COMPARISON OF DIVERSITY AND DISTRIBUTION OF ZINGIBERACEAE AT LATA JANGGUT AND LATA RENYUK, JELI, KELANTAN

By

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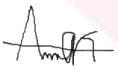
DECLARATION

I declare that this thesis entitled " Comparison Of Diversity And Distribution Of Zingiberaceae At Lata Janggut And Lata Renyuk, Jeli, Kelantan" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

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Comparison of Diversity and Distribution of Zingiberaceae at Lata Janggut and Lata Renyuk, Jeli, Kelantan

ABSTRACT

This study focused on diversity and distribution of Zingiberaceae at Lata Janggut and Lata Renyuk, Jeli, Kelantan as there is still lack of information about ginger diversity here. Method used to do the sampling is random sampling. A random different trails of 500 meter were chosen each day and the Zingiberaceae plant found was tagged using Garmin GPS 64s. A total of six species comprise of four genera of Zingiberaceae were identified in this study. At Lata Janggut, species that was found includes *Alpinia javanica* (three individuals), *Etlingera elatior* (two individuals), *Etlingera punicea* (38 individuals) and *Curcuma longa* (one individuals). At Lata Renyuk, species that was found are *Alpinia galanga* (four individuals), *Etlingera megalocheilos* (nine individuals), *Alpinia javanica* (two individuals), *Etlingera elatior* (18 individuals), *Etlingera punicea* (65 individuals). Based on the Shannon Wiener diversity index, it is shown that both places have a different diversity index. H' value for Lata Janggut is 0.53623 and Lata Renyuk is 1.01284. This clearly shows that Lata Renyuk has a slightly higher diversity compare to Lata Janggut. The diversity of Zingiberaceae at both areas may differ from time to time as these places is a recreational area. It is recommended to increase the day of sampling for the next study to get more and accurate data.

Perbandingan Kepelbagaian dan Taburan Zingiberaceae di Lata Janggut dan Lata Renyuk, Jeli, Kelantan

ABSTRAK

Kajian ini memfokuskan kepada kepelbagaian dan taburan Zingiberaceae di Lata Janggut dan Lata Renyuk, Jeli, Kelantan kerana masih kurang maklumat tentang kepelbagaian halia di sini. Kaedah yang digunakan untuk melakukan persampelan ialah persampelan rawak. Satu laluan rawak berbeza sepanjang 500 meter telah dipilih setiap hari dan tumbuhan Zingiberaceae yang ditemui telah ditanda menggunakan GPS Garmin 64s. Nombor pengumpul dan nama tempatan tumbuhan ini ditunjukkan dalam jadual 4.1 dan 4.2. Selepas proses pengecaman, telah diklasifikasikan bahawa terdapat enam spesies terdiri daripada empat genera Zingiberaceae yang ditemui semasa kajian ini. Di Lata Janggut, spesis yang ditemui termasuk *Alpinia javanica* (tiga individu), *Etlingera elatior* (dua individu), *Etlingera punicea* (38 individu) dan *Curcuma longa* (satu individu). Di Lata Renyuk, spesis yang ditemui ialah *Alpinia galanga* (empat individu), *Etlingera megalocheilos* (sembilan individu), *Alpinia javanica* (dua individu), *Etlingera elatior* (18 individu), *Etlingera punicea* (65 individu). Berdasarkan indeks kepelbagaian Shannon Wiener, menunjukkan kedua-dua tempat mempunyai indeks kepelbagaian yang berbeza. Nilai H' untuk Lata Janggut ialah 0.53623 dan Lata Renyuk ialah 1.01284. Ini jelas menunjukkan bahawa Lata Renyuk mempunyai kepelbagaian yang lebih tinggi sedikit berbanding dengan Lata Janggut. Kepelbagaian Zingiberaceae di kedua-dua kawasan mungkin berbeza dari semasa ke semasa kerana tempat-tempat ini merupakan kawasan rekreasi. Adalah disyorkan untuk meningkatkan bilangan hari untuk persampelan untuk mendapatkan data yang lebih banyak dan tepat.

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LIST OF ABBREVIATIONS

GPS	Global Positioning System
IUCN	International Union for Conservation of Nature

LIST OF SYMBOLS

%	Percentage
H’	Shannon- Wiener diversity index
ln	Natural algorithm

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Kelantan is a state in Malaysia that is in the northeast of Peninsular Malaysia and covers approximately 15,040 km^2 (Brinkhoff, 2023). There are 11 districts in Kelantan and Jeli is one of them. Jeli covers approximately 1330 km^2 of Kelantan area (Brinkhoff, 2023). This state is well known for its biodiversity and its richness of natural resources. It has various waterfalls, forests, and recreational areas that are suitable for people who love nature and adventure. This biodiversity richness also attract researchers to conduct different studies in this state. As it has a lot of area that does not explore much by people, this researcher conduct studies to know about plant and animal diversity here. One of the study is about ginger family, Zingiberaceae.

Zingiberaceae is one of the family names for ginger under the order of Zingiberales (Xu & Chang, 2017). It is a flowering plant found in Asia, Africa, and America that has more than 1300 species and is split into 52 genera of fragrant perennial herbs with spreading horizontal or tuberous rhizomes (Tamokou *et al*., 2017). It can be found mostly in the Southeast Asia region (Hai, 2015). Zingiberaceae plants may thrive in a range of ecological settings, although they are most frequently found in tropical rainforest and other damp places (Boonma *et al*., 2023). They flourish in warm, humid environments with plenty of rainfall and shade, while some species may be found in arid regions with direct sunshine.

This plant family is well known for its spicy flavor and aromatic odor, its rhizomes have long been used as flavoring ingredients and spices in Asian countries, (Zhou *et al*., 2018). Zingiberaceae is also considered a well-studied group of plants with great beneficial medicinal and nutraceutical potential benefits to human health, (Al-Obaidi, 2021). Zaki *et al*., (2019) also reported that Zingiberaceae is one of the wild ginger family containing a good medicinal value.

The distribution of Zingiberaceae in a few countries in Asia has been identified by some researchers. In Meijen, Central Java, Indonesia there are 19 species of Zingiberaceae recorded (Lianah *et al*., 2020). In Nakhon Nayok Province, Central Thailand, there are 155 species from 16 genera and three tribes where Zingiberaceae has the highest diversity (120 species) (Boonma *et al*., 2023). As for Malaysia, there are also a lot of Zingiberaceae plants recorded across this country but Appalasamy *et al*., (2020) said that there is still limited studies reported on wild ginger species in Kelantan.

According to Ibrahim *et al*., (2007) there are approximately 160 species of Zingiberaceae belonging to 18 genera in Peninsular Malaysia. From these 160 species, there are 16 species found in Gua Setir and Gua Ikan in Kelantan with 13 species evaluated based on the Red List of Threatened Species by the International Union for Conservation of Nature (IUCN) (Appalasamy *et al*., 2022). This shows that a lot of studies need to be conducted on Zingiberaceae diversity mainly in Kelantan to protect and conserve this plant from extinction.

1.2 Problem Statement

Zingiberaceae has its economic importance. It is used in various fields such as food, medicine, perfume, and ornamental, (Taylor *et al*., 2009). There are previous studies done by others about the diversity and distribution of Zingiberaceae in Kelantan which includes limestone forest (Appalasamy *et al*., 2022), natural trail of Lojing Highlands, (Appalasamy *et al*., 2020), and Zingiberaceae diversity in Ulu Sat Forest Reserved in Kelantan (Izlamira *et al*., 2020). This shows that there is still lack of knowledge about Zingiberaceae diversity in Lata Janggut and Lata Renyuk, Jeli, Kelantan. Therefore, this study will fill in the gaps about Zingiberaceae diversity in Kelantan.

