Diversity and Habitat Relationships of Zingiberaceae Along Thai-Malaysian Border in Yala and Narathiwat Provinces

Charun Maknoi

Master of Science Thesis in Ecology
Prince of Songkla University
2001

Diversity and Habitat Relationships of Zingiberaceae Along Thai-Malaysian Border in Yala and Narathiwat Provinces

Charun Maknoi

Master of Science Thesis in Ecology

Prince of Songkla University

2001

Thesis Title	Diversity and Habitat Relationships of Zingiberaceae Along Thai-Malaysian Border in Yala and Narathiwat Provinces
Author	Mr. Charun Maknoi
Major Program	Ecology

Advisory Committee

Puangpen Sirirugsa ..... Chairman
(Professor Puangpen Sirirugsa)

Taveesak Saknimit ..... Committee
(Assistant Professor Taweesak Saknimit)

Examining Committee

Puangpen Sirirugsa ..... Chairman
(Professor Puangpen Sirirugsa)

Taveesak Saknimit ..... Committee
(Assistant Professor Taweesak Saknimit)

..... Committee
(Dr. Kitichate Sridith)

..... Committee
(Associate Professor Dr.Sayan Sadoodee)

The Graduate School, Prince of Songkla University, has approved this thesis as partial fulfillment of Master of Science Degree in Ecology.

.....
(Associate Professor Dr. Piti Trisdikoon)
Dean, Graduate School

ชื่อวิทยานิพนธ์ ความหลากหลายและความสัมพันธ์กับแหล่งที่อยู่ของพืชวงศ์ขิง (Zingiberaceae) ตามแนวชายแดนไทย-มาเลเซียในจังหวัดยะลาและนราธิวาส

ผู้เขียน นายจรัญ มากน้อย

สาขาวิชา นิเวศวิทยา

ปีการศึกษา 2543

บทคัดย่อ

สำรวจพืชวงศ์ขิงในแปลงศึกษา 3 แปลง ตามแนวชายแดน ไทย-มาเลเซีย ในจังหวัดนราธิวาสและยะลา ตั้งแต่เดือนเมษายน 2542 ถึงเดือนกรกฎาคม 2543 พบพืชวงศ์ขิงทั้งหมด 39 ชนิด ใน 12 สกุล จัดอยู่ใน tribe Alpinieae 22 ชนิด ใน 6 สกุล tribe Hedychieae 4 สกุล 10 ชนิด tribe Globbeae 1 สกุล 4 ชนิด และ tribe Zingibereae 3 ชนิด ใน 1 สกุล เขียนคำบรรยายลักษณะ สร้างรูปวิธาน และบันทึกภาพถ่าย ในจำนวนนี้เป็นพืชที่พบใหม่ในประเทศไทย 10 ชนิด อีก 8 ชนิดคาดว่าเป็นพืชชนิดใหม่ และเชื่อว่ายังมีพืชชนิดใหม่อยู่ในบริเวณนี้

เก็บดินตัวอย่างจากแปลงตัวอย่างขนาด 1x1 ตารางเมตร ทั้งหมด 51 แปลง โดยเลือกแต่ละแปลงที่มีพืชวงศ์ขิงชนิดเดียวจำนวนมาก วิเคราะห์คุณสมบัติดิน 13 ปัจจัย ปริมาณแสง กำหนดเป็นระดับขั้น ประมวลผลข้อมูลแบบ Ordination โดยวิธี Non-metric Multidimensional Scaling (NDMS) นำเสนอในแผนภูมิกระจาย ระหว่าง Axis 1 และ Axis 2 พบว่าจุดเก็บตัวอย่างไม่แบ่งเป็นกลุ่มที่ชัดเจน หลังจากประมวลผลเพิ่มเติมด้วยวิธี Cluster analysis สามารถจัดกลุ่มตัวอย่างได้ 2 กลุ่ม กลุ่มที่ 1 ประกอบด้วย จุดเก็บตัวอย่าง 42 จุด ของ พืช 34 ชนิด เป็นกลุ่มใหญ่ที่มีตัวอย่างจากพื้นที่ศึกษาทั้ง 3 แห่ง กลุ่มที่ 2 ประกอบด้วย 9 จุด ของพืช 9 ชนิด ในจำนวนนี้ มี 6 ชนิดที่พบในกลุ่มที่1 พืชในกลุ่มที่ 2 พบในบริเวณที่ดินมีคุณสมบัติดีกว่าของกลุ่มที่ 1 ผลการศึกษาแสดงให้เห็นว่าพืชวงศ์ขิงที่พบบริเวณแนวชายแดนไทย-มาเลเซีย ขึ้นอยู่ในพื้นที่ที่ปัจจัยแวดล้อมไม่แตกต่างกันมากนัก

Thesis Title	Diversity and Habitat Relationships of Zingiberaceae Along Thai-Malaysian Border in Yala and Narathiwat Provinces
Author	Mr. Charun Maknoi
Major Program	Ecology
Academic Year	2000

Abstract

The survey of the family Zingiberaceae along the Thai-Malaysian border in Yala and Narathiwat provinces was carried out from April 1999 to July 2000. Thirty-nine species in 12 genera were collected from three study sites. Twenty-two species of six genera are in Alpinieae. Ten species of four genera are in Hedychieae. Four species of one genus and three species of one genus are in Globbeae and Zingibereae respectively. Ten species are new records to Thailand and eight species are expected new species. Descriptions and the photographs of 39 species are provided with identification key to genera and species. It is believed that many undescribed species will be discovered in these areas.

Soil samples were collected from fifty-one plots (1x1 m^2), each plot is with one dominated species of Zingiberaceae. Thirteen soil properties were analyzed and light condition is given in ordinal scale. Sample plots were plotted by axis1 and axis2 of NMS. It is resulted that they are not grouped clearly. However, after processing by cluster analysis, they are divided into two groups. Group I consists of 42 sample plots of 34 species. Group II consists of nine plots of nine species, six of them are also in group I. Soil of group II shows better properties than of group I, such as high water holding capacity, electrical conductivity, cation exchange capacity, porosity and lower percent of sand. It can be concluded that Zingiberaceous plants along Thai-Malaysian border of this study grow in similar environmental condition.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Professor Puangpen Sirirugsa, my thesis advisor for her valuable advice and for her patient correcting my thesis.

I am also grateful to Assistant Professor Taweesak Saknimit, Dr. Kitichate Sridith and Associate Professor Dr. Sayan Sadoodee, my thesis committee members for their valuable suggestion and discussion.

My appreciation is also due to the Biodiversity Research and Training Program (BRT) for financial support (grant no. 542005).

My thanks are also due to Mr. Sunthon Todam for his kind help at Bala forest. I would also like to thank my friends who assisted me in the fields.

Finally, I wish to express my special gratitude to my family for their support and encouragement during my study.

Charun Maknoi

CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

There are approximately 1300 species in 50 genera of Zingiberaceae distributed through out the world mainly in the tropics. Distribution center of this family is in Southeast Asia, where more than half of species occur and many small genera are endemic to this region (Larsen *et. al*, 1998).

At least 200 species in 24 genera of Zingiberaceae distribute through out Thailand(Larsen, 1996). Three genera are already revised, i.e. *Boesenbergia* (Sirirugsa, 1992; Larsen, 1997), *Haniffia* (Larsen and Mood, 2000), *Kaempferia* (Sirirugsa, 1992), but the other genera are under revising.

The species diversity of *Zingiberaceae* in Thailand has been scarcely known. Many areas are still unexplored, including the evergreen rain forest near Thai-Malaysian border where is expected some undescribed species of *Zingiberaceae* to be found. Holttum (1950) reported many species from the Malay Peninsula, some of them are also believed to distribute along the Thai-Malaysian boundary. It has been appeared that new taxa are discovered every year until now (Larsen & Moods, 2000). *Etlingera* occurs 11 species in Malaysia, five of them were found in Thailand. *Hornstedtia* is in the same case, 1 of 6 western Malaysian species was reported in Thailand. Four species of *Camptandra* are endemic to Malaysia, which are found near Thai-Malaysian border, but this genus has never been collected in Thailand.

The habitats of Zingiberaceous plants are variable. Most species grow well in the shades, but some are able to grow in exposed areas (Larsen et al., 1999). Apart from light, other physical factors such as soil and humidity as well as biotic factors also affect the plant lives (Barbour et al., 1980). In term of environmental factor effects, this study concentrated on soil properties and light density of the plant habitats.

OBJECTIVES

1. To investigate species diversity of Zingiberaceae along Thai-Malaysian border in Yala and Narathiwat provinces
2. To classify zingiberaceous plants by environmental factors.

LITERATURE REVIEW

1. Family Descriptions and Classification

Perennial, rhizomatous herb; rhizome sympodially branched, usually horizontal and creeping. Stem short, poorly developed, mostly lengthened by overlapping leaf-sheaths; usually unbranched, sometime of considerable size. Leaves distichous with long and open sheath; lamina usually reduced in lower part of shoot, entire, elliptic, sometime linear or broadly elliptic, glabrous or hairy; lateral veins in pinnate parallel arrangement; petiole variable in length. Inflorescences terminal on the leafy shoot or terminal on a short separate leafless shoots arising directly from rhizome, lax or congest, cylindrical or

fusiform sometime globose with few-to-many flowered; flowers in cincinnus forming a thyrse or sometime in raceme or spike. Flowers bracteolate or sometime ebracteolate, epigynous, bisexual, zygomorphic; floral characters unique within tribe (fig. 2). Calyx tubular, usually 3-lobed or 3-dentate sometime split down along one side. Corolla tubular at base; lobes three varying in size and shape. The most parts of androecial whorls transform into staminodes and labellum, only 1 stamen function. Anther dithecal; theca opening by longitudinal slit or occasionally dehiscing by pores; connective often prolonged in a crest and sometimes also with basal spurs. Gynoecium with 3 carpels; ovary either 3-locular with axile placentation or 1-locular with pareital or basal placentation; style terminal, placed in the furrow of the filament and held between the thecae; stigma funnel-shaped, often ciliate; stylodes 2, epigynous. Fruits dry or fleshy capsule, loculicidal dehiscence or irregular dehiscence or indehiscence. Seeds usually arilate.

Zingiberaceae is divided into 4 tribes (Smith, 1981).

Alpinieae: Inflorescence radical. Distichy of leaves transverse to rhizome; lateral staminodes reduced to small non-petaloid structures, sweelings or absent. Ovary usually trilocular with axile placentation, sometime imperfectly so, very rarely unilocular with parietal placentation.

Globbeae: Lateral staminodes petaloid, free from the lip; filament bow-loke, usually long exserted; ovary unilocular with parietal placentation.

Hedychieae: Distichy of leaves parallel to rhizome; lateral staminodes petaloid, free from the lip; ovary trilocular with axile plaxentation or unilocular with basal or free columnar placentation.

Zingibereae: Distichy of leaves parallel to rhizome; lateral staminodes petaloid, adnate to the lip; ovary trilocular with axile placentation.

2. Diversity of Zingiberaceae

There are approximately 1,300 species in 50 genera of Zingiberaceae found in the world (Larsen, 1998). It distributes mainly in the Tropics, which its center of distribution is in Southeast Asia. Many genera are endemic to this area such as *Burbidgia* in Borneo, *Camptandra* in Malay Peninsula, *Vanoverberghia* in The Philippines and Taiwan (Funakoshi and Ohashi, 2000) and *Cornukaempferia* (Larsen and Mood, 1998) and *Siamenthus* (Mood and Larsen, 1997) in Thailand.

Zingiberaceae in areas around Thailand have been studied for some decades by plant taxonomists from Europe. In the East, Flora of Indochina, i.e. Cambodia, Laos and Vietnam, reported 13 genera with 118 species including *Costus* (Gagnepain, 1908), with endemic taxa, for example *Siliqueamomum tonkinense* H. Baillon. In the North, Flora of China was published with 350 species in 23 genera (Larsen and Cheng, 2000). Nearly half of them are endemic to China. In the West, Flora of British India reported 19 genera 219 species including *Costus* (Hooker, 1894). In the South, Flora of Malay Peninsula recorded 111 species in 22 genera (Ridley, 1890). Holttum (1950) reported 157 species in 23 genera in his "The Zingiberaceae of Malay Peninsula". Some genera were reduced by the following works.

In Thailand, about 200 species in 22 genera were listed in "A Preliminary Checklist of Zingiberaceae of Thailand" (Larsen, 1996). After that, many new taxa were described, such as genus *Cornukaempferia* (Larsen and

Mood, 1999) and *Siamenthus* (Mood and Larsen, 1998). In southern Thailand, Sirirugsa (1989) surveyed *Zingiberaceae* in southern Thailand and reported 40 species in 10 genera. Nine genera of *Alpinieae* in Thailand mostly found in southern part. The genus *Alpinia*, about 200 species, is centered in Southeast Asia. Smith (1990) divided this genus into Subgenera, Sections and Subsections. Three species of *Elettariopsis* were found in Thailand while Kam (1982) reported five species of this genus in Malaysia. Larsen (1996) documented six species of *Etlingera* in Thailand. Eleven species occur in Peninsular Malaysia (Holttum, 1950 and Mood & Ibrahim, 2000). Recently, J. Mood & H. Ibrahim (2000) described *E. conerii* and recommended that this species could be found in Thailand. *Hornstedtia* is a genus with 13 species in Malaysia, some species were documented as endemic to central part of Malaysia, e.g. *H. ophiucus* (Koenig) Retz (Holttum, 1950).

Hedychieae in Thailand is composed of 10 genera. Most of them are centered in the northern and the northeastern parts, such as *Caulokaempferia*, *Cornukaempferia*, *Curcuma*, *Hedychium*, *Kaempferia* and *Stahlianthus*. Sirirugsa (1987) described 4 new species of *Boesenbergia* in Thailand; i.e. *B. acuminata*, *B. basispicata*, *B. petiolata* and *B. siamensis*, and revised this genus in 1992. Thirteen species were recognized. Seven species were included in Peninsular Malaysia. Larsen described *B. tenuispicata* in 1993 and *B. trangensis* and *B. gelatinosa* in 1997 from Peninsular Thailand. Twenty species of *Scaphoclamys* were recognized in Malay Peninsula (Holttum, 1950). Three species were recorded in Thailand. *S. biloba* (Ridl.) Holtt. and *S. klossii* (Ridl.) Holtt. are distributed from Malaysia while *S. obcordata* Sirirugsa & K. Larsen is endemic to Narathiwat province (Sirirugsa and Larsen, 1991).

There are three genera of *Globbeae* in Thailand. Only one genus, *Globba*, was found in southern Thailand. Twelve species of *Globbeae* occur in Malay Peninsula with many subspecies and varieties (Lim, 1972). Lately, Ibrahim and Larsen (1995) described a new species, *G. nawawii*, from Peninsular Malaysia. *Globba* in Malaysia is composed of two sections of totally four. Section *Ceratanthera*: two anther-appendages and section *Marantella*: four anther-appendages and well developed bracts (Larsen, 1972). Theilade (1999) published the synopsis of the genus *Zingiber* of Thailand, with 26 species are recognized. Six species are endemic to Malay Peninsula and 10 species are widespread, one of which, *Z. longibracteatum* I. Theilade, is found in southern Thailand. Four species are cultivated throughout the country, i.e. . It is believed that many more undescribed species of Zingiber in Thailand can be found.

Burkil (1810) reported 50 species in 25 genera of *Zingiberaceae* as economic plants. Several species are very important spices such as ginger (*Zingiber officinale* Rosc.), turmeric (*Curcuma longa* L.) and galangal (*Alpinia galanga* (L.) Willd.). Many species are well-known as ornamental plants, which have been cultivated for a long time

3. Habitat Relationships

Habitat must be distinguished at appropriate spatial scales, and must be provided that individuals recognized and responded to the habitat classification. Microhabitat is a precise location within a habitat where an individual species is normally found (Allaby, 1999). At Hudson Bay Lowland of Ontario, Canada, the landscape were composed of two easily distinguished habitats, but can be demonstrated three habitat types influencing density-dependent habitat selection by red-backed vole (*Clethrionomys gapperi*) (Knight and Morris, 1996). Large scaled habitat is composed of many microhabitats. Their composition gradually changes to each other without clear-cut border. Soil is heterogeneous especially in the tropics (Richards, 1996). Their diversity despite, many of the soils have a number of characteristics in common.

Microclimate is the atmospheric characteristic that prevails within a small space, usually in the layer near the ground that is affected by the ground surface. Special influences include the impact of covered vegetation on humidity (by evapotranspiration), temperature and winds (Allaby, 1999). Microclimate near the forest floor is much different from that above the forest canopy (Withmore, 1990). It is more stable while the climate above the canopy fluctuates more within one day. Many factors affect plant microclimate, including light, humidity, temperature and wind (Jones, 1993). For example, range of relative humidity at ground level is 80-100 % while at 53 m above ground varies from 40% to 100%. Maximum, mean and diurnal ranges of temperatures are significantly lower beneath the rain forest canopy than within or just above it or in gaps or clearings. This is so because the forest canopy,

rather than the ground, is the main heating and radiation surface (Richards, 1996).

Zingiberaceae is one of the important ground floras of Malaysian Rain Forest (Richards, 1996). They are high differentiation. Some species is able to reach 5-6 m in the shrub layer. In general sense, most of the gingers species grow in the humid, shady undergrowth, their leafy shoots emerge among the wet leaf litter of the forest trees especially in Malay Peninsula. Some species grow by the banks of shaded small streams while others grow by the bank of more open or un-shaded stream (Larsen, 1999).

Zingiberaceae was sometimes classified by using other characters rather than morphological characters. Sakai et al. (1999), Zingiberaceae in Lowland Mixed Dipterocarp Forest in Sarawak was divided into three guilds based on pollinators, i.e. Spiderhunter (Nectariniidae), medium-sized Amegilla bees (Anthophoridae) and small Halictid bees (Halictidae). Each guild is significant correlated to floral morphology. Sakai (2000) reported that at least one species was flowering at anytime except the Spiderhunter pollinated group (Sakai, 2000). White et al. (1998) suggested that Zingiberaceous plant serve as key-stoned foods for terrestrial animal in Neotropical forest as well.

