Plant diversity assessment of selected forest sites of Gaya district of Bihar, India

A. Chandra*
Forest Botany Division, Forest Research Institute, Dehradun (Uttarakhand), India
H. B. Naithani
Forest Botany Division, Forest Research Institute, Dehradun (Uttarakhand), India
P. K. Verma
Forest Botany Division, Forest Research Institute, Dehradun (Uttarakhand), India
J. Saxena
Forest Botany Division, Forest Research Institute, Dehradun (Uttarakhand), India
S. Prajapati
Forest Botany Division, Forest Research Institute, Dehradun (Uttarakhand), India
*Corresponding author. Email: anup8in@yahoo.com

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Abstract
Regular inventory and monitoring of biodiversity is paramount for its conservation and sustainable utilization. Gaya district of the Bihar is endowed with rich biodiversity. For proper understanding of plant diversity, quantitative status of the vegetation is essentially required. The aim of the study was to assess different forest sites of the Gaya district of Bihar in India for their plant diversity. Study was carried out in these randomly selected eleven forest sites (Site I to Site XI). A total of 174 species belonging to 150 genera and 58 families (48 Dicotyledons, 7 monocotyledons and 3 pteridophytes) were reported from all eleven study sites. Five largest families in the area were Poaceae (22 spp.), Fabaceae (14 spp.), Asteraceae (11 spp.), Rubiaceae (9 spp.) and Acanthaceae (7 spp). Different diversity attributes such as Important Value Index (IVI), Species richness, Shannon Wiener index, Concentration of dominance and Evenness for tree, shrub and herb layers were estimated. For different sites highest IVI values for tree, shrubby and herbaceous layers were reported. Shannon Wiener Index values for tree, shrubby and herbaceous layer of Nagobar site were estimated 3.76, 1.986 and 2.350 respectively. Tree diversity was highest at Nagobar site whereas shrub and herb diversity was also reasonably better than most of the sites. Hence, it was revealed from the study that Nagobar site was most diverse site in the Gaya district. Study will be immense use for officials of forest department, researcher, students etc. for carrying out conservation and management work. Similar kind of study should be carried out in different forest sites of the country to get capture the status of the plant diversity for conservation and sustainable utilization.

Keywords: Diversity index, Evenness, Important value index, Species richness

INTRODUCTION

Biological diversity means the variety and variability of all living organisms from all sources including terrestrial, marine and other aquatic systems and the ecological complexes of which they are a part. This includes diversity within species and of ecosystems (McNeely et al., 1990). Human demands for food, fodder, fuel, medicine, timber, resins, and oil are directly met by biodiversity (Guar, 1999). Indirect services such as climate regulation, pollution control, soil and water conservation, nutrient cycling, pollination, and recreation (Singh, 2002; Kumar and Sharma, 2015, 2016) are also governed by the biodiversity.

Environment of an area effects the vegetation of an ecosystem (Billings, 1952). The structure and function of the plant community can be understood by phytosociological study of the area. It explains and predicts pattern in a meaningful manner (Gautam and Joshi, 2014). Therefore, for proper understanding of plant diversity of any area, phytosociology aspects should be thoroughly studied. Biodiversity in the wild state has its far reaching importance as species have diverse genotypes which can further be exploited. Forests are storehouse of the biodiversity, therefore, it is need of the hour to assess and conserve the forest
biodiversity. However, owing to burgeoning population coupled with rapid industrialization, plant resources are under tremendous pressure. It has resulted in the decline of plant diversity in the forest ecosystem. Convention of Biological Diversity also asserted the need of regular inventorization and monitoring of biodiversity for sustainable utilization (Leadley et al. 2014).

