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Vegetation analysis of terestrial fern in kemuning tea garden in ngargoyoso village, Indonesia

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Abstract

Kemuning Tea Garden in Ngargoyoso Village is a beautiful area with many tourist destinations. Therefore, in addition to the activities of local people as tea farmers, many outsiders come as tourists. This area has abiotic factors that are suitable for the growth of various types of plants, one of which is ferns, especially terrestrial ferns. This study aims to determine the composition of terrestrial fern vegetation in the kemuning tea garden area. The method used was purposive sampling method, with 6 plots in 3 Stations with different heights: Station 1 (800 - 900 m asl), Station 2 (900 - 1000 m asl), and Station 3 (>1000 m asl). This study obtained 9 species of terrestrial ferns: Pityrogramma calomelanos, Adiantum raddianum, Pteris ensiformis, Pteris biaurita, Christella dentata, Nephrolepis exaltata, Dicranopteris linearis, Lycopodiella cernua, and Dryopteris dilatata; that belong to 3 families: Polypodiaceae, Gleincheniaceae, and Lycopodiaceae. The study results show that the type of Nephrolepis exaltata gets the highest INP value, which is 92,88 %. While the lowest INP index is obtained by Pityrogramma calomelanos, which is 9,52 %. The diversity index obtained by the Shannon-wiener formula is 1,85; which means that the diversity in Kemuning Tea Garden is moderate. These findings highlight the importance of adaptive vegetation management in tea plantation landscapes to maintain fern diversity while supporting sustainable agroecosystem functions.

Introduction

Ferns or pteridophyta divisions are a group of low-lying plants with body parts (leaves, stems, and roots) that can be clearly distinguished. These plants belong to members of Cryptogamae or spore plants, which have hidden reproductive apparatus. Hence it is often dubbed as the tallest low plant (Tjitrosoepomo, 2023). Ferns that have been identified in Indonesia number 2,971 out of a total of 14,000 ferns in the world (Darajati, et al., 2016).

Nowadays, the majority of people think that fern plants can only be used as decorations, such as Paku Suplir (*Adiantum* sp.). But, the reality is that fern plants have various ingredients that can be used as medicines, food sources, and nitrogen sources (*Azolla* sp.) (Batoro, 2019). It even has ecological benefits, such as preventing erosion, maintaining soil moisture, and humus formation (Nasution, Nasution, & Kardhinata, 2018). In addition, the species *Pityrogramma calomelanos* has the ability of phytoextraction of arsenic and phytostabilization of copper in copper-contaminated soils (Ancheta, Quimado, Tiburan, Doronila, & Fernando, 2020).

Fern plants are divided into 4 classes, namely Psilophytinae (ancient ferns) which are mostly extinct, Lycopodiinae (wire ferns), Equisetinae (horsetail ferns), and Filicinae (true ferns). Meanwhile, based on their habitat, fern plants are divided into 3, namely aquatic (aquatic), epiphytic fern, and ground (terrestrial) fern. This plant likes areas with cool air, shaded or not, soil with many nutrients, and moist (Tjitrosoepomo, 2023). Species with good adaptability to the surrounding environment, therefore, have a wide distribution.

Species with broad adaptability tend to have wide distributions and high dominance, which can both support ecosystem resilience and simultaneously limit community-level biodiversity if their dominance suppresses less competitive species.

Kemuning Tea Plantation in Ngargoyoso Village, Karanganyar Regency, Central Java; It has quite high community activity, because apart from being a garden, tourist destinations are also built around it that are crowded with tourists. It is located on the slopes of Mount Lawu with coordinates of 11.1-11.25° E and 7.4-7.6° LS with an altitude of 800 – 1,540 m above sea level. The area has an average temperature of 21.5 °C _(Windhita & Supijatno, 2016). These conditions are in accordance with the growth and development needs of fern plants.

