



Diversity and Distribution of Family Arecaceae at the  
Gunung Stong State Park (GSSP), Kelantan

by

**NUR IZATI BINTI BAHAROM**

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## DECLARATION

I declare that the thesis entitled “Diversity and Distribution of Family Areaceae at Gunung Stong State Park (GSSP), Kelantan” is the result of my own research except as stated in the references. The thesis is not accepted for any degree and is not concurrently submitted in candidature for any other degree.

Signature : .....  .....

Name : NUR IZATI BINTI BAHAROM

Date : 7 AUGUST 2024

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## **Diversity and Distribution of Family Arecaceae at Gunung Stong State Park, Dabong, Kelantan**

### **ABSTRACT**

The study was conducted in Gunung Stong State Park, Dabong Kelantan. The objectives are to determine the diversity of Arecaceae family at Gunung Stong State Park (GSSP) and to map the distribution of Arecaceae at GSSP. The results shows that a total of 69 individuals from the family Arecaceae were collected along the nature trails from the elevation 100 to 1900 m above sea level. From a total of 69 individuals, 13 species and 11 genera were successfully identified. The diversity value of Arecaceae is 2.316 by using the Shannon Wiener Index and 0.2891 by using Simpson Index value. These values show that the diverse data the Shannon-Wiener Index value is higher because it accounts more for species richness and evenness, giving more weight to rare species. The Simpson Index value is lower because it emphasizes the dominance of common species. This information will be useful a baseline data in managing Gunung Stong State Park, Dabong, Kelantan. This finding shows that it is important to conserve valuable trees of the Arecaceae family for future sustainability.

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## **Kepelbagaian dan Taburan Famili Arecaceae di Taman Negeri Gunung Stong, Dabong, Kelantan**

### **ABSTRAK**

Kajian dijalankan di Taman Negeri Gunung Stong, Dabong Kelantan. Objektifnya adalah untuk menentukan kepelbagaian keluarga Arecaceae di Taman Negeri Gunung Stong (GSSP) dan untuk memetakan taburan Arecaceae di GSSP. Daripada keputusan tersebut, ia menunjukkan bahawa sejumlah 69 individu daripada keluarga Arecaceae telah dikumpul di sepanjang denai alam semula jadi dari ketinggian 100 hingga 1900 m dari aras laut. Daripada sejumlah 69 individu, 13 spesies dan 11 genera berjaya dikenalpasti. Nilai kepelbagaian Arecaceae ialah 2.316 dengan menggunakan Indeks Shannon Wiener dan 0.2891 dengan menggunakan nilai Indeks Simpson. Nilai-nilai ini menunjukkan bahawa data pelbagai nilai Indeks Shannon-Wiener adalah lebih tinggi kerana ia lebih menyumbang kepada kekayaan dan kesamarataan spesies, memberikan lebih berat kepada spesies yang jarang ditemui. Nilai Indeks Simpson adalah lebih rendah kerana ia menekankan penguasaan spesies biasa. Maklumat ini berguna sebagai data asas dalam pengurusan di Taman Negeri Gunung Stong, Dabong, Kelantan. Dapatan ini menunjukkan bahawa adalah penting untuk memulihara pokok-pokok berharga keluarga Arecaceae untuk kelestarian masa hadapan.

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## TABLE OF CONTENT

	<b>PAGES</b>
<b>DECLARATION</b>	<b>i</b>
<b>ACKNOWLEDGEMENT</b>	<b>ii</b>
<b>ABSTRACT</b>	<b>iii</b>
<b>ABSTRAK</b>	<b>iv</b>
<b>TABLE OF CONTENTS</b>	<b>v</b>
<b>LIST OF TABLES</b>	<b>vii</b>
<b>LIST OF FIGURES</b>	<b>viii</b>
<b>LIST OF ABBREVIATION</b>	<b>ix</b>
<b>LIST OF SYMBOLS</b>	<b>x</b>
<b>CHAPTER 1 INTRODUCTION</b>	
1.1 Background of Study	1
1.2 Problem Statement	2
1.3 Objective	5
1.4 Scope of Study	4
1.5 Significant of Study	5
<b>CHAPTER 2 LITERATURE REVIEW</b>	
2.1 The Tropical Rainforest in Malaysia	6
2.2 Type of distribution	8
2.3 Habitat and Ecology Species	9
2.4 Morphology of the genus Arecaceae	9
2.5 The Diversity of Arecaceae Family in Malaysia	13
2.6 Economic Value Uses of Arecaceae	15
2.7 Importance to Ecosystem	15
<b>CHAPTER 3 MATERIAL AND METHOD</b>	
3.1 Study Area	16
3.2 Material	16
3.3 Method	18
3.3.1 Sampling method	18
3.3.2 Identification species	18

3.3.3 Data collection	19
3.4 Data Analysis	19
3.4.1 Simpson Index	19
3.4.2 Shannon-Wiener Index	20
3.4.3 Evenness Index	21
3.5 Geographic Information System (GIS)	21
<b>CHAPTER 4: RESULTS AND DISCUSSIONS</b>	
4.1 Checklist of Family Arecaceae in Gunung Stong State Park	22 – 25
4.2 Species Diversity of Arecaceae	26 – 28
4.3 Distribution of Arecaceae	29
4.3.1 <i>Rhopaloblaste singaporensis</i>	30 - 31
4.3.2 <i>Calamus radicalis</i>	36
4.3.3 <i>Salacca zalacca</i>	37
4.3.4 <i>Licuala stongensis</i>	38 – 41
4.3.5 <i>Plectocomia elongate</i>	42
4.3.6 <i>Arenga engleri</i>	42
4.4 Summarize type of distribution	46
<b>CHAPTER 5: CONCLUSION AND RECOMMENDATION</b>	44
<b>REFERENCES</b>	45 – 48

**LIST OF TABLES**

<b>No.</b>	<b>TITLE</b>	<b>PAGES</b>
2.1	Type of Licuala species leaves	11
3.1	The material with their function.	17
4.1	The list of the family Arecaceae recorded at Gunung Stong State Park. Dabong, Kelantan	22
4.2	The calculation of Shannon's diversity ( $H'$ ) and Simpson's Diversity ( $D$ ) indices based on 13 species of Arecaceae	26
4.3	The diameter of leaf, height and elevation of <i>Licuala stongensis</i> at Gunung Stong State Park, Dabong, Kelantan	42
4.4	The summary type of the distribution	46

## LIST OF FIGURES

No.	TITLE	PAGES
2.1	The layer (strata) of Tropical Rain Forest	7
2.2	Type of <i>Licuala</i> species leaves	10
2.3	<i>Licuala</i> species in the forest	12
2.4	The fruit of <i>Licuala grandis</i> species (Source: National Park: Flora and Fauna Web)	13
3.1	The location of Gunung Stong State Park, Kelantan	17
4.1	The distribution of Family Arecaceae recorded on the study site.	29
4.2	<i>Rhopaloblaste singaporensis</i> in Gunung Stong State Park	31
4.3	<i>Pinanga pantiensis</i> leaf	33
4.4	<i>Pinanga simplicifrons</i>	34
4.5	<i>Daemonorops angustifolia</i>	35

## LIST OF ABBREVIATIONS

EN	Endangered
EX	Extinct
GPS	Global Positioning System
GIS	Geographical Information System
Cm	Centimeter
M	Meter
NE	Not Evaluated
LC	Least Concern
DD	Data Deficient
ND	Not Defined

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**LIST OF SYMBOLS**

$\Sigma$	Total
( )	Parentheses
%	Percentage
$\div$	Division
$\times$	Multiply
+	Addition



# CHAPTER 1

## INTRODUCTION

### 1.1 Background of Study

Gunung Stong State Park is located in Kelantan, Malaysia, is a vital biodiversity hotspot renowned for its rich and varied ecosystems (Saw et al., 2005). The park encompasses a range of habitats from lowland dipterocarp forests to montane and riverine areas, each supporting a unique array of plant and animal life. The ecological significance that the Arecaceae family, or palms, perform in this varied ecosystem is significant. Palms are integral to forest structure, soil stabilization, and nutrient cycling, and they provide essential resources and habitats for numerous wildlife species (Dransfield et al., 2008). Within the Arecales order, the Arecaceae family is monotypic. The family includes several indoor and ornamental species, as well as numerous commercially important species like date palms, coconuts, and area nuts. Handles are widely grown and well-known in the world of horticulture.

The distribution of Arecaceae in the tropical forest has been described by many authors (Uhl & Dransfeld, 1987). For example, the diverse plant of Arecaceae family found at Teluk Bahang Permanent Forest Reserve, Penang with the total number of individuals is 551 individuals' species. Studies have shown that one of the species from the Arecaceae family is the endemic species found at the Gunung Stong State Park (GSSP). A report from the Forestry Department of Peninsular Malaysia shows that one endemic species of *Licuala* was recorded in Gunung Stong State Park (GSSP). This species is *Licuala stongensis*. *L. stongensis* was considered as a unique

plant species with peltate leaves and has great potential to be commercialized as an ornamental plant.

