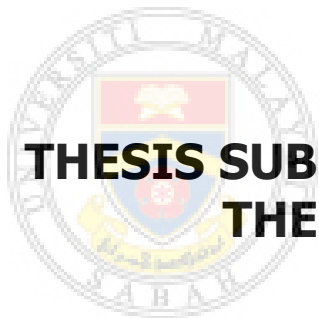


**TAXONOMIC REVISION OF *Ternstroemia*
(PENTAPHYLACACEAE) IN BORNEO**

SUZANA BINTI SABRAN



**THESIS SUBMITTED IN FULFILMENT FOR
THE DEGREE OF MASTER
OF SCIENCE**

**INSTITUTE FOR TROPICAL BIOLOGY AND
CONSERVATION
UNIVERSITI MALAYSIA SABAH
2019**

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Suzana Sabran
11 June, 2019

ABSTRACT

Ternstroemia (Pentaphylacaceae) is a pantropical genus of about 100 species, consisting of trees, shrubs and epiphytes. Previous studies merely listed species and sometimes with brief species descriptions of *Ternstroemia* in separate accounts of the various regions in Borneo. There being no consolidated accounts for Borneo, a taxonomic study of the species of *Ternstroemia* in Borneo was undertaken. The aims of this study are to identify distinguishing characters, construct a taxonomic key to species, prepare descriptions and update the checklist of *Ternstroemia* in Borneo. A total of 120 specimens of *Ternstroemia* species were collected from 19 localities within Sabah and Sarawak from 2013 until 2018. A total of 1312 herbarium specimens of *Ternstroemia* species from 12 herbaria, i.e. A, BO, BRUN, K, KEP, KNP, L, PNH, SAN, SAR, SING and BORH, were examined. This study is the first comprehensive taxonomic revision of the genus in Borneo based on gross morphology of vegetative and reproductive characters. Detailed descriptions of all the *Ternstroemia* species including the key to the species and also an updated checklist of *Ternstroemia* in Borneo was prepared. There is no single morphological character which can be used to delimit any recognised species among the *Ternstroemia* in Borneo. A combination of vegetative and reproductive morphological characters especially the leaves sizes, textures and shapes and also the flower sizes are useful and more applicable ways to distinguish the 17 species of *Ternstroemia* in Borneo. From the study, 17 species of *Ternstroemia* are now recognised in Borneo, including eight species new to science. Sabah and Sarawak has the highest number of species among the geographical areas of Borneo with 17 species, followed by Kalimantan with 13 species and Brunei with 12 species. The number of endemic species of *Ternstroemia* in Borneo is very high with eleven species (64.7%), namely *Ternstroemia beccarii* Stapf ex Ridl., *T. citrina* Ridl., *T. hosei* Ridl., *T. lowii* Stapf, *T. borneensis* S. Suzana & E. Soepadmo, *T. pereirae* S. Suzana & E. Soepadmo, *T. postarii* S. Suzana & E. Soepadmo, *T. longifolius* S. Suzana & E. Soepadmo, *T. crassifolium* S. Suzana & E. Soepadmo, *T. sugaui* S. Suzana & E. Soepadmo and *T. suleimanae* S. Suzana & E. Soepadmo.

