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Floristic Assessment of Forests of Banka District of Bihar, Eastern India

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ABSTRACT
For a proper understanding of the biodiversity of any area, in addition to qualitative parameters, quantitative data is essentially required at regular intervals. The primary aim of the study was to assess the plant diversity in six different randomly selected forest sites (Site I to Site VI) of the Banka district of Bihar, Eastern India. Different diversity attributes *viz*., Species Richness Index, Important Value Index (IVI), Diversity Index, Concentration of Dominance, and Evenness Index for the tree, shrub, and herb layers were estimated. A total of 156 species were reported from the study sites belonging to 131 genera and 58 families (110 dicotyledons, 19 monocotyledons, and 2 pteridophytes). The six largest families in the area were Fabaceae (16 spp.), Poaceae (11 spp.), Rubiaceae (8 spp.), Malvaceae (7 spp.), Moraceae and Euphorbiaceae (6 spp. each). On the basis of different biodiversity attributes, the most diverse site was the Mandar Bahar site (H=2.96), while the lowest diverse was Chaubatia Village (H=1.58). In the shrub layer, the highest diversity index (H=2.97) was recorded in the Biharu Pahar site and the lowest in Chandam Dam (H=2.03). The herb layer had the highest diversity at the Maholia Jungle site (H=2.92) and the lowest at Chaubatia Village (H=2.30). Invasive species such as *Chromolaena odorata* and *Lantana camara* were also reported from various sites. Based on the present report, suitable forest management strategies may be devised for the conservation and sustainable utilization of biodiversity of Banka district, Bihar, Eastern India.

Keywords: Diversity Index, Species Richness, Important Value Index, Conservation

INTRODUCTION

Forest biodiversity implies the variety and variability of all living organisms in the forest including plants, animals and microorganisms. It includes diversity within species and of ecosystems (McNeely et al. 1990). Besides, tangible benefits, biodiversity also provides intangible indirect services such as soil and water conservation, climate regulation, pollution control, nutrient cycling and recreation. Environment plays important role in changes in the pattern of vegetation of an ecosystem (Billings 1952). The phytosociological study provides details and predicts patterns of vegetation aptly (Gautam and Joshi 2014). Plant diversity in wild has more significance as species have diverse genotypes which can be exploited in future. Forests are the storehouse of plant diversity; therefore, it is essential to assess and conserve plant diversity in forest areas. Due to various anthropological pressures coupled with a burgeoning population, plant diversity is under tremendous pressure. Regular inventory and monitoring are essentially required for a proper understanding of phytodiversity. Convention of Biological Diversity also emphasizes the conservation of biodiversity for sustainable development (Leadley et al. 2014).

Floral diversity of Bihar and adjoining Jharkhand state has been surveyed by various workers in the past (Mukharjee 1947, Mooney 1950, Paul 1973, Biswas and Maheshshwari 1980, Bhatacharya and Sarkar 1998, Singh et al. 2001). Qualitative status alone cannot provide comprehensive information of vegetation of the area; therefore, quantitative status should also be taken into account. Diversity indices for various forests have been reported by several workers (Whittakar 1965, Risser and Rice 1971, Knight 1963, Peng et al. 2018).

Banka is one of the thirty-eight districts of Bihar, situated in the southeast of the State. It is located at 24°30'N to 25°30'N altitude and 84°30' E to 87°34'E longitude. It has an average elevation of 75 m. The geographical area of the district is 3020 km^2. The state has a recorded forest area of 6,877 km^2, which is 7.3% of its geographical area. The forest covers the Banka district 260.73 km^2 which is 8.63% of the total geographical area of the district. On the basis of density classes 103.34 km^2 under moderately

dense forests and 157.39 km^2 under open forests. There is no very dense forest in the Banka district, 60% is under open forest and 40% is under moderately dense forest (FSI 2019). No comprehensive account of diversity assessment has been reported from the Banka district to date. Therefore, in the present study, efforts have been made to assess the plant diversity of different forest sites of the Banka district of Bihar, Eastern India**.**

MATERIALS AND METHODS

The study was conducted at the Banka district of Bihar, Eastern India (Fig.1). The climate of the district is characterized by mild winter, hot summer, and hot and humid monsoon season. January is the coldest month with the mean maximum temperature of ~25°C, the mean minimum temperature of ~11°C and the minimum temperature sometimes go down to ~4°C. May is the hottest month with the mean maximum temperature of ~40°C and the mean minimum temperature of ~26°C. In May and June, the maximum temperature may sometimes rise >44°C on particular days. The cumulative annual rainfall in the district is 1056.8 mm. July is the month with the highest rainfall with an average value of 288.2 mm.