Globally, there are 40.7% of the total species found the habitat are in the forest. Overview based on the IUCN Red List, the species of Famili Arecacecae recorded and have been listing shown the population trend for every species of Arecaceae Family. For example, *Licuala telifera* is listed as the least concern shown as stable for population trend. Slender, undergrowth palms that cluster together were mostly found in primary lowland to lower montane forests, sometimes in swamp forests and, less frequently, in transitional moist/heath forests. on soils that are mostly alluvium, occasionally volcanic (IUCN Red List, 2022).

This study to aims, carry out an extensive study of the Arecaceae family within GSSP, recording all species found there. Through the calculation of diversity indices, including the Simpson and Shannon-Wiener indices, the research will measure the evenness and richness of the species, offering a comprehensive evaluation of the Arecaceae community structure. This will draw attention to the ecological relevance of the palms in the park and improve our understanding of their biodiversity. This study also focuses on creating detailed spatial maps showing the distribution patterns of Arecaceae species across various habitats within GSSP, such as lowland forests, montane forests, and riverine areas.

## 1.2 Problem Statement

A significant hotspot for biodiversity, Gunung Stong State Park (GSSP) in Kelantan, Malaysia, is host to a range of ecosystems, from highland areas to lowland dipterocarp forests. Although its ecological importance, insufficient is known about the biodiversity and geographic distribution of plant groups in the park, especially the *Arecaceae* family (Dransfield et al., 2008). The *Arecaceae* family of palms (*Arecaceae*) is essential to the ecosystem because it stabilizes soil, supports a variety of wildlife species, and contributes to the structure of forests. Effective conservation and management efforts are limited, therefore, by an absence of thorough investigations on the diversity and distribution of *Arecaceae* species in GSSP (Henderson, 2002).

Family *Arecaceae* was often overlooked in previous botanical surveys conducted in the area, leaving an incomplete picture of the park's biodiversity (Saw et al., 2005). It is difficult to create plans for managing and protecting these important species and their ecosystems in the absence of thorough data on the species richness and geographic distribution of palms. Furthermore, forecasting how these species would react to environmental changes requires an understanding of the variables influencing *Arecaceae* distribution, such as altitude, soil type, and moisture content (Balslev et al., 2011).

By methodically identifying the species richness of the *Arecaceae* family in Gunung Stong State Park and mapping their distribution across the park's many habitats, this study seeks to close this information gap. The ecological dynamics of *Arecaceae* in GSSP will be better understood through the analysis of diversity indices

and spatial distribution patterns, which will aid in the creation of well-informed conservation plans to protect the park's abundant biodiversity.

### **1.3 Objectives**

The study is carried out to achieve the following objectives:

1. To identify the species diversity of Family Arecaceae species in Gunung Stong State Park (GSSP).
2. To determine the distribution of Family Arecaceae in Gunung Stong State Park.

### **1.4 Scope of Study**

This study is conducted to determine the diversity and distribution of Family Arecaceae in Gunung Stong State Park (GSSP). The location of study is GSSP, Kuala Krai, Kelantan. The method used in this study to determine the diversity of Arecaceae is systematic sampling. Add duration of field survey, date, method for mapping and software used Geographical Information Systematic (GIS).

### **1.5 Significant of Study**

The study provides important insights into the biodiversity of Gunung Stong State Park (GSSP), and contributes to conservation efforts aimed at preserving unique plant species from the Arecaceae family. Understanding the diversity and distribution of Arecaceae contributes to wider ecological knowledge. This insight into the ecological preferences of palm trees can improve our understanding of plant-environment interactions and ecosystem dynamics in the GSSP. This research contributes to a broader scientific understanding of oil palm ecology and biodiversity. Findings from this study can be used as a reference for future research and can be integrated into the global body of knowledge on plant diversity.

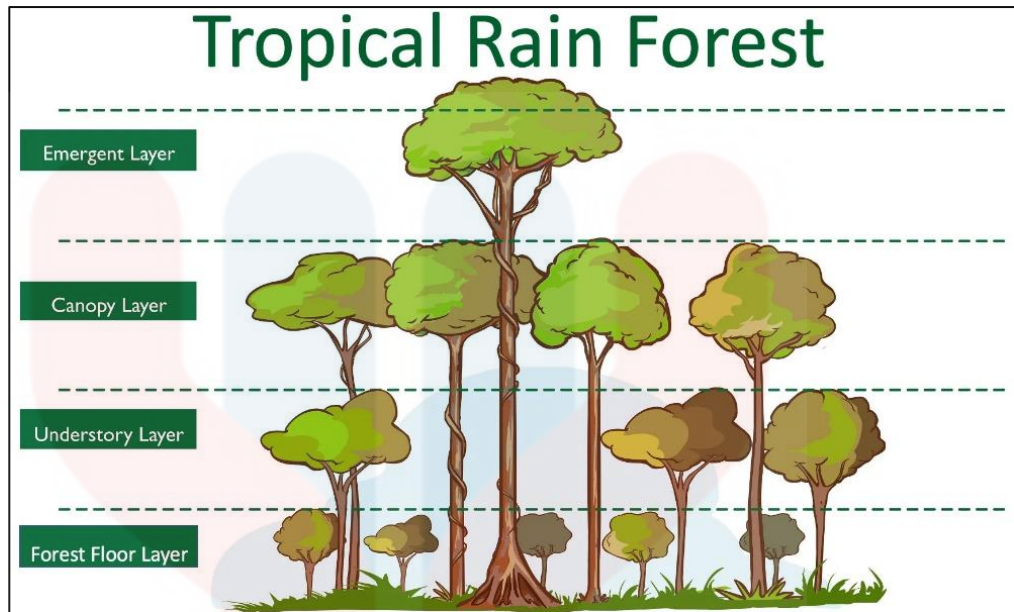
## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 The Tropical Rainforest in Malaysia

The globe and future generations will benefit from the preservation of tropical rainforests, which are a national treasure and legacy. Since only 12 nations worldwide have tropical rainforests, which serve as a place of safety for rare species of biodiversity, this forest is well-maintained and protected (Rasid et al.,2006). Tropical rainforests are also classified as a form of tropical wet forest or tropical moist broadleaf forest by the World Wildlife Fund (WWF, 2007). They are also known as lowland equatorial evergreen rainforests.

Furthermore, two-thirds of all plant and animal species on the globe are found in tropical rainforests. The forest canopy, which is home to distinct flora and animals not found in the lower layers of the forest, accounts for more than 70% of all forest biological information (Nyandwi, 2008). Therefore, the layers of the tropical rainforest have 4 layers that start from the bottom, namely the forest floor layer, understory layer, canopy layer and emergent layer (Figure 2.1). Depending on the species, each layer varies in height and life expectancy.



**Figure 2.1:** The layer (strata) of Tropical Rain Forest

Sixty-one percent of Malaysia's land area, or roughly 33.03 million hectares, is covered by forests. Malaysia is one of the twelve nations with a mega-diversity area rich in a wide range of species and ecosystems. Accordingly, Malaysia's forests are classified as extremely complex, with a high diversity of flora and natural resources (Rasid et al.,2006). Thus, Gunung Stong State Park (GSSP) is among the areas with a rich diversity of flora and fauna (Forestry Department Peninsular Malaysia, 2016). As demonstrated by the research study, which shown numerous species of endemic plants and animals in this study region, including *Licuala stongensis*.

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### **2.3 Type of Distribution**

Three types of sampling procedures—stratified, cluster, and random sampling are dedicated to determining the distribution during the sampling process. The research explains the way that distribution is used in the sampling process. Random sampling is a sampling process that involves taking a random sample unit from the population, recording its y-value, and then reintroducing it to the population. This procedure chooses units at random and returns them after N units (Dolawar Hossan et al., 2023).

Meanwhile, cluster sampling refers to a representative sample of a big group that the researcher has divided into smaller groups that can be obtained by cluster sampling. When a very large sample size and population number are necessary, researchers employ cluster sampling (Dolawar Hossan et al., 2023). For the stratified sampling. This type of sampling separates the population according to a characteristic (e.g., age, gender, income level) into subgroups or strata (Dolawar Hossan et al., 2023).

