

Species diversity, biological spectrum and phenological behavior of vegetation of a Muslim sacred grove in Southwest Bengal, India

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Abstract. Sen UK, Bhakat RK. 2021. *Species diversity, biological spectrum and phenological behavior of vegetation of a Muslim sacred grove in Southwest Bengal, India. Nusantara Bioscience 13: 219-231.* Sacred groves are an age-old and worldwide phenomenon. They are traditionally made up of forest or surrounding forest zones that local people safeguard based on their spiritual relationship with the deities or ancestral spirits believed to reside in them. Social practices play a crucial role in conserving the environment and biodiversity. This research aimed to examine the current flora of a sacred grove's plant resources, biological spectrum, leaf size spectra, conservation status, and management of the Faringdanga Pir Babar Asthana in the Paschim Medinipur District of West Bengal in India. The floristic element of the study area revealed that the vegetation was diverse and composed of 162 species belonging to 148 genera over 51 families under 26 orders according to the Angiosperm Phylogeny Group (APG) IV classification. Because the study area is a sacred grove, it is relatively undisturbed, and traditional beliefs ensure that germplasm in the grove is protected. The current study could serve as a model for phytoclimatic research in India's sacred forests.

Keywords: APG IV, biodiversity conservation, biological spectrum, conserved community area, leaf spectra, life form.

INTRODUCTION

Sacred groves of sacred forests are natural forest patches preserved by local people's religious beliefs, and they serve as a treasure trove of animal and plant species (Parthasarathy and Babu 2021). Sacred groves are traditional resource systems associated with a culture-based conservation paradigm (Hailemariam 2019; Sen and Bhakat 2021b). Furthermore, sacred groves may play a role in conserving biological diversity, ecological functions, ecosystem services, and cultural diversity (Blicharska et al. 2013). A typical sacred grove can range from clumps of a few trees to a few hectares and is usually found near human settlements. Physically, it's a tiny or massive area of forested ground with a mosque inside, but culturally, it's linked to ancestral spirits, myths, rituals, and taboos (Singh et al. 2021). These crucial customary duties have long protected the integrity of sacred groves and appear to play an important role in biodiversity conservation (Aniah and Yelfaanibe 2016). Sacred groves are also known as natural museums of tall or massive trees, medicinal plant repositories, treasure houses of endangered species, urban recreation centers, watershed regulators, a veritable garden for botanists, gene banks of economically important species, environmental laboratories, and ideal places for nature lovers (Parthasarathy and Babu 2021). Biological Diversity Act 2002 has provided legal provisions for conserving significant areas from a biodiversity point of view, as are critical cultural spaces such as sacred groves/trees and sites or other large community conserved areas (NBA 2021). In this regard, the Government of West Bengal has declared Chilkigarh Kanak Durga Sacred Grove, a 55.9 acres remnant forest patch in the Jhargram

District of West Bengal, as a Biodiversity Heritage Site (NBA 2021; WBBB 2021).

Climate determines the types of plants that can thrive in each habitat, and physiognomy refers to the overall appearance of vegetation. It describes the general structure, shape, and life forms of the species that make up the vegetation; physiognomy has been used to classify vegetation types (Hunter et al. 2021). The individual species in a community can be categorized into numerous life forms based on their physiognomy appearance and growth performance. The vegetation's life form is determined by its genetic pool and tolerance for climatic fluctuation. Biological spectra are also essential physiognomic features employed extensively in vegetation study. The spectrum of life forms is thought to be markers of micro and macroclimate (Khan et al. 2018). Leaf size groups, likewise, have been discovered to be highly effective for connections. Knowing leaf size may aid in studying plant physiological processes and communities (Nicotra et al. 2011). The literature on Paschim Medinipur district plant ecology reveals relatively little research on vegetation analyses, life forms, and leaf size spectrum. The method of Raunkiaer (1934) explains and aids in comprehending vegetative flora and structure in connection to current eco-biological conditions. It also represents the impact of contemporary biotic factors on the overall structure and composition of the vegetation, such as overgrazing, overharvesting, and deforestation. In addition, it has various effects on the economic worth of plants. Therefore, these methods can create a sustainable and profitable management plan for plant resource harvesting.

In light of the applications mentioned above for Raunkiaer's concepts, the present effort was started with the

goal of (1) determining variation in life form and leaf size spectra in different plant communities from various climatic zones; (2) Based on the species list, analyze the Raunkiaerian spectra, and (3) elucidate the relationship between vegetation and religious gradient in the study area. Furthermore, the impact of anthropogenic activities and environmental factors on the observed patterns is also discussed.

MATERIALS AND METHODS

Location of the study site and physiography

Consisting of mixed vegetation of deciduous, semi-deciduous, and evergreen species, the present sacred grove (latitude 22°26'45.56''N-22°26'40.92''N and longitude 87°19'02.52''E-87°19'01.15''E; average altitude 52 m asl), popularly known as Faringdanga Pir Babar Asthana (named after its adjacent locality and presiding saints Hazarat Golap Shah and Hazarat Jamaluddin Shah) is situated at the northern part of the Paschim Medinipur District, West Bengal, India. The grove is positioned neighboring Abas Khasjantal Cantonment under the Midnapore Sadar block in the Paschim Medinipur district along the Jharkhand state's border area. It is bordered on the north by the Purulia and Bankura districts and on the west by the district of Jhargram. It has widespread borders with the state of Orissa on the south and the west by the Jharkhand state (Figure 1). The climate is subtropical and

humid. In the hot and dry days of May and June, temperatures can reach 46° C, but on the chilly nights of December and January, it can fall to 8° C.

The district of Paschim Medinipur under the Chota Nagpur Plateau covers an area of 6,308 km². It has a population of 5,913,457 per the 2011 census, with 87.78% of the total population being rural and only 12.22% being urban. The 2011 census showed that 19.07% and 14.88% of the population belonged to the scheduled castes and tribes, respectively (Anon 2011).

This 6-hectare grove represents several chunks of a 300-500 year isolated forest patch in its near-climax stage and is bounded by abandoned fields. The Sufi saints Hazarat Golap Shah and Hazarat Jamaluddin Shah (believed to be offsprings of Hazarat Mohammed) stayed and practiced religious rituals in the mosque's area; after his death, his mortal body was buried in the said mosque. During the Urus-pak festival (on 22/23rd February and 17/18th July, devotees pray to the saints and seek blessing and well-being). Presently, the entire grove is maintained and managed by the descendants of the saints. The whole geographical area and its biotic and abiotic elements are revered. There is a social prohibition on cutting any plant specimen and even lifting leaf litter from the grove is a taboo. To celebrate the worship, devotees collect money and other utensils from everywhere throughout the neighboring areas of the region. The local communities maintain the sanctity of the whole area.