Research with a similar location has been conducted at the Nirmala Citalahab Tea Plantation, Kabandungan Regency, Sukabumi. It was found that 32 species of terrestrial ferns and epiphytes were included in 13 families. Where the diversity of fern plant species found is not not high value (Ranil et al., 2017). Meanwhile, so far there is no data on the structure and composition of terrestrial ferns in Kemuning Tea Garden. Therefore, this study needs to be conducted to determine the composition and structure of terrestrial fern plants in the area by analyzing diversity, density, frequency, dominance, and important values. In Ngargoyoso, Karanganyar has levels of highlands according to sea level height. Some areas still have forest areas where the diversity of ferns is grown. In zone I- lowland (Pagerwunung Nature Reserve, Darupono Kendal), eight families with 15 species, zone II-medium land, consisted of 3 families with 23 zone III upland 16 families with 32 species. The diversity of ferns is influenced by the bioecology in the environment, namely temperature, humidity, pH, and light intensity. There are varies of ferns diversity in Ngargoyoso areas (Sianturi et al., 2021).

Materials and methods

This research was carried out in November 2024 – July 2025, at Kemuning Tea Plantation, Ngargoyoso Village, Karanganyar Regency, Central Java at coordinates 7°35'44" S 111°07'57" E with different altitude ranges, namely Station 1 (800 – 900 m above sea level), Station 2 (900 – 1,000 m above sea level), and Station 3 (> 1,000 m above sea level). Where at each station there are 2 plots, so the total plot used is 6 plots. The plot used is 2 x 2 m.

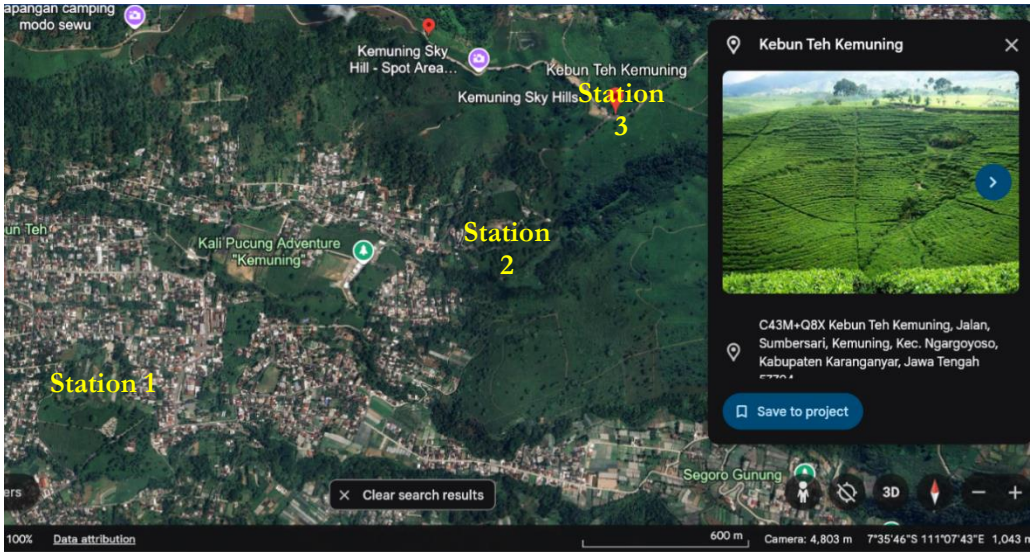

Figure 1. Location Map

The research procedure was divided into four stages. The first stage was the preparation stage, which involved providing and preparing the required tools and materials. The second stage was field implementation, including purposive sampling across the designated plots and measurement of abiotic factors at each station. The third stage was data collection and species identification based on morphological characteristics and verification using relevant literature and the GBIF (Global Biodiversity Information

Facility) database. The fourth stage was documentation and data processing, including recording environmental conditions and organizing the collected data for analysis. Where the tools used to help the research, namely GPS to find out the coordinates; Thermohygrometers to measure air temperature and humidity; Altimeter to measure altitude; meters for measuring the area of the plot; ropes and pegs to limit the plot; stationery for recording found terrestrial fern plants; ruler for measuring fern plants; cellphone for documentation, as well as road boards. The material is in the form of terrestrial fern plants located at the location of the Kemuning Tea Plantation. The study focused on terrestrial fern plants found within the Kemuning Tea Plantation. Sampling was conducted using purposive sampling across six plots of equal size distributed proportionally within three stations representing different elevation ranges. At each station, abiotic factors—including air temperature, air humidity, and altitude—were measured. Data collection involved environmental observations and species identification based on morphological characteristics of fertile fronds, sterile fronds, stems, and sori, which were subsequently verified using relevant literature and the GBIF (Global Biodiversity Information Facility) database. Documentation of habitat conditions and recorded fern species was also carried out. Then a survey was conducted to determine the location of the research, namely 6 plots grouped in 3 stations with different heights.

