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Floristic structure, composition and regeneration status of medicinal plants in Kalbetta State Forest, Mysuru, Karnataka

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Abstract
Tropical forests are rich repositories of medicinal plants and are known for their diverse use. Medicinal plants used in industries as raw materials are mainly collected from forests, cultivated lands, home gardens, waste lands and open spaces. Tremendous pressure on these forests to collect medicinal plants for herbal medicines has led to their substantial depletion. The present study aims at assessing the structure, composition, regeneration status. Utility index of the medicinal plants based on their usage has also been analyzed. Present study indicated a Shannon diversity index of 3.23 for trees and 3.427 for shrubs. Temporal Shannon diversity index among the regeneration showed a higher diversity in Post monsoon season with 4.066 followed by monsoon with 3.898 and summer with 3.893. Dominant species with higher Importance value index were *Eucalyptus tereticornis, Anogeissus latifolia, Chloroxylon swietenia, Cassia siamea, Erythroxylon monogynum*. Utility index showed the dominance of herbaceous species over that of shrubs and trees.

Keywords: medicinal plants, diversity, IVI, utility index, kalbetta

Introduction
The forests are the rich repositories of medicinal plants [1, 2]. Since times immemorial plants have played very important role as medicines. The medicinal plants are an integral part of the Indian traditional healthcare systems. Substantial increase in the use of herbal medicine is seen during recent times [3, 4]. Nearly 80% of the people in the developing countries use medicinal plants for their primary health care [4, 5, 6, 7]. Most of these plants which are used in industries are collected from forests, cultivated lands, home gardens, waste lands and open spaces [9, 10, 11]. Around 560 plant species from India have been listed in the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened species, among these 247 species are in threatened category [12].

There is tremendous pressure on the forests to collect the medicinal plants as raw materials for herbal medicines leading to substantial depletion of medicinal plants [3, 13, 14]. There are umpteen attempts to preserve the medicinal plant rich areas in the forests. The declaration of medicinal plants conservation areas in Karnataka is one such example [15]. In order to meet the demands of the growing herbal medicinal market, there is utmost need to explore and record the availability of medicinal flora in the forest [16]. It is very much essential to survey and record the occurrence of these plants in each of the recorded forest area and this study is such an attempt to know the occurrence, distribution and diversity of these plants in Kalbetta State forest.

Most of the medicinal plants are herbaceous and are seasonal in nature leading to variation in their population at a given point of time. Periodical assessment and conservation of these species is very much essential to build a database on the availability of these species.

The Kalbetta State Forest has rich floral diversity in terms of the family, genera and species [17, 18]. As goes the saying that there is no species without any medicinal value, most of the species found during the study have medicinal properties as per the literature. Hitherto no studies have been under taken on the availability of medicinal plants in the study area. Therefore, this is the pioneering study to survey, document and quantify the availability of medicinal plants.

