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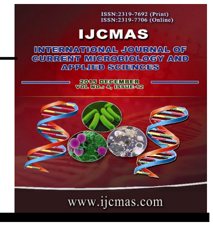

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Original Research Article

Biodiversity and Floristic Composition of Medicinal Plants of Darbhanga, Bihar, India

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Keywords

Biodiversity, Floristic composition and structure, Medicinal plants and Forest areas

A B S T R A C T

The biodiversity, floristic composition and structure of medicinal plants in the eighteen blocks of Darbhanga were studied. A total of 101 plant species belonging to 32 families, 71 genera and 5 life forms were recorded. Fabaceae, Moraceae, Meliaceae and Apocyanaceae were the overall diverse families (in terms of species richness) of the adult species, contributing 44.5% of all the species in the study. Trees were the most dominant life form (46.5%) followed by lianas (14.8%), herbs (9.9%), epiphytes (7.9%), shrubs (2.9 %) and the others (3.7%). Species richness among all life forms was highest in the DB (90.5%). Fabaceae, Moraceae and Meliaceae and Meliaceae were the most diverse families distributed in all the eighteen blocks of Darbhang The trees in all the forest types studied were generally tall. The difference in height of tree species could be partly explained by degradation in the form of logging of tall and big trees which has undoubtedly affected the vertical structure. Even though tree size (dbh) correlated with tree height in all the forest types, the relationship was stronger ($r = 0.741$ to 0.368 ; $p = 0.000$- 0.002). Thus, dbh of trees could be a better predictor of tree height. The forest reserve of Mithila looks floristically rich and structurally complex in the face of logging, farming activities and invasion in some parts of the forest. Thus, there is the need to curb the anthropogenic activities and plant invasion so as to protect the integrity of the forest including medicinal plants.

Introduction

India has a rich herbal heritage which has been described in Ayurveda. It has 16 different agro climatic zones. A large number of plants are available in different bio-geographical zones of India (Gharpure, 2011; Ravi kumar, 2011). According to WHO, 20,000 plant species are used for medicine out of 2, 50,000 all over the world. Of these eight hundred species are being used commercially. In India, the rural population uses about 8000 herbal plants for medicine. India having a rich traditional knowledge of herbs in the Vedas and ancient days remains marginalized in the fields of research on plants and its medicinal use. The country has a rich herbal heritage and about1, 22,600 hectares of land is under cultivation for medicinal plants.

Modern medicines use many ingredients which have side effect on human organs. This has opened up new vistas of research in herbal medicines. Herbal medicines have no side effect in comparison to the synthetic drugs (Cragg, et al.,1996: Haslam, 2003). Important drugs have been analyzed from plants of Indian origin (Stermitz, et al., 1999; Osborn et al., 2000). Darbhanga is located in heart of Mithilanchal in North Bihar, India. It lies between 25.53 degrees – 26.27 degrees N and 85.45 degrees – 86.25 degrees E at an average elevation of 171 feet (52m). Darbhanga is bounded by Madgubani district on north, by Samastipur district on south, by Saharsa on east and by Sitamarhi and Muzaffarpur on west. This district has a total area of 2279 sq. Km. with a population of 3295789.The main rivers are Kamla Balan and Bagmati (Adhwara). The climatic conditions of Darbhanga are somewhat dry and healthy. The winter, summer and rainy seasons are well marked. The overall rainfall is 1142.3mm with maximum i. e.around 92% of rainfall being received during monsoon months.*Curcuma longa* (turmeric), *Carica papaya* (Papaya) *Acacea catechu*, *Mentha* species, *Nicotiana tabacum* are some of the important plants grown by the farmers of this area. Farmers of this area have adopted the cultivation of *Mentha* species, Amla, Neem, Gurmae, Sarpgandha etc. These plants have great use in traditional therapy by Ayurveda as well as modern medicine.

The fertile land of Mithila has the potential to grow many herbs of therapeutic use. People of this area utilize “Tilkor Patta” for eating. The Tilkor (*Momoradica monadelpha*) stimulates insulin secretion from pancreas and therefore it is a used as a herbal product for treatment of diabetes. Not only this, one more species Gurich is found in this region which is also an effective medicine for diabetes. Amla, Jamun, *Aloe vera* and Gugal are also found in plenty in this area. These herbs have got extensive use in modern medicine.

The plants of medicinal importance are mostly wild whose cultivation is an essential requirement. In Mithila Ignorance and lack of preservation knowledge has resulted in the extinction of many plants of medicinal importance.

With the development of synthetic drugs, plant products lost their significance. In the last few decades, however, there has been more interest in drugs obtained from vegetable sources than at any time in historic because of the success with the antibiotics, and other lant drugs such as Rauwolfia (for the treatment of mental disorder), Podophyllum (a cathartic, as well as for curing cancerous tumors in mice), Aloe (a cathartic, as well as for the treatment of atomic radiation burn, Veratrum (hypertensive agent), (Peyote) (psychoactive drug) and sundry others. Sapogenins obtained from many members of Dioscoreaceae and agavaceae, can be converted into cortisone, into male hormone (testosterone) and female hormones (estrogens and progesterone).Sapogenins have many potential uses in the treatment of rheumatoid arthritis and the female hormones are used in contraceptive pills.

The study of drugs and drug plants has developed into modern pharmacognosy which deals with the knowledge of history, botany, preservation and commerce of crude drugs. Nature has provided a rich storehouse of herbal remedies to cure all mankind’s ills. The information on drugs and drug plants whose efficacy in medicine has been established is available in various authentic books known as 'Pharmacopoeia' and the drugs included therein are described as 'official'. The most important of these pharmacopoeia are the United States Pharmacopoeia, British Pharmaceutical Codex, Indian Pharmaceutical Codex and National Formulary.

The medicinal value of drugs is due to the presence of certain substances such as alkaloids, glycosides, resins, volatile oils, gums, tannins, etc. Some of these are powerful poisons if administered indiscriminately, while others are dangerously habit- forming. even the most dangerous drugs can be of value to human beings, if judiciously employed. The danger of self medication is serious and extensive. People who believe themselves ill or simply off- colour physically or mentally, often use wonder- working drugs (happy pills) to relieve themselves from the tensions of modern living. These tranquilizers have proved so effective that their use has increased amazingly and has now outstripped all other drugs with the exception of the antibiotics.

