Diversity of Family Zingiberaceae at Lata Hokkaido and Lata Keding, Jeli, Kelantan

by

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A report submitted in fulfilment of the requirements for the Degree of Bachelor of Applied Science (Natural Resources Science) with Honors

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DECLARATION

I declare that this thesis entitled " Diversity of Family Zingiberaceae at Lata Hokkaido and Lata Keding, 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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Date : 27/7/2024

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Diversity of Family Zingiberaceae at Lata Hokkaido and Lata Keding

ABSTRACT

This study delves into the diversity of the Zingiberaceae family within Lata Hokkaido and Lata Keding, Jeli, Kelantan. Its primary aim is to assess species diversity and abundance in these locations. Employing random sampling methodology, trails spanning 1000 meters were traversed each day, with precise location tagging facilitated by Garmin GPS 64s over a two-day period in each area. Results depict *Alpinia* sp.3 as the dominant species in Lata Hokkaido, boasting 60 individuals, while *Curcuma longa* and *Alpinia* were less represented. Conversely, *Alpinia javanica* emerges as the most abundant species in Lata Keding, whereas *Globba* sp. 1 is the least represented. Notably, *Alpinia* sp.3 and *Alpinia javanica* assert their dominance within their respective habitats, with a moderate overall diversity illustrated by Shannon-Wiener Index values. This research underscores the significance of biodiversity conservation, offering crucial insights into preserving the region's rich flora. Future investigations may explore additional factors influencing species distribution and abundance, alongside assessing the long-term impacts of environmental changes on Zingiberaceae populations in Jeli, Kelantan.

Kepelbagaian Keluarga Zingiberaceae di Lata Hokkaido dan Lata Keding

ABSTRAK

Kajian ini menyelidiki kepelbagaian keluarga Zingiberaceae dalam Lata Hokkaido dan Lata Keding, Jeli, Kelantan. Matlamat utamanya adalah untuk menilai kepelbagaian dan kelimpahan spesies di lokasi ini. Menggunakan metodologi pensampelan rawak, denai sepanjang 1000-meter dilalui setiap hari, dengan penandaan lokasi yang tepat difasilitasi oleh Garmin GPS 64s dalam tempoh dua hari di setiap kawasan. Keputusan menggambarkan *Alpinia* sp.3 sebagai spesies dominan di Lata Hokkaido, mempunyai 60 individu, manakala *Curcuma longa* dan *Alpinia* kurang diwakili. Sebaliknya, *Alpinia javanica* muncul sebagai spesies yang paling banyak di Lata Keding, manakala *Globba* sp. 1 adalah yang paling kurang diwakili. Terutama, *Alpinia* sp.3 dan *Alpinia javanica* menegaskan penguasaan mereka dalam habitat masing-masing, dengan kepelbagaian keseluruhan sederhana yang digambarkan oleh nilai Indeks Shannon-Wiener. Penyelidikan ini menggariskan kepentingan pemuliharaan biodiversiti, menawarkan pandangan penting untuk memelihara flora yang kaya di rantau ini. Penyiasatan masa depan mungkin meneroka faktor tambahan yang mempengaruhi taburan dan kelimpahan spesies, di samping menilai kesan jangka panjang perubahan alam sekitar terhadap populasi Zingiberaceae di Jeli, Kelantan.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

GPS	Global Positioning System
GIS	Geographical Information System
Cm	Centimeter
M	Meter

LIST OF SYMBOLS

∑	Total
( )	Parentheses
%	Percentage
÷	Division
×	Multiply
+	Addition

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The Zingiberaceae family, also known as the ginger family, is the largest family within the Zingiberales order, comprising over 52 genera and 1600 species. These fragrant herbs with creeping horizontal or tuberous rhizomes are found widely across tropical Africa, Asia, and the Americas (Van Balgooy, 2001, and Kress et al., 2005). Botanists have been interested in this family since the Linnean era due to its significant role in providing spices, medicine, cosmetics, and ornamental plants for human use (Newman et al., 2004; Thomas et al., 2015).

Lata Keding is one of the newly developing recreational areas in Jeli. It is in Bukit Kudung Jeli, Kelantan, near Kampung Gemang, Gemang subdistrict, and bordered by the East-West Highway in the north-western corner of Kelantan. It holds various natural and historical treasures. The stunning waterfall, the new recreational area and the resort make Lata Keding famous not only for people around but for tourists. Other than that, Bukit Kudung used to be a stronghold and hiding place for the communists in the past, many still unknown. Behind the beauty of Bukit Kudung, which is 480 meters high, there is also a border stone known as Batu 73, which borders Thailand for 2.3 kilometres (Sulaiman et al.,2023).

1.2 Problem Statement

The most recent publication for the families Zingiberaceae in Peninsular Malaysia was made by Appalasamy et al. in 2022. Ten species of Zingiberaceae have been identified, with research done in Kampung Lati, Pasir Mas, Bukit Tiu, Machang, Kelantan. This research will be conditioned to find out the latest knowledge of Zingiberaceae in Lata Hokkaido and Lata Keding Jeli, Kelantan.

1.4 Objectives

- To determine the species diversity from family Zingiberaceae in Lata Hokkaido and Lata Keding
- To compare the species diversity and abundance for Zingiberaceae

1.5 Scope of Study

The research took place within the confines of Lata Hokkaido and Lata Keding, waterfalls located in the district of Jeli, which is in the state of Kelantan, Malaysia. Jeli was situated in the northeastern part of Peninsular Malaysia, bordering Thailand. The investigation assessed the conservation status of Zingiberaceae species in these areas, including any threats they faced from habitat loss, degradation, or human activities. By evaluating the conservation status of Zingiberaceae populations, the study aimed to provide valuable information for the development of effective conservation strategies and management plans to protect these important plant species and their habitats.

1.6 Significant of Study

There were many advantages to studying the diversity of Zingiberaceae in Lata Hokkaido and Lata Keding, particularly in terms of conservation. It was easier to identify and safeguard rare or endangered species when one was aware of the diversity of plants in the area. This helped with efforts to conserve biodiversity in an indirect way. In addition, examining the distribution taught us about the Zingiberaceae plant family's preferred habitat, which helped us understand habitat management and restoration techniques. Finally, some species in the Zingiberaceae family, like Alpinia Roxb (Warrier, 1995), had important medicinal properties for humans (Go, 2019) (Burkill, 1966).