1.3 Objectives

- To determine the diversity of Zingiberaceae at Lata Janggut and Lata Renyuk, Jeli, Kelantan.
- To determine the species abundance of Zingiberaceae at Lata Janggut and Lata Renyuk, Jeli, Kelantan.
- To compare the diversity and species abundance of Zingiberaceae at Lata Janggut and Lata Renyuk, Jeli, Kelantan.

1.4 Significant of Study

The study of Zingiberaceae diversity in Lata Janggut and Lata Renyuk could give a variety of benefits, especially for conservation purposes. By understanding this plant diversity, it helps in identifying and protecting rare or endangered species. This indirectly contribute to biodiversity conservation efforts. Besides that, studying the distribution will provide us with the knowledge of habitat preference of the Zingiberaceae plant family which leads to learning about habitat restoration and management strategies. Finally, some species of the Zingiberaceae family can provide a variety of medicinal value such as *Etlingera elatior* and *Alpinia javanica*, (Victório, 2011), which will have significance to people.

1.5 Scope of Study

This study only focuses on Zingiberaceae diversity and abundance in Lata Janggut and Lata Renyuk, Jeli, Kelantan. The sampling only covers some area of this study site according to the sampling size.

CHAPTER 2

LITERATURE REVIEW

2.1 Zingiberaceae

Zingiberaceae is the family name for wild ginger under the order of Zingiberales. The commercially significant bananas, *heliconia* and gingers are members of the Zingiberales (Prince & Kress, 2002). The banana families and ginger families which comprises of four families each is the division under Zingiberales order. The banana families are Musaceae (three genera including *Musa*, the banana), Strelitziaceae (three genera including *Strelizia*, the bird of paradise and *Ravenala*, the traveler's palm), Lowiaceae (one genus) and Heliconiaceae (lobster-claws). The ginger families are Costaceae, Zingiberaceae (52 genera), Cannaceae (one genera) and Marantaceae (31 genera). Each family has a different number of species. Prince & Kress (2002), also added that the Zingiberaceae family has about 1000 species, followed by the Marantaceae family, which has roughly 500 species. Lowiaceae and Cannaceae are the smallest families, each with one genus and about ten species.

According to Larsen (2005), The family Zingiberaceae is split into four subfamilies under the current categorization. The freshly found monotypic genus *Tamijia* from North Borneo is a member of the Tamijioideae. The Siphonochiloideae, which is exclusive to tropical Africa and includes the genus *Siphonochilus*. The remaining about 50 genera and over 1300 species are divided into two subfamilies, The most widespread family, Alpinioideae, is represented by *Renealmia*, *Aframomum*, and *Aulotandra* in the Neotropical region and Africa, whereas the

remaining 20 genera and 700 species are all native to the tropics of Asia. The Zingiberoideae is a far more varied family, consisting of about 30 genera and 600 species. They are only depicted in Asia. The phylogenetic tree of the Zingiberaceae family with the four subfamilies is shown in figure 2.1 below.

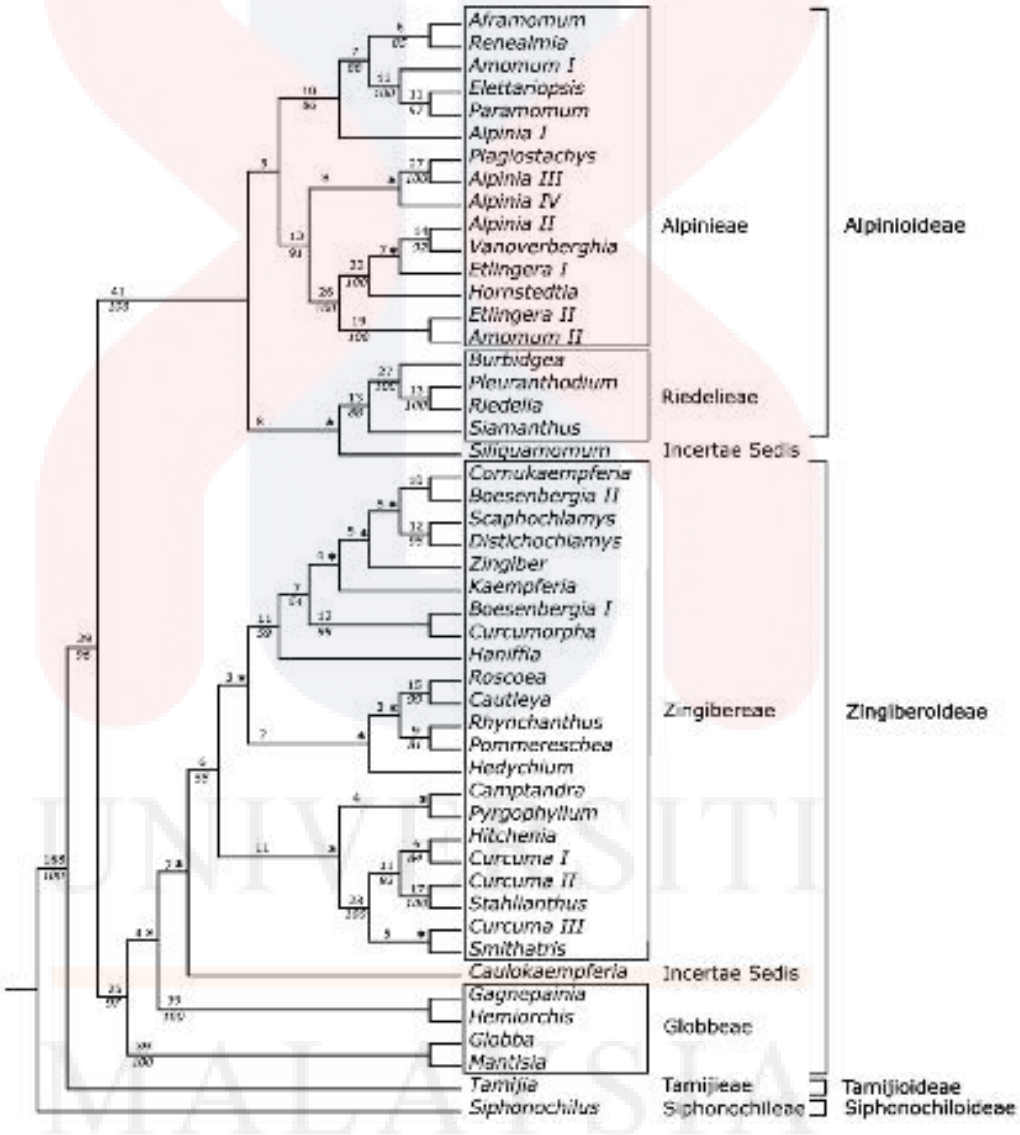

Figure 2.1: Phylogenetic tree of family Zingiberaceae. (Larsen, 2005).

Zingiberaceae are most abundant in lowland woods up to 600 meters above sea level; species richness decreases as elevation increases. Nonetheless, between 1400 to 2300 meters, species including *Alpinia*, *Amomum*, and *Hornstedtia* can still be found in the lower montane forest (Mohamad & Kalu, 2019).

2.2 Morphological Characteristics of Zingiberaceae

Normally this plant family has sympodial (forked) fleshy rhizomes (underground stems) and the plant can grow up to six meters approximately 20 feet in height (Chauhan *et al*., 2020). Some of the species are known as epiphytes (air plants) that have no attachment to the ground and are non parasitic to the plant they are attached to (Petruzzello, 2020). The exodermis of the Zingiberaceae plant family comprises one or more layers of compact suberized cells below a piliferous epidermis (Eswaranpillai & Thangavelu, 2014). Irayanti & Yadnya Putra (2020) said that various plant species are utilized as medicine in Usada, Indonesia that include the Zingiberaceae family. The Zingiberaceae family, which includes ginger plants, is distinguished by traits including rhizome, pseudo-stems, and single leaves (Irayanti & Yadnya Putra, 2020). Figure 2.2 and 2.3 below shows the Zingiberaceae plant flower that has been found in Thailand and Kelantan, Malaysia.

