

DISTRIBUTION OF ZINGIBERACEAE IN CROCKER
RANGE, SABAH, BASED ON HERBARIUM
SPECIMENS.

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PERPUSTAKAAN
UNIVERSITI MALAYSIA SABAH

THESIS SUBMITTED IN PARTIAL
FULFILLMENT FOR THE DEGREE
OF MASTER OF SCIENCE

INSTITUTE FOR TROPICAL BIOLOGY AND
CONSERVATION
UNIVERSITI MALAYSIA SABAH
2011



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SABAH, BASED ON HERBARIUM SPECIMES.

IJAZAH: MASTER OF TAXONOMY AND BIODIVERSITY (COURSEWORK)

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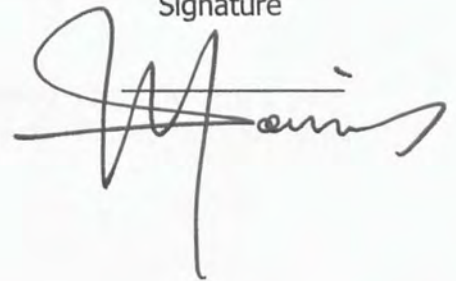
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ACKNOWLEDGEMENTS

First of all, I would like to thank my supervisor Dr. Monica Suleiman for her support and encouragement during the duration of this study. I am grateful to Madam Lam Nyee Fan who has supervised me on the aspects of Zingiberaceae. Her valuable advice is very much appreciated. Sincere thanks also to Mr. Liew Thor Seng for helping me with various problems of the Arcmap software and also for lending me his laptop for data analysis. Special thanks to Azrie Alliamat and Arnie Abdul Harmid, of ITBC Geographic Information System Laboratory, for giving guidance in producing maps using Arcmap software.

I am indebted to Madam Rimi Repin of Kinabalu Park who have allowed me to use some facilities in Kinabalu Park, such as the herbarium and library. Thanks to Mr. Richard Yamie, Mr. Arriffin Johari and Mr. Sinail who have guided me in Zingiberaceae identification.

Thank you to the Institute for Tropical Biology and Conservation and most of all the Centre of Postgraduate Study, UMS, for allowing me to continue this dissertation.

Lastly, thanks to Phin Chooi Yin and Stacy Chong Chai Yin, third year undergrad students who studied gingers for final year thesis, for valuable discussion.

Tymothy Leong Phui Yong
6 February 2011

ABSTRACT

DISTRIBUTION OF ZINGIBERACEAE IN CROCKER RANGE, SABAH, BASED ON HERBARIUM SPECIMENS

This research aimed to study the diversity of Zingiberaceae in Crocker Range and subsequently produce locality and distribution maps based on voucher specimens housed in Kinabalu Park Herbarium (SNP). The maps were produced using ArcMap Software. Ecological and taxonomical data from 430 specimens of Zingiberaceae (14 genera, 76 species) were reviewed. The specimens reviewed were *Alpinia* (80), *Etlingera* (77), *Globba* (62), *Amomum* (54), *Plagiostachys* (35), *Zingiber* (31), *Hornstedtia* (30), *Hedychium* (17), *Boesenbergia* (20), *Burridgea* (8), *Elettariopsis* (8), *Curcuma* (3), *Kaempferia* (3), and *Geocharis* (2). Nine locality maps of Zingiberaceae in Crocker Range were successfully produced: districts of Beaufort, Keningau, Kota Belud and Kota Marudu in one map, Papar, Penampang, Tambunan, Tenom, Tuaran and Ranau. There were 14 distribution maps of Zingiberaceae in Crocker Range generated. In total, 37 locality points of Zingiberaceae within Crocker Range were produced. Genus *Globba* has the widest distribution among all the genera in Crocker Range, while *Kaempferia* has the lowest distribution. Currently, Crocker Range has 121 species of Zingiberaceae. Out of this, 19 are new additions to the Zingiberaceae of Crocker Range, namely *Alpinia galangal*, *Boesenbergia grandis*, *Curcuma domestica*, *Etlingera amomoides*, *E. baculutea*, *E. coccinea*, *E. elatior*, *E. maingayi*, *E. megalocheilos*, *E. nasuta*, *E. rosamaria*, *E. sayapensis*, *Hedychium coronarium*, *Hornstedtia reticula*, *Kaempferia galangal*, *Plagiostachys viridisepala*, *Zingiber acuminatum*, *Z. gracile* and *Z. officinale*.