The next stage is the implementation stage by conducting purposive sampling, which is the selection of samples based on several criteria that are in accordance with the research objectives (Wajdi, et al., 2024). Not forgetting to measure abiotic factors at each station. The abiotic factors measured are air temperature, air humidity, and altitude. Then the data collection stage by observing the surrounding environment, identifying ground ferns through the morphology of fertile leaves, sterile leaves, stems, and sorus; literature with the help of books, journals and the GBIF (Global Biodiversity Information Facility) website. Then the environmental documentation and the terrestrial fern plants found.

The data found were analyzed to look for diversity in density, frequency, dominance, and Important Value Index.

1. Diversity Index

$$H' = -\sum \frac{ni}{N} \log \frac{ni}{N}$$

Information:
H' = Shanno diversity index - weinner
Ni = Number of individuals i-i
N = Total number of individuals of the entire species

2. Density

$$\text{Density (D)} = \frac{\text{individual count}}{\text{sample area}}$$

$$\text{Relative Density (DR)} = \frac{\text{species density}}{\text{density of all species}} \times 100\%$$

3. Frequency

$$\text{Frequency (F)} = \frac{\text{number of subplots found for a species}}{\text{total number of plots}}$$

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

4. Dominance

$$\text{Dominance (D)} = \frac{\text{number of basic fields of a species}}{\text{plot size}}$$

$$\text{Relative Dominance (DR)} = \frac{\text{dominance of a species}}{\text{dominance of all species}} \times 100\%$$

5. Important Value Index (IVI)

DR + FR + DR = IVI

Results and discussion

1. Structure and Composition of Ground Fern Plants

It was found that 9 species of terrestrial fern plants belong to 3 families, namely Polypodiaceae (*Pityrogramma calomelanos, Adiantum raddianum, Pteris ensiformis, Pteris biaurita, Christella dentata, Nephrolepis exaltata*, and *Dryopteris dilatata*), Gleincheniaceae (*Dicranopteris linearis*), and Lycopodiaceae (*Lycopodiella cernua*) (Table 1).

Table 1. Number of Individuals, IVI, Diversity of Ground Ferns in Kemuning Tea Garden

No	Family	Species	∑ Individu	IVI	H'
1	Polypodiaceae	*Pityrogramma calomelanos* (L.) Link	6**	9.52**	-0.10**
2		*Adiantum raddianum* C.Presl	8	13.58	-0.12
3		*Pteris ensiformis* Burm.	27	37.93	-0.25
4		*Pteris biaurita* L.	6	14.68	-0.10
5		*Christella dentata* (Forssk.) Brownsey & Jermy	43	47.59	-0.31
6		***Nephrolepis exaltata* (L.) Schott**	**76***	**92.88***	**-0.37***
7		*Dryopteris dilatata* (Hoffm.) A.Gray	19	27.34	-0.21
8	Gleincheniaceae	*Dicranopteris linearis* (Burm.fil.) Underw.	38	45.87	-0.30
9	Lycopodiaceae	*Lycopodiella cernua* (L.) Pic.Serm.	7	10.61	-0.11
Total			230	300	1.85

***** Indicates the highest values

The species with the highest number of individuals is *Nephrolepis exaltata* with 76, followed by *Christella dentata* with 43, and *Dicranopteris linearis* with 38. While the least number are the species *Pityrogramma calomelanos* and *Pteris biaurita* which number 6 (Table 1). The difference in number is due to the adaptability of each species to the surrounding environment. Plant types that have high adaptation are more common than plant types with low adaptation, terutama pada pertumbuhan paku (Hutasuhut & Febriani, 2019).

