



Faculty of Resource Science and Technology

**Ethnobotanical and Community uses of Zingiberaceae Among the
Bidayuh Community in Jagoi and Singai, Bau Sarawak**

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Ethnobotanical and Community uses of Zingiberaceae Among the Bidayuh
Community in Jagoi and Singai, Bau Sarawak

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A thesis submitted

In fulfillment of the requirements for the degree of Doctor of Philosophy

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



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ABSTRACT

This study introduced the Zingiberaceae family, emphasizing its ethnobotanical significance and diverse applications within the Bidayuh communities of Jagoi and Singai in Bau, Sarawak. The study documented fifty species from 22 genera, focusing on both traditional and newly identified uses in these communities. The methodology involved collecting leaf samples from Gunung Singai and Gunung Jagoi, conducting microscopic analysis, and employing Scanning Electron Microscopy (SEM) to provide comprehensive anatomical and micromorphological data for species differentiation. The demographic data from 170 individuals in Singai and Jagoi enhanced our understanding of usage patterns. The plants were used to treat a range of diseases, including skin issues, diarrhea, and diabetes, underscoring their critical role in traditional healthcare and the potential for broader medicinal applications. Notably, new species identified included *Alpinia songet*, *Amomum jackliamii*, and *Zingiber singiaensis*, among others. Zingiberaceae also played a crucial role in the local economy, utilized for food flavoring, rituals, and handicrafts, linking these practices to the cultural heritage and sustainable development of the community. The study found a significant positive correlation between age and the frequency of medicinal ginger use, suggesting generational knowledge transmission. In addition to documenting traditional uses, the research explored the potential for commercial applications of Zingiberaceae to boost economic development and eco-tourism. By integrating ethnobotanical records, ecological assessments, and economic analyses, the study aimed to promote biodiversity conservation, cultural heritage preservation, and socioeconomic enhancement. This multidisciplinary approach set a precedent for similar studies aimed at unlocking the full

potential of Zingiberaceae in Bau and beyond, advocating for continued research to uncover unknown species and emphasizing the importance of sustainable harvesting and the protection of traditional knowledge.

Keywords: Bidayuh community, Ethnobotany, Medicinal plants, Sarawak, Zingiberaceae

Etnobotani dan Penggunaan Zingiberaceae dalam Kalangan Masyarakat Bidayuh di Jagoi dan Singai, Bau Sarawak

ABSTRAK

*Kajian ini memperkenalkan keluarga Zingiberaceae, menekankan kepentingan etnobotaninya dan aplikasi pelbagai dalam komuniti Bidayuh di Jagoi dan Singai di Bau, Sarawak. Kajian ini mendokumentasikan lima puluh spesies dari 22 genus, dengan fokus pada penggunaan tradisional dan yang baru dikenal pasti dalam komuniti ini. Metodologi yang digunakan melibatkan pengumpulan sampel daun dari Gunung Singai dan Gunung Jagoi, melakukan analisis mikroskopik, dan menggunakan Mikroskopi Elektron Pengimbasan (SEM) untuk menyediakan data anatomikal dan mikromorfologi yang komprehensif untuk pembezaan spesies. Data demografi dari 170 individu di Singai dan Jagoi meningkatkan pemahaman kita tentang corak penggunaan. Tumbuhan-tumbuhan ini digunakan untuk merawat pelbagai penyakit, termasuk masalah kulit, cirit-birit, COVID-19, dan diabetes, menekankan peranan kritikalnya dalam penjagaan kesihatan tradisional dan potensi untuk aplikasi perubatan yang lebih luas. Secara khusus, spesies baru yang dikenal pasti termasuk *Alpinia songet*, *Amomum jackliamii*, dan *Zingiber singiaensis*, antara lain. Zingiberaceae juga memainkan peranan penting dalam ekonomi tempatan, digunakan untuk perisa makanan, ritual, dan kraftangan, menghubungkan amalan ini dengan warisan budaya dan pembangunan lestari komuniti. Kajian ini mendapati korelasi positif yang signifikan antara usia dan kekerapan penggunaan halia ubat, menunjukkan penularan pengetahuan antara generasi. Selain mendokumentasikan penggunaan tradisional, penyelidikan ini meneroka potensi aplikasi komersil Zingiberaceae untuk meningkatkan pembangunan ekonomi dan ekopelancongan. Dengan mengintegrasikan rekod etnobotani, penilaian ekologi, dan analisis ekonomi, kajian ini bertujuan untuk*

mempromosikan pemuliharaan biodiversiti, pemeliharaan warisan budaya, dan peningkatan sosioekonomi. Pendekatan multidisiplin ini menetapkan preseden untuk kajian serupa yang bertujuan untuk membuka potensi penuh Zingiberaceae di Bau dan di tempat lain, menggalakkan penyelidikan berterusan untuk mengenal pasti spesies yang tidak diketahui dan menekankan kepentingan peneuaian lestari dan perlindungan pengetahuan tradisional.

Kata Kunci: *Masyarakat Bidayuh, Etnobotani, Tumbuhan ubatan, Sarawak, Zingiberaceae*

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LIST OF ABBREVIATIONS

CGS	Centre for Graduate Studies
CPD	Critical Point Drier
EO	Essential Oil
IUCN	The International Union for Conservation of Nature
LMDF	Low Mixed Dipterocarp Forest
PIC	Prior Informed Consent
PSF	Peat Swamp Forest
SAR	Sarawak Herbarium
SBC	Sarawak Biodiversity Centre
SEM	Scanning Electron Microscope
SORAS	Sarawak Online Research System
SPSS	Statistical Package for Social Science
UNIMAS	Universiti Malaysia Sarawak

INTRODUCTION

1.1 Study Background

This chapter presents a general introduction and overview of Zingiberaceae, focusing on its usefulness to the local community. It includes the problem statement, plant systematics, the significance of Zingiberaceae for medicinal purposes among ethnic communities, and recent developments in the field of ginger as traditional medicine.

1.2 General Overview of Zingiberaceae for Useful Plant

The Zingiberaceae family is well known for its useful plants, including those used as spices, ornamental plants, and medicinal plants. It is extensively dispersed across the tropics, especially in Southeast Asia (Zahara et al., 2018). There are more than 1,500 species of ginger in 53 genera (Saensouk et al., 2016). The family consists of rhizomatous annual or perennial herbs. The rhizome is formed of separate segments and is sympodially branched (Bai et al., 2018). Rhizomes might be pink, greenish blue, deep yellow, pale yellow, or mixtures of these colors in different species. Scale leaves shield the axillary buds and immature rhizomes. Leafy shoots are often unbranched; some genera have real aerial stems, while others do not. *Kaempferia* has a true stem that is quite short, while *Curcuma* has a pseudo-stem with clasping leaf sheaths. The distichous leaves vary morphologically in terms of structure, shape, size, texture, and venation. Distinctly spaced leaves with fragrant oil cells are distributed transversely or parallel to the rhizome. Most of the staminodes are lateral, slender, lengthy, and exserted filaments. Usually, there are two linear or, very rarely, no epigynous glands at all. The ovary is unilocular or trilocular.

Alpinia Roxb, *Amomum* Roxb, *Boesenbergia* Kuntze, *Curcuma*, *Elettari* Matona, *Hedychium* J. Koeng, *Kaempferia* L, and *Zingiber* Mill are the most often used genera for medicinal purposes.

Volatile oils and oleoresins of export value are present in the plants, which are their defining characteristics. Rhizomes and fruits are generally fragrant, tonic, and stimulating. Some produce an astringent and diaphoretic juice, while others produce enormous amounts of starch that are utilized as food.

Sarawak is one of the most abundant and diversified islands for Zingiberaceae, with 141 species and 18 genera (Lamb et al., 2013). Since the 1990s, efforts to determine the economic value of Sarawak's natural resources have made excellent progress. Unfortunately, earlier investigations focused primarily on specific forest resources, mainly lumber. An economic appraisal of Zingiberaceae is a crucial undertaking as it provides details on the benefits the local community could gain from Zingiberaceae's direct and indirect uses. *Zingiber officinale* Roscoe is one of the most widely used varieties of ginger for cooking and traditional medicine (Ashraf et al., 2017). This species has been traded by merchants for approximately 3,000 years, since the earliest days (Lamb et al., 2013).

1.3 Introduction on Gingers as a Herbal Medicine-Based Niche Tourism

Herbal medicine-based tourism is a specialist sector that emphasizes medicinal plants and may need to grow commercially due to the dynamic and competitive nature of the tourism industry (Herbal Medicine Market Size, Share & Growth Report, 2030). However, this requires a specifically designed study to explore innovation and methods for boosting herbal-medicine-based tourism and to demonstrate how to combine the two for knowledge transfer and education. The proposed approach includes outdoor activities and tourist

workshops in herbal medicine parks, farms, or the natural habitats of the plants. This approach emphasizes the therapeutic properties of medicinal plants, which can play a key role in tourism focused on learning about and consuming traditional medicinal herbs.

Ginger is still a significant spice crop and is frequently grown to meet the demand for fresh ginger in local markets. Traditionally, this herb was utilized by the community to improve digestion and treat menstrual cramps, colds, coughs, and fevers (Jiao et al., 2022). Tour guides knowledgeable about botany and medicinal plants are essential for integrating traditional medicine with tourism (Farsani et al., 2016).

1.4 Economic Significance of Zingiberaceae

The main features of the Chiang Mai Declaration (IUCN, WHO, & WWF, 1993) include guidelines for the conservation and sustainable use of medicinal plants, as listed below:

- I. Ensure that any wild collection is sustainable.
- II. Enhance production, storage, and harvesting methods.
- III. Explore historical information on the application of plants to medicine.
- IV. Conserve populations of medicinal plant species in their native environments
- V. Safeguard populations of medicinal plant species in industrial farms.
- VI. Cultivate therapeutic herbs whenever possible as a source of supply.
- VII. Enhance public support for the preservation of medicinal plants through cooperation and communication.
- VIII. Identify herbal medicines, define their distributions, and assess their abundance.

Zingiberaceae is a family of flowering plants that includes many economically significant species, the most notable of which is ginger (*Zingiber officinale*). The economic significance of Zingiberaceae is primarily attributed to the various uses of its members in ornamental, medicine, and culinary applications (Liang & Chen, 2021). The economic importance of Zingiberaceae is described follows (Table 1.1)

Table 1.1: The economic importance of Zingiberaceae

Category	Example Species	Uses	Economic Importance
Culinary Uses	Ginger (<i>Zingiber officinale</i>)	Used in various cuisines worldwide for flavor and aroma. Common in soups, curries, stir-fries, and baked goods.	Widely traded; essential in food industries globally.
	Turmeric (<i>Curcuma longa</i>)	Used as a spice and food coloring agent in cooking.	Essential in food and health supplements markets.
	Cardamom (<i>Elettaria cardamomum</i>)	Used in sweet and savory dishes, spice blends, known for aromatic and flavorful properties.	High value in spice trade, widely used in culinary products.
Medicinal Uses	Ginger (<i>Zingiber officinale</i>)	Used in traditional medicine for anti-inflammatory and anti-	Contributes to pharmaceutical and health supplement

Table 1.1 continued

		nausea properties. Supplements and extracts widely available.	industries.
	Turmeric (<i>Curcuma longa</i>)	Contains curcumin, used for anti- inflammatory and antioxidant benefits. Common in dietary supplements.	Popular in medicinal and health supplement markets.
Perfumery and Essential Oils	Various species	Essential oils extracted for use in perfumes, cosmetics, and aromatherapy.	Contributes to fragrance and wellness industries.
Ornamental Plants	Ornamental gingers	Cultivated for attractive flowers and foliage, contributing to the horticulture industry.	Supports ornamental plant markets and gardening industries.
Economic Agriculture	Ginger, Turmeric	Cultivated globally, supporting local agricultural economies by providing income to farmers.	Major economic crops in agriculture, contributing to regional economies.

To the Greek and Roman empires, they were brought from the East. Ginger, turmeric, cardamom, and other significant spice crops are still planted today. They have also been widely farmed to meet commercial demand. Ginger is used as a spice, a medication, and a fruit or vegetable. Zingiberaceae have attractive leaves and the potential to be ornamental, according to Lamb (2013).

In summary, the Zingiberaceae provides useful products for food, spices, medicines, dyes, perfume, and aesthetics industries (Siriluck et al., 2014). Their economic significance is not only limited to the direct consumption of these plants but also extends to their use in various value-added products and industries.

1.5 Research on the Zingiberaceae

Research on Zingiberaceae encompasses a broad range of topics, including taxonomy, phytochemistry, pharmacology, ecology and conservation. Scientists and researchers investigate various aspects of these plants to better understand their diversity, uses, and potential applications.

Researchers conduct studies to classify and identify different species within the Zingiberaceae family. This process includes describing new species, revising existing classifications, and developing molecular techniques to understand evolutionary relationships among different taxa. For instance, Kress et al. (2002b) conducted phylogenetic studies and proposed a new classification for the Zingiberaceae family based on molecular data. Similarly, Sakai et al. (2006) conducted systematic studies on Bornean Zingiberaceae, focusing on the Zingiberoideae of Lambir Hills, Sarawak. Their work included extensive field observations and descriptions of new species, contributing significantly to the understanding of Zingiberaceae diversity and taxonomy.

Phytochemical studies focus on identifying and characterizing the chemical compounds present in Zingiberaceae. These compounds can include essential oils, phenolic compounds, terpenoids, and alkaloids. Understanding the chemical composition of these plants contributes to their medicinal, culinary, and industrial applications (Soumya et al., 2023). The Zingiberaceae family contains active phytochemicals shown to have antioxidative, anti-inflammatory, anticancer, and antitumor properties (Ling et al., 2005). *Zingiber officinale*, for example, is rich in antioxidants such as terpenoids, beta-carotene, alkaloids, ascorbic acid, and flavonoids, making it a potential source of natural antioxidants (Stoilova et al., 2007).

Many Zingiberaceae, such as ginger and turmeric, are known for their medicinal properties. Research explores the bioactive compounds responsible for these properties and investigates potential health benefits. Studies may include anti-inflammatory, antioxidant, antimicrobial, and anticancer properties, among others. *Zingiber officinale* has been studied for its anti-diabetic, anti-hyperlipidemic, and anti-liver cancer effects (Motawi et al., 2013). Other species like *Zingiber montanum* and *Etlingera elatior* are noted for their analgesic, anti-inflammatory, and antioxidant properties (Chan et al., 2007; Nhareet et al., 2003).

Research also explores the commercial applications of Zingiberaceae. This includes the development of new products, extraction methods for essential oils, and the identification of market trends for culinary uses. Ginger rhizomes have demonstrated tyrosinase inhibitory abilities, making them valuable for cosmetic applications (Chan et al., 2008). The essential oil from *Zingiber cassumunar* has been found to possess fungitoxic, antimicrobial, and anti-inflammatory properties, highlighting its potential for diverse commercial uses (Tripathi et al., 2008).

Overall, research on Zingiberaceae is multidisciplinary and contributes to a deeper understanding of the plant's biology, ecological roles, and economic significance. This research provides valuable information for conservation efforts, agricultural practices, and the development of new products for various industries.

1.6 Problem Statement

The Bidayuh community in Jagoi and Singai Bau District possesses rich traditional knowledge of Zingiberaceae species, yet comprehensive ethnobotanical documentation is lacking (Ripen et al., 2022). This research aims to document the ethnobotany of Zingiberaceae species used by the Bidayuh community and provide detailed information on their medicinal significance. The gap in identifying unknown species of useful ginger in the Singai and Jagoi forests is significant. Specifically, it seeks to uncover which unknown species of medicinal and culinary ginger may still be discovered in these areas. Despite the rich biodiversity of these forests, many potentially valuable ginger species remain unidentified and undocumented. Banaticla et al. (2023) reported that only 45% of the 1,449 recorded Zingiberaceae species have been assessed, with 297 species (21% of all evaluated species) threatened. This underscores the urgent need for comprehensive studies on the conservation status, nature of threats, and the challenges, gaps, and opportunities in conserving Zingiberaceae species in tropical Asia. This research will contribute to a more comprehensive understanding of the local flora and aid in the conservation of these valuable plant resources.

There is a significant lack of comprehensive documentation and scientific study on the specific uses, benefits, and traditional knowledge associated with Zingiberaceae. This traditional knowledge, often passed down orally through generations, is at risk of being

lost due to modernization and changing lifestyles. Without proper documentation, valuable ethnobotanical knowledge may disappear, resulting in the loss of cultural heritage and potential medicinal resources. Previous research by Baling et al. (2018) on the medicinal plant usage of the Jagoi Bidayuh community in Bau focused on the taxonomy and ecology of Zingiberaceae but did not address the significance of Zingiberaceae for medicinal purposes among the two Bidayuh communities in Bau.

Taxonomic problems for some species, due to similarities in leaf morphology, plant habit, and infrequency in flowering, cannot be completely solved through classification based solely on classical morphology. Furthermore, there has been no study on the micromorphology of Zingiberaceae. Therefore, this research aims to fill this significant gap by exploring the micromorphological characteristics of Zingiberaceae species in the Singai and Jagoi forests. Highlighting the novelty of this work, it will be the first to provide detailed micromorphological data, which can enhance species identification and classification.

This pioneering study will contribute to resolving taxonomic challenges and aid in the conservation of these valuable plant resources. Micromorphological studies on this species enable a micro-level analysis of leaf tissue via scanning electron microscopy (SEM) and electron microscopy with high identification capacity. Plant terminology became more detailed and specific and progressed following the invention of the microscope.

Additionally, this research has significant socio-economic implications. Understanding the traditional uses and properties of these Zingiberaceae plants can lead to the development of new products for medicinal, culinary, and industrial applications, providing economic benefits to the Bidayuh community. Enhanced documentation and

scientific validation of traditional knowledge can open avenues for eco-tourism, sustainable harvesting practices, and the commercialization of ginger products. This could improve the livelihoods of local communities by providing alternative income sources and promoting the conservation of their natural resources. Addressing these issues requires a multidisciplinary approach that includes ethnobotanical documentation, ecological studies, and economic analysis to preserve traditional knowledge, promote biodiversity conservation, and explore the economic potential of Zingiberaceae plants in Bau, Sarawak.

1.7 Objectives of the Study

There are very few studies that have focused on the ethnobotanical and community uses of Zingiberaceae among the Bidayuh community in Jagoi and Singai, Bau, and the effect of altitude on the diversity and density of wild gingers in Sarawak. This study aims to provide systematic documentation of the ethnobotanical and community uses of Zingiberaceae among the Bidayuh community in Jagoi and Singai, Bau, while also adding information on the influence of altitude on the diversity and density of wild gingers in Sarawak. Additionally, this study provides taxonomic information for the identification of ginger using plant cuticles by identifying the stomatal complex types of the leaf samples.

The specific objectives are as follows:

1. To document the ethnobotany of Zingiberaceae species used by the Bidayuh community in Jagoi and Singai Bau District.
2. To provide information on the significance of Zingiberaceae for medicinal purposes among the Bidayuh communities in Singai and Jagoi, detailing how these plants are used to treat various ailments and their importance in traditional medicine.

3. To study the influence of altitude on the diversity and density of useful Zingiberaceae species, documenting species distribution at various elevations and analyzing the relationship between altitude and plant diversity.
4. To conduct the systematic study of ginger focusing on micromorphological studies using microscopy and scanning electron microscopy (SEM) to identify species-specific characteristics and adaptations to different altitudes.
5. To examine the socio-demographic characteristics of the Bidayuh respondents, including gender, age, occupation, income, and religious beliefs, and their impact on the utilization of Zingiberaceae plants.

1.8 Research Hypotheses

Three research hypotheses had been identified and analysed using Statistical Package for Social Science (IBM-SPSS) are:

1. Hypothesis on the Relationship between Elevation and Diversity and Density of Wild Gingers:
 - H_0 : There is no significant correlation between the difference in altitude and the diversity and density of wild gingers in the Singai and Jagoi areas.
 - H_a : There is a significant positive correlation between the difference in altitude and the diversity and density of wild gingers in the Singai and Jagoi areas.
2. Hypothesis on the Relationship between Age and Frequency of Medicinal Ginger Use:
 - H_0 : There is no significant correlation between the age of the respondents and the frequency of medicinal ginger use in the Bidayuh community.

- H_a : There is a significant positive correlation between the age of the respondents and the frequency of medicinal ginger use in the Bidayuh community.
3. Hypothesis on the Influence of Household Income and Location on Frequency of Medicinal Ginger Collection:
- H_0 : There is no significant correlation between household income or village location and the frequency of medicinal ginger collection in the Bidayuh community.
 - H_a : There is a significant correlation between household income or village location and the frequency of medicinal ginger collection in the Bidayuh community.
4. Hypothesis on Differences in Frequency of Medicinal Ginger Collection by Age Group and Village:
- Age Group:
- H_0 : There is no significant difference in the frequency of medicinal ginger collection among different age groups in the Bidayuh community.
 - H_a : There is a significant difference in the frequency of medicinal ginger collection among different age groups in the Bidayuh community.
- Village:
- H_0 : There is no significant difference in the frequency of medicinal ginger collection between the villages of Singai and Jagoi.
 - H_a : There is a significant difference in the frequency of medicinal ginger collection between the villages of Singai and Jagoi.

1.9 Study Justification

The local Bidayuh community in Jagoi and Singai Bau still uses gingers for food and medicine, and there are many more unknown species of useful ginger that may still be discovered in the forest. This study aims to document the traditional knowledge of Zingiberaceae species used by the Bidayuh community in Jagoi and Singai Bau District. This community possesses a rich repository of ethnobotanical knowledge that is at risk of being lost due to modernization and lifestyle changes.

A few documentations of useful ginger by the Bidayuh community have been conducted since 2000 (Baling et al., 2018), but many more useful unknown species of ginger may still be discovered in the forests. Previous studies on medicinal plants used by the Bidayuh community in Singai and Jagoi have primarily focused on documenting medicinal plants among these communities. Another previous study on Zingiberaceae used by the Bidayuh community focused only on the taxonomy and ecology of the plant; however, there is no information on how ecological elevation affects the pattern of diversity and density of wild gingers (Poulsen et al., 2004). The opening up of forests has caused significant changes in local communities' lives and the way they utilize plant resources.

Economic potential is another important aspect of this study. By understanding the traditional uses and properties of Zingiberaceae plants, new products for medicinal, culinary, and industrial applications can be developed. This not only provides economic benefits to the Bidayuh community but also opens avenues for eco-tourism, sustainable harvesting practices, and the commercialization of ginger products.

Finally, the study addresses significant taxonomic challenges. Due to similarities in leaf morphology, plant habit, and infrequency in flowering, some Zingiberaceae species

are difficult to classify using classical morphology alone. Micromorphological studies, utilizing techniques such as scanning electron microscopy (SEM), can provide detailed data that enhance species identification and classification, helping to resolve these challenges (Kress et al., 2002b; Sakai et al., 2006). This pioneering study will be the first to provide detailed micromorphological data for these species, contributing significantly to resolving taxonomic issues and aiding in the conservation and sustainable use of Zingiberaceae plants.

1.10 Study Limitation

This study focuses on only one family of useful plants used by the Bidayuh community in Sarawak. Consequently, the results obtained are limited in their application. Other challenges of this study include difficulties in obtaining the best possible data. Some knowledgeable respondents declined to participate due to concerns about privacy, including fears of sensitive information being shared or misused and apprehensions about their personal or cultural knowledge being exposed to a broader audience. The decline of medicinal plant resources may also influence the documentation, potentially leading to an incomplete reflection of the actual traditional medicinal plant knowledge possessed by the communities in Sarawak.

The information collected and used for the valuation processes was confined to observations and interviews or surveys conducted over a short period. Despite the significant potential of this research on the documentation, plant collection, and identification of useful Zingiberaceae species among the Bidayuh community in Singai and Jagoi, several limitations must be considered. One major limitation is the study's limited geographic scope. By focusing solely on the Singai and Jagoi regions, the research may not

capture the full diversity and usage of Zingiberaceae species across the entire Bidayuh population or other ethnic groups in Sarawak. As a result, the findings may not be generalizable to other regions or communities, potentially limiting the broader applicability of the research outcomes.

Seasonal variations pose another challenge. The availability and usage of Zingiberaceae species can change with the seasons, and the study might not account for these fluctuations. This could lead to incomplete documentation of species and their uses, as certain plants might only be available or utilized during specific times of the year. Additionally, ecological changes such as deforestation and land use alterations could have already impacted the distribution and availability of these plants, further complicating accurate documentation.

Effective communication with local informants is crucial for accurate data collection, yet language and communication barriers present a significant limitation. Differences in dialects or language proficiency can lead to misunderstandings or incomplete information, affecting the quality and reliability of the collected data. Additionally, the study relies heavily on the knowledge of community elders and traditional practitioners, which introduces the risk of memory bias or gaps in knowledge, especially if certain practices have declined or been forgotten over time.

Lastly, ethical and cultural sensitivity must be maintained throughout the research. There is a risk of unintentionally misrepresenting or misappropriating traditional knowledge, which could affect the trust and cooperation of the community. Ensuring ethical considerations and cultural sensitivity is essential but challenging, requiring ongoing attention and respect for the community's traditions and practices. By acknowledging these limitations, the research can be better designed to address potential

issues, and the findings can be interpreted with an understanding of the study's constraints, guiding future research efforts to build on the current study's results.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Ethnobotany, defined by various botanists and researchers, is the study of plant use by indigenous communities. It has evolved over time, with some suggesting it includes understanding plant life in primitive societies and its impact on tribal customs and history. Schultes (1941), the father of modern ethnobotany, defines it as the study of human-plant relationships (Adnan & Othman, 2012). For example, 80% of Ethiopians are thought to use traditional medicine (about 95% herbal) to treat various human health issues, with medicinal plants being a major source for healthcare, prevention, and treatment (Kidane et al., 2014).

Ethnobotany, the scientific study of human interactions with plants, has applications in many areas of contemporary global concern, such as human health, food security, biodiversity conservation, and climate change. Studies on ethnobotany can shed light on how communities engage with their natural resources on a local level. The goal of achieving biocultural conservation can be advanced through the integration of scientific and local knowledge through ethnobotanical studies (Pei et al., 2020).

The family Zingiberaceae is widely dispersed across the tropics, especially in Southeast Asia, and is well-known for its medical properties. Ginger is a valuable natural resource used in a variety of items, including food, spices, medications, dyes, and perfumes (Kumar et al., 2013). There are more than 1200 species in the 53 genera that make up the ginger family (Kress et al., 2002b). The members of Zingiberaceae are annual or perennial

rhizomatous herbs, with rhizomes of various colors ranging from pale yellow, deep yellow, greenish-blue, pink, or combinations of these in different species. The plants are distinguished by the presence of oleoresins and volatile oils with high export value. The fruits and rhizomes are generally aromatic, energizing, and stimulating, with some producing astringent and diaphoretic juice, while others are high in starch and used as food (Kumar et al., 2013).

The gingers share characteristics with bananas, strelitzias (bird-of-paradise flowers), orchidanthas, heliconias, costus (spiral gingers), cannas, and prayer plants as they are grouped in the same order, Zingiberales. The gingers in Borneo exhibit tremendous diversity, divided into 19 genera with almost 250 recognized taxa (and many others still to be identified). They prefer riverine and limestone forests but can be found from lowland coastal forests up to lower montane forests. Borneo, a hotspot for plant diversity, has four genera exclusive to the island. Several ginger species are used as vegetables or fruits, and many have medicinal purposes, producing spices like ginger, galangal, turmeric, and cardamom. While most flowers only last a day, the beautiful inflorescences generate a succession of flowers lasting several days.

Zingiber officinale is currently the tenth most significant spice and is of major economic relevance (Teris et al., 1997). It can be found in a wide variety of meals and beverages. The cosmetic, pharmaceutical, and perfume industries also use the oil in very small amounts. Ginger is utilized as a digestive stimulant and carminative due to several biological actions it possesses. In cases of motion sickness, powdered ginger may be more beneficial than the antihistaminic dimenhydrinate (Teris et al., 1997). The dried sample of *Zingiber officinale* contains 40–60% carbohydrate, 10% proteins, 10% lipids, 5% fibers, 6% inorganic material, 10% residual moisture, and 1-4% essential oil. Over the past 40

years, numerous studies on the makeup of essential oils have been conducted (Teris et al., 1997).

Herbal markets are important for the distribution of related knowledge as well as for the supply of therapeutic plants. An investigation into the customary applications of medicinal plants sold in Kahramanmaraş, Turkey's herbal markets is described by Palabas Uzun and Koca (2020). They discovered that of the 62 taxa of plants that are traded, 26 are threatened globally to some extent. Demand for medicinal plants rises as a result of commercialization, which also raises risks to these species of plants and their inappropriate use. It is important to educate consumers about the proper applications of medicinal plants and the fact that their supply is limited (Uzun & Koca, 2020).

2.2 Zingiberaceae in Rainforest of Sarawak

According to Whitmore (1984), Borneo is a center of diversity and home to 300 ginger species. The stability of the rainforest environment over the years has helped plant species accumulate and grow, which is the main reason why Borneo has so many endemic gingers (Meekiong et al., 2022).

Each type of vegetation has its own niches, and the species recorded for each type of vegetation are as follows (Meekiong et al., 2022):

i. Low mixed Dipterocarp Forest (LMDF)

About 60% of the gingers recorded in Sarawak are from low mixed dipterocarp forest and a few of them are endemic. For instance, *Boesenbergia artropurpurea*, *Boesenbergia flabellate* and *Boesenbergia lambirensis* are recorded only from Lambir Hills National in Miri Division.

ii. Peat Swamp Forest (PSF)

Diversity and density of gingers in the peat swamp forests are low. *Globba*, *Sundamomum* and *Zingiber* are the three common genera. *Apiamomum borneense* and *Hedychium borneense* are often found as epiphytic on the tree branches along the river in the Maludam National Park.

iii. Limestone Forests

The diversity of gingers in this forest is limited. Most of the gingers such as *Boesenbergia grandis*, *Boesenbergia kerbyi* and *Boesenbergia variegata* are endemic to the limestone of Mulu National Park. Other species such as *Borneocola calcicole* and *Borneocola reticosus* are also confined to limestone of Dered Krian National Park.

iv. Kerangas forest

Conamomum xanthophlebium and *Sundamomum borealiborneense*, *Sundamomum bugoense* are the three most common gingers recorded in the kerangas forest in western of Sarawak.

v. Montane Forest

The gingers are rarely recorded on the summit or areas that exposed directly to the sunlight. The species such as *Boesenbergia stenophylla*, *Burbidgea schizochiela*, *Hedychium cylindricum* and *Plagiostachys bracteolata* are often found at the ridges of the slope.

vi. Secondary Forest

The genus of *Etlingera*, *Hornstedtia*, *Plagiostachys*, *Sundamomum* and *Zingiber* are common in this forest. However, the genus of *Boesenbergia*, *Borneocola*, *Camptandra* and *Haplochorema* are rarely encountered in this forest.

vii. Riparian Forest

More than 70% of the ginger species can be found in this forest such as *Alpinia epiphytica*, *Epiamomum epiphyticum* and *Hedychium muluense* that can be found along the Katibas River. *Alpinia mutica*, *Alpinia nieuwenhuizii* and *Globba astrosanguinea* are found along the Mujung River and Gaat River.

2.3 Ethnobotany Study in Malaysia

Malaysia is a multi-racial country with abundant plant resources, including medicinal plants used in ethnobotany. Each ethnic community practices its own ethnobotany system, reflecting their unique beliefs and traditions. For example, Chinese and Indian communities have rich traditions of using plants in food, construction materials, and medicinal practices. Studying the relationship between plants and Malay culture helps preserve cultural integrity and natural heritage (Adnan & Othman, 2012).