ABSTRAK

Disertasi ini adalah kajian tentang diversiti Zingiberaceae di Banjaran Crocker untuk menghasilkan peta localiti dan taburan berdasarkan spesimen dari Sabah Park Herbarium (SNP). Peta dihasilkan dengan Perisian ARCmap. Data ekologi dan taksonomi dari 730 spesimen (14 genera, 76 spesis) Zingiberaceae di Banjaran Crocker dari Sabah Park Herbarium (SNP) dikaji. Genera yang dikaji adalah *Alpinia* (80), *Etlingera* (77), *Globba* (62), *Amomum* (54), *Plagiostachys* (35), *Zingiber* (31), *Hornstedtia* (30), *Hedychium* (17), *Boesenbergia* (20), *Burbridgea* (8), *Elettariopsis* (8), *Curcuma* (3), *Kaempferia* (3), and *Geocharis* (2). Sembilan peta lokaliti di Banjaran Crocker daripada keluarga Zingiberaceae telah dihasilkan mengikut daerah, iaitu daerah Beaufort, Keningau, Kota Belud and Kota Marudu dalam satu peta, Papar, Penampang, Tambunan, Tenom, Tuaran dan Ranau. Empat belas peta taburan Zingiberaceae dihasilkan menggunakan ArcMap dengan 37 lokaliti titik telah dihasilkan. Genus *Globba* mempunyai taburan Zingiberaceae yang paling luas manakala *Kaempferia* hanya dijumpai di satu lokasi sahaja. Disertasi ini telah menyemak sebanyak 121 jenis spesis Zingiberacea di Banjaran Crocker. Sembilan belas spesis adalah rekod baru bagi Banjaran Crocker iaitu spesis *Alpinia galangal*, *Boesenbergia grandis*, *Curcuma domestica*, *Etlingera amomoides*, *E. baculutea*, *E. coccinea*, *E. elatior*, *E. maingayi*, *E. megolochelios*, *E. nasuta*, *E. rosamaria*, *E. sayapensis*, *Hedychium coronarium*, *Hornstedtia reticula*, *Kaempferia galangal*, *Plagiostachys viridisepala*, *Zingiber acuminatum*, *Z. gracile* dan *Z. officinale*.

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CHAPTER 1

1.0 INTRODUCTION

Zingiberaceae (ginger) is a very big family. There are many scopes yet to be studied to understand this Family (Sakai, 1997). Although researches on Zingiberaceae are numerous, quantitative ecology of Zingiberaceae in tropical rain forest, including those in Borneo, has been less studied. Thus, abundance and distribution of Zingiberaceae are rarely mentioned in the literature (Poulsen, 1994). Furthermore, timeline to identify Zingiberaceae species is limited because most of the species can only be identified during their flowering season (Gobilik, 2008).

Descriptions of habitats need to be included in taxonomic studies of Zingiberaceae (Sakai & Nagamasu 2000). In other words, to understand ginger, it requires very good knowledge on ginger ecology such as light, temperature, humidity, water and drainage system, soil nutrients and aeration, and tolerance (Huston, 1995). Soil, light, humidity and temperature are the major factors determining Zingiberaceae distributions (Poulsen, 2006).

There have been numerous collections of Zingiberaceae species by Sabah Park's staff. The specimens are kept in Sabah Park Herbarium (SNP) and mostly are identified to species level. These specimens are very important as they serve as the basis for all other studies on gingers, such as phytochemistry, tourism, pharmaceutical and systematics. Voucher specimens in herbaria are labeled with taxonomical and ecological data. This information can be utilized to produce valuable output, such as species diversity and distribution.

