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Analysis of Understorey Vegetation in The Gondoriyo Teak Forest Semarang City

Analisis Vegetasi Dasar di Hutan Jati Gondoriyo Kota Semarang

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Abstract. The Gondoriyo Teak Forest was a production forest owned by Perhutani KPH Kendal. To maintain the productivity and sustainability of the teak forest, the condition of the understorey plant community also needed attention. This research aimed to identify the dominant understorey plant species and the diversity index (H') of the understorey plants in the Gondoriyo Teak Forest. The understorey vegetation analysis research was conducted in the Jati Gondoriyo Forest area in Semarang City from June 8-10, 2023. The method used was quadrat sampling with 5 m × 5 m quadrats placed systematically. A total of 3 square plots were set up in a zigzag pattern beneath the golden teak stands. The identification results found 20 species of understorey plants from 15 families. The plant species with the highest density, frequency, INP, and SDR was *Microstegium vimineum*. The total diversity index (H') for the understorey plants was 1.74. This indicated that the level of understorey plant community diversity was still at a moderate level.
Keywords: *Microstegium vimineum*; Poaceae; quadrat sampling; species distribution

Abstract. *Hutan Jati Gondoriyo merupakan hutan produksi milik Perhutani KPH Kendal. Agar produktivitas dan kelestarian hutan jati tetap terjaga, maka kondisi komunitas tumbuhan bawah juga perlu diperhatikan. Penelitian ini bertujuan untuk mengetahui jenis tumbuhan bawah dominan dan tingkat keanekaragaman jenis (H') tumbuhan bawah di Hutan Jati Gondoriyo. Analisis vegetasi dasar dilakukan di area Hutan Jati Gondoriyo Kota Semarang pada tanggal 8-10 Juni 2023. Adapun metode yang digunakan ialah sampling kuadrat atau kuadran berukuran 5 m × 5 m yang diletakkan secara sistematic sampling. Terdapat total 3 petak berbentuk persegi di bawah tegakan jati emas yang disusun secara zigzag. Hasil identifikasi ditemukan 20 jenis tumbuhan bawah dari 15 famili. Jenis tumbuhan dengan kerapatan, frekuensi, INP, dan SDR tertinggi dimiliki oleh Microstegium vimineum. Total nilai indeks keanekaragaman (H') pada tumbuhan bawah yaitu 1,74. Ini menunjukkan bahwa tingkat keanekaragaman komunitas tumbuhan bawah masih dalam taraf sedang.*
Kata kunci: *Microstegium vimineum; Poaceae; sampling kuadrat; distribusi spesies*

INTRODUCTION

Golden teak trees (*Cordia subcordata*) are a type of teak tree that grows in the Gondoriyo Teak Forest in Semarang City. The golden teak tree is one of the forestry species that grows ideally in flat topographical areas with slopes of less than 20%, and soil types with sandy clay, loam, or sandy loam textures (Irawan and Suhendro, 2022). According to Firdhiana and Nugroho (2022), teak trees thrive in areas with long dry seasons, lasting 3-6 months per year. The required rainfall is an average of 1250-1300 mm/year, with an average temperature of 22-26°C. Under good environmental conditions, this tree can grow up to 30-40 cm in diameter. The quality of teak wood is considered good for carpentry and other uses. In Indonesia, it is estimated that this plant has been cultivated for 800 years and has undergone naturalization, allowing it to adapt to the climate and soil conditions in tropical regions (Fauzi *et al*., 2021).

Teak trees have good conservation characteristics, including canopies that touch each other. This causes teak trees to reduce the light intensity for plants growing between the spaces in the land (Lysandra and Purnamaningsih, 2019). The type of canopy in teak trees is classified as moderate. As the tree ages, its canopy typically becomes wider. Denser teak stands result in less light penetrating the forest floor, thus lowering the air temperature and increasing humidity under the teak stands (Setiayu *et al*., 2020).

Indonesia manages approximately 1 million hectares of teak forest, which is at least 17.5% of the world's total teak forest area, reaching 5.7 million hectares. Teak wood has long been widely known as material for houses, bridges, and other structures. The reason teak wood is used in construction is due to its strength, durability, and ease of working (Fauzi *et al*., 2021). In Semarang City, there are quite a few teak forests, one of which is the Gondoriyo Teak Forest.

