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Distribution of Ferns at Different Heights in *Gunung Raya* Protected Forest, West Kalimantan

[1]Dea Fitri Natasya, [1]*Entin Daningsih and [1]Anisyah Yuniarti
1. Tanjungpura University, Pontianak, Kalimantan Barat, Indonsesia
*Correspondence email: entin.daningsih@fkip.untan.ac.id

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Abstrak: Tumbuhan paku merupakan jenis keanekaragaman hayati yang tersebar hidup pada lantai hutan dan memegang peran penting dalam fungsi ekologis, seperti pada pembentukan humus, melindungi tanah dari erosi, dan menjaga kelembaban tanah. Penelitian ini bertujuan untuk untuk mengetahui sebaran jenis tumbuhan paku pada ketinggian berbeda di Hutan Lindung Gunung Raya Desa Temajuk dan potensinya bagi masyarakat. Metode dalam penelitian ini, yaitu metode jelajah untuk mengamati tumbuhan paku pada kontur tanah dengan ketinggian 25-125 mdpl, 125-225 mdpl, dan 225-325 mdpl. Parameter lingkungan meliputi temperatur, kelembaban, intensitas cahaya, pH tanah dan kecepatan angin diukur pada setiap ketinggian. Herbarium di buat untuk mengidentifikasi tumbuhan paku. Informasi mengenai potensi tumbuhan paku didapatkan dari masyarakat sekitar. Hasil penelitian menunjukkan terdapat 14 spesies tumbuhan paku yang termasuk dalam 7 famili. Tumbuhan paku yang ditemukan sebanyak 14 jenis pada ketinggian 25-225 mdpl berkurang menjadi 10 jenis pada kontur tertinggi (325 mdpl). Keempat spesies yg tidak ditemukan, yaitu *Stenochlaena palustris*, *Nephrolepis cordifolia*, *Hypolepis punctata*, dan *Davalia divaricata*. Dari 14 jenis tumbuhan paku, 11 diantaranya memiliki potensi sebagai sayuran, obat, tanaman hias, dan bahan kerajinan.
Kata kunci: Hutan lindung; ketinggian; tumbuhan paku.

Abstract: Ferns are a type of biodiversity that is spread to live on the forest floor and plays an important role in ecological functions, such as humus formation, protecting soil from erosion, and maintaining soil moisture. This study aims to determine the distribution of fern species at different heights in the *Gunung Raya* Protection Forest, Temajuk Village and their potential for the community. The method in this study, namely the cruising method to observe ferns on soil contours with an altitude of 25-125 meters above sea level, 125-225 meters above sea level, and 225-325 meters above sea level. Environmental parameters including temperature, humidity, light intensity, soil pH and wind speed were measured at each altitude. Herbarium was made to identify ferns. Information about the potential of ferns was obtained from the surrounding community. The results showed that there were 14 species of ferns belonging to 7 families. Ferns found were as many as 14 species at an altitude of 25-225 masl decreased to 10 species at the highest contour (325 masl). The four species that were not found were *Stenochlaena palustris*, *Nephrolepis cordifolia*, *Hypolepis punctata*, and *Davalia divaricata*. Of the 14 species of ferns, 11 of them have potential as vegetables, medicines, ornamental plants, and craft materials.
Keyword: Altitude; ferns; protected forest.

1. Introduction

Ferns are a type of biodiversity from the flora group that lives in the tropics [1]. This plant is already distinguished in roots, stems and leaves [2]. Ferns are characterized by their young leaves that roll up, but when they grow up the leaves will be open [3].

Ferns inhabits forest areas and is spread to live on the forest floor [4]. As plants that live on the forest floor, ferns play an important role in ecological functions, such as in the formation of humus, protecting soil from erosion, maintaining soil moisture, and is one of the pioneers in the early stages of ecosystem succession [1]. There for, there is an urgent to preserve fern for there important role in area especially in protected forest areas. In addition, ferns can also be used as food, ornamental plants, and as medicinal materials [5]. However, there are still many people who do not know the benefits and role of ferns for the environment. Many ferns grow as wild plants that are ignored by the community [6]. This indicates that many people do not know the potential possessed by ferns and the diversity of plant species, so that people do not care about the damage or loss of fern species.