ABSTRAK

KAJIAN TAKSONOMI *Ternstroemia* (PENTAPHYLACACEAE) DI BORNEO

Ternstroemia (Pentaphylacaceae) merupakan genus pantropikal yang mempunyai kira-kira 100 spesies yang terdiri daripada pokok, tumbuhan renek dan epifit. Spesies *Ternstroemia* belum pernah disemak secara taksonomi. Kajian terdahulu telah menyenaraikan spesies kepada penerangan ringkas mengenai spesies *Ternstroemia* dalam laporan berasingan di kawasan tertentu di Borneo. Tidak ada laporan yang disatukan untuk Borneo, dengan itu kajian taksonomi mengenai spesies *Ternstroemia* di Borneo telah dijalankan. Kajian ini bertujuan untuk mengenalpasti perbezaan ciri-ciri *Ternstroemia*, membentuk kekunci taksonomi spesies, menyediakan deskripsi serta mengemaskini senarai bagi genus *Ternstroemia* di Borneo. Sebanyak 120 spesimen *Ternstroemia* telah dikutip dari 19 lokaliti di Sabah dan Sarawak dari 2013 hingga 2018. Sejumlah 1312 spesimen herbarium dari 12 herbaria, iaitu A, BO, BRUN, K, KEP, KNP, L, PNH, SAN, SAR, SING and BORH, telah diperiksa. Kajian ini merupakan kajian taksonomi yang pertama secara komprehensif, berdasarkan ciri-ciri kasar morfologi dan pembiakan ke atas genus *Ternstroemia* di Borneo. Deskripsi terperinci ke atas semua spesies *Ternstroemia* termasuk kekunci spesies dan juga senarai spesies *Ternstroemia* yang kemaskini di Borneo telah disediakan. Tiada ciri morfologikal yang boleh digunakan untuk memisahkan sebarang spesies *Ternstroemia* yang telah dikenalpasti di Borneo. Kombinasi ciri morfologi vegetatif dan reproduktif terutamanya saiz daun, tekstur dan bentuk serta saiz bunga adalah berguna dan cara yang lebih sesuai untuk membezakan 17 spesies *Ternstroemia* di Borneo. Kekunci spesies yang pertama untuk *Ternstroemia* di Borneo telah dibentuk. Daripada kajian ini, terdapat 17 spesies *Ternstroemia* telah dikenalpasti di Borneo, termasuk lapan baru dalam sains. Sabah dan Sarawak mempunyai bilangan spesies tertinggi di antara kawasan-kawasan geografi di Borneo dengan 17 spesies, diikuti oleh Kalimantan dengan 13 spesies dan Brunei dengan 12 spesies. Bilangan spesies *Ternstroemia* yang endemik di Borneo adalah tinggi dengan 11 spesies (64.7%) iaitu dinamakan *Ternstroemia beccarii* Stapf ex Ridl., *T. citrina* Ridl., *T. hosei* Ridl., *T. lowii* Stapf, *T. borneensis* S. Suzana & E. Soepadmo, *T. pereirae* S. Suzana & E. Soepadmo, *T. postarii* S. Suzana & E. Soepadmo, *T. longifolius* S. Suzana & E. Soepadmo, *T. crassifolium* S. Suzana & E. Soepadmo, *T. sugaui* S. Suzana & E. Soepadmo dan *T. suleimanae* S. Suzana & E. Soepadmo.

LIST OF CONTENTS

	Page
TITLE	i
DECLARATION	ii
CERTIFICATION	iii
ACKNOWLEDGEMENTS	iv
ABSTRACT	v
ABSTRAK	vi
LIST OF CONTENTS	vii
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF SYMBOLS	xiii
LIST OF ABBREVIATIONS	xiv
LIST OF APPENDICES	xvi
CHAPTER 1: INTRODUCTION	1
1.1 Brief Introduction of <i>Ternstroemia Mutis ex L.f.</i>	1
1.2 Uses	2
1.3 Vernacular Names	2
1.4 Objectives	3
CHAPTER 2: LITERATURE REVIEW	4
2.1 Taxonomic History	4
2.1.1 Family Classification	4
2.2 Geographical Distribution	6
2.2.1 World Distribution	6
2.2.2 Distribution in Borneo	7
2.3 Habitats	10
2.4 Habits and Morphology	10
2.4.1 Vegetative Morphology	10
2.4.2 Reproductive Morphology	10