Useful plants are often taken from the forest and replanted in gardens or close to homes, ensuring a ready supply of raw materials for future use, whether for medicinal or other purposes. For this reason, these plants are commonly found in villages. Additionally, a variety of other plants can be found growing on nearby farms, in disturbed forests, or along roadsides and in relatively undisturbed mixed dipterocarp forests (Kulip, 2003). Native communities use native plants in various ways, such as aromatic enhancers, flavorings, or vegetables. However, there are few documented examples of their traditional use, and much indigenous knowledge regarding these native plants has not been transmitted to future generations (Yusli et al., 2021).

Malay women use medicinal herbs and recognize the significance of an elderly female family member's role in postpartum care, including traditional postpartum body massages. Traditional Malay medicine incorporates natural resources from plants,

microbes, animals, and minerals to treat and prevent diseases, heal the body, and enhance overall health. These materials can be used in various forms, including poultices, decoctions, pills, powders, capsules, medicated oils, pastes, infusions, and simple distillates (Othman et al., 2022).

Traditional medicinal plants offer several potential benefits, including low cost, ease of accessibility, and lack of resistance to whole-plant extracts. Traditionally used medicinal plants have been used for thousands of years to treat malaria and are the main components of contemporary anti-malarial medications, such as derivatives of artemisinin and quinine (Al-Adhroey et al., 2010). Herbal remedies were the only source of relief in the past when modern medications were unavailable, typically administered by knowledgeable elders or medicine men (Kulip, 2003).

In Malaysia, medicinal plants have long been used to treat malaria. Research has revealed that seven plant species are used to treat malaria in East Malaysia: *Cassia siamea* L., *Eurycoma longifolia* Jack, *Brucea javanica* Merr., *Alstonia angustiloba* Mig., *Alpinia galanga* Stuntz, and *Tinospora crispa* L. (Al-Adhroey et al., 2010). *Melastoma malabathricum* Linn, used in various parts, has been found to be rich in antioxidants and to possess antimicrobial, anticoagulant, immunomodulatory, anti-ulcer, anti-nociceptive, anti-inflammatory, anti-carcinogenic, and anti-diabetic properties. Therefore, the development of this plant into nutraceuticals has great potential (Samad et al., 2010)

2.4 The Utilization of Zingiberaceae

The Zingiberaceae family of plants is another valuable natural resource that offers humans goods for food, medicine, spices and condiments, cosmetics, dyes, and perfumes. Tropical regions of South and East India are home to the cultivation of this plant for its

rhizome. The family Zingiberaceae is well-known for its ethnomedicine and includes a wide variety of therapeutic plants. Indigenous folk medicines use a few varieties of ginger, such as *Zingiber cassumunar* and *Zingiber zerumbet*. Numerous species of plants are valuable economically and can be used to generate revenue. The crops of Manipur's wild species, *Curcuma caesia*, *Curcuma angustifolia*, *Hedychium spicatum*, and *Hedychium coronarium*, have great potential (Devi et al., 2014). According to Wahidah et al. (2021), the Zingiberaceae family includes plants that are used in traditional medicine. The Indonesian people generally refer to this family as jahe-jahean (gingers) or empon-empon (traditional herbs). Certain plants in the Zingiberaceae family have been traditionally used to treat a variety of ailments. Colo villagers used 14 species of the Zingiberaceae family or empon-empon as medicinal plants: Bangle (*Zingiber purpureum* Roxb), Ginger (*Zingiber officinale*), Red Ginger (*Alpinia purpurata* k. Schum.), Cardamom (*Elettaria cardamomum* (L.) Maton), Kencur (*Kaempferia galanga* L.), Kunci (*Kaempferia pandurata* Roxb.), Turmeric (*Curcuma domestica* Val.), Bitter Ginger (*Zingiber zerumbet*).

Zingiberaceae plants, such as ginger (*Zingiber officinale*) and turmeric (*Curcuma longa*), are extensively used in culinary practices and traditional medicine. The study found that the bioactive compounds in Zingiberaceae are good for health and culinary applications (Kaur & Kapoor, 2002). In Thailand, Zingiberaceae plants are used for about ten different purposes: food, spice, medicine, cut flowers, ornamental, commercial cultivation, fabric dye, cosmetics, rituals, and other socio-religious practices. Some species are also used as materials; for example, the leaf sheath of *Amomum dealbatum* Roxb is used to make mats, and *Etlingera coccinea* (Blume) S. Sakai & Nagam. is used to make roofs by the Sakai ethnic group in the provinces of Trang and Yala (Boonma et al., 2023). Modern pharmacological studies demonstrated that Zingiberaceae exhibit extensive

biological activities, such as antimicrobial, larvicidal, antioxidant, anti-obesity, anti-inflammatory, hypoglycemic, neuroprotective, cardiovascular protective and anti-tumor effects. Zingiberaceae plants have been used to treat various symptoms and diseases, including nausea, vomiting, cough, common cold, and headache, relieving joint pain and menstrual cramp, and preventing stomach ulcers, neurodegenerative diseases, eye inflammation, cardiovascular diseases, diuretic and respiratory disorders (Amiri et al., 2021).

2.5 Zingiberaceae used for medicine in Malaysia

Many ginger species are said to have been utilized historically for both general health and as herbal remedies. *Alpinia zerumbet* leaves are widely used to flavor noodles and wrap rice cakes in Okinawa, Japan, where they are also offered for sale as herbal tea. Tea made from the leaves of *A. zerumbet* has been found to have hypotensive, diuretic, and antiulcerogenic effects (Mpalantinos et al., 1998).

Boiling *Hedychium* species leaves is a common indigestion cure in Peninsular Malaysia (Ibrahim et al., 2001). To relieve stomachache, leaves are occasionally eaten with betel nuts. *Hedychium coronarium* J. Koenig's cooked leaves are used to treat stiff and painful joints in Thailand. The leaves of *Elettariopsis latiflora* Ridl., which are currently included in the genus *Amomum*, have historically been used to treat poisons and alleviate flatulence (Lim et al., 2003).

One of the most popular herbs is *Alpinia galangal* (L.) Willd., also known as lengkuas, and is especially popular in South and Southeast Asia, where it is utilized in cooking. The rhizomes of lengkuas are used in traditional medicine similarly to ginger

(Yang et al., 1999), and it has been reported to contain a number of bioactive chemicals (Janssen et al., 1985; Kondo et al., 1993; Zheng et al., 1993).

One of the traditional folk medicines used by Polynesians for treating diabetes, high blood pressure, cancer, fitness, and many other conditions for over 2000 years is *Zingiber officinale*, also known as common ginger (Tepe et. al., 2006).

Zingiber montanum (Konig), also known as *Zingiber cassumunar* Roxb., has various local names, including "bangley" in Sarawak, "Plai (Phlai)" in Thailand, "Bangle" in Indonesia, and "Bulei" in China. Traditionally, this plant has been used to treat inflammation, pain, and respiratory issues (Han et al., 2021). Some synonyms for *Zingiber cassumunar* Roxb. include *Zingiber cliffordiae*, *Zingiber cassumunar* Roxb., and *Zingiber montanum* (J. Konig) (Sanatombi & Sanatombi, 2016). The rhizome of *Zingiber cassumunar* exhibits inhibitory activity against Epstein-Barr virus activation, contributing to potential cancer prevention methods (Vimala et al., 1999). Additionally, *Zingiber cassumunar* shows potential for use in natural cosmeceutical products, specifically for its anti-aging, skin-whitening, and anti-inflammatory properties (Li et al., 2019). It also has promising anti-allergic effects, as it inhibits nasal pro-inflammatory cytokine production and reduces eosinophilic recruitment in patients with allergic rhinitis (Achararit et al., 2023).

The tropical plant species *Etlingera elatior*, also referred to as "kantan" locally, is a native of Sumatera, Indonesia. The plant is grown in Peninsular Malaysia for its young flower stalks, which are edible raw and can be used to flavour regional foods (Abdelmageed et. al., 2011). This species is a well-liked plant in South-East Asia, where the inflorescences have long been utilized both as food and medicine.

Kra-chai is the local name for *Boesenbergia rotunda* (L.) Mansf. Kulturpfl., also known as *Boesenbergia pandurata* (Robx.) Schltr. In Malaysia, it is sometimes referred to as "temu kunci". The most prevalent *Boesenbergia* species in Malaysia is *Boesenbergia rotunda*. It is frequently used as a food component and a folk remedy in Southeast Asia to treat a variety of illnesses, including leucorrhea, dysentery, dry mouth, stomach pain, and aphthous ulcers. The rhizomes are put to lotions for rheumatism and muscular pains, pastes for body treatment after confinement, and tonics given to women in combinations after childbirth (Burkill, 1935).

Alpinia conchigera Griff., a perennial herbaceous member of the Zingiberaceae family, grows to a height of 2.5 feet and is planted extensively in China, India, and Southeast Asian nations including Thailand, Indonesia, and Malaysia. Local terms for it in Malaysia include "lengkuas raving," "lengkuas kecil," "lengkuas padang," "lengkuas getting," and "chengkenam" (Janssen et al., 1985; Burkill, 1966). The rhizome of *Alpinia conchigera* has been widely used as a spice to flavour food as well as in Thai traditional medicine to treat a variety of illnesses like bronchitis, venereal disease, and skin conditions. The rhizome of *Alpinia conchigera* has been widely used as a spice to flavour food as well as in Thai traditional medicine to treat a variety of illnesses like bronchitis, venereal disease, and skin conditions. It has also been used in Vietnam as a folk remedy to treat cold, stomachache, bloating, digestive disorders, and joint pain (Hanh & Binh, 2014). Moreover, it has been claimed that this plant contains gastroprotective properties (Jin et al., 2021). In Peninsular Malaysia's northern states, it has been utilized as a sporadically in folk medicine to cure fungus infections (Aziz et al., 2013)). This plant has received extensive research for its potential to treat human breast cancer cells, human T-cell lymphoma, and tumour promoter-induced Epstein-Barr virus (Awang et al., 2010).

The perennial tuberous root herb plant *Zingiber zerumbet*, often known as pinecone or shampoo ginger, grows naturally as scattered plants or thickets in wet, shaded areas of lowland or hill slopes (Yu et al., 2008).

Zingiber zerumbet is native to tropical and subtropical Asia and has various pharmacological effects, especially in analgesic and anti-inflammatory models (Chan et al., 2023). In traditional herbal therapy, *Zingiber zerumbet* rhizomes are used in Malay traditional medicine to treat various ailments, including inflammation, fever, toothaches, indigestion, constipation, diarrhea, sprains, pain alleviation, and antispasmodic, antirheumatic and diuretic qualities (Yob et al., 2011).

2.6 Ethnobotany study in Sarawak

Ethnobotany in Sarawak refers to the study of the relationships between the indigenous peoples of Sarawak, a state in Malaysia, and the plants in their environment. Sarawak is known for its rich biodiversity and diverse ethnic groups, and ethnobotany plays a crucial role in understanding how these communities use, manage, and interact with local plant species for various purposes, including traditional medicine, food, shelter, and cultural practices. This field of study helps preserve traditional knowledge, conserve plant species, and may also offer insights for modern applications such as pharmaceuticals or sustainable resource management. Sarawak, a biodiverse region with over 40 sub-ethnic groups, has unique ethnobotanical systems, but rapid urbanization threatens their extinction, leading to nearly non-existent ethnobotanical studies (Rajoo et al., 2022).

Sarawak's diverse population and high biodiversity have led to unique ethnomedicinal systems. However, limited studies have been conducted in Sarawak and Borneo, focusing on major ethnicities like Kenyah, Iban, and Bidayuh communities, or

conducted centuries ago (Rajoo et al., 2022). The consumption of indigenous leafy vegetables (ILV) is a common practice among local people in Bintulu. It serves as an important food resource for local communities in rural areas (Saupi et al., 2020). Wild pepper species are a valuable food source for the Orang Ulu community in Belaga, Sarawak, with potential for commercialization and introduction as a food crop (Alan et al., 2022).

According to Patrick et al. (2022), the use of medicinal plants to treat ailments has been documented since the dawn of human civilization. 20% of all plant species that have been identified worldwide were utilized in public healthcare systems. Medicinal plants are utilized today in the manufacturing of drugs, traditional medicines, beverages, phytopharmaceuticals, galenical, dietary supplements, pharmaceutical auxiliary products, and intermediates. 27 plant species from 20 families are used by native communities in the Central Region of Sarawak as food flavourings or aromatic enhancers, with Zingiberaceae being the most prevalent family and leaves being the most commonly used component (Yusli et al., 2021). Local medicinal plants in Sarawak, Malaysian Borneo show potential anticancer and antimicrobial activity, offering potential for drug discovery and therapeutic applications (Hussain et al., 2020).

According to Abu et al. (2023), today's generation does not take much interest, and there is a threat of extinction of therapeutic expertise, thus it needs to be documented. For this purpose, a review was conducted to investigate the diversity of therapeutic plants and their utilization for different treatments among the local ethnic groups of Sarawak, Malaysia. Information regarding medicinal plants and their utilization was extracted from published articles, books, and thesis using various databases such as Google scholar, Scopus, and web of Science. The study documented the diverse use of 166 therapeutic

plants by local ethnic groups, focusing on treating gastrointestinal and cardiovascular issues. Notably, Rubiaceae, Piperaceae, Leguminosae, Lamiaceae, Annonaceae, and Zingiberaceae were prominent plant families. The study found that decoction was the primary method of medicine preparation, with leaves being the preferred plant component. This sustainable preference gains significance amid the current climate and biodiversity crisis. The critical importance of documenting and preserving this wealth of traditional medicinal knowledge is emphasized for passing on valuable insights to future generations.

Sarawak's rain forests hold potential medicinal value, and its policy supports intellectual property rights for plant-derived drugs, promoting scientific research and promoting sustainable development (Chung, 1996).

2.7 Ethnobotany study of Bidayuh Communities in Sarawak

When Bidayuh first arrived, they settled in Kuching district, Gunung Singai, Gunung Serembu, and Bung Bratak in Bau district, and Kampung Gahat Mawang, Kampung Kujang Mawang in Serian district and in the vicinity of Gunung Penrissen, primarily at Rabak Mikabuh. Nowadays, there are Bidayuh communities all over Sarawak (Patrick et al., 2022).

The Bidayuh people have been utilizing forest resources for their daily needs, including food, shelter, materials for cultural pursuits, medical care, and subsistence. The documentation of the Bidayuh people's custom of using wild plants as medicine is not comprehensive in Sarawak. Previous research concentrated more on plant species known to be anticancer than on other kinds of illnesses (Patrick et al., 2022).

According to Baling et al. (2018), the Jagoi area was once mostly covered in forests, from which the local people have long collected a variety of goods to meet their needs. The

Bidayuh community in the Bau District continues to rely heavily on forest products for food, decorations, traditional medicines, and religious practices. In order to supplement their income, some families in the Jagoi area even sell these goods, including medicinal plants, at the local weekend markets.

The high number of use reports indicates that plant-based treatment remains an integral part of Sarawakian communities. It also reveals the variety of medicinal plant species used by the local community. The high cost of modern healthcare and medical facilities in the nation, combined with easy access to herbal remedies, may be the cause of the high reliance of the local population on these resources (Baling et al., 2018).

2.8 Ethnobotany study on Zingiberaceae

Sarawak is the largest Malaysian state with a land area of 124,000 square kilometers with 9,500 species of recorded plants. Sarawak's population of 2.2 million is made up of 30 ethnic groups, each own unique rich and colourful cultures and traditions. The indigenous communities have, for many generations; relied heavily on the forest to supply them with everything they needed (Chai, 2006).

Ginger has long been valued for its culinary and medicinal uses. In Malaysia and other tropical Asian nations, ginger comes in a variety of species and varieties; some are farmed for commercial purposes, while others are still uncharted territory. Active phytochemicals found in gingers have been shown in scientific studies to have a wide range of biological and therapeutic effects, including anti-inflammatory, antioxidant, and anti-tumor effects (Ujang et al., 2015).

The present study by Fatimah et al. (2023), the Zingiberaceae family includes turmeric, galangal, ginger, and curcuma, which are used as traditional medicine by the Kedungombo Village community.

The only study of gingers in Sarawak was done by Poulsen (2006). This study had described 18 ginger genera and 150 species that were found in Sarawak, however, only a few species were used by the local community for medicinal and been described in this study. *Etlingera kenyalang* is a new species from southern Sarawak, Borneo, with edible shoots, fruits, and leaves used in Iban ethnobotany for ritual purposes during the Gawai Kenyalang Festival (Poulsen & Christensen, 2003).

The study by Yusli et al. (2021) aimed to record and identify communal knowledge from the Central Region of Sarawak regarding the use of indigenous plants as food flavorings or aromatic enhancers. A total of 27 plant species from 20 families were identified for their use by native people as food flavoring or aromatic enhancement. Zingiberaceae was found to be the most prevalent family of plants in this study, with a representation of four species.

2.9 Zingiberaceae's commercial potential in Malaysia

The extraction rhizome of *Curcuma xanthorrhiza* and *Zingiber zerumbet* have been utilised commercially in skin-lightening products in Malaysia (Ujang et al., 2005, Abdul Rahman et al., 2005). The plants were developed by SIRIM Berhad and commercialised by the company Sireh Emas Marketing Sdn. Bhd. in the products Xanzwhite and NLC Phyto Serum. In vitro studies have demonstrated that the aqueous and supercritical fluid extracts have potent anti-tyrosinase action and prevent melanin production.

Alpinia zerumbet leaves are being used in generation for calming tea due to the high content of polyphenol. Some study also found that these leaves are containing collagen synthesis which been used in anti-wrinkle cosmetics by Kanebo Cosmetics.

Pure and natural ginger root extract is now available from Symrise, a global producer of perfumes, flavourings, cosmetic active ingredients, raw materials, and functional components. In three weeks, SymVital® AR has been shown to considerably enhance the smoothness and texture of stressed skin, reduce wrinkles, and improve complexion regularity. Also, it aids in reducing sun damage symptoms in less than two weeks.

With the extraction of *Zingiber zerumbet* derived from supercritical CO₂ fluid extraction, another business, Sederma, has created a novel active ingredient that helps to reduce leg discomfort and early ageing. To increase circulation in the legs and reduce weariness, the active ingredient is supposed to block inflammatory events that cause lipid storage and water retention.

The most often used gingers are from the genera *Alpinia*, *Amomum*, *Boesenbergia*, *Curcuma*, *Kaempferia*, *Elettaria*, *Elettariopsis*, *Etlingera*, *Hedychium*, and *Zingiber*. Several species have been cultivated for use as ornamental plants, fresh vegetables, medicines, sauces, and flavours. Ginger essential oil has high therapeutic values such as anti-inflammatory, analgesic, anticancer, antioxidant, antinociceptive, and antitussive properties (Munda et al., 2018).

2.10 Zingiberaceae for Essential oil

The essential oil of *Zingiber officinale* contain immunostimulatory activity which able to improve humor and cell-mediated immune response mechanisms (Fabio et al.,

2009). The study done by Hua-Li Zhou et al, (2006) found that the volatile oil of ginger influences cell-mediated immune response and nonspecific proliferation of T lymphocyte and may exert beneficial effects in a number of clinical conditions, such as chronic inflammation and autoimmune disease. The bioactivity found in essential oil of *Zingiber officinale* is antiglycation, while the essential oil content in *Curcuma xanthorrhiza* acts as antihyperglycemic and anti-inflammatory (Irmanida et al., 2016).

Cardamom phytochemicals show promising therapeutic potentials as antioxidants and antimicrobials, which could enhance shelf life, reduce oxidative stress, and mitigate chronic diseases like cardiovascular and gastrointestinal diseases (Abdullah et al., 2022).

The study of the chemical composition, antioxidant, and anti-microbial activity of the essential oils obtained from the rhizomes and leaves of *Alpinia conchigera* reveals the presence of bioactive substances. Eucalyptol made up the majority of the rhizome EO (60.58%), whereas -bisabolene made up the majority of the leaf EO (46.70%). In comparison to leaf EO and the standard antioxidant butylated hydroxytoluene, the most prevalent polyphenolic components in rhizome EO had stronger antioxidant activity (Zaman et al., 2021).

2.11 Taxonomy study of wild Zingiberaceae in Sarawak

New combinations of *Scaphochlamys* and *Haplochorema* have been reported in the subfamily Zingiberoideae of Lambir Hills National Park, Sarawak, Malaysia (Sakai & Nagamasu, 2006). The *Scaphochlamys* genus in Borneo includes 24 species, 11 of which are newly identified, and is organized into six informal groups based on morphological characteristics (Hin et al., 2017b). This genus is found in southern Thailand, Peninsular Malaysia, and Borneo, comprising 31 species and six varieties (Searle, 2010). A survey

recorded 28 taxa from 8 genera in southern Peninsular Malaysia, including three species endemic to Johor: *Scaphochlamys lanceolata*, *Scaphochlamys klossii* var. *glomerata*, and *Zingiber* (Sedek et al., 2023). *Scaphochlamys stenophylla*, a new species from Bau, Kuching Division, Sarawak, Malaysian Borneo, was described by Hin & Yeng (2014).

According to Lamb et al. (2013), 14 species of *Zingiber* have been recorded in Sarawak, and 29 species have been identified throughout Borneo. Meekiong et al. (2015) noted that almost all *Zingiber* species were discovered in lowland areas, with exceptions such as *Z. kelabitianum* Theilade & H. Chr. and *Z. pachysiphon* B.L. Burtt & R.M. Sm., which were also found at elevations above 1,600 meters. The diversity of the *Scaphochlamys* genus in Sarawak expanded with the discovery of *S. stenophylla* by Ooi & Wong (2014). With the addition of three new species described in this paper, the total number of *Scaphochlamys* species recorded in Sarawak now stands at 14. The two new *Scaphochlamys* species, named *S. limiana* Meekiong & Yazid and *S. samunsamensis*, were collected from the kerangas forest of Samunsam Wildlife Sanctuary. To date, *S. samunsamensis* has been recorded only in the Samunsam Wildlife Sanctuary and Gunung Pueh (Meekiong et al., 2015).

2.12 Anatomical study of the Zingiberaceae leaf

Tregear (2011) conducted a thorough analysis of the anatomy of the Zingiberaceae family on roughly 70 species. Studying interspecific and intergeneric variation within the family is very important. A more extensive analysis of the family by Tregear (2011) raised the idea that specific anatomical characteristics of the leaf could have diagnostic value for the genus. plant habits, and rarity of flowering.

The study by Zhao et al., (2022), focused on the leaf epidermal characteristics of 22 *Zingiber* species across three sections, employing light microscopy and scanning electron microscopy to explore their phylogenetic and taxonomic significance. The investigation revealed hexagonal or polygonal epidermal cells with non-sinuous anticlinal walls, arranged parallel to leaf veins, a common feature in Zingiberaceae genera. Tetracytic stomata were observed on both adaxial and abaxial epidermis, predominantly in intercostal regions, with higher occurrence on the abaxial surface. Notably, species in sect. *Pleuranthesis* exhibited significantly lower stomatal density than those in sects. *Zingiber* and *Cryptanthium*. Two trichome types were identified: "delicate" trichomes in most species and "stout" trichomes with a swollen base exclusive to *Z. corallinum* and *Z. montanum*. Oil cells were found in both epidermal layers of some species in sects. *Zingiber* and *Cryptanthium*, while crystals were present only in the abaxial epidermis across all species, except in *Z. ellipticum* from sect. *Pleuranthesis*. Although epidermal morphology remained similar across most *Zingiber* species, variations in stomatal density, trichome types, and the distribution of oil cells and crystals provide valuable insights for systematic and taxonomic studies within the genus.

2.13 The effect of difference altitude with the diversity and density of plant

Bruun et al. (2006) identified a clear relationship between altitude and the reduction in species diversity as one moves from the Equator towards the poles. In extreme Arctic environments and on alpine summits, species richness is nearly zero, although the precise mechanisms behind this trend and the factors that influence it are still widely debated. Altitude has been shown to be the most influential factor in determining plant species

composition, particularly in the Kashmir Himalayas, where it explains the greatest variation in plant diversity (Wani et al., 2023).

Dani et al. (2023) found that topographical and climatic factors lead to complex elevation-species richness patterns. Some taxa demonstrate bimodal distribution, while others exhibit multi-modal patterns, with peak diversity occurring at different altitudes. Extremes in temperature and precipitation, often observed at both the highest and lowest elevational ranges, are believed to contribute to diminished species diversity. This pattern can be attributed to the mid-domain effect, a hypothesis suggesting that species richness tends to peak at mid-elevations due to geometric constraints on species ranges.

Altitude significantly affects plant species distribution by influencing key environmental factors such as light, temperature, water availability, and soil conditions. These factors collectively shape the spatial distribution of plant families and the dominance of specific genera (Wang et al., 2023). At higher elevations, trees grow taller and wider, leading to increased spatial heterogeneity in plant structures. Additionally, the diversity of shrub and herb species varies with elevation, as perennial herbs tend to thrive at higher altitudes, while annual herbs flourish in mid-latitudes and lower altitudes (Xu et al., 2017).

Climate plays a critical role in determining plant species distribution. However, its influence diminishes at higher altitudes due to increased endemism and a more homogeneous climate at these elevations (Chauvier et al., 2020). As altitude increases, climatic conditions become more uniform, leading to greater specialization among species and a narrower range of species that can survive. This results in distinct patterns of species distribution across different altitudinal gradients, highlighting the complex interplay between altitude, climate, and plant species diversity

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

This chapter presents the framework used in this study, which involves three phases: ethnobotanical data collection, socio-economic data collection, and data analysis. Before conducting the study, obtaining prior informed consent from the local community in the Singai and Jagoi areas was essential for documenting the traditional knowledge of useful plants under Part V of the Sarawak Biodiversity Regulation 2016. This was followed by the research regulation procedure for applying for a permit to conduct research in the state of Sarawak. Conducted in the Singai and Jagoi forests of Bau District, Sarawak, the study involved collecting Zingiberaceae species through systematic field surveys across various elevations, with detailed documentation and micromorphological analysis of leaf samples. Quantitative analysis included data collection via structured questionnaires administered to 170 households to gather socio-demographic data, traditional plant uses, and awareness of medicinal gingers, as well as systematic vegetation sampling using belt transects to quantify species distribution and density. Statistical techniques such as descriptive statistics, Pearson's correlation coefficient, and One-Way ANOVA were used to analyze the data and identify significant differences between groups. Socio-demographic data were analyzed to understand plant utilization patterns, and the study evaluated conservation status and socio-economic potential, emphasizing ethical considerations and aiming to preserve traditional knowledge and promote sustainable development.

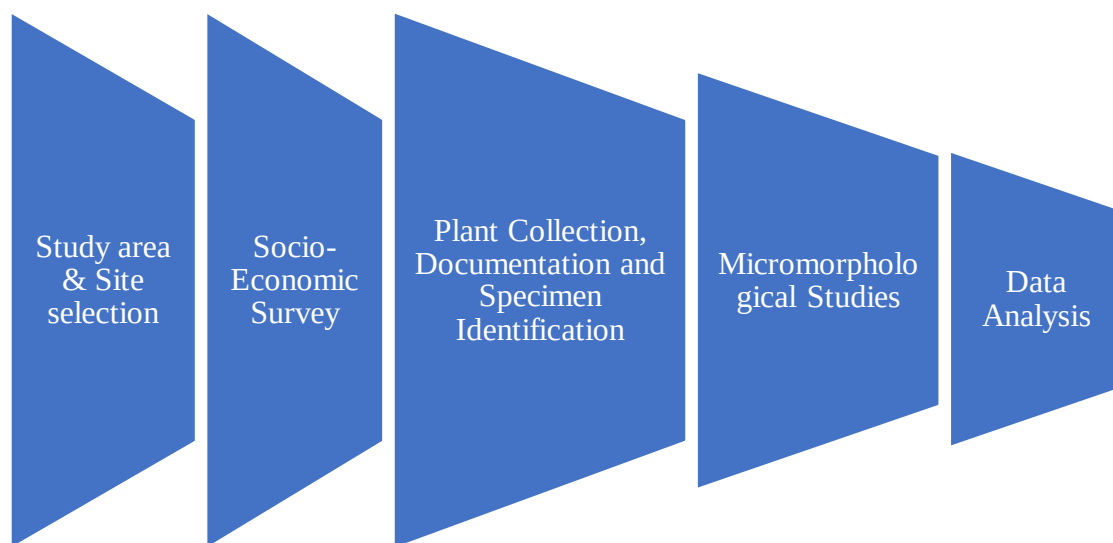


Figure 3.1: Flow Chart of the Step-by-Step Processes in the Study

3.2 Study Site

The study was carried with the 2 Bidayuh communities in Sarawak.



Figure 3.2: Map of Sarawak (Source: <http://www.malaysia-maps.com>)

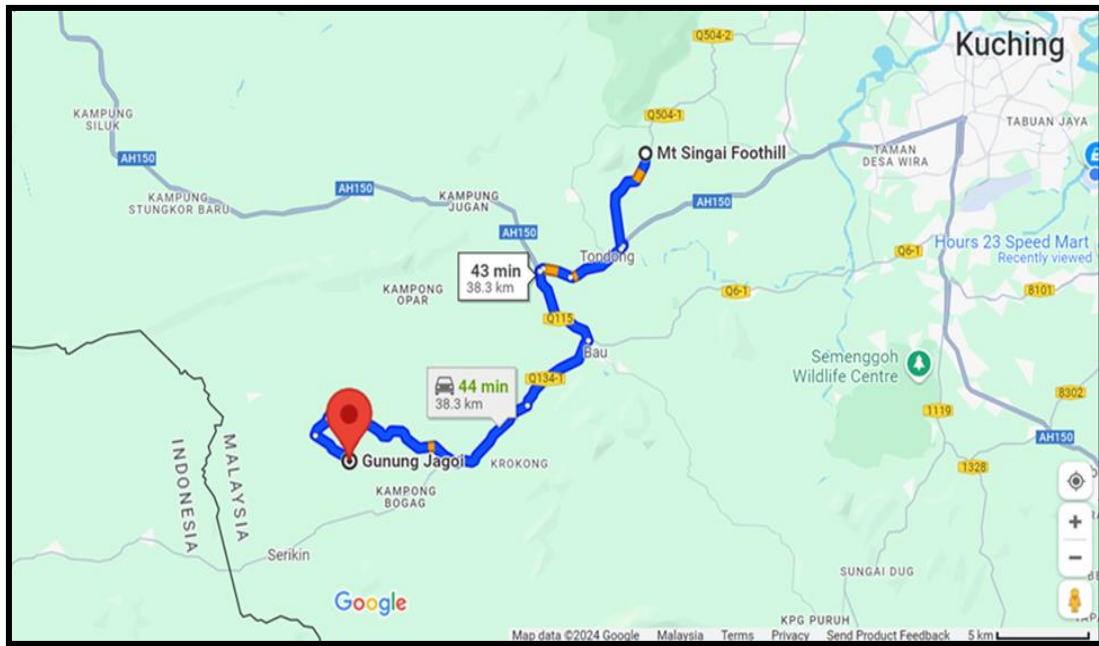


Figure 3.3: Image of Singai and Jagoi, Bau (Source: <http://www.Google Earth Image 2024: Singai/Jagoi Bau Sarawak>)

The study involved two areas of Bidayuh communities in Sarawak: Mount Singai, Singai, and Mount Jagoi. These areas were selected due to the early establishment of Bidayuh settlements (Ripen & Noweg, 2016).

