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Vegetation Analysis of Grassland Community of Manipur,Northeast India

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Abstract

The biological spectrum of the present grassland were represented by 22, 8, 4, 2 and 2 were therophytes, cryptophytes, phanerophytes, chamaephytes and hemicryptophytes respectively. A total of 26 plant species are undertaken for phonological observation. Phenological studies of some important plant species were also observed on sampling dates in different months. During the study period various phenophages were noted such as seedling/sprouting, vegetative, flowering, fruiting, maturation and dead of plant species. A total of 38 plant species were encountered for quantitative analysis. Maximum number of species were recorded in rainy season followed by summer and winter seasons. The total density was recorded to be highest in September and lowest in January. Almost all the species showed aggregated distribution. Species diversity and concentration of dominance are inversely related during the study period. Total density of different plant species varied from 264.98 tillers m^{-2} (January) to1341.91 tillers m^{-2} (September) during the study period. Total vegetation density shows positive relationship with mean monthly air temperature.

Keywords: Life-forms;Phenology; Biological spectrum; Species diversity; Eveness index;Dominance index

Introduction

A natural grassland is a plant community in which the dominant species are perennial grasses, there are few or no shrubs and trees are absent or less in numbers. Tropical grasslands particularly in the north-eastern areas are characterized by a large number of species of annual and perennial grasses, sedges, legumes and forbs. Usually associated with dominant grasses are less abundant grass species and variety of other herbaceous plants, both annual and perennial types, which of certain times of the year give a characteristic aspect to the plant community.

Vegetation analysis of a plant community is an important aspect of ecological study of any piece of vegetation. It reveals the structural pictures of the vegetation and helps in analyzing the community dynamics. The structure and rate of change in vegetational composition are sensitive indicators of the whole environment constituted by prevailing physical and biological factors (Odum, 1963).

Species composition is one of the major anatomical characters of plant community. Thus the structure and nature of the plant community is determined by the species contents and their ecological amplitude. Such type of studies have been carried out by Sant (1964). Cherian and Bole

(1964); Ahuja *et al.* (1968); Gupta and Saxena (1971); Katewa (1990) and Galav *et al.* (2005) in different Indian grassland vegetation. Vegetation environmental studies traditionally employ a component approach involving basic ecological types (life forms). Raunkiaer (1934) expressed climate as the statistical distribution of life forms in the flora of region. Life form composition appears to vary much less with climate than species composition; hence, it is an important character in describing the vegetation (Katewa and Sharma, 1999). Similar work have been done by several workers Singh and Yadava (1974); Misra and Misra (1979); Singh and Joshi (1983) and Pandey *et al.* (1985) from different parts of Indian grassland. Species and individuals can be grouped into life form or growth form classes on the basis of their structure and function (Verma and Das, 1980). Plants similarity in structure and form indicates a similarity in adaptation to the utilization of the environmental resources offered in a given space (Mueller-Dombois and Ellenberg, 1974). Several workers (Nuttonson, 1955; Sosebee and Wiebe, 1973; Taylor, 1974; Dickinson and Dodd, 1976;) have proposed that Phenology is associated with thermal requirements, plant growth rates, evolutionary changes, nutrient transfer, biomass dynamics and seasonality in grassaland ecosystems. Consequently, phonological events may considerably vary in the time of their occurrence, influence competitions as well as association of species (Tiwari, 1980).

The community as a whole usually has seasonal fluctuations and its structural and composition are strongly influenced by the extent to which periodic phenomena in the individuals is adjusted to each other. Many authors have been studied on phonological aspects of grass species in different parts of Indian grassland (Sundriyal *et al.,* 1987 at Garhwal Himalaya; Ram *et al.,* 1988 at Central Himalaya; Kakati and Yadava, 2021 at Imphal (Manipur). Therefore any extensive ecological work on any ecosystem must be proceeded by the analysis of vegetation. Understanding of diversity of forms and vegetation structure of any plant community depends upon the species composition and their relative numbers (Gleason, 1926). The nature of plant community at a place is determined by the species that grows and develops in such environments (Bliss, 1962). While discussing the importance of species diversity, Odum (1963) stressed that the number of species reflected the gene pool and adaptation potential of the community. The structural attributes through which a plant community is studied, are conveniently as analytic and synthetic characters. The analytical characters may be both qualitative and quantitative. The present study deals with qualitative characters such as (i) floristic composition (ii) life-forms (iii) phenology of constituent species and quantitative characters such as (i) density or numerical strength per unit area (ii) frequency or spatial distribution of the component species, (iii) relative degree of abundance of each species and (iv) the ratio of abundance to frequency to indicate the distribution pattern of each species (v) diversity, evenness and dominance index of each species are discussed in this chapter.

METHODS

Site description:

Location

The study site Khongjom is located between $24^0$15′-$24^0$45′N latitudes and $93^0$45′-$94^0$15′E longitudes in Thoubal district of Manipur at an altitude of 922 m amsl and 35 km from Imphal city. It is open to higher altitudinal grassland.

Climate

The area's climate is monsoonal, with a warm, moist summer and a cool, dry winter. The mean maximum temperature varies from 22.32ºC (January) to 30.31ºC (May), and the mean minimum temperature ranges from 4.76ºC (January) to 22.26ºC (July). The average relative humidity of air varies between 59.15% (March) and 82.64% (July). The mean minimum rainfall occurs during January (13.45 mm) and maximum during June (227.32 mm). The average annual rainfall is 1407.81 mm. The year can be divided into three distinct seasons: summer (March to May), rainy (June to October), and winter (November to February).

Soil

The soil in the study area is blackish brown and clayey loam with alluvial in nature. The soil texture in the study site contains sand (36.9 ± 0.001%), silt (4.6 ± 0.231%) and clay (52.66 ± 0.11%) and acidic with pH values ranging from 5.8 to 6.3.

QUALITATIVE CHARACTERS

Floristic composition

Sampling of vegetation has been carried out from March 2020 to March 2021 at monthly interval throughout the year. The collected wild plant species were brought and deposited at Herbarium Manipur University Museum of Plants (MUMP), Department of Botany, Manipur University, Manipur University, Imphal, India. The plant was identified by Dr.Yumkham Sanatombi Devi, Department of Botany, Manipur University Imphal-795003, India.The corresponding voucher ID/deposition numbers of the collected wild plant species were incorporated in the Manuscript as Supplementary file (Appendix I).

Life-forms

Life-forms of different species in the study site is determined after detailed floristic studies (Gupta and Kachroo, 1983). The morphological characters of each species life form, habitat, height and nature of perennating buds are examined in the field.

Phenology

General phenological observations of the plants are recorded during the study period following (Singh and Yadava, 1974). The observations are made each months from March 2020 to February 2021. Six phenophases are noted, and diagrammatically represented. The germination stage includes seed germination (seedling upto 0-2 cm in height in monocots and upto first leaf stage in dicots) or active sprouting of buds in rhizome or rootstocks in perennial species. The intermediate stage between germination and floral initiation is considered as

vegetative phase. Blooming period is referred to as flowering stage. The initiating and developing seed stages have been grouped as fruiting stage, while the presence of fully developed seeds indicated seed maturation stage. This is followed by the senescence stage representing the death of the above ground plant parts.

QUANTITATIVE CHARACTERS

Vegetation analysis

The vegetation analysis of the study area has been studied through tiller analysis. Each annual erect shoot is considered as a plant tiller and in the case of sod forming grasses any portion of the plant possessing an independent shoot and root which can be separated from other is regarded as one tiller (Singh and Yadava, 1974). In this context the term “plant” is synonymous with erect independent shoot in forbs, and tiller in grasses. A total number of 60 quadrats of 50 cm × 50 cm were laid at random in the field during the last week of each month and each quadrat is subdivided into 10 × 10 cm segments. Four such segments selected at random were used for tiller analysis.

Density represents the number of individual per unit area. Frequency as defined by Raunkiaer (1934) indicates the number of sampling units in which a given species occurs and thus expresses the distribution of dispersion of various species in a community. The

abundance is considered with frequency, gives an idea of the distribution pattern of species. The ratio of abundance to frequency is a relative measure of degree of contagiousness of the distribution of any species (Whitford, 1949) and therefore A/F ratio is calculated for each of the species. According to Curtis (1956) this ratio below 0.025 indicates regular distribution, range between 0.025 to 0.050 indicates random distribution and more than 0.050 indicates aggregation/contagious.

Species diversity, evenness index and concentration of dominance

(a) Species diversity

Species diversity is quantified by calculating species diversity index, which is the ratio between the number of individuals of each species and total number of individuals of species. Species diversity can be calculated on density based used the Shannon-Wiener information function (1963):

$$H' = \sum_{i=1}^{s} (Ni/N)\log_2 (Ni/N)$$

where, H′ is the Shannon index of general diversity “Ni” is the total number of individuals of species i, “N” is the total number of all the species in that community.