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Materials and Methodology
Study area
Kalbetta State Forest is located in the Hunsur taluk of Mysuru district in Karnataka, India lies geographically between 76°14'13" E 12°19'14" N and 76° 15'16" E 12°17'29"N geographically (Fig 1) with an elevation range of 840m – 905m MSL and an annual rainfall of 700 to 950 mm. Kalbetta State Forest is classified under Tropical Thorn/ Scrub [19] with an area of of 518.92acres surrounded by agricultural fields all around
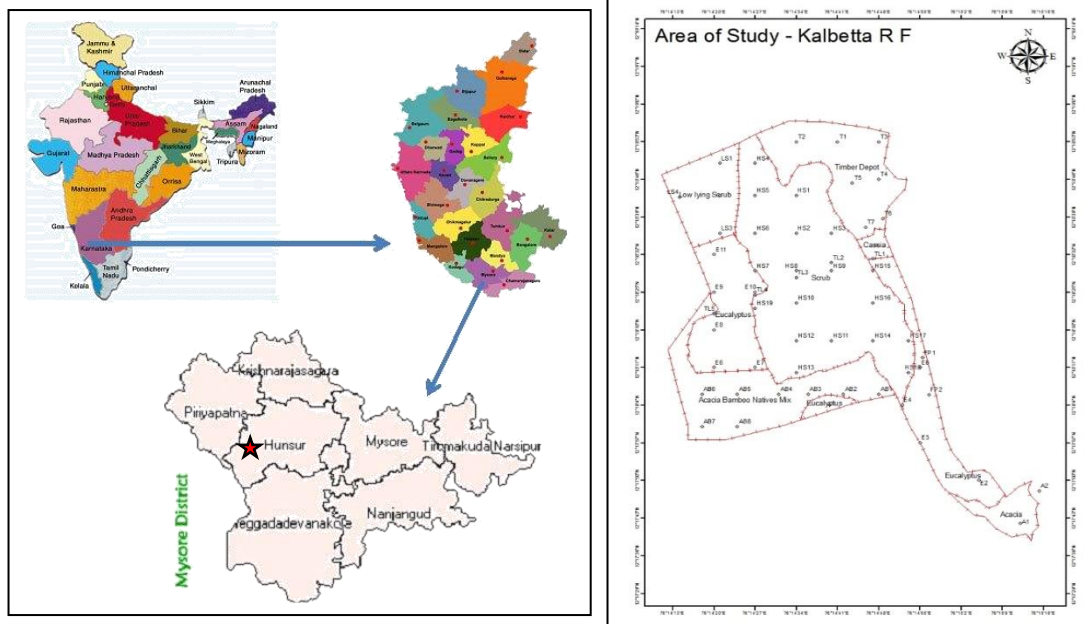
Fig 1: Geographical locations of Kalbetta State Forest

Methodology
A systematic floristic survey was carried out with reference to medicinal plants for over a period of 2 years in 3 different seasons. The sampling method used was stratified sampling with a sampling intensity of 1%. Based on the species area curve method, 57 sample plots of 20x20m dimension were laid for trees using GIS technology (Fish net). Within each of the main plot, three subplots of 5mx5m were laid diagonally for shrubs. Nested plots of 1mx1m subplots (5) were laid within the main plot for regeneration study. Trees >10cm Girth at Breast Height (GBH), shrubs above 1 m in height and regeneration below 1m height were enumerated.

Herbarium specimens along with the photographs of species were prepared and the species identification was done based on the morphological characters using field keys from the floras [20, 21, 22, 23, 24, 25, 26]. Based on the literature survey, the species were recorded for the medicinal usage [21, 26]. Phyto-sociological classification was carried using various floras [20, 23, 25, 28]. Field utility Index was calculated based on the medicinal utility of different plant parts. Appropriate equal weightage was given to each of the plant part used in medicine preparation

In order to know the relationships existing between the species of a community or between the communities, the indices like Shannon-wiener index and Simpson index was calculated.

Shannon-Wiener diversity index (H'): H' = -$\sum \left(\frac{ni}{N}\right) \ln(ni/N)$

where, ni is the total number of individuals of a species and N is the total number of individuals of all species in that vegetation type.

Simpson's index (D): Simpson index (D) = -$\sum (ni/N)^2$

Where, ni and N are the same as those for the Shannon-wiener information function.

Importance Value Index: IVI = Relative Frequency + Relative density + Relative Dominance.

Apart from the above, Girth class and Height class distribution among the tree individuals were analyzed. IUCN status was verified for all the species.

Plant part medicinal utility index: Considering the utility of the plant part used like Leaf/ buds, Bark/ Gum, Root/ Tuber/ rhizome, shoots/ stem, flowers, fruits / seeds in medicine, Plant Part medicinal utility index (PPMUI) was generated which is similar to the Food significance index [29]. Here each of the plant part having medicinal value is assigned with a weightage of numerical value of 1. The PPUI of a particular species is derived as an average weightage of the number of plant parts used.

PPMUI = Number of parts used / Total number of parts.

Plants recorded were screened for their medicinal uses through literature survey.

Results
Species richness: The study showed Kalbetta hosted a higher floristic richness in terms of trees, shrubs, herbs and climbers. An overall estimation showed that the study area comprised of 247 species with medicinal use belonging to 195 genera and 67 families which show rich diversity among species.

The top ten families in terms of percentage of species in each family are shown in Table 1 in the descending order.

