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Floristic Diversity of the Family Fabaceae (Leguminosae) in Community Forests of South Haryana, India

K.C. Meena[1], Neetu Singh[1], M.S. Bhandoria[2], Pradeep Bansal[3], S.S. Yadav[1]

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ABSTRACT

Background: Fabaceae is third largest family of angiosperms and second important family from commercial and economic point of view. The purpose of the present study was to examine the floristic analysis and species diversity of the family Fabaceae in Community Forests of South Haryana, India in view of recent classification recognised by Legume Phylogeny Working Group. Though the community forests are fragmented but still act as local mini biodiversity host spots harbouring rich plant diversity.

Methods: Repeated floristic surveys were conducted in different seasons during the year 2023 and 2024. Detailed field notes were recorded and photographs were taken in the natural conditions.

Result: The outcome of study revealed 61 species belonging to 34 genera, 16 tribes and 4 subfamilies from the studied area. The subfamily Papilionoideae is the most dominant, comprising 10 tribes, 21 genera and 41 species. Phaseoleae is the largest tribe with 7 genera and 9 species, followed by Mimoseae with 4 genera and 4 species. *Indigofera* emerged as the largest genus, comprising 8 species. The Simpson's index value proved that the Fabaceae family in Community Forests has high diversity. The analysis of growth form indicated that the Fabaceae family is dominated by Herbs with a proportion of 48%. Therophytes have highest number of species (44%), followed by Phenerophytes (36%), Chaemephytes (18%), Hemicrytophytes (2%). The findings of the present study will be helpful for botanists, conservationist, policy planners and local people for effective management of community forests.

Key words: Community forests, Fabaceae, Legume, Life forms, Plant diversity.

INTRODUCTION

Fabaceae is one the well-known family of the flowering plants. It got its name from genus *Faba*, which is presently included as species in genus *Vicia* (Jussieu, 1789). In fact, the Latin word *Faba* which literally means bean and this family is popularly also called as the legume, bean or pea family. Leguminosae is the erstwhile name of the family which is contemplated valid as per International Code of Botanical Nomenclature (ICBN) article 18.5 of Vienna code. Worldwide, Fabaceae is the third largest family of the angiosperms after Orchidaceae and Asteraceae (Lewis *et al*., 2005, Christenhusz *et al*., 2016 and LPWG, 2017). It is represented by about 20,000 species belonging to 765 genera which are further grouped into 36 tribes and six sub-families (LPWG, 2017; Kumar *et al*., 2022; Legume Data Portal, 2022). Globally, largest and widespread genera of family is *Astragalus* containing over 2400 species, followed by *Acacia* with about 950 species and *Crotolaria* and *Indigofera* having about 700 species each (Verma and Jain, 2022). Woody legumes are primarily found in tropical and subtropical climates while herbaceous legumes are dominant in temperate regions (Sanjappa, 1992).

About 1297 species belonging to nearly 179 genera represented in India out of which 23% are endemic to India (Bhatia *et al*., 2023). The greatest diversity of legumes in India is occurred in biodiversity hotspots like eastern Himalaya and Western Ghats (Sanjappa, 1992, 1995). Peninsular India has the greatest diversity of legumes, harbouring over 550 species, followed by the Himalayan region with nearly 500 species and north-eastern India with about 400 species. In India, *Crotalaria* is reported as largest genus of legumes with 97 species followed by *Astragalus* containing 85 species (Sanjappa, 1992).

It is ranked second only after family Poaceae in terms of commercial and economic importance, as most of the members of this family are source of protein-rich seeds for the human diet, palatable nutritious fodder, timber, fuelwood, tannins, resins, pulp, toxins, dye, medicines and ornamental plants (Singh *et al*., 2007; Sharma, 2013, Ahmad *et al*., 2016 and Grygier *et al*., 2023). Genus *Phaseolus, Glycine, Pisum, Cicer, Arachis, Medicago* and *Glycyrrhiza* mostly having herbaceous plants are widely cultivated throughout world for economic value to human beings

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(Harris, 2004; Verma and Jain, 2022). Worldwide more than 150 species of Fabaceae have been recorded for use of fodder and food (Olmedilla *et al*., 2010). Certain members of the family function as keystone species in various ecosystems while others act as bottom-up control species (Sanjappa, 2001; Sanjappa, 2020).