Vegetation and Data Analysis

Six random forest sites of Gaya district *viz*., Moholia Jungle, Biharu Pahar, Inarabaran Sub-beat, Chandan Dam, Chaubatia village, and Mandar Bahar were selected for the vegetation analysis and field data were collected during 2014-2015. Random coordinate points were provided by the GIS cell of the Forest Research Institute, Dehradun for the collection of vegetative data. Quadrat number and size were determined by the running mean method (Kershaw 1973) and species-area curve method (Misra 1968), respectively. Quantitative analysis of vegetation for frequency, density and dominance was calculated following Misra (1968). Ten quadrats were randomly laid on each site. Quadrat size of 10m x 10m, 3m x 3m, and 1m x 1m was kept for trees, shrubs and herbs respectively. In each quadrat, the GBH (girth at breast height at 1.37m above ground level) of each tree was measured and recoded individually. In the case of herb and shrub, the collar

Figure 1. Location map of study area

diameter was measured at 2.5 cm above ground level. Species were identified with the help of concerned floras and matched with DD herbarium specimens. Plant nomenclature was updated as per The Plant List (Anon. 2013). Values of Relative frequency, density and dominance were summed to get Importance Value Index (IVI). Different biodiversity indices were estimated as given below:

Species richness index was estimated by the following (Magralef 1958):

Dmg = S-1/ln N

Where S is the total number of species and N is the total number of individuals

Shannon-Wiener information function (Shannon and Wiener 1963) was calculated using the formula:

H= - Σ pi ln pi

Where pi is (Ni/N), Ni = Number of individuals of species i and N= Total number of individuals of all the species.

The concentration of dominance (CD) was measured by Simpson Index (Simpson, 1949).

CD = Σ (pi)^2

Table1. Ten most dominant species with IVI values of tree layer at different forest sites

S.N.	Site-I Species (IVI)	Site-II Species (IVI)	Site-III Species (IVI)	Site-IV Species (IVI)	Site-V Species (IVI)	Site-VI Species (IVI)
1.	*Shorea robusta* (68.58)	*Lannea coromandelica* (105.25)	*Shorea robusta* (46.96)	*Dalbergia sissoo* (72.94)	*Shorea robusta* (118.68)	*Streblus asper* (34.23)
2.	*Terminalia alata* (46.69)	*Shorea robusta* (56.08)	*Butea monosperma* (29.22)	*Lannea coromandelica* (45.61)	*Butea monosperma* (41.08)	*Phoenix sylvestris* (29.64)
3.	*Soymida febrifuga* (26.89)	*Aegle marmelos* (22.51)	*Ficus arnottiana* (22.63)	*Acacia catechu* (25.28)	*Phoenix sylvestris* (36.89)	*Diospyros cordifolia* (25.40)
4.	*Acasia catechu* (24.09)	*Wendlandia heynei* (17.49)	*Boswellia serrata* (22.15)	*Adina cordifolia* (15.98)	*Madhuca longifolia* var. *latifolia* (19.09)	*Flacourtia indica* (22.91)
5.	*Terminalia arjuna* (19.29)	*Butea monosperma* (15.66)	*Madhuca longifolia* var. *latifolia* (21.56)	*Mallotus philippensis* (15.56)	*Borassus flabellifer* (17.84)	*Ziziphus xylopyra* (21.55)
6.	*Lannea coromandelica* (18.80)	*Buchanania lanzan* (15.43)	*Lannea coromandelica* (19.00)	*Butea monosperma* (15.41)	*Casearia tomentosa* (15.13)	*Cassia fistula* (19.87)
7.	*Madhuca longifolia* var. *latifolia* (16.21)	*D. lanceolaria* (15.09)	*Ficus mollis* (16.56)	*Naringi crenulata* (13.18)	*Syzygium cumini* (9.23)	*Ficus mollis* (17.78)
8.	*Anogeissus latifolia* (10.36)	*Madhuca longifolia* var. *latifolia* (14.35)	*Sterculia urens* (16.23)	*Bombax ceiba* (9.73)	*Holarhena pubescens* (9.09)	*Holarhena pubescens* (13.58)
9.	*Semecarpus anacardium* (9.39)	*Ficus arnottiana* (14.00)	*T. alata* (16.05)	*Flocourtia indica* (8.98)	*Alangium salviifolium* (5.17)	*Bridelia retusa* (12.47)
10.	*Dalbergia sissoo* (8.00)	*Croton roxburghii* (12.24)	*Acasia catechu* (12.80)	*Cassia fistula* (8.55)	*Sterculia villosa* (4.94)	*Ehretia laevis* (12.19)

Pielou's evenness index (Pielou, 1966) was calculated using the formula:

$$\boldsymbol{J} = H'/\ln(S)$$

Where '***H'***' is Shannon Weiner diversity and '***S'***' is the total number of species