The type of *Nephrolepis exaltata* is also the species with the highest IVI value, which is 92.88%, followed by *Christella dentata* 47.59%, and *Dicranopteris linearis* 45.87%. Likewise, *Pityrogramma calomelanos* received the lowest IVI, which was 9.52% (Figure 2). Low IVI indicates the lowest dominance of the species. Although the species is not a species that is difficult to find, it can occur. The species is generally not considered rare, its limited occurrence in the study area may be associated with abiotic conditions that are less optimal for its ecological requirements. This interpretation is supported by the measured environmental parameters—such as temperature, humidity, light intensity, and soil conditions—which indicate that certain sampling stations may not fully meet the microhabitat preferences needed for the species' establishment and growth. (Faizza, Ajizah, & Rezeki, 2024).

In contrast to *Pityrogramma calomelanos*, the IVI of *Pteris biaurita* is not the lowest, which is 14.68%. This means that the species with the lowest number of individuals do not always get the lowest IVI. This is due to the value of the frequency or encounter of *Pteris biaurita* on higher plots. IVI is a calculation used to determine the species that dominate a community. This calculation is based on 3 important values, namely Relative Density (DR), Relative Frequency (FR), and Relative Dominance (DR) (Setiawan, 2022). The higher the important value, the higher the IVI (Faida, Sunarto, Sutikno, & Fandeli, 2018).

The diversity value in Kemuning Tea Gardens got a result of 1.85 which means medium. It is calculated by Shannon-Weaver calculations, which have the following product categories: H' < 1 means low vegetation diversity, 1 < H' < 3 means medium, and H'> 3 means high. This diversity value is used to determine the percentage of vegetation diversity in an ecosystem (Yuliana & Ami, 2020). The more plant species that are found, the higher the diversity index as well.

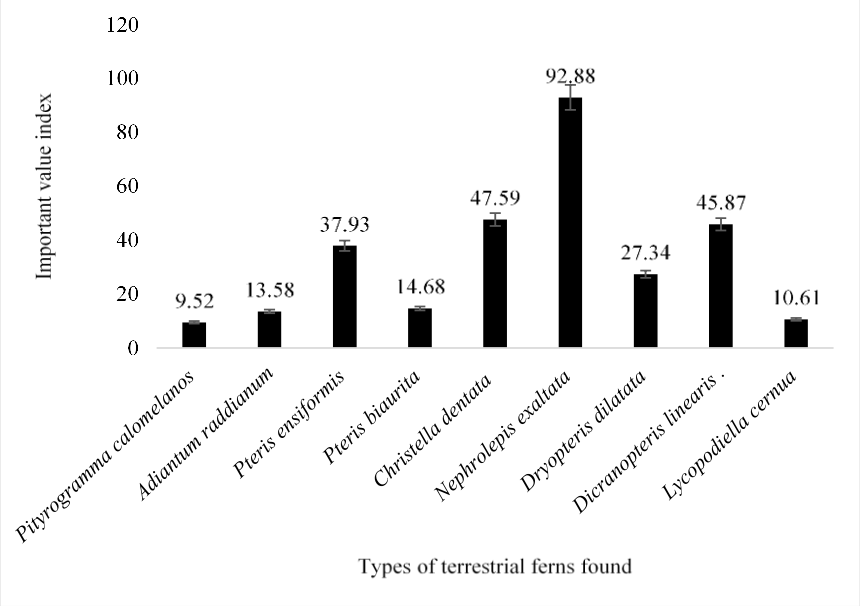

Figure 2. Important Value Index Diagram

The diversity of terrestrial fern plants in Kemuning Tea Gardens is not high. This is because the area is a homogeneous area with quite intense community activities. The relatively low diversity of terrestrial ferns in Kemuning Tea Gardens appears to be associated with the homogeneous habitat conditions and the high level of anthropogenic activity. Furthermore, regular plantation management practices aimed at maintaining tea productivity may contribute to shaping the composition and diversity of the fern understory. In addition, the tea garden itself requires maintenance to keep production optimal. Some of the treatments carried out are pruning tea stalks to avoid epiphytic weeds attached to the stems, fertilizer application, watering, and spraying pesticides to eliminate pests and diseases. These routine management practices may act as a disturbance regime that filters fern species based on their tolerance to light fluctuation, nutrient change, and physical or chemical disturbance. This process can help explain the moderate diversity index and the strong dominance observed in the Kemuning Tea Garden fern community. Where fern plants are often considered as weeds in the tea garden, so they will definitely be destroyed (Irawan, Maulana, Djuita, Ariyanti, & Chikmawati, 2024).