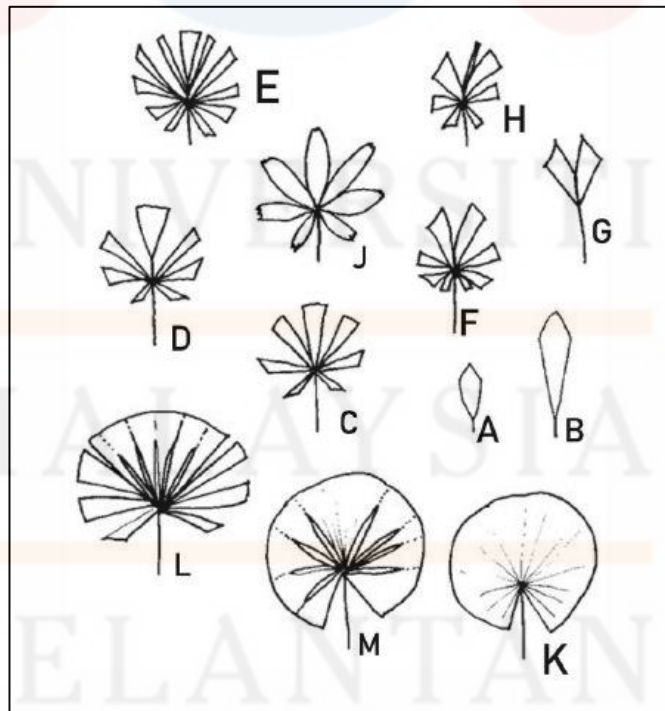
### **2.4 Habitat and Ecology**

Based on the IUCN Red List of Threatened Species recorded shows that there are 695 Family Arecaceae that have a habitat in the forest. Over two thirds of palm species are found in tropical forests, where some reach heights sufficient to comprise the canopy, while other, smaller species are found in the understory (Liubov, 2022). Some species create pure stands in regions that frequently flood or have inadequate drainage. Other types of palms can be found on tropical highlands rising above 1,000 meters. They can also be found in desert oases, grasslands, and scrublands with

standing water. Certain palms have evolved to thrive in very basic lime soils, whereas other palms have evolved to thrive in very acidic soils (Liubov, 2022).

## 2.5 Morphology of genus *Areceaceae*

Every plant has a morphology that progresses from the base to the top. For the *Areceaceae*, one of the genera is *Licuala*, *Licuala* has different types of stem that are said to have different habits, such as stalking and being solitary, stalking and being clustered with one to several dominant shoots, stalking and being clustered with subequal erect shoots, stalking and being clustered with equal decumbent shoots, and succulent and solitary besides succulent clustered (Saw et al., 2003). In addition, the leaf of the genus *Licuala* has the length of the petiole varies. It can be less than 10 cm long in very small species, once petioles in bigger species can grow to be longer than 3 m. (Saw et al., 2003). Thus, there are 12 types of leaves shown in Figure 2.2 and Table 2.1 shows the leaf types of *Licuala* species.



**Figure 2.2:** Leaf type of *Licuala* (Source: Saw, 2003)

**Table 2.1:** Leaf type of *Licuala*

Symbol	Type of <i>Licuala</i> species leaves
A	Eophyll
B	Juvenile adult type or neoteny (juvenile leaves are retained in adult plants)
C	The segmented leaf is kind of an adult.
D	A mid-segment petiolulate segment of the segmented type
E	Pinnate mid-segment in a segmented kind
F	Segmented structure including a divided mid-section
G	Segmented type with bifid mid-segment with loss of lateral segment
H	Segmented with a bifid mid-segment and an additional split
I	sections with lateral curves
J	Entire
K	Fronds with windows punctured in the mid-segment
I	entire leaf having windows.

(Source: Lee Guan Saw, 2003)

Furthermore, the *Licuala*'s inflorescences show relatively straightforward architecture, much like those of the other *Coryphoid* palms (Uhl and Dransfield 1987). The length varies; in tiny species, the inflorescence may not be longer than 15 cm, while in giant species, it may exceed 3 m. The inflorescence is interfoliar, with two branches growing from the main stem (Saw, 2003). In addition, many flowers in the monocotyledon family are like palm flowers in that they share a fundamental trimerous structure. It is believed that regular, perfect, female blooms with three distinct carpels each represent the progenitor circumstances (Tomlinson, 1990). However, not all flowers of *Licuala* have a perfect structure, some plants in West Java only produce female flowers; that is, they have gynoecium, and anthers absent from staminodes (Saw, 2003).



**Figure 2.3:** The *Licuala* species in the forest

The fruit's or exocarp's surface is usually smooth, though it occasionally has a sheen. When ripe, the mesocarp is often fatty rather than fibrous. Fruits from *Licuala* plants are typically tiny, drupaceous, round, or ovoid, and very rarely ellipsoid. There are very few known species that have long, spheroid fruits, such as *L. kiahii* Furtado from *L. mattanensis* and Malaya Borneo-born Becc. Most immature fruits are green. *Licuala* species, while the young fruits of *L. ferruginea* and its relatives are vibrant pink (Saw, 2003). Meanwhile, when the ripe fruit of *L. grandis* (Figure 2.4) the green fruits turn scarlet, smooth and resembling marble and also carries a single seed.

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**Figure 2.4:** The fruit of *Licuala grandis* species (Source: National Park: Flora and Fauna Web)

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## 2.6 Diversity of Arecaceae Family in Malaysia

According to Muscarella et al, (2020), it is mentioned that the Family Arecaceae (palms) is represented by over 2500 species globally and has a variety of growth forms such as shrubs, lianas, and trees. Meanwhile, 46 species of *Licuala* found on the island of Borneo were recorded (Saw, 2012). According to the article Andrian Hock, 74 *Licuala glabra* Griff, Palmae herbarium specimens that were gathered from 22 locations around Peninsular Malaysia. That shows that almost 80% family of Arecaceae can be found in Malaysia. In Gunung Stong State Park also has the findings about the *Licuala*, based on records where *L.stongensis* and *L.speciosa* were found (Latif, 2004).

## 2.7 Economical Value of Family Arecaceae

According to research results from journals and articles, anatomical Arecaceae have special uses that can contribute to the economy. Therefore, there are a few uses of palm, used for food, medicine, household materials, furniture, and other purposes (Johnson, 1998). Many communities throughout the world have historically depended on plant species from the Family Arecaceae, which includes palms, as a source of income (Gruca et al., 2015).

According to Gruca et al., (2015), they are a reliable supply of medicines and raw materials for food and building areas. The seeds, fruits, and roots of this family are the anatomical parts that have been used in medicine. Therefore, the oily mesocarp of the fruit can be used in folkloric medicine in tropical Africa to promote malnutrition, aid in stomachic digestion, reduce body pains, and act as a laxative. In addition to uses in medicine, plant organs like leaves, stems, and flowers are significant sources of nutrients and non-nutritive substances that are used in the

treatment of a wide range of illnesses, including cancer, heart disease, and neurological disorders. (Ajao and Moteetee, 2017; Doughari, 2012).

Furthermore, Arecaceae is a family of trees that offers numerous advantages, including a source of daily nutrients and food sources. In this case, the locals boil the fruits of *R. hookeri* and consume them as snacks. This species' apical branch makes a tasty salad vegetable (Facciola, 2001). The primary output of this species is alcoholic palm wine, which is made from the white, colorless, and sugary sap that is tapped from plant stems just before flowers appear. To turn the collected rubber into alcohol, it is typically allowed to ferment for a few hours or days (Obahiagbon, 2009).

A few leaves from the family: Like *R. hookeri*, Arecaceae leaves can be used as household goods in daily life. *R. hookeri* leaflets are used to construct mats, piassavas, fishing gear, brooms, baskets, trays, and sieves (Obahiagbon, 2009; Adedeji and Aiyeloja, 2016). Leaflets are also used in rural regions to build beds and seats, roof mats for thatched buildings, and sheds for storing farm goods made of yam and corn (Adedeji and Aiyeloja, 2016). Additionally, in Nigeria, leaflets are typically worn as decorations during cultural dances (Adedeji and Aiyeloja, 2016).

