also useful in providing open areas in dense forest with the good growth of grasses and supporting the herbivore population.

- **Eradication of harmful plant species**

Many exotic plant species like *Lantana camara, Parthenium hysterophorus* are widely distributed into the park affects severely to other plant species. Leaves of *Lantana camara* are poisonous to some animals and its fruit is delicacy to many birds which distribute the seed but the eradication programme of this weed is continuously going on by the method of great professor of Delhi University Dr. C.R. Babu. This techniques involves firstly uprooting the plants after severing the root section of the plant 2-3 cm below the collar region. In the next step, the uprooted plant is left topsy-turvy to dry with its roots pointing towards the sky and the branches spread on to the ground. This will drains all the sap out of the plant rendering the branches incapable of striking the root and growing into new plant. Finally, grass slips planted immediately in that area where *Lantana camara* has been removed. In addition, the adjoining areas of Hardwar – Bijnor National highway various stakeholders has constructed so many check posts and shrines and all of these spots are working as a barriers as far elephant's movement is concerned (Joshi and Singh 2008). Presently due to the efforts of park authority for eradication of *Lantana camara* inside the park area many of the species like *Cynodon dactylon, Syzygium cumini, Holarrhena antidysenterica*, *Saccharum spontaneum* are growing rapidly inside the tiger reserve.

- **Gujjar Rehabilitation Programme**

Conservation of biodiversity was often associated with relocation programme of residing peoples inside the village and the relocation has clearly emerged as an important issue in conservation that needs to be observed for more deeply than it has been in the past (Rangarajan and Shahabuddin, 2006). Gujjars are the nomadic community whose members stay inside the forest of the tiger reserve in huts. Their major occupations of these peoples are rearing of cattle like buffalo and cow and selling milk in the local market. Approximately a Gujjar family has 15-20 buffalos and better families may have 30-40 buffalo each. On account of their regular requirements particularly fodder need, Gujjars have been inflicting heavy pressure on precious forest

resources of the reserve. Gujjar community is responsible for lopping of many important fodder plant species like *Ficus rumphii, Emblica officinalis, Anogeissus latifolia, Aegle marmelos, Dendrocalamus strictus, Ficus bengalensis, Ficus religiosa, Bauhinia variegata, Grewia oppositifolia , Lagerstroemia parviflora* etc.. They also used animal corridor to for various activity in past but in view of the provision of Wildlife Protection Act, 1972 and after a long effort done by centre as well as the state government, Gujjars are resettled outside from the RNP area and they are relocated to rehabilitation sites namely Gaindikhatta and Pathri and still this programme is ongoing because of their large number in Chilla range of the tiger reserve.

- **Stoppage of illegal lopping and grazing**
- Lopping of plant species in forest areas is a conventional practice and a significant forest-based economic activity for all those villagers residing in the vicinity of forest areas since it produces intermittent benefits to them from forest resources in the form of fodder and firewood (Gupta 2002). It has been observed that the villagers understand an*d recognize the need for future consumption but due to high rate of consumption from forest resources and secondly lack of technical knowledge about it, intensity of lopping becomes heavy and quite often the entire canopy of trees gets lopped excepting a few young branches in the forest. This severely affects the growth of trees, which constitute resource based on lopping itself and thus the productivity of the forest area as a whole (Rawat 1993). Illegal lopping and grazing are major types of problems in the park. Plant species like *Mallotus phiillipensis, Shorea robusta* bark etc. are preferred food for Asiatic elephant and also used as fuel wood by Gujjars and other people residing in the park. Therefore, collection of firewood causes immense damage to the elephant habitat. Grazing of *Cyanodon dactylon, Kallinga monochephala*, adversely affect the ground flora of the reserve. These activities are now reduced due to the inspection and patrolling by guards and other officials. The regeneration potential of forest has also got strengthen just after the relocation of Gujjars as lopping of important plant species and grazing by their cattle's was stopped after this programme.

Anti – poaching camps

A number of anti poaching huts have been constructed by the park officials to provide safety and guard to flora as well as fauna. The forest guard takes round of their beat and check the sign of illegal entry, poaching of wild fauna. Remote and terrain areas of the forest can be covered by walking along bridge path. The tiger reserve has a good network bridle paths but regular maintenance is needed as their existence is liable to be obliterated by the overgrowth of grasses, shrubs and many other bushes. There are so many bridge and path for patrolling like Calvin road path, Pancchiwala path, patrolling path of Ramgarh and so on. The park officials now can do patrolling at night. Due to these camps collection of NTFPS such as honey, deer antlers, and edible mushroom has been reduced.