Protected forests are forest areas that have a function as a buffer of life systems to control erosion, regulate water systems, and control soil fertility [7]. One of the protected forests in West Kalimantan is *Gunung Raya* Protection Forest in Temajuk Village with an area of 1,200 hectares and a height of 350 meters above sea level (UPT KPH Wilayah Sambas, 2023). The *Gunung Raya* pretected forest is located between Indonesia and Malaysia. One of the biodiversity found in *Gunung Raya* Protection Forest is various ferns.

Ferns can be found at different heights, either on the ground, rocks, or in trees [8]. The spread of ferns at different heights is a form of adaptation of ferns to be able to live in the area. The number of fern species at higher locations will decrease, because only ferns that can adapt can live [9]. This is related to environmental conditions in a location. The distribution of ferns at each altitude is related to bioecological factors such as temperature, light intensity, and wind

speed that can affect the growth of ferns [10]. The spread of ferns in the protected forest of *Gunung Raya* is unknown.

Currently, there is a lot of land clearing around *Gunung Raya* Protection Forest by the community for development and plantations. Activities carried out by the community are anticipated so as not to enter the protected forest area, but the lack of knowledge and attitudes from the community towards the sustainability of protected forests can endanger the existence of protected forests. It can raise concerns about the reduction of forest areas and physical changes in the forest area [11]. This can affect the survival of flora and fauna that live in the forest before being extincted and known, one of which is ferns. Given that data information on the types of plants and animals in an area is very important to serve as a basis for management efforts. Because of that, an inventory of ferns was conducted at each altitude in *Gunung Raya* Protection Forest. This study aimed to determine the distribution of fern species and the potential of ferns found at each altitude in *Gunung Raya* Protection Forest, Temajuk Village, Sambas Regency.

2. Research Method

The form of this research descriptive quantitative, namely fern data from the results of the study are described and calculated the number of species at each height. The research was conducted in December 2023 in *Gunung Raya* Protection Forest, Temajuk Village.

Tools and materials used in this study, namely altimeter to measure the height of the place, compass to determine direction, GPS to determine coordinate points, thermometer to measure air temperature, pH meter to measure soil pH, Lux meter to measure light intensity, hygrometer to measure air humidity, anemometer to measure wind speed, camera for documentation, stationery to record information on ferns found, plastic samples, label paper, spray bottles and 70% alcohol. In addition, tools for making herbarium were newsprint, bamboo sasak, raffia, scissors, markers, Fox glue, insulation, clear cover, and hard cardboard.

Gunung Raya Protection Forest in Temajuk Village has an area of 1,200 hectares and a height of 350 msl (Figure 1). The sampling area used in this study was 2% of the forest area, so the sampling area used was 24 hectares or 240.000 m^2. Samples of ferns were collected using the cruising method by exploring every corner of the location that can represent each altitude [6] and using purposive sampling techniques in sampling. Purposive sampling referred to in this study were sampling based on ferns encountered and if the same type was found at the same altitude more than once then the type was not taken because it was considered to represent the altitude in the area.