CHAPTER 3: MATERIALS AND METHODS	19
3.1 Herbarium Studies	19
3.2 Field Collections	20
3.3 Plant Processing	21
3.4 Photography	22
3.5 Taxonomic Revision	22
CHAPTER 4: RESULTS AND DISCUSSION	25
4.1 Habit and General Morphology	26
4.1.1 Habit	26
4.1.2 The Leaves	26
4.1.3 The Flower	27
4.2 Systematic Treatment of the Genus and Species	29
4.2.1 Genus Description	29
4.2.2 Key to Species of <i>Ternstroemia</i> in Borneo	32
4.2.3 Species Descriptions	34
4.3 Updated Checklist of <i>Ternstroemia</i> in Borneo	97
4.4 Species Endemic to Borneo	107
CHAPTER 5: CONCLUSION AND RECOMMENDATIONS	102
REFERENCES	104
APPENDICES	118

LIST OF TABLES

	Page
Table 3.1 Field Trips Conducted in Various Localities in Sabah and Sarawak (2014–2018)	21
Table 4.1 Updated Checklist of <i>Ternstroemia</i> sp. (Pentaphylacaceae) in Borneo	98
Table 4.2 Updated Number of <i>Ternstroemia</i> Species in Borneo	99
Table 4.3 List of Endemic Species of <i>Ternstroemia</i> Based on Geographical Areas in Borneo	101



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LIST OF FIGURES

		Page
Figure 2.1	Distribution Map of <i>Ternstroemia</i> in the Tropic (in the reddish colour)	7
Figure 2.2	A. <i>Ternstroemia coriacea</i> (SAN 65205); B. <i>T. lowii</i> (SAN 48080) & C. <i>T. aneura</i> (SAN 81964) showing the leaves arrangement and the variation of leaves shape and sizes	12
Figure 2.3	A. Male bud with petal removed, showing the stamens arranged in a few series; B. Stamens showing inner view & C. Stamens showing outer view	15
Figure 2.4	A. Female flower with petals removed; B. Staminodes: inner view on left and outer on right & C. Transverse section of ovary.	16
Figure 2.5	A. Fruit with the obtuse apex & B. Fruit is terminated by the persistent style at the apex	17
Figure 2.6	A. Transverse section of fruit and its four seeds; B. longitudinal section of seed & C. Outer surface of seed	18
Figure 4.1	<i>Ternstroemia aneura</i> Miq. A. Leafy twig of flowers (showing the inflorescences clustered in one point at end of the twig); B. the upper surface of fresh leaves and the reddish young shoots; C. Close-up view of the flowers, showing the stamens in several series (the outer series fused to the base of corolla lobes); D. The lower surface of fresh leaves, showing indistinct lateral and intercostal venations & E. Dried fruits (S 2250)	34
Figure 4.2	<i>Ternstroemia bancana</i> Miq. A. Leafy twig of fruits; B. Close up view of brownish fruits (longitudinal section of fruit showing outer surface one of two seeds; C. Leafy twig of flower bud (SAN 149831) & D. Dried specimen showing the indistinct venation on both surfaces of the leaves also the whitish and angular twig	41
Figure 4.3	<i>Ternstroemia beccarii</i> Stapf ex Ridl. A. Leafy twig of flower buds (SAN 155154), showing the sub-opposite bracteoles, c. 4 mm below the calyx lobes (in the red circle); B. Close-up view of opened flower (SAN 149588) & C. Fruit (Beccari 2928)	45
Figure 4.4	<i>Ternstroemia citrina</i> Ridl. A. Leafy twig of fruits (SAN 159067); B. Close-up view of longitudinal section of fruit, showing the reddish aril of the seeds. The calyx fruit is	49

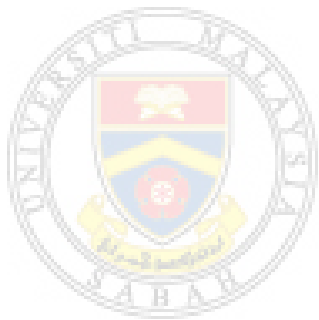
always reflex, not clasping the fruit or corolla lobes (SAN 149588) & **C.** Close-up view of flowers, an oblique leaf base and the shining on the upper surface (Haviland 3017)