(b) Evenness index

It is also one of the statistical abstraction of measuring species diversity. If all the species in a community have equal number of

individuals, the evenness or equitability is high. The index of evenness is calculated according to Pielou (1975) as:

$$e = \frac{H'}{\log S}$$

where, H′ = Shannon's index of species diversity

S = Total number of species

(c) Concentration of dominance (Cd)

Those species, which have the maximum influence over energy flow and the environment, are known as ecological dominants. Simpson (1949) has derived a formula for calculating the index of dominance that shows importance of each species relation to the whole community.

$$Cd = \sum_{i=1}^{s} (Ni/N)^2$$

where, Cd = Concentration of dominance.

Ni = Number of individuals of each species.

N = Total number of individuals of all species.

RESULTS AND DISCUSSION

Floristic composition

A list of 38 species has been recorded and are set in Table 1. Maximum number of species are recorded in the rainy season (37) and this is followed by summer (30) and winter season (21) during the study period. Maximum number of species exhibited during the rainy season than that of summer season (Singh and Yadava, 1974) in tropical grassland at Kurukshetra and (Kakati, 1985) in sub-tropical grassland at Imphal (Manipur). Higher number of species during the rainy season is obvious to favourable temperature and moisture condition.

The species which are present in all seasons are *Andropogon ascinodes, Arundinella setosa, Bothricochloa intermedia, Carex cruciata, Clerodendrum serratum, Cymbopogon flexuosus. C. martinii, Desmodium triflorum, Dichanthium annulatum, Fimbristylis dichotoma, Heteropogon contortus, Imperata cylindrica, Jasminum coarctatum, Microstagium ciliatum, Monocymbium ceresiiforme, Osbeckia nepalensis, Paspalum orbiculare* and *Themeda villosa*.

Maximum number of species is recorded in rainy season followed by summer and winter season. Shanker *et al.* (1973) while studying at Jhansi found the botanical composition with little seasonal trend as the dominant grasses reflected minimum seasonal fluctuation in their analytical characters except for some rainy season which come up in large number in monsoon period. Singh and Yadava (1974) is also observed that a marked seasonal variation in species composition in tropical

grassland at Kurukshetra. Singh and Krishnamurthy (1981) in their review on different tropical grasslands indicated that species number different from season to season but maximum number recorded in rainy season consistently across sites and minimum during summer as most of the species are rainy season and species which can resist adverse climate of summer season were fewer. Simillar observation has also been reported by (Kakati, 1985) in sub-tropical grassland at Imphal (Manipur). High density during the rainy season is obvious to favourable temperature and moisture condition. In fact changes in species composition from season to season highly related to biotic and abiotic factors.

Life-form

The biological spectrum of the present grassland shows that the number of therophyte is highest representing 22 species shown in Table 2. Cryptophyte also contributes considerably higher amount to the total spectrum representing 8 species. While phanerophyte exhibiting 4 species, Chamaephyte and Hemicryptophyte representing 2 species each respectively during the study period. The biological spectrum of the flora of the present study site is compared with the grasslands of other climatic regions of India and that of normal biological spectrum proposed by Raunkiaer (1934) (Table 3).

The percentage of Phenerophytes and therophytes are about four times greater than normal biological spectrum. While chamaephytes in the present grassland is comparatively low than the normal biological

spectrum. The percentage of both hemicryptophytes and Cryptophytes are three times more than normal biological spectrum.

The percentage of therophytes fall within the range reported from other Indian grasslands. However, the percentage of hemicryptophytes is quite low as compared to other Indian grasslands. The percentage of cryptophytes in the present study is comparatively higher than that of different Indian grasslands except the grassland of Jammu and Kashmir while the percentage of chamaephytes is comparatively lower than that of reported other grasslands, although slightly higher than that of Varanasi grassland. However, the percentage of phanerophytes in the present grassland is almost similar to the grassland of Jamu and Kashmir while the value falls within the range of reported from other grasslands.

A comparison of biological spectrum given by Raunkiaer as normal and that of the study site indicates that (i) the percentage of cryptophytes and therophytes are higher and (ii) the percentage of phanerophytes, chamaephytes and hemicryptophytes are lower in the present grassland than the normal spectrum (Fig.1)

Overall study, due to dominance of therophytes and cryptophytes as compared to normal biological spectrum, the flora may be called thero-cryptophytic using Raunkiaer's classification.

Raunkiaer's biological spectrum has been widely used in the ecological classification of plants and is considered important in determining the

differences and similarities among different communities (Jones, 1936). According to Braun-Blanquet (1932), grasslands in general are rich in hemi-cryptophytes. In the present study, therophyte exhibited the maximum number of species which is followed by cryptophyte and phanerophyte.

Singh and Yadava (1974) reported that the percentage of the chamaephytes is more than three times higher and the percentage of therophytes is somewhat lower in the grasslands of Kurukshetra, India. The cause that they have given a better distribution of rainfall on the site in the post-monsoon period. The flora of the tropical grassland at Kurukshetra is found to be thero-cryptophytic in accordance with Raunkiaer's terminology (Singh and Yadava, 1974). The flora of Bhaderwah at Jammu and Kashmir is studied by Kaul and Sarin (1976) who found a geochamaephytic climate for the area. The biological spectra in different altitudinal zone revealed a decrease in phanerophytes and therophytes with a gradual increase in chamaephytes and hemicryptophytes. Verma and Das (1980) suggested that a new approach towards the use of Raunkiaer's biological spectrum. They pointed out that Raunkiaer's life form spectrum must be incorporated with vegetational characteristics and only then a real picture of the vegetation and phytoclimate could be obtained. In the higher elevations of Yusmarg, Kashmir, Gupta and Kachroo (1983) noticed a great change in

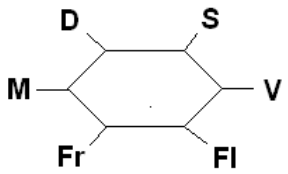
phanerophytes in different altitudinal zones with a geotherophytic plant climate. The percentage of therophytes increased as a result of over grazing through the introduction and spread of weedy grasses and forbs (Gupta and Kachroo, 1983). They also observed that considerable divergence in biological spectra from normal spectrum. During the study period, the percentage of therophytes and cryptophytes is higher in comparison to normal spectrum. Higher percentage of therophytes in grazed area may be due to biotic interferences particularly due to grazing by cattle (Astapati, 2008).

Phenology

In the present study, some of the dominant plant species has been undertaken for phonological study. The sprouting of rhizomes and germination of seeds in majority of the species start during moist summer period and continue their vigorous growth in the later part. In the experimental study site the field becomes lush green during March species like *Cymbopogon flexuosus, Eulalia fastigiata* and *Imperata cylindrica* as well as other associated species grow profusely. Thereafter the field looks like a white sheet of cloth due to the flowering of *Imperata cylindrica* and *Viola serpens* in the month of April and May. Most of the species start flowering during rainy period and reach their peak in September (Photo plate II & III). Some of the species continue to be flowering till November. Many species mature during winter months

and followed by subsequent drying and degeneration. While in January and February no new species is recorded. The grassland becomes pale yellow in colour as most of the species are drying up and wither away from the field.

Out of the total 38 species encountered during the study period from January 2020 to December 2021, only 26 plant species are taken into consideration for the phenological study because of their regular presence throughout the year. Six phonological stages as per Singh and Yadava (1974) are noted and the same are diagrammatically represented by lines radiating from different angles of a hexagonal figures for each month is regard to individual species. The symbol legend, used for different stages is as follows :



Symbol = Phenological stages

S = Sprouting of buds in rhizomes or root stock or germination of seeds

V = Vegetative phase

Fl = Flowering stage

Fr = Fruiting stage

M = Mature stage

D = Drying or death of species

On the basis of flowering stage the species are divided in five categories.

Group A = Those species which flower only in summer season.

Group B = Those species which start flowering in summer season and continue upto rainy season.

Group C = Those species which flower only in rainy season.

Group D = Those species which start flowering in rainy season and continue upto winter season.

Group E = Those species which flower only in winter.

Group A: *Imperata cylindrica* is a perennial grass species which flowers profusely in April and continue flowering till May. Maximum sprouting occurs in March and April through it continues till October. *Viola serpens* is an annual herb which starts flowering in April and continue till June and fruiting occurs during June and July. Maximum vegetative growth shows from July to October and disappear thereafter. It is one of the wild edible plant.

Group B: *Paspalum orbiculare* starts sprouting from the rhizome in February and March and having passed through a vigorous vegetative growth. Flowering occurs in May and continue upto September and followed by subsequent fruiting and maturation. The aerial parts of the plant start drying up from November onward. *Urena lobata* is a perennial shrub, sprouting from the old and perennial stalk in March, flowering profusely from March to August. Fruiting and maturation of seed completed by September and thereafter it dries up from October upto December although the species is not found during January and February.

Group C: Some of the species which flower only in rainy season namely, *Andropogon ascinode, Arundinella setosa, Borreria pusella,*

Desmodium triflorum, Digitania longiflora, Eulalia fastigiata, Fimbristylis dichotoma, Heteropogon contortus, Kyllinga triceps, Microstegium ciliatum, Setaria pallede-fusca and *Sporobolus indicus.*

All the species start their life cycle by emerging through sprouting and seedling either in March or April, when the pre-monsoon start in the last part of February. Some of the speies start flowering in June (*D. longiflora, F. dichotoma* and *K. triceps*) in July (*D. triflorum*, *S. indicus and S. pallide-fusea*, *H. contortus*) and in August (*A. ascinodes, A. setosa, B. pusilla, E. fastigiata* and *M. ciliatum*) and continue upto either in September or October. Fruiting and seed maturation are completed by November and December respectively. Aerial part of the species begin to dry up from November and degenerate slowly. However, some of the species are not observed in the last part of December till February.