CHAPTER 2

LITERATURE REVIEW

2.1. Family Zingiberaceae in Peninsular Malaysia

Malaysia is a nation with a great deal of diversity. Plants come in about 8,300 different species. One of the largest families in the kingdom of plants is Zingiberaceae (Sam, 2018). When it comes to Zingiberaceae species, Malaysia is among the richest nations in Southeast Asia. Approximately 51 genera and 1600 species make up the Zingiberaceae family, which is primarily found in tropical regions of Asia, Africa, and the Americas (Christenhusz and Byng, 2016). The world's richest diversity of Zingiberaceae is currently found in the Malesian floristic region, which includes Malaysia, Indonesia, Brunei, Singapore, the Philippines, and Papua New Guinea (Larsen et al., 1999). The Zingiberaceae family, also known as the ginger family, is an intriguing group of flowering plants that includes 57 genera, six tribes, and four subfamilies. More than 1960 species of this family are distributed throughout tropical and subtropical regions of the world, including Asia, Africa, and the Americas. Southeast Asia, however, has the greatest species diversity (Larsen, 2006). Although Zingiberaceae plants can thrive in a range of ecological settings, they are most frequently found in moist and tropical rainforests.

Certain species are found in arid regions with direct sunlight, but they are found in warm, humid biomes with plenty of rainfall and enough shade. According to Newman et al., (2015), the family contains both terrestrial and epiphytic species. The Zingiberaceae family of plants is widely recognised for its exceptional biodiversity and comprises some of the most important and commercially valuable plants, which come in a variety of hues, forms, and sizes. Furthermore, they have been used for a variety of purposes, and human cultures—particularly those in Southeast Asia—have passed down knowledge of their use for generations (Wong et al, 1999).

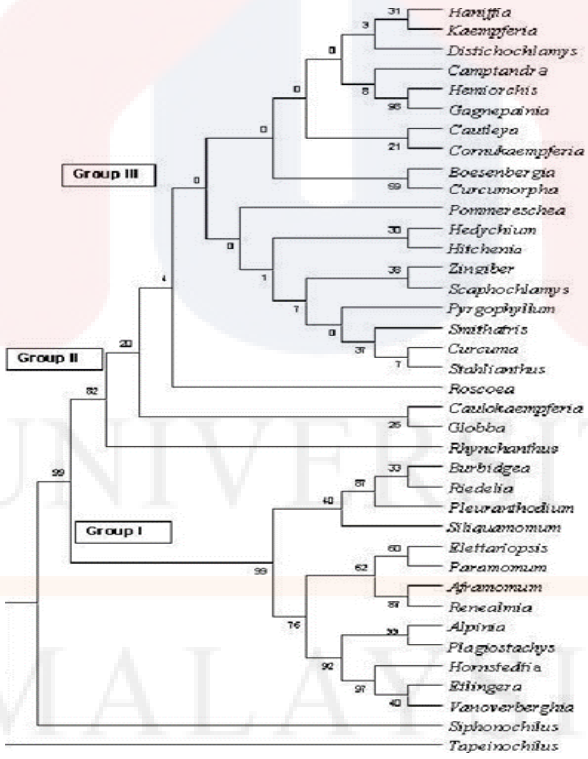

Figure 2 Phylogenetic tree of family Zingiberaceae (Selvaraj et al., 2008)

The derived eumonocots (Arecales, Commelin-ales, Poales) are positioned within the primarily tropical Zingiberales in terms of their phylogenetic relationship. The Zingiberales order includes several notable taxa such as gingers (Zingiberaceae), heliconias (Heliconiaceae), bananas (Musaceae), and birds of paradise (Strelitziaceae). Within this order, the Zingiberaceae family stands out as the largest, with over 1200 species and 53 genera (Kress, 1990). The family Costaceae was previously classified within the Zingiberaceae in earlier taxonomies (Petersen, 1889, and Schumann, 1904) but is now recognized as a separate clade closely related to gingers due to distinct characteristics (Kress, 1990, and Kress et al., 2001).

The Zingiberaceae family exhibits a pantropical distribution, with one genus, Renealmia, located in the Neotropics, four genera (Aframomum, Aulotandra, Siphonochilus, and Renealmia) found in Africa, and the remaining genera distributed across East Asia and the Pacific Islands. Despite numerous species (Theilade and Mood, 1997; Sakai and Nagamasu, 1998; Poulsen, Mood, and Ibrahim, 1999; Williams, Kress, and Thet Tun, 2002) and even genera (Newman, 1995; Mood and Larsen, 1997; Larsen and Mood, 1998; Sakai and Nagamasu, 2000; Kress and Larsen, 2001; Larsen and Jenjittikul, 2001) being described in recent years, the taxonomy of this family remains poorly understood.

The Zingiberaceae family is currently classified into four tribes based on both vegetative and floral characteristics. These tribes include Hedychieae, consisting of 22 genera, Alpinieae with 25 genera, Zingiberaceae with one genus, and Globbeae with four genera (Petersen, 1889; Schumann, 1904; Holttum, 1950; Burtt and Smith, 1972; Larsen et al., 1998). While various morphological traits have been used to distinguish between these four tribes, the distinguishing characteristics are not always exclusive to a particular tribe nor universally applicable to all taxa within a tribe. For example, in the Alpinieae tribe, the plane of leaf arrangement is parallel to the rhizome in most cases (except for Siliquamomum in the Hedychieae) but perpendicular to the rhizome in genera like Rhynchanthus and Pommereschea. Similarly, the ovary is partially unilocular in certain members of the Globbeae tribe like Caulokaempferia, Paracautleya, Scaphochlamys, Siphonochilus, and Riedelia, but unilocular in all other members of the Globbeae family, with a few exceptions (Larsen et al., 1998; Sakai and Nagamasu, 2000).

2.1.1 Morphology of Zingiberaceae

As per Christenhusz and Byng (2016), the Zingiberaceae is an aromatic perennial herb characterized by a pseudo-stem, a single leaf, and inflorescences with distinctive shapes and colors (Irayanti and Yadnya-Putra, 2020). Additionally, it possesses bulbous rhizomes that horizontally creep within the soil (Pitopang et al., 2019). These rhizomes from the Zingiberaceae family have widespread applications in various domains, including food, spices, cosmetics, traditional medicine, dyes, perfumes, and ornamental plants (Saensouk and Saensouk 2021; Trimanto et al., 2018).

The majority of Zingiberaceae members contain a diverse array of bioactive compounds with pharmacological properties, making them valuable in medicinal contexts. These compounds encompass antibacterial qualities (Irayanti and Yadnya-Putra 2020), hepatoprotective effects (Jagtap 2015), anti-inflammatory properties (Sikha et al., 2015), antiviral activity (Pant et al. 2013), antidiabetic potential (Nwozo et al. 2014), anticancer attributes (Pawar et al. 2011), hypocholesterolemic effects (Shafreen et al., 2018), antirheumatic benefits (Abdel-Lateef et al. 2016), antifibrotic actions (Jose et al. 2014), gastroprotective properties (Jeon et al., 2015), as well as antioxidative, cardioprotective, antiarrhythmic, and neuroprotective effects (Nithya and Jayshree 2017). In the realm of taxonomy, morphological characteristics have been extensively employed to facilitate the description and identification of plants (Zahara 2020 and Hassemer et al., 2020). Plant taxonomy historically categorizes plant groups based on their morphological traits, which enable the study of a plant's origins, growth, and physical characteristics (Viscosi and Cardini 2011).

