Journal of
Plant Science & Research

Open Science Publications

Volume 12, Issue 1 - 2025

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Assessment of Plant Life-Form Diversity and Ecological Dynamics in Guntagola Forest Lingasugur Taluk Raichur District Karnataka, India

Research Article

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Article Information: Submission: 22/12/2024; **Accepted:** 07/01/2025; **Published:** 10/01/2025

Abstract

The study examines the diversity and ecological distribution of plant life forms in the Guntagola Forest, located in Lingasugur Taluk, Raichur District, Karnataka, India. Using Raunkiaer's life-form classification system, the research investigates plant adaptation strategies in a semi-arid environment characterized by rocky terrain, sparse vegetation, and limited rainfall. Data were collected through 48 systematically placed 10 m × 10 m quadrats across diverse habitats, including forest patches, grasslands, and rocky outcrops. Species richness, evenness, and spatial distribution were analyzed using GIS tools, and statistical methods were applied to evaluate the relationship between life forms and environmental variables. The results revealed a total of 531 plant species categorized into five major life-form classes: therophytes (243 species, 45.76%), phanerophytes (115 species, 21.66%), chamaephytes (73 species, 13.75%), hemicryptophytes (70 species, 13.18%), and cryptophytes (30 species, 5.65%). A significant deviation from Raunkiaer's Normal Spectrum was observed, with therophytes being highly dominant due to their adaptation to dry and disturbed conditions. In contrast, phanerophytes and hemicryptophytes showed reduced representation, likely due to habitat disturbance and climatic constraints. Environmental factors such as soil moisture and temperature played a crucial role in shaping the distribution patterns of life forms. This study highlights the ecological significance of plant functional diversity in semi-arid regions and provides a comprehensive overview of life-form adaptations to specific climatic and edaphic conditions. The findings contribute to the understanding of biodiversity in the Guntagola Forest and underscore the need for conservation efforts to maintain ecological balance in this fragile ecosystem. Future research may focus on long-term monitoring of life-form dynamics and the impact of anthropogenic activities on vegetation composition..

Keywords: Plant Life Forms; Raunkiaer Classification; Semi-Arid Ecosystems; Species Diversity; Guntagola Forest; Lingasugur; Raichur; Ecological Adaptation

Introduction

Raunkiaer's approach is particularly helpful for categorizing plants in regions with seasonal climates, where the growing season is dictated by the presence of frost and/or water scarcity. Climate is therefore predicted to have a significant influence on the distribution and diversity of life forms in European plant ecosystems. A classification scheme for vascular plant life forms was put forth by Christen Christiansen Raunkiaer in 1934. It was based on the location and level of protection of the renewal buds during times that were not conducive to plant growth, such as dry or cold seasons. The method is based on the idea that plants adjust to (micro)climatic circumstances, especially extremes like frost and drought, by using this strategy to safeguard the perennating organs [1]. Considering that the life forms of the Raunkiaer represent life-history features that maximize organisms' performance under a certain set of environmental variables [2], we anticipate that life forms will react to temperature and moisture gradients in a variety of habitat types. According to earlier research, (continuous) trait syndromes exhibit significant geographic variation at large spatial scales [3], and when responses within distinct habitat types are taken into account, environmental conditions can account for some of these patterns [4,5].