Group D: Besides having flowering period from June to September, the species of this group continue to flower till October and in some cases upto November. *Bothriochloa intermedia* occurs throughout the year. The rhizomatous growth of this species is first noticed in March which is followed by vigorous sprouting in April and May. The species starts flowering from June and continue upto October. Thereafter, fruiting stage starts although

some of the individuals continue to be flowering till November. The aerial parts of the plant start drying up from November onward, however, nodal outgrowth continues to occur in December, January and February. *Dichanthum annulatum*, *Cymbopogon flexuosus*, *C. martinii* and *Microstegium ciliatum* sprout in February and grow profusely upto June and then flower from July to October. The species mature in November and thereafter it dries up in December. Sprouting and vegetative growth occur from March onward till July in case of *Phyllanthus vestigiata* and start flowering from August onward till October. Maturation of seeds begin from October and fruiting is completed during November and December. The species is not found in January and February. *Monocymbium ceresiiforme* and *Panicum palludosum* are also appears in March, flowering starts from August and continues upto October, maturation of seeds is completed by November and December although these species are not found in January and February.

Group E: *Sorghum nitidum* and *Themeda villosa* starts sprouting in April and grows continuously till October thereafter it flowers. These species starts drying up in December and are not recorded in the rest of the winter months.

The seedlings of annuals and perennials start emerging from the ground at the beginning of rainy season. In perennial grasses like *Cymbopogon flexuosus, C. martinii, Eulalia fastigiata, Dichanthium*

annulatum, Heteropogon contortus and *Monocymbium ceresiiforme* and forbs like *Desmodium triflorum* and *Urena lobata*, fresh sprouting starts from the rhizomes and root stalk. Germination of seeds and sprouting of perennating buds are followed by vigorous vegetative growth. Annual plants start flowering by the end of August and early part of September during the rainy season. Fruiting is also observed in some of the species like *Kyllinga triceps, Paspalum orbiculare, Setaria pallide-fusca* and *Urena lobata* during the period although *Borreria pusilla, Digitaria longiflora, Fimbristylis dichotoma, Panicum palludosum* and *Sporobolus indicus* generally bear fruit by the end of September and complete their life cycles and wither away. Some annuals persist during October and after completing their life history wither away by the middle of November, but a few can be encountered as late as December. Perennial species like *Bothriochloa intermedia, Cymbopogon flexuosus, Dichanthium annulalium, Eulalia fastigiata, Heteropogon contortus* and *Monocymbium ceresiiforme* start flowering from middle part of rainy season and continued upto later part of rainy season.

Most of the annual species complete their life cycle by the end of November and wither away. In perennial species also some of the seasonal shoots dry up in the early part of winter season. Among the perennating species *Jasminum coarctatum, Imperata cylindrica* and *Viola serpens* start flowering in the early part of summer season (April)

whereas *Jasminum coarctatum* starts flowering later part of winter and continued upto later part of summer. Rise in temperature during March which helps seed maturation in species. Most of the old aerial parts in the perennial species dry up in winter and annuals also complete their life cycle thereafter wither away during this season. However, on account of some rainfall during the later part of May, fresh sprouts were evident in perennials and seedlings of some annuals.Thus, during the rainy seasom almost all the species produces matures seed and germination of seeds takes place and in winter season the species wither away.The life cycle of plants species depends on the availability of soil moisture, nutrient level, soil temperature and sunlight.

QUANTITATIVE ANALYSIS

The pattern of changes in density, frequency and abundance of constituent plant species differ from species to species and exhibits differential adaptations to growing seasons.

Andropogon ascinodes: With the minimum density in March 2020 (3.64 tillers m^{-2}), the species shows a gradual increase up to August (29.79 tillers m^{-2}). The value decline consistently till February

(5.42 tillers m^{-2}). Maximum frequency is recorded in August (60%) while minimum in February (6.67%). The species is highly abundant in January (56.25 tillers m^{-2}) and least in February (25.00 tillers m^{-2}). The A/F ratio is 8.19 for the month of March 2020.

Apluda aristata: This species is first recorded in April (5.83 tillers m^{-2}) and the value of density increases till it attains the maximum value in September (22.50 tillers m^{-2}) except a slight decrease in the month of June, However the species disappears during December and January and then the species starts increasing the next two months. Minimum and maximum frequency exhibits in April (5.00%) and September (46.67%) respectively. Abundance is recorded to be minimum in July (47.5 tillers m^{-2}) and maximum in April (116.68 plants m^{-2}). The A/F ratio ranges from 1.03 (September) to 23.34 (April).

Arundinella setosa: Starting with 13.75 tillers m^{-2} in March 2020, the value of density gradually increases in May and fluctuates the consequent months. The maximum peak is recorded in September (76.38 tillers m^{-2}) and thereafter decreases till the minimum value of 6.04 tillers m^{-2}) in February. The frequency percentage ranges from 16.67% (February) to 83.33% (September). The species is highly abundant in August (86.5 tillers m^{-2}) and least in February 2020 (36.25 tillers m^{-2}). The A/F ratio is 2.12 for August.

Borreria pusilla: The density values varies from 1.15 plants m^{-2} (November) to 4.27 plants m^{-2} (September). The species disappears during November and December. The maximum values for frequency, abundance and A/F ratio were 30%, 28.12 plants m^{-2} and 5.0 respectively.

Bothriochloa intermedia: With the minimum density in March (10.63 tillers m^{-2}), the species shows a gradual increase upto September (23.96 tillers m^{-2}) and then the value decline consistently upto January (3.96 tillers m^{-2}). Frequency is found to be minimum in January (8.30%) while the maximum in May (91.67%). The abundance values ranges from 28.36 tillers m^{-2} (December) to 45.31 tillers m^{-2} (March'21). The A/F ratio is 5.75 for the months of January.

Carex cruciata: Starting with 0.52 plants m^{-2} in March and consistently increases with a maximum value of 4.17 plants m^{-2} in July. The value declines gradually till December with a minimum value of 0.10 tillers m^{-2}. The frequency fluctuates throughout the year exhibiting the maximum value in August (16.67%) and minimum in December (1.67%). Maximum abundance and A/F ratio are recorded during April (25.00 plants m^{-2}) and 7.50 respectively.

Clerodendrum serratum: The minimum and maximum density is recorded in February (0.10 tillers m^{-2}) and April (1.25 tillers m^{-2}). However, the species is not recorded in September and October as this may have not

been included during sampling. Maximum values for frequency and abundance are recorded to be 13.33% (July) and 18.75 tillers m^{-2} (March) respectively. The A/F ratio is 3.75 for the month of March.

Cymbopogon flexuosus: It exhibits the highest density among the plant species present in this grassland. The density is recorded to be maximum in August (209.69 plants m^{-2}) and minimum in January (65.79 plants m^{-2}). Maximum values for frequency and abundance are recorded to be 65.79% (July) and 313.95 plants m^{-2} (April) while minimum in December (40%) and May (115.72 plants m^{-2}). The A/F ratio is 6.15 for January.

Cymbopogon martinii: The density increase a gradually from March (11.88 tillers m^{-2}) upto May (51.88 tillers m^{-2}) and thereafter, with a slight decrease in June and it again starts increasing till September (77.08 tillers m^{-2}). The species shows a consistent decline attaining the minimum value in February (10.31 tillers m^{-2}). The maximum density corresponds with the vigorous sprouting of the species. Maximum frequency and abundance is recorded during September (43.33%) and October (182.25 tillers m^{-2}) respectively. The A/F ratio is 7.32 for January.

Dichanthium annulatum: The maximum density is recorded in September (139.27 plants m^{-2}) and minimum is January (33.85 plants m^{-2}). The frequency percentage fluctuates throughout the year with maximum of 96.67% in October and (36.67%) in February. The maximum values of

abundance and A/F ratio are recorded to be 157.68 plants m^{-2} and 2.75 respectively in the month of February.

Desmodium floribundum: The maximum density is recorded in September (43.33 tillers m^{-2}) and minimum in March (3.65 tillers m^{-2}). The species exhibits low frequency in November (1.67%) while maximum in May 13.33%). Abundance is found to be highest in April (52.06 tillers m^{-2}) and least in November (6.25 tillers m^{-2}). The A/F ratio is 0.58 for August.

Desmodium triflorum: Starting with a minimum density of 13.65 plants m^{-2} in March'20 and it increases till May (43.33 plants m^{-2}) and decline in June thereafter it consistently increases upto September (40.33 plants m^{-2}). The highest frequency and abundance value is recorded to be 53.33% (September) and 162.88 plants m^{-2} (August) and least in January exhibiting 15% and 43.05 plants m^{-2} respectivley. The A/F ratio is 6.98 for August.