Although not all but majority of species of family Fabaceae have ability to form root nodules in association with nitrogen fixing bacteria *Rhizobium* and other genera for fixing atmospheric nitrogen in the soil (Rainer *et al*., 2018) and helps in maintaining nutrient cycle which ensure better plant growth, wider habitats adaptability and ecological success (Harris, 2004; Ney *et al*., 2019). Keeping in view the global significance of legumes, the year 2016 was declared as International Year of Pulses by United Nations General Assembly (Balan and Pradeep, 2021).

Systematics of Fabaceae has always remained in discussion among the taxonomists and underwent tremendous changes in its classification. On the basis of aestivation of petals and sepals, Bentham (1865) put all legumes under the order Rosales in Leguminosae family which were further grouped into three sub-families, namely, Mimoseae, Caesalpinieae and Papilionaceae. On the contrary, Hutchinson (1973) and Cronquist (1988) established all three sub-families as distinct families under the order Fabales. Under Angiosperm Phylogeny Group classification (APG IV, 2016), all legumes are put in a single family Fabaceae under the order Fabales. Most recently, based on studies of phylogenomics and plastomes DNA, the Legume Phylogeny Working Group have placed all the legumes in a single family Fabaceae which is further divided into six subfamilies *i.e*. Caesalpinioideae, Cercidoideae, Duparquetioideae, Detarioideae, Dialioideae and Papilionoideae (LPWG, 2017; Bruneau *et al*., 2024). The sub-families are further divided into tribes.

The various studies have been conducted in overseas and India for documentation and enumeration of members of Fabaceae family. The initial systematic investigation of Indian legumes was started from Malabar region of South India by a Dutch Botanist Van Rheede in the year 1678 and succeeded to enlist and describe 63 species of 33 genera (Nicolson *et al*., 1988). Later on Lamarck (1785), Willdenow (1802), Candole (1825), Taubert (1894), Roxburgh (1795, 1832), Wallich (1820), Wight and Arnott (1834) fitfully narrated various genera and species of Indian legumes. Baker (1876-78) conducted extensive survey during British India period and documented 183 species across 132 genera which also were reported in "The Flora of British India," published by J.D. Hooker. Later, Sanjappa (1992) documented about 1252 species belonging to 199 genera in India.

Some researchers have also documented the floristic diversity of Haryana but no systematic efforts have been made for investigating composition and diversity of family Fabaceae in the State of Haryana especially in the Community Forests. Moreover, recent nomenclature changes, new classification of family Fabaceae and lack of comprehensive investigation of the species richness at sub-families level necessitated further in-depth studies. Hence, the present study was conducted to prepare the checklist and evaluate the diversity of this family as per new classification for Community Forests of South Haryana.

MATERIALS AND METHODS

Haryana is a Northern Indian state with an area of 44,212 Km^2. The study was conducted in Rewari and Mahendergarh districts (Fig 1). These districts are situated in the most southern tip of the state boundary and bordered with state of Rajasthan. The region is characterised by arid to semi-arid climatic conditions with seasonal scanty annual rainfall amounting 450-500 mm. The topography of the area is representing by rolling landscape, alluvial plans, semi stabilized sand dunes and scattered Aravalli Hills. The soil of the region is sandy to sandy loam with poor organic carbon content. The Dhohan, Sahibi and Krishnawati are seasonal rivers originating from Aravalli hills from Rajasthan seasonally recharge the ground water in the area. The vegetation is tropical dry deciduous and thorny in nature. The district Rewari and Mahendergarh are administratively divided in seven and eight Community Development Blocks respectively. One Community Forest (CF) area from each block of both the districts was selected for floristic study. Thus, fifteen CFs were selected in both the district as per detail given below (Table 1). Extensive and repeated seasonal floristic surveys were conducted in the selected Community Forests. Pre-monsoon and post monsoon Frequent field surveys were conducted during different seasons during 2023 and 2024.