- Figure 4.5 *Ternstroemia coriacea* Scheff. **A.** Leafy twig of flower bud (S 98344); **B.** Close-up view of longitudinal section of flower bud (S 98344) & **C.** Dried specimen of leafy twig of fruits (Teysmann, *s.n.*) 54
- Figure 4.6 Leafy flowers of *Ternstroemia hosei* Ridl. (SAN 149761) 57
- Figure 4.7 *Ternstroemia lowii* Stapf. **A.** Leafy twig of flowers, one of the collections made from Mt. Kinabalu, *c.* 4000 m asl, with bright yellow corolla lobes (SAN 149598); **B.** Close-up view of fruits with persistent stigma at the apex (SAN 155200) & **C.** The shining or waxy on the upper surface of dried leaf (SAN 134182) 60
- Figure 4.8 *Ternstroemia magnifica* Stapf ex Ridl. **A.** Leafy twig of fruits, showing its large leaves and fruits (SS 01); **B.** The smooth and slightly glaucous at the lower surface of dried leaves (Haviland 1984); **C.** Close-up view of mature fruits and longitudinal section of fruit showing outer surface of two unsectioned seeds (SS 01) & **D.** Close-up view of flower (Haviland 1984) 68
- Figure 4.9 Greenish dried leaves of *Ternstroemia patens* Choisy. The fruit and leaves are thin coriaceous make it wrinkle when dried 73
- Figure 4.10 *Ternstroemia borneensis* S. Suzana & E. Soepadmo, sp. nov. **A.** Leafy twig of fruits, showing its distinct intercostal venation on both surfaces; **B.** Upper view of the seed; **C.** Lower view of the seed; **D.** Upper view of the fruit, showing the five lobes of the calyx & **E.** the tip part of the fruit, showing the short permanent stigma (all part are from *SAN 144479*)—Drawing by Bellia Emoi. 76
- Figure 4.11 *Ternstroemia pereirae* S. Suzana & E. Soepadmo, sp. nov. **A.** Leafy twig of flower, showing its distinct intercostal venation on both surfaces and elongate leaves; **B.** inner part of the corolla lobe & **C.** Side view of female flower (all part are from *S 90391*)—Drawing by Bellia Emoi. 78
- Figure 4.12 *Ternstroemia postarii* S. Suzana & E. Soepadmo, sp. nov. **A.** Leafy twig of flowers showing its long pedicel and small flowers; **B.** lower view of flower showing its unequal calyx lobes & **C.** Upper view of the flower bud (all part are from *SAN 41894*)—Drawing by Bellia Emoi. 81

- Figure 4.13 *Ternstroemia longifolius* S. Suzana & E. Soepadmo, sp. nov. 84
A. Leafy twig of fruits showing its long pedicel and flare calyx lobes; **B.** Close-up view of the fruit; **C.** Upper view of the fruit; **D.** Seed in longitudinal section showing the U-shaped embryo; **E, F & G** are the sides view of the seed (all part are from SAN 41894)—Drawing by Bellia Emoi.
- Figure 4.14 *Ternstroemia crassifolium* S. Suzana & E. Soepadmo, sp. nov. 86
A. Leafy twig of fruits showing its sandpaper texture in the lower leaves surface; **B.** In front view side of the seed; **C.** Close-up view from the back side of the seed; **D.** Close-up view of the seed after separated; & **E.** Seed in longitudinal section showing the U-shaped embryo (all part are from SAN 118541)—Drawing by Bellia Emoi.
- Figure 4.15 *Ternstroemia sugaui* S. Suzana & E. Soepadmo, sp. nov. 88
A. Leafy twig of flowers showing its long and slender pedicel and small flower & **B.** calyx lobes (all part are from SAN 81885)—Drawing by Bellia Emoi.
- Figure 4.16 *Ternstroemia suleimanae* S. Suzana & E. Soepadmo, sp. nov. 91
A. Leafy twig of flowers showing its elongated leaves & **B.** side view of the flower showing its short pedicel (all part are from SAN 84336)—Drawing by Bellia Emoi.
- Figure 4.17 *Ternstroemia jemsonii* S. Suzana & E. Soepadmo, sp. nov. 94
A. Leafy twig of fruit, showing its crinkly like leaves venation especially on the lower leaves surface & **B.** Female flower with petal removed (all part are from S 37927)—Drawing by Dg. Ku Rozianah Matusin.
- Figure 4.18 Distribution of *Ternstroemia* species in Each Geographical Area of Borneo 99