Thus far, there has been no distribution maps and comprehensive diversity study on the gingers of Crocker Range. SNP housed hundreds of specimens of gingers but the list is not published. Several fieldworks and expeditions have been carried out by Sabah Parks and other agencies in Sabah in recent years, adding to the number of botanical collections in SNP.



Thus, this study aimed to produce locality and distribution maps of all gingers according to districts in Crocker Range. These maps will be valuable for students or researchers who are interested to study the gingers in Crocker Range in future. This study utilized data from specimens of gingers collected within Crocker Range that are kept in SNP and compared with the list of gingers in Sarawak, Sabah, and Brunei (Gobilik, 2002). This study also updated the current knowledge on the diversity of Zingiberaceae in Sabah.

There are two specific objectives of this study:

- i. To study the distribution of Zingiberaceae in Crocker Range based on specimens in SNP.
- ii. To produce locality maps of Zingiberaceae in Crocker Range based on specimens in SNP.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Family Zingiberaceae

The Zingiberaceae, the largest family in the *Zingiberales*, consists of 53 genera and over 1,200 species. Zingiberaceae are found in all tropical regions of the world, but are more diverse in Afro-Eurasia which is Africa, Asia and Europe, and greatest in Southeast Asia especially in Indo-Malaysia. This useful herb plant is said to be originated from India, China and Java, yet it is also native to Africa and the West Indies (Ibrahim et al, 1999).

The taxonomic study of the family is very difficult because of the ephemeral flowers; often lasting less than a day, but the flower part is the main key for morphological identification of the Zingiberaceae. *Zingiber*, the root of the family name Zingiberaceae, comes from the Sanskrit word 'sringavera' meaning 'horn-shaped,' in reference to the rhizome (Lindl., 1835).

2.1.1 Characteristic of Zingiberaceae

Members of the family are small to large herbaceous plants, even though some species can reach a height of 8 m. The plants are either self-supporting or epiphytic. Zingiberaceae have a rhizome in common, which is typically an underground stem that produces leaves and roots, though in some Zingiberaceae the rhizome grows along the ground, and some others seem to stand on stilts (*Hornstedtia reticulata*) (Lindl., 1835).

Normally, the leaves of Zingiberaceae are arranged distichously which is two leaves in two opposite rows in one plane. The inflorescence is a cluster of specialised leaves supporting one or more highly specialized flowers that sometimes resemble orchids and are indeed often mistaken for orchids, especially the larger



and more spectacular Zingiberaceae flowers such as *Alpinia hansenii* or *Hedychium cylindricum* (Lindl, 1835).

Flowers can be found on or at the tip of the leafy shoot like in many *Alpinia* and *Globba* species, or on the ground where they spring directly from the rhizome on leafless shoots (such as many *Etlingera* sp). In this case the flowers can be far from the leaves. Others have a long flower stem, such as the torch ginger (*Etlingera elatior*). Because of their sometimes spectacular and brilliantly coloured flowers many Zingiberaceae are now grown as ornamental plants in tropical gardens; even the cut flower industry uses flowers and various other parts of Zingiberaceae in floral arrangements: the popular strelitzia and heliconia; birds of paradise flowers are related to Zingiberaceae too, belonging to the order of Zingiberales. Flowers of Zingiberaceae are hermaphroditic, usually strongly zygomorphic, in determinate cymose inflorescences, and subtended by conspicuous, spirally arranged bracts. The perianth is comprised of two whorls, a fused tubular calyx, and a tubular corolla with one lobe larger than the other two. Flowers typically have two of their stamenoids (sterile stamens) fused to form a petaloid lip, and have only one fertile stamen. The ovary is inferior and topped by two nectaries, and the stigma is funnel-shaped. Members of several genera, including *Alpinia*, *Amomum*, *Curcuma*, *Etlingera*, *Globba*, *Hedychium*, *Kaempferia*, and *Zingiber*, are grown as ornamentals or as spices (Poulsen, 1994).