The plants were identified with the help of published literature *viz*. Flora of Haryana by Jain *et al*. (2000) and Kumar (2001); Sanjappa (1995); Jain *et al*. (1982) and Legume Data Portal. The collected plants were photographed and standard techniques were adopted for processing of specimens (Bridson and Forman, 1998). For the documentation of species and the classification of family Fabaceae under tribes and sub-families the system recognised by LPWG (2017) and Lewis *et al*. (2005) was adopted. The basic and widely accepted classification concept of life form and growth form as suggested by Von Humboldt (1806); Raunkiaer (1934); Mueller-Dombois and Ellenberg (1974) were followed to study various plant life forms. The International Plant Names Index (https://www.ipni.org/), The World Flora Online (https://www. worldfloraonline.org/) and Plants of the World Online (https://powo.science.kew.org/) were followed for updated names.

Calculation of species diversity of family fabaceae

The local species diversity of family Fabaceae was evaluated as per the method given by Simpson's Index (1949) which is denoted by "D" and values ranges between

0 and 1. The Simpson's Index is calculated by the following formula:

$$\text{Simpson's diversity index (D)} = \frac{\Sigma \text{ ni (ni-1)}}{\text{N (n-1)}}$$

Where,

N = The total number of all species in Fabaceae family.

ni = The number of species of each genus.

In the present study the diversity score of the Fabaceae family was calculated based on number of species in genus and the number of individuals for each of those species.

RESULTS AND DISCUSSION

In the present study a total of 61 species belonging to 34 genera of family Fabaceae were recorded from the Community Forests of south Haryana (Table 2). Herbs (29 species) followed by trees (20 species), shrubs (8 species) and climbers (4 species) are the major growth form. The dominance of herbs can be referred to the arid and dry habitat conditions. Out of the six known subfamilies of legumes worldwide, four are represented in the study area (Table 3).

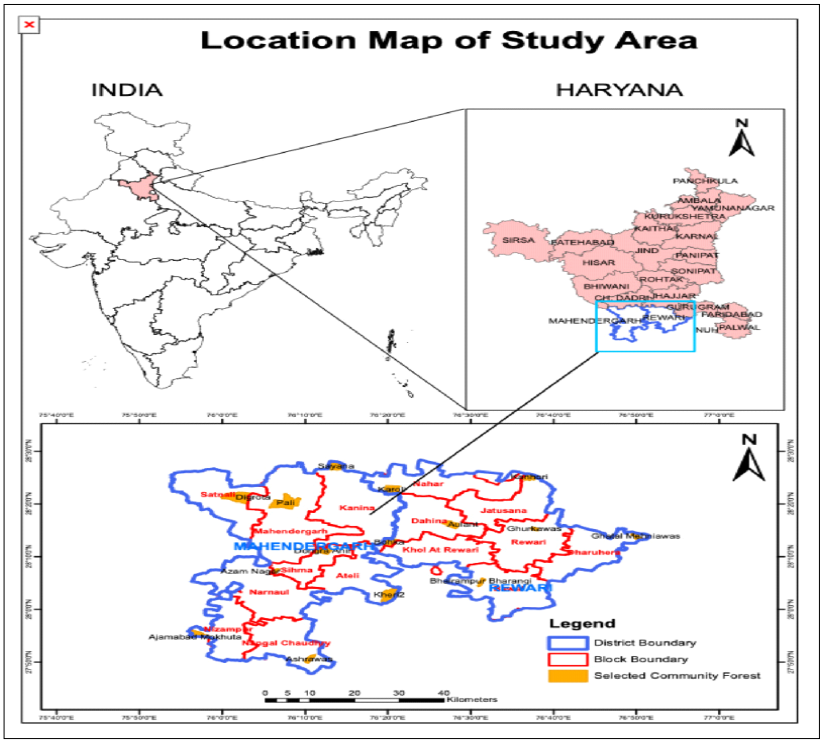


Fig 1: Map of the study site.

Table 1: List of community forests selected for the present study.

