SYSTEMATIC STUDY OF ACANTHACEAE, SUBFAMILIES NELSONIOIDEAE AND ACANTHOIDEAE (*PSEUDERANTHEMUM*), IN THAILAND

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A Thesis Submitted in Partial Fulfillment of the Requirements for the

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การศึกษาด้านอนุกรมวิธานของพรรณพืชวงศ์ Acanthaceae วงศ์ย่อย Nelsonioideae และ Acanthoideae (*Pseuderanthemum*) ในประเทศไทย

นางสาวเทียมหทัย ชูพันธ์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต

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Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

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เทียมหทัย ชูพันธ์ : การศึกษาด้านอนุกรมวิธานของพรรณพืชวงศ์ Acanthaceae วงศ์ย่อย Nelsonioideae และ Acanthoideae (*Pseuderanthemum*) ในประเทศไทย (SYSTEMATIC STUDY OF ACANTHACEAE, SUBFAMILIES NELSONIOIDEAE AND ACANTHOIDEAE (*PSEUDERANTHEMUM*), IN THAILAND) อาจารย์ที่ปรึกษา : ดร.พอล เจ โกรดิ, 479 หน้า.

การศึกษาด้านอนุกรมวิธานของพรรณพืชวงศ์ Acanthaceae วงศ์ย่อย Nelsonioideae และ Acanthoideae (*Pseuderanthemum*) ในประเทศไทย พบตัวอย่างพืชทั้งสิ้น 4 สกุล 45 แทกซา ในจำนวนนี้เป็นพืชถิ่นเดียวของประเทศ 16 แทกซา โดยพบว่าเป็นพืชที่มีการรายงานเป็นครั้งแรก และคาดว่าจะเป็นพืชชนิดใหม่ของโลก 3 แทกซา เป็นพืชปลูกเพื่อเป็นไม้ประดับ 4 แทกซา คือ *Pseuderanthemum carruthersii P. laxiflorum P. metallicum P. reticulatum* เพื่อเป็นสมุนไพร 1 แทกซา คือ *P.* "*palatiferum*" นอกจากนี้ได้จัดทำรูปวิธานระดับสกุล ระดับชนิด และแทกซา ให้คำบรรยายลักษณะทางพฤกษศาสตร์ ภาพถ่ายและภาพวาด ระบุตัวอย่างต้นแบบ ตัวอย่างศึกษาและเอกสารอ้างอิงตามหลักอนุกรมวิธาน พืชมีการกระจายพันธุ์อยู่ทั่วประเทศในนิเวศของป่าหลายแบบ บางชนิดมีการกระจายพันธุ์กว้างและบางชนิดพบเฉพาะพื้นที่

ศึกษาลักษณะของปากใบ เซลล์เยื่อบุผิวใบ ซิสโทลิตท์ และรูปแบบการเรียงตัวของเส้นใบ พบว่า ลักษณะทางกายวิภาคบางประการสามารถนำมาใช้จำแนกพืชในระดับสกุลได้ แต่เป็นได้เพียงข้อมูลพื้นฐานของพืชแต่ละชนิด ศึกษาลักษณะเรณูของพืชด้วยกล้องจุลทรรศน์แบบใช้แสงและกล้องจุลทรรศน์อิเล็กตรอนแบบส่องกราด พบว่า ลักษณะสัณฐานวิทยาของเรณูพืชสามารถนำมาใช้จำแนกพืชในระดับสกุลและระดับที่ต่ำกว่าสกุลได้

การวิเคราะห์สายสัมพันธ์ทางวิวัฒนาการของพืช จากลำดับนิวคลีโอไทด์ในไรโบโซมดีเอ็นเอ internal transcribed spacer (ITS) และคลอโรพลาสต์ดีเอ็นเอชนิด trnL-F ndhF-rpl32R psaI-accD และ trnQ-rps16x1 ด้วยวิธี Maximum parsimony และ Bayesian analysis พบว่า มีลักษณะความผันแปรที่เกิดขึ้นภายในชนิด แต่ยังคงสามารถอธิบายการจัดกลุ่มพืชจากข้อมูลชีวโมเลกุลได้ โดยใช้ลักษณะสัณฐานวิทยาที่เลือกมาช่วยในการวิเคราะห์ นอกจากนี้ยังใช้อธิบายความสัมพันธ์ของพืชทั้งสี่สกุลที่นำมาศึกษา

สาขาวิชาชีววิทยา ลายมือชื่อนักศึกษา ____________________

ปีการศึกษา 2556 ลายมือชื่ออาจารย์ที่ปรึกษา ____________________

ลายมือชื่ออาจารย์ที่ปรึกษาร่วม ____________________

ลายมือชื่ออาจารย์ที่ปรึกษาร่วม ____________________

THIAMHATHAI CHOOPAN : SYSTEMATIC STUDY OF ACANTHACEAE, SUBFAMILIES NELSONIOIDEAE AND ACANTHOIDEAE (*PSEUDERANTHEMUM*), IN THAILAND. THESIS ADVISOR : PAUL J. GROTE, Ph.D. 479 PP.

SYSTEMATIC STUDY/ACANTHACEAE/NELSONIOIDEAE/ACANTHOIDEAE/THAILAND/*STAUROGYNE*/ *NELSONIA*/*OPHIORRHIZIPHYLLON*/*PSEUDERANTHEMUM*

A systematic study of Acanthaceae, subfamilies Nelsonioideae and Acanthoideae (*Pseuderanthemum*) in Thailand was carried out. Four genera and 45 taxa are recognized which 16 taxa of these species are endemic to the country. Three taxa are recorded for the first time and expected to be new to science. Four taxa are introduced plants which are used as ornamental plants, i.e., *Pseuderanthemum carruthersii*, *P. laxiflorum*, *P. metallicum*, and *P. reticulatum*. One introduced plant, *Pseuderanthemum* "*palatiferum*", is used as a medicinal plant. Keys to genera, species and taxa were constructed. For the examined specimens, the description of species included type, bibliographies, photographs, and line drawings. The studied plants were found to be distributed many forest types. Some species are widespread in many habitats, while habitats of some are more restricted.

The study on stomata, epidermal cells, cystoliths, and leaf venation pattern showed that some anatomical characters could be used as a taxonomic tool at the genus level, but only provided basic information at the species level. The

palynological study using light microscope and scanning electron microscope revealed that pollen morphology is useful for genus and lower level identification.

The phylogenetic study was carried out based on the nuclear ribosomal internal transcribed spacer (ITS) and the chloroplast trnL-F, ndhF-rpl32R, psaI-accD, and trnQ-rps16x1 nucleotide sequence data using the Maximum Parsimony and Bayesian analysis. There were character variations within species, but molecular data was still helpful for classification supported with representative morphological characters. Moreover, these results represented the phylogeny in four studied genera.

School of Biology Student's Signature ________________________

Academic Year 2013 Advisor's Signature ________________________

Co-advisor's Signature ________________________

Co-advisor's Signature ________________________

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LIST OF ABBREVIATIONS

Locations

A	=	Herbarium of the Arnold Arboretum, Harvard University, Massachusetts, United State of America
AAU	=	The Herbarium of University of Aarhus, Aarhus, Denmark
ABD	=	The Herbarium of Aberdeen University, Aberdeen, Scotland, United Kingdom
AR	=	Arboretum
BG	=	Botanical Garden
BK	=	The Bangkok Herbarium, Sirindhon Herbarium Building, Agricultural Department, Ministry of Agriculture and Co-operatives, Thailand
BKF	=	The Forest Herbarium, National Park, Wildlife and Plant Conservation Department, Ministry of Natural Resources and Environment, Thailand
BM	=	The Herbarium of Botany Department, Natural History Museum, London, England, United Kingdom
C	=	Botanical Museum of the University of Copenhagen, Copenhagen, Denmark
E	=	The Herbarium of Royal Botanic Gardens Edinburgh, Edinburgh, Scotland, United Kingdom

LIST OF ABBREVIATIONS (Continued)

FP	=	Forest Park
GH	=	The Gray Herbarium, Harvard University, Massachusetts, United State of America
GZU	=	The Herbarium of Karl-Franzens-Universität Graz (University of Graz), Graz, Austria
K	=	The Herbarium of Royal Botanic Gardens, Kew, London, England, United Kingdom
KKU	=	The Herbarium of Khon Kaen University, Khon Kaen, Thailand
KYO	=	The Herbarium of Kyoto University, Botany Department, Kyoto, Japan
L	=	The Nationaal Herbarium Nederland, University of Leiden, Leiden, The Netherlands
NHA	=	No Hunting Area
NP	=	National Park
P	=	The Herbarium of Museum National d'Histoire Naturelle, Paris, France
PH	=	Philadelphia Herbarium, Academy of Natural Science, Philadelphia, United State of America
QBG	=	The Herbarium of Queen Sirikit Botanic Garden, Chiang Mai, Thailand

LIST OF ABBREVIATIONS (Continued)

SUT	=	The Herbarium of Suranaree University of Technology, Nakhon Ratchasima, Thailand (not official herbarium abbreviation).
U	=	The Nationaal Herbarium Nederland, Utrecht University branch, Utrecht, The Netherlands
WS	=	Wildlife Sanctuary

Others

c., ca.	=	(circa, circiter) about
comb.	=	(combinatio) combination
comb. nov.	=	(combinatio nova) new combination of name and epithet
e.g.	=	(exempli gratia) by way of example, for example
excl.	=	(exclusus) excluded
fig.	=	(figura) figure, illustration
i.e.	=	(id est) that is
no.	=	(numero) number
nom. cons.	=	(nomen conservandum) conserved name
nom. illeg.	=	(nomen illegitimum) illegitimate name, one not in accordance with the rules of nomenclature
nom. inval.	=	(nomen invalidum) name not validly published
nom. nud.	=	(nomen nudum) name published without description
nom. rej.	=	(nomen rejiciendus) name to be rejected

LIST OF ABBREVIATIONS (Continued)

nov.	=	(novus) new
n.v.	=	(non visus, non vidi) not seen, I have not seen
ser.	=	series
s.n.	=	(sine numero) without a number, unnumbered
sp.	=	species
spec.	=	specimen
syn.	=	(synonymon, synonymia) synonym, synonymy
t., tab.	=	(tabula) plate (meaning full-page illustration)
var.	=	(varietas) variety
viz.	=	(videlicet) namely
v., vol.	=	(volume) volume
µm	=	micrometer
cm	=	centimeter
m	=	meter
µl	=	microliter
ml	=	milliliter
l	=	liter

CHAPTER I

INTRODUCTION

1.1 Introduction

The Acanthaceae, or *Acanthus* family, are flowering plants with approximately 220-250 genera and 2,500-3,500 species (Cramer, 1998; Deng et al., 2009) of annual to perennial herbs, shrubs, and climbers (subfamily Thunbergioideae), but occasionally they may be large trees while several species are mangrove plants. The family is distributed mainly in tropical and subtropical regions and is well represented in the New World, tropical Africa, Madagascar, and tropical Asia, but rather less so in Australia, and extends less into temperate regions. The family is characteristic of both moist tropical forest and arid regions with a great variety of habits, including aquatic plants and xerophytes (Heywood et al., 2007).

In Thailand, the family Acanthaceae has approximately 40 genera and 230 species of annual to perennial herbs, shrubs, and climbers (Hansen, 1985). Some of the species have been studied taxonomically in some areas but not in all of the country. Moreover, in the past some botanists have studied the family, but most information was scattered or has been lost. Now, some groups of researchers have been studying and revising parts of the family for the Flora of Thailand Project of the Forest Herbarium, National Park, Wildlife and Plant Conservation Department, such as subfamily Acanthoideae, tribe Ruellieae, subtribes Ruelliinae, Andrographinae, Barleriinae at Kasetsart University, and Justiciinae at Khon Kaen University (not including the genus *Pseuderanthemum*); tribe Acantheae; and subfamily Thunbergioideae at Mahidol University (Chaikong, 2001; Sarawichit, 2005; Charoenchai and Vajrodaya, 2009; Somprasong and Vajrodaya, 2009). However, the rest of the family has not been studied yet or only a few studies have been done.

The subfamily Nelsonioideae consists of 7 genera, *Anisosepalum*, *Elytraria*, *Gynocraterium*, *Nelsonia*, *Ophiorrhiziphyllon*, *Saintpauliopsis*, and *Staurogyne*, with approximately 3, 17, 1, 1, 5, 1, and 140 species, respectively, worldwide. There are an estimated 3 genera (*Nelsonia*, *Ophiorrhiziphyllon*, *Staurogyne*) and 27 species in Thailand. The genus *Pseuderanthemum* (subtribe Justiciinae, tribe Ruellieae, subfamily Acanthoideae) is distributed mainly in tropical regions with approximately 60 species, about 7 of which occur in Thailand.

The subfamilies Nelsonioideae and Acanthoideae (genus *Pseuderanthemum*) are groups for which only a few studies have been done in some countries, and most of these are currently unfinished. Very little study has been carried out on the Thai representatives of the groups (genus *Nelsonia*, *Ophiorrhiziphyllon*, *Staurogyne*, *Pseuderanthemum*). The geographical distribution and the economic importance of the group are little known.

In Acanthaceae, the flowers and often the bracts are large and showy in many genera, making them popular ornamentals in tropical gardens or in conservatories in cooler regions. In temperate regions, some species of *Acanthus* are commonly grown outdoors. Several species are grown as house plants, but other economic uses in the family are minimal.

Owoyele et al. (2005) reported that *Nelsonia canescens* has analgesic and anti-inflammatory activities. These findings also justify the traditional use of the plant for treating pain in Nigeria.

Moreover, *Staurogyne merguensis* has been used as a taste-modifier because, after chewing its leaves, a sweet taste is elicited when drinking water. The plant grows wild and native people on Penang Island in Malaysia often cook rice with its leaves to give a sweet taste to the rice (Hiura et al., 1996).

In Thailand, many species commonly grow in the forest, such as *Phlogacanthus curviflorus*, *Acanthus ebracteatus*, *Barleria cristata*, *Staurogyne lanceolata*, *Pseuderanthemum graciliflorum*, and *Thunbergia grandiflora*, and are cultivated as ornamental and medicinal plants. Several introduced species have been used as ornamental plants in gardens, such as *Eranthemum wattii*, *Justicia betonica*, *Pseuderanthemum carruthersii*, *P. reticulatum*, and *Thunbergia erecta*. Moreover, some species have been used as medicinal plants, such as *Barleria lupulina*, *Rhinacanthus nasutus*, *Clinacanthus nutans*, *Pseuderanthemum* "*palatiferum*", and *Andrographis paniculata* (Chayamarit, 2002, 2007; Areekul et al., 2009; Padee and Nualkaew, 2009).

The objectives of the study were to describe, illustrate, and construct an artificial key to the species and record ecological and distributional data for each species of the subfamilies Nelsonioideae and Acanthoideae (*Pseuderanthemum*) (Acanthaceae) in Thailand, and to develop a phylogeny of the groups. Thus, this will help people to identify and name plant correctly, avoiding misidentification and using wrong plants for applied study.

1.2 Research Objectives

The objectives of the study were

1.2.1 To describe, illustrate, and construct an artificial key to the species and record ecological and distributional data for each species of the subfamilies Nelsonioideae and Acanthoideae (*Pseuderanthemum*) in Thailand.

1.2.2 To describe the anatomy and palynology of the taxa.

1.2.3 To develop a phylogeny of the taxa based on morphological characters and molecular data with appropriate data analysis.

1.3 Scope and Limitations

The scope and limitations of the study were

1.3.1 The work was carried out between January 2009 and February 2013 using materials obtained from various localities in Thailand and herbarium specimens from Thailand and abroad.

1.3.2 The work included study of taxonomy, morphology, anatomy, palynology, molecular, ecology, and distribution of the subfamilies Nelsonioideae and Acanthoideae (*Pseuderanthemum*) in Thailand.

1.3.3 Living specimens in Thailand were collected and preserved. The specimens were identified, described, and used for construction of a key to species.

1.4 Expected Results

1.4.1 This study was expected to show the systematics and relationships among the taxa in these groups in Thailand.

1.4.2 This study was expected to show the ecology and geographical distribution of these taxa.

1.4.3 This study was expected to show their actual and potential uses and conservation status. The knowledge will encourage development and exploitation of this resource on a sustainable basis.

1.4.4 This study was expected to provide fundamental information on the diversity of subfamilies Nelsonioideae and Acanthoideae (*Pseuderanthemum*) in Thailand and knowledge for application in management, maintenance, and protection of this group. It also provided data that can be used as an ecological database.

1.4.5 This study was expected to provide important information of these taxa for the Flora of Thailand Project of the Forest Herbarium, National Park, Wildlife and Plant Conservation Department.

1.5 Definitions

Holotype (holotypus) : the one specimen or element used by the author of a name or designated by him as nomenclature type.

Isotype (isotypus) : duplicate of the holotype.

Lectotype (lectotypus) : specimen selected from original material to serve as nomenclature type when the holotype is missing or not designated.

Neotype (neotypus) : substitute type (surrogatum), specimen selected from working purposes as representative when all of original material is missing.

Paratype (paratypus) : specimen cited with the original description other than the holotype.

Syntype (syntypus) : one of the specimens used by the author when no holotype was designated or when two or more were simultaneously designated as type.

Topotype (topotypus) : specimen from the type-locality agreeing with the type-specimen.

CHAPTER II

RESEARCH METHODOLOGY

2.1 Study Areas and Laboratories

This project was carried out at

2.1.1 Herbaria in Thailand, i.e., Forest Herbarium, Bangkok (BKF), Bangkok Herbarium (BK), Herbarium of Suranaree University of Technology, Herbarium of Khon Kaen University (KKU), Herbarium of Queen Sirikit Botanic Garden (QBG), Herbarium of Peninsular Botanical Garden (Thung Khai).

2.1.2 Field trip sites in Thailand were based on data of dried herbarium specimens, from 56 national parks, 18 wildlife sanctuaries, 1 no hunting area, 2 botanical gardens, 1 arboretum, 1 forest park (out of 147 national parks, 58 wildlife sanctuaries, 60 no hunting areas, 16 botanical gardens, 56 arboretums and 113 forest parks in Thailand) (Department of National Parks, Wildlife and Plant Conservation, 2011), and other sites including cultivated species as follow (Table 2.1):

Table 2.1 Field trip sites in Thailand (Sites followed floristic regions and provinces of Thailand).

No	Field trip sites	District - Province
	National Park (NP)	
1.	Salawin NP	Mae Sariang, Mae Hong Son
2.	Huai Nam Dang NP	Mae Taeng, Chiang Mai
3.	Doi Inthanon NP	Chom Thong, Chiang Mai
4.	Doi Suthep-Pui NP	Mueang, Chiang Mai
5.	Doi Fa Hom Pok NP	Fang, Chiang Mai
6.	Khun Chae NP	Wiang Pa Pao, Chiang Rai
7.	Doi Luang NP	Phan, Chiang Rai
8.	Phu Sang NP	Phu Sang, Phayao
9.	Doi Phu Kha NP	Pua, Nan
10.	Doi Khun Tan NP	Mae Tha, Lamphun
11.	Mae Ping NP	Li, Lamphun
12.	Chae Son NP	Mueang Pan, Lampang
13.	Mae Yom NP	Song, Phrae
14.	Wiang Kosai NP	Wang Chin, Phrae
15.	Khun Phawo NP	Mae Ramat, Tak
16.	Lan Sang NP	Mueang, Tak
17.	Thung Salaeng Luang NP	Mueang, Phitsanulok
18.	Phu Hin Rong Kla NP	Nakhon Thai, Phitsanulok
19.	Phu Kradueng NP	Phu Kradueng, Loei

Table 2.1 (Continued).

No	Field trip site	District - Province
20.	Phu Ruea NP	Phu Ruea, Loei
21.	Phu Suan Sai NP	Na Haeo, Loei
22.	Phu Phan NP	Mueang, Sakon Nakhon
23.	Phu Pha Man NP	Chum Phae, Khon Kaen
24.	Phu Wiang NP	Wiang Kao, Khon Kaen
25.	Tat Ton NP	Mueang, Chaiyaphum
26.	Sai Thong NP	Nong Bua Rawe, Chaiyaphum
27.	Khao Yai NP	Pak Chong, Nakhon Ratchasima
28.	Pha Taem NP	Khong Chiam, Ubon Ratchathani
29.	Phu Chong–Na Yoi NP	Na Chaluai, Ubon Ratchathani
30.	Khao Laem NP	Thong Pha Phum, Kanchanaburi
31.	Khuean Srinagarindra NP	Si Sawat, Kanchanaburi
32.	Thong Pha Phum NP	Thong Pha Phum, Kanchanaburi
33.	Sai Yok NP	Sai Yok, Kanchanaburi
34.	Erawan NP	Si Sawat, Kanchanaburi
35.	Kaeng Krachan NP	Kaeng Krachan, Phetchaburi
36.	Kui Buri NP	Kui Buri, Prachuap Khiri Khan
37.	Namtok Huai Yang NP	Thap Sakae, Prachuap Khiri Khan
38.	Namtok Sam Lan NP	Mueang, Saraburi
39.	Pang Sida NP	Mueang, Sa Kaeo
40.	Thap Lan NP	Na Di, Prachin Buri

Table 2.1 (Continued).

No	Field trip site	District - Province
41.	Khao Chamao-Khao Wong NP	Klaeng, Rayong
42.	Khao Khitchakut NP	Khao Khitchakut, Chanthaburi
43.	Namtok Phlio NP	Laem Sing, Chanthaburi
44.	Mu Ko Chang NP	Ko Chang, Trat
45.	Namtok Ngao NP	Mueang, Ranong
46.	Khao Sok NP	Phanom, Surat Thani
47.	Sirinat NP	Thalang, Phuket
48.	Than Bok Khorani NP	Ao Luek, Krabi
49.	Khao Nan NP	Tha Sala, Nakhon Si Thammarat
50.	Khao Luang NP	Lan Saka, Nakhon Si Thammarat
51.	Namtok Yong NP	Thung Song, Nakhon Si Thammarat
52.	Khao Pu-Khao Ya NP	Si Banphot, Phatthalung
53.	Tarutao NP	La-ngu, Satun
54.	Thale Ban NP	Khuan Don, Satun
55.	Bang Lang NP	Bannang Sta, Yala
56.	Budo-Su-ngai Padi NP	Bacho, Narathiwat
	Wildlife sanctuary (WS)	
57.	Doi Wiang La WS	Khun Yuam, Mae Hong Son
58.	Chiang Dao WS	Chiang Dao, Chiang Mai
59.	Thung Yai Naresuan WS	Umphang, Tak
60.	Umphang WS	Umphang, Tak

Table 2.1 (Continued).

No	Field trip site	District - Province
61.	Phu Luang WS	Phu Ruea, Loei
62.	Phu Wua WS	Bung Khla, Bueng Kan
63.	Phu Si Than WS	Kuchinarai, Kalasin
64.	Huai Thap Than–Huai Samran WS	Kap Choeng, Surin
65.	Yod Dom WS	Nam Yuen, Ubon Ratchathani
66.	Huai Kha Khaeng WS	Lan Sak, Uthai Thani
67.	Sap Lang Ka WS	Lam Sonthi, Lop Buri
68.	Khao Ang Rue Nai WS	Sanam Chai Khet, Chachoengsao
69.	Khao Soi Dao WS	Soi Dao, Chanthaburi
70.	Khlong Nakha WS	Suk Samran, Ranong
71.	Thung Raya–Nasak WS	Kra Buri, Ranong
72.	Khlong Yan WS	Khiri Rat Nikhom, Surat Thani
73.	Ton Nga Chang WS	Hat Yai, Songkhla
74.	Hala-Bala WS	Waeng, Narathiwat
	No hunting area (NHA)	
75.	Khao Phra Thaeo NHA	Thalang, Phuket
	Botanical garden (BG)	
76.	Queen Sirikit BG	Mae Rim, Chiang Mai
77.	Peninsular BG (Thung Khai)	Yan Ta Khao, Trang
	Arboretum (AR)	
78.	Phu Paek AR	Phu Ruea, Loei

Table 2.1 (Continued).

No	Field trip site	District - Province
	Forest Park (FP)	
79.	Phu Pha Lom FP	Mueang, Loei

2.1.3 Laboratories and herbaria abroad as follows:

2.1.3.1 Kew Herbarium and Jodrell Laboratory, Royal Botanic Gardens, Kew (K), England, United Kingdom.

2.1.3.2 Herbarium of Royal Botanic Garden, Edinburgh (E), Edinburgh, Scotland, United Kingdom.

2.1.3.3 Herbarium of Natural History Museum (BM), London, England, United Kingdom.

2.1.3.4 Nationaal Herbarium Nederland (L), Leiden, The Netherlands.

2.1.3.5 Botanical Museum of University of Copenhagen (C), Copenhagen, Denmark.

2.1.3.6 Herbarium of University of Aarhus (AAU), Aarhus, Denmark.

2.1.4 Laboratory at the Center for Scientific and Technological Equipment, Suranaree University of Technology, Nakhon Ratchasima.

2.2 Anatomical Studies

Leaves, stems, and seeds of the specimens were taken from fresh, dried, or spirit materials. Many techniques were employed, such as scraping, peeling, sectioning, clearing, and cuticular methods; however, these techniques were modified during the study. Many characters were observed, such as epidermal cells, leaf architecture, leaf venation, trichomes, cystoliths, glands, and seed coat layers, using compound light microscopes and stereomicroscopes (Dilcher, 1974; Sitthiprom and Thammathaworn, 1997) (see Chapter III).

2.3 Palynological Studies

Pollens of the specimens were taken from living or dried plants, or spirit materials. Samples were analyzed using the alkaline method (Wichelen et al., 1999); however, this technique was modified during the study. Many characters of pollen grains were investigated, such as shape, size, symmetry, aperture, exine structure, and sculpturing using light microscopy and scanning electron microscopy (Erdtman, 1966; Ruksat, 1996) (see Chapter IV).

2.4 Taxonomic and Morphological Studies

The first part of this study was review of the literature dealing with subfamilies Nelsonioideae and Acanthoideae, genus *Pseuderanthemum*, in Thailand and neighboring countries. This study was largely based on the examination of the Thai specimens and a large number of non-Thai specimens kept at the herbaria. Field collection and flowering period observations of the specimens were made in Thailand. Living specimens were photographed and noted. Specimens were pressed and dried, and selected organs were fixed. The collected specimens were deposited in herbaria. Living specimens were cultivated for anatomical and other studies. The morphological and taxonomic investigations were made directly from either living specimens from the natural habitat or the dried specimens from herbaria in Thailand or elsewhere (see Chapter V).

2.5 Phylogenetic and Evolutionary Studies

Several distinct characters of the studied groups were selected from morphological, anatomical, or palynological studies. Phylogenetic trees or cladograms were developed to separate the taxa from each other and analyze character evolution with appropriate data analysis (Maddison and Maddison, 1995, 2011; Huelsenbeck and Ronquist, 2001; Swofford, 2002) (see Chapter VI).

2.6 Biogeographical and Biodiversity Studies

A location map was created based on the natural geographical distribution of Thai species and included the cultivated species. An overview of the distribution of each species in these taxa within the genus was made from labels on Thai materials, and ecological observations were made during collection in natural habitats. The forest types followed the *Forests of Thailand* (Santisuk, 2012) (see Chapter VII).

2.7 Research Materials

In the study, the following equipment and materials were used for dried specimen preparation, fixed specimen preparation, and morphological studies: plant presses, herbarium sheets, stereo microscope with digital camera, micrometer, magnifier, digital camera; for anatomical studies: glassware, blades, chemical substances, compound microscope fitted with digital camera, Adobe Photoshop software; for palynological studies: stubs, scanning electron microscope fitted with digital camera; for ecological and distributional studies: global positioning system (GPS), magnetic compass. More details of research methods and materials are presented in chapter III-VII.

2.8 Data Analysis

2.8.1 A phylogeny was developed of the taxa based on morphological characters with appropriate data analysis, using PAUP (Swofford, 2002) and MrBayes (Huelsenbeck and Ronquist, 2001; Huelsenbeck et al., 2012).

2.8.2 A location map was created based on the geographical distribution of Thai species, including the cultivated species, as determined from collections in habitats using a global positioning system with appropriate data analysis, using ArcGIS (Environmental Systems Research Institute [ESRI], 2009).

2.8.3 Character evolution was analyzed based on morphological characters with appropriate data analysis, using Mesquite (Maddison and Maddison, 2011).

CHAPTER III

ANATOMICAL STUDY

3.1 Anatomical Review

Anatomy refers to the study of the tissues and cell structures of organs. There are many organs of plants that are used for study of anatomy, such as leaves, stems, flowers, and seeds. Anatomical studies can be used to classify and identify plants in the same genus that exhibit variation of morphological characters.

3.2 Anatomical Studies

This research has comprehended the leaf anatomical characters of studied group in 2 main categories, i.e., epidermal cells and cystoliths, and leaf venation pattern as follows:

3.3 Study on Leaf Epidermal Cells and Cystoliths

3.3.1 Introduction

Epidermis is the outermost cell layer of plants in primary growth of root, stem, leaf, fruit, and seed. Epidermal cells can be modified to form guard cells. Stomata are openings (the stomatal pores, or apertures) in the epidermis, each bounded by two guard cells, which by changes in shape bring about opening and closing. In some species, they are surrounded by subsidiary cells or accessory cells. There have been several important characters of stomata used in plant taxonomic and phylogenic studies, such as orientation, distribution, type, size, and number of stomatal cells. Moreover, epidermal cells often show several kinds of trichomes (variable epidermal appendages), which have also been used as a taxonomic tool. Trichomes may occur on all parts of the plant and may persist throughout the life of the plant part or may fall off early. Some of the persisting trichomes remain alive; others die and become dry. Although trichomes vary widely in structure within families and smaller groups of plants, they are sometimes remarkably uniform in a given taxon and have long been used for taxonomic purposes (Evert, 2007).

In many plant species, calcium crystals (calcium oxalate and calcium carbonate) are commonly formed under ordinary conditions (Arnott and Pautard, 1970). These crystals are structural components in the leaves of many higher plant families. The type and occurrence of cystoliths (consisting of calcium carbonate) in various parts of the plants has always been considered as a useful character in identification and it has often proved to be of systematic value (Metcalfe and Chalk, 1950; Fahn, 1967; Pireyre, 1961; Solereder, 1908; Kubitzki, 1969; Hsieh and Huang, 1974; Genua and Hillson, 1985). The location of cystoliths, including even xylem and phloem rays but especially in the leaf epidermal tissue, is restricted to a few families (Ben 1980; Mauseth, 1988; Metcalfe and Chalk, 1950; Pireyre, 1961), particularly in Cannabaceae, Moraceae, Urticaceae, and Acanthaceae. They are most frequently found in the epidermis, in hairs, or in special large cells which are termed lithocysts (Fahn, 1967). They are irregular in shape and occasionally completely fill up the cell. In general, the pedicel and the cystolith body are composed of callose, cellulose and pectin (Fahn, 1967; Pireyre, 1961). Two types are known in ways of cystolith formation, i.e. apical cell wall of lithocysts grows down into the lumen of the cell to form stalk and calcified body (Ajello, 1941) and incipient cystolith originates in a vacuole containing calcium carbonate depositions (Scott, 1946). This suggests an essential role of cytoplasm in the cystolith formation.

Cystoliths are usually clearly visible in dried herbarium material as short white streaks. Within Acanthaceae, the taxonomic distribution of cystoliths is restricted to the taxa with retinacula but are absent in Acantheae (Scotland and Vollesen, 2000). Linsbauer (1921), Scott (1946), and Rabiger (1951) also studied particulars concerning their development.

However, our knowledge on the anatomy in Acanthaceae is fragmentary. The present study deals with the occurrence, shape, size, distribution and orientation of cystoliths and was also made in order to find out whether or not epidermal and stomatal characters might be helpful in the delimitation of the studied group (*Nelsonia*, *Ophiorrhiziphyllon*, *Staurogyne*, and *Pseuderanthemum*) in Thailand.

3.3.2 Literature Review

Leaf anatomy of the family Acanthaceae has been investigated; however, several species remain anatomically unknown. Botanists have studied the anatomy within the subfamily Nelsonioideae and Acanthoideae (*Pseuderanthemum*) as follows:

Paliwal (1966) worked on stomata structure and ontogeny of Acanthaceae. Guard cells, subsidiary cells, and stomata orientation and distribution were examined.

Ahmad (1974a) studied the cuticle in some Nelsonioideae. The foliar epidermis and cuticle of *Staurogyne longifolia*, *Elytraria acauli*, and *Nelsonia campestris* were investigated.

Ahmad (1974b) investigated the cuticle and epidermis in some *Eranthemum* and *Pseuderanthemum*. The foliar structure in 6 species of *Pseuderanthemum* was described.

Karlstrom (1980) worked on the epidermis of Asystasieae, Pseuderanthemeae, Graptophylleae and Odontonemeae. The leaf epidermal structures of *Pseuderanthemum* were investigated in 5 species.

Inamdar (1970) and Inamdar et al. (1983) studied the structure of epidermis and stomata in some Acanthaceae. The characters of epidermal and stomatal cells were reported.

Inamdar et al. (1990) investigated the cystoliths of Acanthaceae. The occurrence, type, size, and frequency were worked out in 46 species.

Gill and Nyawuame (1990) studied the phylogenetic and systematic value of stomata in Bicarpellatae. Foliar epidermal morphology and ontogeny of stomata are described for 320 taxa in 13 families, including Acanthaceae.

Kuo-Huang and Yen (1996) investigated the lithocysts in leaves and sepals. The lithocyst formation and distribution in *Justicia procumbens* were reported.

Chaikong (2001) researched the subtribe Barleriinae in Northeastern Thailand. Leaf epidermis of 8 species of *Pseuderanthemum* was investigated.

Lin, Yen, and Kuo-Huang (2004) investigated calcium carbonate formation. The cystoliths in cotyledons of *Justicia procumbens* were examined.

3.3.3 Materials and Methods

Several taxa belonging to the genera of *Nelsonia*, *Ophiorrhiziphyllon*, *Staurogyne, Pseuderanthemum* (Acanthaceae) in Thailand were selected for study (Table 3.2). A few representative mature leaves of each taxa were prepared following the procedure of cuticular method by Dilcher (1974). In this process, the leaves were cut from the median area of the leaf along the margin. These material pieces were placed in 5% sodium hypochlorite until bleached white. The preparations were then placed in distilled water and the upper and lower epidermises were separated using flattened needles. The preparations were then dehydrated in ethanol series, stained with safranin O in 100% ethanol, transferred to xylene and mounted in permount. Photographs of the leaf anatomical characters were taken with a compound light microscope (Olympus CX40). Epidermal cells, stomata, and cystoliths were observed in shape, size, distribution and orientation. Their systematic values were considered.

3.3.4 Results

Several anatomical features of studied taxa in four genera (*Nelsonia*, *Ophiorrhiziphyllon*, *Staurogyne*, and *Pseuderanthemum*) were examined, such as epidermal cells, stomata, cystoliths, and trichomes. The description of each taxa is provided as follows:

Pseuderanthemum axillare (Figure 3.1: 1A-B)

Upper leaf surface: epidermal cells were polygonal, rectangular, approximately 41-72 × 24-34 µm in size, with undulate anticlinal cell walls (cell outline); trichome was peltate, hair uniseriate, multicellular, 60-96 µm long; cystoliths usually solitary, elongated, rarely double, solitary short, or irregular; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 48-77 × 29-41 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 17-24 µm long; trichomes were peltate, hair same as upper surface; cystoliths equally dense in upper leaf surface.

Pseuderanthemum bracteatum (Figure 3.1: 2A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 48-86 × 38-67 µm in size, with undulate walls; trichome was peltate, hair uniseriate, 1-multicellular, 90-440 µm long; cystoliths usually solitary, elongated, rarely double, or solitary short; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 67-108 × 43-58 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 19-24 µm long; trichomes were peltate, hair same as upper surface; cystoliths occasionally found.

Pseuderanthemum carruthersii (elliptic leaf form) (Figure 3.1: 3A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 34-42 × 22-31 µm in size, with straight-round walls; trichome was peltate, no hairs; cystoliths usually solitary, elongated, rarely double, solitary short, round, or irregular; marginal epidermal cells were isodiametric.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 31-36 × 19-24 µm in size, with straight-round walls; stomata diacytic, random orientation, guard cells 19-24 µm long; trichomes were peltate, no hairs; cystoliths occasionally found.

Pseuderanthemum carruthersii (ovate leaf form) (Figure 3.1: 4A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 19-26 × 24-31 µm in size, with straight-round walls; no hairs; cystoliths usually solitary, elongated, rarely short; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 24-31 × 12-19 µm in size, with straight-round walls; stomata diacytic, random orientation, guard cells 10-22 µm long; trichomes were peltate, no hairs; cystoliths occasionally found.

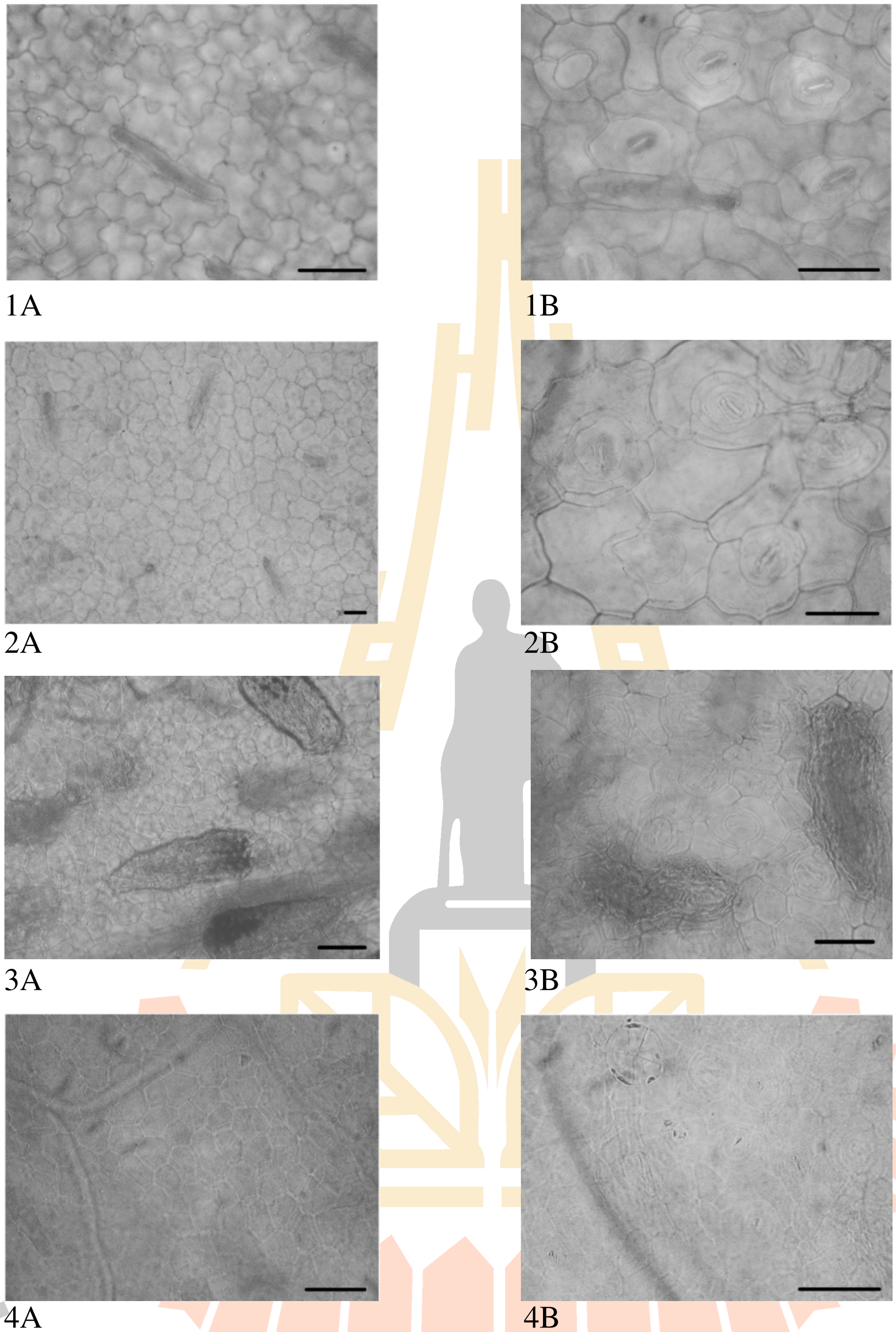


Figure 3.1 Leaf epidermal features under LM.

1) *Pseuderanthemum axillare* 2) *Pseuderanthemum bracteatum*

3) *Pseuderanthemum carruthersii* (A) 4) *Pseuderanthemum carruthersii* (B)

A: Upper surface B: Lower surface

Scale bars = 50 μm

Pseuderanthemum crenulatum (Figure 3.2: 5A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 43-60 × 31-48 μm in size, with straight-round walls; hairs only on vein, uniseriate, multicellular, 200-430 μm long; cystoliths usually solitary, elongated, rarely short; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, isodiametric, approximately 48-72 × 29-60 μm in size, with straight-round walls; stomata diacytic, random orientation, guard cells 24-26 μm long; hairs only on vein; cystoliths occasionally found.

Pseuderanthemum graciliflorum (Figure 3.2: 6A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 36-48 × 24-31 μm in size, with undulate walls; hairs on vein, uniseriate, multicellular, 150-220 μm long; cystoliths usually solitary, elongated, rarely double, solitary short, or irregular; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 29-48 × 19-36 μm in size, with undulate walls; stomata diacytic, random orientation, guard cells 19-26 μm long; trichomes were peltate, hairs uniseriate, multicellular; cystoliths occasionally found.

Pseuderanthemum latifolium (Figure 3.2: 7A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 48-67 × 36-48 µm in size, with straight-round walls; no hairs; cystoliths solitary, elongated; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 48-72 × 26-43 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 24-29 µm long; trichomes were peltate, no hairs; cystoliths occasionally found.

Pseuderanthemum laxiflorum (Figure 3.2: 8A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 24-34 × 22-24 µm in size, with straight-round walls; no hairs; cystoliths usually solitary, elongated, rarely short, round, or irregular; marginal epidermal cells were isodiametric.

Lower leaf surface: epidermal cells were polygonal, isodiametric, approximately 22-29 × 14-24 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 14-19 µm long; no hairs; cystoliths occasionally found.

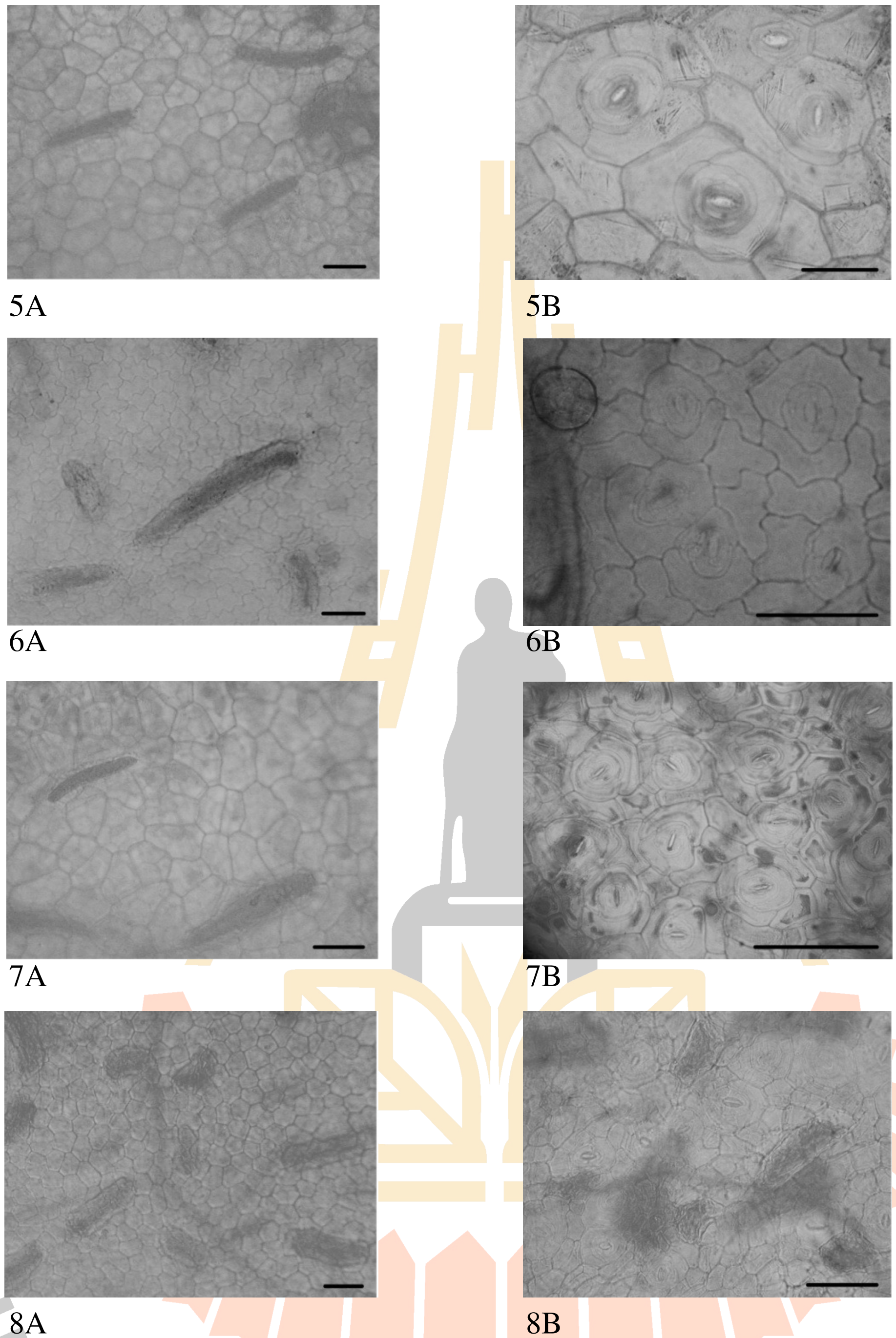


Figure 3.2 Leaf epidermal features under LM.

5) *Pseuderanthemum crenulatum* 6) *Pseuderanthemum graciliflorum*

7) *Pseuderanthemum latifolium* 8) *Pseuderanthemum laxiflorum*

A: Upper surface B: Lower surface

Scale bars = 50 µm

Pseuderanthemum longistylum (Figure 3.3: 9A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 41-72 × 31-48 μm in size, with undulate walls; no hairs; cystoliths usually solitary, elongated, rarely short; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 60-77 × 29-58 μm in size, with undulate walls; stomata diacytic, random orientation, guard cells 24-29 μm long; trichomes were peltate, hairs only on veins; cystoliths occasionally found.

Pseuderanthemum "*palatiferum*" (Figure 3.3: 10A-B)

Upper leaf surface: epidermal cells were polygonal, rectangular, approximately 48-62 × 31-38 μm in size, with undulate walls; trichome was peltate, hairs uniseriate, multicellular, 80-170 μm long; cystoliths usually solitary, elongated, rarely double, solitary short, round, or irregular; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 48-72 × 22-29 μm in size, with undulate walls; stomata diacytic, random orientation, guard cells 19-24 μm long; trichomes were peltate, hairs same as upper surface; cystoliths occasionally found.

Pseuderanthemum parishii (Figure 3.3: 11A-B)

Upper leaf surface: epidermal cells were polygonal, rectangular, approximately 48-65 × 24-41 μm in size, with undulate walls; trichome was peltate, hairs on margin, uniseriate, multicellular, 200-360 μm long; cystoliths usually solitary, elongated, rarely double, solitary short; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 38-67 × 29-53 μm in size, with undulate walls; stomata diacytic, random orientation, guard cells 24-29 μm long; trichomes were peltate, no hairs; cystoliths occasionally found.

Pseuderanthemum reticulatum (elliptic leaf form) (Figure 3.3: 12A-B)

Upper leaf surface: epidermal cells were polygonal, rectangular, approximately 29-60 × 22-29 μm in size, with straight-round walls; no hairs; cystoliths usually solitary, elongated, rarely short; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, isodiametric, approximately 19-31 × 17-26 μm in size, with undulate walls; stomata diacytic, random orientation, guard cells 17-24 μm long; trichomes were peltate, no hairs; cystoliths occasionally found.

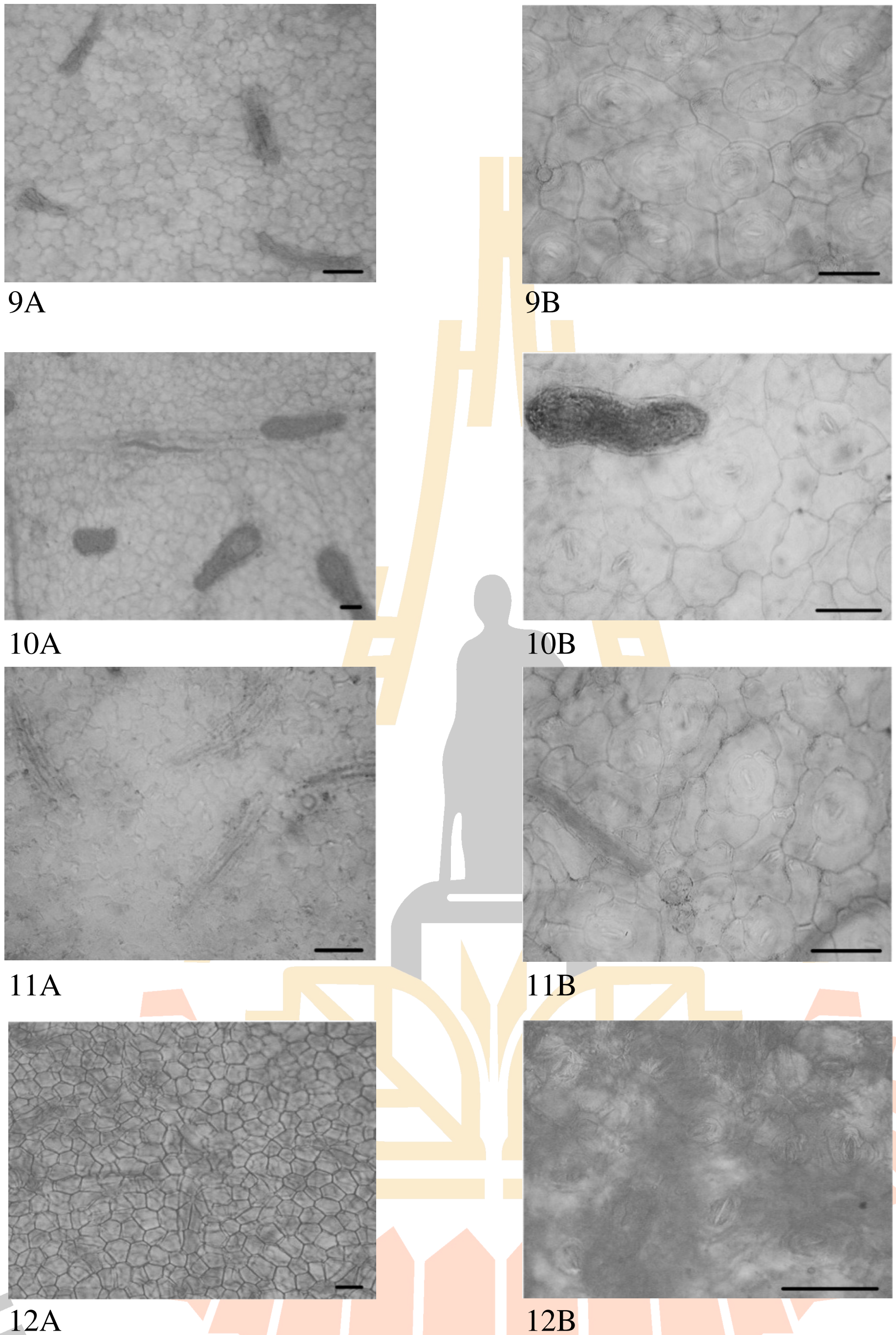


Figure 3.3 Leaf epidermal features under LM.

9) *Pseuderanthemum longistylum* 10) *Pseuderanthemum "palatiferum"*

11) *Pseuderanthemum parishii* 12) *Pseuderanthemum reticulatum* (A)

A: Upper surface B: Lower surface

Scale bars = 50 µm

Pseuderanthemum reticulatum (ovate leaf form) (Figure 3.4: 13A-B)

Upper leaf surface: epidermal cells were polygonal, rectangular, approximately 31-48 × 22-26 μm in size, with straight-round walls; no hairs; cystoliths usually solitary, elongated, rarely double, solitary short, round, or irregular; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, isodiametric, approximately 26-43 × 14-31 μm in size, with undulate walls; stomata diacytic, random orientation, guard cells 14-26 μm long; trichomes were peltate, no hairs; cystoliths occasionally found.

Pseuderanthemum sp1 (Figure 3.4: 14A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 48-84 × 31-72 μm in size, with undulate walls; hairs uniseriate, multicellular, 300-550 μm long; cystoliths usually solitary, elongated, rarely short; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 60-103 × 36-60 μm in size, with undulate walls; stomata diacytic, random orientation, guard cells 22-26 μm long; trichomes were peltate, hairs same as upper surface; cystoliths occasionally found.

Pseuderanthemum sp2 (Figure 3.4: 15A-B)

Upper leaf surface: epidermal cells were polygonal, rectangular, approximately 58-77 × 36-53 µm in size, with undulate wall; no hairs; cystoliths usually solitary, elongated, rarely short; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 41-96 × 24-43 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 17-26 µm long; trichomes were peltate, no hairs; cystoliths occasionally found.

Nelsonia canescens (Figure 3.4: 16A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 48-79 × 43-48 µm in size, with straight-round walls, trichome, hairs uniseriate, multicellular, 100-800 µm long; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, isodiametric, approximately 31-60 × 24-53 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 17-26 µm long; glandular trichome was panduriform; hairs same as upper surface; no cystoliths.