Bihar state and adjoin Jharkhand have been extensively surveyed for its floral wealth by various workers in the past (Wood, 1903; Haines, 1921-1924; Mukharjee, 1947; Mooney, 1950; Paul, 1973; Biswas and Maheshshwari, 1980; Bhattacharya and Sarkar, 1998, Singh et al. 2001 etc.). Qualitative status alone cannot provide the dynamics of vegetation of the area; therefore, quantitative status should be worked out. Diversity indices for various forests have been reported by several workers (Whittakar, 1965; Risser and Rice, 1971; Ralhan et al. 1982; Knight, 1963; Peng et al., 2018; Dad, 2019).

Gaya is one of the thirty-eight districts of Bihar state, India. The district has a common boundary with the state of Jharkhand to the south. The district Gaya is situated between 24o30’ and 25o10’ north latitude and between 84o04’ and 85o05’ east longitude. The forest cover in the Gaya district is 590.31 km2 which is 11.86% of the total geographical area of the state. On the basis of density classes, 134.4 km2 comes under moderately dense forests and 455.91 km2 under open forest. There is no very dense forest in the district (FSI, 2019). To date, no work has been reported on different diversity indices of different sites of the Gaya district. Therefore, in the present study, efforts have been made to assess the plant diversity of different forest sites of Gaya District of Bihar, India.

MATERIALS AND METHODS

Survey and vegetation data
The study was conducted at the Gaya district of Bihar (Fig. 1). The climate of the district is characterized by mild cold winter, hot dry summer, hot and humid summer. Month of May is the hottest with maximum temperature at about 40.50°C and mean minimum temperature at 25.90°C. The day temperature may go above 450°C in a day. January is the coldest month with man maximum temperature at 25.30°C and mean minimum temperature at about 8.90°C. The average rainfall in the district is 590.31mm which is 11.86% of the total geographical area of the state. On the basis of density classes, 134.4 km2 comes under moderately dense forests and 455.91 km2 under open forest. There is no very dense forest in the district (FSI, 2019). To date, no work has been reported on different diversity indices of different sites of the Gaya district. Therefore, in the present study, efforts have been made to assess the plant diversity of different forest sites of Gaya District of Bihar, India.

S= Species richness
Total number of species
Shannon-Wiener information function (Shannon & Wiener, 1963) was calculated using the formula:
\[ H = - \sum p_i \ln p_i \] ...
Eq. 1
Where \( p_i \) is \( (N_i/N) \), \( N_i = \) Number of individuals of species \( i \) and \( N = \) Total number of individuals of all the species.

Concentration of dominance \( (cd) \) was measured by Simpson Index (Simpson, 1949).
\[ Cd = \frac{\sum (p_i)^2}{N} \] ...
Eq. 2
Pielou's evenness index (Pielou, 1966) was calculated using formula:

Fig. 1. Location map of study area, Gaya district.
RESULTS AND DISCUSSION

Plant species vary in their responses to environmental factors. A given species will have a unique set of tolerances to environmental variables, such as light, temperature, moisture, and nutrients. The status of a species is an important indicator for its conservation and sustainable utilization. Importance Value Index (IVI) is a measure of how dominant a species is in a given forest area. Highest IVI species in different sites for tree, shrubby and herbaceous layers are presented in Table 1.  Five largest families in the area were Poaceae (48 Dicotyledons, 7 monocotyledons and 3 pteridophytes) were reported from all eleven study sites. However, there were 71 trees (Table 2), 9 shrubs (Table 3), 20 climbers (Table 4), 49 herbs (Table 5), 20 grass, 2 sedges and 3 pteridophytes (Table 6) species in all eleven sites. However, Sahu et al. (2012) recorded 57 species in dry deciduous forests of Eastern Ghats. Studies from the tropical dry deciduous forest in Sagar district reported a total of 36 trees, 8 shrubs, and 34 herbs (Thakur, 2015). 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 Dyhani, 2019) and 14 tree species under 10 families were reported from Amarkurti, tropical dry deciduous forest of West Bengal (Kumar et al., 2020). Himanshi and Jakhar (2020) reported 76 plant species belonging to 37 families from south-west Haryana. The higher number of species in the present work may be because

