



Faculty of Resource Science and Technology

DIVERSITY AND DENSITY OF GINGERS SPECIES (ZINGIBERACEAE) ON  
LIMESTONE AREAS OF NORTHERN WEST OF SARAWAK

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**Bachelor of Science with Honours  
(Plant Resource Science and Management)  
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**Diversity and Density of Gingers Species (Zingiberaceae) on Limestone Areas of  
Northern West of Sarawak**

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## **DECLARATION**

I hereby declare that no portion of this dissertation has been submitted in support of an application for another degree of qualification of this or any other university or institution of higher learning.

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## ABREVIATION

HUMS : Herbarium of University Malaysia Sarawak

SAR : Sarawak Forest Department Herbarium

ANOVA : Analysis Of Variance

CaCO<sub>3</sub> : Calcium Carbonate

cf. : Closed form

df : Degree of freedom

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# Diversity and Density of Ginger Species (Zingiberaceae) on Limestone Areas of Northern West of Sarawak

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## Abstract

Limestone areas in Sarawak are rich with plant diversity and play an important role as a habitat of many endemic plant species particularly herbaceous plant. Zingiberaceae is the largest family in order Zingiberales. This family consists of 53 genera with approximately 1200 species. The main objectives of this study are to determine the diversity and density of gingers on three selected limestone areas in northern west of Sarawak, viz. Bau, Padawan and Serian. A total of forty five (45) study plots were set up in studies sites and 10 m X 10 m study plots were established randomly in each sites. Twelve genera and 32 species were recorded during this study. Data were analysed using Shannon's Weiver Index for species diversity and One-way ANOVA and T-test for density of gingers in study sites. The Shannon's Weiver Index for Bau, Padawan and Serian is 1.62, 1.59 and 1.50. Genus *Etilingera* was the most abundant genus found in three studies sites. The most diverse foothill limestones was Gunung Poing and the most diverse studies sites was Bau limestones areas.

**Keywords:** Zingiberaceae, species diversity, density, limestone, Sarawak

## Abstrak

Kawasan batu kapur di Sarawak kaya dengan kepelbagaian spesies tumbuhan dan memainkan peranan penting sebagai habitat kepada spesies endemic. Zingiberaceae merupakan famili terbesar dalam Zingiberales. Famili ini mengandungi 53 genera dengan anggaran 1200 spesies. Tujuan utama kajian ini adalah untuk menentukan kepelbagaian dan kepadatan tepus dari tiga kawasan batu kapur yang telah dipilih di bahagian barat laut Sarawak iaitu Bau, Padawan dan Serian. Sebanyak empat puluh lima (45) plot 10 m X 10 m dibuat secara rawak di setiap lokasi kejadian. Dua belas genera dan 32 spesies telah direkodkan semasa kajian ini. Data dianalisis dengan menggunakan Shannon's Weiver Index untuk kepelbagaian spesies dan One-way ANOVA dan T-test untuk kepadatan tepus di kawasan kejadian. Shannon's Weiver Index untuk Bau, Padawan dan Serian adalah 1.62, 1.59 dan 1.50. Genus yang paling banyak dijumpai ialah genus *Etilingera*. Kawasan kaki bukit batu kapur yang merekodkan paling banyak spesies tepus ialah Gunung Poing dan lokasi kejadian yang mempunyai kepelbagaian spesies yang paling tinggi ialah kawasan batu kapur di Bau.

**Kata kunci:** Zingiberaceae, kepelbagaian spesies, kepadatan, batu kapur, Sarawak

## **CHAPTER 1**

### **INTRODUCTION**

Being the third largest island in the world, Borneo is the center of flora diversity. The island is over 1,300 km long and 950 km wide with an area of nearly 740,000 km<sup>2</sup>. Borneo is shared by three countries, Malaysia, Indonesia and Brunei. Sarawak is a tropical area with an equatorial climate situated in the north-west of Borneo. As a part of Borneo Island, Sarawak is one of important centers of plant diversity in the world and also the largest state in Malaysia with an area of approximately 124,449 km<sup>2</sup>, which about 37.5% of Malaysia in terms of size. Ng (2004) stated that 22% of quarters of the Bornean tree flora that have been identified are endemic to Sarawak.