The ethnic communities in these locations continue to practice traditional medicine, with Zingiberaceae plants being of paramount importance (Ripen & Noweg, 2016). Additionally, these communities have a rich heritage and long-standing knowledge of ethnobotanical practices, making them ideal for studying the preservation and application of traditional plant usage. Singai is located about 40 km from Kuching city, and Jagoi is located 60 km from Kuching. Both areas still have a few hectares of nearby forest. The surrounding land along the mountain slope is the last bastion of green virgin tropical rainforest in the area, housing rich biodiversity and supplying clean water to the villages. Locals from the immediate villages collect natural resources from these areas for their use and to sell to tourists at their respective stalls along the roadside and Bau local market.

3.3 Socio-Economic Study

The second phase of data collection is the socio-economic study, which includes three sections: the socio-demographic data of surveyed households, utilization patterns, and the value of Zingiberaceae.

3.3.1 Household Survey

- Statistical calculation for the required sample size
- Determination of the household-purposive sampling method
- Reliability and validity test: Cronbach's Alpha value (0.749) - 20 samples
- Questionnaire interview: 170 household surveys

In this case study, the focus was on the direct usage of, or dependence on, traditional herbs within the Jagoi and Singai communities and their surroundings. The selection process for interviewees involved two main components. Firstly, the type of households to be interviewed was determined. Households participating in the study were identified through discussions with community leaders and key informants. A list of households, known for their full-time residence and use of herbal gingers, was compiled for each selected village. These households were then chosen using a purposive sampling method, prioritizing those with a permanent and continuous presence in the villages and a history of using medicinal gingers.

The second step was to determine the necessary sample size for the household interviews. This decision was influenced by factors such as the desired precision level, available time, and budget constraints. This careful approach ensured that the survey

accurately reflected the community's reliance on traditional herbs, while also considering practical limitations.

3.3.2 Structured Questionnaires Survey

For this study, the questionnaire included both structured questionnaires and perception surveys. The interview questions also covered the socio-demographic characteristics of the respondents, their treatment of illness, the use of plants for traditional medicine, the utilization pattern of traditional medicinal plants, the preference for household medication, and the respondents' awareness and understanding of medicinal gingers. To gather information for the purpose of achieving the study's goals and addressing its hypotheses, a series of structured questionnaires were used. A questionnaire is a pre-written collection of questions that respondents answer, usually within a small range of alternatives. To assess the instruments' validity and reliability, the questionnaires underwent preliminary testing. The questionnaire survey used in the study is shown in Appendix A and B.

3.3.3 Population and Sample

Sampling is a crucial element of the population study. Precision and the level of confidence are key considerations when determining the sample size. The necessary level of confidence, the researcher's tolerable margin of error, and demographic variability all impact the required sample size. Once the desired accuracy of the sample data was decided, the number of respondents needed was calculated. In this study, non-probability sampling was employed. Given the demographic details of the families studied, it was possible to determine the sample size using a purposive sampling method. This method is

applicable when the population is homogeneous and readily available. The sampling process comprises several stages: defining the population of concern, specifying a sampling frame (a set of items or events possible to measure), choosing a sampling method for selecting items or events from the frame, determining the sample size, implementing the sampling plan, collecting data, and reviewing the sampling process. The sampling strategy adopted in this study is homogeneous sampling, where the survey was conducted in a homogeneous population with similar backgrounds and experiences. In this study, two areas, namely Jagoi and Singai, were selected based on their larger population size in Kuching. The effective population size for this study consisted of full-time resident households using medicinal plants. The effective total household population was estimated. It was further assumed that population homogeneity (with similar backgrounds and experiences) was at 90 percent. At a 95% confidence level and a margin of error of 5 percent, the sample size was determined.

This sample size was calculated to provide the necessary level of precision and confidence for the study's objectives. The minimum number of necessary samples to meet the desired constraints is 133 respondents. The number of respondents was distributed equally to ensure a balanced representation of both areas. A total of 170 respondents answered the questionnaires, with 89 from Singai and 81 from Jagoi.

i) Initial sample estimate, n: -

$$n = \frac{Z^2 \times (p) (1-p)}{c^2}$$

$$n = \frac{(\pm 1.96)^2 \times (0.9)(1 - 0.9)}{0.05^2}$$

$$n = 138$$

Equation 3.1

Where,

Z = *Z* value (± 1.96 for 95 percent confidence level)
p = percentage of estimated population homogeneity
c = margin of error

Using the above formula, *n* was found to be 138.

Where,

Z = *Z* value (± 1.96 for 95 percent confidence level)
p = percentage of estimated population homogeneity
c = margin of error

Using the above formula, *n* was found to be 138.

ii) Final sample size, n_1 :-

$$n_1 = \frac{N \times n}{N + n}$$

$$n_1 = \frac{4000 \times 138}{4000 + 138}$$

Equation 3.2

$$n_1 = 133$$

3.4 Documentation, Plant Collection and Specimen's Identification

The first phase of data collection involves ethnobotanical data, which includes plant documentation, taxonomy, and altitude. Plant documentation was conducted at Mount Singai and Mount Jagoi, Bau. The documentation includes:

- Usage and plant preparation
- Local name, botanical description, location and habitat
- Photo of the plants
- Plant species identification
- Altitude

3.5 Specimen Identification

Critical morphological features of each species included in the study were thoroughly examined, such as the leafy shoot, petiole, number of flowers supported by fertile bracts, presence and shape of bracteole, flower, calyx, labellum, presence and shape of staminodes, presence of a staminal tube, anther crest shape, and fruit. New species were identified and described. To find informants knowledgeable about the Zingiberaceae family of medicinal plants, community leaders from Singai and Jagoi were consulted. These informants, experts in the use of Zingiberaceae, were incorporated into the study as field guides. To ensure consistency and avoid discrepancies in species identification and unreliable data, plant collections were conducted with the same informants throughout the research. Field parameters included information on taxonomy, altitude, and all relevant data pertaining to the plant's application. Most ginger species were found in the moist, shaded undergrowth, with their green stems emerging through the humid forest floor, while some grew on cliffs beneath the trees. Herbarium specimens were brought to the Sarawak Herbarium (SAR) of the Sarawak Forest Department for identification and were deposited at the UNIMAS herbarium for reference.

3.6 Specimen Collection

Specimen collection was conducted using the belt transect method at locations in Singai (1°30'26''N, 110°10'11''E) and Jagoi (1°21'42''N, 110°02'18''E). Wild ginger specimens were systematically gathered every 10 meters, with transects spaced 5 meters apart. Sampling took place at 100-meter elevation intervals. The precise number of transects and quadrats established during the assessment is not detailed, nor is it specified if the number of transects and quadrats is consistent across both study locations.

The objectives of this sampling included determining: (a) the total number of wild ginger species present, (b) changes in the spatial distribution of individuals within a species, and (c) the varying presence of species across the transect.

Statistical analysis through Pearson's correlation coefficient was employed to explore the impact of altitude on the diversity and density of wild gingers, with the goal of elucidating the significance and altitudinal influence on the diversity and density of useful Zingiberaceae species.

3.7 Data Analysis

The third phase is data analysis of ethnobotanical which include the taxonomy and altitude analysis and socio-demographic data of surveyed households, utilization pattern and value of Zingiberaceae. The methods used for this study and the subsequent data analysis is described.

3.8 Morphology Studies

The fresh samples of the seven new species of useful Zingiberaceae and three known species were collected for comparison of leaf anatomy characteristics. The purpose of the study is to obtain leaf anatomical evidence and micromorphological characteristics that can support the taxonomic conclusions drawn using other characters for species identification. Two types of taxonomy treatments were conducted to identify the cells of leaf samples for each species.

3.8.1 Microscope Digital Camera

Sample Preparation using Rotary Microtome

Fresh samples of ten useful gingers were collected from Singai and Jagoi, Bau. The purpose of the study is to obtain leaf anatomical evidence and micromorphological characteristics that can support the taxonomic conclusions drawn using other characters for species identification.

The fresh samples were fixed in a 3:1 acetic acid (AA) solution (70% alcohol: 30% acetic acid), sectioned using a sliding microtome (Leica SM2000r), and stained with Safranin and Alcian blue. Subsequently, they were dehydrated in a series of ethanol solutions (50%, 70%, 80%, 90%, and 100%). The sections were then mounted in Canada balsam and left for 2 weeks. Finally, the samples were observed under an Olympus DP72 microscope digital camera.

3.8.2 Scanning Electron Microscopy (SEM)

The leaf samples for both the abaxial and adaxial parts of each species were cut into small pieces. The samples were then immersed in Formalin-Aceto-Alcohol (FAA) fixative (3.7% v/v formaldehyde, 50% ethanol, 5% acetic acid) and subjected to a light vacuum until the samples sank. The samples were fixed overnight (approximately 18 hours) at 4°C. They were then rinsed three times in 25 mm sodium phosphate buffer (pH 7) before being dehydrated in an ethanol series (30%, 50%, 70%, 95%, and 100% dry, 30 minutes each step). The 100% dry ethanol was changed twice, and the tissue was stored overnight at 4°C before using the Critical Point Drier (CPD) the next day.

Sample Preparation using Critical Point Drier (CPD K850)

The chamber was pre-cooled to 5°C before use. The specimens were loaded, and the chamber insert was ensured to be correctly tightened with the thumb-screw. The green valve was turned clockwise to fill the chamber with CO₂ liquid. The specimens were soaked and stirred for 3 minutes while maintaining the temperature below 10°C. This process was repeated three times. The specimens were then heated for 35 minutes to reach 35°C and 1250 psi pressure. The samples were depressurized for 20 minutes. The dried specimens were then mounted on aluminum stubs attached with carbon tape for the coating process. The samples were platinum-coated before SEM imaging.

The aim was to identify differences in trichomes, stomata, epidermal cells, subsidiary cells, epicuticular wax, and glands.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Pattern of Utilization: Plant Use in Bidayuh Communities

Bidayuh community in both areas, Jagoi and Singai use single plants or mix different plants as a medicine in a single disease. It is also found that a single plant is used in different diseases. Of these, 16 species are indicated by informants as medicinal plant, eight species are indicated by informants as edible fruit, four species for ritual ceremonies, three species for food flavouring, two for ornamental and one species each are for slimming, wrapping food, skincare, vegetable and handicraft (Figure 4.1).

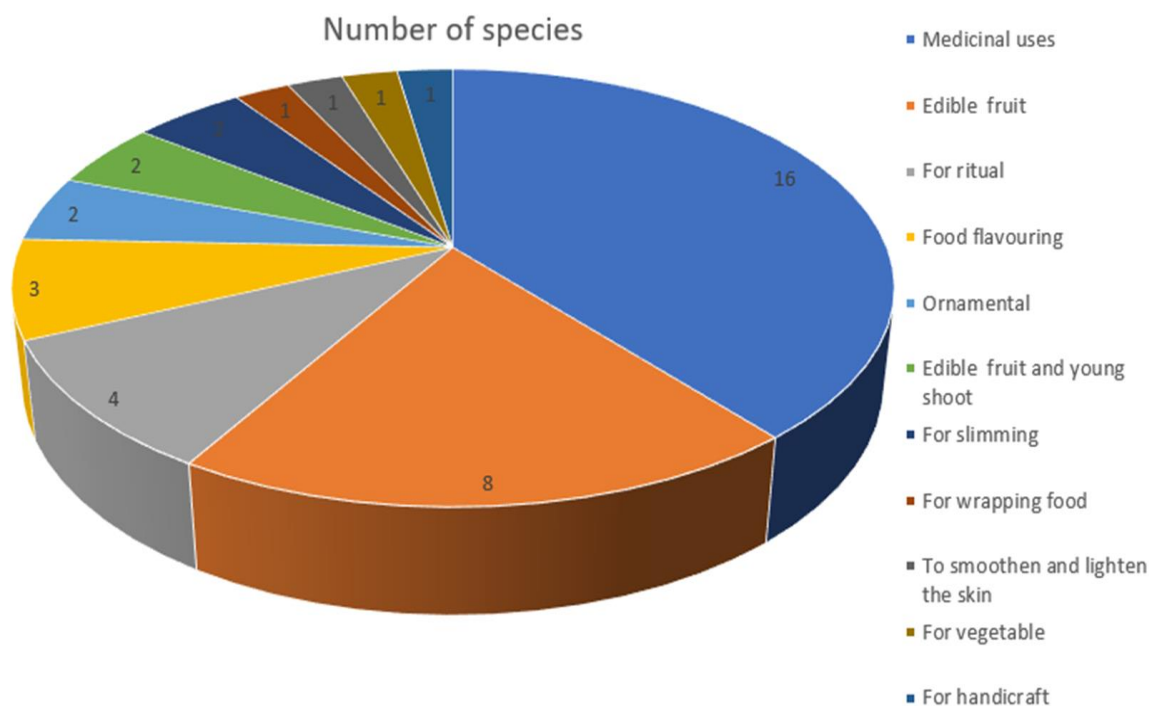


Figure 4.1: Plant Usage

The Bidayuh community in both Jagoi and Singai employs a diverse pattern of plant utilization, reflecting their rich ethnobotanical knowledge and cultural practices. They use

single plants or mix different plants as medicine for treating a single disease, highlighting the complexity and depth of their traditional medicinal systems.

It is also found that a single plant can be used for multiple diseases. This versatility of plants shows how much the Bidayuh community knows about the medicinal properties of their local flora. For example, a plant used to treat stomach ailments might also be used to heal wounds or reduce fever. Bidayuh communities in Malaysia use 44 medicinal plant species to treat 25 ailments, with five primary ailments being fever, wound, post-partum care, hypertension, and skin diseases (Patrick et al., 2022). This flexibility in plant use is well-documented in ethnobotanical studies and highlights the practical application of indigenous knowledge (Balick & Cox, 1997)

Among the Zingiberaceae species studied, 16 species were identified by informants as medicinal plants. This high number of medicinal species within a single plant family highlights the significant role Zingiberaceae play in the traditional healthcare practices of the Bidayuh. Medicinal plants are often chosen based on their efficacy and availability, and the Zingiberaceae family's diverse phytochemical compounds make them suitable for treating a variety of ailments (Kress et al. (2002b).

Eight species are indicated by informants as edible fruits, which are likely integrated into the community's diet and nutrition. The use of plants for food and medicine illustrates the concept of "food-medicine continuum," where the boundary between food and medicine is fluid (Etkin & Ross, 1982). This practice is particularly important in maintaining health and preventing diseases within the community.

Four species are used in ritual ceremonies, demonstrating the cultural significance of plants beyond their practical uses. Ritual use of plants often involves symbolic meanings and is integral to maintaining the cultural heritage and spiritual well-being of the

community (Voeks, 2004). Three species are used for food flavouring, which not only adds to the culinary diversity but also often carries medicinal benefits. For instance, spices and flavouring agents from the Zingiberaceae family are known for their digestive and antimicrobial properties (Ekor, 2014).

Two species are identified for ornamental use, contributing to the aesthetic value and possibly the ecological sustainability of the community's environment. One species each is used for slimming, wrapping food, skincare, as a vegetable, and for handicrafts. These varied uses highlight the comprehensive application of plants in different aspects of daily life, emphasizing their importance in both economic and cultural contexts (Cunningham, 2001).

4.2 Documentation of Useful Zingiberaceae for Medicinal Purposes

All these plants have been recorded to treat 12 human diseases (Figure 4.2). Bidayuh community in both areas, Jagoi and Singai use single plants or mix different plants as a medicine in a single disease. It is also found that a single plant is used in different diseases. Most of the plants are used for the treatment of skin diseases, diarrhoea, headache, gastric, conjunctivitis, white vaginal discharge, diabetic, wound to lower the blood sugar level, to remove wind from the body, to mitigate body pain after childbirth and to improve blood circulation.

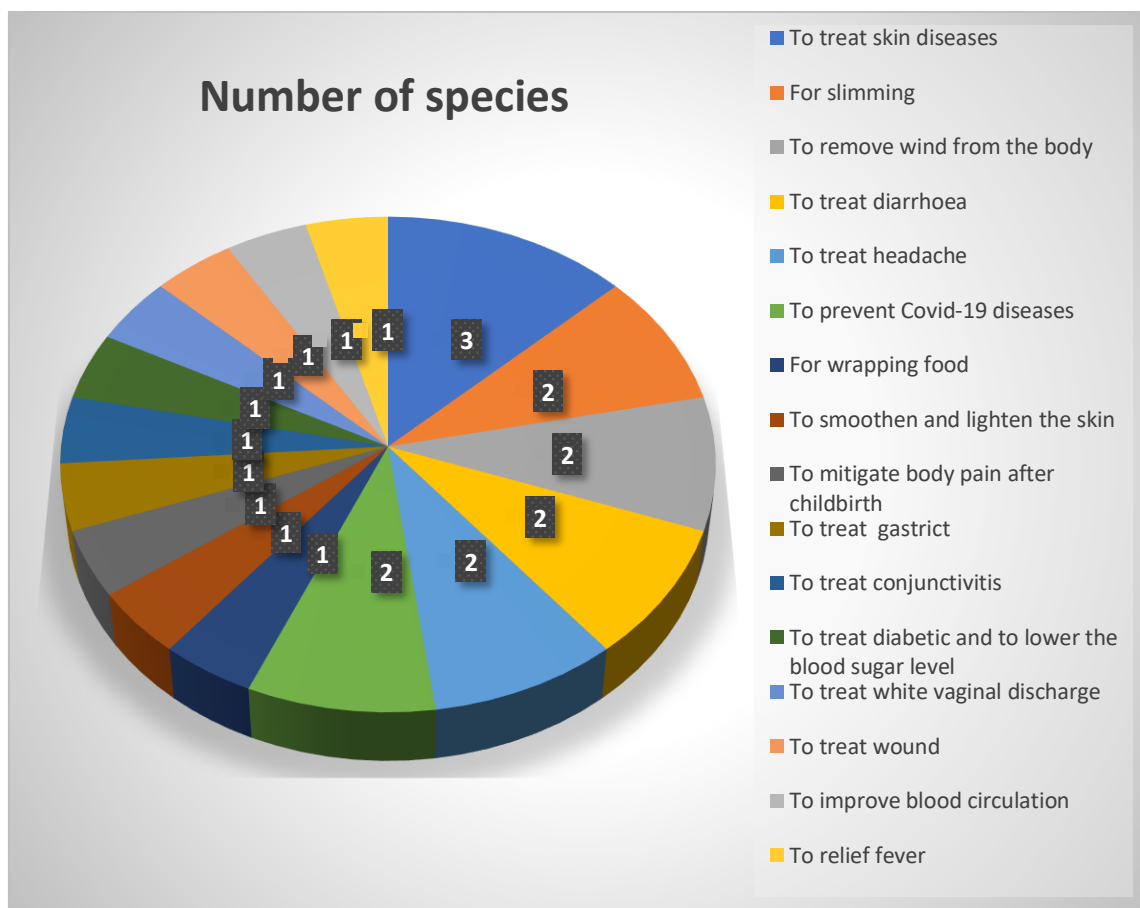


Figure 4.2: Pattern of Utilization of Zingiberaceae for Medicinal Purposes

Discussion

The documentation of useful Zingiberaceae species for medicinal purposes has revealed their extensive use in treating a variety of human diseases within the Bidayuh community in Jagoi and Singai. These plants have been recorded to treat 12 different human diseases, showcasing the broad spectrum of their medicinal applications (Figure 4.2). The utilization of these plants highlights the deep ethnobotanical knowledge possessed by the Bidayuh people and their reliance on natural resources for healthcare.

The Bidayuh community employs both single plants and mixtures of different plants to treat individual diseases. It is also found that a single plant can be used to treat multiple diseases (Baling et al., 2018). This multifunctionality is indicative of the versatility and

rich phytochemical profiles of Zingiberaceae species. For example, a plant used for treating gastric issues might also possess antimicrobial properties that make it effective for treating skin infections or wounds. Such uses are supported by scientific research that shows many Zingiberaceae species contain compounds with broad-spectrum biological activities (Kress et al., 2002b).

Among the diseases treated with these plants are skin diseases, diarrhea, headaches, gastric issues, conjunctivitis, white vaginal discharge, diabetes, wounds, and conditions requiring the lowering of blood sugar levels. Additionally, these plants are used to remove wind from the body, mitigate body pain after childbirth and improve blood circulation. The use of plants for such a wide range of ailments underscores their importance in traditional medicine and their potential for developing new pharmacological agents (Balick & Cox, 1997).

For instance, the treatment of skin diseases and wounds with Zingiberaceae plants can be attributed to their antimicrobial and anti-inflammatory properties. Plants like *Curcuma longa* are well-known for their wound-healing capabilities and are extensively studied for their medicinal properties (Ekor, 2014). Similarly, plants used for gastrointestinal issues, such as diarrhea and gastric problems, often possess antispasmodic and anti-diarrheal properties, which are crucial for managing these conditions (Tafti et al., 2017).

The Bidayuh community's use of Zingiberaceae species to address pandemic-related illnesses underscores their innovative application of traditional knowledge to modern health issues. While definitive evidence of these plants' efficacy against specific viral outbreaks remains scarce, their recognized antiviral, immunomodulatory, and anti-inflammatory qualities suggest a plausible basis for their utilization. Zingiberaceae is used

by the Bidayuh community for medicinal purposes, as they believe it can cure many diseases traditionally (Ripen et al., 2022c).

In conclusion, the documentation of Zingiberaceae species for medicinal purposes among the Bidayuh community underscores the significance of traditional knowledge in healthcare. These plants play a crucial role in treating a wide range of diseases, reflecting their versatile pharmacological properties and the deep understanding of natural medicine within the community. The integration of such traditional practices with modern scientific research can lead to the discovery of new therapeutic agents and promote the conservation of these valuable plant resources (Balick & Cox, 1997; Kress et al., 2002b).

4.3 Socio-demographic Characteristics of the Respondents

Ethnobotany, an interdisciplinary field, is essential for understanding and conserving indigenous cultures and natural habitats, as well as for discovering new medicines and agrochemicals (Prance, 1991). The concept of ethnobotany integrates scientific and anthropological perspectives to explore the role of native plants in indigenous cultures. This examination contributes to the management of cultural and natural resources, community development, and human health. Additionally, ethnobotany plays a role in studying the socio-demographic characteristics of indigenous peoples (Ethnobotany, 2017).

4.3.1 Population Structure and Dynamics

Generally, the demographic information was about gender, age, marital status, household size, occupation, religion, and education level. A total of 170 respondents answered the questionnaires, with 89 from Singai and 81 from Jagoi. The details of the

socio-demographic characteristics of the respondents are presented in Table 4.1. The data is presented using means and percentages.

Table 4.1: Distribution of Respondents by Socio-Demographic Characteristics (n=170)

Socio-demographic variables	Characteristics	Number of Respondents	Percentage (%)
Gender	Male	80	47
	Female	90	53
Age (years)	30 and below	17	10
	31-40	32	18
	41-50	34	20
	51-60	32	17
	61-70	48	28
	71-80	5	4
	80 and above	2	3
Race	Bidayuh	166	97
	Chinese	4	3
Religion	Christian	157	92
	Traditional Religion	13	8
Occupation	Farmer	26	15
	Civil Servant	44	26
	Private sector	53	31
	Entrepreneurs	10	5
	Housewives	25	15
	Others	12	8
Individual Income (RM) Monthly	RM100-RM500	47	28
	RM501-RM1000	18	10

Table 4.1 continued

	RM1001-RM1500	6	4
	RM1501-RM2000	7	5
	RM2001-RM2500	37	22
	RM2501-RM3000	32	18
	RM3001-RM4500	20	11
	RM4501-RM6500	3	2

The collected demographic information includes gender, age, marital status, household size, occupation, religion, and education level. Responses were gathered from 170 individuals, with 89 from Singai and 81 from Jagoi, as detailed in Table 4.1. Analysis of the data reveals a near-equal gender distribution, with females slightly more prevalent at 53% compared to males at 47%. This indicates a minor female predominance in survey participation. The age data points to a significant presence of older individuals, particularly those aged 61-70, who constitute 28% of the sample, suggesting the need for services and programs tailored to older adults. Conversely, younger individuals aged 30 and below are less represented, making up only 10% of respondents, which may indicate a gap in engaging this demographic.

The racial makeup is predominantly Bidayuh at 97%, with a minimal representation of the Chinese community at 3%, indicating that the findings are largely reflective of the Bidayuh population. Regarding religion, 92% of respondents identify as Christians and 8% follow Traditional Religion, emphasizing the importance of culturally sensitive community initiatives. From an occupational perspective, the largest groups include individuals from the private sector (31%) and civil servants (26%), with farmers representing 15%. Entrepreneurs make up 5% of the respondents, highlighting potential areas for promoting entrepreneurial initiatives and economic development.

Income levels among respondents vary, with 28% earning between RM100 and RM500, suggesting a substantial segment of the community is in lower economic brackets. Only 2% of respondents earn between RM4501 and RM6500, highlighting the economic disparities within the community. These socio-demographic characteristics provide actionable insights for policymakers and community planners, emphasizing the need for healthcare enhancements for seniors, economic development initiatives to boost local entrepreneurship and job training, and youth engagement strategies through technology, education, and vocational training. Additionally, integrating cultural and religious considerations in community planning is crucial due to the predominance of the Bidayuh community and the Christian faith, ensuring that future interventions and recommendations align with the community's demographic profile and needs (Schram, 2013).

4.3.2 Respondent's Treatment of Illness

This section discusses how a typical household responds to an illness or a medical problem. It also identifies the frequency of respondent's visits to health center in a year.

i. Health Services

When the respondents were asked what they do if they fall sick, the majority of them (94 persons or 87 %) answered that they prefer to go to the clinic and also prepare home medicine from plants. This is because both areas are more developed where they have a government clinic facility and are easily reached by road. Only 18 (9%) of them admits seeking treatment from a medicine man to treat their ailment and go to clinics. There is only 1 (4%) of them prefer to attend medicine man alone, which is from Jagoi area (Table 4.2.).

Table 4.2: Distribution of respondent's treatment types (n=170)

Treatment Types	Singai	Jagoi	Total	Percentage (%)
Clinic and Home Prepared Medicine	70	81	151	87
Clinic and Attend to Medicine man	12	6	18	9
Attend to Medicine man only	0	1	1	4

Discussion

When respondents were asked what they do when they fall sick, the majority (94 individuals or 87%) reported that they prefer to visit a clinic and also prepare home remedies using plants. This tendency is likely influenced by the availability and accessibility of healthcare facilities in more developed areas, where government clinics are readily accessible by road. Studies have demonstrated that access to healthcare facilities significantly impacts healthcare-seeking behaviors, with individuals in areas that have better access to medical services being more likely to utilize formal healthcare. Socially vulnerable individuals, however, are more likely to experience healthcare inequities and have reduced access to care, underscoring the need for interventions focused on equity (Haggerty et al., 2020)

Furthermore, the preference for combining modern medical treatment with traditional home remedies highlights the continued importance of ethnomedicine in these communities. This dual approach is common in many cultures, where traditional knowledge of medicinal plants is used alongside modern healthcare to provide comprehensive treatment (Xin et al., 2020).

Only 18 respondents (9%) reported seeking treatment from a medicine man in addition to going to clinics. This suggests that while traditional healers still play a role in healthcare, their use is supplementary rather than primary for most people. The reliance on

traditional healers may be due to cultural beliefs, the perceived effectiveness of traditional remedies, or trust in the knowledge of these healers (WHO, 2002).

There is only 1 respondent (4%) from the Jagoi area who prefers to attend a medicine man alone. This indicates that reliance solely on traditional healers is quite rare, reflecting a significant shift towards modern healthcare services in these communities. The decline in exclusive reliance on traditional medicine could be attributed to the increasing availability of modern healthcare services and education about their benefits (Leonard et al., 2002).

4.4 Exploring Undocumented Zingiberaceae in Singai and Jagoi

This research tackles the identification of unrecorded ginger species in the biodiverse Singai and Jagoi forests. Banaticla et al. (2023) note that only 45% of the 1,449 known Zingiberaceae species have been assessed, with 21% endangered, underlining the critical need for detailed studies on their conservation in tropical Asia.

The oral transmission of traditional Zingiberaceae knowledge is vulnerable to modernization and shifting lifestyles, risking the disappearance of valuable ethnobotanical insights and the loss of both cultural heritage and potential medicinal resources. Earlier studies, such as those by Baling et al. (2018), have explored Zingiberaceae taxonomy and ecology in Bau but overlooked their medicinal roles in Bidayuh traditions.

Due to the challenges in distinguishing species based on classical morphology alone, this study explores micromorphological features, enhancing identification and classification through scanning electron microscopy (SEM) and other advanced techniques.

Moreover, understanding the traditional uses of Zingiberaceae could foster new medicinal, culinary, and industrial products, benefiting the Bidayuh economically. Proper

documentation and validation of this knowledge could also boost eco-tourism, encourage sustainable harvesting, and enable the commercialization of ginger products, thus improving community livelihoods.

A multidisciplinary method, integrating ethnobotanical records, ecological assessments, and economic analysis, is employed to maintain traditional knowledge, advance biodiversity conservation, and unlock the economic potential of Zingiberaceae in Bau, Sarawak. Documenting and validating the uses of these species aims to safeguard cultural heritage and support sustainable development, setting a precedent for similar studies in other biodiverse areas.

The specific aims are to record the ethnobotanical use of Zingiberaceae by the Bidayuh in Jagoi and Singai, assess their medicinal importance, explore how altitude affects their diversity and density, perform comparative leaf anatomy and micromorphological studies, and analyze the socio-demographic impact on the utilization of these plants. This study strives to preserve traditional knowledge and deepen our understanding of the ecological and cultural relevance of Zingiberaceae in the Bidayuh community.

4.5 Documentation, Plant Collection and Specimen's Identification

A total of 50 species belonging to 22 genera of useful gingers have been documented for the Bidayuh of Singai and Jagoi (Table 4.3). This report analyzes the documented uses, methods of preparation, and descriptions of 50 species of useful gingers found in the Singai and Jagoi regions. These species belong to 22 different genera and serve various purposes, including medicinal, culinary, handicraft, and ornamental uses. The detailed documentation highlights the significant role these plants play in the lives of the Bidayuh

community.

The usage of these ginger species is diverse. Many species are used for medicinal purposes. For example, *Alpinia songet* is used to treat skin diseases, and *Boeserbergia pulchella* is used to treat conjunctivitis. Several species are used in food preparation, such as *Etlingera coccinea* for food flavoring and *Plagiostachys crocydocalyx* for both food and handicrafts. Some species, like *Geocharis rubra* and *Hornstedtia reticulata*, are used for making strings and weaving materials. Additionally, species such as *Globba pumila* and *Globba francisci* are planted for decorative purposes, while *Sulettaria longituba* is used in rituals.

The methods of preparation are specific to each use. For medicinal purposes, the rhizome is often pounded and applied directly to the skin or consumed. For instance, the rhizome of *Zingiber cassumunar* is pounded and used for massages after childbirth. In culinary applications, parts of the plant, such as the stem or rhizome, are cooked. The stem of *Etlingera coccinea* is cooked with soup to enhance its flavor. For handicrafts, the sheaths of leaves are split into strips and used for weaving, as seen with *Geocharis rubra* and *Hornstedtia reticulata*. For ornamental uses, the plants are grown primarily for their aesthetic value without additional preparation.

The plant descriptions include key characteristics that help in identifying the species. The documented gingers range in height from about 20 cm to 4 meters. Inflorescence and flower color are significant identifying features. For instance, the red inflorescence of *Geocharis rubra* and the white flowers of *Globba pumila* are distinctive. Other notable features include the presence of yellow labellum in *Geocharis rubra* or the purple patches on the leaves of *Etlingera brevilabrum*.