Table 1. Diversity indices for different growth forms at different forest sites of Gaya District, Bihar.

| Site Name of site | Tree Layer | Shrubby Layer | Herbaceous Layer |
|------------------|------------|---------------|------------------|
| Site No.         | SR         | H             | Cd              | E               |
| I. Titi, Imanganj Range | A. Aamajhari, I. Ambar, Bara Chati Range | 2.134 | 0.360 | 7.00 |
| II. North Aakdiha, Gujia Range | 0.802 | 0.836 | 0.866 |
| III. North Aakdiha, Gujia Range | 0.802 | 0.836 | 0.866 |
| IV. South Aakdiha, Gujia Range | 0.802 | 0.836 | 0.866 |
| V. Kurwa Dan Baba 2, Ari Range | 0.802 | 0.836 | 0.866 |
| VI. Kurwa Dan Baba 3, Ari Range | 0.802 | 0.836 | 0.866 |
| VII. Nagobar, Banka Bazar Beat, Imam Ganj Range | 0.802 | 0.836 | 0.866 |
| VIII. Singhpursadar Sub-beat, Binda Banka, Imam Ganj Range | 0.802 | 0.836 | 0.866 |
| IX. Sundhaha Sub-beat, Banka Banka, Imam Ganj Range | 0.802 | 0.836 | 0.866 |

where $H$ is Shannon Weiner diversity and $S$ is the total number of species.

For better understanding of plant population structure of the forest site. In tree layer, highest IVI value was estimated as 200.99 (Site-I, Butea monosperma) followed by 153.19 (Site-II, Shorea robusta), 95.80, (Site-III, Casearia tomentosa), 93.66 (Site-IV, Sterculia urens), 69.74 (Site-VII, Boswellia serrata), 48.09 (Site-V, Madhuca longifolia var. latifolia), 45.47 (Site-XI, Shorea robusta), 42.28 (Site-VII, Anogeissus latifolia) and 30.98 (Site-IV, Ficus benghalensis) (Fig.3). Presence of Butea monosperma in tree as well as shrubby layer reflects the good regeneration of the plant at the site.
of more sites and large area covered under the study. Diversity indices aim to describe general properties of communities that are used to compare different regions and taxa. Diversity indices viz., Shannon-Wiener Diversity Index (H), Concentration of Dominance (cd), Evenness (E) and Species Richness (SR) for different growth forms at different sites of Gaya district is presented in Table 1. The higher value of species richness indicates higher diversity of species. In the tree layer, Nagobar site showed the highest Species Richness (SR) of 38 spp. followed by Sundhaha Sub-beat (23 spp.), South Alakdiha (22 spp.) etc. and the lowest was recorded in Titri (3 spp.). In the case of shrubby layer, the highest Species Richness (SR) value was reported for South Alakdiha (26 spp.) followed by North Alakdiha (20 spp.), Nagobar (18 spp.) etc. and lowest for Titri (1 spp.). The herbaceous layer had highest Species Richness (SR) in Nagobar (37 spp.) followed by Sundhaha Sub-beat (23 spp.), South Alakdiha (22 spp.) etc. and the lowest was recorded in Titri (3 spp.).

Table 2. Tree species reported from eleven forest sites of Gaya district.