Limestone is a sedimentary rock consisting mainly of the mineral calcite (calcium carbonate, CaCO<sub>3</sub>). A pure limestone contains 100% calcite. The impure limestones such as sandy limestone, marly limestone and dolomitic limestone contains impurities include chert (microcrystalline, cryptocrystalline quartz or amorphous silica), clay, organic matter and iron oxides. One of limestone unique feature is it partially soluble in acid. The solubility of limestone in water and weak acid solutions leads to karst landscapes, in which water erodes the limestone over thousands to millions of years. Most cave systems formations are through limestone bedrock.

The limestone outcrops cover nearly 520 km<sup>2</sup> (0.4%) of Sarawak which mainly located in southern Sarawak. Limestone areas in Sarawak are widespread and rich with plant diversity (Banda *et al.*, 2004). The unique physical, aesthetic and biological characteristics of limestone area have made it become significant in biodiversity conservation (Lapis and Servaz-Audije, 2004).

The gingers family, Zingiberaceae, grow vigorously in a wide range of habitats ranging from riverine to limestone area and from lowland to the upper montane regions. Gingers often growing in shady area but some of the native species are able to tolerate the full exposure of sun (Larsen *et al.*, 1999). The gingers are various in sizes, from few centimeters height of *Scaphochlamys* to gigantic herb of *Etilingera* that reached up to 8 m height. The gingers are often aromatic rhizomes with 2-ranked leaves that have an open sheath. Most members of the gingers possess large and showy flowers (Kress and Pedersen, 1999; Sakai and Inoue, 1999).

In Southeast Asia there are abundant numbers of gingers spices that are widely used, not only because of their unique flavor but also because of their medicinal and ornamental values (Aggarwal and Shishodia, 2006). The rhizomes of Zingiberaceae plants extraction contain many essential oils, including terpenes, alcohols, ketones, flavonoids, carotenoids and phytoestrogens that use as medicine (Larsen *et al.*, 1999).

## **Problem Statement**

The gingers family is one of among many important plant families for human. Many studies particularly on taxonomical, molecular and ethnobotanical have been conducted. However, very little studies on ecological particularly on diversity and density of gingers on limestone areas. Therefore, this study is aiming to:-

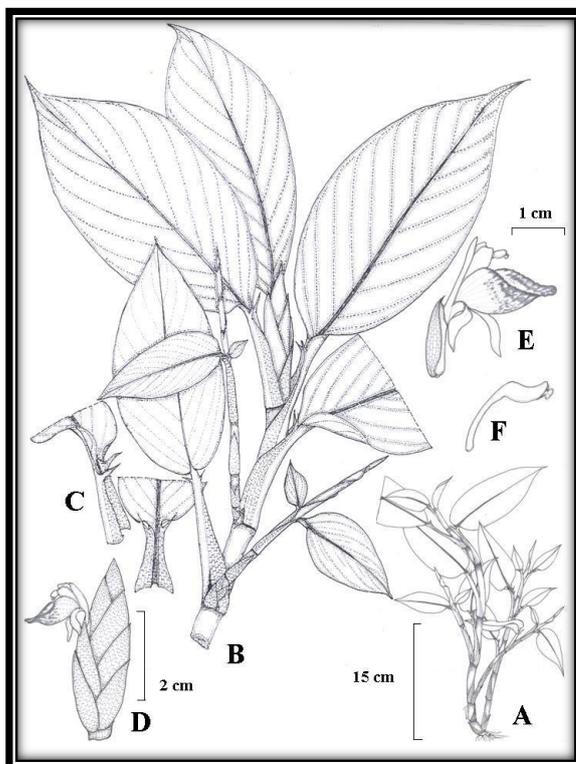
1. Study the diversity of gingers on limestone of northern west of Sarawak.
2. Study the density of gingers on limestone of northern west of Sarawak.
3. Identify the gingers species on limestone of northern west of Sarawak.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Order Zingiberales