LIST OF SYMBOLS

&	-	and
%	-	percent
!	-	specimens seen

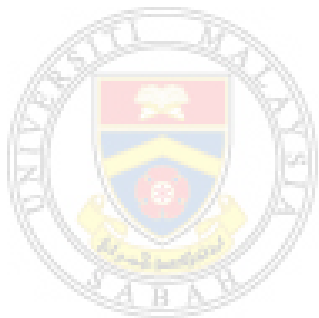


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LIST OF ABBREVIATIONS

A	-	one of the series issued by the North Borneo Forest Department; acronym for Herbarium of the Arnold Arboretum, US
Acc. No.	-	accession number of the herbarium specimen
aff.	-	<i>affinis</i> (Latin); akin to
alt.	-	altitude
a.s.l	-	above sea level
BO	-	acronym for Herbarium Bogor, Indonesia
BRUN	-	acronym for Herbarium, Forestry Department Brunei
Bt.	-	<i>bukit</i>
C	-	Celsius
ca.	-	<i>circa, circum</i> (Latin); about or approximately
Div	-	division
E	-	east; acronym for Herbarium, Royal Botanic Gardens, Edinburgh, UK
EB	-	Endemic to Borneo
ed.	-	edited; edition; editor
e.g.	-	<i>exemplum gratia</i> (Latin); example
et al.	-	<i>et alii</i> (Latin); and other
FR	-	Forest Reserve
FRC	-	Forest Research Centre
FRIM	-	Forest Research Institute of Malaysia
f.	-	(after a personal name) <i>filius</i> , the son
ft.	-	feet/foot
G	-	acronym for Herbarium. Conservatoire et Jardin Botaniques de la Villa de Geneve, Switzerland; <i>gunung</i>
i.e.	-	<i>id est</i> (Latin); that is
ined.	-	inedited
K	-	acronym for Herbarium, Royal Botanic Gardens, Kew, UK
KEP	-	stand for Kepong, Malaya; acronym for Herbarium, Forest Research Institute of Malaysia
Kg.	-	<i>Kampung</i>
KNP	-	Kinabalu National Park
L	-	acronym for National Herbarium, Leiden, the Netherland
m	-	meter
mm	-	millimetres
Mt.	-	mount
N	-	north
NE	-	north east
NP	-	National Park
NW	-	north west
NP	-	National Park
op. cit.	-	<i>opus citatum</i> (Latin); the work cited
PF	-	Pristine Forest
PNH	-	acronym for Philippines National Herbarium, Manila, Philippines

RSNB	-	Royal Society North Borneo
S	-	south
SAR	-	acronym for Herbarium Sarawak Forestry Department, Kuching, Sarawak
SAN	-	acronym for Herbarium Sabah Forestry Department, Sandakan, Sabah
SFN	-	Singapore Field Number
SNP	-	Sabah National Parks
Sg.	-	<i>sungai</i>
SING	-	acronym for Herbarium, Botanic Gardens, Singapore
s.n	-	<i>sine numero</i> (Latin); without a collection number
sp.	-	species
St.	-	Saint
US	-	United States; acronym for United States National Herbarium, Smithsonian Institution, Washington, USA
var.	-	variety
viz.	-	<i>videre licet</i> (Latin); namely
W	-	west
WAG	-	solution of water, Alcohol and Glycerol