Qualitative and quantitative descriptions and observations of morphological features, such as leaf blade shape and length, can be made to identify, describe, classify, and resolve taxonomic puzzles (Iroka et al. 2015). Morphological characteristics can vary between plant species, including members of the same species (Susetyarini et al., 2020). Notably, differences are often observed in leaves, stems, and flowers, influenced by factors like position, environment, and developmental stage (Iroka et al., 2015). In many instances, morphological features differentiate between juvenile and mature plants due to the evolving and imperfect morphological structures in young plants (Susetyarini et al., 2020).

Some Zingiberaceae species discovered in Gunung Telapak Burok are relatively rare, with fewer than five known localities, as depicted in Figure 2.1. H. *cyanescens*, for instance, was initially identified and described in Negeri Sembilan in 1903 (Ridley, 1922). It is typically found on the slopes and ridges of Bukit Tangga, with infrequent flowering occurrences in Gunung Telapak Burok. This rarity can be attributed to its limited naming history, as only three species have been named so far, and its concealed flowers, hidden beneath the forest litter (Abdullah et al., 2019). Furthermore, the rhizome of H. cyanescens exhibits a distinct purple hue, contrasting with the typical brown coloration of wild ginger rhizomes. Conservation efforts, as noted by Appalasamy et al. (2014), often serve as a preliminary step for more comprehensive research endeavors, including the exploration of potential antimicrobial extracts from lesser-studied wild plants, documentation of traditional knowledge, and investigation into medicinal properties.

Figure 2.1 Some of the Zingiberaceae species found in Gunung Telapak Burok, Gunung Berembun Forest Reserve, Negeri Sembilan. A: *Camptandra ovata*, B: *Alpinia vitellina*, C: *Wurfbainia uliginosa*, D: *Zingiber longibracteatum*, E: *Meistera ochrea*, F: *Conamomum utriculosum* (Appalasamy et al., 2020)

2.1.2 Importance of Zingiberaceae for Medicinal Use

Alpinia conchigera, sometimes referred to as "lengkuas genting" in the local dialect, is a plant that grows up to 12 metres tall. According to reports, this species in Peninsular Malaysia produces the smallest flowers of all the species in the genus *Alpinia* (Ibrahim et al., 2007). The rhizome will be ground into a paste, which can be applied topically to treat bone pain. By treating fungal infections on the skin, the paste and kerosene combination helps (Ong and Nordiana, 1999). Rhizome extract and water combined have the potential to lessen dysmenorrhea. Rhizome extract and fresh milk are often combined and consumed in the morning as energy drinks. *Alpinia galangal*, an herb that grows up to three metres tall, is referred to as "lengkuas" locally. The Kelantan community frequently uses the rhizome of this species in cooking, as in the "singgang ikan" dish. The leaves can be a component of a beverage meant to alleviate diarrhoea. Throughout the confinement period, the leaves can also be combined with other herbs, like *pandanus amaryllifolius*, to be used as a postnatal treatment (Nor Syahaiza and Appalasamy, 2021). The spice known as "buah pelaga," or *Amomum kepulaga*, is frequently used in cooking. Fruit consumption helps reduce nausea, and a fruit and clove combination help lessen the addiction to smoking (Rusdi et al., 2019). The species above are well known for various purposes such as spices, medicines, and ornamental plants as shown in Table 1.

Table 1 Species, local name by Kelantan people and traditional uses of ginger species found in Kelantan (Appalasamy et al., 2022).

Herbarium Specimen No.	Scientific Name	Local Name	Traditional Uses
NSAZ001	*Alpinia conchigera*	Lengkuas genting	Bone ache, fungal infection (panau). dysmenorrhea Spice, anti-inflammatory, diarrhoea Spice, prevent nausea, reduce smoking addiction
NSAZ002	*Alpinia galanga*	Lengkuas	Spice, diabetes, stomachache, fungal infection, postna treatment
NSAZ003	*Amomum kepulaga*	Buah pelaga	reduce smoking addiction
NSAZ004	*Curcuma longa*	Kunyit	Colouring, stomachache, postnatal treatment, anti- inflammatory
NSAZ005	*Curcuma xanthoriza*	Temulawak	Yellow fever, hepatitis, stomach ulcers, anti- inflammatory, pimple
NSAZ006	*Elettariopsis curtisi*	Pepijat	Postnatal treatment
NSAZ007	*Kaempferia galanga*	Cekur	Postnatal treatment, swelling, itchiness
NSAZ008	*Gastrochilus panduratun*	Tepus sehelai setahun	Postnatal treatment
NSAZ009	*Zingiber officinale*	Halia	Spice, diabetes, stomachache, fungal infection, postnatal treatment
NSAZ010	*Zingiber zerumbet*	Lempoyang	Postnatal treatment, anemia, joint ache, hypertension

The *Alpinia* Roxb genus is primarily located in the Indo-Pacific region (Sabu, 2006). Its rhizomes, rich in essential oils, are used as a carminative and for bronchial issues. They are also a component of medicated "Pān," a remedy for soothing sore throats and eliminating bad breath (Warrier, 1995). In Ayurveda, there are two preparations, "Rāsnā saptaka kvātham" and "Rāsnā -adikāmath," known for their anti-inflammatory properties (Thakur et al., 1989). Furthermore, Thakur et al. (1989) mentions its role as a cardiac stimulant carminative in "Arq Pan." Additionally, these rhizomes are beneficial in the treatment of rheumatoid arthritis, inflammations, dyspepsia, stomach pain, obesity, diabetes, headaches, tubercular glands, cough, asthma, hiccups, and imbalances related to the vata and kapha doshas. Caraka includes *Rāsnā (Alpinia)* in the *Vayaḥsthāpana Varga*, a category of drugs known for maintaining youthful vigor and strength (Joy et al., 1998).

According to Saji and Sasikumar (2004), *C. amada Roxb*'s name originates from the Bengali term for "mango ginger," which aptly describes the rhizome's distinct mango-like flavor. Since the time of the *Caraka Samhita* (Gupta et al., 2010), these rhizomes have been widely employed in Ayurveda and other traditional medicines (Moon et al., 2010). The rhizomes exhibit a range of properties, including bitterness, sweetness, sourness, aroma, cooling effect, appetizing quality, carminative action, digestive aid, stomachic nature, demulcent properties, vulnerary effects, fever-reducing abilities, alexertic attributes, aphrodisiac qualities, laxative potential, diuretic properties, expectorant action, anti-inflammatory characteristics, and antipyretic effects (Warrier et al., 1995). Additionally, the rhizome can intensify amphetamine toxicity, possesses hypothermic and central nervous system (CNS) activity, and is effective against *Vibrio cholerae*. It also functions as a trypsin inhibitor (Hussain et al., 1992). This versatile rhizome is beneficial in addressing conditions related to pitta imbalances, anorexia, dyspepsia, flatulence, colic, bruises, wounds, chronic ulcers, skin ailments, pruritus, fever, constipation, strangury, hiccups, cough, bronchitis, sprains, gout, halitosis, otalgia, and inflammations (Singh et al., 2002).