The results showed that higher percentage of species are represented by Leguminosae family with 16.60% followed by Malvaceae 7.69%, Compositae 6.48%, Rubiaceae 6.48%, Apocynaceae 6.07%, Phyllanthaceae 4.05%, Poaceae 4.05%, Acanthaceae 3.24%, Euphorbiaceae 2.83% and Lamiaceae 2.83%.

Table 1: Top Ten families of species representation in the study area

Family	% of Species	Total Species count
Leguminosae	16.60	41
Malvaceae	7.69	19
Compositae	6.48	16
Rubiaceae	6.48	16
Apocynaceae	6.07	15
Phyllanthaceae	4.05	10
Poaceae	4.05	10
Acanthaceae	3.24	8
Euphorbiaceae	2.83	7
Lamiaceae	2.83	7

Diversity analysis
Data when subjected to different diversity analysis for each of the habit showed a higher diversity. Shannon Diversity for trees showed 3.23 which are comparatively higher [30] for scrub and thorny forest. Simpsons index with 0.06 and Simpsons Index of diversity of 0.939.
Shannon Diversity for shrubs showed 3.427 and the corresponding values of Simpsons index with 0.05 and Simpsons Index of diversity of 0.939.

Table 2: Diversity indices in the study area

Habitat	Season	Shannon Index	Simpson's Index	Simpsons Index of Diversity
Trees		3.23	0.06	0.939
Shrubs		3.427	0.05	0.95
Regeneration	Summer	3.893	0.031	0.969
	Monsoon	3.898	0.033	0.967
	Post Monsoon	4.066	0.029	0.97

Shannon Diversity for regeneration plots showed higher diversity in Post monsoon with 4.066 followed by monsoon season with 3.898, summer with 3.893.
Simpson's index for regeneration plots too showed a higher diversity in post monsoon season with 0.029 followed by monsoon with 0.033, summer with 0.031
Simpson's index for regeneration plots too showed a higher diversity in post monsoon season with 0.97 followed by summer with 0.969, monsoon with 0.967.
Importance Value Index (IVI): Top 15 species having high importance value are indicated with respective Basal area and Volume (Table 3)

Table 3: Top 15 Tree species with medicinal value.

Species	Family	Basal Area m²	Volume m³	IVI
Eucalyptus tereticornis	Myrtaceae	2.64	12.62	28.27
Anogeissus latifolia	Combretaceae	0.53	0.68	18.32
Acacia chundra	Leguminosae	1.07	2.40	17.68
Chloroxylon swietenia	Rutaceae	1.04	2.00	17.19
Cassia siamea	Leguminosae	1.55	4.42	16.94
Erythroxylum monogynum	Erythroxylaceae	0.30	0.41	9.88
Ziziphus mauritiana	Rhamnaceae	0.37	0.64	6.97
Canthium dicoccum	Rubiaceae	0.23	0.35	5.40
Delonix regia	Leguminosae	0.61	1.30	5.25
Boswellia serrata	Bursearceae	0.36	0.92	5.03
Tectona grandis	Lamiaceae	0.24	0.56	4.94
Strychnos potatorum	Loganiaceae	0.23	0.35	4.79
Ixora arborea	Rubiaceae	0.16	0.21	4.68
Santalum album	Santalaceae	0.12	0.22	4.44
Diospyros melanoxylon	Ebenaceae	0.16	0.20	4.16

Important value index showed *Eucalyptus tereticornis* as the dominant species among trees in the study area followed by *Anogeissus latifolia, Acacia chundra, Chloroxylon swietenia,* *Cassia siamea, Erythroxylon monogynum, Ziziphus mauritiana, Canthium dicoccum, Delonix regia, Boswellia serrata, Tectona grandis, Strychnos potatorum, Ixora arborea, Santalum album, Diospyros melanoxylon and so on.* Presence of *Eucalyptus tereticornis* in higher numbers indicates the plantation activity carried out extensively in selected areas. The composition of other native species put together forms a larger tree strata found widely distributed in the hillock and low-lying areas.