The table 4.3 shows that Mount Singai, Singai hosts 34 species of useful gingers,

while Mount Jagoi has 13 species. Additionally, 3 species are found in both Mount Singai, Singai, and Mount Jagoi.

In conclusion, the various uses and preparation methods of the documented ginger species underscore their importance to the Bidayuh community in Singai and Jagoi, as detailed in Table 4.3. The descriptions provided assist in identifying and conserving these valuable plants. This study highlights the critical role of documenting traditional knowledge to ensure its preservation and ongoing utilization. By understanding and cataloging the multiple applications of these plants, we can appreciate the rich cultural heritage and promote sustainable practices within the community.

Table 4.3: List of documented useful Zingiberaceae among the Bidayuh community of Singai and Jagoi, Bau

No	Prefix (MK)	Genera	Species	Local Name	Usage	Method of Preparation	Plant Description	Location
1	MK 1 (B)	<i>Geocharis</i>	<i>rubra</i> Ridl	Bunga birieh	String	The sheaths of matured leaf are splits into strips and use as string	Wild ginger about 1m tall. The erect red inflorescence above the ground. Flowers are red, labellum yellow with reddish stripes	Mount Singai, Singai
2	MK 2 (B)	<i>Alpinia</i>	<i>songet</i> Ripen & Meekiong	Bua songet	The pounded rhizome is applied on skin diseases	The pounded rhizome is applied on skin diseases	Wild ginger about 1 meter tall. Green to black fruit	Mount Singai, Singai
3	MK 3 (B)	<i>Boeserbergia</i>	<i>pulchella</i> (Ridl.) Merr	Roi torun	To treat conjunctivitis	The whole plant pounded to extract the sap. The sap drops into the eyes	Wild ginger about 30-60 cm tall. The erect red inflorescence is	Mount Singai, Singai

Table 4.3 continued

							spindle-shaped bearing many flowers that opening 1-3 at a time. Flowers are white and red,	
4	MK 4 (B)	<i>Hornstedtia</i>	<i>reticulata</i> (K. Schum.) K. Schum	Topu torun	Handicraft	The sheaths of the leafy shoot are split into strips used for weaving mats, basket and tray.	Wild ginger about 3 m tall. The red inflorescence above the ground. Flowers are red with reticulate bract.	Mount Singai, Singai
5	MK 5 (B)	<i>Sulettaria</i>	<i>longituba</i> Holt.	Bunga batuh	Ritual	The plant was used during the ritual	Wild ginger about 30 cm tall. White flower	Mount Singai, Singai
6	MK 6 (B)	<i>Globba</i>	<i>astrosanguine</i> <i>a</i> Teijsm. & Binn	Likuyang	To mitigate body pain after childbirth	The pounded rhizome is use for massaging the body of mother after childbirth	Wild ginger about 30 cm tall. Red flower	Mount Singai, Singai & Jagoi

Table 4.3 continued

7	MK 7 (B)	<i>Globba</i>	<i>brachyanthera</i> K. Schun	Bunga torun	To treat smallpox	The leaves and the young shoots are pounded into a fine paste and apply on the skin.	Wild ginger about 70 cm tall. White flower	Mount Singai, Singai
8	MK 8 (B)	<i>Globba</i>	<i>pumila</i> Ridl.	Bunga torun	Ornamental	Plant as ornamental	Wild ginger about 30 cm tall. White flower	Mount Singai, Singai
9	MK 9 (B)	<i>Globba</i>	<i>francisci</i> Ridl	Bunga torun	Ornamental	Plant as ornamental	Wild ginger about 30 cm tall. Yellow flower	Mount Singai, Singai
10	MK 10 (B)	<i>Etlingera</i>	<i>brevilabrum</i> (Valeton) R.M Sm	Bunga britik	The pounded rhizome is applied ton skin diseases	The pounded rhizome is applied ton skin diseases	Red flower. Has more or less patches of purple on the leaves, and very clear in young leaves	Mount Singai, Singai
11	MK 11 (B)	<i>Plagiostachys</i>	<i>crocydocalyx</i> (K. Schum) B.L Burt & R.M Sm	Bua manuk	For food and handicraft	The fruit is edible, the young shoot is eaten cooked, and the sheaths of the leafy shoot are	Giant gingers about 3-4m tall, clump- forming plant has an enormous, slimy	Mount Singai, Singai

Table 4.3 continued

						split into strips used for weaving mats, basket and tray.	inflorescence and the flowers are yellow.	
12	MK 12 (B)	<i>Scaphochlamys</i>	<i>calicicola</i> <i>A.D.Poulsen</i> & <i>R.J.Searle</i>	Bungadorod	To wrap the wound	The leaves are used to wrap the wound	Herb 30-60 cm tall. The rhizome crawls horizontally on the ground, is strong, and has a diameter of about 7 mm. Stems up to 1.5 cm long, slender, glabrous, hidden at base of leaves. There are inflorescences near the base of the leaves in leafless pods, with flowers from base to apex. Corolla lobes	Mount Singai, Singai

Table 4.3 continued

							superimposed on white lobes, white with pale yellow-green center.	
13	MK 13 (B)	<i>Amomum</i>	<i>longipedunculatum</i> R.M.Sm	Topu torun	For food	Edible shoot	Wild gingers about 1 m tall. Long erect peducles and cone shape inflorescence. Green fruit	Mount Singai, Singai
14	MK 14 (B)	<i>Etlingera</i>	sp.	Topu torun	To treat skin diseases	The pounded rhizome is applied ton skin diseases	Wild gingers about 1.5 m tall	Mount Singai, Singai
15	MK 15 (B)	<i>Zingiber</i>	sp.	Roi torun	To treat headache	The pounded rhizome produces flesh smell	Wild gingers about 70 m tall.	Mount Singai, Singai
16	MK 16 (B)	<i>Hornstedtia</i>	<i>conica</i> Ridl.	Topu torun	Edible fruit and young shoot	Edible fruit and young shoot	Wild gingers about 1.5 m tall, inflorescence with white bracts and red margins. The flowers	Mount Singai, Singai

Table 4.3 continued

							are with pink lip and a white centre	
17	MK 17 (B)	<i>Sundamomum</i>	<i>borealibornee</i> (I.M. Turner) A.D Poulsen & M.F Newman	Bunga sija	Edible fruit	Edible fruit	Wild gingers about 1 m tall, flower with white open labellum, yellow lip and red vein on the throat	Mount Singai, Singai
18	MK 18 (B)	<i>Sundamomum</i>	<i>laxesquamosum</i> (S.Sakai & nagam.) A.D. Poulsen & M. F Newman	Bunga sija	Edible fruit	Edible fruit	Wild gingers about 1 m tall	Mount Singai, Singai
19	MK 19 (B)	<i>Alpinia</i>	<i>glabra</i> Ridl.	Sibodug	Edible fruit and young shoot	Edible fruit and young shoot	Wild gingers about 1 m tall, inflorescence terminal and the flowers are red. Green fruit.	Mount Singai, Singai
20	MK 20 (B)	<i>Alpinia</i>	<i>ligulata</i> K.	Sibodug	Edible fruit	Edible fruit and the	Wild gingers about 1	Mount Singai,

Table 4.3 continued

			Schum		and the leaves are for wrapping food	leaves are for wrapping food	m tall, inflorescence terminal and the flowers are yellowish. Yellow fruit.	Singai
21	MK 21 (B)	<i>Alpinia</i>	<i>havilandii</i> K. Schum	Topu tegak	To treat gastric	The rhizome is pounded and boil with water. The warm water taken as tea.	Wild gingers about 2 m tall, inflorescence terminal and the flowers are red. Green fruit.	Mount Singai, Singai
22	MK 22 (B)	<i>Alpinia</i>	<i>beamanii</i> R.M.Sm*	Bua manuk	Edible fruit	Edible fruit	Wild gingers about 1 m tall, inflorescence terminal and the flowers are light green or creamy green. Green fruit.	Mount Singai, Singai
23	MK 23 (B)	<i>Meistera</i>	<i>gyrolophos</i> (R.M. Sm)	Bunga sija	Edible fruit	Edible fruit	Wild gingers about 1 m tall, inflorescence	Mount Singai, Singai

Table 4.3 continued

			Skornick & M.F. Newman				prostrates on the forest floor with numerous red bracts and bright orange labellum. Spiny green fruit.	
24	MK 24 (B)	<i>Etlingera</i>	<i>coccinea</i> (Bl.) Sakai & Nagam	Topu	Food flavouring	The stem is cook with soup for food flavouring	Wild gingers about 2 m tall, inflorescence at ground level with numerous red flowers and long yellow lip with an enrolled and red margin. The stem produces aromatic smell.	Mount Singai, Singai
25	MK 25 (B)	<i>Alpinia</i>	<i>galanga</i> (L.) Willd.	Rikug	1. To treat skin diseases 2. Food	1. The rhizome pounded and apply on the skin 2. The rhizome are	Planted gingers about 2 m tall, inflorescence	Mount Jagoi

Table 4.3 continued

					flavouring for sweet taste 3. To relief fever	pounded and cook with duck (talo) for food flavouring and give sweet taste 3. The rhizome pounded and used for massage	terminal. Rhizome taste sweet	
26	MK 26 (B)	<i>Etlingera</i>	<i>elatior</i> (Jack) R.M. Sm	Kantan	Food flavouring	The stem is cook with soup for food flavouring	Cultivated gingers about 2 m tall, inflorescence is erect to 2m with pinkish bracts and recurved. Numerous red flowers and long yellow lip with an inrailed and red margin.	Mount Jagoi
27	MK 27 (B)	<i>Curcuma</i>	<i>longa</i> Val.	Umi'et	1. To treat diarrhoea	1. The rhizome pounded to extract the juice.	Planted gingers about 30 m tall and	Mount Jagoi

Table 4.3 continued

					2. To treat wound 3. Food flavouring	Drink the juice. 2. The rhizome pounded and rubbed onto the affected area. 3. The leaves are used in cooking for flavouring	fragrance smell of leaf. Rhizome with yellow colour	
28	MK 28 (B)	<i>Curcuma</i>	<i>zaedoria</i> Val.	Ta'mu budak	1. To lighten the skin 2. To treat white vaginal discharge 3. For Covid-19 prevention	1,2 & 3. The rhizome pounded and boiled in water for 30 minutes. Drink the water.	Planted gingers about 60 m tall and fragrance smell of leaf with purple band along upper midribs. Rhizome with yellow colour	Mount Singai, Singai & Jagoi
29	MK 29 (B)	<i>Curcuma</i>	<i>xanthorrhiza</i>	Umi'et mopuk	1. To lighten the skin 2. To treat white vaginal discharge	1,2 & 3. The rhizome pounded and boiled in water for 30 minutes. Drink the water.	Planted gingers about 60 m tall and fragrance smell of leaf. Rhizome with yellow colour	Mount Jagoi

Table 4.3 continued

					3. For Covid-19 prevention			
30	MK 30 (B)	<i>Zingiber</i>	<i>cassumunar</i> Roxb.	Ngolai	1. Used for massage mother after childbirth to improve blood circulation 2. Claimed by community to treat cancer	1. The rhizome pounded and poultice the abdomen of the mother and bandage 2. The rhizome sliced and boiled in water for 30 minutes. Drink the water.	Planted gingers about 40 m tall and fragrance smell of leaf. Rhizome with yellow orange	Mount Jagoi
31	MK 31 (B)	<i>Zingiber</i>	<i>officinale</i> Roscoe	Ro'ie	To remove wind from the body	The rhizome pounded and boiled in water for 2-3 hours. Drink the water.	Planted gingers about 30 m tall. Rhizome with spicy taste	Mount Jagoi
32	MK 32 (B)	<i>Amomum</i>	<i>oliganthum</i> K.Schum	Bua roja	Edible fruit	Edible fruit	Wild gingers about 1 m tall, inflorescence on the ground and	Mount Jagoi

Table 4.3 continued

							with cream to orange colour of flower. Spiny green fruit.	
33	MK 33 (B)	<i>Zingiber</i>	<i>officinale</i> var <i>rubrum</i>	Ro'ie birieh	For slimming	The rhizome pounded and applied on the stomach	Planted gingers about 30 m tall. Rhizome with spicy taste and red color	Mount Jagoi
34	MK 34 (B)	<i>Kaempferia</i>	<i>galanga</i>	Sokul	To remove wind from the body	The rhizome pounded and boiled in water for 2-3 hours. Drink the water.	Planted gingers about 20 m tall. Rhizome with aromatic smell and cream colour	Mount Jagoi
35	MK 35 (B)	<i>Amomum</i>	sp.	Dowen poras	For freshener	The leaves are crush and smell as freshener	Cultivated gingers about 40 cm tall and fragrance smell of leaf	Singai
36	MK 36 (B)	<i>Plagiostachys</i>	<i>albiflora</i> Ridl.	Bua manuk	To lower fever in baby	Mash the leaves and gently rub on the forehead	Giant gingers about 3-4m tall, clump-forming plant has an	Mount Jagoi

Table 4.3 continued

							enormous, slimy inflorescence and the flowers are yellow. Very strong sour smell of the fruit.	
37	MK 37 (B)	<i>Hedychium</i>	<i>coronarium</i> J. Koenig	Bunga stuli	To treat headache	The flowers are boil. The water is for bath	Wild ginger about 1 m tall. Scented white flowers with yellow bases.	Mount Jagoi
38	MK 38 (B)	<i>Costus</i>	<i>speciosus</i>	Bunga buda	To treat diabetic and to lower the blood sugar level	The rhizome boiled in water for 30 minutes. Drink the water.	Wild ginger about 1 m tall. Leaves spirally arranged on the stem. Rhizome tuberous, 1-2 cm thick, highly branched, yellowish green inside. Flower white, numerous, in	Mount Jagoi

Table 4.3 continued

							dense spike and bracts ovate, acute, with bright-red colour.	
39	MK 39 (B)	<i>Curcuma</i>	<i>caesia</i> Roxb.	Miet songet	For skin care and slimming	The rhizome pounded and boiled in water for 30 minutes. Drink the water.	Wild ginger about 20 cm tall. Black rhizome	Mount Jagoi
40	MK 40 (B)	<i>Amomum</i>	<i>jackliamii</i> Ripen & Meekiong	Dowen poras	For headache	The leaves are crushed and rubbed on forehead for headaches.	Wild gingers about 30 m tall and lemon grass smell of leaf	Mount Singai, Singai
41	MK 41 (B)	<i>Amomum</i>	<i>cerasinum</i>	Bua torun	Edible fruit	Edible fruit	The leafy shoot is about 3 m tall, the corolla is cherry-red and the lip is white with red bands.	Mount Singai, Singai

Table 4.3 continued

42	MK 42 (B)	<i>Amomum</i>	<i>macroglossa</i> K. Schum	Bua torun	Edible fruit	Edible fruit	A clump of leafy stem raised up on stilt roots. The inflorescence on a short peduncle end in a round flowering head with golden-brown bracts. Flowers have a large rounded white lip with a yellow centre.	Mount Singai, Singai
43	MK 43 (B)	<i>Amomum</i>	sp. nov. ined.	Dowen pangu	To remove the bad smell on the hand or any part of the body	The leaves are rub on the hand	Wild gingers about 70 cm tall and fragrance (pangu) smell of leaf	Mount Singai, Singai
44	MK 44 (B)	<i>Boeserbergia</i>	<i>flavoalba</i> R.M. Sm	Jrangau	To reduce the pain of	The root are chew and put near to the tooth	Wild gingers about 25 cm tall. White	Mount Singai, Singai

Table 4.3 continued

					toothache (numb agent)		flower with yellow and red stripe	
45	MK 45 (B)	<i>Etlingera</i>	sp. nov. ined.	Topu torun	Food flavouring	The stem is cook with soup for food flavouring	Wild gingers about 2 m tall, inflorescence at ground level with numerous red flowers with long lip. The stem produces aromatic smell.	Mount Singai, Singai
46	MK 46 (B)	<i>Sullettaria</i>	<i>suculosa</i> (K.Schum.) A.D. Poulsen	Bua manuk	Food source for animal	The inflorescence is eaten by animal such as wild boar	A wild ginger forms clump of leafy shoots from spreading rhizomes, 2-3 m tall with 18-25 pairs of leaves. The inflorescence very long trailing on the soil surface or leaf	Mount Singai, Singai

Table 4.3 continued

							litter. The flower are white.	
47	MK 47 (B)	<i>Zingiber</i>	<i>singaiensis</i> Ripen & Meekiong	Bunga manuk	Food source for animal	The inflorescence is eaten by animal such as wild boar and bird. It is potentially to be use as ornamental as the inflorescence has orange and pink colour	Wild ginger about 70 cm tall. The leaves are broad 4-6 pairs. The bracts are pink colour, erect and peduncle about 10-15cm.	Mount Singai, Singai
48	MK 48 (B)	<i>Zingiber</i>	sp. nov. ined	Bunga birieh	Food source for animal	The inflorescence is eaten by animal such as wild boar and as ornamental	Wild ginger about 70 cm tall. The leaves are broad 4-6 pairs. The bracts are bright red, not so erect and peduncle about 10-15 cm.	Mount Singai, Singai
49	MK 49 (B)	<i>Globba</i>	<i>rubra</i> Ridl	Bunga	Ornamental	Plant as ornamental	Wild ginger about 30	Mount Singai,

Table 4.3 continued

				buda			cm tall. White flower	Singai & Jagoi
50	MK 50 (B)	<i>Sulettaria</i>	<i>meekiongii</i> Ripen & Teo	Tongun sija	String	The sheaths of matured leaf are splits into strips and use as string	A wild ginger 1 m tall with 5-8 pairs of leaves. The leaves are with white hair. The inflorescence with brownish colour of bract trailing on the soil surface. The flower is white, and the fruit is ellipsoid and red colour.	Mount Singai, Singai

Discussion

The ethnobotanical study of useful gingers among the Bidayuh community in Singai and Jagoi offers valuable insights into the diverse applications and preparation methods of 50 documented species. This documentation highlights the intricate relationship between the Bidayuh people and their natural environment, underscoring the importance of preserving traditional knowledge for future generations.

A significant gap remains in identifying unknown species of useful gingers in the Singai and Jagoi forests. Specifically, the study seeks to uncover which unknown species of medicinal and culinary gingers may still be discovered in these areas.

Medicinal Uses

Zingiberaceae is highly regarded in Bidayuh Bau, Sarawak for its distinctive flavors and ornamental and medicinal properties, as noted by Ripen et al. (2022). In Nakhon Nayok Province, Central Thailand, the Mueang district boasts the greatest diversity of Zingiberaceae, which are widely used traditionally, according to Boonma et al. (2023). In Central Java, Indonesia, Zingiberaceae are plentiful and show promise for use in food, medicine, and as ornamentals, though more study is needed on their growth and cultivation (Lianah et al., 2020). The family is also crucial in Northeast India for its medicinal benefits, especially for gastrointestinal and respiratory conditions, with 41% of species used medicinally (Tushar et al., 2010). In Udon Thani Province, Thailand, Zingiberaceae species are diversely used for medicinal purposes, food, ornamentals, rituals, spices, perfumes, and cosmetics, with various plant parts such as rhizomes, roots, pseudostems, young inflorescences, leaves, and fruits being utilized (Saensouk & Saensouk, 2021). Ginger has immunomodulatory, anti-tumorigenic, anti-inflammatory, and anti-oxidant

properties, making it a safe and effective herbal medicine for various diseases and conditions (Ali et al., 2007).

Culinary Uses

Several ginger species are integral to the culinary traditions of the Bidayuh. The use of *Etlingera coccinea* for food flavoring and *Plagiostachys crocydocalyx* in both food and handicrafts illustrates the multifunctional nature of these plants. The culinary applications not only enhance the flavor of dishes but also contribute to the nutritional value of the diet. The specific methods of preparation, such as cooking the stem with soup, demonstrate the unique culinary heritage of the Bidayuh community. This practice not only preserves traditional recipes but also ensures the continued use of these plants in daily life (Lim, 2016).

Handicrafts and Ornamental Uses

Ornamental gingers *Hedychium coronarium* and *Alpinia purpurata* exhibit various pharmacological effects. *Hedychium coronarium* has attracted more research attention, whereas *Alpinia purpurata* has been studied less, as noted by Chan & Wong (2015). Moreover, Marques et al. (2019b) found that increasing nitrogen doses up to 400 kg ha⁻¹ through fertigation in protected environments produces about 77 commercial flowers of 100 cm height per tussock per year, which supports the commercial production and standardization of ornamental ginger.

Biodiversity and Conservation

The study highlights the rich biodiversity of Mount Singai and Mount Jagoi, revealing the presence of 34 species in Mount Singai and 13 in Mount Jagoi, including 3 species common to both. These findings underline the ecological importance of these areas, where the Bidayuh Bau community cultivates Zingiberaceae species for medicinal and culinary purposes (Ripen et al., 2022b).

Zingiberaceae family, is noted for its diversity and traditional uses, particularly in Southeast Asia, a key region for its variety. In Thailand, research shows significant diversity, such as in Nakhon Nayok Province with 155 species across 16 genera, and Udon Thani Province with 47 species from 9 genera, highlighting the genera *Curcuma* and *Kaempferia* as the most diverse (Saensouk & Saensouk, 2021b). Similar biodiversity is observed in Nam Nao National Park and the Cinchona Forest Reserve in the Philippines (Saensouk & Saensouk, 2021b).

Concern for conservation is critical, evidenced by several species being listed as rare or endangered. For example, in Nam Nao National Park, eight species are classified as least concern on the IUCN Red List, while two are noted in the Thailand Red Data: Plants (S. Saensouk et al., 2016). Studies in Eastern India also underscore the family's genetic diversity, which is vital for conservation and breeding programs (Mohanty et al., 2013). This genetic diversity is explored through PCR-based markers that aid in species distinction and conservation efforts.

Overall, the ecological and cultural significance of Zingiberaceae, coupled with its considerable species diversity, underscores the need for sustained conservation strategies and the protection of traditional knowledge associated with its use.

4.6 New species

A total of seven species were identified as new species of useful gingers. All of these new species are used by the local community for various purposes, demonstrating the ongoing importance of traditional knowledge in identifying and utilizing local flora.

4.6.1 *Sulettaria meekiongii* Ripen & S.P. Teo sp. nov.

The new species is similar to *Sulettaria polycarpa* with short stilt-rooted pseudostem and white flowers. The new species, however, can be differentiated by pure white flowers and fruits enclosed by the bracts, while *S. polycarpa* with white flowers with a yellow band at the median of labellum and fruits are exposed.

Type: Borneo, Sarawak, Kuching Division, Singai, Gunung Singai, mixed dipterocarp forest, alluvial soils, 01°34'16.56''N, 110°12'11.45''E, 989 m above sea level, 9 April 2022, Meekiong, K. & Ripen, J.E., MK4026 (SAR – holo; SBC, Herbarium Universiti Malaysia Sarawak – iso).

Description: Plant clumping, up to 10 pseudostems, 50-70cm tall, with short stilt-rooted up to 7-10cm long, light green color. Rhizome c. 1-1.2cm diam., orange brownish colour; the base of the shoot with 6-8 leafless sheaths, long leaf sheaths about 10 cm, green to dark green wrap around the stem, abaxial slightly silvery and glabrous. Leaves provided of 6–8 pairs, alternate arrangement; leaf blades elongate, 20–30 x 3–5 cm, apex acuminate, acumens about 1–2 cm long. Leaf margin entire, smooth around the entire leaf. Upper surface green to dark green, with prominent veined or corrugated, lower surface light green to green, slightly veined. Petiole 6 mm long; ligule short, c. 4 mm, green with brown edges, apex rounded, darker when dried. Inflorescences arise close to the base of pseudostem, 3-4, erect, conical. rachis 3-5cm long. Bracteoles tubular, boat-shaped, 2 x 3

cm, reddish, floral stalk, 15mm long, glabrous, calyx tubular, 8–10 mm, long, creamy to reddish at the base. Flowers tubiform, c. 4 cm long; 2–3 flowers open at a time with obovate to elliptic labellum and entire, thin, crisp margin. Ovary 5mm long, 1mm diam., glabrous, dorsal lobe oblong, 8–12 x 1.5–2 mm, curved backward, glabrous, apex hooded, lateral lobes 2, oblong, 8–11 x 1.2–2 mm, curved backward, glabrous, apex rounded, pale white. Labellum pale yellow, center yellow. Staminodes absent. Anther 5mm, pale yellow on a short filament 15mm, crested.

Habitat: This species thrives very well on ridges and gentle slopes in mixed dipterocarp forests, and alluvial soils at altitudes 90–120 m above sea level.

Distribution: Currently only recorded from the type locality, Mount Singai, Kuching, Sarawak.

Etymology: The species epithet name is after Meekiong Kalu, a botanist from Universiti Malaysia Sarawak, who first collected the specimen.

Phenology: Flowering were recorded in April to August

Notes: In the type locality, this new species has sympatric growth with few other gingers species, such as *Alpinia havilandii* K. Schum., *Sulettaria surculosa* (K. Schum.) A.D. Poulsen & Martisen, *Geocharis rubra* Ridl., *Plagiostachys albiflora* Ridl., *Globba brachyanthera* K. Schum., *G. atrosanguinea* Teijsm. & Binn., *Zingiber acuminatum* Val. var. *borneense* R.M. Sm., *Etlingera coccinea* (Bl.) Sakai & Nagam. and *Amomum* sp.

Specimens examined: MK4026, Borneo, SARAWAK, Kuching Division, Singai, Gunung Singai, mixed dipterocarp forest, alluvial soils, 01°34'16.56''N, 110°12'11.45''E, 989 m above sea level, (SAR – holo; SBC, Herbarium Universiti Malaysia Sarawak – iso).

Traditional use: The sheaths of matured leaf are splits into strips and use as string.

Discussion

Morphologically, based on the inflorescence type, the genus *Sulettaria* can be divided into two informal groups. Group I – all the members that were previously treated under the genus *Amomum*. Most of the species in this group are characterized by erect inflorescence and with short or long stilt roots. While Group II – all the members that were previously placed under the genus *Elettaria*. The key characteristic is long prostrate and creeping inflorescence. Therefore, on the field characteristic, the placement of Group I in the genus *Sulettaria* is still under deliberation although the previous studies shows that this group closely related to *Sulettaria* group (Kalu et al., 2023).

Corollary

The discovery of the new *Sulettaria* was fortuitous but indicates that there are still novelties to be encountered, at least for Zingiberaceae, within the Kuching Division, Sarawak, notwithstanding pass-encompassing studies. With the finding of this new species, the number of *Sulettaria* in Sarawak has now increased to 14 species.

Figure 4.3 illustrates the various parts of the plant *Sulettaria meekiongii* Ripen & S.P. Teo. Panel A showcases the inflorescence with flowers, highlighting the plant's reproductive structure. Panel B provides a close-up of a flower, allowing a detailed view of its intricate features. Panel C zooms in further to display the labellum and stamen, crucial components for pollination. Panel D shows the plant with unmaturred fruit, giving insight into its development stage. Additionally, Panel E captures the ovary with its calyx, while Panel F highlights the oval-shaped and reddish bracts, which add to the plant's distinctive appearance. Panel G presents the whole plant, offering a comprehensive view of its overall

structure. Panel H focuses on the rhizome, the underground stem that supports the plant. Panel I shows the short stilt-rooted nature of the plant, indicative of its growth habit. Panel J revisits the inflorescence with flowers, emphasizing its floral characteristics. Panel K displays the short ligule, a small appendage found at the base of the leaf blade. Finally, Panel L highlights the acuminate apex, showcasing the pointed tip of the plant's leaves. . These detailed illustrations collectively provide a thorough understanding of the morphological features of *Sulettaria meekiongii* Ripen & S.P. Teo.

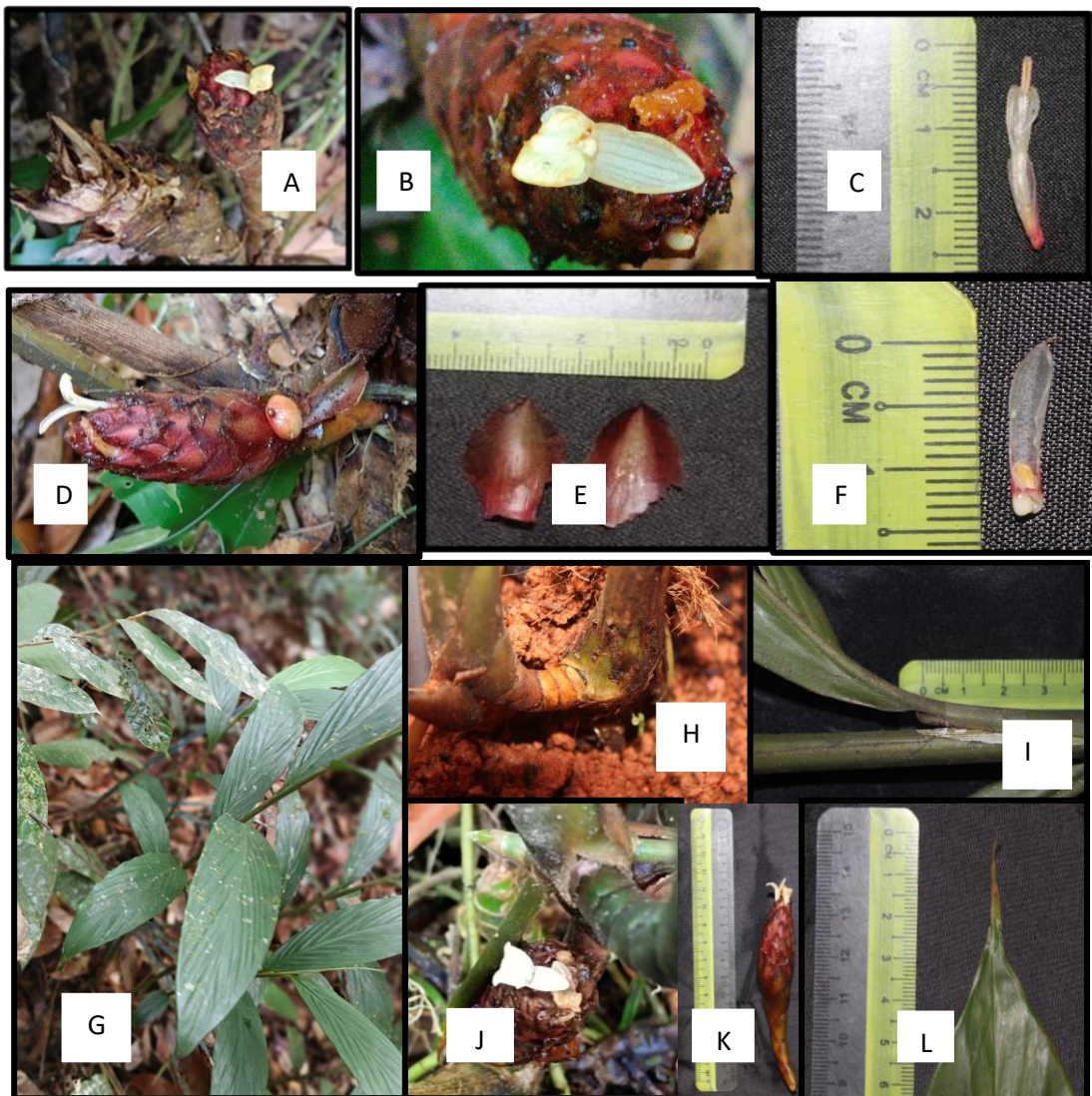


Figure 4.3: Morphological features of *Sulettaria meekiongii* Ripen & S.P. Teo. A. Inflorescence with flowers. B. Close up flower C. Close up of labellum and stamen D. Plant with unmaturred fruit. E. Ovary with calyx. F. Oval shaped and reddish bracts. G. Whole plant. H. Rhizome. I. Ligule short. J. Short stilt rooted. K. Inflorescence with flowers. L. Apex acuminate.