Many methods of ordination are used for classifying group of organism such as microhabitat of animal in salt marsh (,), forest type (Pemadasa and Mueller-Dombois, 1979) and lake type (,). The first known method is Principal Component Analysis (PCA). Later on, many methods have been developed, e.g. Canonical Analysis, Detrend Correspondent Analysis and Multi-dimensional Scaling. New method comes over the weakness of the early one. Walker (1998) suggested that the purpose of MDS is to construct a map of configuration of the samples in a specific number of dimensions base on

dissimilarity matrix not original data matrix. MDS is simple in concept and base on dissimilarity matrix so there is complete freedom to define similarity of community composition in whatever terms are biologically meaningful. The weakness of MDS is that it requires a large number of repeats from different configuration. Therefore, NMDS is a suitable ordination method for data collected from the field.

CHAPTER 2

MATERIALS AND METHODS

1. Study sites

The survey of Zingiberaceae was carried out in the evergreen forest in Narathiwat and Yala provinces ,near the Thai-Malaysian borders. Three study sites were located in different altitudes, site A, site B and site C (Fig.1). Site A is located at 5° 47' 50" N, 101° 49' 30" E in Hala-Bala Wildlife Sanctuary, Ban Lo Jude, Waeng district, Narathiwat province, with altitude 100-200 m from mean sea level. The main stream of this site is Klong Ai Ka Ding, where the Sirinthorn Waterfalls originated. Site B is located at 5° 50' 39" N, 101° 13' 15" E in Ban Chulaporn Pattana 10, Betong district, Yala province, with altitude 400-500 m from mean sea level. The main stream of this site is Klong Kapa. Site C is located at 6° 17' 30" N, 100° 52' 43" E in Ban Bahoybao, Kabang district, Yala province, with altitude 100-200 m from mean sea level. The main stream of this site is Klong Tepa, where is connected to Songkhla province. Climates of the study sites are shown in table 1.

Soil conditions of the study sites are as below:

Site A: low humid, old alluvial soil.

Site B and C: mostly shallowly steep-sloped soil

(Data from general soil map, Royal Thai Survey Department, 1980).

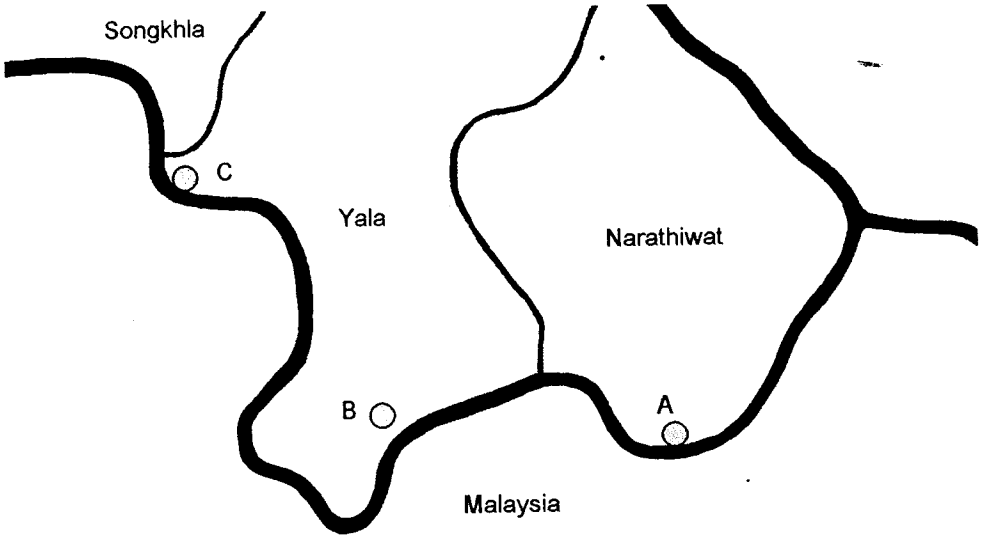


Fig 1. Location of study sites (A, B and C).

Table 1 Climates of study sites (mean of 10 years, 1990-2000).

Study site	Rainfall (mm/year)	Relative Humidity (%)	Temperature (° C)
Waeng, Narathiwat	3485.5	82	27.1
Betong, Yala	1875.0	76	32.8
Sabayoi, Songkhla*	1750.1	78	27.8

Source: Climatology Division, Metriorological Department.

*Closest available metriorological data of site C.

2. Taxonomic Study

Materials

1. Pruning scissors
2. Spade
3. Plastic bags
4. Plastic bottles
5. Liquid preservative (70% Ethyl alcohol)
6. Permanent marker
7. Notebook
8. Pencil
9. Camera, flash and films
10. Absorbent cloths
11. Newspaper
12. Press frames
13. Cord
14. Cardboard supports

Methods

1. Collect plant specimens with all vegetative parts, flower(s) and/or fruit.
2. Preserve flowers in liquid preservative.
3. Take photographs and field notes of color, smell and habitat.
4. Specimen processing as direction in "The Herbarium Handbook" (Bridson and Forman, 1992).

5. Identify, make descriptions and identification keys to species of every genus.
6. Specimens deposit at PSU, QSBG and BKF.

3. Habitat relationships

Materials

1. Soil core
2. Spade
3. Plastic bags
4. Elastics
5. Aluminum foil
6. Notebook
7. Permanent marker
8. Pencil
9. Oven (maximum temperature more than 110° C)
10. Personal Computer with program PC-ORD for Windows version 3.20

Methods

1. Collect soil samples randomly within 1x1 m^2 plot around Zingiberaceous plants at 0-15 cm depth during dry period or at least several days after rain.
2. Separate soil sample in two parts, keep small amount in aluminum foil for moisture measurement, other part keep in plastic bag.

3. Weight soil samples in aluminum foil then dry in oven at 105° C for 24 hours, and leave them until reach room temperature in dessicator then weight again.

Moisture content = ((wet weight –dry weight)/dry weight)*100 (percent)

4. Process other part of soil samples as indicated in "Directions of Soil and Water Collection" by the Agricultural Chemistry Division, Department of Agriculture.
5. Soil properties were analyzed at Agricultural Chemistry Division, Department of Agriculture, including pH, percents of Organic Matter, phosphorus, potassium, electroconductivity, water holding capacity, cation exchange capacity, percent of sand-silt-clay, particle density and porosity.
6. Light was determined in ordinal scale from 1-4; 1-dense shade under closed canopy, 2-fairy shaded under dense canopy, 3-forest gap and 4-open areas.
7. Data was analyzed by Ordination and Cluster Analysis method by PC-ORD for Windows version 3.20.

CHAPTER 3

RESULTS

1. Biodiversity of Zingberaceae

Thirty-nine species in 12 genera of the family Zingiberaceae were collected in the study sites (table 2). The tribe Alpinieae, the largest one, includes 6 genera and 22 species. The tribe Hedychieae, the second large, has 4 genera and 10 species. The tribe Globbeae, only 1 genus with 4 species occur. The last tribe, Zingibereae present only 3 species.

Table 2 List of species found in the study sites

No	Scientific Name	Status*	Study site		
			A	B	C
	Tribe Alpinieae				
1	Alpinia javanica Bl.		/	-	/
2	Alpinia oxymitra K. Schum.		-	-	/
3	Alpinia aff. rafflesiana Bl.	NS	-	/	-
4	Amomum aculeatum Roxb.		-	-	/
5	Amomum biflorum Jack		-	-	/
6	Amomum hastilabium Ridl.		/	-	-
7	Elettariopsis curtisii Bak.		-	-	/
8	Elettariopsis smithae Kam		-	/	/
9	Etlingera elatior (Jack) R.M. Smith		-	/	-
10	Etlingera hemisphaerica (Bl.) R.M. Smith	NR	-	/	/
11	Etlingera littoralis (Koenig) R.M. Smith		/	/	/

Table 2 (continue)

No	Scientific Name	Status*	Study site		
			A	B	C
12	Etlingera maingayi (Bak.) R.M. Smith		/	/	-
13	Etlingera metriocheilos (Griff.) R.M. Smith	NR	/	/	-
14	Etlingera pauciflora (Ridl.) R.M. Smith	NR	/	/	-
15	Etlingera punicea (Roxb.) R.M. Smith		/	/	-
16	Etlingera subterranea (Holtt.) R.M. Smith	NR	/	-	-
17	Etlingera triorgyalis (Bak.) R.M. Smith	NR	/	-	-
18	Etlingera aff. pauciflora (Ridl.) R.M. Smith	NS	-	/	-
19	Hornstedtia conica Ridl.	NR	/	/	-
20	Hornstedtia leonurus (Ridl.) Ridl.	NR	/	-	-
21	Hornstedtia ophiucus (Koenig) Retz.	NR	-	/	-
22	Plagiostachys aff. albiflora Ridl.	NS & NGR	/	/	-
	Tribe Globbeae				
23	Globba cernua Bak.		-	/	-
24	Globba patens Miq.		/	/	/
25	Globba pendula Roxb.		/	/	/
26	Globba aff. curtisii Kam	NS	/	-	-
	Tribe Hedychieae				
27	Boesenbergia curtisii (Bak.) Schltr.		-	-	/
28	Boesenbergia plicata (Ridl.) Holtt.		-	/	-
29	Boesenbergia prainiana (Bak.) Schltr.		/	-	-
30	Boesenbergia pulcherrima (Wall.) Ktze.		-	-	/
31	Boesenbergia (L.) Mansf. (sp.1)	NS	-	/	/
32	Boesenbergia (L.) Mansf. (sp.2)	NS	/	-	-
33	Camptandra parvula Ridl.	NGR	/	-	-
34	Haniffia albiflora K. Larsen & J. Mood		/	-	-
35	Scaphoclamys biloba Ridl.		/	-	-

Table 2 (continue)

No	Scientific Name	Status*	Study site		
			A	B	C
36	Scaphoclamys perakensis Holtt.	NR	/	-	-
	Tribe Zingibereae				
37	Zingiber spectabile Griff.		/	/	/
38	Zingiber aff. flagelliforme J. Mood & I. Theilade	NS	-	-	/
39	Zingiber aff. puberulum var. ovoidium Holtt.	NS	/	-	-

* NGR – New generic record; NR – New record; NS – Expected new species

Description of 39 species and key to genera and species are provided.

Key to tribes and genera of Zingiberaceae

1. Style exserted well beyond the anther tip, the elongate anther tip wrapped round the style (Zingibereae) **12. Zingiber**

1'. Style not exserted beyond the anther; crest, if present, never wrapped around the style **2**

2. Filament usually long-exserted from the flower, arched as a bow, the style forming the string of the bow; ovary unilocular with parietal placentation (Globbeae) **7. Globba**

2'. Filament usually short; if long, then ovary always trilocular **3**

3. Lateral staminodes petaloid, usually free from labellum; plane of distichy of leaves parallel to rhizome (Hedychieae) **4**

3'. Lateral staminodes absent or represented by small teeth; plane of distichy transverse to rhizome (Alpinieae) **7**

4. Inflorescence lateral on separated leafless stem; leafy stem 60 cm tall or more **10. Haniffia**

4'. Inflorescence terminal on leafy stem; leafy stem upto 10 cm tall **5**

5. Bract one per inflorescence; stem elongate, 10 cm tall 9. Camptandra

5'. Bracts more than one per inflorescence; leafy stem very short 6

6. Inflorescence exposed from leaf-sheaths; bracts spirally arranged 11. Scaphoclamys

6'. Inflorescence enclosed in leaf-sheaths, if exposed, then bracts distichous 8. Boesenbergia

7. Inflorescence terminal or break through leaf-sheath 8

7'. Inflorescence laterally on leafless stem 9

8. Inflorescence terminal on leafy stem 1. Alpinia

8'. Inflorescence break through leaf-sheath 6. Plagiostachys

9. Inflorescence a compact head, surrounded by involucral bracts usually larger than flower bracts 10

9'. Inflorescence not a compact head, without involucral bracts 11

10. Inflorescence cone-shaped; involucral bracts rigid, firmly covered flowers; flowers open 1 or 2 at a time 5. Hornstedtia

10'. Inflorescence not cone-shaped; involucral bracts not rigid; at least 3 flowers open simultaneously 4. Etlingera

11. Inflorescence directly from base of leafy stem 3. Elettariopsis

11'. Inflorescence directly from rhizome 2. Amomum

TRIBE ALPINIEAE

I Alpinia Roxb.

Three species were found in this study, of which 1 is expected new species.

Key to the species

1. Flowers in raceme, ebracteolate, greenish white **2. A. oxymitra**

1'. Flowers in cincinnus, bracteoles campanulate or funnel-shaped 2

2. Inflorescence drooping, short hairy; bracteoles campanulate; labellum yellow with white edge **1. A. javanica**

2'. Inflorescence upright, long hairy; bracteoles funnel-shaped; labellum orange with white edge **3. A. aff. rafflesiana**

1. *Alpinia javanica* Bl. (fig. 4)

Leafy stem 3 m tall. **Leaves** petiolate, petiole 5-20 cm long, short hairy; blades narrowly ovate-lanceolate to narrowly ovate, 40-80 x 9-14 cm, upper surface short hairy, lower surface glabrous, base unequally cuneate, apex acuminate, ciliate; ligule 2-lobed, 2.5 cm long, hairy, ciliate; sheaths purplish, hairy near ligule. **Inflorescence** terminal, drooping; sterile bracts concave, 10 x 3 cm, short hairy, apex caudate; lower bracts concave, 5-8 x 3-5 cm, short hairy, apex rounded; upper bracts ca. 3 x 3 mm; bracteoles campanulate, 1.5x1.5 cm, pale pink and turn brown, hairy at base. **Flowers** in cincinnus; stalk of cincinnus 2-5 cm long, glabrous; pedicel 5 mm long, hairy. **Calyx** funnel form, 1.5 cm long, pink, hairy at base. **Corolla** tube yellow, 1.5 cm long, short hairy; lobes pink with white tip, basal part yellow, glabrous; dorsal lobe hooded, 2.5 x 1.3 cm, apex thick; lateral lobes concave, 1.5 x 1.1 cm, apex rounded. **Staminodes** 2 mm long, apex 2-lobed, sometime with elongate tip, inner surface glandular hairy, red with darker tip. **Labellum** concave, apex 3-

lobed, 3.5 x 4 cm, glabrous, bright yellow with red stripes from base towards mid-lobe, edge white, wrinkled. **Stamen**: filament flat, cream, 1.3 x 0.4 cm, glandular hairy; anther yellow, 1.1 x 0.7 cm, glandular hairy at base; connective yellow, glandular hairy. **Ovary** yellowish green, 5 mm long, hairy; stylodes cylindrical, 3 mm long, glabrous; style white, hairy; stigma cup-shaped, white, ciliate.

2. *Alpinia oxymitra* **K. Schum.** (fig. 5)

Leafy stem 1.5 m tall, tufted. **Leaves** sessile; blades linear, upto 50x2.5 cm, glabrous on both surfaces, base cuneate, apex long acuminate; ligule obliquely triangular, 5-7 mm long, glabrous, apex rounded, ciliate; sheaths glabrous. **Inflorescence** terminal, upright; peduncle short; rachis up to 18 cm long, sparsely hairy; ebracteate; bractoles caducous, hooded, 1.5x1 cm, densely white hairy, apex long acuminate. **Flowers** in raceme, greenish white. **Calyx** 1.2 cm long, apex 3-toothed, split down one side 5 mm, white hairy, ciliate at apex. **Corolla** tube 1.5 cm long, hairy; lobes elliptic-oblong to ovate oblong, 1.5x0.6 cm, white hairy, ciliate at apex; dorsal lobe rounded, cuculate; lateral lobes rounded apex. **Staminodes** fan-shaped, 3.5x6 mm, greenish with red spot at base. **Labellum** 3-lobed, 2x2 cm, greenish white with red spot on either side of base. **Stamen**: filament flat, 1x0.2 cm; anther 5x2 mm, crest 3-lobed, 4 mm long; connective hairy. **Ovary** hairy, 3 mm long; stylodes cylindrical, connate, 1.5 mm long, apex bilobed; stigma cup-shaped, 1 mm wide, ciliate. **Fruit** cylindrical, with longitudinal ridges, green turn to yellow when mature; seeds black with white arils.

3. *Alpinia* aff. *rafflesiana* Wall. (fig.6)

Leafy stem 1.5 m tall, tufted. **Leaves** petiolate, petiole 1-1.5 cm long, hairy; blades obovate, 30-50 x 4-10 cm, pubescent on both surfaces, base cuneate, apex caudate; ligule deeply bilobed, 7 mm long, thick, rigid, shiny, turn black when dry, ciliate; sheaths hairy. **Inflorescence** terminal, upright, compact, 8 cm long; peduncle, bracts, bracteoles, calyx, corolla and ovary densely silky hairy; bracts brown with white apex. **Flowers** dense, in cincinnus of two. **Calyx** 1 cm long, apex 3-lobed. **Corolla** tube 2 cm long; lobes oblong, 1.4-1.7 x 0.7-1 cm, white with brown hair,. apex hooded. **Staminodes** triangular, 2 mm long, orange-red with pale orange longitudinal lines. **Labellum** 3-lobed, 2.5x2 cm, orange-red with pale orange longitudinal lines, margin white; mid-lobe 1x1 cm, side lobes 3x7 mm. **Stamen**: filament 1x0.2 cm, yellow with orange-red base; anther 5x4 mm; connective glandular hairy. **Ovary** 2 mm long; stylodes 2 mm long, cylindrical; stigma cup-shaped, pale yellow. **Fruit** rounded, 1.5 cm in diameter, pubescent.

This species is similar to *A. rafflesiana* Wall., but differs by corolla white instead of orange; labellum orange with paler longitudinal bands in the middle, edge white, auricle absent.

II Amomum Roxb.

Three species were found in this study.