Around 1896, Warming was the first to use the term "Life form" [7]. Plant life forms are characterized by their morphological or vegetative adaptability to their surroundings. It can be useful for comparing the kinds of flora found in various locations [8]. According to [9,10], the growth form is the real structure of the shoot apex, whereas life form is the physiognomy of vegetation. However, the growth form can be regarded as the plant's general morphological property that can be investigated. Based on physiognomy, several ecologists attempted to categorize the different plant life forms [11]. Theophrastus, for instance, divided the vegetation or plant community into species such as trees, shrubs, and herbs. For most ecologists, the taxonomy of plant life forms was acceptable. The biological spectrum is the range of plant life forms in a plant community, expressed as a different ratio or percentage. This biological spectrum aids in exposing the diverse vegetation kinds and climatic conditions of various geographic places [12]. It is possible to identify the dominant species in a natural environment or plant community and investigate the effects of human activity on these ecosystems with the aid of the biological spectrum. Numerous studies on plant life forms have been conducted both in India [13-15] and internationally [16-19]. In cool-temperate climates, hemicryptophytes and chamaephytes can survive, while therophytes and geophytes can endure in arid and cold conditions. Many phanerophyte species are limited to areas that don't experience drought or frost frequently [31-35]. The Guntagola Forest in Lingasugur Taluk is a semi-arid region with diverse flora adapted to specific climatic and edaphic factors. This study employs Raunkiaer's life form classification system to analyze plant functional diversity. The research aims to document the life form distribution, examine species richness, and provide insights into the ecological significance of these patterns.

Material and Methods

Study Area

The Guntagola Forest is located in the Lingasugur Taluk, characterized by rocky terrain, sparse vegetation, and a semi-arid climate. It lies between 16.28°N latitude and 76.51°E longitude (Figure 1). Gulbarga District borders Lingasugur taluk on the north and west, while Raichur District's Devadurga taluk borders it on the east. North Karnataka's Lingasugur Taluk along with Guntagola Forest have a semi-arid environment with hot summers and little precipitation. In terms of agroclimate, it is located in the arid agroclimatic zone in the northeast. The region typically receives 608 mm of rainfall annually [6]. On average, there are roughly 45 rainy days in a year. The majority of the rainfall, or roughly 66.9% of the annual rainfall, falls between June and September during the southwest monsoon season, according to an examination of the seasonal fluctuation of rainfall. Nearly 24% comes from the northeast monsoon or post-monsoon (October to December), with the remaining 9.1% coming from dry weather and the pre-monsoon season (January to May) and experiencing a mean annual temperature of 27°C.

Vegetation Sampling and Calculation

Vegetation data were collected using 10 m × 10 m quadrats systematically placed across the study area. A total of 48 quadrats were sampled, covering forest patches, grasslands, and rocky outcrops. During the survey, most of the species were identified and recorded on site, if immediate identification was not possible, specimens were collected for later identification with keys. Unidentified plants were collected, dried using standard herbarium techniques and identified. Plant species identification was conducted using the following references: *Flora of Gulbarga District* by Seetharam *et al.*, (2000), *Flora of the Presidency of Madras* (Volumes I to III) by Gamble (1957), *Flora of North Eastern Karnataka* by N.P. Singh (1988), and the detailed studies *Flora of Karnataka* (Volume I, 1984 and Volume II, 1996) by Saldanha & Larsen. Photographs and voucher specimens of the identified species were deposited in the Herbarium of the Department of Botany at Sunrise University, Alwar, Rajasthan (HSUR). The degree of dispersion of individual species within a region in relation to the total number of species observed is referred to as relative frequency [25].

$$\text{Relative Frequency} = \frac{\textit{Number of occurrence of the species}}{\textit{Number of occurrence of all the species}} X100$$

To develop the biological spectrum of the region, the percentage distribution of these species in various living forms was determined [24]. The resulting values were contrasted with Raunkiaer's normal spectrum [18]. The following formula was used to get the life-form percentage:

$$\%\ \text{Life form} = \frac{\textit{Number of species in any life form}}{\textit{Total number of species of all life forms}} X100$$

Classification System

Raunkier divided plants into five groups- Phanerophytes, Chamaephytes, Hemicryptophytes, Cryptophytes, and Therophytes- according to where the renewal bud was found in unfavorable conditions. Phanerophytes are plants that have renewal buds positioned higher than 0.25 meters above the ground. Plants with renewal buds that are less than 0.25 meters above the ground are known as chamaephytes. Plants with renewal buds somewhat above the earth's crust are known as hemicryptophytes. Plants with an underground renewal bud, such as a rhizome, bulb, or tuber, are known as cryptophytes. Therophytes are primarily annual plants that, under adverse conditions, develop seed as a renewal bud [9,18,20].