District	Community block	Name of community forests	Longitude	Latitude	Elevation (M)
Mahendergarh	Nizampur	Azmabad mukhota	75°56′10.57″E	27°55′54.08″N	364
Mahendergarh	Nangal chaudhary	Ashrawas	76°11′3.27″E	27°51′18.48″N	385
Mahendergarh	Narnaul	Azam Nagar	76°6′50.73″E	28°7′0.99″N	315
Mahendergarh	Satnali	Digrota	76°1′36.78″E	28°21′16.44″N	330
Mahendergarh	Sihma	Deroli Ahir	76°9′11.89″E	28°9′21.28″N	314
Mahendergarh	Ateli	Kheri	76°19′45.92″E	28°2′16.09″N	313
Mahendergarh	Mahendergarh	Pali	76°7′16.52″E	28°20′4.05″N	284
Mahendergarh	Kanina	Syana	76°13′36.90″E	28°27′10.94″N	258
Rewari	Nahar	Karoli	76°20′6.88″E	28°22′47.60″N	269
Rewari	Dahina	Aulant	76°27′37.96″E	28°15′48.38″N	281
Rewari	Khol	Bohka	76°19′46.72″E	28°13′15.53″N	302
Rewari	Bawal	Behrampur bharangi	76°31′12.85″E	28°5′25.09″N	281
Rewari	Jatusana	Kanhori	76°36′11.02″E	28°24′49.75″N	253
Rewari	Rewari	Ghurkawas	76°37′25.09″E	28°15′20.99″N	266
Rewari	Dharuhera	Ghatal mahaniawas	76°49′48.02″E	28°14′7.53″N	285

Table 2: Checklist of species of family Fabaceae in community forests of South Haryana.