Key to the species

1. Leafy stem upto 60 cm tall, bearing 4-5 leaves; inflorescence directly from rhizome 50 cm apart from leafy stem **5. A. biflorum**

1'. Leafy stem 2 m or more; leaves many; inflorescence from rhizome near base of leafy stem 2

2. Peduncle up right, 15 cm or more — **4. A. aculeatum**

2'. Peduncle prostrate, not longer than 10 cm — **6. A. hastilabium**

4. *Amomum aculeatum* Roxb. (fig.7)

Leafy stem 2.5 m tall. **Leaves** sessile; blades narrowly ovate-lanceolate, 45x6.5 cm, both surfaces glabrous, base broad cuneate, apex acuminate; ligule 1-1.3 cm long, short hairy near apex, apex truncate or shallowly 2-lobed; sheaths glabrous. **Inflorescence** radical, directly from rhizome near leafy shoot; scape slightly curved, pointed, 25 cm long; sheaths broadly elliptic to ovate-lanceolate, 1.5-6 x 1.5-3 cm, short hairy, apex acute. **Flowers** crown at top; pedicel 3 mm long, hairy. **Calyx** 2 cm long, apex 3-lobed, split down one side 5 mm long, hairy. **Corolla** tube 1.5 cm long, sparsely hairy; dorsal lobe concave, 2x2.5 cm, glabrous; lateral lobes oblong, 2.5 x 1 cm, glabrous, apex rounded. **Staminodes** reduced, 3x1 mm, apex acuminate. **Labellum** 3x4 cm, 3-lobed, glabrous. **Stamen**: filament 1.5x0.2 cm, short hairy; anther 1.2x0.4 mm, hairy; connective hairy; crest 3-lobed, mid-lobe short, apex truncate; side-lobes 5x2 mm, apex rounded. **Ovary** 3 mm long, hairy. **Fruits** ovoid, 2.5-1.5 cm, spiny; stalks 3 cm long.

5. *Amomum biflorum* Jack (fig.8)

Leafy stem 60-75 cm tall, well spaced. **Leaves**: petiolate, petioles 1.5 cm long, glabrous; blades obovate, 24-31 x 4.5-7.5 cm, lower surface pubescent, base cuneate, apex caudate, cauda 1.5-2.5 cm long; ligule 2-lobed, 1.5 mm long, apex round, ciliate; sheaths short hairy, ciliate. **Inflorescence** radical, directly from rhizome, far from leafy stem; scape 1 cm long, bearing 2-3 flowers; bracts oblong, 1.5x0.9 cm, apex mucronate, outer

surface short hairy; bracteoles tubular, 1.2 cm long, split down one side, outer surface short hairy. **Calyx** 3 cm long, apex 2-lobed, outer surface hairy, pink. **Corolla** tube white, as long as calyx, hairy; dorsal lobe 2x0.7 cm, apex hooded; lateral lobes 1.7x0.6 cm, apex hooded. **Labellum** clawed, 2.5x2.2 cm, white with yellow median band and red lines on either side, edge reflexed. **Stamen**: filament flat, 6x3 mm; anther thick; crest 3-lobed; mid-lobe broad, truncate; side lobes narrower, truncate. **Ovary** 2 mm long, hairy; stigma flat, hairy at edge.

6. *Amomum hastilabium* **Ridl.** (fig.9)

Leafy stem 2 m tall, tufted. **Leaves**: sessile; blades lanceolate, 45-50 x 8-10 cm, lower surface sparsely hairy on vein, base cuneate, apex acuminate, ciliate; ligule 3-4 mm long, glabrous, apex truncate or shallowly 2-lobed; sheaths glabrous. **Inflorescence** lateral, directly from rhizome near leafy shoot; scape prostrate, 4-5 cm long; sheaths triangular to ovate, 1-4 x 1-2 cm, appressed hairy, apex acute to mucronate; bracts ovate, 3x1.5 cm, appressed hairy, apex acuminate; bracteoles tubular, 1.5 cm long, base densely hairy, apex unequally 3-lobed. **Flowers** pedicelate, pedicel 1 mm long, densely hairy. **Calyx** 2 cm long, densely hairy at base. **Corolla** tube 1.5 cm long, hairy; dorsal lobe concave, 1.8x0.8 cm, hairy, apex hooded; lateral lobes oblong, 1.5x0.4 cm, hairy, apex rounded. **Staminodes** reduced, narrowly triangular, 2 mm long, apex acuminate. **Labellum** 2.5x2 cm, apex reflexed, edge wrinkled. **Stamen**: filament 3x2 mm, flat, glabrous; anther 7x3 mm; crest very small, 2-lobed. **Ovary** 3 mm long, hairy.

III Elettariopsis Baker

Two species were found in this study.

Key to the species

1. Leaf-sheath loosely clasped, not forming pseudostem; leaves large, 50-75 x 9--10 cm 7. E. curtisii

1'. Leaf-sheath firmly clasped, to form stem, 30 cm tall or more; leaves small, 10-30 x 4.5-6 cm 8. E. smithae

7. *Etariopsis curtisii* Bak. (fig.10)

Leafy stem short. **Leaves** 2; petiolate, petiole 10 –15 cm long, glabrous; blades obovate-lanceolate, 50-75 x 9-10 cm, both surfaces glabrous, base attenuate, apex acuminate; ligule 2-lobed, 2 mm long, glabrous; sheaths glabrous. **Inflorescence** lateral, from base of leafy stem; scape 7 cm long, glabrous; sheaths ovate, 2x1 cm, apex acute, bracts ovate, 1.3x0.7 cm, glabrous, apex acute; bracteoles rounded, 1x1 cm, glabrous, apex acute. **Calyx** tube 3 cm long, glabrous; calyx lobes oblong, 1x0.3 cm, glabrous, apex acuminate. **Corolla** tube 6 cm long, glabrous; dorsal lobe narrowly elliptic, 2x0.8 cm, glabrous, apex cuculate; lateral lobes oblong, 2x0.6 cm, glabrous, apex hooded. **Staminodes** reduced to small glands. Labellum clawed, claw 15 x 5-7 mm, blade semiorbicular, 1.5x2.5 cm, apex rounded, edge wrinkled, white with red lines on each side of yellow median band. **Stamen**: filament 3x3 mm, upper half broader, glabrous; anther 5x4 mm, glabrous; connective glabrous; crest 6 x 7 mm. **Ovary** 3 mm long, short hairy; stylodes 5 mm long, needle-shaped.

8. *Elettariopsis smithae* Kam (fig.11)

Leafy stem 30-55 cm tall. **Leaves** 2-4; petiolate, petiole 0.5 -6 cm long, glabrous; blades oblong to obovate-lanceolate, 10-30 x 4.5-6 cm, glabrous on both surfaces, base cuneate to attunate, apex caudate, finely serrate near apex; ligule 2 mm long, glabrous to hairy, apex 2-lobed; sheaths glabrous to short hairy. **Inflorescence** lateral, from base of leafy stem; scape 2-7 cm long, glabrous, branched; sheaths triangular to elliptic, 0.4-2.0 x 0.8-1.0 cm, glabrous to short hairy, apex acute, entire or ciliate; bracts oblong, 1.5x0.5 cm, glabrous, apex acute; bracteoles ovate, 2x1 cm, glabrous, apex acute. **Calyx** 1.8-3 cm long, short hairy, apex 2-acute lobed, split down one side 0.8-1 cm. **Corolla** tube 5 cm long, sparsely hairy; dorsal lobe elliptic, 2.0x0.9 cm, glabrous, apex hooded; lateral lobes oblong, 1.8x0.6 cm, glabrous, apex slightly hooded. **Labellum** clawed, claw 1x0.8 cm; blade semicircular, 2.0x2.5 cm, glabrous, edge wrinkled, white with yellow median band and red lines on either sides. **Stamen**: filament 5x5 mm, glabrous; anther 6x3 mm, finely hairy; connective glabrous; crest 7x8 mm, apex truncate. **Ovary** 4 mm long, finely hairy.

IV Etlingera Giseke

Ten species were found in this study.

Key to the species.

1. Peduncle erect, upright, 30 cm tall or more 2

1'. Peduncle prostrate, up to 20 cm long 4

2. Peduncle 30 cm tall; involucral bracts 3 cm long **12. E. maingayi**

2'. Peduncle at least 80 cm tall; involucral bracts 6 cm long or more 3

3. Involucral bracts bright red with green base **10. E. hemisphaerica**

3'. Involucral bracts pink or red with white edge **9. E. elatior**

4. Inflorescence bearing 2-3 flowers 5

4'. Inflorescence bearing many flowers 7

5. Labellum 2.5 cm long, dark red with pink edge **18. E. aff. pauciflora**

5'. Labellum 5 cm long, color in different pattern 6

6. Labellum red with yellow patch in center **14. E. pauciflora**

6'. Labellum red with white margin **16. E. subterranea**

7. Involucral bracts 5 cm broad **17. E. triorgyale**

7'. Involucral bracts much narrower 8

8. Leaf-sheaths red; stigma dark red to black **13. E. metriocheilos**

8'. Leaf-sheaths green or yellowish green; stigma red or bright red 9

9. Bracteoles 5 cm long; labellum red or red with yellow or orange margin **11. E. littoralis**

9'. Bracteoles 3 cm long; labellum red with yellow patch in center **15. E. punicea**

9. ***Etlingera elatior*** **(Jack) R. M. Smith** (fig.12)

Leafy stem 3-4 m tall, tufted. **Leaves** petiolate, petiole 1-3 cm long, short hairy; blades obovate-lanceolate, 45-70 x 10-15 cm, lower surface pubescent, upper surface glabrous, base broadly cuneate, apex acute; ligule 1-2 mm long, short hairy, apex rounded; sheaths short hairy. **Inflorescence** lateral, from rhizome near base of leafy stem; scape erect, 1-1.2 m tall; sheaths elliptic to narrowly oblong, 10-17 x 4.5 cm, glabrous, wrap around scape, loosely imbricate, apex rounded. **Involucral bracts** 10-13, broadly ovate, 7-9 x 3-4 cm, glabrous, apex mucronate, red with white margins; bracts similar to involucral bract but smaller, gradually smaller inside to 4x0.8 cm;

bracteoles tubular, 2.5 cm long, glabrous, apex 2-lobed, split down one side 1 cm, white. **Calyx** 3.5 cm long, glabrous, apex 3-lobed, split down one side 2 cm, white with red lobes. **Corolla** tube 1 cm long, glabrous, white; lobes narrow oblong, 2.5 x 0.5-0.7 cm, glabrous, apex hooded, white with red apex. **Labellum** 1.5 cm long, apex rounded, red with white margins. **Stamen**: filament 3 mm long, hairy, white; anther 6 mm long, red; connective red. **Ovary** 5 mm long, hairy; stylodes needle-shaped lobes at apex; style hairy; stigma 2 mm wide, red, ciliate.

10. ***Etlingera hemisphaerica*** **(Bl.) R. M. Smith** (fig.13)

Leafy stem 4-5 m tall, tufted. **Leaves** petiolate, petiole 2-2.5 cm long, glabrous; blades narrowly lanceolate, 55-70 x 10-11.5 cm, glabrous, upper surface purplish green with white patches along midrib, lower surface purplish, base obtuse, apex caudate, cauda 1.5 cm long, ciliate; ligule 1.7 cm long, unequally 2-lobed, hairy, edge translucent; sheaths purplish, glabrous. **Inflorescence** lateral, directly from rhizome; peduncle up to 1 m tall, upper half pubescent, lower half glabrous; sheaths lanceolate, 9-11 x 3 cm, well spaced, glabrous. **Involucral bracts** ovate, 6-7 x 2 cm, red, lower half green, glabrous, apex acute; bracts lanceolate, 3.5x0.7 cm, slightly concave, hairy at base and along the median ridge; bracteoles tubular, 3.2 cm long, apex 2-lobed, split down one side 2 cm, base hairy. **Calyx** 4 cm long, red with yellow apex, apex hooded, split down one side 2.3 cm, lower half densely hairy. **Corolla** tube 7 cm long, hairy; lobes hooded, 2.2x5 cm, glabrous. **Labellum** 2.6 cm long, as long as corolla lobes or slightly longer, red with pale edge, apex emarginate. **Stamen**: filament hairy, 3 mm long; connective glabrous; anther 9x2.5 mm,

hairy. **Ovary** 6 mm long, densely hairy; stigma with mucilaginous edge. **Fruits** obovoid, densely hairy, green when young, beak 1-1.5 cm long.

11. ***Etlingera littoralis*** **(Koenig) R. M. Smith** (fig.14)

Leafy stem 2.5-3 m tall. **Leaves** petiolate, petiole 2.5-3 cm long, glabrous or hairy; blades lanceolate, 50-80 x 7-15 cm, upper surface glabrous, lower surface glabrous or hairy, base cuneate, apex acuminate to shortly caudate, ciliate; ligule 1.5-2 cm long, hairy, apex rounded to acute, ciliate; sheaths glabrous or hairy. **Inflorescence** lateral, directly from rhizome; scapes 3-6 cm long, densely silky hairy; sheaths broadly ovate to ovate-oblong, 1.3-3.5 x 1.0-1.2 cm, hairy, especially at base, apex acute. **Involucral bracts** ca. 8, obovate to ovate-oblong, 5.5-6.5 x 2.0-2.5 cm, hairy, apex mucronate; bracts similar to involucral bract but narrower to about 1 cm wide; bracteoles tubular, 5.5 cm long, lower half hairy, apex 2-lobed, split down one side 3 cm. **Calyx** 8 cm long, glabrous, apex 2-lobed, split down one side 2.5 cm. **Corolla** tube 4.5 cm long, glabrous; lobes glabrous, apex rounded; dorsal lobe ovate-lanceolate, 2.5 x 0.5 cm; lateral lobes narrowly lanceolate, 2.0 x 0.3 cm. **Labellum** narrowly lanceolate, 6.0 x 1.2 cm, apex rounded, side lobes indistinct. **Stamen**: filament 4 x 3 mm, glabrous; anther 10 x 5 mm; connective glabrous. **Ovary** 5 mm long, hairy; stylodes 5 mm long, apex acuminate; stigma peltate, hairy, ciliate.

12. ***Etlingera maingayi*** **(Bak.) R. M. Smith** (fig.15)

Leafy stem 2 m tall. **Leaves** sessile; blades obovate-lanceolate, 25-35 x 4-6 cm, glabrous on both surfaces, base cuneate, apex caudate, ciliate; ligule 7 mm long, glabrous, apex rounded, ciliate; sheaths glabrous. **Inflorescence**

lareral, from rhizome near base of leafy shoot; scape erect, 30-65 cm long, 3-5 cm in diameter, hairy; sheaths elliptic, 2.5 x 1.5 cm, densely hairy, well spaced, apex mucronate, ciliated. **Involucral bracts** broadly elliptic, 3 x 2.5 cm, densely brown hairy, apex mucronate, ciliate; bracts obovate-oblong, 3 x 0.8 cm; bracteoles tubular, 2 cm long, apex unequally 3-lobed, hairy, ciliate. **Calyx** 3 cm long, hairy, apex small 3-lobed, split down one side 1.2 cm. **Corolla** tube 1.2 cm long, glabrous; dorsal lobe lanceolate, 1.8 x 0.3 cm, glabrous, apex hooded, ciliate at apex; lateral lobes linear, 1.5 x 0.2 cm, glabrous, apex rounded. **Labellum** 2 x 0.5 cm, glabrous, apex 2-lobed, red. **Stamen**: filament very short, hairy; anther 8 x 3 mm, hairy; connective glabrous. **Ovary** 2-3 mm long, glabrous.

13. *Etlingera metriocheilos* (Griff.) R. M. Smith (fig.16)

Rhizome thick, 3.5 cm diameter; sheaths red. **Leafy stem** 5 m tall, base swollen to 10 cm in diameter. **Leaves** petiolate, petiole 3-4 cm long, glabrous; blades narrowly obovate, 75-115 x 16-23 cm, green, glabrous, base cuneate, apex short caudate; ligule lanceolate, 2.5 cm long, glabrous, apex acute; sheaths red, glabrous. **Inflorescence** lateral, from rhizome near base of leafy stem; peduncle 10-18 cm long; sheaths broadly lanceolate, 2-7 x 2-2.5 cm, glabrous, apex acute. **Involucral bracts** elliptic to lanceolate, 6-9 x 1.5-3.5 cm, slightly concave, dark red, short hairy along margin, apex acute, ciliate; bracts narrowly obovate-lanceolate, 5.5-9.5 x 0.3-1.5 cm, dark red with lighter margin, short hairy along margin, apex rounded, slightly hooded, ciliate, tip with longer hair, inner bracts smaller; bracteoles tubular, 4 cm long, hairy, split down one side 2.5 cm, pale red, apex acute, ciliate. **Calyx** 6 cm long, glabrous, split down one side 2.5 cm, apex 2-lobed, dark red, gradually lighter

towards base. **Corolla** tube 3 cm long, white with pale red; lobes narrowly ovate to elliptic, 2.5 x 0.5-0.6 cm long, red, hairy, apex rounded, ciliate. **Labellum** clawed, claw red with dark red patch in the middle and white edge, blade 2 cm wide, reddish pink, apex rounded. **Stamen** pale red, glabrous: filament 5x3 mm; anther white, 11x4 mm. **Ovary** hairy; stigma dark red, 5 mm wide. Infructescence on ground; sheaths, involucral bracts and bracts persistent; fruits brown, obovoid, hairy, often ridged longitudinally towards the base.