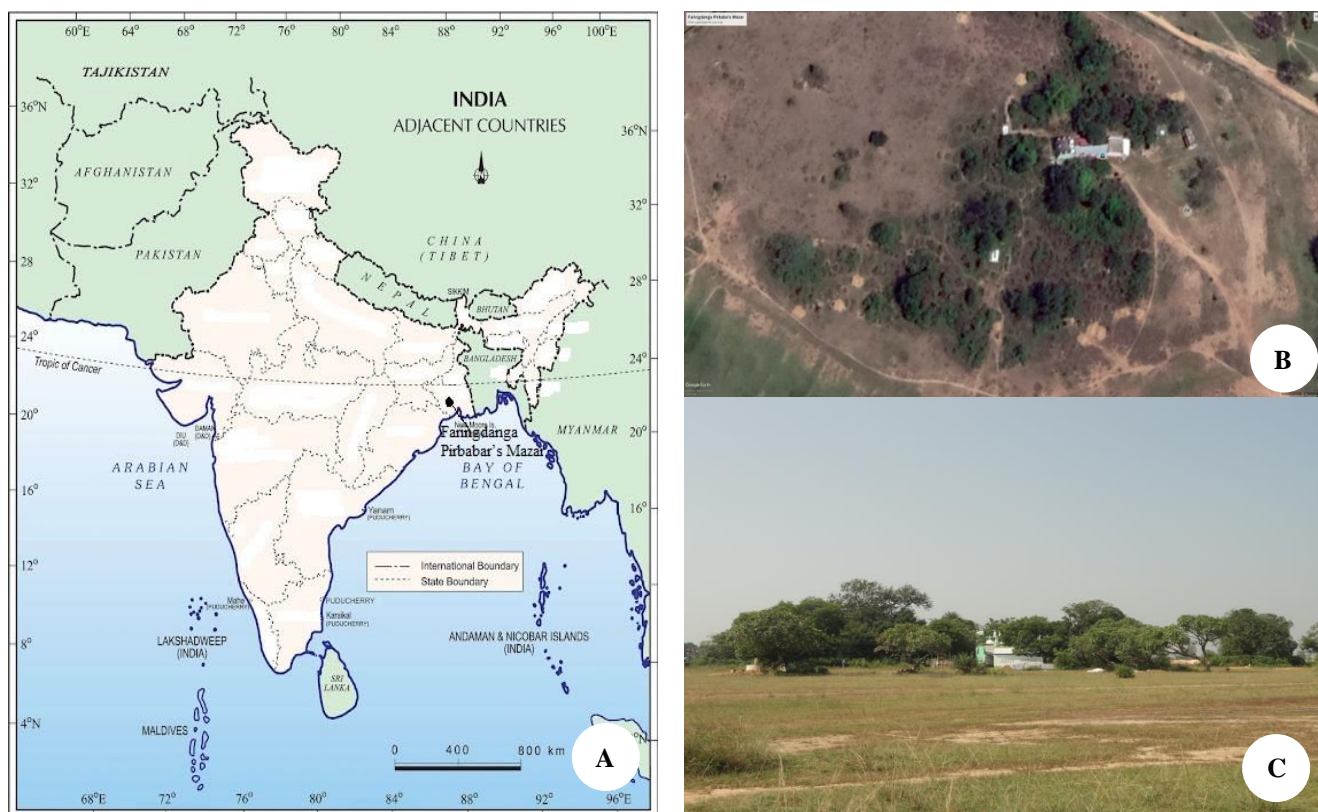


Figure 1. Location of the study area in Paschim Medinipur District, West Bengal, India: A. Faringdanga Pirbabar Mazar in West Bengal of India; B. Google Earth image of the study area; C. Faringdanga Pirbabar Mazar sacred grove in West Bengal of India

Field survey and data collection

Before the field survey, thorough permission was taken from Faringdanga Pir Babar Asthana sacred grove management to study and collect plant samples. The study area was thoroughly investigated during the year 2012-2018 in different seasons. It presented a prospect of composting plant compilation and field interpretation during the entire flowering and fruiting of the maximum species quantity. Phytosociological data were collected by laying 20m×20m quadrates for tree species, 5m×5m for shrubs and lianas, and 1m×1m for herbs and grasses. Based on "spot identification," a brief floristic study was conducted. The specimens were processed, poisoned, mounted on herbarium sheets, and preserved in Vidyasagar University's Herbarium. Photographs of some common, locally uncommon, endemic, and valuable plants in the sacred grove were taken. The herbarium sheets were checked with annotated materials available at Vidyasagar University's Herbarium Section and the Botanical Survey of India. Various related catalogs, regional flora (Prain 1903), monographs, revision works, and other literature (Paria 2005; Anon 2010) have been consulted for identification purposes. The plant's scientific name was checked with the World Checklist of Vascular Plants (WCVP 2021) website, and only the accepted names were used.

Analysis of vegetation

According to the Angiosperm Phylogeny Group (APG) IV classification, the floristic list was taxonomically arranged by clade, order, and family according to Angiosperm Phylogeny Group (APG) IV classification (Chase et al. 2016). For each species, several voucher specimens, habit, life span, nativity, flowering and fruiting time, Raunkiaer's life form with sub-type, leaf spectra, the lamina shape, IUCN status (IUCN 2021), and plant growing seasons were inferred (Table 1). The resulting biological spectrum was then compared to Raunkiaer's standard spectrum to identify the grove's phytoclimate (Raunkiaer 1934; Mueller-Dombois and Ellenberg 1974). Leaf size information was employed to assess plants' physiological systems and identify plant associations. The Raunkiaer (1934) figure was used to estimate the number of leaves in the field. Finally, a list of invasive alien species was prepared according to Reddy et al. (2008).

RESULTS AND DISCUSSIONS

Taxonomic composition

A total of 162 taxa belonging to 148 genera distributed in 51 families from 26 orders were recorded from the sacred grove. The top two clades were Asterids and Rosids. More than 79% of the flora was represented by Eudicot and Core Eudicot orders. The most represented orders (≥ 10 species) were from Poales 21 (12.96%), Fabales 18 (11.11%), Lamiales 14 (8.64%), Gentianales 13 (8.02%), Malpighiales 13 (8.02%) and Asterales 12 (7.41%) (Table 1, Figure 2). Gastauer and Neto (2017) highlighted a similar distribution from Brazil. Gnanasekaran et al. (2012) conducted similar

research on angiosperms in a sacred grove in the Cuddalore area of Tamil Nadu, India. Pérez-Luque et al. (2014) and Sen and Bhakat (2021a) have illustrated similar types of order contributions.

The eleven best-represented families (with ≥ 5 species) were Fabaceae 18 (11.11%), Poaceae 14 (8.64%), Asteraceae 12 (7.41%), Euphorbiaceae 9 (5.56%), Malvaceae 9 (5.56%), Apocynaceae 7 (4.32%), Cyperaceae 7 (4.32%), Lamiaceae 7 (4.32%), Rubiaceae 6 (3.70%), Acanthaceae 5 (3.09%) and Menispermaceae 5 (3.09%) (Table 1, Figure 3). Whereas three families contained 4 (2.47%), four families contained 3 (1.85%), and six families comprised 2 (1.23%) species each. The other 27 families had only a single species (Table 1).

In India, several studies (Ghildiyal et al. 2016; Sen and Bhakat 2019, 2020) have discovered the same type of dominant families in sacred groves, and many other authors have demonstrated hegemony in the global context (Badshah et al. 2016; Khan et al. 2018; Farooq et al. 2019; Sherwani 2019; Asif et al. 2020; Haq et al. 2021). Moreover, they consistently backed our findings, with the Fabaceae, Poaceae, and Asteraceae families emerging as the most common study region.

The most represented genera were *Cyperus* and *Solanum*, each containing 4 and 3 species, respectively. Nine genera, e.g., *Chrysopogon*, *Cleome*, *Croton*, *Dioscorea*, *Euphorbia*, *Senna*, *Sida*, *Spermacoce*, and *Ziziphus*, hold 2 species each. Another 137 species contain a single genus respectively (Table 1).

Species diversity in different growth forms

The present floristic study of the sacred grove showed that they harbored a total of 162 plant species [130 dicots (80.25%) and 32 monocots (19.75%)] belonging to 148 genera [121 dicots (81.76%) and 27 monocots (18.24%)] under 51 families [41 dicots (80.39%) and 10 monocots (19.61%)] in 26 orders [19 dicots (73.08%) and 7 monocots (26.92%)]. Among these, 79 (48.76%) reported species were herbs. Other highly reported species were 30 shrubs (18.52%), 23 trees (14.20%), and 30 climbers (18.52%), respectively. Amongst the total 130 dicots (80.25%) and 32 monocots (19.75%), herbs, shrubs, trees, and climbers represented 54, 29, 21, 26, and 25, 1, 2, 4 species, respectively, representing 33.33%, 17.90%, 12.96%, 16.05% and 15.43%, 0.62%, 1.23%, 2.47% of the total species (Table 1 & 2, Figure 4).

Life span and nativity

In the sacred grove, 68 annual plants (39.63%) go through their life cycle in one growing season, and 94 perennial plants (59.91%) can survive the most unfavorable conditions and stay alive for more than two years (Table 1). Of the total recorded 162 species, 104 species were native, while 58 species were aliens, most of which thrive in the grove's disturbed habitats. Alien plant species were frequently able to colonize disturbed sites more quickly than native species, independent of their life history strategy, because they tended to be more plastic than native plants and, in some fitness components, superior to natives (Davidson et al. 2011).