Digitaria longiflora: Starting with 5.73 tillers m^{-2} in April, density gradually increases till it attains the maximum value in September (13.13 tillers m^{-2}). The values decline consistently with the minimum value of December (2.29 tillers m^{-2}) while the species disappears during January and February. The frequency fluctuates throughout the year exhibiting the maximum value in July (41.67%) and minimum in December (10%). However, abundance is recorded to be maximum in April (34.37 tillers m^2). The A/F ratio is 2.29 for December.

Eulalia fastigiata: The density increases from March'20 (83.13 tillers m^{-2}) and consistently increases upto August (207.38 tillers m^{-2}). The maximum density corresponds with the vigorous sprouting of the species. And again it declines gradually with a minimum value of 29.79 tillers m^{-2} in January and a slight increase is observed in February and March'21. Maximum frequency is recorded in August, September and October (100%) while minimum in March'20 (33.33%). The species is highly abundant in June (209.95 tillers m^{-2}) and lowest in January (85.11 tillers m^{-2}). The A/F ratio exhibited in the month of March'21 (6.41).

Fimbristylis dichotoma: The density is recorded to be maximum in August (11.46 tillers m^{-2}) and minimum in June (2.29 tillers m^{-2}). The frequency fluctuates throughout the year with maximum of 46.67% in September and minimum of 15% in June. Maximum and minimum values of abundance are recorded to be 52.87 tillers m^{-2} (September) and 15.25 tillers m^{-2} (May and June) respectively. The A/F ratio is 2.43 for August.

Heteropogon contortus: The maximum density value is recorded in August (139.27 tillers m^{-2}) and thereafter it declines with a minimum value of 13.85 tillers m^{-2} in January. Maximum frequency is recorded during April, August and September (78.33%). While minimum is observed in Janaury (26.67%). Abundance value ranges from 51.93 tillers

m^{-2} (January) to 207.98 tillers m^{-2} (October). The A/F ratio exhibits for the month of August and September (1.97).

Imperata cylindrica: The maximum density attains in April (125.60 plants m^{-2}) whereas sthe species starts flowering in this month just after the maximum growth. The density is recorded to be minimum in January (10.29 plants m^{-2}) which is due to the completion of its life cycle during December and January. Frequency and abundance are also recorded to be maximum in April and September with their values are 96.67% and 132.20 plants m^{-2} respectively. The A/F ratio is 8.49 for the month of November.

Jasminum coarctatum: It exhibits minimum density in January (1.04 tillers m^{-2}) and maximum in March (6.56 tillers m^{-2}). Starting with frequency of 5.0% in January it attains the highest value in April (30%) and thereafter it shows fluctuation from 8.33% to 25% in different months. The species is highly abundant in March (26.25 tillers m^{-2}) and the least in April (6.93 tillers m^{-2}). The A/F ratio is 4.16 for January.

Kyllinga triceps: The density is recorded to be minimum in April (1.04 tillers m^{-2}) and maximum in September (5.63 tillers m^{-2}). Thereafter, the species shows disappear during December and January which is due to death and shattering of the species. Frequency and abundance are also recorded to be maximum in September (26.67%) and April (31.25 tillers m^{-2}) respectively. The A/F ratio is 9.38 for April.

Microstegium ciliatum: Density attains the maximum value in September (82.85 tillers m^{-2}) and the least in March 2020 (8.85 tillers m^{-2}). Frequency and abundance are also recorded to be maximum in September and their values are 66.67% and 124.25 tillers m^{-2} respectively. The A/F ratio is 3.18 for March 2020.

Monocymbium ceresiiforme: It exhibits maximum density in August (36.46 plants m^{-2}) while minimum in January (2.92 plants m^{-2}). The frequency fluctuates throughout the year exhibiting the maximum value in July (41.67%) and minimum in December and January (13.33%). The species is highly abundant in September (109.37 plants m^{-2}) and least in February (16.68 plants m^{-2}). The A/F ratio is 3.64 for the month of September.

Ophiopogon wallichianus: Starting with 8.33 plants m^{-2} in March, density gradually increases till it attains the maximum value in August (21.67 plants m^{-2}). It declines upto October and then the subsequent four months i.e., from November to February, the species is found to be absent which may be due to completion of its life cycle and again starts sprouting from March 2021. Maximum frequency, abundance and A/F ratio are recorded to be 21.67% (August), 12.5 plants m^{-2} (September) and 0.49 (July) respectively.

Panicum paludosum: The maximum density exhibits in June (1.04 plants m^{-2}) and minimum in January (0.31 plants m^{-2}). Maximum frequency and abundance is recorded in March'21 and their values are 13.33% and 17.18 plants m^{-2} respectively. The A/F ratio is 4.69 for September.

Phyllanthus vestigiata: Density and abundance are recorded to be minimum in May with 2.08 tillers m^{-2} and December 8.68 tillers m^{-2} respectively while maximum in July with 6.04 tillers m^{-2} and 25.87 tillers m^{-2} respectively. The frequency is found to be minimum in May (11.67%) and maximum in September (46.67%). The A/F ratio is 2.14 for May.

Paspalum orbiculare: Density attains the maximum value in November (46.79 plants m^{-2}) and least in April (7.08 plants m^{-2}). The frequency fluctuates throughout the year exhibiting the maximum value in November (48.33%) and minimum in January (13.33%). However, abundance is recorded to be maximum in January (117.25 plants m^{-2}). The A/F ratio is 8.79 for January.

Scleria pergracilis: This species is first recorded in May and disappears after November, with the lowest value of density in November (1.04 plants m^{-2}) and reaches a peak value in September (7.71 plants m^{-2}). Maximum frequency and abundance is recorded during September

(26.67%) and August (60.68 plants m^{-2}) respectively. The A/F ratio is 9.38 for November.

Sorghum nitidum: Density attains the maximum value in April (7.5 tillers m^{-2}) and the least in October (0.31 tillers m^{-2}). The frequency fluctuates throughout the year exhibiting the maximum value in April (18.33%) and minimum in October (1.67%). However, abundance is recorded to be maximum in April (40.93 tillers m^{-2}). The A/F ratio is 3.90 for May.

Sporobolus indicus: The highest density is observed in September (25.0 tillers m^{-2}) and least in December (2.08 tillers m^{-2}). The maximum value for frequency is recorded to be 55% in September while the minimum in December (10%). The value of maximum abundance and A/F ratio are recorded to be 53.12 tillers m^{-2} (August) and 1.97 (June) respectively.

Themeda villosa: The highest density is recorded in November (65.63 tillers m^{-2}) while least in August (10.96 tillers m^{-2}). The frequency percentage fluctuates throughout the year and attains a peak in November (81.67%) whereas minimum in May and July (18.33%). The maximum values for abundance and A/F ratio are 146.04 tillers m^{-2} and 8.09 in the month of May.

Viola serpens: Density and frequency is recorded to be maximum in April as 22.13 tillers m^{-2} and 35% respectively while minimum is observed both

in November with 1.84 tillers m^{-2} and 5% in September respectively. The highest value for abundance is recorded to be 97.72 tillers m^{-2} in May and least in November (36.80 tillers m^{-2}). The A/F ratio is 7.36 for the month of November.

Among the important fodder grasses like *Cymbopogon flexuosus* exhibited the highest density followed by *Eulalia fastigiata*, *Imperata cylindrica* and *Heteropogon contortus* as well as they were found more frequent during the study period. *Desmodium triflorum* is also found more frequent among the legumes. On the other hand, among the forbs Viola serpens is found more frequent and it shows high density. The vegetative part is also used as vegetable curry. Those species are highly palatable and therefore need to conserve for the cattles fodder.

Distribution pattern in plants

According to the criteria proposed by Curtis and Cottam (1956), the abundance/frequency ratios of various species indicated contagious distribution throughout the study period. The contagious distribution is the characteristics of natural vegetation and have also been reported by several workers (Greig-Smith, 1957; Kershaw, 1973; Singh and Yadava, 1974; Ralhan *et al*., 1982 and Kakati, 1985). The dominance of

contagious distribution may be due to the fact that majority of herb species reproduce vegetatively (Galav *et al*., 2005).

Species diversity, evenness or equitability and concentration of dominance

Shannon index of general diversity (H′) ranges from 3.25 (January) to 4.03 (September) while evenness (e) or equitability index varies from 0.84 (February) to 1.11 (April). The maximum value for concentration of dominance is recorded in the month of April (0.22) whereas minimum value is observed in the month of September (0.08). The relatively lower values for concentration of dominance are in accordance with high species diversity in this period (Fig.3, 4 and 5).

The maximum values of species diversity is observed in two peaks (April and September). Higher diversity values occurred in rainy season which indicated that climatic factors especially rainfall is highly responsible for abundant plant growth. Evenness (e) is another major component of diversity in the apportionment of individuals among the species. It is also influenced by seasonality of climate, the value of evenness is found to be minimum in January and February (dry period) during the present study. Decline in these months occurred due to lack of adequate precipitation. The maximum value for concentration of dominance is recorded in summer whereas minimum value in rainy season. Higher value in species diversity and low value in concentration of dominance may be due to the different level of biotic disturbance communities. In general, species diversity and concentration of dominance are inversely related. Similar observation has also been reported by

Galav *et al.* (2005) studied on the grassland community of Southern Aravali Hills of Rajasthan.