The active principles of plant drugs are commonly more concentrated in storage organs. Roots, seeds, bark and leaves are much represented in the *Materia Medica*, flowers are less commonly used, while woods and woody parts of herbaceous stems are usually relatively inert.

Floristic composition and studies of medicinal plants are essential in view of their value in understanding the extent of plant biodiversity [World observation Monitoring Centre (WCMC), 1992]. Knowledge of floristic composition is also useful in identifying important elements of plant diversity, protecting threatened and economic species, and monitoring the state of reserves, among others (Tilman, 1988; Ssegawa and Nkuutu, 2006). Thus, the study of floristic composition and structure becomes more imperative in the face of the ever increasing threat to ecosystem. Studies have shown that composition and structure of plants are influenced by a number of factors (Klinge et al., 1995; Haugaasen et al., 2003). Prominent among these factors are disturbances which are thought to be key aspects, and the cause of local species variation within an ecosystem based on their intensity, scale and frequency (Hill and Curran, 2003; Laidlaw et al., 2007). Disturbances can alter the successional pattern and subsequent composition, diversity, and structure of the plant (Doyle, 1981; Busing, 1995). Logging which has immediate and direct effects on composition and structure (Parthasarathy, 2001) also creates canopy openings which may cause regeneration problems, especially in exposed conditions where soils dry out rapidly and nutrient loss through run-off becomes common. Canopy openings readily support the growth of invasive weeds and other herbaceous plants which usually interfere with regeneration and impede recovery of trees and shrubs (Epp, 1987; Hawthorne, 1993 and 1994; Madoffe et al., 2006). Invasive weeds threaten biodiversity by displacing native species and disrupting community structure (Parker et al., 1999; Richardson et al., 2000; Sala et al., 2000; Stein et al., 2000). Soil water availability is also considered a key factor for the regeneration, survival and growth of seedling communities (Lieberman and Lieberman, 1984; Ceccon et al., 2002). Light conditions influence regeneration pathways strongly (Haugaasen et al., 2003) and ultimately affect the composition and structure of flora of an ecosystem. It has been reported that light limitation alone may prevent seedling survival regardless of other resource levels (Tilman, 1982). Flooding as a limiting factor influences seedling and sapling species distribution, and establishment (Klinge et al., 1995; Wittmann and Junk, 2003), probably as a result of physiological stress from highly anoxic conditions, as well as physical flood disturbance (Haugaasen and Peres, 2006). Mithila is generally believed to be floristically rich, containing many tropical timber species and medicinal plants as well. Carefully compiled and up-to date information on these plant resources is however lacking. Therefore, an attempt has been made to study the biodiversity and floristic composition of medicinal plants of Darbhanga.

Methodology

The study was carried out in the eighteen blocks covering almost all the areas of Darbganga. These include:

Darbhanga block (DB), Keoti block (KB), Tardih (TB), Hanuman nagar (HnB), Hayaghat (HB), Manigacchi (MB), Singhwara (SB), Jale (JB), Baheri (BaB), Bahadurpur (BhB), Benipur (BnB), Alinagar (AB), GauraBauram (GB), Biraul (BrB), Kusheshwar Asthan East (KuB), Kusheshwar Asthan (KB), Kiratpur (KpB) and Ghanshyampur (GhB).

The medicinal plants were collected from November 2014 to October 2015 and identified and their dbh (diameter at breast height) measured with a diameter tape. The height of all plants was determined with a clinometers. In each quadrate all trees (dbh ≥ 10 cm) were examined for the presence of climbers (lianas with dbh ≥ 2 cm and vines). Trees were also surveyed for epiphytes according to the method described by Addo-Fordjour et al. (in press). Trees (dbh ≥ 10 cm) were classified into four groups based on their height; understorey (< 20 m), lowe canopy (20-30 m), upper canopy (30-40 m) and emergent (> 40 m) species. The percentage canopy cover of each plot was determined by a spherical densitometer. At each plot four readings from the four cardinal directions were taken at four different points. The average of all readings for plots in each block (18 readings) was calculated and used as the percentage canopy cover of that forest type (Anning et al., 2008). The diameter of lianas was determined at 1.3 m from the rooting base (Addo-Fordjour et al., 2009). Each quadrate of 25 m x 25 m was subdivided into twenty-five 5 m x 5 m small quadrates and fifteen of these (accounting for 60% of the plot area) were randomly sampled for herbs and regeneration of the tree species. All herbs with (≤ 2 m high with dbh < 10 cm) were identified and counted. Identification was performed by a plant taxonomist aided by manuals and Floras (Hawthorne, 1990; Arbon- nier, 2004; Poorter et al., 2004; Hawthorne and Jongkind, 2006). Identification of the species was confirmed at the KNUST, Kumasi and the Forestry Commission, Kumasi herbaria.

Data Analyses

Differences in plant densities between the forest types were tested using one-way ANOVA. The relationship between tree size (dbh) and height in the forest blocks was determined by Pearson correlation analysis. These analyses were performed using Minitab 15 software at a significance level of 5%. The diversity of plant species in the forest types was quantified using the Shannon-Wiener species diversity index (Gimaret-Carpentier et al., 1998; Blanc et al., 2000; Parthasarathy, 2001). The Jaccard's index of similarity (*I*) was calculated for each pair wise plot comparison (Blanc et al., 2000) and this was used to generate a dendrogram showing floristic similarities. The index is given by;

$$I = \frac{C}{Ux + Uy + C} \times 100$$

Where,
C = number of species common to both plot X and Y
Ux = number of sp[ecies found only in plot X
Uy = number of species found only in plot y.

Epiphytes were excluded from all the above mentioned analyses since their densities could not be determined. Importance value index of the species was calculated as the sum of the species relative density, relative frequency and relative dominance (Kiruki and Njung'e, 2007; Addo-Fordjour et al., 2008).

Besides these areas, some indigenous plants of Darbhanga used as medicine are also identified, and their medicinal values have been summarized.

Results and Discussion

Important medicinal plants in Darbhanga collected in rural areas of eighteen blocks, their habit and the families they belong have been presented in Table-1

In Mithilanchal area of Bihar which includes Darbhanga and Madhubani, the major plants used in indigenous system of medicines have been presented in Table-2

Family dominance of medicinal plant species in the Darbhanga has been presented in Table-3

A total of 101 adult plant species were identified in the eighteen blocks of Darbhanga. These belonged to 32 families, 71 genera and 5 life forms (Table 1 and Figure 2). Fabaceae, Moraceae, Meliaceae and Apocyanaceae were the overall diverse families (in terms of species richness) of the adult species, contributing 44.5% of all the species in the study (Figure 2). Trees were the most dominant life form (46.5%) followed by lianas (14.8%), herbs (9.9%), epiphytes (7.9%), shrubs (2.9 %) and the others (3.7%).