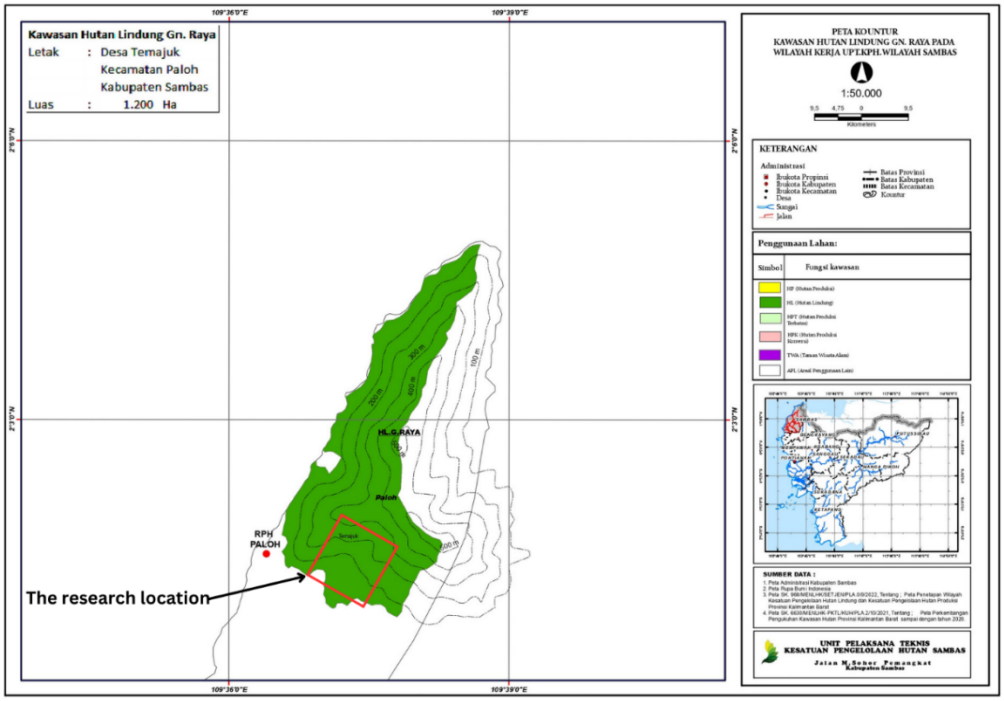

Figure 1. Research Location Map

The exploration was carried out by following the contours starting from an altitude range of 25-125 msl, 125-225 msl, and 225-325 msl (Figure 2). Exploration was carried out in a zig-zag manner, namely 10 meters to the left and 10 meters to the right. The zig-zag method was used to expand the exploration area so that more types of nails are obtained.

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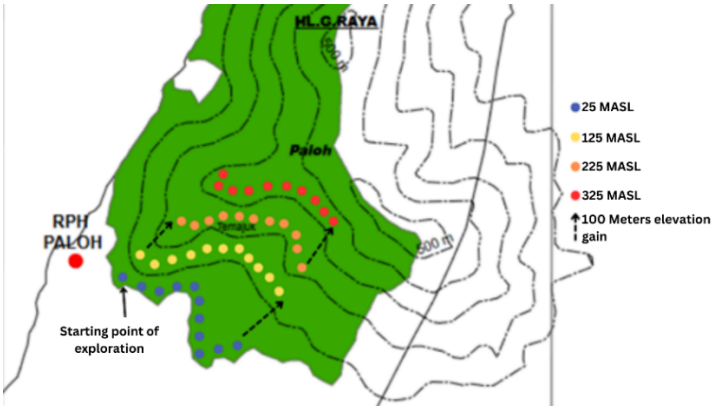

Figure 2. Cruising Paths at Each Altitude a Fern Study

In addition, environmental factors were measured at each height of the location, including air temperature, air humidity, light intensity, soil pH, and wind speed [12]. Identification was carried out in *Gunung Raya* Protection Forest, Temajuk Village by looking at the morphological characteristics of ferns [13]. Herbarium is made for ferns that have not been identified yet. All organs of fern parts are taken for making herbarium. Identification was done in the laboratory of Biology Education FKIP Tanjungpura University.

3. Result and Discussion

The results of the fern inventory research in *Gunung Raya* Protection Forest, Temajuk Village, Sambas Regency with an area of 2% (24 Hectares) of the forest area, obtained 14 species of ferns that are scattered according to their height. The following was an image of the 14 types of ferns found in the *Gunung Raya* Protection Forest, Temajuk Village (Figure 3)

(a) (b) (c) (d)