## 2.8 Importance of Family Arecaceae to Ecosystem

Microfungi play a major part in the breakdown of organic matter and the recycling of nutrients for plant uptake, making them essential parts of our environment. Additionally, they are significant in other uses of human existence, such as medicine manufacturing, biocontrol agents, and manufacturing of industrial substances. Findings from the microfungus study: 43 species of microfungi were found on both kinds of leaves; of these, 31 species were found on living leaves and 18 species in litter. Out of the 25 and 12 species that were solely identified from live and litter leaves, respectively, only six species were common to both leaf types. (Adebola Lateef et.al., 2015)

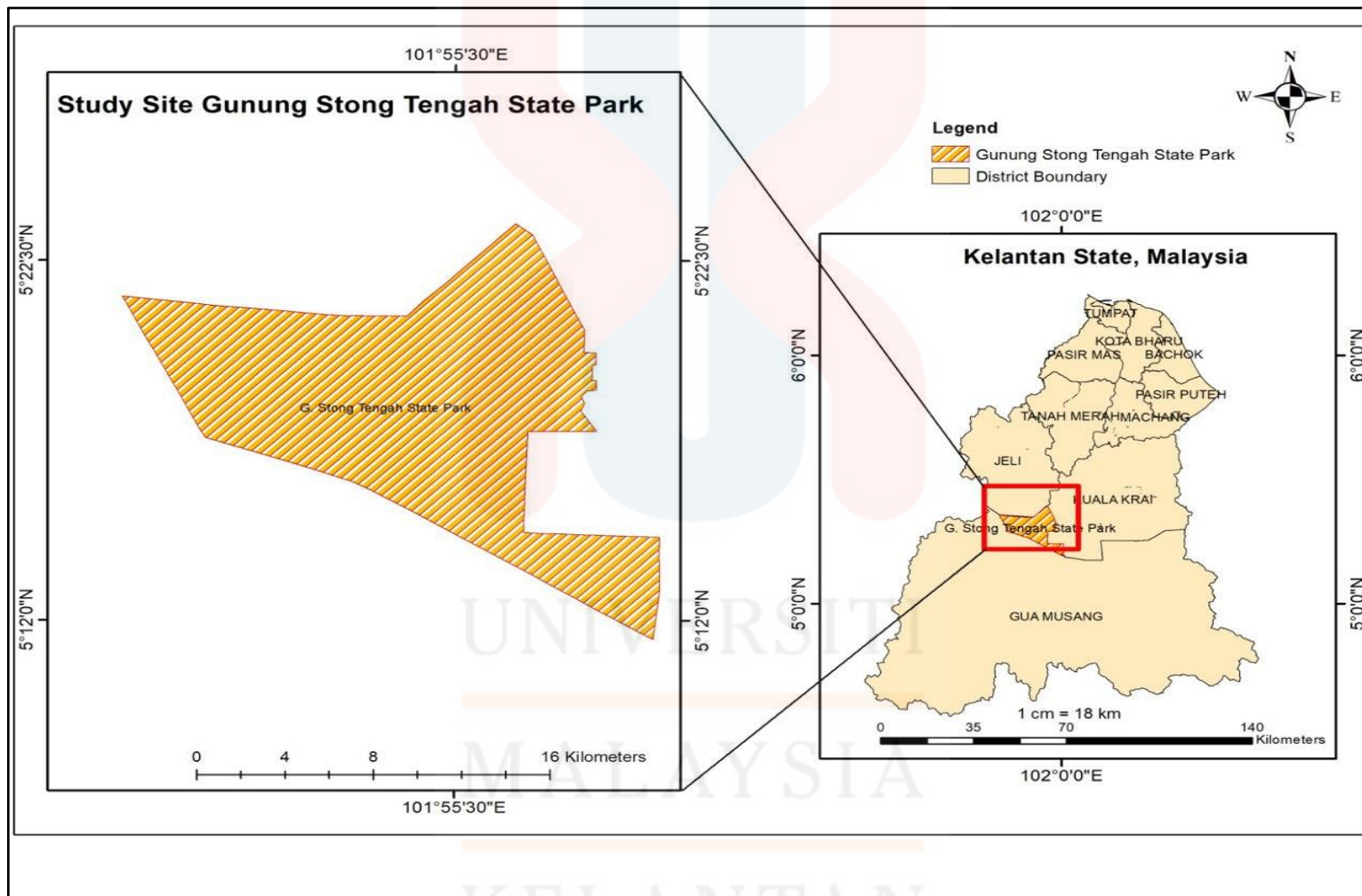
## CHAPTER 3

### MATERIAL AND METHODS

#### 3.1 Study Area

Gunung Strong State Park (GSSP) is in the district of Kuala Krai, Kelantan and being one of the ecotourism places in Malaysia as shown in Figure 3.1. GSSP was established on 31 March 2006. Gunung Stong is one of the highest mountains in Kelantan with a height of 1,442 meters. Gunung Stong provides an interesting and exciting forest full of natural treasures, and wildlife such as elephants. The study area is laying between latitude  $5.3364^{\circ}$  N, and longitude  $101.9378^{\circ}$  E. Universiti Malaysia Kelantan, Jeli Campus is 46 km away from Gunung Stong in Kuala Krai, Kelantan. On the other hand, Kota Bharu, the capital of Kelantan, is 149 km away from the place, and Gua Musang is 64 km away.

Gunung Stong was given the nickname Wildlife Life due to its suburban location surrounded by hills and other vegetation because Malaysia has constant heat and precipitation, it is thought that this research area is rich in plant diversity and dispersion (Henderson, 1954).



**Figure 3.1:** The location of study area Gunung Stong State Park, Kelantan

### 3.2 Material

The material used in this study is presented in Table 3.1 below:

**Table 3.1:** The material and their function.

Name	Function
1. Global Positioning System (GPS) receiver	A radio wave receiver used to provide coordinates that give the exact position of an element in a certain space (Gunung Stong State Park)
2. Flagging Tape	To indicate boundaries and landmarks that have been measured. And used as a place to mark tree species that have been identified.
3. Measuring Tape	To surveying to measure horizontal, vertical or slope distances for every distance when do mapping.
4. Camera Phone	To capture and will identify the species found using any app like planetNet.
5. Noted book and pen	To write and record the species found using the pen

### 3.3 Method

#### 3.3.1 Sampling Method

The method used involves identifying several tracks within the Gunung Stong State Park (GSSP) that cover different altitudes and habitat types. This sampling was marked along the trails. This ensures that the sampling captures the ecological diversity of the park. For example, a trek might include a trail leading to a waterfall, a peak or winding through a forest. By choosing diverse trails, it is possible to better understand how different environmental conditions affect the distribution of species. Sampling was done along the trail, starting from an elevation of 100 to 1900 m above sea level (a.s.l). Random sampling helps avoid over or under-represented areas, providing a more accurate picture of species distribution.

### **3.3.2 Species Identification**

The second technique is general identification, which involves looking for more information. A part of Gunung Stong that cannot be accessed by the quadrat to be made is one of the general methods. Because the elements of the area such as the height and flat area of Gunung Stong State Park are difficult to define, the tree species of the Arecaceae family have been captured and identified using the PlantNet and Google Lens applications. This method was created so that tree identification can be made. The identification of trees from the Arecaceae family is also done using methods from the analysis of research books such as Plant Systematics Second Edition (Michael, 2010)

### **3.3.3 Data Collection**

Every plant species that was encountered, including its local name, habitat type, ecology, and GPS coordinates, had been fully documented based on the sample approaches utilised. Then, the species found were marked according to pictures that symbolize the family Arecaceae found in the area. Key features such as distribution, and plant height as well had been recorded in the field book to facilitate the division of species diversity found. All identified species had been captured for identification.

### 3.5 Data Analysis

#### 3.5.1 Simpson Index

Simpson (1949) created the diversity index, a probability measure whereby a lower diversity indicates a higher likelihood of two randomly chosen individuals belonging to the same species. When there is only one species of diversity, there is a one in chance that two randomly chosen individuals will be same. The formula of the Simpson Index is shown below:

$$D = \sum_{i=1}^s \left(\frac{n_i}{N}\right)^2 \quad \text{Equation 3.1}$$

Where:

$n_i$  = the number of individuals in species  $i$ ,

$N$  = total number of individuals of all species

$n_i/N = p_i$  (proportion of individuals of species  $i$ )

$S$  = species richness

### 3.5.2 Shannon-Wiener Index

According to Spellerberg (1991), species diversity is a reflection or measure of a relationship between a small number of species and their individuality. The standard index used in ecological studies is the Shannon Diversity Index (Spellerberg & Fedor, 2003) as shown in Equation (3.1):

$$H = - \sum_{i=1}^s (P_i) \ln(P_i) \quad \text{Equation 3.2}$$

Where:

H' = Shannon Diversity Index

P<sub>i</sub> = The number of individuals of a species over the total number of individuals overall

S = Total number of species

ln = Natural logarithm

### 3.6 Geographic Information System (GIS)

An analysis and display system for data with a geographical reference is called a Geographic Information System (GIS) software ArcGIS. It makes use of information linked to a certain place. GIS was used in this study to create a distribution map. Therefore, this study uses a map method, the map is used to show the distribution of species where the value and location are known. So, based on the distribution map created, can see the distribution for every species listed in the study area, Gunung Stong State Park.

## CHAPTER 4

### RESULTS AND DISCUSSION

#### 4.1 Checklist of Family Arecaceae in Gunung Stong State Park

The result shows that from a total of 69 individuals collected, 13 species from the family of Arecaceae were identified in Gunung Stong State Park as tabulated in Table 4.1 below.