The density of the ten most important species which are present in the different months throughout the year are shown in Fig 6. and Fig 7, it is clear that density of individual species fluctuates throughout the year in response to the changes in environmental conditions. The pattern of changes in density differ from species to species and exhibit differential adaptations to growing seasons. Out of the ten species considered for diagrammatic representation, four species namely, *Bothriochloa intermedia*, *Desmodium triflorum*, *Imperata cylindrica* and Viola serpens exhibit maximum density during summer months while *Arundinella setosa*, *Cymbopogon flexuosus*, *Eulalia fastigiata* and *Heteropogon contortus* attains maximum density during rainy season. *Paspalum orbiculare* and *Themeda villosa* shows maximum density in winter season.

Total density

The total density of the vegetation fluctuates throughout the year. The total density in the beginning of the study is recorded to be 456.29 tillers m^{-2} in the month of March'20. There is a sudden increase in April (911.75 tillers m^{-2}). Which may be due to the maximum contribution of tillers by *Imperata cylindrica* and *Viola serpens* and thereafter decline in May. The value again increases from June upto September (1341.91 tillers m^{-2}), which may be due to considerable amount of rainfall during these period. Density exhibits a decreasing trend from October onward till January (264.98 tillers m^{-2}) which may be due to the death and shattering of most of the species. Thereafter a slight increase from February upto March'21. Some of the species start emerging in the month of February and March.

The magnitude of increase or decrease in total density of the vegetation varied in different months.A comparison of monthly variation of total density of present study with some other Indian grasslands reveals that density is higher in this grassland than those of Ujjain (Misra, 1973); Ratlam (Billore, 1973) and Jhansi (Gupta and Misra, 1978) but lower than that of Varanasi (Singh, 1967). However, the present values lies between the range of Kurukshetra (Singh and Yadava, 1974) and Imphal (Kakati, 1985) (Table 6). The variation is probably due to differences in botanical composition, availability of water, and climatic conditions. The maximum total density in the present grassland is recorded in September while the maximum value of total density in other study sites is also recorded either in September or October at the time rainy season. The increase in total density during the rainy season reflected the active growth of various annual and perennial species with advent of June rains. The decline after September is caused by the death of annual species, as well as death of some tillers of perennial grasses. Therefore the grasses are never subjected to complete dryness whereas, the grasslands situated in north and Central part of India experience a hot and dry summer months of April and May.

The total density is related to mean air temperature in different months according to the regression,

$$\hat{Y} = 64.286\,\bar{x} - 587.78$$

where $\hat{Y}$ = is the total density (tillers m^{-2}) and $\bar{x}$ is the air temperature (^0C). It shows highly significant with positive relationship and 79% of the variability in total density pattern can be explained by air temperature variation ($r = 0.889$; $P<0.001$) shown in Fig 8.

The total density is related to the amount of rainfall in different months according to the regression,

$$\hat{Y} = 1.934\,\bar{x} + 552.39$$

where $\hat{Y}$ = is the total density (tillers m^{-2}) and $\bar{x}$ is the amount of rainfall (mm). The relationship shows positive correlation and explains 50% variability in the total density due to variability in monthly rainfall ($r = 0.707$; $P<0.001$) shown in Fig.9.Thus the density of vegetation is strongly influence by the air tempaerature and rainfall.

Conclusion

The flora of the grassland under study, can be designated as therocryptophytes, on the basis of the biological spectrum. The tropical grasslands, in general are dominated by therophytes and cryptophytes because of the strong periodicity in climate and intense biotic pressure .The therophytic plants are more dominant during rainy season while cryptophytes or hemicryptophytes, having been able to withstand several grazing pressure due to hidden subsurface position of birds, dominate the vegetation during winter and summer seasons. Phenological study of the

constituent species reflects strong seasonality and periodicity. Emergence of most of the species start during moist summer and also continue through the rainy season. Six phenological stages are observed from sprouting as emergence to death of the species. The species are grouped into five categories on the basis of flowering phase and its length, e.g. summer, summer-rainy, rainy, rainy-winter and winter. The situation in the present grassland is quite different from other Indian grasslands which may be due to climatic variation among the sites.

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Declarations

Data availability:

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.All data generated or analysed during this study are included in this artcle.

Ethics approval and consent to participate: The plant was identified by Dr.Yumkham Sanatombi Devi, Department of Botany, Manipur University Imphal-795003, India.

The collected studied plant species were stored at Manipur University Museum of Plants (MUMP), Department of Botany, Manipur University, Manipur University, Imphal, India and the corresponding voucher ID/deposition numbers of the studied plant species is provided in the Manuscript.

Permission Statement: The present study site covers under Private Farmland and is owned by Dr. Elangbam Jadu Singh, Thoubal District, Manipur, India and he has given permission for our study. The author has no conflict of Interest during the course of study.

Consent for publication: Not applicable.

Competing interests: 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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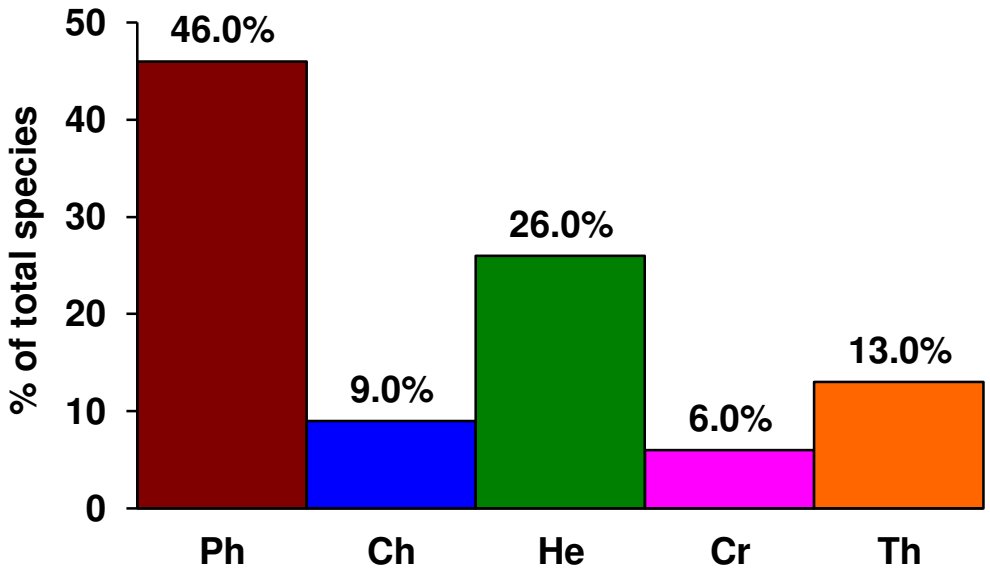
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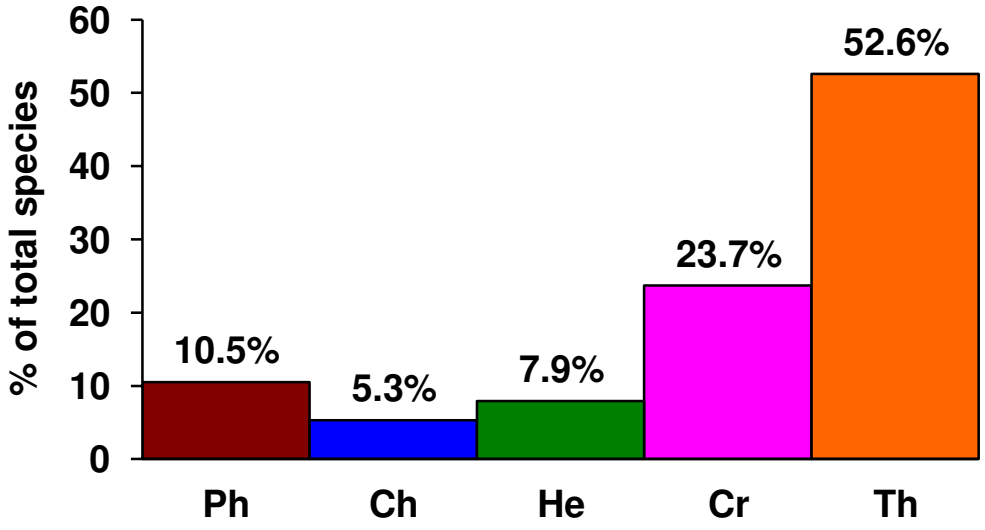
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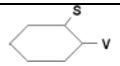
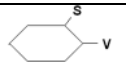
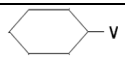
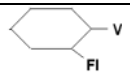
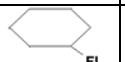
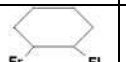
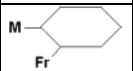
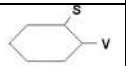
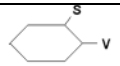
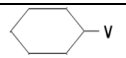
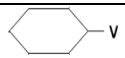
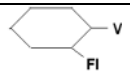
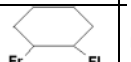
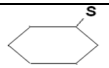
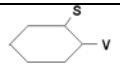
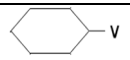
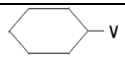
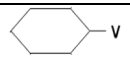
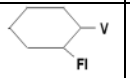
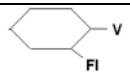
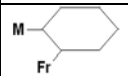
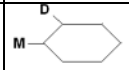
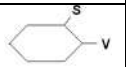
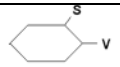
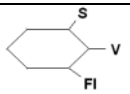
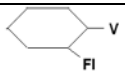
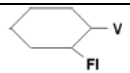
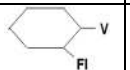
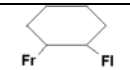
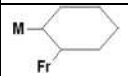
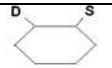
(a) Normal Biological spectrum of Raunkiaer