2.2 Shannon-Weiner Diversity Index and Species Abundance

The Shannon-Weaver diversity index is a commonly employed metric for assessing diversity across different habitats (Clarke and Warwick, 2001). It operates under the assumption that individuals are randomly selected from a large, independent population, and that all species are adequately represented in the sample (Shannon and Weaver, 1949). Typically, the Shannon-Weaver diversity index yields values ranging from 1.5 to 3.5. This index is rooted in communication theory and quantifies uncertainty through the Shannon Function denoted as "H′." This term corresponds to the concept of entropy as defined by

$$H = -\sum_{i=1}^{s} pi * In\ pi \qquad \text{Equation 2.1}$$

Where:

H'= Shannon Diversity Index

Pi = The number of individuals of a species over the total number of individuals overall

S = Total number of species

ln = Natural logarithm

The diversity index, denoted as H′, is calculated using the proportion of each species in the sample, represented as p i, and the natural logarithm of this proportion, ln p i, as described by Shannon and Weaver in 1949, Spellerberg and Fedor in 2003, and Magurran in 2004.

Species abundance is calculated by dividing range, the amount, the quantity, of species from one cluster by the overall number of species from all teams (McGill et al., 2007). The abundance of formula species to be used is as follows:

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

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Study Area

Lata Hokkaido and Lata Keding are waterfall areas located in the district of Jeli, Kelantan, Malaysia. Jeli is situated in the northeastern part of Peninsular Malaysia, bordering Thailand. According to Figure 3.1, its coordinates of 5°39'00"N and 101°45'41"E for Lata Hokkaido and Figure 3.2, its coordinates of 5°44'48"N and 101°50'53"E for Lata Keding. Lata Hokkaido and Lata Keding consists of forest, hill forest and waterfall.

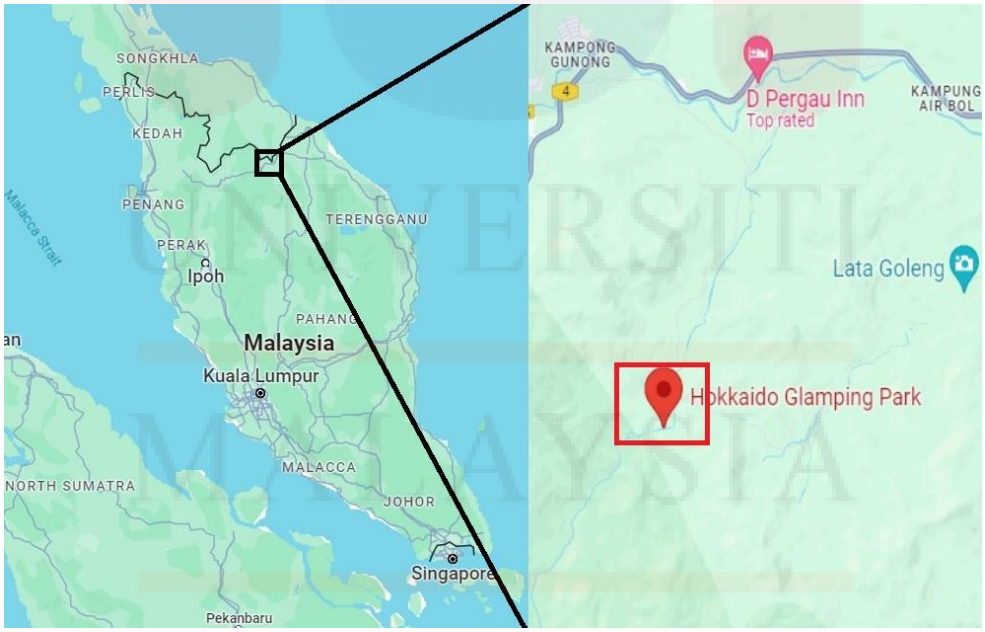

Figure 3.1: Map of Peninsular Malaysia shows the study area, Lata Hokkaido, Jeli, Kelantan (the area in the red box) (Google Maps, 2023).

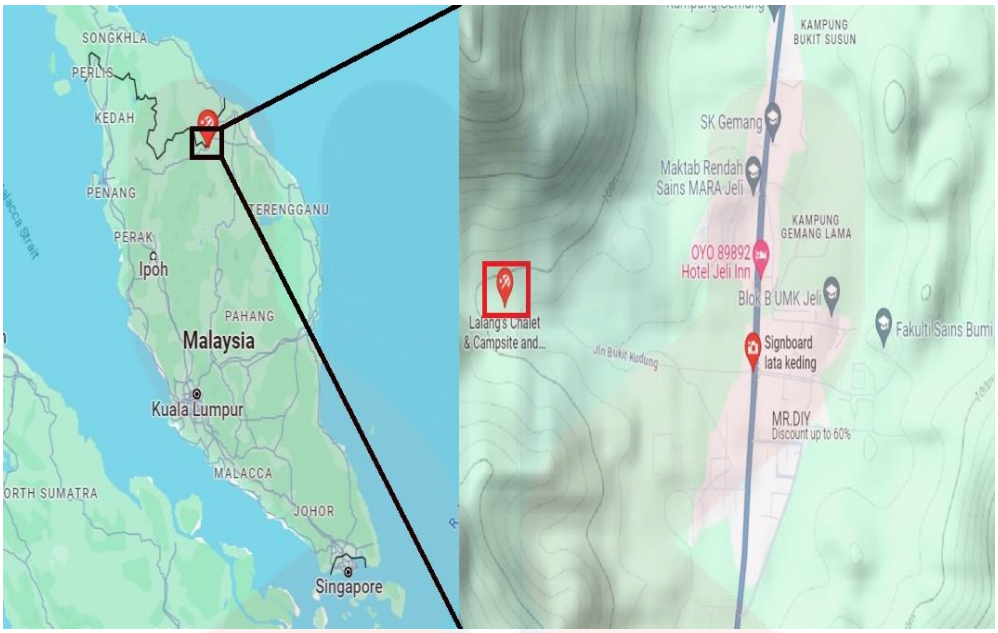

Figure 3.2: Map of Peninsular Malaysia shows the study area, Lata Keding, Jeli, Kelantan (the area in the red box) (Google Maps, 2023).