Table 1. List of angiosperm taxa of Faringdanga Pir Babar Asthana sacred grove, West Bengal, India, according to the APG IV classification system

Name of the species	Voucher specimen	Habit	Life-span	Nativity	Fl. & Fr. time	Raunkiaer's life-form	Sub-type	Leaf spectra	Shape of the lamina	IUCN Red List Status	Summer	Rainy	Winter
MESANGIOSPERMS													
MAGNOLIIDS													
Magnoliales Juss. ex Bercht. & J.Presl													
Annonaceae Juss.													
<i>Annona squamosa</i> L.	USAN1	T	P	E	Mar.-Sep.	Ph	N	Me	La	LC	P	P	P
INDEPENDENT LINEAGE: UNPLACED TO MORE INCLUSIVE CLADE													
MONOCOTS													
Alismatales R.Br. ex Bercht. & J.Presl													
Araceae Juss.													
<i>Scindapsus officinalis</i> (Roxb.) Schott	USAR1	C	P	N	-	Cr		Ma	Ov	NE	P	P	P
Dioscoreales Mart.													
Dioscoreaceae R. Br.													
<i>Dioscorea glabra</i> Roxb.	USD11	C	P	N	Sep.-Mar.	Cr		Me	Sg	NE	A	P	P
<i>Dioscorea pubera</i> Blume	USD12	C	P	N	Oct.-Jan.	Cr		Me	Co	NE	A	P	P
<i>Tacca leontopetaloides</i> (L.) Kuntze	USD13	H	P	N	Aug.-Nov.	Cr		Na	Sp	LC	A	P	P
Asparagales Link													
Orchidaceae Juss.													
<i>Vanda tessellata</i> (Roxb.) Hook. ex G. Don	USOR1	H	P	N	Apr.-Jul.	Ph	N	No	Su	LC	P	P	P
Hyoxidaceae R. Br.													
<i>Curculigo orchiioides</i> Gaertn.	USHP1	H	P	N	Aug.-Oct.	Cr		Mi	La	NE	A	P	A
Asparagaceae Juss.													
<i>Agave sisalana</i> Perrine	USAP1	S	P	E	Mar.-Oct.	Ch		Mg	Su	NE	P	P	P
<i>Asparagus racemosus</i> Willd.	USAP2	C	P	E	Aug.-Dec.	Cr		Le	Ac	NE	P	P	A
Arecales Bromhead													
Areaceae Bercht. & J.Presl													
<i>Phoenix sylvestris</i> (L.) Roxb.	USAE1	T	P	N	Feb.-Jun.	Ph	M	Mi	Pa	NE	P	P	P
Commelinales Mirb. ex Bercht. & J.Presl													
Commelinaceae Mirb.													
<i>Murdannia spirata</i> (L.) G.Brückn.	USCM1	H	A	N	Sep.-Jan.	He		Na	Su	LC	A	P	A
Zingiberales Grisebach													
Zingiberaceae Martinov													
<i>Globba marantina</i> L.	USZ11	H	P	N	Aug.-Sep.	Cr		Ma	La	LC	A	P	P
Poales Small													
Cyperaceae Juss.													
<i>Cyperus brevifolius</i> (Rottb.) Hassk.	USCY1	H	P	E	May-Oct.	He		Le	Ac	LC	A	P	A
<i>Cyperus rotundus</i> L.	USCY2	H	P	E	Sep.-Dec.	He		Na	Ac	LC	A	P	P
<i>Cyperus compressus</i> L.	USCY3	H	P	N	Jul.-Nov.	He		Le	Ac	LC	A	P	P
<i>Cyperus iria</i> L.	USCY4	H	P	E	Aug.-Dec.	He		Le	Ac	LC	A	P	P
<i>Fimbristylis aestivalis</i> (Retz.) Vahl	USCY5	H	P	E	Feb.-May	He		Le	Ac	NE	A	P	P
<i>Fuirena ciliaris</i> (L.) Roxb.	USCY6	H	P	E	Sep.-Jan.	He		Le	Ac	LC	A	P	P
<i>Rhynchospora wightiana</i> (Nees) Steud.	USCY7	H	P	N	Aug.-Oct.	He		Le	Li	NE	A	P	A
Poaceae Barnhart													
<i>Alloteropsis cimicina</i> (L.) Stapf	USPA1	H	A	E	Jul.-Oct.	He		Le	Co	NE	A	P	A
<i>Aristida setacea</i> Retz.	USPA2	H	P	N	Aug.-Dec.	He		Le	Ac	NE	A	P	P
<i>Bambusa bambos</i> (L.) Voss	USPA3	T	P	N		Ph	M	Me	Ac	NE	P	P	P
<i>Chloris barbata</i> Sw.	USPA4	H	P	E	Aug.-Nov.	He		Le	Li	NE	A	P	P
<i>Chrysopogon aciculatus</i> (Retz.) Trin.	USPA5	H	P	N	Sep.-Dec.	He		Le	Li	NE	A	P	P
<i>Chrysopogon zizanioides</i> (L.) Roberty	USPA6	H	P	N	Jun.-Oct.	He		Le	Li	NE	A	P	P
<i>Cynodon dactylon</i> (L.)Pers.	USPA7	H	P	E	All	He		Le	Li	NE	P	P	P
<i>Desmostachya bipinnata</i> (L.) Stapf	USPA8	H	P	E	Jun.-Oct.	He		Le	Ac	LC	A	P	A
<i>Imperata cylindrica</i> (L.) P.Beauv.	USPA9	H	P	E	Oct.-Dec.	He		Le	Li	LC	A	P	P
<i>Oplismenus burmanni</i> (Retz.) P.Beauv.	USPA10	H	P	N	Sep.-Nov.	He		Le	Ov	NE	A	P	P
<i>Panicum notatum</i> Retz.	USPA11	H	P	N	Sep.-Nov.	He		No	Li	NE	A	P	A