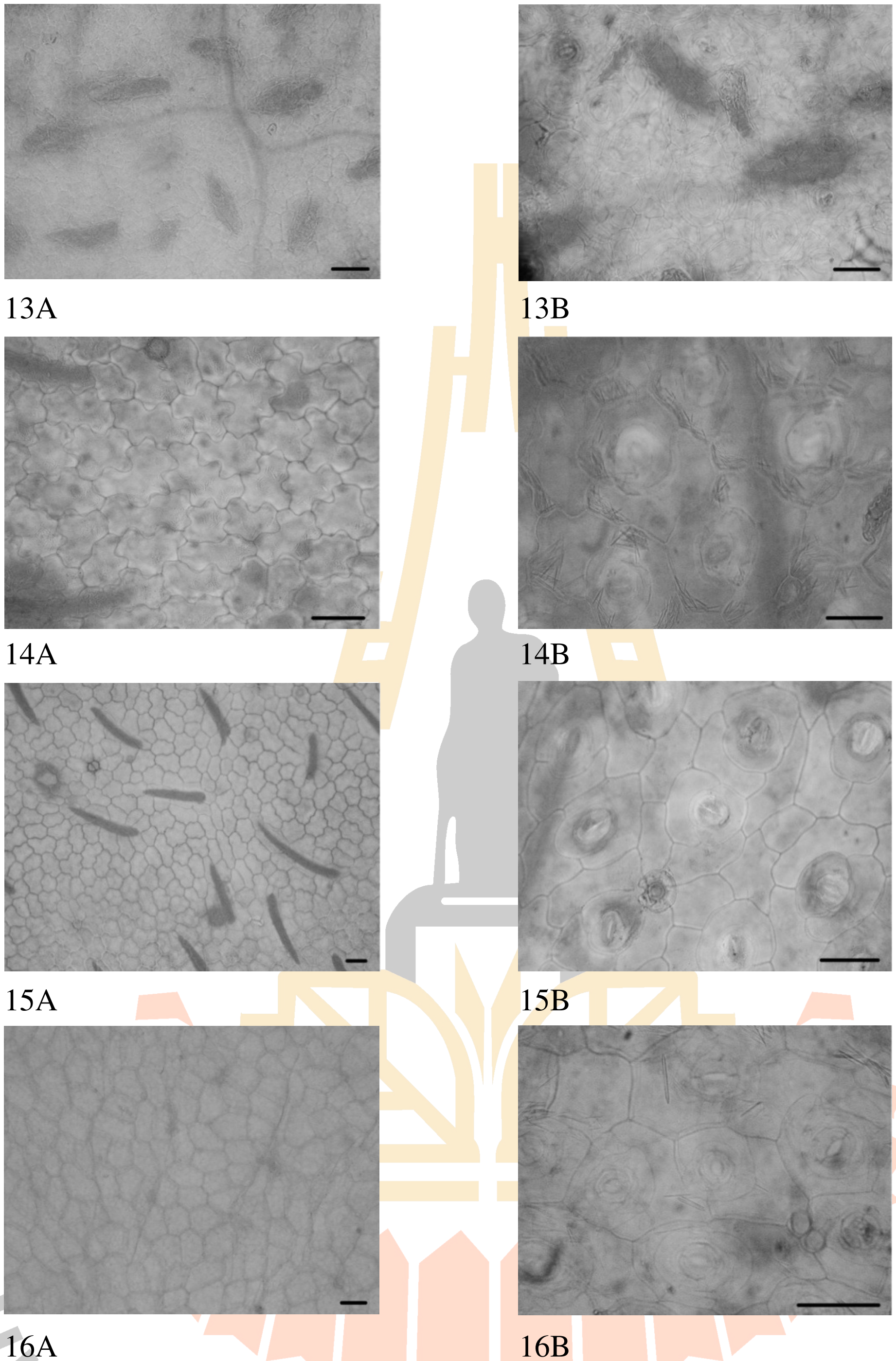


Figure 3.4 Leaf epidermal features under LM.

13) *Pseuderanthemum reticulatum* (B) 14) *Pseuderanthemum* sp1

15) *Pseuderanthemum* sp2 16) *Nelsonia canescens*

A: Upper surface B: Lower surface

Scale bars = 50 µm

Ophiorrhiziphyllon macrobotryum (Figure 3.5: 17A-B)

Upper leaf surface: epidermal cells were polygonal, rectangular, approximately 24-48 × 17-22 μm in size, with undulate walls, glandular trichome was panduriform, hairs uniseriate, multicellular, 50-170 μm long; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 36-46 × 19-31 μm in size, with undulate walls; stomata diacytic, random orientation, guard cells 24-26 μm long; glandular trichome was panduriform; hairs same as upper surface; no cystoliths.

Staurogyne argentea (Figure 3.5: 18A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 48-72 × 34-55 μm in size, with straight-round walls, no hairs; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, isodiametric, approximately 55-86 × 46-53 μm in size, with straight-round walls; stomata diacytic, random orientation, guard cells 24-26 μm long; glandular trichome was panduriform; hairs uniseriate, 60-220 μm long; no cystoliths.

Staurogyne concinnula (Figure 3.5: 19A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 50-70 × 38-53 µm in size, with straight-round walls, hairs uniseriate, multicellular, 20-350 µm long; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, isodiametric, approximately 53-72 × 29-53 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 26-29 µm long; glandular trichome was panduriform; hairs same as upper surface; no cystoliths.

Staurogyne glauca (Figure 3.5: 20A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 48-72 × 36-48 µm in size, with undulate walls; stomata rarely found; hairs uniseriate, multicellular, 140-400 µm long; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, isodiametric, approximately 48-55 × 36-43 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 22-24 µm long; glandular trichome was panduriform; hairs same as upper surface; no cystoliths.

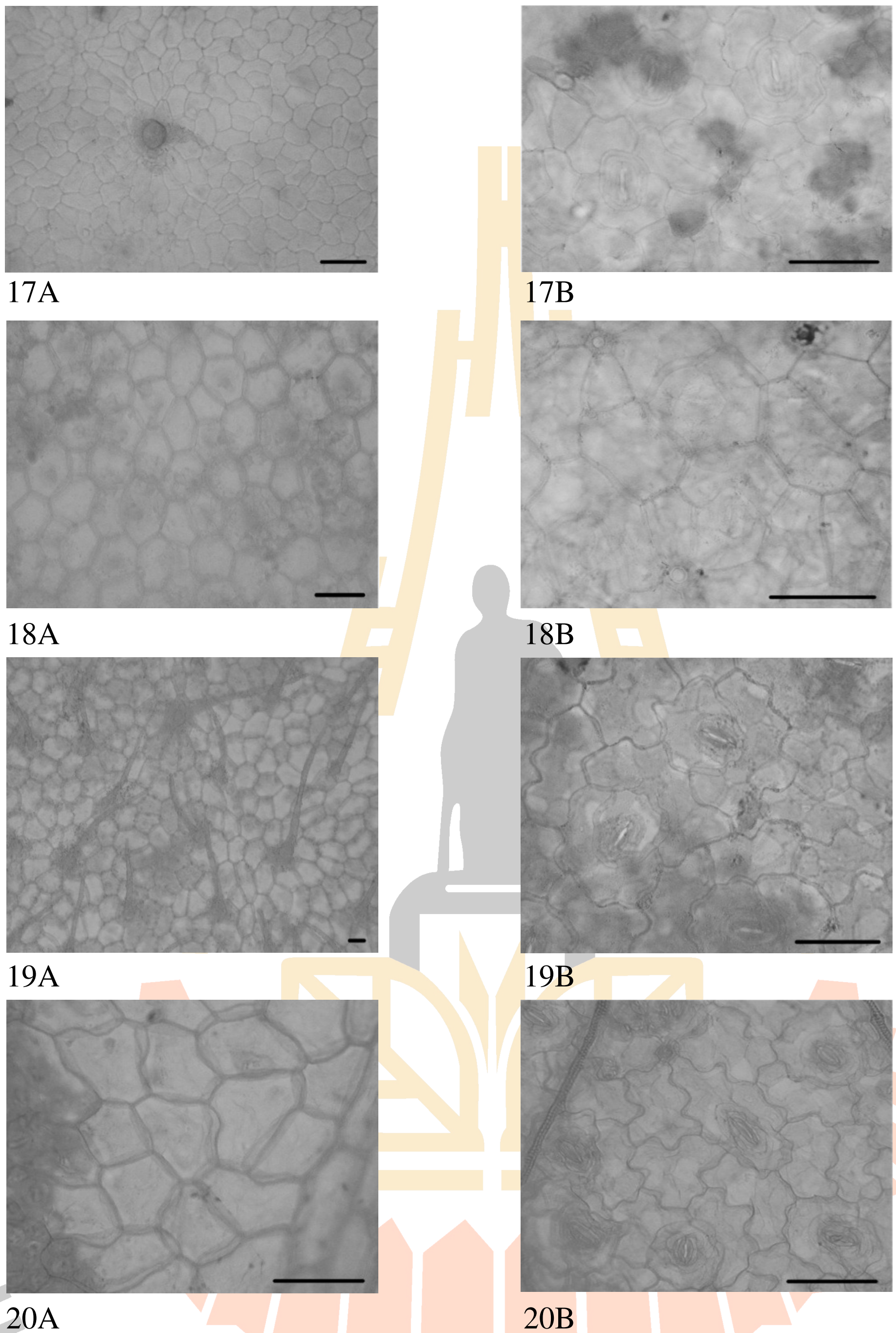


Figure 3.5 Leaf epidermal features under LM.

17) *Ophiorrhiziphyllon macrobotryum* 18) *Staurogyne argentea*

19) *Staurogyne concinnula* 20) *Staurogyne glauca*

A: Upper surface B: Lower surface

Scale bars = 50 µm

Staurogyne helferi (Figure 3.6: 21A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 46-55 × 36-48 μm in size, with straight-round walls; glandular trichome was panduriform, hairs uniseriate, multicellular, 220-400 μm long; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, with undulate walls; stomata diacytic, random orientation, guard cells 26-31 μm long; glandular trichome was panduriform; hairs same as upper surface; no cystoliths.

Staurogyne incana (Figure 3.6: 22A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 60-79 × 34-60 μm in size, with straight-round walls, glandular trichome was panduriform, hairs uniseriate, multicellular, 200-420 μm long; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 48-67 × 36-41 μm in size, with undulate walls; stomata diacytic, random orientation, guard cells 24-26 μm long; glandular trichome was panduriform; hairs same as upper surface; no cystoliths.

Staurogyne lanceolata (Figure 3.6: 23A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 48-53 × 31-36 µm in size, with straight-round walls, hairs uniseriate, multicellular, 300-550 µm long; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 55-67 × 31-48 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 22-26 µm long; glandular trichome was panduriform; hairs same as upper surface; no cystoliths.

Staurogyne lasiobotrys (Figure 3.6: 24A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 48-82 × 34-55 µm in size, with undulate walls, hairs uniseriate, multicellular, 80-170 µm long; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 67-108 × 43-62 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 24-26 µm long; glandular trichome was panduriform; hairs same as upper surface; no cystoliths.

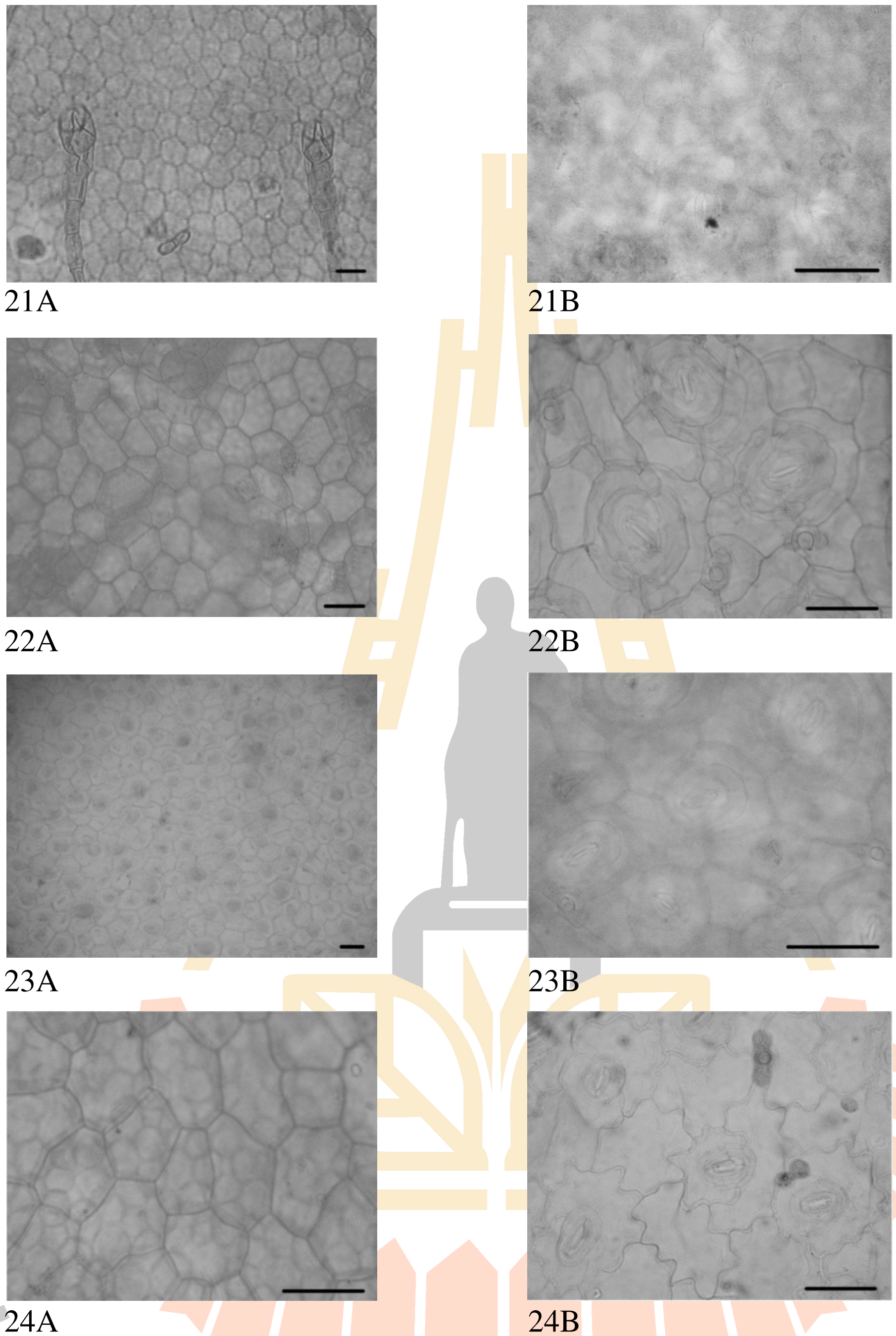


Figure 3.6 Leaf epidermal features under LM.

21) *Staurogyne helferi* 22) *Staurogyne incana*

23) *Staurogyne lanceolata* 24) *Staurogyne lasiobotrys*

A: Upper surface B: Lower surface

Scale bars = 50 µm

Staurogyne major (Figure 3.7: 25A-B)

Upper leaf surface: epidermal cells were polygonal, rectangular, approximately 41-67 × 24-31 µm in size, with undulate walls, trichome, hairs uniseriate, multicellular, 100-200 µm long; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, isodiametric, approximately 48-67 × 36-46 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 26-28 µm long; glandular trichome was panduriform; no hairs; no cystoliths.

Staurogyne merguensis (Figure 3.7: 26A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 53-72 × 46-58 µm in size, with straight-round walls; no hairs; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, isodiametric, approximately 24-36 × 22-36 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 26-34 µm long; glandular trichome was panduriform; hairs uniseriate, multicellular, 200-250 µm long; no cystoliths.

Staurogyne punctata (Figure 3.7: 27A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 48-65 × 29-48 μm in size, with undulate walls, hairs only on veins, uniseriate, multicellular; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 60-79 × 34-55 μm in size, with undulate walls; stomata diacytic, random orientation, guard cells 24-29 μm long; glandular trichome was panduriform; no cystoliths.

Staurogyne setigera (Figure 3.7: 28A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 53-72 × 36-60 μm in size, with straight-round walls; no hairs; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, with undulate walls; stomata diacytic, random orientation, guard cells 24-31 μm long; glandular trichome was panduriform; hairs uniseriate, multicellular; no cystoliths.

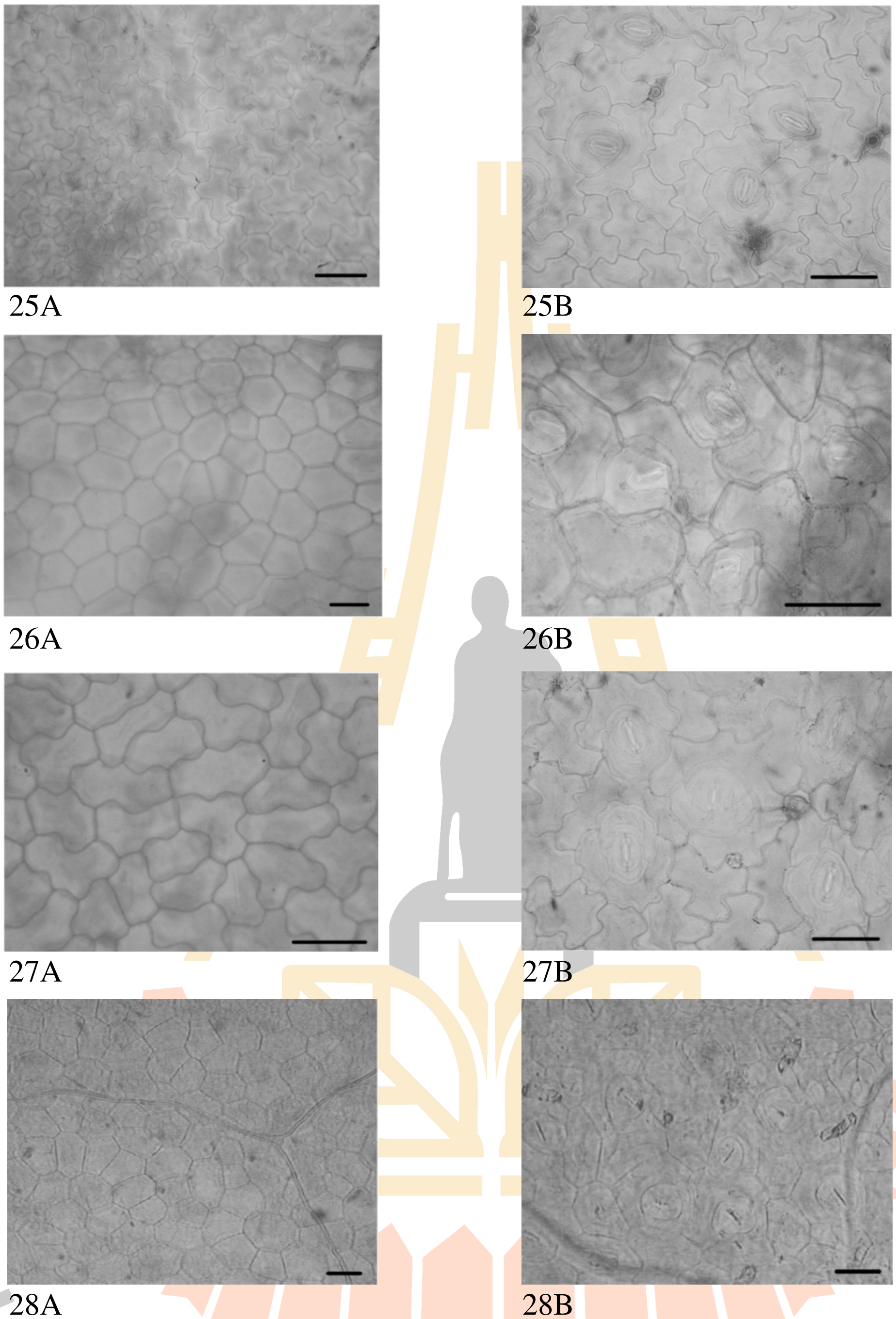


Figure 3.7 Leaf epidermal features under LM.

25) *Staurogyne major* 26) *Staurogyne merguensis*

27) *Staurogyne punctata* 28) *Staurogyne setigera*

A: Upper surface B: Lower surface

Scale bars = 50 µm

Staurogyne spatulata (Figure 3.8: 29A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 60-82 × 36-53 µm in size, with straight-round walls, trichome, hairs uniseriate, multicellular, 140-1130 µm long; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, rectangular, approximately 48-77 × 24-38 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 19-24 µm long; glandular trichome was panduriform; hairs same as upper surface; no cystoliths.

Staurogyne subglabra (Figure 3.8: 30A-B)

Upper leaf surface: epidermal cells were polygonal, isodiametric, approximately 50-72 × 36-46 µm in size, with undulate walls; no hairs; no cystoliths; marginal epidermal cells were rectangular.

Lower leaf surface: epidermal cells were polygonal, isodiametric, approximately 60-1152 × 48-84 µm in size, with undulate walls; stomata diacytic, random orientation, guard cells 26-31 µm long; glandular trichome was panduriform; hairs uniseriate, multicellular, 120-230 µm long; no cystoliths.

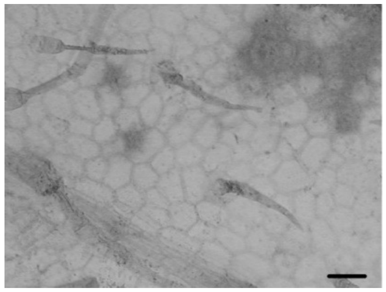
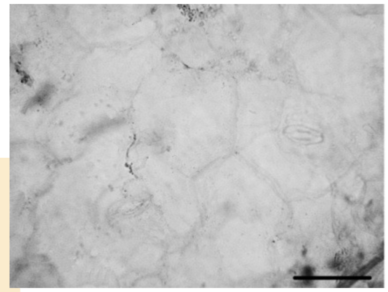
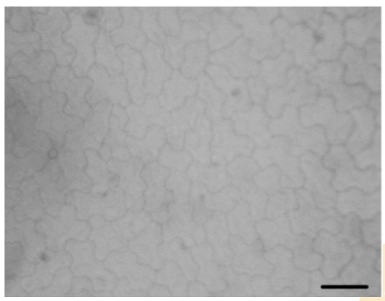
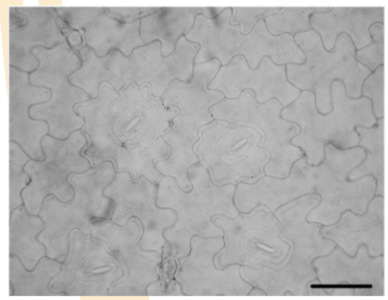

29A

29B

30A

30B

Figure 3.8 Leaf epidermal features under LM.

29) *Staurogyne spatulata* 30) *Staurogyne subglabra*

A: Upper surface B: Lower surface

Scale bars = 50 µm

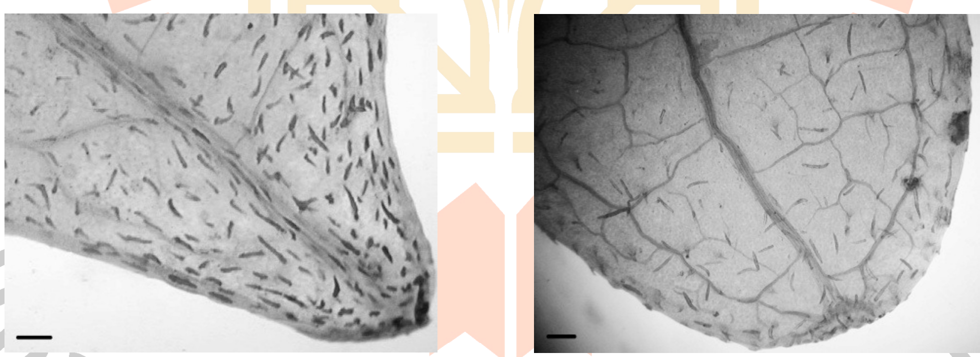


Figure 3.9 The orientation of cystoliths in the leaves of *Pseuderanthemum*.

A: parallel to midrib and leaf margin with random in central area.

B: parallel to leaf margin with random in central area and midrib.

Scale bars = 200 µm

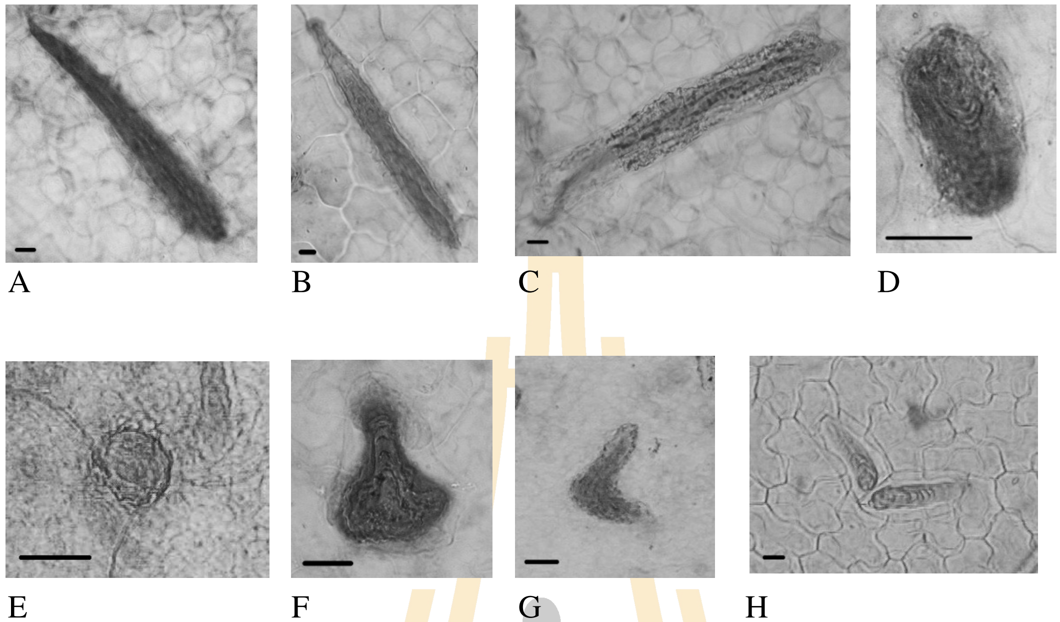


Figure 3.10 The various types of cystoliths in the leaves of *Pseuderanthemum*.

A: elongated, tapering at one end, B: elongated, tapering at both ends, C: elongated, blunt at both ends, D: short, blunt at both ends, E: rounded, F-G: irregular, H: double. Scale bars = 10 µm

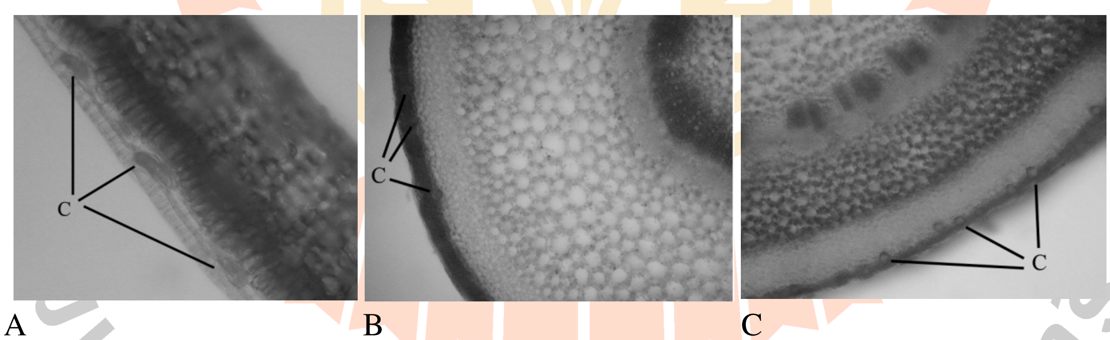


Figure 3.11 The occurrence and outline of cystoliths in *Pseuderanthemum* using cross sections of fresh materials under LM.

A: leaf, B: petiole, C: young branch

Table 3.1 Size, length and breadth ratio, and shape of cystoliths in the leaves of *Pseuderanthemum*.

No	Taxa	Size (μm)		Length/Breadth	Shape
		Length	Breadth		
1	*P. axillare*	151	29	5.2	a-b-c-d-f-g
2	*P. bracteatum*	114	27	4.2	a-c-d-g
3	*P. carruthersii* (A)	135	56	2.4	a-c-d-e-f-g
4	*P. carruthersii* (B)	105	37	2.8	a-c-d
5	*P. crenulatum*	149	26	5.7	a-c-d
6	*P. graciliflorum*	150	37	4.1	a-b-c-d-f-g
7	*P. latifolium*	257	50	5.1	a-c
8	*P. laxiflorum*	134	30	4.5	a-c-d-e-f
9	*P. longistylum*	146	31	4.7	a-b-c-d
10	*P. "palatiferum"*	117	61	1.9	a-c-d-e-f-g
11	*P. parishii*	179	29	6.2	a-c-d-g
12	*P. reticulatum* (A)	141	39	3.6	a-c-d
13	*P. reticulatum* (B)	110	31	3.5	a-b-c-d-e-f-g
14	*P.* sp1	204	35	5.8	a-b-c-d
15	*P.* sp2	206	23	9.0	a-c-d

a: elongated, tapering at one end

b: elongated, tapering at both ends

c: elongated blunt at both ends

d: short, blunt at both ends

e: rounded

f: irregular

g: double

Table 3.2 The epidermal features of studied taxa in Thai Acanthaceae.

Species	Upper surface				Lower surface			
	length (µm)	width (µm)	shape	outline	length (µm)	width (µm)	shape	outline
P. axillare	54	29	REC	U	65	34	REC	U
P. bracteatum	71	49	ISO	U	85	50	REC	U
P. carruthersii (A)	36	24	ISO	S-R	33	21	REC	S-R
P. carruthersii (B)	27	24	ISO	S-R	26	14	REC	S-R
P. crenulatum	52	39	ISO	S-R	58	41	ISO	U
P. graciliflorum	39	29	ISO	U	39	25	REC	U
P. latifolium	55	42	ISO	S-R	25	13	REC	U
P. laxiflorum	29	23	ISO	S-R	25	19	ISO	U
P. longistylum	54	40	ISO	U	69	45	REC	U
P. "palatiferum"	54	36	REC	U	57	25	REC	U
P. parishii	57	33	REC	U	53	35	REC	U
P. reticulatum (A)	42	24	REC	S-R	25	22	ISO	U
P. reticulatum (B)	37	24	REC	S-R	35	24	ISO	U
P. siamense	-	-	-	S-R	-	-	-	U
P. sp1	67	50	ISO	U	75	48	REC	U
P. sp2	67	45	REC	U	68	33	REC	U
N. canescens	63	45	ISO	S-R	46	33	ISO	U
O. macrobotryum	36	20	REC	U	39	25	REC	U
S. argentea	60	45	ISO	S-R	65	48	ISO	S-R
S. concinnula	61	48	ISO	S-R	63	44	ISO	U
S. glauca	55	45	ISO	U	51	39	ISO	U
S. helferi	51	41	ISO	S-R	-	-	-	U
S. incana	66	47	ISO	S-R	61	39	REC	U
S. lanceolata	50	34	ISO	S-R	60	39	REC	U
S. lasiobotrys	64	45	ISO	U	89	55	REC	U
S. major	52	28	REC	U	60	40	ISO	U
S. merguensis	67	49	ISO	S-R	66	54	ISO	U
S. punctata	57	38	ISO	U	70	41	REC	U
S. setigera	64	51	ISO	S-R	-	-	-	U
S. spatulata	65	46	ISO	S-R	58	33	REC	U
S. subglabra	59	39	ISO	U	89	66	ISO	U

* REC: rectangular, ISO: isodiametric, U: Undulate, S: straight, R: round.

Table 3.3 The stomata and trichomes of studied taxa in Thai Acanthaceae.

Species	Stomata			Non-glandular trichome			Glandular trichome
	length (μm)	width (μm)	type	Length (μm)	type	nature	
P. axillare	21	12	diacytic	60-96	uniseriate	2-multi	-
P. bracteatum	23	13	diacytic	200-360	uniseriate	1-multi	-
P. carruthersii (A)	21	13	diacytic	-	-	-	-
P. carruthersii (B)	16	11	diacytic	-	-	-	-
P. crenulatum	25	19	diacytic	200-430	uniseriate	multi	-
P. graciliflorum	23	16	diacytic	150-220	uniseriate	multi	-
P. latifolium	25	13	diacytic	-	-	-	-
P. laxiflorum	17	10	diacytic	-	-	-	-
P. longistylum	26	19	diacytic	-	uniseriate	multi	-
P. "palatiferum"	22	13	diacytic	80-170	uniseriate	multi	-
P. parishii	26	14	diacytic	200-360	uniseriate	2-celled	-
P. reticulatum (A)	20	12	diacytic	-	-	-	-
P. reticulatum (B)	20	11	diacytic	-	-	-	-
P. siamense	-	-	-	-	uniseriate	multi	-
P. sp1	24	14	diacytic	300-550	uniseriate	multi	-
P. sp2	23	15	diacytic	-	-	-	-
N. canescens	22	14	diacytic	100-800	uniseriate	2-multi	PAN-L
O. macrobotryum	25	14	diacytic	50-170	uniseriate	1-multi	PAN-U,L
S. argentea	24	16	diacytic	60-220	uniseriate	1-2-cell	PAN-L
S. concinnula	27	14	diacytic	20-350	uniseriate	multi	PAN-L
S. glauca	24	12	diacytic	140-400	uniseriate	1-multi	PAN-L
S. helferi	28	14	diacytic	220-400	uniseriate	multi	PAN-U,L
S. incana	25	15	diacytic	200-420	uniseriate	multi	PAN-U,L
S. lanceolata	23	12	diacytic	300-550	uniseriate	1-multi	PAN-L
S. lasiobotrys	25	15	diacytic	80-170	uniseriate	1-multi	PAN-L
S. major	28	16	diacytic	100-200	uniseriate	1-multi	PAN-L
S. merguensis	30	16	diacytic	200-250	uniseriate	multi	PAN-L
S. punctata	26	14	diacytic	100-130	uniseriate	multi	PAN-L
S. setigera	27	12	diacytic	-	uniseriate	1-multi	PAN-L
S. spatulata	22	12	diacytic	140-1130	uniseriate	multi	PAN-L
S. subglabra	29	15	diacytic	120-230	uniseriate	2-multi	PAN-L

L: lower surface, U: upper surface, multi: multicellular, PAN: panduriform, PEL: peltate.

3.3.5 Conclusions and Discussion

As the results, the epidermal cells are polygonal, isodiametric (*Pseuderanthemum*, *Nelsonia*, *Staurogyne*), or rectangular (*Pseuderanthemum*, *Ophiorrhiziphyllon*, *Staurogyne*) in various directions and are irregularly arranged. The cells of the epidermis have sinuous, arched (*Pseuderanthemum*, *Nelsonia*: lower surface, *Ophiorrhiziphyllon*, *Staurogyne*), or straight-round walls (*Pseuderanthemum*, *Nelsonia*: upper surface, *Staurogyne*). Cuticle is thin or thick and striated. The presence of glandular hairs occurs with 4-8 (general 8-) celled heads and the non-glandular hairs are sparse and inconspicuous in *Pseuderanthemum*. If undulation were found in upper epidermal cells, it was also found in the lower epidermis, but in upper epidermal cells with straight-round walls, there could be found undulation or straight-round walls in lower epidermal cells. When there is a difference in the degree of undulation between the two surfaces of the leaves, the cells of the lower epidermis have walls more undulated than those of the upper epidermis. The cells on the lower and upper epidermis are almost equal in size in most species. No great differences in stomatal size (i.e., the size of guard cells) between the lower and upper epidermis were found in most of those species which have stomata on both surfaces of the leaves. The occurrence of stomata on midribs seems to be regular, occasional, or sparse.

Upper epidermal cells tended to show the largest size in *Nelsonia*, followed by *Pseuderanthemum* and *Staurogyne*, and then *Ophiorrhiziphyllon*. When considering the species level, the largest cells were observed in *P. bracteatum* and the smallest in *P. carruthersii* (B). Their shape was more angular than undulate.

In lower epidermal cells, the largest ones tended to show in *Staurogyne* and *Pseuderanthemum*, followed by *Nelsonia*, and then *Ophiorrhiziphyllon*. The largest cells were found in *S. subglabra* and the smallest in *P. latifolium* at the species level. Most species in the *Pseuderanthemum* and *Staurogyne* showed cells with undulate walls, but only in *S. argentea* and *P. carruthersii* occurred straight-round walls.

Leaf trichomes were found almost all studied taxa, usually on veins, but differed in the length, density, and distribution. There was no hair on the leaves of 8 taxa, i.e., *P. carruthersii* (A and B), *P. latifolium*, *P. laxiflorum*, *P. metallicum*, *P. reticulatum* (A and B), and *P.* sp2. Non-glandular trichomes were uniseriate type, uni- or multicellular nature with 1-many celled base. Glandular trichomes were panduriform, occurring only in Nelsonioideae. Panduriform trichomes were mostly distributed on the lower surface but could be found on both surfaces in *O. macrobotryum*, *S. helferi*, and *S. incana*. Peltate trichomes were observed mostly in the lower surface of *Pseuderanthemum*, except in *P. axillare*, *P. bracteatum*, *P. graciliflorum*, *P.* "*palatiferum*", and *P. parishii*, where they were presented in both surfaces. Therefore, some features of leaf epidermal cells can be used to separate some species from the others.

The stomata in the studied group occur on both adaxial and abaxial surfaces of the leaf in *Staurogyne glauca*, although more stomata occur on the lower surface than on the upper. No stomata were found in the upper epidermis of the remaining species studied belonging to the *Pseuderanthemum*, *Nelsonia*, *Ophiorrhiziphyllon*, and *Staurogyne*. The mature stomata of studied group are typically diacytic or caryophyllaceous type with a pair of guard cells at right angles to the subsidiary cells. The stomata are surrounded by two, three, or four subsidiary cells, and all three types occur on the same surface of the epidermis. The stomata are irregularly oriented and distributed in the areas between veins. Abnormal stomata with one guard cell with or without pore, contiguous stomata, aborted guard cells, and arrested development also occur.

In this study, there was no cystoliths in all taxa of the subfamily Nelsonioideae (*Nelsonia*, *Ophiorrhiziphyllon*, *Staurogyne*). However, cystoliths were found in all taxa of Thai *Pseuderanthemum* (Acanthoideae). Their shape and size were variable, both within a sample and between different samples. The nature and distribution of cystoliths is a valuable character in the Acanthaceae.

The cystoliths in the leaves were mainly found as eyebrow-shaped or rod-shaped crystals. All calcium carbonate crystals or cystoliths were located in the epidermal lithocysts. They never completely fill up the cell lumen. The surface is always more or less granular, but without the sharp point characteristic for crystals. However, pedicels were rarely observed in these materials, in which, it was considered pedicels are absent.

During the present investigation, their shape varied from round to long cylinder, which was divided into 7 types of shape: (a) elongated, tapering at one end, (b) elongated, tapering at both ends, (c) elongated blunt at both ends, (d) short, blunt at both ends, (e) rounded, (f) irregular, and (g) double (Fig. 3.10). The most common shape for all of materials was elongated cystoliths tapering at one end, while Karlstrom (1980) reported that the elongated cystoliths blunt at both ends dominated in *Pseuderanthemum*. They are occasionally elongated, tapering at both ends in *Pseuderanthemum axillare*, *P. graciliflorum*, *P. longistylum*, *P.* sp1, and *P. reticulatum* (B: species with ovate-shaped leaves), and rounded cystoliths in all taxa except in *P. latifolium*, but rarely accompanied by irregular cystoliths in *P. axillare*, *P. carruthersii* (A: species with elliptic leaves), *P. graciliflorum*, *P. laxiflorum*, *P.* "*palatiferum*", and *P. reticulatum* (B). They are mostly simple or solitary crystals but double cystoliths rarely occurred in *P. axillare*, *P. bracteatum*, *P. carruthersii* (A), *P. graciliflorum*, *P.* "*palatiferum*", *P. parishii*, and *P. reticulatum* (B). As a result, *P. reticulatum* (B) was characterized by the greatest presence of various types of cystoliths, while *P. latifolium* showed the least difference of cystolith types. Moreover, the outline of cystoliths was round, ovate, or oblong in cross sections of selected fresh materials in additional investigations (Figure 3.11).

The irregular and double cystoliths were rarely found. The cystoliths of this genus have only been considered as short, broad, blunt at both ends, which was used to distinguish *Pseuderanthemum bicolor* from *Eranthemum roseum*, with elongated, narrow, tapering at one end (Inamdar, Chaudhari, and Rao, 1990). Moreover, more categories of cystoliths have been reported in *Pseuderanthemum*, i.e., elongated with tapering at both ends, rounded, irregular, and double. Inamdar, Chaudhari, and Rao (1990) reported that cystoliths in Acanthaceae are mostly simple or solitary but double cystoliths occur predominantly and occasionally in some species. The rounded cystoliths have occasionally been found, and the irregular cystoliths have been rarely observed. Nevertheless, those cystolith shapes were also occasionally and rarely seen in this study of Thai *Pseuderanthemum* spp.

The size of the cystoliths varied in the genus *Pseuderanthemum* and even within the same species. The minimum and maximum length and breadth ranged from 105 μm to 257 μm and 23 μm to 50 μm, respectively. The minimum length was noticed in *P. carruthersii* (B: species with ovate-shaped leaves) and maximum in *P.*

latifolium, while *P*. sp2 and *P*. "*palatiferum*" exhibited minimum and maximum breadth, respectively.

Length and breadth ratio of cystoliths has been employed to determine the nature of cystoliths. This ratio varied for this particular genus, making the different type of cystoliths for the genus. This ratio varied from 1.9 to 9.0, but the ratio from the most common type of the cystoliths, i.e., elongated, tapering at one ends remains constant. The length and breadth ratio of cystoliths was highest in *P*. sp2, *P*. *parishii*, and *P*. sp1, respectively. As a result the highest ratio of *P*. sp2 showed that their cystoliths were very long cylinders or linear, while the lowest ratio of *P*. "*palatiferum*" indicated that their cystoliths were oblong or oval (Table 3.1). The size of cystoliths in Thai *Pseuderanthemum* spp. showed a greater range than in *P*. *bicolor*, *P*. *alatum*, *P*. *cinnabaricum*, *P*. *indicum*, and *P*. *tunicatum*, which ranged from 68-95 µm in length and 18-36 µm in breadth, but did not vary significantly in the ratio, except in *P*. *tuberculatum* with 197 µm, 18 µm, and 11.4 in length, breadth, and ratio respectively (Inamdar, Chaudhari, and Rao, 1990; Karlstrom, 1980).

In *Pseuderanthemum*, the different ratios of light intensities between the adaxial and abaxial surfaces of the leaves may play a role in the formation of lithocysts and the cystolith inside. The distribution of cystoliths in the leaves of *Pseuderanthemum*, mostly occurred in the adaxial epidermis, where the light intensity is higher, with variation in the density for this genus; however, the cystoliths in *P*. *axillare* were equally located in both surfaces. It may have been caused by their leaves being narrow and arranged with less angle to their stem or branches, so that both surfaces can be exposed to the light at the same rate (Zindler-Frank, 1980; Wu, 1995; Okazaki et al., 1986; Franceschi and Horner, 1980).

The orientation of cystoliths in Thai *Pseuderanthemum* occurred in two patterns: (a) cystoliths arranged random in the central area of leaves, and (b) cystoliths arranged parallel to midrib and leaf margin in 2-3 marginal cell lines along the margin of leaf. Almost all *Pseuderanthemum* spp. showed their cystoliths arranged parallel to midrib and leaf margin and random in the central area of leaves, excepted in *P. axillare*, their cystoliths being arranged random even at the midrib (Figure 3.9). There were trichomes on both adaxial and abaxial epidermises of leaves in some taxa of *Pseuderanthemum*, but in these trichomes no cystoliths could be found.

As already mentioned before, cystoliths occurred in the leaves of all examined samples of *Pseuderanthemum*. Although cystolith size, shape and distribution are variable, their occurrence is constant and therefore they constitute a character of systematic value; in other words, the characteristics of cystoliths may be profitably used as a taxonomic tool. Especially in this order, cystoliths were a common character for the leaves.

3.4 Study on Leaf Venation Pattern

3.4.1 Introduction

Leaves are vascularized by a venation system that extends through the petiole in an arrangement that is often taxon specific. Within the lamina the vasculature divides into one of several major venation patterns. Veins are primarily cylindrical bundles of vascular tissue that occur mainly in the median plane of the mesophyll. Among dicotyledons, venation patterns consist of one or more branched major veins and a more or less dense network of smaller minor veins that frequently terminate in freely ending veinlets within the areoles (mesophyll islets bounded by veins of higher order). If freely ending veinlets are absent, the venation pattern is termed closed. Veinlets can be branched or unbranched and end in one or two tracheids of normal appearance, or the terminal elements can be greatly enlarged or thick-walled and sclerotic. Vein orders are distinguished on the basis of vein size, with secondary veins branching from the primary vein, tertiary veins originating from secondaries, and so on. Secondary veins may terminate at the leaf margin or join with adjacent secondaries to form a series of closed marginal loops (Hickey, 1973; Hickey and Wolfe, 1975).

Leaf architectures are generally neglected in taxonomic and comparative morphological studies. Studies of modern plants have been content, in most cases, with brief descriptions of leaf outline, margin, and major vein configuration. So, our knowledge on the leaf architecture in Acanthaceae is very little. Therefore, the present study was undertaken with a view to give a comprehensive account of the leaf venation pattern in studied taxa belonging to *Pseuderanthemum*, *Nelsonia*, *Ophiorrhiziphyllon*, and *Staurogyne* (Acanthaceae) in Thailand.

3.4.2 Literature Review

Kerner and Oliver (1897), Hickey (1973), Hickey and Wolfe (1975), and Melville (1976) made valuable contributions to the study of leaf architecture of angiosperm leaves, including some Acanthaceae.

Chaudhari and Inamdar (1984) studied the leaf architecture of some Acanthaceae. The leaf architectural pattern in 27 genera and 35 species were investigated.

In the past, Bremekamp (1965a) was of the opinion that Lindau's (1895) Nelsonioideae is closely related to the tribe Rhinantheae of the Scrophulariaceae and should, therefore, be transferred to the latter on the presence of a well developed endosperm, nature of placentation, and dehiscence of the fruit. The venation pattern in *Elytraria acaulis*, *Nelsonia canescens* and *Staurogyne zeylanica* of Nelsonioideae is pinnate camptodromous, being eucamptodromous in *Nelsonia canescens* and festooned brochidodromous in the remaining two taxa. On the basis of embryological, morphological, and epidermal studies of Johri and Singh (1959), Paliwal (1966), Inamdar (1970), and Ahmad (1974a), the transfer of these taxa to the Scrophulariaceae was not supported. All the three taxa manifest the type of venation pattern shown by the majority of the species studied in the Acanthaceae. However, much remains to be done as regards the leaf architecture in Scrophulariaceae and Acanthaceae (Verghese, 1969).

In other studies, the venation pattern is pinnate in Scrophulariales (Hickey and Wolfe, 1975). Scrophulariales (Takhtajan, 1969) comprises 18 families including Acanthaceae. Out of the 35 species studied of the Acanthaceae, *Acanthus ilicifolius* exhibited a pinnate craspedodromous pattern and *Lepidagathis trinervis* showed on acrodromous pattern, while the major venation pattern conformed to pinnate camptodromous type with eucamptodromous in 26 and festooned brochidodromous secondaries in 7 species (Chaudhari and Inamdar, 1984). This clearly reveals that the diversity expressed in morphological features is not shown by the type of venation pattern in general.

3.4.3 Materials and Methods

The material of four genera (*Nelsonia*, *Ophiorrhiziphyllon*, *Staurogyne*, and *Pseuderanthemum*) and 40 taxa of Acanthaceae in Thailand were selected for this study (Table 3.4). They were collected from different localities including cultivated species throughout the country. The voucher specimens are kept in the Herbarium or Biodiversity Laboratory, the Center for Scientific and Technological Equipment, Suranaree University of Technology. A few representative mature leaves of each taxa were prepared following the procedures of the clearing method of Dilcher (1974). In this process, the leaves were left in 10% sodium hydroxide at room temperature until the leaf became translucent. The leaf was removed and washed in water 2 times and placed in 5% sodium hypochlorite until bleached white. The preparations were then washed in water 2 times and dehydrated in an ethanol series. The preparations were stained with 1% safranin O in 100% ethanol, transferred to 100% ethanol, solution of equal parts of ethanol and xylene, and then xylene, respectively. The leaf was mounted in Permount between two glass slides. Photographs of the cleared leaves were taken with a compound light microscope (Olympus CX40) and a digital camera (Canon EOS1100D). The pattern of leaf venation, ultimate marginal venation, veins, veinlets and areoles were observed. The terminology of Hickey (1973), Dilcher (1974), Hickey and Wolfe (1975), Melville (1976), and Ellis et al. (2009) have been followed to describe the leaf architecture. Their systematic value in these taxa was considered.

3.4.4 Results

Morphological description

The leaves are simple, opposite and decussate. An examination of a number of fresh and herbarium specimens of 4 genera and 40 taxa of Thai Acanthaceae reveals variation in leaf shape ranging from ovate or lanceolate to elliptic, spatulate, oblong, or even oblanceolate. However, *Pseuderanthemum axillare* shows the distinct shape of leaves, small narrow oblong, within the same genus. The margin is entire evenly hairy along the margin in *Nelsonia canescens* and widely curved in *P. carruthersii* (A), *P. metallicum*, and *P. reticulatum* (A), which make their leaves asymmetric. The apex may be acute, obtuse, or attenuate. The base is mostly acute, cuneate, or obtuse to round, occasionally decurrent or cordate. The texture of leaf is chartaceous or coriaceous; moreover, in 7 taxa of *Pseuderanthemum* are found crispy leaves, i.e., *P. carruthersii* (A and B), *P. latifolium*, *P. metallicum*, *P. reticulatum* (A and B), and *P.* sp2 (Table 3.4).

Venation pattern

The major venation pattern in 4 genera conformed to the pinnate camptodromous type with festooned brochidodromous or eucamptodromous (Table 3.5) with variation in the same genus. The brochidodromous type showed in 24 taxa, i.e., *Pseuderanthemum axillare*, *P. bracteatum*, *P. carruthersii* (B), *P. crenulatum*, *P. graciliflorum*, *P. latifolium*, *P. laxiflorum*, *P.* "*palatiferum*", *P. siamense*, *P.* sp2, *Ophiorrhiziphyllon macrobotryum*, *Staurogyne cuneata*, *S. dispar*, *S. glauca*, *S. griffithiana*, *S. lanceolata*, *S. lasiobotrys*, *S. major*, *S. merguensis*, *S. obtusa*, *S. punctata*, *S. setigera*, *S. subglabra*, and *S. tenuispica*. The eucamptodromous pattern was represented in 16 taxa, i.e., *Pseuderanthemum carruthersii* (A), *P. longistylum*, *P*. sp1, *P. metallicum*, *P. parishii*, *P. reticulatum* (A and B), *Nelsonia canescens*, *Staurogyne argentea*, *S. concinnula*, *S. filipes*, *S. helferi*, *S. incana*, *S. longeciliata*, *S. singularis*, and *S. spatulata*.

The primary vein, which is the thickest vein of the leaf, traverses straight from the base to the apex of the leaf. Its thickness gradually decreases towards the apex. The primary vein size, which can be analyzed from the ratio of vein-width and leaf-width, varied from massive, stout, to moderate, respectively. The massive size was found in 2 taxa: *Pseuderanthemum metallicum* and *Staurogyne lanceolata*, stout size showed in 25 taxa: *Pseuderanthemum axillare*, *P. carruthersii* (A), *P. laxiflorum*, *P.* "*palatiferum*", *P. reticulatum* (A), *P.* sp2, *Ophiorrhiziphyllon macrobotryum*, *Staurogyne argentea*, *S. concinnula*, *S. cuneata*, *S. dispar*, *S. glauca*, *S. griffithiana, S. helferi*, *S. incana*, *S. lasiobotrys*, *S. longeciliata*, *S. merguensis*, *S. obtusa*, *S. punctata, S. setigera*, *S. singularis*, and *S. spatulata*, *S. subglabra*, and *S. tenuispica*, and moderate size was demonstrated in 13 taxa: *Pseuderanthemum bracteatum*, *P. carruthersii* (B), *P. crenulatum*, *P. latifolium*, *P. graciliflorum*, *P. longistylum*, *P.* sp1, *P. parishii*, *P. reticulatum* (B), *P. siamense*, *Nelsonia canescens*, *Staurogyne filipes* and *S. major*.

The secondary veins are the next smaller order of veins arising from the primary vein. The number of secondaries on one side of the primary vein varied from species to species, but there tended to be a greater number of secondary veins in the Nelsonioideae group (*Nelsonia*, *Ophiorrhiziphyllon*, *Staurogyne*) than in Acanthoideae (*Pseuderanthemum*). The secondaries did not merge into the margin in all studied samples (Table 3.5).

Intersecondary veins were commonly observed in all the species studied. Intersecondary veins originate from the primary vein. They are intermediate in thickness between second and third order veins. The predominant angle of tertiary veins (the average angle of tertiary origin on the exmedial (lower) side of the secondaries is compared with the average of the same on the admedial (upper) side of the secondary veins) was right-right angle (RR), right-acute angle (RA), right-obtuse angle (RO), acute-right angle (AR), acute-acute angle (AA), acute-obtuse angle (AO), and obtuse-acute angle (OA), respectively. The angle between primary and secondary vein varied from 30-80 degrees even in the same species. However, the narrowest angle was found in *Pseuderanthemum* sp2 and the widest angle showed in *Staurogyne griffithiana*, *S. obtusa*, and *S. tenuispica*, with 30-40 degrees and 40-80 degrees, respectively. The species details are given in Table 3.5.

Marginal ultimate venation was looped in all the species investigated (Figures 3.13-3.20). The areoles in the majority of the taxa studied were well developed. The shape and size differed even in the same leaf. The shape of areoles can be polygonal or irregular. They usually contained one vein ending but closed areoles were found occasionally. The freely ending veinlets were mostly simple, linear or curved, or divided dichotomously once (Figure 3.12).

