

# Distribution and Diversity of Family Rubiaceae in Pulau Banding, Gerik, Perak

Nik Badrul Nek Adek<sup>1</sup>, Afrina Awang<sup>1</sup>, Nur Hafizah Zulkeflee<sup>1</sup>, Nur Akilah Ismail<sup>1</sup>, Zulhazman Hamzah<sup>1</sup>, Aweng Eh Rak<sup>1</sup>, Muhammad Firdaus Abdul Karim<sup>1,2</sup> and Nazahatul Anis Amaludin<sup>1\*</sup>

<sup>1</sup>Faculty of Earth Science, Universiti Malaysia Kelantan, Kampus Jeli, 17600, Jeli, Kelantan, Malaysia.

<sup>2</sup>UMK-Tropical Rainforest Research Centre (UMK-TRaCe), Tasik Banding, Royal Belum, 33300, Gerik, Perak.

**Abstract.** The distribution and diversity of the Rubiaceae species were investigated along one trail at Pulau Banding, Gerik, Perak. This study aims to identify and estimate the diversity of the Rubiaceae species. The diversity and distribution of the Rubiaceae species were calculated using Shannon-Wiener's Diversity Index, Simpson's Diversity Index and relative abundance index. A total of 139 individuals from nine species were recorded from Pulau Banding, Perak which are *Mitracarpus hirtus*, *Gardenia carinata*, *Aidia densiflora*, *Hypobathrum hirtum*, *Coffea arabica*, *Psychotria marginata*, *Lasianthus constrictus*, *Porterandia anisophyllea* and *Ixora finlaysoniana*. The values of the Shannon-Wiener's Diversity Index ( $H'$ ) and Simpson's Diversity Index (D) are 1.55 and 3.27, respectively. This indicates that *M. hirtus* is the most dominant species, encompassing 49% of all recorded Rubiaceae. Since it has many benefits such as food, timber, medicine, and the diversity of conservation value, this is vital as baseline data for researchers to propose solutions to the stakeholders and conservation sustainability of the Rubiaceae family as plant resources in Pulau Banding, Perak.

## 1 Introduction

The name Rubiaceae was first published by Antoine Laurent de Jussieu in 1789. Family Rubiaceae (order Gentianales) is also known as the coffee, madder, or bedstraw family. Rubiaceae include terrestrial trees, shrubs, herbs, and lianas that are easily identified by their simple, opposite leaves with interpetiolar stipules and actinomorphic sympetalous flowers.

Family Rubiaceae is one of the largest flowering plant families, with 620 genera and about 13,500 species recorded worldwide, mostly in tropical and warm areas [1]. Genera in Rubiaceae are mostly shrubs (*Gardenia*, *Ixora*, *Mussaenda*, *Hamelia*), trees (*Morinda*, *Adina*), and herbs (*Galium*, *Rubia*). They live in a range of habitat, from dry and desert-like conditions to moist tropical rainforests, and their altitude spans from low elevations in tropical rainforests and mangrove coastal vegetation to alpine altitudes above 4,000 m [2].

---

\* Corresponding author: [nazanis@umk.edu.my](mailto:nazanis@umk.edu.my)

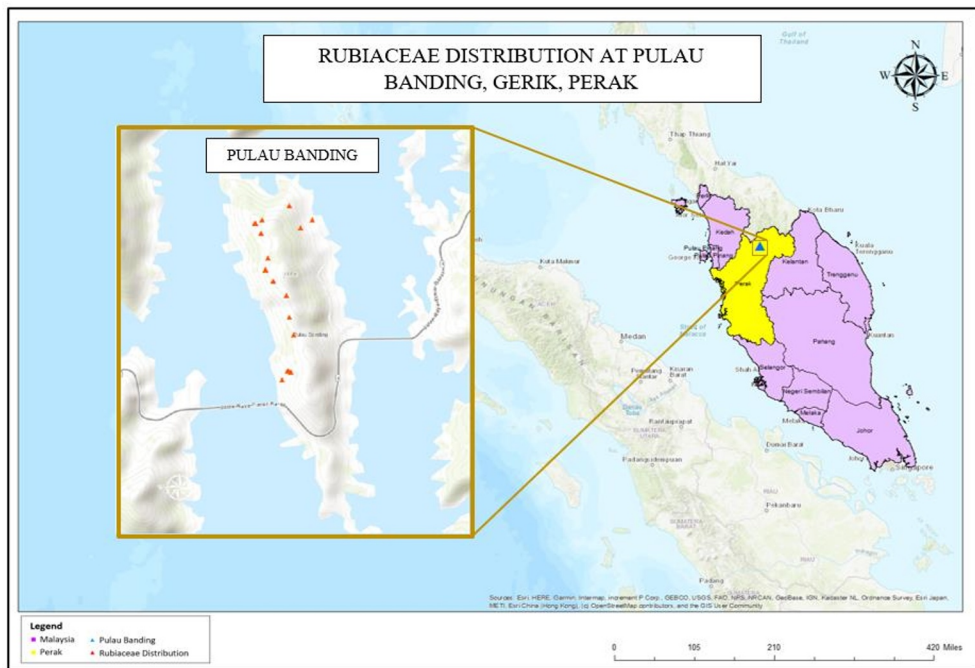
Rubiaceae are adaptable to a wide variety of environmental circumstances such as types of soil, elevations, and structures of the community [3].