14. ***Etlingera pauciflora*** **(Ridl.) R. M. Smith** (fig.17)

Rhizome slender, 6 mm in diameter. Leafy stem 3 m tall. **Leaves** sessile; blades narrowly lanceolate, 50-55 x 8.5-9.5 cm, glabrous on both surfaces, base cuneate, apex caudate; ligule triangular, 1.3-1.7 cm long, glabrous, apex rounded, sometime with ciliate apex; sheaths glabrous, ciliate. **Inflorescence** lateral, directly from rhizome, lower part often embeded in soil, bearing 1-3 flowers, open simultaneously; peduncle 3-4 cm long, hairy on upper part; sheaths narrowly ovate, 1.5-6 x 0.7-1 cm, apex acute, upper sheaths hairy at base. **Involucral bracts** narrowly ovate, 4-6 x 1.2 cm, hairy at base and apex, apex acute; bracts similar to involucral bract; bracteoles tubular, 2.5-4.5 cm long, hairy, apex 2-lobed, split down one side 2.5 cm. **Calyx** 7 cm long, hairy, apex 3-acute lobed, split down one side 2.5 cm. **Corolla** tube 5 cm long, glabrous; lobes red, 3.5 cm long, glabrous; dorsal lobe elliptic-oblong, 1.2 cm wide, apex acute; lateral lobes narrowly obovate, 7 mm wide, apex rounded. **Labellum** clawed, 5x1 cm, claw orange-yellow with red margin, blade orange-red, apex rounded. **Stamen**: filament glabrous, 3 mm long, broadest near base ca. 5 mm; anther 1x0.5 cm, hairy along slit.

Ovary 3 mm long, hairy on upper part; stylodes 5 mm long, tip hairy; stigma white, 4 mm wide, ciliate.

15. ***Etlingera punicea*** **(Roxb.) R. M. Smith** (fig.18)

Leafy stem 2.5-3 m tall. **Leaves** petiolate, petiole short; blades lanceolate, 75-100 x 12-16 cm, upper surface glabrous, lower surface sparsely hairy on veins, base broadly cuneate, ciliate, apex acute to acuminate; ligule 8-10 mm long, unequally shallowly 2-lobed, densely hairy, ciliate; sheaths sparsely hairy, ciliate near ligule. **Inflorescence** lateral, from rhizome near leafy shoot; scape prostrate, 3-5 cm long, densely silky hairy; sheaths distichous, ovate, 1-4 x 0.7-1.5 cm, densely silky hairy at base. **Involucral bracts** 10, broadly ovate, 5.5 x 2.3 cm, hairy at base, apex cuculate; bracts narrowly obovate-lanceolate, 3-5 x 0.5-1 cm, hairy, apex truncate to mucronate; bracteoles tubular, 3 cm long, apex 3-lobed, split down one side 1.5 cm, hairy, ciliate at apex. **Calyx** 5 cm long, sparsely hairy, apex 3-lobed, split down one side 1,5 cm, ciliate at apex. **Corolla** tube 4-5 cm long, glabrous; dorsal lobe concave, 2.5 x 1 cm, glabrous, apex hooded; lateral lobes narrowly oblong, 2x0.5 cm, glabrous, apex rounded. **Labellum** clawed, claw 1 cm long; blade elliptic, 2.5x1.2 cm, apex 2-lobed, red with bright yellow median band. **Stamen**: filament 5x2 mm, glabrous; anther 7x4 mm, hairy. **Ovary** 4 mm long, hairy; stylodes 5 mm long; style hairy; stigma hairy, ciliate.

16. ***Etlingera subterranea*** **(Holtt.) R. M. Smith** (fig.19)

Leafy stem 2 m tall. **Leaves** petiolate, petiole 6-8 mm long, glabrous; blades obovate-lanceolate, 35-50 x 8-9.5 cm, glabrous on both surfaces, green with purplish patches on either side of midvein, base obtuse, apex

acuminate; ligule triangular, 6-7 x 6 mm, apex rounded, glabrous; sheaths glabrous. **Inflorescence** lateral, directly from rhizome, ca. 30 cm apart from leafy shoot, bearing 8 flowers; scape erect, 7-12 cm long, sparsely hairy; sheaths narrowly ovate, 2-4 x 1 cm, sparsely hairy, apex acute. **Involucral bracts** 2, ovate-oblong, 4x1.4 cm, rigid, hairy particularly near margin, apex acute, ciliate; bracts similar to involucral bract, the inner bracts narrower, with denser and longer hairs; bracteoles tubular, 3 cm long, hairy, apex 2-lobed, split down one side 1.5 cm. **Calyx** 6 cm long, hairy, apex 2-3 lobed, split down one side 1 cm. **Corolla** tube 4.5 cm long, glabrous; lobes oblong, 2.2 cm long, red, hairy and ciliate at apex; dorsal lobe 5 mm wide, apex acuminate; lateral lobes 3 mm wide, apex rounded. **Labellum** clawed, claw 6 cm long, dark red with white edge, blade obovate, 1.5 cm wide, red, apex 2-lobed. **Stamen**: filament 3x3 mm, hairy; anther 1x0. 4 cm wide, hairy. **Ovary** 5 mm long, hairy; stylodes connate, streaked one side to base, apex lobed; stigma black, 2.5 mm wide, ciliate.

17. *Etlingera triogyale* (Bak.) R. M. Smith (fig.20)

Leafy stem 3-4 m tall. **Leaves** petiolate, petiole 3-4 cm long, short hairy; blades obovate, 78x 17 cm, lower surface pubescent, base obliquely cuneate, apex acute; ligule 1.5-2 cm long, 2 cm wide at base, short hairy, apex rounded; sheaths glabrous. **Inflorescence** lateral, directly from rhizome near base of leafy stem; peduncle 7-12 cm long, densely hairy; sheaths ovate, 2-4 x 1 cm, short hairy at base, apex acute. **Involucral bracts** obovate, 7-9 x 3.5-3 cm, red, base hairy, apex mucronate, the inner one longer and narrower; bracts narrowly obovate, 7x1 cm, hairy, apex acute; bracteoles tubular, 6 cm long, hairy, apex 2-lobed, split down one side 2 cm. **Calyx** 8 cm long, hairy,

apex unequally 3-spiny lobed, split down one side 4 cm. **Corolla** tube 5 cm long, hairy; lobes narrowly oblong, red, glabrous; dorsal lobe 3x0.6 mm, apex rounded; lateral lobes 2.5x0.4 mm, apex acute. **Labellum** clawed, claw 6 cm long, blade obovate, 1.7 cm wide, red with white edge, apex rounded. **Stamen**: filament very short; anther 1x0.5 cm. **Ovary** 6 mm long, densely hairy; stylodes slightly unequal, 8-9 mm long, 2 mm wide, apex acute; stigma red, 4 mm wide.

18. *Etlingera* aff. *pauciflora* (Ridl.) R.M. Smith (fig.21)

Leafy stem 1.5 – 2 m tall. **Leaves** petiolate, petiole short, glabrous; blades obovate-lanceolate, 55-65 x 10-12 cm, glabrous on both surfaces, base cuneate, apex acuminate; ligule 2-lobed, 4-6 mm long, glabrous; sheaths hairy. **Inflorescence** lateral, from rhizome near base of leafy shoot; scape 1.5–2 cm long, hairy; sheaths hairy at base; bracts obovate-oblong, 4x1.2 cm, finely hairy outside, apex 3-lobed, mid-lobe mucronate, lateral lobes rounded; bracteoles tubular, 3.5 cm long, finely hairy, apex acuminate, split down one side 2.5 cm. Flowers few, open 1 or 2 simultaneously. **Calyx** 5 cm long, split down one side 2.5 cm, apex elongate 3-lobed, recurved, 8 – 10 mm long. **Corolla** tube 3.5 cm long, finely hairy; lobes finely hairy, apex small mucronate; dorsal lobe obovate, 2x1 cm; lateral lobes oblong, 2.0x0.5 cm. **Labellum** suborbicular, 2.5x1.5 cm, apex long and narrow, 2-lobed, lobes 7 mm long, pink with dark red in the middle. **Stamen**: filament 3 mm long, flat, edge with 2 small teeth on each side; anther 7 x 3 mm, hairy; connective glabrous; crest small with triangular lobe on each end of connective. **Ovary** 3 mm long, hairy; stylodes 3 mm long, connate, with 2 streaked, apex

acuminate, the middle part 2 mm long, apex truncate. **Fruits** obconical, 2 cm long, 1.5 cm diameter, red, hairy.

This species is similar to *E. pauciflora* in few flowered inflorescence, but differs by the following characters: leaves glabrous; ligule shorter, glabrous; inflorescence on ground; bracts and bracteoles shorter; calyx lobes elongate; labellum recurved dark red with pink edge, apex broadly bifid.

V Hornstedtia Retz.

Three species were found in this study.

Key to the species.

1. Labellum much longer than stamen, edge wrinkled **19. H. conica**

1'. Labellum as long as stamen, edge entire or recurved **2**

2. Most part of inflorescence underground; involucral bracts upto 2 cm broad **20. H. leonurus**

2'. Whole inflorescence above ground; involucral bracts at least 3 cm broad **21. H. ophiucus**

19. ***Hornstedtia conica*** **Ridl.** (fig.22)

Rhizome slender, often above ground. Leafy stem 3 m tall, base swollen. **Leaves** petiolate, petiole 2 cm long, glabrous; blades lanceolate, 50x9 cm, glabrous on both surfaces, base truncate, apex caudate; ligule lanceolate, ribbed, glabrous, apex acute; sheaths finely ribbed with cross bars. **Inflorescence** lateral, fusiform, 7.5 cm long, ca. 20 cm apart from leafy stem; peduncle 3.5 cm long. **Involucral bracts** ovate, 2.5-8 x 3-3.5 cm, finely ribbed, appressed short hairy, apex acute; bracts ovate-lanceolate, narrowly tapering to apex, 9.5x2 cm, glabrous; bracteoles narrowly lanceolate, narrowly

tapering to apex, 4x0.6 cm, glabrous. **Calyx** 5-6 cm long, hairy, apex unequally 2-lobed, split down one side 2.5 cm. **Corolla** tube 5.5 cm long, glabrous; lobes slightly unequal, 2x0.6 cm, glabrous; dorsal lobe hooded. **Labellum** obovate-oblong, 3x0.5-0.7 cm, with 2 thicken middle band, apex rounded, edge wrinkled. **Stamen** 1.5x0.4 cm; anther hairy. **Ovary** 7-10 mm long, hairy. **Infructescence** same length as inflorescence but slightly broader; young fruit white.

20. *Hornstedtia leonurus* (Ridl.) Ridl. (fig.23)

Rhizome underground; leafy stem 3-4 m tall, tufted. **Leaves** petiolate, petiloe 1.5 cm long, glabrous; blades oblong, 62x15.5 cm, glabrous, with yellow patch in the middle along mid-vein, base unequally cordate, apex acuminate; ligule 7 mm long, apex rounded; sheaths shallowly ribbed, glabrous, dark brown. **Inflorescence** 9x1.5 cm, most length embeded in soil; largest involucral bract 7.5x1.8 cm, fine ribbed, short white hairy, apex acute; bracts ovate-lanceolate, narrowly tapering to apex, 7x1 cm, hairy outside; bracteoles tubular, hairy; outer one 7 cm long, apex deeply 2-lobed; inner one 5 cm long, apex acute. **Calyx** 7 cm long, silky hairy, denser on the veins, apex acute, split down one side 2 cm. **Corolla** tube 6 cm long, glabrous; lobes 3.5 cm long, hooded; dorsal lobe narrowly ovate, 1.5 cm wide; lateral lobes lanceolate, 6 mm wide. **Labellum** 3 cm long, dark red; mid-lobe narrowly triangular, 1x0.8 cm, apex rounded. **Stamen**: filament 1.7 cm long, glabrous; anther 1.3 cm long, hairy along suture. **Ovary** 5 mm long, densely hairy.

21. *Hornstedtia ophiucus* (Koenig) Retz. (fig.24)

Rhizome woody, c. 2-3 cm across, shallowly underground. Leafy stem 3 m tall. **Leaves** petiolate, petiole c. 1 cm long or shorter; blades narrowly lanceolate, 60x10 cm, chartaceous, lower surface appressed hairy, base cuneate, apex acuminate; ligule broad triangular, 1x1.2 cm, outside pubescence, apex acute; sheaths with prominent veins and white fleckles at beak. **Inflorescence** lateral, near base of leafy stem, conical, 12.5 cm long including short peduncle. **Involucral bracts** lanceolate, 5-9 x 3-3.5 cm, greenish with reddish margins, densely white stiff hairy, apex acute with short spine. **Calyx** 6.5 cm long, hairy at base, apex acute, open one side 2.5 cm. **Corolla** tube red, 8 cm long, glabrous; dorsal lobe 1.5x0.8 cm, glabrous, apex hooded; lateral lobes 1.8x0.4 cm, glabrous, apex acute, recurved. **Labellum** ovate, 1.8x0.8 cm, red with white edge at base, apex rounded, recurved. **Stamen** 1.2 cm long, densely glandular hairy, filament short. **Ovary** 7 mm long, hairy.

VI Plagiostachys Ridl.

Only one species was found in this study.

22. *Plagiostachys* **aff.** *albiflora* **Ridl.** (fig.25)

Rhizome thick, 2.5-3 cm in diameter, white. Leafy stem 1.2 m tall, tufted. **Leaves** petiolate, petiole 1-4 cm long, short hairy; blades narrowly elliptic to obovate, 5-9 x 65 cm, upper leaves narrower, green, purplish when young, short hairy on both surfaces, especially on midrib, denser on lower surface and on upper half of upper surface, base cuneate, apex caudate, cauda 1.5-3.5 cm long; ligules 1.5 cm long, 2- acute lobed, outer surface

densely short hairy; sheaths densely short hairy, especially on edges. **Inflorescence** 5-8 cm long, protruding from leaf-sheaths at about 9-12 cm above ground; peduncle 1.5-2 cm long, hairy; sheath few, narrowly ovate, 1-1.5 x 3-4 cm, outer surface with densely short hairs and on upper half of inner surface. **Flowers** dense; pedicel 2 mm long, hairy; ebracteate; bracteoles tubular, 1.2 cm long, densely short hairy, apex hooded, with fleshy cuculated tip, split down one side 8 mm, creamy white. **Calyx** 1 cm long, white, glabrous, apex 3-red lobed, thick, fleshy, decayed before anthesis. **Corolla** tube white, 7 mm long, glabrous; lobes red, shallowly boat-shaped, dorsal lobe elliptic, 4.5x9 mm, with translucent edges, apex hooded; lateral lobes oblong, 4x6 mm, apex rounded, ciliate. **Staminodes** triangular, 2 mm long, white with red spots at base, base swollen, apex acute. **Labellum** obovate, 8x8 mm, white with yellow median band and red lines on either sides with small right angle lateral red lines, base with a red spot on each side, apex divided, acuminate. **Stamen**: filament 2x1 mm, flat, scattered glandular hairy; anther 4x2 mm; connective scattered glandular hairy; crest 0.5 mm long, 2-lobed. **Ovary** 2 mm long, glabrous; stylodes connate, 3-lobed, ca. 1 mm long, 1 mm wide; base of style swollen, adnate to corolla tube above the stylodes. **Fruits** rounded 1.5 cm wide, green when young.

This species is similar to *P. albiflora* Ridl., but differs by the following characters: leaves smaller, hairy; petiole and ligule hairy; calyx shorter; stamen glandular hairy.

TRIBE GLOBBEAE

VII Globba L.

Four species were found in this study.

Key to the species

1. Anther appendages 2	25. G. pendula
1'. Anther appendages 4	2
2. Inflorescence drooping	23. G. cernua
2'. Inflorescence up right or curved but not drooping	3
3. Flowers orange; bracts orange to dull yellow	24. G. patens
3'. Flowers yellow; bracts green	26. G. aff. curtisii

23. ***Globba cernua*** **Bak.** (fig.26)

Leafy stem 35-80 cm tall. **Leaves** sessile; blades oblong to lanceolate, 12-18 x 3-7 cm, scattered hairy on lower surface, denser on vein, upper surface hairy at tip, base cuneate, apex caudate; ligule membranous, 1 mm long, hairy, apex truncate, ciliate; sheaths short hairy. **Inflorescence** terminal, short hairy; peduncle 8-20 cm long; rachis 4.5-5.5 cm long; stalks of cincinnus glabrous, up to 15 mm long; basal bracts linear, 1.8x0.2 cm, gradually smaller towards apex, green, short hairy, apex acute; bracteoles concave, 4x3 mm, glabrous, apex hooded. **Calyx** 5 mm long, short hairy, apex 3-lobed, pale yellow. **Corolla** tube pale yellow, 1 cm longer than calyx, short hairy; dorsal lobe hooded, 7x4 mm, short hairy; lateral lobes concave, 5x3 mm, short hairy. **Staminodes** linear, 12x2.5 mm, pale yellow, glandular hairy, apex acute. **Labellum** 10 mm long, scattered glandular hairy , deeply 2-lobed, curved backwards, with olive color spot at the middle. **Stamen**: filament 2 cm long; anther 2.5x1.5 mm, appendages two on each side, 2 mm long, with small

tooth between them; crest very small, apex rounded. **Ovary** glabrous; stigma cup-shaped, ciliate.

24. ***Globba patens*** **Miq.** (fig.27)

Leafy stem 60 cm tall. **Leaves** 4-5, sessile; blades elliptic, 10-20 x 4-8 cm, glabrous above, densely hairy below, sometime purplish beneath, base cuneate, apex acuminate; ligule 2-lobed, 3 mm long, densely hairy; sheaths hairy. **Inflorescence** terminal, densely hairy; scape 15-20 cm long; flowers crown at top; rachis 1-2 cm long; sterile bracts many, ovate to oblong, 2-8 mm long, orange to yellow, hairy; bracts ovate, 3x2 mm, apex acute, densely hairy outside, bearing cincinnus of 4 flowers; bracteoles similar to bract but slightly smaller. **Calyx** 4 mm long, apex 2-acuminate lobed, hairy. **Corolla** tube 1.5 cm long, glabrous; lobes concave, 5x3 mm, glabrous. **Staminodes** obovate-lanceolate, 5x1.5 mm, glabrous. **Labellum** 7x6 mm, with red spot at the middle, apex 2-acute lobed. **Stamen**: filament 1.5 cm long; anther with 2 appendages on each side. **Ovary** 1 mm long, hairy.

