

COMPARATIVE LEAF MORPHOLOGICAL,
ANATOMICAL AND PHYTOCHEMICAL
STUDY OF SOME TAXA IN
LAMIACEAE AND
VERBENACEAE

NORHAZILA BINTI HUSSIN

UNIVERSITI PENDIDIKAN SULTAN IDRIS

2023



05-4506832



pustaka.upsi.edu.my



Perpustakaan Tuanku Bainun
Kampus Sultan Abdul Jalil Shah



PustakaTBainun



ptbupsi

COMPARATIVE LEAF MORPHOLOGICAL, ANATOMICAL AND
PHYTOCHEMICAL STUDY OF SOME TAXA IN LAMIACEAE
AND VERBENACEAE

NORHAZILA BINTI HUSSIN



05-4506832



pustaka.upsi.edu.my



Perpustakaan Tuanku Bainun
Kampus Sultan Abdul Jalil Shah



PustakaTBainun



ptbupsi

THESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENT FOR
DEGREE OF DOCTOR OF PHILOSOPHY (BIOLOGY)

FACULTY OF SCIENCE AND MATHEMATICS
UNIVERSITI PENDIDIKAN SULTAN IDRIS

2023



05-4506832



pustaka.upsi.edu.my



Perpustakaan Tuanku Bainun
Kampus Sultan Abdul Jalil Shah



PustakaTBainun



ptbupsi



Please tick (✓)

Project Paper

Masters by Research

Master by Mixed Mode

PhD

<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>
<input checked="" type="checkbox"/>

INSTITUTE OF GRADUATE STUDIES**DECLARATION OF ORIGINAL WORK**

This declaration is made on the **12th** day of **September 2023**

i. Student's Declaration:

I, **NORHAZILA BINTI HUSSIN, P20132002392, FACULTY OF SCIENCE AND MATHEMATICS** (PLEASE INDICATE STUDENT'S NAME, MATRIC NO. AND FACULTY) hereby declare that the work entitled **COMPARATIVE LEAF MORPHOLOGICAL, ANATOMICAL AND PHYTOCHEMICAL STUDY OF SOME TAXA IN LAMIACEAE AND VERBENACEAE** is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

Signature of the student

ii. Supervisor's Declaration:

I, **ASSOC. PROF. DR. NOR NAFIZAH MOHD NOOR** (SUPERVISOR'S NAME) hereby certifies that the work entitled **COMPARATIVE LEAF MORPHOLOGICAL, ANATOMICAL AND PHYTOCHEMICAL STUDY OF SOME TAXA IN LAMIACEAE AND VERBENACEAE** (TITLE) was prepared by the above named student, and was submitted to the Institute of Graduate Studies as a * partial/full fulfillment for the conferment of **DEGREE OF DOCTOR OF PHILOSOPHY** (PLEASE INDICATE THE DEGREE), and the aforementioned work, to the best of my knowledge, is the said student's work.

10/11/2023

Date

Signature of the Supervisor





**INSTITUT PENGAJIAN SISWAZAH /
INSTITUTE OF GRADUATE STUDIES**

**BORANG PENGESAHAN PENYERAHAN TESIS/DISERTASI/LAPORAN KERTAS PROJEK
DECLARATION OF THESIS/DISSERTATION/PROJECT PAPER FORM**

Tajuk / Title: COMPARATIVE LEAF MORPHOLOGICAL, ANATOMICAL AND
PHYTOCHEMICAL STUDY OF SOME TAXA IN LAMIACEAE AND
VERBENACEAE

No. Matrik /Matric's No.: P20132002392

Saya / I : NORHAZILA BINTI HUSSIN

(Nama pelajar / Student's Name)

mengaku membenarkan Tesis/Disertasi/Laporan Kertas Projek (Kedoktoran/Sarjana)* ini disimpan di Universiti Pendidikan Sultan Idris (Perpustakaan Tuanku Bainun) dengan syarat-syarat kegunaan seperti berikut:-

acknowledged that Universiti Pendidikan Sultan Idris (Tuanku Bainun Library) reserves the right as follows:-

1. Tesis/Disertasi/Laporan Kertas Projek ini adalah hak milik UPSI.
The thesis is the property of Universiti Pendidikan Sultan Idris
2. Perpustakaan Tuanku Bainun dibenarkan membuat salinan untuk tujuan rujukan dan penyelidikan.
Tuanku Bainun Library has the right to make copies for the purpose of reference and research.
3. Perpustakaan dibenarkan membuat salinan Tesis/Disertasi ini sebagai bahan pertukaran antara Institusi Pengajian Tinggi.
The Library has the right to make copies of the thesis for academic exchange.
4. Sila tandakan () bagi pilihan kategori di bawah / *Please tick () for category below:-*

SULIT/CONFIDENTIAL

Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub dalam Akta Rahsia Rasmi 1972. / *Contains confidential information under the Official Secret Act 1972*

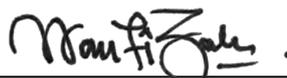
TERHAD/RESTRICTED

Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan ini dijalankan. / *Contains restricted information as specified by the organization where research was done.*

TIDAK TERHAD / OPEN ACCESS



(Tandatangan Pelajar/ Signature)



(Tandatangan Penyelia / Signature of Supervisor)
& (Nama & Cop Rasmi / Name & Official Stamp)

Tarikh: 10/11/2023

Prof. Madya Dr. Nor Nafizah Mohd Noor
Pensyarah
Jabatan Biologi
Fakulti Sains & Matematik
Universiti Pendidikan Sultan Idris

Catatan: Jika Tesis/Disertasi ini **SULIT @ TERHAD**, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan ini perlu dikelaskan sebagai **SULIT** dan **TERHAD**.

Notes: If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentiality or restriction.



ACKNOWLEDGEMENTS

Alhamdulillah, thank you Allah.

I would like to express my sincere appreciation to the Ministry of Education for providing MyPhD, MyBrain scholarship which allowed me to pursue this study. This study also was made possible through financial support from the Ministry of Education Fundamental Research Grant Scheme (FRGS) 2014-0113-108-02 and Universiti Pendidikan Sultan Idris Research Grant (GPU) 2014-0072-108-01.

I wish to express my deep sense of gratitude and indebtedness to those who helped me directly or indirectly during my long PhD journey. Especially I am indebted to my supervisor Assoc. Prof. Dr. Nor Nafizah Mohd Noor and my co-supervisor Assoc. Prof. Dr. Fatimah Mohamed who always give suggestions and criticisms for the improvement of this research. Thank you to both of you for the continuous guidance, patience, and motivation. I really appreciate everything both of you have done for me. Thanks again.