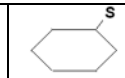
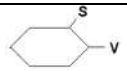
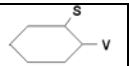
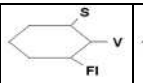
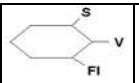
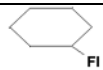
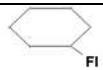
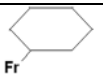
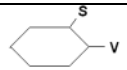
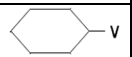
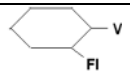
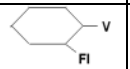
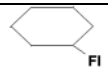
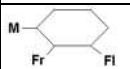
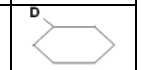
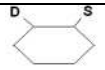
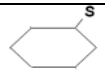
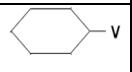
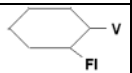
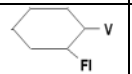
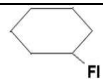
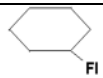
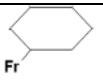
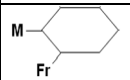
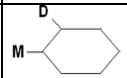
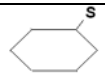
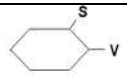
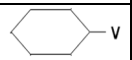
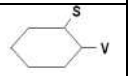
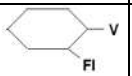
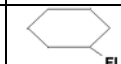
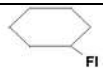
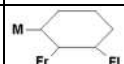


(b) Biological spectrum of the present study site

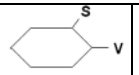
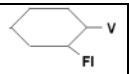
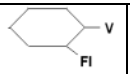
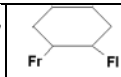
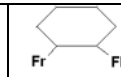
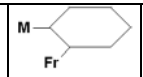
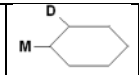
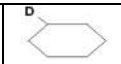
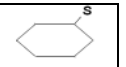
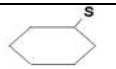
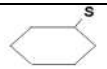
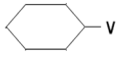
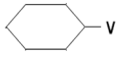
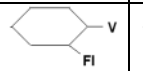
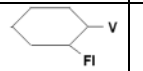
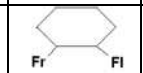
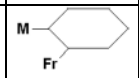
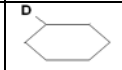
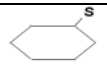
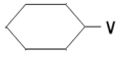
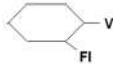
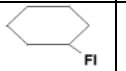
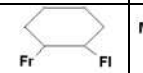
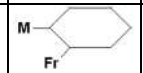
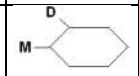
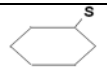
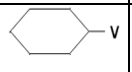
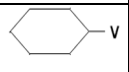
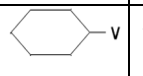
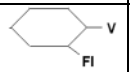
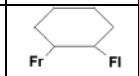
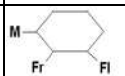
Fig.1: Raunkiaer's normal spectrum and its comparision with present study.

Fig 2: Phenological stages of various species encountered in different months during study period.

Species name	MAR'20	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN'21	FEB
Andropogon ascinodes												
Arundinella setosa												
Borreria pusilla												
Bothriochloa intermedia												
Cymbopogon flexuosus												
C. martinii												
Desmodium triflorum												
Dichanthium annulatum												

Digitaria longiflora												
Eulalia fastigiata												
Fimbristylis dichotoma												
Heteropogon contortus												
Imperata cylindrica												

Species name	MAR'20	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN'21	FEB
Jasminum coarctatum												
Kyllinga triceps												
Microstegium ciliatum												
Panicun paludosum												

Paspalum orbiculare												
Phyllanthus vestigiata												
Setaria pallidefusca												
Sorghum nitidum												
Sporobolus indicus												
Themeda villosa												
Urena lobata												
Viola serpens												
Monocymbium ceresiiforme												

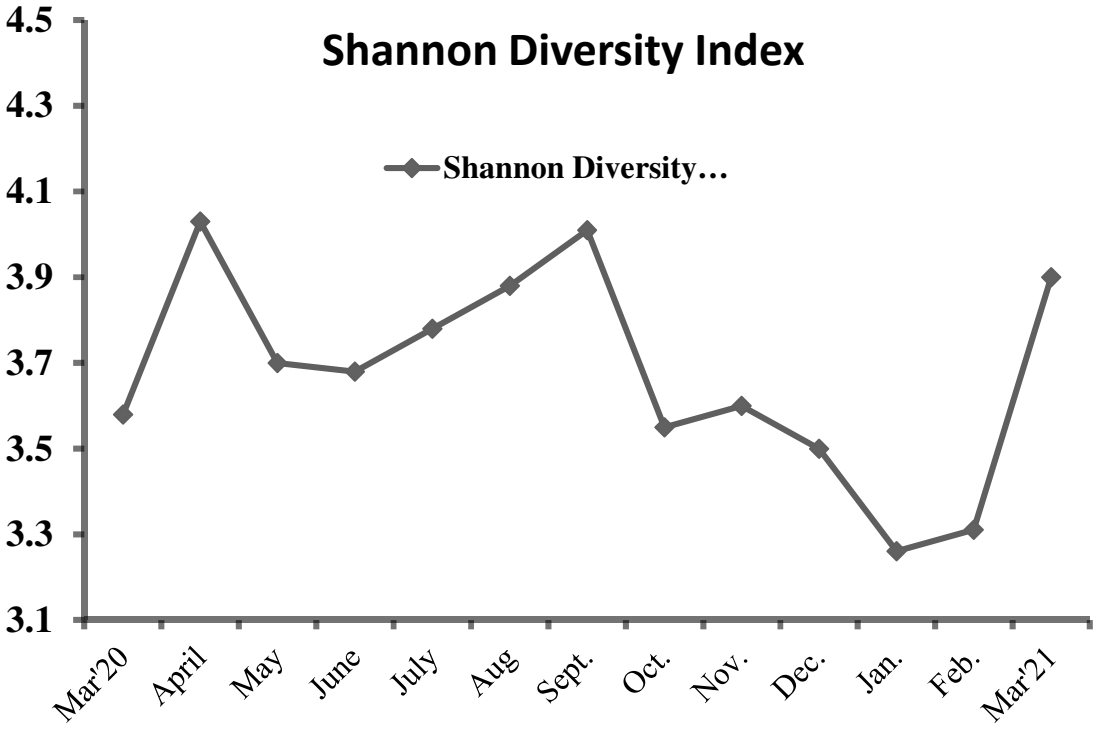


Fig.3: Monthly variations in Shannon's diversity index in the study site.

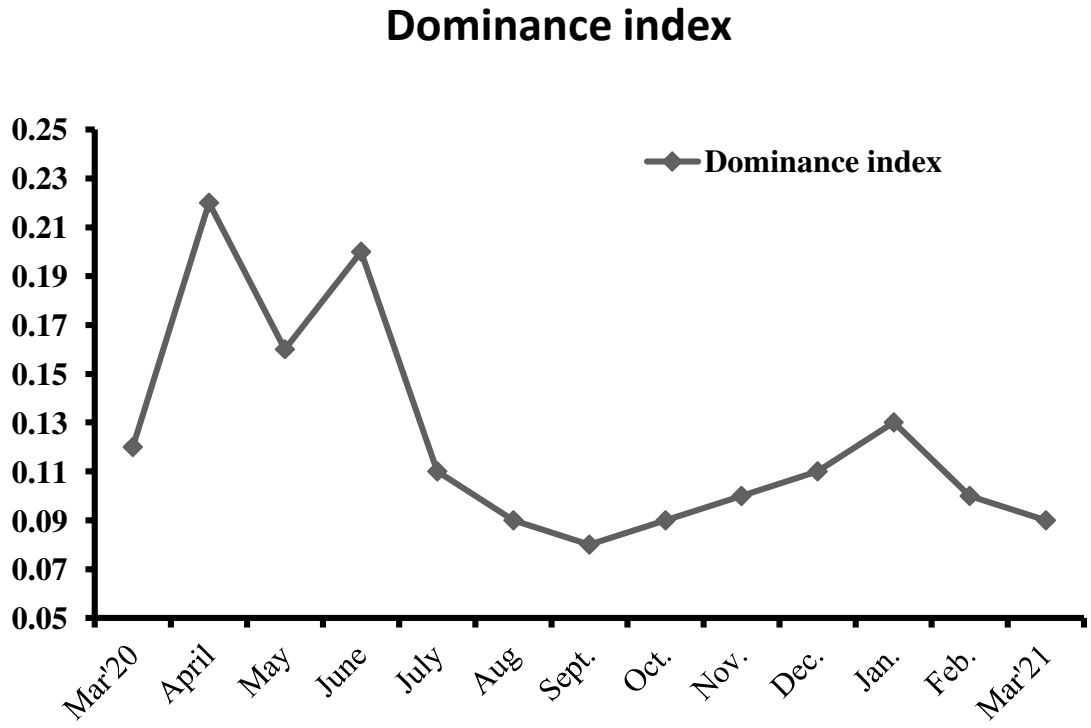


Fig.4: Monthly variations in Dominance index in the study site.