Generally, species richness among all life forms was highest in the DB (90.5%) followed by the KB (87.6%), HnB (77%), HB (73%), BnB (70.25%) and GB (68.95%). Fabaceae, Moraceae and Meliaceae and Meliaceae were the most diverse families distributed in all the eighteen blocks of Darbhanga. The most important families in the DF were Fabaceae, Moraceae and Meliaceae and Apocyanaceae (Figure 2). In forest areas of TB, MB, BaB, BhB, AB,BrB, KuB, KpB and GB the medicinal plant species were in the range of 48 to 59.8%. In the forest area of other blocks the incidence of medicinal plant species were low in the range of40.30 to 29.97% (Table- 4). *C. odorata* was the most dominant species of herb in terms of number of individuals accounting for 69% of individual herbs in the DB and 45% of all the herbs in the forest areas of eighteen blocks.

There were a total of 4167 individuals of woody species (excluding epiphytes) identified in the forest areas of eighteen blocks. Trees were more abundant (2916 individuals/ha) followed by lianas (1603 individuals/ha) and shrubs (248 individuals/ha) (Table - 4). Tree density was greatest in the KuB (290/ha) followed by GbB (287/ha), BrB (285/ha), BaB (280/ha), HB (250/ha), SB (215/ha) and MG (214/hac). Density of Liana was maximum in HnB (126/ha) followed by HB (124/ha), DB (121/ha), and TB and AB (108/ha each). Other areas have low density of Liana. Similarly density of shrubs was maximum in KB (19/ha) followed by JB and KuB (17/ha), MG (18/ha), SB (16/ha) and HB (15/ha). Others have low density of shrubs. Shannon-Wiener index was greater in the GhB (*H´* = 3.80) compared to BaB (*H´*= 3.70) and MG, GB, HnB and JB (*H´* =23.50 to 3.60). Others have H' value of less than 3.0 (Table 4). Density of plant species differed significantly between the forest types ($F=8.96$: $df = 2$; $p = 0.000$). In all, *C. mildbraedii* was by far the most abundant species accounting for an average 10% of stems in all the habitats whereas *T. scleroxylon* was the most dominant species in terms of basal area representing 25% on the average (Table- 4). The overall dominant species in terms of the species importance value (average) were *T. scleroxylon* (28.2) and *C. mildbraedii* (23.7). The commonest species were *C. mildbraedii* and Alafia *barteri* with the average occurrence of 6.8 and 5.2 % respecttively. On forest type basis *C. mildbraedii*, *C.* zenkeri, *L. welwitschii*, *_ansiona altissima*, *N. papaverifera* and *T. scleroxylon* were the dominant species in all the forest areas of eighteen blocks (Table 3). *B. papyrifera*, *C. mildbraedii*, *N. papaverifera*, *P. africanum* and *S. oblonga* were the donant species in terms of basal area representing 25% on the average (Table 3). The overall dominant species in terms of the species importance value (average) were *T. scleroxylon* (28.2) and *C. mildbraedii* (23.7). The commonest species were *C. mildbraedii* and _lafia *barteri* with the average occurrence of 6.8 and 5.2 % respecttively.

On forest type basis *C. mildbraedii*, *C.* zenkeri, *L. welwitschii*, *_ansiona altissima*, *N. papaverifera* and *T. scleroxylon* were the dominant species in the in all the areas selected for present investigation (Table 3). *B. papyrifera*, *C. mildbraedii*, *N. papaverifera*, *P. africanum* ,*S. oblonga* and *T. scleroxylon* were the species that dominated the woody flora. In terms of size, majority of the trees were of the lower diameter class (10-30 cm)(Table-4) The number of individual trees in the categories decreased with increasing size of the trees. Larger diameter trees (90- 110 and > 110 cm) were not found in any areas selected for present invstigation. Mean basal area recorded was in the range of 32.6±0.8 (TB) to 64.7±2.6 m^2/ha (BrB) (Table 4). In the same way, mean canopy cover and height were higher in the MG (81.3±4.3) followed by GB (80.5±3.4, SB (78.5±3.0, JB (76.6±3.5, KuB (76.2±1.6), BaB (72.5±1.5) and GhB (68.5±2.8).The canopy cover of other forest areas ranged between 35.5±0.8 and 64.7±2.6. In the present investigation it was found that there was a significant positive relationship between tree size and height in all the forest types selected for present studies ($r2 = 0.812$; $p = 0.000$, $r2 = 0.741$; $p = 0.000$ and $r2 =0.362$; $p = 0.002$).