Data Analysis

Species richness and evenness were calculated for each quadrat. Spatial distribution maps were generated using GIS software, and statistical analyses were performed to evaluate the relationship between life forms and environmental variables.

Results and Discussion

Diversity of Species Composition

A thorough analysis of plant diversity revealed that 90 families were represented, varying significantly in the number of genera and species within each family. The family *Acanthaceae* had 11 genera

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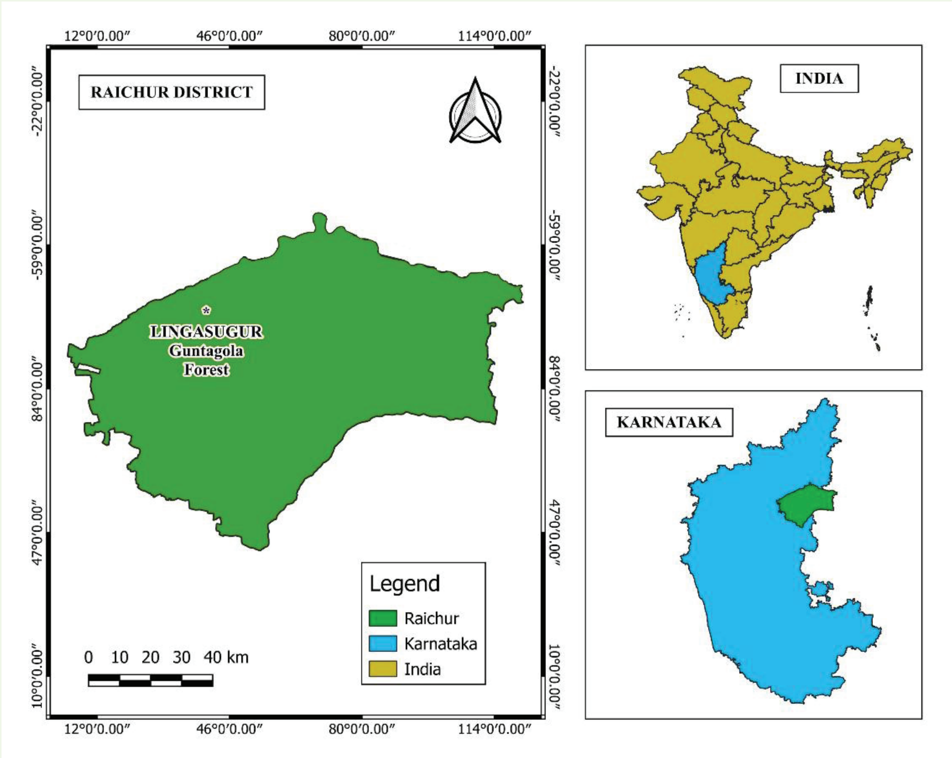

Figure 1: Study Area of Guntagola Forest Lingasugur

comprising 18 species, whereas *Amaranthaceae* also exhibited 11 genera but with 16 species. Notably, *Apocynaceae* included 12 genera and 14 species. In contrast, *Aizoaceae* and *Asperagaceae* displayed comparatively lower diversity, with 2 genera and 4 species each. Among the prominent families, *Asteraceae* emerged as one of the richest families, comprising 30 genera and 38 species, followed closely by *Fabaceae*, which exhibited the highest diversity with 38 genera and 85 species. The grass family, *Poaceae*, was another dominant group, containing 48 genera and 60 species. Families such as *Convolvulaceae* and *Euphorbiaceae* demonstrated moderate richness, comprising 8 genera, 21 species, and 10 genera, 20 species, respectively. The *Malvaceae* family contributed significantly to species diversity, including 12 genera and 26 species.