Species	Habit	Lifeform	Sub family	Tribe
Abrus precatorius L.	C	Ph	Papilionoideae	Abreae
Acacia auriculiformis A. Cunn. ex Benth.	T	Ph	Caesalpinioideae	Acacieae
Albizia lebbeck Benth.	T	Ph	Caesalpinioideae	Ingeae
Albizia procera (Roxb.) Benth.	T	Ph	Caesalpinioideae	Ingeae
Alhagi maurorum Medik.	H	He	Papilionoideae	Phaseoleae
Alysicarpus bupleurifolius (L.) DC.	H	Th	Papilionoideae	Desmodieae
Alysicarpus monilifer (L.) DC.	H	Th	Papilionoideae	Desmodieae
Alysicarpus rugosus (Willd.) DC.	H	Th	Papilionoideae	Desmodieae
Alysicarpus tetragonolobus Edgew.	H	Th	Papilionoideae	Desmodieae
Alysicarpus vaginalis (L.) DC.	H	Th	Papilionoideae	Desmodieae
Bauhinia purpurea L.	T	Ph	Cercidoideae	Cercideae
Bauhinia variegata L.	T	Ph	Cercidoideae	Cercideae
Butea monosperma (Lam.) Kuntze	T	Ph	Papilionoideae	Phaseoleae
Cajanus scarabaeoides (L.) Thouars	S	Th	Papilionoideae	Phaseoleae
Cassia fistula L.	T	Ph	Caesalpinioideae	Cassieae
Clitoria ternatea L.	C	Th	Papilionoideae	Phaseoleae
Crotalaria burhia Buch-Ham. ex Benth.	H	Th	Papilionoideae	Crotalarieae
Crotalaria juncea L.	H	Th	Papilionoideae	Crotalarieae
Dalbergia sissoo Roxb. ex DC.	T	Ph	Papilionoideae	Dalbergieae
Delonix regia (Bojer ex Hook.) Raf.	T	Ph	Caesalpinioideae	Cassieae
Erythrina suberosa Roxb.	T	Ph	Papilionoideae	Phaseoleae
Erythrina variegata L.	S	Ph	Papilionoideae	Phaseoleae
Grona triflora (L.) H.Ohashi & K.Ohashi	H	Th	Papilionoideae	Desmodieae
Indigofera colutea (Burm.f.) Merr.	S	Th	Papilionoideae	Genisteae
Indigofera cordifolia B.Heyne ex Roth	H	Th	Papilionoideae	Genisteae
Indigofera hirsuta L.	H	Th	Papilionoideae	Genisteae
Indigofera linifolia (L.f.) Retz.	H	Th	Papilionoideae	Genisteae
Indigofera linnaei Ali	H	Th	Papilionoideae	Genisteae
Indigofera oblongifolia Forssk.	H	Th	Papilionoideae	Genisteae
Indigofera tinctoria L.	H	Th	Papilionoideae	Genisteae
Indigofera uniflora Buch.-Ham. ex Roxb.	H	Th	Papilionoideae	Genisteae
Parkinsonia aculeata L.	T	Ph	Caesalpinioideae	Mimoseae
Lathyrus aphaca L.	H	Th	Papilionoideae	Fabeae
Leucaena leucocephala (Lam.) de Wit.	S	Ph	Caesalpinioideae	Mimoseae
Macroptilium lathyroides (L.) Urb.	C	Th	Papilionoideae	Phaseoleae
Medicago polymorpha L.	H	Th	Papilionoideae	Trifolieae
Medicago sativa L.	H	Th	Papilionoideae	Trifolieae
Melilotus albus Medik.	H	Th	Papilionoideae	Trifolieae
Melilotus indicus (L.)All.	H	Th	Papilionoideae	Trifolieae
Neltuma juliflora (Sw.) Raf.	T	Ph	Caesalpinioideae	Mimoseae
Pithecellobium dulce (Roxb.) Benth.	T	Ph	Caesalpinioideae	Ingeae
Pongamia pinnata (L.) Pierre	T	Ph	Papilionoideae	Millettieae
Prosopis cineraria (L.). Druce	T	Ph	Caesalpinioideae	Mimoseae
Rhynchosia minima (L.) DC.	C	Ch	Papilionoideae	Phaseoleae
Rhynchosia arufescens DC.	S/C	Ch	Papilionoideae	Phaseoleae
Senna auriculata (L.) Roxb.	S	Ch	Caesalpinioideae	Cassieae
Senna occidentalis (L.) Link	H	Ch	Caesalpinioideae	Cassieae
Senna siamea (Lam.) H.S.Irwin & Barneby	T	Ph	Caesalpinioideae	Cassieae
Senna tora (L.) Roxb.	H	Ch	Caesalpinioideae	Cassieae
Sesbania bispinosa (Jacq.) W.Wight	S	Th	Papilionoideae	Sesbaniieae

Table 2: Continue....

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Tamarindus indica L.	T	Ph	Detariodeae	Detarieae
Tephrosia falciformis Ramaswami	H	Ch	Papilionoideae	Millettieae
Tephrosia purpurea (L.) Pers.	H	Ch	Papilionoideae	Millettieae
Tephrosia strigosa (Dalzell) Santapau & Maheshw.	H	Ch	Papilionoideae	Millettieae
Tephrosia villosa (L.) Pers.	S	Ch	Papilionoideae	Millettieae
Trifolium alexandrinum L.	H	Ch	Papilionoideae	Trifolieae
Trifolium fragiferum L.	H	Ch	Papilionoideae	Trifolieae
Vachellia leucophloea (Roxb.) Maslin, Seigler & Ebinger	T	Ph	Caesalpinioideae	Acacieae
Vachellia nilotica (L.) Willd. ex Del.	T	Ph	Caesalpinioideae	Acacieae
Vachellia tortilis (Forssk.) Galasso & Banfi	T	Ph	Caesalpinioideae	Acacieae
Vicia hirsuta (L.) Gray	H	Th	Papilionoideae	Fabeae

Habit:- Herb (H); Shrub (S); Climber (C); Tree (T).

Life form: Phanerophytes (Ph); Chamaephytes (Ch); Hemicryptophytes (H); Therophytes (Th).