Scanning Electron Micrographs of *Sulettaria meekiongii*

Figure 4.4 presents Scanning Electron Micrographs of *Sulettaria meekiongii*, offering a microscopic view of the plant's surface features. Panel A and B illustrate the distribution of trichomes and stomata on the adaxial lamina, showcasing the arrangement and density of these structures on the upper leaf surface. Panel C highlights long, simple, non-glandular trichomes, including pyramidal and unicellular types, found on the adaxial side of the leaf. Panel D zooms in on the short and cone-shaped trichomes of the adaxial lamina, providing a detailed look at their unique morphology.

In the lower leaf surface, Panel E shows the distribution of trichomes and stomata on the abaxial lamina, contrasting with the adaxial side. Panel F captures the rectangular epicuticular wax on the abaxial leaf surface, emphasizing the plant's protective layer. Panel G focuses on trichomes without segments, highlighting a variation in trichome structure. Lastly, Panel H compares short and long trichomes on the adaxial leaf surface, demonstrating the diversity of trichome lengths. These micrographs collectively reveal the intricate surface anatomy of *Sulettaria meekiongii*, contributing to a deeper understanding of its morphological adaptations.

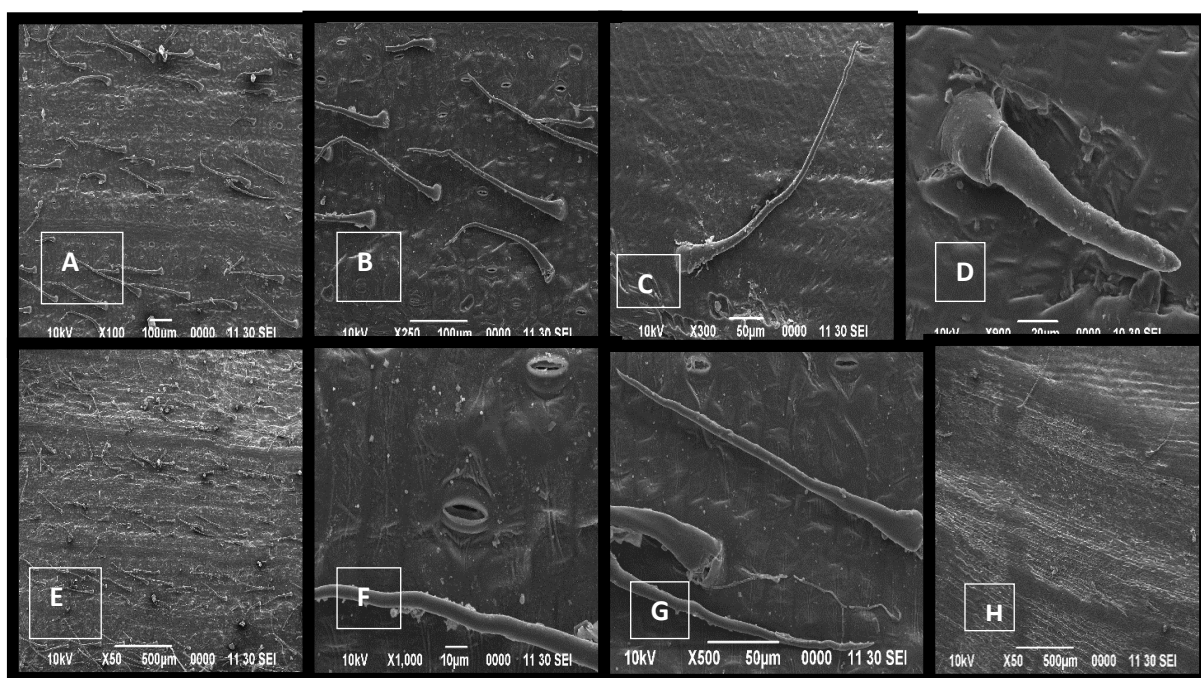


Figure 4.4: Scanning Electron Micrographs of *Sulettaria meekiongii* A. Distribution of trichomes and stomata on adaxial lamina. B. Distribution of trichomes and stomata on adaxial lamina. C. Long, simple, non-glandular trichomes, pyramidal, and unicellular trichome of leaf adaxial. D. Short and cone shape trichome of adaxial lamina. E. Distribution of trichomes and stomata on abaxial lamina. F. Rectangular of epicuticular wax on leaf abaxial. G. trichomes without segment. H. Short and long trichomes of leaf adaxial.

4.6.2 *Alpinia songet* Ripen & Meekiong sp. nov.

Appearance similar to *A. aquatica* and *A. galanga*; but readily distinguished by the deflexed sepals and large black matured fruits.

Type: Borneo, Sarawak, Kuching Division, Singai, Gunung Singai, mixed dipterocarp forest, alluvial soils, : 01°34'16.56''N, 110°12'11.45''E, 562 m above sea level, 9 April and 7 July 2022, Meekiong, K. & Ripen, J.E., MK4026 (SAR – holo; SBC, Herbarium Universiti Malaysia Sarawak – iso).

Description: Plant clumping, up to 10 pseudostems, 1.4–1.7 m tall, basal part pale green with stout rhizomes; rhizome c. 3–4 mm diam., yellow colour; base of shoot with 3–4 leafless sheaths, long leaf sheaths about 16–20 cm, green to dark green wrap around the

stem, abaxial slightly silvery and glabrous. Leaves provided of 6–8 pairs, alternate arrangement; leaf blades elongate, 12–27 x 1.5–4 cm, apex acuminate, acumen about 1–2 cm long. Leaf margin entire, smooth around the entire leaf edge and serrate at the upper part toward apex; petiole 10–18 cm long; ligule short, c. 2 mm, green with brown edges, apex rounded, darker when dried. Inflorescence terminal, erect, rachis 10–12 cm long, 20–25 cincinni (1–3 flowers per cincinni), 2 primary bracts, 3–5 cm and 8–15 cm long, papery when dried. Flower c. 4 cm long; 2–5 flowers open at a time; bracteole boat-shaped, 1–2 x 3 cm, light bright, fallen off, floral stalk, 10–12 mm long, glabrous, green; calyx tubular, 8–10 mm, long, creamy white; ovary 5–6 mm long, 1–2 mm diam., glabrous, greenish whit; dorsal lobe oblong, 8–12 x 1.5–2 mm, curved backward, glabrous, apex hooded, watery green; lateral lobes 2, oblong, 8–11 x 1.2–2 mm, curved backward, glabrous, apex rounded, watery green. Labellum shorter than lobes, 5–7 cm long, middle part larger, 1–3 mm wide, apex trilobes; median lobe elongated, apex fork-shaped, or split and widely opened, glabrous, pinkish; staminodes 16–20 mm long, like horn; anther 6–8 mm long, greenish, crested. Fruit globose or rounded, 2–2.5 cm diam., calyx persistent, green and turned to black when ripe. Mesocarp thick, c. 3 mm, three locules with many seeds. Seed obpyriform or pyramidal, 7–12 mm diam., surface wrinkled, black.

Corollary

The discovery of the new *Alpinia* was fortuitous but indicates that there are still novelties to be encountered, at least for Zingiberaceae, within the Kuching Division, Sarawak, notwithstanding pass encompassing studies. With the finding of this new species, the number of *Alpinia* in Sarawak has now increased to 14 species. With a lot of work still to be done and many areas yet to be surveyed, it is projected that the number of *Alpinia* taxa in Sarawak might reach 18.

Habitat: This species thrives very well on ridges and gentle slopes in mixed dipterocarp forest, on alluvial soils at altitudes 90–120 m above sea level.

Distribution: Currently only recorded only from the type locality, Mount Singai, Kuching, Sarawak.

Etymology: The epithet name is from Bidayuh ethnic word, *songet* means black, which refers to the black colour of mature fruits.

Notes: In the type locality, this new species has sympatric growth with *Alpinia glabra* var. *reticulata*, on the ridges and gentle slopes. Without vegetative parts, it might be confused or mistakenly identify (vs *A. aquatica*), due to the plant appearance.

Traditional use: The ripen fruit are eaten by bird and wild boar and the rhizome is used to treat skin diseases.

Figure 4.5 illustrates various stages and parts of the *Alpinia songet* plant. Image A shows the inflorescence with flowers approximately 4 cm long. Image B captures a green flower, while image C provides a close-up of the labellum and stamen. Image D features a plant with immature fruit, and image E displays the immature fruit with a semipersistent calyx. Image F shows a black mature fruit. Image G shows the whole plant in, while image H focuses on the rhizome and roots. Image I presents the terminal inflorescence, and image J depicts a fruit with an open seed. Lastly, image K highlights seeds with white flesh. These images collectively offer a comprehensive view of the plant's morphology and reproductive structures

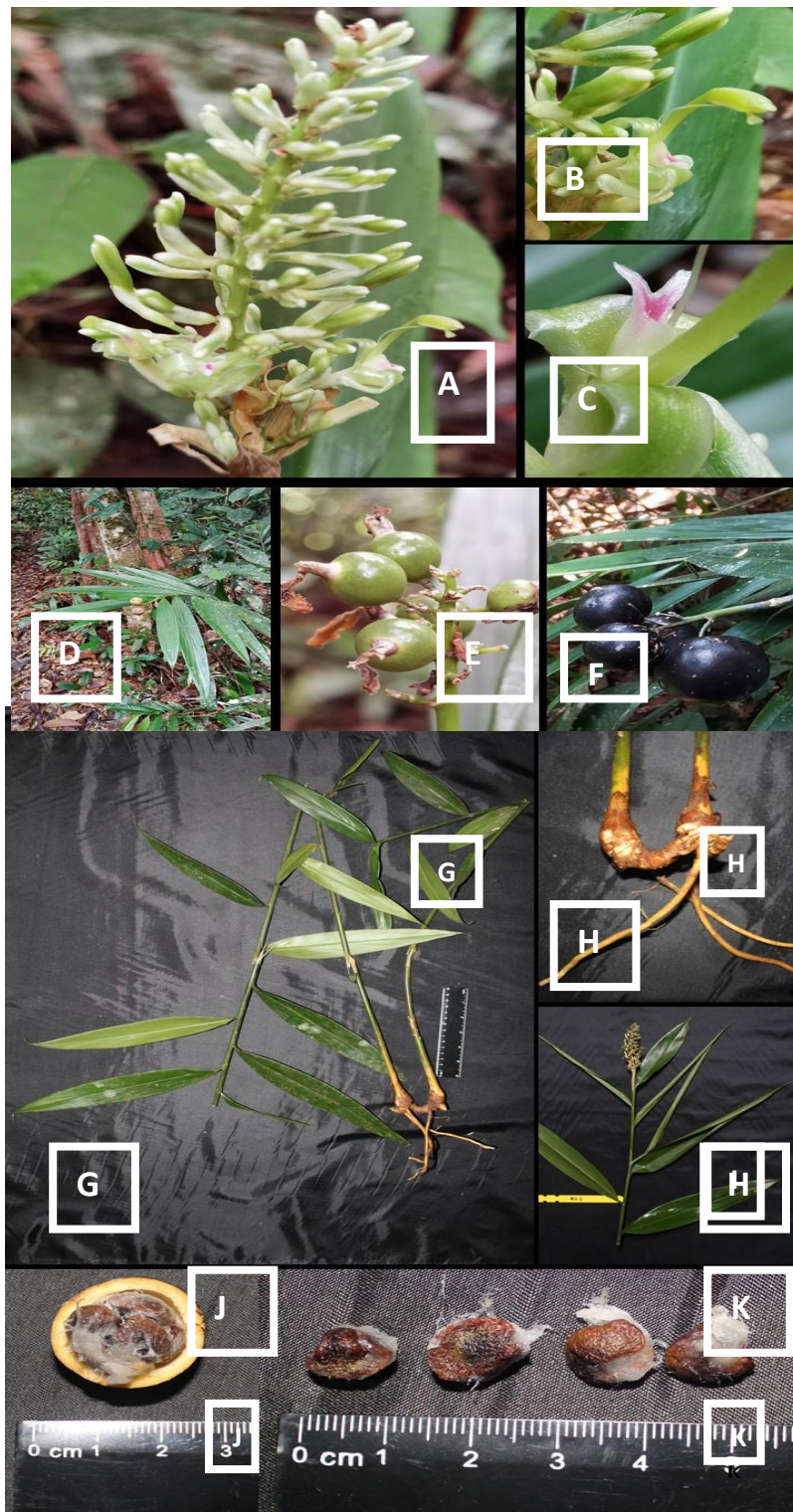


Figure 4.5: Morphological features of *Alpinia songet* A. Inflorescence with flowers c. 4 cm long. B. Green flower C. Close up of labellum and stamen D. Plant with unmaturing fruit. E. Unmaturing fruit with semipersistent calyx, F. Black matured fruit. G. Whole plant. H. Rhizome and roots. I. Terminal inflorescence. J. Fruit with open seed. K. Seeds with white flesh

Digital microscope images show the transverse sections of the leaf lamina of *Alpinia songet*

Figure 4.6: Digital microscope images show the transverse sections of the leaf lamina of *Alpinia songet*, highlighting the apex part of the lamina (A) with scale bars of 200 μm , the middle part of the lamina (B) with scale bars of 200 μm , and the base part of the lamina (C) with scale bars of 200 μm . Additionally, the transverse sections of the leaf midribs are displayed, illustrating the apex part of the midrib (D) with scale bars of 200 μm , the middle part of the midrib (E) with scale bars of 200 μm , and the base part of the midrib (F) with scale bars of 200 μm .

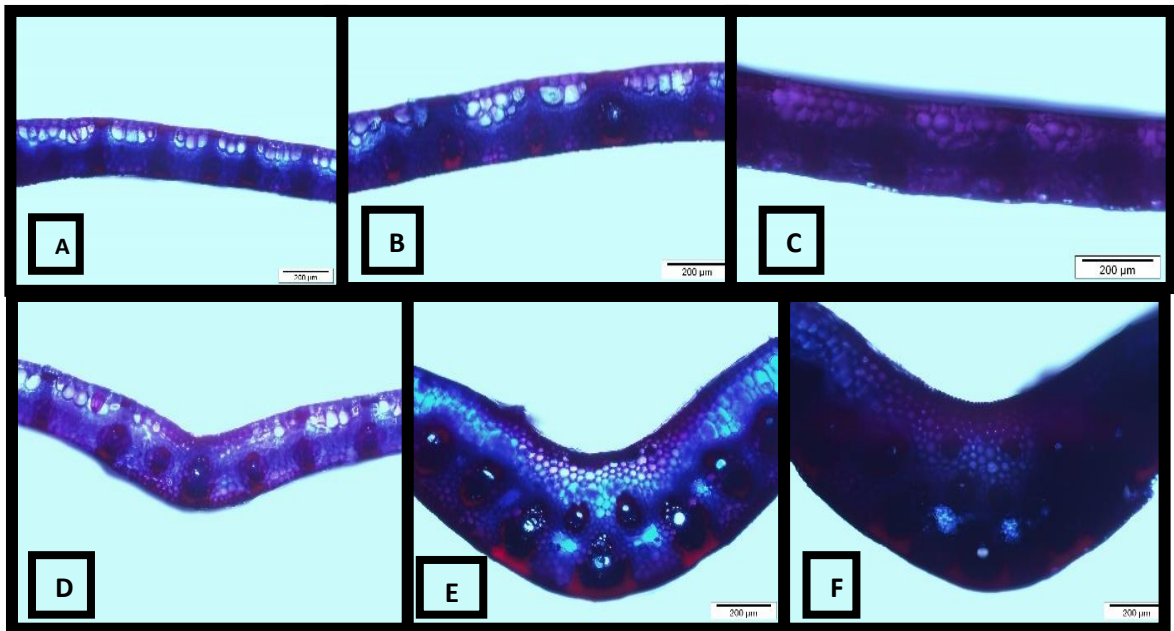


Figure 4.6: Digital microscope images show the transverse sections of the leaf lamina of *Alpinia songet* A: Apex part of lamina Scale bars=200 μm B. Middle part of lamina Scale bars=200 μm C: Base part of lamina Scale bars = 200 μm . Transverse sections of leaf midribs of *Alpinia songet* D: Apex part of midrib Scale bars = 200 μm . E: Middle part of midrib Scale bars = 200 μm . F. Base part of midrib Scale bars = 200 μm .

Scanning Electron Micrographs of *Alpinia songet*

Figure 4.7 displays various aspects of the *Alpinia songet* leaf structure using scanning electron micrographs. Image A shows the distribution of trichomes and stomata on the abaxial lamina, while image B illustrates their distribution on the adaxial lamina. Image C highlights the distribution of wax on the trichomes of the leaf's adaxial surface, and image D focuses on a short and cone-shaped trichome on the abaxial lamina. Image F provides a close-up of an open stoma, essential for gas exchange. Image G shows the distribution of rectangular crystalloids of epicuticular wax on trichomes, and image H displays their distribution on stomata. Lastly, image I highlights the rectangular form of wax crystalloids, emphasizing their uniformity and structural characteristics. These wax crystalloids play a significant role in protecting the leaf by reflecting sunlight and reducing water loss.

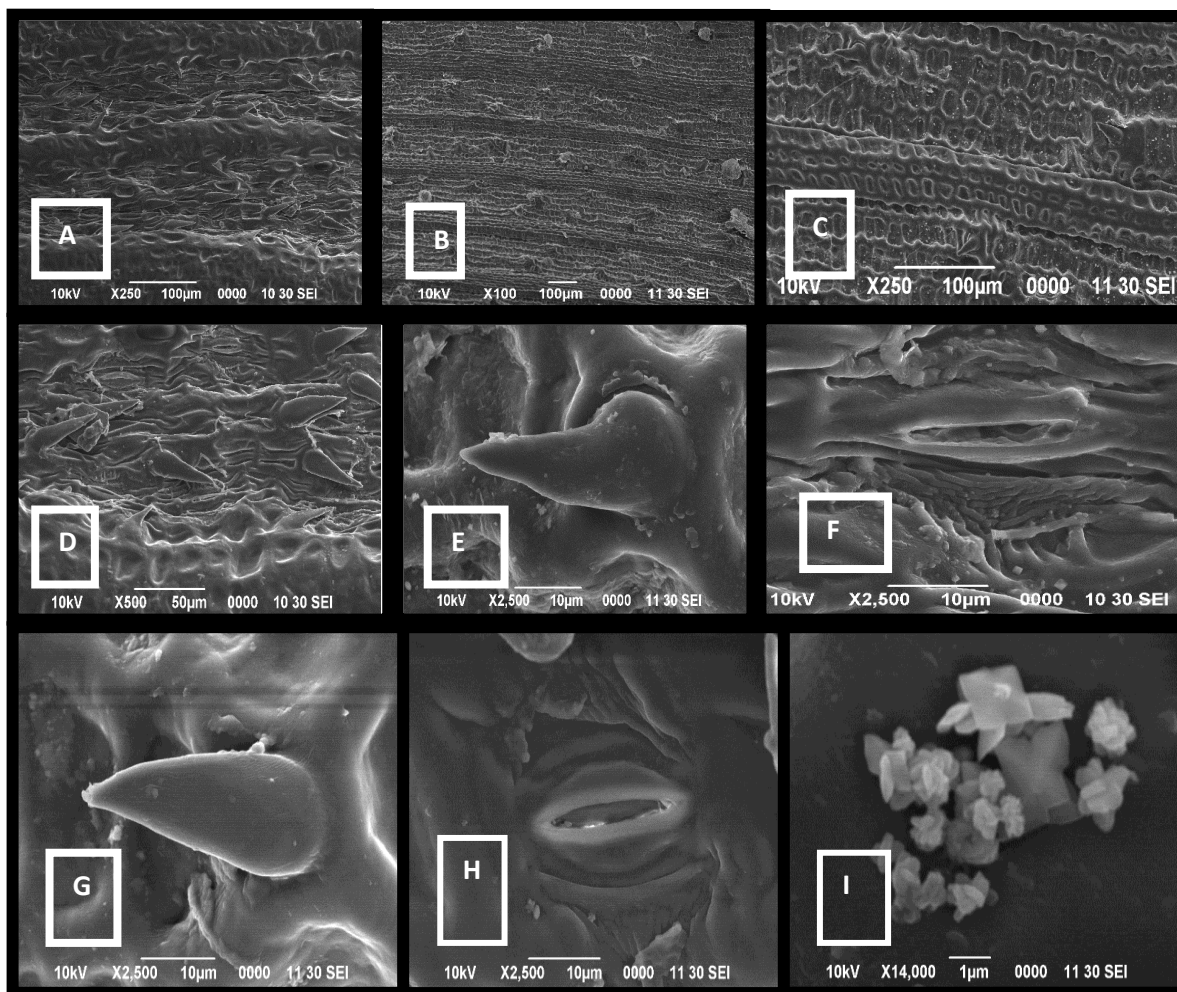


Figure 4.7: Scanning Electron Micrographs of *Alpinia songet*. A. Distribution of trichomes and stomata on abaxial lamina. B. Distribution of trichomes and stomata on adaxial lamina. C. Distribution of wax on trichomes of leaf adaxial. D. Distribution of short and cone shape trichome. E. Short and cone shape trichome of abaxial lamina. F. Open stomata. G. Distribution of rectangular crystalloid of epicuticular wax on trichome. H. Distribution of rectangular crystalloid of epicuticular wax on stomata. I. Wax crystalloid rectangular form.

4.6.3 *Zingiber singaiensis* Ripen & Meekiong sp. nov

Appearance similar to *Zingiber flammeum*

Type: Borneo, SARAWAK, Kuching Division, Singai, Mount Singai, mixed dipterocarp forest, alluvial soils, : 01°34'16.56''N, 110°12'11.45''E, 989 m above sea level, 24 July 2022, Meekiong, K. & Ripen, J.E., MK4026 (SAR – holo; SBC, Herbarium Universiti Malaysia Sarawak – iso).

Description: Short ginger with only 40-70cm tall, basal part pale green with stout rhizomes; rhizome c. 3–4 mm diam., yellow colour; base of shoot with 3–4 leafless sheaths, long leaf sheaths about 16–20 cm, green to dark green wrap around the stem, abaxial slightly silvery and glabrous. Leaves provided of 4–6 pairs, thick structure, alternate arrangement; leaf blades elongate, 12–27 x 1.5–4 cm, apex acuminate, acumen about 1–2 cm long. Leaf margin entire and smooth; petiole 10–18 cm long; ligule short, c. 2 mm, green with brown edges, apex rounded, darker when dried. Upper surface light green and shiny, lower surface dull green, silvery indicate that wax present on lower surface.

The inflorescence arises on a separate shoot directly from the rhizome. The inflorescence with cone- like appearance, has closely overlapping bracts and bracts forms open pouch when its produce flower. Peduncle greenish to pink or orange. The bracts produce pink and orange color, 4-5cm x 4-5cm

Flower c. 4 cm long; only 1 flower open at a time; bracteole boat-shaped, 1–2 x 3 cm, cream, fallen off, floral stalk, 10–12 mm long, glabrous, green; calyx 8–10 mm, long, creamy white; ovary 5–6 mm long, 1–2 mm diam., glabrous, greenish whit; dorsal lobe oblong, 8–12 x 1.5–2 mm, curved backward, glabrous, apex hooded, watery green; lateral lobes 2, oblong, 8–11 x 1.2–2 mm, curved backward, glabrous, apex rounded, watery

green. Labellum shorter than lobes, 5–7 cm long, middle part larger, 1–3 mm wide, apex trilobes; median lobe elongated, apex fork-shaped, or split and widely opened, glabrous, pinkish; staminodes 16–20 mm long, like horn; anther 6–8 mm long, greenish, crested.

Habitat: This species thrives very well on ridges and gentle slopes in mixed dipterocarp forest, on alluvial soils at altitudes 90–120 m above sea level.

Distribution: Currently only recorded only from the type locality, Mount Singai, Kuching, Sarawak.

Etymology: The epithet name is from the location it was found, Singai.

Notes: In the type locality, this new species has sympatric growth with xxx, on the ridges and gentle slopes. Without vegetative parts, it might be confused or mistakenly identify, due to the plant appearance.

Traditional use: The inflorescence is eaten by animal such as wild boar and bird. It is potentially to be use as ornamental as the inflorescence has orange and pink colour.

Morphological features of *Zingiber singaiensis*

Figure 4.8 provides a comprehensive view of the *Zingiber singaiensis* plant, starting with a full image of the plant (A), showcasing its overall structure and foliage. The figure then highlights the inflorescence with its vibrant orange color (B). A close-up of the labellum and stamen (C) is included, illustrating the intricate floral details. The white flower with a cone-like flowering head (D) is shown, emphasizing its unique structure. Finally, the figure presents the inflorescence with an opened pink bract and black seed (E), showcasing the plant's reproductive parts and seed details.

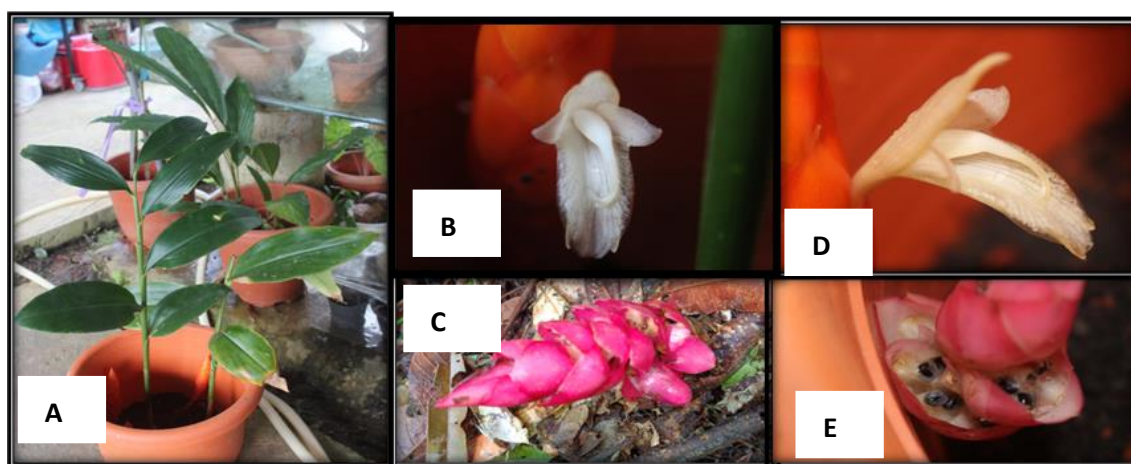


Figure 4.8: Morphological features of *Zingiber singaiensis* A. *Zingiber singaiensis* plant. B. Inflorescence with orange color. C. Close up of labellum and stamen D. White flower Cone-like flowering head. E. Inflorescence with opened pink bract and black seed

***Zingiber singaiensis* Flower and Its Dissected Parts in Comparison**

Figure 4.9 offers a comprehensive look at the *Zingiber singaiensis* flower and its dissected parts. It starts with a close-up of the flower (A), highlighting its intricate details. The labellum, dorsal corolla lobes, and stamen are shown together (B), providing insight into the flower's main structures. The three distinct lobes of the labellum are presented (C), followed by a focus on the dorsal corolla lobes (D). The long, creamy white stamen is depicted (E), emphasizing its prominence, and the anther of the flower is highlighted (F), showcasing the part that contains the pollen. This detailed examination provides a clear comparison of the flower's components.

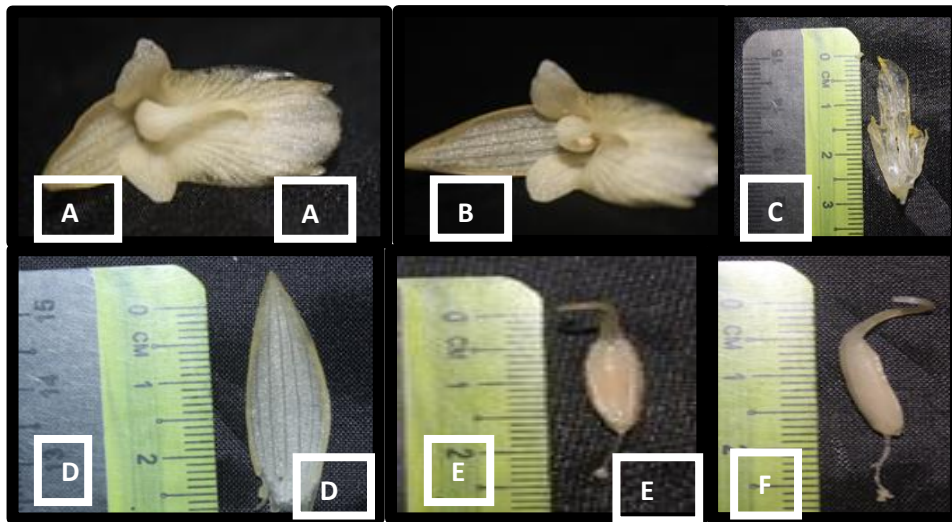


Figure 4.9: *Zingiber singaiensis* Flower and Its Dissected Parts in Comparison A. Close up of flower. B. Labellum, dorsal corolla lobes and stamen. C. Three lobes of labellum. D. Dorsal corolla lobes. E. Long, creamy white stamen. F. Anther of flower.

Figure 4.10 illustrates transverse sections of both the leaf lamina and midribs of *Zingiber singaiensis*, each part measured with scale bars of 200 μm . It begins with the apex part of the lamina (A), followed by the middle part (B), and the base part (C). The transverse sections continue with the leaf midribs, showing the apex part of the midrib (D), the middle part (E), and the base part (F). This detailed analysis provides a clear view of the anatomical differences across various sections of the leaf lamina and midribs, enhancing the understanding of the plant's structural composition.

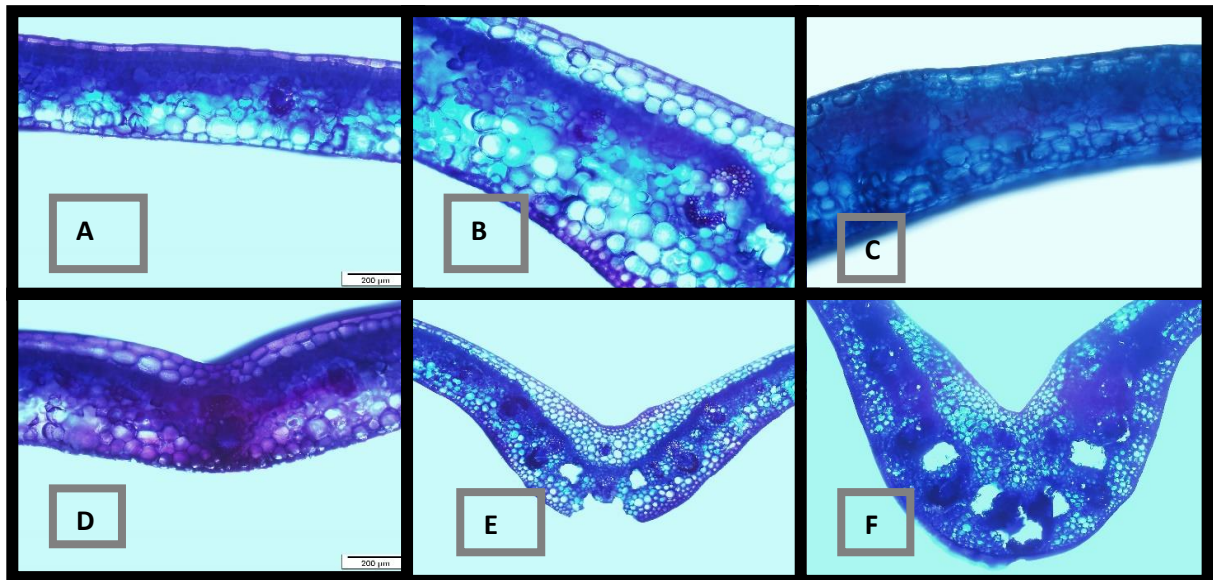


Figure 4.10: Transverse Sections of Leaf Lamina of *Zingiber singaiensis* . A: Apex part of lamina Scale bars=200 μm B. Middle part of lamina Scale bars=200 μm C: Base part of lamina Scale bars = 200 μm . Transverse sections of leaf midribs of *Zingiber singaiensis* D: Apex part of midrib Scale bars = 200 μm . E: Middle part of midrib Scale bars = 200 μm . F. Base part of midrib Scale bars = 200 μm .