3.2 Materials

The tools and supplies that were utilized were zip lock bags, a digger hoe, ruler, camera, cutter, knife, field notebook, ethanol, methylene blue, beaker (100 ml), measuring cylinder, microscope, distilled water, slides, old newspapers, herbarium sheets, glue, cello tape, plywood boards, thread, tagging sheets, needle, and Global Positioning System (GPS) with Garmin GPS 64. The UMK Faculty of Earth Science provided all the materials.

3.3 Wild Zingiberaceae Sampling in Lata Hokkaido and Lata Keding, Jeli, Kelantan

This method involved random sampling in Lata Hokkaido and Lata Keding, Jeli, Kelantan. Each day, a different trail was chosen, and the location was tagged using Garmin GPS 64s for 2 days in one place. Each trail had a distance 1000 m in Lata Hokkaido and Lata Keding. For every trail, the gingers were searched at both sides of the trail for 5 m to avoid bias and to make sure the surrounding area was covered in the sampling. When a flowering wild ginger species were found, the characteristics of the leaf and flower, color, and smell were observed. Clear and detailed pictures were taken for a better view of the morphological characters. The coordinate point was recorded (Brockelman, 1980). Then, the inflorescence and rhizomes of ginger plants were taken out from the ground using a spade or hoe. Later, each ginger was kept in a zip lock bag with a specific number to indicate each specimen collected. The entire collected specimen was transported to Muzium Sumber Asli of UMK Jeli Campus and set aside for herbaria specimen preparation.

3.4 Collection of Zingiberaceae Plant Specimen

Herbarium specimens and living plants were gathered. The herbarium collection method was used to produce herbarium specimens. Since it was crucial for identification, only productive plant material was gathered for herbarium specimens. Specimens were cut repeatedly using a pair of cutting tools. Some living, unidentified plants were gathered as well. The Global Positioning System (GPS) was utilized to determine the area's latitude and longitude. Photos of fruits, flowers, and natural environments were taken. To avoid damage, the specimens to be collected were kept inside the sack. A killer jar filled with 70% ethanol was used to store flowers and fruits to prevent specimens from becoming too brittle (Royal Botanic Garden Edinburgh, 2023). The dried herbarium specimens were kept in Muzium Sumber Asli of UMK Jeli Campus.

3.5 Identification of Zingiberaceae Specimen

The identification of wild ginger specimens was conducted at Muzium Sumber Asli of UMK Jeli Campus, using flower identification keys of Zingiberaceae and comparing the pictures and specimens of ginger species with information in books such as Larsen et al. (1999), Poulsen (2006), journals, or other reliable sources such as Kepong Herbarium from Forest Research Institute Malaysia (FRIM) and Kew's Herbarium.

3.6 Determination of Species Diversity and Abundance of Zingiberaceae Specimen

Shannon-Weiner Diversity Index and Species Abundance

The Shannon-Weaver diversity index is one widely used index for comparing diversity between various habitats (Clarke and Warwick, 2001). It assumes that individuals are randomly sampled from an independent large population, and all the species are represented in the sample (Shannon and Weaver, 1949). The value of the Shannon-Weaver diversity index usually ranges from 1.5 to 3.5. The Shannon-Weaver diversity index is based on communication theory. The uncertainty is measured by the Shannon Function "H′." This term is the measure corresponding to the entropy concept defined by

$$H = -\sum_{i=1}^{s} pi * In\ pi \qquad \text{Equation 3.1}$$

Where:

H'= Shannon Diversity Index

Pi = The number of individuals of a species over the total number of individuals overall

S = Total number of species

ln = Natural logarithm

Where H′ is the diversity index, p i is the proportion of each species in the sample, and ln p i is the natural logarithm of this proportion (Shannon and Weaver, 1949; Spellerberg and Fedor, 2003; Magurran, 2004).

The species abundance formula was used to measure the species diversity of Zingiberaceae. Species abundance was calculated by dividing the range, the amount, the quantity, of species from one cluster by the overall number of species from all teams (McGill et al., 2007). The formula for species abundance that was used is as follows:

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

CHAPTER 4

RESULT AND DISCUSSION

4.1 Diversity and Abundance of Zingiberaceae at Lata Hokkaido and Lata Keding in Jeli, Kelantan.

The diversity of Zingiberaceae in Lata Hokkaido and Lata Keding was represented by the coordinates taken for every wild ginger found. The coordinates were shown in the tables below. Diversity maps were generated using Geographic Information System software, ArcGIS 10.3, which indicated the diversity of Zingiberaceae surrounding Lata Hokkaido and Lata Keding. Figure 4.1 shows the map of diversity of the Zingiberaceae family of at Lata Hokkaido in Jeli, Kelantan. Based on the map, the existing species is *Alpinia* sp. 1, *Alpinia* sp. 2, *Alpinia* sp. 3, *Alpinia* sp. 4, *Alpinia javanica*, *Curcuma longa* and Etlingera elatior. It is evident that *Alpinia* sp.3 emerged as the most prevalent species in Lata Hokkaido, with 60 individuals, while *Curcuma longa* and *Alpinia* were least represented with 7 and 13 individuals respectively. Overall, relative abundance of these Zingiberaceae species within the specified location, highlighting *Alpinia* sp. 3 as the most prevalent species in the area.

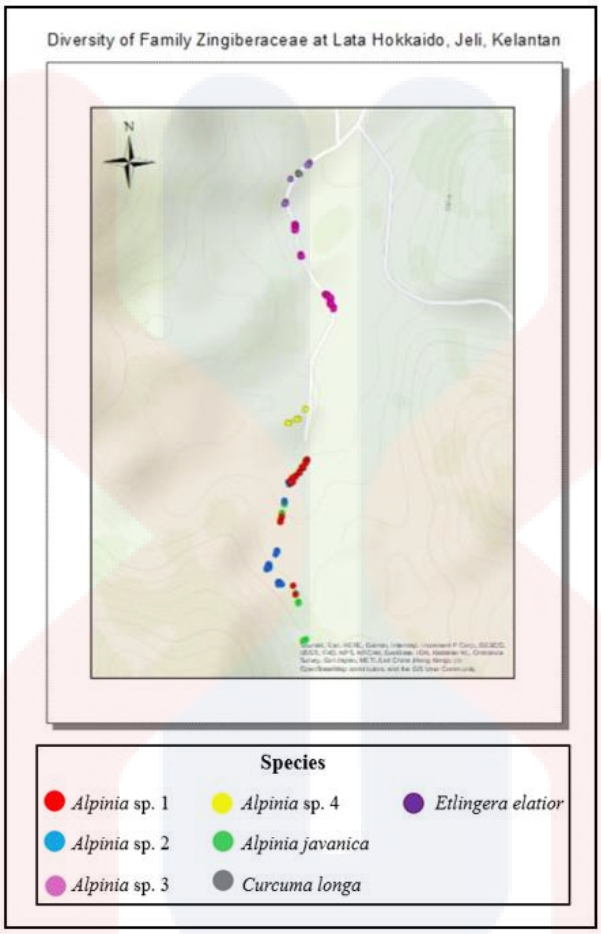

Figure 4.1: Map of Diversity of Family Zingiberaceae at Lata Hokkaido, Jeli, Kelantan

Figure 4.2 shows the map of diversity of the Zingiberaceae family of at Lata Keding in Jeli, Kelantan. Based on the map, the existing species is *Alpinia* sp. 5, *Alpinia* sp. 6, *Globba* sp. 3, *Alpinia javanica*, *Etlingera punicea* and *Etlingera elatior*. In Lata Keding, *Alpinia javanica* was the most abundant with 39 individuals, whereas *Globba* sp. 1 was least represented with only one individual. Overall, relative abundance of these Zingiberaceae species within Lata Keding, highlighting *Alpinia javanica* as the most dominant species in terms of population.