The Gondoriyo Teak Forest is located in Gondoriyo Village, Ngaliyan District, Semarang City. This teak forest is one of the production forests owned by Perhutani KPH Kendal (Shidiqy *et al*., 2018). As a production forest, its primary function is to sustainably provide timber and other forest products (Ongky *et al*., 2020). The forest is designed to not disrupt the external ecosystem when logging occurs. To support the optimal growth of teak trees, vegetation analysis methods need to be conducted as a benchmark to measure and provide information on existing vegetation components. Additionally, to maintain the productivity and sustainability of the teak forest, the survival of the understorey plants in the teak forest ecosystem also needs to be considered (Irawan and Suhendro, 2022). One of the components that need attention is the ground vegetation community.

Understorey vegetation is a community of short ground-covering plants found beneath the forest canopy, excluding trees (Kusmana *et al*., 2022). Understorey vegetation consists of all plant species that show distribution patterns according to space and time, characterized by the dominant growth form or the most abundant in number based on their characteristics (Harjosuwarno, 1990). The communities included in understorey vegetation consist of grasses, ferns, lianas, shrubs, and herbs (Kusmana *et al*., 2022). Understorey vegetation forms the lowest stratification component. The composition and diversity of understorey vegetation affect the life of other plants in the forest community (Marfi, 2018).

The presence of vegetation in an area can have a positive impact on ecosystem balance. According to Indriani *et al*. (2017), the presence of understorey plants in a tree stand plays a role in conserving soil and water. This is because understorey plants have complex root systems that can form dense networks. Additionally, understorey plants also help protect the soil from the risk of erosion by rainwater and increase the organic matter content in the soil. The presence of ground vegetation can be used as a bioindicator of microclimate in forest ecosystems (Norris *et al*., 2020).

In recent years, research has been conducted to identify the components of understorey vegetation in specific forest ecosystems. Kardiannor *et al*. (2022) studied understorey vegetation analysis in a peat swamp forest ecosystem, identifying *Chrysopogon aciculatus* as the dominant weed with an important value of 48.83% (Poaceae: Family) and an H' value of 1.30 (moderate). Research by Nur and Chairul (2023) on understorey vegetation analysis in a geopark area found *Lygodium circinnatum* as the dominant plant with an important value of 30.79% (Lygodiaceae: Family) and an H' value of 2.57 (moderate). Additionally, Suri and Solfiyeni (2024) conducted a study on understorey vegetation analysis in the Kenagarian Padang Mentinggi Protection Forest, identifying *Clidemia hirta* as the dominant species with an important value of 32.01% (Lygodiaceae: Family) and an H' value of 3.18 (high). Currently, research on understorey vegetation analysis in golden teak forests has not been extensively elaborated, making such research important to conduct. This study aims to identify the dominant understorey plants and the species diversity level (H') of understorey plants in the Gondoriyo Teak Forest.

MATERIALS AND METHOD

The research was conducted in the Gondoriyo Teak Forest, Ngaliyan Subdistrict, Semarang City. The research site is situated at coordinates 7°00'04.19" S and 110°18'25.33" E. The map was processed using ArcGIS software version 10.4 without imagery. The teak forest, which is the focus of the study, is located at the border of Wates Village and Gondoriyo Village. The type of land where the golden teak grows is clay fraction land (Figure 1).

The research was conducted from June 8-10, 2023. The tools used included a hand counter, mobile phone camera, 100 cm measuring tape, 20 m measuring tape, writing tools, and a field notebook. The materials used were raffia and boundary stakes. The study employed a 5 m × 5 m quadrat sampling method arranged in a systematic sampling pattern (Oosting, 1958). A total of 3 square plots were placed under the golden teak stands in a zigzag pattern (Figure 2). In each plot, the types of plants and the number of individuals that comprised the understorey vegetation were recorded and counted.

The formulas required for field data processing in quadratic method vegetation analysis were as follows.