Studies on biodiversity, floristic composition and structure in the forests of eighteen blocks of Darbhanga are instrumental in the sustainability of forests since they play a major role in the conservation of medicinal plant species, and the management of forest ecosystems as a whole (Tilman, 1988; Ssegawa and Nkuutu, 2006). That notwithstanding, only a few studies (Hall and Swaine, 1981; Vordzogbe et al., 2005; Anning et al., 2008) in this regard have been conducted in forest areas. For this reason, the results of this study cannot be compared with a wide range of other similar studies in different blocks of Darbhanga. On the whole, floristic composition of the forest regions of Darbhanga was found to be lower than many other tropical areas. For instance, Vordzogbe et al. (2005) reported of much higher species richness (80 species/ha) in a moist semi-deciduous forest in Ghana. Even at a higher diameter cut-off point of ≥ 30 cm, Parthasarathy (2001) recorded 125 species in a tropical wet evergreen forest in Sengaltheri of the Western Ghats in India. On the other hand, Anning et al. (2008) recorded a much lower species richness (37 species/ha) in another disturbed semideciduous forest located in Ghana. On the basis of only trees (dbh ≥ 10 cm) the number of species recorded in this study (28 species/ha) was relatively lower in comparison with similar studies in other tropical forests. For example, Campbell et al. (1986) and Riswan (1987) recorded 189 species/ha and 160 species/ha in Brazilian Amazon and Lempake Indonesia respectively. The cutting of mature trees for timber, farming, collection of fuel wood and other non-timber forest products, and their attendant invasion of some parts of the forest might have had effects on the species composition of the reserve (Terborgh, 1992; Odoom, 2005; Opoku, 2006). Trees constituted the predominant life form in all the forest types reminiscent of other studies (Vordzogbe et al., 2005; Anning et al., 2008). Although shrubs and herbs were generally less prominent in all the forest types, the diversity of herbs was greater in all the areas of eighteen blocks of Darbhanga. This might be an indicator of greater anthropogenic disturbances in the forest areas of Darbhanga (Mishra et al., 2008). The comparatively high proportion of *Ficus* spp. in the epiphytic flora is good for the health of the forest reserve since a lot of *Ficus* spp. are keystone species in many tropical forests (Lambert and Marshall, 1991). The dominance of *C. mildbraedii* and *T. scleroxylon* in the flora of the forest areas is considered as a major characteristic of semi-deciduous forests (Taylor, 1960; Hall and Swaine, 1981; Vordzogbe et al., 2005). Furthermore, the dominance of Fabaceae, Moraceae and Meliaceae and Apocyanaceae in some semi-deciduous forests has been reported (Vordzogbe et al., 2005; Anning et al., 2008). Thus, the semi-deciduousness of the forest reserve in Darbhanga as well as the dominance of these species (*C. mildbraedii* and *T. scleroxylon*) (Hall and Swaine, 1981) has been maintained for more than two decades. The presence of some species such as *A. barteri*, *B. bespubescens*, *C. mildbraedii* and *G. simplicifolia* in all the eighteen blocks may indicate their wider range of ecological adaptation (Senbeta et al., 2005; Addo-Fordjour et al., 2008). Floristic composition did not vary much between the various forest types of Darbhanga. Plant diversity (*H*) was quantitatively higher in the DB than in the other forest types which continue to be disturbed by human activities. This is buttressed by the density of plant species which was also significantly greater ($p = 0.000$) in the DB compared to the other blocks. Logging and farming activities in all the eighteen blocks have affected plant diversity through the removal of plant species, creation of gaps, and consequently a reduction in the canopy cover of these forests. Both canopy gaps and farming activities Darbhanga have favoured the growth of invasive species among the native species, with *C. odorata* and *B. papyrifera* which have been identified as notorious invasive weeds being common phenomena. Though invasive species have been found to exert severe negative consequences on biodiversity, displacing native species and disrupting community structure (Ambika, 1996; Parker et al., 1999; Richardson et al., 2000; Sala et al., 2000; Stein et al., 2000; Madoffe et al., 2006). This could be attributed to the early stage of invasion in the Darbhanga, indicating that invasion is yet to have it full impact on the flora of the area. Therefore, there is still an opportunity for management intervention to control *B. papyrifera* and *C. odorata* so as to protect the biodiversity of the forest. Compared with other tropical forests, the forest areas of Darbhanga vertically presented a higher structural complexity

The trees in all the forest types studied were generally tall. The difference in height of tree species could be partly explained by degradation in the form of logging of tall and big trees which has undoubtedly affected the vertical structure. Even though tree size (dbh) correlated with tree height in all the forest types, the relationship was stronger (r = 0.741 to 0.368 ; p = 0.000-0.002). Thus, dbh of trees could be a better predictor of tree height. Age of trees has been found to influence the relationship between tree height and dbh with younger forests showing a stronger relationship than matured forests (Ryan and Yoder, 1997). Thus, the cutting down of matured trees was at least partly responsible for the better correlation between these parameters compared to the other forest types. Generally, tree density in relation to vertical structure of the forest, decreased with increasing height of canopy layers. The cutting down of large trees could explain the relatively lower mean basal area of woody species in these forest types.

The greatest diversity of saplings (H´) in the DB could be attributed to higher sunlight intensity in the forest floor (following gap creation) that supported growth and development of seedlings and saplings. Invasion of the forest areas by *B. papyrifera* and *C. odorata* partly contributed to the poor regeneration of this forest. Sapling and seedling diversity decreased with increasing cover of *B. papyrifera* and *C. odorata* until there were no seedlings or saplings of the native species in areas where the invasive species had formed monotypic stands. This is supported by the findings of Sharma and Raghubanshi (2006). *B. papyrifera* alone constituted 47 % of all the regenerating stems in the DIF, showing their dominance among the regenerating species. The continual dominance of these species may likely affect the regeneration of more native species. The devastating effects of *B. papyrifera* on the regeneration capacity of some native species have also been reported (CSIR, 2002). Seedling diversity was poor in the DB but the relatively higher numbers of saplings and trees in the smaller diameter class may indicate the ability of the DB to recruit more seedlings into the adult phase. This finding is supported by the work of Mishra et al. (2008) in which a higher rate of conversion of saplings to trees was recorded in undisturbed forests.

Human disturbances have influenced the biodiversity, floristic composition of the district Darbhanga to some extent. Invasion on the other hand did not have much effect on floristic composition of the Darbhanga due to the early stage of invasion. Thus, proper management intervention is required to mitigate the impact of *B. papyrifera* and *C. odorata* before it gets out of control. Logging affected the structural complexity of the forest reserve through the removal of large and tall trees as well as gap creation. The forest regions of Darbhanga had better capacity of recruiting saplings into the adult stage. Invasion of the DIF by *B. papyrifera* and *C. odorata* affected regeneration of native species. The forest reserve of Mithila looks floristically rich and structurally complex in the face of logging, farming activities and invasion in some parts of the forest. Thus, there is the need to curb the anthropogenic activities and plant invasion so as to protect the integrity of the forest including medicinal plants