Several families exhibited lower diversity, containing only 1 genus and 1 species, reflecting minimal representation in the survey. These include *Amaryllidaceae*, *Anacardiaceae*, *Annonaceae*, *Aponogetonaceae*, *Asphodelaceae*, *Basellaceae*, *Bignoniaceae*, *Brassicaceae*, *Campanulaceae*, *Celastreaceae*, *Colchicaceae*, *Cornaceae*, *Elatinaceae*, *Gieskiaceae*, *Hernandinaceae*, *Hydrocharitaceae*, *Lauraceae*, *Linderniaceae*, *Magnoliaceae*, *Martyniaceae*, *Mazaceae*, *Moringaceae*, *Nymphaceae*, *Nelumbonaceae*, *Onagraceae*, *Papaveraceae*, *Passifloraceae*, *Plumbaginaceae*, *Polygonaceae*, *Pontederiaceae*, *Scrophulariaceae*, *Simaroubaceae*, *Typhaceae*, *Ulmaceae*, *Violaceae*, *Vitaceae*, *Xyridaceae*, *Isoetaceae*, *Selaginellaceae*, *Ophioglossaceae*, and *Pteridaceae*. The survey also revealed moderate representation in families such as *Boraginaceae* (6 genera, 12 species), *Cyperaceae* (7 genera, 22 species), and *Plantaginaceae* (5 genera, 5 species). *Cucurbitaceae* showed 8 genera and 9 species, while *Rubiaceae* exhibited 7 genera and 7 species. Families with intermediate diversity include *Molluginaceae* with 3 genera and 4 species, *Orobanchaceae* with 2 genera and 6 species, and *Nyctaginaceae* with 2 genera and 3 species. Similarly, *Rhamnaceae* and *Rutaceae* displayed 4 species each, while *Lamiaceae* and *Verbenaceae* represented 11 genera, 15 species and 5 genera, 6 species, respectively. In families where species richness was comparatively low, such as *Caryophyllaceae* and *Lythraceae*, 2-3 species were recorded. The *Solanaceae* family showed a moderate diversity of 3 genera comprising 5 species. This comprehensive survey highlights the dominant role of families like *Fabaceae*, *Poaceae*, and *Asteraceae* in shaping plant diversity, while numerous smaller families exhibited limited representation with only single genera and species. These findings underscore the variability in floristic richness across families and their ecological significance within the surveyed region (Table 1).

A comprehensive survey revealed the presence of 91 generic names of plant species, with varying numbers of species represented under each genus. The genus *Barleria* comprises 3 species, while *Blepharis*, *Dipteracanthus*, *Rungia*, *Trianthema*, *Zaleya*, *Aerva*, *Calotropis*, *Aristolochia*, *Bidens*, *Launaea*, *Tricholepis*, *Cordia*, *Trichodesma*, *Opuntia*, *Polycarpea*, *Terminalia*, *Convolulus*, *Cuscuta*, *Cucumis*, *Fuirena*, *Schoenoplectiella*, *Eriocaulon*, *Chrozophora*, *Jatropha*, *Stylosanthes*, *Delonix*, *Anisomeles*, *Leucas*, *Ammania*, *Abutilon*, *Trimufetta*, *Glinus*, *Boehravia*, *Sesamum*, *Chloris*, *Dichanthium*,

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Table 1: Family, Number of Species and Relative Frequency