Composition. The analysis was based on the number of individuals, species, and families comprising the community. Subsequently, dominant families are analyzed using the following formula**.**

Dominant Families = $\frac{Number\ of\ individuals\ in\ a\ family}{The\ number\ of\ individuals} \times 100\%$

If te result is > 20%, then the family is considered co-dominant (Johnston and Gillman, 1995).

Structure. It is important to note several vegetation characteristics including density, frequency, and importance value of each species to obtain information about its vegetation structure. Density and frequency calculations utilize the following formulas (Mueller and Ellenberg, 1974).

Density (D) = $\frac{The\ number\ of\ individuals\ of\ a\ species}{Area\ of\ the\ entire\ sample\ plot}$

Relative Density (RD) = $\frac{Density\ of\ a\ species}{Density\ of\ all\ species} \times 100\%$

Frequency (F) = $\frac{The\ number\ of\ plots\ occupied\ by\ a\ species}{The\ total\ number\ of\ sample\ plots}$

Relative Frequency (RF) = $\frac{Frequency\ of\ a\ species}{Frequency\ of\ all\ species} \times 100\%$

Importance value is a numerical representation of the level of dominance of a species in vegetation. The importance value of undergrowth plants is obtained by summing the relative density (RD) with the relative frequency (RF) (Brower and Zar, 1990).

SDR (Summed Dominance Ratio). Alternatively, the parameter of comparison of importance values was used to determine the dominance of plant species. Summed Dominance Ratio (SDR) can be calculated using the following formula (Mueller and Ellenberg, 1974).

SDR = $\frac{IVI}{2}$

The level of mastery of plant species is determined using the following formula (Mueller and Ellenberg, 1974).

(I) = $\frac{SDR_{highest} - SDR_{lowest}}{3}$

Keterangan:

I = Species mastery class interval

Criteria for the level of species mastery:

(1) Low mastery level: SDR < $(SDR_{highest} + I)$
(2) Medium mastery level: SDR = $(SDR_{highest} + I)$ – $(SDR_{lowest} + 2I)$
(3) High mastery level: SDR > $(SDR_{lowest} + 2I)$

Species Diversity. After obtaining the importance values, these values are then used to determine the Shannon-Wiener Species Diversity Index (H') in the community using the following formula (Mueller dan Ellenberg, 1974).

H' = $-\sum_{i=1}^{s}\left(\frac{ni}{N}\right) ln\left(\frac{ni}{N}\right)$

Keterangan:

H' : The value of diversity
s : Number of species
ni : Number of individuals of the i-th species
N : Number of individuals of all species

A larger H' value indicates a higher level of species diversity. (Southwood dan Henderson, 2000) state that the Shannon-Wiener Species Diversity Index (H') typically ranges from 1 to 3. The magnitude of species diversity values is defined as follows:

(1) H'> 3,0 indicates high species diversity
(2) 1,0 ≤ H' ≤ 3,0 indicates moderate species diversity
(3) H' < 1,0 indicates low species diversity