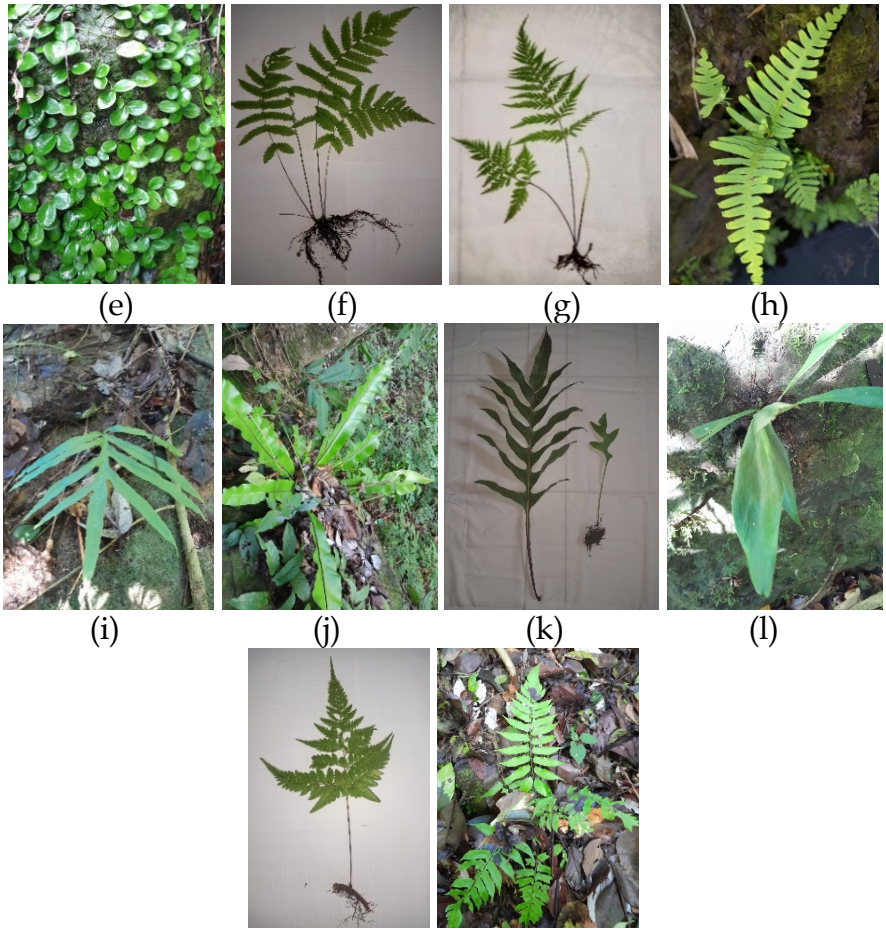

Figure 3. Ferns found in *Gunung Raya* Protection Forest (a) *Nephrolepis cordifolia* Presl.; (b) *Stenochlaena palustris* Bedd.; (c) *Cyclosorus parasiticus* Linn.; (d) *Hypolepis punctata* (Thbg) Mett., Kuhn.; (e) *Pyrrosa nummularifolia* (Sw.) Ching, Bull.; (f) *Thelypteris singalanensis* (Bak.) Ching, Bull.; (g) *Pityrogramma calomelanos* Link.; (h) *Gleichenia linearis* Clarke.; (i) *Phymatodes scolopendria* Burm.; (j) *Asplenium nidus* L.; (k) *Drynaria quercifolia* (L.) J. Sm.; (l) *Antrrophyum callifolium* Bl.; (m) *Davalia divaricata* Bl.; and (n) *Cyclosorus glandulosus* (Bl.) Ching, Bull.

Meanwhile, data on each fern found in *Gunung Raya* Protection Forest, Temajuk Village can be seen in Table 1.

Table 1. Fern Species found in the Research Track in *Gunung Raya* Protection Forest, Temajuk Village

No	Name of Species	Local name	Family	Way of life
1	*Nephrolepis cordifolia* Presl.	*Paku Uban*	Polypodiaceae	Terrestrial/epiphyte
2	*Stenochlaena palustris* Bedd.	*Miding*	Blechnaceae	Terrestrial/epiphyte
3	*Cyclosorus parasiticus* Linn.	*Pajik*	Thelypteridaceae	Terrestrial
4	*Hypolepis punctata* (Thbg) Mett., Kuhn.	*Paku Dayak*	Dennstaedtiaceae	Terrestrial
5	*Pyrrosa nummularifolia* (Sw.) Ching, Bull.	*Buah Hujan*	Polypodiaceae	Epiphyte
6	*Thelypteris singalanensis* (Bak.) Ching, Bull.	-	Thelypteridaceae	Terrestrial/epiphyte
7	*Pityrogramma calomelanos* Link.	*Paku Perak*	Pteridaceae	Terrestrial/epiphyte
8	*Gleichenia linearis* Clarke.	*Resam*	Gleicheniaceae	Terrestrial
9	*Phymatodes scolopendria* Burm.	*Sannah*	Polypodiaceae	Epiphyte

No	Name of Species	Local name	Family	Way of life
10	*Asplenium nidus* L.	*Sarang Burung*	Polypodiaceae	Epiphyte
11	*Drynaria quercifolia* (L.) J. Sm.	*Daun Kepala Tupai*	Polypodiaceae	Epiphyte
12	*Antrrophyum callifolium* Bl.	-	Adiantaceae	Epiphyte
13	*Davalia divaricata* Bl.	-	Polypodiaceae	Epiphyte
14	*Cyclosorus glandulosus* (Bl.) Ching, Bull.	-	Thelypteridaceae	Terestial

The fern species found were included in 7 families, namely the Polypodiaceae, Blechnaceae, Thelypteridaceae, Dennstaedtiaceae, Pteridaceae, Gleicheniaceae, and Adiantaceae. Based on the results of the study, the most ferns found in the research path in the *Gunung Raya* Protection Forest, Temajuk Village were species from the Polypodiaceae. The family a Polypodiaceae has the most species number, which were around 170 genus and 7,000 species [14]. The wide distribution and many species members of the Polypodiaceae were due to the ability of this type of fern to adapt to diverse habitats at different altitudes [15].