| S.N. | Species                        | Family            |
|------|--------------------------------|-------------------|
| 1    | Acacia catechu (L.f.) Wild.    | Mimosaceae        |
| 2    | Adina cordifolia (Roxb.) Hook.f. ex Brandis | Rubiaceae |
| 3    | Aegle marmelos(L.) Corr. in Trans. L. Soc. | Rutaceae |
| 4    | Allanthus excelsaRoxb.        | Simarubaceae      |
| 5    | Alangiumchinense(Lour.) Harms | Alangiaceae       |
| 6    | Albizia lebeck(L.) Bent.in Hook | Mimosaceae        |
| 7    | Anogeissus latifolia (Roxb. ex DC.) Wall. ex Guill. &Perr. | Combretaceae |
| 8    | Azadirachta indica A. Juss.   | Meliaceae         |
| 9    | Balanites roxburghiiPlanch.   | Balanitaceae      |
| 10   | Bauhinia racemosaLam.         | Caesalpinaceae    |
| 11   | Bombax ceiba L.               | Bombacaceae       |
| 12   | Borassus flabellifer L.       | Areaceae          |
| 13   | Boswellia serrata Roxb. ex Colebr | Burseraceae |
| 14   | Bridelia retusa (L.) Spreng.  | Euphorbiaceae     |
| 15   | BuchananialanzanSpreng.       | Anacardiaceae     |
| 16   | Butea monosperma(Lam.) Taub.  | Fabaceae          |
| 17   | Casearia graveolens Dalz.     | Flacourtaceae     |
| 18   | Casearia tomentosa Roxb.      | Flacourtaceae     |
| 19   | Cassia fistula L.              | Flacourtaceae     |
| 20   | Catunaregam spinosa (Thunb.) Tirveng. | Rubiaceae |
| 21   | Cochlospermumreligiosum(L.)   | Cochlospermaceae  |
| 22   | Alston. Handb. Fl.Ceyl.       |                    |
| 23   | Croton roxburghiiBalak        | Euphorbiaceae     |
| 24   | Dalbergia sissoo Roxb.        | Fabaceae          |
| 25   | DilleniapentagynaRoxb.        | Dilleniaceae      |
| 26   | Diospyros cordifoia Roxb.     | Ebenaceae         |
| 27   | Diospyros melanoxylonRoxb.    | Ebenaceae         |
| 28   | Roxy.var.tupru(Buch.-Ham.) V Singh | Ebenaceae |
| 29   | Ehretia acuminata R.Br.var. serrata (Roxb.) Johnston | Boraginaceae |
| 30   | EhretialevisRoxb.            | Boraginaceae      |
| 31   | Erithrina variegataL.         | Fabaceae          |
| 32   | Ficus arnottiana(Miq.) Miq.   | Moraceae          |
| 33   | Ficus benghalensisL.          | Moraceae          |
| 34   | Ficus mollisVahl.             | Moraceae          |
| 35   | Ficus racemosal.              | Moraceae          |
| 36   | Flacourtia indica (Burm.f.) Merr. | Flacourtaceae |