Table.1 Important Medicinal plants of Darbhanga

Species	Family	Habit
Acacia kamerunensis Gand.	Fabaceae	Liana
Acacia pentagona (Schum. & Thonn.) Hooker f.	Fabaceae	Liana
Acanthaceae sp.	Acanthaceae	Herb
Afromomum sp.	Zingiberaceae	Herb
Afzelia bella Harms	Fabaceae	Tree
Aidia genipiflora (DC.) Dandy	Rubiaceae	Shrub
Alafia barteri Oliv.	Apocynaceae	Liana
Albizia adianthifolia (Schum.) W.F. Wight	Fabaceae	Tree
Albizia glaberrima (Schum. & Thonn.) Benth.	Fabaceae	Tree
Albizia zygia (DC.) J.F. Macbr.	Fabaceae	Tree
Alstonia boonei De Wild.	Apocynaceae	Tree
Amphimas pterocarpoides Harms	Fabaceae	Tree
Anchomanes difformis (Blume) Engl.	Araceae	Herb
Antiaris toxicaria (Rumph ex Pers.) Leschen.	Moraceae	Tree
Antrocaryon micraster A. Chev. & Guillaum.	Anacardiaceae	Tree
Baphia nitida Lodd.	Fabaceae	Tree
Baphia pubescens Hook.f.	Fabaceae	Tree
Blighia sapida Kon.	Sapindaceae	Tree
Blighia welwitschii (Hiern) Radlk.	Sapindaceae	Tree
Bombax buonopozense P.Beauv.	Bombacaceae	Tree
Bridelia atroviridis Müll.Arg.	Euphorbiaceae	Tree
Bridelia grandis Pierre ex Hutch.	Euphorbiaceae	Tree
Broussonetia papyrifera Vent.	Moraceae	Tree
Bussea occidentalis Hutch.	Fabaceae	Tree
Calpocalyx brevibracteatus Harms	Fabaceae	Tree
Calycobolus africanus (G.Don) Heine	Convolvulaceae	Tree
Calyptrochilum emarginatum Schltr.	Orchidaceae	Epiphyte
Capsicum sp.	Solanaceae	Herb
Ceiba pentandra (L.) Gaertn.	Bombacaceae	Tree
Centrocema pubescens Benth.	Fabaceae	Herb
Chromolaena odorata (L.) King & Robinson	Asteraceae	Herb
Chrysophyllum perpulchrum Mildbr. ex Hutch. &	Sapotaceae	Tree
Dalziel *Chrysophyllum* sp.	Sapotaceae	Tree
Cissus sp.	Vitaceae	Liana
Combretum bipindense Engl. & Diels	Combretaceae	Liana
Combretum smeathmannii G.Don	Combretaceae	Liana
Combretum sp.	Combretaceae	Liana

Cordia millenii Baker	Boraginaceae	Tree
Cordia senegalensis Juss.	Boraginaceae	Tree
Corynanthe pachyceras K.Schum.	Rubiaceae	Tree
Rhaphidophora africana N.E.Br.	Araceae	Vine
Dalbergia hostilis Benth.	Fabaceae	Liana
Diospyros viridicans Hiern	Ebenaceae	Tree
Entandrophragma angolense (Welw.) DC.	Meliaceae	Tree
Ficus asperifolia Miq.	Moraceae	Shrub
Ficus exasperata Vahl	Moraceae	Shrub
Ficus sur Forssk.	Moraceae	Tree
*Ficus tessellata*Warb.	Moraceae	Epiphyte
Ficus thonningii Blume	Moraceae	Epiphyte
Ficus trichopoda Baker	Moraceae	Epiphyte
Ficus umbellata Vahl	Moraceae	Epiphyte
Ficus vogelii Miq.	Moraceae	Epiphyte
Funtumia elastica (Preuss) Stapf	Apocynaceae	Tree
Griffonia simplicifolia (Vahl ex DC.) Baill.	Fabaceae	Liana
Guarea cedrata (A.Chev.) Pellegr.	Meliaceae	Tree
Hippocratea sp.	Celastraceae	Liana
Hymenostegia afzelii (Oliv.) Harms	Fabaceae	Tree
Khaya anthotheca (Welw.) C.DC.	Meliaceae	Tree
Khaya grandifolia C.DC.	Meliaceae	Tree
Khaya ivorensis A.Chev.	Meliaceae	Tree
Lannea welwitschii (Hiern) Engl.	Anacardiaceae	Tree
Lecaniodiscus cupanioides Planch. ex Benth.	Sapindaceae	Tree
Leptoderris sp.	Fabaceae	Liana
Lovoa trichilioides Harms	Meliaceae	Tree
Macaranga heudelotii Baill.	Euphorbiaceae	Tree
Mansonia altissima (A.Chev.) A.Chev.	Sterculiaceae	Tree
Marantocloa leucantha (K.Schum.) MilneRedh.	Marantaceae	Herb
Microdesmis puberula Hook.f.	Pandaceae	Tree
Microsorum punctatum (L.) Copel.	Polypodiaceae	Epiphyte
Microsorum scolopendria Copel.	Polypodiaceae	Epiphyte
Milicia excelsa (Welw.) C.C.Berg.	Moraceae	Tree
Millettia chrysophylla Dunn	Fabaceae	Liana
Morinda lucida Benth.	Rubiaceae	Tree
Morus mesozygia Stapf	Moraceae	Tree
Motandra guineensis (Thonn.) A.DC.	Apocynaceae	Liana
Myrianthus arboreus P.Beauv.	Cecropiaceae	Tree
Olyra latifolia L.	Poaceae	Herb
Panicum maximum Jacq.	Poaceae	Grass

Parquetina nigrescens (Afzelius) Bullock	Asclepiadaceae	Liana
Pennisetum purpureum K.Schum.	Poaceae	Grass
Piptadeniastrum africanum (Hook.f.) Brenan	Fabaceae	Tree
Pisonia aculeata L.	Nyctaginaceae	Liana
Pteris sp.	Pteridaceae	Fern
Pycnanthus angolensis (Welw.) Warb.	Myristicaceae	Tree
Ricinodendron heudelotii (Baill.) Pierre ex Pax	Euphorbiaceae	Tree
Atropa belladonna L.	Solanaceae	Herb
Digitalis spp. Linn.	Scrophulariaceae	Herb
Rauwolfia serpentine Benth. Ex Kurtz.	Apocyanaceae	Undershrub
Catheranthus roseus	Apocyanaceae	Herb
Rinorea oblongifolia (C.H. Wright) Marquand ex Chipp	Violaceae	Tree
Salacia elegans Welw. ex Oliv.	Celastraceae	Liana
Salacia owabiensis Hoyle	Celastraceae	Liana
Salacia sp.	Celastraceae	Liana
Smilax kraussiana Meisn.	Smilacaceae	Liana
Sterculia oblonga Mast.	Sterculiaceae	Tree
Sterculia rhinopetala K.Schum.	Sterculiaceae	Tree
Sterculia tragacantha Lindl.	Sterculiaceae	Tree
Terminalia superba Engl. & Diels	Combretaceae	Tree
Trichilia monadelpha (Thonn.) J.J.de Wild.	Meliaceae	Tree
Trichilia prieureana A.Juss.	Meliaceae	Tree
Trilepisium madagascariense DC.	Moraceae	Tree