**Table 4.1:** List of the family Arecaceae recorded at GSSP, Kelantan

No.	Species (Family Arecaceae)	Common Name	Genera	No of Individual ( <i>n</i> )	IUCN Red List
1.	<i>Arenga engleri</i>	Formosa Palm	Arenga	4	Not Evaluated (NE)
2.	<i>Calamus radicalis</i>	Climbing Rattan	Calamus	1	Not Evaluated (NE)
3.	<i>Caryota Mitis</i>	Fishtail Palm	Caryota	2	Least Concern (LC)
4.	<i>Cocos nucifera</i>	Coconut Palm	Cocos	2	Data Deficient (DD)
5.	<i>Daemonorops augustifolia</i>	Lesser Rattan or Narrow-leaved Rattan	Daemonorops	5	Not Evaluated (NE)
6.	<i>Lavistona speciosa</i>	Western Fan Palm	Lavistona	3	Least Concern (LC)
7.	<i>Licuala stongensis</i>	Stong Licuala Palm (no widely recognized common)	Licuala	5	Not Evaluated (NE)

		<i>name, named)</i>			
8.	<i>Rhopalostylis sapida</i>	Nikau Palm	Rhopalostylis	2	Least Concern (LC)
9.	<i>Pinanga pantiensis</i>	Panti Pinanga Palm	Pinanga	10	Endangered (EN)
10.	<i>Pinanga simplicifrons</i>	Simplicifrons Palm or Pinanga Palm	Pinanga	9	Least Concern (LC)
11.	<i>Plectocomia elongata</i>	Rattan Palm or Rattan Cane	Plectocomia	5	Not Evaluated (NE)
12.	<i>Rhopoloblaste singaporensis</i>	Singapore Rhopaloblaste Palm	Rhopoloblaste	16	Critically Endangered (CE)
13.	<i>Salacca zalacca</i>	Salak or Snake Fruit Palm	Salacca	5	Not Evaluated (NE)
	<b>Total Individual</b>	-	<b>11</b>	<b>69</b>	-
	<b>Total species</b>	-		<b>13</b>	-

Based on Table 4.1 shows that, after the identification made, the species from Family Areaceae was counted. Based on the analysis, *Rhopoloblaste singaporensis*, *R. singaporensis* have the highest total number of individuals with the coordinated mark of 16 while *Calamus radicalis*, *C. radicalis* has the lowest total number with a coordinated mark of 1 only. Meanwhile, the other species have individual numbers upper than one and above than 16 individual species. This indicates that *R. singaporensis* is either well-suited to the environmental conditions of the study area or it has been more successful in its competition for resources compared to other species. *C. radicalis* has the smallest population, with only 1 individual recorded. This could suggest that *C. radicalis* is less adapted to the local conditions, faces more significant competition from other species to other limiting factors such as disease, predation, or human activity.

The IUCN Red List of Threatened Species, developed by the International Union for Conservation of Nature (IUCN), is a critical resource for assessing the global conservation status of plant and animal species (IUCN, 2024). It categorizes species based on their risk of extinction, providing essential data for conservation efforts. For example, the *R. singaporensis*, commonly known as the Singapore Rhopaloblaste Palm, is listed as Critically Endangered (CE) due to its very limited distribution and the ongoing threat to its habitat. Another species was recorded is the *Pinanga pantiensis* or Panti Pinanga Palm, categorized as Endangered (EN). This classification is based on its restricted range and the declining quality of its habitat.

On the other hand, more widely distributed species like the *Caryota mitis* (Fishtail Palm) and *Rhopalostylis sapida* (Nikau Palm) are listed as Least Concern (LC) because they face lower extinction risks and have stable populations. The IUCN Red List also highlights species with insufficient data to assess their status accurately. For example, the *Cocos nucifera* (Coconut Palm) is classified as Data Deficient (DD), indicating that more information is needed to determine its risk of extinction. Other species, such as the *Arenga engleri* (Formosa Palm) and *Calamus radicalis* (Climbing Rattan), are listed as Not Evaluated (NE) meaning that the data of the species wasn't assessed for the IUCN Red List.

Overall, the IUCN Red List is a vital tool for conservationists, policymakers, and researchers. It helps prioritize conservation actions, shape environmental policies, and raise awareness about the plight of threatened species and their ecosystems. By systematically evaluating species, the Red List aids in tracking biodiversity trends and implementing strategies to protect and restore natural habitats (IUCN, 2023).

## 4.2 Species Diversity of Arecaceae

The diversity of Arecaceae as examined using the Shannon's diversity ( $H'$ ) and Simpson's Diversity ( $D'$ ) indices is shown in Table 4.2.

**Table 4.2:** The calculation of Shannon's diversity ( $H'$ ) and Simpson's Diversity ( $D'$ ) indices based on 13 species of Arecaceae

Species	Number of Individual ( $n$ )	$pi$	$pi^2$	$\ln pi$	$\ln*pi$ <b>In</b>
<i>Arenga engleri</i>	4	0.0580	0.0034	-2.8478	-0.1651
<i>Calamus radicalis</i>	1	0.0145	0.0002	-4.2341	-0.0614
<i>Caryota Mitis</i>	2	0.0290	0.0008	-3.5410	-0.1026
<i>Cocos nucifera</i>	2	0.0290	0.0008	-3.5410	-0.1026
<i>Daemonorops Augustifolia</i>	5	0.0725	0.0053	-2.6247	-0.1902
<i>Lavistona speciosa</i>	3	0.0435	0.0019	-3.1355	-0.1363
<i>Licuala Stongensis</i>	5	0.0725	0.0053	-2.6247	-0.1902
<i>Rhopalostylis sapida</i>	2	0.0290	0.0008	-3.5410	-0.1026
<i>Pinanga pantiensis</i>	10	0.1449	0.0210	-1.9315	-0.2799
<i>Pinanga Simplicifrons</i>	9	0.1304	0.0170	-2.0369	-0.2657
<i>Plectocomia elongata</i>	5	0.0725	0.0053	-2.6247	-0.1902
<i>Rhopoloblaste Singaporensis</i>	16	0.2319	0.0538	-1.4615	-0.3389
<i>Salacca zalacca</i>	5	0.0725	0.0053	-2.6247	-0.1902
Total	69	1	-	-	-2.3160
Total species	13	-	-	<b><math>H'</math></b>	<b>2.3160</b>
				<b><math>D'</math></b>	<b>0.8921</b>

From the result Table 4.2 summarizes the biodiversity of a community of 13 different species using the Shannon-Wiener diversity index ( $H'$ ). This index considers both the number of species present (richness) and the evenness of their distribution. Each species' relative abundance ( $P_i$ ) is calculated by dividing the number of individuals of that species by the total number of individuals across all species from the individual data is 69 individuals from 13 species. The natural logarithm of  $P_i$  ( $\ln(P_i)$ ) is then multiplied by  $P_i$  to give  $P_i \cdot \ln(P_i)$ , which quantifies each species contribution to the overall diversity. Summing these values for all species gives a total

of approximately -2.316. Taking the negative of this sum yields the Shannon-Wiener diversity index ( $H'$ ), which in this case is about 2.316. This value indicates a moderate level of diversity, suggesting that while some species are more dominant like *R.singaporensis* with 16 individuals, there is still a reasonably even distribution among the species present, contributing to the community's ecological balance.

The data was also used to calculate Simpson's Diversity Index ( $D$ ) and its related measure, the Simpson's Index of Diversity ( $1 - D$ ), which quantifies the biodiversity of a community by considering both species richness and evenness of species distribution. To assess the community's biodiversity, the sum of all " $n(n-1)$ " values is calculated, resulting in 506. This sum represents the total number of ways to choose two individuals of the same species from the community. Next, the total number of individuals in the community ( $N$ ) is determined to be 69, and  $N(N-1)$  is computed as  $69 \times 68$ , equaling 469. The Simpson's Index of Diversity, calculated as  $1 - D$ , gives a complementary view:  $D = 1 - 0.108$ . This value represents the probability that two randomly chosen individuals from the community will belong to different species. In this case, a value of 0.892 indicates a high level of diversity, suggesting a well-balanced ecosystem where individuals are distributed relatively evenly among the different species.

### 4.3 Distribution of Arecaceae

Gunung Stong State Park, a 21,950-ha protected area managed by the Forestry Department Kelantan, is in the Dabong sub-district, Kuala Krai (Maseri and Mohd-Ros, 2005). There are a lot of tree families that can be found in this area such as the family of Arecaceae. The distribution of Arecaceae in the area shows a rich and diverse path community with a balanced distribution of species. The high diversity indices highlight the ecological significance of the park and the importance of conserving its biodiversity. Gunung Stong State Park's environment is stronger and usually in good condition because of this varied collection of palm species.