| S.N. | Species                        | Family            |
|------|--------------------------------|-------------------|
| 37   | Garuga pinnata Roxb.           | Burseraceae       |
| 38   | Gmelina arborea Roxb.          | Verbenaceae       |
| 39   | Grewia asiatica L.             | Tiliaceae         |
| 40   | Haplophragmaadenophyllum (DC.) Dop | Bignoniaceae |
| 41   | Helicteresierosal.             | Sterculiaceae     |
| 42   | Holarrhenapubescent(Buch.-Ham.) Wall.ex.G.Don | Apocynaceae |
| 43   | Holoptelea integrifolia (Roxb.) Planch | Ulmaceae |
| 44   | Hymenidictyonorixense(Roxb.)   | Rubiaceae         |
| 45   | Ilora pavettaAndr.             | Rubiaceae         |
| 46   | Lagerstroemia parviflora Roxb. | Lythraceae        |
| 47   | Lamnocaromandela(Houtt.) Merr. | Anacardiaceae     |
| 48   | Madhuca longifolia (Koenig)    | Sapotaceae        |
| 49   | Macbr.var.latifolia            | Sapotaceae        |
| 50   | Malolotusphilippines(Lam.)     | Euphorbiaceae     |
| 51   | Manilkara hexandra(Roxb.)      | Sapotaceae        |
| 52   | Mitragynaparvifolia(Roxb.)     | Burseraceae       |
| 53   | Murrayapaniculata(L.) Jack, Malayan | Rutaceae |
| 54   | Nyctanthesarbor-tristis L.     | Oleaceae          |
| 55   | Phoenix sylvestris (L.) Roxb.  | Arecaceae         |
| 56   | Phyllanthus emblicaL.          | Phyllanthaceae    |
| 57   | Premna latifolia Roxb.         | Verbeneaceae      |
| 58   | Pterocarpus marsumupium Roxb.  | Fabaceae          |
| 59   | Schleicheraoleosa(Lour.) Oken | Sapindaceae       |
| 60   | Semecarpus anacardium L.       | Anacardiaceae     |
| 61   | ShorearobustaGaernf.t., Fruct. | Dipterocarpaceae  |
| 62   | Sterculia urensRoxb., Pl. Coram Sterospermumchelonoides(L.f.) DC. | Sterculiaceae |
| 63   | Strebus asper Lour.            | Bignoniaceae      |
| 64   | Syzygicmicum(L.) Skeels        | Moraceae          |
| 65   | Tamarindus indica L.           | Myrtaeaceae       |
| 66   | Terminalia alataHeyne ex Roth | Caesalpiniacae    |
| 67   | Terminalia arjuna (Roxb. ex DC.) Wight. &Arn. | Combretaceae |
| 68   | Terminalia bellirica(Gaertn.)  | Combretaceae      |
| 69   | Wrightia tinctoria (Roxb.) R.Br. | Apocynaceae |
| 70   | Ziziphus mauritianav.ar.mauritianaLam. | Rhamnaceae |
Fig. 2. Highest Important Value Index (IVI) of tree species in different sites (I: Titri site, II- AamasJhari, III- Patluka Murrai Pahar, IV: Bharamyoni Mandir, V: North Alakdiha, VI: South Alakdiha, VII: Kurwa Dan Baba 2, VIII: Kurwa Dan Baba, IX: Nagobar, X: Singhpusdar, XI: Sundhaha).

Fig. 3. Highest Important Value Index (IVI) of shrubby layer species in different sites (I: Titri site, II- AamasJhari, III- Patluka Murrai Pahar, IV: Bharamyoni Mandir, V: North Alakdiha, VI: South Alakdiha, VII: Kurwa Dan Baba 2, VIII: Kurwa Dan Baba, IX: Nagobar, X: Singhpusdar, XI: Sundhaha).

Fig. 4. Highest Important Value Index (IVI) of herbaceous layer species in different sites (I: Titri site, II- Aamas Jhari, III- Patluka Murrai Pahar, IV: Bharamyoni Mandir, V: North Alakdiha, VI: South Alakdiha, VII: Kurwa Dan Baba 2, VIII: Kurwa Dan Baba, IX: Nagobar, X: Singh pursdar, XI: Sundhaha).
Table 3. Shrub species reported from eleven forest sites of Gaya district

| S.N. | Species                                | Family          |
|------|----------------------------------------|-----------------|
| 1    | Carissa opaca Stapf ex Haines          | Apocynaceae     |
| 2    | Clerodendrum viscosumVent.             | Verbenaceae     |
| 3    | Jatropha gossypifoliaL.                | Euphorbiaceae   |
| 4    | Lantana camara L. var. aculeata (L.)   | Verbenaceae     |
|      | Mold.                                   |                 |
| 5    | Mimosa himala-yana Gamble              | Mimosaceae      |
| 6    | Pavetta crassilcaulis Brenek.          | Rubiaceae       |
| 7    | Securinegavirosa (Roxb. ex Willd.) Baill.| Phyllanthaceae |
| 8    | Tephrosia purpura (L.) Pers.           | Fabaceae        |
| 9    | Woodfordiafruticosa (L.) Kurz          | Lythraceae      |