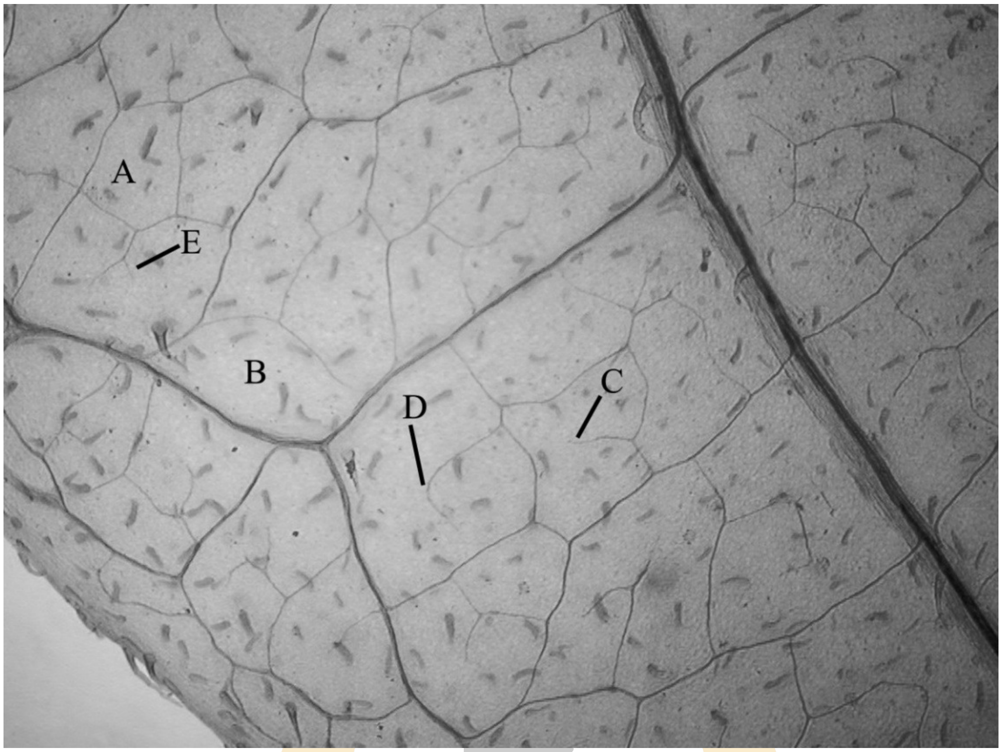


Figure 3.12 Areoles and veinlets of studied taxa in Acanthacae.

A-B: different shapes of areoles (A: polygonal, B: irregular)

C-E: type of veinlets (C: simple, linear, D: simple, curved, E: dichotomous branching)

Table 3.4 Leaf features of studied taxa in Acanthaceae.

Species	Shape	Apex	Base	Texture
P. axillare	oblong	acute	cuneate	coriaceous
P. bracteatum	elliptic	attenuate	cuneate	coriaceous
P. carruthersii (A)	elliptic	acute	cuneate	coriaceous
P. carruthersii (B)	wide ovate	acute	acute	coriaceous
P. crenulatum	elliptic	attenuate	acute	chartaceous
P. graciliflorum	elliptic	attenuate	cuneate	chartaceous
P. latifolium	elliptic	attenuate	acute	coriaceous
P. laxiflorum	elliptic	acute	acute	coriaceous
P. longistylum	elliptic	attenuate	obtuse	coriaceous
P. metallicum	elliptic	acute	cuneate	coriaceous
P. "*palatiferum*"	lanceolate	attenuate	acute	chartaceous
P. parishii	oblanceolate	attenuate	acute	chartaceous
P. reticulatum (A)	elliptic	acute	acute	coriaceous
P. reticulatum (B)	wide ovate	acute	obtuse	coriaceous
P. siamense	elliptic	attenuate	acute	chartaceous
P. sp1	elliptic	attenuate	acute	coriaceous
P. sp2	elliptic	attenuate	acute	coriaceous
N. canescens	wide elliptic	obtuse	obtuse	chartaceous
O. macrobotryum	elliptic	attenuate	decurrent	chartaceous
S. argentea	elliptic	attenuate	cuneate	chartaceous
S. concinnula	oblanceolate	obtuse	acute	chartaceous
S. cuneata	elliptic	acute	acute	chartaceous
S. dispar	ovate	acute	acute	chartaceous
S. filipes	elliptic	acute	cuneate	chartaceous
S. glauca	spatulate	obtuse	decurrent	chartaceous
S. griffithiana	ovate	obtuse	obtuse	coriaceous
S. helferi	elliptic	obtuse	acute	chartaceous
S. incana	elliptic	obtuse	obtuse	chartaceous
S. lanceolata	lanceolate	obtuse	acute	chartaceous
S. lasiobotrys	elliptic	acute	acute	chartaceous
S. longeciliata	elliptic	acute	decurrent	chartaceous
S. major	lanceolate	attenuate	acute	chartaceous
S. merguensis	elliptic	obtuse	cordate	coriaceous
S. obtusa	ovate	acute	obtuse/cordate	chartaceous
S. punctata	narrow elliptic	acute	acute	chartaceous
S. setigera	lanceolate	acute	acute	chartaceous
S. singularis	lanceolate	acute	acute	chartaceous
S. spatulata	spatulate	acute	decurrent	chartaceous
S. subglabra	elliptic	acute	acute	chartaceous
S. tenuispica	elliptic	obtuse	cordate	coriaceous

Table 3.5 Leaf venation pattern of studied taxa in Acanthaceae.

Species	1° vein size	Predominantly 3° vein origin angle	Ultimate marginal venation	Venation pattern	No. of 2° vein along one side	Angle between 1° and 2° vein
P. axillare	stout	RR, AR	looped	BRO	6-7	45-70
P. bracteatum	moderate	RR, RA	looped	BRO	4-5	40-50
P. carruthersii (A)	stout	RR, RA	looped	EUC	6-7	55-65
P. carruthersii (B)	moderate	RR, RO	looped	BRO	6-7	60-65
P. crenulatum	moderate	RR, OA	looped	BRO	7-8	45-65
P. graciliflorum	moderate	RR, AR	looped	BRO	5-6	45-60
P. latifolium	moderate	RR, AR	looped	BRO	7-8	45-65
P. laxiflorum	stout	RA, RR	looped	BRO	5-6	55-75
P. longistylum	moderate	RR, RO	looped	EUC	6-7	40-60
P. metallicum	massive	RR, RA	looped	EUC	7-8	45-65
P. "palatiferum"	stout	RR, RO	looped	BRO	6-7	50-70
P. parishii	moderate	RR, RA	looped	EUC	6-7	50-65
P. reticulatum (A)	stout	RR, AR	looped	EUC	6-7	50-65
P. reticulatum (B)	moderate	RR, RA	looped	EUC	6-7	60-70
P. siamense	moderate	RR, RO	looped	BRO	8-10	55-70
P. sp1	moderate	RR, RA	looped	EUC	6-7	45-55
P. sp2	stout	RR, RA	looped	BRO	7-8	30-40
N. canescens	moderate	RR, RA	looped	EUC	7-9	40-50
O. macrobotryum	stout	RO, RR	looped	BRO	9-10	50-70
S. argentea	stout	RR, RO	looped	EUC	10-11	55-70
S. concinnula	stout	RR, RA, RO	looped	EUC	6-7	60-70
S. cuneata	stout	RR, RA	looped	BRO	7-8	30-60
S. dispar	stout	RR, AR	looped	BRO	6-7	40-50
S. filipes	moderate	RR, RA	looped	EUC	5-6	30-50
S. glauca	stout	RR, RO	looped	BRO	7-8	40-60
S. griffithiana	stout	RR, AR	looped	BRO	6-7	40-80
S. helferi	stout	RR, AR	looped	BRO	7-8	50-65
S. incana	stout	RR, RA	looped	EUC	8-9	50-60
S. lanceolata	massive	RR, RO	looped	BRO	9-10	50-60
S. lasiobotrys	stout	RR, RA, RO	looped	BRO	7-8	50-60
S. longeciliata	stout	RR, AR	looped	EUC	8-9	50-65
S. major	moderate	RR, RA, RO	looped	BRO	7-8	50-65
S. merguensis	stout	RR, AA, AO	looped	BRO	10-11	50-70
S. obtusa	stout	RR, AR	looped	BRO	7-8	50-80
S. punctata	stout	RR, RO	looped	BRO	9-10	50-60
S. setigera	stout	RR, RO	looped	BRO	8-9	50-55
S. singularis	stout	RR, AA	looped	EUC	10-11	50-60
S. spatulata	stout	RR, RA	looped	EUC	10-11	50-65
S. subglabra	stout	RR, AA	looped	BRO	10-11	60-70
S. tenuispica	stout	RR, AA	looped	BRO	7-8	40-80

RR: right-right angle, RA: right-acute angle, RO: right-obtuse angle, AA: acute-acute angle, AR: acute-right angle, AO: acute-obtuse angle, BRO: brochidodromous, EUC: eucamptodromous.

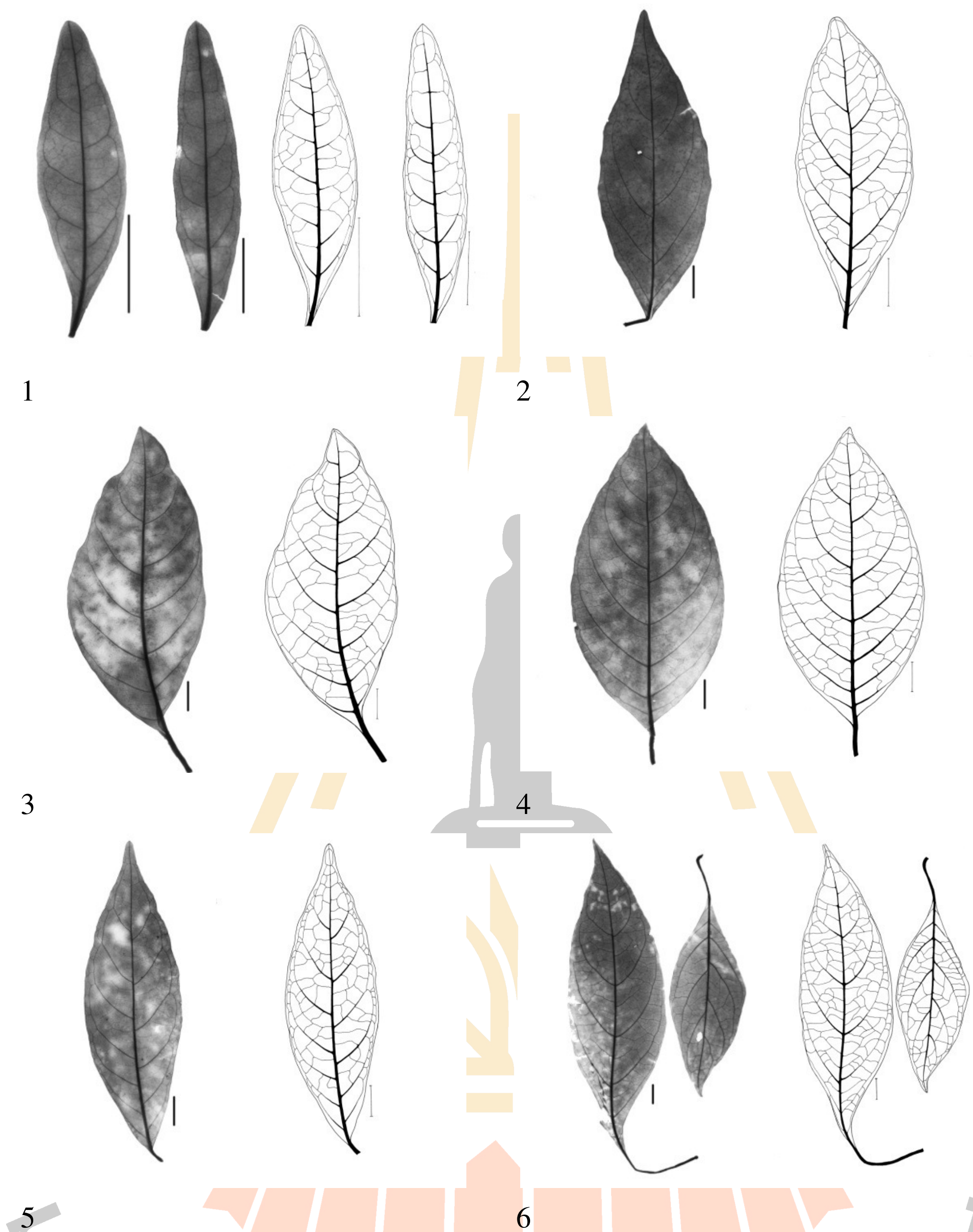


Figure 3.13 Leaf venation patterns of studied taxa.

1) *Pseuderanthemum axillare* 2) *Pseuderanthemum bracteatum*

3) *Pseuderanthemum carruthersii* (A) 4) *Pseuderathemum carruthersii* (B)

5) *Pseuderanthemum crenulatum* 6) *Pseuderanthemum graciliflorum*

Scale bars = 1 cm

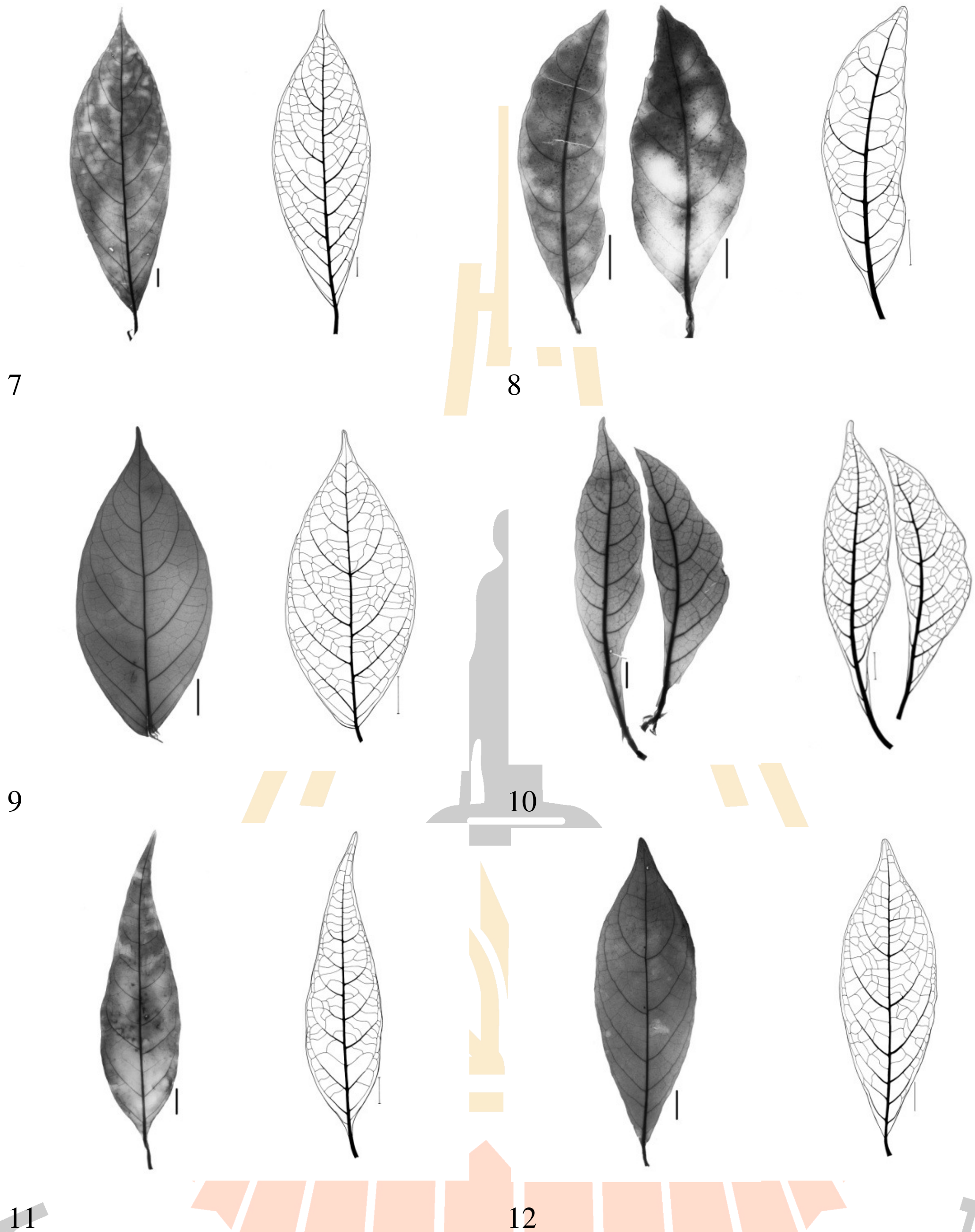


Figure 3.14 Leaf venation pattern of studied taxa.

7) *Pseuderanthemum latifolium* 8) *Pseuderathemum laxiflorum*

9) *Pseuderanthemum longistylum* 10) *Pseuderanthemum metallicum*

11) *Pseuderathemum* "*palatiferum*" 12) *Pseuderanthemum parishii*

Scale bars = 1 cm

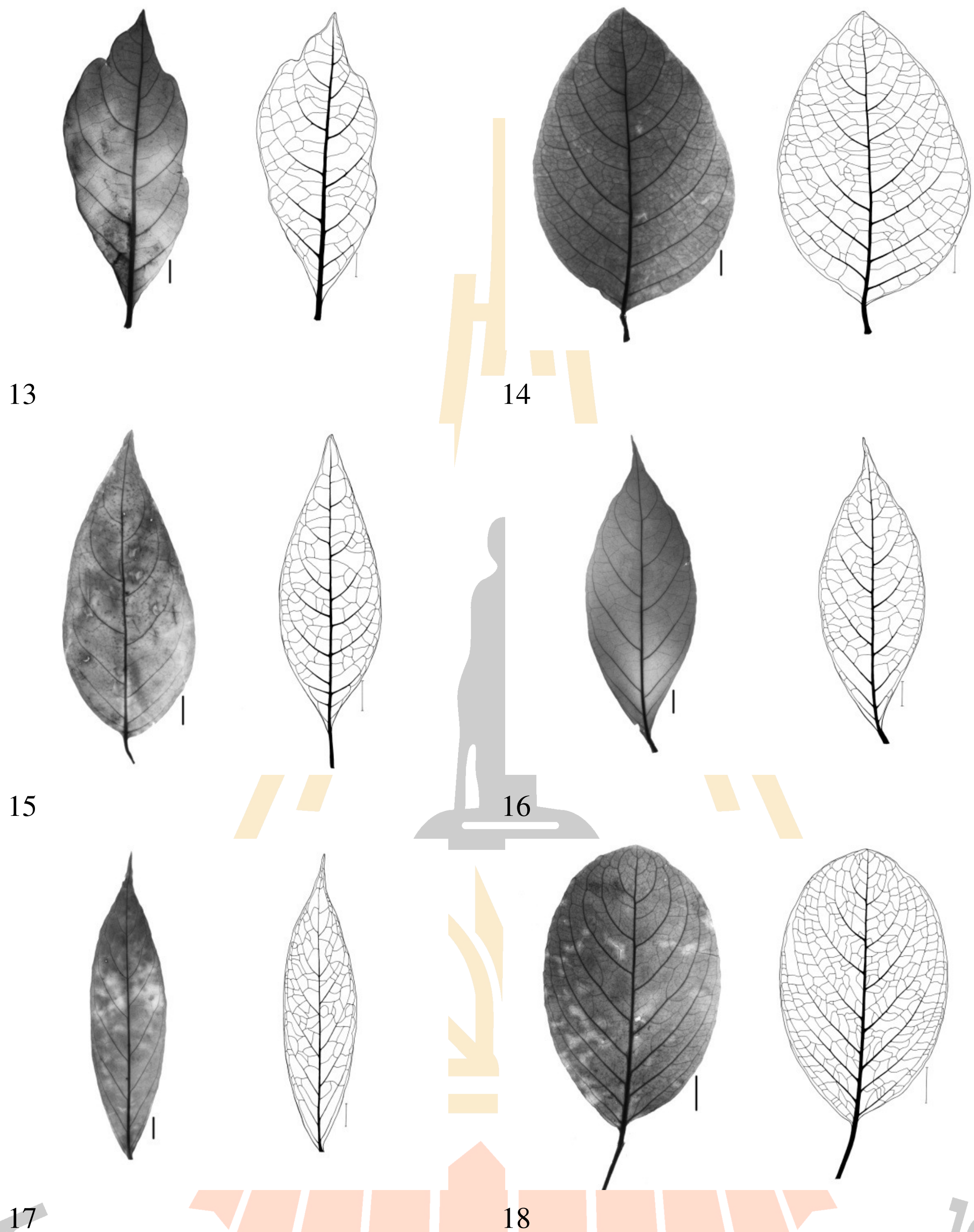


Figure 3.15 Leaf venation patterns of studied taxa.

13) *Pseuderanthemum reticulatum* (A) 14) *Pseuderanthemum reticulatum* (B)

15) *Pseuderathemum siamense* 16) *Pseuderanthemum* sp1

17) *Pseuderanthemum* sp2 18) *Nelsonia canescens*

Scale bars = 1 cm

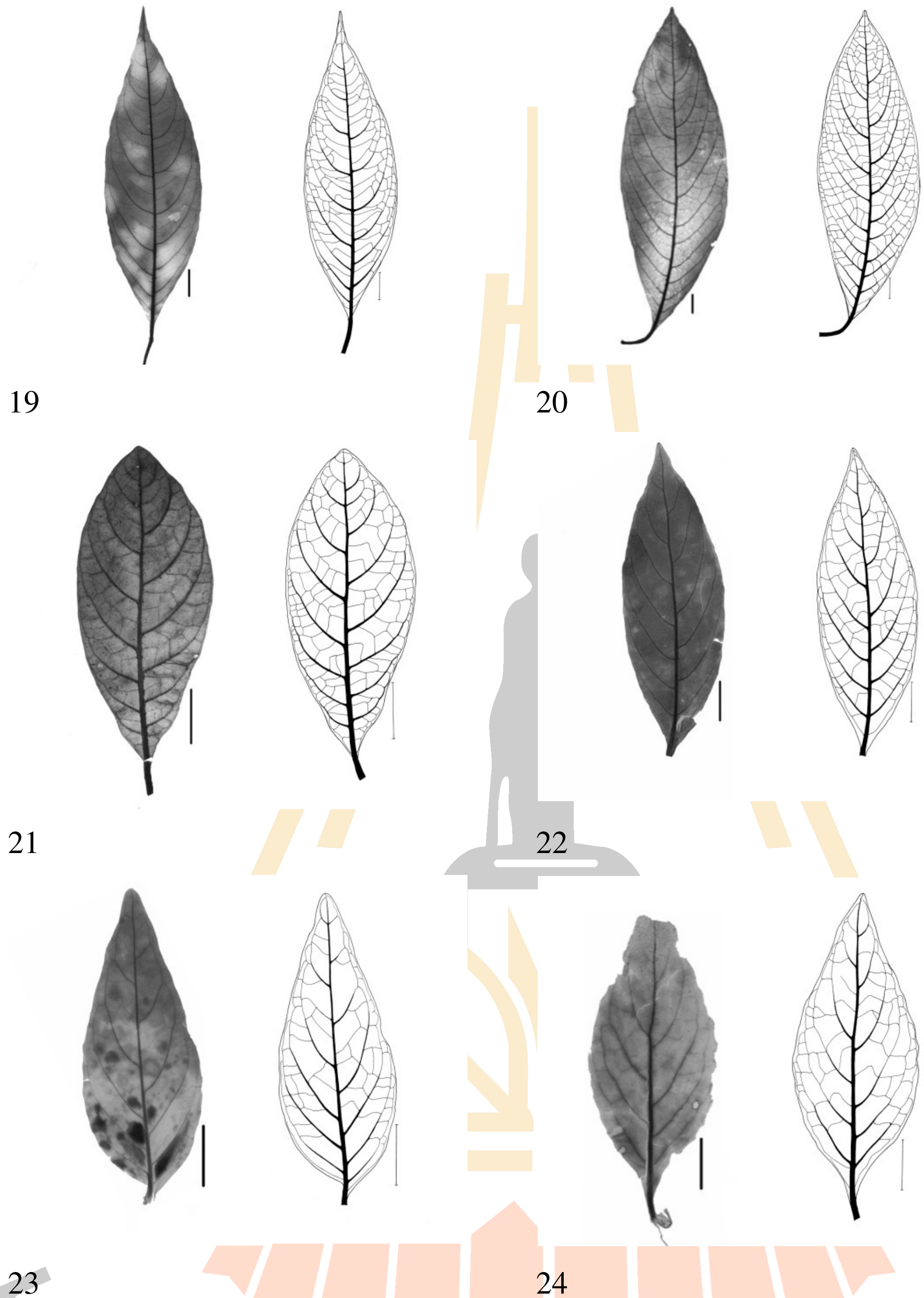


Figure 3.16 Leaf venation patterns of studied taxa.

19) *Ophiorrhiziphyllon macrobotryum* 20) *Staurogyne argentea*

21) *Staurogyne concinnula* 22) *Staurogyne cuneata*

23) *Staurogyne dispar* 24) *Staurogyne filipes*

Scale bars = 1 cm

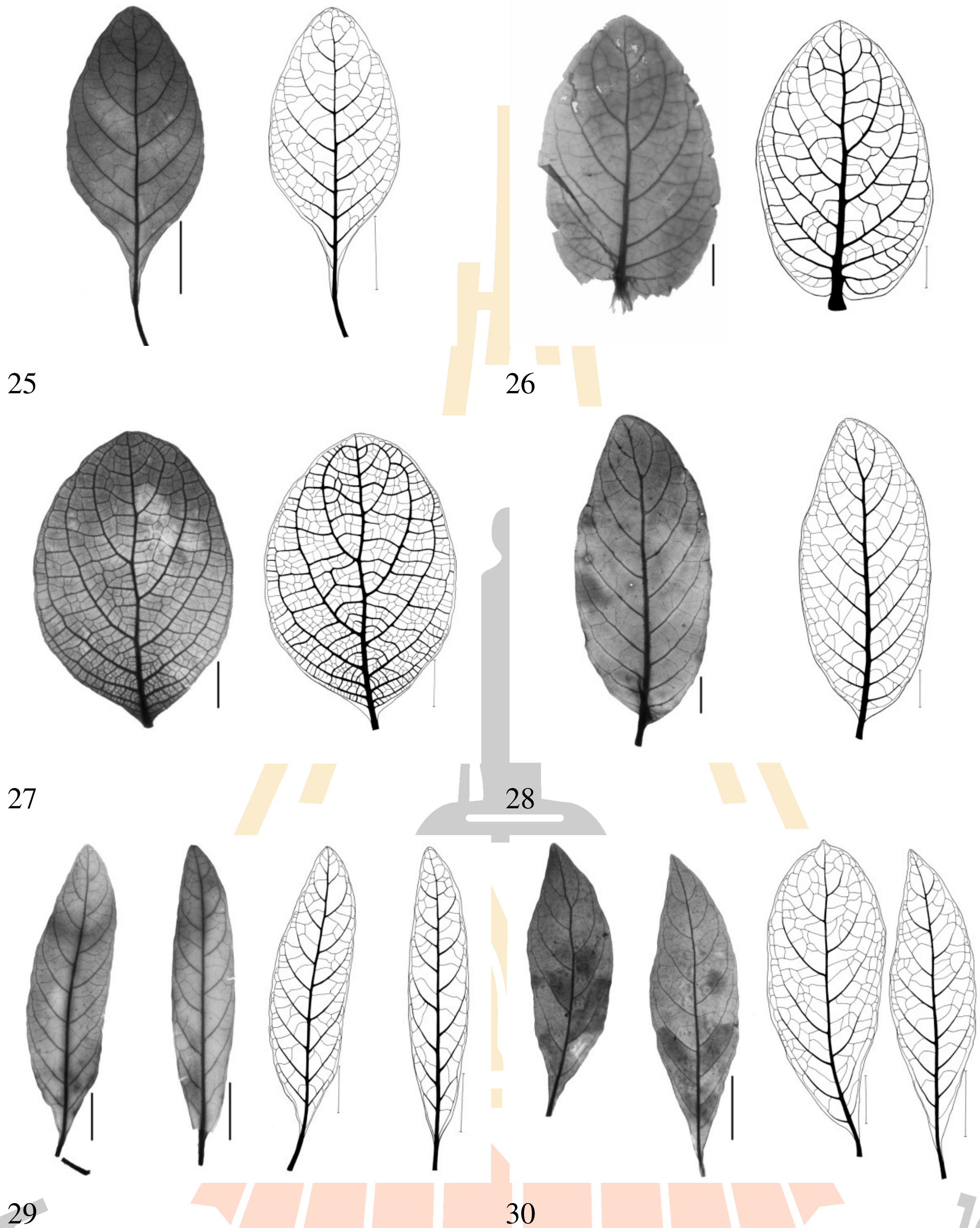


Figure 3.17 Leaf venation patterns of studied taxa.

25) *Staurogyne glauca* 26) *Staurogyne griffithiana*

27) *Staurogyne helferi* 28) *Staurogyne incana*

29) *Staurogyne lanceolata* 30) *Staurogyne lasiobotrys*

Scale bars = 1 cm

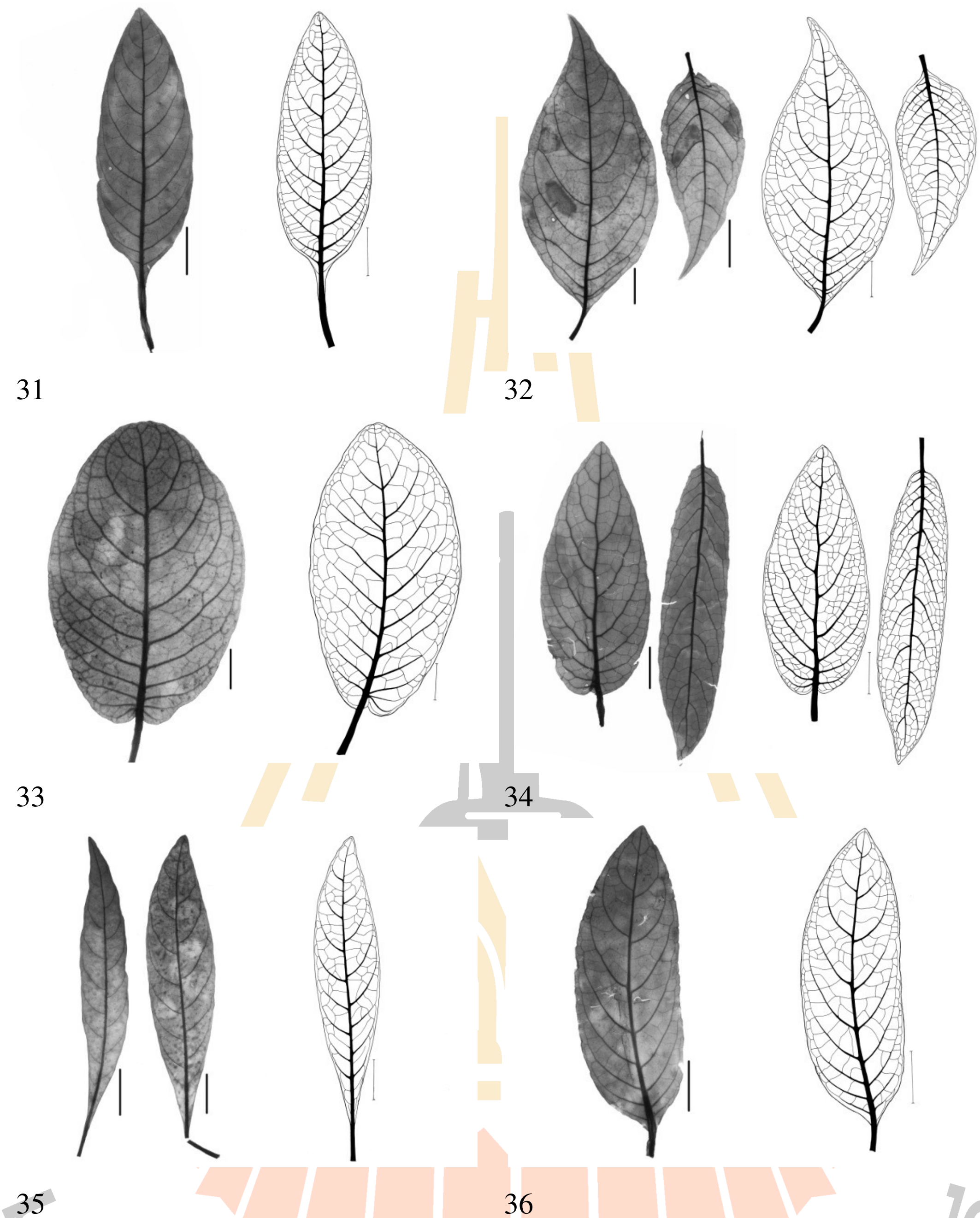


Figure 3.18 Leaf venation patterns of studied taxa.

31) *Staurogyne longeciliata* 32) *Staurogyne major*

33) *Staurogyne merguensis* 34) *Staurogyne obtusa*

35) *Staurogyne punctata* 36) *Staurogyne setigera*

Scale bars = 1 cm

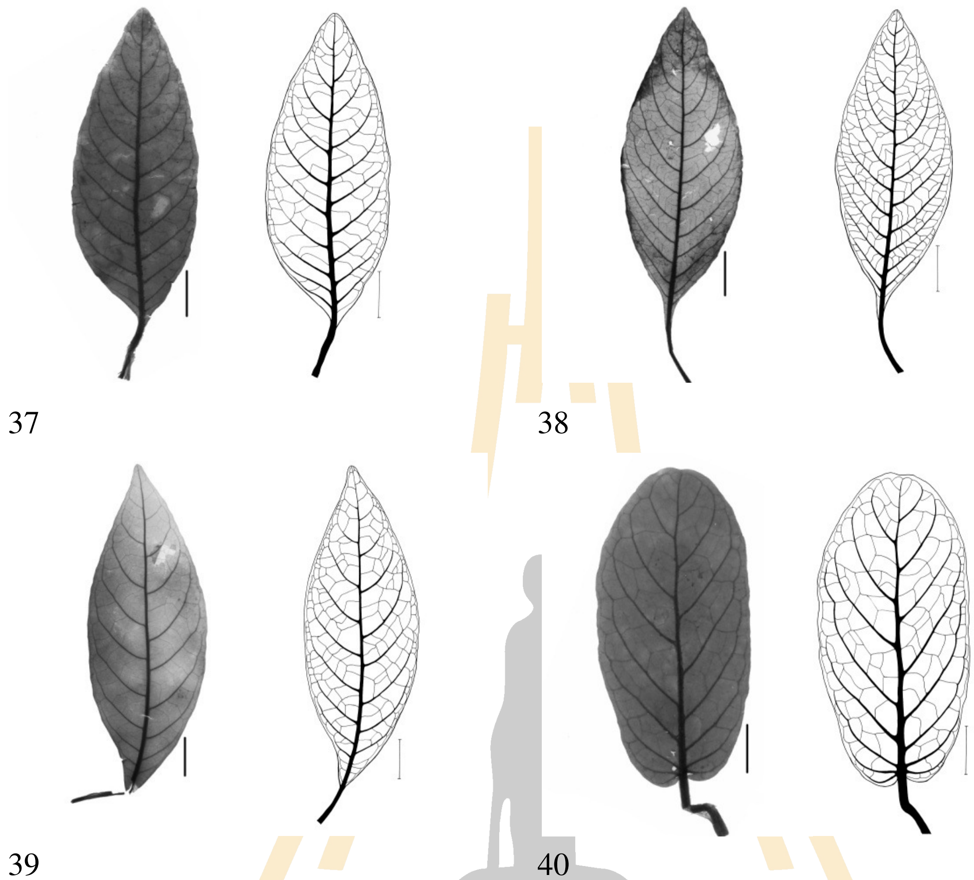


Figure 3.19 Leaf venation patterns of studied taxa.

37) *Staurogyne singularis* 38) *Staurogyne spatulata*

39) *Staurogyne subglabra* 40) *Staurogyne tenuispica*

Scale bars = 1 cm

3.4.5 Conclusions and Discussion

As demonstrated in this present study, the leaf venation patterns of studied taxa were pinnate eucamptodromous (16 taxa) or festooned brochidodromous (24 taxa) with variation among the species of *Pseuderanthemum*, *Nelsonia*, *Ophiorrhiziphyllon*, and *Staurogyne*. In Eucamptodromous, secondary veins upturned and gradually diminishing apically inside the margin, connected to the superadjacent secondaries by a series of cross veins without forming prominent marginal loops. While brochidodromous, secondary veins joined together in a series of prominent arches. This study also supported the previous views (Hickey and Wolfe, 1975; Chaudhari and Inamdar, 1984). However, much remains to be done as regards the leaf architecture in Acanthaceae and related groups.

The primary vein size varied from massive, stout, to moderate respectively. The secondary veins did not merge into the margin in all studied samples, so the marginal ultimate venation was looped in all taxa. The number of secondary veins on one side of the primary vein varied from species to species, but it tended to show more secondary veins in the Nelsonioideae group (*Nelsonia*, *Ophiorrhiziphyllon*, *Staurogyne*) than those in Acanthoideae (*Pseuderanthemum*).

During the present investigation, the uni-veined category was also represented in all studied taxa as in the study of Chaudhari and Inamdar (1984). Intersecondary veins were common. The predominant angle of tertiary veins were right-right angle (RR), right-acute angle (RA), right-obtuse angle (RO), acute-right angle (AR), acute-acute angle (AA), acute-obtuse angle (AO), and obtuse-acute angle (OA), respectively.

The areoles were variable in shape and size. They usually contained one veinlet ending but also no veinlet. The vein endings were usually simple, linear or curved, or divided once dichotomously. However, because of the significant variation occurring within the same leaf regarding the size and shape of each vein-islet (areole), these characters cannot be used as a tool for taxonomic considerations, the same as in the studies of other plant families of Nicely (1965), Sehgal and Paliwal (1974), and Inamdar and Murthy (1978).

However, the results of this study can be used as basic knowledge to compare with other group of plants including Acanthaceae for classification and also used to integrate with other characters to separate them from each other phylogenetically. Moreover, study in more details of leaf architecture may present more useful characters for taxonomic purposes.

CHAPTER IV

PALYNOLOGICAL STUDY

4.1 Introduction

Palynology is the study of spores and pollen grains. Pollen is an important characteristic for identifying species and contributes to our understanding of past and present biodiversity. Many characteristics of pollen grains can be used for identification, such as shape, size, symmetry, exine sculpture, and aperture. Pollen morphology is important in understanding taxonomy and phylogeny. In addition to providing valuable data about extant plants for systematic studies, pollen can provide information about environmental change and is the most widespread and important of plant fossils. Pollen and spores can provide important evidence of past vegetation and taxonomic history since details of wall morphology can be specific to family, genus or even species (Erdtman, 1966; Wodehouse, 1965).

The purpose of this chapter is to examine the pollen morphology of selected species in the genera *Pseuderanthemum*, *Nelsonia*, *Ophiorrhiziphyllon*, and *Staurogyne* in Thailand, which may be useful to support the classification or identification of species.

4.2 Literature Review

In Acanthaceae, disagreement between classifications of Acanthaceae is due to the sheer magnitude of morphological diversity of pollen morphology in the

Acanthaceae has been interpreted in a number of ways (Radlkofer, 1883; Lindau, 1893, 1895; Raj, 1973).

The pioneer studies of Radlkofer (1883), Lindau (1893, 1895) recognized 11 pollen types to account for the variation of pollen morphology within Acanthaceae. The eleven pollen types Lindau (1893, 1895) recognized were: Glatter, runder pollen, Spaltenpollen, Daubenpollen, Rippenpollen, Spangenpollen, Rahmenpollen, Knötchenpollen, Stachelpollen, Gürtelpollen, Wabenpollen, and Pollen von anderer Form (Imlay, 1938). Variations within that particular type were then treated as subtypes. Lindau's tribal classification of the family (Lindau, 1895), across its entire geographical range, recognized 4 subfamilies, and 19 tribes within the subfamily Acanthoideae (plants with retinacula present). He diagnosed all of the tribes of the Acanthoideae as belonging to either the Contortae or Imbricatae based on aestivation of the corolla. Within these two groups his diagnoses of the tribes were based primarily on pollen morphological characters and it is widely assumed that Lindau's tribal classification is based on pollen morphology (Bhaduri, 1944; Raj, 1973). In this context, it is worth noting that ten of the tribes that Lindau adopted had been recognized by previous classifications (although often at different rank) that did not use pollen morphology (Nees, 1847a; Anderson, 1867; Bentham, 1876). The tribal classification illustrates that many of Lindau's pollen types are found in more than one and sometimes many tribes, and that the relationship between the pollen types and the classification is not a direct one. Several of the Lindau pollen types comprise pollen morphologies that are similar only in the most superficial sense. Aperture number of pollen from Acanthaceae genera is very variable (Lindau, 1895; Raj, 1973). The variability of this character can therefore be viewed as providing potential evidence (shared similarity) for a close relationship between certain taxa. Acanthaceae classification, based upon an understanding of “true” character similarity combined with an appreciation of character congruence and conflict, still need. The role of pollen morphology, in relationship to Acanthaceae classifications, will remain problematic until pollen morphological structure are better understood both in themselves and analysed in the wider context of other morphological characters. Clearly much remains to be done.

Pollen morphological studies of the family Acanthaceae were conducted from time to time. A number of workers have studied the pollen of various taxa belonging to Acanthaceae. However, several species remain palynologically unknown. Botanists have studied the palynology within the family Acanthaceae as follows:

Erdtman (1966) reported the palynological study of 35 genera and 55 species of Acanthaceae, which showed isopolar, mostly radial symmetry and rarely bilateral symmetry, 2-many apertures with pseudocolpae. Moreover, pollen features of Acanthaceae were similar to pollen of Bignoniaceae and Pedaliaceae.

Raj (1973) studied the pollen of 63 genera and 143 species in Barleriinae of Acanthaceae in India, Malaysia, Philippines, New Guinea, and Congo. Three species of *Pseuderanthemum* were spheroidal in shape, 3-colporate with reticulate sculpture, 3-3.5 µm thick wall, and 65-75 µm in diameter.

Scotland (1992a, 1992b, 1993) studied the pollen morphology of 6 genera of Andrographideae and 36 genera of Acanthaceae with contorted corolla aestivation.

Furness (1996) studied and described the pollen morphology of 64 species of *Acanthopsis*, *Acanthus*, and *Blepharis*.

Carine and Scotland (1998) analyzed pollen morphology of 66 of 74 species of *Strobilanthes* from southern India and Sri Lanka.

Scotland and Vollensen (2000) studied the pollen morphology of Acanthaceae and found it to be useful as a taxonomic tool. *Pseuderanthemum velutinum* represented 3-colporate pollen with pseudocolpae.

Chaikong (2001) studied the pollen morphology of subtribe Barleriinae in Northeastern Thailand. Pollen of 7 taxa in *Pseuderanthemum* was investigated.

Wang and Blackmore (2003) studied the pollen morphology of 37 species of *Strobilanthes* in China and its taxonomic implications.

Halbritter and Hesse (2005) studied the specific ornamentation of orbicular walls and pollen grains, as exemplified by Acanthaceae. The coherent orbicular walls and the respective pollen ornamentation were analyzed.

4.3 Materials and Methods

Several taxa belonging to the genera *Nelsonia*, *Ophiorrhiziphyllon*, *Staurogyne, Pseuderanthemum* (Acanthaceae) in Thailand were selected for study (Table 4.1). Pollen grains were taken from living or dried plants, or spirit materials. Samples were analyzed using a technique modified from the comparison of different pollen treatments in Cyperaceae (Wichelen et al., 1999). In this process, the anthers were removed from the flowers or flower buds. These material pieces were placed in 10% potassium hydroxide (KOH) in a centrifuge tube. A fine forceps was used to release pollen from their anther into the solution. After 30 minutes, the preparation tubes were then centrifuged at 5,000 rpm for 1 minute. The solution was removed and the pollen grains were left at the bottom. Distilled water was added into the tube for cleaning and absolute ethanol was used for storage, respectively.

Compound Light Microscopic Study

A drop of suspension was prepared on a glass slide. The preparations were then mounted in glycerine and sealed with nail coating solution. The pollen grains were then examined under a compound light microscope (LM) using 40x objective and 10x eye piece for morphological observation, measurement, and taking photographs.

Scanning Electron Microscopic Study

A drop of suspension was prepared on a stub. The preparations were then dried in a hot air oven at 60°C for 20 minutes. The stub with dried pollen was placed in a Neo Coater (MP-1920NCTR) for gold coating for 6 minutes. The SEM stub was then investigated with a scanning electron microscope (JEOL JSM-6010LV) at 10 kV at different magnifications and orientations. SEM photographs were taken showing the pollen grain in overall morphology and the details of its sculpture.

4.4 Results

Many palynological characters of the studied taxa in four genera (*Nelsonia*, *Ophiorrhiziphyllon*, *Staurogyne, Pseuderanthemum*) were investigated, such as shape, size, symmetry, aperture, exine structure, and sculpturing using compound light microscopy (LM) and scanning electron microscopy (SEM). The specific terms of palynological study followed Erdtman (1966). The description of each taxa is provided as follows (Table 4.1):

Pseuderanthemum axillare (Figure 4.1: 1A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape suboblate to oblate spheroidal; type 3-colporate, hexapseudocolpate; size 30.0-40.0 μm in polar axis length (P) and 37.5-40.0 μm in equatorial axis length (E); exine 3.75-5.0 μm thick; exine sculpture foveolate; apertures round.

Pseuderanthemum bracteatum (Figure 4.1: 2A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape oblate spheroidal; type 3-colporate, hexapseudocolpate; size 50.0-65.0 μm in polar axis length (P) and 55.0-70.0 μm in equatorial axis length (E); exine 5.0 μm thick; exine sculpture foveolate; apertures round.

Pseuderanthemum carruthersii (A: elliptic leaf form) (Figure 4.1: 3A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape subprolate; type 3-colporate, hexapseudocolpate; size 40.0-50.0 µm in polar axis length (P) and 32.5-40.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture foveolate; apertures round.

Pseuderanthemum carruthersii (B: ovate leaf form) (Figure 4.1: 4A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colporate, hexapseudocolpate; size 37.5-42.5 µm in polar axis length (P) and 35.0-42.5 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture foveolate; apertures round.

Pseuderanthemum crenulatum (Figure 4.2: 5A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape subprolate; type 3-colporate, hexapseudocolpate; size 32.5-40.0 µm in polar axis length (P) and 25.0-35.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture foveolate or perforate; apertures round.

Pseuderanthemum graciliflorum (Figure 4.2: 6A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colporate, hexapseudocolpate; size 45.0-65.0 µm in polar axis length (P) and 40.0-60.0 µm in equatorial axis length (E); exine 2.5-5.0 µm thick; exine sculpture foveolate or perforate; apertures round.

Pseuderanthemum latifolium (Figure 4.2: 7A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape oblate spheroidal; type 3-colporate, hexapseudocolpate; size 47.5-57.5 µm in polar axis length (P) and 52.5-65.0 µm in equatorial axis length (E); exine 5.0 µm thick; exine sculpture foveolate; apertures round.

Pseuderanthemum laxiflorum (Figure 4.2: 8A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colporate, hexapseudocolpate; size 37.5-55.0 µm in polar axis length (P) and 37.5-50.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture foveolate; apertures round.

Pseuderanthemum longistylum (Figure 4.3: 9A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape suboblate; type 3-colporate, hexapseudocolpate; size 40.0-52.5 µm in polar axis length (P) and 50.0-65.0 µm in equatorial axis length (E); exine 3.75-5.0 µm thick; exine sculpture foveolate; apertures round.

Pseuderanthemum "*palatiferum*" (Figure 4.3: 10A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape suboblate to oblate spheroidal; type 3-colporate, hexapseudocolpate; size 45.0-50.0 µm in polar axis length (P) and 50.0-62.5 µm in equatorial axis length (E); exine 3.75-5.0 µm thick; exine sculpture foveolate; apertures round.

Pseuderanthemum parishii (Figure 4.3: 11A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colporate, indistinct hexapseudocolpate; size 65.0-87.5 µm in polar axis length (P) and 72.5-80.0 µm in equatorial axis length (E); exine 5.0-7.5 µm thick; exine sculpture micro-foveolate; apertures round.

Pseuderanthemum reticulatum (A: elliptic leaf form) (Figure 4.3: 12A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape subprolate to prolate; type 3-colporate, hexapseudocolpate; size 37.5-52.5 µm in polar axis length (P) and 32.5-37.5 µm in equatorial axis length (E); exine 3.75-5.0 µm thick; exine sculpture foveolate; apertures round.

Pseuderanthemum reticulatum (B: ovate leaf form) (Figure 4.4: 13A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal to subprolate; type 3-colporate, hexapseudocolpate; size 37.5-52.5 µm in polar axis length (P) and 35.0-37.5 µm in equatorial axis length (E); exine 5.0 µm thick; exine sculpture foveolate; apertures round.

Pseuderanthemum siamense (Figure 4.4: 14A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colporate, hexapseudocolpate; size 70.0-87.5 µm in polar axis length (P) and 70.0-87.5 µm in equatorial axis length (E); exine 5.0 µm thick; exine sculpture foveolate; apertures round.

Pseuderanthemum sp1 (Figure 4.4: 15A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape suboblate to oblate spheroidal; type 3-colporate, hexapseudocolpate; size 40.0-55.0 µm in polar axis length (P) and 50.0-57.5 µm in equatorial axis length (E); exine 5.0 µm thick; exine sculpture foveolate; apertures round.

Nelsonia canescens (Figure 4.4: 16A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colpate; size 17.5-21.25 µm in polar axis length (P) and 17.5-20.0 µm in equatorial axis length (E); exine 1.25 µm thick; exine sculpture foveolate; apertures colpate long narrow with acute ends.

Ophiorrhiziphyllon macrobotryum (Figure 4.5: 17A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal type 3-colpate; size 16.25-25.0 µm in polar axis length (P) and 16.25-22.5 µm in equatorial axis length (E); exine 1.25 µm thick; exine sculpture psilate; apertures colpate long narrow with acute ends.

Staurogyne argentea (Figure 4.5: 18A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape subprolate to prolate; type 3-colpate; size 30.0-42.5 µm in polar axis length (P) and 25.0-30.0 µm in equatorial axis length (E); exine 1.25-2.5 µm thick; exine sculpture foveolate; apertures colpate long narrow with acute ends.

Staurogyne concinnula (Figure 4.5: 19A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape subprolate; type 3-colpate; size 27.5-32.5 μm in polar axis length (P) and 22.5-27.5 μm in equatorial axis length (E); exine 1.25-2.5 μm thick; exine sculpture foveolate; apertures colpate long narrow with acute ends.

Staurogyne cuneata (Figure 4.5: 20A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colpate; size 30.0-37.5 μm in polar axis length (P) and 30.0-35.0 μm in equatorial axis length (E); exine 2.5 μm thick; exine sculpture micro-foveolate; apertures colpate long narrow with acute ends.

Staurogyne dispar (Figure 4.6: 21A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape subprolate; type 3-colpate; size 35.0-42.5 μm in polar axis length (P) and 27.5-37.5 μm in equatorial axis length (E); exine 2.5 μm thick; exine sculpture foveolate; apertures colpate long narrow with acute ends.

Staurogyne filipes (Figure 4.6: 22A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape oblate spheroidal; type 3-colpate; size 22.5-27.5 μm in polar axis length (P) and 25.0-30.0 μm in equatorial axis length (E); exine 2.5 μm thick; exine sculpture rugulate; apertures colpate long narrow with acute ends.

Staurogyne glauca (Figure 4.6: 23A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape oblate spheroidal; type 3-colpate; size 17.5-20.0 µm in polar axis length (P) and 17.5-22.5 µm in equatorial axis length (E); exine 1.25 µm thick; exine sculpture foveolate; apertures colpate long narrow with acute ends.

Staurogyne griffithiana (Figure 4.6: 24A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colpate; size 25.0-30.0 µm in polar axis length (P) and 25.0-27.5 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture foveolate; apertures colpate long narrow with acute ends.

Staurogyne helferi (Figure 4.7: 25A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape suboblate to oblate spheroidal; type 3-colpate; size 25.0-37.5 µm in polar axis length (P) and 30.0-32.5 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture foveolate; apertures colpate long narrow with acute ends.

Staurogyne multiflora (Figure 4.7: 26A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colpate; size 27.5-32.5 µm in polar axis length (P) and 25.0-30.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture micro-foveolate; apertures colpate long narrow with acute ends.

Staurogyne kingiana (Figure 4.7: 27A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape subprolate to prolate; type 3-colpate; size 32.5-37.5 µm in polar axis length (P) and 22.5-30.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture micro-foveolate; apertures colpate long narrow with acute ends.

Staurogyne lanceolata (Figure 4.7: 28A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colpate; size 27.5-35.0 µm in polar axis length (P) and 25.0-35.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture micro-foveolate; apertures colpate long narrow with acute ends.

Staurogyne lasiobotrys (Figure 4.8: 29A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colpate; size 25.0-30.0 µm in polar axis length (P) and 22.5-30.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture foveolate; apertures colpate long narrow with acute ends.

Staurogyne longeciliata (Figure 4.8: 30A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape subprolate ; type 3-colpate; size 20.0-32.5 µm in polar axis length (P) and 17.5-25.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture micro-foveolate; apertures colpate long narrow with acute ends.

Staurogyne major (Figure 4.8: 31A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colpate; size 27.5-37.5 µm in polar axis length (P) and 25.0-35.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture rugulate; apertures colpate long narrow with acute ends.

Staurogyne merguensis (Figure 4.8: 32A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal to subprolate; type 3-colpate; size 27.5-37.5 µm in polar axis length (P) and 25.0-32.5 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture rugulate; apertures colpate long narrow with acute ends.

Staurogyne obtusa (Figure 4.9: 33A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colpate; size 27.5-32.5 µm in polar axis length (P) and 25.0-30.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture rugulate; apertures colpate long narrow with acute ends.

Staurogyne parvicaulis (Figure 4.9: 34A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape subprolate; type 3-colpate; size 20.0-25.0 µm in polar axis length (P) and 17.5-20.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture foveolate; apertures colpate long narrow with acute ends.

Staurogyne punctata (Figure 4.9: 35A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colpate; size 25.0-32.5 µm in polar axis length (P) and 25.0-30.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture micro-foveolate; apertures colpate long narrow with acute ends.

Staurogyne racemosa (Figure 4.9: 36A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape subprolate; type 3-colpate; size 32.5-37.5 µm in polar axis length (P) and 25.0-32.5 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture rugulate; apertures colpate long narrow with acute ends.