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LIST OF APPENDICES

	Page
APPENDIX A Summary of Valid Names of <i>Ternstroemia</i> sp. (Pentaphylacaceae) in Borneo	113
APPENDIX B Publication and Presentations	118



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CHAPTER 1

INTRODUCTION

1.1 Brief Introduction of *Ternstroemia* Mutis L.f.

Ternstroemia Mutis ex L.f. is an evergreen tree, shrub or rarely epiphytes of tropical to warm-temperate region in the family Pentaphylacaceae. The type of this genus is *Ternstroemia meridiolis* Mutis ex L.f. from South America. Species of *Ternstroemia* are mostly recorded from montane forests (upper and lower montane forests), kerangas forest or mixed dipterocarp forests, particularly along river banks, on ultramafic and clay sandy soils from sea level up to 4000 m above sea level (Ridley, 1922; Keng, 1978; Kobuski, 1963; Beaman & Anderson, 2004; Balderas *et al.*, 2008).

The genus *Ternstroemia* was listed in various accounts based on geographical territories without any detailed description of each species (Cockburn, 1980; Argent *et al.*, 1997; Coode *et al.*, 1996 & Anderson, 1980). In Sabah, Cockburn (1980) recorded nine species of *Ternstroemia* based on morphological characters of specimens available at the Sabah Forestry Herbarium (SAN) at that time. He also provided a key to the species, based on leaf and flowers parts. However, he admitted that materials were lacking during his revision. There were a few species of *Ternstroemia* that were found in Sabah but were not included in his identification key. Such situation is similar in Kalimantan whereby only two species were stated by Argent *et al.* (1997). In Sarawak, Anderson (1980) listed ten species of *Ternstroemia* including *T. macrocalyx* Airy Shaw, collected from Mt. Hose, which is no longer valid and one undetermined species. In Brunei, there are ten species recorded, including three unidentified taxa. The keys by the previous reports were mainly based on morphological characters of vegetative and reproductive parts of the plants. Hence,

a comprehensive taxonomic treatment of *Ternstroemia* for the whole island of Borneo is needed.

1.2 Uses

The wood of *Ternstroemia* are normally used by local community in Malaysia for house construction materials such as internal flooring, door or window frame, carvings and other furniture. In Irian Jaya, Indonesia, the bark of *T. robinsonii* Merr. and also the fruit and bark of *T. toquian* (Blco.) Fernandez-Villar were used as fish poison, as it contains saponin (Sosef *et al.*, 1998; Perry, 1985). According to Sosef *et al.* (1998), in Taiwan, the leaves of *T. gymnanthera* (W. & A.) Beddome are reported used by mountain people to allay malaria. These species are not found in Borneo. In Sabah, some information in the specimen's label especially the specimens collected from Ranau and Telupid Districts *i.e.*, Daim A. 363 and Salick *et al.* 9007, noted that the wood of *T. bancana* and *T. patens* are normally used by local people for house constructions and fire wood. In Peninsular Malaysia, the wood of *T. bancana* (cited rather light or reddish-brown) listed as timber species by Ridley (1922). In terms of conservation, *T. bancana* is said to have a good potential for forest restoration purpose as its seed could be 90% germinated within a month period (Sosef *et al.*, 1998).