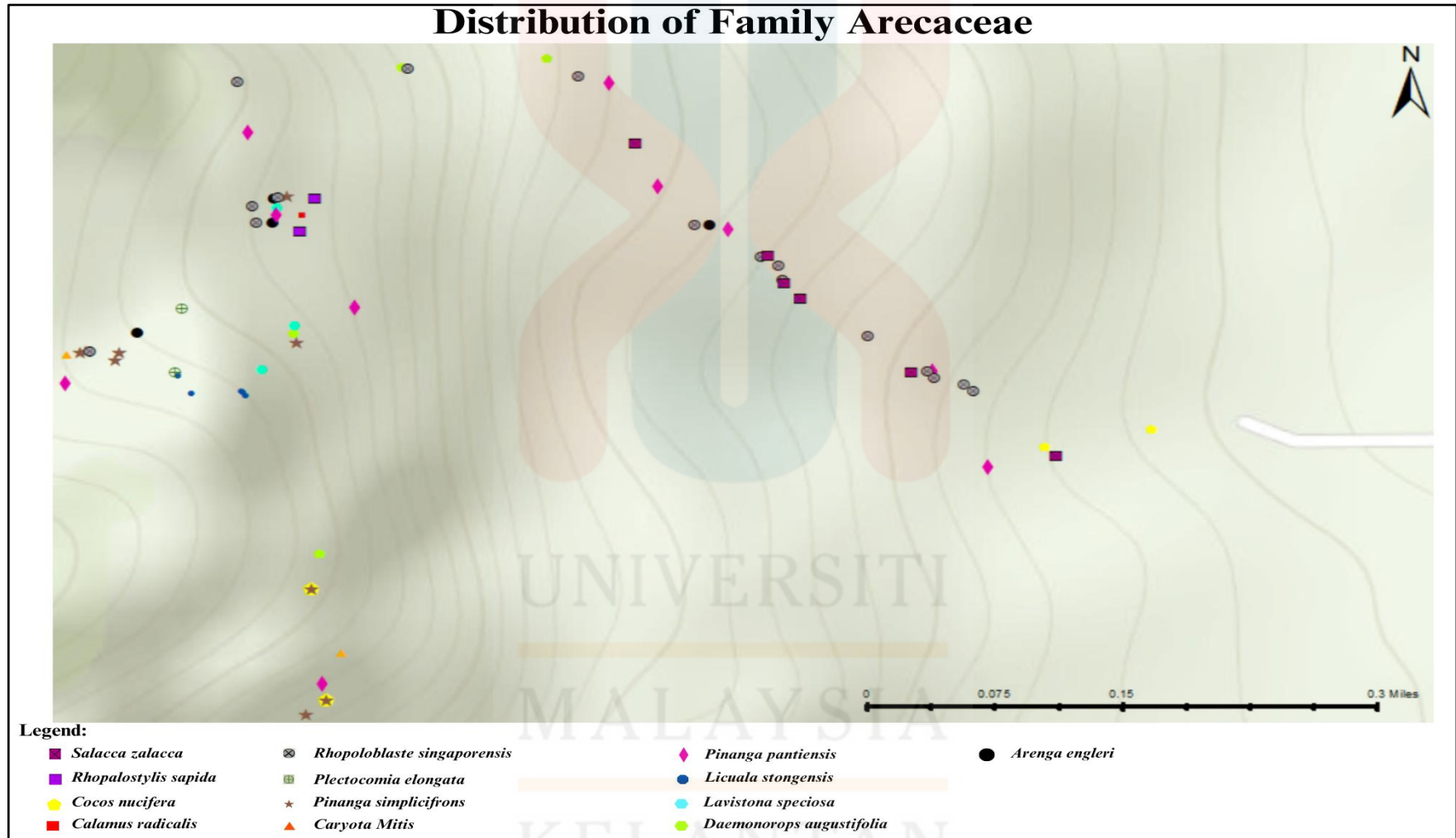


Figure 4.1: The distribution of Family Arecaceae recorded on the study site.

Figure 4.1 shows the maps for species distribution of palm species representing 13 species, 11 genera and 69 individuals have been tagged along the trails with coordinates and elevation for each species by using the software of Geographical Information System (GIS). Based on the figures shown that every species or genera have their own distribution either cluster or random distribution.

#### 4.3.1 *Rhopaloblaste singaporensis*

Based on Figure 4.1, *Rhopaloblaste singaporensis* which is shades of round gray. This shows that *R. singaporensis* (figures 4.2) is a species that may be found in any habitat, whether it be high or low. The species *R. singaporensis* is found between the foothills of Gunung Stong and along the sampling trail until it reaches an elevation of 1900m in Gunung Stong State Park with the 16 number of individual recorded. Being a species that does not live in groups and can therefore be found anywhere, the distribution of species is random.

All *Rhopaloblaste* species are small, solitary palms that grow to a height of 15 to 20 meters or more, except for *R. singaporensis*, which is a small, clustered palm that grows to a height of no more than 5 meters (Roy Banka and Willian John Baker, 2004). All of them are pleonanthic monoecious, unarmed palms that grow mostly as understorey or midstorey species in lowland tropical rain forests. Certain *Rhopalolaste singaporensis* can grow up in the forest canopy starting from the bottom to the top canopy.



**Figure 4.2:** The *Rhopaloblaste singaporensis* in Gunung Stong State Park

Based on previous study, the habitat of the genus *Rhopaloblaste*, all *Rhopaloblaste* species are robust to moderately sized solitary palms that grow to a height of 15 to 20 meters from above sea level (a.s.l), apart from *R. singaporensis*, which is a small, clustered palm that grows to a height of up to 5 meters. Plenanthic monoecious palms, which are all armed, are primarily found growing as understorey or midstorey species in lowland tropical rain forests. There are species that can grow in the forest canopy (Roy Banka et. al., 2004).

Therefore, tropical rain forest palms, or *Rhopaloblaste* species, can be found from low elevations of about sea level to 900 meters. They do not extend into mid- or higher montane forests instead, they are typically found in lowland rain forests and in lower montane forests (Roy Banka et. al., 2004). Unlike *R. singaporensis* which is at a high altitude as has been recorded, there are 5 species of *R. singaporensis* which are

at an elevation above 500m from the baha camp which is at an elevation of 1400m along the trails.

#### **4.3.2 *Pinanga pantiensis* and *Pinanga simplicifrons***

*Pinanga pantiensis*, *P. pantiensis* (Figure 4.3) and *Pinanga simplicifrons*, *P. simplicifrons* (Figure 4.4) is a species of palm in the family Arecaceae. *P. pantiensis* have being marked with the point individual 10 marked at Gunung Stong State Park with the different elevation and longitude meanwhile the number of individuals of *P.simplicifrons* is 9 species only. This species being a second data have a lot of distribution at GSSP. *P.pantiensis* and *P.simplicifrons* is a lesser-known species within the genus *Pinanga*, which includes various palm species predominantly found in Southeast Asia (Lee Guan Saw, 1998). It is commonly found in tropical rainforest environments, often thriving in the understory where light conditions are subdued. This habitat preference suggests it is adapted to shaded environments. These two species exhibit almost identical amounts of distributions because they share the same ecology and habitat within the same genus.



**Figure 4.3:** The *Pinanga pantiensis* leaf

Based on previous study, *P.pantiensis*. The data are recorded at the Johor Kota Tinggi, Gunung Panti. Based on that data, the data is clustering, it usually has one or two dominant stems. The data collected by Lee Guan Saw (1998) showing the same data recorded at the Gunung Stong State Park shows the clustering for both genus *Pinanga* in this study. The result is shown by looking at the map distribution (*Figure 4.1*) with the difference legend, for *Pinanga simplicifrons* (brown star) and *Pinanga pantiensis* (diamond purple). The genus *Pinanga* is known for its tendency to grow in clumps or clusters, a feature that can be attributed to several ecological and biological factors among which many species in the genus *Pinanga* reproduce through seeds that germinate and grow close to the parent plant. This leads to the formation of clusters of young palms around mature ones (Dransfield et al., 1998). The close spacing helps

in protecting the palm trees and ensures that they benefit from the micro-environment created by the larger plants.



**Figure 4.4:** The *Pinanga simplicifrons*

#### **4.3.3 *Daemonorops Augustifolia***

*Daemonorops angustifolia* (Figure 4.5), commonly known as Narrow-leaved Rattan or Lesser Rattan, belongs to the Arecaceae family. This species is notable for its long, flexible canes, which are used extensively in the production of rattan furniture and other handicrafts. The genus *Daemonorops* is indigenous to Southeast Asia, encompassing a variety of species adapted to different ecological niches within tropical rainforests. The data of *Daemonorops angustifolia* are recorded with the 5 individuals with the difference longitude, latitude and elevation. Based on the map distribution (Figure 4.1) shown that this species is random distribution because the

elevation every species difference marked with the legend 'round neon green'. So, *Daemonorops angustifolia* can live everywhere and every elevation or layer of tropical rainforest.