The fruits of Zingiberaceae are often fleshy and sometimes open by three slits (*Hedychium cylindricum*) to reveal brightly coloured seeds. Actually, the seeds are black (or brown), but they are covered in fruit flesh (the aril), an arrangement to attract birds and other animals who eat the fruit and thus distribute the seeds (Ibrahim, 1998).

Several Zingiberaceae species are used in the food industry as spices and condiments, and some species are used in medicine. Zingiberaceae also play an important role in rainforest ecology as pioneer plants. After landslides, moderate forest fires and in abandoned hill-rice fields Zingiberaceae can be seen amongst the very first plants that occupy those open sites. Despite their importance in the

flower and food industry, in rainforest ecology and their many uses the knowledge of their basic taxonomy, their distribution and conservation status is still incomplete (Scholz, 2009).

2.1.2 Genera of Zingiberaceae

There are a total of 53 genera in Zingibeaceae recorded in The Phylogeny and a New Classification of the Gingers (Zingiberaceae) (Kress *et al.*, 2002) (Table 2.1). This family has four subfamilies, namely *Alpiniodeae*, *Zingiberoideae*, *Tamijoideae* and *Siphonochiloideae* (Figure 2.1).

Table 2.1: The genera in Zingiberaceae

1. <i>Aframomum</i>	20. <i>Geostachys</i>	39. <i>Pyrgophyllum</i>
2. <i>Alpinia</i>	21. <i>Globba</i>	40. <i>Renealmia</i>
3. <i>Amomum</i>	22. <i>Haniffia</i>	41. <i>Rhynchanthus</i>
4. <i>Aulotandra</i>	23. <i>Haplochorema</i>	42. <i>Riedelia</i>
5. <i>Boesenbergia</i>	24. <i>Hedychium</i>	43. <i>Roscoea</i>
6. <i>Burbridgea</i>	25. <i>Hemiorchis</i>	44. <i>Scaphochlamys</i>
7. <i>Camptandra</i>	26. <i>Hitchenia</i>	45. <i>Siamanthus</i>
8. <i>Caulokaempferia</i>	27. <i>Hornstedtia</i>	46. <i>Siliquamomum</i>
9. <i>Cautleya</i>	28. <i>Kaempferia</i>	47. <i>Siphonochilus</i>
10. <i>Cornukaempferia</i>	29. <i>Laosanthus</i>	48. <i>Smithatris</i>
11. <i>Curcuma</i>	30. <i>Leptosolena</i>	49. <i>Stadiochilus</i>
12. <i>Curcumorpha</i>	31. <i>Mantisia</i>	50. <i>Stahlianthus</i>
13. <i>Cyphostigma</i>	32. <i>Nanochilus</i>	51. <i>Tamijia</i>
14. <i>Distichochlamys</i>	33. <i>Paracautleya</i>	52. <i>Vanoverberghia</i>

15. <i>Elettaria</i>	34. <i>Parakaempferia</i>	53. <i>Zingiber</i>
16. <i>Elettariopsis</i>	35. <i>Paramomum</i>	
17. <i>Etlingera</i>	36. <i>Plagiostachys</i>	
18. <i>Gagnepainia</i>	37. <i>Pleuranthodium</i>	
19. <i>Geocharis</i>	38. <i>Pommereschea</i>	