25. ***Globba pendula*** **Roxb.** (fig.28)

Leafy stem upto 35 cm tall. **Leaves** 4-6, sessile; blades narrowly ovate or eliptic, apex caudate, base cuneate, midvein stiff hairy, lower surface pale green with densely white hairs; ligule bilobed, apex rounded, ciliate; sheaths glabrous. **Inflorescence** terminal, pointed, lax; peduncle 4.5 cm long; rachis 10 cm long. **Flowers** yellow, in cincinnus. **Calyx** 6 mm long (include ovary), apex 3-lobed, apex of upper two lobes hooded. **Corolla** tube 1.5 cm long; lobes slightly equal, 5 mm long, dorsal lobe hooded, sparsely hairy. **Staminodes** 8x3 mm, narrowly elliptic. **Labellum** 11 mm long, 2-lobe, upper part stiff hairy.

Stamen: filament 13 mm long; anther 2 mm long, appendages 2, basal, 3 mm long. **Ovary** glabrous.

26. *Globba* aff. *curtisii* Holtt. (fig.29)

Leafy stem 30-50 cm tall. **Leaves** sessile; blades oblong, 9-14 x 3.5-4.5 cm, upper surface short hairy on vein, lower surface short hairy, base cuneate, apex acuminate; ligule 2-lobed, 1 mm long, short hairy, apex acute, ciliate; sheaths short hairy, ciliate on upper half. **Inflorescence** terminal, 12 cm long short hairy; peduncle of cincinnus upto 10 mm long, short hairy, green; bracts broad elliptic, 7x4 mm, green, short hairy, apex acute; bracteoles obovate, 2x1 mm, green, short hairy, apex acute. **Flowers** yellow; pedicel very short. **Calyx** 5 mm long, apex 3-lobed, glabrous. **Corolla** tube 1 cm longer than calyx, short hairy; lobes concave, 4-5 x 3 mm, short hairy, apex hooded. **Staminodes** linear, 12x2 mm, glabrous, apex acute. **Labellum** 8 mm long, deeply 2-lobed, curve backwards, with red spot at cleft. **Stamen**: filament 2 cm long; anther 2x1.5 mm; appendages two pairs, 3 mm long, translucent yellow; crest very small, apex truncate. **Ovary** 2 mm long, glabrous; stigma cup-shaped, ciliate.

This species is similar to *G. curtisii* Holtt., but differs by the following characters: leaves hairy; bracts smaller, green, hairy.

TRIBE HEDYCHIEAE

VIII Boesenbergia Kuntz.

Six species were found in this study.

Key to the species

1. Stem well developed, sometime prostrate on ground, 15 cm long or more
30. B. pulcherrima

1'. Stem poorly developed 2

2. Inflorescence elongate, exposed from leaf-sheath 3

2'. Inflorescence compact, enclosed by leaf-sheath 4

3. Labellum yellow or orange with red dots scattered in the middle
28. B. plicata

3'. Labellum white with red patch in the middle **29. B. prainiana**

4. Anther poricidal opening **27. B. curtisii**

4'. Anther longitudinal opening 5

5. Labellum yellow with two red patches on either side of grove in the middle
31. B. aff. rotunda sp1

5'. Labellum pale yellow with two pink spots at base **32. B. aff. rotunda sp2**

27. *Boesenbergia curtisii* (Bak.) Schltr. (fig.30)

Leafy stem short. **Leaves** 4-5, petiolate; petiole 10-20 cm long, hairy; blades oblong, 25-35 x 7-14 cm, both surfaces hairy, denser on lower surface, base cuneate, apex acuminate; ligule 2-lobed, 0.6-2.0 cm long, hairy; sheath glabrous. **Inflorescence** terminal, compact, enclosed in uppermost leaf-sheath; scape 0.5 cm long, densely silky hairy; outermost bract the largest, narrowly obovate-oblong, 5.0x1.5 cm, hairy, apex acute; other bracts narrowly obovate-lanceolate, 4.0x0.5 cm, hairy, apex acute; bracteoles obovate-lanceolate, 4.5x1.0 cm, hairy, apex acute. **Calyx** 2 cm long, apex 2-lobed, split down one side 0.5 cm, hairy. **Corolla** tube 6 cm long, glabrous; corolla lobes lanceolate, slightly concave, 2.0x0.5 cm, apex acuminate, glabrous; lateral lobes slightly

smaller. **Staminodes** oblong, 1.5x0.5 cm, glabrous. **Labellum** saccate, 2.0x1.2 cm, edges wrinkled, hairy in the middle especially on ridges. **Stamen**: filament 3x2 mm, flat; anther 4x3 mm, poricidal opening; connective short hairy; crest small, 2-lobed. **Ovary** 3 mm long, hairy; stigma cup-shaped, ciliate.

28. *Boesenbergia plicata* (Ridl.) Holtt. (fig.31)

Leafy stem short. **Leaves** 4-5; petiolate, petiole ca. 18 cm long, sparsely hairy; blades elliptic, 40-45 x 10-16 cm, lower surface hairy at least on vein, base broadly cuneate to shallowly cordate, apex acuminate; ligule 2-lobed, 2-2.5 cm long, sparsely hairy; sheaths hairy. **Inflorescence** terminal, between two uppermost leaf-sheaths; peduncle 3 cm long, densely long hairy; bracts distichous, facing to the same side, concave, 6-7.5 x 1.2 cm, outer surface densely hairy, apex acuminate; bracteoles elliptic, slightly concave, 4.5x1.5 cm, 2-ridged, outer surface densely hairy, apex 3-small teethed. **Calyx** 1.0 cm long, apex truncate, split down one side 5 mm, glabrous. **Corolla** tube 4 cm long, glabrous; corolla lobes concave; dorsal lobe 2.2x1 cm long, glabrous; lateral lobes slightly narrower. **Staminodes** short clawed, 2.5x1.5 cm, apex rounded. **Labellum** concave, 3 cm long, yellow with red dots scattered in the middle, edge wrinkled. **Stamen**: filament 1 cm long, sparsely glandular hairy; anther 1x0.5 cm. **Ovary** 4 mm long, glabrous; stigma cup-shaped, ciliate.

29. *Boesenbergia prainiana* (Bak.) Schltr. (fig.32)

Leafy stem short. **Leaves** 1-2; petiole 3-6 cm long, hairy; blades elliptic, 10-22 x 4-11 cm, lower surface green to pale purple, sparsely hairy, base cuneate, apex acute; ligule 2-lobed, 2 mm long, densely hairy; bladeless

sheaths 1-2, dark purple, sparsely hairy; leaf-sheaths sparsely hairy. **Inflorescence** terminal, between uppermost leaf-sheath, elongate; scape 2.5-4.5 cm long, densely hairy; rachis 6-11 cm long, densely hairy, completely covered by distichous bracts; bracts boat-shaped, 2.5x1 cm, outer surface hairy at base, apex acuminate; bracteoles boat-shaped, 2x0.5 cm, hairy outside, apex 3-toothed. **Calyx** 6 mm long, apex 3-unequal lobed, glabrous. **Corolla** tube 2 cm long, glabrous; dorsal lobe boat-shaped, 1.5x0.7 cm, apex hooded, glabrous; lateral lobes oblong, 1.5x0.5 cm, apex slightly hooded, glabrous. **Staminodes** elliptic, 7x4 mm, glabrous, apex rounded. **Labellum** saccate, 2.5x1.5 cm, edge wrinkled, glabrous. **Stamen**: filament 2x1 mm, flat, glabrous; anther 6x2.5 mm; connective hairy. **Ovary** 4 mm long, glabrous; stigma cup-shaped, edges lobed, glabrous.

30. ***Boesenbergia pulcherrima*** **(Wall.) Ktze.** (fig.33)

Leafy stem slender, sometime procumbent, 25-30 cm tall, greenish white or reddish. **Leaves**: petiolate, petiole 0.8-1 cm long; blades elliptic to oblong, 7-14 x 2-5 cm, glabrous on both surfaces, green above, pale green below, base unequal cuneate, apex acuminate; ligule deeply 2-lobed, 1 cm long, apex acute, glabrous; sheaths 2-4.5 cm long, glabrous, greenish white or reddish. **Inflorescence** terminal, between two uppermost leaf sheaths, 4 cm long; peduncle 2 mm long; bracts ovate, 3.5x1.5 cm, gradually shorter and narrower; bracteoles elliptic, 2x1 cm, glabrous, apex 3-lobed. **Calyx** 6 mm long, apex 3-lobed, funnel shape, glabrous. **Corolla** tube 2 cm long, glabrous; corolla lobes 1.2x0.7 cm, glabrous, apex hooded. **Staminodes** obovate, 9x6 mm, glabrous, apex rounded. **Labellum** saccate, 2.2x2.7 cm, whitish with red median band from apex towards base, margin wrinkled and reflex. **Stamen**:

32. *Boesenbergia* aff. *rotunda* (L.) Mansf. (sp2) (fig.35)

Leafy stem short. **Leaves** 4-7; petiolate, petiole 15 cm long, hairy; blades obovate-lanceolate, 36-45 x 7.5-9 cm, lower surface hairy, base attenuate, apex acuminate; ligule 2-lobed, 1.5-2 cm long, glabrous; sheaths hairy, especially the innermost. **Inflorescence** terminal, compact, enclosed between two uppermost leaf-sheaths; bracts linear, 6x1 cm, sparsely long hairy, apex acuminate, the outermost much broader; bracteoles lanceolate, 5.5x1.3 cm, sparsely long hairy, apex 3-lobed. **Calyx** tubular, 1.7 cm long, apex 3-toothed, densely long hairy. **Corolla** tube 7 cm long, sparsely hairy; dorsal lobe concave, 3.2x1.0 cm, cucullate, apex acuminate; lateral lobes lanceolate, 2.2x0.7 cm, cucullate, apex acute. **Staminodes** obovate-lanceolate, 2.5x0.9 cm. **Labellum** broadly oblong, slightly concave, 3.0x2.0 cm, apex 2-lobed, edge wrinkled. **Stamen**: filament flat, 9x2 mm, hairy; anther 9x4 mm; connective hairy; crest 2 mm long, 2- acute lobed. **Ovary** 5 mm long, glabrous; stigma cup-shaped, lobed, ciliate.

This species is similar to *B. rotunda* (L.) Mansf., but differs by the following characters: petiole longer; ligule shorter, glabrous; blades proportionally narrower, lower surface hairy; bracts and bracteoles larger; corolla tube longer; lobes larger; staminodes larger; labellum yellow.

IX Camptandra Ridl.

Only one species was found in this study.

33. *Camptandra parvula* Ridl. (fig.36)

Leafy stem 8-10 cm tall, tufted. **Leaves** 7-8; petiolate, petiole 7-12 mm long, hairy; blades oblong, 6.5-10 x 2-4.5 cm, upper surface hairy near apex,

lower surface hairy, base cuneate, apex acuminate, ciliate at apex; ligule membranous, 2-acute lobed, 3 mm long, hairy, ciliate; sheaths hairy, upper half ciliate. **Inflorescence** terminal; peduncle short hairy, 5 mm long; bract one, green, rounded, 2.3x2.5 cm, folded, apex acuminate, short hairy at apex; bracteoles suborbicular, 5x4 mm, glabrous, apex emarginated. **Flowers** in cincinnus of five. **Calyx** funnel-shaped, 5 mm long, glabrous, apex unequally 3-lobed, lobes rounded. **Corolla** tube white, 1.7 cm long, glabrous; lobes white, hooded, 1 cm long, glabrous; dorsal lobe with short hairy and spiny apex; lateral lobes ovate, 5 mm wide. **Staminodes** clawed, 2.7x9 mm, blades elliptic, apex rounded, white with pale yellow patch at base, sparsely hairy at base. **Labellum** rounded, 2x2 cm, white with yellow median band, with scarlet band on either side and narrowly pale yellow band towards margins, apex deeply 2-lobed, base hairy. **Stamen**: filament white, glabrous, 1 mm long; anther white, 2 mm long, basal spurs 2 mm long, glabrous. **Ovary** green, glabrous, 3 mm long; stigma 1.5 mm broad, hairy.

X Haniffia Holtt.

One species occurs in Thailand and was found in this study.

34. ***Haniffia albiflora*** **K. Larsen & J. Mood** (fig.37)

Leafy stem 45-65 cm tall. **Leaves** 11-17, sessile; blades narrowly obovate, 13-20 x 2-3 cm, glabrous on both surfaces, base cuneate, apex caudate; ligule triangular, 3 mm long, apex truncate, ciliate; sheaths glabrous. **Inflorescence** lateral, rising from base of leafy stem, with 2-4 flowers; scape 1-5 cm long, completely covered by sheathes in two rows; sheaths ovate, 2.3 x 0.9 cm, apex rounded to acute, lower sheaths smaller; ebracteolate. **Calyx** 4-6

cm long (include ovary), glabrous, apex unequally 3-lobed. **Corolla** tube white, 2 cm longer than calyx, glabrous; dorsal lobe elliptic, 2.5 x 1 cm, apex acute; lateral lobes elliptic, 2x0.8 cm, apex rounded to acute. **Staminodes** oblong, 2.5x0.8 cm, glandular hairy, apex retuse. **Labellum** obovate, 2.5-3 x 1.5-2 cm, apex 2-lobed, white with yellow patch in the middle. **Stamen**: filament 60x1.5 mm, flat; anther 8 mm long; crest 1 mm long, rounded. **Ovary** hairy; stigma cup-shaped, ciliated. **Fruits** brown, 3-lobed, 7 mm long, 1 cm in diameter.

XI Scaphoclamys Baker

Two species were found in this study.

Key to the species.

1. One leaf per shoot; rachis 5 cm long **35. S. biloba**

1'. Leafy stem bearing 3--4 leaves; rachis 7 cm long or more **36. S. perakensis**

35. ***Scaphoclamys biloba*** **Ridl.** (fig.38)

Leafy stem short. **Leaves** 1; petiolate, petiole 21 cm long, sparsely long hairy; blade obovate-lanceolate, 26x6 cm, upper surface glabrous, lower surface sparsely long hairy, upper half purplish, base cuneate, apex acute; ligule 2-lobed, 3 mm long, densely long hairy; leaf-sheath 0.5 cm long; sparsely long hairy; bladeless sheath 2.5–9 cm, purplish; ligule 2-lobed, 4 mm long. **Inflorescence** terminal, enclosed in leaf-sheaths; scape 5.5 cm long, loosely long hairy; sheaths 2, obovate-lanceolate, 1.5-2 x 0.5 cm, apex acute, bracts spirally arranged, lanceolate, 2.5 x 0.5 cm, sparsely hairy on both surfaces, apex acute; bracteoles elliptic, 2.2x1.0 cm, sparsely short hairy, apex acute. **Calyx** 7 mm long, glabrous, apex small 3-teeth, split down one side 4 mm. **Corolla** tube 3 cm long, glabrous; dorsal lobe elliptic, 1.7x0.6 cm,

apex acute; lateral lobes oblong, 1.6x0.5 cm, apex acute. **Staminodes** oblong, 1.6x0.5 cm, glabrous on both surfaces, apex rounded. **Labellum** broad obovate, 2.0x1.7 cm, glabrous, apex 2-rounded lobed. **Stamen**: filament 4 x 2 mm, flat, sparsely glandular hairy; anther 4x1.5 mm, convex; crest small, rounded, undulate, 0.5 mm long. **Ovary** 2 mm long, hairy.

36. *Scaphoclamys perakensis* Holtt. (fig.39)

Leafy stem short. **Leaves** 2, petiolate; petiole 15-17 cm long, hairy; blades elliptic, 30-35 x 11.5-12.5 cm, upper surface glabrous, lower surface hairy, base attenuate, apex acute; ligule 2-lobed, 4 mm long, glabrous; sheaths glabrous or sparsely hairy near ligule. **Inflorescence** terminal, scape 17 cm long, glabrous; bracts broadly elliptic, 3.5x2.5 cm, glabrous, greenish brown, bearing 9 flowers in cincinnus, apex acute; bracteoles distichous, obovate, 1.5-2.3 x 0.4-1.0 cm, the inner bracteoles smaller, apex acute. **Calyx** 6 mm long, glabrous, apex shallowly 3-lobed, split down one side 1.5 mm. **Corolla** tube 2.5 cm long, glabrous; dorsal lobe oblong, 1.3x0.4 cm, glabrous, apex acute; lateral lobes lanceolate, 1.1x0.3 cm, glabrous, apex acute. **Staminodes** broadly elliptic, 5x2 mm, glandular hairy, apex acute. **Labellum** elliptic, 1.3x0.7 cm, glandular hairy, apex 2-lobed. **Stamen**: filament flat, 1 mm long; anther 4x2 mm; connective glandular hairy; crest 0.5 mm long, shallowly 2-lobed. **Ovary** cylindrical, 5 mm long, glabrous.

TRIBE ZINGIBEREAE

XII Zingiber Mill.

Three species were found in this study.

Key to the species.

1. Peduncle erect, 30 cm tall or more **37. Z. spectabile**

1'. Peduncle prostrate **2**

2. Upper bracts green, lower bracts red; not produce plantlets at elongate tip **38. Z. aff. puberulum var. ovoidium**

2'. All bracts dark red; often produce plantlets at tip of elongate leafy stem **39. Z. aff. velutinum**

37. *Zingiber spectabile* Griff. (fig.40)

Leafy stem 2-3 m tall, tufted. **Leaves** sessile; blades narrowly obovate-lanceolate, 60x9 cm, hairy at base, base broadly cuneate, apex acute; ligule shallowly 2-lobed, 1.5 cm long, glabrous, upper part with membranous edge; sheaths hairy near base. **Inflorescence** lateral, directly from rhizome, cylindrical; peduncle upright, 30-50 cm long, densely short hairy; bracts obovate, 4.5x3.5 cm, green turn yellow then red, apex decurved, short hairy; bracteoles elliptic, 3.5x1.7 cm, short hairy, apex rounded. **Calyx** 2.5 cm long, apex rounded or emarginate, split down one side 1.3 cm, glabrous. **Corolla** tube 3 cm long, glabrous; lobes 2.5 x 0.5-1 cm, lateral lobes narrower, glabrous, apex acuminate. **Labellum** 3-lobed, 2.5x2.5 cm, glabrous, dark purplish with pale yellow dots; mid-lobe 1.5x1.5 cm, apex 2-lobed; side lobes 5x2 mm. **Stamen**: filament very short or sessile; anther 1.2 cm long, glabrous; crest 1.5 cm long, dark purplish. **Ovary** 4 mm long, glabrous; style dark purplish.