**Figure 4.5:** The *Daemonorops angustifolia*

On the other hand, *Daemonorops angustifolia*, the least common rattan species, was discovered close to the Jelawang Waterfall. According to Dransfield (1979), it was likewise a very erratic and widespread species that was sporadically found in valley bottoms but was mostly found in lowland forests close to sea level and up to 800 meters in the mountains. This proves the analysis data recorded in this study because 5 individuals of this species are located on the elevation 500 meters from the baha camp.

#### 4.3.4 *Calamus radicalis*

In Gunung Stong State Park, have found a genus *Calamus* which is *Calamus radicalis*. This *Calamus* shows an endemic species in GSSP because only one individual was successfully recorded along the trail. Based on distribution map, this species is symbol with the 'square pink' and the data unidentified either cluster or random because the number of individuals only 1. The characteristic that distinguishes this variety from others is that their pair of terminal leaves are usually joined along  $\frac{1}{4}$  of their length. Zakaria et al. (2009) stated that the lower number of species in forest reserves could be related to the condition of the study plot or evidence of anthropogenic activity.

Based on the analysis, the least species in the Gunung Stong State Park area is *Calamus radicalis* with only 1 individual counted at the elevation 468m. Based on figure 4.3 this species was marked as the symbol 'square orange'. Then, *Calamus radicalis* is one of the species of Arecaceae (palm family) found in Gunung Stong State Park. *Calamus radicalis* is a species of rattan palm. Climbing palms, ratans are prized for their long, thin stems, which are frequently employed in crafts and furniture construction. This species is the only species found along the track and is in the starting area before starting the track.



**Figure 4.6:** The *Calamus radicalis*

#### 4.3.5 *Salacca zalacca*

The snake fruit, *Salacca zalacca* belongs to the Arecaceae family and is often known as salak in Malaysian Malay. This exotic fruit's high antioxidant content gives it a variety of possible pharmacological benefits. Because of its sweet flavor, it is frequently consumed. It is a nutrient-dense fruit since it has a lot of natural sugar and fiber, as well as vitamins and minerals (Mohammed S. M. Saleh et al., 2018). The *Salacca zalacca* palm grows in dense clusters and has short, sturdy stems that can give the impression of being stemless (acaulescent). The total of this species has 5 individual species with the symbol 'square purple'. Distribution of *Salacca zalacca* was recorded with coordinated at the elevation range from 144m to 278m, this species detected growth together with the other genus of *Salacca*. Based on the analysis, this species showed clustering because the habitat stays in 20m – 30m only from each

other's. Based on the previous study, the morphology of *Salacca zalacca* is the salak is a very wavy palm that can grow short and nearly stemless in some varieties. This plant has the potential to reach a height of 6 meters and is predicted to yield fruit for 50 years on average. Typically, they are grown in low-lying, humid environments (Mohammed et al., 2018).

#### 4.3.6 *Licuala stongensis*

*Licuala stongensis*, commonly known as Stong Licuala Palm, is a palm species native to tropical regions, particularly in Malaysia. This species is characterized by its large, fan-shaped leaves and its adaptability to various elevations. On the way to the trail, one of the endemic species of licuala was also recorded and the coordination was already marked. The endemic species that was found at Gunung Stong State Park is *Licuala Stongensis* with 5 individuals. Based on MyBis data, this species was list on the listed red category as Not Evaluated (NE). This is referred to as a species that has been listed as not evaluated (NE) on the IUCN Red List of Threatened Species is one of undergone assessment by the International Union for Conservation of Nature (Dictionary,2024). Then, based on Figures 4.1, this species with the symbol 'blue around' is in a state of close distance because the state of trees and samplings of this species are not far from each other. Observations are made with the difference between the *Licuala stongensis* species together with the other genus of *Licuala*.



**Figure 4.7:** The species of *Licuala stongensis*

Based on previous study or research, *Licuala stongensis* refers to the area of the species found its Gunung Stong State Park, found ahead of the previous study. Based on that, *Licuala stongensis* only have 1 species only at the GSSP. After revisiting the area, this species already growth at different longitudes and latitude. Based on the analysis, this species shown clustering because growth at the same spot.

MALAYSIA

KELANTAN

**Table 4.3:** The diameter of leaf, height and elevation of *Licuala stongensis* at Gunung Stong State Park, Dabong, Kelantan.

Species/Genus	Diameter of leaf (cm)		Height (cm)	Elevation (m)
	Leaf width	Leaf length		
<i>Licuala stongensis</i>	77.0	72.3	182.880	1497
	64.1	60.8	60.960	1499
	77.2	81.4	243.840	1501
	64.3	43.2	182.880	1529
	67.2	62.3	121.920	1527

Table 4.2 shows the analysis data of the diameter, height and elevation recorded. The diameter data are measured with the measured tape (Figure 4.5), as the analysis of the diameter for every species shows the difference size. The leaf diameter of *Licuala stongensis* varies significantly, as shown in the collected data in Table 4.2. The measurements indicate that the leaves of this species can reach substantial widths, contributing to the palm's fan-like appearance. The variability in leaf diameter reflects the species' adaptability to different environmental conditions, which may influence leaf size. Meanwhile, the heights indicate that *Licuala stongensis* palms can range from relatively short to moderately tall. The height of these palms may be influenced by factors such as age, environmental conditions, and genetic variation. The tree height distance is not more than 10cm. Then, the elevation data shows that *Licuala stongensis* can thrive at elevations around 1500 meters above sea level. The slight variations in elevation suggest that this species can tolerate a range of conditions within this altitude



**Figure 4.8:** The measuring tape use to measure the *Licuala stongensis* leaf

*Licuala stongensis* ecological preferences and adaptability are measured at various altitudes. *Licuala stongensis* is well suited to capture light in its native woodland habitat, which may differ in light availability, as evidenced by the size of its leaves. In the meantime, the varying heights demonstrate that the species can flourish in a variety of environments, from the lower reaches of the forest to more exposed regions. The species' capacity to survive at elevations around 1500 meters suggests that it may adapt to mountain environments, which may differ in terms of soil composition and have colder temperatures than lowland tropical forests.

#### 4.3.7 *Plectocomia elongata*

*Plectocomia elongata* (Figure 4.6) has data with the point marked 5 individuals with the difference range and individuals. *Plectocomia elongata* is a species of rattan palm belonging to the Family Arecaceae. The habitat is commonly found in tropical rainforest environments, particularly in the understory and mid-canopy layers. The specific population size of *Plectocomia elongata* can vary significantly depending on the location and habitat conditions. It is often found in patches where conditions are suitable. As a component of the forest understory, it contributes to the overall biodiversity and structural complexity of the ecosystem.

Based on the data collected, the distribution of *Plectocomia elongata* is random. This species with the symbols '+ round with green colour'. It's because this species can growth anywhere either at the higher elevation or lower elevation. For example, the higher elevation recorder at elevation 550m and the lower elevation recorder 300m.



**Figure 4.9:** The *Plectocomia elongate*

#### **4.3.8 *Arenga engleri***

Based on the distribution map, it shows that the *Arenga engleri* data with the symbol ‘round black’ shown the random distribution. The total individual of this species is 4 individuals with the difference elevation. *Arenga engleri*, commonly known as the Formosa Palm, is a species of palm native to Taiwan and the Ryukyu Islands of Japan. This palm is recognized for its attractive appearance, making it a popular choice for ornamental planting in gardens and landscapes.

The morphology of this species is *Arenga engleri*, a medium-sized palm that typically reaches heights of 3-5 meters. The palm is characterized by its clustering growth habit, where multiple stems grow from a single root system. Each stem is adorned with pinnate (feather-like) leaves that can reach up to 2 meters in length. The leaves are dark green on the upper surface and grayish-green underneath. The plant

produces small, fragrant flowers that are yellowish to cream-colored. The flowers are arranged in inflorescences that emerge from the base of the leaves. After pollination, the palm produces small, round fruits that turn black when ripe (Dransfield et. al., 1998). *Arenga engleri* is found in subtropical regions, thriving in areas with moderate temperatures and high humidity. It prefers well-drained soils and can tolerate a range of light conditions, from full sun to partial shade. In its native habitats in Taiwan and the Ryukyu Islands, it often grows in forested areas and along riverbanks.