RESULTS AND DISCUSSION

A total of 156 species belonging to 131 genera and 58 families (110 dicotyledons, 19 monocotyledons and 2 pteridophytes) were reported from the study area. The six largest families in the area were Fabaceae (16 spp.), Poaceae (11 spp.), Rubiaceae (8 spp.), Malvaceae (7 spp.) and Moraceae & Euphorbiaceae (6 spp. each). Habit-wise, there were 75 trees, 17 shrubs, 27 climbers, 37 herbs (including 11 grasses, 2 sedges and 2 pteridophytes) in all six sites. However, a total of 57 species were reported from the dry deciduous forests of Eastern Ghats by Sahu et al. (2012). Thakur (2015) recorded 36 trees, 8 shrubs, and 34 herbs from the tropical dry deciduous forest in the Sagar district. A total of 29 tree species belonging to 17 families were recorded from six sites of tropical dry deciduous forests of Central India (Joshi and Dhyani 2019) and 14 tree species under 10 families were reported from Amarkutir, tropical dry deciduous forest of West Bengal (Kumar et al. 2020). Himanshi and Jakhar (2020) reported 76 plant species belonging to 37 families from southwest Haryana. Recently, Chandra et al. (2021a, b) reported 126 and 174 species from the Aurangabad and Gaya districts of Bihar, respectively. The variation in the number of species in the present work may be because of climatic and edaphic conditions and the extent of the area covered under the study.

Species composition and distribution is mainly affected by the environment which varies from species to species. The quantitative status of species is a major factor for its conservation and sustainable utilization. Important Value Index (IVI) provides information on how dominant is a species in a given forest area. The ten most dominant tree species with IVI values at different sites of Banka district of Bihar, Eastern India are presented in Table 1. In the tree layer, at three sites (I, III, V) *Shorea robusta* was the most dominant species whereas, at sites II,

IV, and VI dominant species were *Lannea coromandelica*, *Dalbergia sissoo,* and *Streblus asper,* respectively. In the majority of sites (II, III, IV, V, and VI) of shrub layers, *Lantana camara* was the major species, while *Carissa opaca* was dominant at site-I. On the other hand, in the herb layer, *Cyperus niveus* was the most dominant grass species at the site I, *Heteropogon contortus* at sites II and V, *Fimbristylis dichotoma* at site III, *Oplismenus burmannii* at site IV, and *Evolvulus nummularius* at site VI.

Diversity indices aim to describe the general properties of communities that are used to compare different regions and taxa. Diversity indices *viz*., Species Richness Index (Dmg), Shannon-Wiener Diversity Index (H), Concentration of Dominance (CD) and Evenness (E) for different growth forms at different sites of Banka district is presented in Table 2. A higher value of species richness index (Dmg) indicates higher diversity of species. In the tree layer, the Mandar Bahar site showed the highest richness value of 4.02 followed by Inarabaran Sub-beat (3.72), Chandan Dam (3.47), *etc*. and the lowest was recorded for Biharu Pahar (1.62). In the case of the shrub layer, the highest species richness value was estimated for Moholia Jungle (3.75) followed by Biharu Pahar (2.69), Inarabaran Sub-beat (2.59), etc. and the lowest for Mandar Bahar (1.84). The herb layer had the highest species richness value in Moholia Jungle (2.90) and the lowest in Biharu Pahar (1.58).

In the tree layer, the highest Diversity Index (H) was estimated for the Mandar Bahar site (2.96) followed by Inarabaran Sub-beat (2.87), Chandan Dam (2.83), etc. and lowest for Chaubatia village (1.58). In the shrub layer, the highest Diversity Index (H) value was estimated for Biharu Pahar (2.97) followed by Moholia Jungle (2.93), Inarabaran Sub-beat (2.76) etc. and lowest for Chandan Dam (2.03). The herb layer had the highest Diversity Index (H) Moholia Jungle (2.92) followed by Biharu Pahar (2.76), Chandan Dam (2.75), *etc*. and lowest for Chaubatia village (2.30). The higher value of the Diversity Index (H) indicates the variability in the type of species and heterogeneity in communities, whereas the lesser value points to homogeneity in the community. In the present study, the diversity index value range was within 0.67 to 4.03 as reported

Table 2. Diversity indices for different growth forms at different sites of Banka District of Bihar