The Figure 4.11 presents scanning electron micrographs of various features of the *Zingiber singaiensis* leaf. It starts with the abaxial (A) and adaxial (B) surfaces of the leaf, providing detailed images of these two distinct layers. The distribution of stomata on the abaxial lamina is shown in (C), highlighting the positioning and density of these essential gas exchange structures. The micrographs also reveal smooth coverings resembling ‘resinous layers’ and ‘soft waxes’ on the leaf surface (D). Additionally, a short and stunted trichome on the abaxial lamina is depicted in (E), and a close-up of a stoma with bean-shaped guard cells is shown in (F), emphasizing the specialized structures involved in regulating gas exchange. These detailed images offer a comprehensive view of the leaf's microscopic anatomy.

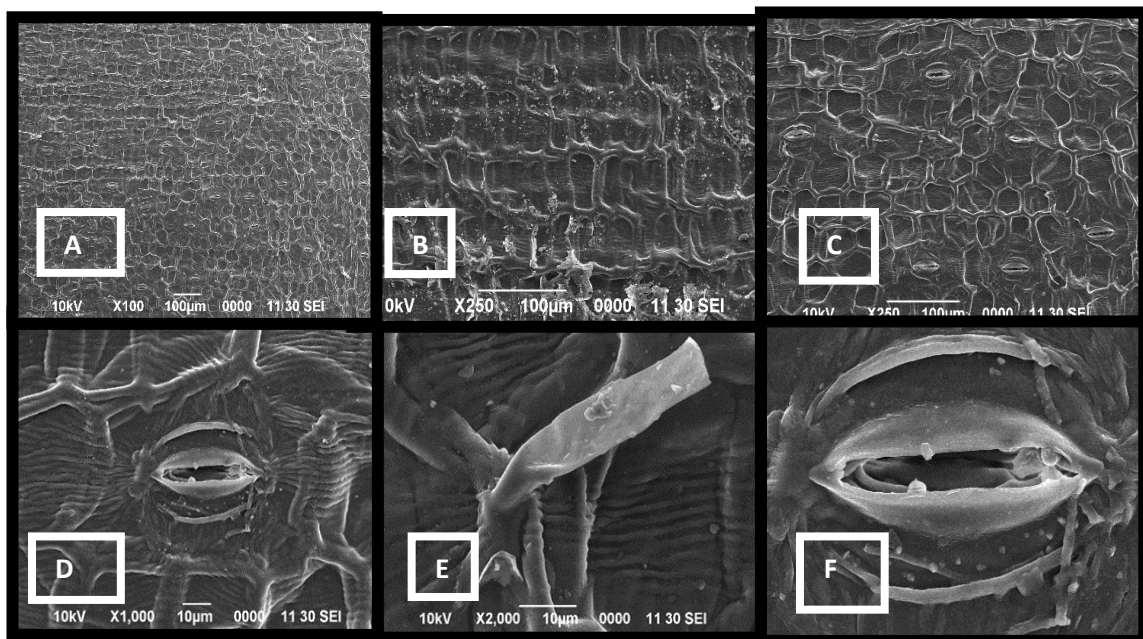


Figure 4.11: Scanning Electron Micrographs of *Zingiber singaiensis* A. Leaf abaxial B. Leaf adaxial. C. Distribution of stomata on abaxial lamina. D. Smooth coverings like ‘resinous layers’ and ‘soft waxes’. E. Short and stunted trichome of abaxial lamina. F. Stomata with bean-shaped guard cells

Corollary

The discovery of the new *Zingiber* was fortuitous but indicates that there are still novelties to be encountered, at least for Zingiberaceae, within the Kuching Division, Sarawak, notwithstanding past encompassing studies. With the finding of this new species, the number of *Zingiber* in Borneo has now increased to 34 species.

4.6.4 *Amomum jackliamii* Ripen & Meekiong sp. nov.

Description: *Amomum jackliamii* is a perennial herbaceous species with creeping rhizome, crump with 5cm distance between each plant, up to about 60 cm tall, provided of 5-7 leaves, on a 10, 15-20 cm long petiole, 13-18 cm long and 4-7 cm broad, with entire margin and about 1-2 cm long caudate apex, upper surface green colour and under surface of the young leaves brownish colour. The leaves produce lemony smell and strong smell on the root when crushed. Leafy shoot 5–6 leaves. Lamina oblanceolate to narrowly elliptic, 15–30 cm long and 5–10 cm wide, apex caudate 2-3cm long, leaf margin glabrous and with white prickly hairs towards the leaf tip at both edges of the leaf at the apex, adaxially surface reddish to dark green when matured with clearly embossed veins, abaxially surface green, both surfaces glabrous. Inflorescences from the base of the pseudostem on short peduncle, grow on the ground at soil level and usually hidden by the thick layer of vegetal debris covering the soil of the forest, with white-cream flowers, the lip has a yellow centre bordered by two red lines, about 8.5 cm long, that gradually open. Tubular calyx, about 2 cm long, corolla with 14-5cm cm long tube, dorsal lobe spatulate and concave (cucullate) and ovate latera lobes, ovate labellum with creped margins, of white colour with yellow centre bordered by two red lines that serves as guide for the

pollinating insect. The fruit was not seen. Fast growing species with ornamental and scented plant and growing in humid area.

Habitat: This species thrives very well on ridges and gentle slopes in mixed dipterocarp forests, and alluvial soils at altitudes 90–120 m above sea level.

Distribution: Currently only recorded from the type locality, Mount Singai, Kuching, Sarawak.

Traditional use: Locally known as Dowen poras due to its leaves that produce a slightly lemon grass smell. The leaves are crushed and rubbed on forehead for headaches.

Morphological features of *Amomum jackliamii* Ripen & Meekiong sp. nov

Figure 4.12 illustrates various features of the *Amomum jackliamii* plant, capturing its distinctive botanical characteristics. The general appearance of the plant is displayed in Plate A, while Plate B highlights the erect inflorescence. Plate C focuses on the white prickly hairs toward the leaf tip, emphasizing their unique texture. In Plate D, the inflorescence with flowers prostrate in the surface soil is shown, providing a ground-level perspective. Plate E offers a close-up view of the inflorescence, allowing for a detailed examination of its structure. Lastly, Plates F and G zoom in on the labellum and stamen, showcasing the intricate details of these floral components.



Figure 4.12: Morphological features of *Amomum jackliamii* Ripen & Meekiong sp. nov. A. *Amomum jackliamii* plant. B. Erect inflorescence C. White prickly hairs towards the leaf tip D. Inflorescence with flowers prostrate in the surface soil E. Close up of inflorescence F. Close up of labellum, stamen..

***Amomum jackliamii* Flower and Its Dissected Parts in Comparison**

Figure 4.13 illustrates the *Amomum jackliamii* flower and its dissected parts in comparison. It begins with a close-up of the labellum and stamen (H), providing intricate details of these floral components. The front view of the flower (I) showcases the overall appearance of the bloom. The labellum, dorsal corolla lobes, and stamen (J) are displayed together to highlight their arrangement and structure. A side view close-up of the flower

(K) emphasizes additional structural details, and the figure concludes with an image of the flower including its calyx (L), presenting a comprehensive view of its morphology.



Figure 4.13: *Amomum jackliamii* Flower and Its Dissected Parts in Comparison. H. Close up of labellum and stamen. I Front view of flower J. Labellum, dorsal corolla lobes and stamen. K. Close up of flower (side view) L. Flower with calyx

Digital microscope images show the transverse sections of the leaf lamina of *Amomum jackliamii*

Figure 4.14 presents transverse sections of the leaf lamina and midribs of *Amomum jackliamii*, detailing various parts of the leaf structure. Section A shows the apex part of the lamina with scale bars of 200 μm , section B illustrates the middle part of the lamina also with scale bars of 200 μm , and section C depicts the base part of the lamina, maintaining the same scale bars of 200 μm . Additionally, transverse sections of the leaf midribs are shown: section D features the apex part of the midrib with scale bars of 200 μm , section E

displays the middle part of the midrib with the same scale bars, and section F presents the base part of the midrib, again with scale bars of 200 μm .

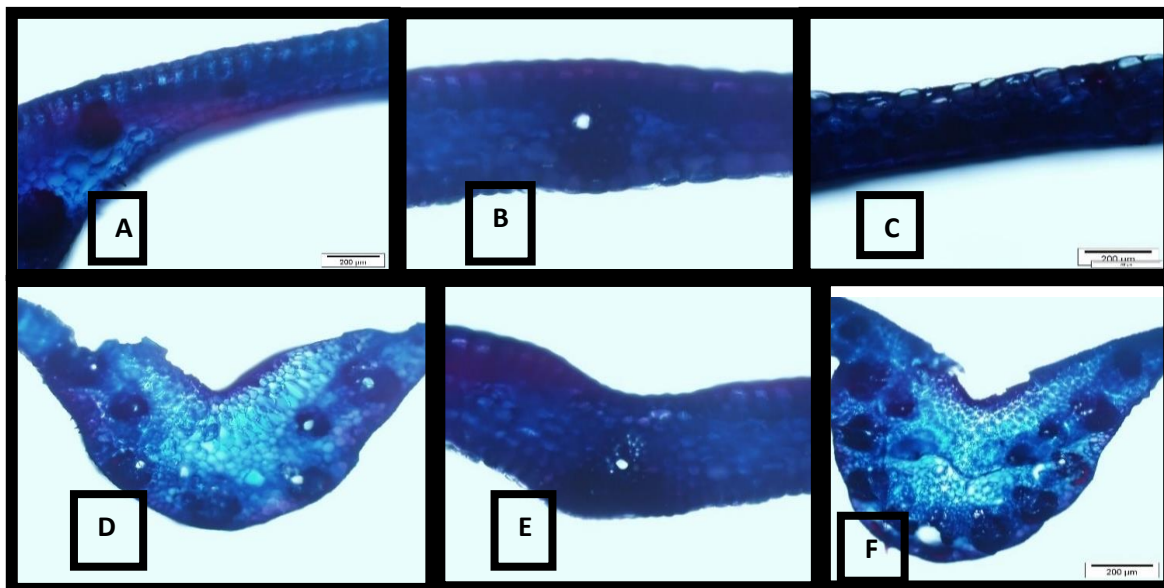


Figure 4.14: Transverse Sections of Leaf Lamina of *Amomum jackliamii* A: Apex part of lamina Scale bars=200 μm B. Middle part of lamina Scale bars=200 μm C: Base part of lamina Scale bars = 200 μm . Transverse sections of leaf midribs of *Amomum jackliamii* D: Apex part of midrib Scale bars = 200 μm . E: Middle part of midrib Scale bars = 200 μm . F. Base part of midrib Scale bars = 200 μm .

Scanning Electron Micrographs of *Amomum jackliamii*

Figure 4.15 features scanning electron micrographs of *Amomum jackliamii*, highlighting various microscopic structures. Image A shows the distribution of stomata and trichomes on the leaf's abaxial surface. Image B illustrates the wax distribution around stomata on the abaxial leaf surface. Image C captures short and stunted trichomes of the abaxial lamina. Image D depicts the distribution of stomata and trichomes on the leaf's adaxial surface. Image E presents a half-opened stomata on the adaxial leaf surface, while image F reveals the fissured layer of epicuticular wax on the abaxial leaf surface.

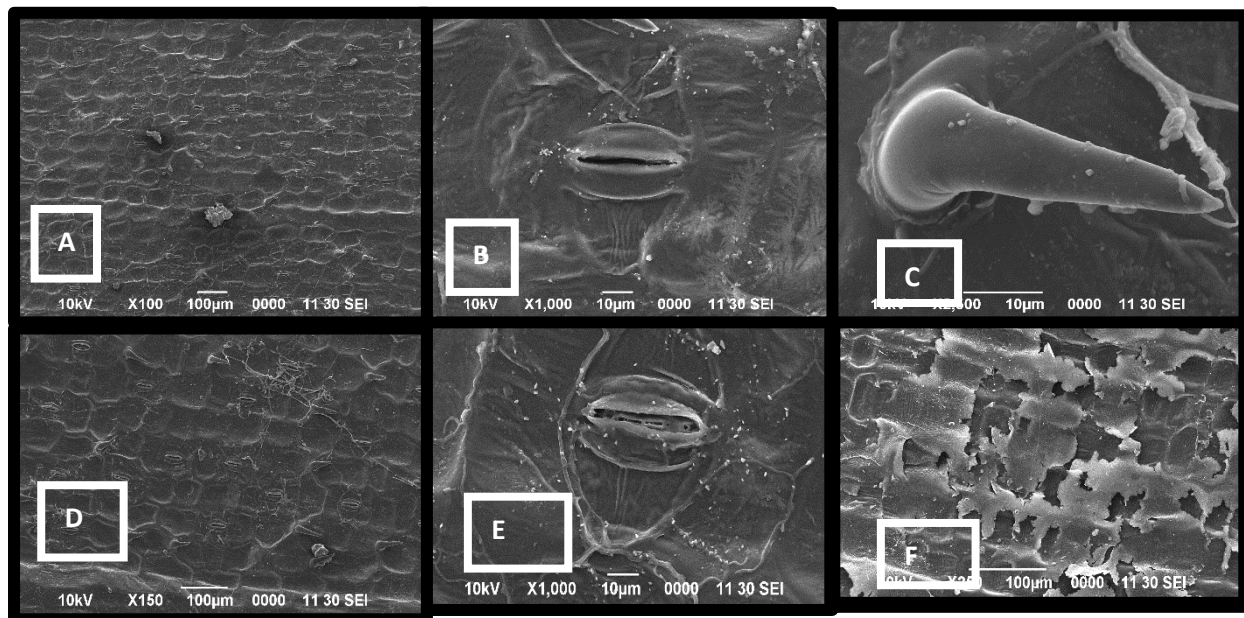


Figure 4.15: Scanning Electron Micrographs of *Amomum jackliamii* A. Distribution of stomata and trichome of leaf abaxial. B. Distribution of wax around stomata of leaf abaxial C. Short and stunted trichome of abaxial lamina. D. Distribution of stomata and trichome of leaf adaxial E. Half opened stomata of leaf adaxial F. Fissured layer of epicuticular wax on leaf abaxial.

4.6.5 *Amomum* sp. nov. ined (Collection no: MK43 (B))



Figure 4.16: *Amomum* sp. nov. ined

The wild ginger growing on Mount Singai, Singai, is locally known as *Dowen Pangu*. This ginger species reaches about 70 cm in height. The leaves produce a fragrant smell, which is used to remove bad odors from the hands or any part of the body. This new species is similar to *Amomum curtisii*, with its flower borne on a slender, erect stem that emerges directly from the ground, indicating it comes from a rhizome buried beneath the soil. It typically shows a single flower, a common trait for some species in the *Amomum* genus where flowers may appear solitary or in small clusters. However, the new species can be differentiated by its prominent, colorful labellum, which is predominantly white with a bright yellow central streak and a hint of pink or red at the base.

4.6.6 *Etlingera* sp. nov. ined. (Collection no: MK45 (B))



Figure 4.17: *Etlingera* sp. nov. ined

The wild ginger growing on Mount Singai, Singai is locally known as *Topu Torun*. This ginger reaches about 2 meters in height, with an inflorescence at ground level featuring numerous red flowers with long lips. The stem produces an aromatic smell and is cooked in soup for flavoring. The new species looks similar to *Etlingera coccinea*, with the arrangement of flowers emerging from a central point and their tubular shape aligning well

with the characteristics of *Etlingera coccinea*. However, the inflorescence has a central cluster from which bright red, elongated and without yellow floral tube.

4.6.7 *Zingiber* sp. nov. ined. (Collection no: M48 (B))

The wild ginger growing on Mount Singai, Singai is locally known as Bunga Birieh. This wild ginger grows to about 70 cm tall. The leaves are broad and consist of 4-6 pairs. The inflorescence is eaten by animals such as wild boar and is also used for ornamental purposes due to the beautiful bright red color of the bracts. This new species is similar to *Zingiber zerumbet*, with a distinctive red, cone-like inflorescence. The tightly packed bracts form a structure resembling a pinecone, and the vibrant red color of the inflorescence is striking. However, it differs in having a white labellum that is not marked with yellow.



Figure 4.18: *Zingiber* sp. nov. ined

Discussion

The discovery of seven new species of useful gingers among the Bidayuh community in Singai and Jagoi is a testament to the richness of biodiversity in these regions and the ongoing importance of traditional knowledge in identifying and utilizing local flora. Each

new species adds to our understanding of the ecological and cultural landscape, highlighting the Bidayuh community's deep connection to their environment.

4.7 Useful Zingiberaceae Used by the Both Bidayuh Community of Singai and Jagoi

Out of 50 species of medicinal plants documented, 22 species are most commonly used by the respondents in this area (Table 4.4).

Table 4.4: The Most Common Useful Zingiberaceae Used by the Bidayuh Community of Singai and Jagoi

No	Usage by Singai	Usage by Jagoi	No of Species	Species
1	Food flavouring	Food flavouring	1	<i>Geocharis rubra</i> Ridl
2	Handicraft	Handicraft	1	<i>Hornstedtia reticulata</i> (K. Schum.) K. Schum
3	Ornamental	Ornamental	2	<i>Globba pumila</i> Ridl.
				<i>Globba francisci</i> Ridl
4	For food and handicraft	Handicraft	1	<i>Plagiostachys crocydocalyx</i> (K. Schum) B.L Burtt & R.M Sm
5	Edible fruit and young shoot	Edible fruit and young shoot	2	<i>Hornstedtia conica</i> Ridl.
				<i>Alpinia glabra</i> Ridl.
6	Edible fruit and the	Edible fruit and	1	<i>Alpinia ligulata</i> K.

Table 4.4 continued

	leaves are for wrapping food	the leaves are for wrapping food		Schum
7	Food flavouring	Food flavouring	1	<i>Etlingera coccinea</i> (Bl.) Sakai & Nagam
8	To treat skin diseases	To treat skin diseases	1	<i>Alpinia galanga</i> (L.) Willd.
	Food flavouring for sweet taste	Food flavouring for sweet taste		
	To relief fever	To relief fever		
9	To treat diarrhoea	To treat diarrhoea	1	<i>Curcuma longa</i> Val.
	To treat wound	To treat wound		
	Food flavouring	Food flavouring		
10	To lighten the skin	To lighten the skin	1	<i>Curcuma zaedoria</i> Val.
	To treat white vaginal discharge	To treat white vaginal discharge		
	For Covid-19 prevention	For Covid-19 prevention		
11	To remove wind from the body	To remove wind from the body	1	<i>Zingiber officinale</i> Roscoe
12	Edible fruit	Edible fruit	1	<i>Amomum oliganthum</i> K.Schum
13	For freshener	For freshener	1	<i>Amomum</i> sp.
14	To lower fever in baby	To lower fever in baby	1	<i>Plagiostachys albiflora</i> Ridl.

Table 4.4 continued

15	To treat headache	To treat headache	1	<i>Hedychium coronarium</i> J. Koenig
16	To treat diabetic and to lower the blood sugar level	To treat diabetic and to lower the blood sugar level	1	<i>Costus speciosus</i>
17	Ornamental	Ornamental	1	<i>Globba rubra</i> Ridl
18	To treat conjunctivitis	Ornamental	1	<i>Boeserbergia pulchella</i> (Ridl.) Merr
19	To mitigate body pain after childbirth	Ritual	1	<i>Globba astrosanguinea</i> Teijsm. & Binn
20	The pounded rhizome is applied on skin diseases	Ornamental	1	<i>Etlingera brevilabrum</i> (Valeton) R.M. Sm.

Both the Singai and Jagoi communities share several uses for wild ginger species. For instance, *Geocharis rubra* Ridl is used for food flavoring, while *Hornstedtia reticulata* (K. Schum.) K. Schum is utilized in handicrafts. Both communities employ *Globba pumila* Ridl and *Etlingera coccinea* (Bl.) Sakai & Nagam for ornamental purposes and food flavoring, respectively. They also use *Alpinia galanga* (L.) Willd to treat skin diseases, flavor food with a sweet taste, and relieve fever. *Curcuma longa* Val serves to treat diarrhea, heal wounds, and flavor food, while *Curcuma zaedoria* Val is used to lighten skin, treat white vaginal discharge, and prevent COVID-19. *Zingiber officinale* Roscoe helps to remove wind from the body, and *Plagiostachys albiflora* Ridl is used to lower

fever in babies. *Hedychium coronarium* J. Koenig is employed to treat headaches, and *Amomum oliganthum* K.Schum provides edible fruit. Both communities also use *Amomum* sp. as a freshener.

The Singai and Jagoi communities exhibit distinct uses for certain species of wild ginger, reflecting their unique cultural practices and medicinal knowledge. *Boeserbergia pulchella* (Ridl.) Merr, for instance, is employed by the Singai to treat conjunctivitis, showcasing its medicinal value in their community. On the other hand, the Jagoi appreciate this species for its aesthetic qualities, using it as an ornamental plant. This divergence highlights how the same species can be integrated differently into local traditions and everyday life based on the community's needs and preferences.

Similarly, *Globba astrosanguinea* Teijsm. & Binn is utilized by the Singai to alleviate body pain after childbirth, indicating its role in postnatal care within their culture. In contrast, the Jagoi incorporate this plant into their rituals, signifying its spiritual or ceremonial importance. Additionally, *Etlingera brevilabrum* (Valeton) R.M Sm is used by the Singai for its medicinal properties, specifically to treat skin diseases by applying its pounded rhizome. Meanwhile, the Jagoi use this species for ornamental purposes, appreciating its visual appeal. These contrasting uses underscore the diverse applications and significance of wild ginger species across different communities.

Discussion

The shared uses of wild ginger species by the Singai and Jagoi communities reflect their similar cultural practices and medicinal knowledge. For example, *Geocharis rubra* Ridl is used for food flavoring, and *Hornstedtia reticulata* (K. Schum.) K. Schum is used in handicrafts by both communities, demonstrating the importance of these plants in their daily lives.

The medicinal uses of *Alpinia galanga* (L.) Willd, *Curcuma longa* Val, and *Curcuma zaedoria* Val highlight the communities' reliance on traditional medicine for treating common ailments. *Alpinia galanga* is known for its carminative, antipyretic, and anti-inflammatory qualities, making it valuable in treating diseases such as bronchitis, heart diseases, and diabetes (Kaushik, 2011). Similarly, *Curcuma longa* is used to treat diarrhea, wounds, and as a food flavoring, while *Curcuma zaedoria* is employed to lighten skin, treat white vaginal discharge, and prevent COVID-19.

The ornamental uses of species like *Globba pumila* Ridl and *Etlingera coccinea* (Bl.) Sakai & Nagam emphasize their aesthetic value in the communities. The visual appeal of these plants contributes to the cultural landscape and is integral to local rituals and ceremonies.

Distinct uses of certain species highlight the unique cultural practices of each community. For instance, *Boeserbergia pulchella* (Ridl.) Merr is used by the Singai to treat conjunctivitis, while the Jagoi appreciate its ornamental qualities. Similarly, *Globba astrosanguinea* Teijsm. & Binn is utilized by the Singai to alleviate body pain after childbirth, whereas the Jagoi incorporate it into rituals.

The documented uses and chemical properties of these plants underscore their potential for pharmaceutical product development. *Alpinia galanga*, for example, contains essential oils and flavones known for antimicrobial, antioxidant, and anti-cancer activities (Jaju, 2009). *Etlingera brevilabrum* β -sitosterol content makes it a suitable cure for hypercholesterolemia and inflammation, among other conditions (Mahdavi, 2014).

Additionally, *Alpinia ligulata* rhizome oil is rich in (E)-methyl, showing activity against two fungal species, three Gram-positive bacteria, and three Gram-negative bacteria (Yusoff et al., 2011). *Etlingera coccinea* contains 85 compounds, of which 26 are

terpenoids. The majority of compounds in *E. coccinea* are monoterpenes, followed by alcohols, alkanes, alkenes, sesquiterpenes, aldehydes, ketones, fatty acid derivatives, esters, amines, and norterpene. The rhizome has the highest terpenoid abundance (43.34%), known for its bioactive qualities like anticancer and antioxidant (Nora, 2021).

In conclusion, the shared and distinct uses of wild ginger species by the Singai and Jagoi communities highlight the importance of traditional knowledge in preserving biodiversity and cultural heritage. Continued documentation and study of these plants will aid in promoting sustainable practices and the development of pharmaceutical products.

4.8 The Influence of Altitude with the Diversity and Density of Useful Zingiberaceae

Forty species of useful Zingiberaceae were discovered in their natural habitats, as listed in Table 4.5. The responses of these plant species to altitude varied. For analytical purposes, the study grouped the Zingiberaceae into three elevation categories based on their distribution across different altitudes. Species like *Etlingera elatior*, *Globba brachyanthera*, and *Hedychium coronarium* are included in the Lowland category, which ranges from 100 to 200 meters, where they thrive in the warmer, more humid environments. The Mid-Elevation category, spanning 201 to 300 meters, includes species such as *Zingiber sp. nov. ined.* and *Globba rubra* at 218 meters and goes up to 258 meters for *Alpinia glabra* and *Hornstedtia conica*, suggesting a preference for cooler and more diverse soil moisture conditions. The Highland category, which starts at 300 meters, features species like *Amomum oliganthum* and *Zingiber singaiensis* at elevations of 350 meters and higher, where the cooler temperatures and distinct soil compositions, along with less competition and unique ecological interactions, may shape their presence. This

categorization of altitudes highlights the varied ecological niches occupied by the Zingiberaceae and underscores the importance of tailored conservation strategies for these different elevation bands. Consistently found at the same elevation, certain plant species likely benefit from the ideal climatic, soil, and water conditions available there. According to Crimmins et al. (2011), climate changes have triggered a noticeable downward shift in the optimum elevations for plant species, primarily driven by changes in regional climatic water balance rather than temperature. Furthermore, Chauvier et al. (2020) affirm that climate is the predominant factor influencing plant species distribution in the European Alps, with soil and land cover also playing critical roles.

Table 4.5: Useful Zingiberaceae according to its elevation distribution

No	Species	Elevation (m)
1	<i>Etlingera elatior</i> (Jack) R.M. Sm	137
2	<i>Globba brachyanthera</i> K. Schum	137
3	<i>Globba pumila</i> Ridl.	137
4	<i>Globba francisci</i> Ridl	137
5	<i>Globba astrosanguinea</i> Teijsm. & Binn	137-250
6	<i>Sulettaria longituba</i> Holtt.	158
7	<i>Boeserbergia pulchella</i> (Ridl.) Merr	158-160
8	<i>Hornstedtia reticulata</i> (K. Schum.) K. Schum	158-250
9	<i>Alpinia havilandii</i> K. Schum	170
10	<i>Plagiostachys crocydocalyx</i> (K. Schum) B.L Burt & R.M Sm	172
11	<i>Scaphochlamys calcicola</i> A.D.Poulsen & R.J.Searle *	172
12	<i>Amomum longipedunculatum</i> R.M.Sm*	172

Table 4.5 continued

13	<i>Etlingera</i> sp.	172
14	<i>Zingiber</i> sp.	172
15	<i>Sundamomum borealiborneense</i> (I.M. Turner) A.D Poulsen & M.F Newman	172
16	<i>Sundamomum laxesquamosum</i> (S.Sakai & Nagam.) A.D. Poulsen & M.F Newman	172
17	<i>Alpinia beamanii</i> R.M.Sm	172
18	<i>Meistera gyrolophos</i> (R.M. Sm) Skornick & M.F. Newman	172
19	<i>Etlingera coccinea</i> (Bl.) Sakai & Nagam.	172
20	<i>Amomum</i> sp.	172
21	<i>Hedychium coronarium</i> J. Koenig	172
22	<i>Costus speciosus</i>	172
23	<i>Geocharis rubra</i> Ridl	178
24	<i>Plagiostachys albiflora</i> Ridl.	178
25	<i>Etlingera brevilabrum</i> (Valeton) R.M Sm	172-250
26	<i>Alpinia ligulata</i> K. Schum	172-250
27	<i>Alpinia glabra</i> Ridl.	172-253
28	<i>Hornstedtia conica</i> Ridl.	172-258
29	<i>Zingiber</i> sp. nov. ined.	218
30	<i>Globba rubra</i> Ridl	218
31	<i>Etlingera</i> sp. nov. ined.	350
32	<i>Amomum oliganthum</i> K.Schum	530
33	<i>Sulettaria succulosa</i> (K.Schum.) A.D. Poulsen	530

Table 4.5 continued

34	<i>Amomum</i> sp. nov. ined.	530
35	<i>Boeserbergia flavoalba</i> R.M. Sm	530
36	<i>Amomum cerasinum</i>	530
37	<i>Amomum macroglossa</i> K. Schum	530
38	<i>Zingiber singaiensis</i> Ripen & Meekiong	540
39	<i>Sulettaria meekiongii</i> Ripen & Teo	540
40	<i>Alpinia songet</i> Ripen & Meekiong	540

A total of 19 species were recorded exclusively from Singai and were not found in Jagoi (Table 4.6). This discrepancy is attributed to the different elevations of the two areas, which support different types of ginger species. The Singai forest, being at a higher altitude compared to Jagoi, hosts a unique range of ginger species do not present in the lower altitude Jagoi forest.

Table 4.6: List of Useful Zingiberaceae only found in Singai

No	Prefix (MK)	Genera	Species
1	MK 5 (B)	<i>Sulettaria</i>	<i>longituba</i> Holtt.
2	MK 13 (B)	<i>Amomum</i>	<i>longipedunculatum</i> R.M.Sm*
3	MK 14 (B)	<i>Etlingera</i>	sp.
4	MK 15 (B)	<i>Zingiber</i>	sp.
5	MK 17 (B)	<i>Sundamomum</i>	<i>borealiborneense</i> (I.M. Turner) A.D Poulsen & M.F Newman*
6	MK 18 (B)	<i>Sundamomum</i>	<i>laxesquamosum</i> (S.Sakai & nagam.) A.D. Poulsen & M.F Newman*

Table 4.6 continued

7	MK 23 (B)	<i>Meistera</i>	<i>gyrolophos</i> (R.M. Sm) Skornick & M.F. Newman*
8	MK 26 (B)	<i>Amomum</i>	sp.
9	MK 37 (B)	<i>Zingiber</i>	sp. nov. ined.**
10	MK 41 (B)	<i>Etlingera</i>	sp. nov. ined.**
11	MK 42 (B)	<i>Amomum</i>	<i>oliganthum</i> K.Schum
12	MK 43 (B)	<i>Sulettaria</i>	<i>suculosa</i> (K.Schum.) A.D. Poulsen*
13	MK 44 (B)	<i>Amomum</i>	sp. nov. ined.**
14	MK 45 (B)	<i>Boeserbergia</i>	<i>flavoalba</i> R.M. Sm*
15	MK 46 (B)	<i>Alpinia</i>	<i>songet</i> Ripen & Meekiong**
16	MK 47 (B)	<i>Amomum</i>	<i>Cerasinum</i>
17	MK 48 (B)	<i>Amomum</i>	<i>macroglossa</i> K. Schum*
18	MK 49 (B)	<i>Zingiber</i>	<i>singaiensis</i> Ripen & Meekiong **
19	MK 50 (B)	<i>Sulettaria</i>	<i>meekiongii</i> Ripen & Teo**

A total of 5 species were used exclusively by the Bidayuh community in Singai. This is due to the unavailability of these 5 species in Jagoi (Table 4.7).