Figure 2.2: There are 29 species of Zingiberaceae in Khao Nan and Khao Luang National Parks, Nakhon Si Thammarat, Thailand. (Kittipanangkul & Ngamriabsakul, 2011). Line 1, left to right; *Alpinia mutica*, *Alpinia javanica*, *Alpinia zerumbet*, *Amomum aculeatum*, *Amomum biflorum*. Line 2, left to right; *Amomum hastilabium, Amomum uliginosum, Amomum sp., Elettariopsis curtisii, Etlingera elatior*. Line 3, left to right; *Etlingera fulgens, Etlingera littoralis, Etlingera pauciflora, Etlingera subterranea, Hornstedtia leonurus.* Line 4, left to right; *Globba pendula, Globba leucantha, Boesenbergia basispicata, Boesenbergia plicata, Curcuma aurantiaca.* Line 5, left to right; *Curcuma longa, Curcuma rubescens, Curcuma zedoaria Hedychium khaomaenense, Kaempferia pulchra.* Line 6, left to right; *Zingiber newmanii, Zingiber officinale, Zingiber ottensii, Zingiber zerumbet.*

Figure 2.3: Identified wild ginger family in the limestone forest of Kelantan (Appalasamy *et al*., 2022). (a) *Alpinia javanica;* (b) *Etlingera littoralis;* (c) *Etlingera maingayi;* (d) *Etlingera punicea;* (e) *Plagiostachys sp.;* (f) *Wurfbainia uliginosa;* (g) *Globba leucantha;* (h) *Globba patens;* (i) *Bosenbergia plicata;* (j) *Sundamomum hastilabium;* (k) *Zingiber aurantiacum;* (l) *Zingiber ottensii;* (m) *Zingiber puberulum;* (n) *Zingiber spectabile;* (o) *Zingiber wrayi;* (p) *Zingiber petiolatum.*

2.3 Distribution of Zingiberaceae in Asia

There are some studies done by researchers about diversity of Zingiberaceae in different places of Asian country such as Thailand, Indonesia and Malaysia. In Thailand, there are some published papers found that records Zingiberaceae diversity in Nakhon Nayok Province and Nam Nao National park. In Nam Nao National Park, there are 38 species recorded with *Curcuma* and *Zingiber* has the highest number of species. There are also one new species recorded that is *Etlingera yunnanensis* (Saensouk *et al*., 2016). Study in Nakhon Nayok province revealed that there are 155 species from 16 genera and 3 tribe with *Zingibereae* has the highest diversity (120 species) (Boonma *et al*., 2023). In Bueng Kan Province, there are 13 genera and 67 species of Zingiberaceae found with *Curcuma* has the highest diversity (Ragsasilp *et al.*, 2022).

The Zingiberaceae plant family has a wide range of habitat distribution and the species of this wild ginger in Malaysian forest is the most studied, said Appalasamy *et al*., (2022). There are 22 species of Zingiberaceae found In Gunung Telapak Burok, Negeri Sembilan (Appalasamy & Arumugam, 2020). In Panti Forest Reserve and Labis Forest Reserve, Johor, there are 28 taxa from 8 genera including *Alpinia*, *Etlingera* and *Globba* recorded (Sedek *et al.*, 2023). In Sarawak, there are 12 genera and 39 species recorded at Kubah Natonal Park (Ibrahim, 2005).

There are previous studies done by others about the diversity and distribution of Zingiberaceae in Kelantan which includes limestone forest (Appalasamy *et al.,* 2022), Natural trail of Lojing Highlands, (Appalasamy *et al*., 2020), Zingiberaceae diversity in Ulu Sat Forest reserved in Kelantan (Izlamira *et al*., 2020) and many others. This shows that there is still a lack of information about Zingiberaceae diversity and

distribution in Lata Janggut and Lata Renyuk, Jeli, Kelantan. Therefore, this study will help to fill the gaps about Zingiberaceae diversity in Kelantan.

According to Mybis (Mybis, 2023), there are about 48 species of Zingiberaceae that have been listed under the International Union for Conservation of Nature (IUCN) endangered species while 21 records are found for critically endangered species. Among this endangered species there are few that is native to Malaysia which are *Alpinia corneri*, *Boesenbergia stenophylla*, *Etlingera newmanii* and *Zingiber argenteum*. According to Banaticla-Hilario & Altamirano (2023), They only assess 45% of the 1449 species recorded in Tropical Asia, and 297 species that is 21% of all evaluated species are threatened. The distribution of this endemic species in tropical Asia is shown in figure 2.4 below.

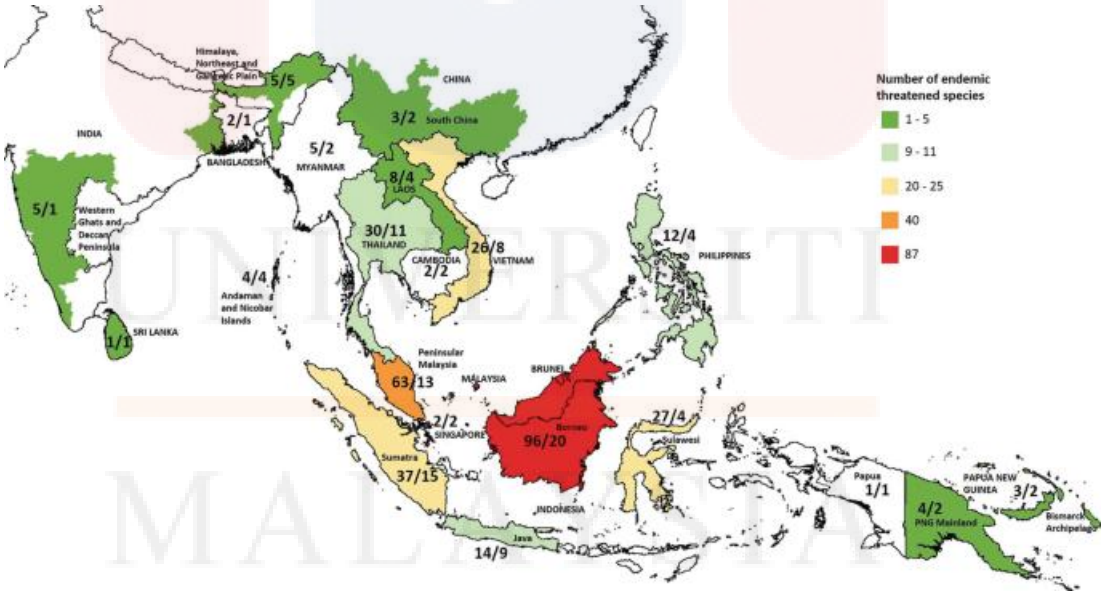

Figure 2.4: Distribution of endemic threatened species of Zingiberaceae in Tropical Asia. (Banaticla-Hilario & Altamirano, 2023)

2.4 Species Diversity and Species Abundance

According to the Cambridge Dictionary, diversity is the fact of many different types of things or people being included in something, a range of different things or people. A diversity index is a mathematical measure of species diversity in each community. Species diversity is defined as the abundance and number of species in a particular area (Ha & Schleiger, 2022). Species diversity can be calculated by using the diversity index formula. The most common use formula is Shannon diversity index.