Sl. No.	Family	No. of Species	Relative Frequency
1	Acanthaceae	18	3.39
2	Aizoaceae	4	0.75
3	Amaranthaceae	16	3.01
4	Amaryllidaceae	1	0.19
5	Anacardiaceae	1	0.19
6	Annonaceae	1	0.19
7	Apocynaceae	14	2.64
8	Aponogetonaceae	1	0.19
9	Aracaceae	2	0.38
10	Araceae	2	0.38
11	Aristolochiaceae	2	0.38
12	Asperagaceae	4	0.75
13	Asphodelaceae	1	0.19
14	Asteraceae	38	7.16
15	Basellaceae	1	0.19
16	Bignoniaceae	1	0.19
17	Boraginaceae	12	2.26
18	Brassicaceae	1	0.19
19	Cactaceae	3	0.56
20	Campanulaceae	1	0.19
21	Capparaceae	6	1.13
22	Caryophyllaceae	2	0.38
23	Celastraceae	1	0.19
24	Cleomaceae	6	1.13
25	Colichiaceae	1	0.19
26	Combratceae	3	0.56
27	Commelinaceae	14	2.64
28	Convoluvulaceae	21	3.95
29	Cornaceae	1	0.19
30	Cucurbitaceae	9	1.69
31	Cyperaceae	22	4.14
32	Elatinaceae	1	0.19
33	Eriocaulaceae	2	0.38
34	Euphorbiaceae	20	3.77
35	Fabaceae	85	16.01
36	Gentianaceae	5	0.94
37	Gieskiaceae	1	0.19
38	Hernandinaceae	1	0.19
39	Hydrocharitaceae	1	0.19
40	Lamiaceae	15	2.82
41	Lauraceae	1	0.19
42	Linderniaceae	1	0.19
43	Lythraceae	3	0.56
44	Magnoliaceae	1	0.19
45	Malvaceae	25	4.71
46	Martyniaceae	1	0.19
47	Mazaceae	1	0.19
48	Melastomataceae	1	0.19
49	Meliaceae	2	0.38
50	Menispermaceae	2	0.38
51	Molluginaceae	4	0.75
52	Moraceae	3	0.56
53	Moringaceae	1	0.19
54	Myrtaceae	2	0.38
55	Nyctaginaceae	3	0.56
56	Nymphaceae	1	0.19
57	Nelumbonaceae	1	0.19
58	Onagaraceae	1	0.19
59	Orobanchaceae	6	1.13
60	Papavaraceaea	1	0.19
61	Passifloraceae	1	0.19
62	Pedaliaceae	3	0.56
63	Phyllanthaceae	5	0.94
64	Plantaginaceae	5	0.94
65	Plumbaginaceae	1	0.19
66	Poaceae	60	11.30
67	Polygalaceae	4	0.75
68	Polygonaceae	1	0.19
69	Pontederiaceae	1	0.19
70	Portulacaceae	3	0.56
71	Rhamnaceae	4	0.75
72	Rubiaceae	7	1.32
73	Rutaceae	4	0.75
74	Sapindaceae	1	0.19
75	Scrophulariaceae	1	0.19
76	Simaroubaceae	1	0.19
77	Solanaceae	5	0.94
78	Typhaceae	1	0.19
79	Ulmaceae	1	0.19
80	Verbinaceae	6	1.13
81	Violaceae	1	0.19
82	Vitaceae	2	0.38
83	Xyridaceae	1	0.19
84	Zygophyllaceae	2	0.38
85	Salviniaceae	2	0.38
86	Marsilleaceae	2	0.38
87	Isoetaceae	1	0.19
88	Selaginellaceae	1	0.19
89	Ophioglossaceae	1	0.19
90	Pteridaceae	1	0.19

Dinebra, *Setaria*, *Themeda*, *Urochloa*, *Lantana*, and *Cissus* each account for 2 species. The genera *Justicia*, *Alternthera*, *Amaranthus*, *Merremia*, *Acalypha*, *Albizia*, *Ocimum*, *Corchorus*, *Grewia*, *Pavonia*, *Aristida*, *Portulaca*, and *Solanum* include 3 species each. The genera *Blumea*, *Heliotropium*, *Commelina*, *Cyanotis*, *Vachellia*, and *Striga* each have 5 species. *Cleome* and *Fimbristylis* both consist of 6 species, while *Alycicarpus* contains 6 species as well. Notably, *Euphorbia* has 7 species, *Ipomea*, *Cyperus*, and *Crotalaria* each include 10 species, and *Indigofera* stands out with 12 species. Genera with intermediate diversity include *Murdannia*, *Capparis*, *Rhynchosia*, *Senna*, *Tephrosia*, *Hibiscus*, *Sida*, *Phyllanthus*, *Eragrostis*, *Polygala*, and *Ziziphus*, each comprising 4 species.