Staurogyne setigera (Figure 4.10: 37A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape subprolate to prolate; type 3-colpate; size 30.0-42.5 µm in polar axis length (P) and 25.0-30.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture foveolate; apertures colpate long narrow with acute ends.

Staurogyne singularis (Figure 4.10: 38A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape subprolate; type 3-colpate; size 25.0-30.0 µm in polar axis length (P) and 20.0-25.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture foveolate; apertures colpate long narrow with acute ends.

Staurogyne spatulata (Figure 4.10: 39A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colpate; size 20.0-25.0 µm in polar axis length (P) and 20.0-22.5 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture rugulate; apertures colpate long narrow with acute ends.

Staurogyne tenuispica (Figure 4.10: 40A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape prolate spheroidal; type 3-colpate; size 27.5-32.5 µm in polar axis length (P) and 25.0-30.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture rugulate; apertures colpate long narrow with acute ends.

Staurogyne sp3 (Figure 4.11: 41A-C)

Pollen grains simple, bilateral symmetry, isopolar; shape oblate spheroidal; type 3-colpate; size 22.5-27.5 µm in polar axis length (P) and 22.5-30.0 µm in equatorial axis length (E); exine 2.5 µm thick; exine sculpture rugulate; apertures colpate long narrow with acute ends.

Table 4.1 Pollen features in studied taxa.

Taxa	Aperture	Size (µm)		Shape	Sculpture	Exine
		P	E			thickness
Pseuderanthemum axillare	3-colporate	30.0-40.0	37.5-40.0	SO-OS	foveolate	3.75-5.0
P. bracteatum	3-colporate	50.0-65.0	55.0-70.0	OS	foveolate	5.0
P. carruthersii (A)	3-colporate	40.0-50.0	32.5-40.0	SP	foveolate	2.5
P. carruthersii (B)	3-colporate	37.5-42.5	35.0-42.5	PS	foveolate	2.5
P. crenulatum	3-colporate	32.5-40.0	25.0-35.0	SP	perforate	2.5
P. graciliflorum	3-colporate	45.0-65.0	40.0-60.0	PS	perforate	2.5-5.0
P. latifolium	3-colporate	47.5-57.5	52.5-65.0	OS	foveolate	5.0
P. laxiflorum	3-colporate	37.5-55.0	37.5-50.0	PS	foveolate	2.5
P. longistylum	3-colporate	40.0-52.5	50.0-65.0	SO	foveolate	3.75-5.0
P. "palatiferum"	3-colporate	45.0-50.0	50.0-62.5	SO-OS	foveolate	3.75-5.0
P. parishii	3-colporate	65.0-87.5	72.5-80	OS-P	MF	5.0-7.5
P. reticulatum (A)	3-colporate	37.5-52.5	32.5-37.5	SP-P	foveolate	3.75-5.0
P. reticulatum (B)	3-colporate	37.5-52.5	35.0-37.5	PS-SP	foveolate	5.0
P. siamense	3-colporate	70.0-87.5	70.0-87.5	PS	foveolate	5.0
P. sp1	3-colporate	40.0-55.0	50.0-57.5	SO-OS	foveolate	5.0
Nelsonia canescens	3-colpate	17.5-21.3	17.5-20.0	PS	foveolate	1.25
Ophiorrhiziphyllon macrobotryum	3-colpate	16.3-25.0	16.3-22.5	PS	psilate	1.25
Staurogyne argentea	3-colpate	30.0-42.5	25.0-30.0	SP-P	foveolate	1.25-2.5
S. concinnula	3-colpate	27.5-32.5	22.5-27.5	SP	foveolate	1.25-2.5
S. cuneata	3-colpate	30.0-37.5	30.0-35.0	PS	MF	2.5
S. dispar	3-colpate	35.0-42.5	27.5-37.5	SP	foveolate	2.5
S. filipes	3-colpate	22.5-27.5	25.0-30.0	OS	rugulate	2.5
S. glauca	3-colpate	17.5-20.0	17.5-22.5	OS	foveolate	1.25
S. griffithiana	3-colpate	25.0-30.0	25.0-27.5	PS	foveolate	2.5
S. helferi	3-colpate	25.0-37.5	30.0-32.5	SO-OS	foveolate	2.5
S. incana	3-colpate	27.5-32.5	25.0-30.0	PS	MF	2.5
S. kingiana	3-colpate	32.5-37.5	22.5-30.0	SP-P	MF	2.5
S. lanceolata	3-colpate	27.5-35.0	25.0-35.0	PS	MF	2.5
S. lasiobotrys	3-colpate	25.0-30.0	22.5-30.0	PS	foveolate	2.5
S. longeciliata	3-colpate	20.0-32.5	17.5-25.0	SP	MF	2.5
S. major	3-colpate	27.5-37.5	25.0-35.0	PS	rugulate	2.5
S. merguensis	3-colpate	27.5-37.5	25.0-32.5	PS-SP	rugulate	2.5
S. obtusa	3-colpate	27.5-32.5	25.0-30.0	PS	rugulate	2.5
S. parvicaulis	3-colpate	20.0-25.0	17.5-20.0	SP	foveolate	2.5
S. punctata	3-colpate	25.0-32.5	25.0-30.0	PS	MF	2.5
S. racemosa	3-colpate	32.5-37.5	25.0-32.5	SP	rugulate	2.5
S. setigera	3-colpate	30.0-42.5	25.0-30.0	SP-P	foveolate	2.5
S. singularis	3-colpate	25.0-30.0	20.0-25.0	SP	foveolate	2.5
S. spatulata	3-colpate	20.0-25.0	20.0-22.5	PS	rugulate	2.5
S. tenuispica	3-colpate	27.5-32.5	25.0-30.0	PS	rugulate	2.5
S. sp3	3-colpate	22.5-27.5	22.5-30.0	OS	rugulate	2.5

P: polar axis length; E: equatorial axis length; SP: subprolate; PS: prolate spheroidal; SO: suboblate; P: prolate; OS: oblate spheroidal; MF: micro-foveolate.

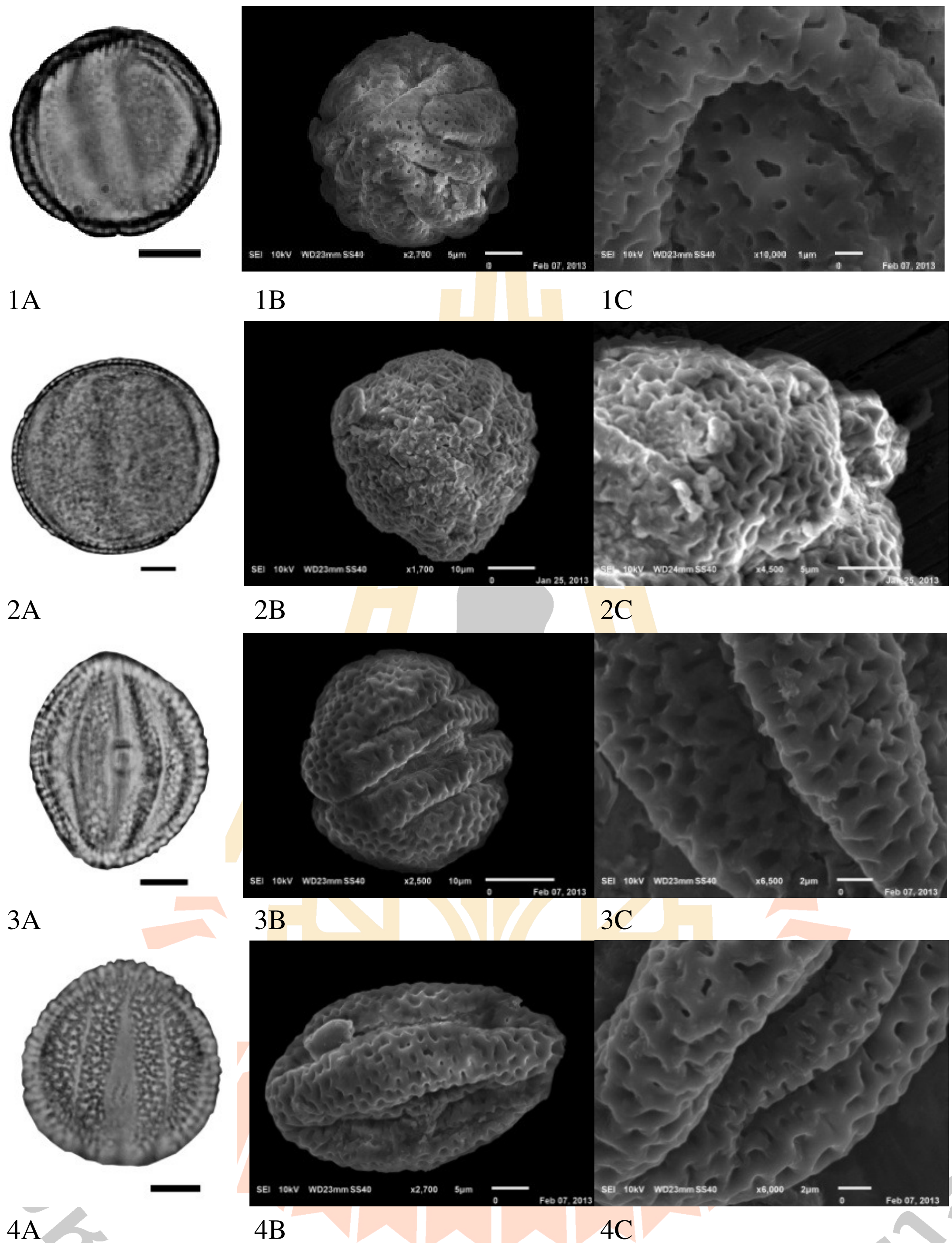


Figure 4.1 Pollen features under LM, SEM, and SEM close-up.

1) *Pseuderanthemum axillare* 2) *Pseuderanthemum bracteatum*

3) *Pseuderanthemum carruthersii* (A) 4) *Pseuderanthemum carruthersii* (B)

LM scale bars = 10 µm

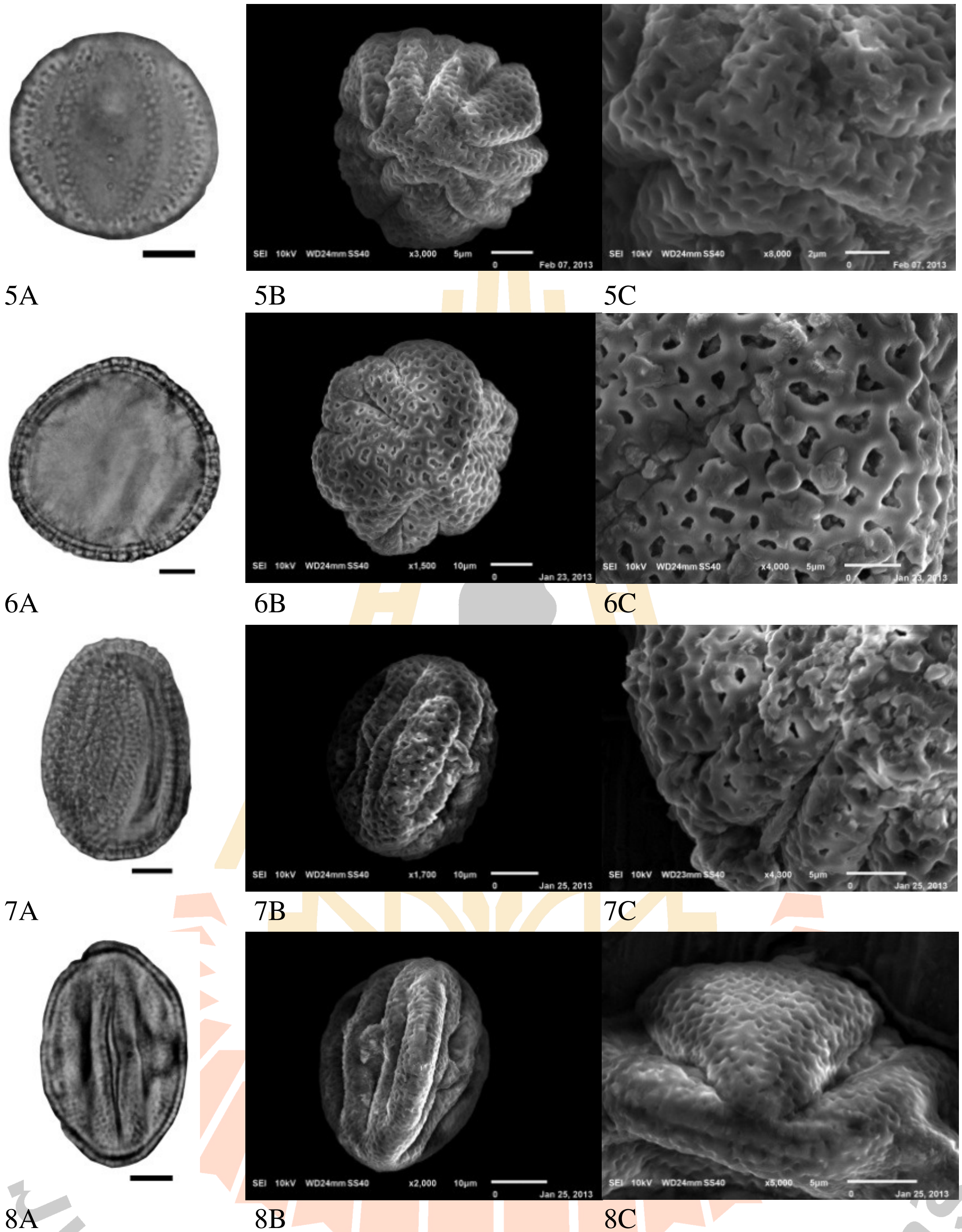


Figure 4.2 Pollen features under LM, SEM, and SEM close-up.

5) *Pseuderanthemum crenulatum* 6) *Pseuderanthemum graciliflorum*

7) *Pseuderanthemum latifolium* 8) *Pseuderanthemum laxiflorum*

LM scale bars = 10 µm

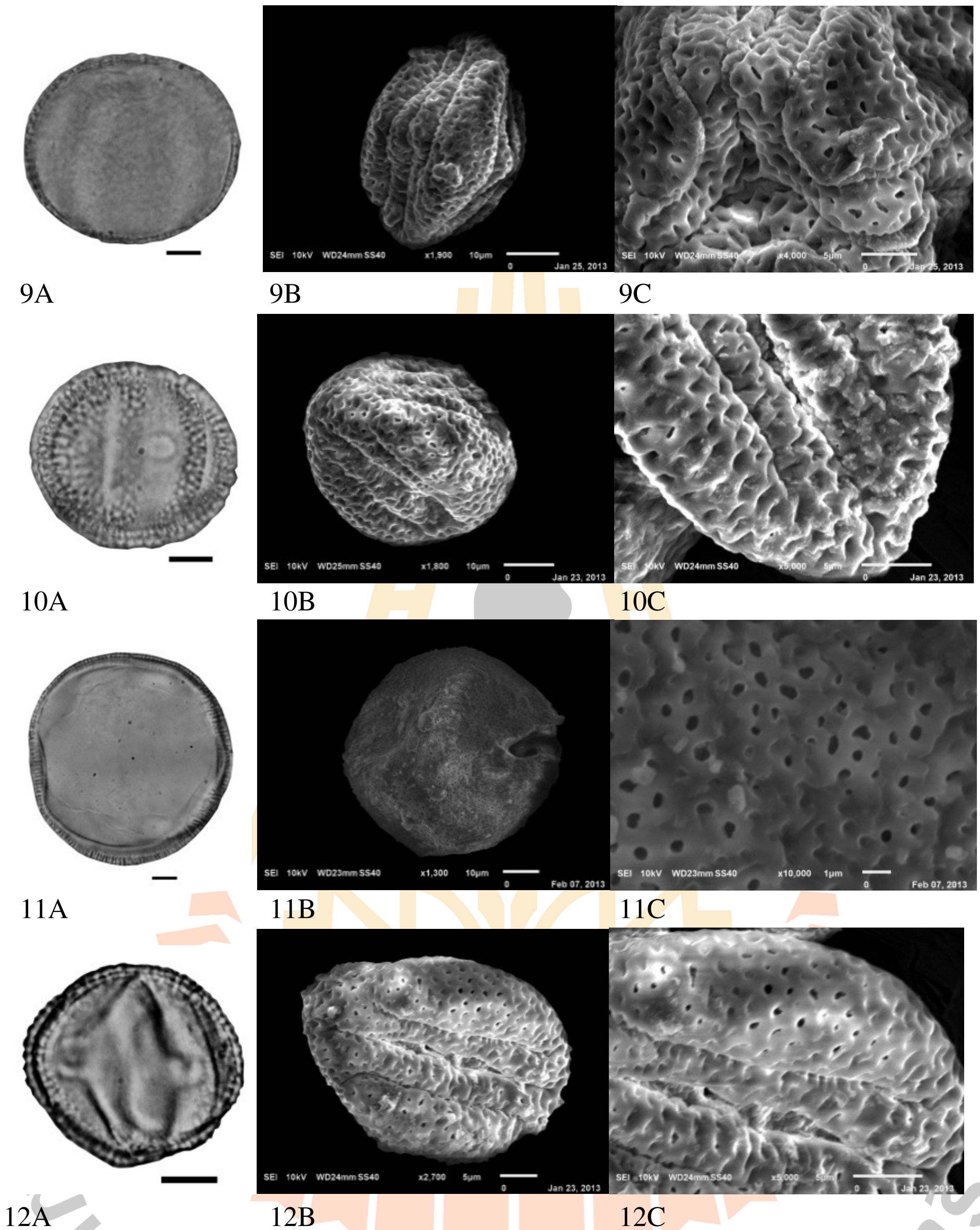


Figure 4.3 Pollen features under LM, SEM, and SEM close-up.

9) *Pseuderanthemum longistylum* 10) *Pseuderanthemum* "*palatiferum*"

11) *Pseuderanthemum parishii* 12) *Pseuderanthemum reticulatum* (A)

LM scale bars = 10 µm

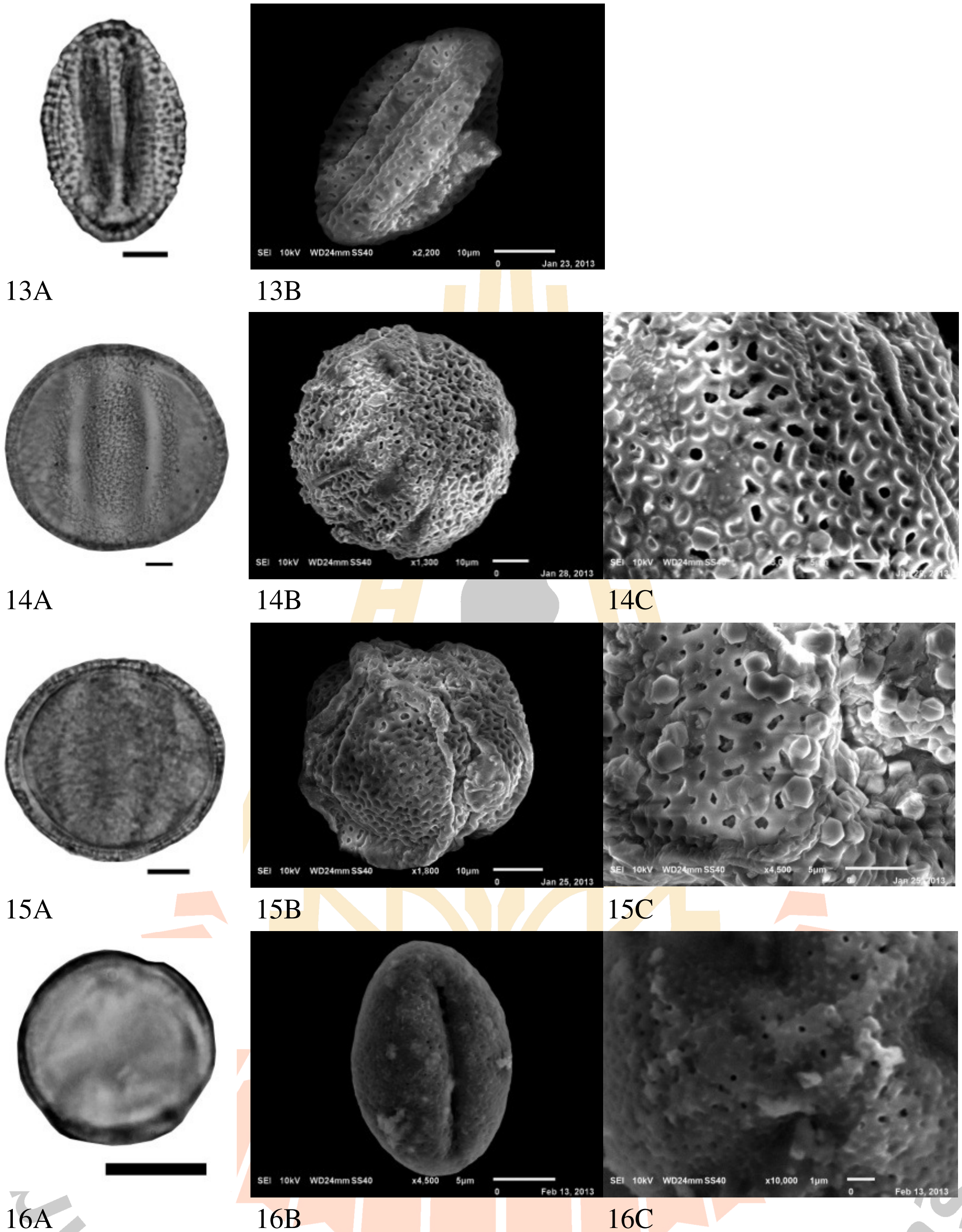


Figure 4.4 Pollen features under LM, SEM, and SEM close-up.

13) *Pseuderanthemum reticulatum* (B)   14) *Pseuderanthemum siamense*

15) *Pseuderanthemum* sp1   16) *Nelsonia canescens*

LM scale bars = 10 µm

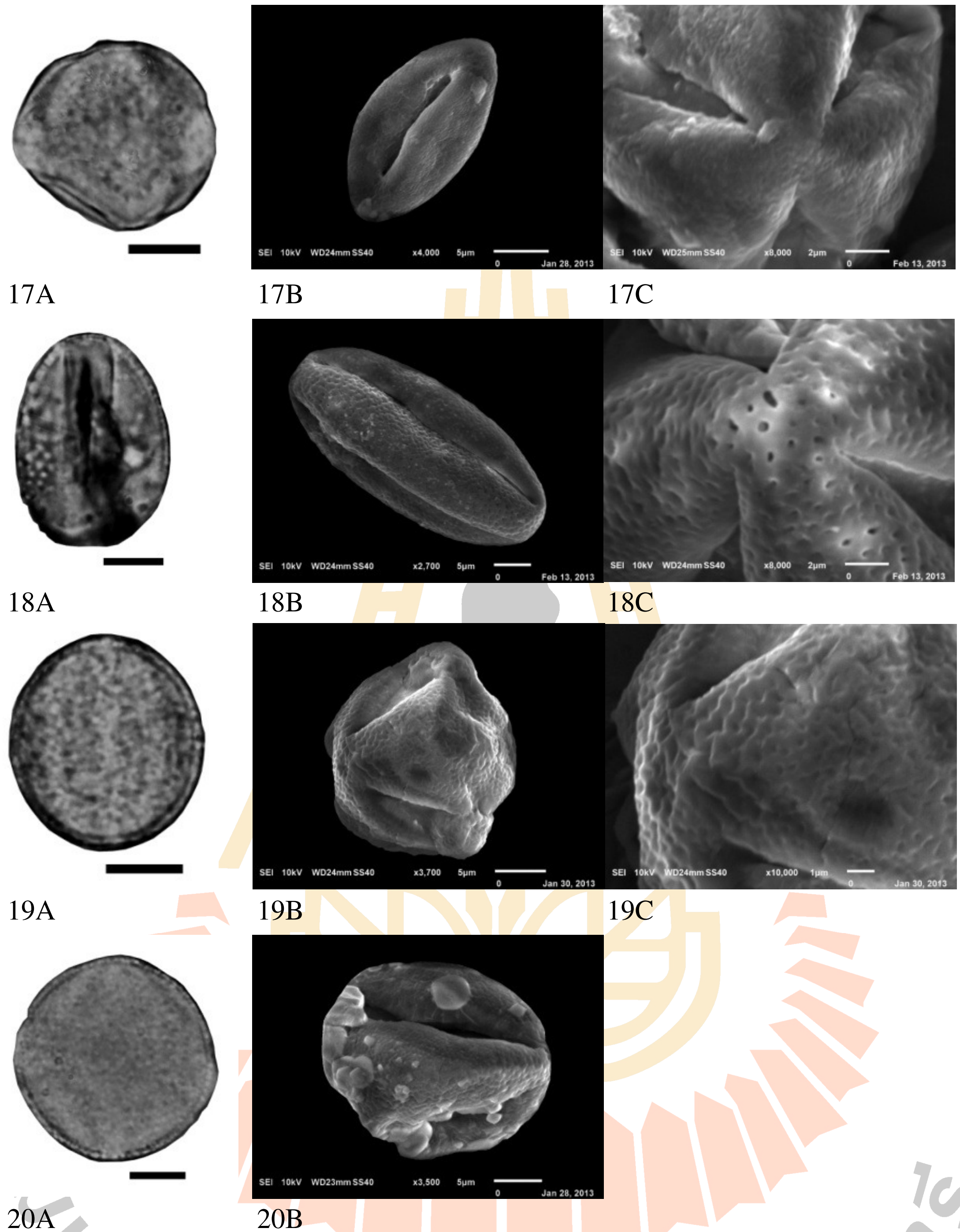


Figure 4.5 Pollen features under LM, SEM, and SEM close-up.

17) *Ophiorrhiziphyllon macrobotryum* 18) *Staurogyne argentea*

19) *Staurogyne concinnula* 20) *Staurogyne cuneata*

LM scale bars = 10 µm

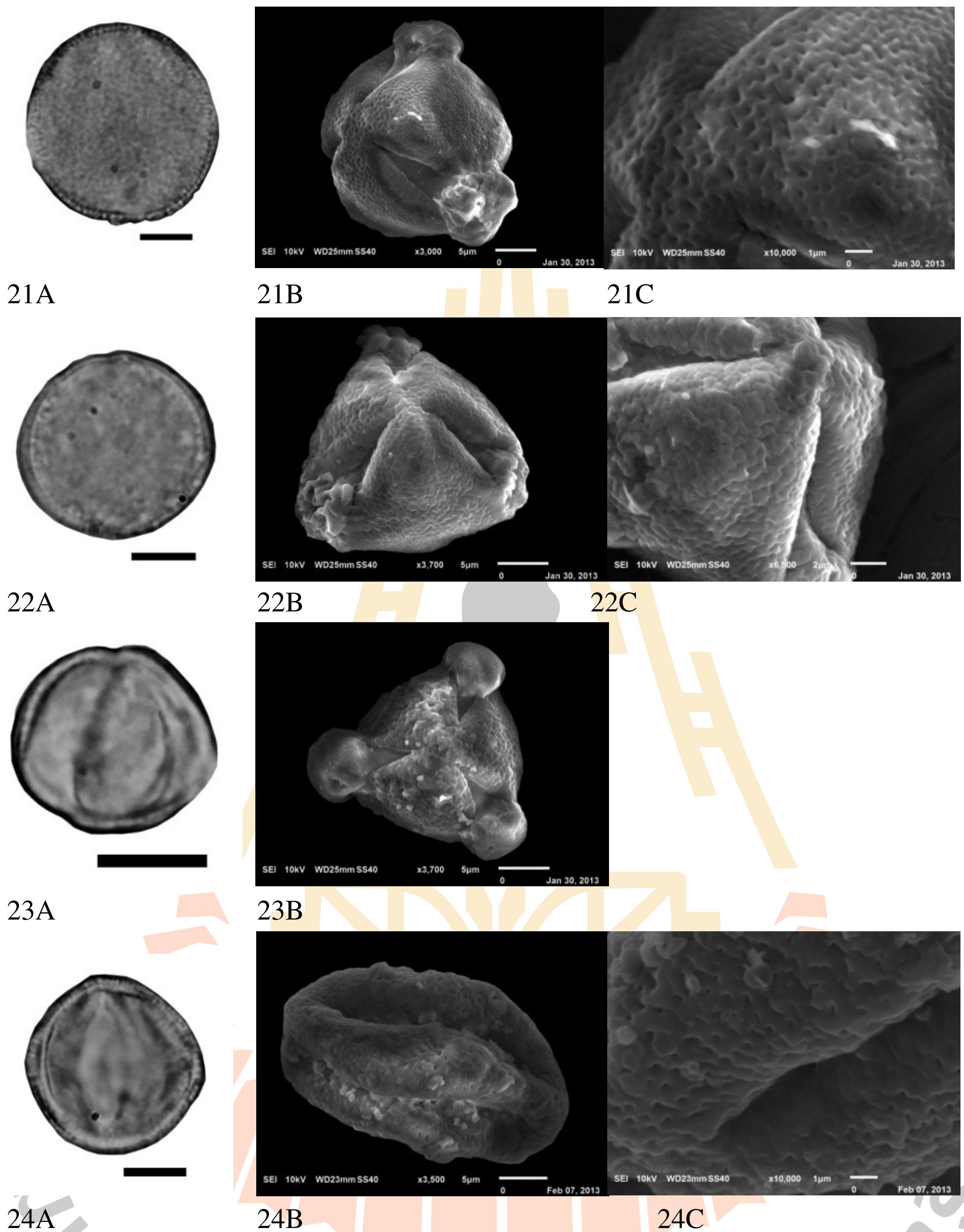


Figure 4.6 Pollen features under LM, SEM, and SEM close-up.

21) *Staurogyne dispar* 22) *Staurogyne filipes*

23) *Staurogyne glauca* 24) *Staurogyne griffthiana*

LM scale bars = 10 µm

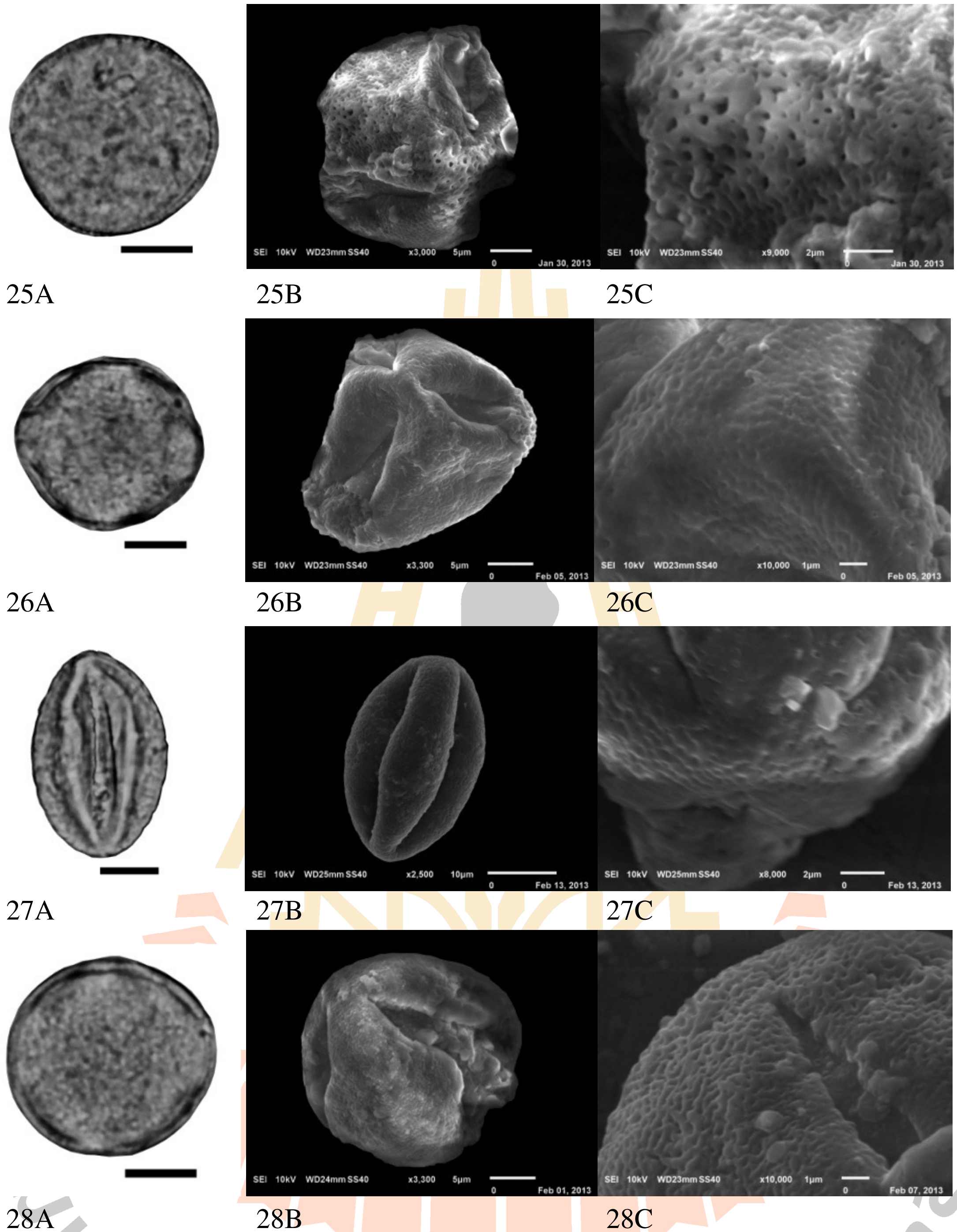


Figure 4.7 Pollen features under LM, SEM, and SEM close-up.

25) *Staurogyne helferi* 26) *Staurogyne incana*

27) *Staurogyne kingiana* 28) *Staurogyne lanceolata*

LM scale bars = 10 µm

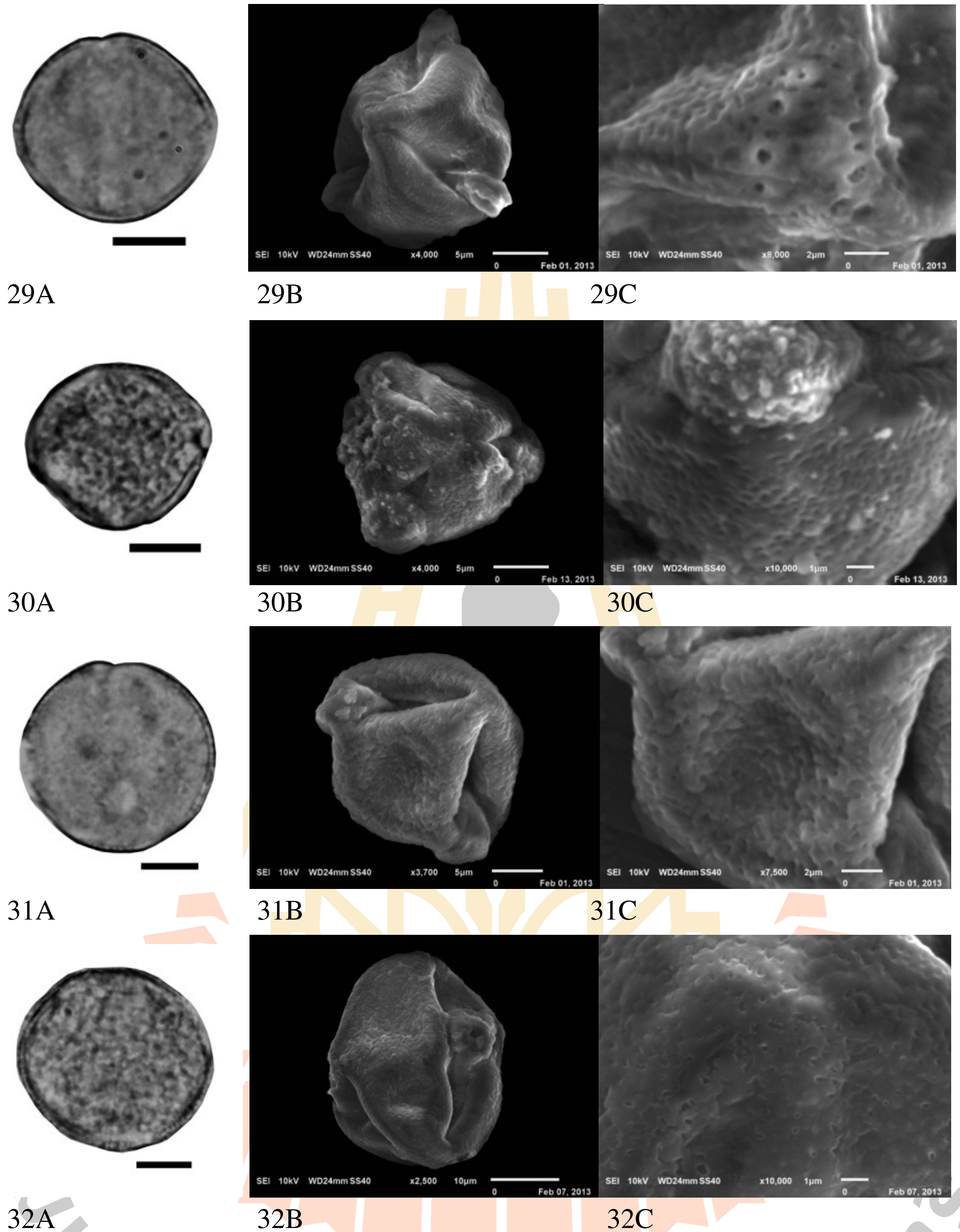


Figure 4.8 Pollen features under LM, SEM, and SEM close-up.

29) *Staurogyne lasiobotrys* 30) *Staurogyne longeciliata*

31) *Staurogyne major* 32) *Staurogyne merguensis*

LM scale bars = 10 µm

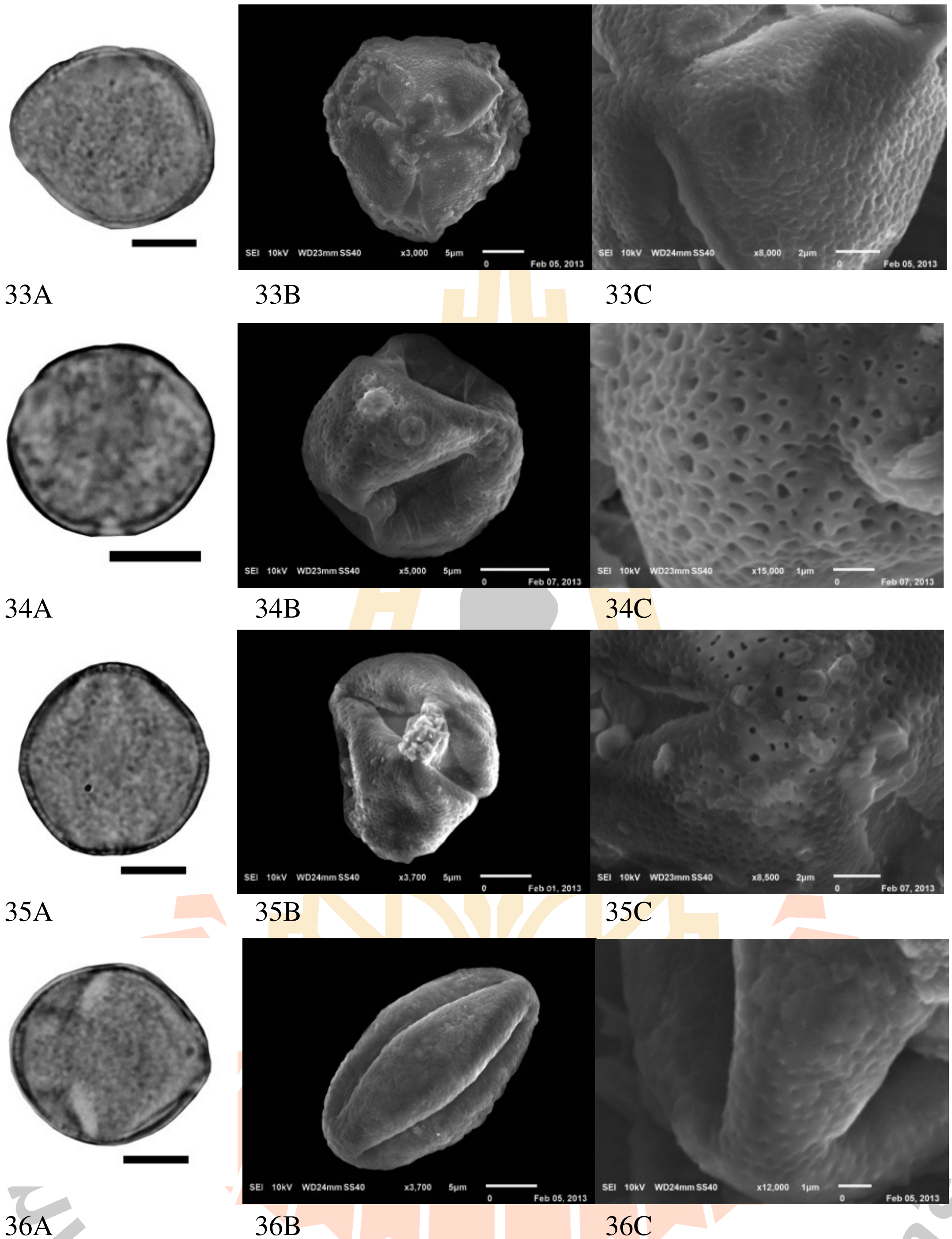


Figure 4.9 Pollen features under LM, SEM, and SEM close-up.

33) *Staurogyne obtusa* 34) *Staurogyne parvicaulis*

35) *Staurogyne punctata* 36) *Staurogyne racemosa*

LM scale bars = 10 µm

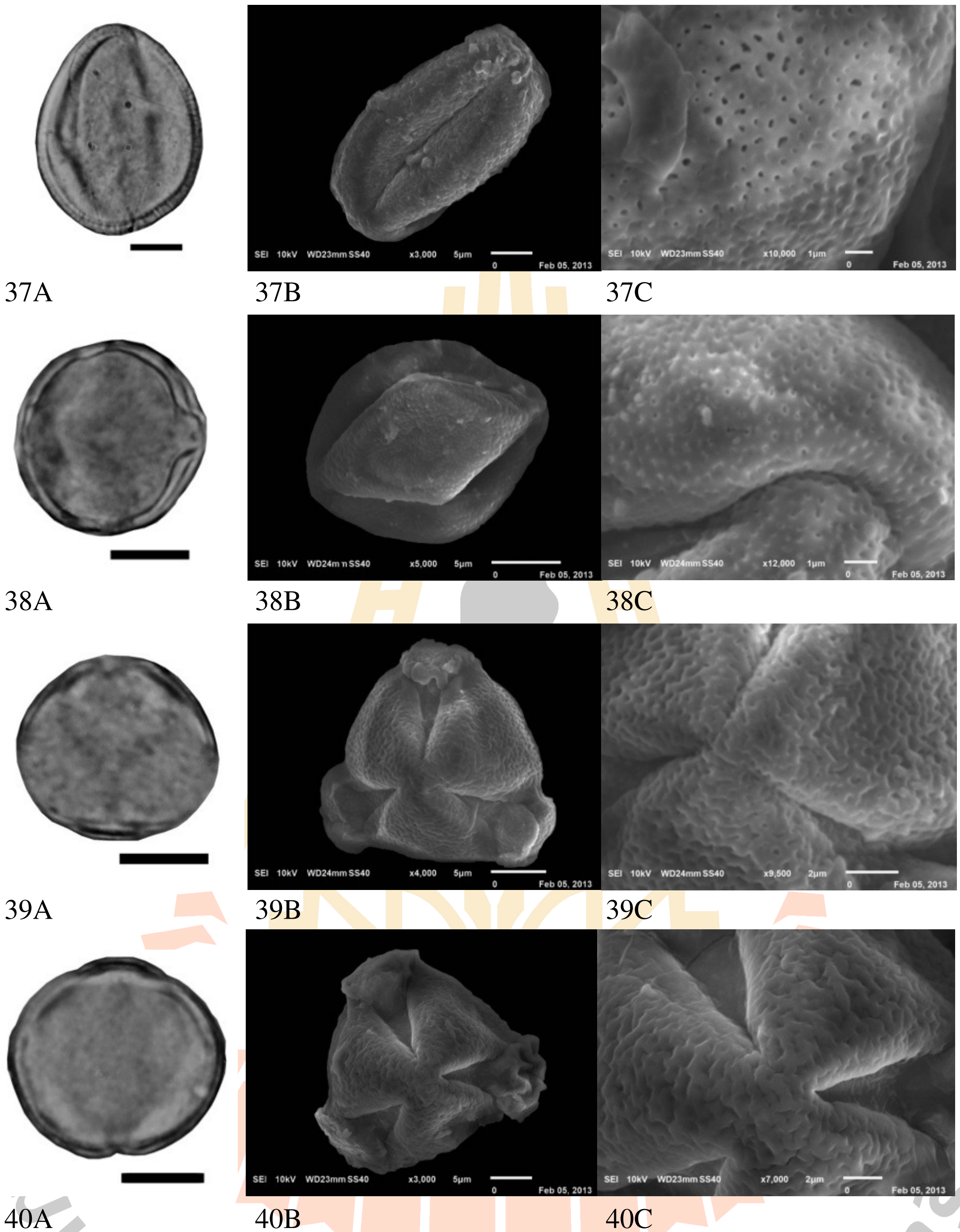
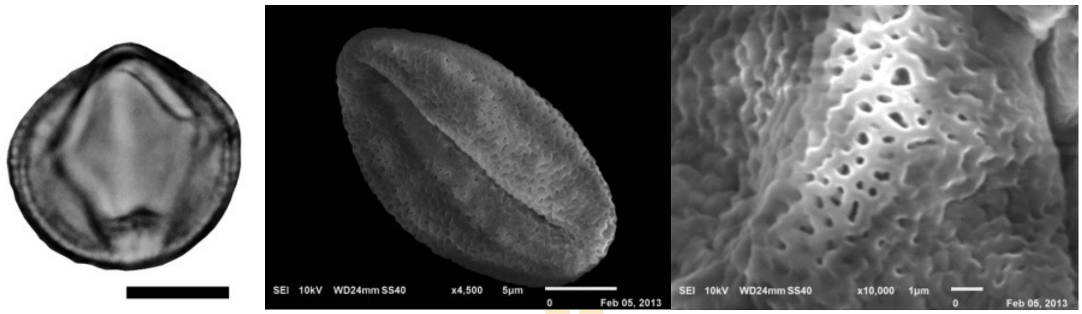


Figure 4.10 Pollen features under LM, SEM, and SEM close-up.

37) *Staurogyne setigera* 38) *Staurogyne singularis*

39) *Staurogyne spatulata* 40) *Staurogyne tenuispica*

LM scale bars = 10 µm



41A 41B 41C

Figure 4.11 Pollen features under LM, SEM, and SEM close-up.

41) *Staurogyne* sp3

LM scale bar = 10 µm

4.5 Conclusions and Discussion

The result showed that there were 2 distinct different types of pollen in 2 subfamilies. Their shapes and sizes varied even in the same genus. The wall ornamentation revealed some differences at the fine level not visible at the coarse level. Usually, we can classify pollen shape into 5 categories: peroblate, oblate, subspheroidal, prolate, and perprolate. But for more detail, the shape was divided into 4 subcategories in shape of subspheroidal, i.e., suboblate, oblate spheroidal, prolate spheroidal, and subprolate.

In Acanthoideae (15 taxa of *Pseuderanthemum*), pollen type was tricolporate with hexapseudocolpi; the longitudinal ribs were reduced to nine with three broader than the other six and three pores at the equator with each pore between two narrow ridges. Their apertures were round. The polar axis length (P) was 30.0-87.5 µm, and equatorial axis length (E) was 25.0-87.5 µm. The largest size was represented in *Pseuderanthemum siamense*, followed by *P. parishii*, and *P. graciliflorum*; while the smallest was shown in *P. axillare* and *P. crenulatum*. The shape varied from suboblate to prolate. Foveolate tectum was found in 12 taxa, i.e., *P. axillare*, *P. bracteatum*, *P. carruthersii* (A and B), *P. latifolium*, *P. laxiflorum*, *P. longistylum*, *P.* "*palatiferum*", *P. reticulatum* (A and B), *P. siamense*, and *P.* sp1. Micro-foveolate only showed in *P. parishii*, which was diagnostic for this species, and perforate was revealed in *P. crenulatum* and *P. graciliflorum*, while the different size of their pollen could be used as a taxonomic tool. The wall thickness varied from 2.5-7.5 µm, depending on species.

This study conformed to the pollen type of *Pseuderanthemum* Radlk. as tricolporate (Chaikong, 2001) and to Lindau's classification as "Spangenpollen" or grains ellipsoid, with 3 broad bands and 3 pairs of narrow bands all meeting at or near the poles, the bands finely pitted or granular, 3 germ-pores in the grooves between the pairs of narrow bands. Moreover, tricolporate with hexapseudocolpi in *Pseuderanthemum* was also revealed in some genera of Acanthaceae, i.e., *Asystasia*, *Clinacanthus*, *Dicliptera*, *Graptophyllum*, *Pachystachys*, *Rhinacanthus*, and *Peristrophe*, but show some differences in details of ornamental wall and uniting at the apex of the narrow bands (Lindau, 1895; Imlay, 1938; Scotland and Vollesen, 2000).

In Nelsonioideae (26 taxa of *Nelsonia*, *Ophiorrhiziphyllon*, and *Staurogyne*), the pollen type was tricolpate. This pollen type is quite distinct from other genera in Acanthaceae except in tribe Acantheae, subfamily Acanthoideae that possessed retinaculate fruits but lacked cystoliths (Lindau, 1895; Bremekamp, 1965a; Scotland and Vollesen, 2000). Their apertures were longitudinal narrow colpi with acute ends. The polar axis length (P) was 16.3-42.5 µm and equatorial axis length (E) was 17.5-

37.5 µm. The largest size was represented in *Staurogyne dispar*; while the smallest was shown in *Nelsonia canescens*, *Staurogyne glauca*, and *S. parvicaulis*. The shape varied from suboblate to prolate. Foveolate tectum was found in 11 taxa, i.e., *N. canescens*, *S. argentea*, *S. concinnula*, *S. dispar*, *S. griffithiana*, *S. glauca*, *S. helferi*, *S. lasiobotrys*, *S. parvicaulis*, *S. setigera*, and *S. singularis*. Rugulate was represented in 8 taxa of *S. filipes*, *S. major*, *S. merguensis*, *S. obtusa*, *S. racemosa*, *S. spatulata*, *S. tenuispica*, and *S.* sp3. Micro-foveolate was shown in 6 taxa of *S. cuneata*, *S. kingiana*, *S. punctata*, *S. lanceolata*, *S. longeciliata*, and *S. incana*. And psilate only revealed in *Ophiorrhiziphyllon macrobotryum*. The wall thickness varied from 1.25-2.5 µm, depending on species. These types of ornamental wall including the variation of size and shape are useful for the identification and delimitation of species.

In size, *Staurogyne dispar* represented the largest pollen, while *Nelsonia canescens* showed the smallest one. Moreover, *S. glauca* and *S. parvicaulis* revealed the most tiny pollen within the genus but were different in shape of oblate spheroidal and subprolate, respectively, and also dissimilar in wall thickness. Furthermore, the larger size of pollen conformed with the biggest size of flower and the habit of small shrubs, i.e., *S. argentea*, *S. cuneata*, *S. dispar*, *S. kingiana*, *S. punctata*, *S. major*, and *S. racemosa*.

The sculpturing pattern of the wall is an important factor in the discrimination of species or even genera. Psilate tectum was restricted to *Ophiorrhiziphyllon macrobotryum*. The result conformed to Lindau's pollen type of *Ophiorrhiziphyllon* as "Glatter, runder pollen" or "smooth round pollen" with 3 germ-pores, and smooth exine (Lindau, 1895; Imlay, 1938). This result can be used to distinguish *Ophiorrhiziphyllon* from *Staurogyne* beside longer fertile stamens exserted with oblong anthers, corolla zygomorphic (conspicuously 2-lipped). *S. dispar* was separated from the other 3 species, i.e., *S. concinnula*, *S. parvicaulis*, and *S. singularis* with foveolate ornamental wall and subprolate pollen shape by showing the largest pollen size. *S. glauca* and *S. spatulata* were evaluated as a complex species because of a similarity of inflorescence and flowers, but pollen characteristics can be used to separate them, i.e., pollen sculpture (foveolate vs regulate), pollen shape (oblate spheroidal vs prolate spheroidal), and also a little difference in size and wall thickness. Moreover, Hansen (1995) has reduced *S. longeciliata* into *S. lanceolata* because of a similarity of hairs on bracts. In this study, *S. lanceolata* and *S. longeciliata* both possessed micro-foveolate walls but were still different in shape of prolate spheroidal and subprolate with variation in size, especially in equatorial axis length. *S. longeciliata* also represented the smallest pollen in the micro-foveolate group.

The presence of tricolpate pollen is a constant feature of all genera within Thai Nelsonioidae and is diagnostic of this group within Acanthaceae. This study conformed to the pollen type of *Nelsonia* R. Br., and *Staurogyne* Wall. (Wheeler et al, 1992) as colpate and which of Lindau's classification as "Spaltenpollen" or grains globose or ellipsoid, or almost 3-sided, with 3 very small grooves, with or without 3 germ-pores (Lindau, 1895; Imlay, 1938). However, it differed from to the pollen of *Staurogyne* sp. from China which have been reported as 3-colporate, with the exine ornamental being psilate (Tsui and Hu, 2005).

As mentioned above, some species of studied taxa showed specific characters of pollen which may be used as taxonomic tools to separate them from the others or be used as homologue to develop a phylogeny together with other characters such as morphological and anatomical features.

According to pollen grains were often destroyed when using acetolysis method. In this research, samples were analyzed using the technique, which was modified from the comparison of different pollen treatments in Cyperaceae (Wichelen et al., 1999). This method could protect pollen from collapse and could also keep samples that contained very few pollen grains. However, this technique should be adapted or developed to get a good result as doing acetolysis method depend on species. Furthermore, study of pollen morphology is still needed. More materials in Thailand or even from other countries are useful to confirm the identification and more useful for the future study of Acanthaceae classification.