My sincere thanks to En. Abu Husin Harun who always assisted me in several ways especially in field sample collection, also to KEP and UKMB for providing herbarium vouchers for plant observations.

I take the opportunity to thank the Universiti Pendidikan Sultan Idris staff Kak Ira, En. Hashimi and to all Biology and Chemistry lab assistants for advice and loans of lab apparatus. I wish to thank the following friends Norlida, Nina, Atul, Nur Hidayat, Nasibah, Amirah, Syana, Ain, Mas, Fina, and all for the accompany in this journey. Thank you to all for encouragement and moral support.

Lastly, I express my special appreciation to my family, especially to my late ayah Hussin Abdullah, umi Normah Mohd. Ali, all my sisters Norhafiza, Norhazani, Norhasima, Norhasraf, Norhanim, and also to my nieces and nephew, Kakak Damia, Darwisy, Zara, and Medina. I am grateful to my family, who always encouraged and inspired me for the task. Thank you for always make me strong, for prayers, and encouraged me to complete this journey.



ABSTRACT

The comparative study was conducted to investigate the systematics of six genera of Lamiaceae and two genera of Verbenaceae. Three aspects of the study, which were morphological, anatomical and phytochemical, were carried out to determine significant taxonomic characters. The data obtained were then used to construct taxonomic keys for genera and species involved. A total of 22 species were collected from several forest reserves in Malaysia. Samples were prepared for herbarium vouchers, anatomical study, and phytochemical procedures. Morphological characters were observed and recorded. Anatomical slides of leaf were prepared using standard microtechnique method, while phytochemical screening was conducted using Qualitative Phytochemical Screening and Thin Layer Chromatograph (TLC). All characters obtained were numerically analyzed using the Multivariate Statistical Package (MVSP) and Phylogeny Analysis Using Parsimony (PAUP). The findings showed that some characters have high taxonomic significant value. Leaves margin and venation are diagnostic characters in morphological findings. Petiole and midrib outline, petiole and midrib vascular bundle, type of stomata, type of trichomes and the presence of vascular subsidiaries are the diagnostic characters in anatomical findings. In phytochemical study, terpenoids, flavonoids, and alkaloids are present in almost all species studied, while saponins are only detected in nine species, namely *Congea forbesii*, *Congea griffithiana*, *Sphenodesme racemosa*, *Clerodendrum breviflorum*, *Clerodendrum disparifolium*, *Lantana camara*, *Stachytarpheta indica*, *Stachytarpheta jamaicensis* and *Stachytarpheta cayennensis*. Numerical analysis showed that two main clades were formed at 0.709 and 0.821 of GGSc value to indicate the delineation of the two families. Morphological and anatomical findings able to contribute solution to taxonomic problem, while phytochemical data provide vital preliminary information of the studied species. Finally, it is concluded that all aspects of studies numerically support the classification of Li et al., therefore implicates that the findings can serve as important taxonomic references to the current classification of the families.

KAJIAN PERBANDINGAN MORFOLOGI, ANATOMI DAN FITOKIMIA DAUN BEBERAPA TAKSON DALAM LAMIACEAE DAN VERBENACEAE

ABSTRAK

Kajian perbandingan ini telah dijalankan bertujuan untuk mengkaji sistematik enam genus daripada famili Lamiaceae dan dua genus daripada famili Verbenaceae. Tiga aspek kajian iaitu morfologi, anatomi dan fitokimia dijalankan bagi menentukan ciri taksonomi yang signifikan. Data yang diperoleh seterusnya digunakan untuk membina kunci taksonomi bagi genus dan spesies yang terlibat. Sejumlah 22 spesies diperolehi daripada beberapa hutan simpan di Malaysia. Sampel disediakan untuk baucar herbarium, kajian anatomi dan prosedur fitokimia. Karakter morfologi diperhatikan dan direkodkan. Slaid anatomi disediakan menggunakan kaedah piawai mikroteknik manakala saringan fitokimia dijalankan menggunakan kaedah *Qualitative Phytochemical Screening* dan *Thin Layer Chromatograph (TLC)*. Kesemua karakter dianalisis secara numerik menggunakan *Multivariate Statistical Package (MVSP)* dan *Phylogeny Analysis Using Parsimony (PAUP)*. Dapatan kajian menunjukkan beberapa karakter mempunyai nilai taksonomi signifikan yang tinggi. Margin dan peruratan daun adalah karakter diagnostik bagi dapatan morfologi. Garis luar bagi petiol serta tulang daun, bentuk berkas vaskular petiol dan tulang daun, jenis stomata, jenis trikoma dan kehadiran vaskular subsidiari adalah karakter diagnostik bagi dapatan anatomi. Kajian fitokimia pula menunjukkan kehadiran terpenoid, flavonoid dan alkaloid dalam hampir kesemua spesies yang dikaji manakala saponin hadir pada sembilan spesies iaitu *Congea forbesii*, *Congea griffithiana*, *Sphenodesme racemosa*, *Clerodendrum breviflorum*, *Clerodendrum disparifolium*, *Lantana camara*, *Stachytarpheta indica*, *Stachytarpheta jamaicensis* dan *Stachytarpheta cayennensis*. Analisis numerik mempamerkan dua klade utama terbentuk dengan nilai GGSc pada 0.709 dan 0.821 yang menunjukkan persempadan dua famili. Dapatan morfologi dan anatomi mampu menyumbang kepada penyelesaian masalah taksonomi manakala data fitokimia memberikan maklumat awal yang penting bagi spesies yang dikaji. Akhirnya, ia dapat disimpulkan bahawa semua aspek yang dikaji secara numerik menyokong klasifikasi oleh Li et al., oleh itu memberi implikasi bahawa dapatan ini boleh berfungsi sebagai rujukan taksonomi yang penting kepada pengelasan famili yang terkini.