<i>Perotis indica</i> (L.) Kuntze	USPA12	H	P	N	Jul.-Nov.	He		Le	Ac	NE	A	P	A
<i>Setaria parviflora</i> (Poir.) Kerguelen	USPA13	H	P	N	Aug.-Nov.	He		Le	Li	LC	A	P	A
<i>Tragus mongolorum</i> Ohwi	USPA14	H	P	N	Aug.-Oct.	He		Le	Ac	NE	A	P	A
EUDICOTS													
Ranunculales Juss. ex Bercht. & J.Presl													
Papaveraceae Juss.													
<i>Argemone mexicana</i> L.	USPP1	H	A	E	Dec.-Apr.	Th		Ma	Sp	NE	P	A	P
Menispermaceae Juss.													
<i>Cissampelos pareira</i> L.	USMN1	C	P	N	Jul.-Jan.	Ph	N	Me	Co	NE	P	P	P
<i>Cocculus hirsutus</i> (L.) W.Theob.	USMN2	C	P	N	Aug.-Nov.	Ph	N	Me	Co	NE	P	P	P
<i>Stephania japonica</i> (Thunb.) Miers	USMN3	C	P	N	Jul.-Dec.	Ph	N	Me	Or	NE	P	P	P
<i>Tiliacora acuminata</i> (Lam.) Miers	USMN4	C	P	N	Nov.-May	Ph	N	Me	Ov	NE	P	P	P
<i>Tinospora sinensis</i> (Lour.) Merr.	USMN5	C	P	N	Feb.-Jun.	Ph	N	Me	Co	NE	P	P	P
ROSIDS													
Vitales Juss. ex Bercht. & J.Presl.													
Vitaceae Juss.													
<i>Ampelocissus tomentosa</i> (Roth) Planch.	USVT1	C	P	N	Aug.-Dec.	Ph	N	Me	Sg	NE	P	P	P
<i>Causonis trifolia</i> (L.) Mabb. & J.Wen	USVT2	C	P	N	Aug.-Dec.	Ph	N	No	Co	NE	A	P	P
<i>Cayratia pedata</i> (Lam.) Gagnep.	USVT3	C	P	N	Aug.-Feb.	Ph	N	No	Ov	VU	P	P	P
<i>Cissus quinquangularis</i> Chiov.	USVT4	C	P	N	Jul.-Jan.	Ph	N	No	Co	NE	P	P	P
Fabales Bromhead													
Fabaceae Lindl.													
<i>Abrus precatorius</i> L.	USFA1	C	P	N	Aug.-Mar.	Ph	N	Na	Ob	NE	A	P	P
<i>Acacia auriculiformis</i> A.Cunn. ex Benth.	USFA2	T	P	N	Feb.-Oct.	Ph	M	Me	Ob	LC	P	P	P
<i>Albizia lebeck</i> (L.) Benth.	USFA3	T	P	N	Mar.-Feb.	Ph	MM	Mi	Ob	NE	P	P	P
<i>Cassia fistula</i> L.	USFA4	T	P	N	Feb.-Dec.	Ph	N	No	Su	LC	P	P	P
<i>Chamaecrista mimosoides</i> (L.) Greene	USFA5	H	A	N	Mar.-Dec.	Th		Na	La	LC	A	P	A
<i>Crotalaria retusa</i> L.	USFA6	S	A	E	Jul.-Jan.	Ch		Mi	Ov	NE	P	P	P
<i>Flemingia strobilifera</i> (L.) W.T.Aiton	USFA7	H	A	N	Feb.-Sep.	Ch		Na	Ov	NE	A	P	P
<i>Grona triflora</i> (L.) H.Ohashi & K.Ohashi	USFA8	H	P	N	Jul.-Feb.	Th		Me	Ov	NE	A	P	P
<i>Guilandina bonduc</i> L.	USFA9	C	P	N	Aug.-Apr.	Ph	N	Me	Co	LC	P	P	P
<i>Mimosa pudica</i> L.	USFA10	H	P	E	Jul.-Nov.	Th		Na	La	LC	A	P	P
<i>Mucuna pruriens</i> (L.) DC.	USFA11	C	A	N	Sep.-May	Ph	N	No	Co	NE	A	P	P
<i>Pithecellobium dulce</i> (Roxb.) Benth.	USFA12	T	P	N	Feb.-Jul.	Ph	M	Mi	Co	LC	P	P	P
<i>Pseudarthria viscida</i> (L.) Wight & Arn.	USFA13	H	P	N	Oct.-Jan.	Th		Mi	Ov	NE	A	P	A
<i>Senna occidentalis</i> (L.) Link	USFA14	S	A	E	Aug.-Dec.	Ch		No	Oo	NE	A	P	P
<i>Senna siamea</i> (Lam.) H.S.Irwin & Barneby	USFA15	T	P	E	Sep.-Dec.	Ph	MM	No	Oo	LC	P	P	P
<i>Tephrosia pumila</i> (Lam.) Pers.	USFA16	H	P	N	Jul.-Oct.	Th		Na	Oo	LC	A	P	P
<i>Vigna vexillata</i> (L.) A.Rich.	USFA17	C	A	N	Jul.-Oct.	Ph	N	Mi	Co	NE	A	P	A
<i>Zornia gibbosa</i> Span.	USFA18	H	A	N	Aug.-Nov.	Th		Na	La	NE	A	P	A
Rosales Bercht. & J.Presl													
Rhamnaceae Juss.													
<i>Ventilago denticulata</i> Willd.	USRH1	C	P	N	Nov.-Mar.	Ph	N	Me	La	NE	P	P	P
<i>Ziziphus nummularia</i> (Burm.f.) Wight & Arn.	USRH2	S	P	N	Sep.-Mar.	Ph	N	No	Ov	NE	P	P	P
<i>Ziziphus oenopolia</i> (L.) Mill.	USRH3	C	P	N	Nov.-Mar.	Ph	N	No	Ov	LC	P	P	P
Ulmaceae Mirb.													
<i>Holoptelea integrifolia</i> (Roxb.) Planch	USUL1	T	P	N	Jan.-Jun.	Ph	MM	Me	Ov	NE	P	P	P
Moraceae Gaudich.													
<i>Ficus benghalensis</i> L.	USMO1	T	P	N	Mar.-Sep.	Ph	MM	Ma	Co	NE	P	P	P
<i>Streblus asper</i> Lour.	USMO2	T	P	N	Feb.-Jun.	Ph	N	Mi	Oo	LC	P	P	P
Cucurbitales Juss. Ex Bercht. & J. Presl													
Cucurbitaceae Juss.													
<i>Cayaponia laciniosa</i> (L.) C.Jeffrey	USCU1	C	A	N	Jun.-Jan.	Ph	N	Mi	Sg	NE	A	P	A
<i>Coccinia grandis</i> (L.) Voigt	USCU2	C	A	N	Mar.-Dec.	Ph	N	Me	Sg	NE	P	P	P
<i>Melothria trilobata</i> Cogn.	USCU3	C	A	N	Jul.-Feb.	Ph	N	Me	Ov	NE	A	P	P
<i>Trichosanthes tricuspidata</i> Lour.	USCU4	C	A	N	Apr.-Sep.	Ph	N	Me	Ha	NE	P	P	P
Oxalidales Bercht. & J. Presl													
Oxalidaceae R. Br.													
<i>Oxalis corniculata</i> L.	USOX1	H	A	E	All	Th		Na	Cu	NE	P	P	P
Malpighiales Juss. ex Bercht. & J.Presl													
Violaceae Batsch													
<i>Afrohybanthus enneaspermus</i> (L.) Flicker	USVII	H	P	N	Jul.-Nov.	Th		Na	La	NE	A	P	A
Salicaceae Mirb.													
<i>Flacourtia indica</i> (Burm. f.) Merr.	USSA1	S	P	N	Sep.-May.	Ch		Mi	Ov	LC	P	P	P
Euphorbiaceae Juss.													
<i>Acalypha indica</i> L.	USEU1	H	A	E	All	Th		No	Ov	NE	A	P	P
<i>Breynia vitis-idaea</i> (Burm.f.) C.E.C.Fisch.	USEU2	S	P	N	Jun.-Jan.	Ch		No	Ov	LC	p	p	p

<i>Chrozophora rotleri</i> (Geiseler) Spreng.	USEU3	H	A	E	Jul.-Feb.	Th		Na	Co	NE	A	P	P
<i>Croton bonplandianus</i> Baill.	USEU4	H	P	E	All	Th		No	Co	NE	P	P	P
<i>Croton bonplandianus</i> Baill.	USEU5	H	P	E	All	Th		No	Ov	NE	P	P	P
<i>Euphorbia antiquorum</i> L.	USEU6	T	P	N	Jan.-Apr.	Ph	N	Le	Oo	NE	P	P	P
<i>Euphorbia hirta</i> L.	USEU7	H	A	E	Feb.-Dec.	Th		Na	Co	NE	A	P	P
<i>Jatropha gossypifolia</i> L.	USEU8	S	P	E	Mar.-Aug.	Ch		Ma	Oo	LC	P	P	P
<i>Suregada multiflora</i> (A.Juss.) Baill.	USEU9	T	P	N	Mar.-Jul.	Ph	N	Mi	Ov	NE	P	P	P
Phyllanthaceae Martinov													
<i>Breynia vitis-idaea</i> (Burm.f.) C.E.C.Fisch.	USPY1	S	P	N	Apr.-Dec.	Ch		Mi	Ov	LC	P	P	P
<i>Phyllanthus debilis</i> J.G.Klein ex Willd.	USPY2	H	A	N	Apr.-Sep.	Th		Le	Ov	NE	A	P	P
Myrtales Juss. ex Bercht. & J.Presl													
Combretaceae R.Br.													
<i>Combretum indicum</i> (L.) DeFilipps	USCO1	C	P	N	All	Ph	N	Me	Ov	NE	P	P	P
Myrtaceae Juss.													
<i>Syzygium cumini</i> (L.) Skeels	USMY1	T	P	N	Mar.-Jul.	Ph	MM	Me	La	LC	P	P	P
Sapindales Juss. Ex Bercht. & J.Presl													
Anacardiaceae R.Br.													
<i>Mangifera indica</i> L.	USAN1	T	P	N	Feb.-Jun.	Ph	M	Ma	Ob	DD	P	P	P
Sapindaceae Juss.													
<i>Allophylus cobbe</i> (L.) Forsyth f.	USSP1	C	P	N	Jul.-Oct.	Ph	M	No	Ov	NE	A	P	A
<i>Cardiospermum halicacabum</i> L.	USSP2	C	A	N	Jul.-Dec.	Ph	N	No	Sp	LC	A	P	P
<i>Dodonaea viscosa</i> Jacq.	USSP3	S	P	N	Nov.-Apr.	Ph	N	No	Ob	LC	A	P	P
Rutaceae Juss.													
<i>Aegle marmelos</i> (L.) Corrêa	USRU1	T	P	N	May-Jul.	Ph	M	Me	Ov	NT	P	P	P
<i>Murraya paniculata</i> (L.) Jack	USRU2	S	P	N	Apr.-Jun.	Ph	N	Na	Ov	NE	P	P	P
Simaroubaceae DC.													
<i>Ailanthus excelsa</i> Roxb.	USSII	T	P	N	Jan.-Oct.	Ph	MM	Ma	Ob	NE	P	P	P
Meliaceae Juss.													
<i>Azadirachta indica</i> A. Juss.	USML1	T	P	N	Mar.-Jul.	Ph	M	No	La	LC	P	P	P
<i>Melia azedarach</i> L.	USML2	T	P	E	Feb.-Nov.	Ph	M	No	La	LC	P	P	P
Malvales Juss. ex Bercht. & J.Presl													
Malvaceae Juss.													
<i>Abutilon indicum</i> (L.) Sweet	USMA1	S	A	N	Sep.-Apr.	Ch		Ma	Co	NE	A	P	P
<i>Azanza lampas</i> (Cav.) Alef.	USMA2	S	A	N	Sep.-Dec.	Ch		No	Sg	NE	P	P	P
<i>Byttneria herbacea</i> Roxb.	USMA3	H	A	N	Sep.-Nov.	Th		No	Co	NE	A	P	P
<i>Corchorus aestuans</i> L.	USMA4	H	A	E	Jul.-Nov.	Th		Me	Ov	NE	A	P	A
<i>Malachra capitata</i> (L.) L.	USMA5	H	A	E	Sep.-Nov.	Th		Mi	Ha	NE	A	P	A
<i>Melochia corchorifolia</i> L.	USMA6	H	A	E	May.-Jun.	Th		Na	Co	LC	A	P	A
<i>Sida acuta</i> Burm.f.	USMA7	S	A	N	Aug.-Dec.	Th		No	Co	NE	A	P	P
<i>Sida cordifolia</i> L.	USMA8	S	A	N	Aug.-Dec.	Th		Mi	Co	NE	A	P	A
<i>Urena lobata</i> L.	USMA9	S	A	E	Sep.-Dec.	Ch		No	Ha	LC	A	P	P
Brassicales Bromhead													
Capparaceae Juss.													
<i>Capparis zeylanica</i> L.	USCP1	C	P	N	Mar.-Oct.	Ph	M	No	La	NE	P	P	P
Cleomaceae Bercht. & J.Presl													
<i>Cleome monophylla</i> L.	USCE1	H	A	E	Aug.-Oct.	Th		Mi	Co	NE	A	P	P
<i>Cleome viscosa</i> L.	USCE2	H	A	E	Sep.-Apr.	Th		No	Ob	NE	A	P	P
SUPERASTERIDS													
Santalales R.Br. ex Bercht. & J.Presl													
Loranthaceae Juss.													
<i>Macrosolen capitellatus</i> (Wight & Arn.) Danser	USLO1	S	A	N	Mar.-Sep.	Ph	N	No	Li	NE	A	P	P
Caryophyllales Juss. ex Bercht. & J.Presl													
Polygonaceae Juss.													
<i>Persicaria hydropiper</i> (L.) Delarbre	USPL1	H	A	N	May-Jan.	Th		Na	La	LC	A	P	P
Caryophyllaceae Juss.													
<i>Vaccaria hispanica</i> (Mill.) Rauschert	USCR1	H	A	N	Jan.-Mar.	Th		Le	Su	NE	A	P	A
Amaranthaceae Juss.													
<i>Achyranthes aspera</i> L.	USAM1	H	A	N	Sep.-Feb.	Th		Mi	Ov	NE	A	P	A
<i>Alternanthera sessilis</i> (L.) R. Br. ex DC.	USAM2	H	A	E	Jul.-Feb.	Th		Mi	Ov	LC	P	P	P
<i>Amaranthus spinosus</i> L.	USAM3	H	A	E	All	Th		Na	Ov	NE	P	P	P
<i>Ouret lanata</i> (L.) Kuntze	USAM4	H	A	E	Nov.-Jan.	Th		Le	Ov	NE	A	P	P
Nyctaginaceae Juss.													
<i>Boerhavia diffusa</i> L.	USNC1	H	A	N	Jun.-Dec.	Th		Mi	Re	NE	A	P	A
Portulacaceae Juss.													
<i>Portulaca oleracea</i> L.	USPR1	H	A	E	Jun.-Dec.	Th		Mi	Oo	NE	P	P	P
Cactaceae Juss.													
<i>Opuntia stricta</i> (Haw.) Haw.	USCC1	S	P	E	Apr.-Aug.	Ch		Le	Ac	LC	P	P	P