The study encompassed an extensive assessment of plant families, identifying a total of 90 families with varying numbers of species and relative frequencies. Among these, Fabaceae was found to be the most dominant family, comprising 85 species, accounting for 16.01% of the total relative frequency, reflecting its widespread adaptability and ecological significance in the study area (Plate 1). This was

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Plate 1: Some of the selected plant species at Guntagola Forest Lingasugur, Raichur.

followed by Poaceae, represented by 60 species (11.30%), which highlights its critical role in providing essential vegetation cover, particularly in grasslands and open habitats. The third most prevalent family was Asteraceae, with 38 species (7.16%), underscoring its wide adaptability and prominence in various habitats. Families with a moderate representation included Cyperaceae with 22 species (4.14%), known for its dominance in wetland ecosystems, and Malvaceae, represented by 25 species (4.71%), which indicates its ecological diversity and prevalence in both cultivated and wild settings. Euphorbiaceae followed closely with 20 species (3.77%), highlighting its ecological versatility and significant contribution to biodiversity. Other noteworthy families include Acanthaceae with 18 species (3.39%), Amaranthaceae with 16 species (3.01%), and Apocynaceae with 14 species (2.64%), all of which play crucial roles in maintaining ecological balance and providing resources such as nectar for pollinators.There are a number of ways that herbaceous species can tolerate drastic changes in climate [38].

A range of families showed notable, albeit smaller, representations, such as Convolvulaceae (21 species, 3.95%), Commelinaceae (14 species, 2.64%), and Boraginaceae (12 species, 2.26%), indicating their ecological significance within specific niches. The Lamiaceae family, with 15 species (2.82%), is well-documented for its medicinal and aromatic plants, further emphasizing the multifaceted contributions of these families. Several families were represented by fewer species but demonstrated localized ecological importance. For example, Cucurbitaceae contributed 9 species (1.69%), often associated with climbing or creeping habits, and Rubiaceae, which includes 7 species (1.32%), plays a vital role in tropical ecosystems. Capparaceae and Orobanchaceae, each with 6 species (1.13%), and smaller families such as Gentianaceae, Phyllanthaceae, Plantaginaceae, and Solanaceae, each with 5 species (0.94%), highlight the ecological diversity within the study area. Interestingly, many families were represented by only one or two species, collectively contributing to the overall biodiversity and ecological complexity of the region. Examples include Amaryllidaceae, Anacardiaceae, Araceae, and Magnoliaceae, each contributing a single species (0.19%). Families such as Aracaceae, Caryophyllaceae, and Vitaceae each comprised two species (0.38%), emphasizing their limited yet significant role in specific habitats. Families such as Marsilleaceae, Isoetaceae, Selaginellaceae, and Ophioglossaceae, which were each represented by one species, underline the presence of unique taxa

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with specialized ecological adaptations. Similarly, aquatic families such as Nymphaceae, Hydrocharitaceae, and Pontederiaceae were represented minimally, suggesting their occurrence in specific aquatic or semi-aquatic ecosystems. Meanwhile, the diversity observed across 90 plant families demonstrates a rich and varied floristic composition, with dominant families like Fabaceae, Poaceae, and Asteraceae contributing significantly to the regional biodiversity. Families with moderate or low representation provide essential ecosystem services and highlight the intricate ecological dynamics present in the study area. These findings underscore the importance of preserving both dominant and less-represented families to maintain ecological balance and biodiversity.

Biological Spectrum

The study analyzed the distribution of plant species based on Raunkiaer's life form classification, revealing significant variations in the proportion of life form classes. The total number of species analyzed was 531, categorized into five primary life form classes: Therophytes, Cryptophytes, Hemicryptophytes, Chamaephytes, and Phanerophytes (Table 2). The results were compared with Raunkiaer's Normal Spectrum to assess deviations from the expected global norms. Therophytes were found to be the most dominant life form, accounting for 243 species, representing 45.76% of the total flora. This percentage significantly exceeds Raunkiaer's Normal Spectrum value of 13%, resulting in a positive deviation of 32.76%. The predominance of therophytes reflects the adaptability of annual plants to the region's climatic conditions, particularly in areas with a pronounced dry season or disturbed habitats. Particularly, in Central Europe's temperate zone, hemicryptophytes were the most prevalent living type. On the other hand, chamaephyte and therophyte species were more prevalent in arid temperate zones and the Mediterranean [1].