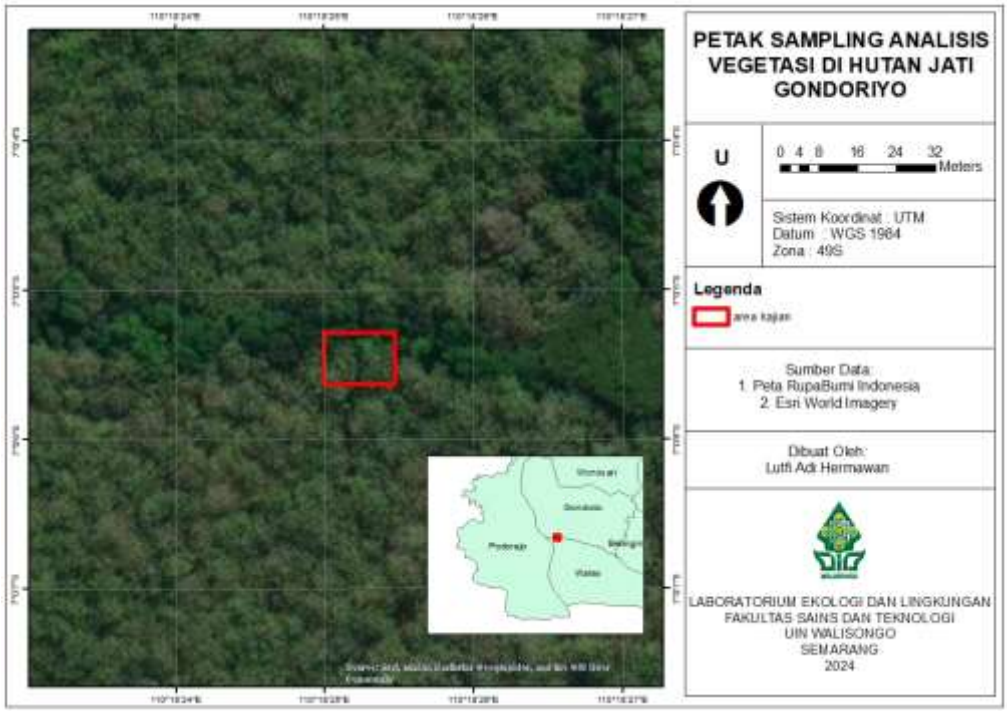

Figure 1. Understorey vegetation analysis location map (Source: Data Processing Results, 2024).

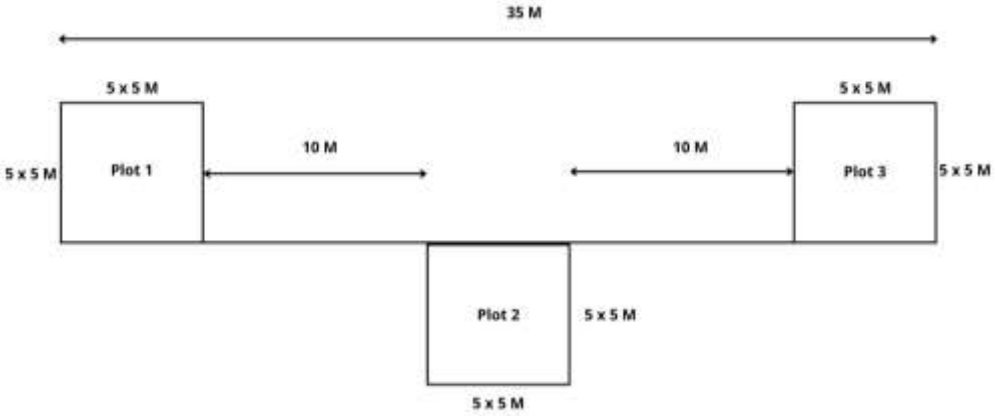

Figure 2. Observation plot design in a land cover area of Gondoriyo Teak Forest

RESULT

Based on research conducted in the Gondoriyo Teak Forest area, a total of 20 species of understorey plants from 15 families were found. The highest number of individuals came from the Poaceae family, with 166 individuals (Table 1). The highest Important Value Index (IVI) was recorded for *Microstegium vimineum* at 50.72% (Table 2).

Table 1. Families comprising the understorey vegetation beneath the golden teak stands

Family	Number of Species	Individuals	Percentage of Individuals (%)
Moraceae	1	4	1.78
Calophyllaceae	1	2	0.89
Fabaceae	1	1	0.44
Piperaceae	1	1	0.44
Myrtaceae	1	1	0.44
Asteraceae	3	10	4.44
Urticaceae	1	2	0.89
Lygodiaceae	2	7	3.11
Marantaceae	1	2	0.89
Poaceae	2	166	73.78*)
Violaceae	1	1	0.44

Family	Number of Species	Individuals	Percentage of Individuals (%)
Acanthaceae	1	1	0.44
Malvaceae	2	21	9.33
Araceae	1	1	0.44
Urticaceae	1	5	2.22
Totals	**20**	**225**	**100**

Desc: *) Dominant families

Table 2. Density (D), Relative Density (RD), Frequency (F), Relative Frequency (RF), Importance Value Indeks (IVI), and Summed Dominance Ratio (SDR) from Understorey vegetation Gondoriyo teaks forest