ASTERIDS**Cornales Link****Cornaceae Bercht. & J.Presl**

<i>Alangium salviifolium</i> (L.f.) Wangerin	USCN1	T	P	N	Mar.-Jul.	Ph	N	Me	Ov	LC	P	P	P
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Gentianales Juss. ex Bercht. & J.Presl**Rubiaceae Juss.**

<i>Meyna spinosa</i> Roxb. ex Link	USRU1	S	P	N	Mar.-Jun.	Ch		Me	Ov	NE	P	P	P
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<i>Morinda citrifolia</i> L.	USRU2	T	P	N	Feb.-May	Ph	N	Ma	Ov	NE	P	P	P
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<i>Oldenlandia corymbosa</i> L.	USRU3	H	A	N	Aug.-Feb.	Th		Le	Ov	LC	A	P	P
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<i>Scleromitron pinifolium</i> (Wall. ex G.Don)	USRU4	H	A	N	Sep.-Nov.	Th		Na	Li	NE	A	P	A
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R.J.Wang

<i>Spermacoce hispida</i> L.	USRU5	H	A	N	All	Th		Na	Li	NE	A	P	P
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<i>Spermacoce brachystema</i> R.Br. ex Benth.	USRU6	H	A	E	Jul.-Dec.	Th		Na	Ov	NE	A	P	A
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Apocynaceae Juss.

<i>Calotropis gigantea</i> (L.) W.T.Aiton	USAO1	S	P	E	Mar.-Feb.	Ch		Ma	Ob	NE	P	P	P
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<i>Cascabela thevetia</i> (L.) Lippold	USAO2	S	P	E	All	Ph	N	Mi	La	LC	P	P	P
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<i>Gymnema sylvestre</i> (Retz.) R.Br. ex Sm.	USAO3	C	P	N	Apr.-Mar.	Ph	N	Mi	La	NE	A	P	P
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<i>Hemidesmus indicus</i> (L.) R.Br.	USAO4	C	P	N	Aug.-Jan.	Ph	N	Mi	Ob	NE	P	P	P
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<i>Pergularia daemia</i> (Forssk.) Chiov.	USAO5	C	P	N	Sep.-Jan.	Ph	N	Me	Co	LC	A	P	P
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<i>Plumeria rubra</i> L.	USAO6	T	P	N	Oct.-May	Ph	M	No	La	LC	P	P	P
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<i>Rauvolfia tetraphylla</i> L.	USAO7	S	P	N	Feb.-Dec.	Ch		No	La	NE	P	P	P
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Solanales Juss. ex Bercht. & J.Presl**Convolvulaceae Juss.**

<i>Evolvulus alsinoides</i> (L.) L.	USCV1	H	A	N	Jul.-Feb.	Th		Na	La	NE	A	P	P
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Solanaceae Juss.

<i>Solanum americanum</i> Mill.	USSO1	H	A	E	Dec.-Jun.	Th		Ma	Ov	NE	A	P	A
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<i>Solanum sisymbriifolium</i> Lam.	USSO2	S	A	E	Jul.-Mar.	Ch		Ma	Ov	NE	A	P	P
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<i>Solanum nigrum</i> L.	USSO3	H	A	E	Jul.-Mar.	Ch		Ma	Ov	NE	A	P	P
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Lamiales Bromhead**Plantaginaceae Juss.**

<i>Scoparia dulcis</i> L.	USPL1	H	A	E	May-Dec.	Th		Mi	Ob	NE	A	P	P
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Acanthaceae Juss.

<i>Andrographis paniculata</i> (Burm.f.) Nees	USAC1	H	A	N	Sep.-Apr.	Th		No	Ov	NE	A	P	A
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<i>Barleria prionitis</i> L.	USAC2	S	P	N	Dec.-Apr.	Ch		Mi	La	NE	A	P	A
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<i>Ecbolium viride</i> (Forsk.) Alston	USAC3	H	P	N	Dec.-Apr.	Ch		Mi	Ov	NE	A	P	A
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<i>Ruellia tuberosa</i> L.	USAC4	H	A	N	Aug.-Nov.	Th		Mi	Ov	NE	A	P	P
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<i>Rungia pectinata</i> (L.) Nees	USAC5	H	A	E	All	Th		Mi	Ov	NE	A	P	P
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Verbenaceae J.St.Hil.