Phanerophytes, the second most represented class, included 115 species, constituting 21.66% of the total. However, this value is markedly lower than the Normal Spectrum value of 46%, indicating a negative deviation of 24.34%. This discrepancy suggests reduced representation of woody, perennial plants, which may be attributed to habitat disturbance, anthropogenic activities, or climatic factors limiting the growth of tall vegetation. Chamaephytes, with 73 species (13.75%), showed a slight positive deviation of 4.75% from the Normal Spectrum value of 9%. This indicates the adaptability of small shrubs and low woody plants to the local environmental conditions, particularly in semi-arid or nutrient-poor soils. Hemicryptophytes accounted for 70 species (13.18%), which is notably lower than the Normal Spectrum value of 26%, resulting in a negative deviation of 12.82%. This underrepresentation might be linked to the ecological conditions of the study area, which may not favor the persistence of perennial herbaceous plants with basal buds surviving harsh conditions. Cryptophytes were the least represented life form, comprising 30 species and contributing 5.65% to the total flora. This is close to the Normal Spectrum value of 6%, with a minimal negative deviation of 0.35%. This alignment suggests the presence of species adapted to surviving unfavorable seasons through underground storage organs. Hemicryptophytes may lose aboveground biomass in cold areas with frequent frost, protecting their perennating buds that are at or near the soil surface [36]. However, the life form analysis indicates a predominance of therophytes, highlighting the region's adaptation to dry or disturbed conditions, while phanerophytes and hemicryptophytes were underrepresented compared to global norms. These deviations provide insights into the ecological and climatic influences shaping the vegetation structure and offer a basis for understanding the adaptive strategies of plant species in the study area (Figure 2). The current analysis of the many Raunkier plant life forms in Ahmedabad's Law Garden reveals that a high proportion of phanerophytes suggests a phanaerophyticphytoclimate [22].

Distribution Patterns

The spatial distribution of plant life forms in the Guntagola Forest was distinctly influenced by habitat characteristics. Hemicryptophytes and therophytes exhibited high prevalence in open grasslands and rocky outcrops, where environmental conditions such as limited soil depth, reduced moisture retention, and high exposure to sunlight created challenging growth environments. Hemicryptophytes, with renewal buds at or near the soil surface, demonstrated resilience in these habitats by adapting to periodic drought and temperature extremes. Therophytes, primarily annual plants, thrived in these

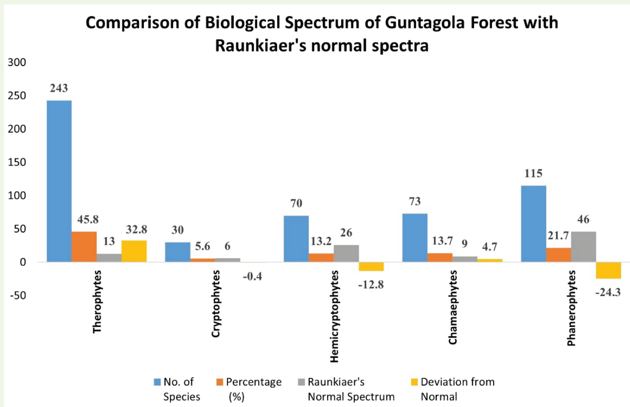

Figure 2: Life Form Pattern in Study Area

Table 2: Comparison of Biological Spectrum (% of all life forms) in Guntagola Forest with Raunkiaer's Normal Spectrum

Sl. No.	Life Form Classes	No. of Species	Percentage (%)	Raunkiaer's Normal Spectrum	Deviation from Normal
1	Therophytes	243	45.76	13	32.76
2	Cryptophytes	30	5.65	6	-0.35
3	Hemicryptophytes	70	13.18	26	-12.82
4	Chamaephytes	73	13.75	9	4.75
5	Phanerophytes	115	21.66	46	-24.34
	Total	**531**	**100**	**100**	