38. *Zingiber* aff. *puberulum* var. *ovoidium* J. Mood & I. Theilade (fig.41)

Leafy stem 2-2.5 m tall. **Leaves** petiole, petiole 4 mm long; blades narrowly oblong, 30-40 x 8-10 cm, upper surface sparsely short hairy, lower surface denser, base cuneate, apex acuminate; ligule shallowly 2-rounded lobed, 2 mm long; sheath, ligule and petiole densely short hairy, ciliate. **Inflorescence** lateral, directly from rhizome, ovoid, 6 x 3.5 cm; scape 8-15 cm long, procumbent; sheaths elliptic, 3.5x1.5 cm, densely short hairy, apex obtuse, ciliate; apex acute; bracts elliptic, 4.5x2 cm, densely short hairy, apex acute, ciliate. **Calyx** 2.2 cm long, glabrous, apex rounded, split down one side 1.3 cm. **Corolla** tube 3.2 cm long, glabrous; dorsal lobe concave, 2.2x0.8 cm, apex acute; lateral lobes 1.7x0.4 cm. **Labellum** 2.5 cm long, as long as lateral corolla lobe; mid-lobe 1.5x1.3 cm, apex bifid; side lobes 8x4 mm, apex rounded. **Stamen**: filament very short or sessile; anther 1.3x0.4 cm; crest 8 mm long. **Ovary** 4 mm long, densely hairy.

This species is similar to *Z. puberulum* var. *ovoidium* Holtt., but differs by the following characters: ligule 2-lobd; leaves hairy; peduncle prostrate; corolla tube shorter; lateral lobes shorter; mid-lobe of labellum broader, apex bifid.

39. *Zingiber* aff. *velutinum* J. Mood & I. Theilade (fig.42)

Leafy stem 2.5-3 m tall, upright or bending to touch ground, apex longate to 1-2 m or more and often produce plantlets at tip. **Leaves** petiolate, petiole 1.5 cm long; blades obovate-lanceolate, 46-59 x 12-14 cm, lower surface hairy, base cuneate, apex acuminate; ligule unequal 2-lobed, 1 cm long; ligule and petiole densely hairy. **Inflorescence** lateral, from rhizome near base of leafy stem, narrowly ovoid, 18 x 5 cm; scape 14 cm long, procumbent;

bracts elliptic, 6x3.5 cm, densely hairy, apex acute; bracteoles lanceolate, 3x1 cm, hairy, apex acute. **Calyx** 3-3.5 cm long, glabrous, apex small 3-toothed, split down one side 1.5-2 cm. **Corolla** tube 5 cm long, sparsely hairy; dorsal lobe concave, 3.5 x 0.8 cm, apex acute; lateral lobes 2.5x0.5 cm. **Labellum** 3.2 cm long, as long as lateral corolla lobe, white to cream; mid-lobe 1.5x1.2 cm, apex bifid; side lobes 2x3 mm, rounded. **Stamen**: filament very short; anther 1.6x0.5 cm; crest 1.5 cm long. **Ovary** 6 mm long, densely hairy; stigma cup-shaped, ciliate.

This species is similar to *Z. velutinum* J. Mood & I. Theilade, but differs by the following characters: leaves broader; ligule longer; inflorescence larger; bracteoles narrower; calyx longer; corolla tube shorter; dorsal lobe longer; mid-lobe of labellum bifid.

2. Habitat Relationships

Average value of environmental data of study sites were shown in table 3. Environmental data of sample plots were analyzed by NMS and plotted between Axis1 and Axis2 (fig. 2). All sample plots are clustered in the middle. They were classified by cluster analysis into 2 groups (fig. 3). Group I consists of 42 plots of 34 species and group II consists of 9 plots of 9 species (table 4). Environmental properties of each group are shown in table 5.

Table 3 Average environmental data of study sites.

Environment factors	Site A		Site B		Site C	
	Mean	SE	Mean	SE	Mean	SE
pH	4.59	0.09	5.09	0.18	5.03	0.15
Electrical Conductivity(millimhos at 25° C)	0.07	0.02	0.11	0.03	0.10	0.03
Organic Matter (%)	4.43	0.49	4.39	0.70	3.82	0.52
P (ppm)	3.89	0.83	7.82	2.48	9.06	4.04
K (ppm)	70.16	10.23	93.59	10.47	106.35	25.54
Moisture (%)	37.64	2.43	46.38	2.90	21.27	1.93
Light	2.47	0.29	2.41	0.28	2.47	0.21
Particle Density (g/cm^3)	2.51	0.01	2.52	0.02	2.55	0.01
Porosity (%)	50.66	0.88	52.32	1.20	54.09	0.94
Sand (%)	64.21	1.53	64.18	3.10	58.77	3.26
Silt (%)	14.74	0.97	15	1.26	19.29	2.48
Clay (%)	21.05	1.42	20.82	2.65	23.76	3.13
Cation exchange capacity (me/100 g)	6.27	0.43	7.26	0.67	6.97	0.73
Water holding capacity (%)	36.67	1.32	39.01	1.98	40.63	1.65

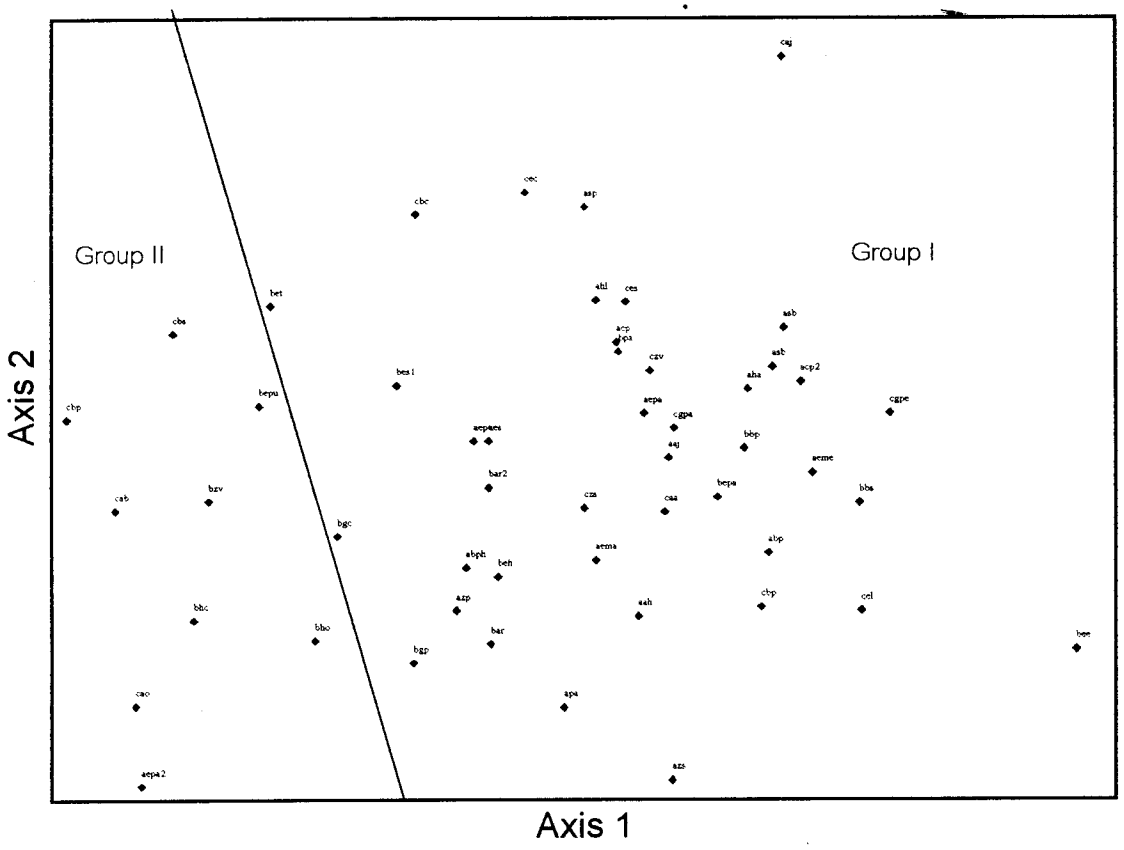


Fig. 2 Microhabitats plotted on Axis1 and Axis2 of NMS. Line, draw after cluster analysis, separated sample plots into groups.

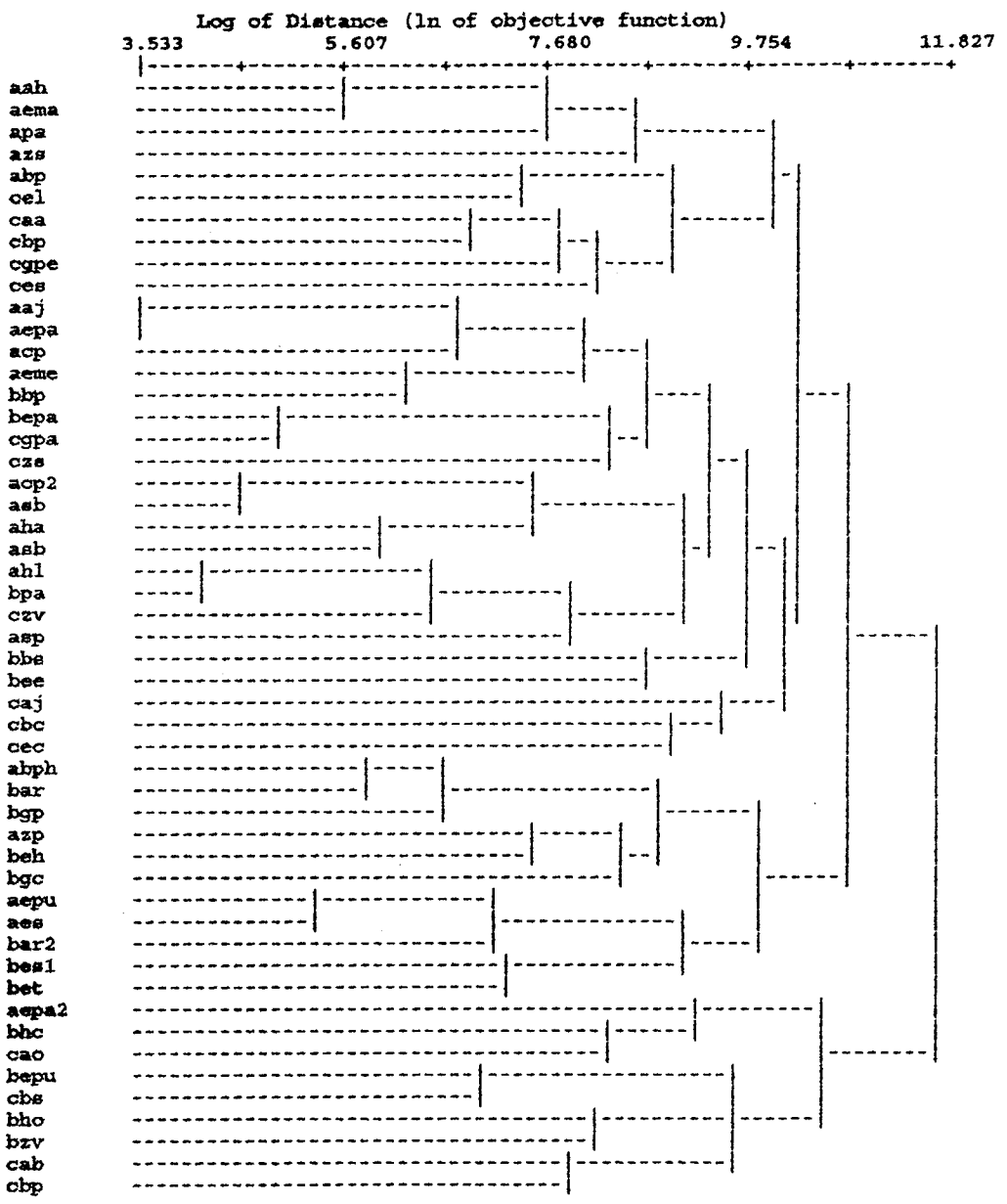


Fig. 3 Dendrogram of cluster analysis.

Table 4 Species list of environmental groups.

No.	Scientific Name	Group I	Group II
	Tribe Alpinieae		
1	Alpinia javanica Bl.	*	
2	Alpinia oxymitra K. Schum.		*
3	Alpinia aff. rafflesiana Bl.	*	
4	Amomum aculeatum Roxb.	*	
5	Amomum biflorum Jack		*
6	Amomum hastilabium Ridl.	*	
7	Elettariopsis curtisii Bak.	*	
8	Elettariopsis smithae Kam	*	
9	Etlingera elatior (Jack) R. M. Smith	*	
10	Etlingera hemisphaerica (Bl.) R. M. Smith	*	
11	Etlingera littoralis (Koenig) R. M. Smith	*	
12	Etlingera maingayi (Bak.) R. M. Smith	*	
13	Etlingera metriocheilos (Griff.) R. M. Smith	*	
14	Etlingera pauciflora (Ridl.) R. M. Smith	*	*
15	Etlingera punicea (Roxb.) R. M. Smith	*	*
16	Etlingera subterranea (Holtt.) R. M. Smith	*	
17	Etlingera triorgyalis (Bak.) R. M. Smith	*	*
18	Etlingera aff. pauciflora (Ridl.) R.M. Smith	*	
19	Hornstedtia conica Ridl.		*
20	Hornstedtia leonurus (Ridl.) Ridl.	*	
21	Hornstedtia ophiucus (Koenig) Retz.	*	
22	Plagiostachys aff. albiflora Ridl.	*	
	Tribe Globbeae		
23	Globba cernua Bak.	*	
24	Globba patens Miq.	*	
25	Globba pendula Roxb.	*	

Table 4 (continue).

No.	Scientific Name	Group A	Group B
	Tribe Hedychieae		
26	Boesenbergia curtisii (Bak.) Schltr.	*	
27	Boesenbergia plicata (Ridl.) Holtt.	*	
28	Boesenbergia prainiana (Bak.) Schltr.	*	
29	Boesenbergia pulcherrima (Wall.) Ktze.	*	*
30	Boesenbergia aff. rotunda (L.) Mansf. (sp.1)	*	*
31	Camptandra parvula Ridl.	*	
32	Haniffia albiflora K. Larsen & J. Mood	*	
33	Scaphoclamys biloba Ridl.	*	
34	Scaphoclamys perakensis Holtt.	*	
	Tribe Zingibereae		
35	Zingiber spectabile Griff.	*	
36	Zingiber aff. puberulum var. ovoidium Holtt.	*	
39	Zingiber aff. velutinum J. Mood & I. Theilade	*	*

Table 5 Environmental data of environmental groups.

Property	group I		group II	
	mean	se	mean	se
pH	5.31	0.21	4.80	0.09
Electrical Conductivity (millimohs at 25° C)	0.20	0.06	0.07	0.01
Organic Matter (%)	5.21	0.73	4.01	0.37
P (ppm)	6.11	1.49	4.67	0.61
K (ppm)	164.89	11.29	74.37	10.08
Moisture (%)	36.58	5.95	35.21	2.12
Light	2.44	0.44	2.47	0.16
Particle Density (g/cm^3)	2.52	0.02	2.53	0.01
Porosity (%)	56.36	0.62	51.51	0.66
Sand (%)	55.56	3.82	63.67	1.67
Silt (%)	16.33	1.08	16.30	1.19
Clay (%)	28.11	3.24	20.74	1.51
Cation Exchange Capacity (me./100 g)	9.36	0.62	6.31	0.36
Water Holding Capacity (%)	44.31	1.57	37.62	1.06

CHAPTER 4

DISCUSSION

1. Species diversity of Zingiberaceae along Thai-Malaysian Border in Yala and Narathiwat Provinces

There are totally 39 species in 12 genera of the family Zingiberaceae found in this study. Twenty-two species in six genera are in *Alpinieae*. Ten species are in four genera of *Hedychieae*. Four and three species are in *Globbeae* and *Zingibereae* respectively. Number of species in this study is fewer than those recorded by Holttum (1950), Kam (1982), Larsen (1996), Lim (1972), Sirirugsa (1987 and 1992) and Theilade (1996 and 1999), which were at least 70 species from both Thailand and Malaysia. Twenty species from the former records were included in this study and approximately 50 species were not found. Several species from this study are new records to Thailand and some are expected new to science.

Species, new records to Thailand:

Ten species from the collected specimens along the Thai-Malaysian border are newly recorded to Thailand, i.e. (1) *Camptandra parvula*, (2) *Etlingera hemisphaerica*, (3) *E. metriocheilos*, (4) *E. pauciflora*, (5) *E. subterranea*, (6) *E. triogyale*, (7) *Hornstedtia conica*, (8) *H. leonurus*, (9) *H. ophiucus* and (10) *Scaphoclamys perakensis*. All of them are indigenous species of Peninsular Malaysia. As *Camptandra parvula*, a newly recorded

species for Thailand, is the only one species of the genus, thus *Camptandra* is also a newly recorded genus of Thailand. The genus *Etlingera* in Thailand, with 5 newly recorded species from this study added, has been 12 species at present. All three species of *Hornstedtia* collected in this study are newly recorded for Thailand. However, one species, *H.scyphifera* (Koenig) Steud documented by Larsen (1996) was expected from this area but not found in any study site. The species *Scaphoclamys perakensis* Holtt. collected from Hala-Bala Wildlife Sanctuary is slightly different from the type (Holttum, 1950), but according to his note, the description was done from dried specimens. Moreover, the studied specimen has 9 flowers in each bract instead of 3-4 flowers as the type. Further study on this character may be needed.

Species, new to science:

Eight species are expected new to science, i.e. (1) *Alpinia aff. rafflesiana*, (2) *Boesenbergia* aff. *rotunda* (sp1), (3) *B.* aff. *rotunda* (sp2), (4) *Etlingera* aff. *pauciflora*, (5) *Globba* aff. *curtisii*, (6) *Plagiostachys* aff. *albiflora*, (7) *Zingiber* aff. *velutinum* and (8) *Zingiber* aff. *puberulum* var. *ovoidium*. Each species is described and made the diagnosis. They will be studied carefully with the related type specimens and will be publicized.