Table.2 Major Plants used as Indigenous Medicines in Darbhanga

Species	Family	Used in Diseases
Calotropis gigantica	Asclipiadaceae	Liver, intestine spleen, piles
Adhotoda vasica	Acanthaceae	T.B., Cough, Hyperplasia
Clitoria ternatia (Aprajita)	Fabaceae	Swelling, Mental headache, Jaundice
Achyranthus Aspera	Nyctaginaceae	Appetite, Eyesight
Nelumbian speciosum	Nymphaeaceae	Skin diseases, piles
Cucumis utilissimus	Cucurbitaceae	Urinary disorder, Gall bladder, cholesterol
Nerium odorum	Apocyanaceae	Skin diseases, joint pain
Strychros Nuxvomica	Loganiaceae	Nervous system, Joint pain, Dysentery
Cucumis melo	Cucurbitaceae	Urinary disorder, kidney pain
Daucus Carota	Umbelliferae	Bile, nervous system, Asthma
Leucas cephalotus	Lemiaceae	Rheumatism, Cough, Anorexia
Calendula officinalis	Asteraceae	Asthma, Cough, tooth, Skin disease
Aloe vera	Liliaceae	Liver, spleen, Skin disease
Ricinus Communis	Euphorbiaceae	Heart pain, joint pain, piles
Mentha spp.	Lemiaceae	Urinary disorder, Worm killer
Eclipta alba	Asteraceae	Cough, Skin diseases, Liver, spleen
Moringa pterygosperma	Moringaceae	Anticancer, painkiller, ulcer, cough, liver, spleen, fever
Aconitum napellus	Ranunculaceae	Neuralgia and Rheumatism
Cassia anguistifolia	Caesalpinaceae	Laxative used in habitual constipation
Withania somnifera	Solanaceae	Diuretic, Rheumatism, applied to ulcer carbuncle

Table.3 Family Dominance of Medicinal Plants

Family	Number of Species
Fabaceae	18
Moraceae	13
Euphorbiaceae	4
Apocyanaceae	6
Combretaceae	4
Sterculariaceae	4
Meliaceae	8
Celastraxeae	4
Poaceae	3
Bombaceae	2
Solanaceae	2
Polypodiaceae	2
Rubiaceae	2
Marantaceae	1
Ppandaceae	1
Asclepiadaceae	1
Nyctaginaceae	1
Ebenaceae	1
Acanthaceae	1
Zingiberaceae	1
Rubiaceae	2
Araceae	2
Anacardiaceae	2
Sapindaceae	2
Boraginaceae	2
Cecropiaceae	1
Bombaceae	2
Convulvulaceae	1
Orchidaceae	1
Asteraceae	1
Sapotaceae	2
Vitaceae	1

Table.4 Abundance and Dominance of Woody Medicinal Plant Species in Various Blocks of Darbhanga

Species	DB	KtB	TB	HnB	HB	MG	SB	JB	BaB	Bh B	BnB	AB	Gb	BrB	KuB	KB	KpB	GhB
Acacia kamerunensis	-	-	0.25	0.55	0.57	0.25	0.75	1.25	-	-	-	-	0.65	-	-	-	-	-
Acacia pentagona	-	-	0.35	0.35	0.65	0.26	0.55	0.15	0.25	0.65	-	-	0.35	-	-	-	-	0.75
Acanthaceae sp	0.67	0.75	-	-	-	-	-	-	0.55	-	-	-	0.65	-	-	-	-	-
Afromomum sp	-	-	-	-	-	-	-	-	-	-	0.55	0.65	0.35	-	-	-	-	-
Afzelia bella	-	-	-	-	-	0.57	-	-	-	-	-	-	0.65	-	-	-	-	-
Aidia genipiflora	-	-	-	-	-	0.58	-	-	-	-	-	-	0.45	-	-	-	-	-
Alafia barteri	-	-	-	-		0.55	-	-	-	-	-	-	0.65	-	-	-	-	-
Albizia adianthifolia	2.55	3.5	5.6	6.5	7.5	7.5	4.5	4.5	6.5	7.5	3.4	7.5	6.5	-	-	-	-	-
Albizia zygia	3.5	2.6	-	-	-	1.5	-	-	-	-	-	0.75	6.0	-	-	-	-	4.5
Alstonia boonei	-	-	-	-	-	5.5	-	-	-	-	-	-	-	-	4.7	-	-	-
Amphimas pterocarpoides	-	-	-	7.5	-	-	-	-	-	5.5	-	-	-	6.5	-	4.2	1.5	2.5
Anchomanes difformis	-	-	-	-	-	-	-	-	-	-	8.5	-	-	-	5.4	-	-	-
Antiaris toxicaria	2.5	-	-	-	-	-	4.6	-	-	-	-	-	-	-	-	5.5	-	-
Antrocaryon micraster	-	-	0.5	-	-	-	1.5	-	3.5	-	-	-	-	-	-	-	5.5	-
Baphia nitida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65	-
Baphia pubescens	0.55	-	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-	-	-
Blighia sapida	5.5	-	4.5	-	-	-	6.4	-	-	-	5.5	-	-	-	-	2.7	-	-
Blighia welwitschii	-	-	-	3.6	-	-	-	-	4.5	-	-	-	-	2.5	-	-	-	-
Bombax buonopozense	7.5	-	-	-	8.5	9.4	-	-	-	-	-	-	6.5	-	-	4.5	-	-
Bridelia atroviridis	-	-	-	-	-	-	-	-	-	-	-	-	5.5	-	-	-	-	-
Bridelia grandis	-	-	-	-	-	-	-	-	-	-	-	-	6.0	-	-	-	-	-
Broussonetia papyrifera	-	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bussea occidentalis	-	5.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calpocalyx brevibracteatus	-	-	-	4.5	-	-	-	-	3.5	-	-	-	-	2.7	-	-	-	-
Calycobolus africanus	-	-	-	-	-	-	-	-	4.6	-	-	-	-	-	-	-	-	-
Calyptrochilum	-	-	-	-	-	-	-	-	2.5	-	-	-	-	-	-	-	-	-