The Shannon-Wiener Diversity Index was first suggested by Claude Shannon in 1948. Other names for it include Shannon's diversity index. The index and the idea of uncertainty are connected. We can be very confident of the identification of an organism we might pick at random (high confidence or low uncertainty) if, for instance, a community has relatively little variety. When selecting an organism at random from a highly diversified population, we face increased uncertainty about the species we will select (low certainty or high uncertainty), (Libre texts, 2023). The formula for the Shannon-Wiener index is as follows:

$$H' = -\sum_{i=1}^{s} pi * lnpi$$

Where:

H’ = The value of Shannon Wiener diversity Index

p_i = proportion of individuals of species I,

ln is the natural logarithm of p_i

S = The number of species in community.

Furthermore, species abundance is the number of individuals of that species in a particular area (Evans *et al*., 2014). Species abundance can be calculated by using the species abundance formula as shown below.

$$\text{Relative Species Abundance} = \frac{Total\ number\ of\ individual\ of\ a\ species}{total\ number\ of\ species} \times 100$$

CHAPTER 3

METHODOLOGY

3.1 Study Site

The study site chosen are Lata Janggut and Lata Renyuk, Jeli, Kelantan. The coordinate of Lata Janggut is 5°40'15"N 101°46'12"E while the coordinate for Lata Renyuk is 5°34'44"N 101°52'35"E. Both places are well known as a recreational area and its amazing waterfall.

Lata Janggut is located about seven kilometers from Jeli town. It is popular for its beautiful calmness nature. This area has been developed by Jeli district leader with the cooperation of Ministry of Tourism Malaysia and the South Kelantan Development Authority (KESEDAR). Lata Janggut has three tier waterfalls where its output is about 3 acres (Kamarudin, 2022). It is located within the tropical rainforest area and it is well known for its high biodiversity, dense vegetation and a significant annual rainfall. Most of the tree there is high and forming a closed canopy with smaller plant growing on the layer. The environment at Lata Janggut can be said as humid and warm that make it suitable for plants and animals to survive. Map of Lata Janggut is shown in Figure 3.1 below.

Lata Renyuk is located in Kampung Renyuk about 14 km from Jeli town. There is also a mini hydroelectric power plant that is still operating until now. This place is suitable for those who loves nature as it has a beautiful flora and fauna. Various activities can be done at this place like hiking, swimming and bird watching. The environment at Lata Renyuk is humid and warm. It is also covered by big tree canopy and has a significant amount of rainfall. This gives a high humidity and

moderate temperature that help the survival of plants and animals here. Map of Lata Renyuk is shown in the Figure 3.2 below.

Figure 3.1: Location of Lata Janggut, Jeli, Kelantan (Google Maps, 2024). The red pin shows the location of Lata Janggut, Jeli, Kelantan.

Figure 3.2: Location of Lata Renyuk, Jeli, Kelantan (Google Earth, 2024). The red pin shows the location of Lata Renyuk, Jeli, Kelantan.

3.2 Materials

Global Positioning System (GPS) [Garmin Gps map 64s, Malaysia] was used to record plant coordinates. Pen and notebook was used to record the data such as the colour of the plant and flower, and the area nearby the plant like if it is near the water or the area was opened or shady.

3.3 Method

3.3.1 Sampling of Zingiberaceae at Lata Janggut and Lata Renyuk, Jeli, Kelantan

The method that is used to do a sampling of Zingiberaceae is simple random sampling. Few different trails of 500 meter at Lata Janggut and Lata Renyuk, Jeli, Kelantan were chosen and tagged using the GPS. The sampling was done for five days and different trail was chosen each day. In this 500 meter trails, the Zingiberaceae plant within three meter to the right and left of the trails was recorded (Appalasamy *et al*., 2020). Notes about the species, habitat, odor, and color was recorded to ease the identification process.

3.3.2 Identification of Zingiberaceae

The specimens were removed from the plastic bag and processed for the identification of plant species. The identification of Zingiberaceae species was done by referring to books such as Larsen *et al*., (1999), Poulsen (2006) and by referring to the online herbarium website like Kew's Herbarium.

3.3.3 Analysis of Species Diversity and Species Abundance of Zingiberaceae

Species diversity is defined as the abundance and number of species in a particular area (Ha & Schleiger, 2022). It shows the variety of species that can be found in an area. Species diversity can be calculated by using The Shannon -Wiener Index as follows:

$$H' = -\sum_{i=1}^{s} pi * lnpi$$

Where:

H' = The value of Shannon Wiener diversity Index

p_i = proportion of individuals of species$i$,

ln is the natural logarithm of p_i

S = The number of species in the community.

The number of individuals found in the area were recorded and inserted in the formula to get the index value. The value of Shannon Wiener diversity Index usually range from 0 to 1. The higher the value of H', the higher the diversity of that species in that community (Zach, 2022). As for species abundance the formula that was used is as follows:

$$\text{Relative Species Abundance} = \frac{Total\ number\ of\ individual\ of\ a\ species}{total\ number\ of\ species} \times 100$$

The total number of individuals of a species found during the sampling was divided by the total number of species found and multiply by 100. The answer shows the percentage of abundance of that particular species. The value of relative species

abundance is directly proportional to the number of individuals of that species found. Higher number of individuals will give a higher percentage of species abundance.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Diversity and Distribution of Zingiberaceae at Lata Janggut, Jeli, Kelantan

Sampling of Zingiberaceae were carried out for two days at Lata Janggut, Jeli, Kelantan. Four different types of Zingiberaceae plant were found within two different trails of 500 meter from both side of Sungai Long. The plant were identified for the classification of genus and species.

The result of identification of this Zingiberaceae plants has classified that there are two species belong to genus *Etlingera* which are *Etlingera punicea* and *E. elatior*. The other two genus found are *Alpinia* and *Curcuma* and dedicated to species *Alpinia javanica* and *Curcuma longa* appropriately. Each species was tagged using GPS application Garmin GPS 64s and the coordinates are shown in Appendix A.

The distribution map was plotted using software ArcMap version 10.8. The distribution map of Zingiberaceae at Lata Janggut is shown in Figure 4.1. The common name of the Zingiberaceae species found at Lata Janggut are showed in Table 4.1 together with the tagged numbers.

