

**PHYLOGENETIC AND MORPHOLOGICAL STUDY OF  
*SCHISMATOGLOTTIS* (ARACEAE) IN SABAH,  
MALAYSIA**



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**UMS**  
UNIVERSITI MALAYSIA SABAH

**INSTITUTE FOR TROPICAL BIOLOGY  
AND CONSERVATION  
UNIVERSITI MALAYSIA SABAH  
2023**

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*SCHISMATOGLOTTIS* (ARACEAE) IN SABAH,  
MALAYSIA**

**NURUL HASANAH BINTI HARISIN**



**THIS IS SUBMITTED IN FULFILMENT OF  
THE REQUIREMENTS FOR THE DEGREE OF  
MASTER OF SCIENCE**

**INSTITUTE OF TROPICAL BIOLOGY  
AND CONSERVATION  
UNIVERSITI MALAYSIA SABAH  
2023**

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*SCHISMATOGLOTTIS (ARACEAE) IN SABAH, MALAYSIA***  
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Tarikh : 29 September 2023



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## DECLARATION

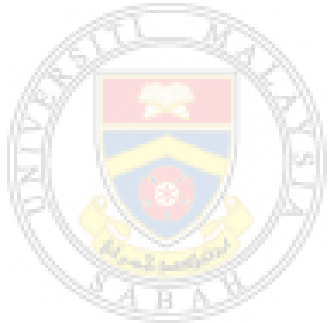
I hereby declare that the material in this thesis is my own except for quotations, equations, summaries, and references, which have been fully acknowledged.

27 June 2023



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This journey will continue one fine day.

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27 June 2023.

## ABSTRACT

The tribe Schismatoglottideae is one of the most species-rich and diverse Araceae taxa in Borneo. Schismatoglottideae contains a diverse group of rainforest terrestrial, lithophytic or rheophytic herbs centred in Borneo. The genus *Schismatoglottis* has more than 175 species with the majority endemic in Borneo with strictly geological obligated. This study was carried out to archive these following objectives; (1) To investigate phylogeny construction by using the Internal Transcribed Spacer (ITS) region on selected *Schismatoglottis* in Sabah, (2) To investigate phylogeny construction by using trnL-F region on selected *Schismatoglottis* in Sabah, and (3) To mapping the morphology characteristics of the selected Schismatoglottis genus based on constructed phylogenetic tree. A total of 22 taxa were collected from nine different localities within Sabah, these are Kinabalu National Park (Sayap substation), Kadamaian-Kinabalu Park (Kota Belud), Kionsom Recreational Area, Imbak Canyon Conservation Area, Mensalong Forest Reserve (Kota Marudu), Danum Valley Conservation Area, Tawau Hills Park, Sungai Rawog Conservation Area and Mantailang (Tenom) Crocker Range Park. Phylogenetic analyses of *Schismatoglottis* were carried out in this study based on nuclear of Internal Transcribed Spacer (ITS) and chloroplast DNA (trnL-F) sequences. Analysis of combined datasets analyzed with Maximum Likelihood and Bayesian Inference methods. The phylogenetic relationship of two combined DNA regions was done employing 22 taxa and one outgroup (*Apoballis mutata*). The phylogenetic tree of combined analysis for ITS gene in this study produced five clades, whereas the phylogenetic tree of combined analysis for trnL-F region in this study produced four clades. Meanwhile, the phylogenetic tree of Maximum Likelihood analysis by using concatenate data, produced two major clades, and the phylogenetic tree of Bayesian Inference analysis using the same concatenate data produced five clades. The outcomes of each of the four different phylogenetic trees yield four sister clades that are identical to one another. The four consistent sister clades give a prove that using two phylogenetic methods (Maximum Likelihood, use heuristic search to find the best tree, while Bayesian Inference use posterior probability) would be needed to confirm the four sister clades. Through genetic, morphological, or other investigations, phylogenetic relationships between various species or organisms are intended to be understood. Due to several variables, including data selection, analysis methods, and underlying assumptions, these studies may yield varying results depending on the methodologies utilised. The data selection and quality, the handling of missing data, the differences in the phylogenetic method utilised, and other factors were the justifications for the divergent results. In conclusion, incorporating morphological and molecular data into phylogenetic research can offer a more comprehensive and robust view on evolutionary relationships, providing a richer and more accurate representation of the tree of life.