The order Zingiberales has five sub-classes consists of Alismatidae, Arecidae, Commelinidae, Liliadae and Zingiberidae. The order Zingiberales comprises eight families (Marantaceae, Cannaceae, Zingiberaceae Costaceae, Heliconiaceae, Strelitziaceae, Musaceae, and Lowiaceae) that shared similar characteristics. The unique characteristics that shared among them are rhizomatous herb; young leaf roll and present or midrib; present of ligule; involucre bract; stamen and filament formed staminoid structure; and zigomorphic flower (Kress, 1990; Larsen *et al.*, 1999).



- A: rhizomatous herb
- B: young leaf roll and present or midrib
- C: present of ligule
- D: involucre bract
- E: stamen and filament formed staminoid structure
- F: zigomorphic flower

**Figure 1:** Characteristics of Zingiberales

The eight families within the order Zingiberales then have been divided into two groups: the monophyletic families (Marantaceae, Cannaceae, Zingiberaceae, and Costaceae) and the basal, paraphyletic families (Heliconiaceae, Strelitziaceae, Musaceae, and Lowiaceae). The monophyletic families had 1 functional stamen while the paraphyletic families had 5 functional stamens (Kress, 1991; Kress *et al.*, 2001). Costaceae was included in the family Zingiberaceae in earlier classification because both Costaceae and Zingiberaceae shared the same inflorescence and floral characters (Larsen *et al.*, 1999). The separation between these two families was due to the lack of aromatic oils, branched aerial stems, spiromonostichous leaves with a closed sheath and tubular in Costaceae (Kress *et al.*, 2001; Larsen *et al.*, 1999).

## **2.2 Family Zingiberaceae**

The family Zingiberaceae is the largest family of the order Zingiberales that consists of 53 genera with approximately 1200 species (Kress, 1990). The Malesian region is one of the highest diversity of genera and species of Zingiberaceae (Larsen *et al.*, 1999). Zingiberaceae are pantropical perennial terrestrial, rarely epiphytic, aromatic rhizomatous herbs with simple distichous leaves. Flowers are hermaphroditic, usually strongly zygomorphic, in determinate cymose inflorescences, and subtended by conspicuous, spirally arranged bracts. The perianth is comprised of 2 whorls, a fused tubular calyx, and a tubular corolla with one lobe larger than the other two.

Flowers typically have two of their stamenoids (sterile stamens) fused to form petaloid lip, and have only one fertile stamen. The ovary is inferior and topped by two nectaries, the stigma is funnel-shaped (Kress and Pedersen, 1999).

The Zingiberaceae was divided into four tribes, namely Alpinieae, Globbeae, Hedychieae and Zingiberieae were found mainly in the tropic throughout the world (Larsen *et al.*,1998). The characters that used to distinguishing the tribes were morphological features on both vegetative and floral characteristics such as number of locules and placentation in the ovary, development of staminodia, modifications of the fertile anther and the rhizome–shoot-leaf orientation (Larsen *et al.*,1999).

New phylogenetic analyses suggest at least some of these morphological traits are homoplasious and three of the tribes are paraphyletic. The African genus *Siphonochilus* and Bornean genus *Tamijia* are basal clades. The former Alpinieae and Hedychieae for the most part are monophyletic taxa with Globbeae and Zingiberieae included within the later. The results of these phylogenetic investigations are used to propose a new classification of the Zingiberaceae that recognizes four tribes namely Alpinieae, Globbeae, Hedychieae and Zingibieae (Kress *et al.*, 2002).