IUCN category: By identifying, analyzing and establishing the vulnerable species which are more prone to extinction in the study area, it becomes imperative to formulate the conservation strategies. In the present study data was analyzed by consulting the available literature on the vulnerability, rarity, threatened and endangered status of the species. The data showed 13 species was recorded under Vulnerable and 1 species recorded were near Threatened (Table 4).

Table 4: Species characterized under IUCN categories.

IUCN Category	Species count
Near Threatened	1
Vulnerable	13

Vulnerable species as recorded in the study area are *Acacia ferruginea, Andrographis serpyllifolia*, *Canthium dicoccum*, *Chloroxylon swietenia*, *Dalbergia latifolia*, *Evolvulus alsinoides, Gardenia gummifera, Gloriosa superba, Gmelina arborea, Gymnema sylvestre, Randia dumetorum, Santalum album* and *Terminalia chebula*. Species which is associated with near threatened category as per IUCN is *Pterocarpus marsupium.*

Regeneration Status
Top 10 tree species in terms of count found in the sample plots were *Anogeissus latifolia* (14.14%), *Acacia chundra* (9.30%), *Chloroxylon swietenia* (9.00%), *Erythroxylon monogynum* (7.50%), *Eucalyptus tereticornis* (7.50%), *Cassia*

siamea (4.75%), *Ziziphus mauritiana* (4.10%), *Canthium dicoccum* (3.60%), *Santalum album* (3.50%) and *Ixora arborea* (3.40%).

Top 10 species within shrub plots represented in terms of count found in the sample plots were *Lantana camara* (11.24%), *Dodonaea viscosa* (8.64%), *Chomelia asiatica* (8.53%), *Erythroxylon monogynum* (6.14%), *Randia dumetorum* (5.72%), *Anogeissus latifolia* (5.62%), *Ixora arborea* (5.62%), *Ziziphus rugosa* (3.75%), *Jasminum rottlerianum* (3.64%) and *Santalum album* (3.12%).

In the regeneration plots, the status of trees, shrubs and herbs is as follows:

Trees: *Ixora arborea* (2.35%), *Erythroxylon monogynum* (1.58%), *Acacia chundra* (1.32%), *Maytenus emarginata* (1.26%), *Ziziphus mauritiana* (1.17%), *Chloroxylon swietenia* (0.95%), *Acacia sinuata* (0.95%), *Randia dumetorum* (0.80%), *Ziziphus rugosa* (0.78%) and *Flacourtia indica* (0.66%).

Shrubs: *Chomelia asiatica* (4.28%), *Lantana camara* (3.58%), *Dodonaea viscosa* (2.96%), *Jasminum pubescens* (1.93%), *Chromolaena odorata* (1.79%), *Pterolobium indicum* (1.69%), *Breynia vitis-idaea* (0.97%), *Jasminum rottlerianum* (0.70%), *Asparagus racemosus* (0.53%) and *Secamone emetica* (0.47%).

Herbs: *Heteropogon contortus* (5.41%), *Hemidesmus indicus* (4.90%), *Mitracarpus verticillatus* (4.49%), *Stachytarpheta indica* (4.38%), *Heliotropium supinum* (3.85%), *Evolvulus alsinoides* (3.64%), *Blepharis maderaspatensis* (3.46%), *Atylosia scarabaeoides* (3.25%), *Toddalia asiatica* (2.08%) and *Sopubia delphinifolia* (2.00%).

the domination of *Anogeisus latifolia* in the top position where as it does not find a place among the top 10 species of trees in the regeneration plots. *Ixora arborea* which occupies the tenth position in tree plots occupies top position in the regeneration plots which is a positive indication of its spread.

It is observed that few species like *Maytenus emarginata, Acacia sinuata, Randia dumetorum, Ziziphus rugosa* and *Flacourtia indica* which did not find a place in the top 10 dominant tree species appear abundantly in the regeneration plots indicating the pattern of succession.

The general distribution of Shrub species in sample plots shows the domination of *Lantana camera* in the top position where as it occupies the second position among the top 10 species of shrubs in the regeneration plots. *Chomelia asiatica* which occupies the third position in shrub plots occupies top position in the regeneration plots which is a positive indication of its spread. It is observed *Toddalia asiatica* which was found in the top ten dominant species in shrub plots did not appear among the top ten species of regeneration plots and interestingly *Secamone emetica* which was not found among the top 10 species in shrub plots appeared among the top 10 species of regeneration plots.