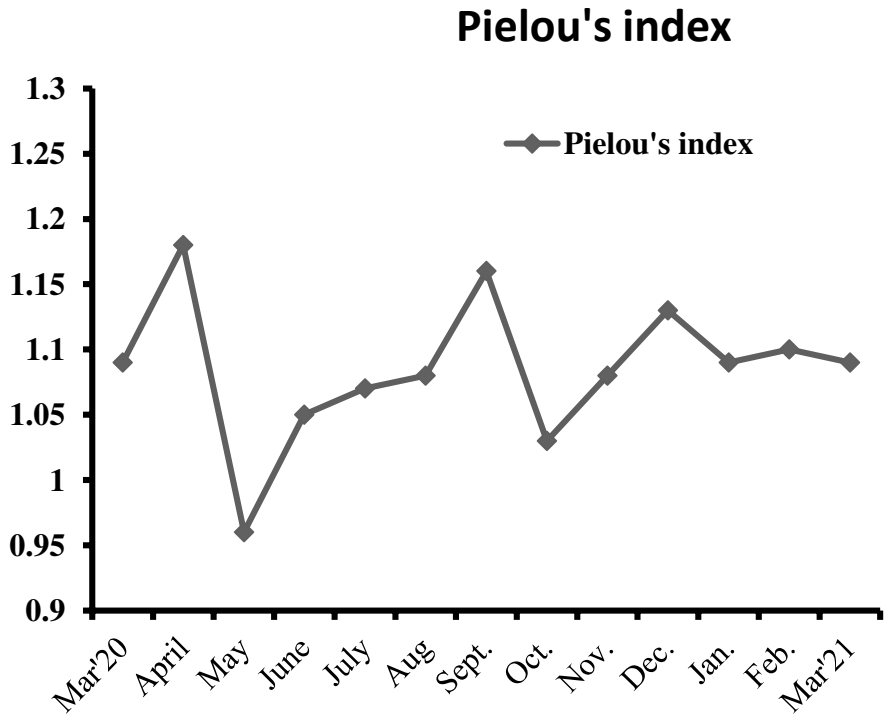
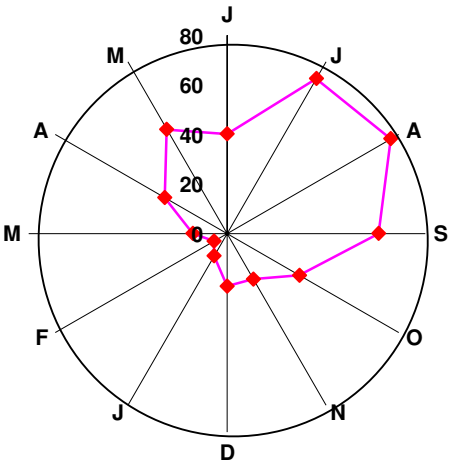
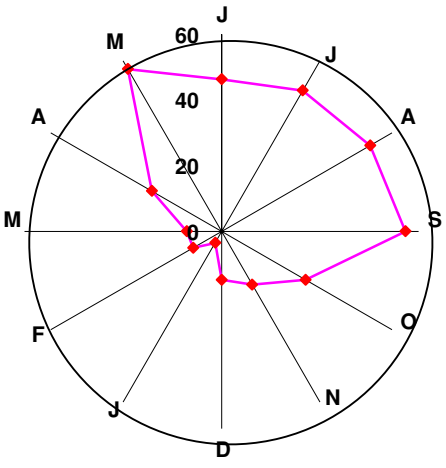


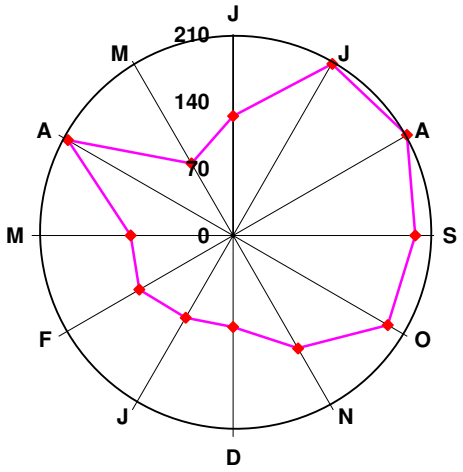
Fig. 5: Monthly variations in Pielou's index in the study site.



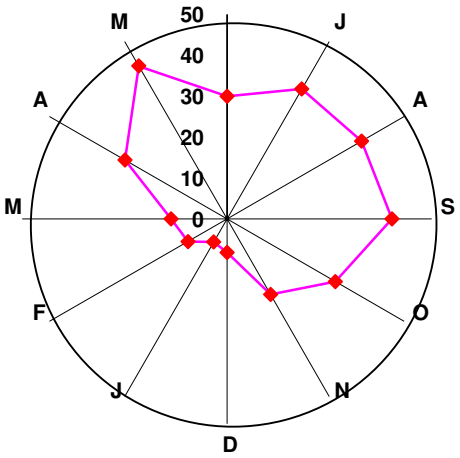
Arundinella setosa



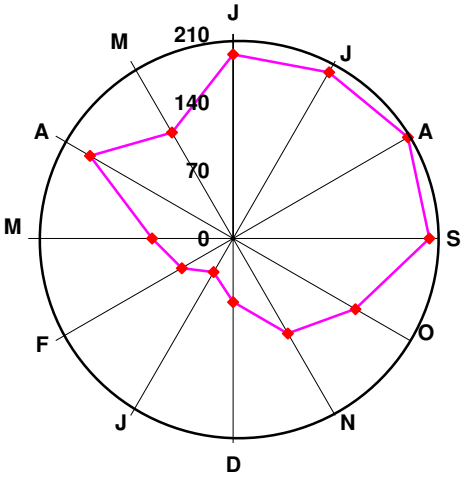
Bothriochloa intermedia



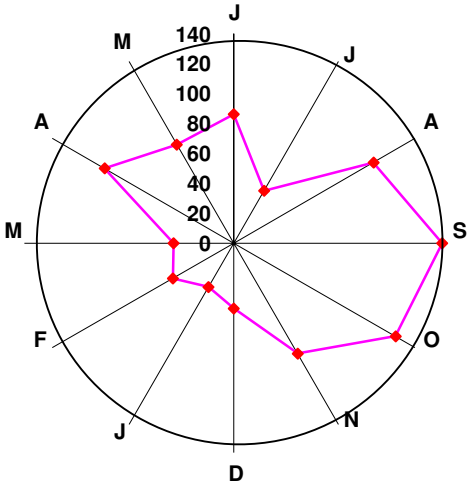
Cymbopogon flexuosus



Desmodium triflorum

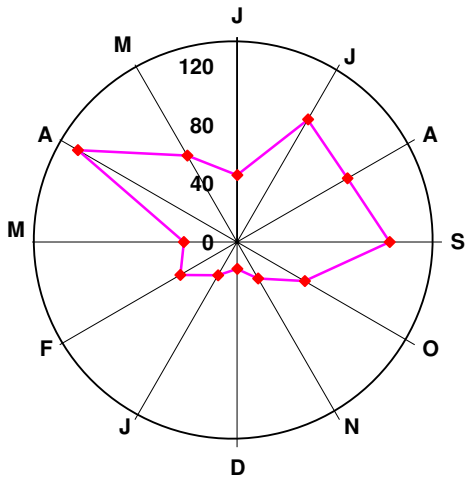


Eulalia fastigiata

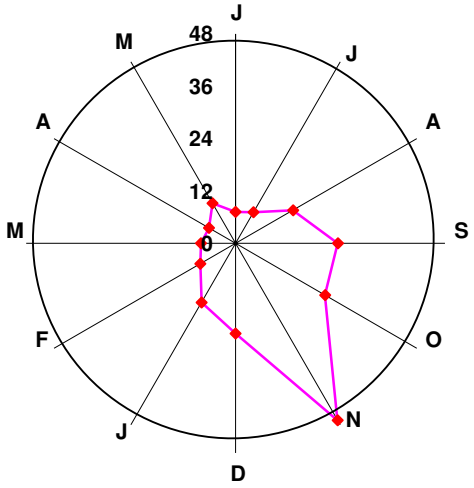


Heteropogon contortus

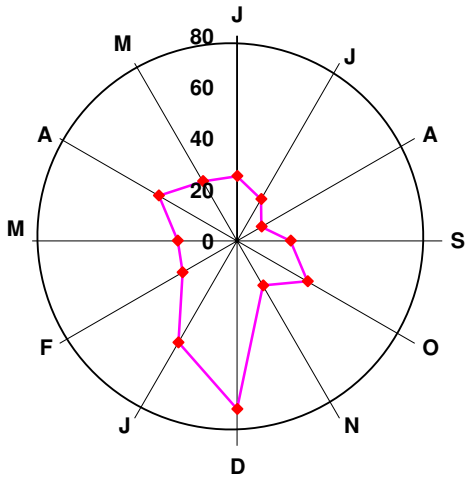
Fig.6 : Variation in density of six species present in the grassland throughout the year.