The leaves are simple, undivided, and entire, opposite or decussate, rarely whorled (which is sometimes interpreted as opposite leaves with expanded stipules), or spiral by suppression, stipulate, opposite leaves' stipules connate, and frequently bear structures called collators that produce mucilaginous compounds that protect the young shoot. The seeds are usually endospermous but sometimes winged [4]. Fruit comes in a variety of forms, including berry, capsule, drupe, or schizocarp, and is frequently red [5]. Thus, this study aims to identify the species and estimate the diversity of the Rubiaceae in Pulau Banding, Perak.

## 2 Methodology

### 2.1 Study area

The study area is located in Pulau Banding (5.5500° N, 101.3333° E) (Figure 1), a 243-hectare inland forest encircled by the Temengor Lake in Gerik, Perak. The area remains warm and humid throughout the year with temperatures ranging between 23°C and 32°C and the average annual rainfall is 2205 mm. It is one of the oldest tropical rainforests in the world and it is believed exist from 130 million years ago. It is also one of the largest virgin forest reserves in Malaysia [6]. More than two decades ago before Banding or even Temengor Lake ever existed, many rivers from the mountain ranges flowed into the Temengor's lowlands and gorges, creating a vast catchment area. This area was a source of water supply to the neighbouring villages and indigenous people's (Orang Asal) settlements nearby.



**Fig. 1.** The study area at Pulau Banding, Perak

## 2.2 Sampling Method

The method used in this study is a random sampling technique along a trail in the Pulau Banding, Perak which is used for estimating the diversity and abundance of species. The Shannon-Wiener's Diversity Index ( $H'$ ), Simpson's Diversity Index (D), and relative abundance index were used in this study to determine the species and diversity of the Rubiaceae in Pulau Banding. The specimen was collected randomly as well as an observation of individuals along a trail to collect each detected Rubiaceae [7]. A total of 20 sites along 6 km trail, were marked for data collection. For every encounter of Rubiaceae species, a quadrat with of  $10 \times 10$  m,  $5 \times 5$  m and  $1 \times 1$  m was set up either for tree, shrub, or herb type, respectively. The information that was recorded such as species count in each quadrat, the altitude, latitude, and longitude.

## 2.3 Data Collection

The data collection was conducted within four consecutive days along 6 km trail of Pulau Banding's forest starting from the UMK Tropical Rainforest Research Centre (UMK-TRaCe). Important information such as the habitat, life forms, morphological characteristics such as leaves, flowers, fruits, and stems number of individuals of each species were also recorded. Photographs of each Rubiaceae species were also taken as digital information for further species identification. The geographical parameters such as longitude, latitude and elevation were recorded using a handheld Global Positioning System (GPS) Garmin eTrex® 20.

## 2.4 Specimen Identification

All collected specimens were identified using the book Arboretum Trees of Pasoh Forest Reserve [8] and Koleksi Pokok Taman Botani Kepong [9] either in-situ or ex-situ. The species was identified up to the species level based on their morphological characteristics such as leaves, flowers, fruits and stems. For the specimen voucher preparation, two samples of each species were collected and were deposited in the herbarium of Faculty of Earth Sciences.