emarginatum																		
Capsicum sp.	5.5	2.4	3.5	4.7	1.5	1.5	1.5	2.7	2.5	2.6	2.0	3.5	5.5	4.5	5.0	4.7	4.6	3.7
Ceiba pentandra	7.6	7.0	-	-	-	-	7.0	-	-	5.0	6.5	-	4.5	3.6	3.5	4.0	-	-
Centrocema pubescens	-	-	-	-	-	-	-	-	5.0	-	-	-	6.5	-	-	-	-	7.4
Chromolaena odorata	4.5	4.0	3.5	2.7	3.5	-	-	-	5.0	-	-	-	6.5	-	-	-	-	-
Chrysophyllum perpulchrum	6.5	6.0	4.0	3.5	1.2	0.5	-	0.6	-	0.4	-	-	-	0.7	-	-	-	-
Chrysophyllum sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.5	2.0	2.5
Cissus sp.	-	-	-	-	-	-	2.6	-	-	-	-	5.0	-	-	-	-	-	-
Combretum bipindense	4.0	-	-	4.7	6.5	-	-	-	-	3.8	-	-	-	2.7	2.5	-	-	-
Combretum smeathmannii	3.5	-	-	3.4	4.5	-	3.0	-	-	4.0	-	-	-	3.0	3.0	-	-	-
Combretum sp	-	-	-	3.0	-	-	-	-	-	-	-	-	-	2.5	2.7	-	-	-
Cordia millenii	-	-	-	-	-	-	-	-	-	-	4.5	-	-	-	-	-	-	4.0
Cordia senegalensis	-	-	-	-	-	-	-	-	-	-	5.0	-	-	-	-	-	-	5.5
Corynanthe pachyceras	-	0.57	-	-	-	-	-	-	-	-	0.55	-	-	-	-	-	-	0.45
Rhaphidophora africana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.85	-
Dalbergia hostilis	7.5	6.5	5.0	4.7	4.6	3.5	2.8	3.6	6.5	6.5	4.5	4.5	1.0	0.5	-	-	-	-
Diospyros viridicans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	0.7	-
Entandrophragma angolense	0.5	-	-	-	-	-	-	-	-	0.7	-	-	-	-	0.5	-	-	-
Ficus asperifolia	2.5	-	-	-	-	3.6	-	-	-	-	-	-	5.5	-	-	-	-	-
Ficus exasperata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ficus sur	2.5	-	-	4.5	-	-	6.5	-	-	-	-	1.5	-	-	-	-	-	0.4
Ficus tessellata	2.5	-	-	3.5	-	-	5.0	-	-	-	-	1.7	-	-	-	-	-	0.6
Ficus thonningii	0.5	0.7	-	0.5	-	0.6	-	-	-	-	-	-	0.5	-	0.4	-	-	-
Ficus trichopoda	0.7	0.4	-	-	-	0.5	-	-	-	-	-	0.5	-	0.7	-	-	-	-
Ficus umbellata	2.5	-	-	-	-	3.5	-	-	-	4.5	-	-	-	-	-	4.0	3.5	-
Ficus vogelii	-	-	-	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	0.5
Funtumia elastica	-	-	-	-	1.5	-	-	-	-	-	-	-	2.6	-	-	-	0.8	-

Griffonia simplicifolia	-	3.5	-	-	-	-	-	0.5	-	-	-	-	-	0.4	-	-	-	-
Guarea cedrata	-	-	5.0	-	-	-	-	-	-	-	4.5	-	-	-	-	-	-	-
Hippocratea sp.	-	-	-	0.3	-	-		-	-	-	-	-	-	-	-	-	-	0.6
Hymenostegia afzelii	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-
Khaya anthotheca	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-	-	-	-
Khaya grandifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-
Khaya ivorensis	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-
Lannea welwitschii	-	0.6	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-
Lecaniodiscus cupanioides	-	0.5	-	-	-	-	5.5	-	-	-	-	-	-	-	3.6	-	-	-
Leptoderris sp.	2.5	-	-	-	3.0	-	-	-	-	-	3.5	-	-	-	-	-	-	-
Lovoa trichilioides	-	-	0.7	0.5	-	0.6	-	1.0	-	-	-	-	0.5	-	-	-	-	-
Macaranga heudelotii	2.5	-	-	-	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-
Mansonia altissima	-	0.6	-	-	-	-	-	-	0.7	-	-		-	-	-	-	0.8	-
Marantocloa leucantha	-	-	4.0	-	-	-	-	5.2	-	-	-	3.6	-	-	-	6.0	-	-
Microdesmis puberula	-	-	-	0.7	-	-	-	-	-	0.5	-	-	-	0.4	-	-	-	-
Microsorum punctatum	-	-	-	0.3	-	-	-	-	-	0.5	-	-	-	0.5	-	-	-	-
Microsorum scolopendria	-	-	-	0.5	-	-	-	-	-	0.5	-	-	-	0.6	-	-	-	-
Milicia excelsa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7
Millettia chrysophylla	-	0.5	-	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-
Morinda lucida	-	-	-	-	2.5	-	-	-	-	-	-	2.7	-	-	-	3.0	-	-
Morus mesozygia	-	-	2.5	-	-	-	-	2.0	-	-	-	-	-	-	-	2.5	-	-
Motandra guineensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-
Myrianthus arboreus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-
Olyra latifolia	-	-	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-	4.0	-
Panicum maximum	-	2.7	-	-	4.0	-	-	-	-	1.8	-	-	-	-	-	3.0	-	-
Parquetina nigrescens	-	-	-	-	-	0.8	-	-	-	-	-	-	0.6	-	-	-	-	-