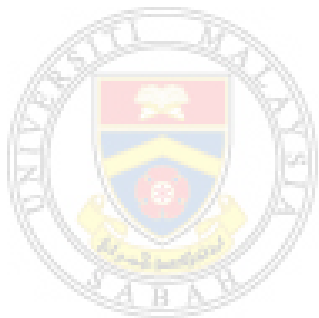
1.3 Vernacular Names

In Sarawak, *Ternstroemia* is locally known as "Medang pajal" particularly by the Iban community (Anderson, 1980) as seen on specimen labels from Sarawak (S. 2177, S 2242, Jarkhan 52242, S 80655 and S 81344) and also based on personal communication with local botanists and collectors in Sarawak. This term is also referring to certain species based on the leaves sizes (either small or big) *e.g.*, *T. hosei* Ridl. known as "Medang pajal daun kecil" due to its small leaves. For the species that have a big leaves size *i.e.*, *T. magnifica* Stapf ex Ridl., it is known as "Medang pajal daun besar" Anderson (1980). The most common species of Bornean *Ternstroemia* is *T. aneura* Miq., which is known as "Medang pijat" by the Brunei, Kedayan and Malay communities or known as "Sisil" by the Dusun community in Brunei Darussalam (Coode *et al.*, 1996). There are no vernacular names for this genus in Sabah and Kalimantan.

1.4 Objectives

The objective of this study are as follows:

- a. To identify distinguishing characters, construct a taxonomic key to species and prepare descriptions of *Ternstroemia* in Borneo
- b. To update the checklist of *Ternstroemia* in Borneo.



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CHAPTER 2

LITERATURE REVIEW

2.1 Taxonomic History

Historically, *Ternstroemia* was placed in the Ternstroemiaceae family, as stated in a number of earlier publications, e.g. Mutis (1782), De Candolle (1823), Choisy (1855), Miquel (1859), Scheffer (1870), Dyer (1874), King (1890) and Ridley (1922). However, later this genus was included in the family of Theaceae (under the subfamily Ternstroemioideae) by several authors, e.g. Merrill (1914), Kobuski (1940), Keng (1962, 1972), Barker (1980), Cockburn (1980), Argent *et al.* (1997) and Lattif *et al.* (1998). It was distinguished from the Theaceae based on anther insertion and shape, fruit dehiscence and number of other macro and microscopic characters. The generic name known as *Ternstroemii* is derived after Christopher Tarnstrom (1703–1746), a Swedish botanist.

2.1.1 Family Classification

The classification of *Ternstroemia* has been frequently changed by numerous authors. Thus, Theaceae and Ternstroemiaceae have become a good example of a taxonomic group with controversial circumscription and uncertain phylogenetic affinities, requiring detailed investigation (Luna & Ochoterena, 2004). Sosef *et al.* (1998) mentioned that the revisional taxonomic work on the Asian members of *Ternstroemia* are urgently needed. The taxonomy study on *Ternstroemia* species has not been fully elucidated and a close study in the field especially on bark and fresh leaves characteristics are needed to distinguishing the *Ternstroemia* species in Borneo (Corkburn, 1980). From 1782 until the beginning of the 20th century, the classification of this genus was based on morphological similarity. For example, Keng

(1962), in his morphological studies of Theaceae, classified the genus of *Ternstroemia* under the subfamily Ternstroemioideae and tribe Ternstroemieae, based on the fleshy or rarely coriaceous pericarp. The most comprehensive phylogenetic relationship studies of Theaceae based on morphology were carried out by Prince and Park (2001) and Luna & Ochoterena (2004). The authors of these studies concluded that Theaceae and Ternstroemiaceae (*Ternstroemia* included) should be considered as two separate families. However, Engler (1897) described Pentaphylacaceae as a different family from Ternstroemiaceae based on its spirally arranged leaves and five anthers with terminal pores opening with small lids, compared with Ternstroemiaceae with alternate leaves and numerous anthers in several series, opening lengthwise and only very rarely having terminal pores.

The recent classification of flowering plants, Angiosperm Phylogeny Group (APG) IV (Stevens, 2001 onwards), which was based predominantly on molecular evidences, recognised *Ternstroemia* under the subfamily Ternstroemieae in the family Pentaphylacaceae. Pentaphylacaceae is a family in Order Ericales (among the 23 families). The main characters for this family are flowers are solitary from axils of reduced leaves, style is hollow, testa multiplicative and having the U-shaped or curved embryo.