Discussion

It has been argued that if the different environmental changes produced by disturbances are large, it would be lethal to the various numbers of the species and can be replaced by the immigrants (Sheil, 1999). In the present study area it was observed that the different plant community like *Shorea robusta- Mallottus phillipensis-Acatia catatue, Dalbergia sisoo, Holeptelia integrifolia,-Cassia fistula* and mixed forest community in the tiger reserve has evolved due to the different anthropogenic activity, different temperature at different areas of the park, different types of soil, rainfall pattern and different climatic condition. All of the factors also have been observed in different plant communities in the study area. The concept of diversity is considered a significant attribute of an organized community (Hairston et al., 1964). High level of frequency of a species in a forest indicates its high distribution due to optimum climatic condition. In the present study area *Holoptelia integrifolea* was the species which have 100% frequency. Kukshal *et al.,* (2009) had observed 100% frequency of *Callipedium parviflorum* in tropical forest of Garhwal Himalaya. The species with abundant number and diversity always give higher diversity in the forest (Kharkwal, 2009). The Shannon diversity index for trees was 1.88, for shrubs 1.89 and for shrub it was 2.89. These values of the Shannon diversity index was comparable with several workers like Raturi, 2012 (0.78-3.45); Gairola *et al*.,2011 (2.43-3.33) and Singh, 2013 (0.95-3.30) from Western part of the Himalayas in Uttarakhand. On the other hand, the Pieloe Eveness index for tree was 0.68, 0.86 for shrubs and 0.88 for herb. Similar results obtained from the study of Uniyal *et al*.,(2010) from Garhwal Himalayas whose results was 0.47-0.83 for trees, 0.69-0.87 for shrubs. The Simpson Index was 0.19 for trees, 0.33 for shrubs and 0.05 for herb in the present study area. Malil, (2015) also reported similar results from the Western part of Himalaya whose results was 0.06-0.1 for higher and lower altitude in tree layer and 0.08-0.09 in shrub layer for lower and mid altitude

The Margalef species richness index for trees was 2.60, 1.21 for shrub and 4.82 for herbs in the present study area. These values are comparable with the studies carried out by Malik, (2015) which ranges from 2.37-4.63 for trees, 1.78-3.06 for shrub. Similar results was also reported from different parts of the Uttarakhand Himalaya by Uniyal *et al*., (2010) whose value ranges 2.21-7.00 for trees and 3.74-5.93 for shrubs, Gairola *et al*., (2011) which range 1.36-2.17 for trees and 0.63-1.69 for shrubs. Every species play significant role and

there is a definite quantitative relationship between abundant and rare species in an area (Bhandari *et al*., 1999). The high importance value index of the species states its dominance and ecological success, its better power of regeneration and ecological amplitude in the area. *Holoptelia integriflola* in tree strata *Lantana camara* in shrub strata and *Abutilon indicum* in herb strata showed maximum in the present study area. High importance value index always indicates that all the available resources are being utilized by that species and left over being trapped by other competitors species and associated species in the area. In present study area, the abundance to frequency ratio of species showed clumped or contagious pattern of distribution. These results area comparable with those other workers like Joshi and Tiwari, 1990; Bhandari et al., 1995; Pande *et al*., 1996; Bhandari *et al*., 1997) from Garhwal Himalaya and for others forest ecosystem as well (Kershaw, 1973; Kunhikannan *et al*., 1998; Singh and yadava, 1974). The clumped pattern of distribution of species may be due to multitude of environmental conditions (Kershaw, 1973; Saxena and Singh, 1982)

Conclusion

The study indicates that Rajaji tiger reserve has huge potentials of floral as well as faunal diversity. The tiger reserve was established to prevent the Asiatic elephant in 1983, but now it also inhabits large population of tiger. In some areas, the reserve is facing serious threats due to the anthropogenic pressure. The tiger reserve is the second largest conserve area of Uttarakhand in Shivallic landscape and facing serious problems in the past but it had maintains its floral as well as faunal diversity due to the large area of the reserve forest. The resettlement of the tribal people from the conserved areas is always a controversial topic. The rehabilitation programme for the Gujjars and villagers in the tiger reserve by government has faced many problems. But this programme is continuing going on because of the tribal communities still residing in some area of the forest. The forest has large number of faunal wealth which can be used for future aspects. Due to the large efforts of the government and the forest officials the wild animals are safely using wildlife corridor for their usual activity. So many aromatic and medicinal plants are increasing in the forest due to all these efforts. But proper care, maintenance of the tiger reserve needed so that the wildlife can be prevented.

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