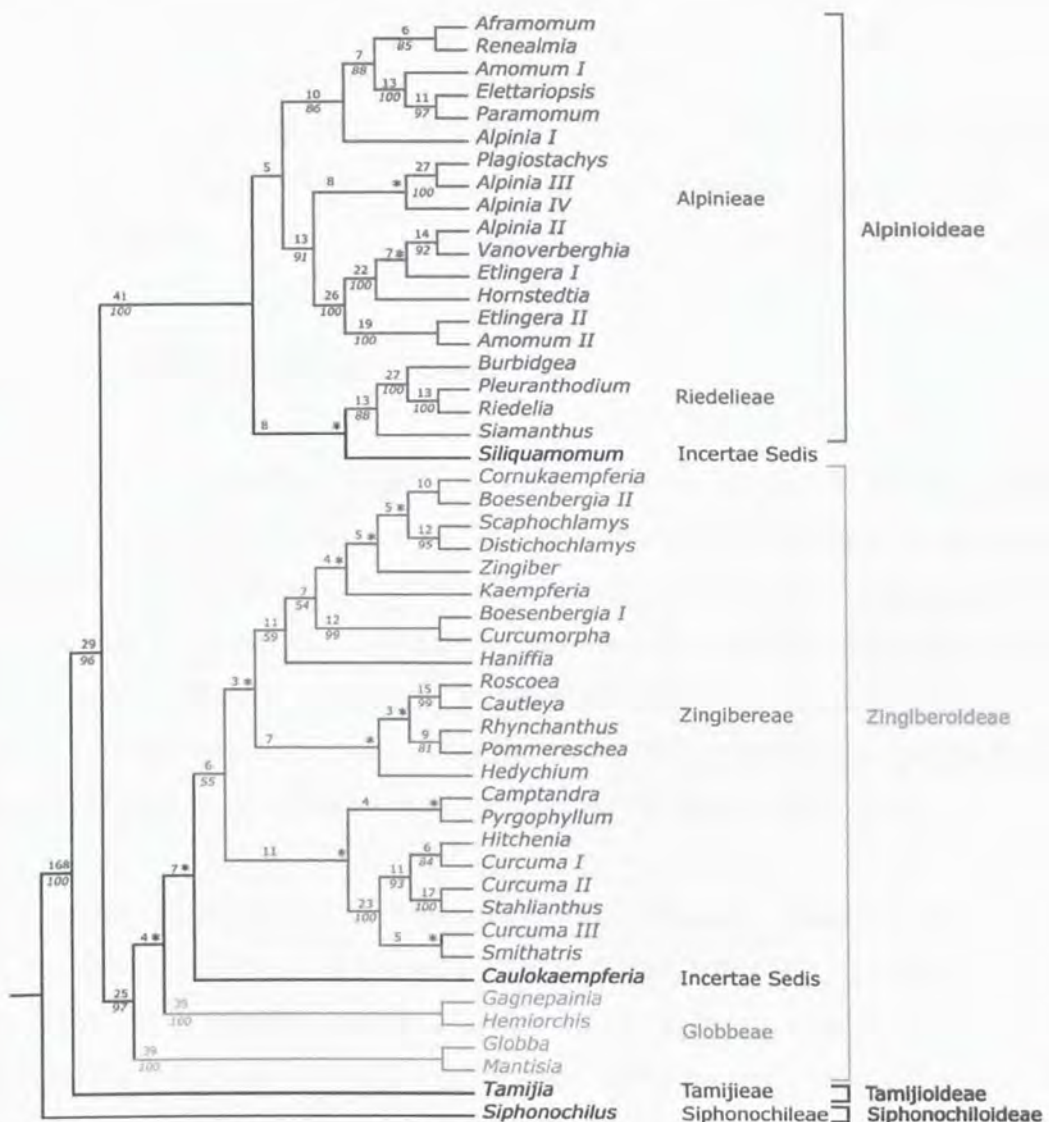


Figure 2.1: The Phylogeny and a New Classification of the Zingiberaceae
(Kress *et al.*, 2002)

2.2 Ecology of *Zingiberaceae*

Many *Zingiberaceae* species have been found abundant in areas that are wet, moist and well illuminate. Hence, in Sabah *Zingiberaceae* are abundant within 800-1000m above sea level where the humidity is higher and forest floor is better illuminated. Generally, *Zingiberaceae* are mostly terrestrial perennials but a few species may be epiphytic, such as several species in *Hedychium*, *Burbridgea* and occasionally *Amomum*. *Zingiberaceae* can also occasionally stay dormant with visible foliage under dry conditions but will grow again once conditions become suitable. *Zingiberaceae* can be placed in seven groups based on their most common habitats: (i) Epiphytic species, (ii) riverine species, (iii) disturbed on secondary forest species, (iv) mountain species, (v) primary forest species, (vi) small species on damp forest floor and (vii) species of swampy vegetation (Gobilik, 2002).