2. Discovery of Types of Ground Fern Plants on the Plot

Based on the species of terrestrial fern plants found, no species were found in the entire plot (6 plots). The most encounters were only in 5 plots (20.83%), namely *Nephrolepis exaltata* and *Pteris ensiformis*. Meanwhile, the least encounters were *Pityrogramma calomelanos* and *Lycopodiella cernua* which were found in only 1 plot (4.17%) (Table 2). Although *Lycopodiella cernua* also has the lowest incidence of plots, such as *Pityrogramma calomelanos*, the number of individuals is higher than that of *P. calomelanos*, so the IVI is higher, which is 10.61%. Likewise with *Pteris ensiformis* which, although found in almost all plots, but because the number of individuals found is less than that of *Nephrolepis exaltata*, it does not obtain the highest IVI.

Table 2. Types of Terrestrial Ferns and Their Occurrence in Plots

No	Family	Species	P 1	P 2	P 3	P 4	P 5	P 6	Encounter on the plot	Percentage (%)
1	Polypodiaceae	*Pityrogramma calomelanos* (L.) Link	√						1	4.17**
2		*Adiantum raddianum* C.Presl	√					√	2	8.33
3		*Pteris ensiformis* Burm.	√	√	√	√		√	5	20.83
4		*Pteris biaurita* L.	√				√		2	8.33

No	Family	Species	P 1	P 2	P 3	P 4	P 5	P 6	Encounter on the plot	Percentage (%)
5		*Christella dentata* (Forssk.) Brownsey & Jermy	√		√	√			3	12.50
6		***Nephrolepis exaltata* (L.) Schott**		√	√	√	√	√	**5**	**20.83***
7		*Dryopteris dilatata* (Hoffm.) A.Gray					√	√	2	8.33
8	Gleincheniaceae	*Dicranopteris linearis* (Burm.fil.) Underw.			√		√	√	3	12.50
9	Lycopodiaceae	*Lycopodiella cernua* (L.) Pic.Serm.				√			1	4.17
Total									**24**	**100**

***** Indicates the highest values

The species of terrestrial fern plants that are often found is *Nephrolepis exaltata*. This species is most commonly found in Plot 5 which is shaded by tea plants. Where this plant is found between the sidelines of the tea plant and the edge of the tea plant growing area. Although the air humidity in Plot 5 (station 3) is lower than *the* other plots, this plant is known for its stable growth ability and high adaptation. This plant has a good tolerance to high and low light intensity, so it can grow in open and shaded places (Anderson, 2024).

While the type of terrestrial fern plant that is difficult to find is *Pityrogramma calomelanos*. This type of plant likes shaded areas. Where in this study, plots with the shade of large trees were only found in plot 1, which is the location where the *Pityrogramma calomelanos* type was found. Although this species is not difficult to find, this can happen due to the presence of other species that dominate the area or abiotic factors that are not suitable for the growth and development needs of the species (Syafrudin, Haryani, & Wiedarti, 2016).

3. Environmental Conditions

The research location has a temperature ranging from 25-31°C, namely Station 1 (26.6 °C); Station 2 (25.6 °C); and Station 3 (31 °C) (Table 3). The results of these measurements show that the higher the plain, the higher the temperature. Where Station 3 has the highest altitude (> 1,000 m asl) has the highest temperature (31°C). However, this is not in accordance with the theory that the higher the plain, the lower the temperature (Hutasuhut & Febriani, 2019). This is because the sampling process is carried out when the weather is sunny and hot, precisely at 09.00 – 12.00 WIB. In addition, it also coincides with the transition period from the dry season to the rainy season, so it still leaves high temperatures, but the air humidity is already low, namely Station 1 (41%), Station 2 (39%), and Station 3 (35%) (Fitrianti, 2016; Putri, 2018).