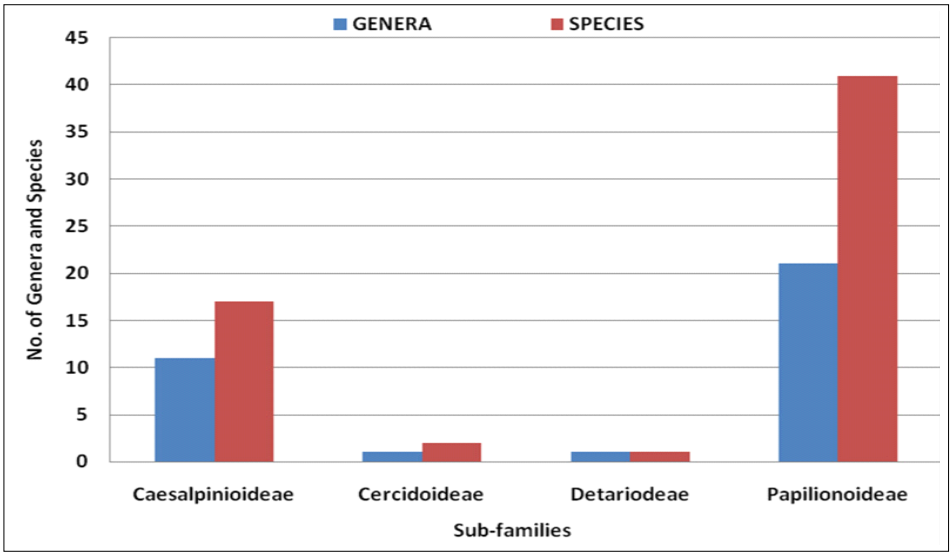


Fig 2: Sub families, genera and species of fabaceae.

Table 3: Sub-families and tribes of fabaceae.

Sub-family	No. of tribes
Caesalpinoideae	04
Cercidoideae	01
Papilionoideae	10
Detarieae	01
Total	16

Many plant species belonging to family Fabaceae are used for numerous purposes. Pandey and Kumar (2024) reviewed the diversity of grain legumes of Himalayan region of Uttarakhand of India and highlighted their importance in meeting protein and micronutrient security. Jahan and Rahaman (2022) investigated that out of 254 species of family Fabaceae, 169 species belonging to 61 genera possessed therapeutic potential. Jat *et al*. (2024) reviewed the bioactive compounds and their potential uses of legume crops. Singh *et al*. (2024) evaluated the antimicrobial and antioxidant properties of *Trigonella foenum-graecum* concluded that it oil has good pharmacological potential.

The subfamily Papilionoideae is the most species-rich, comprising 10 tribes, 21 genera (63%) and 41 species (67%). This is followed by Caesalpinioideae, which includes 4 tribes, 11 genera (32%) and 17 species (28%). Cercidoideae is represented by single tribe and one genera (2.9%) and two species (3%), while Detaroideae consists of single tribe, single genus (2.9%) and single species (1.6%) (Fig 2). According to the classification of global legumes by Lewis *et al*. (2005), a total of 36 tribes have been identified, out of which 16 tribes (44.44% of the total) are found in the Community Forests of south, Haryana.

Phaseoleae is the largest tribe with 9 genera and 7 species, followed by Mimoseae with 4 genera and 4 species, Cassieae and Trifolieae both with 3 genera, 6 species, Acacieae with 3 genera and 5 species. Desmodieae, Fabeae, Ingeae and Millettieae are represented by 2 genera each and 6 spp, 2 spp, 3 spp and 5 spp. respectively. Tribe Genisteae represented by one genus and 8 species,

Cercideae and Crotalarieae with one genus and 2 species each while tribe Abreae, Dalbergieae, Detarieae and Sesbaniieae with one genera and one species each (Fig 3).

At the genus level, *Indigofera* emerges as the largest, comprising of 8 species. It is followed by *Alysicarpus* with 5 species and *Senna* and *Tephrosia* with 4 species each while *Vachellia* with 3 species; *Bauhinia, Crotolaria*, *Albizia, Erythhrina, Medicago, Melilotus, Rhynchosia* and *Trifolium* with 2 species each. The remaining 21 genera are represented by a single species (Fig 4).

Table 4: Life form composition of the enumerated species.