2.3 Studies of *Zingiberaceae* in Sabah

Early studies on the *Zingiberaceae* of Sabah were carried out in the late 19th century, especially at Mount Kinabalu. However, more intensive studies have only started about 20-30 years ago. Smith initiated the intensive taxonomic study of *Zingiberaceae* in Borneo including Sabah from 1982 to 1990 and nearly all of the species listed for Borneo were noted or described during this period. Although the gingers in Sabah have been studied over the years, there are still many genera that are not well studied, thus many species remain undescribed (Gobilik, 2002).

Generally, the progress of revision of *Zingiberaceae* in Sabah is fairly slow and assessment of the actual number of ginger species known and unknown is still poor. In previous research on *Zingiberaceae* of Crocker Range, most of the studies were carried out at Kinabalu Park, particularly along its nature trails. For some investigated trails, plants were collected, documented and processed for herbarium specimens (Ibrahim, 1998b). Whereas, in other locations of the Crocker Range lesser studies were carried out as compared to Kinabalu Park. Collection and identification of ginger species on Crocker Range have been done by Sabah Parks

during scientific expeditions and fieldworks. All of the specimens collected are preserved in SNP for reference.

The species failed to adapt the environmental condition in that place due to high herbivory and mortality, physiological limitations and environmental physical limitations such as insufficient light, nutrients deficiency, desiccation or high temperature. Some Zingiberaceae species can maintain their population because individuals of the same species have different dispersion rates, nutrient requirements, adaptation ability. Gobilik suggested there are 156 species of Zingiberaceae in Sabah (Gobilik, 2002).

Etlingera is among the most diverse and attractive of the genera found in Borneo. The present revision treats 42 taxa, including 16 new species, one new subspecies, one new variety, and one new combination. This more than doubles the number of species since modern careful revision was begun by Rosemary M. Smith 20 years ago (Poulsen, 2006).

In year 2000, There are three new species of Zingiberaceae added in Borneo, *Boesenbergia hosensis* found in Sarawak, *Amomum botryoideum* occurs in Brunei and *Boesenbergia armeniaca* occurs in both Sabah and Brunei. (Cowley, 2000).

The was a Zingiberaceae of Crocker Range checklist has been made during the Scientific Expedition 2002 at Crocker Range based on field work and examination of the herbarium material in several herbaria. Twelve genera and 45 species have been record from Crocker Range, namely *Alpinia beamanii*, *Alpinia glabra*, *Alpinia hansenii*, *Alpinia havilandii*, *Alpinia ligulata*, *Alpinia nieuwenhuizii*, *Amomum anomalum*, *Amomum coriaceum*, *Amomum dimorphum*, *Amomum kinabaluense*, *Amomum ligulatum*, *Amomum oliganthum*, *Amomum sceletescence*, *Boesenbergia gracilipes*, *Boesenbergia pulchella*, *Burbidgea schizochelia*, *Elettariopsis* sp., *Etlingera brevilabrum*, *Etlingera fimbriobracteata*, *Etlingera littoralis*, *Etlingera muluensis*, *Etlingera punicea*, *Etlingera velutina*, *Geocharis fusiformis*, *Globba atosanguinea*, *Globba franciscii*, *Globba pendula*, *Globba*

propinqua, *Globba tricolor* var. *gibbsiae*, *Hedychium cylindricum* , *Hedychium borneense*, *Hornstedtia gracilis*, *Hornstedtia incana*, *Plagiostachys albiflora*, *Plagiostachys crocydocalyx*, *Plagiostachys glandulosum*, *Plagiostachys parva*, *Plagiostachys strobilifera*, *Zingiber griffithii*, *Zingiber latifolium*, *Zingiber longipedunculatum*, *Zingiber pendulum*, *Zingiber phillippsii*, *Zingiber velutinum*, *Zingiber viridiflavum* (Atsuko et al, 2002).