Table 3. Abiotic Factors

Station	Plot	Coordinate Point	Altitude (m asl)	Air Temperature (◦C)	Air Humidity (%)
1	1	S07◦ 36.394" E111◦ 06.981"	800 - 900	26,6	41
	2	S07◦ 36.397" E111◦ 06.943"			
2	3	S07◦ 35.968" E111◦ 07.813"	900 - 1000	25,6	39
	4	S07◦ 35.981" E111◦ 07.779"			
3	5	S07◦ 35.751" E111◦ 07.955"	1000 <	31	35
	6	S07◦ 35.626" E111◦ 08.242"			

The diversity differences at the observation station are not very noticeable. Plant species of ground ferns at Station 1 (Plots 1 and 2) were found as many as 6 species, Station 2 (Plots 3 and 4) as many as 5 species, and Station 3 (Plots 5 and 6) as many as 6 species. This is due to the difference in altitude used is only 100 m above sea level, and is still classified as the optimal altitude for the growth and development of

terrestrial ferns. According to research conducted by Hutasuhut and Febriani, the higher the plain, the lower the air temperature. So that there are not many types of plants that are able to adapt to the environment (Hutasuhut & Febriani, 2019).

The difference in terrestrial fern diversity between Kemuning Tea Garden and the Nirmala Citalahab Tea Plantation is closely associated with variations in key environmental factors (elevation, humidity, canopy cover, and soil moisture) that regulate species species dominance and evenness, ultimately influencing the Shannon–Wiener diversity index. Where in the tea plantation were found 32 species in 18 families, of which 7 were epiphytic ferns and 25 species of terrestrial ferns. The diversity difference is caused by differences in abiotic factors (Roziaty et al., 2016). The temperature and humidity of the air in the Nirmala Tea Garden Area ranged from 26 °C and 67–77 %, while in Kemuning Tea Plantation it is 25 – 31°C and 35 – 41%. This means that the Nirmala Tea Garden is more humid than the Kemuning Tea Plantation. In addition, in this study, no measurements were made of other abiotic factors, such as soil pH, soil temperature, soil moisture, light intensity, and wind speed, which can affect the occurrence of ground fern plants (Figure 3).