#### **4.3.9 *Cocos nucifera* and *Caryota Mitis***

At Gunung Stong State Park, there are 3 species that have a distribution of less than 2, it's *Cocos nucifera* and *Caryota Mitis*. These species have limited distribution, with fewer than 2 recorded individuals for *Cocos nucifera* and for *Caryota Mitis* 1 individual recorded. This suggests that the species is not naturally widespread in the park and might be present in cultivated or disturbed areas rather than in natural forest settings. Based on figure 4.1, *Cocos nucifera* and *Calamus radicalis* show a cluster distribution, because these two species grow small between latitudes and longitudes, the distance between individuals is not too far and not too close. Therefore, this species shows the ecology of this species living in groups.

#### **4.3.10 *Rhopalostylis sapida***

*Rhopalostylis sapida*, commonly known as the nikau palm, is a species of palm native to New Zealand. It belongs to the *Arecaceae* family and is the only palm native to this region. The species typically grows in coastal and lowland forest areas, often in moist, shaded environments. Based on data recorded, *Rhopalostylis sapida* has a random distribution in Gunung Stong State Park and only two individuals have been

recorded. *Rhopalostylis sapida* might not encourage clustering or regular spacing due to identical circumstances in its habitat, such as similar soil types, moisture levels, and light availability. Because of this consistency, the species can spread randomly as seeds land and effectively germinate wherever. This species is referred to the genus *Rhopalostylis*. The genus *Rhopalostylis* is known for species that typically grow in specific environments. In their native habitat, they are often found in moist, shaded areas of coastal and lowland forests. If similar conditions are met in Gunung Stong State Park, it might allow these palms to grow in random spots where suitable microhabitats exist (Dransfield et al., 2008).

#### **4.3.11 *Livistona speciosa***

The taraw palm, or *Livistona speciosa*, is a species of palm belonging to the *Arecaceae* family. It can be found throughout Malaysia and other regions of Southeast Asia. Typically, this species lives in tropical forests and places with lots of sunlight and damp soil. Based on data recorded, the distribution of this species shows that the random distribution. A random distribution pattern means that individuals are spread unpredictably and independently of each other. This type of distribution occurs when environmental conditions are relatively uniform, and there are no strong interactions between individuals, such as competition or facilitation (Townsend, & Harper, 2006). The genus *Livistona* is known for species that can thrive in a variety of environments, from coastal regions to inland forests. In their natural habitats, *Livistona* species are often adapted to thrive in conditions with periodic disturbances, such as storms or flooding, which can contribute to their random distribution patterns (Dransfield et al., 2008). This is the reasons this species growth at the elevation below 1000 meter from above sea level (a.sl).

#### 4.4 Summarize type of distribution

Based on all the data recorded, the summarize type of the distribution is shown in table 4.4.

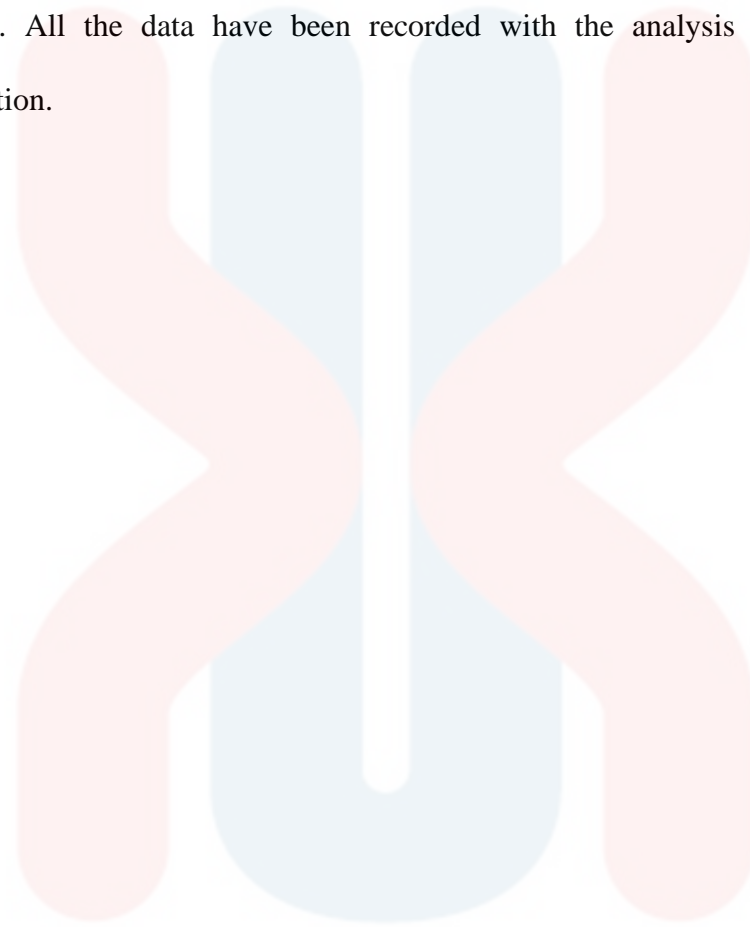
**Table 4.4:** The summary type of the distribution

Species Name (Scientific Name)	Number of Individuals	Type of Distribution
<i>Arenga engleri</i>	4	Random
<i>Calamus radicalis</i>	1	ND
<i>Caryota Mitis</i>	2	ND
<i>Cocos nucifera</i>	2	ND
<i>Daemonorops augustifolia</i>	5	Random
<i>Livistona speciosa</i>	3	Random
<i>Licuala stongensis</i>	5	Clustered
<i>Rhopalostylis sapida</i>	2	Random
<i>Pinanga pantiensis</i>	10	Clustered
<i>Pinanga simplicifrons</i>	9	Clustered
<i>Plectocomia elongata</i>	5	Random
<i>Rhopoloblaste singaporensis</i>	16	Clustered
<i>Salacca zalacca</i>	5	Clustered

**ND – Not Defined**

The summary shows that the data recorded has the different types of distribution for every species found at GSSP. Based on that, Random distribution patterns can be seen in species like *Plectocomia elongata*, *Rhopalostylis sapida*, *Arenga engleri*, *Daemonorops augustifolia*, and *Livistona speciosa*. This is probably because of environmental conditions. The observed random spatial patterns are the result of these elements together. Meanwhile, clustered distribution patterns are seen in species such as *Salacca zalacca*, *Rhopoloblaste singaporensis*, *Pinanga pantiensis*, *Licuala stongensis*, and *Pinanga simplicifrons*. These clusters are influenced by social behavior, reproductive tactics, and habitat preferences. These species may have mutualistic connections that encourage clustering, profit from vegetative reproduction, and flourish in particular microhabitats. Next, for species such as

*Calamus radicalis*, *Caryota mitis*, and *Cocos nucifera*, the distribution type is not determined due to insufficient data. Further studies are needed to establish their spatial patterns. All the data have been recorded with the analysis with the type of distribution.



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KELANTAN

## CHAPTER 5

### CONCLUSION & RECOMMENDATIONS

#### 5.1 Conclusion

As conclusion, 13 species from the Arecaceae family have been successfully plotted on Geographic Information System (GIS) software. These maps have shown the potential diversity and distribution of the Arecaceae family in Gunung Stong State Park (GSSP), Dabong, Kelantan. From the results, the species of the Arecaceae family are a total of 69 individuals from 13 Arecaceae species were collected at GSSP, Kelantan. *Rhopoloblaste Singaporensis* is the most abundant species with 16 individuals. It is followed by *Pinanga pantiensis* with a total of 10 individuals. The least abundant species is *Calamus radicalis* with one individual. An educational track can be planned to conserve the existing Arecaceae family. Distribution the pattern of 13 Arecaceae species was identified randomly and non-uniformly along the route. The distribution of Arecaceae species is low in diversity. However, this study area contains The Arecaceae family that benefits from the Gunung Stong State Park patch may be one of them tourist attraction because this mountain is an interesting attraction.

## 5.2 Recommendations

Several strategies are recommended to better understand the diversity and distribution of Arecaceae species in Gunung Stong State Park. First, conduct a comprehensive habitat survey using GIS technology to map different habitats such as lowland rainforest and riverine areas. This will help identify key factors affecting species distribution and highlight areas in need of conservation. Establish long-term monitoring plots to track changes in population size and health of Arecaceae species over time. Regular monitoring will provide important data to understand their life cycle and the impact of environmental changes. The study of genetic diversity is important to assess the resilience of this species. Techniques such as DNA coding can help preserve genetic resources and guide conservation efforts. Ecological and ethnobotanical research should document the role of Arecaceae species in ecosystems and their traditional uses by local communities. This information can encourage sustainable use practices and integrate local knowledge into conservation plans. Finally, assess the impact of climate change on Arecaceae species by using climate models to predict habitat changes and develop strategies to help species adapt, such as assisted migration and habitat management.

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