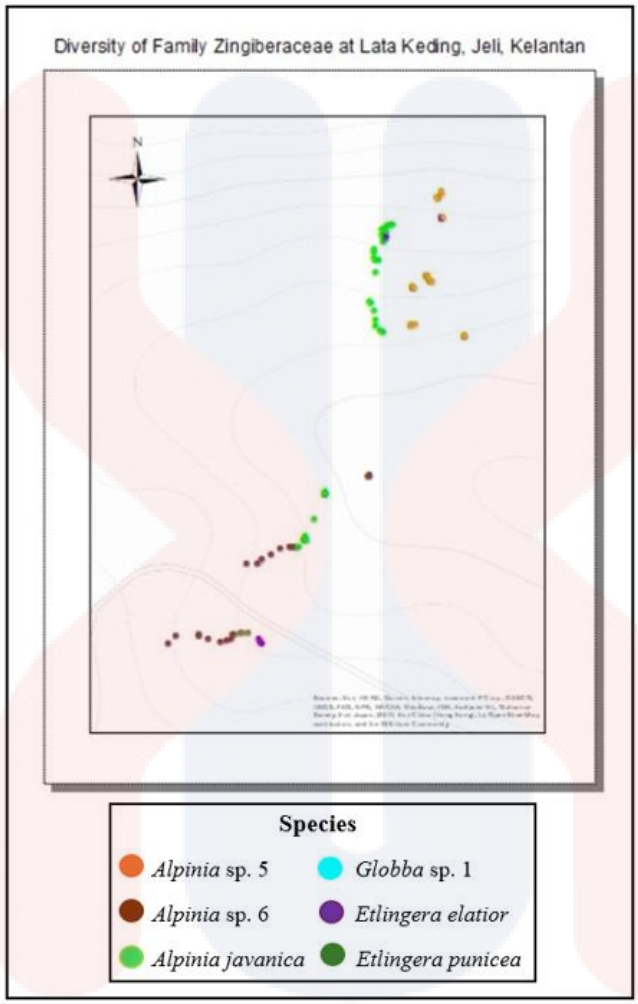

Figure 4.2: Map of Diversity of Family Zingiberaceae at Lata Keding, Jeli, Kelantan.

Table 2: Species and Common Name of Zingiberaceae found at Lata Hokkaido

Species	Collector's Number	Common Name
Alpinia sp. 1	*SR*01,03,04,05,06,07,08,09,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,43,44,45,46,47,48,72, 73	Apus
Alpinia sp. 2	*SR*29,30,31,32,33,34,35,36,37,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71	Apus
Alpinia sp. 3	*SR*21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80	Apus
Alpinia sp. 4	*SR*81,82,83,84,85,86,87,88,89,90,91,92,93,94	Apus
Alpinia javanica	*SR*02,38,39,40,41,42,74,75,76,77,78,79,80	Lengkuas Hutan
Etlingera elatior (Jack) R.M.Sm.	*SR*01,02,03,04,05,06,07,08,16,17,18,19,20	Bunga Kantan
Curcuma longa	*SR*09,10,11,12,13,14,15	Kunyit

Table 3: Species and Common Name of Zingiberaceae found at Lata Keding

Species	Collector's Number	Common Name
Alpinia sp. 5	*SR*28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50	Apus
Alpinia sp. 6	SR,01,02,03,21,22,23,24,25,27,28,37,38,39,40,41,42,43,44,45	Apus
Etlingera elatior (Jack) R.M.Sm.	*SR*23,24,25,26,27,28,29,30,31,32	Bunga Kantan
Alpinia javanica	*SR*01,02,03,04,05,06,07,08,09,10,11,12,13,14,15,16,17,18,19,20,21,22	Lengkuas Hutan
Globba sp. 1	*SR*26	
Etlingera punicea	*SR*33,34,35,36	Tepus

Table 4 presents the species abundance of the Zingiberaceae family observed at Lata Hokkaido in Jeli, Kelantan. Each row represents a different species within the family, identified by its scientific name. The "Number of Individual" column specifies the count of individual plants found for each species in the studied area. Meanwhile, the "Relative Species Abundance (%)" column indicates the percentage of each species relative to the total number of individuals sampled. From the data, it is evident that *Alpinia* sp. 3 is the most abundant species, comprising 60 individuals and constituting 34.48% of the total sampled.

Table 4: Species Abundance of Zingiberaceae at Lata Hokkaido, Jeli, Kelantan

Scientific Name	Number of Individual	Relative Species Abundance (%)
Alpinia sp. *1*	35	20.11
Alpinia sp. 2	32	18.39
Alpinia sp. 4	14	8.05
Alpinia sp. 3	60	34.48
Etlingera elatior (Jack) R.M.Sm.	13	7.47
Curcuma longa	7	4.02
Alpinia javanica	13	7.47
Total	174	100

Following closely is *Alpinia* sp. 1 with 35 individuals, representing 20.11% of the total. Conversely, *Alpinia* have the lowest abundance, each accounting for only 4.02% and 7.47% of the total, respectively. This table provides valuable insights into the distribution and prevalence of different Zingiberaceae species within the specified location, aiding in the understanding of local ecosystem dynamics and biodiversity.

The studies presented offer valuable insights into the abundance of Zingiberaceae species in different locations. The first study, conducted at Lata Hokkaido in Jeli, Kelantan, analyzes the species abundance of the Zingiberaceae family. Through quantitative analysis,

it identifies *Alpinia* sp. 3 as the most abundant species, comprising 34.48% of the total sampled, followed by Alpinia sp. 1. Conversely, *Curcuma longa* and *Alpinia* exhibit the lowest abundance. This study provides a detailed understanding of Zingiberaceae distribution and prevalence within the specified location, contributing to ecosystem dynamics and biodiversity comprehension.