Life forms	No. of species	Life form (%)
Phanerophytes (Ph)	22	36
Chamaephytes (Ch)	11	18
Hemicryptophytes (H)	01	02
Therophytes (Th)	27	44

Life forms

Life forms are a vital aspect of understanding vegetation, offering an initial insight into its ecological characteristics (Mueller-Dombois and Ellenberg, 1974). Raunkiaer (1934) classified plants into five main life forms-Phanerophytes (Ph), Chamaephytes (Ch), Hemicryptophytes (H), Cryptophytes (Cr) and Therophytes (Th). The results revealed that the Therophytes consisting of 27 species representing (44%) of total species was dominant life form followed by Phenerophytes with 22 species representing (36%), Chamaephytes 11 species (18%) and Hemicryptophytes

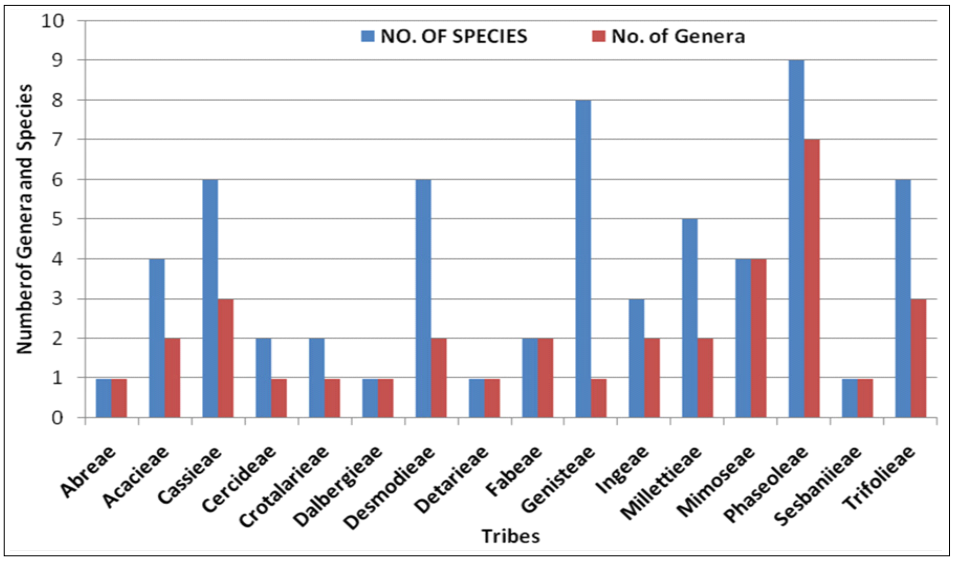


Fig 3: Tribes wise distribution of genera and species.

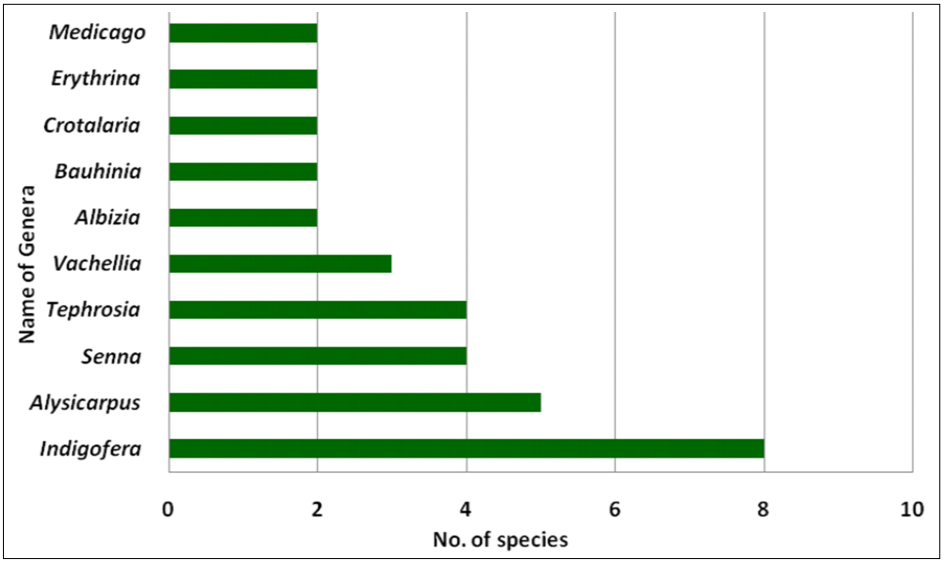


Fig 4: Top ten genera of family fabaceae.