## **ABSTRAK**

### **KAJIAN FILOGENETIK DAN MORFOLOGI GENUS SCHISMATOGLOTTIS (ARACEAE) DI SABAH.**

'Tribe' Schismatoglottideae ialah salah satu taksa Araceae yang paling kaya dengan spesies dan pelbagai di Borneo. Schismatoglottideae mengandungi pelbagai kumpulan herba daratan, lithophytic atau rheophytic hutan hujan yang berpusat di Borneo. Genus Schismatoglottis mempunyai lebih daripada 175 spesies dengan majoriti endemik di Borneo dengan eadaan geologi yang khusus (geological obligated). Kajian ini dijalankan (1) Untuk menyiasat pembinaan filogeni dengan menggunakan 'Internal Transcribed Spacer' (ITS) pada Schismatoglottis terpilih di Sabah. (2) Untuk menyiasat pembinaan filogeni dengan menggunakan trnL-F pada Schismatoglottis terpilih di Sabah. (3) Untuk memetakan ciri morfologi genus Schismatoglottis yang dipilih berdasarkan pokok filogenetik yang dibina. Sebanyak 22 taksa telah diambil dari sembilan lokaliti berbeza di Sabah iaitu Taman Negara Kinabalu (Substesyen Sayap), Taman Kadamaian-Kinabalu (Kota Belud), Kawasan Rekreasi Kionsom, Kawasan Pemuliharaan Imbak Canyon, Hutan Simpan Mensalong (Kota Marudu), Kawasan Pemuliharaan Lembah Danum, Taman Bukit Tawau, Hutan Simpan Segaliud Lokan dan Taman Banjaran Crocker Mantailang (Tenom). Analisis filogenetik Schismatoglottis telah dijalankan dalam kajian ini berdasarkan nuklear 'Internal Transcribed Spacer' (ITS) dan urutan DNA kloroplas (trnL-F). Analisis set data gabungan dianalisis dengan kaedah 'Maximum Likelihood' dan 'Bayesian Inference'. Hubungan filogenetik dua bahagian DNA gabungan telah dilakukan dengan menggunakan 22 taksa dan satu 'outgroup' (*Apoballis mutata*). Pokok filogenetik analisis gabungan untuk gen ITS dalam kajian ini menghasilkan lima klad, manakala pokok filogenetik analisis gabungan untuk trnL-F dalam kajian ini menghasilkan empat klad. Manakala, pokok filogenetik analisis 'Maximum Likelihood' dengan menggunakan data gabungan, menghasilkan dua klad utama dan pokok filogenetik analisis 'Bayesian Inference' menggunakan data gabungan yang sama menghasilkan lima klad. Hasil daripada setiap empat pokok filogenetik yang berbeza menghasilkan empat 'sister' klad yang sama antara satu sama lain. Empat 'sister' klad yang konsisten memberikan bukti bahawa menggunakan dua kaedah filogenetik ('Maximum Likelihood', gunakan carian heuristik untuk mencari pokok terbaik, manakala 'Bayesian Inference' menggunakan kebarangkalian posterior) diperlukan untuk mengesahkan empat 'sister' klad. Melalui penyiasatan genetik, morfologi atau lain-lain, hubungan filogenetik antara pelbagai spesies atau organisma bertujuan untuk difahami. Disebabkan oleh beberapa pembolehubah, termasuk pemilihan data, kaedah analisis, dan andaian asas, kajian ini mungkin menghasilkan keputusan yang berbeza-beza bergantung pada metodologi yang digunakan. Pemilihan dan kualiti data, pengendalian data yang hilang, perbezaan dalam kaedah filogenetik yang digunakan, dan faktor lain adalah justifikasi untuk keputusan yang berbeza. Kesimpulannya, menggabungkan data morfologi dan molekul ke dalam penyelidikan filogenetik boleh menawarkan pandangan yang lebih komprehensif tentang hubungan