From the results of the study, fern species from the Polypodiaceae can be found at every altitude of the study site. Members of this family are generally epiphyte ferns that grow on stem or rocks [16]. This can be seen from the results of the study, where the fern species found belonging to the Polypodiaceae were mostly epiphyte ferns, such as *Pyrrosa nummularifolia*, *Phymatodes scolopendria*, *Asplenium nidus*, *Drynaria quercifolia*, and *Davalia divaricata* (Figure 3).

On the research track in *Gunung Raya* Protection Forest, Temajuk Village, ferns spread almost at every altitude. In the altitude range of 25-125 masl and 125-225 masl, 14 species of ferns were found, while in the altitude range of 225-325 masl, only 10 species of ferns were found (Table 2).

Table 2. Fern Species Found at Each Altitude in *Gunung Raya* Protection Forest, Temajuk Village

No.	Name of Species	Location Altitude (masl)		
		25 -125	125 – 225	225 - 325
1	*Stenochlaena palustris* Bedd.	✓	✓	-
2	*Nephrolepis cordifolia* Presl.	✓	✓	-
3	*Hypolepis punctata* (Thbg) Mett., Kuhn.	✓	✓	-
4	*Davalia divaricata* Bl.	✓	✓	-
5	*Cyclosorus glandulosus* (Bl.) Ching, Bull.	✓	✓	✓
6	*Cyclosorus parasiticus* Linn.	✓	✓	✓
7	*Pyrrosa nummularifolia* (Sw.) Ching, Bull.	✓	✓	✓
8	*Thelypteris singalanensis* (Bak.) Ching, Bull.	✓	✓	✓
9	*Pityrogramma calomelanos* Link.	✓	✓	✓
10	*Gleichenia linearis* Clarke.	✓	✓	✓
11	*Phymatodes scolopendria* Burm.	✓	✓	✓

No.	Name of Species	Location Altitude (masl)		
		25 -125	125 – 225	225 - 325
12	*Aspelinum nidus* L.	✓	✓	✓
13	*Drynaria quercifolia* (L.) J. Sm.	✓	✓	✓
14	*Antrrophyum callifolium* Bl.	✓	✓	✓

Altitude is one of the factors that can affect the number of fern species in a place [8]. Some research on the inventory of ferns, showing the results that ferns can be spread at different altitudes. Pradipta et al. (2023) staded 15 species of ferns were obtained, where at the highest altitude (747-1215 masl) only 3 species of ferns were obtained [8]. Katili (2013) also showed that ferns decreased in number at an increase in location altitude, where there were only 3 species of ferns at an altitude of 1450 masl [10]. The results of research in *Gunung Raya* Protected Forest, Temajuk Village showed that the number of fern species decreased at the highest contour (325 masl). The numbers of ferns scattered at an altitude of 25-225 masl were as many as 14 species was reduced to only 10 species at an altitude of 225-325 masl (Table 2). Fern species were not found at the highest contour, namely *Stenochlaena palustris*, *Nephrolepis cordifolia*, *Hypolepis punctata*, and *Davalia divaricata*. This was due to changes in environmental conditions at that location where the air temperature was lower in the highest altituded than the two previous altitude ranges (Table 3).

The altitude of the place is closely related to environmental conditions, such as climate, light intensity, and wind conditions. Some environmental factors that affect the growth of ferns, namely light intensity, altitude, air temperature and humidity, soil pH, and wind speed [8]. The average range of measurements of environmental factors in the *Gunung Raya* Protection Forest, Temajuk Village can be seen in Table 3.