## 2.5 Data Analysis

### 2.5.1 Shannon-Wiener's Diversity Index ( $H'$ )

The Shannon-Wiener's Index is a measure derived from Claude E. Shannon and Norbert Wiener's information theory [10] as shown in Equation 1. The index is used to estimate species diversity. The index takes into account the number of species living in a habitat (richness) and their relative abundance (evenness).

$$H' = - \sum_{i=1}^S (p_i \ln p_i) \quad (1)$$

$H'$  = Shannon diversity index

$p_i$  = Proportion of individuals of species in a whole species

$p_i = n / N$

Where:

n = Individuals of a given type/species

N = Total number of individuals in a community

∑ = Sum symbol

Log/ln = Usually the natural logarithm, but the base of the logarithm is arbitrary (10 and 2 based logarithms are also used).

### 2.5.2 Simpson's Diversity Index (D)

Simpson's Index is a measure of diversity that takes both the total number of species and their relative abundance into account [11]. The number of plant species as well as the number of individuals of each species, should be recorded, as well as whether or not they can be identified from one another. The Simpson's Diversity Index formula is shown below:

$$D = 1 / \left( \frac{\sum n(n-1)}{N(N-1)} \right) \quad (2)$$

### 2.5.3 Relative Abundance Index

A measure of how frequent or rare a species is in relation to other species in a specific area or community, the relative species abundance index is one of the components of biodiversity. The relative abundance value is expressed in the percentage form of an organism of a particular kind relative to the total number of organisms in the study area. [12].

$$\text{Relative Abundance} = \frac{\text{Number of individuals}}{\text{Total number of individual}} \times 100 \quad (3)$$

## 3 Results and Discussion

### 3.1 Checklist of Rubiaceae Species in Pulau Banding, Perak

A total of 139 individuals from nine species of Rubiaceae family were recorded from Pulau Banding, Perak. The nine species of Rubiaceae found in this study are *Mitracarpus hirtus*, *Gardenia carinata*, *Aidia densiflora*, *Hypobathrum hirtum*, *Coffea arabica*, *Psychotria marginata*, *Lasianthus constrictus*, *Porterandia anisophyllea* and *Ixora finlaysoniana*. Table 1 shows the checklist of the family Rubiaceae recorded in Pulau Banding, Perak. The status of each species was referred to the latest IUCN Red List categories [13].

**Table 1.** List of species of Rubiaceae family recorded in Pulau Banding, Perak.

No	Species	Common Name	No. of Individuals (n)	Relative Abundance (%)	IUCN Red List
1	<i>Aidia densiflora</i> (Wall.) Masam.	Menterbang	4	2.88	Not Evaluated (NE)
2	<i>Coffea arabica</i> L.	Arabic coffee	6	4.32	Endangered (EN)
3	<i>Gardenia carinata</i> Wall. ex Roxb.	Cempaka Hutan	32	23.02	Data Deficient (DD)
4	<i>Hypobathrum hirtum</i> (Ridl.) Mulyan. & Ridsdale	Kopi Hutan	9	6.47	Not Available (NA)
5	<i>Ixora finlaysoniana</i> Wall. ex G.Don	-	9	6.47	Not Evaluated (NE)

6	<i>Lasianthus constrictus</i> Wight	-	1	0.72	Not Available (NA)
7	<i>Mitracarpus hirtus</i> (L.) DC.	Tropical Girdlepod	68	48.92	Not Available (NA)
8	<i>Porterandia anisophylla</i> (Jack ex Roxb.) Ridl.	Tinjau Belukar	5	3.60	Not Available (NA)
9	<i>Psychotria marginata</i> Sw.	-	5	3.60	Not Available (NA)
<b>Total individuals</b>		-	139	-	-
<b>Total species</b>		-	9	-	-