CHAPTER V

TAXONOMIC AND MORPHOLOGICAL STUDIES

5.1 Introduction

The flowering plant family Acanthaceae consists of 220-250 genera and 2,500-4,000 species (Scotland and Vollesen, 2000, Heywood, 2007; McDade et al., 2008), although disagreement exists as to exact numbers because the extent of synonymy is difficult to assess. Three classifications have been proposed for the family across its entrie geographical range (Nees, 1847a; Bentham, 1876; Lindau, 1895). The delimitation and subdivision of the family Acanthaceae has resulted in the recognition of many conflicting taxonomic groups because of the use of different characters or combinations of characters (Nees, 1832, 1847; Anderson, 1867; Bentham, 1876; Clarke, 1885; Burkill and Clarke, 1899; Lindau, 1893, 1895; Bremekamp, 1965a). These different approaches and their subsequent disparate results partly reflect the history of conflicting aims and methods for constructing classifications.

Lindau (1895) is the most recent taxonomic treatment of Acanthaceae that accounts for all genera (Appendix A). The lack of such a classification since Lindau (1895) reflects the extent of the task, the regional basis of many accounts, the lack of agreement as to the major sub-divisions, and a lack of consensus concerning the exact limits of the family. Bremmekamp (1965a) presented a classification of Acanthaceae

(Appendix B) that differed from that of Lindau (1895) in some important respects. However, a major limitation with Bremekamp's classification was that a list of group membership was not provided for many taxa.

Regarding the major divisions of the Lindau (1895) and Bremekamp (1965a) classifications, Lindau (1895) recognized four subfamilies, three of which comprise genera that do not posses retinaculate fruits (Nelsonioideae, Thunbergioideae, Mendoncioideae). Mendoncioideae and Thunbergioideae represented two very similar subfamilies of climbing plants separated on the basis of the capsular fruits of Thunbergioideae or the drupaceous fruits of Mendoncioideae. Lindau's Acanthoideae, comprising genera with retinaculate fruits, was subdivided into two groups based on corolla aestivation patterns (Imbricate and Contortae). Further subdivisions were based primarily on pollen morphology (Appendix A). Bremekamp's Acanthaceae excluded genera that lack retinaculate fruits. He placed Nelsonioideae within Scrophulariaceae, recognized Thunbergiaceae and Mendonciaceae as distinct families and divided his restricted Acanthaceae into two groups on the basis of presence and absence of cystoliths, articulated stems, monothecate anthers, and colpate pollen. Further subdivisions were based primarily on pollen morphology (Appendix B).

Moreover, Benoist (1935) reported Acanthaceae as having 6 tribes: Thunbergiees, Nelsoniees, Ruelliees, Barleriees, Acanthees, and Justicees. Bremekamp (1965a) analyzed the family into 5 tribes: Acantheae, Ruellieae, Lepidagathideae, Andrographideae, and Justicieae. Hansen (1985) divided it into 4 subfamilies: Thunbergioideae, Nelsonioideae, Acanthoideae, and Ruellioideae, which was further divided into 4 tribes: Ruellieae, Lepidagathideae, Andrographideae, and Justicieae.

More recently, published molecular studies (Hedren et al., 1995; Scotland et al., 1995; McDade and Moody 1999) highlight the aspects of disagreement between Lindau (1895) and Bremekamp (1965a). These studies have largely converged on a topology of Acanthaceae that supports some taxa recognized by Lindau (1895) and others recognized by Bremekamp (1965). Scotland and Vollesen (2000) reviewed recent literature and provided a list of currently accepted genera of Acanthaceae in a new classification (Appendix C). They divided Acanthaceae into 3 subfamilies, which will be accepted for classification in this research, viz., Acanthoideae, Nelsonioideae, and Thunbergioideae. The subfamily Acanthoideae was divided into 2 tribes, Acantheae and Ruellieae. The tribe Ruellieae was divided into 4 subtribes, Ruelliinae, Justiciinae, Andrographinae, and Barleriinae. Two small subfamilies, both lacking cystoliths and retinacula, are recognized outside the main group, the Nelsonioideae, coming fairly close to Scrophulariaceae, and the Thunbergioideae, which are predominantly climbers with a reduced calyx and poricidal anthers. In the subfamily Acanthoideae, the tribe Acantheae also lack cystoliths and have characteristic anthers, while the 2 subtribes, Ruelliinae and Barleriinae, of Ruellieae differ in their corolla aestivation, left contorted and quincuncial, respectively (McDade and Moody, 1999; McDade et al., 2000; McDade et al., 2008). Following the Angiosperm Phylogeny Group (2003, 2009) or Angiosperm phylogeny website (Stevens, 2001 onwards), the family Acanthaceae can be classified, based on molecular and morphological data, in the following higher level taxa: plant kingdom, angiosperms, eudicots, core eudicots, asterids, euasterids I (APG II) or lamiids (APG III), Order Lamiales, Family Acanthaceae.

5.2 Literature Review

The subfamily Nelsonioideae consists of 7 genera and 170 species of herbs and shrubs that occur primarily in tropical regions of the Old World and the New World. There are an estimated 3 genera and 27 species in Thailand. The genus *Pseuderanthemum* (subfamily Acanthoideae, tribe Ruellieae, subtribe Justiciinae) has approximately 60 species of herbs and shrubs, about 7 of which occur in Thailand. Botanists have studied the taxonomy within the family Acanthaceae, but only the genera of subfamily Nelsonioideae and the genus *Pseuderanthemum* will be mentioned as follows:

Bentham (1869) studied Acanthaceae in Australia. A key to species and descriptions are shown. There were 3 genera and 4 species of *Nelsonia*, *Ebermaiera* (synonym of *Staurogyne*), and *Eranthemum* (synonym of *Pseuderanthemum*).

Clarke (1885) investigated Acanthaceae in India. Keys to species and descriptions are given. There were 5 genera and 44 species of *Elytraria*, *Ebermaiera*, *Nelsonia*, *Ophiorrhiziphyllon*, and *Eranthemum*.

Craib (1912) contributed to the flora of Siam and provided the descriptions for each species. There were 4 genera and 7 species of *Staurogyne*, *Ophiorrhiziphyllon*, *Nelsonia*, and *Eranthemum*.

Ridley (1923) studied the taxonomy of Acanthaceae in the Malay Peninsula. Keys to genera and species and descriptions are provided. There were 3 genera and 29 species of *Pseuderanthemum*, *Nelsonia*, and *Staurogyne*.

Benoist (1935) studied the taxonomy of Acanthaceae in the Indo-Chinese region. Descriptions and keys to species, based on characters of sepals, petals, number of stamens, shape of petal tube, and number of pollen lobes, are shown. There were 4 genera and 27 species of *Pseuderanthemum*, *Nelsonia*, *Ophiorrhiziphyllon*, and *Staurogyne*.

Imlay (1939) investigated the flora of Thailand and listed 2 genera and 10 species of *Pseuderanthemum* and *Staurogyne*.

Backer and Bakhuizen (1965) studied the Acanthaceae on Java Island in Indonesia. The identification at the generic level mostly was based on stamen number, corolla tube length, filament fusion, corolla division, and aestivation. There were 2 genera and 11 species of *Staurogyne* and *Pseuderanthemum*.

Maxwell (1986) investigated the vascular plants of Khao Khieo wildlife sanctuary. The habit and flowering period of *Pseuderanthemum palatiferum* are provided but a description and a key to species is not included.

Koyama (1986) listed the pteridophytes and dicotyledons of Phu Kradung in Thailand. There were 2 genera and 3 species of *Pseuderanthemum* and *Staurogyne*.

Hansen (1989) noted on Southeast Asian Acanthaceae. New combinations in the group are *Pseuderanthemum lapathifolium* and *P. latifolium*. *Antheliacanthus* is a synonym of *Pseuderanthemum*.

Hansen (1995) also noted on Southeast Asian Acanthaceae. *Staurogyne parvicaulis* was described as a new species. *Staurogyne longeciliata* is a synonym of *S. lanceolata*, and so is *S. lanceolata* var. *scabridula*. *Ebermaiera subcapitata* is still kept in *Staurogyne setigera*. *Staurogyne malaccensis* is a synonym of *S. setigera*, and so is *S. malaccensis* var. *stenophylla*.

Cramer (1998) studied the Acanthaceae in Sri Lanka. Keys to genera and species and descriptions are provided. There were 3 genera and 5 species of *Pseuderanthemum*, *Elytraria*, and *Staurogyne*.

Hsieh and Huang (1998) described the Acanthaceae in Taiwan, including *Staurogyne concinnula*. Moreover, Hsieh et al. (1999) reported on *Staurogyne debilis* in Taiwan. Taxonomic descriptions, habitat information, a line drawing of the species, and a key to the Taiwanese species of *Staurogyne* are shown.

Scotland et al. (1994) investigated corolla ontogeny in 33 species of 23 genera of Acanthaceae. Five distinct aestivation patterns are described and illustrated: left contort, quincuncial, ascending cochlear, descending cochlear, and open.

Scotland and Vollesen (2000) analyzed and noted on the classification of Acanthaceae relative to recent molecular studies, pollen morphology, corolla aestivation, and other potentially informative morphological characters. The major pollen types of Acanthaceae are illustrated.

Chaikong (2001) researched the taxonomy of subtribe Barleriinae in Northeastern Thailand. Keys to genera and species, and descriptions of 8 species of *Pseuderanthemum* are provided.

The Forest Herbarium (2001) listed the plant names in Thailand. There were 3 genera and 10 species of *Nelsonia*, *Staurogyne*, and *Pseuderanthemum*.

Maxwell and Elliott (2001) listed the vegetation and vascular flora of Doi Sutep-Pui national park, northern Thailand. There were 4 genera and 6 species of *Nelsonia*, *Ophiorrhiziphyllon*, *Staurogyne* and *Pseuderanthemum*.

Maxwell (2006) investigated the vascular plants of Ko Hong hill, Songkhla Province. There were 2 genera and 3 species of *Staurogyne* and *Pseuderanthemum*.

Hu et al. (2011) studied the Acanthaceae of China. There were 4 genera and 24 species of *Staurogyne*, *Ophiorrhiziphyllon*, *Nelsonia*, and *Pseuderanthemum*.

5.3 Materials and Methods

The first part of this study was review of the literature dealing with subfamilies Nelsonioideae and Acanthoideae, genus *Pseuderanthemum*, in Thailand and neighboring countries. This study was largely based on the examination of the Thai specimens and a large number of non-Thai specimens kept at the herbaria in Thaialnd and overseas. Field collection and flowering period observations of the specimens was made in Thailand. Living specimens were photographed and noted. Specimens were pressed and dried, and selected organs were fixed. The collected specimens were deposited in herbaria. Living specimens were cultivated for anatomical and other studies. The morphological and taxonomic investigation was made directly from either living specimens from the natural habitat or the dried specimens from herbaria in Thailand or elsewhere (Chapter I and II). Vernacular names followed The Forest Herbarium (2001) or from the author own investigation. Keys, illustrations, and ecological information are provided.

5.4 Results

Forty-five taxa were found from the study of subfamilies Nelsonioideae and Acanthoideae, genus *Pseuderanthemum*, in Thailand based on the examination of the specimens kept at the herbaria in Thailand and overseas, field collection, and flowering period observations of the specimens throughout Thailand. The description of genera and species are provided with illustrations and artificial key to species in alphabetical order.

Description of Acanthaceae

The habits are herbs, shrubs, or climbers, rarely small trees. The leaves are opposite or decussate (may be basal to sub-opposite), rarely alternate, simple, and usually entire (deeply divided in *Acanthus*), without stipules, and occasionally spiny. Except in subfamilies Nelsonioideae and Thunbergioideae and in the tribe Acantheae, the leaves have cystoliths that are visible with a magnifying lens as streaks or rod-shaped structures in the epidermis. The inflorescences usually develop into cymes or racemes, or flowers are sometimes solitary. The inflorescence bracts are often well developed and showy. The flowers are bisexual, zygomorphic to nearly actinomorphic, and hypogynous. The calyx consists mostly of 5 free or fused sepals. The corolla is 5-parted, sympetalous, usually 2-lipped (bilabiate) or sometimes the upper lip lacking with a long or short tube. The stamens are usually 2, 4, or rarely 5 in number, with staminodes present in some taxa. The ovary is bicarpellate and develops into a capsule with 2 to 8 (16) seeds, or a single-seeded drupe (*Mendoncia*). Other than in subfamilies Nelsonioideae and Thunbergioideae, each seed is carried on a stiff hook-shaped structure called a retinaculum or jaculator, arising from the axile placenta. This feature allows identification of the great majority of the species to this family. The family is well known for the remarkable diversity of its pollen in size, shape, pores, and exine structure and ornamentation. Many genera can be characterized by a distinctive pollen type.

There are approximately 220-250 genera and 2,500-4,000 species in tropical and subtropical regions of the world; and approximately 40 genera and 230 species in Thailand (Hansen, 1985; Simpson, 2010; Heywood, 2007; Deng et al., 2009).

Taxonomic Study of Other Genera in Nelsonioideae

Anisosepalum E. Hossain, Notes Roy. Bot. Gard. Edinburgh 31: 377. 1972 [Type: *Anisosepalum humbertii* (Mildbr.) E. Hossain comb. nov., Locality: central Africa]; Champluvier, Bull. Jard. Bot. Nat. Belgique 61(1/2): 127. 1991; Scotland & Vollesen, Kew Bull. 55(3): 582. 2000; Vollesen, Fl. Trop. East Africa 21. 2008.

Perennial or shrubby herbs without cystoliths. Leaves opposite or in whorls, with scattered peltate subsessile orange glands beneath. Flowers one per bract, alternate, in terminal lax or dense racemoid cymes, pedicellate; bracts fused to the pedicel, persistent, 3-veined from base; bracteoles similar to the larger sepals, inserted on base of calyx and covering the lateral sepals. Calyx deeply divided into 5 unequal sepals, two lateral small, hyaline, 1-veined, 1 dorsal and two ventral herbaceous, 3-veined. Corolla 2-lipped; tube linear, broadening gradually upward or abruptly campanulate; upper lip flat or ± hooded, entire or emarginate, lower lip deeply 3-lobed with two narrow lateral lobes and broad rounded central lobe with 2-4 bosses at base. Stamens 4, didynamous, inserted deep in the tube, included or shortly exserted; filaments linear; anthers 2-thecous, thecae elliptic, with small apiculus at base, divergent, inserted at same height on a broad connective; staminode absent. Ovary 2-locular, with 6-8 ovules per locule; style linear; stigma deeply 2-lobed with 2 linear lobes, or lower lobe reduced, the upper lobe bifid. Capsule sessile, oblong-triangular, obtuse, glabrous, apical part sterile and ± recurved when mature; retinaculae papilliform, unindurated. Seed black, ovoid, flattened, rugose, with a hilar excavation.

Three species in Central Tropical Africa, i.e., *Anisosepalum lewallei* P. Bamps, *A. alboviolaceum* (Benoist) E. Hossain, and *A. humbertii* (Mildbr.) E. Hossain.

Elytraria Michaux, Fl. Bor. Amer. 1: 8. 1803 [Type: *Elytraria virgata* Michx., Locality: Carolinae] nom. cons.; Vahl, Enum. 1: 106. 1804; Endlicher, Gen. Pl. 697. 1839; Nees in Candolle, Prodr. 11: 62. 1847; Miquel, Fl. Ind. Bat. 2: 770. 1856; Anderson, J. Linn. Soc. Bot. 9: 449. 1867; Clarke in Hooker, Fl. Brit. India 4: 394. 1885; Burkill and Clarke, Fl. Trop. Africa 5: 27. 1899; Bremekamp, Reinwardtia 3: 249. 1955; Hossain, Notes Roy. Bot. Gard. Edinburgh 31: 378. 1972; Scotland & Vollesen, Kew Bull. 55(3): 584. 2000; Vollesen, Fl. Trop. East Africa 11. 2008; --- *Tubiflora* Gmelin, Syst. Nat. 2: 27. 1791 [Type: *Tubiflora caroliniensis* J. F. Gmel., Locality: Carolinae] nom. rej.; Kuntze, Rev. Gen. Pl. 2: 500. 1891; Lindau in Engler & Prantl, Nat. Pflanzenfam. 4(3b): 289. 1895; Benoist in Humbert, Fl. Madagascar 1: 24. 1967; Scotland & Vollesen, Kew Bull. 55(3): 584, 589. 2000.

Acaulous or short-stemmed annual or perennial herbs (rarely taller shrubs). Leaves in basal or apical rosettes. Flowers single, in dense cylindrical spikes from the rosettes, spikes sessile, unbranched or with branches from the base of the terminal spike; peduncles with scattered to imbricate scale-like sterile bracts, spirally arranged, persistent, without or with indistinct midrib; bracteoles 2, narrowly ovate-elliptic. Calyx divided almost to the base into 5 sepals; dorsal much wider than the rest, the two lateral slightly wider than the two ventral which are united higher up than the rest. Corolla weakly 2-lipped, sometimes cleistogamous; tube linear, cylindric, widened into a short throat; lower lip 3-lobed, lobes often bifid. Stamens 2 (rarely 4 or 2 plus 2 staminodes), included in the throat; filaments short; anthers 2-thecous, thecae at same height, oblong or broadly elliptic, without basal appendages, connective produced apically. Ovary 2-locular, with 6-10 ovules per locule; stigma oblong-spathulate or rounded, entire or 2-lobed. Capsule 10-20-seeded, ellipsoid, sessile, rostrate (sterile apical appendage) with recurved apical part when ripe, retinaculae absent. Seed minute, ovoid-ellipsoid, often with ± truncate ends, rugose and pitted.

A pantropical genus of approximately 25 species. Mostly in America, but with 5-10 species in Africa, Madagascar and SE Asia (Vietnam), e.g., *Elytraria marginata* Vahl, *E. acaulis* (L.f.) Lindau, *E. minor* Dokosi.

Gynocraterium Bremekamp, Bull. Misc. Inform. Kew 1939(10): 557. 1940 [Type: *Gynocraterium guianense* Bremek., Locality: Guiana]; Scotland & Vollesen, Kew Bull. 55(3): 584. 2000.

Herb without cystoliths. Leaves opposite. Flowers one per bract, in terminal dense spikes; bracts and bracteoles linear. Calyx deeply divided into 5 unequal sepals, two lateral and two ventral small, 1-veined, and one dorsal herbaceous, 3-veined. Corolla 2-lipped, tube widened almost from base; upper lip 2-lobed; lower lip 3-lobed. Stamens 4, didynamous, included in corolla-tube; anther 2-thecous, thecae elliptic, with a filiform appendage at base, divergent, inserted at same height. Ovary partly 2-locular, with 6 ovules per locule; style linear; stigma rounded. Capsule not seen.

One species in Guiana, i.e., *Gynocraterium guianense* Bremek.

Saintpauliopsis Staner, Bull. Jard. Bot. Etat Bruxelles 13: 8. 1934 [Type: *Saintpauliopsis lebrunii* Staner, Locality: central tropical Africa]; Burtt, Notes Roy. Bot. Gard. Edinburgh 22(4): 313. 1958; Champluvier, Bull. Jard. Bot. Nat. Belgique 61(1/2): 154. 1991; Scotland & Vollesen, Kew Bull. 55(3): 588. 2000; Vollesen, Fl. Trop. East Africa 19. 2008.

Perennial herb without cystoliths. Leaves opposite. Flowers one per bract, alternate, in open terminal racemes, pedicellate; bracts glumaceous, fused to the pedicel, persistent; bracteoles glumaceous, similar to the larger sepals, inserted on and fused to the base of calyx, covering the two lateral sepals. Calyx deeply divided into 5 unequal sepals, two lateral, small and hyaline, one dorsal and two ventral, larger, glumaceous. Corolla 2-lipped, campanulate; tube widened almost from base; upper lip 2-lobed, hooded; lower lip 3-lobed, with flat lateral lobes and spoon-shaped median lobe without rugula. Stamens 4, didynamous, included in corolla-tube; anther 2-thecous, thecae elliptic, with a filiform appendage at base, divergent, inserted at same height on a broad connective; staminode absent. Ovary partly 2-locular, with numerous ovules; style linear; stigma 2-lobed, upper lobe small, lower larger, truncate. Capsule sessile, oblong-triangular, obtuse, apical part sterile and recurved at maturity, ± included in calyx, glabrous; retinaculae papilliform, unindurated. Seed papillose.

One species in Central Africa, i.e., *Saintpauliopsis lebrunii* Staner

Taxonomic Treatment of Studied Group in Thailand

KEY TO THE GENERA

1. Explosive capsule with retinacula — ***Pseuderanthemum***
1. Non-explosive capsule without retinacula
    2. Spike inflorescences, Calyx 4-partite — ***Nelsonia***
    2. Raceme inflorescences, Calyx 5-partite
        3. Fertile stamens 2, exserted, staminodes 2 — ***Ophiorrhiziphyllon***
        3. Fertile stamens 4, inserted, staminode 0-1 — ***Staurogyne***

Acanthoideae

Pseuderanthemum Radlk.

Pseuderanthemum Radlkofer, Sitzungsber. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. München 13: 282. 1883. nom. inval. nom. nud. (not designated) n.v.; Ridley, Fl. Malay Penin. 2: 588. 1923; Benoist in Lecomte, Fl. Indo-Chine. 4: 716. 1935; Milne-Redhead, Kew Bull. 1936: 255. 1936; Scotland & Vollesen, Kew Bull. 55(3): 587. 2000; Deng, Gao, & Xia, Fl. Hong Kong 3: 177. 2009; Darbyshire, Vollesen, & Kelbessa, Fl. Trop. East Africa 478. 2010; Hu, Deng, & Daniel in Wu et al., Fl. China 19: 439. 2011.

Pseuderanthemum Radlkofer ex Lindau, Lindau in Engler & Prantl, Nat. Pflanzenfam. 4: 330. 1895; Leonard, Contr. US Natl. Herb. 31: 729. 1958. [Type: *Pseuderanthemum bicolor* (Schrank) Radlkf., lectotype chosen by Leonard].

[Generic name remained invalid in 1884 and was validated in 1895]

Eranthemum T. Anderson, J. Linn. Soc. Bot. 9: 425. 1867 nom. illeg., non Linn. (1753).

Antheliacanthus Ridley, J. Fed. Malay States Mus. 10: 109. 1920. [Type: *Antheliacanthus micranthus* Ridl., Locality: Thailand-Koh Gah]; Scotland & Vollesen, Kew Bull. 55(3): 582, 587. 2000.

Buceragenia Greenman, Proc. Amer. Acad. Arts 32: 303. 1897. [Type: *Buceragenia minutiflora* Greenm., Locality: Cuernavaca]; Scotland & Vollesen, Kew Bull. 55(3): 583. 2000.

Chrestienia Montrouz., Beauvis. Gen. Montrouz. 88. 1901. [Type: *Chrestienia* Montrouz., Locality:] (Montrouz, 1901) n.v.; Scotland & Vollesen, Kew Bull. 55(3): 583, 587. 2000.

Pigafetta Adanson, Fam. Pl. 2: 223. 1763 [Type: -] nom. rej., non Blume (1877); Darbyshire, Vollesen, & Kelbessa, Fl. Trop. East Africa 478. 2010.

Herbs or shrubs. Leaves simple, opposite, beset with cystoliths, glabrous to rather densely pubescent, petiolate. Leaf blade margin entire or obtusely toothed. Leaf venation opposite or alternate. Cymes terminal or axillary. Bracts and bracteoles often small, linear. Flowers opposite, zygomorphic to nearly actinomorphic, sessile or with short pedicel. Calyx synsepalous, deeply 5-divided; segments linear, equal. Corolla sympetalous, tube slender, terete, slightly dilated at throat; limb spreading, 5-lobed; lobes imbricate, abaxial one slightly larger, color white or purple or pink. Stamens 2, inserted at throat, included or exserted; filaments very short; anthers 2-celled, cells equal, parallel and at equal level, and without appendages at base, longitudinally dehiscent. Staminodes 2 or absent. Ovary with 2 ovules per cell. Stigma 2-lobed. Capsule clavate, with 2 seeds per locule, basally contracted into a stalk, constricted between the seeds, retinacula well-developed. Seeds 1-4, ovoid, flat, surface corrugate.

Sixteen species (18 taxa) were found throughout the country. Five species are introduced as cultivated ornamental and medicinal plants. Eleven species are native to Thailand:

KEY TO THE SPECIES

1. Leaves linear to narrowly oblong, wider less than 0.5 cm wide **1. *P. axillare***
1. Leaves other shapes, wider than 0.5 cm
    2. Thick and very brittle leaves present
        3. Inflorescence > 15 cm long with distant flowers, corolla tube > 2 cm long, leaves usually symmetric
            4. Leaves not reddish purple underneath, normally paler green along veins on upper surface, leaves ovate **7. *P. latifolium***
            4. Leaves normally reddish purple underneath, never paler green along veins on upper surface, leaves lanceolate **16. *P.* sp2**
        3., Inflorescences < 15 cm long with dense flowers, corolla tube ≤ 1.5 cm long, leaves often asymmetric
            5. Corolla and style white, stem pale brown

6. Plant with yellowish or whitish green leaves **13. *P. reticulatum***

6. Plant not yellowish or whitish green leaves **10. *P. metallicum***

5. Corolla and style reddish purple, stem dark purple **3. *P. carruthersii***

2. Thick and very brittle leaves absent

7. Flowers dark purple-dotted on lobes

8. Corolla white, dark purple-dotted on 5 lobes **2. *P. bracteatum***

8. Corolla purple, dark purple-dotted on lower lobes or 5 lobes

9. Dark purple-dotted only on 1-3 lower lobes, leaves glabrous

10. purple-dotted only middle lower lobes, usually in three lines at base, red veins underneath leaves present, inflorescences ≤ 10 cm long, unbranched **14. *P. siamense***

10. purple-dotted on one to three lower lobes, but not in lines on middle one, red veins underneath leaves absent, inflorescences > 10 cm long, branched **9. *P. longistylum***

9. Dark purple-dotted on all of 5 lobes, leaves pubescent **15. *P.* sp1**

7. Flowers not as above

11. Stamens exserted, flowers zygomorphic

12. Corolla white, leaves brown puberulous **11. *P.* "*palatiferum*"**

12. Corolla purple, leaves glabrous

13. Margin of corolla lobes wavy

14. Flowers normally whorled, secondary veins purple **5. *P. glomeratum***

14. Flowers not whorled, secondary veins not purple **12. *P. parishii***

13. Margin of corolla lobes not wavy

15. Corolla tube funnel, never tongue-like area at base of middle lower lobe **8. *P. laxiflorum***

15. Corolla tube salverform, usually tongue-like area at base of middle lower lobe **6. *P. graciliflorum***

11. Stamens inserted, flower nearly actinomorphic **4. *P. crenulatum***

1. *Pseuderanthemum axillare* J. B. Imlay, Bull. Misc. Inform. Kew 1939(3): 132. 1939, [Type: Thailand, Nakhon Ratchasima, Sikhio, in bamboo scrub, alt. 200 m, 21 January 1931; A.F.G. Kerr 19909 (BK, BM, K)]. Figures 5.1-5.2.

Perennial herbs, up to 50 cm tall, erect, branched, pubescent. **Leaves** opposite-decussate; petioles 0.1-0.2 cm long; blade linear to narrow oblong or linear to narrow lanceolate, 1.5-5 by 0.3-1.2 cm, apex acute or obtuse, base cuneate or obtuse, puberulous. secondary veins 5-7 pairs, opposite or alternate. **Inflorescence** 1-3 flowered, axillary cyme, subsessile; bracts 2, oblong to elliptic, ca. 3 by 0.2 cm; pedicels ca. 0.5 cm long; bracteoles small, linear, ca. 0.3 by 0.05 cm, attenuate. **Flowers** up to 3 by 2 cm, zygomorphic, salverform. **Calyx** lobes 5, 0.5-0.6 cm long, with glandular hairs. **Corolla** lobes 5 (2 adaxial, 3 abaxial), pale purple with paler lines, elliptic, 0.8-1 by 0.4-0.5 cm, apex obtuse. **Stamens** included, anthers oblong, 0.15 cm long, filaments 1 cm long; staminodes 2, ca. 0.1 cm long. **Ovary** cylindrical, pubescent; style 1.4 cm long, glabrous. **Fruits** capsule brown, ca. 2 by 0.5 cm. **Seeds** 4, brown, orbicular, ca. 0.5 cm in diameter.

Thailand.--- EASTERN: **Nakhon Ratchasima**, Sikhio, 21 Jan. 1931, A.F.G. Kerr 19909 (type! **BK**, **BM**, **K**), 23 Dec. 1923, A.F.G. Kerr 8095 (paratype! **BK**, **BM**, **K**); **Ubon Ratchathani**, Pha Taem NP, 22 Dec. 2010, T. Choopan 2010-086 (**BKF, SUT**), 24 Aug. 2011, T. Choopan 2011-326 (**SUT**).

Distribution.--- Endemic to Thailand.

Ecology.--- In shaded mixed deciduous forest with bamboo, dry dipterocarp forest, sandy soil, at 100-500 m altitude. Flowering: December-January.

Vernacular.--- Khem Bai Kaep (เข็มใบแคบ), Khem Pha Taem (เข็มผาแต้ม) (Researcher).

Notes.--- This species is distincted from other taxa within the same genus by linear to narrow elliptic or linear to narrow lanceolate leaves (long slender), flower axillary, subsessile, and corolla lobes apex crenulate (small round teeth).

Figure 5.1 *Pseuderanthemum axillare* J. B. Imlay.

A: habit, B: ventral leaf, C: flower, D: fruit.

A

B

Figure 5.2 *Pseuderanthemum axillare* J. B. Imlay.

A: habit, B: inflorescence with opened flowers.

2. *Pseuderanthemum bracteatum* J. B. Imlay, Bull. Misc. Inform. Kew 1939(3): 133. 1939, [Type: Thailand, Nakhon Sawan, Takhli, alt. 200 m, 26 November 1928; Put 2113 (BK, BM, K)]; Hô, Câyco Viêtnam. 3(1): 76. 1993. Figures 5.3-5.4.

Perennial herbs or subshrubs, up to 50 cm tall, erect, rarely branched, pubescent**.** **Leaves** opposite-decussate; petioles 0.4-0.5 cm long; blade elliptic or ovate, 3-11 by 2-6 cm, apex acute or acuminate, base acute or attenuate, puberulous, secondary veins 4-6 pairs, opposite or alternate. **Inflorescence** terminal cyme, up to 20 cm long; bracts 2, elliptic or leaf-like, 2-3 by 0.5-1.3 cm; pedicels ca. 0.5 cm; bracteoles 2, small, linear, 0.15-0.4 by 0.05 cm. **Flowers** up to 3.5 by 2.5 cm, zygomorphic, salverform. **Calyx** lobes 5, 0.7-0.8 cm long, puberulous. **Corolla** lobes 5 (2 adaxial distinctly separate, 3 abaxial), white with purple dots, elliptic, 1-1.2 by 0.4-0.5 cm, apex obtuse, puberulous. **Stamens** included, anthers oblong, 0.2 cm long, filaments 1 cm long; staminodes 2, ca. 0.1 cm long. **Ovary** cylindrical, pubescent; style 1.5 cm long, glabrous. **Fruits** capsule brown, ca. 2.2 by 0.5 cm, puberulous. **Seeds** 4, pale brown, orbicular, ca. 0.5 cm in diameter.

Thailand.--- NORTHERN: **Nakhon Sawan**, Takhli, 26 Nov. 1928, Put 2113 (type! **BK**, **BM**, **K**); **Sukhothai**, Mueang Kao, 9 Mar. 1972, J.F. Maxwell 72-80 (**AAU**, **BK**, **L**,);--- NORTH-EASTERN: **Kalasin**, Phu Sithan WS, 22 Dec. 2010, T. Choopan 2010-094 (**SUT**); **Khon Kaen**, Pha Nok Khao, 22 Feb. 1958, P. Suvarnakoses 1355 (**BKF**, **K**); **Sakon Nakhon**, Phu Phan, 25 Feb. 1993, P. Chantaranothai, D.J. Middleton, J. Parnell & D. Simpson 932 (**K**), 15 Feb 2000, P. Chaikong 19/43 (**KKU**), 23 Dec. 2010, T. Choopan 2010-095 (**SUT**);--- EASTERN:

Chaiyaphum, Chaung Sam Maw, 31 Jan. 1931, A.F.G. Kerr 19976 (paratype! **BK**, **BM**, **K**); **Si Sa Ket**, Phumisarol, 15 Mar. 1967, S. Phusomsaeng s.n. BKF no. 036516 (**BKF**, **L**), Khao Phra Vihan NP, 21 Dec. 2005, R. Pooma, K. Phattarahirankanok, S. Sirimongkol & M. Poopath 6022 (**BKF**), 25 Nov. 2005, S. Suddee, H.A. Perdersen, S. Watthana, S. Suwanachat & C. Hemrat 2621 (**BKF**); **Ubon Ratchathani**, Yod Dom WS., 20 Dec. 2010, T. Choopan 2010-078 (**SUT**), Phu Chong-Na Yoy NP, 21 Dec. 2010, T. Choopan 2010-083 (**SUT**);--- CENTRAL: **Lop Buri**, Lam Narai, 5 Apr. 1975, T. Smitinand 12040 (**BKF**); **Saraburi**, Muak Lek, 15 Dec. 1990, K. Larsen, S.S. Larsen, W. Nanakorn, W. Ueachirakan & P. Sirirugsa 41997 (**AAU**);--- SOUTH-EASTERN: **Prachin Buri**, Thaplan NP, 22 Feb. 2009, T. Choopan 2009-003 (**SUT**).

Distribution.--- Thailand, Laos, Vietnam.

Ecology.--- In shaded mixed deciduous forest with bamboo, dry dipterocarp forest, dry evergreen forest, sandy soil, at 150-400 m altitude. Flowering: January-February.

Vernacular.--- Khem Bai Pradap (เข็มใบประดับ) (Researcher).

Notes.--- This species was distinguished from other taxa within the same genus by the leaf-like bracts are very conspicuous with long dentate calyx, and two adaxial corolla lobes are distinctly separated.

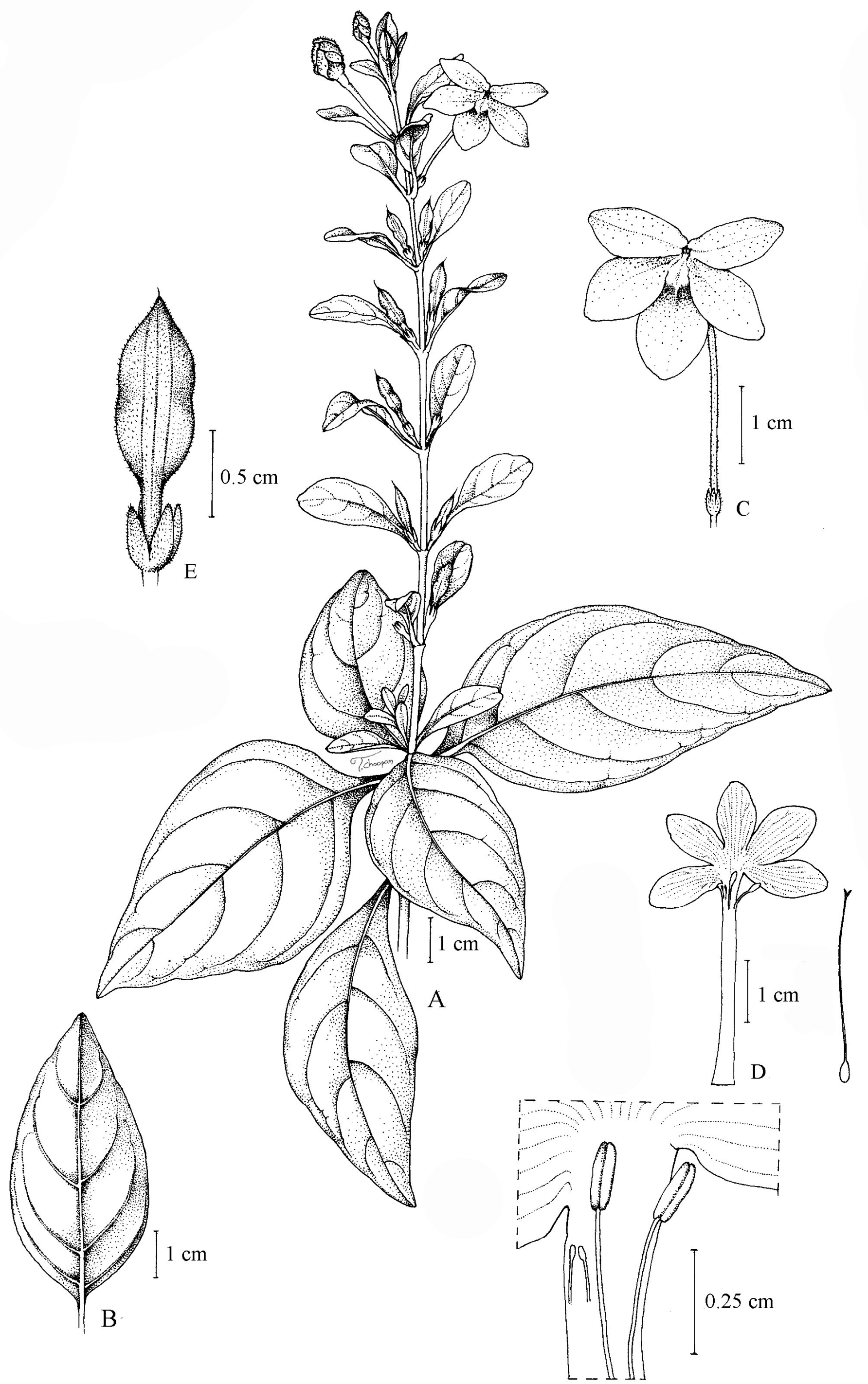


Figure 5.3 *Pseuderanthemum bracteatum* J. B. Imlay.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.4 *Pseuderanthemum bracteatum* J. B. Imlay.

A: habit, B: inflorescence with opened flower.

3. *Pseuderanthemum carruthersii* (Seem.) Guill., Ann. Mus. Colon. Marseille 5-6: 48. 1948. [Type: see *Eranthemum carruthersii*]; Deng, Gao, & Xia, Fl. Hong Kong 3: 178. 2009. Figures 5.5-5.8.

___*Eranthemum carruthersii* Seem., Fl. Vitiensis 185. 1866. [Type: Australia, Aneitum and Eromanga; McGillivray s.n. (BM, P)].

___*Pseuderantnemum carruthersii* (Seem.) Guill. var. *atropurpureum* (W. Bull) Fosberg, n. comb., Phytologia 5: 290. 1955; Hô, Câyco Viêtnam. 3(1): 75. 1993.

___*Pseuderanthemum carruthersii* var. *atropurpureum* (W. Bull) Fosberg, Smithsonian Contr. Bot. 45: 26. 1980.

Eranthemum atropurpureum W. Bull, Gard. Chron., ser. 3: 619. 1875.

___*Pseuderanthemum atropurpureum* (W. Bull) Radlk., Sitzungsber. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. München 13(1): 286. 1883.

___*Pseuderanthemum atropurpureum* (W. Bull) L. H. Bailey, Gent. Herb. 1: 130. 1923.

Shrubs, up to 200 cm tall, erect, branched, reddish purple with longitudinal lines. **Leaves** opposite-decussate; petioles purple, 1-2 cm long; blade reddish purple or pinkish red, elliptic or ovate, asymmetric (in elliptic-leaf plants) or symmetric (in ovate-leaf plants), leathery-crispy, 6-15 by 3.5-8.5 cm, apex acute, base cuneate or acute, glabrous; margin smooth or widely curved, secondary veins 5-7 pairs, opposite or alternate. **Inflorescence** terminal or rarely axillary cymes, bracts 2, lanceolate, 1.5-2 by 0.5-1 cm; pedicels ca. 0.6 cm long; bracteoles 2 in 2 lateral flowers (no bracteole in the middle one), reddish purple, lanceolate, 0.3 cm long, with glandular hairs.

Flowers up to 1.5 by 2 cm, zygomorphic, cylindrical with enlarged throat. **Calyx** lobes 5, reddish purple, lanceolate, 0.4-0.5 cm long, with glandular hairs on both surfaces. **Corolla** lobes 5 (2 adaxial connate at middle and basal portion, 3 abaxial free), pink with reddish purple dots, elliptic to oblong, 1 by 0.4-0.5 cm, apex obtuse. **Stamens** reddish purple, slightly exserted, anthers elliptic, 0.15 cm long, filaments 1.4-1.5 cm long; staminodes 2, 0.3 cm long. **Ovary** cylindrical, reddish purple, glabrous; style 1-1.2 cm long, glabrous. **Fruits** not developed.

Thailand.--- (1) Asymmetric elliptic-leaf plants;--- NORTH-EASTERN: **Maha Sarakham**, Chiang Yuen, 19 Apr. 2009, T. Choopan 2011-322 (**BKF**, **SUT**);--- CENTRAL: **Bangkok**, Jun. 1954, T. Smitinand 2808 (**BKF**), Klong San-Thonburi, 7 Nov. 1970, J.F. Maxwell (**L**)

(2) Symmetric-ovate leaf plants;--- EASTERN: **Nakhon Ratchasima**, Mueang, Jan. 2010, T. Choopan 2011-323 (**BKF**, **SUT**);--- CENTRAL: **Bangkok**, 7 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 40 (**C**), 3 Dec. 1969, J.F. Maxwell s.n. (**BK**, **L**).

Distribution.--- India, Pakistan, Malaysia, Thailand, Vietnam, Indonesia (Sumatra), Philippines, Australia, New Caledonia, Phoenix Islands, Marshall Islands, Caroline Islands, Santiago Island.

Ecology.--- Cultivated as ornamental plants, at 150-500 m altitude. Flowering: April-June.

Uses.--- Introduced and cultivated as ornamentals.

Vernacular.--- Bai ngoen (ใบเงิน) Bai thong (ใบทอง) Bai nak (ใบนาก) (General).

Notes.--- Two distinct cultivated taxa were found in Thailand, i.e., (1) Asymmetric elliptic-leaf plants and (2) Symmetric ovate-leaf plants.

Chromosome count.--- n = 21 (Daniel and Chuang, 1993).

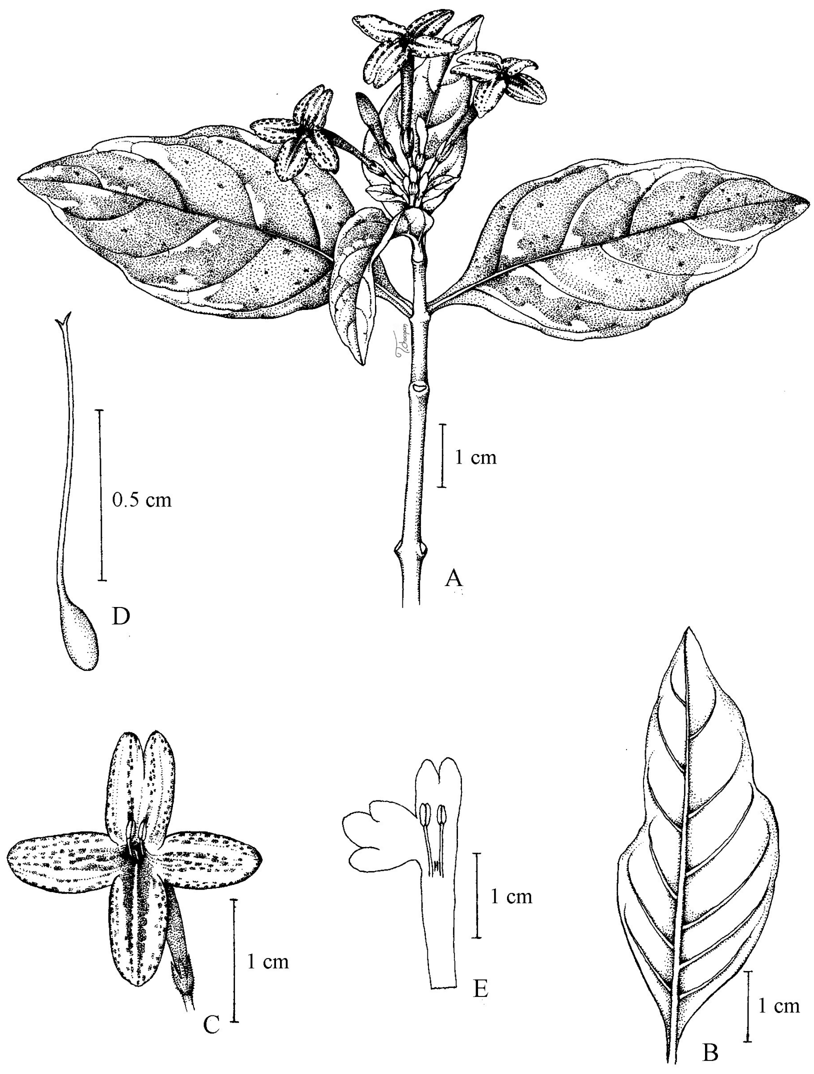


Figure 5.5 *Pseuderanthemum carruthersii* (Seem.) Guill. (asymmetric leaf plants).

A: habit, B: ventral leaf, C: flower, D: pistil, E: stamens.

A

B

Figure 5.6 *Pseuderanthemum carruthersii* (Seem.) Guill. (asymmetric leaf plants)

A: habit, B: inflorescence with opened flower.

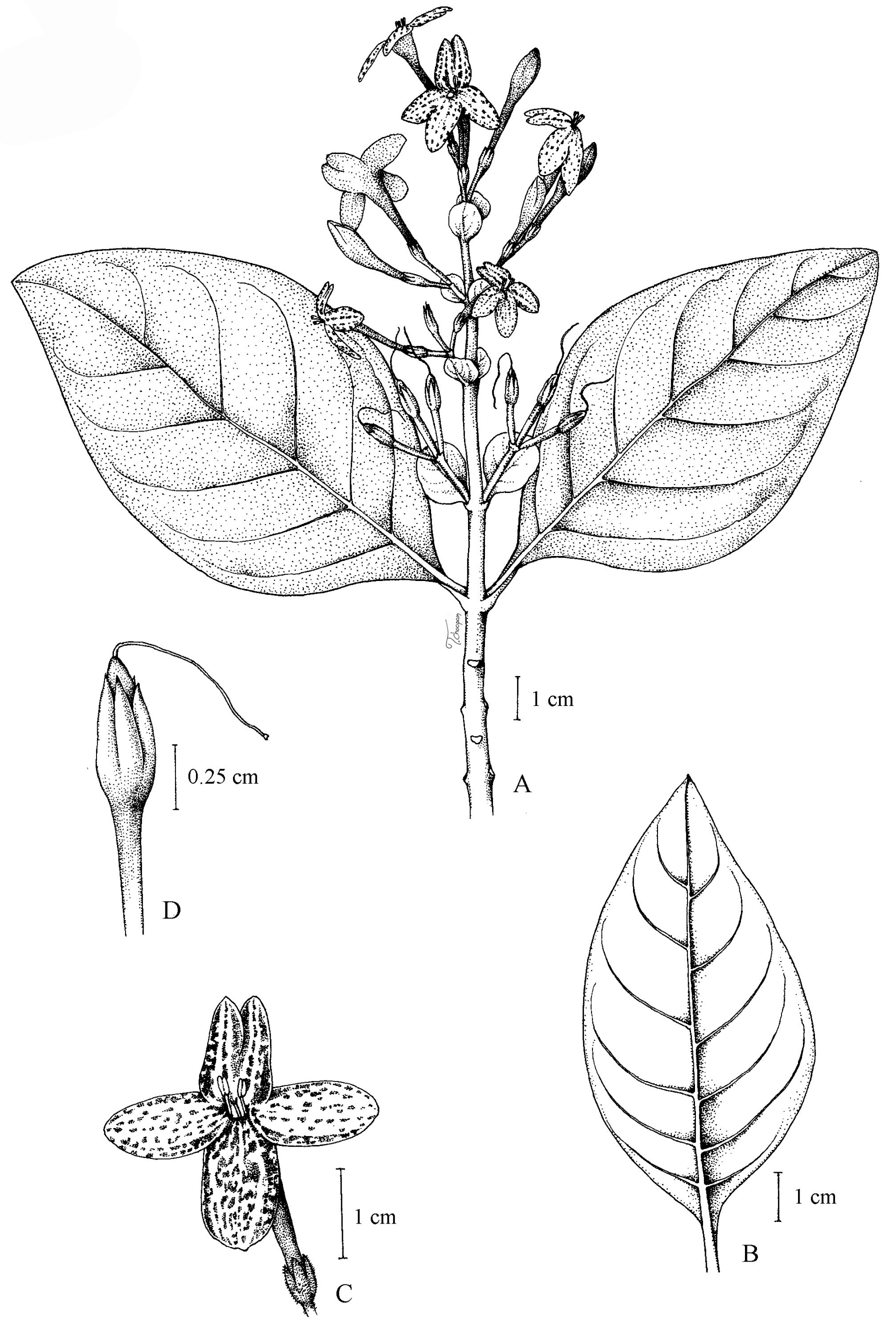


Figure 5.7 *Pseuderanthemum carruthersii* (Seem.) Guill. (symmetric leaf plants)

A: habit, B: ventral leaf, C: flower, and D: undeveloped fruit.

A

B

Figure 5.8 *Pseuderanthemum carruthersii* (Seem.) Guill. (symmetric leaf plants)

A: habit, B: inflorescence with opened flowers.

4. *Pseuderanthemum crenulatum* (Wall. ex Lindl.) Radlk., Sitzungsber. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. München 13: 282. 1883, [Type: see *Eranthemum crenulatum*]; Ridley, Fl. Malay Penin. 2: 589. 1923; Benoist in Lecomte, Fl. Indo-Chine 4: 720. 1935; Maxwell, Fl. Ko Hong Hill 240. 2006; Hu, Deng, & Daniel in Wu et al., Fl. China 19: 439. 2011. Figures 5.9-5.10.

___*Eranthemum crenulatum* Wall. ex Lindl., in Edwards et al., Bot. Reg. 11: 879. 1825. [Type: tab. 879, Griffith s.n. Kew Distrib. no 6175 (K, P), Cuming 2357 (paratype! K, P)]; Clarke in Hooker, Fl. Brit. India 4: 497. 1885. Not of *Eranthemum crenulatum* Nees

___*Eranthemum crenulatum* Wall. ex Nees, in Wallich, Pl. Asiat. Rar. 3: 107. 1832, [Type: Malabar, Concan, Wallich cat. no. 2491 (BM, GZU)]; Nees in Candolle, Prodr. 11: 453. 1847; Anderson, J. Linn. Soc. Bot. 9: 523. 1867; Clarke in Rosenvinge, Bot. Tidsskr. 24: 349. 1902b.

Pseuderanthemum crenulatum (Wall. ex Lindl.) Radlk. var. *ecorticatum* Imlay, Bull. Misc. Inform. Kew 1939(3): 135. 1939. [Type: **Chumphon**, Ta Ngaw, 17 January 1927, A.F.G. Kerr 11491 (BK, holotype! BM); Tasan, 22 December 1928, A.F.G. Kerr 16271 (BK, paratype! BM); **Phangnga**, Thapput, 5 March 1930, A.F.G. Kerr 19355 (paratype! K).

Pseuderanthemum crenulatum (Wall. ex Lindl.) Radlk. var. *glabrum* Imlay, Bull. Misc. Inform. Kew 1939(3): 136. 1939. [Type: **Phangnga**, Nop Pring, A.F.G. Kerr 19367 (n.v.); **Nakhon Si Thammarat**, Thung Song, 18 February. 1929, Put 2366 (paratype! BK, BM, K).

Perennial herbs, up to 30 cm tall, erect, unbranched. **Leaves** opposite-decussate; petioles 0.4-0.6 cm long; blade elliptic or lanceolate, 4-12.5 by 2-4 cm, apex acute to attenuate, base cuneate or decurrent, glabrous, secondary veins 5-8 pairs, opposite or alternate. **Inflorescence** terminal cymes; bracts 2, linear, 0.2 by 0.05 cm; pedicels 0.1-0.25 cm long; bracteoles 2, linear, 0.1-0.2 cm long, with glandular hairs. **Flowers** up to 1.4 by 2 cm, zygomorphic, salverform. **Calyx** lobes 5, 0.3-0.4 cm long, puberulous. **Corolla** lobes 5, pink or pale purple, elliptic, 0.8-1 by 0.4-0.5 cm, apex obtuse, puberulous. **Stamens** included, anthers elliptic, 0.15 cm long, filaments 0.5 cm long; staminodes 2, ca. 0.1 cm long. **Ovary** cylindrical, glabrous; style 1.4 cm long. **Fruits** capsule brownish black, ca. 2 cm long, puberulous. **Seeds** 4, brown orbicular, ca. 0.4 cm in diameter.