### 2.3 Genus

According to Poulsen (2006) there are 18 genera of gingers recorded in Sarawak such as *Alpinia*, *Amomum*, *Boesenbergia*, *Burbidgea*, *Camptandra*, *Elettaria*, *Elettariopsis*, *Etilingera*, *Geocharis*, *Geostachys*, *Globba*, *Haplochorema*, *Hedychium*, *Hornstedtia*, *Plagiostachys*, *Scaphochlamys*, *Tamijia*, and *Zingiber*. The largest genus of Bornean gingers are *Amomum* with 41 species. *Etilingera* on the other hand, represents the second largest genus of Bornean gingers with 40 known species recorded. However the genus *Scaphochlamys* with 30 described species only has six known species recorded in Borneo and all the six species are found in Sarawak (Boyce, 2006).

### 2.4 Diversity and Density

Cox (1990) has defined the diversity as the richness of habitat and region in a species. The best indicators of species diversity are the species richness and evenness of individuals' distribution among the species (Brower, 1997).

The order Zingiberales morphologically diverse and rich in species particularly suited for studying the evolution of floral diversity (Kress, 1990). The center of distribution of family Zingiberaceae is lied in the tropics especially in Southeast Asia (Larsen *et al.*, 1998). Poulsen (1997) has reported that the family Zingiberaceae shows the highest species diversity among herbaceous families in Bornean lowland forests. According to Sakai and Nagamasu (1998) more than 150 species of Zingiberaceae have been identified in Borneo.

## 2.5 Uses and Economics Importance

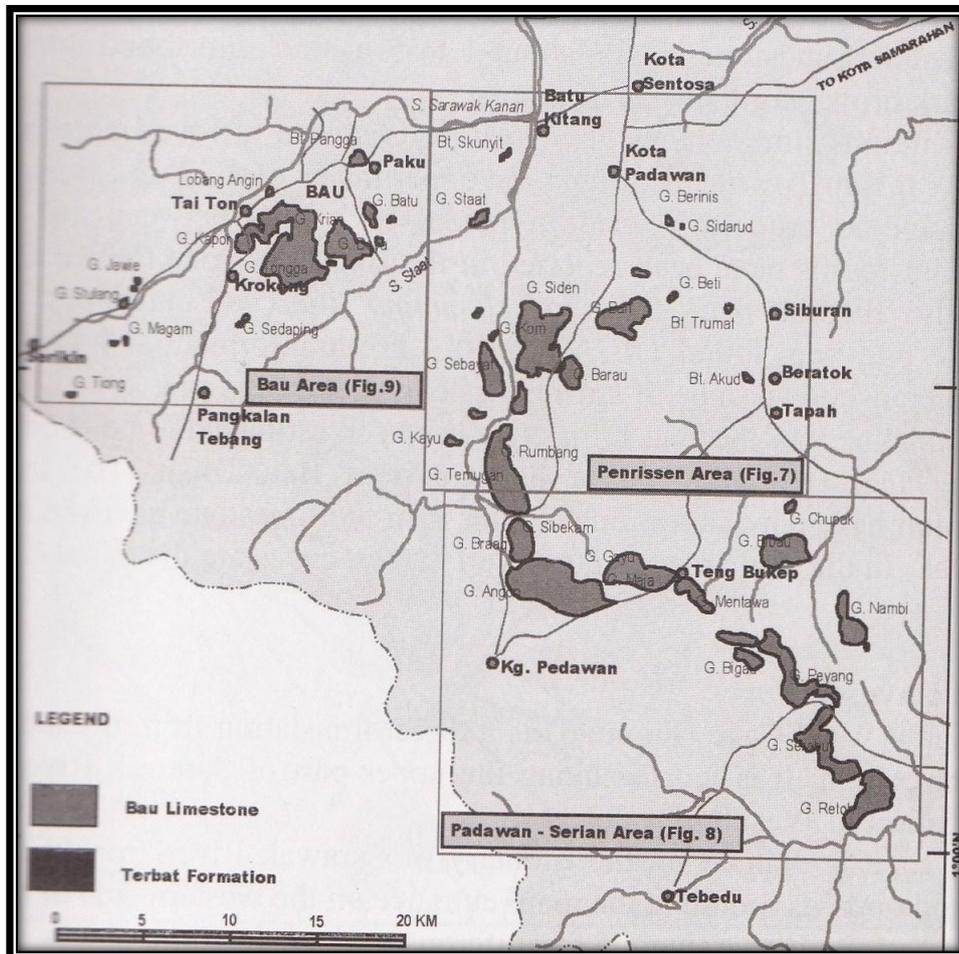
The presence of essential oil in some genera of gingers are used in the perfume industry for examples *Alpinia* and *Hedychium* (Aggarwal and Shishodia, 2006). Zingiberaceae are important as an ornamental plants, spices, or medicinal plants. The examples of gingers that used as ornamental plant are the Shell gingers (*Alpinia*), Siam or Summer tulip (*Curcuma alismatifolia*), *Globba*, Ginger lily (*Hedychium*), *Kaempferia*, Torch-ginger *Nicolaia*, *Renealmia*, and Ginger (*Zingiber*). The spices ginger are Ginger (*Zingiber*), Galangal or Thai ginger (*Alpinia galanga* and others), Melegueta pepper (*Aframomum melegueta*), Myoga (*Zingiber mioga*), Turmeric (*Curcuma*), Cardamom (*Amomum*, *Elettaria*). *Zingiber officinale* or locally known as Halia has been used for many years as spices and in traditional forms of medicine to treat diarrhoea (Larsen *et al.*,1999).