CHAPTER 3

3.0 METHODOLOGY

3.1 Study sites inside the herbarium

Crocker Range (Figure 3.1) is located on the west coast of Sabah, stretching from Kota Marudu District at the North until Tenom at the south on the island of Borneo. Crocker Range covers 10 Districts, namely Beaufort, Keningau, Kota Belud, Kota Marudu, Papar, Penampang, Tambunan, Tenom, Tuaran, and Ranau. There are two National Parks in Crocker Range: Kinabalu Park and Crocker Range Park. Kinabalu Park covers an area of 754 square kilometers surrounding Mount Kinabalu. At 4,095 metres, it is the highest mountain on the island of Borneo, and also in South East Asia. The park headquarters is 88 kilometers away from the city of Kota Kinabalu. Sabah Park has been authorized to manage the reserve forested areas. Crocker Range Park covers 1,399 square kilometers, making it the largest park in Sabah. It covers the south Crocker Range, of 1200-1800 meter above sea level.

Crocker Range contains a variety of flora and fauna that ranges over four climate zones; from rich lowland dipterocarp forest through the montane oak, rhododendron, to the coniferous forests, to the alpine meadow plants, and to the stunted bushes of summit zone. There are over 5,000 – 6,000 species of vascular plants, comprising of over 200 families and 1,000 genera such as 1,000 orchid species, including five species of slipper orchids, 608 fern species, nine *Nepenthes* species (pitcher-plants, including four endemic species), 26 *Rhododendron* species (five species are endemic to Kinabalu), 52 palm species, six bamboo species, and most important is about 30 ginger species (Scholz, 2009).



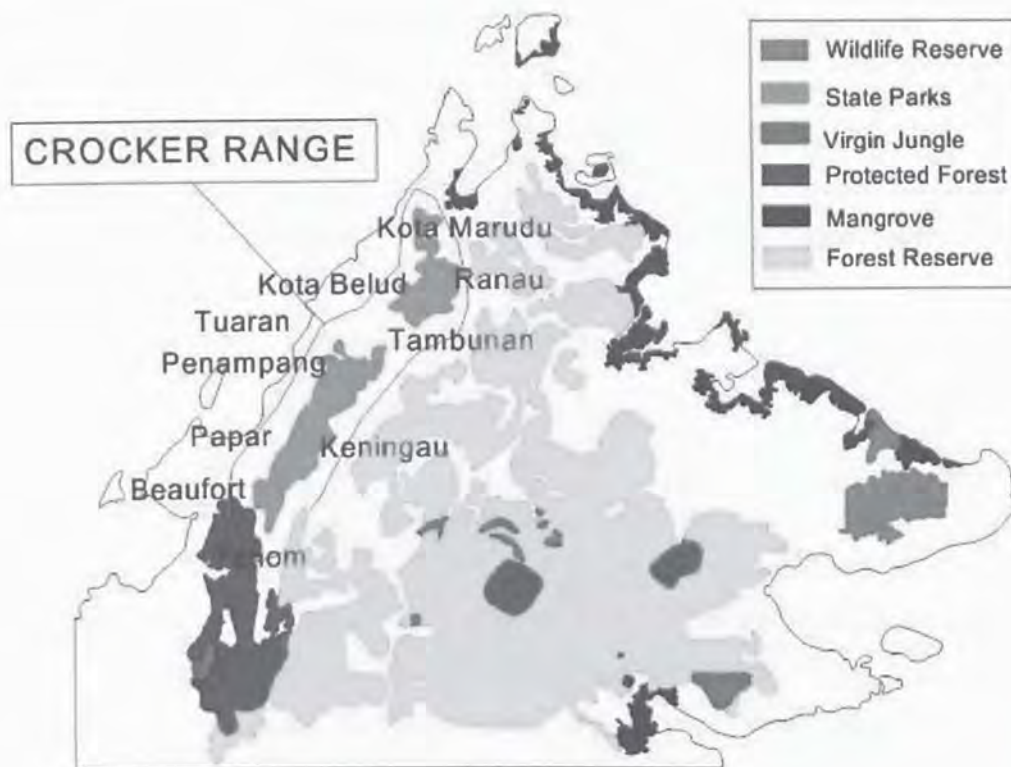


Figure 3.1: Map of Sabah showing the location of Crocker Range

3.2 Data collection

Source of specimen for this study were obtained from the Kinabalu Park's Herbarium (SNP). A field sheet was prepared which contain columns for species, species code, district, localities and altitude. All together there are 784 herbarium specimens for gingers of Crocker Range gathered from SNP (Appendix 1). Most of the specimens were collected from various nature trails in Kinabalu Park, especially at the Park Headquarters and Poring Hot Spring areas. Beside Kinabalu Park, specimens were collected from other locations including from Crocker Range Park.