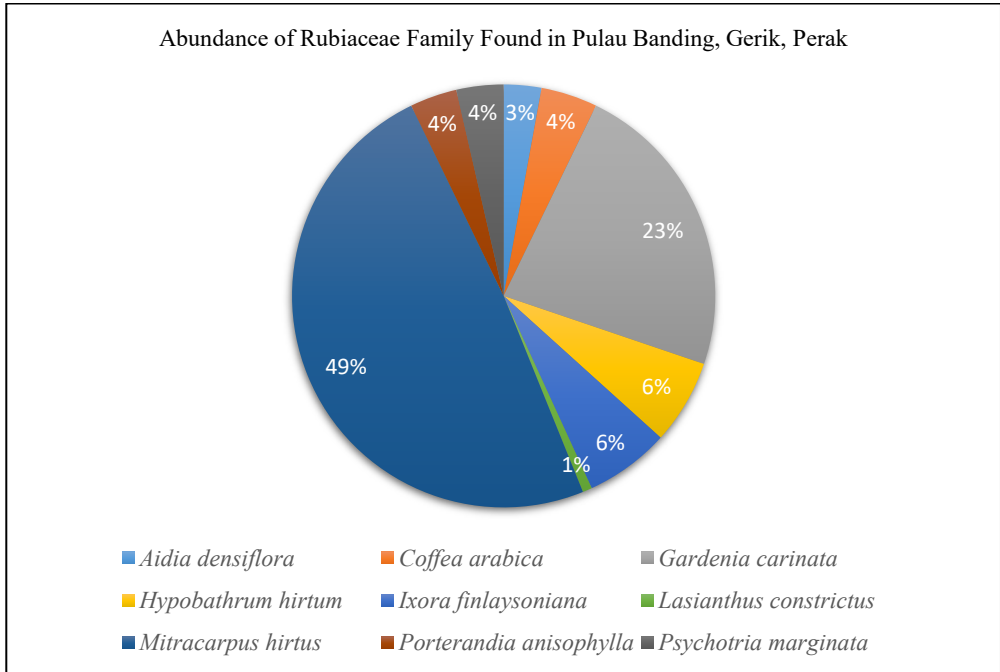
### 3.2 Diversity Indices and Species Abundance

From the result, the Shannon-Wiener's Index ( $H'$ ) for a community of nine species with 139 individuals is 1.55 (Table 2). The  $H'$  value is 1.55 which indicates the species diversity recorded along the trail is considered low because refers to the range between 1.5 to 3.5, although in certain extraordinary cases, it can exceed 4.5 and above [14]. This result indicated that the species *A. densiflora*, *C. arabica*, *G. carinata*, *H. hirtum*, *I. finlaysoniana*, *L. constrictus*, *M. hirtus*, *Porterandia anisophyllea* and *Psychotria marginata* are low in term of diversity. In addition, the value of Simpson's Diversity Index ( $D$ ) is estimated at 3.27. There are two conditions based on the Shannon Diversity Index ( $H'$ ) a low value means the domination of a few species but a high value means a large number of species with similar abundances [15].

The most abundant species of Rubiaceae is *M. hirtus* with 68 individuals (49%) counted, followed by *G. carinata* with 32 individuals (23%). The less abundant species is *L. constrictus* with only 1% or one individual as represented in Figure 2.

**Table 2.** The calculation of Shannon's diversity ( $H'$ ) and Simpson's Diversity ( $D$ ) indices based on nine species of Rubiaceae.

Species	No. of Individuals ( $n$ )	$p_i$	$p_i^2$	$\ln p_i$	$p_i * \ln p_i$
<i>Aidia densiflora</i>	4	0.0288	0.0008	-3.5482	-0.1021
<i>Coffea arabica</i>	6	0.0432	0.0019	-3.1427	-0.1357
<i>Gardenia carinata</i>	32	0.2302	0.0530	-1.4687	-0.3381
<i>Hypobathrum hirtum</i>	9	0.0647	0.0042	-2.7372	-0.1772
<i>Ixora finlaysoniana</i>	9	0.0647	0.0042	-2.7372	-0.1772
<i>Lasianthus constrictus</i>	1	0.0072	0.0001	-4.9345	-0.0355
<i>Mitracarpus hirtus</i>	68	0.4892	0.2393	-0.7150	-0.3498
<i>Porterandia anisophyllea</i>	5	0.0360	0.0013	-3.3250	-0.1196
<i>Psychotria marginata</i>	5	0.0360	0.0013	-3.3250	-0.1196
<b>Total</b>	<b>139</b>	<b>1</b>	<b>0.3060</b>	<b>-</b>	<b>-1.5548</b>
<b>Total species</b>	<b>9</b>	<b>-</b>	<b>-</b>	<b>H'</b>	<b>1.5548</b>
				<b>D</b>	<b>3.2675</b>



**Fig. 2.** The pie chart shows family Rubiaceae abundance captured in sampling locations.

### 3.3 Distribution Pattern of Rubiaceae

#### 3.3.1 Ecology Pulau Banding

According to Figure 3, the distribution of nine species of Rubiaceae was recorded along the trail. The distribution pattern of the Rubiaceae may have a random distribution because it was dispersed randomly with no predictable pattern. Random sampling was chosen to collect the species occurrences that were found along the trail at Pulau Banding. The elevation was recorded where the Rubiaceae were found at the range between 260 m to 414 m above sea level.