Thailand.--- PENINSULAR: **Chumphon**, Ta Ngaw, 17 Jan. 1927, A.F.G. Kerr 11491 (**BK**, holotype! var. *ecorticatum* **BM**); Tasan, 22 Dec. 1928, A.F.G. Kerr 16271 (**BK**, paratype! var. *ecorticatum* **BM**), Khao Din, 30 Dec. 1973, S. Sutheesorn 2749 (**BK**); **Krabi**, Ao Luk, 8 Oct. 1970, C. Charoenphol, K. Larsen & E. Warncke 3450 (**AAU**, **BKF**, **L**), Pipi Island, 9 Apr. 1930, A.F.G. Kerr 18903 (**BK**, **BM**, **C**, **K**, **L**), Nai Chong, 19 Jan. 1966, B. Hansen & T. Smitinand 12013 (**C**, **L**), 20 Jan. 1966, B. Hansen & T. Smitinand 12026 (**C**, **E**), 11 Feb. 1966, B. Hansen & T. Smitinand 12227 (**BKF**, **L**), Than Bokhorani, 16 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyoma, T. Yahara & T. Santisuk 27399 (**AAU**, **BKF** 3 sheets, **C**, **K**, **L** 2 sheets), 27405 (**BKF** 2 sheets, **L**); **Nakhon Si Thammarat**, Thung Song, 18 Feb. 1929, Put 2366 (paratype! var. *glabrum* **BK**, **BM**, **K**), Khao Luang, 3 Feb. 1966, E. Hennipman 3822 (**BKF**, **C**, **K**), 5 Nov. 1951, T. Smitinand 1039 (**BKF**), 25 Jan. 1966, B. Hansen

& T. Smitinand 12057 (**BKF**, **C**), 5 Mar. 1983, H. Koyama, H. Terao & T. Wongprasert 34048 (**BKF**, **L**), 24 Jan. 1966, S. Suthisorn 870 (**BK**), 22 Nov. 1951, P. Suvarnakoses 152 (**BKF**), 23 May 2011, T. Choopan 2011-297 (**SUT**), Krung Ching waterfall-Tha Sala, 2 Mar. 1986, J.F. Maxwell 86-128 (**BKF**, **L**), 21 Feb. 1991, C. Niyomdham 2247 (**BKF** 2 sheets), Lansaka, 24 Nov. 1984, J.F. Maxwell 84-480 (**BKF**), Feb 1922, E. Smith 390 (**BK**); **Narathiwat**, Bacho, 22 Dec. 1968, anonymous 32 (**BKF**), 16 Dec. 1968, B. Sangkhachand 1575 (**BK**), Hala-Bala WS, 20 Feb. 2002, C. Niyomdham & P. Puujaa 6632 (**BKF**); **Pattani**, Bannang Sta, 25 Jul. 1923, A.F.G. Kerr s.n. (**BM**), 28 Jul. 1923, A.F.G. Kerr 7399 (**BK**, **BM**, **K**); **Phangnga**, Thapput, 5 Mar. 1930, A.F.G. Kerr 18363 (**BM**, **L**) & 19355 (paratype! var. *ecorticatum* **K**), Suwan Kuha cave-Mueang, 15 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyoma, T. Yahara & C. Niyomdham 27354 (**BKF** 2 sheets, **C**, **L** 2 sheets) & 27376 (**BKF**, **L**), Ko Song-Similan NP, 25 Nov. 1992, C. Niyomdham & P. Puujaa 3308 (**BKF**), Ko Paed-Similan NP, 28 Nov. 1992, C. Niyomdham & P. Puujaa 3355 (**BKF**); **Phatthalung**, Mueang, 20 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyoma, T. Yahara & T. Santisuk 27759 (**BKF** 2 sheets, **L** 2 sheets), Khao Pu-Khao Ya, 19 May 2011, T. Choopan 2011-270 (**BKF**, **SUT**); **Phuket**, Nai Han beach, 14 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyoma, T. Yahara & C. Niyomdham 27292 (**BKF** 2 sheets, **L**), Nai Thon beach, 24 Dec. 1976, A.F.G. Kerr 34 (**AAU**); **Ranong**, Kaper, 7 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyoma, T. Yahara & C. Niyomdham 26352 (**BKF** 2 sheets, **L**) & 26379 (**BKF**, **L**), Khao Phota Luangkaeo, 11 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 27002 (**L**), 27024 (**BKF** 2 sheets, **L**), 27045 (**BKF**); **Satun**, Padang Besar, 23 Dec. 1927, A.F.G. Kerr 13563 (**BK**, **BM**, **K**), 10 Jan. 1928, A.F.G. Kerr 13967 (**BK**, **BM**), Mueang, 18 Dec.

1979, T. Shimizu, H. Toyokuni, H. Koyoma, T. Yahara & T. Santisuk 27581 (**BKF**), Kuan Kalong, 15 Oct. 1970, C. Charoenphol, K. Larsen & E. Warncke 3848 (**AAU**, **BKF**, **L**), Thale Ban, 4 Nov. 1990, K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa 41099 (**AAU**), 5 Nov. 1990, K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa 41134 (**AAU**), Ya Roy waterfall, 6 Nov. 1990, K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa 41175 (**AAU**, **C**); **Songkhla**, Ban Pin, 27 Mar. 1928, A.F.G. Kerr 14840 (**BK**, **BM**), Boriphat waterfall-Rattaphum, 21 Dec. 1978, Hamilton & Congdon 90 (**AAU**, **BKF**), 18 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyoma, T. Yahara & T. Santisuk 27592 (**BKF** 2 sheets, **C**, **L** 2 sheets), 21 Dec. 1965,Umpai 269 (**BK**), Ton Nga Chang WS, 21 May 2011, T. Choopan 2011-286 (**SUT**); **Surat Thani**, Sanyao, 22 Feb. 1930, A.F.G. Kerr 18192 (**BK**, **BM**), 23 Feb. 1930, A.F.G. Kerr 18215 (**BK**, **BM**, **C**, **K**, **L**), Khao Sok-Phanom, 12 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyoma, T. Yahara & C. Niyomdham 27071 (**BKF**, **L**) & 27078 (**BKF** 2 sheets, **L**), 2 Mar. 1983, H. Koyama, H. Terao & T. Wongprasert 33953 (**BKF**); **Trang**, Chawng, 24 Jan. 1958, T. SØrensen, K. Larsen & B. Hansen 566 (**BKF**, **C**, **E**), Khao Chong, 9 Oct. 1970, C. Charoenphol, K. Larsen & E. Warncke 3513 (**AAU**, **L**), 10 Oct. 1970, C. Charoenphol, K. Larsen & E. Warncke 3588 (**AAU**, **BKF**, **K**, **L**), 6 Feb. 1969, S. Phusomsaeng & S. Pinnin 68 (**AAU**, **BKF**, **L**), 9 Jan. 1968, B. Sangkhachand 1505 (**BKF**, **C**, **E**, **L**), 24 Feb. 1969, P. Sangkhachand 1693 (**BK**), 26 Nov. 1969, P. Sangkhachand 2194 (**BK**), 25 Jan. 1966, K. Iwatsuki & N. Fukuoka 5499 (**BKF**, **L**), 1 Feb. 1985, P. Sirirugsa 948 (**C** 2 sheets, **L**), 9 Jul. 2000, D.J. Middleton, T. Boonthavikoon, S.J. Davies, C. Hemrat & M.F. Newman 366 (**BKF**), Yan Ta Khao, 20 May 2011, T. Choopan 2011-278

(**SUT**), Khao Thong Lang, 19 Jan. 1966, B. Hansen & T. Smitinand 12013 (**BKF**), 20 Jan 1966, 12026 (**BKF**, **K**), Kradan Island, 11 Feb. 1966, B. Hansen & T. Smitinand 12227 (**C**, **E**, **K**, **L**), Mueang, 17 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyoma, T. Yahara & T. Santisuk 27489 (**BKF**), 1 Feb 1985, J.F. Maxwell 85-136 (**BKF**).

Distribution.--- China, India, Myanmar, Malaysia, Thailand, Laos, Vietnam, Indonesia (Java, Borneo).

Ecology.--- In shaded moist evergreen forest, at 80-350 m altitude. Flowering: December-April.

Vernacular.--- Niao ma (เหนียวหมา) Lai phueak (ไหลเผือก) (Peninsula).

Notes.--- The flowers distinct from other taxa within the same genus by corolla lobes without dark purple dots as in *P*. *parishii*, but their anthers are inserted and the corolla lobes are not wave.

There were 2 herbarium sheets of type specimens no. 6175 (described as *P*. *graciliflorum*), one of which is *P*. *crenulatum* and another is *P*. *graciliflorum*.

There were 2 varieties in Thailand, i.e., *P*. *crenulatum* var. *ecorticatum* and *P*. *crenulatum* var. *glabrum*. In this study, the researcher still kept both of them in *P*. *crenulatum*. The characters of 2 varieties are insufficiently different to be considered as varieties.

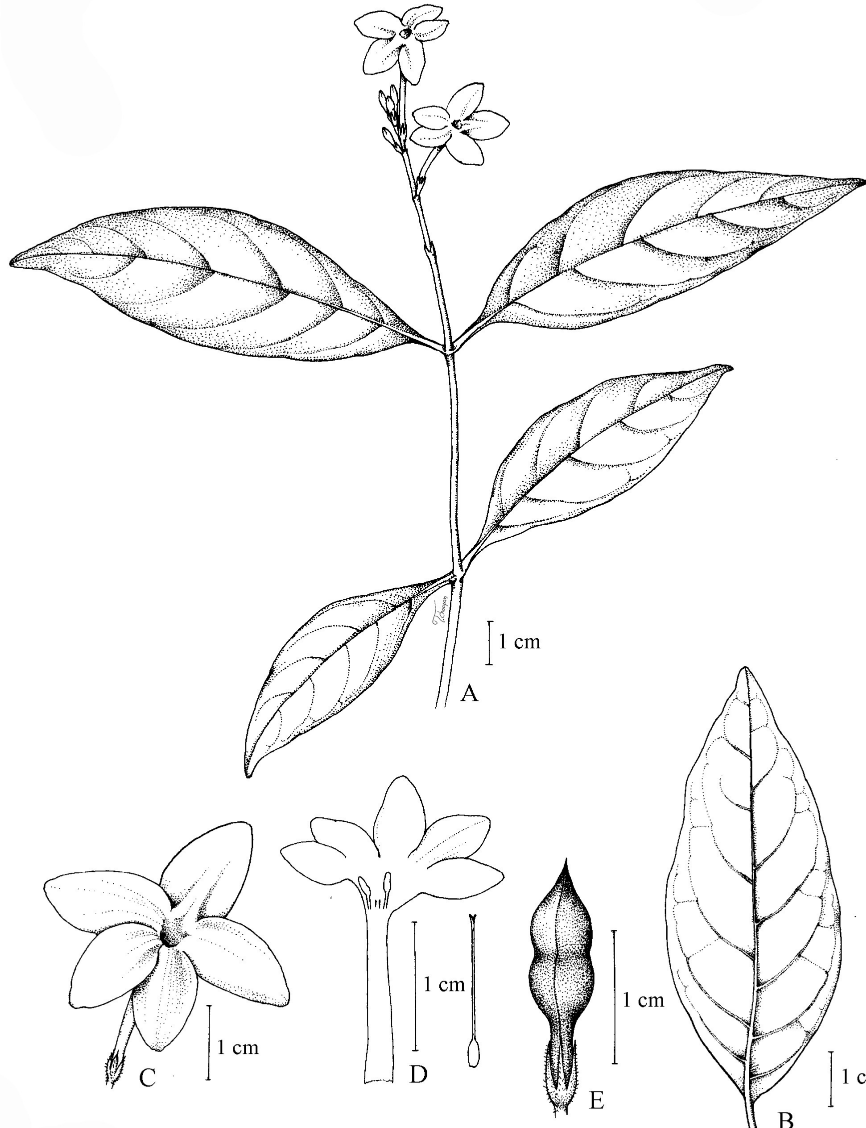


Figure 5.9 *Pseuderanthemum crenulatum* (Wall. ex Lindl.) Radlk.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.10 *Pseuderanthemum crenulatum* (Wall. ex Lindl.) Radlk.

A: habit, B: inflorescence with opened flowers.

5. *Pseuderanthemum glomeratum* J. B. Imlay, Bull. Misc. Inform. Kew 1939(3): 133. 1939, [Type: Thailand, Nan, Doi Wao, 23 February 1912; A.F.G. Kerr 2438 (BM, K)]. Figures 5.11-5.12.

Perennial herbs, up to 30 cm tall, erect, unbranched, pubescent. **Leaves** opposite-decussate; petioles purplish-green, 1.5-3 cm long, long puberulous; blade elliptic or lanceolate, 10-16 by 4-6.5 cm, apex obtuse with shortly acuminate, base acute or attenuate, glabrous, secondary veins 7-9 pairs, opposite or alternate, purplish red. **Inflorescence** terminal clustered cymes, branched, with glandular hairs; bracts 2, linear, 0.3 by 0.1 cm, with glandular hairs; pedicels ca. 0.3 cm long, with glandular hairs; bracteoles small, linear, 0.25 by 0.05 cm. **Flowers** up to 5 by 2.5 cm, zygomorphic, salverform. **Calyx** lobes 5, ca. 0.6 cm long, with glandular hairs. **Corolla** lobes 5 (2 adaxial, 3 abaxial), purple, elliptic, 0.8-1 by 0.4-0.5 cm, apex obtuse, margin curved. **Stamens** subexserted, anthers elliptic, 0.3 cm long, filaments 0.9-1.1 cm long; staminodes 2, ca. 0.1 cm long. **Ovary** cylindrical, glabrous; style 4 cm long, glabrous. **Fruits** capsule brown, up to ca. 2.5 by 0.5 cm, with glandular hairs. **Seeds** 4, brown, orbicular, 0.3-0.4 cm in diameter.

Thailand.--- NORTHERN: **Nan**, Doi Wao, 23 Feb. 1912, A.F.G. Kerr 2438 (type! **BM**, **K**,).

Distribution.--- Endemic to Thailand.

Ecology.--- In shaded hill evergreen forest, at 700-1000 m altitude.

Vernacular.--- Khem Doi Wao (เข็มดอยวาว) (Researcher).

Notes.--- *P. glomeratum* is distinguished from *P. parishii* by flowers always occuring in cluster or whorl, longer peduncle, secondary veins on one side 7-9 in purplish red color, corolla lobes short, and staminode 0.2-0.5 cm long.

Figure 5.11 *Pseuderanthemum glomeratum* J. B. Imlay.

A: habit, B: flower, C: fruit.

A

B

Figure 5.12 *Pseuderanthemum glomeratum* J. B. Imlay.

A: herbarium sheet (type!), B: dried flowers.

6. *Pseuderanthemum graciliflorum* (Nees) Ridl., Fl. Malay Penin. 2: 591. 1923, [Type: see *Eranthemum graciliflorum* Nees]; Suvatti, Fl. Thailand 2: 1117. 1978; Hansen, Nordic J. Bot. 9(2): 213. 1989; Maxwell, Fl. Ko Hong Hill 240. 2006. Figures 5.13-5.14.

___*Eranthemum graciliflorum* Nees, in Wallich, Pl. Asiat. Rar. 3: 107. 1832, [Type: Penang; Wall. cat. 2427 (K)].

Eranthemum acuminatissimum Miq., Fl. Ind. Bat. 2: 835. 1856, [Type: Java, Jawa Tengah, Ungarang, Ungaram; F. W. Junghuhn s.n. (K, U)].

___*Pseuderanthemum acuminatissimum* (Miq.) Radlk., nom. inval., Sitzungsber. Math. – Phys. Cl. Königl. Bayer. Akad. Wiss. München 13: 1883.

___*Pseuderanthemum acuminatissimum* (Miq.) Benoist, n. comb. in Lecomte, Fl. Indo-Chine 4: 721. 1935.

Eranthemum andersonii Mast., Gard. Chron. 1869 (6): 134. 1869. [Type: Singapore, T.Anderson]; Curtis, Bot. Mag. 95: t.5771. 1869; Clarke in Hooker, Fl. Brit. India 4: 499. 1885.

___*Pseuderanthemum andersonii* (Mast.) Lindau, Lindau in Engler & Prantl, Nat. Pflanzenfam. 4(3b): 330. 1895.

Eranthemum malaccense C. B. Clarke, in Hooker, Fl. Brit. India 4: 498. 1885, [Type: Malacca, Griffith s.n. Kew Distrib. no 6175 (K), Cuming, 2389 (K)]; Clarke in Rosenvinge, Bot. Tidsskr. 24: 349. 1902b; Clarke, J. Asiat. Soc. Bengal 74(3): 678.

1908; Ridley, J. Straits Branch Roy. Asiat. Soc. 59: 152. 1911; Ridley, Fl. Malay Penin. 2: 591. 1923.

___Synonym: *Pseuderanthemum malaccense* (C. B. Clarke) Lindau, Frag. Fl. Philippinae 40. 1904; Lindau in Engler & Prantl, Nat. Pflanzenfam. 4(3b): 330. 1895; Curtis, Bot. Mag. 137: t.8368. 1911.

Shrubs, up to 200 cm tall, erect, branched, pubescent. **Leaves** opposite-decussate; petioles 1-5 cm long; blade elliptic or ovate, 5-15 by 2-7 cm, apex acute or acuminate, base cuneate or acute or obtuse or decurrent, puberulous, secondary veins 4-9 pairs, opposite or alternate. **Inflorescence** terminal or axillary dense compound cymes; bract 1, lanceolate, 0.3-0.7 by 0.1 cm, puberulous; pedicels 0.1-0.3 cm long; bracteoles 3, small, narrow lanceolate, 0.2 cm long, puberulous. **Flowers** up to 4 by 2 cm, zygomorphic, salverform. **Calyx** lobes 5, linear-lanceolate, 0.4-0.5 cm long, puberulous. **Corolla** lobes 5 (2 adaxial, 3 abaxial), purple with reddish-purple dots at the middle abaxial lobe (tongue-like patch), elliptic, 0.7-1 by 0.4-0.6 cm. apex obtuse, with glandular hairs on tube. **Stamens** slightly exserted, anthers oblong, 0.1 cm long, filaments 0.4-0.5 cm long; staminodes 2, ca. 0.1 cm long. **Ovary** cylindrical, glabrous; style 3-4.5 cm long, nearly glabrous or puberulous. **Fruits** capsule brownish black, 2-2.5 by 0.5-0.8 cm. **Seeds** 4, brown orbicular, 0.3-0.4 cm in diameter.

Thailand.--- Ban Wo-Toh Moh, 18 Apr. 1931, M.C. Lakshnakara 698 (**BK**, **BM**, **K**,); NORTHERN: **Chiang Mai**, 29 Jan. 1921, A.F.G. Kerr 4718 (**BK** 2 sheets, **K**), Wat Chiang Dao, 24 Sep. 1971, G. Murata, K. Iwatsuki & C. Phengklai 14872 (**BKF**), Doi Chiang Dao, 31 Dec. 1955, P. Suvarnakoses 1055 (**BKF**, **K**), 14 Dec.

1962, K. Bunchuai 38176 (**K**), 6 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33147 (**BKF**, **C**, **K**), 17 Jan. 1973, S. Suthisorn 2277 (**BKF**), 18 Mar. 1950, H.B.G. Garrett 1285 (**K**, **L** 2 sheets), 4 Dec. 1951, H.B.G. Garrett 1362 (**L** 2 sheets), 14 Dec. 1962, K. Bunchuai 1252 (**BKF**, **L**), 14 Dec. 1978, Bjørnland & Schumacher 481 (**BKF**, **C**), 15 Jan. 1989, J.F. Maxwell 89-66 (**AAU**, **BKF**), 5 Nov. 1989, J.F. Maxwell 89-1362 (**L**), 5 Jun. 1973, R. Geesink, D. Phanichapol & T. Santisuk 5714 (**L** 2 sheets), 23 Mar. 2011, T. Choopan 2011-190 (**SUT**), Doi Langka, 18 Nov. 1933, H.B.G. Garrett 832 (**BKF**, **C**, **K** 2 sheets, **L** 2 sheets), Fang, 4 Apr. 1921, A.F.G. Kerr 5223 (**BM**, **K**), 27 Feb. 1958, T. Sørensen, K. Larsen & B. Hansen 1720 (**C**, **E**), 14 Jan. 1988, Y. Pasisooksantivatana, J. Sadakorn & P. Penchitra 2242-88 (**BK**), Khun Mae Tawn, 13 Sep. 1988, H.B.G. Garrett 1079 (**K**), Doi Suthep, 23 Mar. 1949, Soradech 424 (**BKF**), 23 Mar. 1965, C. Chermsirivathana & C. Hambanand 363 (**BK**, **BKF**), Mae Rim, 22 Oct. 1993, W. Nanakorn 048 (**QBG**), 18 Nov. 1993, W. Nanakorn 169 (**QBG**), 18 Jan. 2006, K. Singkaew s.n. QBG no. 25542 (**QBG**), 27 Oct. 1989, J.F. Maxwell 89-1303 (**E**, **L**), 9 Jan. 1990, J.F. Maxwell 90-44 (**E**, **L**), 23 Mar. 2010, T. Choopan 2010-012 (**BKF**, **SUT**), Doi Sa Ket, 26 Oct. 2007, W. Pongamornkul 2144 (**QBG**), Wang Tao, 13 Feb. 1958, T. Sørensen, K. Larsen & B. Hansen 1065 (**BKF**, **C**), Maesa, 9 Nov. 1992, M. Balik & W. Nanakorn 3428 (**AAU**), Mok Pha waterfall, 24 Nov. 1993, K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Ueachirakan 44795 (**AAU**), Chiangmai University, 15 Apr. 1992, J.F. Maxwell 92-151 (**E**), Sangamphaeng, 3 Dec. 1989, J.F. Maxwell 89-1500 (**E**, **L**), 19 Oct. 1995, P. Palee 328 (**BKF**), Mae Cham, 16 Jul. 1922, A.F.G. Kerr s.n. (**BM**), Mae Taeng, 29 Oct. 2004, J.F. Maxwell 04-646 (**BKF**), Doi Lon, 22 Nov. 2004, J.F. Maxwell 04-719 (**BKF**); **Chiang Rai**, Maesai, 14 Feb. 1983, H. Koyama, H. Terao &

T. Wongprasert 33511 (**C**) & 33513 (**BKF**, **L**), 15 Feb. 2005, J.F. Maxwell 05-115 (BKF), 28 Oct. 2005, J.F. Maxwell 05-612 (**BKF**), 21 Sep. 2010, M. van de Bult 1070 (**BKF**), Doi Tam Tu Pu, 2 Nov. 1924, H.B.G. Garrett 205 (**BKF**, **BM**, **C**, **K**, **L**), Mueang, 28 Nov. 1987, J.F. Maxwell 87-1518 (**BKF**), Doi Tung, 24 Sep. 1967, K. Iwatsuki, N. Fukuoka, M. Hutoh & D. Chaiglom 10971 (**BKF**, **C**), Chiang Kham, 7 Jan. 1968, Prayad 1183 (**BK**), Doi Luang, 25 Sep. 1997, O. Petrmitr 126 (**BKF**, **L**), 17 Feb. 1998, O. Petrmitr 282 (**BKF**, **L** 2 sheets), 29 Nov. 1991, J.F. Maxwell 91-1073 (**AAU**, **E**, **L**), 29 Oct. 1997, J.F. Maxwell 97-1281 (**BKF**, **L**), 14 Jan. 2011, T. Choopan 2011-155 (**SUT**), Huai Pa Han-Khun Mae Taun, 13 Sep. 1938, H.B.G. Garrett 1079 (**L** 2 sheets), Khun Chae NP, 4 Nov. 1997, J.F. Maxwell 97-1462 (**BKF**, **L**), Doi Mae Salong, 7 Nov. 1993, J.F. Maxwell 93-1365 (**L**), Huai Nam Rin village, 21 Dec. 1994, J.F. Maxwell 94-1287 (**BKF**, **L**); **Lampang**, Mae Long, 19 Nov. 1924, Winit 807 (**BK**, **BKF**), Lamping-Mae Saloi, 26 Oct. 1925, Winit 1484 (**BK**, **BKF**), Chae Son NP., 20 Oct. 1995, J.F. Maxwell 95-906 (**BKF**, **L**), 8 Jan. 1996, J.F. Maxwell 96-33 (**L**) & 96-35 (**BKF**), 19 Feb. 1996, J.F. Maxwell 96-283 (**BKF**, **L**), 15 Jan. 2011, T. Choopan 2011-167 (**SUT**), Doi Khun Tan NP, 3 Dec. 1994, J.F. Maxwell 94-1258 (**BKF**, **L**); **Nan**, Tad Man waterfall-Chiang Klang, 18 Nov. 1993, K. Larsen, S.S. Larsen, C.T. NØrgaard, K. Pharsen, P. Puudjaa & W. Uerchirakan 44547 (**AAU**, **K**), Doi Phuka NP, 7 Oct. 1998, P. Srisanga 281 (**BKF**, **QBG**), 23 Sep. 2000, P. Srisanga 1622 (**BKF**, **QBG**); **Phitsanulok**, Thung Salaeng Luang NP, 30 Sep. 1967, M. Tagawa K. Iwatsuki, T. Shimizu, N. Fukuoka & M. Hotoh 11246 (**BKF** 2 sheets, **C**, **K**), 11 Dec. 1965, M. Tagawa K. Iwatsuki, N. Fukuoka 2046 (**BKF** 2 sheets, **C**, **K**), 11 Oct. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk 18380 (**AAU**, **BKF** 3 sheets, **C**, **K**), 17 Sep. 1990, P. Chantaranothai, J.

Parnell & D. Simpson 90/302 (**K**), 29 Dec. 1982, H. Koyama, H. Terao, T. Wongprasert 31931 (**BKF**, **C** 2 sheets, **K**), 21 Oct. 1984, G. Murata, C. Phengklai, S. Mitsuta, T. Yahara, H. Nagamasu & N. Nantasan 38256 (**BKF**), 22 Oct. 1984, G. Murata, C. Phengklai, S. Mitsuta, T. Yahara, H. Nagamasu & N. Nantasan 38533 & 38471 (**BKF**), 24 Nov. 1966, Prayad 532 (**BK**), s.d., S. Phusomsaeng 92 (**BKF**, **L**); **Phrae**, 11 Jan. 1972, C.F. van Beusekom, C. Phengkhlai, R. Geesink & B. Wongwan 4807 (**BKF**, **L**), Huai Rai, 16 Sep. 1982, anonymous 404 (**BKF**), Wiang Kosai NP., 20 Mar. 2011, T. Choopan 2011-178 (**SUT**);--- NORTH-EASTERN: **Phetchabun**, 18 Dec 1906, C.C. Hosseus 716 (**BM**, **K**), Wang Thong, 28 Dec. 1982, H. Koyama, H. Terao & T. Wongprasert 31872 (**BKF**), Wang Chom Pu, 14 Jan. 1969, Vacharapong 295 (**BK**); **Sakon Nakhon**, Phu Phan, 10 Dec. 1980 Umpai 632 (**BK**);--- EASTERN: **Buri Ram**, 17 Nov. 1976, C. Phengklai et al. 3248 (**BKF**); **Nakhon Ratchasima**, Khao Yai, 18 Nov. 1962, T. Smitinand 7901 (**BKF**, **L**), 31 Oct. 1970, C. Charoenphol, K. Larsen & E. Warncke 4346 (**AAU**), 14 Mar. 1968, C.F. van Beusekom & C. Phengklai 31 (**E**), 21 Nov. 1982, H. Koyama, H. Terao, C. Niyomdham & T. Wongprasert 30181 (**BKF**);--- CENTRAL: **Bangkok**, 1899, R. Zimmermann s.n. (**L**) & 104 (**BM**), 4 Feb. 1983, H. Terao 33145 (**BKF**), 6 Nov. 1930, M.C. Lakshnakara 432 (**BK**), 7 Mar. 1958, T. Sørensen, K. Larsen & B. Hansen 1977 (**C**);--- SOUTH-EASTERN: **Chanthaburi**, 11 Dec. 1935, A. Vesterdal 474 (**C**), Khao Pra Baht, 23 Nov. 1930, M.C. Lakshnakara 512 (**BK**, **BM**, **C**, **K**), Pong Namron (hot spring), 27 Sep. 1958, B. Sangkhachand 502 (**BKF**), 28 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & D. Phanichaphol 23881 (**BKF** 2 sheets) & 23882 (**BKF** 2 sheets) & 23890 (**BKF**), Khao Sa Bab, 7 Nov. 1993, K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W.

Uerchirakan 44284 (**AAU**, **BKF**), 5 Nov. 1954, B. Sangkhachand 302 (**BKF**), Khao Soi Dao WS., 9 Nov. 1969, C.F. van Beusekom & T. Smitinand 2055 (**AAU**, **BKF**, **C**, **E**, **L**), 18 Dec. 1974, R. Geesink & P. Hiepko 7901 (**BKF**, **L**), 15 Nov. 2010, T. Choopan 2010-016 (**BKF**, **SUT**), Khao Chamao-Khao Wong NP, 7 Nov. 1994, J.F. Maxwell 94-1191 (**BKF**, **L**), 5 Sep. 1972, K. Larsen, S.S. Larsen, I. Nielsen & T. Santisuk 32441 (**AAU**, **C**, **L**), 17 Nov. 2010, T. Choopan 2010-037 (**BKF**, **SUT**), Pliew waterfall, 19 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 525 (**C**) & 526 (**C** 2 sheets); **Prachin Buri**, Khao Singto, 10 Nov. 1930, A.F.G. Kerr 19834 (**BK**, **BM**, **K**), 9 Nov. 1930, Marcan 2564 (**K**), Khao Yai, 11 Jan. 1999, T. Wongprasert et al. s.n. (**BKF**); **Rayong**, Klaeng, 23 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & D. Phanichaphol 23408 (**BKF** 2 sheets), 23434 (**BKF** 2 sheets), 24 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & D. Phanichaphol 23550 (**BKF** 2 sheets);--- SOUTH-WESTERN: **Kanchanaburi,** Sai Yok, 11 Feb. 1959, B. Sangkhachand 773 (**BKF**, **K**), Ban Tha Khanun, 11 Jan. 1985, H. Koyama, F. Konta & W. Nanakhorn 49006 (**BKF**, **L**), Klang Dong-Sisawat, 29 Jan. 1962, K. Larsen 9365 (**BKF**, **C**, **E**), Wangka, 7 Feb. 1926, A.F.G. Kerr 10455 (**BK**, **BM**), Ban Klang, 24 Jan. 1962, K. Larsen 9236 (**BKF**, **C**, **E**), Thongphaphum, 21 Nov. 1997, K. Chayamarit 996 (**BKF** 2 sheets), Sangkhlaburi, 3 Dec. 2005, R. Pooma, C.C. Berg & K. Phattarahirankanok 5841 (**BKF**, **E**), Thung Yai Naresuan WS, 18 Jan. 1994, J.F. Maxwell 94-105 (**BKF**) & 94-112 (**BKF**); **Phetchaburi**, Kaeng Krachan NP, 23 Jan. 2005, K. Williams, S. Sudee, J. Hemrat & N. Rithphet 1020 (**BKF**, **E** 2 sheets, **K**); **Prachuap Khiri Khan**, Kui Buri, 22 Jan. 2004, D.J. Middleton 2372 (**BKF**, **K**);--- PENINSULAR: **Chumphon**, Mueang, 26 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33722 (**BKF**) & 33731 (**BKF**), Pha To, 2 May 1974, Tyapan 201 (**BK**), Langsuan, 9 Feb. 1927, A.F.G. Kerr 11907 (**BK**, **BM**), 26 Feb. 1927, 12117 (**BK**, **BM**, **C**, **K**, **L**); **Krabi**, 9 Nov. 1930, Marcan 2564 (**C**), Khao Pra Bangkram, 14 Feb. 1991, C. Niyomdham et al. 2086 (**BKF**), Nai Chong, 19 Jan. 1966, B. Hansen & T. Smitinand 12004 (**BKF**, **C**, **K**), 23 Feb. 1982, S. Sutheesorn 5232 (**BK**), Apr. 1915, Vanpruk 740 (**K**), 24 Feb. 1959, Umpai s.n. (**BK**); **Nakhon Si Thammarat**, 27 Nov. 1951, P. Suvarnakoses 183 (**BKF**), Khao Luang, 3 Feb. 1966, E. Hennipman 3822 (**L**), 7 Feb. 1966, E. Hennipman 3921 (**BKF**, **C**, **K**, **L**), Apr. 1922, E. Smith 716 (**BK**, **BM**, **K**), 2 May 1928. A.F.G. Kerr 15574 (**BK**, **BM**, **K**), 20 Feb. 1991, C. Niyomdham et al. 2199 (**BKF**), 20 Jan. 1966, M. Tagawa, K. Iwatsuki & N. Fukuoka 4716 (**BKF**), 5 Mar. 1983, H. Koyama, H. Terao & T. Wongprasert 34051 (**BKF**), 25 Aug. 1967, K. Iwatsuki, H. Koyama, M. Hutoh & A. Chintayungkun 8545 (**BKF**), 23 May 2011, T. Choopan 2011-295 (**BKF**, **SUT**), Khiriwong, 18 May 1924, P. Suvarnakoses 9293 (**K**), 18 May 1954, P. Suvarnakoses 823 (**BKF**), 9 Oct. 1957, B. Sangkhachand 719 (**BKF**), 22 Jul. 1951, T.S. 681 (**BKF**), 23 Feb. 1962, Phloenchit 1810 (**BKF**), 12 May 2010, T. Choopan 2010-014 (**SUT**), Thung Song, 18 Feb. 1929, Put 2367 (**BK**, **BM**, **K**), Ronphibun, Feb. 1922, E. Smith 383 (**BK**, **BM**), Yong waterfall NP., 4 Mar. 1983, H. Koyama, H. Terao & T. Wongprasert 33993 (**BKF**), 22 May 2011, T. Choopan 2011-291 (**SUT**), Walailak University, 31 May 1995, W. Nanakorn 3573 (**QBG**), Lansaka, 17 Mar. 1985, W. Ramsri 2 (**BKF**), s.d., P. Suvarnakoses 542 (**BKF**), Kungching waterfall, 2 Mar. 1986, J.F. Maxwell 86-124 (**BKF**); **Narathiwat**, Nikomwaeng, 19 Mar. 1968, Prayad 1235 (**BK**), Mar. 1968, S. Phusomsaeng 435 (**BKF**), 27 Feb. 1974, K. Larsen & S.S. Larsen 32686 (**AAU**), Sukhirin, 16 Feb. 1997, P. Puujaa 382 (**BKF**); **Pattani**, Betong, 2 Aug. 1923, A.F.G. Kerr 7476 (**BK**, **BM**, **K**), 24 Aug. 1923, A.F.G. Kerr s.n. (**BM**), 26 Aug. 1923, A.F.G.

Kerr 7662 (**BK**, **BM**) & 7919 (**BK**, **K**), Banang Sta, 27 Jul. 1923, A.F.G. Kerr 7374 (**BK**, **BM**, **K**), 28 Jul. 1923, 7395 (**BK**, **BM**, **K**); **Phangnga**, Thapput, 24 Feb. 1971, J. Sadakorn 221 (**BK** 2 sheets), 5 Mar. 1972, J. Sadakorn 672 (**BK** 2 sheets); **Phatthalung**, Phatthalung WRS, 22 Feb. 2002, P. Puudjaa 1031 (**BKF**); **Ranong**, La-Un, 2 Jan. 1929, A.F.G. Kerr 16495 (**BK**, **BM**, **K**),Klong Kam Puang, 26 Apr. 1973, R. Geesink & T. Santisuk 4945 (**AAU**, **BKF**, **C**, **E**, **K**, **L** 2 sheets), Khao Phota Luangkaeo-Kaper, 27 Feb. 1983, H. Koyama, H. Terao, T. Wongprasert 33807 (**BKF**, **C**, **K**), 9 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 26634 (**BKF** 2 sheets), Klong Naka WS, 3 Feb. 1979, T. Koyama, C. Phengklai, P.J. O'Connor & C. Niyomdham 15208 (**AAU**, **BKF** 3 sheets), 25 Apr. 1973, R. Geesink & T. Santisuk 4874 (**L**) & 4920 (**L**), Kra Buri, 28 Feb. 1968, Vacharapong 166 (**BK**); **Satun**, 10 Mar. 1928, M.C. Lakshnakara 327 (**BK**, **K**), Tarutao Island, 27 Feb. 1966, H.M. Burkill 3974 (**BKF**, **C**, **L**), 3 Mar. 1970, C. Chermsirivathana 1613 (**BK**) & 1614 (**BK**), 13 Dec. 1979, G. Congdon 249 (**AAU**), Kuan Kalong, 15 Jul. 1966, C. Phengklai 1298 (**BKF**, **L**), Padang Besar, 23 Dec. 1927, A.F.G. Kerr 13572 (**BK**, **BM**); **Songkhla**, Ko Hong Hill, 20 Mar. 1993, P. Chantaranothai, D.J. Middleton, J. Parnell, D. Simpson & K. Sridit 1250 (**K**), Had Yai, 27 Oct. 1993, K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Uerchirakan 44080 (**AAU**, **BKF**), 19 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk 27717 (**BKF**), 15 Sep. 1984, J.F. Maxwell 84-214 (**BKF**), 20 Mar. 1986, J.F. Maxwell 86-182 (**AAU**, **BKF**, **E**), 4 Jun. 1992, K. Larsen, S.S. Larsen, S.S. Renner, C. Niyomdham, W. Ueachirakan & P. Sirirugsa 42644 (**AAU**), 11 Jun. 1992, K. Larsen, S.S. Larsen, S.S. Renner, C. Niyomdham, W. Ueachirakan & P. Sirirugsa 42808 (**AAU**), Ton Nga Chang WS, 19 Dec. 1979, T.

Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk 27707 (**BKF**), 17 Dec. 1984, J.F. Maxwell 84-532 (**BKF**), Suan Tun waterfall, 12 Feb. 1985, J.F. Maxwell 85-176 (**BKF**, **C**), Boriphat waterfall, 1990, K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa 41228 (**AAU**), Khao Choomsak, 27 Jan. 1979, G. Congdon 230 (**AAU**), Khao Tang Kuan, 24 Feb. 1941, T. Premrasami s.n. (**BKF** 2 sheets); **Surat Thani**, Khao Kuap-Krut, 27 Dec. 1929, A.F.G. Kerr 17836 (**BK**, **BM**), Ban Rai-Krut, 29 Nov. 1924, A.F.G. Kerr 9483 (**BK**, **K**), Ban Krut, 20 Feb. 1930, A.F.G. Kerr 18159 (**BM**), Tao Island, 27 Dec. 1926, A.F.G. Kerr 11106 (**BK**, **BM**, **K**), 20 Feb. 1930, A.F.G. Kerr 12159 (**BK**, **K**), 12 Apr. 1927, A.F.G. Kerr 12659 (**BK**, **BM**, **K**), Samui Island, 10 Apr. 1927, A.F.G. Kerr 12618 (**BK**, **BM**, **K**), 4 Feb. 1987, J.F. Maxwell 87-144 (**AAU**, **BKF**), 15 Feb. 2005, K. Chayamarit, N. Suphuntee, P. Inthachup & M. Thanaros 58 (**BKF** 2 sheets), Pha-ngan Island, 4 Dec. 1974, R. Geesink, P. Hiepko & C. Phengklai 7754 (**BKF**, **C**, **K**, **L**), Pha-Luei Island, 1 Jun. 1960, Chirayupin 145 (**BK**), Khao Sok NP, 2 Mar. 1983, H. Koyama & H. Terao & T. Wongprasert 33947 (**BKF**, **C**), Pet Island, 28 Jan. 1935, G. Seidenfaden 2460 (**C**), Bang Bao, 6 Feb. 1935, G. Seidenfaden 2531 (**C**), 9 Mar. 1957, K. Gram & C.S. Larsen 143 (**C**), Baw Rai-Krat, 29 Nov 1924, A.F.G. Kerr 9483 (**BM**), Klong Saeng WS, 15 Feb. 1994, J.F. Maxwell 94-204 (**BKF**); **Trang**, s.d., P. Vanpruk 740 (**E**), Khao Soi Dao, 27 Apr. 1930, A.F.G. Kerr 19143 (**BK**, **BM**, **K**), Khao Chong, 7 Feb. 1966, C. Boonnab 324 (**BKF**), 5 Jan. 1979, Hamilton & G. Congdon 194 (**AAU**, **BKF**), 6 Mar. 1976, C. Chermsirivathana 2170 (**BK**), 2 Mar. 1969, P. Sangkhachand 1731 (**BK**), 1 Feb. 1985, P. Sirirugsa 958 (**C**), Yan Ta Khao, 22 Mar. 1998, V. Chamchumroon s.n. (**BKF**), 20 May 2011, T. Choopan 2011-279 (**BKF**, **SUT**), Khao Phab Pha, 11 Mar. 1974, K. Larsen & S.S. Larsen 33133 (**AAU**, **BKF**, **L**).

Distribution.--- China, Myanma, Malaysia, Thailand, Laos, Vietnam, Indonesia, Philippines.

Ecology.--- In shaded hill and moist evergreen forest, cultivated as ornamental plants throughout country, at 30-900 m altitude. Flowering: September-March.

Uses.--- Cultivated as ornamental plants. Roots used to treat fever.

Vernacular.--- Thao lang lai (เฒ่าหลังลาย), Chiang phra pa (เฉียงพร้าป่า), Yai plang (ยายปลัง), Yai Klang (ยายกลั้ง) (Surat Thani), Rong mai (ร่องไม้), Rong mai (รงไม้), Khem Mawng (เข็มม่วง) (General).

Notes.--- This species is distinguished from other taxa within the same genus by dense inflorescence, flowers being 3 or usually more to each bract, corolla tube being profusely glandular pubescent and usually without any other kind of pubescence, and middle abaxial lobe showing tongue-like patch.

There were 2 herbarium sheets of type specimens no. 6175 (described as *P. graciliflorum*), one of which is *P. crenulatum* and another is *P. graciliflorum*.

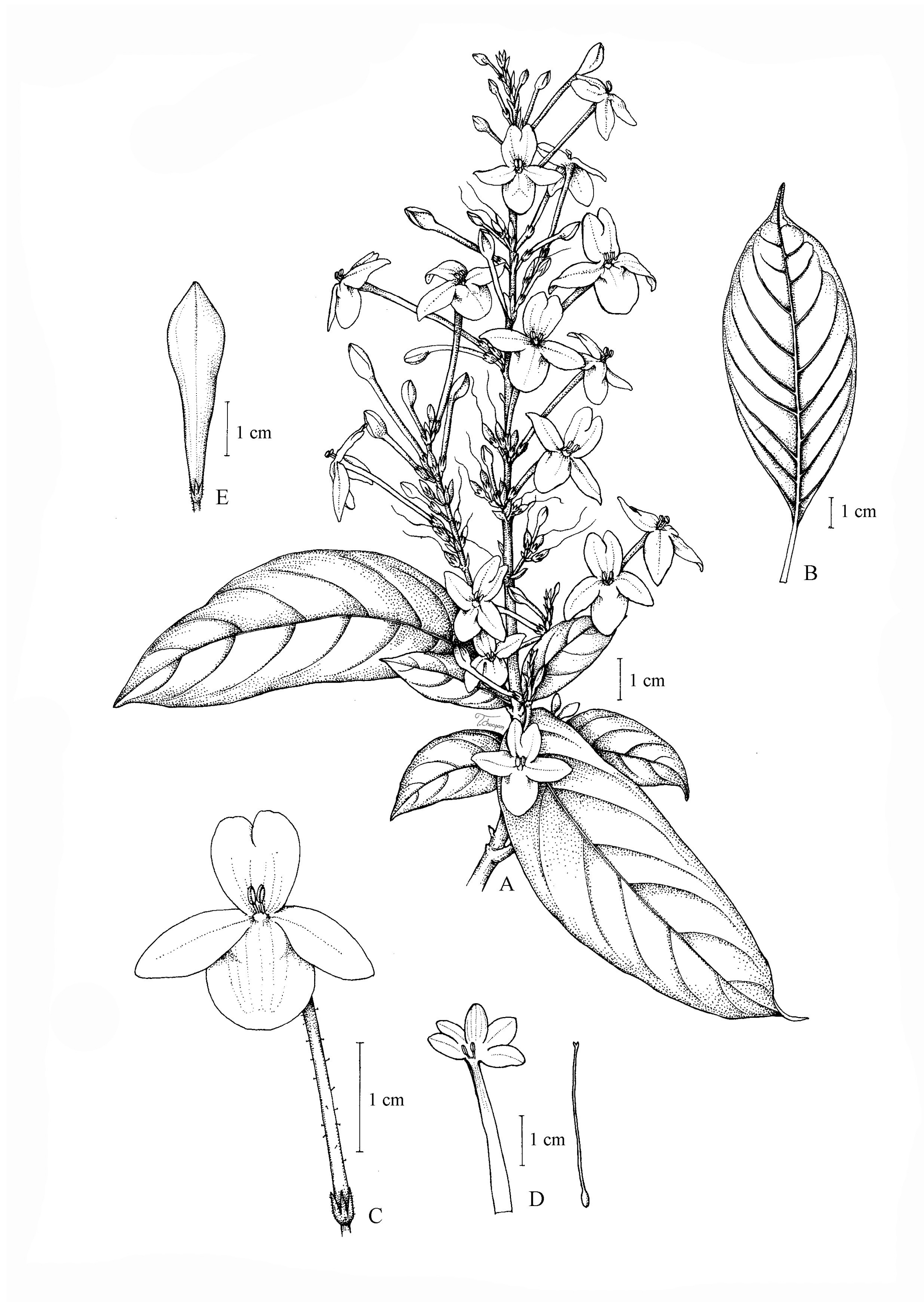


Figure 5.13 *Pseuderanthemum graciliflorum* Ridl.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.14 *Pseuderanthemum graciliflorum* Ridl.

A: habit, B: inflorescence with opened flowers.

7. *Pseuderanthemum latifolium* (Vahl) B. Hansen, Nordic J. Bot. 9(2): 213. 1989, [Type: see *Antheliacanthus micranthus*]; Maxwell & Elliott, Fl. Doi Sutep-Pui Nat. Park 109. 2001; Hu, Deng & Daniel in Wu et al., Fl. China 19: 440. 2011. Figures 5.15-5.16.

___*Antheliacanthus micranthus* Ridl., J. Fed. Malay States Mus. 10: 109. 1920, [Type: Thailand, Koh Gah, 5 Nov. 1919, C.B. Kloss 6594 (holotype! K)].

___*Justicia latifolia* Vahl, Symb. Bot. 2: 4. 1791. [Type: J. G. Köenig s.n. (holotype! C)].

Justicia palatifera Wall., Pl. Asiat. Rar. 1: 80. 1830, [Type: typified by Wall. op. cit. tab. 92].

___*Eranthemum palatiferum* (Wall.) Nees, in Wallich, Pl. Asiat. Rar. 3: 108. 1832; Nees in Candolle, Prodr. 11: 457. 1847a; Curtis, Bot. Mag. 98: t.5957. 1872; Clarke in Hooker, Fl. Brit. India 4: 498. 1885; Anderson, J. Linn. Soc. Bot. 9: 524. 1867.

___*Pseuderanthemum palatiferum* (Wall.) Radlk., Sitzungsber. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. München 13: 286. 1883.

Eranthemum malabaricum Clarke, in Hooker, Fl. Brit. India 4: 497. 1885 [Type: India, Wight]; Trimen, Handb. Fl. Ceylon 3: 325. 1895.

___*Pseuderanthemum malabaricum* (Clarke) Gamble, Fl. Madras 2(6): 1064. 1924.

Eranthemum pumilio C. B. Clarke, in Rosenvinge, Bot. Tidsskr. 24: 350. 1902b; Clarke, Fl. Koh Chang 6: 200. 1902a [Type: Thailand, Trat, Koh Chang, 5 & 7 January 1900; J. Schmidt 59 & 98 (C)]; Suvatti, Fl. Thailand 2: 1114. 1978.

Shrubs, up to 100 cm tall, erect, rarely branched, glabrous. **Leaves** opposite-decussate; petioles 1-6 cm long; blade lanceolate or ovate, 5-20 by 1-10 cm, leathery-crispy (herbaceous, freshy), green with paler green areas along veins, apex acute or acuminate, base obtuse or attenuate, glabrous, secondary veins 7-9 pairs, opposite or alternate. **Inflorescence** terminal cymes, with white hairs; bracts 2 linear, 0.3 by 0.05 cm; pedicels 0.1-0.2 cm long; bracteoles small, linear, 0.3 by 0.05 cm, attenuate. **Flowers** up to 3 by 2.6 cm, zygomorphic, salverform. **Calyx** lobes 5, 0.5-0.6 cm long, with glandular hairs. **Corolla** lobes 5 (2 adaxial, 3 abaxial), purple with reddish purple dots (V-shaped) at the middle abaxial lobe, elliptic, 1-1.3 by 0.4-0.5 cm, apex obtuse, puberulous. **Stamens** slightly exserted, anthers oblong, 0.15 cm long, filaments 1 cm long; staminodes 2, ca. 0.1 cm long. **Ovary** cylindrical, hairs on top; style purple, 1 cm long, glabrous. **Fruits** capsule brownish black, up to 2 by 0.5 cm, puberulous. **Seeds** 4, brown, orbicular, ca. 0.5 cm in diameter.

Thailand.--- Gah Island (Ra), 5 Nov. 1919, C.B. Kloss 6594 (type! **K**);---NORTHERN: **Chiang Mai**, Doi Fahhompok NP, 22 Mar. 2011, T. Choopan 2011-187 (**BKF**, **SUT**), Doi Chiang Dao WS, 15 Jan. 1989, J.F. Maxwell 89-52 (**BKF**), 11 Mar. 1989, J.F. Maxwell 89-328 (**AAU**, **BKF**), 21 Mar. 1989, J.F. Maxwell 89-368 (**BKF**, **L**); 21 Mar. 1950, H.B.G. Garrett 1289 (**L**), 25 Mar. 1950, H.B.G. Garrett 1295 (**K** 2 sheets, **L**), 25 Mar. 1955, H.B.G. Garrett 1442 (**L**), 28 Mar. 1955, H.B.G. Garett 1443 (**K**, **L**), 14 Mar. 1956, P. Suvarnakoses 1109 (**BKF**), 20 Feb. 1958, K. Bunchuai 734 (**BKF**), 5 Jul. 1959, K. Bunchuai 904 (**BKF**), 10 Apr. 1996, S. Gardner 920 (**L**), 6 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33150 (**BKF**), 23 Mar. 2011, T. Choopan 2011-194 (**SUT**), Doi Suthep-Pui NP, 9 May 1989, J.F. Maxwell

89-581 (**BKF**), Wang Tao, 22 Apr. 1958, T. Sørensen, K. Larsen & B. Hansen 2954 (**C**); **Chiang Rai**, Doi Luang NP., 14 Jan. 2011, T. Choopan 2011-154 (**SUT**), Mae Sai, 14 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33511 (**BKF**, **L**); **Lampang**, Doi Khun Tan NP, 15 Feb. 1995, J.F. Maxwell 95-97 (**L**); **Mae Hong Son**, Khun Yuam, 13 Jan. 1983, H. Koyama, H. Terao & T. Wongprasert 32437 (**BKF**); **Phrae**, Huai Rai, s.d., anonymous 17124 (**BKF**), Huai Hom Noi, 17 Mar. 1951, C. Phengklai 35 (**BKF**, **K**); **Sukhothai**, Mueang Kao, 8 Mar. 1972, J.F. Maxwell 72-69 (**BK**), Ramkamhaeng NP, 27 Jan. 1995, J.F. Maxwell 95-13 (**BKF**, **L** 2 sheets); **Tak**, Khun Pha Wor NP., 21 Jan. 1983, H. Koyama, H. Terao & T. Wongprasert 32826 (**BKF**), 26 Mar. 2011, T. Choopan 2011-205 (**BKF**, **SUT**), Umphang WS., 27 Mar. 2011, T. Choopan 2011-210 (**BKF**, **SUT**);--- NORTH-EASTERN: **Phetchabun**, Tha Duang, 4 Mar. 1931, A.F.G. Kerr 20359 (**BK**, **BM**);--- SOUTH-EASTERN: **Trat**, Chang Island, 5 Jan. 1900, J. Schmidt 59 (type! **C**), 6 Jan. 1900, J. Schmidt 83 (**C**), 7 Jan. 1900, J. Schmidt 98 (paratype! **C**), 9 Jan. 1900, J. Schmidt 121 (**C**), 15 Jan. 1900, J. Schmidt s.n. (**C**), 4 Feb 1900, J. Schmidt 392 (**C**), Jan. 1900, J. Schmidt 791 (**C**); --- SOUTH-WESTERN: **Kanchanaburi**, Bam Pompee-Sangklaburi, 25 Mar. 1968, C.F. van Beusekom & C. Phengklai 104 (**BKF**, **C**, **E**, **K**, **L**), 24 Mar. 1967, Prayad 711 (**BK**), between Khao Yai and Khao Ngi Yai, 8 Apr. 1968, C.F. van Beusekom & C. Phengklai 404 (**BKF** 2 sheets, **E**, **K**, **L**), Wangka, 6 Feb. 1926, A.F.G. Kerr 10658 (**K**), Tha Khanun, 23 Jan. 1926, A.F.G. Kerr 10292 (**BK**, **BM**, **C**, **K**), Thung Yai Naresuan WS, 20 Mar. 1993, J.F. Maxwell 93-298 (**BKF** 2 sheets, **L**), 19 Jan. 1994, J.F. Maxwell 94-112 (**L**), Sangkhlaburi, 19 Feb. 1950, Prayoon 49 (**BKF**), 25 Feb. 2005, M. van de Bult 832 (**BKF**), Greung

Gavia, 3 Feb. 1962, K. Larsen 9526 (**C**), Tham Pra, 23 Dec. 1961, C. Phengklai 309 (**BKF**).

Distribution.--- China, India, Nepal, Bhutan, Myanmar, Malaysia, Thailand, Laos, Vietnam, Cambodia.

Ecology.--- In shaded evergreen forest, at 300-500 m altitude. Flowering: September-March.

Vernacular.--- Khem Thi Lo Su (เข็มทีลอซู) (Researcher).

Notes.--- This species is distinguished from *P. graciliflorum* (Nees) Ridley by the corolla tube (at least in upper half) being pubescent, sometimes with a few glandular hairs and by the flowers being solitary or rarely 2 or 3 to each bracts. The flowers are distinguished from other taxa within the same genus by the middle abaxial lobe with dark purple dots aligned in a V-shape. Their herbaceous or freshy leaves are quite larger than in other species and distinct with paler green or yellowish green area along veins.