Plant Species	Local Name	Individuals	D	RD (%)	F	RF (%)	IVI (%)	SDR (%)	H'
Ficus septica	Awar-awar	4	0.05	1.78	0.67	8.33	10.11	5.06	0.07
Calophyllum inophyllum L.	Nyamplung	2	0.03	0.89	0.33	4.17	5.06	2.53	0.04
Clitoria ternatea L.	Telang	1	0.01	0.44	0.33	4.17	4.61	2.31	0.02
Piper betle L.	Sirih	1	0.01	0.44	0.33	4.17	4.61	2.31	0.02
Syzygium polyanthum	Salam	1	0.01	0.44	0.33	4.17	4.61	2.31	0.02
Synedrella nodiflora L.	Jotang Kuda	1	0.01	0.44	0.33	4.17	4.61	2.31	0.02
Pipturus argenteus	Senu	2	0.03	0.89	0.33	4.17	5.06	2.53	0.04
Lygodium flexuosum L.	Ribu-ribu Gajah	3	0.04	1.33	0.33	4.17	5.5	2.75	0.06
Maranta arundinacea L.	Garut	2	0.03	0.89	0.33	4.17	5.06	2.53	0.04
Microstegium vimineum	Rumput Bambu	86	1.15	38.22	1	12.5	50.72	25.36	0.37
Rinorea amapensis	-	1	0.01	0.44	0.33	4.17	4.61	2.31	0.02
Clinacanthus nutans	Dandang Gendis	1	0.01	0.44	0.33	4.17	4.61	2.31	0.02
Urena lobata L.	Pulutan	11	0.15	4.89	0.67	8.33	13.22	6.61	0.15
Lygodium palmatum	-	4	0.05	1.78	0.33	4.17	5.94	2.97	0.07
Lasia spinosa L.	Sambeng	1	0.01	0.44	0.33	4.17	4.61	2.31	0.02
Spilanthes paniculata	Jotang	8	0.11	3.56	0.33	4.17	7.72	3.86	0.12
Emilia sonchifolia L.	Tempuh Wiyang	1	0.01	0.44	0.33	4.17	4.61	2.31	0.02
Iliamna rivularis	-	10	0.13	4.44	0.33	4.17	8.61	4.31	0.14
Laportea aestuans L.	Jelatang	5	0.07	2.22	0.33	4.17	6.39	3.19	0.08
Muhlenbergia schreberi	-	80	1.07	35.56	0.33	4.17	39.72	19.86	0.37
Total		**225**	**3**	**100**	**8**	**100**	**200**	**100**	**1.74**

DISCUSSION

The results of the research conducted in the Gondoriyo Teak Forest in Semarang City show that the dominant group of plants is the Poaceae family, comprising 73.78% of the total individuals (Table 1). No co-dominant family was found in the sampling location because, according to Samin *et al*. (2016) a family is considered co-dominant if its percentage is > 10% and < 20%. If the percentage exceeds 20%, the family is classified as dominant. The species within the Poaceae family include *Microstegium vimineum* with 86 individuals and *Muhlenbergia schreberi* with 80 individuals (Table 2). The Poaceae family is a group of understorey plants with lightweight reproductive mechanisms, making them easily dispersed. Plants in the Poaceae family have simple living requirements and can thrive in various habitat types Setiayu *et al*. 2020). Their high adaptability, such as the ability to grow in both wet and dry habitats, allows Poaceae members to be widely distributed. In the study by Basrudin dan Wahyuni (2017) it was mentioned that 40% of the 250 plant species are understorey plants belonging to the Poaceae and Asteraceae families.