TABLE OF CONTENTS

	Page
DECLARATION OF ORIGINAL WORK	ii
DECLARATION OF THESIS	iii
ACKNOWLEDGEMENTS	iv
ABSTRACT	v
ABSTRAK	vi
TABLE OF CONTENT	vii
LIST OF TABLES	viii
LIST OF FIGURES	xii
LIST OF ABBREVIATIONS	xiv
APPENDIX LIST	xxii
CHAPTER 1 INTRODUCTION	
1.1 Introduction	1
1.2 Research Background	3
1.3 Problem Statements	5
1.4 Research Objectives	8
1.5 Research Questions	8
1.6 Research Significance	9
1.7 Study Limitation	10

CHAPTER 2 LITERATURE REVIEW

2.1	Introduction	11
2.2	Verbenaceae and Lamiaceae Taxonomic Treatments	12
2.3	Review of Morphological Study	19
2.4	Review of Anatomical Study	43
2.5	Review of Phytochemical Study	45
2.6	Existing Taxonomic Key	48
2.7	Economic Importance and Medicinal Value	49

CHAPTER 3 MORPHOLOGICAL STUDY

3.1	Introduction	53
3.2	Methodology	53
3.2.1	Sample Collection	54
3.2.2	Herbarium Preparation	54
3.2.3	Data Observation	55
3.2.4	Morphological Dichotomous Key	56
3.3	Result and Discussion	56
3.3.1	Distribution of Lamiaceae and Verbenaceae	61
3.3.2	Morphological Characteristics of Lamiaceae and Verbenaceae	77
3.3.2.1	Diagnostic Characters	93
3.3.2.2	Taxonomic Key and Species Description	94

CHAPTER 4 ANATOMICAL STUDY

4.1	Introduction	164
4.2	Methodology	165
4.2.1	Sectioning and Staining	165
4.2.2	Epidermal Peel	166
4.2.3	Leaf Clearing	166
4.2.4	Leaf Epidermal SEM Observation	167
4.3	Result and Discussion	167
4.3.1	Anatomical Characteristics of Lamiaceae and Verbenaceae	186
4.3.1.1	Diagnostic Characters	239
4.3.1.2	Taxonomic Key	240
4.3.1.3	Species Descriptions	243

CHAPTER 5 PHYTOCHEMICAL STUDY

5.1	Introduction	259
5.2	Methodology	260
5.2.1	Plant Materials	261
5.2.2	Extraction Procedure	261
5.2.3	Qualitative Phytochemical Screening	261
5.2.4	Thin Layer Chromatography (TLC) Analysis	263
5.3	Result and Discussion	264
5.3.1	Qualitative Phytochemical Screening	264
5.3.2	Thin Layer Chromatography (TLC) Analysis	277

CHAPTER 6 NUMERICAL ANALYSIS

6.1	Introduction	289
6.2	Methodology	290
6.3	Result and Discussion	290
6.3.1	Morphotaxonomic Analysis	291
6.3.2	Anatomy-Taxonomic Analysis	300
6.3.3	Chemotaxonomic Analysis	307
6.3.4	Combined Taxonomic Analysis	313

CHAPTER 7 GENERAL DISCUSSION AND CONCLUSION

7.1	Introduction	319
7.2	General discussion	319
7.3	Implications	324
7.4	Recommendations	325
7.5	Conclusion	326

REFERENCES	327
-------------------	------------

APPENDIX

LIST OF TABLES

Table No.		Page
2.1	Comparison of subfamilies classification of Lamiaceae and Verbenaceae	14
2.2	Chronology of genera placement based on previous studies	16
2.3	Representatives of Lamiaceae trees in Tropical Asia	18
2.4	Morphological character descriptions of <i>Peronema canescens</i>	21
2.5	Morphological character descriptions of <i>Petraeovitex</i> species	25
2.6	Morphological character descriptions of <i>Congea</i> species	28
2.7	Morphological character descriptions of <i>Sphenodesme</i> species	30
2.8	Morphological character descriptions of <i>Clerodendrum</i> species	33
2.9	Flower morphological character of <i>Clerodendrum</i> and <i>Rothea</i> (Leeratiwong & Chantaranothai, 2010)	34
2.10	Morphological character descriptions of <i>Rothea serrata</i>	36
2.11	Morphological character descriptions of <i>Lantana</i> species	38
2.12	Morphological character descriptions of <i>Stachytarpheta</i> species	41
2.13	Phytochemical constituent contained in several species of Lamiaceae and Verbenaceae	47
2.14	List of species and their medicinal values	52
3.1	List of specimen collected	57
3.2	List of herbarium specimen observed	64
3.3	Morphological observations on leaf general feature	78
3.4	Morphological observations on petiole and petiolule	79
3.5	Morphological observations on leaf blade feature	80
3.6	Morphological observations on leaf serration	82

3.7	Morphological observations on leaf venation	83
3.8	Diagnostic characters	93
4.1	Anatomical observations on petiole cross-section	175
4.2	Anatomical observations on midrib cross-section	177
4.3	Anatomical observations on lamina cross-section	179
4.4	Anatomical observation on margin cross-section	180
4.5	Epidermal anticlinal wall pattern, stomata characters and leaf venation	181
4.6	Leaf surface sculpturing, stomata and epicuticular wax	182
4.7	Leaf surface trichomes	184
4.8	Anatomical diagnostic characters	239
5.1	Qualitative Phytochemical Screening	264

LIST OF FIGURES

		Page
2.1	<i>Petraeovitex</i> species classification by Munir, (1965)	23
3.1	Map of studied Lamiaceae and Verbenaceae species in Peninsular Malaysia	62
3.2	Type of leaf margin	88
3.3	Type of leaf venation	91
3.4	<i>Peronema canescens</i> Jack, voucher no. NHH052	97
3.5	<i>Petraeovitex bambusetorum</i> King & Gamble, voucher no. NHH026	101
3.6	<i>Petraeovitex membranacea</i> var. <i>malesiana</i> Munir, voucher no. NHH076	104
3.7	<i>Petraeovitex wolfei</i> J. Sinclair, voucher no. NHH091	107
3.8	<i>Petraeovitex scortechinii</i> King & Gamble, voucher no. Kepong 124893	109
3.9	<i>Petraeovitex trifoliata</i> Merr., voucher no. NHH021	112
3.10	<i>Congea forbesii</i> King & Gamble, voucher no. NHH0137	116
3.11	<i>Congea griffithiana</i> Munir, voucher no. Kepong 12444446	118
3.12	<i>Sphenodeseme racemosa</i> (C. Presl) Moldenke, voucher no. NHH007	122
3.13	<i>Sphenodeseme triflora</i> Wight, voucher no. NHH062	125
3.14	<i>Sphenodeseme pentandra</i> Jack, voucher no. NHH058	128
3.15	<i>Clerodendrum nutans</i> Wall. ex Jack, voucher no. NHH079	132
3.16	<i>Clerodendrum phyllomega</i> Steud., voucher no. NHH064	134