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areas due to their ability to complete their life cycles quickly under favorable conditions and survive unfavorable periods as seeds. Conversely, phanerophytes, which include trees and large shrubs with renewal buds positioned above 0.25 meters from the ground, were primarily restricted to forested patches. These habitats provided the necessary stability, moisture availability, and shade for their growth and reproduction. Short-lived therophytes can survive as seeds that dormantly rest in seed banks until favourable circumstances for regrowth and germination occur [37]. Geophytes, characterized by underground storage organs such as bulbs and rhizomes, were found in specific microhabitats such as shaded areas and moist depressions, where environmental conditions favored prolonged dormancy and resource conservation. Similarly, hydrophytes, adapted to aquatic and semi-aquatic conditions, were confined to seasonal water bodies and marshy areas, reflecting their dependence on waterlogged soils and consistent moisture availability. According to the biological spectrum construction and life form classification of the Chiktan valley of Kargil district in the Ladakh region of the North West Himalaya, hemicryptophytes (40.50%) and therophytes (24.05%) dominated the local landscape, with chamaephytes (17.72%), phanerophytes, and geophytes (8.86%) following closely behind [23].

Environmental Influences

Environmental factors, particularly soil moisture and temperature, emerged as significant determinants of plant life form distribution in the Guntagola Forest. The dominance of therophytes in arid and disturbed habitats highlights their adaptation to low soil moisture and high temperatures, enabling them to establish, reproduce, and persist in environments with extreme seasonal variability. These life forms leveraged seed dormancy as a survival mechanism during adverse conditions. In contrast, hydrophytes exhibited a strong dependence on waterlogged or moisture-rich soils, thriving in areas with seasonal or permanent water availability. These species showed a restricted distribution pattern, confined to water bodies and wetlands. This study underscores the critical role of environmental variables in shaping the structure and diversity of vegetation, with life forms exhibiting unique adaptive strategies to persist under specific climatic and edaphic conditions. Such findings provide a framework for understanding plant community responses to environmental gradients and for implementing conservation strategies tailored to semi-arid ecosystems like the Guntagola Forest. A similar study was conducted, the flora of Tons Valley in Garhwal Himalaya is dominated by phanerophytes (29.06%) and therophytes (17.83%) and others are least in percentage [12].

Conclusion

The study provides a comprehensive evaluation of plant life forms in the Guntagola Forest, employing Raunkiaer's classification system to analyze the ecological adaptations of vegetation in a semi-arid environment. The dominance of therophytes, constituting 45.76% of the flora, underscores their adaptability to dry and disturbed conditions, while the reduced representation of phanerophytes (21.66%) and hemicryptophytes (13.18%) highlights the influence of climatic constraints and anthropogenic activities on woody and perennial species. Significant deviations from Raunkiaer's Normal Spectrum were observed, reflecting the unique environmental conditions of the study area. These findings underscore the ecological importance of plant life forms in maintaining biodiversity and ecosystem stability in semi-arid regions. The research highlights the need for targeted conservation efforts to preserve the delicate balance of this ecosystem, particularly in the face of ongoing habitat degradation and climate variability. Further studies focusing on long-term ecological dynamics and human impacts are essential to enhance conservation planning and sustainable management of semi-arid landscapes.

Acknowledgement

The authors would like to extend their deepest gratitude to Raviraju Balappa D and Vigneshwaran for their invaluable time and insights, pivotal to this study's success. They also profoundly appreciate Sunrise University, Alwar, Rajasthan, for its institutional support. The authors are especially indebted to Helen Lalitha Kumari J James for their expert guidance and unwavering support, which were instrumental throughout the research process.

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Citation: Theophilus Deenadayal, Jain T. Assessment of Plant Life-Form Diversity and Ecological Dynamics in Guntagola Forest Lingasugur Taluk Raichur District Karnataka, India. J Plant Sci Res. 2025;12(1): 271

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