## CHAPTER 3

### MATERIALS & METHODS

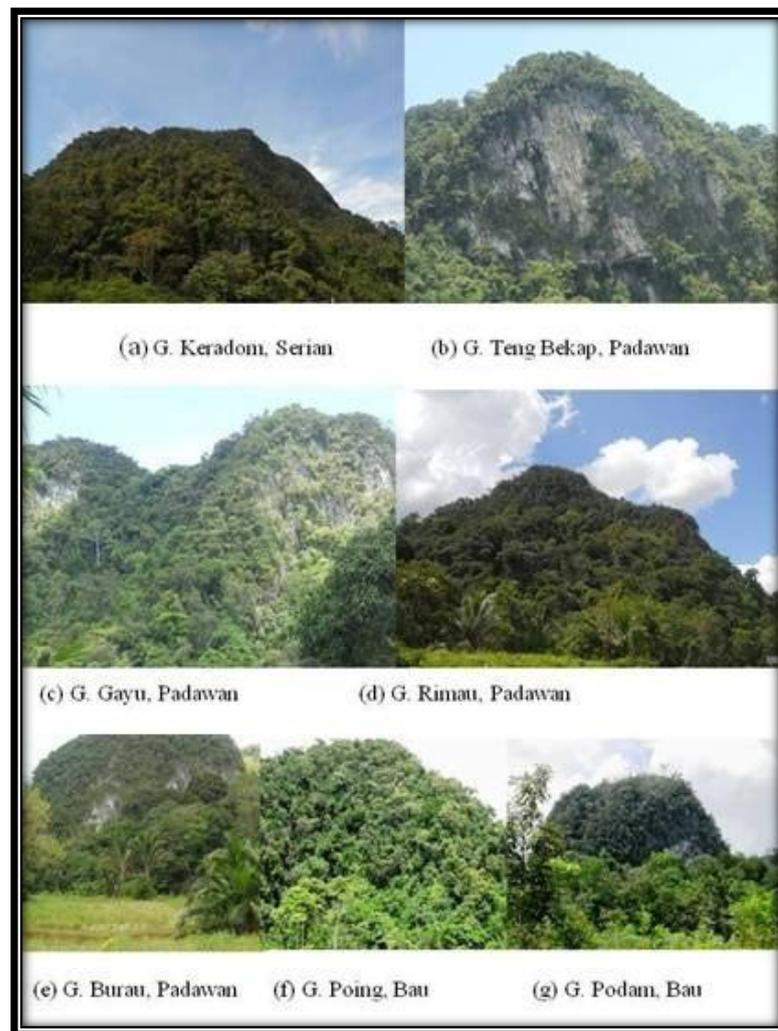
#### 3.1 Study Sites

The limestone areas of northern west of Sarawak were selected for this study. Three major limestone areas namely Bau, Padawan and Serian were selected to represent the study area as shown in Figure 2.