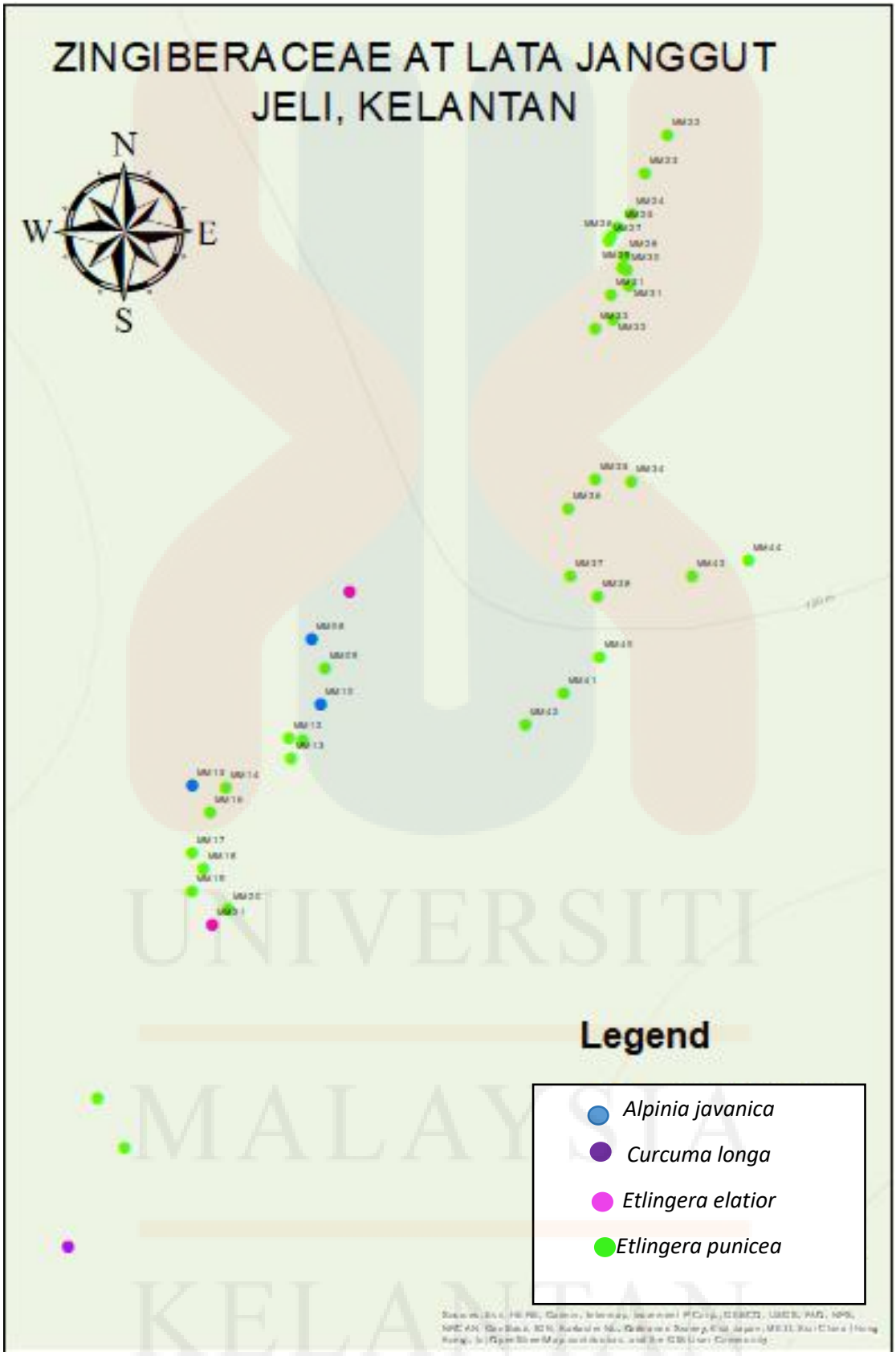

Figure 4.1: Map of Zingiberaceae Distribution at Lata Janggut, Jeli, Kelantan. Each colour shows a species as shown in the map legend.

Table 4.1: Species and Common Name of Zingiberaceae found at Lata Janggut, Jeli, Kelantan

Scientific Name	Common Name	Collector's Number
Curcuma longa	Kunyit	MM04
Etlingera elatior	Bunga Kantan	MM01, 19
Etlingera punicea		MM02, 03, 05, 06, 07, 09, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44
Alpinia javanica	Lengkuas hutan	MM08, 10, 15

4.1.1 ***Alpinia javanica* Blume (var. *javanica)***

Alpinia is a genus of flowering plant in the Zingiberaceae family. The name *javanica* is due to it was first found in Java. Then it is also recorded in Maluku, Thailand and Peninsular Malaysia (Julius, 2014). This genus is well known for its wide range of biomedical applications as the species under it possess many bio active compounds that against harmful microbes to fight cancer by regulating the different signaling pathway system (Ghosh & Rangan, 2013). *Alpinia javanica* is a native plant to Asia and its commonly known as Lengkuas Hutan for Malaysians.

This plant can grow up to 3.3 meter tall and the leaves usually 60 - 70 cm (Julius, 2014). *A. javanica* is also a inflorescence species and has a hairy structure underneath the leaves. The upper surface of the leave is glabrescent or hairless. Flower of *A. Javanica* is white with a little yellow in colour and its normally facing downwards. Before the flower bloom, they look like a bunch of fruit that is round

and green in colour about 2.5 centimeter which looks like grapes. The stem of this plant is green in colour and the rhizomes is irregular in shape and usually brownish in colour. Plant, leaves and flower of *A. javanica* that has been found during this research is shown in Figure 4.2 below.

Figure 4.2: Plant, leaves, flower and fruit of *Alpinia javanica* found at Lata Janggut, Jeli, Kelantan. (a) Plant, (b) flower, (c) fruit and (d) leaves.

A. javanica is a least concern or stable species and not listed under IUCN Red List of Threatened Species (Ardiyani, 2019). It is commonly found in an open forest, river banks and by the roadsides at lowland area (Julius, 2014). According to mybis, this species can be found in Johor, Kedah, Kelantan, Pahang, Perak, and Terengganu. In Lata Janggut, Jeli, Kelantan, there are three individual recorded at different area alongside the walking trails chosen and it is shown in blue colour point in figure 4.1 above. The distribution map of *A. Javanica* in few country in Asia is shown in the Figure 4.3 below.

Figure 4.3: Distribution map of *Alpinia javanica* as indicated by orange dots in few country in Asia, (IUCN, 2019)

4.1.2 *Curcuma longa* L.

Curcuma longa L. is a scientific name for turmeric that belong to a group of spice plants used worldwide especially in southeast Asia country. *C. longa* or commonly known as 'kunyit' by the Malaysians has been used as a medicine (its rhizomes) to cure many diseases like diabetes mellitus (Karlowicz-Bodalska *et al.*,

2017). This plant can grow to one meter in height and the leaves is oblong in shape. The upper part of the leaves is dark green with a green midrib while the below part is very light green. Its leaves can be up to 70 centimeter in length and the stem is green in colour (NParks, 2022). Its rhizome is orange in colour and the shape is usually cylindrical.

C. longa prefer an open area with full sun and also a lots of water. It can be found at open forest and also river banks. According to mybis, this plant has been found in Sabah and also Kuala Lumpur. During this research, only one individual found near the river and its height is 36 inches. Figure 4.4 below shows *C. longa* L. that is found at Lata Janggut.

Figure 4.4: *Curcuma longa* plant found at Lata Janggut, Jeli, Kelantan.

4.1.3 *Etlingera elatior* (Jack) R. M. Sm.

Etlingera elatior is a species under Zingiberaceae family and commonly known as 'bunga kantan' by the locals and it is native to Asia. This species has been use as food flavouring by the Asians as it has an aromatic smell. Besides being used to cook, it also has a medicinal importance. A study done by Jackie *et al*., (2011) shows that *E. elatior* has an antioxidant effect against lead.

The height of this plant range from 3-6 meter and the stem is green in colour. It can be found in a secondary forest normally at expose habitat and also damp places near river (Poulsen, 2006). Its leaves shape is lanceolate, it is dark green in colour and it has an aromatic smell. Flower of *E. elatior* is pink in colour. According to mybis this species has been recorded in Johor, Selangor, Kuala Lumpur and Sabah. There are two individuals of *Etlingera elatior* found at Lata Janggut. Figure 4.5 below shows the plant of *E.elatior* found at Lata Janggut.

Figure 4.5: Plant of *Etlingera elatior* found at Lata Janggut, Jeli, Kelantan.

4.1.4 *Etlingera punicea* (Roxb.) R. M. Sm.

Elingera punicea is categorized as a robust perennial herbs and it can grow up to seven meter in height. It has underground rhizomes and has been cultivated by locals for food and also medicine (Fern *et al*., 2022). It is a native plant with red and slight yellow colour flower. The flower can be found on the ground near the plant. This plant prefers a shady to full sun area. According to KEW's Royal Botanic Garden, this plant prefers a wet tropical biome. This can be seen during the research where most of this plant was found near the river banks. The distribution of *E. punicea* in Malaysia is shown in the Figure 4.6 below.