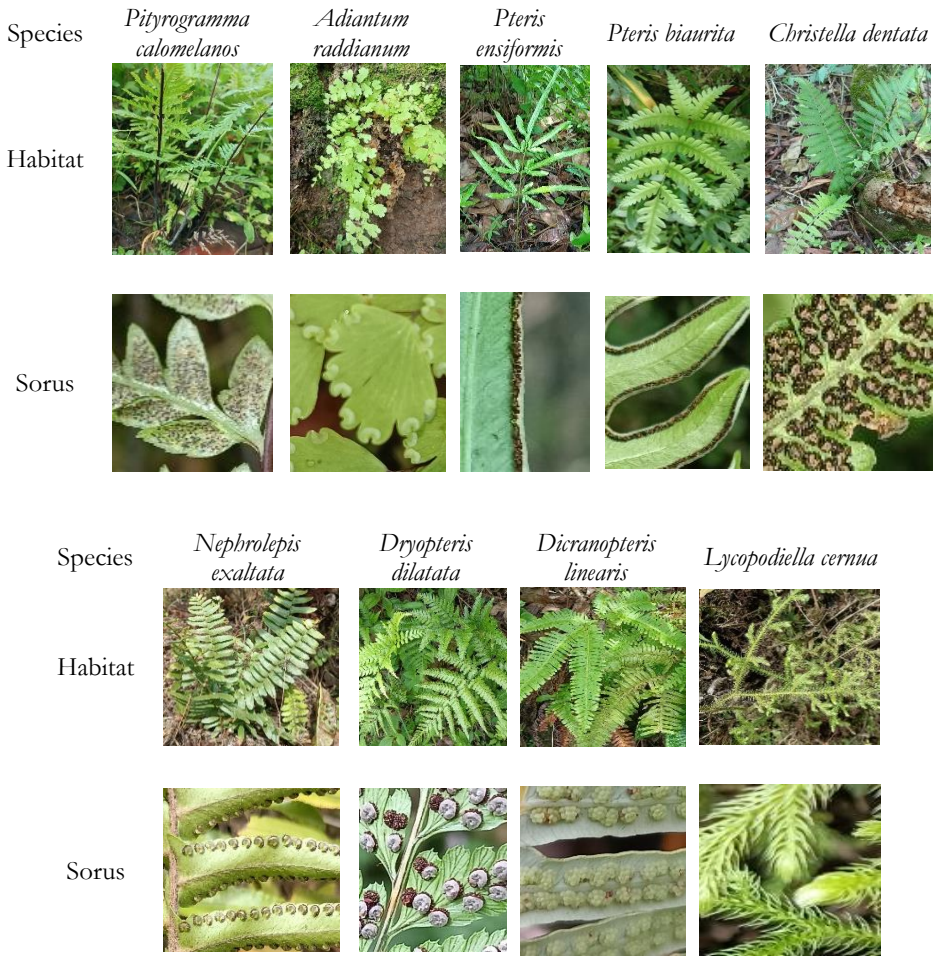

Figure 3. Types of terrestrial ferns found

In this study, habitat refers to the environmental conditions where each fern species was found growing, including substrate type, moisture level, light exposure, and microhabitat characteristics within the tea plantation landscape (Sianturi et al., 2021). These parameters were recorded to describe the ecological preferences and distribution patterns of each species across different elevation gradients (Hasanah et al., 2021; Ranil et al., 2017). Morphological observations, particularly sorus characteristics, are presented separately to avoid misinterpretation between ecological habitat data and taxonomic diagnostic features

(Caxambú et al., 2015). This separation ensures clearer ecological analysis and improves the accuracy of species identification and vegetation assessment.

Conclusion

Research conducted at the Kemuning Tea Garden found 9 species of terrestrial ferns (*Pityrogramma calomelanos, Adiantum raddianum, Pteris ensiformis, Pteris biaurita, Christella dentata, Nephrolepis exaltata, Dryopteris dilatata, Dicranopteris linearis,* and *Lycopodiella cernua*) belonging to 3 families (Polypodiaceae, Gleincheniaceae, and Lycopodiaceae). The species Nephrolepis exaltata has the highest INP value of 92.88 %, while the lowest INP value is 9.52 % for Pityrogramma calomelanos. The Shannon-Wiener species diversity index (H') at Kemuning Tea Garden is moderate at 1.85. Finally, this study provides baseline data for future ecological monitoring and can support the development of sustainable tea landscape management strategies in the Kemuning area.

Author Statements

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Competing of interest: The authors declare no competing interests.
Generative AI: "not applicable".
Data availability: The raw data supporting the conclusions of this article, including the monthly abundance counts, Shannon-Wiener index calculations, and environmental variable measurements of ferns (*Pterydophytes*).

References

Ancheta, M. H., Quimado, M. O., Tiburan, C. L., A. Doronila, & Fernando, E. S. (2020). Copper and arsenic accumulation of Pityrogramma calomelanos, Nephrolepis biserrata, and Cynodon dactylon in Cu- And Au- mine tailings. University Knowledge Digital Repository. https://www.ukdr.uplb.edu.ph/journal-articles/346

Anderson, O. R. (2024). An Ecophysiological Study of Cultivated *Nephrolepis exaltata* (L.) Schott cv. Bostoniensis (Boston Fern). *International Journal of Biodiversity and Conservation*, 16(2): 72-78. https://doi.org/10.5897/IJBC2024.1613

Batoro, J. (2019). Pengantar Umum Keanekaragaman Hayati dan Tumbuhan Racun. Media Nusa Creative.

Caxambú, M. G., Geraldino, H. C. L., & Solvalagem, A. C. M. (2015). Ferns and Lycophytes in Two Areas of Ecotone between Seasonal Semideciduous Forest and Mixed Ombrophilous Forest in Campo Mouro, Parana, Brazil. *Open Journal of Forestry*, 05(02), 195–209. https://doi.org/10.4236/ojf.2015.52018

Darajati, W. (2016). Indonesian Biodiversity Strategy and Action Plan. BAPPENAS.

Faida, L. R. (2018). GUNUNGSEWU: Menguak Jejak Sejarah Flora, Merekonstruksi Kawasan Karst. Gadjah Mada University Press.

Faizza, K.N., Ajizah, A. & Rezeki, A. (2024). Keragaman Jenis Tumbuhan Paku (Pteridophyta) di Tepian Sungai Kembang Desa Arang Kabupaten Banjar. *BIOEDUKASI Jurnal Pendidikan Biologi Universitas Muhammadiyah Metro*, 15(2): 271-284.