3.17	<i>Clerodendrum breviflorum</i> Ridl., voucher no. NHH088	136
3.18	<i>Clerodendrum disparifolium</i> Blume, voucher no. NHH100	139
3.19	<i>Rothea serrata</i> (L.) Steane & Mabb., voucher no. NHH050	143
3.20	<i>Lantana camara</i> L., voucher no. NHH046	147
3.21	<i>Lantana indica</i> Roxb., voucher no. NHH073	150
3.22	<i>Stachytarpheta jamaicensis</i> (L.) Vahl, voucher no. NHH067	154
3.23	<i>Stachytarpheta cayennensis</i> (Rich.) Vahl specimen, voucher no. NHH082	157
3.24	<i>Stachytarpheta mutabilis</i> (Jacq.) Vahl, voucher no. NHH040	160
3.25	<i>Stachytarpheta indica</i> specimen, voucher no. NHH043	162
4.1	Types of petiole outline	168
4.2	Types of petiole vascular bundle	169
4.3	Types of midrib outlines	170
4.4	Types of midrib vascular bundle	171
4.5	Types of primary sculpturing	172
4.6	Types of stomata sculpturing	174
4.7 (a)	Petiole cross section of A- <i>Peronema canescens</i> , B- <i>Petraeovitex membranacea</i> , C- <i>Petraeovitex wolfei</i> , D- <i>Petraeovitex scortechinii</i> , E- <i>Petraeovitex trifoliata</i> , F- <i>Petraeovitex bambusetorum</i>	189
4.7 (b)	Petiole cross section of G- <i>Congea forbesii</i> , H- <i>Congea griffithiana</i> , I- <i>Sphenodesme racemosa</i> , J- <i>Sphenodesme triflora</i> , K- <i>Sphenodesme pentandra</i>	190
4.7 (c)	Petiole cross section of L- <i>Clerodendrum nutan</i> , M- <i>Clerodendrum phyllomega</i> , N- <i>Clerodendrum breviflorum</i> , O- <i>Clerodendrum disparifolium</i> , P- <i>Rothea serrata</i>	191

- 4.7 (d) Petiole cross section of Q- *Lantana camara*, R-*Lantana indica*, S-*Stachytarpheta mutabilis* T-*Stachytarpheta jamaicensis* U-*Stachytarpheta indica*, V-*Stachytarpheta cayennensis* 192
- 4.8 (a) Midrib cross section of A- *Peronema canescens* B-*Petraeovitex bambusetorum*, C-*Petraeovitex membrancea*, D-*Petraeovitex wolfei*, E- *Petraeovitex scortechinii*, F- *Petraeovitex trifoliata* 196
- 4.8 (b) Midrib cross section of G-*Congea forbesii*, H-*Congea griffthiana*, I- *Sphenodesme racemosa*, J- *Sphenodesme triflora*, K- *Sphenodesme pentandra* 197
- 4.8 (c) Midrib cross section of L-*Clerodendrum nutans*, M-*Clerodendrum phyllomega*, N-*Clerodendrum breviflorum*, O-*Clerodendrum disparifolium*, P-*Rothea serrata* 198
- 4.8 (d) Midrib cross section of Q- *Lantana camara*, R-*Lantana indica*, S-*Stachytarpheta mutabilis* T-*Stachytarpheta jamaicensis* U-*Stachytarpheta indica*, V-*Stachytarpheta cayennensis* 199
- 4.9 (a) Lamina cross section of A- *Peronema canescens*, B-*Petraeovitex bambusetorum*, C-*Petraeovitex membrancea*, D-*Petraeovitex wolfei*, E- *Petraeovitex scortechinii*, F- *Petraeovitex trifoliata*, G-*Congea forbesii*, H-*Congea griffthiana*, I- *Sphenodesme racemosa*, J- *Sphenodesme triflora*, K- *Sphenodesme pentandra*, L- *Clerodendrum nutans* 201
- 4.9 (b) Lamina cross section of M-*Clerodendrum phyllomega*, N-*Clerodendrum breviflorum*, O-*Clerodendrum disparifolium*, P-*Rothea serrata* Q- *Lantana camara*, R-*Lantana indica*, S-*Stachytarpheta mutabilis* T-*Stachytarpheta jamaicensis* U-*Stachytarpheta indica*, V-*Stachytarpheta cayennensis* 202
- 4.10 (a) Margin cross section of A- *Peronema canescens*, B-*Petraeovitex bambusetorum*, C-*Petraeovitex membrancea*, D-*Petraeovitex wolfei*, E- *Petraeovitex scortechinii*, F- *Petraeovitex trifoliata*, G-*Congea forbesii*, H-*Congea griffthiana*, I- *Sphenodesme racemosa*, J- *Sphenodesme triflora*, K- *Sphenodesme pentandra*, L- *Clerodendrum nutans* 204