Table 5: Number of species of each genus in the Fabaceae family.

Genus	No. of species (ni)	(n-1)	ni (ni-1)
Abrus	1	0	0
Acacia	1	0	0
Albizia	2	1	2
Alhagi	1	0	0
Alysicarpus	5	4	20
Bauhinia	2	1	2
Butea	1	0	0
Cajanus	1	0	0
Cassia	1	0	0
Clitoria	1	0	0
Crotalaria	2	1	2
Dalbergia	1	0	0
Delonix	1	0	0
Erythrina.	2	1	2
Grona	1	0	0
Indigofera	8	7	56
Pakinsonia	1	0	0
Lathyrus	1	0	0
Leucaena	1	0	0
Macroptilium	1	0	0
Medicago	2	1	2
Melilotus	2	1	2
Mimosa	1	0	0
Neltuma	1	0	0
Pithecellobium	1	0	0
Pongamia	1	0	0
Prosopis	1	0	0
Rhynchosia	2	1	2
Senna	4	3	12
Sesbania	1	0	0
Tamarindus	1	0	0
Tephrosia	4	3	12
Trifolium	2	1	2
Vachellia	3	2	6
Vicia	1	0	0
	61		122

with only one species (2%) (Table 4). The Therophytes life forms indicate the typical desert vegetation in this region.

Species diversity of fabaceae

Species level measurement of biodiversity is necessary to evaluate the ecosystem stability, sustainability and productivity for maintaining balance in any ecosystem (Ardakani, 2004). The local diversity can be evaluated with the help of various mathematical tools (Eshaghi, 2009) and Simpson (1949). The species richness is widely used for assessment of plant diversity of particular area or region. The value of Simpson's index is denoted by "D" which range between 0 and 1. When the value is closer to 1, it represent more diversity and value closer to 0 shows less diversity (Ket, 2012). It simply means that as species richness and evenness increases, the diversity increases. The Simpson's Index is calculated by the following formula:

$$\text{Simpson's diversity index (D)} = 1 - \frac{\Sigma \text{ ni (ni-1)}}{\text{N (n-1)}}$$

Where,

N = The total number of all species in Fabaceae family.

ni = The number of species of each genus.

The diversity score of the Fabaceae family is given in Table 5.

Simpson's Diversity Index (D) is calculated as under-

Σni (ni-1) = 2+ 20+2+2+2+56+2+2+2+12+12+2+6 = 122

N (N-1) = 61 (61-1) = 3660

Simpson's Diversity index = 1- (122/ 3660)

= 1- 0.0333

= 0.967

Thus, the Sampson's diversity index revealed that the family Fabaceae has high diversity in the study area.

CONCLUSION

The community forests of south Haryana are rich reserviour of legumes. Total 61 species belonging to 34 genera and 16 tribes were reported from this region. The Sampson's Index also revealed that the Fabaceae has a high diversity in the study area. The high proportion of herbaceous growth form indicates harsh dry climatic conditions of the area. Therophytes lifeform displayed the maximum of species which also indicate the arid climatic conditions. Though these community forests serve as local mini biodiversity hubs but now-a-days, the floristic diversity in these ecosystems is under severe pressure from many natural and anthropogenic factors. The immediate attention is needed to conserve and protect these unique ecosystems to provide various goods and services to the local communities in perpetuity.

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Author's contribution statement

K.C. Meena: investigation, methodology, writing-original draft, field-studies; S.S. Yadav: conceptualization, data analysis; methodology, investigation, resources, writing-review and editing; Neetu Singh: Writing-review and editing; Makhan Singh and Pradeep Bansal: species identification, field studies data curation.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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