The Asteraceae family includes the most plant species compared to other families. Plants in this family are commonly found because they can thrive in any habitat. Asteraceae can be found in shrub, herb, or tree forms. A characteristic feature of Asteraceae is their epigenous inflorescence type, marked by dense, composite flower arrangements resembling a disc, often referred to as a flower head (Megawati *et al*., 2017). The flower system on the flower head consists of many individual flowers on a single stem (Amandari *et al*., 2023). Plants in the Asteraceae family are usually broad-leaved terrestrial

weeds (Simanjuntak, 2017). Three species found in the Asteraceae family are *Synedrella nodiflora* L., *Spilanthes paniculata*, and *Emilia sonchifolia* L. However, the Asteraceae family is not classified as dominant or co-dominant because its percentage is only 4.44%. Asteraceae is considered a cosmopolitan family because it has a significant concentration of species, especially in temperate, subtropical, and cold regions (Medeiros-Neves *et al*., 2018).

The research results show that the grass *Microstegium vimineum* is the species with the largest number of individuals (86 individuals) and the highest density level (1.15) (Table 2). According to Basrudin dan Wahyuni (2017), a higher density value indicates that a plant species has a high adaptive capability. Therefore, *Microstegium vimineum* has a high adaptive capability in the ecosystem where it grows.

The highest frequency value of understorey plants is held by *Microstegium vimineum* at 1 (Table 2). Basrudin dan Wahyuni (2017) state that the frequency value is useful as a vegetation parameter that describes the distribution level of plant species in an ecosystem and can even indicate the distribution pattern of plants. Based on the research results, it is known that *Microstegium vimineum*, a species from the Poaceae family, has the widest distribution or is most frequently found in all plots. According to Setiayu *et al*. (2020), plants with a wide tolerance to relatively constant forest environmental conditions are not limited by these factors and can be present in large numbers. Conversely, plants with a narrow tolerance to dynamic forest environmental conditions will find these factors limiting for their growth, thus they will be present in relatively small numbers.

Based on the obtained data, there are 4 plant species with an Importance Value Index (IVI) ≥ 10%. A plant species can influence its community if it has an IVI ≥ 10%. This also applies to understorey plants. The species that have a significant impact on the understorey plant community *include Ficus septica* (10.11%), *Microstegium vimineum* (50.72%), *Urena lobata* L. (13.22%), and *Muhlenbergia schreberi* (39.72%). The high IVI values of these four species indicate that they are key characteristics of the understorey plant community in the golden teak stands in the Gondoriyo Forest. High IVI values show that these plant species have a large number of individuals, with high density and frequency as well (Nuraida *et al*. 2022).

The dominance levels of understorey plant species found at the research site are divided into two categories: low and high. The determination of dominance levels is based on the Species Dominance Ratio (SDR). There are 18 plant species with low dominance levels and 2 species with high dominance levels, namely *Microstegium vimineum* (SDR 25.36%) and *Muhlenbergia schreberi* (SDR 19.86%). Another study by Kolo *et al.* (2020) in the teak production forest area of Nenuk Village, Naekasa, Belu Regency found the highest dominance level in *Ottochloa nodosa* (SDR 37.39%). According to Asmayannur *et al*., (2012), this dominance level reflects a plant species' ability to persist and thrive in specific habitat conditions.

Based on the data analysis, the total Shannon-Wiener diversity index (H') for the understorey plants in the study plots is 1.74 (Table 2). According to the Shannon-Wiener index (H'), the understorey vegetation community beneath the golden teak stands has a moderate level of vegetation diversity, with a value of $1 \leq H' \leq 3$ (Basrudin dan Wahyuni, 2017). In other studies, for instance, the understorey vegetation diversity in the teak forest of Lamorende Village, Tongkuno Subdistrict, Muna Regency, also shows moderate diversity (H' 1.23) (Marfi, 2018). Similarly, the understorey vegetation community in KBK Jati Padangan, Bojonegoro, exhibits moderate diversity (H' 1.82) (Nikmah *et al*., 2016).

CONCLUSION

The identification of understorey plants in the golden teak (*Cordia subcordata*) stands at Gondoriyo Forest revealed 20 plant species from 15 families. Among the 20 identified species, *Microstegium vimineum* had the highest values in terms of density, frequency, Importance Value Index (IVI), and Dominance Value (SDR). The total Shannon-Wiener diversity index (H') for the understorey plants is 1.74. This indicates that the understorey plant community in Gondoriyo Forest has a moderate level of diversity.

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