**Figure 2 :** Limestone hills in Bau, Padawan and Serian study area,(Adopted from Banda *et al.*, 2004)

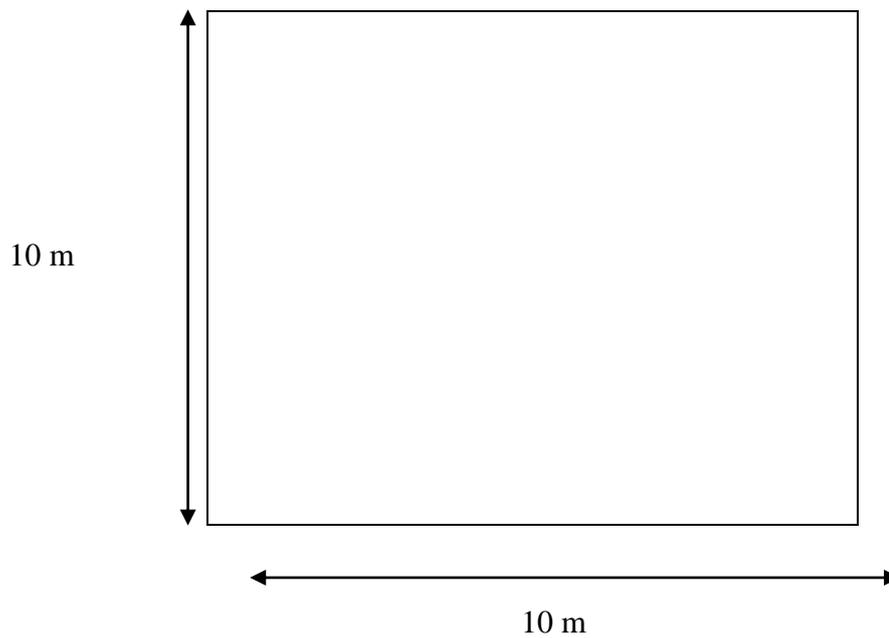
Figure 3 shows several pictures of selected limestone areas in Bau, Padawan and Serian. The selected limestone areas in Padawan were Gunung Gayu, Gunung Burau, Gunung Rimau, Gunung Teng Bekap, Gunung Staat, and Gunung Serapat. Five limestone areas in Serian that has been selected were Gunung Keradom, Gunung Retoh, Gunung Penyaling Kecil, Gunung Sabu and Gunung Majau. The selected limestone areas in Bau were as follows Gunung Podam, Gunung Poing, Gunung Ropih, Gunung Tai Ton, Gunung Simpang Boring and Gunung Batu Payong.



**Figure 3 :** The selected limestone areas in Serian, Padawan and Bau

### 3.2 Sampling Method

Fifteen study plots of 10 m X 10 m were set up randomly in each studies sites as shown in Figure 4. The total of study plots that had been set up were forty five (45) plots. The study plots were established in foothill limestone area.



**Figure 4 : Study Plot**

### **3.3 Specimen Collection**

The herbarium specimens and living plants were collected. Preparation of herbarium specimens were followed the standard herbarium collection method accordingly (Bridson and Forman, 1992). Only fertile specimen was collected for herbarium specimen. Any unidentify species were collected as living collection. Heavy duty polythene bags were used during the specimens collection to avoid damages on specimens during in the field. The flowers were preserved in specimen bottle/jar with 70% alcohol concentration. The dried herbarium specimens were kept in the Herbarium of Universiti Malaysia Sarawak (HUMS) and the duplicates were deposited at Sarawak Forest Department Herbarium (SAR). The living plants were planted in Greenhouse of Universiti Malaysia Sarawak.

### **3.4 Specimen Identification**

The identification of specimens were conducted at Sarawak Forest Department Herbarium (SAR), used identification keys and matching photos through the book such as Poulsen (2006), Larsen *et al.*, (1999) and various galleries photos in the internet.