<i>Lantana camara</i> L.	USVE1	S	P	E	Nov.-Feb.	Ch		No	Ov	NE	P	P	P
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Lamiaceae Martinov

<i>Anisomeles indica</i> (L.) Kuntze	USLA1	S	A	E	Sep.-Jan.	Ch		No	Ov	NE	A	P	A
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<i>Clerodendrum infortunatum</i> L.	USLA2	S	P	N	Feb.-Jul.	Ch		Ma	Co	NE	A	P	P
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<i>Leonotis nepetifolia</i> (L.) R.Br.	USLA3	S	A	E	Apr.-Jul.	Th		Me	Co	NE	A	P	A
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<i>Leonurus sibiricus</i> L.	USLA4	S	A	N	Sep.-Feb.	Ch		Mi	La	NE	A	P	A
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<i>Mesosphaerum suaveolens</i> (L.) Kuntze	USLA5	S	A	E	Sep.-Jan.	Ch		Me	Ov	NE	A	P	A
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<i>Ocimum basilicum</i> L.	USLA6	H	P	N	May-Jul.	Ch		Na	Ov	NE	A	P	A
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<i>Vitex negundo</i> L.	USLA7	T	P	N	Mar.-Jun.	Ph	N	Mi	Ov	LC	P	P	P
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Asterales Link**Asteraceae Bercht. & J.Presl**

<i>Ageratum conyzoides</i> (L.) L.	USAT1	H	A	E	Nov.-Mar.	Th		Mi	Ov	LC	A	P	P
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<i>Blumea lacera</i> (Burm.f.) DC.	USAT2	H	A	E	Aug.-Feb.	Th		Mi	La	NE	A	P	P
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<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob.	USAT3	S	A	E	Mar.-Sep.	Ch		Mi	Ov	NE	A	P	P
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<i>Cyanthillium albicans</i> (DC.) H.Rob.	USAT4	H	A	N	Aug.-Mar.	Th		Mi	Li	NE	A	P	P
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<i>Eclipta prostrata</i> (L.) L.	USAT5	H	A	E	All	Th		Mi	La	LC	A	P	P
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<i>Enydra fluctuans</i> Lour.	USAT6	H	A	N	Dec.-Mar.	Th		Mi	La	LC	A	P	P
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<i>Parthenium hysterophorus</i> L.	USAT7	H	A	E	Oct.-Mar.	Th		Me	Ob	NE	P	P	P
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<i>Sonchus oleraceus</i> L.	USAT8	H	A	N	Sep.-Jan.	Th		Na	Ha	NE	A	P	P
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<i>Sphaeranthus senegalensis</i> DC.	USAT9	H	A	E	Nov.-Apr.	Th		Le	Ov	LC	A	P	P
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<i>Synedrella nodiflora</i> (L.) Gaertn.	USAT10	H	A	E	Sep.-Jan.	Th		No	Ov	LC	A	P	P
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<i>Tridax procumbens</i> L.	USAT11	H	A	E	All	Th		Na	Sg	NE	A	P	A
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<i>Xanthium strumarium</i> L.	USAT12	H	A	E	Sep.-Apr.	Th		Me	Sg	NE	A	P	A
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Note: In Habit: C-Climber, H-Herb, S-Shrub, T-Tree; In Life-Span: A-Annual, B-Biennial, P-Perennial; In Flowering and Fruiting time: Jan.-January, Feb.-February, Mar.-March, Apr.-April, Jun.-June, Jul.-July, Aug.-August, Sep.-September, Oct.-October, Nov.-November, Dec.-December, All- All season; In Raunkiaer's Life-form and Sub-type: Ch-Chamaephytes, Cr-Cryptophytes, H-Hemicryptophytes, M-Mesophanerophyte, MM-Megaphanerophytes, N-Nanophanerophytes, Ph-Phanerophytes, T-Therophytes; In Leaf spectra: Le-Leptophyll, Na-Nanophyll, Mi-Microphyll, No-notophyll, Me-Mesophyll, Ma-Macrophyll, Mg-Megaphyll; In IUCN Status: EN-Endangered, LC-Least Concern, NE-Not Evaluated, NT-Nearly Threatened, VU-Vulnerable; Leaf Lamina: Ac-Acicular, Co-Cordate, Cu-Cuneate, Ha-Hastate, La-Lanceolate, Li-Linear, Lu-Lunate, Ob-Oblong, Oo-Obovate, Or-Orbicular, Ov-Ovate, Pa-Palm-like, Re-Reniform, Sg-Sagittate, Sp-Spathulate, Su-Subulate

Table 2. Total angiosperm taxa

Group	Orders	Families	Genera	Species				Total
				Herbs	Shrubs	Trees	Climber	
Dicots	19	41	121	54	29	21	26	130
Monocots	7	10	27	25	1	2	4	32
Total	26	51	148	79	30	23	30	162