Figure 4.6: Distribution of *Etlingera punicea* as indicated by orange dots in Malaysia (Saw, 2019)

There are a lot of this plant species found at Lata Janggut, however there are no flower found. This is maybe due to this flower only bloom for a few periods of time (Appalasamy & Arumugam, 2020). The distribution of *E. punicea* at Lata Janggut is shown in figure 4.1 above in the green colour dots. From the map, it is shown that this species has more than 30 individuals. Figure 4.7 below shows the plant of *E. punicea* found at Lata Janggut, Jeli, Kelantan.

Figure 4.7: Plant of *Etlingera punicea* found at Lata Janggut, Jeli, Kelantan.

4.2 Diversity and distribution of Zingiberaceae at Lata Renyuk, Jeli, Kelantan.

Three days were dedicated to Zingiberaceae sampling in Lata Renyuk, Jeli, Kelantan. Within three separate paths spanning 500 meters on either side of Sungai Renyok, five distinct species of Zingiberaceae plants were discovered. The plant was identified in order to classify its species and genus.

The result of identification of this Zingiberaceae plants has classified that there are three species belong to genus *Etlingera* which are *Etlingera punicea, Etlingera megalocheilos* and *Etlingera elatior*. The other two species found is from the genus *Alpinia* which dedicated to species *Alpinia javanica* and *Alpinia galanga* appropriately. Each species was tagged using GPS application Garmin GPS 64s and the coordinates are shown in Appendix A.

The distribution map was plotted using software ArcMap version 10.8. The distribution map of Zingiberaceae at Lata Janggut is shown in figure 4.8. The

common name of the Zingiberaceae species found at Lata Janggut are showed in table 4.2 together with the tagged numbers. .

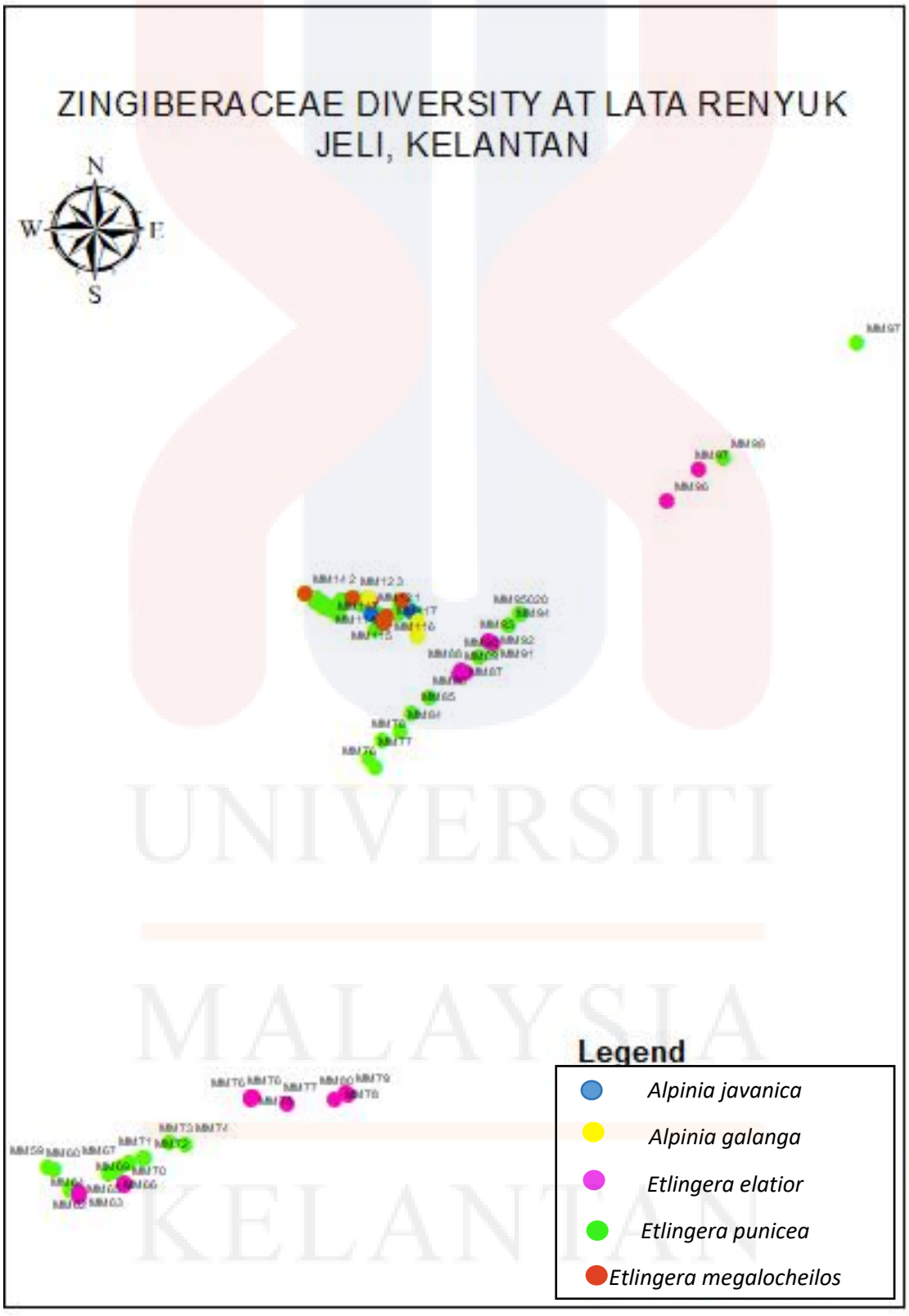

Figure 4.8: Distribution map of Zingiberaceae at Lata Renyuk, Jeli, Kelantan.

Table 4.2: Species and Common Name of Zingiberaceae found at Lata Renyuk, Jeli, Kelantan

Scientific Name	Common Name	Collector's Number
Alpinia galanga	Lengkuas	MM102,103,104,120
Etlingera elatior	Bunga Kantan	MM87,88,89,92,93,96,97
Etlingera punicea		MM101,105,107,108,110,111,112,113, 122,124,125,126,127,128,129,130,131, 132,133,134,135,136,137,138,139,140, 141,142
Alpinia javanica	Lengkuas Hutan	MM106,119
Etlingera megalocheilos	Kantan liar	MM109,114,115,116,117,117,121,123, 143

4.2.1 *Etlingera megalocheilos* (Griff.) A. D. Poulsen.

Etlingera megalocheilos is also known as 'kantan liar' and it is native to Malaysia. The distribution of this species has been recorded in Peninsular Malaysia (Khaw, 2001; Poulsen, 2007), Sumatra (Poulsen, 2007), Java (Poulsen, 2007) and Borneo (Poulsen, 2006; Poulsen, 2007). According to mybis, this species has been recorded in Kelantan and Selangor. This species is listed as least concern under the International Union for Conservation of Nature (IUCN). The distribution map of *E. megalocheilos* in Malaysia is shown in figure 4.9.

Figure 4.9: Distribution of *Etlingera megalocheilos* as shown by orange dots in Malaysia (Poulsen & Olander, 2019)

The plant that found at Lata Renyuk is mostly 50 centimeter to 1.7 meter in height. It is found about 1.5 meter near the river and the area is shady. Stem of this plant is green in colour and the leaves has a medicated oil like smell. Flower of this plant can be found on the ground near the plant. The flower is bright red colour. There are about nine individual of this species found at Lata Renyuk, Jeli, Kelantan. Only two flower of this species found during this research. The picture of plant and flower of *Etlingera megalocheilos* found at Lata Renyuk, Jeli, Kelantan is shown in figure 4.10 below.