**Fig. 3.** The distribution of Rubiaceae family found along the trail at Pulau Banding, Perak.

### 3.3.2 Anthropogenic Activities

Another factor that can influence sampling results is the presence of anthropogenic activities. Anthropogenic activities in Pulau Banding, which is near to tourist areas and developed areas lead to the damage of the island's landscape due to the creation and development of man-made structures. Even though Royal Belum has been established as an ecotourism spot in Malaysia, it is a tourist area and at the same time it is still conserving the ecosystem, however, when this attracts many tourists to visit the area the tourism activities will increase significantly. This can destroy the local diversity since the sampling area is a part of a tourist hiking trail. Hiking activities can cause damage to the local flora since there will be a high amount of anthropogenic activity, such as people going in and out of the trail. Thus, this factor could be the reason for the small amount of Rubiaceae specimens that were sampled.

## 4 Conclusions

As a conclusion, a total of 139 individuals from nine species of Rubiaceae were collected in Pulau Banding, Perak. *Mitracarpus hirtus* (tropical girdlepod) is the most abundant species with 68 individuals (49%). It was followed by *G. carinata* (cempaka hutan) with 32 individuals (23%). The less abundant species is *L. constrictus* with 1% or one individual. An education trail can be planned to conserve the existing Rubiaceae family. The distribution pattern of nine species of Rubiaceae is identified as random and not uniform along 6 km trail. The species distribution of Rubiaceae is low in diversity however, this study area contains Rubiaceae family that are benefit such compartment of Pulau Banding might be one of the attractions for tourists because this is a small island compared to Royal Belum Temengor.

We would like to express our thanks to Tropical Rainforest Research Centre (UMK-TRaCE), Universiti Malaysia Kelantan for providing hostel and facilities during conducting this study. Thank you to the Faculty of Earth Science for laboratory assistance (Mohammed Firdaus bin Mohd Ridzuan) analysis and for preparing the herbarium specimen vouchers.

## References

1. P.F. Stevens, Angiosperm phylogeny version 14. <http://www.mobot.org/MOBOT/research/APweb/> (2017)
2. S.D. Karou, T. Tchacondo, D.P. Ilboudo, J. Simpo, *J. Biol. Sci.* **14**(3): 149-169 (2011)
3. P. Aaron, R.G. Davis, M. Diane, M. Bridson, M. Ruhsam Justin, N.A. Brummitt, *Ann. Missouri Bot. Gard.* **96**(1): 68-78 (2009)
4. G.S Michael, *Plant Systematics* (Academic Press, 2010)
5. E. Sturla, The Rubiaceae; or coffee madder or bedstraw family. Southwest Desert Flora. [https://southwestdesertflora.com/WebsiteFolders/Family\\_Species/Rubiaceae\\_Species](https://southwestdesertflora.com/WebsiteFolders/Family_Species/Rubiaceae_Species) (2011)
6. K.D. Kanniah, K.P. Tan, A.P. Cracknell, A.R. Huete, N.H. Idris, A.M.S. Lau, A. Ahmad, *Singap. J. Trop. Geogr.* **39**(1) 90-109 (2018)
7. R. Glennie, S.T. Buckland, L. Thomas, *PloS One* **10**(3) (2015)
8. C.L. Joann, M.Y. Ahmad Shahar, A.A. Aminudin, M.N. Mohammad Rozaimi, H.C. Abu Husin, C. Fletcher, A.G. Zhafri, (Forest Research Institute Malaysia, Kepong 2021)
9. M. Adnan, Z. Ahmad Firdaus, H. Muhammad Ammar, M. Moorthy, Koleksi pokok taman botani kepong. *FRIM Special Publication* **5**(20): 23-234 (2018)
10. C. Shannon, *Bell Syst. Tech. J.* **27**, 379–423 (1948)
11. E.H. Simpson, *Nature* **163**, 688 (1949)
12. S.P. Hubbell, *The unified neutral theory of biodiversity and biogeography* (Princeton University Press, Princeton 2001)
13. The IUCN Red List of Threatened Species ©2022 [cited 2023 October 1]. <https://www.iucnredlist.org/>
14. A.E. Magurran, *Ecological diversity and its measurement* (Princeton University Press, 1988)
15. I. Saiful, A. Latiff, *J. Trop. For. Sci.* **26**(2) 188–202 (2014)