Fitrianti, R. N. (2016). Studi Keanekaragaman Pterydophyta Terestial Di Kawasan Hutan Wisata Air Terjun Jumog Desa Berjo Ngragoyoso Karanganyar Provinsi Jawa Tengah. Skripsi. Universitas Muhammadiyah Surakarta

Hasanah, U., Hadisunarso, & Praptosuwiryo, T. N. (2021). Composition, community structure, and vertical distribution of epiphytic ferns on Cyathea junghuhniana in Gede-Pangrango National Park, Indonesia. Biodiversitas, 22(11), 4968–4976. https://doi.org/10.13057/BIODIV/D221132

Hutasuhut, M. A. & Febriani, H. (2019). Keanekaragaman Paku-pakuan di Kawasan Taman Wisata Alam Sicike-cike. *Jurnal Biolokus*, 2(1): 146-157. https://jurnaltarbiyah.uinsu.ac.id/index.php/biolokus/article/view/441

Irawan, A. Maulana, L. Djuita, N. R., Ariyanti, N.S., & Chikmawati, T. (2024). Diversitas dan Komposisi Flora Paku (Pteridophyta) di Perkebunan Teh Nirmala Citalahab, Kecamatan Kabandungan, Sukabumi, Jawa Barat. *Jurnal Sumberdaya HAYATI*, 10(3): 128-135.

Nasution, J., Nasution, J., & Kardhinata, E. H. (2018). Inventarisasi Tumbuhan Paku di Kampus I Universitas Medan Area. *KLOROFIL: Jurnal Ilmu Biologi dan Terapan*, 1(2), 105. https://doi.org/10.30821/kfl:jibt.v1i2.1603

Putri, D. A. (2018). Inventarisasi Pterydophyta Langka di Kawasan Air Terjun Jumog, Ngargoyoso, Karanganyar, Jawa Tengah. Skripsi, Universitas Muhammadiyah Surakarta

Ranil, R. H. G., Pushpakumara, D. S. A. Wijesundara, P. D. Bostock, A. Ebihara, and C. R. Fraser-Jenkins. 2017. "Diversity and Distributional Ecology of Tree Ferns of Sri Lanka: A Step towards Conservation of a Unique Gene Pool." *Ceylon Journal of Science* 46(5):127–35. https://doi:10.4038/cjs.v46i5.7460.

Roziaty, E., Agustina, P., & Nurfitrianti, R. (2016). Pterydophyta Epifit Kawasan Wisata Air Terjun Jumog Ngargoyoso Karanganyar Jawa Tengah. 9, 76–78. https://doi.org/10.20961/bioedukasi-uns.v9i2.8586

Setiawan, S. (2022). Analisis Vegetasi Habitat Burung Rangkong. Fakultas Kehutanan Universitas Hasanuddin.

Sianturi, A., Ridlo, S., & Retnoningsih, A. (2021). Diversity and distribution of ferns at different altitudes in Central Java. *Journal of Physics: Conference Series*, *1918*(5). https://doi.org/10.1088/1742-6596/1918/5/052016

Syafrudin, Yudi; Haryani, Tri Saptari; dan Wiedarti, Sri. (2016). Keanekaragaman dan Potensi Paku (Pteridophyta) di Taman Nasional Gunung Gede Pangrango Cianjur (TNGGP). *Ekologia*, 16(2): 24-31.

Tjitrosoepomo, Gembong. (2023). Taksonomi Tumbuhan (Schizophyta, Thallophyta, Bryophyta, Pteridophyta), Edisi Revisi. Gadjah Mada University Press.

Wajdi, F. (2024). Metode Penelitian Kuantitatif. Widna Media Utama.

Windhita, A., & Supijatno. (2016). Pengelolaan Pemetikan Tanaman Teh (*Camellia sinensis* (L.) O Kuntze) di Unit Perkebunan Rumpun Sari Kemuning, Karanganyar, Jawa Tengah. *Buletin Agrohorti*, 4(2), 224–232. https://doi.org/10.29244/agrob.v4i2.15025

Yuliana, A. I. (2020). Analisis Vegetasi dan Potensi Pemanfaatan Gulma Lahan Persawahan. LPPM UNHAWA.