Table 4.7: Zingiberaceae Species Only Used by Bidayuh Community of Singai

No	Prefix (MK)	Genera	Species	Method of Preparation
1	MK 2 (B)	<i>Geocharis</i>	<i>rubra</i> Ridl	String
2	MK 7 (B)	<i>Globba</i>	<i>brachyanthera</i> K. Schun	To treat smallpox
3	MK 12 (B)	<i>Scaphochlamys</i>	<i>calicicola</i> A.D.Poulsen & R.J.Searle	To wrap the wound
4	MK 22 (B)	<i>Alpinia</i>	<i>beamanii</i> R.M.Sm	Edible fruit
5	MK 49 (B)	<i>Globba</i>	<i>rubra</i> Ridl	Ornamental

Discussion

The diversity and density of useful Zingiberaceae plants are influenced by altitude, primarily due to changes in environmental factors associated with elevation. According to Paudel et al. (2019), with increased elevation, plant height and leaf area decrease while stomata density increase in Himalayan alpine gingers (*Roscoeia alpina* and *Roscoeia purpurea*).

Several factors contribute to how altitude impacts the diversity and density of these plants. One of the primary factors is temperature. As altitude increases, the temperature generally decreases. Higher altitude leads to stronger spatial heterogeneity in plant community diversity, with perennial herbs growing well at higher latitude and higher altitude, while annual herbs thrive at middle latitude and lower altitude (Xu et al., 2017).

4.9 Morphology, Taxonomic Treatment and Microscopic

According to Kress and Larsen (2009), a reassessment of the Zingiberaceae family's taxonomic classification, initially based on morphological data from 1889, revealed that earlier classifications inadequately reflected evolutionary relationships. Their phylogenetic analysis, utilizing DNA sequences from the nuclear internal transcribed spacer (ITS) and plastid matK regions, indicated convergent evolution among certain morphological traits and demonstrated paraphyly in three of the four originally designated tribes. This led to a restructured classification into four subfamilies: Siphonochiloideae, Tamijioideae, Alpinoideae, and Zingiberoideae. This revised taxonomy, aligning more closely with genetic evidence, enhances our understanding of the phylogenetic and evolutionary dynamics within this diverse family. Research on Zingiberales underscores the critical role of morphological data in taxonomic evaluations, enriching our understanding of the

evolutionary trajectories within this diverse order, as further detailed by Prince & Parks (2001).

4.9.1 Comparative Leaf Anatomy and Micromorphological of Useful Zingiberaceae with the Different Level of Altitude

Leaf epidermal micromorphology in *Zingiber* species provides valuable data for systematic and taxonomic studies within this genus (Zhao et al., 2022). Anatomical features of Zingiberaceae roots are instrumental in identifying plants and authenticating medicinal materials (Uma & Muthukumar, 2014). Plants adapt to high-altitude environments by decreasing leaf area and increasing leaf thickness, mesophyll tissue thickness, and stomatal density. These adaptations result in lower transpiration rates, higher internal temperatures, and enhanced photosynthetic capabilities (Liu et al., 2020b). The leaf anatomy of *Alpinia zerumbet* (Pers.) Burt & Smith exhibits a dorsiventral mesophyll organization, with oil cells distributed throughout and an amphistomatic structure, including a hypodermis on both surfaces (De Albuquerque & De Jesus Neves, 2004).

Anatomic characteristics for useful Zingiberaceae

During the field work, the sample of the seven new species of useful Zingiberaceae and three known species was collected for comparison. The leaf anatomy of this useful Zingiberaceae was identified. Results show that there is interspecific variation in the structure of the leaf midrib and petiole which can be used for species identification. It is also part of a study to investigate the possibility of using leaf anatomy for possible

identification of the species in Zingiberaceae, a difficult task due to similarities in leaf morphology and plant habit as well as infrequency in flowering.

4.9.2 Generic Anatomical Descriptions of Zingiberaceae at Low Elevation of 100-200 Metre Above Sea Level Using Microscope Digital Camera

Lamina

I. Epidermal Cells

In species with no hypodermis, adaxial cells wide and tall (No: 1-9)

II. Trichomes

Simple and unicellular (No:4-9)

III. Chlorenchyma

Palisade cells in 1-2 layers in certain species, the second layer smaller and wider and resembling mesophyll cells, sometimes making it indistinguishable; spongy cells in 2-6 layers.

The anatomical study of Zingiberaceae species at low elevations (100-200 metres above sea level)

The anatomical study of Zingiberaceae species at low elevations (100-200 metres above sea level) revealed significant variations in leaf lamina structure. These variations were observed through transverse sections captured with a microscope digital camera, providing detailed insights into the cellular and tissue organization of the lamina. These findings highlight the adaptive anatomical features that support the plants' survival in lowland environments.

In species without a hypodermis, the adaxial epidermal cells are notably wide and tall, as seen in Figures 4.19 through 4.21 (No. 1-9). This characteristic suggests an adaptation that enhances the structural integrity and protective function of the leaf surface. For example, *Boesenbergia pulchella* (Ridl.) Merr. shows a well-defined mesophyll structure in the middle part of the lamina (No. 1), with scale bars indicating 1000 μm . The apex part (No. 2) displays denser cell arrangements and prominent vascular bundles at 200 μm , while the base part (No. 3) highlights a broad vascular structure, also scaled at 1000 μm . These features optimize light capture and gas exchange, supporting the plant's survival in lowland environments.

The presence of simple and unicellular trichomes is a common feature across the studied Zingiberaceae species (No. 4-9). These trichomes play crucial roles in protection and adaptation. In *Globba rubra* Ridl., the middle part of the lamina (No. 4) demonstrates a typical mesophyll arrangement conducive to efficient photosynthesis. The base part (No. 6) features simple and unicellular trichomes (No. 5), with scale bars at 200 μm . These trichomes likely provide defense against herbivores and help mitigate environmental stress. The anatomical adaptations observed in *Globba rubra* indicate specialized functions of different leaf parts, contributing to the plant's resilience and adaptability in its native habitat.

The anatomical characteristics of *Globba astrosanguinea* Teijsm. & Binn further emphasize the diversity within Zingiberaceae. The middle part of the lamina (No. 7) displays a complex mesophyll structure, whereas the base part (No. 8) and apex part (No. 9) show simple and unicellular trichomes, both with scale bars at 200 μm . These trichomes are crucial for minimizing water loss and providing physical defense. The distinct anatomical features of *Globba astrosanguinea*, particularly the variations in trichome

structure, highlight the plant's adaptation mechanisms to cope with the environmental conditions at low elevations.

The chlorenchyma in these species consists of palisade cells arranged in 1-2 layers, with the second layer sometimes being smaller and wider, resembling mesophyll cells and making it indistinguishable in some cases. The spongy cells are arranged in 2-6 layers, providing a structure that facilitates efficient gas exchange and photosynthesis. This arrangement was particularly noted in *Boesenbergia pulchella*, where the mesophyll's complexity supports the plant's adaptive strategies in lowland environments. The detailed anatomical study of these Zingiberaceae species at low elevations underscores the intricate adaptations that enable their survival and ecological success. These findings highlight how structural features, such as epidermal cells, trichomes, and chlorenchyma, contribute to the plants' ability to thrive in specific environmental conditions. Understanding these adaptations provides valuable insights into the ecological dynamics and evolutionary processes influencing plant species in lowland habitats.

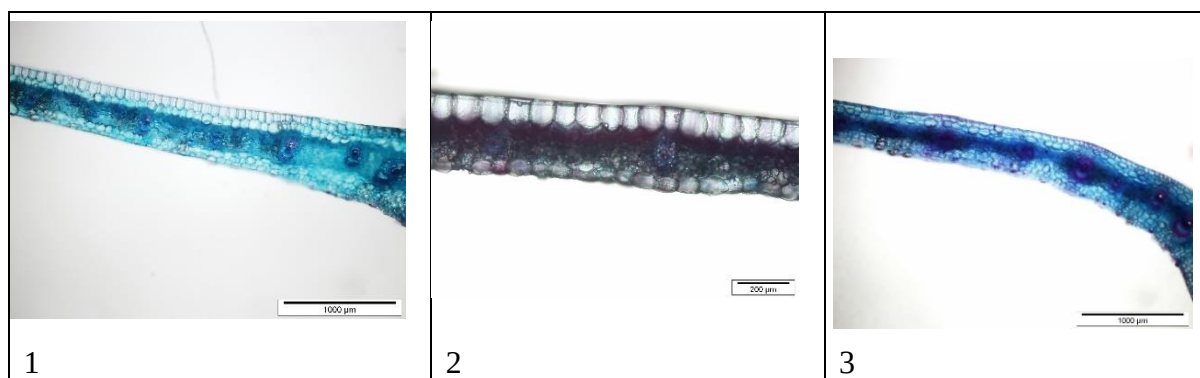


Figure 4.19: Transverse Sections of Leaf Lamina of *Boesenbergia pulchella* (Ridl.) Merr. No 1: Middle part of lamina of *Boesenbergia pulchella* (Ridl.) Merr. Scale bars = 1000 µm. No 2: Apex part of lamina of *Boesenbergia pulchella* (Ridl.) Merr. Scale bars = 200 µm. and No 3: Base part of lamina of *Boesenbergia pulchella* (Ridl.) Merr. Scale bars = 1000 µm.

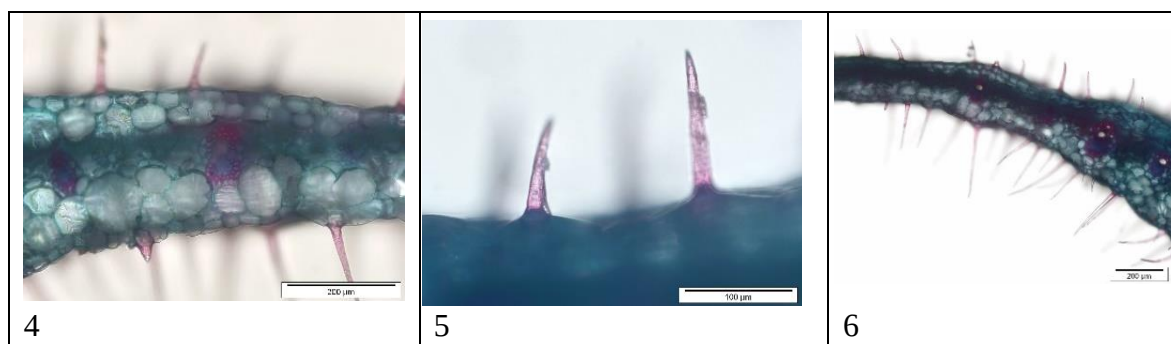


Figure 4.20: Transverse Sections of Leaf Lamina of *Globba rubra* Ridl. No 4: Middle part of lamina of *Globba rubra* Ridl. No 5: Simple and unicellular trichome of *Globba rubra* at base part of lamina. Scale bars = 200 µm. No 6: Base part of lamina of *Globba rubra* Ridl. Scale bars = 200 µm.

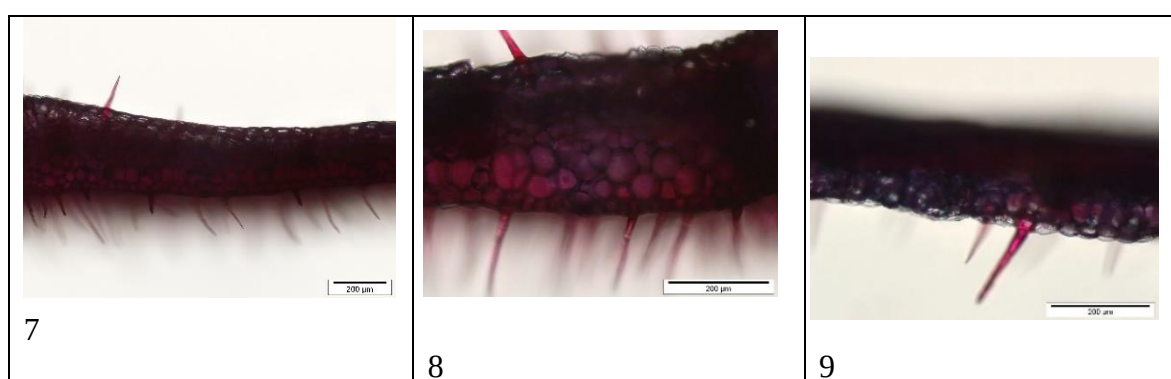


Figure 4.21: Transverse sections of leaf lamina of *Globba astrosanguinea* Teijsm. & Binn. No 7: Middle part of lamina of *Globba astrosanguinea* Teijsm. & Binn No 8: Simple and unicellular trichome of *Globba astrosanguinea* Teijsm. & Binn at base part of lamina. Scale bars = 200 µm. No 9: Apex part of lamina of *Globba astrosanguinea* Teijsm. & Binn Scale bars = 200 µm

Discussion

The anatomical study of Zingiberaceae species at low elevations (100-200 metres above sea level) revealed significant variations in leaf lamina structure. These variations were observed through transverse sections captured with a microscope digital camera, providing detailed insights into the cellular and tissue organization of the lamina (Kumar et al., 2011). These findings highlight the adaptive anatomical features that support the plants' survival in lowland environments (Jones & Luchsinger, 1986).

In species without a hypodermis, the adaxial epidermal cells are notably wide and tall, as seen in Figures 4.19 through 4.21 (No. 1-9) (Metcalf, 1973). This characteristic

suggests an adaptation that enhances the structural integrity and protective function of the leaf surface (Evert, 2006). For example, *Boesenbergia pulchella* (Ridl.) Merr. shows a well-defined mesophyll structure in the middle part of the lamina (No. 1), with scale bars indicating 1000 μm (Figure 4.20). The apex part (No. 2) displays denser cell arrangements and prominent vascular bundles at 200 μm , while the base part (No. 3) highlights a broad vascular structure, also scaled at 1000 μm (Figure 4.19). These features optimize light capture and gas exchange, supporting the plant's survival in lowland environments (Lazar, 2003).

The presence of simple and unicellular trichomes is a common feature across the studied Zingiberaceae species (No. 4-9) (Zhao et al., 2022). In *Globba rubra* Ridl., the middle part of the lamina (No. 4) demonstrates a typical mesophyll arrangement conducive to efficient photosynthesis (Figure 4.19). The base part (No. 6) features simple and unicellular trichomes (No. 5), with scale bars at 200 μm (Figure 4.20). These trichomes likely provide defense against herbivores and help mitigate environmental stress (Levin, 1973). The anatomical adaptations observed in *Globba rubra* indicate specialized functions of different leaf parts, contributing to the plant's resilience and adaptability in its native habitat (Groom et al., 2004).

The anatomical characteristics of *Globba astrosanguinea* Teijsm. & Binn further emphasize the diversity within Zingiberaceae (Figure 4.21). The middle part of the lamina (No. 7) displays a complex mesophyll structure (Figure 4.21), whereas the base part (No. 8) and apex part (No. 9) show simple and unicellular trichomes, both with scale bars at 200 μm (Figure 4.21). These trichomes are crucial for minimizing water loss and providing physical defence (Esau, 1977). The distinct anatomical features of *Globba astrosanguinea*,

particularly the variations in trichome structure, highlight the plant's adaptation mechanisms to cope with the environmental conditions at low elevations (Esau, 1977).

The chlorenchyma in these species consists of palisade cells arranged in 1-2 layers, with the second layer sometimes being smaller and wider, resembling mesophyll cells and making it indistinguishable in some cases (Lazar, 2003). The spongy cells are arranged in 2-6 layers, providing a structure that facilitates efficient gas exchange and photosynthesis (Lazar, 2003). This arrangement was particularly noted in *Boesenbergia pulchella*, where the mesophyll's complexity supports the plant's adaptive strategies in lowland environments (Figure 4.20). The detailed anatomical study of these Zingiberaceae species at low elevations underscores the intricate adaptations that enable their survival and ecological success (Evert, 2006). These findings highlight how structural features, such as epidermal cells, trichomes, and chlorenchyma, contribute to the plants' ability to thrive in specific environmental conditions (Jones & Luchsinger, 1986).

Midrib

I. Outline

Adaxial surface flat to curved, abaxial surface arched to V-shaped for *Boesenbergia pulchella* (Ridl.) Merr. *Globba astrosanguinea* Teijsm. & Binn and *Globba rubra* Ridl

II. Trichomes

Simple, unicellular in some species (No: 4-9).

III. Collenchyma

Annular and thick-walled cells present as fibre-like cells below adaxial epidermis (No: 2,6, 7,8 & 9).

IV. Vascular Tissue

Scattered vascular bundles are distributed among the parenchyma cells close to the adaxial epidermis (No: 1-9).

V. Crystals

Solitary in parenchyma cells in all species.

The anatomical study of leaf midribs in Zingiberaceae species at low elevations (100-200 metres above sea level)

The anatomical study of leaf midribs in Zingiberaceae species at low elevations (100-200 metres above sea level) reveals significant structural adaptations. These adaptations, observed through transverse sections captured with a microscope digital camera, provide insights into the cellular and tissue organization that support these plants' survival in lowland environments (Metcalf, 1973). Understanding these structural variations is crucial for comprehending how these plants have evolved to thrive in specific environmental conditions (Evert, 2006).

The leaf midrib outline varies among species. In *Boesenbergia pulchella* (Ridl.) Merr., the adaxial surface is flat to curved, while the abaxial surface is arched to V-shaped. Similarly, *Globba astrosanguinea* Teijsm. & Binn and *Globba rubra* Ridl. exhibit a flat to curved adaxial surface and an arched to V-shaped abaxial surface, as shown in Figures 4.22 through 4.24. These variations in midrib structure likely contribute to the mechanical support and flexibility of the leaves, allowing them to adapt to different environmental conditions (Esau, 1977). Such structural adaptations are essential for maintaining leaf integrity and function under various stressors (Lazar, 2003).

Trichomes are an essential feature in the midribs of these species. Simple and unicellular trichomes are present in some species, as seen in Figures 4.22 through

4.24 (No. 4-9). These trichomes play a crucial role in protecting the leaf surface from herbivores and environmental stress (Zhao et al., 2022). For instance, the presence of simple, unicellular trichomes in *Globba astrosanguinea* Teijsm. & Binn (No. 6) highlights their defensive function against potential threats (Levin, 1973). Trichomes play important roles in water absorption and metal detoxication, which have implications for ecology, the environment, and agriculture (Amada et al., 2019).

Collenchyma cells, characterized by their annular and thick-walled structures, are present as fibre-like cells below the adaxial epidermis in these species (No. 2, 6, 7, 8, & 9). These cells provide additional support and strength to the leaf midrib, ensuring that the leaf can withstand mechanical stress (Evert, 2006). The transverse sections of *Boesenbergia pulchella* (Ridl.) Merr. (Figures 4.25) and *Globba rubra* Ridl. (Figures 4.25) illustrate the presence of these supportive collenchyma cells. This structural reinforcement is particularly important in maintaining leaf rigidity and resilience against physical damage (Metcalf, 1973).

The vascular tissue in these species is arranged in scattered vascular bundles distributed among the parenchyma cells close to the adaxial epidermis. This arrangement, observed in Figures 4.21 through 4.23 (No. 1-9), facilitates the efficient transport of water, nutrients, and photosynthates throughout the leaf (Esau, 1977). The scattered vascular bundles in *Boesenbergia pulchella* (Ridl.) Merr. (No. 1-3) and *Globba rubra* Ridl. (No. 7-9) indicate an adaptive strategy to optimize resource distribution within the leaf (Jones & Luchsinger, 1986). Efficient vascular systems are essential for sustaining metabolic processes and overall plant health (Lazar, 2003).

Crystals are solitary in the parenchyma cells of all studied species. The presence of these crystals, as shown in Figures 4.23 through 4.25, suggests a role in deterring herbivory

and possibly in regulating calcium levels within the leaf tissues. The transverse sections of *Globba astrosanguinea* Teijsm. & Binn (No. 4-5) and *Boesenbergia pulchella* (Ridl.) Merr. (No. 1-3) highlight these solitary crystals, emphasizing their contribution to the leaf's defensive mechanisms (Levin, 1973). These crystals not only provide a chemical defense but also contribute to the structural integrity of the leaf (Zhao et al., 2022).

The detailed anatomical study of leaf midribs in Zingiberaceae species at low elevations underscores the structural adaptations that enable their survival and ecological success. The variations in midrib outline, presence of trichomes, supportive collenchyma, efficient vascular tissue arrangement, and solitary crystals all contribute to the plants' ability to thrive in specific environmental conditions (Metcalf, 1973).

Understanding these adaptations provides valuable insights into the ecological dynamics and evolutionary processes influencing plant species in lowland habitats (Evert, 2006; Lazar, 2003).



Figure 4.22: No 1 & 2: Transverse Sections of Leaf Midribs of *Boesenbergia pulchella* (Ridl.) Merr. No 3: Middle part of leaf midrib of *Boesenbergia pulchella*. Scale bars = 1000 μm.

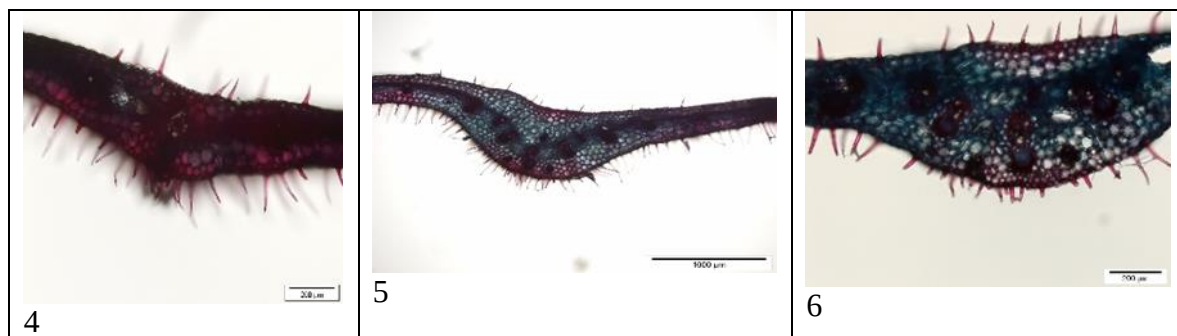


Figure 4.23: Transverse sections of leaf midribs of *Globba astrosanguinea* Teijsm. & Binn. No 4: Middle part of midrib of *Globba astrosanguinea* Teijsm. & Binn. Scale bars = 200 µm. No 5: Base part of midrib of *Globba astrosanguinea* Teijsm. & Binn. Scale bars = 1000 µm. No 6: Simple, unicellular trichome of *Globba astrosanguinea* Teijsm. & Binn.

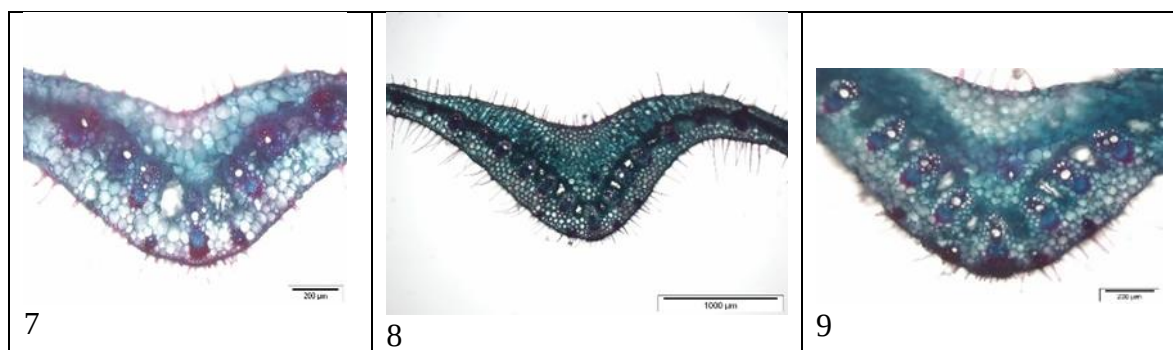


Figure 4.24: Transverse sections of leaf midribs of *Globba rubra* Ridl. No 7: Middle part of midrib of *Globba rubra*. No 8: Apex part of midrib of *Globba rubra*. Scale bars = 200 µm. No 9: Base part of midrib of *Globba rubra*. Scale bars = 200 µm.

4.9.3 Generic Anatomical Descriptions of Zingiberaceae at Middle Elevation of 500 Metre Above Sea Level Using Microscope Digital Camera

The anatomical study of Zingiberaceae species collected from Mount Singai at elevations of 500 meters above sea level involved the use of a microscope digital camera to capture detailed transverse sections of the leaf lamina and midrib. This analysis focused on three species: *Alpinia songet*, *Boesenbergia flava* and *Zingiber singaiensis*. The transverse sections provided insights into the structural adaptations of these plants to their specific environmental conditions. The figures presented in this report highlight key

differences and similarities in the anatomical features of the leaf lamina and midrib of these species (Kress et al., 2002b).

Figure 4.25 presents the transverse sections of the leaf lamina and midrib of *Alpinia songet*. Image No. 1 shows the middle part of the lamina with scale bars set at 1000 μm , providing a broad view of the lamina structure. This section reveals the arrangement of palisade and spongy mesophyll cells that optimize light capture and gas exchange (Knapp et al., 1988). Image No. 2 displays the apex part of the midrib, with scale bars at 200 μm , illustrating the detailed cellular arrangement and vascular tissues. The vascular system of wild ginger is arranged in two distinct zones, with communication between them achieved through extensive bridging from departing inner system leaf traces (Bell, 1980b). Image No. 3 captures the middle part of the midrib, also at a scale of 200 μm , highlighting the consistent anatomical features across different sections of the midrib, which are essential for structural support and nutrient distribution.

Similarly, Figure 4.26 illustrates the transverse sections of the leaf lamina and midrib of *Boesenbergia flavoalba*. Image No. 4 shows the middle part of the lamina with scale bars at 1000 μm , indicating the general structure and tissue organization (Kress et al., 2002b). The mesophyll structure observed supports efficient photosynthesis and gas exchange, similar to that seen in *Alpinia songet*. Image No. 5 focuses on the apex part of the midrib with scale bars at 200 μm , detailing the intricate vascular and supportive tissues that are critical for the plant's adaptation to middle elevation conditions (Knapp et al., 1988). Image No. 6 captures the middle part of the midrib, also with 200 μm scale bars, revealing the consistent anatomical characteristics within the midrib. These structural features ensure mechanical support and efficient resource distribution within the (Yadav et al., 2020).

The detailed anatomical study of these Zingiberaceae species at middle elevations underscores their structural adaptations for survival and ecological success. The robust vascular bundles, well-defined mesophyll layers, and supportive collenchyma cells observed in both species indicate evolutionary strategies that enable these plants to optimize resource use and withstand environmental stresses (Barrett & Helenurm, 1987). Understanding these adaptations provides valuable insights into the ecological dynamics and evolutionary processes influencing plant species in middle elevation habitats (Givnish, 1987).

The images and analyses collectively contribute to a comprehensive understanding of the structural biology of Zingiberaceae species at this elevation. The consistent anatomical features observed in the leaf lamina and midrib across different sections highlight the importance of these structures in maintaining leaf integrity and function. Such detailed anatomical studies are crucial for elucidating the adaptive strategies of plant species to specific environmental conditions (Barrett & Helenurm, 1987).

Figure 4.28 presents the transverse sections of the leaf lamina and midrib of *Zingiber singaiensis*. This analysis focused on *Zingiber singaiensis*, providing insights into the structural adaptations of this plant to its specific environmental conditions. The figures presented in this report highlight key differences and similarities in the anatomical features of the leaf lamina and midrib of this species (Kress et al., 2002b).

Image No. 1 shows the middle part of the lamina with scale bars set at 1000 μm , providing a broad view of the lamina structure. This section reveals the arrangement of palisade and spongy mesophyll cells that optimize light capture and gas exchange (Knapp et al., 1988). The presence of a well-defined mesophyll layer supports efficient

photosynthesis, crucial for the plant's adaptation to high elevation environments where light intensity can be lower due to frequent cloud cover (Yadav et al., 2020).

Image No. 2 displays the apex part of the lamina of *Zingiber singaiensis*, with scale bars at 200 μm , illustrating the detailed cellular arrangement and vascular tissues. The apex part shows denser cell arrangements and prominent vascular bundles, which are essential for maintaining leaf rigidity and efficient transport of nutrients and water. This structural adaptation is vital for plants at high elevations, where temperature fluctuations and wind exposure can be significant (Axelrod, 1966).

Image No. 3 captures the middle part of the midrib, also at a scale of 200 μm , highlighting the consistent anatomical features across different sections of the midrib. The robust vascular bundles surrounded by supportive collenchyma cells are crucial for providing mechanical support and ensuring efficient resource distribution within the leaf (Barrett & Helenurm, 1987).

The detailed anatomical study of *Zingiber singaiensis* at high elevations underscores its structural adaptations for survival and ecological success. The robust vascular bundles, well-defined mesophyll layers, and supportive collenchyma cells observed indicate evolutionary strategies that enable this plant to optimize resource use and withstand environmental stresses. Understanding these adaptations provides valuable insights into the ecological dynamics and evolutionary processes influencing plant species in high elevation habitats (Kress et al., 2002b).

The images and analyses collectively contribute to a comprehensive understanding of the structural biology of Zingiberaceae species at this elevation. The consistent anatomical features observed in the leaf lamina and midrib across different sections highlight the importance of these structures in maintaining leaf integrity and function (Knapp et al.,

1988). Such detailed anatomical studies are crucial for elucidating the adaptive strategies of plant species to specific environmental conditions (Yadav et al., 2020).



Figure 4.25: Transverse Sections of Leaf Lamina and Midrib of *Alpinia songet* No 1: Middle part of lamina of *Alpinia songet* Scale bars = 1000 µm. No 2: Apex part of midrib of *Alpinia songet* Scale bars = 200 µm. and No 3: Middle part of midrib of *Alpinia songet* Scale bars = 200 µm.

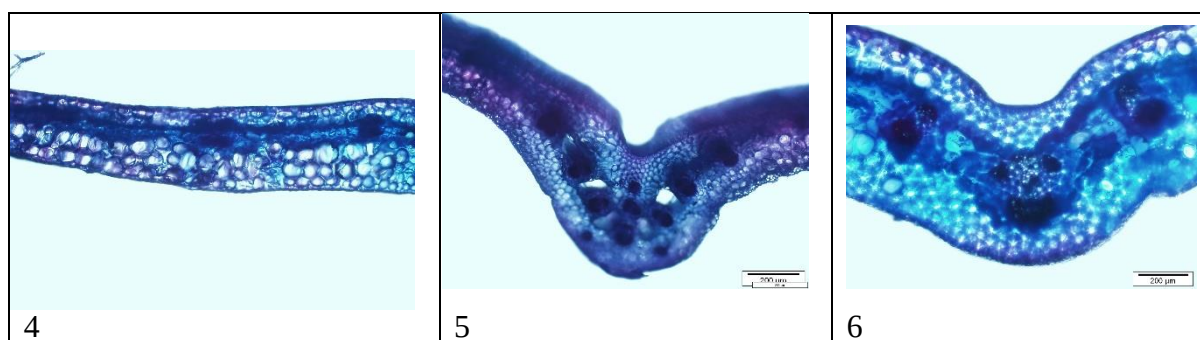


Figure 4.26: Transverse Sections of Leaf Lamina and Midrib of *Boesenbergia flavoalba* No 4: Middle part of lamina of *Boesenbergia flavoalba* Scale bars = 1000 µm. No 5: Apex part of midrib of *Boesenbergia flavoalba* Scale bars = 200 µm. and No 6: Middle part of midrib of *Boesenbergia flavoalba* Scale bars = 200 µm.