Maps used were obtained from several relevant authorities in Sabah. Maps obtained are as followings:

1. Sabah Map showing Forest Reserve with scale 1:500,000, Jabatan Ukur dan Pemetaan Malaysia (JUPEM)
2. Sabah map showing road and towns with scale 1:500,000, JUPEM

3. District Map, Jabatan Tanah dan Ukur.
4. Contour Map with scale 1: 50,000, JUPEM
5. Map of Kinabalu Park, Sabah, Malaysia, Sabah Parks
6. Kinabalu Park Natural Trails
7. Stations and Control Posts of Crocker Range Park, Sabah Parks
8. Map of Salt Trail Trekking, Sabah Parks
9. Trails Map of Crocker Range Parks HQ, Sabah Parks

3.2.1 Data Analysis

After gathering the herbarium data, another new checklist (Appendix 2) was made because not all the data from Appendix 1 are useful to produce maps. Some data in Appendix 1 are outside Crocker Range, no location description or repeated specimens. This checklist was divided according to localities and district. Then, species number in Appendix 2 compared with the List of Gingers in Sarawak, Sabah, Brunei and in several areas therein by Gobilik, 2002 (Appendix 3) to calculate the diversity of ginger in Sabah.

3.3 Locality Maps

Most of the specimens in SNP are without coordinates because they are collected more than 20 years ago, where at that time usage of GPS was still not common. During those time locations coordinates were obtained from A Sabah Gazetteer (Tangah & Wong, 1995). Thus, coordinate were only approximate from the actual locations where the specimen were collected because the coordinates in the gazetteer were only along roads, rivers, towns, and villages accessible by car. Whereas, most of the specimens are collected along trails in the Parks which the coordinates can not be found in the gazetteer.

Base map were scanned by using scanner. Then, the selected information required namely, district, road, river, forest reserve, district's boundary and location names were drawn by using Autocad software.

The distance between two known points can be measured by scaling method. The scale for the base map is 1: 500,000. Therefore, 1cm on paper is equal to 5000m or 5 km on actual ground. Location's point shown on the map may represents more than one specimen's location even though the point has only one latitude and longitude value (Appendix 1). This is due to the small scale of 1:500,000 used in order to fit the map into an A4 size paper. Thus, 1 cm on the map is 5000 m or 5 km on actual ground.

Map produced by JUPEM and Lands and Survey Department have control points on it, and are usually marked with a triangle symbol e.g. Δ Mt. Alab, Tambunan N6456867.472, E 238044.045 or Latitude $5^{\circ} 49' 51''$, Longitude $116^{\circ} 20' 18''$. This coordinate values are available at the Control Section, Lands and Survey Department Kota Kinabalu. In order to coordinate a map, firstly, a control point was selected for each district. Then a new point was made anywhere beside the drawing and changed it centre x, y at properties into the true coordinates value which have been selected earlier. Finally, the whole drawing was moved and the control point was put into the new coordinated point. With this, the whole drawing was coordinated into the correct coordinated value. A Total of 9 localities maps were produce according to district: Beaufort, Keningau, Kota Belud and Kota Marudu in one map, Papar, Penampang, Tambunan, Tenom, Tuaran, and Ranau (Appendix 4).

3.5 Distribution Maps Production

The distribution map of gingers was produced using ARCmap in the Geographic Information System (GIS) Laboratory, ITBC. Firstly, the base map was registered and digitized. Then, all data file in excel was converted to SHP file using both google earth and DNRgarmin software. Finally, all the SHP files were put in layers in ARCmap software to produce the distribution maps.

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