- 4.10 (b) Margin cross section of M-*Clerodendrumn phyllomega*, N-*Clerodendrum breviflorum*, O-*Clerodendrum disparifolium*, P-*Rotheca serrata* Q- *Lantana camara*, R-*Lantana indica*, S-*Stachytarpheta mutabilis* T-*Stachytarpheta jamaicensis* U-*Stachytarpheta indica*, V-*Stachytarpheta cayennensis* 205
- 4.11 (a) Adaxial surfaces of A- *Peronema canescens* B-*Petraeovitex bambusetorum*, C-*Petraeovitex membrancea*, D-*Petraeovitex wolfei*, E- *Petraeovitex scortechinii*, F- *Petraeovitex trifoliata* 208
4. 11 (b) Midrib cross section of G-*Congea forbesii*, H-*Congea griffithiana*, I- *Sphenodesme racemosa*, J- *Sphenodesme triflora*, K- *Sphenodesme pentandra* 209
4. 11 (c) Adaxial surfaces of L-*Clerodendrum nutans*, M-*Clerodendrumn phyllomega*, N-*Clerodendrum breviflorum*, O-*Clerodendrum disparifolium*, P-*Rotheca serrata* 210
4. 11 (d) Adaxial surfaces of Q-*Lantana camara*, R-*Lantana indica*, S-*Stachytarpheta mutabilis* T-*Stachytarpheta jamaicensis* U-*Stachytarpheta indica*, V-*Stachytarpheta cayennensis* 211
- 4.12 (a) Abaxial surfaces of A-*Peronema canescens* B-*Petraeovitex bambusetorum*, C-*Petraeovitex membrancea*, D-*Petraeovitex wolfei*, E-*Petraeovitex scortechinii*, F- *Petraeovitex trifoliata* 212
- 4.12 (b) Abaxial surfaces of G-*Congea forbesii*, H-*Congea griffithiana*, I- *Sphenodesme racemosa*, J- *Sphenodesme triflora*, K- *Sphenodesme pentandra* 213
- 4.12 (c) Abaxial surfaces of L-*Clerodendrum nutan*, M-*Clerodendrumn phyllomega*, N-*Clerodendrum breviflorum*, O-*Clerodendrum disparifolium*, P-*Rotheca serrata* 214
- 4.12 (d) Adaxial surfaces of Q-*Lantana camara*, R-*Lantana indica*, S-*Stachytarpheta mutabilis* T-*Stachytarpheta jamaicensis* U-*Stachytarpheta indica*, V-*Stachytarpheta cayennensis* 215
- 4.13 (a) Leaf venation of A-*Petraeovitex bambusetorum*, B-*Petraeovitex membrancea*, C-*Petraeovitex wolfei*, D-*Petraeovitex scortechinii*, E- *Petraeovitex trifoliata*, F-*Peronema canescens* 216

4.13 (b)	Leaf venation of G- <i>Congea forbesii</i> , H- <i>Congea griffithiana</i> , I- <i>Sphenodesme racemosa</i> , J- <i>Sphenodesme triflora</i> , K- <i>Sphenodesme pentandra</i>	217
4.13 (c)	Abaxial surfaces of L- <i>Clerodendrum nutans</i> , M- <i>Clerodendrumn phyllomega</i> , N- <i>Clerodendrum breviflorum</i> , O- <i>Clerodendrum disparifolium</i> , P- <i>Rotheca serrata</i>	218
4.13 (d)	Adaxial surfaces of Q- <i>Lantana camara</i> , R- <i>Lantana indica</i> , S- <i>Stachytarpheta mutabilis</i> T- <i>Stachytarpheta jamaicensis</i> U- <i>Stachytarpheta indica</i> , V- <i>Stachytarpheta cayennensis</i>	219
4.14	Types of non-glandular trichomes	224
4.15	Types of glandular trichomes	225
4.16	Micrograph of wax types	227
4.17	Micrograph result of <i>P. canescens</i> adaxial surface (A, B), <i>P. canescens</i> abaxial surface (C,D), <i>P. bambusetorum</i> adaxial surface (E, F) of <i>P. bambusetorum</i> abaxial surface (G, H)	228
4.18	Micrograph result of <i>P. membranacea</i> adaxial surface (A, B), <i>P. membranacea</i> abaxial surface (C,D), <i>P. wolfei</i> adaxial surface (E, F) of <i>P. wolfei</i> abaxial surface (G, H)	229
4.19	Micrograph result of <i>P. scorctechinii</i> adaxial surface (A, B), <i>P. scorctechinii</i> abaxial surface (C,D), <i>P. trifoliata</i> adaxial surface (E, F) of <i>P. trifoliata</i> abaxial surface (G, H)	230
4.20	Micrograph result of <i>C. forbesii</i> adaxial surface (A, B), <i>C. forbesii</i> abaxial surface (C,D), <i>C. griffithiana</i> adaxial surface (E, F) of <i>C. griffithiana</i> abaxial surface (G, H)	231
4.21	Micrograph result of <i>S. racemosa</i> adaxial surface (A, B), <i>S. racemosa</i> abaxial surface (C,D), <i>S. triflora</i> adaxial surface (E, F) of <i>S. triflora</i> abaxial surface (G, H)	232
4.22	Micrograph result of <i>S. pentandra</i> adaxial surface (A, B), <i>S. pentandra</i> abaxial surface (C,D), <i>R. serrata</i> adaxial surface (E, F) of <i>R. serrata</i> abaxial surface (G, H)	233

- 4.23 Micrograph result of *C. nutans* adaxial surface (A, B), *C. nutans* abaxial surface (C,D), *C. phyllomega* adaxial surface (E, F) of *C. phyllomega* abaxial surface (G, H) 234
- 4.24 Micrograph result of *C. breviflorum* adaxial surface (A, B), *C. breviflorum* abaxial surface (C,D), *C. disparifolium* adaxial surface (E, F) of *C. disparifolium* abaxial surface (G, H) 235
- 4.25 Micrograph result of *L. camara* adaxial surface (A, B), *L. camara* abaxial surface (C,D), *L. indica* adaxial surface (E, F) of *L. indica* abaxial surface (G, H) 236
- 4.26 Micrograph result of *S. mutabilis* adaxial surface (A, B), *S. mutabilis* abaxial surface (C,D), *S. jamaicensis* adaxial surface (E, F) of *S. jamaicensis* abaxial surface (G, H) 237
- 4.27 Micrograph result of *S. indica* adaxial surface (A, B), *S. indica* abaxial surface (C,D), *S. cayennensis* adaxial surface (E, F) of *S. cayennensis* abaxial surface (G, H) 238
- 5.1 Phytochemical study procedure 260
- 5.2 (a) Result from Shinoda test show the colour changes of (A) *P. canescens* (B) *P. bambusetorum* (C) *P. membranacea* (D) *P. wolfeii* (E) *P. scortechinii* (F) *P. trifoliata* (G) *C. forbesii* (H) *C. griffithiana* (I) *S. racemosa* (J) *S. triflora* (K) *S. pentandra* (L) *R. serrata* 266
- 5.2 (b) Result from Shinoda test show the colour changes of (M) *C. nutans* (N) *C. phyllomega* (O) *C. breviflorum* (P) *C. disparifolium* (Q) *L. camara* (R) *L. indica* (S) *S. mutabilis* (T) *S. jamaicensis* (U) *S. indica* (V) *S. cayennensis* 267
- 5.3 (a) Precipitate observation of (A) *P. canescens* (B) *P. bambusetorum* (C) *P. membranacea* (D) *P. wolfeii* (E) *P. scortechinii* (F) *P. trifoliata* (G) *C. forbesii* (H) *C. griffithiana* (I) *S. racemosa* (J) *S. triflora* (K) *S. pentandra* (L) *R. serrata* 269
- 5.3 (b) Precipitate observation of (M) *C. nutans* (N) *C. phyllomega* (O) *C. breviflorum* (P) *C. disparifolium* (Q) *L. camara* (R) *L. indica* (S) *S. mutabilis* (T) *S. jamaicensis* (U) *S. indica* (V) *S. cayennensis* 270
- 5.4 (a) Arrows show the reddish-brown layer of (A) *P. canescens* (B) *P. bambusetorum* (C) *P. membranacea* (D) *P. wolfeii* (E) *P. scortechinii* (F) *P. trifoliata* (G) *C. forbesii* (H) *C.* 272