Remarks of some species:

The distribution of *Etlingera punicea* and *Scaphoclamys biloba* in Thailand are found in the areas nearby the Malaysian border, where is their northernmost limit of distribution range. *Alpinia javanica* distributes further North to Phattalung and Nakhon Si Thamarat. *Boesenbergia prainiana* is a rare species in Thailand but commonly found in Narathiwat province.

Boesenbergia pulcherrima is not common in the study sites, but this species has wider distribution range up to central and northern parts of Thailand. The collected specimens are smaller than those described by Sirirugsa (1992) but agree with ones made by Holttum (1950). *Haniffia albiflora* is another rare species which is endemic to Narathiwat province. Some incomplete specimens belong to species *Amomum uliginosum* Koenig and *Hedychium longicornutum* Griff., *Elettariopsis* sp. and *Zingiber* sp. have been commonly found but not included in this study.

The survey of Zingiberaceae along the Thai-Malaysian border in this study was done in a wide range of exploration. It was possible that some species have been overlooked because of many study sites and time-limited. Safety is another limited factor caused the author could not be accessible to the core area of some study sites. The further study in particularly spots along the Thai-Malaysian border is still needed. Although this study was the preliminary study on diversity of Zingiberaceae along the border, the results showed that several undescribed species have been found.

2. Habitat relationships of Zingiberaceae

The sample microhabitats clustered in the center (fig. 2). They are unclearly grouped, but after cluster analysis, they are divided into 2 groups, I and II (fig. 3). Group I consists of 42 plots with 34 species while group II is 9 plots with 9 species (table 5). Species present in group II are mostly collected from site B and C. *Etlingera pauciflora* in this group is collected from site A, but it also presents in site B. Group I contains all remaining species collected from every sites and 6 species of group II.

Eight environmental factors of group II are higher than those of group I, five are a little bit different and only one factor of group I is greater than in group II. In general view, group II seems to have better soil condition with higher level of organic matters, phosphorus, potassium, electrical conductivity, cation exchange capacity, water holding capacity and lower percent of sand. In general, Zingiberaceous plants grow on sandy clay loam soil, that contains a balanced mixture of coarse and fine particle. The sample soil is slightly weak acid with high organic matter and high water holding capacity. Toumisto et al. (1998) suggested that soil physical factors, such as water holding capacity, porosity and soil texture play an important roles on plant's distribution pattern, as in the occurrence and abundant of *Adiantum* species that varied among the site with regard to soil texture and concentration of exchangeable bases. Casper et al. (1996) mentioned that soil nutrient heterogeneity has little effect on population level but strongest effect on individuals as present in *Abutilon theophrasti*.

Light is not considered as an important factor in this study. It is given in ordinal scale because of difficulty in measurement. It fluctuates in high

amplitude between periods of the day, open and shaded area and between clear and clouded sky. It is an important factor that affects plant's distribution pattern. Four species of *Begonia* that coexist on Bukit Dulong Lambu in Sabah, Borneo occur in different light condition (Kiew, 1998).

Some factors are not included in raw data because they cannot measure for each sampling plot, for example, rainfall, temperature and relative humidity from Climatology Division. In large scale, all study sites are very close to each other. They are located in the same climatic region, eastern south Thailand. The climate of each site is not much different. For example, Dry season is not found in all sites but occurs as dryer period 2 and 4 months in site B and C respectively (see appendix 1). The more important factor is microclimate that affects directly to plants but cannot be measured for each sample plot.

Soil properties are the important factors for classification of plant's habitat preference. It is recommended that future study should focus on soil physical properties with more samples and more diverse habitats. The study sites should also be located in different climatic regions in order to obtain clear effects of environmental factors on plant distribution patterns.

CHAPTER 5

CONCLUSION

Thirty-nine species in twelve genera of the family Zingiberaceae were collected in this study. Twenty-two species in six genera are in the tribe *Alpinieae*. Ten species are in four genera of the tribe *Hedychieae*. Four and three species are in the tribe Globbeae and Zingibereae respectively. Ten species are new records to Thailand; namely *Camptandra parvula* Ridl, *Etlingera hemisphaerica* (Bl.) R. M. Smith, *E. metriocheilos* (Griff.) R. M. Smith, *E. pauciflora* (Ridl.) R. M. Smith, *E. subterranea* (Holtt.) R. M. Smith, *E. triogyale* (Bak.) R. M. Smith, *Hornstedtia conica* Ridl., *H. leonurus* (Ridl.) Ridl., *H. ophiucus* (Koenig) Retz. and *Scaphoclamys perakensis* Holtt. All of them are indigenous species of Peninsular Malaysia. Eight species are expected new to science, i.e. one species of *Alpinia*, two species of *Boesenbergia*, one species of *Etlingera*, one species of *Globba*, one species of *Plagiostachys* and two species of *Zingiber*. Many indigenous species of Malaysia were commonly found in the study sites, Thai-Malaysian border.

From the study on habitat relationships of *Zingiberaceae*, it is revealed that the studied species of *Zingiberaceae* can be classified into two groups. Group II show that the plants grow in better soil condition. It is also noted that some environmental factors showed no effects to the habitats, therefore the classification based on habitats could hardly be done.

BIBLIOGRAPHY

Allaby, N. 1994. The Concise Oxford Dictionary of Ecology. New York: Oxford University Press.

Baker, J.G. 1894. Scitamineae. In J.D. Hooker (ed.), Flora of British India vol. 6, pp. 198-264. Great Britain: L. Reeve & Co., Ltd.

Bridson, D. and Forman, L. 1992. The Herbarium Handbook, Great Britain, Royal Botanic Garden Kew.

Burkill, I.H. 1966. A Dictionary of the Economic Products of the Malay Peninsula, Malaysia, Ministry of Agriculture and Co-operatives.

Casper, B.B. and Cahill, J.F. 1996. Limited effects of soil nutrient heterogeneity on population of Abutilon theopharsti (Malvaceae). American J. Bot. 83 (3): 333-341.

Funakoshi, H. and Ohashi, H. 2000. Vanoverberghia sasakiana H. Funak. & H. Ohashi (Zingiberaceae), a new species and a new generic record for the Flora of Taiwan. Taiwania 45(3): 270-275.

Hillel, D. 1982. Introduction to Soil Physics, California: Academic Press, Inc.

Holttum, R.E. 1950. Zingiberaceae of the Malay Peninsular. Gardens' Bulletin Singapore 13(1): 1-282.

Ibrahim, H. and Larsen, K. 1995. A new species of Globba (Zingiberaceae) from Peninsular Malaysia. Nordic J. Bot. 15(2): 157-159.

Jones, M.B. 1993. Plant microclimate in D.O. Hall et al. (eds.). Photosynthesis and Production in a Changing Environment: a Field and Laboratory Manual, pp. 47-64. London: Chapman & Hall.

Kam, Y.K. 1982. The genus Elettariopsis (Zingiberaceae) in Malaya. Notes Roy. Bot. Gard. Edinbg. 40(1): 139-152.

Kiew, R. 1998. Niche partitioning in limestone Begonias in Sabah, Borneo, including two new species. Gardens' Bulletin Singapore 50: 161-169.

Knight, T.W. and Morris, D.W. 1996. How many habitats do landscape contain? Ecology 77(6): 1756-1764.

Larsen, K. 1972. Studies in the Genus Globba in Thailand. Notes Roy. Bot. Gard. Edinbg. 31(2): 229-241.

. 1993. Boesenbergia tenuispicata (Zingiberaceae): a new species from Thailand. Nordic J. Bot. 13(3): 281-283.

. 1996. A preliminary checklist of the Zingiberaceae of Thailand. Thai Forest Bulletin (Botany) 24: 35-49.

. 1997. Further studies in the genus Boesenbergia (Zingiberaceae). Nordic J. Bot. 17(4): 361-366.

Larsen, K. and Mood, J. 1998. Siamenthus, a new genus of Zingiberaceae from Thailand. Nordic J. Bot. 18(4): 393-397.

. 2001. A revision of the genus Haniffia (Zingiberaceae). Nordic J. Bot. 20(3): 285-290.

Larsen, K., Ibrahim, H., Khaw, S.H. and Saw, L.G. 1999. Gingers of Peninsular Malaysia and Singapore, Malaysia: Natural History Publications (Borneo).

Larsen, K., Lock, J.M., Maas, H. and Maas, P.J.M. 1998. Zingiberaceae. In K. Kubitzki (ed.), The Families and Genera of Vascular Plants (vol. IV), pp. 474-495. Germany: Springer.

Lim, S.N. 1972. Cytogenetics and Taxonomy of the genus Globba L. (Zingiberaceae) in Malaya I: Taxonomy. Notes Roy. Bot. Gard. Edinbg. 31: 243-269.

Mood, J. and Ibrahim, H. 2000. A new species of Etlingera (Zingiberaceae) from Peninsular Malaysia and southern Thailand. Nordic. J. Bot. 20(3): 279-283.

Richards, P.W. 1996. The Tropical Rain Forest, an Ecological Study (2nd ed.), U.S.A., Cambridge University Press.

Sakai, S. 2000. Reproductive phenology of gingers in lowland mixed dipterocarp forest in Borneo. Journal of Tropical Ecology. 16(3): 337-359.

Sakai, S., Kato, M. and Inoue, T. 1999. Three pollination guilds and variation in floral characteristics of Borneo gingers (Zingiberaceae and Costaceae). American J. Bot. 86(5): 646-658.

Sirirugsa, P. 1987. Three new species and one new combination in Boesenbergia (Zingiberaceae), from Thailand. Nordic J. Bot. 7(4): 421-425.

. 1992. A revision of the genus Boesenbergia Kuntze (Zingiberaceae) in Thailand. Nat. His. Bull. Siam Soc. 40: 67-90.

Sirirugsa, P. and Larsen, K. 1991. A new species of Scaphoclamys (Zingiberaceae) from Thailand. Nordic J. Bot. 11(1): 93-95.

Smith, R. M. 1981. Zingiberaceae: Synoptic Keys to Tribes. England, Royal Botanic Garden Edinburgh.

.1990. Alpinia (Zingiberaceae): a proposed new infrageneric classification. Edinb. J. Bot. 47(1): 1-75.

Theilade, I. 1996. Revision of the genus Zingiber in Peninsular Malaysia. Gardens' Bulletin Singapore 48: 207-235.

. 1999. A Synopsis of the Genus Zingiber (Zingiberaceae) in Thailand. Nordic. J. Bot. 19(4): 389-410.

Tuomisto, H. 1998. Edaphic distribution of some species of the fern genus Adiantum in western Amzonia. Biotropica 30(3): 392-399.

White, L.J.T., Rogers, M.E., Tutin, C.E.G., Williamson, E.A. and Fernandez, M. 1995. Herbaceous vegetations for keystone food availability. Afr. J. Ecol. 33(2): 124-141.

Withmore, T.C. 1990. An Introduction to Tropical Rain Forests, U.S.A., Oxford University Press.

Wu, D. and Larsen, K. 2000. Zingiberaceae. In Wu Z. and P.H. Raven (eds.), Flora of China vol. 24, pp. 322-377. U.S.A.: Missouri Botanical Garden Press.

เกษตรเคมี, กอง. ไม่ระบุปีที่พิมพ์ การเก็บตัวอย่างดินและน้ำเพื่อการวิเคราะห์. กรมวิชาการเกษตร, กรุงเทพฯ.

พวงเพ็ญ ศิริรักษ์ 2532. การสำรวจพืชวงศ์ขิงในบริเวณภาคใต้ของประเทศไทย. ภาควิชาชีววิทยา คณะวิทยาศาสตร์ มหาวิทยาลัยสงขลานครินทร์.

APPENDIX

a)

b)

Fig. 4 *Alpinia javanica* Bl. a) flower, b) fruits.

a)

b)

Fig. 5 *Alpinia oxymitra* K. Schum. a) inflorescence b) flower.

a)

b)

Fig. 6 *Alpinia* aff. *rafflesiana* Bl. a) inflorescence, b) flower.

a)

b)

Fig. 7 *Amomum aculeatum* Roxb. a) inflorescence, b) flowers.

a)

b)

Fig. 8 *Amomum biflorum* Jack a) flower, b) habit

a)

b)

Fig. 9 *Amomum hastilabium* Ridl. a) inflorescence, b) flower.

a)

b)

Fig. 10 *Elettariopsis curtisii* Bak. a) inflorescence, b) flower.

a)

b)

Fig. 11 *Elettariopsis smithae* Kam a) flower, b) inflorescence.

a)

b)

Fig. 12 *Etlingera elatior* (Jack) R. M. Smith
a) inflorescence, b) infructescence.

a)

b)

Fig. 13 *Etlingera hemisphaerica* (Bl.) R. M. Smith
a) inflorescence, b) infructescence.

a)

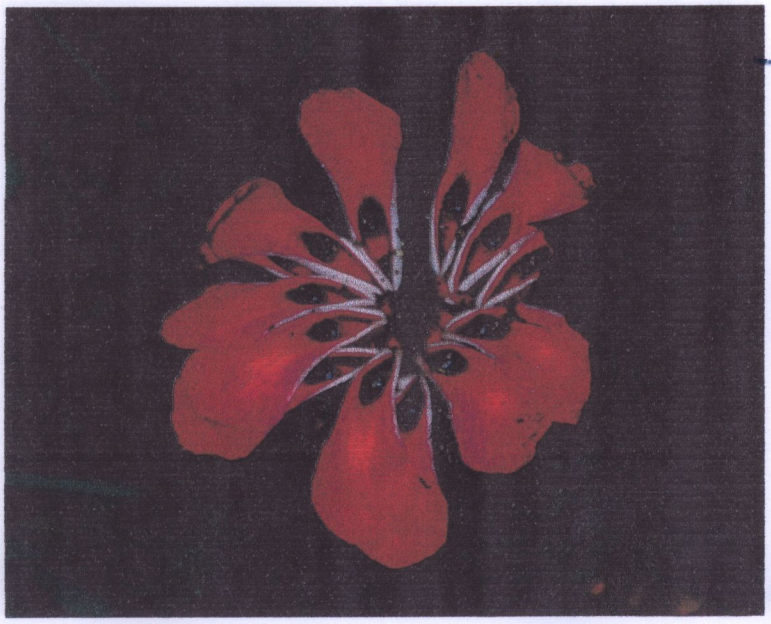
b)

Fig. 14 *Etlingera littoralis* (Koenig) R. M. Smith
a) red flowers, b) red with yellow edge flowers.

a)

b)

Fig. 15 *Etlingera maingayi* (Bak.) R. M. Smith
a) flowers, b) inflorescence.



a)

b)

Fig. 16 *Etlingera metriocheilos* (Griff.) R. M. Smith
a) inflorescence, b) flower.

a)

b)

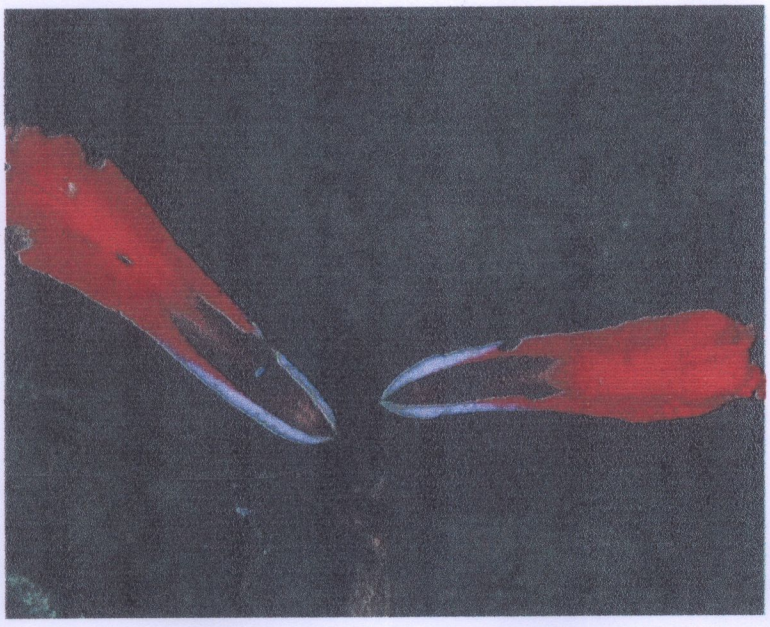
Fig. 17 *Etlingera pauciflora* (Ridl.) R. M. Smith
a) inflorecence, b) flower.

a)

b)

Fig. 18 *Etlingera punicea* (Roxb.) R. M. Smith
a) inflorescence, b) flower.

a)



b)

Fig. 19 *Etlingera subterranea* (Holtt.) R. M. Smith
a) inflorescence, b) flowers.

a)

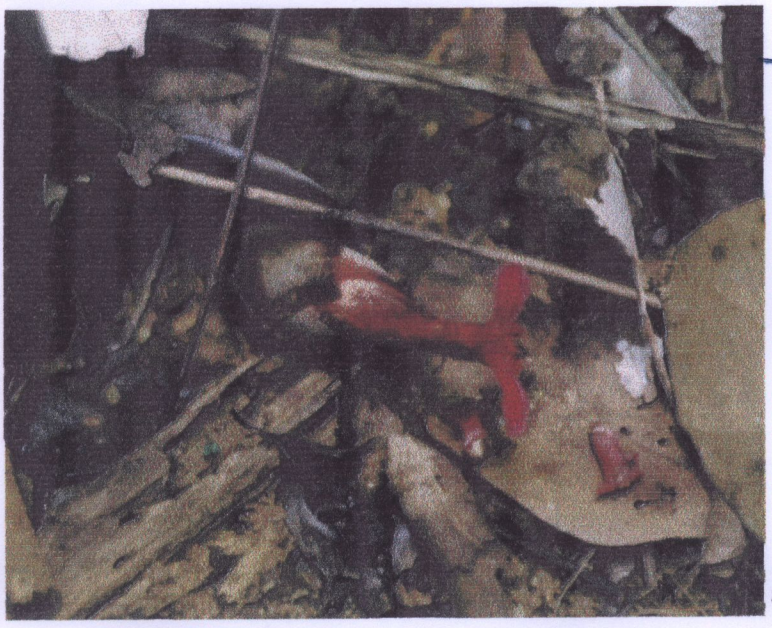
b)

Fig. 20 *Etlingera triorgyale* (Bak.) R. M. Smith
a) inflorescence, b) flowers.

a)

b)

Fig. 21 *Etlingera* aff. *pauciflora* (Ridl.) R.M. Smith
a) inflorescence, b) flower with curved calyx lobes.



a)

b)

Fig. 22 *Hornstedtia conica* Ridl. a) inflorescence, b) flowers.