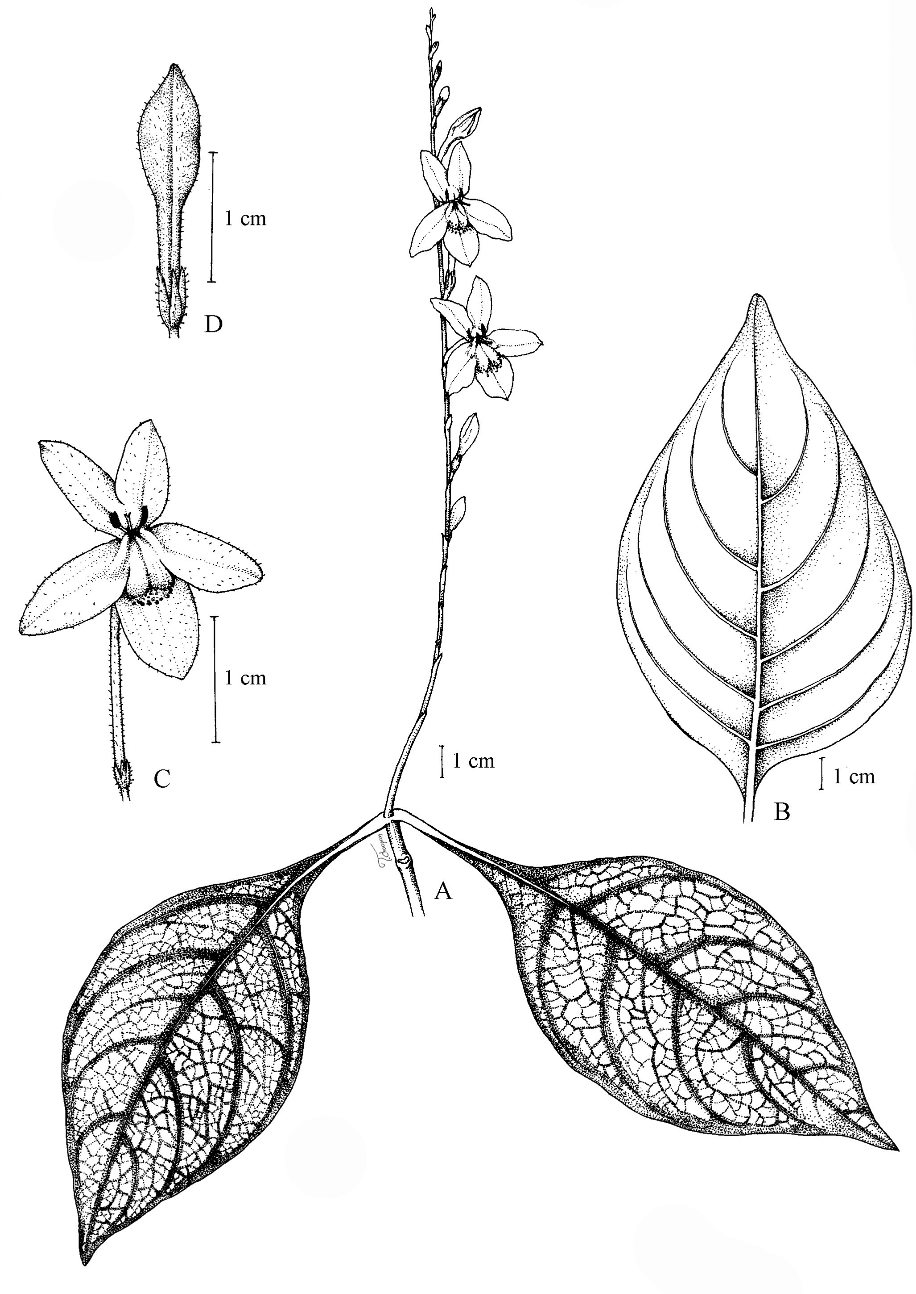


Figure 5.15 *Pseuderanthemum latifolium* (Vahl) B. Hansen.

A: habit, B: ventral leaf, C: flower, D: fruit.

A

B

Figure 5.16 *Pseuderanthemum latifolium* (Vahl) B. Hansen.

A: habit, B: inflorescence with opened flowers.

8. *Pseuderanthemum laxiflorum* (A. Gray) F. T. Hubb. ex L. H. Bailey, Rhodora 18(211): 159. 1916, [Type: United States, Feejee (Fiji) Islands; Wilkes s.n. (P)]. Figures 5.17-5.18.

___*Eranthemum laxiflorum* A. Gray, Proc. Amer. Acad. Arts. 5: 349. 1862, [Type: Fiji, Viti Levu; Graeffe s.n. (BM, GH)].

___*Pseuderanthemum laxiflorum* (A. Gray) F. T. Hubb., in Fosberg, Smithsonian Contr. Bot. 45: 26. 1980.

Shrubs, up to 40 cm tall, erect, branched, pubescent. **Leaves** opposite-decussate; petioles 0.6-0.8 cm long; blade lanceolate, 5-10 by 1.5-2 cm, apex acute or acuminate, base acute, glabrous, secondary veins 4-6 pairs, opposite or alternate, of. **Inflorescence** terminal or axillary cymes; bracts 2, elliptic or leaf-like, 1 by 0.4-0.5 cm; pedicels 0.8-0.9 cm long; bracteoles 2 in 2 lateral flowers (no bracteole in the middle one), elliptic, 0.4 by 0.1 cm, puberulous. **Flowers** up to 4 by 4 cm, zygomorphic, funnel-form with enlarged at throat. **Calyx** lobes 5, 0.6-1 cm long, puberulous. **Corolla** lobes 5 (2 adaxial, 3 abaxial), dark pinkish purple, elliptic, 1.5-1.7 by 0.5-0.7 cm, apex obtuse. **Stamens** exserted, anthers oblong, 0.2 cm long, filaments 1 cm long; staminodes 2, ca. 0.1 cm long. **Ovary** cylindrical, pubescent; style 3 cm long, glabrous. **Fruits** capsule brown, up to 2 by 0.3 cm, puberulous. **Seeds** 4, brown, orbicular, ca. 0.3 cm in diameter.

Thailand.--- EASTERN: **Nakhon Ratchasima**, Mueang, 25 Nov. 2011, T. Choopan 2011-324 (**BKF**, **SUT**).

Distribution.--- Japan, Thailand, Fiji.

Ecology.--- Cultivated as ornamental plants, at 150-350 m altitude. Flowering: September-March.

Uses.--- Introduced and cultivated as ornamentals.

Vernacular.--- Thep Phanom (เทพพนม) (General).

Notes.--- This species distinguished from other species by having predominantly axillary cymes, flowers distinctly extending at throat and the flower is quite large and dark pinkish purple without dots.

Figure 5.17 *Pseuderanthemum laxiflorum* (A. Gray) F. T. Hubb. ex L. H. Bailey.

A: habit, B: ventral leaf, C: flower, D: fruit.

A

B

Figure 5.18 *Pseuderanthemum laxiflorum* (A. Gray) F. T. Hubb. ex L. H. Bailey.

A: habit, B: inflorescence with opened flower.

9. *Pseuderanthemum longistylum* J. B. Imlay, Bull. Misc. Inform. Kew 1939: 134. 1939, [Type: Thailand, Bangkok, 20 November 1930; A.F.G. Kerr 19866 (BM, BK, K)]. Figures 5.19-5.20.

Perennial herbs or subshrubs, up to 50 cm tall, erect, unbranched, pubescent. **Leaves** opposite-decussate; petioles 0.5-2 cm long; blade green with paler areas scattered above, elliptic, 3.5-11 by 2-6 cm, apex acute or acuminate, base cuneate or acute, glabrous, secondary veins 5-7 pairs, opposite or alternate. **Inflorescence** terminal or axillary cymes, pubescent; bracts 2, minute lanceolate; pedicels 0.1-0.2 cm long; bracteoles small, minute lanceolate. **Flowers** up to 4 by 3.2 cm, zygomorphic, salverform. **Calyx** lobes 5, linear, 0.5-0.6 cm long, with glandular hairs. **Corolla** lobes 5 (2 adaxial, 3 abaxial), purple with reddish purple dots on the middle lobe or 3 lobes of abaxial lip, elliptic, 1-1.5 by 0.5-0.7 cm, apex obtuse. **Stamens** included, anthers oblong, 0.15 cm long, filaments 1 cm long; staminodes 2, ca. 0.1 cm long. **Ovary** cylindrical, puberulous; style 2.6 cm long, glabrous. **Fruits** capsule brown, up to ca. 1.8 by 0.5 cm, puberulous. **Seeds** 4, brown, orbicular, ca. 0.5 cm in diameter.

Thailand.--- NORTHERN: **Lamphun**, Doi Khun Tan NP, 15 Feb. 1995, J.F. Maxwell 95-97 (**BKF**); **Phrae**, 17 Mar. 1961, C. Phengklai 26196 (**K**);--- NORTH-EASTERN: **Loei**, Wang Saphung, 9 Mar. 1924, A.F.G. Kerr s.n. (**BK**, **BM**);--- EASTERN: **Chaiyaphum**, Phu Khieo, 24 Feb. 1931, A.F.G. Kerr 20247 (**BK**, **BM**, **K**), Nong Bua Daeng, 3 Mar. 1931, A.F.G. Kerr 20311 (**BM**), Tatton NP, 23 Nov. 2010, T. Choopan 2010-048 (**BKF**, **SUT**); **Nakhon Ratchasima**, Lam Phraphloeng

Dam, 29 Jan. 1983, H. Koyama, H. Terao & T. Wongprasert 33106 (**BKF**, **L**);--- CENTRAL: **Bangkok**, s.d., A.F.G. Kerr 494 (**BM**), 6 Feb. 1920, A.F.G. Kerr 3995 (**BM**, **K** 2 sheets), 8 Aug. 1920, A.F.G. Kerr s.n. (**BM**), 4 Feb. 1923, A.F.G. Kerr s.n. (**BK**), 18 Feb. 1923, A.F.G. Kerr 6752 (**BK**, **BM**, **K**), 20 Nov. 1930, A.F.G. Kerr 19866 (type! **BK**, **BM**, **K**), 15 Feb. 1932, Put s.n. (**BK**), 22 Feb. 1970, J.F. Maxwell 70-30 (**AAU**), 15 Feb. 1932, Put s.n. (**BM**); **Lop Buri**: 20 Oct. 1984, S. Mitsuta, T. Yahara, H. Nagamasu & N. Nantasan 38205 (**BKF**), Sab Champa, 4 Dec. 1982, H. Koyama & H. Terao 30589 (**BKF**), 19 Nov. 1984, G. Murata, C. Phengklai, S. Mitsuta, T. Yahara, H. Nagamasu & N. Nantasan 50953 (**BKF**) & 68110 (**BKF**); **Nakhon Nayok**, Nang Rong waterfall, 22 Nov. 1982, H. Koyama, H. Terao, C. Niyomdham & T. Wongprasert 30229 (**BKF**), Salika waterfall, 4 Apr. 1972, J.F. Maxwell 72-182 (**AAU**, **BK**); **Samut Prakan**, Phrapadaeng, 22 Feb. 1970, J.F. Maxwell 70-30 (**BK**); **Saraburi**: Phukae BG, 3 Dec. 1982, H. Koyama & H. Terao 30541 (**BKF**), 4 Dec. 1982, H. Koyama & H. Terao 30556 (**BKF**, **C**), 6 Oct. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk 17876 (**BKF**), Tham Phra Phothisat, 7 Oct. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk 19401 (**BKF** 2 sheets, **C**, **L** 2 sheets), Namtok Sam Lan NP, 26 Jan. 1975, R. Geesink & J.F. Maxwell 8370 (**BKF**, **L**), 9 Dec. 1973, J.F. Maxwell 73-725 (**BK**) & 73-729 (**AAU**), 6 Mar. 2004, J.F. Maxwell 04-126 (**BKF**), Phra Bat Temple, 7 Feb. 1971, J.F. Maxwell 71-56 (**AAU**, **BK**), Muak Lek waterfall, 19 Feb. 1962, K. Larsen 9687 (**C** 2 sheets);--- SOUTH-EASTERN: **Chanthaburi**, 11 Dec. 1935, A. Vesterdal 441 (**C**), s.d. 1936?, A. Vesterdal 5 (**C**), Khao Chamao-Khao Wong NP, 23 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyoma, T. Yahara & D. Phanichaphol 23560 (**BKF**), 17 Nov. 2010, T. Choopan 2010-035 (**BKF**, **SUT**), Khao Soi Dao, 11 Nov.

1969, C.F. Beusekom & T. Smitinand 2117 (**AAU**, **BKF**, **C**, **E**, **K**, **L**), 15 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 352 (**C**), 14 Nov. 2010, T. Choopan 2010-015 (**BKF**, **SUT**), Khao Khitchakud NP, 29 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & D. Phanichaphol 26041 (**BKF** 2 sheets, **L** 2 sheets), 15 Nov. 2010, T. Choopan 2010-021 (**SUT**), Krathing waterfall, 21 Oct. 1972, J.F. Maxwell 72-448 (**AAU**, **BK**), Khao Sabap, 6 Jun. 1948, Chit 348 (**BKF**); **Chon Buri**, Khao Khieo, 11 Jan. 1975, J.F. Maxwell 75-7 (**BK**, **L**), Khao Sa Bap-Phliew waterfall, 7 Nov. 1993, K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Ueachirakan 44294 right-hand side (**AAU**), Sattahip, 2 Jan. 1972, J.F. Maxwell 72-14 (**AAU**, **BK**), Sichang Island, 7 Nov. 1969, C.F. van Beusekom & T. Smitinand 2043 (**AAU**, **C**, **L** 2 sheets); **Prachin Buri**, Chakan Arboretum, 30 Jan. 1983, H. Koyama, H. Terao & T. Wongprasert 33113 (**BKF**); **Rayong**, Samed Island, 12 Jan. 1985, O. Ryding 913 (**AAU**); **Trat**, Ban Kadan, 21 Nov. 1971, J.E. Vidal 5797 (**AAU**), Namtok Phliew NP, 2 Dec. 1964, Sakol 293 (**BK**), 16 Nov. 2010, T. Choopan 2010-025 (**BKF**, **SUT**), Chang Island, Jan. 1922, E. Smith 281 (**BK**);--- SOUTH-WESTERN: **Kanchanaburi**, Tha Khanun, 23 Jan. 1926, A.F.G. Kerr 10292 (**C**), 20 Feb. 1926, A.F.G. Kerr 10533 (**BK**, **BM**, **K**), Sisawat, 13 Jan. 1926, A.F.G. Kerr 10202 (**BK**, **BM**, **K**), Sai Yok, 25 Jan. 1983, H. Koyama, H. Terao & T. Wongprasert 32876 (**BKF**), 26 Jan. 1983, H. Koyama, H. Terao & T. Wongprasert 32971 (**BKF**), 32976 (**BKF**), 10 Dec. 1961, K. Larsen 8651 (**C**), 28 Dec. 1961, K. Larsen 9011 (**C**), 2 Jan. 1962, K. Larsen 9105 (**C**), Erawan NP, 25 Jan. 1962, K. Larsen 9260 (**BKF**, **C**), 18 Nov. 1971, C.F. van Beusekom, C. Phengkhlai, R. Geesink & B. Wongwan 3828 (**BKF**, **L**), Tham Than Lod NP, 7 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 22007 (**BKF**), Had Phalom, 20 Dec. 1961, K.

Larsen 8834 (**C**); **Phetchaburi**, Kaeng Krachan NP, 4 Dec. 1993, K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Ueachirakan 45042 (**AAU**), 25 Dec. 2007, P. Phonsena, W. Chausook & N. Loetsombunsuk 5754 (**BKF**), Tha Yang, 6 Feb. 2008, J.F. Maxwell 08-29 (**QBG**); **Prachuap Khiri Khan**, Bangsaphan, 28 Dec. 1927, Put 1416 (**BK**, **BM**, **K**), 27 Dec. 1927, Put 1400 (**BM**), 5 Sep. 2008, D.J. Middleton, V. Chamchumroon, P. Triboun, S. Saengrit & R. Simma 4285 (**AAU**, **BKF**, **E**), 12 Feb. 1970, C.F. van Beusekom & T. Santisuk 2813 (**L**), 13 Nov. 1944, Thaeo 124 (**BKF**), Pran Buri, 26 Nov. 1929, Put 2455 (**BK**, **BM**, **K**), 8 Feb. 1964, S. Phengnaren 161 (**BKF**), 4 Feb. 1964, T. Smitinand 8509 (**BKF**), Khao Chrongwan, 18 Aug. 1967, T. Shimizu, N. Fukuoka & A. Nalampoon 7684 (**BKF**), Huai Yang waterfall, 24 Oct. 1964, C. Chermsirivathana 176 (**BK**), 4 Oct. 1930, Put 3192 (**BK**, **BM**), 6 Mar. 1983, H. Koyama, H. Terao & T. Wongprasert 34095 (**BKF**); **Ratchaburi**, Suan Pheung, 27 Jan. 2001, C. Niyomdham 6403 (**BKF**), Khao Nam Tok, 10 Sep. 1966, K. Larsen, T. Smitinand & E. Warncke 1359 (**AAU**); **Uthai Thani**, Huai Kha Khaeng WS, 12 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 22267 (**BKF** 2 sheets, **L**) & 22284 (**BKF** 2 sheets**, L**);---PENINSULAR: **Chumphon**, Thasae, 16 Jan. 1987, J.F. Maxwell 87-69 (**BKF**, **L**), Hot spring forest park, 26 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33724 (**BKF**) & 33736 (**BKF**), Matra Island, 10 Jun. 1969, Faray 166 (**BK**); **Ranong**, Lam Liang, 28 Dec. 1928, A.F.G. Kerr 16418 (**BK**, **BM**, **K**), Chang Island, 11 Jan. 1929, A.F.G. Kerr 16609 (**BK**, **BM**, **K**), Klaung Kampaum, 29 Jan. 1929, A.F.G. Kerr 16879 (**BK**, **BM**), Klong Naka WS, 20 Feb. 2002, V. Chamchumroon, C. Puff & N. Koonkhunthod 1276 (**BKF**); **Surat Thani**, Baw Rai-Krut, 28 Nov. 1924, A.F.G. Kerr 9460 (**BK**, **BM**, **K**), Ban Krut, 20 Feb. 1930, A.F.G. Kerr 18163 (**BK**, **BM**, **K** 2 sheets), Tao Island, 29 Dec. 1924, A.F.G. Kerr 11149 (**BK**, **BM**, **K**), 13 Apr. 1927, A.F.G. Kerr 12708 (**BK**, **BM**, **K**), 10 Jul. 1927, A.F.G. Kerr s.n. (**BK**, **BM**), 20 Sep. 1928, A.F.G. Kerr s.n. (**BM**), Dan Chumphon-Krut, 20 Dec. 1929, A.F.G. Kerr 17644 (**BK**, **BM**), Khao Kuap-Krut, 24 Dec. 1929, A.F.G. Kerr 17732 (**BM**).

Distribution.--- Endemic to Thailand.

Ecology.--- In shaded mixed deciduous forest with bamboo and evergreen forest with sand stone, sandy soil, at 100-500 m altitude. Flowering: October-December.

Uses.--- All parts of plant used to bath and cure wound.

Vernacular.--- Miat nok (เหมียดนก). Ya khamoy (ยาขโมย), Phaya Chon (พญาโจน)

Notes.--- This species is distinctly 1-5 long-branched at base of inflorescences with lax cyme. The corolla lobes are purple with reddish purple dots on the middle lobe or 3 lobes of abaxial lip.

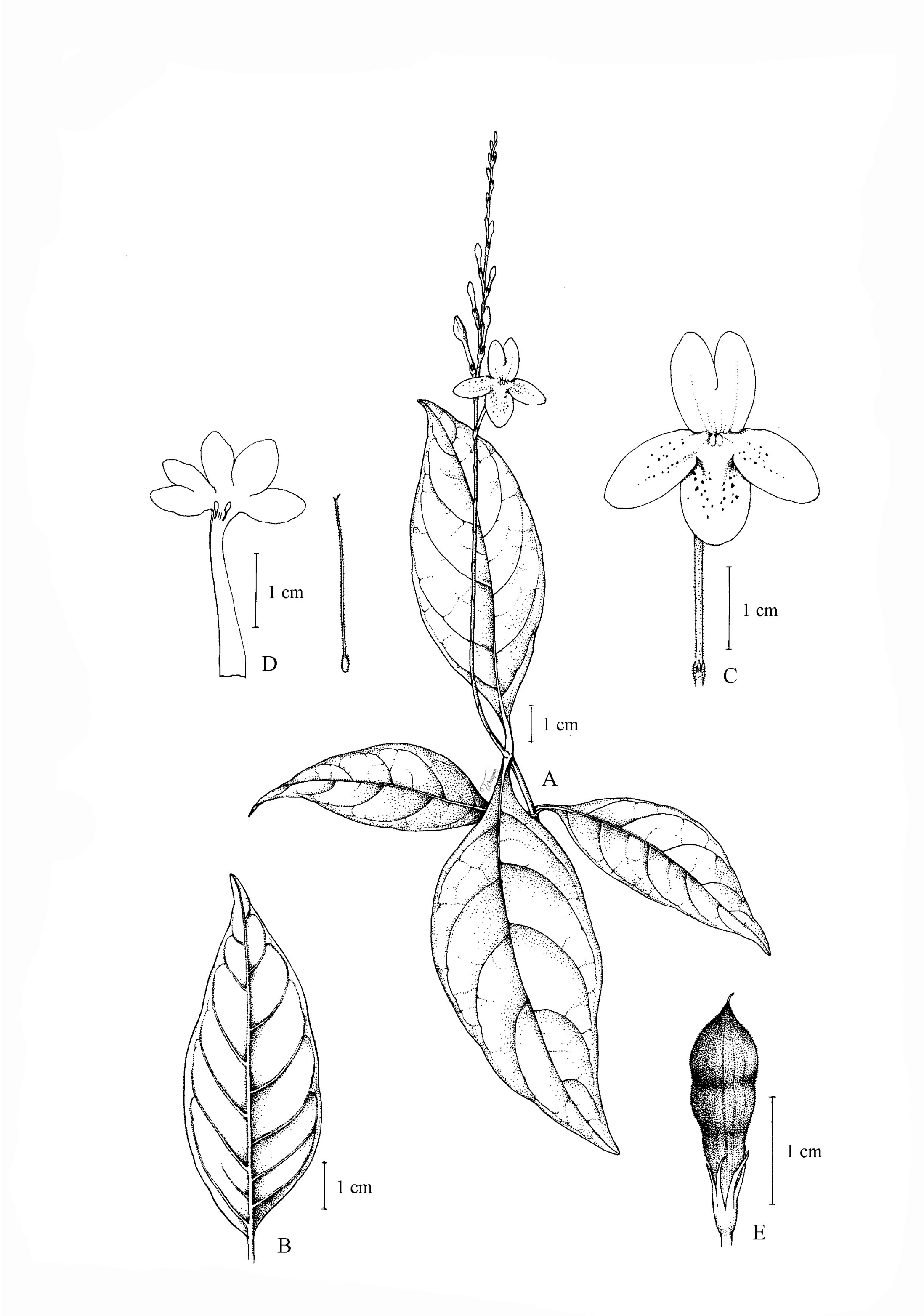


Figure 5.19 *Pseuderanthemum longistylum* J. B. Imlay.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.20 *Pseuderanthemum longistylum* J. B. Imlay.

A: habit, B: inflorescence with opened flowers.

10. *Pseuderanthemum metallicum* Hallier, Ann. Jard. Bot. Buitenzorg 15: 26. 1898, [Type: typified by Hallier tab. 9, West Sumatra, Sungei paguh; Teysm. 1185 (Herb. Bog.), Nordostsumatra, Delhi; de Hann 1895 (Hort. Bog.), Permandian, Radjah buntuh, Sinangkong in Delhi; Jaheri 1895 (Hort. Bog.)]. Figures 5.21-5.22.

Shrubs, up to 200 cm tall, erect, branched, glabrous. **Leaves** opposite-decussate; petioles grey, 0.5-1.0 cm long; blade purplish grey or whitish grey with white areas along margin, elliptic, asymmetric, leathery-crispy, 7-14 by 1-4 cm, apex acute or acuminate, base cuneate or acute, glabrous, margin wildly curved, secondary veins 7-9 pairs, opposite or alternate. **Inflorescence** terminal or rarely axillary cymes; pedicels ca. 0.1-0.2 cm long. **Flowers** up to 1.3 by 2 cm, zygomorphic, funnel-formed with enlarged at throat. **Calyx** lobes 5, 0.4 cm long. **Corolla** lobes 5, white, elliptic to oblong, 0.6 by 0.4-0.5 cm, apex obtuse. **Stamens** included, anthers oblong, 0.15 cm long, filaments ca. 1 cm long; staminodes 2, ca. 0.1 cm long. **Ovary** cylindrical, glabrous; style 1 cm long, glabrous. **Fruits** not developed.

Thailand.--- EASTERN: **Nakhon Ratchasima**, Mueang, 15 Oct. 2011, T. Choopan 2011-329 (**BKF**, **SUT**).

Distribution.--- Thailand, China, Indonesia.

Ecology.--- Cultivated as ornamental plants, at 150-350 m altitude. Flowering: April-June.

Uses.--- Introduced and cultivated as ornamentals.

Vernacular.--- Bai ngoen (ใบเงิน) (Researcher).

Notes.--- This species is similar to *P. carruthersii* and *P. reticulatum* (elliptic leaves) with the leaves usually being asymmetric and leathery-crispy but is distinguished by the color of leaves being purplish grey or silver-purple with white area along leaf margin and the shape of leaves being narrower than the other 2 taxa.

Figure 5.21 *Pseuderanthemum metallicum* Hallier.

A: habit, B: dorsal leaf, C: ventral leaf, D: flower.

A

B

Figure 5.22 *Pseuderanthemum metallicum* Hallier.

A: habit, B: ventral leaf surface.

11. *Pseuderanthemum* "*palatiferum*" (Nees) Radlk. ex Lindau, in Engler & Prantl Nat. Pflanzenfam. 4(3b): 330. 1895 [(Wall.) Radlk.]; Hô, Câyco Viêtnam 3: 77. 1993. Figures 5.23-5.24.

Shrubs, up to 200 cm tall, erect, branched, puberulous. **Leaves** opposite-decussate; petioles 1-2 cm long, puberulous; blade lanceolate, 10-12 by 3-4 cm, apex acute or acuminate, base acute or acuminate, puberulous, secondary veins 5-8 pairs, opposite or alternate. **Inflorescence** terminal or axillary cymes; bracts 2, oblong to elliptic, 0.3 by 0.1 cm; pedicels ca. 0.5 cm long; bracteoles small, linear, 0.3 by 0.05 cm, attenuate. **Flowers** up to 3 by 2 cm, zygomorphic, salverform. **Calyx** lobes 5, 0.5-0.6 cm long, puberulous. **Corolla** lobes 5 (2 adaxial, 3 abaxial), white, elliptic, 1 by 0.4-0.5 cm, apex obtuse, puberulous. **Stamens** slightly exserted, anthers oblong, 0.15 cm long, filaments 1 cm long, glabrous; staminodes 2, ca. 0.1 cm long. **Ovary** cylindrical, pubescent; style 3 cm long, puberulous. **Fruits** not seen.

Thailand.--- NORTH-EASTERN: **Maha Sarakham**, Chiang Yuen, 12 Oct. 2011, T. Choopan 2011-328 (**BKF**, **SUT**);--- EASTERN: **Yasothon**, Kho Wang, 11 Mar. 2012, P. Sittisart 1 (**BKF** 2 sheets).

Distribution.--- Thailand, Laos, Vietnam.

Ecology.--- Cultivated as medicinal plants, at 150-500 m altitude. Flowering: December-January.

Uses.--- Introduced and cultivated as medicinal plants.

Vernacular.--- Phaya wanorn (พญาวานร), Wan ngoc (ว่านฮ๊อก) (General).

Notes.--- This species is distinguished from *P. graciliflorum* (Nees) Ridley by the corolla being white, with yellow patches on midlobe of abaxial lip, the narrower lobes and by the flowers being solitary or rarely 2 or 3 to each bract. Moreover, it is distinguished by the leaves being lighter green and the shape of leaves being lanceolate with wavy surfaces.

The specimens from Vietnam have been misidentified as *Pseuderanthemum palatiferum* (Wall.) Radlk., which is the synonym of *P. latifolium* (Vahl) B. Hansen. There needs to be a new name and designated type specimen for this species.

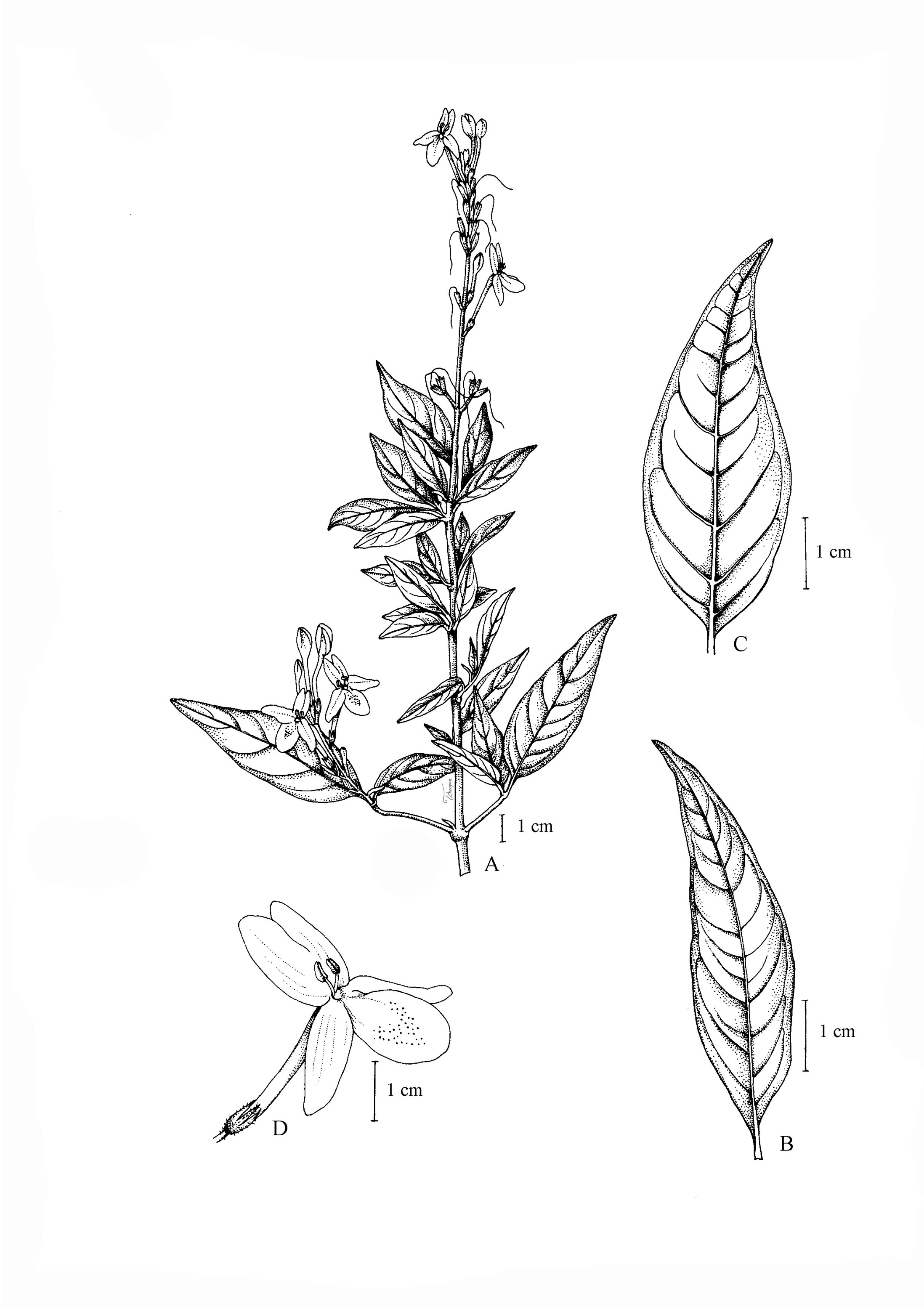


Figure 5.23 *Pseuderanthemum* "*palatiferum*" (Nees) Radlk. ex Lindau.

A: habit, B: dorsal leaf, C: ventral leaf, D: flower.

A

B

Figure 5.24 *Pseuderanthemum* "*palatiferum*" (Nees) Radlk. ex Lindau.

A: habit, B: dried inflorescence with opened flowers.

12. *Pseuderanthemum parishii* (T. Anders.) Lindau, in Engler & Prantl, Nat. Pflanzenfam. 4(3b): 330. 1895, [Type: see *Asystasia parishii*]; Benoist in Lecomte, Fl. Indo-Chine 4: 719. 1935; Maxwell & Elliott, Fl. Doi Sutep-Pui Nat. Park 109. 2001. Figures 5.25-5.26

___*Asystasia parishii* T. Anders., J. Linn. Soc. Bot. 9: 526. 1867, [Type: Tenasserim; Parish 409 (K)].

___*Eranthemum parishii* Clarke, in Hooker, Fl. Brit. India 4: 499. 1885.

Eranthemum crenulatum var. *grandiflorum* Hook, in Curtis, Bot. Mag. 90: t.5440. 1864, excl. syn.

Perennial herbs, up to 30 cm tall, erect, unbranched, pubescent. **Leaves** opposite-decussate; petioles 1-2 cm long; blade elliptic, 8-12 by 2.5-3.5 cm, apex acute or acuminate, base acute, puberulous, secondary veins 4-7 pairs, opposite or alternate. **Inflorescence** terminal cymes; bracts 2, linear to narrow lanceolate, 0.6-1.6 by 0.2-0.3 cm; pedicels ca. 0.5 cm long; bracteoles small, linear, 0.1 by 0.05 cm. **Flowers** up to 4.5 by 2.5 cm, zygomorphic, salverform. **Calyx** lobes 5, 0.5-0.6 cm long, with densely glandular hairs. **Corolla** lobes 5 (2 adaxial, 3 abaxial), purple, elliptic, 1-1.2 by 0.4-0.5 cm, apex obtuse, margin wavy, glabrous. **Stamens** exserted, anthers oblong, 0.25 cm long, filaments 1-1.1 cm long, glabrous; staminodes 2, ca. 0.1 cm long. **Ovary** cylindrical, pubescent; **style** 3-3.2 cm long, hairs at base. **Fruits** capsule brown, up to 2-2.2 by 0.5 cm. **Seeds** 4, brown, orbicular, 0.3-0.4 cm in diameter.

Thailand.--- NORTHERN: **Chiang Mai**, Doi Suthep, 14 Jan. 1910, A.F.G. Kerr 938 (**K**, **L**), 29 Dec. 1904, C.C. Hosseus 267 (**BM**, **E**, **K**, **L**), 30 Jan. 1988, J.F. Maxwell 88-115 (**BKF** 2 sheets, **L**), 25 Dec. 1988, J.F. Maxwell 88-1399 (**L**), 23 Jan. 1990, J.F. Maxwell 90-110 (**L**), 7 Jan. 1993, J.F. Maxwell 93-16 (**BKF**, **L**), 2 Feb. 1959, T. Sørensen, K. Larsen & B. Hansen 6836 (**BKF**, **C**), 5 Feb. 1977, E.F. Anderson 4230 (**C**), Fang, 27 Jan. 1969, H.P. Nooteboom, B. Tantisewie & T. Phengklai 859 (**BKF**, **C**, **K**), Mae Sa NP, 15 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33576 (**BKF**), Bo Luang, 2 Feb. 1964, B. Hansen, G. Seidenfaden & T. Smitinand 11030 (**BK**, **BKF**, **C**, **E**, **K**, **L**); **Chiang Rai**, Doi Luang NP, 21 Dec. 1997, O. Petrmitr 180 (**BKF**, **L**), 17 Feb. 1998, O. Petrmitr 281 (**BKF**, **L**), Doi Hang, 29 Dec. 1924, H.B.G. Garrett 208 (**BKF**), Chiang Kham, 7 Dec. 1967, Prayad 1104 (**BK**); **Lampang**, Chae Son NP, 7 Jan. 1992, J.F. Maxwell 92-15 (**E**, **L**), 28 Jan. 1997, M. Panatkool 140 (**L**), 15 Jan. 2011, T. Choopan 2011-162 (**BKF**, **SUT**), Doi Khun Tan NP, 29 Dec. 1994, J.F. Maxwell 94-1327 (**BKF**, **L**); **Nan**, Doi Phu Ka NP, 17 Jan. 2002, P. Srisanga 2393 (**BKF**, **QBG**), Sila Peth waterfall, 14 Dec. 1990, K. Larsen, S.S. Larsen, W. Nanakorn, W. Ueachirakan & P. Sirirugsa 41960 (**AAU**, **BKF**, **C**); **Phitsanulok**, Thung Salaeng Luang NP, 9 Feb 1964, B. Hansen, G. Seidenfaden & T. Smitinand 11087 (**BKF**, **C**, **K**, **L**), 11 Jan. 2011, T. Choopan 2011-124 (**SUT**), Nakhon Thai, 20 Dec 1905, C.C. Hosseus 722a (**BM**, **E** 2 sheets, **K**), Chattakan, 24 Nov. 2006, S. Watthana & H. Kurzweil 2172 (**QBG**); **Phrae**, Mae Yom NP, 8 Dec. 1993, J.F. Maxwell 93-1448 (**L**), 12 Jan. 2011, T. Choopan 2011-128 (**BKF**, **SUT**);--- NORTH-EASTERN: Ban Na Luang-UDAWN, 6 Jan. 1966, E. Hennipman 3519 (**BKF**, **C**, **L**); **Khon Kaen**, Pha Nok Khao, 17 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara, C. Niyomdham 23240 (**BKF** 2 sheets,

C, **L** 2 sheets), 21 Dec. 1982, H. Koyama, H. Terao & T. Wongprasert 31480 (**C**, **L**), 16 Dec. 1963, Umpai 151 (**BK**); **Loei**, Phu Luang, 24 Nov. 1957, D. Bunpheng 964 (**BKF, K**), 7 Dec. 1965, M. Tagawa, K. Iwatsuki & N. Fukuoka 1913 (**BKF**, **L**), 20 Nov. 1968, C. Chermsirivathana 1182 (**BK**), 19 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33678 (**BKF**, **L**), Phu Kradueng NP, 17 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 22707 (**BKF**), 17 Dec. 1982, H. Koyama, H. Terao & T. Wongprasert 31202 (**BKF**, **C**, **L**), 10 Dec. 2011, P. Chaikong 60/44 (**KKU**), 25 Dec. 2010, T. Choopan 2010-111 (**BKF**, **SUT**); **Sakon Nakhon**,9 Dec. 1962, Adisai 213 (**BK**), Phu Phan, 14 Dec. 1962, P. Suvarnakoses 2005 (**BKF**, **L** 2 sheets);--- EASTERN: **Chaiyaphum**, Ban Khwae, 6 Jan. 1970, T. Lekakul 34 (**BKF**), Muang, 12 Jan. 1970, T. Lekakul 62 (**BKF**), Nam Phrom, 10 Dec. 1971, C.F. van Beusekom, C. Phengkhlai, R. Geesink & B. Wongwan 4101 (**BKF**, **C**, **L**);--- SOUTH-WESTERN: **Kanchanaburi**, Sai Yok, 19 Feb. 2000, J.F. Maxwell 00-69 (**BKF**, **L**), Mon Bala Ming, 12 Feb. 2003, M. van de Bult 637 (**BKF**); **Phetchaburi**, Kaeng Krachan NP, 3 Dec. 1993, K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Ueachirakan 45109 (**AAU**), 14 Dec. 2002, D.J. Middleton, S. Suddee & C. Hemrat 1635 (**AAU**, **BKF**, **E**); **Uthaithani**, Huai Kha Khaeng WS, 2 Feb. 1976, J.F. Maxwell 76-55 (**AAU**, **BK**, **L**).

Distribution.--- Myanmar, Thailand, Vietnam.

Ecology.--- In shaded mixed deciduous forest, hill evergreen forest, sandy soil, at 300-1,000 m altitude. Flowering: October-January.

Vernacular.--- Dok Dai (ดอกไดู)-Nan.

Notes.--- This species is distinguished from other taxa in the same genus by the stamens being distinctly exserted and by the margin of corolla lobes being wavy.

Figure 5.25 *Pseuderanthemum parishii* (T. Anders.) Lindau.

A: habit, B: flower, C: stamens, D: fruit.

A

B

Figure 5.26 *Pseuderanthemum parishii* (T. Anders.) Lindau.

A: habit, B: inflorescence with opened flower.

13. *Pseuderanthemum reticulatum* Radlk., Sitzungsber. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. München 13: 282. 1883, [Type: Java, Gekultiveerd Java, 27 April 1939; anonymous s.n. (L)]; Benoist in Lecomte, Fl. Indo-Chine 4: 718. 1935. Figures 5.27-5.30

___*Eranthemum reticulatum* W. Bull, Gard. Chron. 3: 619. 1875; Curtis, Bot. Mag. 122: t.7480. 1896.

___*Eranthemum reticulatum* Hort. ex A. De Vos, Belgique Hort (Ill. Hort. 26: t.349. 1879). 26: 151. 1876 n.v..

Pseuderanthemum carruthersii (Seem.) Guill. var. *reticulatum* (W. Bull) Fosberg new comb., new status, Smithsonian Contr. Bot. 45: 26. 1980.

Shrubs, up to 200 cm tall, erect, branched, yellowish green with longitudinal lines. **Leaves** opposite-decussate; petioles yellowish green, 1-2 cm long; blade elliptic or ovate, asymmetric (in elliptic-leaf plants) or symmetric (in ovate-leaf plants), leathery-crispy, reddish green with yellow along veins, 10-15 by 6-9 cm, apex acute, base acute, glabrous, secondary veins 5-7 pairs, opposite or alternate. **Inflorescence** terminal cymes; bracts 2, elliptic or ovate, 1.5-2 by 0.5-1 cm; pedicels 0.3-0.5 cm long; bracteoles 2 in 2 lateral flowers (no bracteole in the middle one), yellowish green, elliptic or lanceolate, 0.3 cm long, glabrous. **Flowers** up to 1.3 by 1 cm, zygomorphic, funnel-formed with enlarged at throat. **Calyx** lobes 5, yellowish green, lanceolate, 0.3 cm long, with glandular hairs on both surfaces. **Corolla** lobes 5 (2 adaxial, 3 abaxial), white with pink dots near the throat, elliptic to oblong, 1-1.3 by 0.4-0.5 cm, apex obtuse. **Stamens** slightly exserted, anthers elliptic, 0.15 cm long, filaments 0.5-0.6 cm long, glabrous; staminodes 2, up to 0.2-0.3 cm long. **Ovary** cylindrical, glabrous; style 1.3-1.5 cm long, glabrous. **Fruits** capsule brown, ca. 1 by 0.3 cm. **Seeds** 4, brown, orbicular, ca. 0.1 cm in diameter.

Thailand.--- (1) Elliptic-leaf plants:--- NORTH-EASTERN: **Khon Kaen**, 20 Jul. 2000, P. Chaikong 30/43 (**KKU**);--- CENTRAL: **Saraburi,** Wang Noi, 27 May 2011, T. Choopan 2011-320 (**BKF**, **SUT**).

(2) Ovate-leaf plants:--- NORTH-EASTERN: **Maha Sarakham**, Chiang Yuen, 19 Apr. 2011, T. Choopan 2011-321 (**BKF**, **SUT**);--- CENTRAL: **Bangkok**, 7 Mar. 1958, T. Sørensen, K. Larsen & B. Hansen 1974 (**C**), 20 Dec. 1984, B. Chirawanich 23 (**BK**), Thonburi, 7 Nov. 1970, J.F. Maxwell 70-81 (**BK**).

Distribution.--- Hongkong, India, Pakistan, Singapore, Thailand, Vietnam, New Guinea, Indonesia, Philippines, Africa and Mascarene Islands, Marshall Islands, America, Hawaii.

Ecology.--- Cultivated as ornamental plants, at 150-350 m altitude. Flowering: April-June.

Uses.--- Introduced and cultivated as ornamentals.

Vernacular.--- Ratsamee chan (รัศมีจันทร์), Saeng Chan Lek (แสงจันทร์เล็ก) (General).

Notes.--- This species differs from *P. carruthersii* mainly in the pronouncedly ovate leaves with a yellow zone along the midrib and veins (in symmetric ovate leaves) and the elliptic leaves in grayish green with white zone along the margin (in asymmetric elliptic leaves). Moreover, the flowers are white with pinkish purple dots.

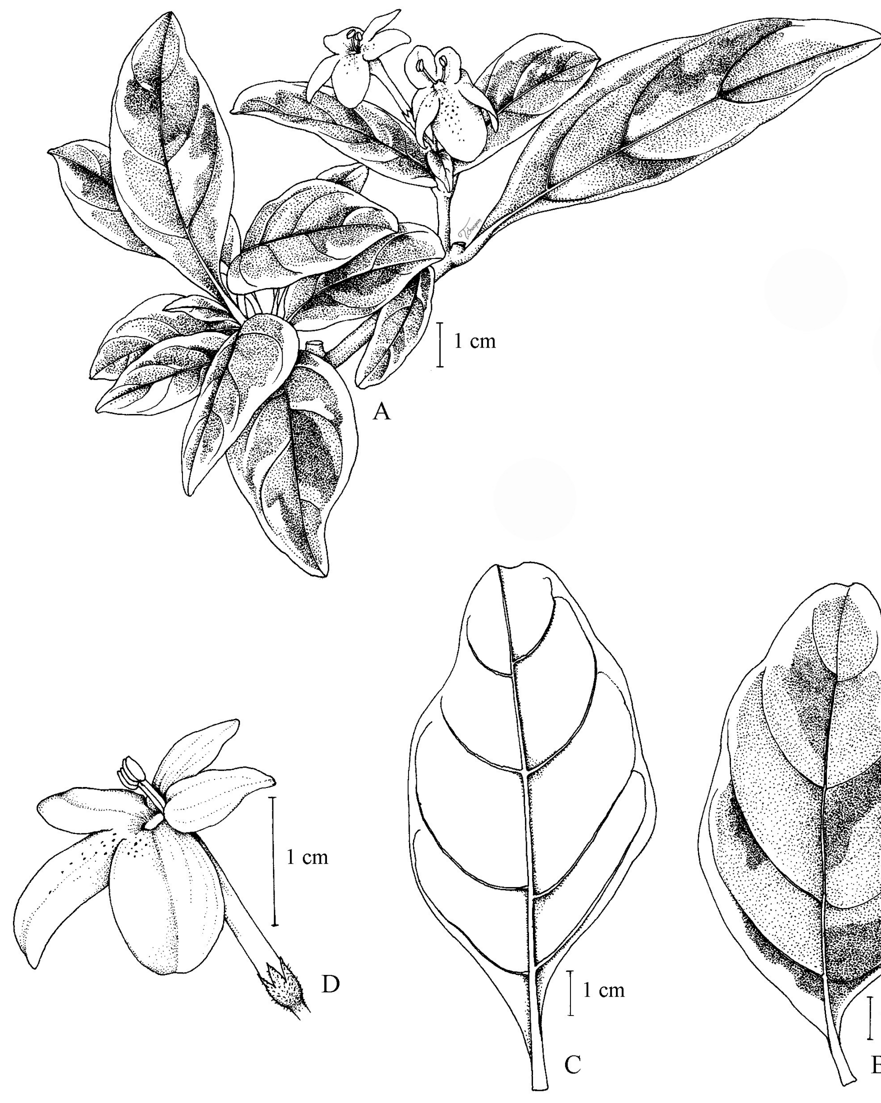


Figure 5.27 *Pseuderanthemum reticulatum* Radlk. (asymmetric leaf plants)

A: habit, B: dorsal leaf, C: ventral leaf, D: flower.

A

B

Figure 5.28 *Pseuderanthemum reticulatum* Radlk. (asymmetric leaf plants)

A: habit, B: inflorescence with opened flowers.

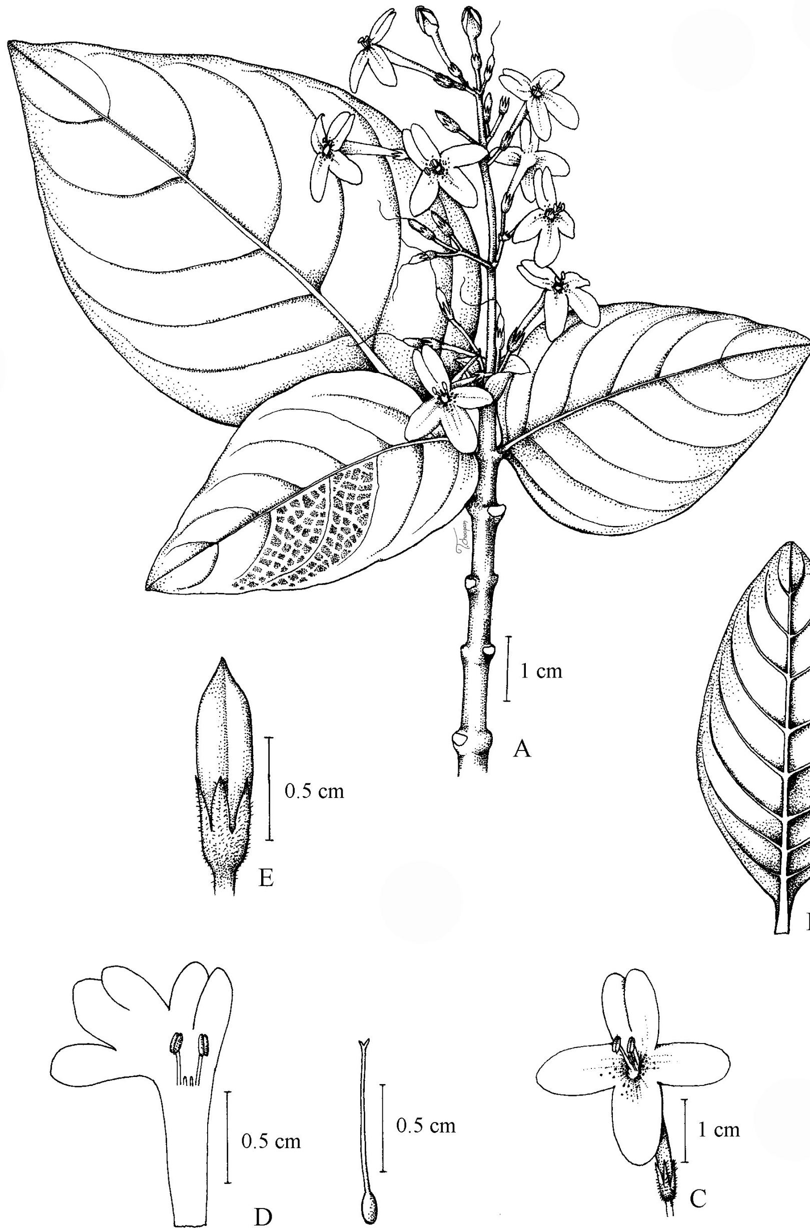


Figure 5.29 *Pseuderanthemum reticulatum* Radlk. (symmetric leaf plants)

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.30 *Pseuderanthemum reticulatum* Radlk. (symmetric leaf plants)

A: habit, B: inflorescence with opened flowers.

14. *Pseuderanthemum siamense* J. B. Imlay, Bull. Misc. Inform. Kew 1939: 134. 1939, [Type: Thailand, Doi Pha Ngua-Nan, 21 February 1922; H.B.G. Garrett 141 (BKF, K)]. Figures 5.31-5.32.

Perennial herbs, up to 20 cm tall, erect, rarely branched, pubescent. **Leaves** opposite-decussate; petioles 1-3 cm long; blade green with red veins underneath, elliptic, 8-13 by 3-5 cm, apex acute or acuminate, base cuneate or acute, puberulous, secondary veins 8-10 pairs, opposite or alternate. **Inflorescence** terminal cymes, unbranched, puberulous; bracts 2, linear, 0.25-0.3 by 0.05 cm, puberulous; pedicels ca. 0.2 cm long; bracteoles small, linear, 0.3 by 0.05 cm. **Flowers** up to 3 by 2 cm, zygomorphic, salverform. **Calyx** lobes 5, 0.5-0.6 cm long, with glandular hairs. **Corolla** lobes 5 (2 adaxial, 3 abaxial), purple with 3 purplish pink lines at abaxial lip, elliptic, 1 by 0.4-0.5 cm, apex obtuse, margin wavy, puberulous outside. **Stamens** included, anthers oblong, 0.25 cm long, puberulous, filaments 0.5 cm long, glabrous; staminodes 2, up to ca. 0.1 cm long, puberulous. **Ovary** cylindrical, glabrous; style 3 cm long, puberulous. **Fruits** capsule brownish black to black, up to ca. 2 by 0.5 cm, with glandular hairs. **Seeds** 4, brown, orbicular, ca. 0.5 cm in diameter.

Thailand.--- NORTHERN: **Chiang Mai**, Chiang Dao, 8 Mar. 1965, C. Chermsirivathana 315 (**BK**, **BKF**), 23 Mar. 2011, T. Choopan 2011-191 (**BKF**, **SUT**), Doi Suthep-Pui NP, 9 Apr. 1911, A.F.G. Kerr 1779 (**BM**, **K**), 12 Apr. 1912, A.F.G. Kerr 2543 (**BM**, **E**, **K**), 22 Mar. 2011, T. Choopan 2011-182 (**SUT**); **Nan**, Doi Ngua, 21 Feb. 1922, H.B.G. Garrett 141 (type! **BKF**, **K** 3 sheets); **Phrae**, Wiang Ko

Sai NP, 20 Mar. 2011, T. Choopan 2011-177 (**BKF**, **SUT**); **Phitsanulok**, Phu Hin Rong Kla NP, 10 Jan. 2011, T. Choopan 2011-118 (**BKF**, **SUT**).

Distribution.--- Endemic to Thailand.

Ecology.--- In shaded hill evergreen forest, at 400-1,200 m altitude. Flowering: December-January.

Vernacular.--- Khem Bai Daeng (เข็มใบแดง) (Researcher).

Notes.--- This species is distinguished from the others by the leaves having red veins under surface and distinguished from *P*. *parishii* by inflorescence unbrached with flowers subsessile, corolla puberulous outside with obtuse lobes, filament 0.5 cm long, and staminodes puberulous.