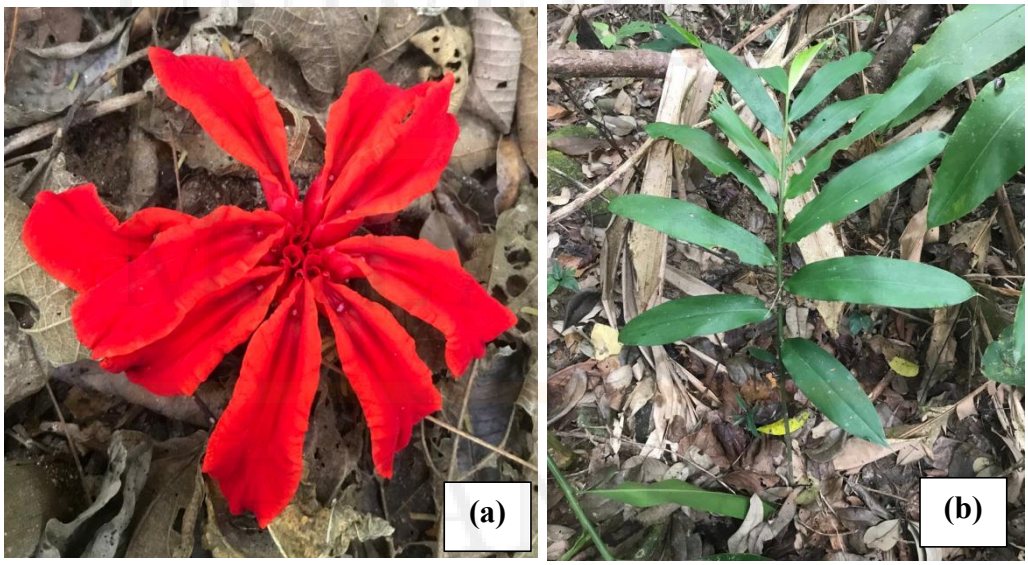

Figure 4.10: Plant and flower of *Etlingera megalocheilos* found at Lata Renyuk, Jeli, Kelantan. (a)flower of *Etlingera megalocheilos* and (b) Plant of *Etlingera megalocheilos.*

4.2.2 *Alpinia galanga* (L.) Wild.

Alpinia galanga or commonly known as 'lengkuas' by Malaysians is a native plant to our country. It is also known as Siamese ginger. Its rhizomes is use by many people as a flavoring in some dishes. The rhizome is underground, highly branched and red to light yellow in colour. This plant can grow up to 3.5 meter in height (NParks, 2024). The plant found at Lata Renyuk is just four individuals and it is young as there is no rhizomes found. It also has a fragrant, yellow-white flowers that occur in large cluster on a spike- like or racemose inflorescence (10-30 centimeter long, 5-7 centimeter wide) (NParks, 2024). During this research there are no flower found. According to India Biodiversity Portal, the flowering season of *Alpinia galanga* is during April-December. The plant picture of this species found at Lata Renyuk is shown in figure 4.11 below.

Figure 4.11: Plant of *Alpinia galanga* found at Lata Renyuk, Jeli, Kelantan.

4.2.3 *Etlingera elatior* (Jack) R. M. Sm.

Etlingera elatior or commonly known as bunga kantan is a plant that can live in a full sun, semi shade area and require a lot of water (NParks, 2024). It is a herbaceous plant and it is autothrophic plant. This plant normally grows in large colonies. This plant is widely distributed in Malaysia. According to mybis, it was recorded in Johor, Sabah, Kuala Lumpur and Selangor. The distribution map of E.elatior in these country is shown in figure 4.12 below. It is labeled as data deficient under the International Union for Conservation of Nature (IUCN).

Figure 4.12: Distribution of *Etlingera elatior* in Malaysia (mybis, 2024)

There are a lot of *Etlingera elatior* plant found at Lata Renyuk, Jeli, Kelantan. This may be due to some of the sampling areas being near housing area of the locals there. A few *E. elatior* flower were found during the sampling. The young flowers that are spear-head in shape and light pink in colour were found. The fruiting head that is globular in shape also has been found. The picture is shown in Figure 4.13 below. All the plants found grows in a large colonies and most of them grows in a full sun area as mentioned in the NParks website.

Figure 4.13: *Etlingera elatior* plant, fruit and flower found at Lata Renyuk, Jeli,Kelantan. (a)Plant of *Etlingera elatior*, (b)Fruit of *Etlingera elatior,* (c)Young flower of *Etlingera elatior and* (d) Flower of *Etlingera elatior*

4.3: Comparison of Species Diversity and Abundance of Zingiberaceae at Lata Janggut and Lata Renyuk.

Based on the data collected, the species diversity of Zingiberaceae at both places was calculated using Shannon-Wiener diversity index formula. The diversity of plants are calculated and expressed by the Shannon-Wiener diversity index (H'). The index of species diversity of Zingiberaceae at Lata Janggut is H'= 0.53623 and Lata Renyuk is H'= 1.01284. According to Zach (2022), higher value of H' shows a higher diversity. Lata Renyuk has a higher species diversity of Zingiberaceae

compared to Lata Janggut. On the other hand, the diversity of Zingiberaceae at both Lata Janggut and Lata Renyuk is much lower compared to natural trail of Lojing Highland, Kelantan where seven genus were recorded by Appalasamy *et al*., (2020). This could be due to Lata Janggut and Lata Renyuk has been access by people compared to Lojing Highland. This statement was supported by Sivarajah & Linatoc, (2021), that forest which has been explored by human may have less species diversity compared to undisturbed area.

Moreover, based on some videos and articles in social media, has showed that Lata Renyuk has been explored by 2020 means while for Lata Janggut was published from 2013 onwards. Therefore, Lata Renyuk is not much explored by people except by the locals there compared to Lata Janggut. This may contribute to a higher species diversity at Lata Renyuk compared to Lata Janggut. Besides the diversity of plants, several other studies were carried out at Lata Janggut including comparison of heavy metal quality at Lata Janggut and Lata Keding (Abdul Malek *et al*., 2020), Benthic macro-invertebrates diversity and composition at Lata Janggut recreational area, Kelantan, Malaysia (Aweng *et al*., 2021) and others. These may contribute to the disturbance to diversity of plants in Lata Janggut.

The relative species abundance of each species found at Lata Janggut and Lata Renyuk is shown in table 4.3 and 4.4 below. Relative species abundance is directly proportional to the number of each species. The data showed that *E. punicea* is the highest relative species abundance at Lata Janggut and Lata Renyuk where the percentage are 86.36% and 66.33% respectively. The *E.punicea* was previously reported by Appalasamy *et al*., (2020) will be well growth at wet soil condition which is the same as the sampling area that is near the river. The abundance of *E.*

punicea is also high in other places in Kelantan such as Lojing Highland (Appalasamy *et al*., 2020) and Limestone Forest of Kelantan (Appalasamy *et al.*, 2022).

The abundance of *E. elatior* at Lata Janggut is lower compared to Lata Renyuk. This could be due to the sampling area at Lata Renyuk is nearby housing area while Lata Janggut is near a recreational area. The abundance of *A. javanica* is higher at Lata Janggut that is 6.82% compared to Lata Renyuk only 2.04%. This species were also recorded in other place in Kelantan such as Gua Setir (Appalasamy *et al*., 2022).

There were two species of Zingiberaceae that only found at Lata Renyuk *E. megalocheilos* and *A. galanga*, the species abundance are 9.18% and 4.08% respectively. Three individuals of *E. megalocheilos* was recorded by Appalasamy *et al*., (2020) at Lojing Highland, Kelantan and this species is also recorded by Mohd Darus & Norfatin Fazlyn, (2020) at Agro Techno Park of University Malaysia Kelantan, Jeli campus. This shows that Lata Renyuk has a higher abundance of *E. megalocheilos* where nine individuals found with flowers compared to Lojing Highland.