In contrast, the second study, conducted in Penang Hill, focuses on orchid diversity, showcasing a high level of orchid abundance and variety. Through qualitative and quantitative analysis, it identifies 85 orchid species from 61 genera, with seven new species records discovered during the study period. The Western Hill emerges as a hotspot for orchid diversity, attributed to environmental factors such as elevation. Specific species like *Grammatophyllum speciosum* and *Paphiopedilum callosum* var. *sublaeve* are highlighted for their abundance, underscoring the need for conservation measures. This study offers a broader perspective on orchid diversity in Penang Hill, emphasizing the significance of conservation efforts to protect indigenous species.

In summary, while both studies contribute to our understanding of plant abundance, they differ in their focal points and approaches. Both studies offer valuable insights into plant abundance within specific ecosystems, albeit focusing on different plant families and locations. The first study provides a quantitative analysis of Zingiberaceae abundance, while the second study combines quantitative findings with qualitative insights to highlight orchid diversity and conservation concerns in Penang Hill.

Table 5 presents the species abundance of Zingiberaceae observed at Lata Keding in Jeli, Kelantan. Each species is represented by the number of individuals found, alongside their relative species abundance expressed as a percentage of the total. Among the species recorded, *Alpinia javanica* stands out as the most abundant, constituting 41.05% of the total population observed, with 39 individuals counted. Following this, *Alpinia* sp. 5 and *Alpinia* sp. 6 are also notable, representing 24.21% and 20% of the population, respectively. Other species, such as *Etlingera elatior*, *Etlingera punicea*, and *Globba* sp. 1, exhibit lower abundance percentages ranging from 1.05% to 9.47%. In total, 95 individuals were recorded across all species, collectively representing the entirety of the observed Zingiberaceae population in the area.

Table 5: Species Abundance of Zingiberaceae at Lata Keding, Jeli, Kelantan

Scientific Name	Number of Individual	Relative Species Abundance (%)
Alpinia sp. 5	23	24.21
Alpinia sp. 6	19	20
Etlingera elatior (Jack) R.M.Sm.	9	9.47
Globba sp. 1	1	1.05
Etlingera punicea	4	4.21
Alpinia javanica	39	41.05
Total	95	100

The studies presented offer valuable insights into the abundance of Zingiberaceae species in different locations. Both studies provide valuable insights into plant abundance within specific regions, focusing on different plant families and ecosystems. The first study examines the species abundance of Zingiberaceae at Lata Keding in Jeli, Kelantan, through a quantitative analysis. Notably, *Alpinia javanica* emerges as the most abundant species, comprising 41.05% of the total population observed, with *Alpinia* sp. 5 and *Alpinia* sp. 6 also exhibiting significant abundance percentages. The study provides

detailed information on the abundance of various Zingiberaceae species within the specified area, offering insights into ecosystem dynamics and biodiversity.

In contrast, the second study investigates orchid diversity in disturbed forests in Kelantan and Terengganu. Through a comprehensive assessment, it identifies a total of 109 orchid species, with a significant number being new records for the region. The study highlights the influence of logging activities on orchid abundance, noting a high density of epiphytic orchids in logged forests due to fallen trees. Additionally, it identifies rare and endemic orchid species, providing important information for conservation efforts. This study offers a broader perspective on plant abundance, emphasizing the impact of human activities on ecosystem dynamics and the distribution of orchids in the studied areas.

In summary, while both studies contribute to our understanding of plant abundance and biodiversity, they differ in their focal points and approaches. The first study provides a quantitative analysis of Zingiberaceae abundance in a specific location, while the second study offers insights into orchid diversity in disturbed forests and the influence of human activities on plant abundance.

The species abundance between Tables 1 and 2 of Zingiberaceae at Lata Hokkaido and Lata Keding in Jeli, Kelantan, several differences and similarities emerge. In Table 1, *Alpinia* sp. 3 dominates the population with a relative species abundance of 34.48%, followed by *Alpinia* sp. 1 and *Alpinia* sp. 2, representing 20.11% and 18.39%, respectively. However, in Table 2, *Alpinia javanica* takes precedence, constituting 41.05% of the total population observed, followed by *Alpinia* sp. 5 and *Alpinia* sp. 6, with 24.21% and 20%, respectively. The species composition between the two tables differs notably; for instance,

Curcuma longa is present in Table 1 but absent in Table 2, while *Globba* sp. 1 is only observed in Table 2.

Additionally, while *Alpinia* sp. 1 and *Alpinia* sp. 2 are prevalent in Table 1, they are absent in Table 2. Despite these disparities, both tables exhibit similar total population sizes, with 174 individuals in Table 1 and 95 individuals in Table 2. Overall, these comparisons underscore the variability in species composition and abundance within different ecological niches even within the same region.

The studies presented offer valuable insights into the diversity and abundance of Zingiberaceae species in different locations. Table 3 provides data comparing two specific sites, Lata Hokkaido, and Lata Keding, while the second discusses findings from Panti Forest Reserve and Labis Forest Reserve in southern Peninsular Malaysia. In terms of species diversity, the study in Table 3 employs the Shannon-Wiener index to assess diversity within communities. It reveals that Lata Hokkaido exhibits a higher Shannon-Wiener index compared to Lata Keding, suggesting slightly greater species diversity in the former location. This indicates that Lata Hokkaido may support a wider range of Zingiberaceae species compared to Lata Keding.

Conversely, the study in the second a total of 28 taxa of Zingiberaceae across both Panti Forest Reserve and Labis Forest Reserve. While Panti Forest Reserve shows higher species richness with 24 taxa, Labis Forest Reserve has a lower diversity with only 4 taxa recorded. This suggests a significant discrepancy in species diversity between the two forest reserves studied in Malaysia. Furthermore, both studies highlight the presence of rare and threatened species within their respective locations. The study in Table 3 mentions the occurrence of *Alpina* sp.1 and *Alpinia* sp. 5 as dominant species, while the second text

identifies rare and threatened species such as Scaphochlamys lanceolata, categorized as Endangered.

These findings underscore the importance of conservation efforts to protect the biodiversity of Zingiberaceae species in these regions. In summary, the research presented in Table 3 concentrates on numerical metrics like species abundance, richness, and the Shannon-Wiener index to evaluate diversity between two distinct sites, whereas the second text offers descriptive observations regarding the existence of rare and endangered species within various forest reserves in southern Peninsular Malaysia. Both investigations offer significant insights into the ecological makeup and conservation requirements of Zingiberaceae species within their respective geographical areas.

4.2 Identification of Morphological Characteristics of Zingiberaceae in Lata Hokkaido and Lata Keding

Figure 4.3 show *Etlingera punicea,* a common species found in lowland forests throughout the Peninsula. It also occurs in Thailand, Borneo, Java, and Sumatra (Smith, 1986). *Etlingera punicea*, commonly known as Tepus, displays distinctive characteristics that are easy to understand. Its rhizomes extend about 12 cm below ground, appearing slender with a diameter of around 1.5 cm. The plant's leafy shoots can grow anywhere from 2 to 5 meters tall, either closely clustered or widely spaced apart. The sheaths surrounding these shoots are prominently ribbed with crossbars and covered in tufts of short, white hairs, sometimes appearing smooth.