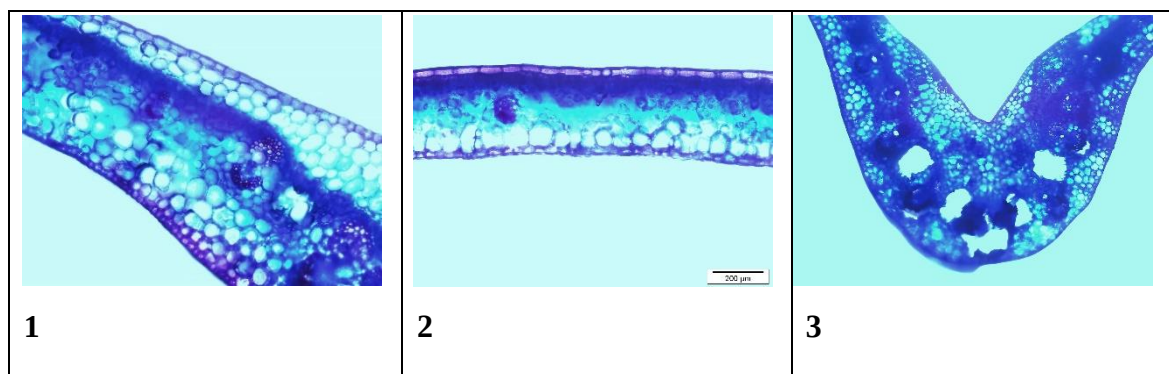


Figure 4.27. Transverse Sections of Leaf Lamina and Midrib of *Zingiber singaiensis* No 1: Middle part of lamina of *Zingiber singaiensis* Scale bars = 1000 µm. No 2: Apex part of lamina of *Zingiber singaiensis* Scale bars = 200 µm. and No 3: Middle part of midrib of *Zingiber singaiensis* Scale bars = 200 µm.

4.9.4 Scanning Electron Microscopy (SEM) Imaging of Abaxial and Adaxial Leaf of useful Zingiberaceae

The science of morphology is crucial for defining and classifying taxa and understanding their relationships within certain groups. Micromorphological studies on plants enable detailed analysis of pollens, leaves, tissues, and seeds using scanning electron microscopy (SEM). SEM provides high magnification through high-resolution imaging techniques, allowing for the acquisition of detailed morphological information. This level of detail is essential for distinguishing different species and identifying new taxa.

During fieldwork, a complete sample of Zingiberaceae species was collected, and its leaf micromorphology was identified. The results show differences in micromorphological characteristics among the species. Figure 4.28 presents SEM images of four species: *Alpinia songet*, *Amomum singaiensis*, *Globba astrosanguinea*, and *Sulettaria meekiogii*. Each species exhibits distinctive trichome characteristics on their abaxial surfaces, with long, simple, non-glandular trichomes being a common feature. These trichomes lack glandular tips and display a high degree of variability in shape.

Alpinia songet and *Amomum singaiensis* both have long, simple, non-glandular trichomes that are pyramidal and unicellular, contributing to the rigidity and texture of the leaf surfaces. *Globba astrosanguinea* shows the highest variability in trichome shapes, aiding in differentiation from other species. *Sulettaria meekiogii* has distinctive smooth-walled, long, non-glandular trichomes, highlighting its unique morphological adaptations.

Taxonomic significance of trichome micromorphology in useful Zingiberaceae

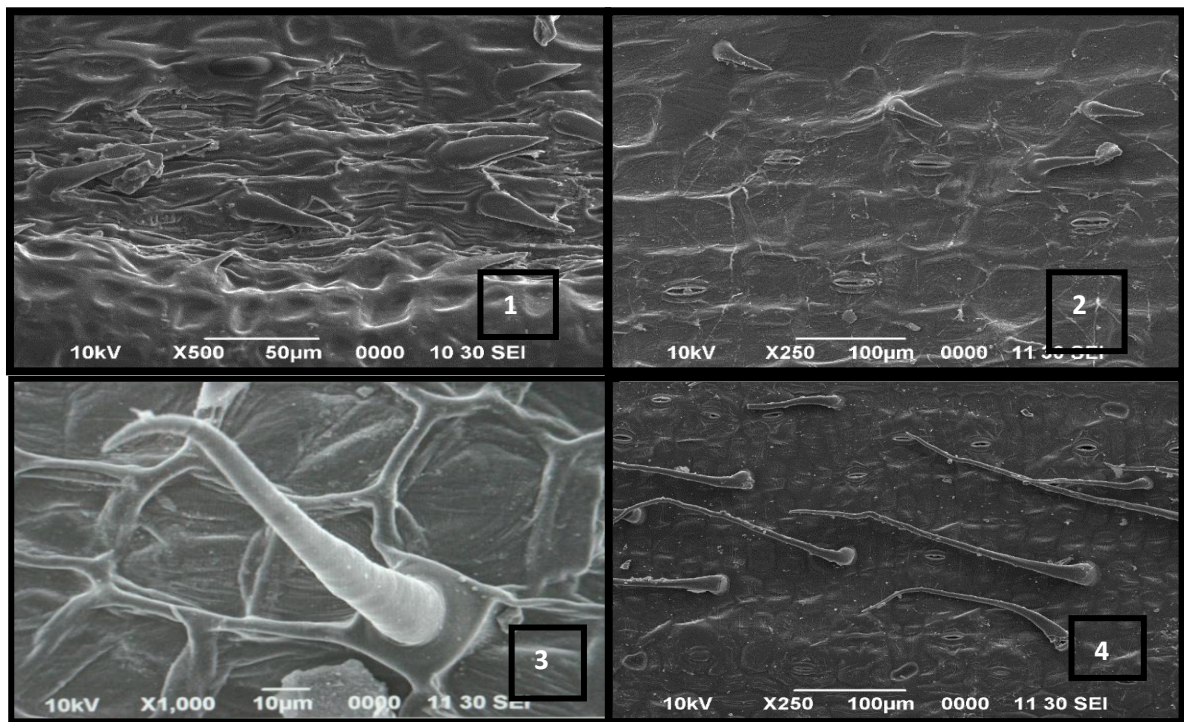


Figure 4.28: Scanning Electron Micrographs of Zingiberaceae. 1 – *I. Alpinia songet* 2- *Amomum singaiensis*. Abaxial surface showing long, simple, non -glandular trichomes, pyramidal, and unicellular trichome, 3-*Globba astrosanguinea*. 4- *Sulettaria meekiogii*. Abaxial surface showing long, simple, non-glandular trichomes, pyramidal, and smooth walled.

Table 4.8 describes midrib characteristics, noting the adaxial surface as flat to curved and the abaxial surface as arced to V-shaped in species such as *Boesenbergia pulchella*, *Globba astrosanguinea*, *Globba rubra*, and *Curcuma zedoaria*. Simple, unicellular trichomes and thick-walled collenchyma cells for structural support were also noted. The vascular tissues are scattered among parenchyma cells, indicating efficient nutrient transport.

Table 4.8: Transverse Sections of Leaf Margins of Useful Zingiberaceae Species Using Microscope Digital Camera

Leaf part	Characteristic	Species
Lamina	Epidermal Cell- species with no hypodermis	<i>Boesenbergia pulchella</i> (Ridl.) Merr <i>Globba astrosanguinea</i> Teijsm. & Binn
	Trichome unicellular	<i>Globba astrosanguinea</i> Teijsm. & Binn <i>Globba rubra</i> Ridl
	Chlorenchyma Palisade cells in 1-2 layers, the second layer smaller and wider, spongy cells in 2-6 layers.	<i>Boesenbergia pulchella</i> (Ridl.) Merr <i>Globba astrosanguinea</i> Teijsm. & Binn
Midrib	Adaxial surface flat to curved, abaxial surface arced to V-shaped	<i>Boesenbergia pulchella</i> (Ridl.) Merr. <i>Globba astrosanguinea</i> Teijsm. & Binn <i>Globba rubra</i> Ridl <i>Curcuma zaedoria</i>
	Trichomes Simple, unicellular in some species	<i>Globba astrosanguinea</i> Teijsm. & Binn
	Collenchyma	<i>Globba rubra</i> Ridl

Table 4.8 continued

	Annular and thick-walled cells present	
	Vascular Tissue Scattered and distributed among the parenchyma cells	<i>Boesenbergia pulchella</i> (Ridl.) Merr. <i>Globba astrosanguinea</i> Teijsm. & Binn <i>Globba rubra</i> Ridl <i>Curcuma zaedoria</i>

Table 4.9, using SEM, showed variable shapes of epidermal cells in *Alpinia songet* and *Amomum jackliamii*, along with short, simple, non-glandular trichomes that are pyramidal and unicellular. SEM also highlighted long, simple, non-glandular trichomes in *Globba astrosanguinea* and *Sulettaria meekiogii*.

Table 4.9: Image of Abaxial and Adaxial Leaf Sample Using Scanning Electron Microscope (SEM)

Leaf part	Characteristic	Species
Abaxial surface	Variable in shape of epidermal cells	<i>Alpinia songet</i> Ripen & Meekiong <i>Amomum jackliamii</i> Ripen & Meekiong
	Short, simple, non-glandular trichomes, pyramidal, and unicellular trichome,	<i>Alpinia songet</i> Ripen & Meekiong <i>Amomum jackliamii</i> Ripen & Meekiong
	Long, simple, non-glandular trichomes, pyramidal, and smooth walled	<i>Globba astrosanguinea</i> Teijsm. & Binn <i>Sulettaria meekiogii</i> Ripen & Teo

In conclusion, while the microscope digital camera effectively identifies key structural components, SEM excels in detailed surface topography and precise trichome morphology. Together, these methods offer a comprehensive understanding of micromorphological adaptations in Zingiberaceae.

Discussion

The science of morphology is crucial for defining and classifying taxa and understanding their relationships within certain groups. Morphological studies provide foundational knowledge that is essential for taxonomy, phylogenetics, and evolutionary biology (Knapp et al., 1988). In particular, micromorphological studies using scanning electron microscopy (SEM) enable detailed analysis of pollen, leaves, tissues, and seeds. SEM provides high magnification through high-resolution imaging techniques, allowing for the acquisition of detailed morphological information that is essential for distinguishing different species and identifying new taxa (Goldstein et al., 2017).

During fieldwork, a complete sample of Zingiberaceae species was collected, and their leaf micromorphology was identified. The results show differences in micromorphological characteristics among the species. Figure 4.29 presents SEM images of four species: *Alpinia songet*, *Amomum singaiensis*, *Globba astrosanguinea*, and *Sulettaria meekiogii*. Each species exhibits distinctive trichome characteristics on their abaxial surfaces, with long, simple, non-glandular trichomes being a common feature. These trichomes lack glandular tips and display a high degree of variability in shape. Such micromorphological details are vital for taxonomic differentiation and understanding the ecological adaptations of these species (Kress et al., 2002b).

Alpinia songet and *Amomum singaiensis* both have long, simple, non-glandular trichomes that are pyramidal and unicellular, contributing to the rigidity and texture of the

leaf surfaces. These structural adaptations may help protect the leaves from herbivory and environmental stress, which is a common feature in plants adapting to specific ecological niches (Zhao et al., 2022). *Globba astrosanguinea* shows the highest variability in trichome shapes, aiding in differentiation from other species. The presence of diverse trichome forms can be indicative of specific evolutionary pressures and ecological roles (Levin, 1973). *Sulettaria meekiogii* has distinctive smooth-walled, long, non-glandular trichomes, highlighting its unique morphological adaptations.

Table 4.7 describes midrib characteristics, noting the adaxial surface as flat to curved and the abaxial surface as arched to V-shaped in species such as *Boesenbergia pulchella*, *Globba astrosanguinea*, *Globba rubra*, and *Curcuma zedoaria*. Simple, unicellular trichomes and thick-walled collenchyma cells for structural support were also noted. The vascular tissues are scattered among parenchyma cells, indicating efficient nutrient transport. These anatomical features are essential for maintaining structural integrity and facilitating efficient physiological functions, particularly in diverse environmental conditions (Yadav et al., 2020).

Table 4.8, using SEM, showed variable shapes of epidermal cells in *Alpinia songet* and *Amomum jackliamii*, along with short, simple, non-glandular trichomes that are pyramidal and unicellular. SEM also highlighted long, simple, non-glandular trichomes in *Globba astrosanguinea* and *Sulettaria meekiogii*. The ability of SEM to reveal detailed surface topography and precise trichome morphology makes it a powerful tool for plant anatomical studies. These detailed observations are crucial for understanding species-specific adaptations and their evolutionary significance (Barthlott et al., 1998).

In conclusion, while the microscope digital camera effectively identifies key structural components, SEM excels in detailed surface topography and precise trichome

morphology. Together, these methods offer a comprehensive understanding of micromorphological adaptations in Zingiberaceae. The combination of these techniques provides valuable insights into the ecological and evolutionary processes that shape plant morphology, aiding in the accurate classification and understanding of plant species (Knapp et al., 1988).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Overview on Conclusion and Recommendation

The study successfully achieved its objectives, providing a comprehensive ethnobotanical documentation of Zingiberaceae species used by the Bidayuh community in Jagoi and Singai Bau District. Through detailed documentation, it was established that these plants hold significant medicinal, culinary, and cultural value within the community. The findings revealed that the Bidayuh community utilizes a diverse range of Zingiberaceae species for treating various ailments, reflecting deep-rooted traditional knowledge and practices.

The influence of altitude on the diversity and density of useful *Zingiberaceae* species is evident, with notable variations observed at different elevations. Comparative studies of leaf anatomy and micromorphology provided insights into species-specific characteristics and adaptations, highlighting the plants' ability to thrive under varying altitudinal conditions.

Socio-demographic factors, including gender, age, occupation, income, and religious beliefs, were found to significantly impact the utilization of Zingiberaceae plants. The study underscored the importance of traditional knowledge passed down through generations, particularly among older individuals who frequently use these plants for medicinal purposes. Additionally, the cultural significance of these plants in religious rituals and ceremonies was highlighted, emphasizing their integral role in the community's cultural heritage.

5.2 Major Finding

5.2.1 Socio-Demographic Influences on the Utilization of Zingiberaceae Plants Among the Bidayuh Communities of Singai and Jagoi

The socio-demographic analysis of the Bidayuh communities utilizing Zingiberaceae plants has highlighted how factors such as gender, age, occupation, income, and religious beliefs significantly influence the use of these plants. Notably, older individuals in these communities tend to use wild ginger species more frequently, which can be attributed to their extensive traditional knowledge. Additionally, the shared uses of these plants between the Singai and Jagoi communities reflect their common cultural heritage, underscoring the deep-rooted cultural significance of Zingiberaceae in their daily lives and traditional practices. The demographic profile of these communities reveals a notable number of older adults, which suggests a demand for healthcare services geared towards age-related conditions. Conversely, the underrepresentation of youth in these findings highlights a potential area for educational outreach and engagement. These population dynamics provide critical insights into structuring community-focused healthcare and educational programs that are tailored to meet the specific needs of the Bidayuh people.

Cultural considerations also play a pivotal role in community engagement, especially given the predominance of Christianity alongside traditional religious practices within the Bidayuh communities. These factors necessitate culturally sensitive approaches in deploying health and educational initiatives, ensuring that such programs are respectful of and aligned with the community's cultural values and religious beliefs.

Economic factors further influence the development of interventions within these communities. With a significant portion of the population earning below RM500, there is a critical need for economic development programs that focus on boosting local

entrepreneurship and job training initiatives. These programs can help in fostering sustainable development and enhancing the quality of life, making it essential to develop targeted interventions that respect cultural values and effectively address specific community needs.

5.2.2 Documentation of Ethnobotany

This research explores the biodiverse forests of Singai and Jagoi to document previously unrecorded species of Zingiberaceae. A significant number of these species are unassessed or endangered, emphasizing the urgent need for conservation efforts in tropical Asia. Modernization threatens the preservation of traditional knowledge, risking the loss of ethnobotanical wisdom and the potential medicinal benefits these plants may offer.

Advanced techniques such as scanning electron microscopy (SEM) enhance our ability to distinguish between closely related species, offering a more refined classification than traditional morphological methods. This precision enables the discovery of new medicinal, culinary, or industrial applications for these plants, potentially boosting local economies and supporting community livelihoods through sustainable practices.

The study documented 50 species across 22 genera, revealing their diverse applications in medicinal, culinary, handicraft, and ornamental uses. For example, *Alpinia songet* is used to treat skin diseases, while *Etlingera coccinea* is employed for food flavoring. This extensive documentation not only underscores the essential role these plants play in the daily lives of the Bidayuh community but also aids in preserving valuable cultural heritage and conserving vital plant species.

Integrating ethnobotanical records with ecological and economic analyses, the study aims to preserve traditional knowledge, promote biodiversity conservation, and explore the

economic potential of these plants. This approach sets a valuable precedent for similar studies globally, potentially guiding eco-tourism initiatives that could bring economic benefits while ensuring the sustainable use of these resources.

5.2.3 Medicinal Significance

The research revealed that 22 of the documented species are predominantly used for medicinal purposes, treating ailments such as skin diseases, conjunctivitis, and postpartum body pain, highlighting the significance of Zingiberaceae in traditional Bidayuh medicine. The detailed preparation methods, like the pounded rhizomes of *Zingiber cassumunar* used for massages, demonstrate a deep-rooted knowledge of plant-based remedies.

The shared uses of Zingiberaceae by both the Singai and Jagoi communities emphasize a deep cultural connection and a collective knowledge of these plants. These species serve various functions, from food flavoring to ritual practices, underscoring their integral role in the daily and cultural life of these communities.

Additionally, the variation in how some species are utilized between the two communities illustrates a rich tapestry of cultural identity and practices. This shows how cultural contexts influence the use of natural resources. Documenting these uses not only preserves valuable cultural heritage but also highlights the importance of these plants in biodiversity conservation and sustainable community development.

5.2.4 Influence of Altitude

The study on Zingiberaceae species across different altitudes reveals significant variations in diversity and density, with 30 species observed at lower elevations (100–299 meters) and fewer at higher altitudes. This variation in species distribution is largely

influenced by environmental factors such as temperature and microclimates, which affect plant adaptation and survival. The stratification of species across different elevation bands underscores the need for altitude-specific conservation strategies to effectively sustain these ecologically and culturally important species.

Further analysis highlights the significant correlation between altitude and the diversity of useful gingers, offering valuable insights for future conservation efforts and sustainable use amid changing environmental conditions. These findings are crucial for developing management strategies that address the impacts of climate change and habitat fragmentation.

The study also provides in-depth insights into the anatomical adaptations that enable Zingiberaceae to thrive at lower elevations, where conditions are less stressful compared to higher altitudes. Through detailed microscopic analysis, notable adaptations include the development of tall and wide epidermal cells in species lacking a hypodermis, enhancing their structural integrity and defense against physical impacts and biological threats. The presence of simple, unicellular trichomes, particularly in species like *Globba rubra* and *Globba astrosanguinea*, showcases an evolutionary response to lowland threats, aiding in water stress management and temperature regulation.

Additionally, the examination of leaf lamina across varying elevations reveals how structural features such as chlorenchyma layers and vascular tissue arrangements support the ecological success of these plants. The variability among species highlights the dynamic nature of evolutionary adaptations within the family. Such detailed studies are essential for understanding the complex relationships between plant morphology, environmental adaptation, and evolutionary processes, and are instrumental in informing

conservation strategies and ecological management practices to sustain these species in their natural habitats.

5.2.5 Comparative Leaf Anatomy and Micromorphological Studies

The research on Zingiberaceae, using microscopy and Scanning Electron Microscopy (SEM), provided detailed insights into species-specific anatomical features and adaptations to different altitudes. The study highlighted significant variations in the structure of the leaf lamina and midrib, such as robust vascular bundles and specialized trichomes that support survival under specific environmental conditions. These adaptations, particularly observed at high altitudes, include features that minimize water loss while maximizing photosynthetic efficiency, which is vital for survival in environments with increased solar radiation and lower atmospheric pressure.

SEM emerged as a critical tool in this study, offering high-resolution imaging that illuminates the intricate surface structures of plant leaves. This technique is pivotal in differentiating species and understanding their adaptive strategies, enriching our understanding of plant taxonomy and phylogenetics. The SEM analysis revealed distinctive trichome characteristics and variability in trichome shapes across species such as *Alpinia songet*, *Amomum singaiensis*, and *Globba astrosanguinea*. These features are essential for the plants' interaction with their environment, providing physical barriers against herbivory and desiccation, and potentially offering advantages in moisture retention and pest deterrence.

The study also delved into the functional implications of micromorphological features observed through SEM. Detailed views of leaf surface adaptations showed how specific trichome types and their arrangement significantly influence the plant's ability to

perform photosynthesis efficiently, manage water loss, and interact with pollinators and predators. Additionally, the midrib's structural support, with its optimized arrangement of vascular tissues and support cells, is crucial for leaf architecture stability and efficient nutrient transport, enhancing plant health and growth.

The integration of SEM with traditional botanical methods offers a robust approach to studying plant science, providing a comprehensive view of the adaptations and evolutionary strategies employed by different species within the Zingiberaceae family. This technique not only aids in the accurate identification and classification of species but also offers profound insights into ecological interactions and evolutionary pressures shaping these plants. Such detailed micromorphological studies contribute significantly to conservation efforts and the sustainable use of plant resources, underscoring the adaptive significance and taxonomic applications of these findings in resolving species ambiguities and enhancing phylogenetic analyses.

5.3 Key Findings and Contributions

Biodiversity Documentation

It provides valuable documentation of the species diversity and traditional knowledge associated with these plants.

Adaptive Strategies

The study offers insights into the anatomical adaptations of Zingiberaceae species across different altitudes, contributing to the understanding of plant ecology and evolution.

5.4 Recommendations for Future Research

Further exploration and documentation of unknown *Zingiberaceae* species in the region are essential for uncovering new discoveries and enhancing biodiversity conservation efforts. Implementing conservation strategies to protect the habitats of these species is crucial for maintaining ecological balance and supporting traditional practices. Additionally, integrating traditional knowledge with modern scientific techniques can foster the development of new medicinal and culinary applications, promoting the sustainable use and preservation of *Zingiberaceae* plants.

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APPENDICES

Appendix A

Household Survey Questionnaire

Part I

Date of Interview: _____

Name of Kampung: _____

A. Respondent's profile

1. Name : _____

2. Gender: Male () Female ()

3. Age: _____ years old

4. Race: _____

5. Religion: _____

6. Occupation: _____

7. Monthly income: _____

B. Household's Particular

1. Number of household (in 1 house) _____

2. Household Monthly income: _____

3. Household Education Background

Level of Education	Tick (✓)
Never go to school (year 0)	
Primary school (year 6)	
Secondary school (year 11)	
Diploma (year 14)	
Degree and above (year 16 and above)	

C. Respondent's Treatment of Illness

1. What is the first thing you do when you feel sick?

Health Services	Tick (✓)
1. Go to Hospital/clinic:	
2. Prepare home medicine	
3. Go to a healer/bomoh	
4. Go to pharmacy	
5. Prepare medicinal plant	

2. How frequently do you attend the Health Center

Frequency	Tick (✓)
1. Always	
2. Frequently	
3. Occasionally	
4. Never	

D. Household's Utilization of Plants for Medicinal Purposes

1. Do you use plants to treat complaints?	Tick (✓)
Yes	
No	

If Yes, go to question No 2, 3, 4,5 & 6

2. Do you pay for the medicine?	Tick (✓)
Yes	
No	
NA	

3. Are they (the plants) easy to obtain?	Tick (✓)
Yes	
No	
NA	

4. Where do you obtain them?

Item	Tick (✓)
1. Gather	
2. Purchase	
3. Keep at home	
4. Parents	
5. Friends	
6. Others	
NA	

5. Who taught you to select specific plants as possible sources for extracts that could yield certain response?

Item	Tick (✓)
1. Mother & Father	
2. Friends & neighbours	
3. Grandparents	
4. Healers	
5. Public	
6. Others	
NA	

6. Reason for using traditional medicine in treatment of sickness:

Reason	Tick (✓)
1. Confident	
2. Belief that modern medication cannot treat the illness	
3. Effective	
4. Easily obtained	
5. No expenses incurred	
6. Others	
NA	

7. Reasons for using only modern medicine in treatment of sickness:

Reason	Tick (✓)
1. Confident that its effective	
2. Cannot be treated by TM	
3. Scientific and rationale	
4. Easily obtained	
5. Others	

8. Family Health Condition and Treatment of Health Problems

i. Is there anyone in the house suffering from chronic diseases?	Tick (✓)
Yes	
No	

ii. Values of Households Accessibility to Modern and Traditional Medicine

Types of Illness	Modern (√)	Cost per year (RM)	Traditional (√)	Cost per year (RM)
A. Internal Illness (Organ)				
Stomachache/Diarrhea				
Influenza				
Headache				
Backache				
Hip ache				
Toothache				
Fever				
Cough/ Throat irritation				
Asthma				
Diabetics				
Highblood				
Jaundice				
Heart Attack				
Constipation				
Sore Eyes				
Appendicitis				
Ulcer				
Gastric				
B. Illness Caused by External agents				
Bleeding from a cut				
Swollen Body				
Scabies Wound				
Sprain				

Snake bite				
Insect bite				
Malaria				
Boil				
Burned				
C. Skin Infections				
Measles				
Small pox				
Chicken pox				
Ring-worm				
Skin disease				
D. Others (Pls specify)				

iii). Use of Medication

Types of Illness	Traditional medication only	Modern medication only	Both
A. Internal Illness (Organ)			
Stomachache/Diarrhea			
Influenza			
Headache			
Backache			
Hip ache			
Toothache			
Fever			
Cough/ Throat irritation			
Asthma			
Diabetics			

Highblood			
Jaundice			
Heart Attack			
Constipation			
Sore Eyes			
Appendicitis			
Ulcer			
Gastric			
B. Illness Caused by External agents			
Bleeding from a cut			
Swollen Body			
Scabies Wound			
Sprain			
Snake bite			
Insect bite			
Malaria			
Boil			
Burned			
C. Skin Infections			
Measles			
Small pox			
Chicken pox			
Ring-worm			
Skin disease			
D. Others (Pls specify)			

11. How do you evaluate the following factors at present

Level of satisfactory	Tick (✓)
Unsatisfactory	
Average	
Satisfactory	

Part 2

1. Opinion on medicinal ginger

Level	Tick (✓)
Don't know about the medicinal ginger	
Know about the medicinal ginger but never use it	
Know about the medicinal ginger and had use it	

2. Reason why medicinal ginger is important

Reason	Tick (✓)
Don't know	
Safe as it is natural based plant	
Not expensive compare to modern medicine	
Effective	

3. Suggestion to improve the awareness on medicinal plant

Suggestion	Tick (✓)
Establish specific government agency for local community and medicinal plant purposes, eg: ABS	
Government agency need to be more consistent and firm in managing useful plant conservation	
Educate the public on the importance of medicinal plant	

Appendix B

Household Survey Questionnaire				
Bahagian 1				
Tarikh interview:				
Nama Kampung:				
A. Latar Belakang Responden				
1. Nama _____				
2. Jantina: Lelaki () Perempuan ()				
3. Umur: _____				
4. Bangsa				
5. Agama				
6. Tahap pendidikan:				
7. Pekerjaan: _____				
8. Pendapatan Bulanan: _____				
B. Maklumat Isirumah				
1. Bilangan isi rumah (dalam 1 rumah):				
2. Lingkungan umur isirumah:				
3. Pendapatan seisirumah:	_____			
4. Sejarah pendidikan isirumah	_____			
Tahap Pelajaran	Tick (✓)			
Tiada pelajaran (year 0)				
Sekolah rendah (year 6)				
Sekolah menengah (Year 11)				
Diploma (year 14)				

Degree dan Atas (year 16)				
C. Kemudahan Isisrumah ke Pusat Kesihatan				
1. Apakah Perkara Pertama yang dilakukan apabila sakit				
Health Services	Tick (√)			
1. Pergi ke klinik/hospital:				
2. Menyediakan ubat dirumah				
3. Berjumpa dengan bomoh/bidan				
4. Pergi Ke Farmacy				
5. Lain				
2. Kadar Kekerapan ke Pusat Kesihatan				
Kekerapan	Tick (√)			
1. Selalu				
2. Sederhana				
3. Kadang kala				
4. Tidak pernah				
D. Penggunaan tumbuhan sebagai ubatan oleh Isi rumah				
1. Adakah Menggunakan Tumbuhan untuk Mengubati Sakit?	Tick (√)			
Ya				
Tidak				
<i>Jika Ya, terus ke soalan No 2, 3, 4,5 & 6</i>				
2. Adakah Kamu Bayar untuk Ubatan?	Tick (√)			
Ya				
Tidak				

NA				
3. Adakah Tumbuhan Tersebut Mudah dijumpai?	Tick (√)			
Ya				
Tidak				
NA				
4. Di manakah Anda Menjumpainya?				
Perkara	Tick (√)			
1. Kutip				
2. Beli				
3. Menyimpan di rumah				
4. Dari Orang Tua/ibu bapa				
5. Kawan				
6. Lain-lain				
NA				
5. Siapakah yang Memberitahu anda tentang sesuatu tumbuhan dengan setiap Penggunaannya?				
Item	Tick (√)			
1. Ibu Bapa				
2. Kawan dan Jiran				
3. Datuk & Nenek				
4. Pengamal/Bomoh				
5. Orang Awam				
6. Lain-lain				
NA				

6. Sebab Menggunakan Tumbuhan Ubatan:				
Sebab	Tick (√)			
1. Yakin				
2. Percaya Bahawa Ubatan Moden Tidak Dapat Menyembuh Penyakit				
3. Kesan yang positif				
4. Senang dijumpai				
5. Tidak perlu/ kurang bayaran				
6. Lain				
NA				
7. Sebab Menggunakan Ubatan Moden:				
Sebab	Tick (√)			
1. Yakin ianya berkesan				
2. Tidak dapat diubah menggunakan Ubatan Tradisi				
3. Saintifik dan Rasional				
4. Mudah Dijumpai				
5. Lain-lain				
8. Keadaan Kesihatan dan Rawatan Ahli Isi Rumah				
i. Adakah Sesiapa Ahli Isi rumah Menghadapi Penyakit Kronik?	Tick (√)			
Ya				
Tidak				

ii. Nilai Perubatan Moden dan Tradisional				
Types of Illness	Modern (√)	Times/Cost per year (RM)	Traditional (√)	Times/Cost per year (RM)
A. Internal Illness (Organ)				
To relief fever				
To treat diarrhoea				
To treat white vaginal discharge				
For Covid-19 prevention				
To remove wind from the body				
To lower fever in baby				
To treat headache				
To treat diabetic and to lower the blood sugar level				
B. Illness Caused by External agents				
To treat wound				
To treat conjunctivitis				
C. Skin Infections				
Measles (glimut)				
Small pox				
Chicken pox				
Ring-worm (bagi)				
Skin disease (kudis, ti'ie)				
D. Others (Pls specify)				

Appendix C

Plant Collection

[illegible]