S.N. Sites	Tree Layer				Shrubby Layer				Herbaceous Layer			
	SR	H	CD	E	SR	H	CD	E	SR	H	CD	E
I. Moholia Jungle Kalothar Beat, Katoria Range	2.82	2.48	0.12	0.83	3.75	2.93	0.10	0.82	2.90	2.92	0.09	0.82
II. Biharu Pahar, Suia Beat, Katoria Range	1.62	1.96	0.21	0.82	2.69	2.97	0.07	0.90	1.58	2.76	0.08	0.94
III. Inarabaran Sub-beat, Kadhar Beat	3.72	2.87	0.08	0.88	2.59	2.76	0.09	0.86	2.31	2.65	0.11	0.78
IV. Chandan Dam, Kadhar Beat	3.47	2.83	0.08	0.90	2.25	2.03	0.29	0.66	2.62	2.75	0.11	0.79
V. Chaubatia Village, Chatrapal, Kakwara Tola	2.10	1.58	0.38	0.59	2.21	2.38	0.16	0.77	1.64	2.30	0.14	0.76
VI. Mandar Bahar, Baunsi Beat	4.02	2.96	0.07	0.89	1.84	2.51	0.11	0.87	2.23	2.70	0.11	0.80

(SR= Species Richness; H=Diversity Index; CD=Concentration of dominance; E=Evenness)

in tropical forests of the Indian subcontinent by (Kumar et al. 2010; Sundarapandian and Swamy 2000, Verma et al. 2015, Himanshi and Jakhar 2020, Chandra et al. 2021a, b, c).

In the tree layer, Concentration of Dominance (CD) was highest in the Chaubatia village site (0.38) followed by Biharu Pahar (0.21), Moholia Jungle (0.12), *etc*. and the lowest in the Mandar Bahar (0.07). The shrub layer had the highest value of CD in Chandan Dam (0.29) followed by Chaubatia village (0.16), Mandar Bahar (0.11), *etc*. and the lowest in Biharu Pahar (0.07). In the herb layer, the highest CD was estimated for Chaubatia village (0.14) and the lowest for Biharu Pahar (0.08). The higher value of CD signifies the homogenous nature of the community and such communities are dominated by few dominant species, while the lower value of CD indicates the dominance shared by many plant species (Kumar and Saikia 2021).

In the tree layer, the highest Evenness (E) value was estimated for Chandan Dam (0.90) followed by Mandar Bahar (0.89), Inarabaran Sub-beat (0.88), *etc*. and the lowest in Chaubatia village (0.59). The shrub layer had the highest Evenness value for Biharu Pahar (0.90) followed by Mandar Bahar (0.87), Inarabaran Sub-beat (0.86), *etc*. and the lowest for Chaubatia village (0.77). In the herb layer, the highest value of Evenness (E) was reported in Biharu Pahar (0.94) followed by Moholia Jungle (0.82), Mandar Bahar (0.80), *etc*. and the lowest in Chaubatia village (0.76). A higher value of Evenness (E) indicates that species are evenly distributed and vice-versa. In the present study, Pielou's Evenness Index (E) for the tree, shrub, and herb layers showed a similar trend reported in different tropical forests of India including Udaipur, Rajasthan (Kumar et al. 2010), Western Ghats (Sundarapandian and Swamy 2000), Bundelkhand region of Uttar Pradesh (Verma et al. 2015), South West Haryana (Himanshi and Jakhar 2020), Nalanda, Aurangabad, and Gaya districts of Bihar (Chandra et al. 2021a, b, c).

CONCLUSIONS

Regular monitoring of biodiversity is paramount for its sustainable utilization. The present study revealed that the floristic diversity of the Banka district in the forest area is fairly high. On the basis of different biodiversity attributes viz. species richness, diversity index, the concentration of dominance and evenness in the tree layer, the Mandar Bahar site is the most diverse site in the Banka district followed by Inarabaran, Chandan Dam, Maholia Jungle, Biharu Pahar and Chaubatia Village. In the shrubby layer, the highest diversity was estimated for Biharu Pahar and the lowest for the Chandan Dam site. The highest diversity in the herbaceous layer was reported for the Maholia Jungle site and the lowest for Chaubatia Village. The low diversity of tree species indicates disturbances in the area. Low diversity in the sites may be due to the disturbance in the area. Invasive alien species (IAS) like *C. odorata* and *L. camara* were reported from the sites. Their presence was quite substantial in a number of sites. These species may pose a serious threat to indigenous species in near future. Besides these species, anthropological activities such as felling of trees for timber, fodder and fuelwood, grazing, encroachment *etc*. are challenges for the conservation of biodiversity. These activities should be identified and suitable management strategies to be developed for the improvement of biodiversity. In order to curb the indiscriminate exploitation of forest resources, People inhabiting the fringes of forests should be acquainted with important and adverse effects of loss of biodiversity. Villagers should be made aware of the sustainable utilization of plant diversity through mass awareness programmes. The findings of the study will be beneficial to officials of the state forest department in implementing current management plans and developing future strategies for the sustainable use of forest resources.

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