Table 4.3: Species Abundance of Zingiberaceae at Lata Janggut, Jeli, Kelantan.

LATA JANGGUT		
Scientific Name	Number of Individual	Relative Species Abundance (%)
Alpinia javanica	3	6.82
Etlingera elatior	2	4.55
Curcuma longa	1	2.27
Etlingera punicea	38	86.36
Total	44	100.00

Table 4.4: Species Abundance of Zingiberaceae at Lata Renyuk, Jeli, Kelantan.

LATA RENYUK		
Scientific Name	Number of Individual	Relative Species Abundance (%)
Alpinia javanica	2	2.04
Etlingera elatior	18	18.37
Alpinia galanga	4	4.08
Etlingera punicea	65	66.33
Etlingera megalocheilos	9	9.18
Total	98	100.00

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From the result it shows that the genus *Alpinia*, *Etlingera* and *Curcuma* is widely distributed in Jeli district. This wild ginger usually can be found at different habitat including lowland and high elevation area. Most of the individuals found are at the riverbanks, humid and shady area. There are some species that can tolerate high temperature or expose to direct sunlight. This wild ginger species also can be found at secondary forest like this study area.

Finally, the distribution map of Zingiberaceae diversity at Lata Janggut and Lata Renyuk, Jeli, Kelantan has been generated by using ArcGis version 10.8. The Shannon-Wiener diversity index and also species abundance has been determined.

5.2 Recommendation

It is recommended to carryout this kind of study at various area that has not been recorded yet. For the next study, a wider sampling size will help to improve the data and provide a better understanding of Zingiberaceae plants. The increment in days of sampling also give a better result and it can covers more area of the selected places.

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APPENDIX A

Appendix A: Appendix A shows species name of Zingiberaceae, longitude and latitude coordinate to map the distribution of Zingiberaceae at Lata Janggut and Lata Renyuk, Jeli, Kelantan.

Species Name	Longitude Decimal Degree	Latitude Decimal Degree
E.elatior	101.770149	5.670348
E.elatior	101.76982	5.669547
E.elatior	101.87541	5.578803
E.elatior	101.87542	5.578794
E.elatior	101.875907	5.578624
E.elatior	101.875908	5.578596
E.elatior	101.876169	5.578681
E.elatior	101.876171	5.578663
E.elatior	101.876916	5.579175
E.elatior	101.876919	5.579182
E.elatior	101.876929	5.579191
E.elatior	101.877139	5.579154
E.elatior	101.877419	5.579171
E.elatior	101.8775	5.579201
E.elatior	101.877488	5.579213
E.elatior	101.878154	5.581687
E.elatior	101.878169	5.581721
E.elatior	101.878187	5.581708
E.elatior	101.878349	5.581874
E.elatior	101.878331	5.581895

E.elatior	101.879383	5.582715
E.punicea	101.770094	5.670163
E.punicea	101.77004	5.669988
E.punicea	101.770005	5.669996
E.punicea	101.770011	5.669948
E.punicea	101.769854	5.669875
E.punicea	101.769814	5.669818
E.punicea	101.769774	5.669718
E.punicea	101.769797	5.669682
E.punicea	101.769772	5.669628
E.punicea	101.769861	5.669586
E.punicea	101.76982	5.669547
E.punicea	101.770913	5.671441
E.punicea	101.77086	5.671353
E.punicea	101.770826	5.671252
E.punicea	101.770797	5.671223
E.punicea	101.770777	5.671198
E.punicea	101.770773	5.671187
E.punicea	101.770808	5.671153
E.punicea	101.770807	5.671124
E.punicea	101.770818	5.67112
E.punicea	101.770819	5.671081
E.punicea	101.770777	5.671059
E.punicea	101.770781	5.670998

E.punicea	101.770742	5.67098
E.punicea	101.770827	5.670611
E.punicea	101.770738	5.670616
E.punicea	101.770676	5.670544
E.punicea	101.770748	5.670382
E.punicea	101.770748	5.670334
E.punicea	101.770752	5.67019
E.punicea	101.770667	5.670102
E.punicea	101.770573	5.670027
E.punicea	101.770974	5.670382
E.punicea	101.771106	5.670419
E.punicea	101.769546	5.669129
E.punicea	101.769609	5.669009
E.punicea	101.769327	5.668451
E.punicea	101.76923	5.66766
E.punicea	101.768748	5.667484
E.punicea	101.877901	5.582056
E.punicea	101.877799	5.582088
E.punicea	101.877839	5.582108
E.punicea	101.877802	5.582118
E.punicea	101.877667	5.582055
E.punicea	101.877667	5.582047
E.punicea	101.877661	5.581957
E.punicea	5.582106	5.582106

E.punicea	101.877531	5.582147
E.punicea	101.877478	5.582127
E.punicea	101.877475	5.58212
E.punicea	101.87746	5.582133
E.punicea	101.877459	5.582127
E.punicea	101.877437	5.582054
E.punicea	101.877408	5.582094
E.punicea	101.877393	5.582073
E.punicea	101.87741	5.582074
E.punicea	101.877399	5.582074
E.punicea	101.877423	5.582055
E.punicea	101.87739	5.582076
E.punicea	101.877395	5.582077
E.punicea	101.877352	5.582089
E.punicea	101.877342	5.582116
E.punicea	101.877343	5.582112
E.punicea	101.877309	5.582144
E.punicea	101.877308	5.582112
E.punicea	101.877295	5.582126
E.punicea	101.877248	5.58217
E.punicea	101.8778	5.581359
E.punicea	101.877876	5.581464
E.punicea	101.877982	5.581563
E.punicea	101.878271	5.581795

E.punicea	101.878347	5.581853
E.punicea	101.878444	5.581983
E.punicea	101.878514	5.582046
E.punicea	101.878518	5.582046
E.punicea	101.879717	5.58297
E.punicea	101.880869	5.583772
E.punicea	101.881418	5.583414
E.punicea	101.881473	5.583377
E.punicea	101.875332	5.57959
E.punicea	101.875331	5.579587
E.punicea	101.875347	5.579567
E.punicea	101.875309	5.579545
E.punicea	101.875214	5.579009
E.punicea	101.875233	5.57901
E.punicea	101.87523	5.578996
E.punicea	101.875255	5.579002
E.punicea	101.875327	5.578926
E.punicea	101.875326	5.578934
E.punicea	101.87533	5.578937
E.punicea	101.875346	5.578925
E.punicea	101.875372	5.578927
E.punicea	101.875712	5.578775
E.punicea	101.875755	5.578763
E.punicea	101.875867	5.578647

E.punicea	101.875854	5.578643
E.punicea	101.876083	5.578737
E.punicea	101.876115	5.578749
E.punicea	101.876145	5.578776
E.punicea	101.876198	5.578794
E.megalocheilos	101.877814	5.582138
E.megalocheilos	101.877707	5.582002
E.megalocheilos	101.877717	5.582014
E.megalocheilos	101.877714	5.581996
E.megalocheilos	101.877719	5.582042
E.megalocheilos	101.877699	5.582009
E.megalocheilos	101.877628	5.582133
E.megalocheilos	101.877526	5.582146
E.megalocheilos	101.877244	5.582171
A.javanica	101.877631	5.582047
A.javanica	101.877866	5.582071
A.javanica	101.770059	5.670233
A.javanica	101.770079	5.670078
A.javanica	101.769774	5.669879
A.galanga	101.877915	5.582012
A.galanga	101.877915	5.581922
A.galanga	101.877901	5.581984
A.galanga	101.877612	5.582146
C.longa	101.769473	5.668775