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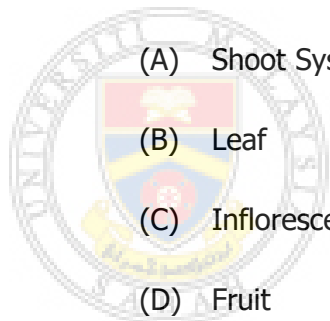


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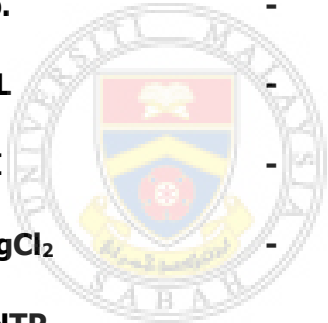
<b>g</b>	-	gram
<b>U</b>	-	Unit
<b>μL</b>	-	Microlitre
<b>°C</b>	-	Degree Celsius
<b>mM</b>	-	Millimolar
<b>μM</b>	-	Micromolar



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## LIST OF ABBREVIATIONS

<b>ITBC</b>	-	Institute for Tropical Biology and Conservation
<b>ITS</b>	-	Internal Transcribed Spacer
<b>DNA</b>	-	Deoxyribonucleic Acid
<b>PCR</b>	-	Polymerase Chain Reaction
<b>m a.s.l.</b>	-	metre above sea level
<b>ddH<sub>2</sub>O</b>	-	Double distilled water
<b>sp.</b>	-	species (singular)
<b>ML</b>	-	Maximum Likelihood
<b>BI</b>	-	Bayesian Inference
<b>MgCl<sub>2</sub></b>	-	Magnesium Chloride
<b>dNTP</b>	-	Deoxynucleoside triphosphate
<b>BS</b>	-	bootstrap
<b>PP</b>	-	posterior probability



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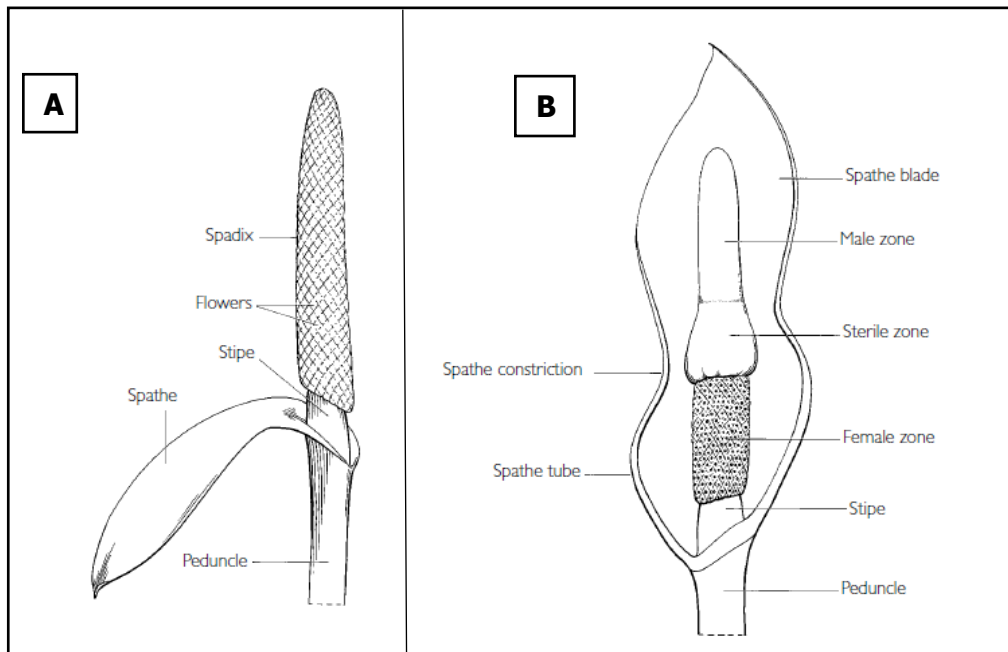
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# CHAPTER 1