- griffithiana* (I) *S. racemosa* (J) *S. triflora* (K) *S. pentandra* (L) *R. serrata*
- 5.4 (b) Arrows show the reddish-brown layer of (M) *C. nutans* (N) *C. phyllomega* (O) *C. breviflorum* (P) *C. disparifolium* (Q) *L. camara* (R) *L. indica* (S) *S. mutabilis* (T) *S. jamaicensis* (U) *S. indica* (V) *S. cayennensis* 273
- 5.5 (a) Froth detection of (A) *P. canescens* (B) *P. bambusetorum* (C) *P. membranacea* (D) *P. wolfeii* (E) *P. scortechinii* (F) *P. trifoliata* (G) *C. forbesii* (H) *C. griffithiana* (I) *S. racemosa* (J) *S. triflora* (K) *S. pentandra* (L) *R. serrata* 271
- 5.5 (b) Froth detection of (M) *C. nutans* (N) *C. phyllomega* (O) *C. breviflorum* (P) *C. disparifolium* (Q) *L. camara* (R) *L. indica* (S) *S. mutabilis* (T) *S. jamaicensis* (U) *S. indica* (V) *S. cayennensis* 275
- 5.6 *Flavonoids spot* (A) *P. canescens* (B) *P. bambusetorum* (C) *P. membranacea* (D) *P. wolfeii* (E) *P. scortechinii* (F) *P. trifoliata* (G) *C. forbesii* (H) *C. griffithiana* (I) *S. racemosa* (J) *S. triflora* (K) *S. pentandra* (L) *P. R. serrata* (M) *C. nutans* (N) *C. phyllomega* (O) *C. breviflorum* (P) *C. disparifolium* (Q) *L. camara* (R) *L. indica* (S) *S. mutabilis* (T) *S. jamaicensis* (U) *S. indica* (V) *S. cayennensis* 278
- 5.7 *Alkaloids spots* (A) *P. canescens* (B) *P. bambusetorum* (C) *P. membranacea* (D) *P. wolfeii* (E) *P. scortechinii* (F) *P. trifoliata* (G) *C. forbesii* (H) *C. griffithiana* (I) *S. racemosa* (J) *S. triflora* (K) *S. pentandra* (L) *P. R. serrata* (M) *C. nutans* (N) *C. phyllomega* (O) *C. breviflorum* (P) *C. disparifolium* (Q) *L. camara* (R) *L. indica* (S) *S. mutabilis* (T) *S. jamaicensis* (U) *S. indica* (V) *S. cayennensis* 279
- 5.8 *Terpenoids spots* (A) *P. canescens* (B) *P. bambusetorum* (C) *P. membranacea* (D) *P. wolfeii* (E) *P. scortechinii* (F) *P. trifoliata* (G) *C. forbesii* (H) *C. griffithiana* (I) *S. racemosa* (J) *S. triflora* (K) *S. pentandra* (L) *P. R. serrata* (M) *C. nutans* (N) *C. phyllomega* (O) *C. breviflorum* (P) *C. disparifolium* (Q) *L. camara* (R) *L. indica* (S) *S. mutabilis* (T) *S. jamaicensis* (U) *S. indica* (V) *S. cayennensis* 280
- 5.9 *Saponins spots* (A) *P. canescens* (B) *P. bambusetorum* (C) *P. membranacea* (D) *P. wolfeii* (E) *P. scortechinii* (F) *P. trifoliata* (G) *C. forbesii* (H) *C. griffithiana* (I) *S. racemosa* 281

(J) *S. triflora* (K) *S. pentandra* (L) *P. R. serrata* (M) *C. nutans* (N) *C. phyllomega* (O) *C. breviflorum* (P) *C. disparifolium* (Q) *L. camara* (R) *L. indica* (S) *S. mutabilis* (T) *S. jamaicensis* (U) *S. indica* (V) *S. cayennensis*

6.1	Morphology Gower General Similarity Coefficient dendrogram	294
6.2	A cladogram of parsimonious tree based on morphological characters	297
6.3	Neighbour-joining tree based on morphological characters	299
6.4	Anatomical Gower General Similarity Coefficient dendrogram	302
6.5	A cladogram of parsimonious tree based on anatomical characters	304
6.6	Neighbour-joining tree based on anatomical characters	306
6.7	Phytochemical Gower General Similarity Coefficient dendrogram	308
6.8	Parsimony tree based phytochemical characters	310
6.9	Neighbour-joining tree based on phytochemical characters	312
6.10	Combined Gower General Similarity Coefficient dendrogram	314
6.11	Parsimony tree based on combined characters	316
6.12	Neighbour-joining tree based on combined characters	318

LIST OF ABBREVIATIONS

FRIM	Forest Research Institute Malaysia
KEP	Kepong Herbarium
UKMB	Universiti Kebangsaan Malaysia Bangi Herbarium
K	Kew Herbarium
L	Leiden Herbarium
SING	Singapore Botanic Garden Herbarium
CS	Cross-section
SEM	Scanning electron microscope
FEVs	Freely ending ultimate veins
FL	Flexuous
ST	Straight
CV	Convex
C	Concave
HPLC	High-Performance Liquid Chromatography

APPENDIX LIST

A	Morphological key characters
B	Anatomical key characters
C	Phytochemical key characters
D	MVSP (Morphology)
E	MVSP (Anatomy)
F	MVSP (Phytochemistry)
G	MVSP (Combined)
H	PAUP-Parsimony (Morphology)
I	PAUP-Neighbor joining (Morphology)
J	PAUP-Parsimony (Anatomy)
K	PAUP-Neighbor joining (Anatomy)
L	PAUP-Parsimony (Phytochemistry)
M	PAUP-Neighbor joining (Phytochemistry)
N	PAUP-Parsimony (Combined)
O	PAUP-Neighbor joining (Combined)
P	Outgroup (<i>Tectona grandis</i>)

CHAPTER 1

INTRODUCTION

This chapter discusses the research background, problem statements, study objectives, and research questions underpinning the topic under study. It furthers the significance of this study and study limitations faced in the process. In general, the current study delves into researching two plant families, which are the Lamiaceae and Verbenaceae.