In the regeneration plots, the distribution of herb species is dominated by *Heteropogon contortus* (5.41%) followed by *Hemidesmus indicus* (4.90%), *Mitracarpus verticillatus* (4.49%), *Stachytarpheta indica* (4.38%), *Heliotropium supinum* (3.85%), *Evolvulus alsinoides* (3.64%), *Blepharis maderaspatensis* (3.46%), *Atylosia scarabaeoides* (3.25%), *Toddalia asiatica* (2.08%), *Opuntia delphinifolia* (2.00%) and so on.

Discussion

The general distribution of tree species in sample plots shows

Plant part medicinal utility index: plant species

Table 5: Top 15 species having higher Plant part medicinal utility Index A-Leaf/buds; B-Bark/ Gum; C-Root / Tuber/ rhizome; D-Shoots / Stem; E-Flowers; F-Fruit/ Seeds

Species	Family	A	B	C	D	E	F	Index	Medicinal uses
Hedyotis pumila L.f.	Zingiberaceae	1	1	1	1	1	1	1	Eye diseases, treatment of sprains
Achyranthes aspera L.	Amaranthaceae	1	1	1	1	1	1	1	hemorrhoids, indigestion, cough, asthma
Barleria prionitis L.	Acanthaceae	1	1	1	1	1	1	1	fever, respiratory diseases. Toothache
Bidens pilosa L.	Compositae	1	1	1	1	1	1	1	antibacterial, hepato protective
Hybanthus enneaspermus (L.) F.Muell.	Violaceae	1	1	1	1	1	1	1	remedy for swellings, inflammations and for dry fevers
Securinega leucopyrus Brandis.	Euphorbiaceae	1	1	1	1	1	1	1	juice of the leaves used along with tobacco to destroy worms
Waltheria indica L.	Malvaceae	1	1	1	1	1	1	1	taken to relieve fevers, coughs, colds, bladder ailments
Ageratum conyzoides L.	Compositae	1	1	1	1	1		0.833	Nervous tonic, infusion used as diarrhea
Azadirachta indica A. Juss.	Meliaceae	1	1		1	1	1	0.833	antiviral, antifungal
Blepharis maderaspatensis (L.) B. Heyne ex Roth.	Acanthaceae	1	1	1	1	1		0.833	Anti-inflammatory, antioxidant, aphrodisiac, sore eyes
Cassia siamea Lam.	Leguminosae	1	1	1	1		1	0.833	fruit for intestinal worms, convolutions in children, laxative, analgesic and anti inflammatory
Diospyros malabarica (Desr.) Kostel.	Ebenaceae	1	1		1	1	1	0.833	Fruits and bark used in diarrhea, ulcers and wounds
Memecylon edule Roxb.	Melastomataceae	1		1	1	1	1	0.833	irregular menstruation, skin diseases, herpes to treat bruises
Vernonia cinerea (L.) Less.	Compositae	1		1		1	1	0.666	malaria, dysentery, astringent,
Abutilon inidcum (L.) Sweet.	Malvaceae	1	1	1	1			0.666	Aphrodisiac, laxative, diuretic
Adhatoda vasica Nees	Acanthaceae	1	1	1	1			0.666	leaves contain vasaka used in bronchial troubles, dysentery

Conclusion

The findings of the study showed the rich medicinal plant diversity of Kalbetta forests. The study showed substantial representation of the trees, shrubs, climbers and herbs which

are of high medicinal value. The diversity indices of all the three forms of the flora showed quite high values. The regeneration plots showed highest diversity during post monsoon season. The diversity during summer and monsoon

showed marginal variation. Periodical assessment and conservation of these species is very much essential to build a database on the availability of these species. These findings call for the adoption of proper and immediate strategies for the conservation of medicinal plants in Kalbetta State Forest. Further studies relating to the assessment of growth rate and sustainable harvesting methods of these invaluable medicinal resources could be initiated in order to fill the gaps in the pharmaceutical sector.

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