Based on this classification, there are three tribes under the family Pentaphylacaceae: (i) Pentaphylaceae P.F. Stevens & A.L. Weitzman (only one genus included *i.e.*, *Pentaphylax*, found in Kwantung and Hainan to Sumatra), (ii) Ternstroemieae de Candolle (only one genus included *i.e.*, *Ternstroemia*, found in tropics, especially in Malesia to South America) and (iii) Freziereae de Candolle (consisting three genus *i.e.*, *Adinandra*, *Eurya* and *Freziera*, found in Southeast Asia to Malesia, Hawaii, Central to South America).

In this classification, it was pointed out that *Ternstroemia* looks rather dissimilar with the other genera within the family Pentaphylacaceae by the following characters: (i) the alternate or subopposite leaves which are arranged spirally and clustered towards the branch tips, lower leaves surfaces often with black spots, margins entire to crenulate or with black and deciduous (ii) the axillary, usually

solitary, perfect flowers with a campanulate corolla, many stamens and a superior ovary and (ii) the fruit irregularly dehiscent containing a few seeds with a sarcotesta.

2.2 Geographical Distribution

The family Pentaphragaceae is widely distributed. Some genera are found exclusively in East Asia, Africa or America, but *Ternstroemia* has a more extensive distribution, being found in Asia, Africa, America and Australia. Exact distribution in the world and also in Borneo are mostly based on the herbarium specimens and also relevant references (Baker, 1980; Balderas et al., 2008; Burkill, 1996; Beaman & Anderson, 2004 & Corner; 1997).

2.2.1 World Distribution

There are an estimated of 130 *Ternstroemia* species worldwide distributed almost equally between the eastern and western hemispheres throughout tropical and subtropical biomes (Boom, 1989). Based on the taxonomic revision of *Ternstroemia* in Papuasia by Barker (1980), this genus comprises of about 100 species. In Asia it extends from Sri Lanka, India and Myanmar to Indo China, China, Japan, Taiwan, Thailand, the entire Malesian region (Sumatra, Borneo, the Philippines, Java and Celebes), New Guinea, east to Fiji and south to north-eastern Australia. Only two species are present in Africa. The main centre of distribution lies in Central and South America (Barker, 1980; Sosef *et al.*, 1998 & Every, 2009) and a secondary centre from Ceylon to China, Japan, Taiwan and Malesia (Figure 2.1).



Figure 2.1: Distribution Map of *Ternstroemia* in the Tropic (in the reddish colour)

Source: <http://www.mobot.org/MOBOT/research/APweb/>

In Malay Archipelago, there are two species of *Ternstroemia* recorded *i.e.*, *T. rubiginosa* Jack and *T. pentapetala* Jack. Both recorded from the islands of Sumatra and Penang, respectively (Jack, 1821). A year later, three species of *Ternstroemia* were added by Jack (1822), *i.e.*, *T. acuminata* Jack, *T. serrata* Jack and *T. cuspidata* Jack in Malay Archipelago (mainly from Sumatra Island).

A total of seven species of *Ternstroemia* were also recognised by Keng (1978) in the Peninsular Malaysia, *i.e.*, *T. bancana* Miq., *T. corneri* H. Keng, *T. evenia* (King) A.C. Smith, *T. maclellandiana* Ridl., *T. montana* Ridl., *T. penangiana* Choisy and *T. wallichiana* (Griff.) Engler. There is one more species added by Latiff *et al.* (1998) *i.e.*, *T. magnifica* Stapf ex Ridl. There are four additional species of *Ternstroemia* in Peninsular Malaysia were reported by Yao (2016) *i.e.*, *T. bancana* Miq., *T. coriacea* Scheff., *T. patens* Choisy and *T. penangiana* Choisy. This is the latest compilation for *Ternstroemia* in Peninsular Malaysia.

2.2.2 Distribution in Borneo

Borneo has been frequently recognised as one of the most important centres of plant diversity in the world and is frequently referred to as the greatest harbour for flowering plants (10,000–12,000 species are recorded here); representing about 5–6% of the world total (Merrill, 1950; Steenis, 1950; Kiew, 1984 and Mat-Salleh *et al.*,