Fig. 23 *Hornstedtia leonurus* (Ridl.) Ridl.: flower.

a)

b)

Fig. 24 *Hornstedtia ophiucus* (Koenig) Retz.
a) inflorescence, b) flower.

a)

b)

Fig. 25 *Plagiostachys* aff. *albiflora* Ridl.
a) flowers, b) fruit.

a)

b)

Fig. 26 *Globba cernua* Bak. a) inflorescence, b) bulbils.

a)

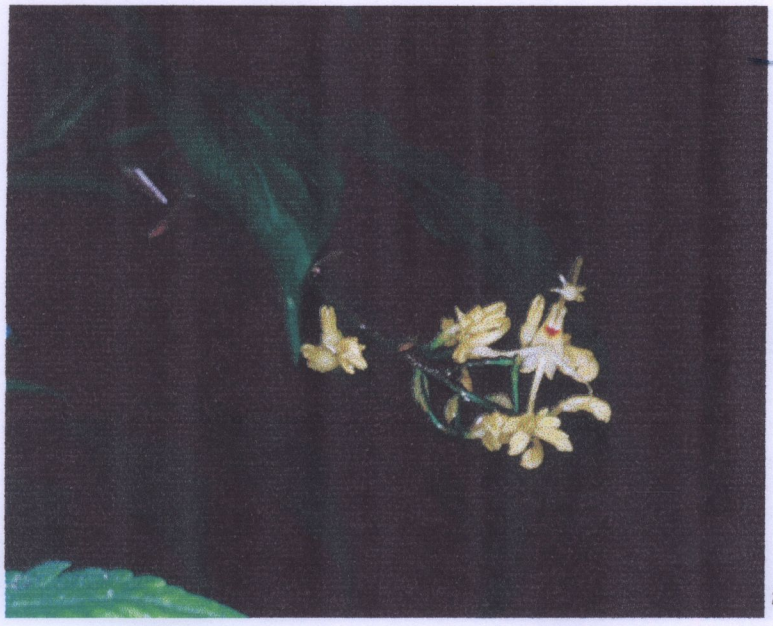
b)

Fig. 27 *Globba patens* Miq. a) inflorescence, b) bulbils.

a)

b)

Fig. 28 *Globba pendula* Roxb. a) flower, b) inflorescence.



a)

b)

Fig. 29 *Globba* aff. *curtisii* Holtt. a) inflorescence, b) flower.

a)

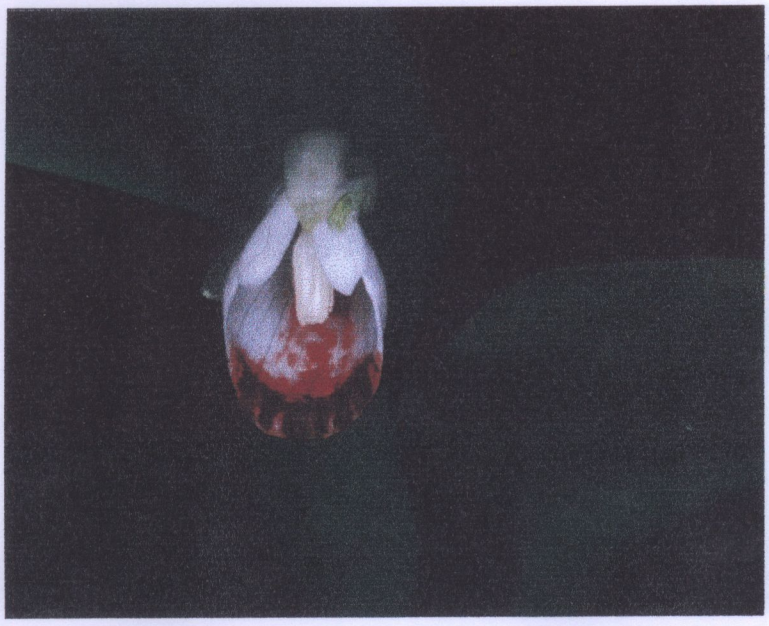
b)

Fig. 30 *Boesenbergia curtisii* (Bak.) Schltr. a) flower, b) flower and fruit.

a)

b)

Fig. 31 *Boesenbergia plicata* (Ridl.) Holtt.
a) yellow flower, b) orange flower.



a)

b)

Fig. 32 *Boesenbergia prainiana* (Bak.) Schltr.
a) flower, b) plant with inflorescence.

Fig. 33 *Boesenbergia pulcherrima* (Wall.) Ktze.: flower.

a)

b)

Fig. 34 *Boesenbergia* aff. *rotunda* (L.) Mansf. (sp.1)
a) flower, b) plants.

a)

b)

Fig. 35 *Boesenbergia* aff. *rotunda* (L.) Mansf. (sp.2)
a) inflorescence, b) flowers.

a)

b)

Fig. 36 *Camptandra parvula* Ridl. a) flower, b) plant.

a)

b)

Fig. 37 *Haniffia albiflora* K. Larsen & J. Mood
a) flower, b) leaves.

Fig. 38 *Scaphoclamys biloba* Ridl.: flower.

a)

b)

Fig. 39 *Scaphoclamys perakensis* Holtt. a) flower, b) inflorescence.

a)

b)

Fig. 40 *Zingiber spectabile* Griff. a) flower, b) inflorescence.

Fig. 41 *Zingiber* aff. *puberulum* var. *ovoidium* Holtt.
: inflorescence.

a)

b)

Fig. 42 *Zingiber* aff. *velutinum* J. Mood & I. Theilade
a) flower, b) plantlets.

Table 6 Monthly Rainfall (MM), Rain-days and Daily Maximum of study sites

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Narathiwat	Mean Amt.	206.7	112.1	168.4	149.9	219.0	249.0	278.2	339.6	355.9	304.5	507.3	594.9	3485.5
	Mean R-day	11.4	5.5	7.2	6.7	10.5	12.0	12.0	13.7	16.1	13.9	19.4	17.9	146.3
	Ext. Max.	134.3	118.5	111.9	136.4	118.8	88.4	88.2	92.1	100.5	180.9	155.2	209.5	209.5
Songkhla	Mean Amt.	18.8	27.3	55.8	94.9	152.2	130.1	108.8	136.9	165.2	237.5	328.4	294.2	1750.1
	Mean R-day	3.4	2.7	3.5	5.6	9.1	8.4	7.7	9.5	11.7	18.0	19.3	13.1	112.0
	Ext. Max.	37.8	49.0	64.0	118.9	146.3	55.7	67.5	102.7	69.2	101.6	123.0	136.8	146.3
Yala	Mean Amt.	43.2	72.8	144.8	194.9	176.6	111.0	133.9	167.0	177.8	268.8	228.2	156.0	1875.0
	Mean R-day	3.3	4.6	7.9	11.4	10.5	8.2	8.5	11.3	11.1	17.3	14.4	9.3	117.8
	Ext. Max.	55.0	56.0	74.0	75.5	83.0	65.0	93.0	92.1	83.0	70.0	98.7	107.0	107.0

Table 7 Relative Humidity (%) of study sites

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Narathiwat	Average	82	81	81	80	80	81	81	82	83	84	87	86	82
	Mean max.	93	93	94	93	93	94	94	95	95	95	96	95	94
	Mean min.	70	69	66	65	63	64	64	64	65	68	75	75	67
	Minimum	53	48	50	39	38	40	46	42	36	45	50	55	36
Songkhla	Average	76	77	77	77	77	76	76	77	78	83	85	82	78
	Mean max.	85	86	88	89	89	89	89	90	90	93	93	90	89
	Mean min.	69	67	67	65	63	61	60	60	63	70	74	74	66
	Minimum	52	32	48	44	40	40	40	35	39	44	48	59	32
Yala	Average	76.32	73.45	70.82	71.5	73.6	75.8	75.65	75.59	76.54	79	82.36	82.85	76.00
	Mean max.	105.73	105.45	105.18	104.82	106.6	107.3	107.3	106.45	106.90	107.45	107.54	108	106.17
	Mean min.	58.73	52.73	47.64	49.54	53.6	57.9	58.1	56.91	58.27	63.27	70	72	58.13
	Minimum	30	24	23	25	30	36	41	34	33	40	41	43	35.22

Table 8 Mean Temperature of study sites

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Yala	Mean	31.43	32.81	34.64	35.06	34.4	33.62	33.24	33.17	32.89	32.11	30.47	29.76	32.80
	Maximum	35.4	37.2	38.3	40	38.8	37.7	36.7	36.8	36	35.5	34.3	34.5	40
	Mean	22.24	22.3	22.74	23.53	24.01	23.82	23.48	23.3	23.29	23.26	23.12	22.73	23.15
	Minimum	21.1	21.3	21.9	22.8	23.8	23	23	22.8	22.7	22.8	22.6	22.1	21.1
	Average	26.84	27.55	28.69	29.29	29.20	28.72	28.36	28.24	28.09	27.69	26.79	26.24	27.98
Narathiwat	mean	26.3	26.6	27.3	28.1	28.4	27.8	27.6	27.3	27.1	26.9	26.2	26	27.1
	mean max.	29.9	30.6	31.8	32.8	33.5	33.1	32.8	32.7	32.3	31.5	29.9	29.2	31.7
	maximum	32.5	33.6	34.7	37	38.2	37	36.2	38.3	35.7	37.8	34.8	33.3	38.3
	mean min.	23.1	23.2	23.4	24	24.4	24	23.7	23.5	23.5	23.6	23.5	23.3	23.6
	minimum	19.2	18.7	18.8	22.3	21.7	20.3	20.5	21.6	21.6	21.7	21.2	20.2	18.7
Songkhla	mean	27.2	27.4	28.1	28.7	28.9	28.6	28.3	28	27.7	27.2	26.7	26.6	27.8
	mean max.	29.7	30.4	31.3	32.4	33.2	33	32.9	32.7	32.3	31	29.7	29	31.5
	maximum	32	34.1	35.2	36.1	36.3	36.5	36.3	35.9	35.8	35.5	33.4	31.8	36.5
	mean min.	24.8	24.8	25	25.3	25.5	25.2	24.8	24.7	24.5	24.3	24.3	24.3	24.8

Table 9 Soil properties of sample plots

	Moisture	Light	EC	OM	P	K	Particle	Porosity	Sand	Silt	Clay	c.e.c.	whcapasity	pH
aah	25.7458	4	0.027	3.32	1	81	2.53	44.66	70	12	18	4.1	28.42	4.8
aaj	41.42691	2	0.05	3.42	2	54	2.49	50.2	66	16	18	6.8	36.41	4.5
abp	28.00691	1	0.039	5.24	6	54	2.5	44.4	74	8	18	5.1	30.31	4.4
abph	47.35484	3	0.048	7.98	6	98	2.42	51.24	69	18	13	8.8	41.54	5
acp	47.36479	4	0.038	3.42	1	47	2.52	55.56	58	21	21	6.8	45.41	4.3
acp2	28.24179	1	0.028	2.25	2	34	2.58	52.32	63	21	16	4.7	35.05	4.2
aema	34.56273	1	0.072	4.5	4	81	2.54	48.82	71	14	15	6	33.79	4.5
aeme	36.75945	2	0.04	2.72	3	38	2.55	46.27	71	13	16	4.2	30.41	4.8
aepa	40.61041	3	0.042	4.16	2	52	2.54	51.97	62	14	24	6	37.98	4.4
aepa2	60.29777	4	0.05	5.14	4	225	2.52	53.97	66	16	18	7.9	39.62	5.4
aepu	48.42884	1	0.054	7.18	5	81	2.46	55.28	58	18	24	10.7	41.73	4.8
aes	53.24866	2	0.3	1.1	1	82	2.55	54.51	58	14	28	5	39.31	4.6
aha	34.93577	2	0.024	5.81	2	41	2.51	48.21	65	9	26	5.4	33.4	4.3
ahl	38.06054	3	0.055	7.72	3	46	2.45	52.24	55	11	34	9.2	39.85	4
apa	22.37905	4	0.053	5.27	1	98	2.5	44.8	73	7	20	4.6	28.64	4.3
asb	25.52461	1	0.025	7.98	2	34	2.53	48.62	61	14	25	5.1	33.04	4.6

Table 9 (continue)

	Moisture	Light	EC	OM	P	K	Particle	Porosity	Sand	Silt	Clay	c.e.c.	whcapasity	pH
asb	23.39115	2	0.044	1.68	4	41	2.58	50.39	60	22	18	4.6	33.63	4.7
asp	39.63225	3	0.07	2.2	9	38	2.47	57.08	50	16	34	8	50.31	4
azp	39.14141	4	0.239	3.16	16	108	2.54	51.97	70	16	14	6.2	37.89	5.4
bar	57.98711	1	0.054	4.5	6	97	2.5	50.4	73	17	10	7.2	38.57	6
bar2	55.10003	2	0.279	3.59	17	80	2.51	52.19	60	19	21	8.1	39.15	4.2
bbp	49.35599	3	0.032	2.15	4	44	2.56	47.66	65	19	16	5.5	33.38	5.5
bbs	66.23512	4	0.034	2.28	2	34	2.57	50.19	71	15	14	5.5	35.72	5
bee	45.68319	1	0.021	0.37	1	29	2.62	56.49	91	3	6	1.9	23.08	5.2
bepa	37.35114	3	0.046	1.61	3	61	2.54	45.67	64	22	14	3.7	28.02	4.9
bepu	30.1847	4	0.44	2.11	4	128	2.65	57.36	46	21	33	10.9	44.7	5.1
bes1	42.45971	1	0.068	6.78	5	88	2.43	59.26	52	15	33	8.1	50.82	4.2
bet	45.36791	2	0.12	9.94	5	96	2.38	58.82	46	9	45	13.4	56.14	3.7
bgc	52.98805	3	0.074	6.38	12	113	2.47	42.1	60	13	27	9	45.38	4.3
bgp	59.54757	4	0.089	10.68	10	107	2.43	54.32	75	13	12	8.7	40.48	4.5
bhc	39.05183	1	0.13	2.08	3	185	2.56	55.08	59	18	23	6.2	38.67	6.3
bhe	28.39096	2	0.063	2.42	3	105	2.57	46.4	62	21	17	6.4	34.18	6
bho	60.83898	2	0.049	5.57	9	141	2.52	53.17	67	13	20	6.8	38.38	5.2

Table 9 (continue)

	Moisture	Light	EC	OM	P	K	Particle	Porosity	Sand	Silt	Clay	c.e.c.	whcapasity	pH
bpa	41.91542	3	0.024	3.16	3	48	2.56	54.3	57	13	30	5.4	39.29	5
bzs	24.80774	1	0.209	6.1	14	81	2.49	49.4	89	7	4	6.1	31	5.9
bzv	51.22182	4	0.053	4.93	2	154	2.51	56.57	54	17	29	10.5	46.26	5.6
caa	16.17365	2	0.056	3.22	4	66	2.58	51.94	63	25	12	7.9	36.7	6.1
cab	20.45478	3	0.388	8.32	16	170	2.44	56.97	54	15	31	10.4	44.13	5
caj	16.72096	3	0.031	2.45	4	32	2.6	56.15	40	44	16	5.9	41.79	5.2
cao	25.54909	2	0.498	7.58	5	202	2.46	58.13	70	14	16	10.1	45.75	6.1
cbc	20.50262	4	0.028	3.05	1	73	2.54	57.09	43	11	46	7.9	45.48	4.6
cbp	9.470955	1	0.12	6.92	9	154	2.44	58.2	50	12	38	10.7	51.68	4.3
cbp	15.51605	2	0.045	2.48	9	58	2.56	52.34	75	19	6	3.2	39.52	5
cbr	32.15207	1	0.06	4.23	3	125	2.56	57.81	34	21	45	10.7	49.62	4.8
cec	18.24433	2	0.054	4.72	5	63	2.52	56.35	54	44	35	7.5	42.13	4
ceh	22.45763	3	0.083	5.47	3	469	2.49	56.22	50	14	36	11.7	47.29	6
cel	19.64976	3	0.046	1.11	4	52	2.6	50.38	85	7	8	3.6	33.66	5.3
ces	13.67911	2	0.024	2.52	2	60	2.59	53.67	56	18	26	3.7	41.77	4.7
cgpa	34.44976	2	0.042	1.74	4	60	2.62	48.09	58	21	21	3.9	30.22	4.3
cgpe	10.16316	3	0.036	1.24	1	52	2.65	45.8	64	19	15	2.8	26.41	4.4

Table 9 (continue)

	Moisture	Light	EC	OM	P	K	Particle	Porosity	Sand	Silt	Clay	c.e.c.	Whcapasity	pH
czs	37.06017	3	0.08	2.95	6	70	2.55	57.65	72	16	12	7.8	42.56	5.6
czv	27.56269	4	0.053	2.62	3	52	2.55	53.33	59	13	28	5.2	37.62	5.2

VITAE

Name: Mr. Charun Maknoi

Birth Date: May 2, 1971

Educational Attainment:

Degree	Name of Institution	Year of Graduation
B. Sc. (Botany)	Chulalongkorn University	1994

Scholar ship Awards during Enrolment:

Biodiversity Research and Training Program (BRT), grant no. 542005.

Work — Position and Address:

Technical Officer - Research Department, Botanical Garden Organization
Prime Minister's Office.
P.O. Box 7 Maerim,
Chiang Mai 50180