Lamiaceae is a family under the umbrella of the Lamiales order, whereby it is grouped together with Verbenaceae, Acanthaceae, Bignoniaceae, and 21 other families. In English, it is also known as the mint family in which the family follows the name from the genus of European herbs, *Lamium*, meaning throat in Greek (LaFrankie, 2010). The alternative name, Labiatae, meanwhile, is translated into two-



lipped: the corolla or calyx is divided into two differently shaped parts forming the upper and lower lips (Glimn-Lacy & Kaufman, 2006).

Lamiaceae consists of 236 genera with 7200 species (Harley et al., 2004), is common in open areas, and is typically made up of trees, shrubs, lianas, or herbs with simple or compound leaves and lack any stipules (Bramley, Go & de Kok, 2010). It is cosmopolitan in nature, ranging from tropical forests to arctic tundra and from sea level to high altitude. Besides, the leaves are opposite or very rarely alternate, while the stems are characteristically quadrangular in sections in the more herbaceous genera (Gray, 2011).

Traditionally, Lamiaceae are related to the Verbenaceae or *Verbena* family and viewed as a pair family (Walters & Lavelle, 2012). In theory, these two families are naturally related to each other in which the same characteristics are shared, such as quadrangular stems, opposite leaves that lack stipules but display a scar at the node, a lipped flower, and an ovary with two carpels, each equipped with two ovules (Cronquist, 1981).

The *Verbena* family, in contrast, consists of 34 genera with about 1200 species recorded. Mainly from the New World and with a few groups in Asia, Africa, Europe, and Madagascar, it consists of aromatic herbs, shrubs, sometimes tree, and rarely lianas with opposites and sometimes whorled leaves (Atkins, 2004).

Both families are known for their rich source of biologically active compounds and various medicinal values (Venkateshappa & Sreenath, 2013; Atkins,





2004), rendering a valid revision of its classification and identification necessary. Furthermore, the combination of data identification and distribution will undoubtedly yield robust biodiversity information and contribute to family conservation.

1.2 Research Background

In the 1990s, a series of non-molecular and molecular research on several genera of the family Lamiaceae-Verbenaceae had been undertaken (Ryding, 1995; Cantino, 1992; Cantino, Olmstead, & Wagstaff, 1997; Wagstaff & Olmstead, 1997; Wagstaff, Hickerson, Spangler, Reeves & Olmstead, 1998). Accordingly, some of the Verbenaceae genera were reclassified under the Lamiaceae family based on the molecular findings by Cantino et al. (1997). The study has been further strengthened by a phylogenetic study by Wagstaff et al. (1998), which has displayed that many genera classified in Verbenaceae supposedly belong to Lamiaceae.

As a result of the Verbenaceae genera transfer in the 1990s as mentioned above and a morphological study conducted by Harley et al. (2004), Bramley, Forest, and de Kok (2009) have stated that the Lamiaceae members are to be reorganised across all levels, resulting movement of numerous subfamilies, genera, and species.

In Peninsular Malaysia, 15 genera and 78 species of Verbenaceae reportedly exist according to Turner (1995), some of which include certain Lamiaceae species. They comprise *Callicarpa*, *Clerodendrum*, *Congea*, *Glossocarya*, *Vitex*, *Gmelina*,





Premna, *Sphenodesme Petraeovitex*, *Teijsmanniodendron*, and *Peronema*, as well as *Phyla*, *Verbena*, *Lantana*, and *Stachytarpheta*.

Meanwhile, Kiew, Chung, Saw, and Soepadmo (2010) have highlighted that the Verbenaceae genera in Peninsular Malaysia are reduced to a few genera due to the incorporation of some (e.g. *Peronema*, *Petraeovitex*, *Premna*, *Sphenodesme*, *Symphorema*, *Callicarpa*, *Clerodendrum*, *Congea*, *Glossocarya*, *Gmelina*, *Tectona*, *Teijsmanniodendron*, and *Vitex*). This leads to the expansion of the Lamiaceae family, except for *Phyla*, and mostly of tropical American origin (*Lantana*, *Stachytarpheta*, *Citharexylum*, and *Verbena*).

Regarding the aforementioned genera transfer, previous studies include those undertaken in the context of the Malaysian region, namely by de Kok (2008, 2012, 2013). Moreover, research on the Lamiaceae family across a few genera has been conducted in Peninsular Malaysia, which includes that on *Vitex* by Nafizah et al. (2018) and *Clerodendrum* by Mazatul (2018). Meanwhile, researchers such as Go (1999), Phongoudome (2000), Abraham-Oanes (2002) and Bramley et al. (2010), have published their own Sabah and Sarawak-focused research on the topic. Bramley et al. (2010), for example, have recorded 25 genera and the key to the species of seven genera based on their respective morphological characters, while de Kok, Sengun, and Bramley (2016) have underlined 44 species across 21 genera of Lamiaceae and two new recorded species (i.e. *Vitex rotundifolia* and *Callicarpa pentandra*) in Singapore. Alternatively, Bramley (2019) has presented 50 genera of Lamiaceae in the newest Flora Malesiana, with 304 species thereby recognised as native or naturalised. They also include genera formerly recognised under the Verbenaceae.





According to Kiew, Chung, Saw, and Rafidah (2007), morphological and anatomical characteristics are critical in organising different plants for systematic purposes and understanding the relationship between them. Besides, such knowledge provides a mountain of details and accessible information for further research and investigation. This study, in particular, includes both families of Lamiaceae and Verbenaceae, henceforth focusing on the similarities and dissimilarities between them in terms of the morphological, anatomical, and phytochemical aspects. The following six genera of Lamiaceae were formerly grouped under Verbenaceae, namely *Petraeovitex*, *Peronema*, *Congea*, *Sphenodesme*, *Clerodendrum*, and *Rothea*, and thus studied with the two genera of Verbenaceae (i.e. *Lantana* and *Stachytarpheta*). Therefore, the results obtained in this work can be very important and deemed helpful in understanding the phylogenetic relationships within these two families.