Table 4. Climber species reported from eleven forest sites of Gaya district

| S.N. | Species                                | Family          |
|------|----------------------------------------|-----------------|
| 1    | Abrus precatiorious L.                 | Fabaceae        |
| 2    | Acacia pennata (L.) Wild               | Mimosaceae      |
| 3    | Asparagus racemosus Willd.             | Liliaceae       |
| 4    | Atylosia carabaeoides (L.) Bent.        | Fabaceae        |
| 5    | Butea parviflora Roxb.                 | Fabaceae        |
| 6    | Capparis zeylanical.                   | Capparaceae     |
| 7    | Cissampelos pareira L. var. hirsuta (Buch.-Ham.ex DC.) Forman | Menispermaceae |
| 8    | Cocculus hirsutus (L.) Diels           | Menispermaceae  |
| 9    | Combretum roxburghii Spreng Voigt ex Haines | Combretaceae   |
| 10   | Dioscoreabellophylla (Prain) Voigt ex Haines | Dioscoreaceae     |
| 11   | Hemidesmus indicus (L.) R.Br.          | Asclepiadaceae  |
| 12   | Ichneocarpus frutescens (L.)           | Apocynaceae     |
| 13   | Ipomoea hederifolia L.                 | Convolvulaceae  |
| 14   | Ludwigia cattaviis (Jacq.) Raven       | Onagraceae      |
| 15   | Milletia extensa (Benth.) Baker        | Fabaceae        |
| 16   | Mucuna nigricans (Lour.) Steud.        | Fabaceae        |
| 17   | Poranpaniculata Roxb.                 | Convolvulaceae  |
| 18   | Pupalia lapaceae (L.) Juss             | Amaranthaceae   |
| 19   | Ventilagodentricula Wild.              | Rhamnaceae      |
| 20   | Ziziphus oenoplia (L.) Mill.           | Rhamnaceae      |

Sub-beat (36 spp.), Patluka Murrai Pahar (32 spp.), North Alakdiha and South Alakdiha (26 spp. each) etc. and lowest in Kurwa Dan Baba (12 spp.).

In the tree layer, highest Diversity Index (H) was observed for Nagobar (3.376) followed by South Alakdiha (2.788), Kurwa Dan Baba (2.599) etc. and lowest for Titri (0.335). There was no tree in the AamasJhari site. In the shrub layer, highest Diversity Index (H) value was observed for North Alakdiha (2.328) followed by South Alakdiha (2.281), Kurwa Dan Baba-2 (2.273) etc. and lowest for Patluka Murrai Pahar (1.278). In the herbaceous layer, the highest Diversity Index (H) was observed for Sundhaha Sub-beat (2.843) followed by North Alakdiha (2.739), South Alakdiha (2.719) etc. and lowest for Titri (1.786). The higher value of 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 in tropical forests of the Indian subcontinent by (Kumar et al., 2010; Sundarapandian and Swamy, 2000; Verma et al., 2015, Himanshi and Jakhar, 2020).

In the tree layer, Concentration of Dominance (cd) was highest in case of Titri site (0.850) followed by Kurwa Dan Baba 2 (0.437), Patluka Murrai Pahar (0.310) etc. and lowest in Nagobar (0.474). The shrub layer had highest value of Concentration of Dominance (cd) in Titri (1.000) followed by Patluka Murrai Pahar (0.443), Sundhaha Sub-beat (0.276) etc. and lowest in Kurwa Dan Baba 2 (0.142). In the herbaceous layer, the highest value of Concentration of Dominance (cd) was estimated for Titri (0.827) followed by Nagobar (0.187), Bharamyoni Mandir (0.178) etc. and lowest for South Alakdiha (0.087). The higher value of Concentration of Dominance (cd), the greater is the homogenous nature of community and vice-versa. In other words, such communities are dominant by single species. The lower value of the concentration of dominance indicates that the dominance of plant is shared by many species.