These sheaths may vary in color, ranging from green to yellowish with purple blotches. The ligule, located at the apex of the sheath, is about 0.5 to 1 cm long and densely covered in short, brown hairs. The leaf blades, typically found in pairs of around 10, vary in size, with the largest measuring about 58 x 9 cm at the top, 62 to 91 x 14 to 17 cm in the middle, and 18 to 22 x 7 cm at the base. The upper surface of the leaf blades is smooth or slightly raised along the veins, while the lower surface is hairless. The inflorescence, mostly underground, features well-developed sterile bracts forming a narrow, cylindrical structure.

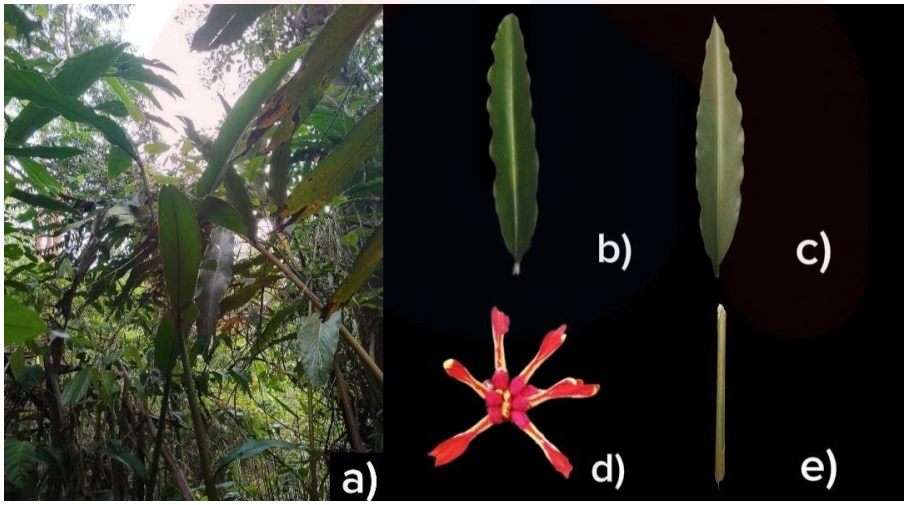

Figure 4.3: *Etlingera punicea*. a) habit. b) adaxial surface of the leaf. c) abaxial surface of the leaf. d) flowers. e) pseudostem.

Figure 4.4 shows the *Alpinia javanica*. This plant has big leaves, 60-100 × 16-21.5 cm, velvety hairy underneath and on the margins, but glabrescent or glabrous on the upper surface except on the midrib. It has an unequal base and caudate apex. The ligule is deeply bilobed, 1-2.5 cm long, dark brown and fringed with hairs. The petioles are 2.5–10 cm long and are briefly hairy. It is 5-31 cm-long inflorescence is held erect or droops slightly with its flowers facing down. The rachis and peduncle are red. The calyx is tubular, c. 1.8 cm long, pinkish white turning pink in fruiting specimens. The corolla has a broadly obovate labellum (4-5 cm long), which is concave and envelops the stamen and it is crinkled on its margin. The lateral staminodes are red and about (4-8) mm long, with an irregular shape. The immature fruits are green and rounded, 2.5 cm in diameter, and are covered with short hairs.

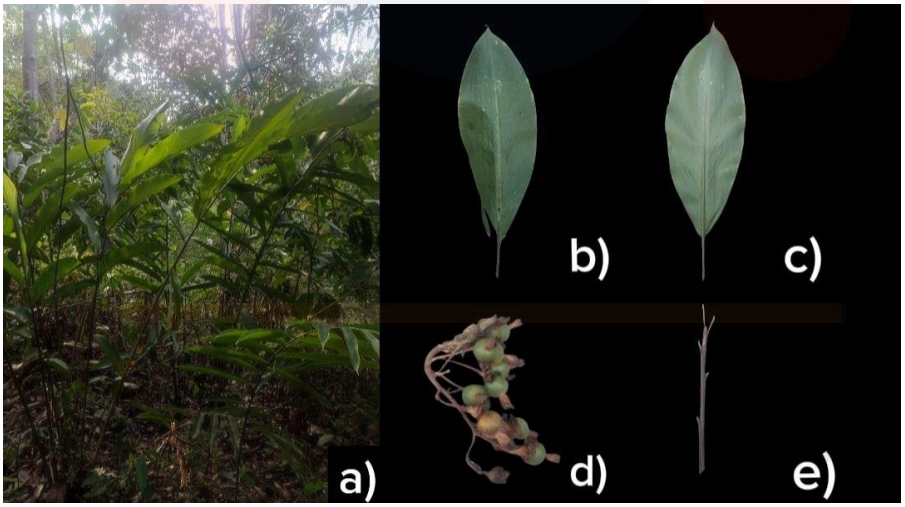

Figure 4.4: *Alpinia javanica*. a) habit. b) adaxial surface of the leaf. c) abaxial surface of the leaf. d) fruits. e) pseudostem.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, this study has provided comprehensive insights into the diversity of Zingiberaceae species at Lata Hokkaido and Lata Keding in Jeli, Kelantan. The objectives of the research were successfully met through the implementation of random sampling methods in the study areas. Analysis of the collected data revealed notable differences in species abundance and composition between the two locations.

At Lata Hokkaido, *Alpinia* sp. 3 emerged as the most abundant species, while at Lata Keding, *Alpinia javanica* dominated the population. These findings highlight the variability in species composition within different ecological niches, even within the same region. Furthermore, comparisons between the species abundance tables underscored the importance of considering multiple factors in understanding ecosystem dynamics and biodiversity. The Shannon-Wiener index analysis provided additional insights into the diversity of species communities at Lata Hokkaido and Lata Keding. While both locations exhibited similar species abundance, Lata Hokkaido demonstrated slightly higher species diversity and richness compared to Lata Keding.

Overall, this study contributes valuable information to the field of biodiversity research and underscores the importance of conservation efforts to preserve the rich flora found in the region. Future research could explore additional factors influencing species distribution and abundance, as well as the long-term impacts of environmental changes on Zingiberaceae populations in Jeli, Kelantan.

5.2 Recommendation

Based on the comprehensive analysis conducted on the species diversity and abundance of the Zingiberaceae family in Lata Hokkaido and Lata Keding, Jeli, Kelantan, several recommendations can be proposed for further research and conservation efforts are Further investigation into the microhabitat preferences of Zingiberaceae species within Lata Hokkaido and Lata Keding could provide valuable insights into their ecological requirements. By examining factors such as soil composition, moisture levels, and canopy cover, researchers can better understand the specific environmental conditions favored by different species. This knowledge is essential for designing targeted conservation strategies aimed at preserving key habitat components essential for the survival of Zingiberaceae populations.

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