## INTRODUCTION

### 1.1 Background

The Araceae family is well-known, and its members are known as Aroids. The family consists of about seven subfamilies, 32 tribes, and 144 genera with 6,000 estimated species (Mayo *et al.*, 1997). Currently, 4,000 species of Araceae were formally described and updated in an ongoing list since 2011 until now (Boyce & Croat, 2011). The family is defined by having minute sessile either unisexual or bisexual flowers located on spadix (Figure 1.1). The spadix is usually bisexual or unisexual and covered by a solitary spathe on either a long or short peduncle (Mayo *et al.*, 1997). The tribe Schismatoglottideae Nakai is one of the most diverse in the Araceae family with excess than 120 species with more than 95% of which are endemic (Low *et al.*, 2018). The tribe includes *Schismatoglottis* Zoll. & Moritzi, the biggest genus, in addition, includes four minor genera, or "satellites": *Bucephalandra* Schott, *Aridarum* Ridl, *Piptospatha* N.E. Br. and *Phymatarum* M. Hotta (Hay & Yuzammi, 2000). Although the Schismatoglottideae tribe is prevalent in southeast Asia, it poses many challenges to the current definition of the genus boundaries.



**Figure 1.1 : Inflorescence types: A, bisexual flowered spadix with a simple, undifferentiated spathe; B, unisexual flowered spadix with a spathe divided into a limb (blade) and convolute lower tube.**

Source : Mayo *et al.* (1997)

The species belonging to the Araceae family was one of the most popular choices among so-called "flower lovers" due to the wide range of colours and the fact that it required little maintenance. *Schismatoglottis scintillans* for example is a wild species of Araceae described in 2013 (Scherberich & Boyce, 2013). This species is a plant that has the potential to be an aesthetic foliage plant due to its small size, high degree of attractiveness, and the fact that it is simple to cultivate. In addition, there are currently a lot of flower shops throughout Malaysia that offer a wide range of Araceae plants locally known as "keladi" in Malay.

Nearly 25% of the *Schismatoglottis* species found in Malesia are only known from their types, and nearly 50% are only known from three or fewer herbarium records. It is conceivable that might be some occurrences may be attributed to inadequate collection efforts. Nevertheless, the notable recurrence of such cases unmistakably underscores an elevated degree of exceedingly localized endemism within this genus, notably concentrated in the Borneo region. Highly localized species can occasionally be widely distributed within their specified region, for example, *Schismatoglottis imbakensis* (Kartini *et al.*, 2020). However, based on the current distribution data, several species of *Schismatoglottis* are potentially at risk of extinction due to the loss of quite small sections of their natural habitat, for instance, *Schismatoglottis imbakensis* is only found in the primary lowland mixed dipterocarp forest on Cretaceous Harzburgite and Serpentinite outcrops, where it grows on steep, muddy riverbanks above the flood zone, at a height of around 270 m asl. It is also endemic to the area. Before any species is suggested for classification as endangered, botanists with ready access to the field must confirm their conservation status (Hay & Yuzammi, 2000).

Worldwide, the genus *Schismatoglottis* (included within the Schismatoglottideae tribe) has more than 175 species (Kartini *et al.*, 2017). The majority of *Schismatoglottis* species are able to propagate spontaneously in their natural habitats, either from complete or partial leaf fragments. Most species are locally endemic and normally found in geologically obligated. There is substantial evidence of vicariance events, particularly in limestone-restricted species where partially isolated limestone outcrops are frequently connected with allopatric local endemism (Ting *et al.*, 2012; Wong & Boyce, 2011; Wong, 2010).

*Schismatoglottis* is a unique plant. The plants are characterized by their large, glossy, green leaves that can range in size from a few centimeters to over a meter long. The leaves are usually heart-shaped or, and often have distinctive patterns or variegations.