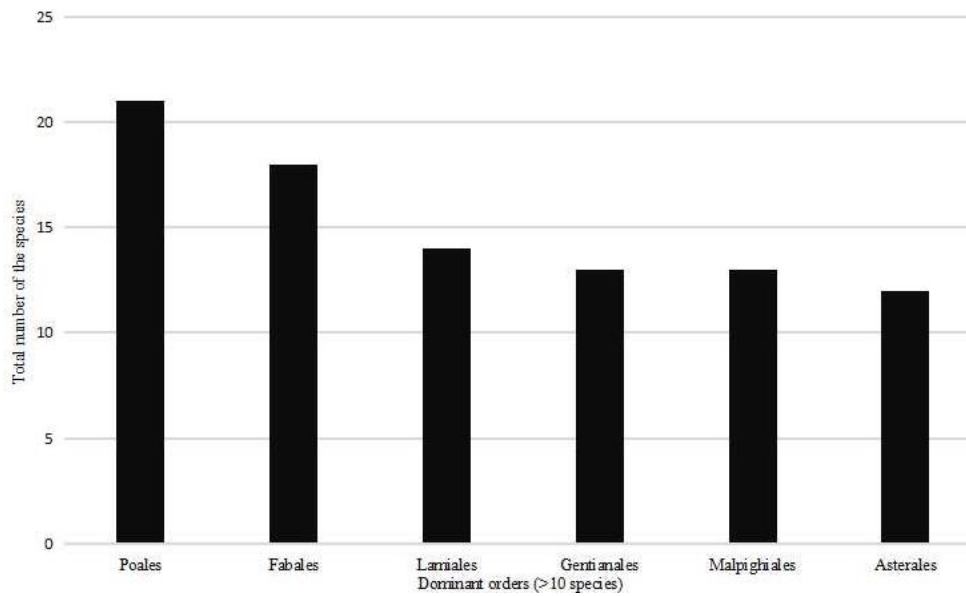


Figure 2. Dominant orders (>10 species) of the sacred grove

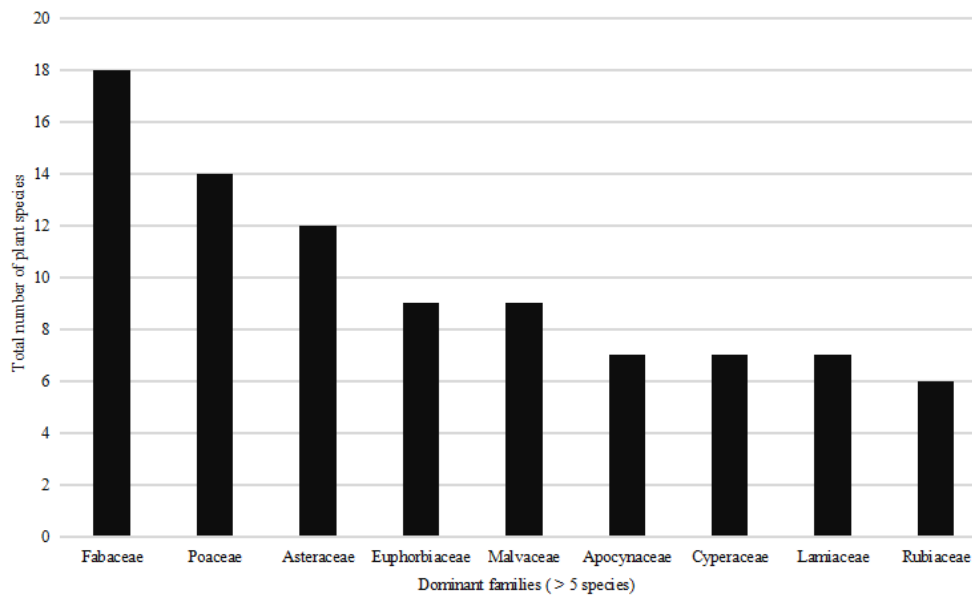


Figure 3. Dominant families (>5 species) of the sacred grove

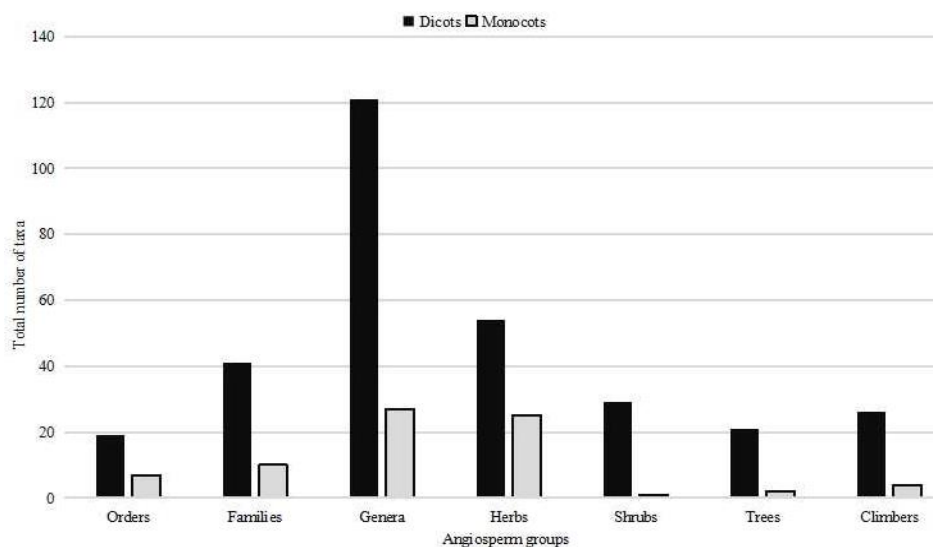


Figure 4. Total angiosperm taxa

Therefore, common invasive species growing in the grove were herbs (*Alternanthera sessilis*) and shrubs (*Chromolaena odorata*, *Mesosphaerum suaveolens*, *Lantana camara*). In recent years, unsustainable anthropogenic activities in this grove have been regarded as a severe threat to the local vegetation (Blondel 2006). Exotic species had already started to naturalize in the study region, especially in newly created forest gaps and degraded areas. It was observed during the present study that alien plants (*C. odorata*, *M. suaveolens*) spread very rapidly in the gaps in the forest (Martin et al. 2009). Other alien species discovered during the current investigation in the region are expected to become essential plant invaders shortly, necessitating immediate attention and management.

Life form and biological spectrum

The biological spectrum showed that 55 Phanerophytes (33.95%) were the most frequent, followed by 53 Therophytes (32.72%), 26 Chamaephytes (16.05%), 21 Hemicryptophytes (12.96%) and 7 Cryptophytes (4.32%). Of the Phanerophytes, 38 Nanophanerophytes (23.46%) were more common than 11 Mesophanerophytes (6.79%) and 6 Megaphanerophytes (3.70%) (Table 3).

Therophytes and Chamaephytes had shown a greater percentage of 19.72% and 7.05%, respectively, than the normal spectrum of the “Thero-chamaephyte” phytoclimate. Further, the number of Hemicryptophytes (13.04%), Phanerophytes (12.05%), and Cryptophytes (1.68%) were comparatively smaller in percentage than the normal spectrum. It was also noted that the Phanerophytes, Nanophanerophytes (8.46%) were somewhat larger, and Mesophanerophytes (21.21%) and Megaphanerophytes (0.70%) were comparatively smaller in values than the normal spectrum (Table 3, Figure 5).

The observed flora was compared to Raunkiaer's (1934) standard range, created for world flora, and reflected homogeneous climatic conditions (Sharma and Raina

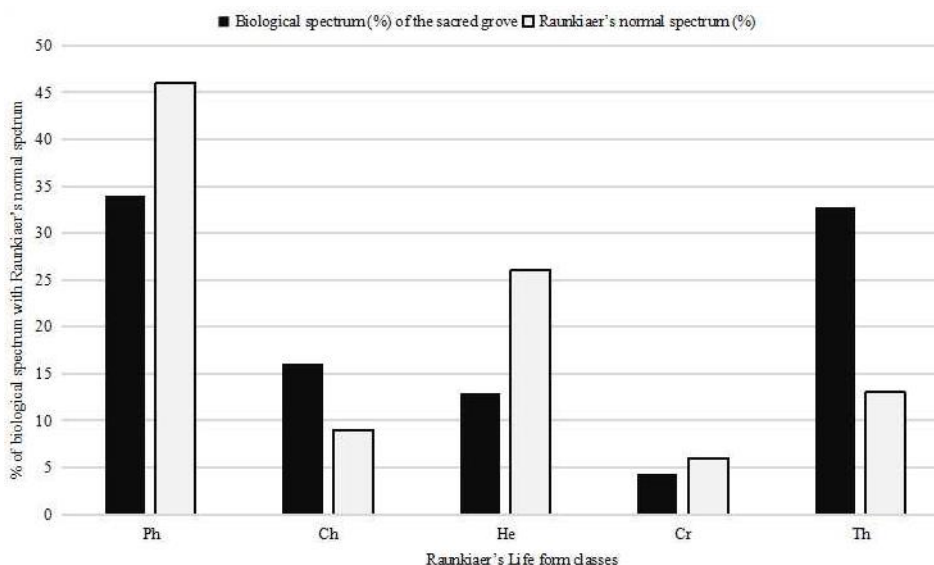
2017). The χ^2 test demonstrated a significant difference ($\chi^2 = 45.603$, $df = 4$, $P < 0.0001$) between the observed flora and Raunkiaer's normal spectrum, which meant this difference was statistically highly significant (de Paula et al. 2017) (Table 3). The Phanerophytes' life form had the highest, partly due to the local protection under certain taboos of the sacred grove.

The highest percentage of therophytes in the area may be related to the subtropical character, which is often associated with various factors such as the region's soil and climatic conditions, combined with anthropogenic activities such as grazing, lopping, felling, deforestation, the introduction of annual weeds, etc. (Sharma and Raina 2017). Thus, the present study revealed that the vegetation was predominantly of sub-tropical type, with a higher percentage of Therophytes and Chamaephytes than the normal biological spectrum. Therophyte prevalence was also an indicator of biotic pressure. Therophyte development is reported to prefer in disturbed areas (Al-Yemeni and Sher 2010; Zemmar et al. 2020; Nafeesa et al. 2021; Haq et al. 2021). Our findings agree with them as the Therophytes dominated in the present area under investigation, which had hot, dry, and waterlogged conditions in parts combined with overgrazing, resulting in harsh conditions. Nazir and Malik (2006) reported that Nanophanerophytes and Therophytes were the biological spectra of Sarsawa Hill Kotli. The prevalence of Therophytes was also expressed in the present study.

The results also agree with Sher and Khan (2007) and Kar et al. (2010), who also argued that Therophytes and Nanophanerophytes are the characteristics of sub-tropical ecosystems. Structurally and floristically, the sub-tropical dry forests are less complex than wet forests, comprising about half or less of the moist forest tree species (Hasnat and Hossain 2020). The forests constituted a refuge for valuable and endangered plants and animals. Further study is necessary to quantify the data and suggest plans to conserve the sacred groves.

Table 3. Biological spectrum (% of all life forms) of the sacred grove and its comparison with Raunkiaer's normal spectrum

Life forms	Total no. of species	Biological spectrum (%) of the sacred grove	Raunkiaer's normal spectrum (%)	Deviation= (Raunkiaer's normal spectrum- Biological spectrum)
Phanerophytes (Ph)	55	33.95	46.00	-12.05
Megaphanerophytes (MM)	6	3.70	3.00	+0.70
Mesophanerophyte (M)	11	6.79	28.00	-21.21
Nanophanerophytes (N)	38	23.46	15.00	+8.46
Chamaephytes (Ch)	26	16.05	9.00	+7.05
Hemicryptophytes (He)	21	12.96	26.00	-13.04
Cryptophytes (Cr)	7	4.32	6.00	-1.68
Therophytes (Th)	53	32.72	13.00	+19.72
Total	162	100.00	100	

**Figure 5.** Comparison of the biological spectrum with Raunkiaer's normal spectra

Leaf size spectra, leaf lamina, and phenology

The overall leaf size spectrum shows that there were Leptophyllous 26 (16.05%), Nanophyllous 24 (14.81%), Microphyllous 35 (21.60%), Notophyllous 33 (20.37%), Mesophyllous 29 (17.90%), Macrophyllous 14 (8.64%) and Megaphyllous 1 (0.62%) plants. Concerning the range of leaf sizes, microphyll was largely followed by Notophyll, Mesophyll, Leptophyll, Nanophyll, Macrophyll, and Megaphyll. Poaceae 12 (7.41%) was the dominant Leptophyllous family, whereas Fabaceae 6 (3.70%), Asteraceae 6 (3.70%), Menispermaceae 5 (3.09%), and Solanaceae 3 (1.85%) were the major Mesophyllous, Microphyllous, Mesophyllous, and Macrophyllous families respectively. Whereas Notophyllous 4 (2.47%) was equally distributed in Euphorbiaceae, Fabaceae, and Malvaceae families, and Asparagaceae 1 (0.62%) was the only Megaphyllous family (Table 1 and 4, Figure 6).