1.3 Problem Statements

In Peninsular Malaysia, only a few outdated studies of Lamiaceae species have been recorded, whereby they were undertaken by Henderson (1959), Oxon (1978), Corner (1988), and Turner (1995). These studies have recorded the morphological descriptions of vegetative and reproductive characteristics of said species in detail. Nevertheless, they also reflect the limited amount of morphological studies and show that anatomical studies available are not comprehensive, rendering these studies far from complete. To date, an extensive study on Lamiaceae in the context of Peninsular





Malaysia is yet to be recorded, especially one that could provide full morphological, anatomical, micromorphological, and phytochemical descriptions as supporting pieces of evidence.

In this study, leaves denote the part of plant chosen to be thoroughly investigated. According to Kulkarni, Rai, Jahagirdar, and Upparamani (2013), plant classification based on leaf characteristics is the foremost choice compared to other methods like cell and molecular characteristics.

Taxonomic classification requires the incorporation of several research fields, such as plant morphology, anatomy, and phytochemicals. Previous molecular and non-molecular studies on these families were performed in the 1990s and the results obtained led to this study, albeit prioritising other aspects, namely their morphological, anatomical, and phytochemical elements. Turrill (1936) and Cutler, Botha, and Stevenson (2008) have further added that the judgement of taxonomic classification can only present a final value when all methods or fields are utilised to undertake the revisions of plant classification towards the production of a more natural system. Here, they encompass the morphology, pollen, physiology, cytology, chemistry, or molecular biology studies accordingly.

Moreover, prior works have underlined the prevailing confusion on classifying Lamiaceae members, of which some have remained unplaced while others are deemed problematic (Harley et al., 2004; Wagstaff et al., 2008). Here, LaFrankie (2010) has indicated that a large number of species are closely related to each other and possess morphological complexity that leads to many taxonomic problems. The researcher is





then of the opinion that carrying out additional detailed studies to handle such problematic genera, such as *Peronema*, *Petraeovitex*, *Clerodendrum*, and *Rothea*, is a requirement. This will allow one to address any taxonomic issues faced and improve their knowledge of the family classification. For example, Steane, de Kok, and Olmstead (2004) and Yuan, Mabberley, Steanes, and Olmstead (2010) have identified the genus *Clerodendrum* as problematic, wherein their investigations did not yield any satisfactory resolution pertaining to the relationships between said species and other genera.

In another study, Harley et al. (2004) have documented ten genera as unplaced, whereby a subsequent phylogenetic study by Li et al. (2016) has initiated the transfer of certain problematic genera to three new subfamilies. This indicates that the morphological and molecular data yield contradictory results, proving that further extensive studies for the Lamiaceae family as a whole are needed.

Similar to Lamiaceae, the Verbenaceae species also have their own taxonomic issues, including *Lantana* and *Stachytarpheta*. Members of *Lantana*, for instance, are closely allied and difficult to be differentiated (Howard, 1969), while those of *Stachytarpheta* present their own taxonomic uncertainty within the species. The study have identified four problematic species, specifically *S. jamaicensis*, *S. cayennensis*, *S. indica*, and *S. urticifolia*, which pose difficult identification processes due to minor differences in morphological characteristics (Chandler, Westaway, & Conn, 2014).

Thus, this study was mainly geared towards addressing the problems highlighted earlier, particularly by obtaining significant data on the studied species in



both Lamiaceae and Verbenaceae families across the morphological, anatomical and phytochemical aspects.

1.4 Research Objectives

The objectives of this study were:

- i. To investigate the taxonomic values of leaf morphological, anatomical, and phytochemical characteristics of selected Lamiaceae and Verbenaceae species
- ii. To construct the morphological and anatomical keys based on the leaf characteristics of selected Lamiaceae and Verbenaceae members
- iii. To evaluate the relationship and dissociation between the Lamiaceae and Verbenaceae species through numerical analysis
- iv. To map the distribution of selected Lamiaceae and Verbenaceae genera in Peninsular Malaysia

1.5 Research Questions

In reference to the research objectives stated above, the research questions devised for this study are as follows:

- i. Are there any taxonomic values of leaf morphological, anatomical, and phytochemical characteristics for the selected Lamiaceae and Verbenaceae species to revise the placement?
- ii. Could the morphological and anatomical keys based on the leaf of selected Lamiaceae and Verbenaceae members be constructed?
- iii. What is the relationship and dissociation between Lamiaceae and Verbenaceae members through numerical analysis?
- iv. What is the distribution of the selected Lamiaceae and Verbenaceae families in Peninsular Malaysia?

1.6 Research Significance

This research is critical in clearing any confusion that is arising regarding the problematic genera and correctly identifying the species of Lamiaceae. Furthermore, the family members are well-known for their rich ethnomedicinal properties, whereby the importance of phytochemical constituent data is important in classifying the species and identifying the presence or absence of any inherent medicinal value, as well as their possible economical utilisation in the future. Accordingly, the findings are aimed towards aiding the process of Lamiaceae identification and resolving the systematic conflicts and classification of the plant family, which is to complement the classification of Lamiaceae itself. Here, the significance of the data obtained from the morphological, anatomical, and phytochemical studies is discussed in relation to current taxonomic opinions on Lamiaceae.

Henceforth, this study is a fundamental stepping stone in providing value to Malaysian biodiversity, namely via an exploration of diversity possessed by Lamiaceae in Peninsular Malaysia. It will also help in supporting the Economic Transformation Programme 2010 through the change of National Key Economic Areas (NKEA) while concurrently reinforcing the vision of National Biodiversity 1998 for the purpose of presenting Malaysia as a centre of excellence for biodiversity in 2020.

1.7 Study Limitation

This study focused on the Lamiaceae species from Peninsular Malaysia. Therefore, study samples were collected in several localities in the region, whereas only one species was collected in Mulu, Sarawak of the East Malaysia region. The observation of species of both plant families in Peninsular Malaysia was made based on field collections and herbarium sample availability, with a total of 22 species successfully collected. Despite the small number, each species was a representative of the genus available in Peninsular Malaysia, except for the *Clerodendrum* species. For Verbenaceae, however, only a few species could be found in Peninsular Malaysia. Thus, the results obtained in this research were yielded from leaf observations, while other plant parts such as flowers were not included in the process. The focus placed on the leaf was underpinned by its critical role in plant identification and the fact that flowers would not be obtainable throughout the whole year, whereby some flowers could only be found at specific times in a year.