Table 3. Measurement Results of Environmental Parameters in *Gunung Raya* Protection Forest, Temajuk Village

No	Parameters	Unit	Measurement Result			Everage
			25 -125	125 – 225	225 - 325	
1.	Air temperature	°C	26	25,66	24,99	25,55
2.	Soil temperature	°C	27	26,33	25,49	26,27
3.	Air humidity	%	77,83	80,66	80,5	79,66
4.	soil pH	-	6,41	6,48	6,66	6,51
5.	Light Intensity	W/m²	14,2	13,4	13,9	13,83
6.	Wind speed	m/s	3,31	3,23	3,36	3,3

The results of air temperature measurements in this study decreased from 26 to 24,9°C. Purwantara, 2015 stated every 100 meters increase in altitude will decrease the air temperature by 0,6°C [17]. At the study site, each increase in altitude decreased the temperature by 1,1°C. The decreasing temperature resulted in 4 fern species not appearing on the highest contour. The lack of 4 species at this altitude suggests the ferns were more responsive to air temperature than other environmental parameters. From the results of the temperature measurements taken, it can be seen that the temperature decreased with each increase in altitude. Katili (2013) stated that as the altitude of a place increases, the temperature at that location will decrease [10]. The results of air humidity measurements show a range between of 77-80%. Pradipta et al. (2023) stated that the optimal humidity for fern growth is 60-80% [8]. Similarity of humidity causesed the number of fern species at the research site not much different.

Soil pH measurements showed results ranging from 6,4-6,6. Soil pH can affect the process of nutrient absorption and growth of ferns [8]. Ferns can grow optimally in acidic soil conditions with acidity ranging from 5,5-6,5 [18]. From the results of measurements taken at the research site, the range of soil pH at different heights was almost the same, which was still in the optimal range for fern growth.

Of the 14 species of ferns found in the *Gunung Raya* Protection Forest of Temajuk Village, 11 species can be used by the surrounding community as vegetables, medicinal plants, ornamental plants, and craft materials. The usage of ferns in the research location can be seen in Table 4.

Table 4. The usage of fern species in *Gunung Raya* Protection Forest, Temajuk Village

No	Benefit	Percentage (%)	Name of Species	Family
1	Vegetable	22	*Nephrolephis cordifolia* Presl.	Polypodiaceae
			Stenochlaena palustris Bedd.	Blechnaceae
			Cyclocorus parasiticus Linn.	Thelypteridaceae
2	Medicinal plant	14	*Pyrrosa nummularifolia* (Sw.) Ching, Bull.	Polypodiaceae
			Phymatodes scolopendria Burm.	Polypodiaceae
3	Ornamental plant	29	*Pityrogramma calomelanos* Link.	Pteridaceae
			Asplenium nidus L.	Polypodiaceae

No	Benefit	Percentage (%)	Name of Species	Family
			Drynaria quercifolia (L.) J. Sm.	Polypodiaceae
			Davalia divaricate Bl.	Polypodiaceae
4	Craft materials	14	*Hypolepis punctata* (Thbg) Mett., Kuhn.	Dennstaedtiaceae
			Gleichenia linearis Clarke.	Gleicheniaceae
5	Underutilized	21	*Thelypteris singalanensis* (Bak.) Ching, Bull.	Thelypteridaceae
			Antrrophyum callifolium Bl.	Adiantaceae
			Cyclosorus glandulosus (Bl.) Ching, Bull.	Thelypteridaceae

The utilization of ferns by the community is one example of the fern use found in the area. However, this utilization also needs to be controlled so that it is not overused, in order to preserve and maintain the role of ferns for forest ecosystems [19].

4. Conclution

There were 14 species of ferns found on the research track in the *Gunung Raya* Protection Forest of Temajuk Village, which belonged to 7 families, namely Polypodiaceae, Blechnaceae, Thelypteridaceae, Dennstaedtiaceae, Pteridaceae, Gleicheniaceae, and Adiantaceae. The fern were dominated by the Polypodiaceae. The 14 species of ferns found at 25-225 masl decreased to 10 species at the highest contour (325 masl). Fern species were not found at the highest contour, namely *Stenochlaena palustris*, *Nephrolepis cordifolia*, *Hypolepis punctata*, and *Davalia divaricata*. This change in number was more related to the decrease in temperature from 26°C to 24,9°C than to other environmental factors, such as air humidity, light intensity, wind speed, and soil pH. Of the 14 species of ferns found in the *Gunung Raya* Protection Forest of Temajuk Village, 11 of them have potential as vegetables, medicines, ornamental plants, and craft materials.

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