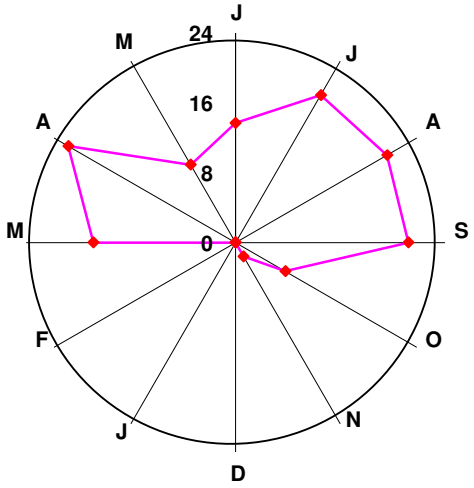
Imperata cylindrica



Paspalum orbiculare



Themeda villosa



Viola serpens

Fig.7 : Variation in density of four species present in the grassland throughout the year.

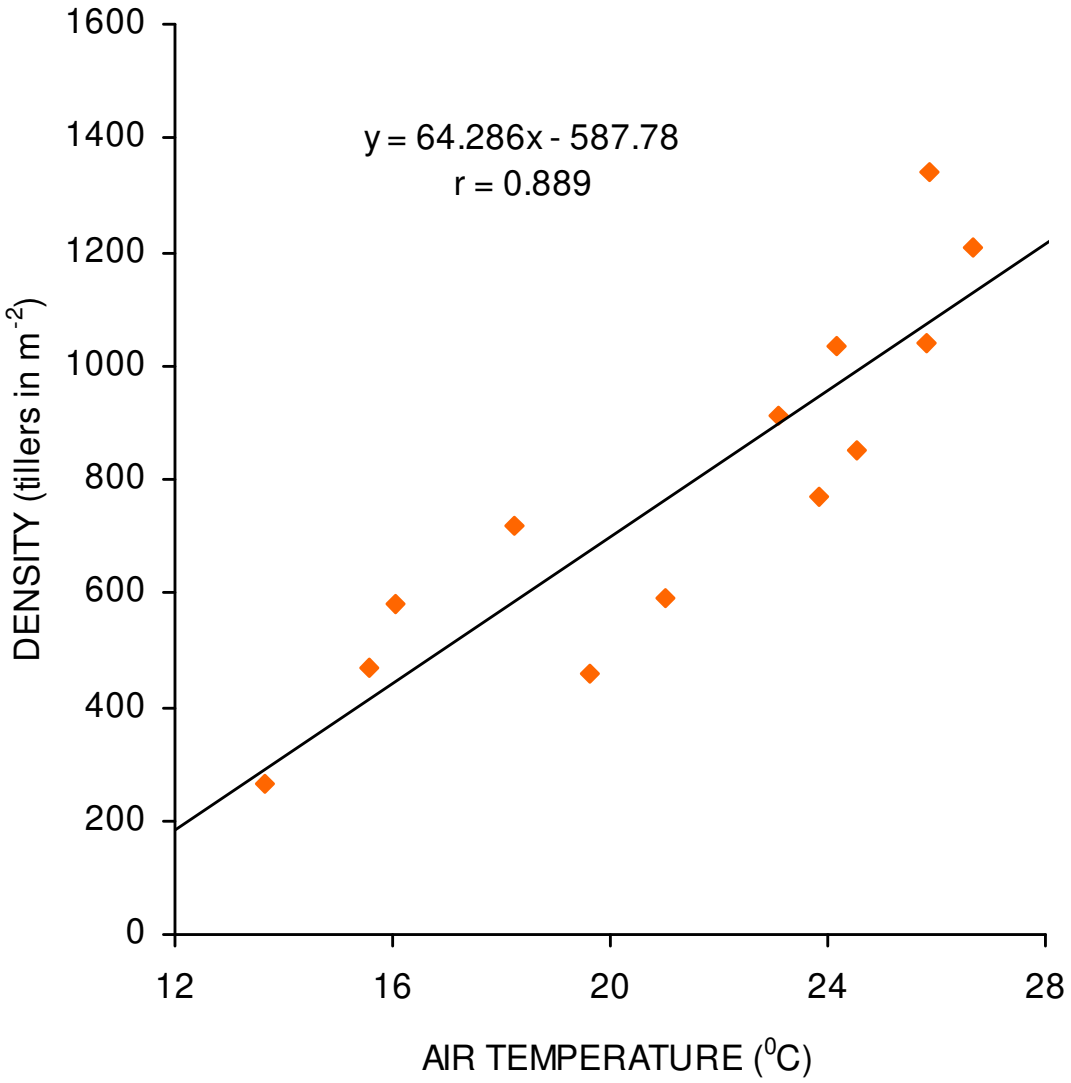


Fig. 8: Relationship between air temperature and total vegetation density throughout the study period.

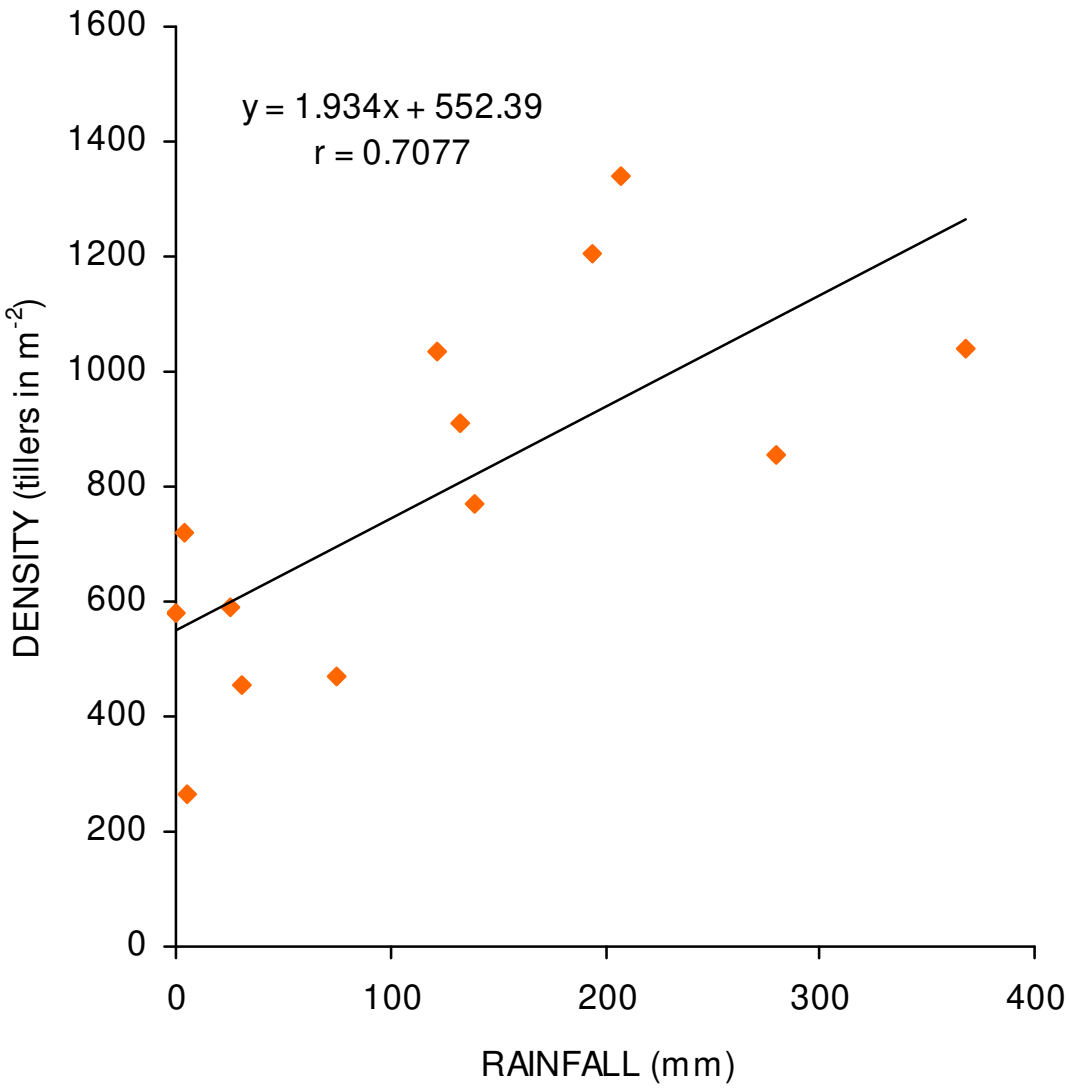


Fig. 9: Relationship between rainfall and total vegetation density throughout the study period.

Supplementary Files

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- Table.docx