In the case of tree layer, highest Evenness (E) value was estimated for Nagobar site (0.929) followed by South Alakdiha (0.902), Kurwa Dan Baba (0.868) etc. and lowest for Titri (0.305). In the case of shrub layer, the highest Evenness (E) value was recorded for Kurwa Dan Baba 2 site (0.620) followed by Bharamyoni Mandir (0.815), AamasJhari (0.800) etc. In the herbaceous layer, highest value of Evenness (E) was estimated for Kurwa Dan Baba 2 site (0.907) followed by Kurwa Dan Baba (0.896), North Alakdiha (0.841), Aamas Jhari (0.838) etc. and lowest for Titri (0.631). The higher value of Evenness (E) indicates that species are evenly distributed and vice-versa. In the present study, Pielou Index (E) for tree, shrubby and herbaceous layers showed a similar trend reported by different workers in tropical parts of India viz. Udaipur Rajasthan (Kumar et al. 2010), Western Ghat (Sundarapandian and Swamy, 2000), Bundelkhand region of Uttar Pradesh (Verma et al., 2015) and South West Haryana (Himanshi and Jakhar 2020).
Conclusion

It reveals from the study that forest sites of Gaya district possess a significantly high floristic diversity. On the basis of different diversity attributes viz. species richness, diversity index, the concentration of dominance and evenness in the tree layer, Nagobar site is the most diverse site followed by South Alakdiha, Kurwa Dan Baba, North Alakdiha etc. where AamasJhari site is devoid of any tree species. Shrub and herb diversity was also considerably higher than most of the sites in Nagobar site. The low diversity of tree species indicates the disturbance in sites such as AamasJhari, Titri, and Patluka Murrai Pahar. Anthropogenic activities such as tree felling for fuelwood and timber, grazing, encroachment, etc., may be factors for the depletion of plant diversity. Hence, suitable management strategies should be developed for the improvement of the diversity of the tree species in the low diversity sites. Villagers living in the fringes of forests should be

Table 5. Herb species reported from eleven forest sites of Gaya district.

| S.N. | Species                                      | Family        |
|------|----------------------------------------------|---------------|
| 1    | Achyranthes aspera L.                         | Amaranthaceae |
| 2    | Aervasanguinolenta (L.)Bl.                    | Amaranthaceae |
| 3    | Ageratum conyoides L.                         | Asteraceae    |
| 4    | Alysicarpus vaginalis (L.) DC.                | Fabaceae      |
| 5    | Anisomeles indica (L.) Kuntze                | Lamiaceae     |
| 6    | Bacopa procumbens (Miller) Greenman          | Scrophulariaceae |
| 7    | Biophytum sensitivum (L.) DC.                | Oxalidaceae   |
| 8    | Blumea amollis (D.Don) Merr.                 | Asteraceae    |
| 9    | Desmodium triflorum (L.) DC.                 | Acanthaceae   |
| 10   | Elephantopussscaber (Buch.-Ham. ex D.Don) Kuntze | Asteraceae |
| 11   | Elephantopussscaber (Buch.-Ham. ex D.Don) Kuntze | Asteraceae |
| 12   | Elephantopussscaber (Buch.-Ham. ex D.Don) Kuntze | Asteraceae |
| 13   | Euphobia hirta L.                             | Convolvulaceae |
| 14   | Evolvulus alsnoides (L.) L.                   | Convolvulaceae |
| 15   | Evolvulus nummularius (L.) L.                 | Convolvulaceae |
| 16   | Gnaphalium pensylvanicum Willd.              | Asteraceae    |
| 17   | Hyptissuaveolens (L.) Poit.                  | Lamiaceae     |
| 18   | Indigofera linifolia (L.f.) Retz.             | Fabaceae      |
| 19   | Justicea diffusa Willd                       | Acanthaceae   |
| 20   | Justicea simplex D. Don                      | Acanthaceae   |
| 21   | Launaea procumbens (Roxb.) Ramayya & Rajagopal | Asteraceae |
| 22   | Leucas pluketii (Roth) Spreng.               | Lamiaceae     |
| 23   | Nelsonia canescens (Lam.) Spreng.            | Acanthaceae   |
| 24   | Oxalis corniculata L.                         | Oxalidaceae   |
| 25   | Peristrophe panliculata (Forssk.) Brummit    | Acanthaceae   |
| 26   | Phyllanthus amarus Schum. & Thonn.           | Phyllanthaceae |
| 27   | Phyllanthus virgatus Forst.f.                | Phyllanthaceae |
| 28   | Podocarpus macrophyLLus (Kurz)               | Podocarpaceae |
| 29   | Quercus serrata Willd.                       | Fagaceae      |
| 30   | Quercus palustris L.                          | Fagaceae      |
| 31   | Rhamnus purshiana L.                         | Caprifoliaceae |
| 32   | Rumex crispus L.                             | Polygonaceae  |
| 33   | Scrophularia auriculata L.                    | Scrophulariaceae |
| 34   | Solidago rugosa L.                            | Asteraceae    |
| 35   | Solidago virgaurea L.                        | Asteraceae    |
| 36   | Solidago virgaurea L.                        | Asteraceae    |
| 37   | Streptanthus tomentosus (L.) DC.              | Asteraceae    |
| 38   | Taraxacum officinale F.H.                    | Asteraceae    |
| 39   | Triumfettarhombosella Jacq.                  | Tiliae        |
| 40   | Vernonia cinerea (L.)                         | Acanthaceae   |
| 41   | Vicoa indica (L.) DC.                         | Acanthaceae   |