The leaf spectrum revealed information about a community's plant adaption and association. Small-sized leaves were present at the base, while the large ones were at higher altitudes and correlated with climatic warming and water availability in the soil (Badshah et al. 2016). The median type of leaf size indicated the presence of

subtropical climate type. Mesophyll, Notophyll, and Microphyllous elements were dominant in the sacred grove, which meant moisture availability or wet condition. In the present study, due to Therophytes and Chamaephytes, the proportion of different leaf size groups was observed to change seasonally (Haq et al. 2019). However, the Phanerophytes and some Chamaephytes preserved almost the same status in all seasons.

As regards the shape of leaf lamina, ovate 49 (30.25%) was found to be the maximum, followed by cordate 24 (14.81%), lanceolate 23 (14.20%), acicular 13 (8.02%), linear 12 (7.41%), oblong 11 (6.79%), obovate 7 (4.32%), sagittate 7 (4.32%), subulate 5 (3.08%), hastate 4 (2.47%), spatulate 3 (1.85%), cuneate 1 (0.62%), orbicular 1 (0.62%), palmate 1 (0.62%) and reniform 1 (0.62%) (Table 1, Figure 6). Leaf spectra tell us about the community's plant adaptation and association. Small leaves were present at the base, whereas the broad leaves were present upwards, which correlated with climate warming and water availability in the soil (Wright et al. 2017). The medium leaf size revealed the sub-tropical climate. In the sacred grove, meso- and microphyllous elements were dominant, showing moisture and perennial water availability or wet

condition (Sen and Bhakat 2021a). Leaf laminae in the sacred grove came in various shapes and sizes, ranging from oval to lunate. The leaf shape helps plants optimize light capture and water loss and minimizes the avoidable energy consumption in leaf production (Cowling and Field 2003). The distribution of leaf sizes in different resource-poor environments strongly supports this theory (Reich et al. 2003). Not only did the leaf laminas differ in size, but certainly, leaves also had distinct serrations, and the blades of some leaves were almost fully dissected. Leaf dissection aids plants in reducing self-shading and, as a result, ensures that nearby leaves receive adequate light (Westoby et al. 2002).

The vegetation phenology observed during different seasons revealed that most of the species were dominant in rainy seasons 161 (99.38%), followed by winter 124 (76.54%) and summer 66 (40.74%). Habit-wise species content varied seasonally; in the summer season, Tree>Climber>Shrub>Herb; rainy season, Herb>Shrub/Climber>Tree; winter season, Herb>Climber>Shrub>Tree, respectively (Table 1, Figure 7). Variations in species composition within the community accompanied seasonal changes. The vegetation phenology recorded over different seasons demonstrated a substantial variance in vegetation, owing to the study region's well-defined seasons. Expectedly, it may be attributed to a high proportion of therophytes, cryptophytes, and chamaephytes in the region that appeared during the rainy and winter seasons (Haq et al. 2019).

IUCN categories

Among these 162 plants, 111 plants have not been evaluated till now. There were 48 Least Concerned (LC), 1 Nearly Threatened (NT), 1 Data Deficient (DD), and 1

Vulnerable (VU) species. *Aegle marmelos* was the Nearly Threatened tree species, whereas climber *Cayratia pedata* was the vulnerable species according to the IUCN (2021) (Table 1). The result of the threatened species assessment showed that most of them belong to perennial tree species. When the present phytosociological study was compared with the IUCN Red Listed data, it was observed that those plants were still present in the sacred groves with total regenerative capacity. Still, as per the local people's concept, those plants gradually disappeared in nearby areas. This study highlights the status and distribution of the species in the study area, the ecological characteristics required for their survival, and the threats to some species identified by the IUCN (2021) criteria. Various factors may be ascribed to habitat disturbance and vulnerability within the space, including anthropogenic activities, overgrazing which had a great negative impact on seedlings, and peripheral loss of land.

Table 4. Life-form analysis with different leaf size

Raunkiaer's life form	Leaf spectra							Total
	Le	Na	Mi	No	Me	Ma	Mg	
Ph	1	2	11	17	20	4		55
MM			1	1	2	2		6
M			2	5	3	1		11
N	1	2	8	11	15	1		38
Ch	1	2	7	7	2	6	1	26
He	18	2		1				21
Cr	1	1	1		2	2		7
Th	5	17	16	8	5	2		53
Total	26	24	35	33	29	14	1	162

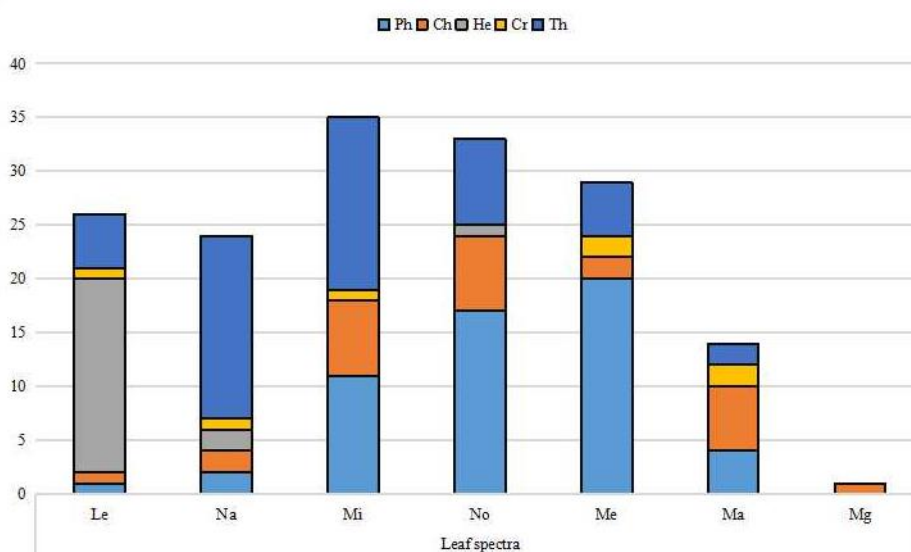


Figure 6. Analysis of life forms with different leaf sizes

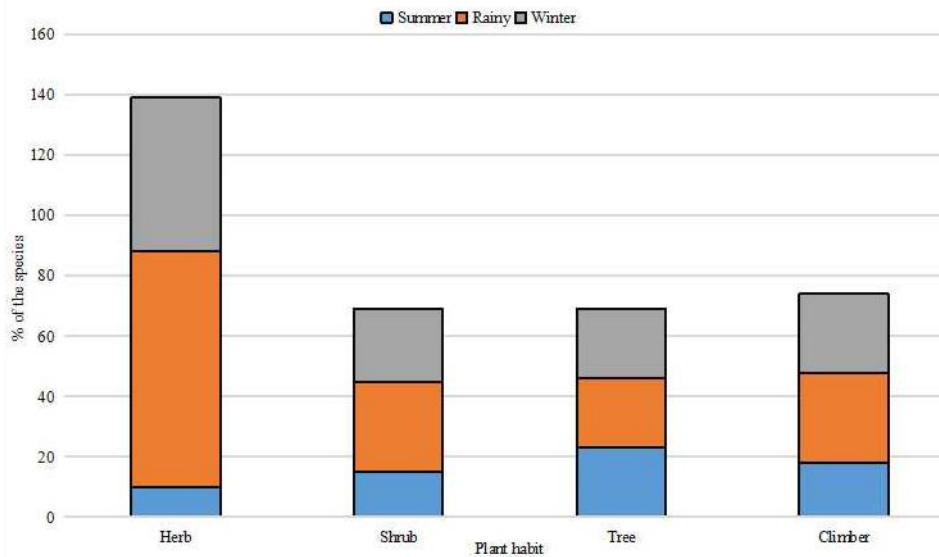


Figure 7. Vegetation phenology of the study area

In conclusion, the importance of cultural linkages in perpetuating the sacred groves has been well established. Indeed, the groves continued existence throughout millennia is a testament to the belief system's persistence. Finally, the current study has confirmed the presence of well-preserved sacred groves among the urban societies of West Bengal in Paschim Medinipur district. The study also demonstrates the importance of belief systems in preserving the integrity of the sacred grove in the face of modernism. According to the conservation values, these groves could serve as the nucleus for micro-level biodiversity protection. However, immediate and robust management measures are required to protect these biodiversity islands.

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