Pennisetum purpureum	-	-	-	-	-	0.7	-	-	-	-	-	-	0.5	-	-	-	-	-
Piptadeniastrum africanum	-	-	-	-	-	0.7	-	-	-	-	-	-	0.5	-	-	-	-	-
Pisonia aculeata	1.5	-	-	-	-	-	-	1.7	-	-	-	-	-	-	1.5	-	-	-
Pteris sp.	6.5	5.0	6.5	6.0	4.0	2.5	4.0	2.5	3.5	3.0	2.7	2.0	3.5	1.5	1.7	5.0	5.0	4.5
Pycnanthus angolensis	3.5	-	-	-	5.0	-	-	-	-	-	-	2.5	-	-	-	-	-	4.5
Ricinodendron heudelotii	1.5	-	-	0.7	-	-	-	-	0.5	-	-	-	0.5	-	-	-	-	0.6
Atropa belladonna	3.2	-	-	3.5	-	-	4.0	-	-	-	-	3.5	-	-	-	-	4.5	4.0
Digitalis spp	-	4.0	3.5	-	-	7.0	-	-	6.0	-	-	-	5.0	-	-	4.5	-	-
Rauwolfia serpentine	-		-	-	5.5	-	-	-	-	-	6.5	-	-	6.0	-	-	7.5	7.6
Catheranthus roseus	2.5	2.0	1.0	1.5	2.7	3.5	3.7	4.5	3.7	3.5	3.0	2.5	2.0	3.6	5.0	5.5	2.6	3.7
Rinorea oblongifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0	4.5	3.0
Salacia elegans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	0.7	1.7
Salacia owabiensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	0.5	0.8	1.6
Salacia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	2.7	1.8	1.5
Smilax kraussiana	1.7	-	-	2.5	-	-	3.0	-	-	-	4.7	-	-	-	-	-	-	-
Sterculia oblonga	3.6	-	3.5	-	2.7	-	-	2.5	-	3.0	-	-	-	4.0	1.5	-	-	-
Sterculia rhinopetala	2.3	-	3.6	-	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Sterculia tragacantha	-	-	-	-	4.5	-	-	-	-	-	-	-	-	2.7	-	-	0.7	-
Terminalia superba	1.5	3.5	-	5.0	-	-	-	-	-	-	-	1.4	-	-	1.6	-	1.5	-
Trichilia monadelpha	-	-	-	-	-	0.5	-	-	-	-	0.7	-	-	-	-	-	-	-
Trichilia prieureana	-	-	-	-	-	1.5	-	-	-	-	2.0	-	-	-	-	-	-	-
Trilepisium madagascariense	-	-	-	-	-	2.0	-	-	-	-	1.7	-	-	-	-	-	-	-

Table.4 Summary Characteristics of the Floristic Composition and Structure of the Medicinal Plants in Eighteen Blocks of Darbhanga

Characteristics	DB	KtB	TB	HnB	HB	MG	SB	JB	BaB	BhB	BnB	AB	GB	BrB	KuB	KB	KpB	Gh B
Number of tree individuals (density/ha)	85	95	107	154	250	214	215	150	280	230	107	114	217	285	290	126	120	287
Number of individual shrubs (density/ha)	8	12	10	13	15	18	16	17	10	14	17	13	9	11	17	19	11	8
Density of Liana/ha	121	105	108	126	124	60	58	69	52	104	85	108	75	85	83	80	78	82
Shannon-Wienner Index	2.5	2.6	2.9	3.5	3.4	3.6	2.8	3.5	3.7	2.8	2.9	3.1	3.6	3.4	2.6	2.5	2.4	3.8
Shannon-Wienner Index for sampling	1.30	1.34	1.35	2.70	2.50	1.45	2.50	1.36	1.35	1.34	2.68	2.36	1.85	1.80	1.75	2.30	2.45	1.75
Mean canopy height (m)	35.5 ±3.5	36.6 ±3.2	29.8± 3.4	32.5± 2.5.	34.40± 2.6	28.30 ±1.58	27.50± 1.75	26.35 ±2.50	27.25 ±3.12	32.15 ±1.78	30.26 ±2.15	29.10± 2.16	27.35± 1.85	35.15±1.26	29.15±2.65	27.14±1.85	28.16 ±3.10	36.85±3.17
Mean canopy cover (%)	54.3 ±4.5	60.5 ±2.5	61.5± 2.6	64.5± 2.4	71.2±4 .2	81.3± 4.3	78.5±3 .5	76.6± 3.5	72.5± 1.5	68.5± 5.0	56.2± 2.6	58.5±3 .6	59.5±4. 5	80.5 ±3.4	76.2 ±1.6	70.7 ±2.7	69.4± 3.7	68.5 ±2.8
Mean basal area (m^2/ha)	52.5 ±3.2	35.5 ±0.8	32.6± 0.8	45.2± 1.2	43.5±3 .2	55.6± 3.5	60.4±2 .6	58.5± 0.8	53.5± 2.5	54.5± 4.5	38.6± 3.2	37.5±0 .9	63.5±2. 5	64.7 ±2.6	61.4 ±4.0	40.5 ±4.5	46.7± 3.6	51.8 ±3.7

Fig.1 Composition of Medicinal Plant Species in the Various Life forms Identified in Darbhanga

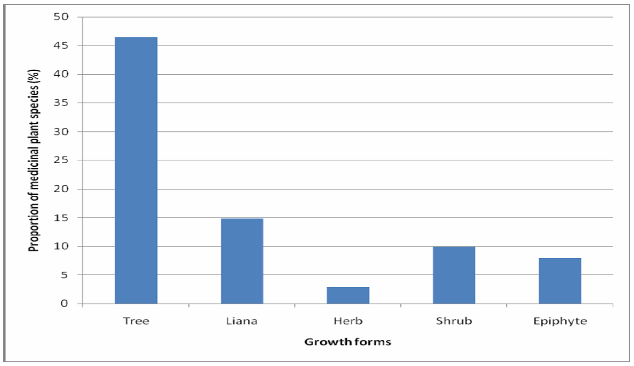
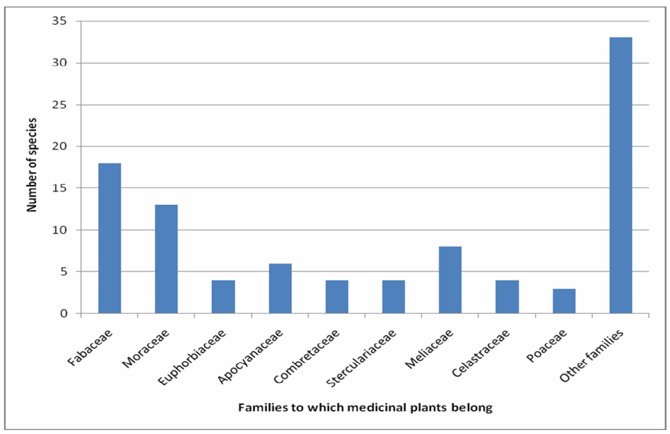


Fig.2 Family Dominance of Medicinal Plant Species in Darbhanga



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