Table 5. Herb species reported from eleven forest sites of Gaya district.
Table 6. Sedges, Grass and Pteridophytes reported from eleven forest sites of Gaya district.

| S.N. | Species                  | Family            |
|------|--------------------------|-------------------|
| 1    | Cyperus niveus Retz.      | Cyperaceae        |
| 2    | Cyperus rotundus L.       | Cyperaceae        |
| Grasses |                        |                   |
| 1    | Apludamutical.            | Poaceae           |
| 2    | Aristida adscensionis L.  | Poaceae           |
| 3    | Bothriochloapertusa (L.)  | Poaceae           |
| 4    | Brachiariaramosa (L.) Stapf | Poaceae       |
| 5    | Brachiariareptans (L.)    | Poaceae           |
| 6    | C.A. Gardner & C. E. Hubb. | Poaceae         |
| 7    | Chryso pogon fulvus (Spr.) | Poaceae         |
| 8    | Cynodon dactylon (L.) Pers. | Poaceae       |
| 9    | Dactyloliumaegepygium (L.) Wild. | Poaceae |
| 10   | Desmodium angenticum (L.) DC. | Poaceae |
| 11   | Dichanthium annulatum (Forssk.) Stapf | Poaceae |
| 12   | Eragrostilamarandaoides (Trin.) Bor | Poaceae |
| 13   | Eragrostistenenella (L.) P. Beauv. ex Roem. & Schult. | Poaceae |
| 14   | Melanochrisjaquemontii-jaub. & Spach. | Poaceae |
| 15   | Opismenus burmanni (Retz.) | Poaceae           |
| 16   | P. Beauv.                 | Poaceae           |
| 17   | Pvimisetum glaucum (L.) R. Br. | Poaceae |
| 18   | Sporobolus indicus (L.) R. Br. var. diander (Retz.) Jovet. & Guedes | Poaceae |

| Pteridophytes |                     |                |
|---------------|---------------------|----------------|
| 1             | Adiantum incisum Forssk. | Adiantaceae    |
| 2             | Cheilanthes farinosa (Forssk.) | Cheilanthaceae |
| 3             | Lygodium flexuosum (L.) Sw. | Lygodiaceae    |

made aware of the importance of forest biodiversity conservation and its sustainable utilization through a mass awareness programme. The finding of the study will be useful for researchers and officials of the State Forest Department for formulation and implementation of future management study of the area.

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Conflict of interest

The authors declare that they have no conflict of interest.

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