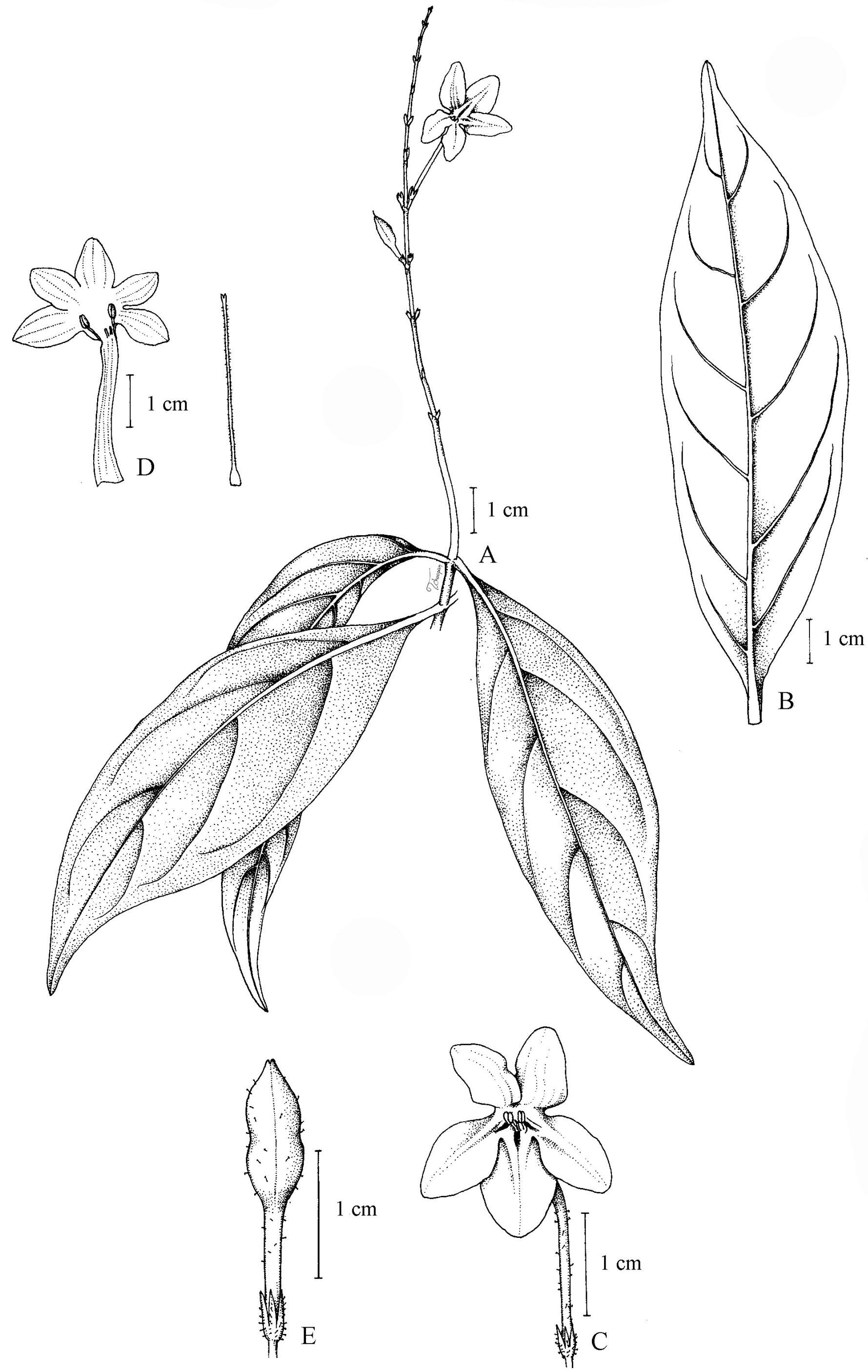


Figure 5.31 *Pseuderanthemum siamense* J. B. Imlay.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.32 *Pseuderanthemum siamense* J. B. Imlay.

A: habit, B: inflorescence with opened flower.

15. *Pseuderanthemum* sp1. Figures 5.33-5.34.

Perennial herbs or subshrubs, up to 50 cm tall, erect, unbranched, pubescent. **Leaves** opposite-decussate, petioles 1-3 cm long, pubescent, blade elliptic, 9-17 by 5-17 cm, apex acute or acuminate, base cuneate or acute, pubescent, secondary veins 5-7 pairs, opposite or alternate. **Inflorescence** terminal or axillary cymes; bracts 2, oblong to elliptic, 3 by 0.2 cm; pedicels 0.1-0.2 cm long; bracteoles small, linear, 0.3 by 0.05 cm, attenuate. **Flowers** up to 4 by 3.2 cm, zygomorphic, salverform. **Calyx** lobes 5, 0.5-0.6 cm long, with glandular hairs. **Corolla** lobes 5 (2 adaxial, 3 abaxial), purple with reddish purple dots on all 5 lobes, elliptic, 1-1.5 by 0.5-0.7 cm, apex obtuse. **Stamens** included, anthers oblong, 0.15 cm long, filaments 1 cm long; staminodes 2, ca. 0.1 cm long. **Ovary** cylindrical, puberulous; style 2.4-3 cm long, glabrous. **Fruits** capsule brown, up to ca. 2 by 0.5 cm, puberulous. **Seeds** 4, brown, orbicular, ca. 0.5 cm in diameter.

Thailand.--- SOUTH-EASTERN: **Chanthaburi**, Khao Chamoa-Khao Wong NP, 23 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & D. Phanichaphol 23402 (**BKF**), 23416 (**BKF** 2 sheets, **L**) & 23433 (**BKF** 2 sheets, **C** 2 sheets, **K**, **L** 2 sheets), 24 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & D. Phanichaphol 23551 (**BKF**), 8 Nov. 1994, J.F. Maxwell 94-1204 (**BKF**, **L**), 17 Nov. 2010, T. Choopan 2010-036 (**BKF**, **SUT**); **Trat**, Namtok Phliew NP, 16 Nov. 2010, T. Choopan 2010-027 (**BKF**, **SUT**), Khao Sa Bap-Phliew waterfall, 7 Nov. 1993, K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Ueachirakan 44294 left-hand side (**AAU**).

Distribution.--- Known from Thailand only.

Ecology.--- In shaded mixed deciduous forest with bamboo and evergreen forest, at 100-500 m altitude. Flowering: October-December.

Vernacular.--- Miat nok khon (เหมียดนกขน) (Researcher).

Notes.--- This species is distinguished from *P. longistylum* by leaves being pubescent instead of glabrous and by the corolla lobes being purple with reddish purple dots on all 5 lobes instead of dotted on lower lip.

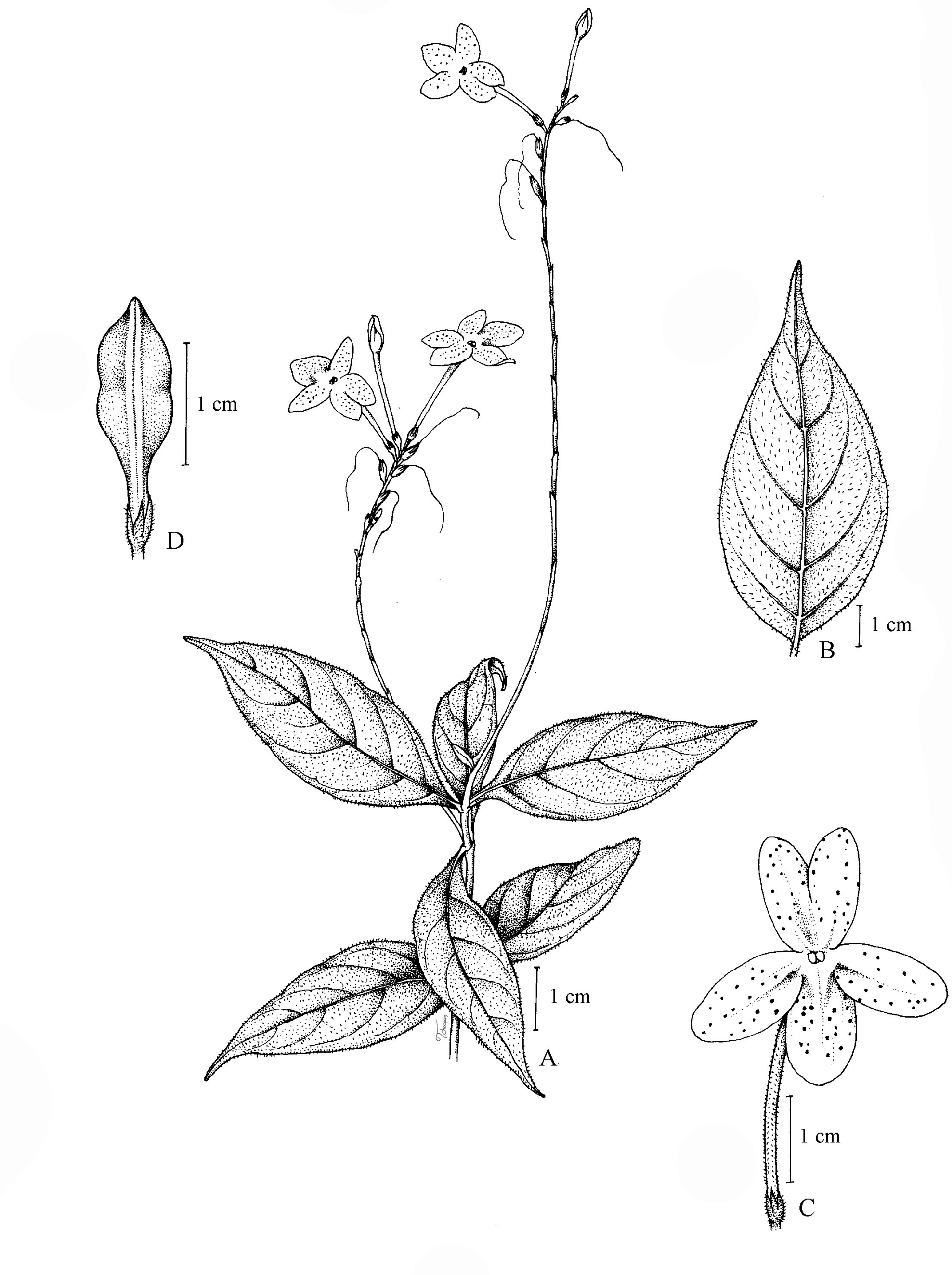


Figure 5.33 *Pseuderanthemum* sp1.

A: habit, B: ventral leaf, C: flower, D: fruit.

A

B

Figure 5.34 *Pseuderanthemum* sp1.

A: habit, B: inflorescence with opened flower.

16. *Pseuderanthemum* sp2. Figures 5.35-5.36.

Perennial herbs, up to 50 cm tall, erect, branched, glabrous. **Leaves** opposite-decussate; **petioles** greenish purple, 1-3 cm long; blade greenish purple above with reddish purple below, leathery-crispy, elliptic, 8-20 by 3-7 cm,. apex acute, base cuneate or acute, glabrous; secondary veins 7-8 pairs, opposite or alternate. **Inflorescence** terminal or axillary cymes. Other reproductive parts still not seen.

Thailand.--- SOUTH-WESTERN: **Kanchanaburi**, Sai Yok NP, 8 Feb. 1962, K. Larsen 9644 (**C** 2 sheets), 13 May 2011, T. Choopan 2011-227 (**BKF**, **SUT**);--- PENINSULAR: **Ranong**, Thung Raya-Nasak WS, 25 May 2011, T. Choopan 2011-316 (**BKF**, **SUT**).

Distribution.--- Known from Thailand only (Kanchanaburi, Ranong).

Ecology.--- In shaded evergreen forest along stream, at 100-400 m altitude. Flowering: December-January.

Vernacular.--- Khem Bai Muang (เข็มใบม่วง) (Researcher).

Notes.--- This species differs from *P. siamense* by the leaves being leathery-crispy (herbaceous) with deep red-purple color on whole surface underneath and by showing very long branched inflorescences and growing along stream.

Figure 5.35 *Pseuderanthemum* sp2.

A: habit, B: dorsal leaf, C: ventral leaf.

A

B

Figure 5.36 *Pseuderanthemum* sp2.

A: habit, B: ventral leaf surface.

Nelsonioideae

Nelsonia R. Br.

Nelsonia Robert Brown, Prodr. Fl. Nov. Holl. 1: 480. 1810. [Type species: *Justicia brunelloides* Lam., Locality: Java]; Nees in Wallich, Pl. Asiat. Rar. 3: 75. 1832; Endlicher, Gen. Pl. 697. 1839; Nees in Candolle, Prodr. 11: 65. 1847a; Miquel, Fl. Ind. Bat. 2: 770. 1856; Anderson, J. Linn. Soc. Bot. 9: 450. 1867; Bentham in Bentham & Hooker, Gen. Pl. 2: 1073. 1876; Clarke in Hooker, Fl. Brit. India 4: 394. 1885; Lindau in Engler & Prantl, Nat. Pflanzenfam. 4(3b): 289. 1895; Burkill & Clarke, Fl. Trop. Africa 5: 28. 1899; Clarke, J. Asiat. Soc. Bengal 74(3): 633. 1908; Ridley, Fl. Malay Penin. 2: 558. 1923; Benoist in Lecomte, Fl. Indo-Chine 4: 621. 1935; Bremekamp, Reinwardtia 3: 247. 1955; Leonard, Contr. US Natl. Herb. 31: 10. 1958; Scotland & Vollesen, Kew Bull. 55(3): 586. 2000; Hu, Deng & Daniel in Wu et al., Fl. China 19: 371-372. 2011.

Note: The genus named for David Nelson, a gardener accompanying Cook on his last voyage, consists of a single species (Leonard, 1958).

Banjolea S. Bowdich, Exc. Madeira 1: 258. 1825. [Type: *Banjolea violacea* Bowdich, Locality: Madeira].

Herbs, diffuse, softly villous. Leaves simple, opposite, entire, petiolate, leaf blade pinnately veined. Inflorescences spike, ovate or cylindrical, terminal or axillary. Bract ovate, glandular-villous, alternate or spirally scattered, Bracteoles 0. Calyx 4-partite, unequal, lanceolate. Corolla 2-lipped, purple or white, tube slender, apically curved. Corolla lobes 5, obtuse. Stamens 2, inserted at contracted point of corolla tube, included. Anthers 2-celled, subglobose, parallel at equal level. Ovary cone-shaped, with 8 ovules per cell. Stigma 2-lobed, unequal. Capsule cone-shaped, 2-celled. Seeds 14--18, small, seated on minute papillae, not on hard retinacula (retinacula absent), flat, surface smooth.

One species has been found throughout the country and this species is native to Thailand:

17. *Nelsonia canescens* (Lam.) Spreng., Syst. Veg. (ed. 16) 1: 42. 1825, [Type: see *Justicia canescens*]; Nees in Candolle, Prodr. 11: 67, 1847a; Bremekamp, Reinwardtia 3: 248. 1955; Maxwell & Elliott, Fl. Doi Sutep-Pui Nat. Park 108. 2001; Hu, Deng & Daniel in Wu et al., Fl. China 19: 371-372. 2011. Figures 5.37-5.38.

___*Justicia canescens* Lam., Tabl. Encycl. 1: 41. 1791. [Type: Senegal, Guinea, 1789; D. Roussillon 53 (C, isotype! P)]; Vahl, Enum. 1: 122. 1804.

Nelsonia campestris R. Brown, Prodr. Fl. Nov. Holl. 1: 481. 1810. [Type: Australia, Queensland, Gulf of Carpentaria, 18 November 1802; R. Brown 2941 (lectotype! BM, K, P)]; Roemer & Schultes, Syst. Veg. 1: 173. 1817; Clarke in Hooker, Fl. Brit. Ind. 4: 394. 1885; Burkill & Clarke, Fl. Trop. Africa 5: 28. 1899; Clarke, J. Asiat. Soc. Bengal 74(3): 633. 1908; Ridley, J. Straits Branch Roy. Asiat. Soc. 59: 147. 1911; Ridley, Fl. Malay Penin. 2: 558. 1923; Benoist in Lecomte, Fl. Indo-Chine 4: 621. 1935; Suvatti, Fl. Thailand 2: 1117. 1978; Hô, Câyco Viêtnam. 3(1): 34. 1993.

Nelsonia tomentosa A. Dietrich, Sp. Pl., ed. 1: 419. 1831, [Type; Calcutta; Griffith s.n. (n.v.)]; Nees in Wallich, Pl. Asiat. Rar. 3: 79. 1832; Nees in Candolle, Prodr. 11: 65. 1847a; Miquel, Fl. Ind. Bat. 2: 770. 1856; Anderson, J. Linn. Soc. Bot. 9: 450. 1867.

Justicia origanoides Vahl, Enum. 1: 122. 1804, [Type: s.l., anonymous s.n. (C)].

___*Nelsonia origanoides* Roemer & Schultes, Syst. Veg. 1: 173. 1817.

Herbs, up to 30 cm tall, creeping and ascending, branched, softly villous. **Leaves** opposite-decussate; petioles 2-4 cm long; blade elliptic, 6.5-12 by 3.5-6 cm, apex acute or obtuse, base acute, puberulous, secondary veins 7-9 pairs, opposite or alternate. **Inflorescence** terminal or axillary spike, 1.5-4 cm long; bracts 2, elliptic or leaf-like, 0.6-0.75 by 0.3-0.4 cm; bracteoles 0. **Flowers** up to 1.5 by 1.5 cm, zygomorphic, cylindrical. **Calyx** lobes 4, 2-lipped, 0.3 cm long, with glandular hairs. **Corolla** lobes 5 (2 adaxial, 3 abaxial), bluish purple with dark purplish on adaxial surface, elliptic, 0.5 by 0.3 cm, apex obtuse. **Stamens** included, anthers subglobose, 0.05-0.1 cm in diameter, filaments 0.05-0.1 cm long; staminodes 0. **Ovary** cylindrical, glabrous; style 0.1-0.2 cm long, glabrous. **Fruits** capsule yellowish brown, up to ca. 0.5 by 0.2 cm, glabrous. **Seeds** 16-18, brown, orbicular, ca. 0.1 cm in diameter.

Thailand.--- NORTHERN: **Chiang Mai**, Doi Khum, 23 Jan. 1911, A.F.G. Kerr 1657 (**BM**, **K** 2 sheets, **L**), Doi Suthep, 28 May 1906, C.C. Hosseus 443 (**BM**, **K**) & 490 (**BM**, **K**), 19 Feb. 1989, J.F. Maxwell 89-232 (**BKF**, **L**), 20 Feb. 1990, J.F. Maxwell 90-219 (**E**), 8 Mar. 1950, K. Suvatabandha 313 (**BK**), Doi Chiang Dao, 15 Mar. 1956, H.B.G. Garrett 1479 (**K**), 9 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33249 (**BKF**, **L**), 8 Mar. 1965, C. Chermsirivathana 314 (**BK**), 14 Jan. 1973, S. Sutheesorn 2274 (**BK**), 15 Feb. 1958, T. Sørensen, K. Larsen & B. Hansen 1128 (**C** 2 sheets, **E**), 18 Feb. 1958, T. Sørensen, K. Larsen & B. Hansen 1325 (**C** 2 sheets), 5 Jan. 1989, J.F. Maxwell 89-4 (**L**), 19 Jan. 1991, J.F. Maxwell 91-78 (**AAU**), 23 Mar. 2011, T. Choopan 2011-189 (**SUT**), Doi Fahompok NP. 22 Mar. 2011, T. Choopan 2011-188 (**BKF**, **SUT**), Fang, 21 Feb. 1958, T. Sørensen, K. Larsen & B. Hansen 7943 (**C**), 22 Feb. 1958, T. Sørensen, K. Larsen & B. Hansen 1446 (**C**) & 1479 (**C**, **E**), 10 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33302 (**C**, **L**), Mae Rim, 14 Mar. 1991, J.F. Maxwell 35 (**E**), Mae Taeng, 20 Jan. 1992, J.F. Maxwell 92-41 (**E**), Doi Saket, 26 Feb. 1993, J.F. Maxwell 93-199 (**BKF**); **Chiang Rai**, Ban Miya-Thoeng, 12 Feb. 1970, S. Sutheesorn 1638 (**BK**), Khun Chae NP, 16 Mar. 2005, R. Pooma, K. Phattarahirankanok, S. Sirimongkol & M. Poopath 4852 (**BKF**), Doi Glah, 10 Apr. 2006, J.F. Maxwell 06-293 (**BK**); **Lampang**, Doi Khun Tan NP, 18 Feb. 1995, J.F. Maxwell 95-134 (**BKF**, **L**); **Mae Hong Son**, Khun Yuam, 3 Mar. 1989, J.F. Maxwell 89-303 (**AAU**, **BKF**, **E**), Doi Wiang La WS, 24 Mar. 2011, T. Choopan 2011-197 (**SUT**), Salawin NP, 25 Mar. 2011, T. Choopan 2011-199 (**BKF**, **SUT**), Pang Mapha, 26 Feb. 1968, B. Hansen & T. Smitinand 12739 (**AAU**, **C**); **Nan**, Doi Phuka NP, 13 Jan. 2011, T. Choopan 2011-138 (**BKF**, **SUT**); **Phrae**, near Pang Poog, 17 Feb. 1910, A.F.G. Kerr 982 (**BM**, **K**); **Tak**, Mae Tak, 3 Mar. 1958 T. Sørensen, K. Larsen & B. Hansen 1874 (**C** 2 sheets, **K**), Sob Moei, 25 Mar. 2011, T. Choopan 2011-201 (**SUT**), Khun Pha Wor NP, 25 Mar. 2011, T. Choopan 2011-202 (**BKF**, **SUT**), Umphang WS, 27 Mar. 2011, T. Choopan 2011-209 (**BKF**, **SUT**);--- NORTH-EASTERN: **Loei**, Phu Luang WS, 11 Apr. 1968, C. Chermsirivathana 813 (**BK**); **Nong Khai**, Mekong river bank, 16 Dec. 1982, H. Koyama, H. Terao & T. Wongprasert 31119 (**BKF**, **C**, **L**), Phu Wua WS, 24 Dec. 2010, T. Choopan 2010-100 (**BKF**, **SUT**); **Sakon Nakhon**, Phu Phan NP, 25 Feb. 1993, P. Chantaranothai, D.J. Middleton, J. Parnell & D. Simpson 961 (**K**);--- CENTRAL: **Angthong**, Klang Temple-Mueang, 7 Mar. 1976, J.F. Maxwell 76-134 (**AAU**, **BK**, **L**); **Bangkok**, 25 Jan. 1920, A.F.G. Kerr 3950 (**BK**, **BM**, **K**), 8 Feb. 1920, A. Marcan 53 (**BM**), 19 Feb. 1922, A. Marcan 683 (**BM**), 20 Jan. 1924, A. Marcan 1615 (**BM**); **Nakhon Nayok**, s.d., V. Banyorosh s.n. (**BK**); **Nonthaburi**, 18 Jan. 1955, V. Varikul 20 (**BK**);--- SOUTH-EASTERN: **Prachin Buri**, Thaplan NP, 22 Feb. 2009, T. Choopan 2009-002 (**BKF**, **SUT**);--- SOUTH-WESTERN: **Kanchanaburi**, Phomphee-Sangkhlaburi, 25 Mar. 1968, C.F. van Beusekom & C. Phengklai 107 (**AAU**, **C**, **E**, **K**, **L**), 4 Mar. 1978, C. Phengklai 3095 (**E**, **K**),E-Tong, 21 Feb. 1967, C. Chermsirivathana 670 (**BK**), Thong Pha Phum, 6 Feb. 1962, K. Larsen 9609 (**C**, **K**), Sai Yok NP, 3 Jan. 1962, K. Larsen 9126 (**C**), 5 Jan. 1962, K. Larsen 9153 (**C**), 13 May 2011, T. Choopan 2011-228 (**BKF**, **SUT**); --- PENINSULAR: **Krabi**, Than Bok Khorani NP, 19 Jan. 1987, J.F. Maxwell 87-99 (**AAU**, **BKF**, **L**), 18 May 2011, T. Choopan 2011-266 (**BKF**, **SUT**); **Nakhon Si Thammarat**, Wang Hin, 26 Feb. 1987, J.F. Maxwell 87-235 (**AAU**, **BKF**, **L**), Chawang, s.d., S. Thawon 40 (**BKF**, **C**), Namtok Yong NP, 22 May 2011, T. Choopan 2011-293 (**BKF**, **SUT**); **Phangnga**, Thap Put, 24 Feb. 1971, J. Sadakorn 222 (**BK**), Song Phi Nong waterfall-Khuraburi, 4 Feb. 1979, T. Koyama, C. Phengklai, C. Niyomdham & P.J. O'Connor 15248 (**AAU**, **BKF**); **Ranong**, 30 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 837 (**C** 2 sheets), Klong Naka WS, 12 Mar. 1987, C. Niyomdham & R. Kubat 1396 (**AAU**, **C**, **E**, **K**, **L**), 15 May 2011, T. Choopan 2011-245 (**BKF**, **SUT**), Chang, 13 Feb. 1912, A.F.G. Kerr 2337 (**BM**, **K** 2 sheets),Rong Kwaung, 14 Feb. 1912, A.F.G. Kerr 2337A (**BM**), Khao Phota Luangkaeo-Kaper, 27 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33818 (**BKF**, **C**, **L**), Namtok Ngao NP, 15 May 2011, T. Choopan 2011-238 (**BKF**, **SUT**), Thung Raya-Nasak WS, 25 May 2011, T. Choopan 2011-315 (**BKF**, **SUT**); **Satun**, Taphan Lek, 9 Mar 1928, A.F.G. Kerr 14403 (**BK**, **BM**, **C**, **K**, **L**), Thale Ban NP, 20 May 2011, T. Choopan 2011-282 (**SUT**); **Surat Thani**, Ban Ha, 19 Feb. 1930, A.F.G. Kerr 18126 (**BK**, **BM**, **K**), Khao Sok NP, 2 Mar. 1983, H. Koyama, H. Terao & T. Wongprasert 33944 (**C**, **L**), 16 May 2011, T. Choopan 2011-252 (**BKF**, **SUT**);

Trang, Khao Chong, 4 Jul. 1969, P. Sangkhachand 1958 (**BK**), 12 Jul. 1969, P. Sangkhachand 1982 (**BK**).

Distribution.--- China, India, Sri Langka, Bangladesh, Pakistan, Nepal, Bhutan, Myanmar, Malaysia, Singapore Thailand, Laos, Vietnam, Cambodia, Indonesia, Philippines, Australia, Congo, Tanzania, Ethiopia, Senegal, Cameroon, Zambia, Nigeria, Ghana, Panama, Brazil (endemic in the warmer regions of Africa, Asia, and Australia, and as an introduced weed in tropical America).

Ecology.--- In opened areas of mixed deciduous forest with bamboo, evergreen forest, sandy soil, at 100-1000 m altitude. Flowering: January-May.

Uses.--- Medicinal plants.

Vernacular.--- Salet phang phon (เสลดพังพอน) (Northern), Yaa Khon (หญ้าขน) (Ranong).

Notes.--- Because of the fusion of the two lower lobes of the morphological pentamerous calyx, *N. canescens* shows 4 appearent calyx lobes. Moreover, this species is distinguished from 2 genera (*Ophiorrhiziphyllon* and *Staurogyne*) in the same subfamily by the absence of bracteoles and the absence of staminodes.

Chromosome count: n=18, 2n = 36 (Daniel and Chuang, 1993).

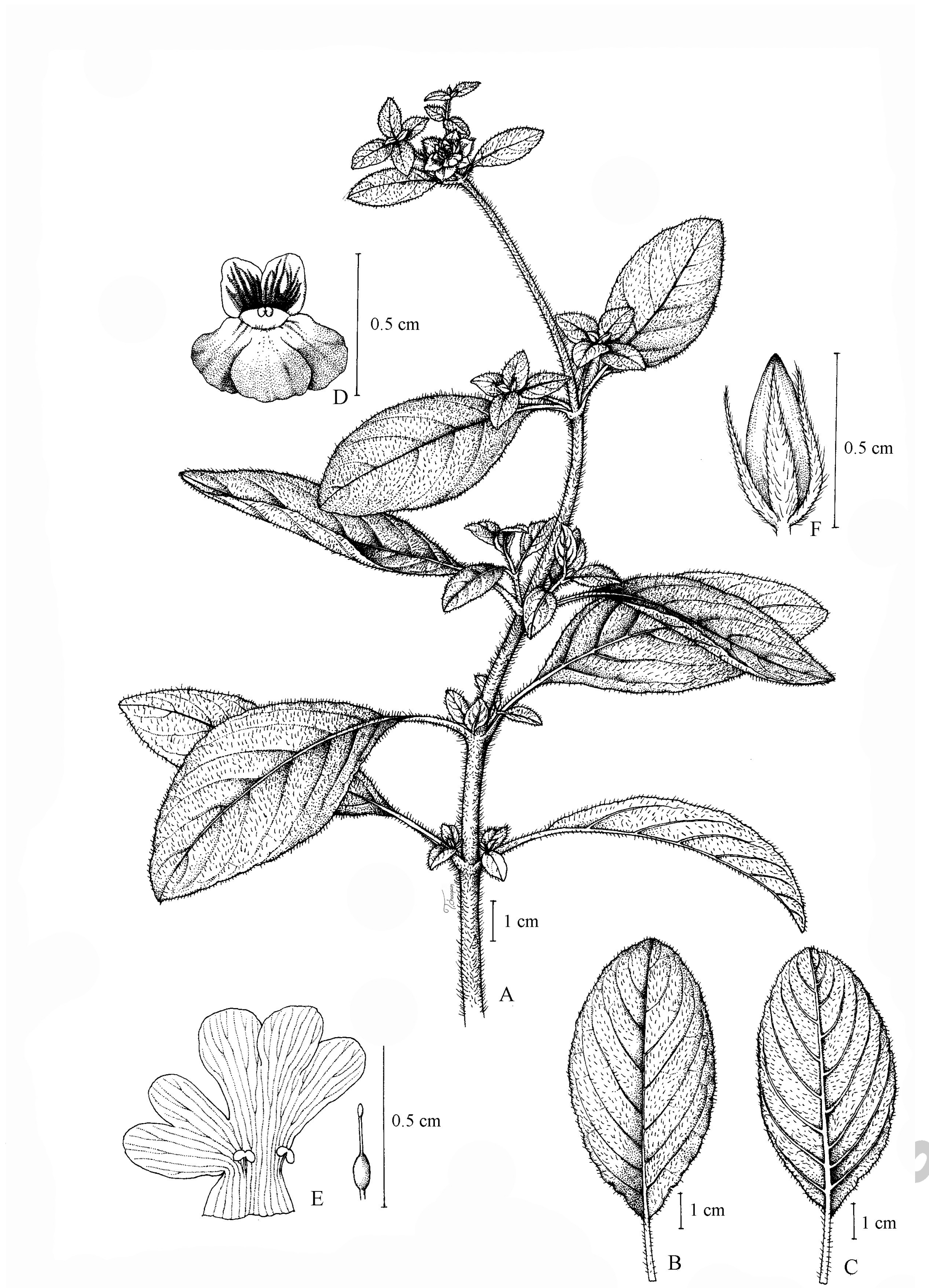


Figure 5.37 *Nelsonia canescens* (Lam.) Spreng.

A: habit, B: dorsal leaf, C: ventral leaf, D: flower, E: pistil and stamens, F: fruit.

A

B

Figure 5.38 *Nelsonia canescens* (Lam.) Spreng.

A: habit, B: inflorescence with opened flower.

Ophiorrhiziphyllon Kurz

Ophiorrhiziphyllon Kurz, J. Asiat. Soc. Bengal 40: 76. 1871, [Type: *Ophiorrhiziphyllon macrobotryum* Kurz, Locality: Karen Hills]; Bentham & Hooker, Gen. Pl. 2: 1074. 1876; Clarke in Hooker, Fl. Brit. India 4: 403. 1885; Benoist in Lecomte, Fl. Indo-Chine. 4: 636. 1935; Scotland & Vollesen, Kew Bull. 55(3): 586. 2000; Hu, Deng & Daneil in Wu et al., Fl. China 19: 376. 2011.

Phyllophiorhiza Kuntze, Lexicon Gen. Phanero. 435. 1902.

Herbs, stem erect. Leaves opposite; leaf blade elliptic, ovate, or lanceolate, glabrous except on veins, abaxially pale, adaxially green, pinnately veined, base acute to sometimes rounded and sometimes decurrent, margin entire, apex acute. Racemes terminal, single or 1- or 2-branched at base, two small leaves and two bracts at base; peduncle and rachis pubescent or glandular hairy; bracts at base of pedicel, subulate but apically linear. Bracts, bracteoles, and calyx segments pubescent and glandular hairy. Calyx 5-parted; segments subequal. Corolla with annulus hairs at base of tube, 2-lipped curved; abaxial lip 3-lobed; adaxial lip 2-lobed. Fertile stamens 2, long filament, anthers 2-celled, elliptic or oblong, erect, exserted, cells divaricate, mucronate at base, parallel at equal level, longitudinally dehiscent. Ovary ovate. Stigma 2-lobed. Capsule 2-valved, with 2 row of seeds per valve and each row with many seeds.

Only 1 species has been found throughout country and this species is native to Thailand:

18. *Ophiorrhiziphyllon macrobotryum* Kurz, J. Asiat. Soc. Bengal 40: 76. 1871, [Type: Martaban, Karen hills, Taipo-moutains, Thoungyeen; Brandis s.n. (K)]; Clarke in Hooker, Fl. Brit. India. 4: 403. 1885; Benoist in Lecomte, Fl. Indo-Chine. 4: 636. 1935; Maxwell & Elliott, Fl. Doi Sutep-Pui Nat. Park 108. 2001; Hu, Deng & Daniel in Wu et al., Fl. China 19: 376-377. 2011. Figures 5.39-5.40.

Ophiorrhiziphyllon poilanei Benoist, in Lecomte, Fl. Indo-Chine 4: 637. 1935, [Type: Laos, NE Muong Ngai, Luang Prabang; Poilane 20703 (L)].

___*Ophiorrhiziphyllon poilanei* Benoist & Benoist, Not. Sys. 5: 107. 1936.

Herbs, up to 40 cm tall, erect, unbranched, puberulous. **Leaves** opposite-decussate; petioles 2-4 cm long; blade elliptic, 7-15 by 3-5 cm, apex acute or acuminate, base cuneate or acute, glabrous, secondary veins 7-10 pairs, opposite or alternate. **Inflorescence** terminal racemes; bracts 2, lanceolate to elliptic or leaf-like, 0.4 by 0.1 cm, pubescent; pedicels ca. 0.1 cm long; bracteoles 2, linear, 0.1-0.4 cm long, pubescent. **Flowers** up to 1 by 0.5 cm, zygomorphic, tubular with a ring white hairs. **Calyx** lobes 5, subequal, 0.2 cm long, with glandular hairs. **Corolla** lobes 5 (2 adaxial, 3 abaxial), yellowish white or pale rose, elliptic, 0.2 by 0.2 cm, apex obtuse. **Stamens** exserted, anthers oblong, 0.15 cm long, filaments, 0.8 cm long, glabrous; staminodes 2, ca. 0.1 cm long. **Ovary** oblong, glabrous; style 0.8 cm long, glabrous. **Fruits** capsule brown, up to 0.35-0.55 by 0.2 cm, glabrous. **Seeds** 8-10, brown, orbicular, ca. 0.1 cm in diameter.

Thailand.--- NORTHERN: **Chiang Mai**, Doi Suthep, 19 Feb. 1911, A.F.G. Kerr 1678 (**BM**, **C**, **K**, **L**), 28 Feb. 1915, A.F.G. Kerr 3536 (**BM**, **E**, **K** 2 sheets), 28 Oct. 1949, P. Suvarnakoses 97 (**BKF**, **K**), 10 Mar. 1966, B. Sukkri 75 (**BKF**, **L**), 16 Feb. 1989, J.F. Maxwell 89-206 (**BKF**, **L**), 13 Mar. 2000, J.F. Maxwell 00-125 (**BKF**, **L**), 12 Feb. 1958, T. Sørensen, K. Larsen & B. Hansen 6898 (**BKF**, **C**), 10 Mar. 1966, C. Chermsirivathana 481 (**BK**), Pangboh, 9 Mar. 1965, T. Smitinand 8675 (**BK**, **BKF**, **K**), Doi Angka, 2 Mar. 1931, H.B.G. Garrett 654 (**BKF**, **C**, **K** 2 sheets, **L**), Doi Inthanon NP, 11 Dec. 1984, H. Koyama et al. 48860 (**BKF**), 26 Feb. 1979, T. Koyama, C. Phengklai, C. Niyomdham, M. Tamura, H. Okada & P.J. O'Connor 15555 (**AAU**, **BKF**), 4 Feb. 1998, F. Konta & C. Phengklai 3958 (**BKF**), 7 Jan. 1998, P. Srisanga, C. Puff & W. Pongamornkul 98 (**BKF**, **QBG**), 30 Jan 1996, W. Nanakorn et al. 5900 (**QBG**) & 5933 (**QBG**), 18 Feb. 1999, P. Suksathan 1576 (**QBG**), 12 Feb. 2001, K. Chayamarit 2380 (**BKF** 2 sheets), 3 Feb. 1978, B. Lojtnant & C. Niyomdham 131 (**AAU**), Doi Fah Hom Pok, 12 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33414 (**BKF**, **C**, **K**, **L**) & 33455 (**BKF**), Mae Sao-Fang, 11 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33357 (**BKF**, **L**), Thung Jo, 8 Mar. 1978, C. Niyomdham 63 (**AAU**, **BKF** 2 sheets, **K**), Doi Chong, 18 Feb. 1968, B. Hansen & T. Smitinand 12648 (**C**), Doi Khun Huai Pong, 4 Mar. 1968, B. Hansen & T. Smitinand 12817 (**BKF**, **C**, **E** 2 sheets), Mon Tha Thong waterfall, Mar. 1997, K. Chayamarit & C. Phathanacharoen 662 (**BKF**), Doi Lohn, 2 Mar. 1997, J.F. Maxwell 97-170 (**BKF**), Doi Chiang Dao, 4 Mar. 1995, J.F. Maxwell 95-211 (**BKF**, **L**), 15 Feb. 1990, J.F. Maxwell 90-210 (**L**), Chom Thong, 9 Mar. 1991, J.F. Maxwell 91-252 (**E**, **L**); **Chiang Rai**, Doi Tung, 16 Feb. 2005, J.F. Maxwell 05-129 (**BKF**); **Kamphaeng Phet**, Mae Wong NP, 15 Dec. 1998, M. van de Bult 194 (**BKF**); **Mae**

Hong Son, Mae Sariang, 2 Mar. 1991, J.F. Maxwell 91-213 (**E**, **L**); **Nan**, Doi Wao, 25 Feb. 1912, A.F.G. Kerr 2453 (**BM**, **E**, **K**), Doi Phuka, 25 Feb. 1921, A.F.G. Kerr 4910 (**AAU**, **BK**, **BM**, **K**), 20 Feb. 1989, T. Santisuk 6928 (**BKF**), 11 Feb. 1999, P. Srisanga 476 (**BKF**, **QBG**), 12 Jan. 2000, P. Srisanga 1270 (**QBG**), 15 Jan. 2002, P. Srisanga 2345 (**BKF**, **QBG**), 13 Jan. 2011, T. Choopan 2011-135 (**BKF**, **SUT**), Pab Dalm waterfall-Mae Wang, 18 Mar. 2004, J.F. Maxwell 04-154 (**BKF**).

Distribution.--- China, Myanmar, Thailand, Laos, Vietnam.

Ecology.--- In shaded hill evergreen forest with moisture, at 800-1,400 m altitude. Flowering: January-March.

Vernacular.--- Butsaba Doi Phuka (บุษบาดอยภูคา) (Researcher).

Notes.--- *O. macrobotryum* is distinguished from genus *Staurogyne* by 2 longer fertile stamens exserted with oblong anther, the sterility of the shorter ones, and the dehiscence of the thecae by very short slits (but if Benoist is right in referring to this genus a species of *O. hypoleucum* provided with 4 fertile stamens and with thecae dehiscing by slits extending from top to base, so in these characters it shows an approach to *Staurogyne*; the difference is reduced to a single point, viz., the exsertion of the stamens, and this can hardly be regarded as sufficient to justify the maintenance of the genus), corolla zygomorphic (conspicuously 2-lipped), corolla tubular with a ring of white hairs. However, the presence of psilate tectum in pollen is an important character for maintaining a separate genus.

Figure 5.39 *Ophiorrhiziphyllon macrobotryum* Kurz.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.40 *Ophiorrhiziphyllon macrobotryum* Kurz.

A: habit, B: dried inflorescence with opened flowers.

Staurogyne Wall.

Staurogyne Wall., Pl. Asiat. Rar. 2: 80, t. 86. 1831. [Type: *Staurogyne argentea* Wall., Locality: Sillet]; Endlicher, Gen. Pl. 708. 1839; Kuntze, Rev. Gen. Pl. 2: 497. 1891; Ridley, Fl. Malay Penin. 2: 558. 1923; Benoist in Lecomte, Fl. Indo-Chine. 4: 622. 1935; Bremekamp, Reinwardtia 3: 163. 1955; Leonard, Contr. US Natl. Herb. 31: 5. 1958; Scotland & Vollesen, Kew Bull. 55(3): 588. 2000; Deng, Gao, & Xia, Fl. Hong Kong 3: 163. 2009; Hu, Deng & Daniel in Wu et al., Fl. China 19: 372. 2011.

Note: The name derived from “stauros”, a cross, and “gyne”, woman, i. e., pistil in allusion to the 3-lobed cross-shaped stigma (Leonard, 1958).

___*Ebermaiera* Nees, in Wallich, Pl. Asiat. Rar. 3: 75, 79. 1832; Bentham & Hooker, Gen. Pl. 2: 1074. 1876; Clarke in Hooker, Fl. Brit. India 4: 395. 1885; Champluvier, Bull. Jard. Bot. Nat. Belgique 61(1/2): 98. 1991; Scotland & Vollesen, Kew Bull. 55(3): 584, 588. 2000.

___*Ebermeyera* Nees & *Ebermayera* Nees, Endlicher, Gen. Pl. 698. 1839; Miquel, Fl. Ind. Bat. 2: 772. 1856.

Note: the genus *Ebermaiera* was named for Henrich Ebermaier, a German physician of Dusseldorf, who, in collaboration with Frederich Nees, wrote and edited a Handbook of Medical-pharmaceutical Botany. Type species: *E. humilis* Nees. Type locality: Burma (Leonard, 1958).

Ancistrostylis T. Yamazaki, J. Japanese Bot. 55(1): 1. 1980. [Type: *Ancistrostylis harmandii* (Botani) Yamazaki]; Scotland & Vollesen, Kew Bull. 55(3): 582, 588. 2000.

Erythracanthus Nees, in Wallich, Pl. Asiat. Rar. 3: 75, 80. 1832, [Type: *Erythracanthus racemosus* Nees, Locality: Penang]; Endlicher, Gen. Pl. 698. 1839; Champluvier, Bull. Jard. Bot. Nat. Belgique 61(1/2): 98. 1991; Scotland & Vollesen, Kew Bull. 55(3): 584, 588. 2000.

Note: The name is derived from "erythros", red, and "acanthus", in allusion to the deep red-purple color of the lower surface of the leaf blades (Leonard, 1958).

Neozenkerina Mildbraed, Notizbl. Bot. Gart. Mus. Berlin-Dahlem 7: 491. 1921. [Type: *Neozenkerina bicolor* Mildbr., Locality: Südkameruner]; Champluvier, Bull. Jard. Bot. Nat. Belgique 61(1/2): 98. 1991; Scotland & Vollesen, Kew Bull. 55(3): 586, 588. 2000.

Staurogynopsis Mangenot & Aké Assi, Bull. Jard. Bot. Etat Bruxelles 29: 27. 1959 [Type: *Staurogynopsis paludosa* Mangenot & Aké Assi, Locality: Yapo, Côte d'Ivoire]; Champluvier, Bull. Jard. Bot. Nat. Belgique 61(1/2): 98. 1991; Scotland & Vollesen, Kew Bull. 55(3): 588. 2000.

Stiftia Pohl ex Nees, in Candolle Prodr. 11: 70. 1847a nom. nud.; Champluvier, Bull. Jard. Bot. Nat. Belgique 61(1/2): 98. 1991.

Zenkerina Engler, Bot. Jahrb. Syst. 23(4): 497. 1897. [Type: *Zenkerina kamerunensis* Engl., Locality: Kamerun]; Champluvier, Bull. Jard. Bot. Nat. Belgique 61(1/2): 98. 1991; Scotland & Vollesen, Kew Bull. 55(3): 588, 589. 2000.

Herbs, annual or perennial or rarely subshrubs. Stem usually single, decumbent from base or procumbent, ascending from roots, sometimes nearly erect or erect, shrubby at base. Leaves opposite or apically on stem alternate, usually petiolate; leaf blade pinnately veined, margin usually entire. Inflorescences racemes or spikes, terminal or axillary; simple or compound, dense or lax, rarely capitate; bracts at base of pedicel spirally arranged, leaflike or overtopping flowers or small and inconspicuous. Bracteoles 2, near the base of calyx, similar to calyx segments or smaller and narrower than bracts, 1-veined. Calyx deeply 5-parted; segments subequal or unequal, occasionally adaxial one larger and broader. Corolla tube cylindrical, throat narrow, nearly campanulate, lobes of limb equal, sometimes slightly 2-lipped. Stamens 4, didynamous, included; filaments hairy, hirsute towards apex or rarely glabrous; anther cells globose or nearly so, base with an appendage, connective short, enlarged, and abaxially hirsute. Staminodes unequal, filamentous, sometimes absent. Disc inconspicuous. Ovary 2-celled, with 12--60 ovules in 2 (or 4) columns. Style glabrous; stigma 2 or 3-lobed, lobes equal or not. Capsule oblong, with 12--60 seeds, valves compressed, apex acute to slightly obtuse, no retinacula. Seed globose, ultimately nearly smooth or with obscure shallow pits.

Approximately 27 species have been found throughout the country and all of them are native to Thailand:

KEY TO THE SPECIES

1. Inflorescence capitate

2. Flower ≤ 1 cm long, corolla white with red patch at lobe base,

stem ≤ 10 cm tall **40. *S. setigera***

2. Flower > 1 cm long, corolla white without red patch at lobe base,

stem > 10 cm tall

3. Corolla tube glabrous, staminode 0 **19. *S. argentea***

3. Corolla puberulous, staminode 1 **20. *S. aristata***

1. Inflorescences raceme or panicle

4. Inflorescence dense raceme, unbranched

5. Bract > 0.3 cm wide

6. Leaves oblanceolate

7. Bract 0.3-0.5 cm wide, filament ≤ 0.7 cm long, puberulous,

staminode 1 **23. *S. densifolia***

7. Bract > 0.5 cm wide, filament > 0.7 cm long, glandular hairs,

staminode 0 **28. *S. helferi***

6. Leaves elliptic or lanceolate

8. Calyx and corolla puberulous, filament glabrous, staminode 1

27. *S. griffithiana*

8. Calyx and corolla glabrous, filament with glandular hairs,

staminode 0

9. Bract puberulous, calyx unequal > 0.3 cm long, corolla white

24. *S. dispar*

9. Bract glabrous, calyx subequal ≤ 0.3 cm long, corolla pink or pale rose **22. *S. cuneata***

5. Bract ≤ 0.3 cm wide

10. Leaves lanceolate, stem unbranched or rarely branched

11. Staminode 1, inflorescence, bract, calyx, corolla with glandular hairs **38. *S. parvicaulis***

11. Staminode 0, inflorescence, bract, calyx, corolla puberulous **31. *S. lanceolata***

10. Leaves elliptic or spatulate, stem always branched

12. Calyx puberulous, stem decumbent ≤ 10 cm tall **36. *S. incana***

12. Calyx with glandular hairs, stem erect > 10 cm tall

13. Bract and filament puberulous **33. *S. longeciliata***

13. Bract and filament with glandular hairs

14. Inflorescence > 3 cm long, corolla lobes straight, calyx unequal, leaves densely puberulous **42. *S. spatulata***

14. Inflorescence ≤ 3 cm long, corolla lobes curved, calyx subequal, leaves glabrous **26. *S. glauca***

4. Inflorescence lax raceme, branched

15. Stem ≤ 10 cm tall, decumbent ascending or short

16. Leaves lanceolate or oblanceolate, ≤ 2.5 cm wide

17. Inflorescence ≤ 5 cm long, corolla white with pink lobes **41. *S. singularis***

17. Inflorescence > 5 cm long, corolla purple **21. *S. concinnula***

16. Leaves broadly elliptic or oblong, > 2.5 cm wide

18. Calyx subequal, leaves membranous with upper surface puberulous **37. *S. obtusa***

18. Calyx unequal, leaves coriaceous with upper surface glabrous

19. Calyx, corolla, and filament puberulous **35. *S. merguensis***

19. Calyx, corolla, and filament with glandular hairs **44. *S. tenuispica***

15. Stem > 10 cm tall, erect

20. Stem and leaves puberulous **25. *S. filipes***

20. Stem and leaves glabrous

21. Bract and calyx > 1 cm long **29. *S. kingiana***

21. Bract and calyx ≤ 1 cm long

22. Corolla white, calyx glabrous

23. Calyx ≤ 0.5 cm long, filament with glandular hairs, staminode 1, leaves ≤ 2 cm wide **30. *S. puncata***

23. Calyx > 0.5 cm long, filament puberulous, staminode 0, leaves > 2 cm wide, **43. *S. subglabra***

22. Corolla other colors, calyx hairy

24. Corolla one anterior lobe with white tip, staminode 0, leaves showing white areas along vein **32. *S. lasiobotrys***

24. Corolla lobes without white tip, staminode 1, leaves never white along vein

25. Flower ≤ 1 cm long, bract with glandular hairs **45. *S.* sp3**

25. Flower > 1 cm long, bract puberulous

26. Filament puberulous, calyx > 0.5 cm long **34. *S. major***

26. Filament with glandular hairs, calyx ≤ 0.5 cm long **39. *S. racemosa***

19. *Staurogyne argentea* Wall., Pl. Asiat. Rar. 2: 80, t. 86. 1831, [Type: India, Sillet; N. Wallich cat. no. 4905 (E, K!)]. Figures 5.41-5.42.

___*Ebermaiera argentea* (Wall.) Nees, in Candolle, Prodr. 11: 76. 1847a, [Type: India, Sillet, Tavoy; Wallich s.n., Malacca; Griffith s.n.]; Miquel, Fl. Ind. Bat. 2: 773. 1856.

Staurogyne argentea Wall. var. *brevi-aristata* J. B. Imlay, Bull. Misc. Inform. Kew 1939(3): 109. 1939. [Type: Thailand, Pato-Langsuan, Chumphon, 1 March 1927, A.F.G. Kerr 12171 (holotype! ABD); Ranong, 20 January 1929, A.F.G. Kerr 17523 (paratype! K)].

Herbs, up to 30 cm tall, erect, unbranched. **Leaves** opposite-decussate; petioles 1-3.5 cm long; blade elliptic, 10-15 by 3-5 cm, apex acute or acuminate, base cuneate or acute, glabrous, secondary veins 9-11 pairs, opposite or alternate. **Inflorescence** terminal capitates; bract 1, elliptic, 1.2 by 0.2 cm; pedicels 0.1-0.2 cm long; bracteoles 2, linear, ca. 1.2 cm long, glabrous or puberulous only at basal margin. **Flowers** up to 1.5 by 1 cm, actinomorphic, tubular with reddish purple lines in throat. **Calyx** lobes 5, unequal (2 short, 3 long), linear, 1-1.5 cm long, glabrous or puberulous only at basal margin. **Corolla** lobes 5, white, elliptic, 0.5 by 0.3 cm, apex obtuse, glabrous. **Stamens** included, anthers globose, 0.15 cm in diameter, filaments 0.8-1 cm long; staminodes 0. **Ovary** oblong, glabrous; style 0.8 cm long, glabrous; stigma 3-lobed. **Fruits** capsule brown, up to ca. 0.7 by 0.2 cm, glabrous. **Seeds** 8-10, brown, orbicular, ca. 0.1 cm in diameter.

Thailand.--- PENINSULAR: **Chumphon**, Tasae, 22 Dec. 1928, A.F.G. Kerr 16280 (**BK**, **BM**, **K**), Pha To-Langsuan, 1 Mar. 1927, A.F.G. Kerr 12171 (holotype! **ABD**), 3 Mar. 1927, A.F.G. Kerr 12187 (**BK**, **BM**, **C**, **L**), Thung Maphrao, 19 Jul. 1972, K. Larsen, S.S. Larsen, I. Nielsen & T. Santisuk 31155 (**AAU**, **BKF**, **C**, **K**); **Krabi**, Nai Chong, 24 May 1960, C. Chermsirivathana 62 (**BK**); **Nakhon Si Thammarat**, Thung Song, 24 Jul. 1929, Rabil 184 (**BK**, **BM**, **K**), Ronphibun, Feb. 1922, E. Smith 433 (**BK**, **BM**); **Narathiwat**, Janae, 17 Mar. 1985, C. Niyomdham 865 (**K**); **Pattani**, Betong, 13 Aug. 1923, A.F.G. Kerr 7618 (**BK**); **Phangnga**, Nang Manora waterfall, 1990, P. Sirirugsa 1207 (**C**), Khao Phra Mi, 6 Jul. 1972, K. Larsen & S.S. Larsen, I. Nielsen & T. Santisuk 30690 (**E**), Khao Lum Phee, 22 Jun. 2006, K. Williams, R. Pooma, M. Poopath 2057 (**BKF**); **Phatthalung**, Khao Den, 19 Apr. 1928, A.F.G. Kerr 15313 (**BK**, **BM**, **K**), Khao Soi Dao, 29 Apr. 1930, A.F.G. Kerr 19225 (**BK** 2 sheets, **BM**, **K**); **Ranong**, 20 Jan. 1929, A.F.G. Kerr 17523 (paratype! **K**), 2 May 1974, K. Larsen & S.S. Larsen 33574 (**AAU**), Khao Phota Luangkaeo, 29 Nov. 1974, C.F. van Beusekom, P. Hiepko & C. Phengklai 7702 (**L**); **Surat Thani**, Khao Sok NP, 15 Sep. 1994, P.C. Boyce 972 (**K**), 25 Oct. 1990, K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa 40902 (**AAU**, **C**) & 40908 (**AAU**), 17 May 2011, T. Choopan 2011-258 (**BKF**, **SUT**); **Trang**, Chawng, 12 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 605 (**C**), 24 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 583a (**C**), Khao Chong, 13 Nov. 1990, K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa 41309 (**AAU**), 14 Apr. 1928, A.F.G. Kerr 15180 (**BM**, **BK**, **K**), 9 Oct. 1970, C. Charoenphol, K. Larsen & E. Warncke 3512 (**AAU**, **K**), 11 Aug. 1975, J.F. Maxwell 75-758 (**AAU**, **BK**, **L**), 17 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T.

Yahara & T. Santisuk 27471 (**BKF** 2 sheets), 5 Aug. 1975, S. Sutheesorn 3360 (**BK**), 8 Mar. 1976, C. Chermsirivathana 2200 (**BK**), 15 Jul. 2003, P. Chantaranothai s.n. (**KKU**), 16 Nov. 1969, B. Sangkhachand 2152 (**BK**), 2 Dec. 1969, S. Phusomsaeng & S. Pinnin 322 (**BKF**, **L**).

Distribution.--- India, Nicobar, Myanmar, Malaysia, Thailand.

Ecology.--- In shaded moist evergreen forest, at 100-500 m altitude. Flowering: March-May.

Vernacular.--- Krab (กราบ) (Peninsula).

Notes.--- This species distinct by the larger white flowers in capitate inflorescences within the same genus.

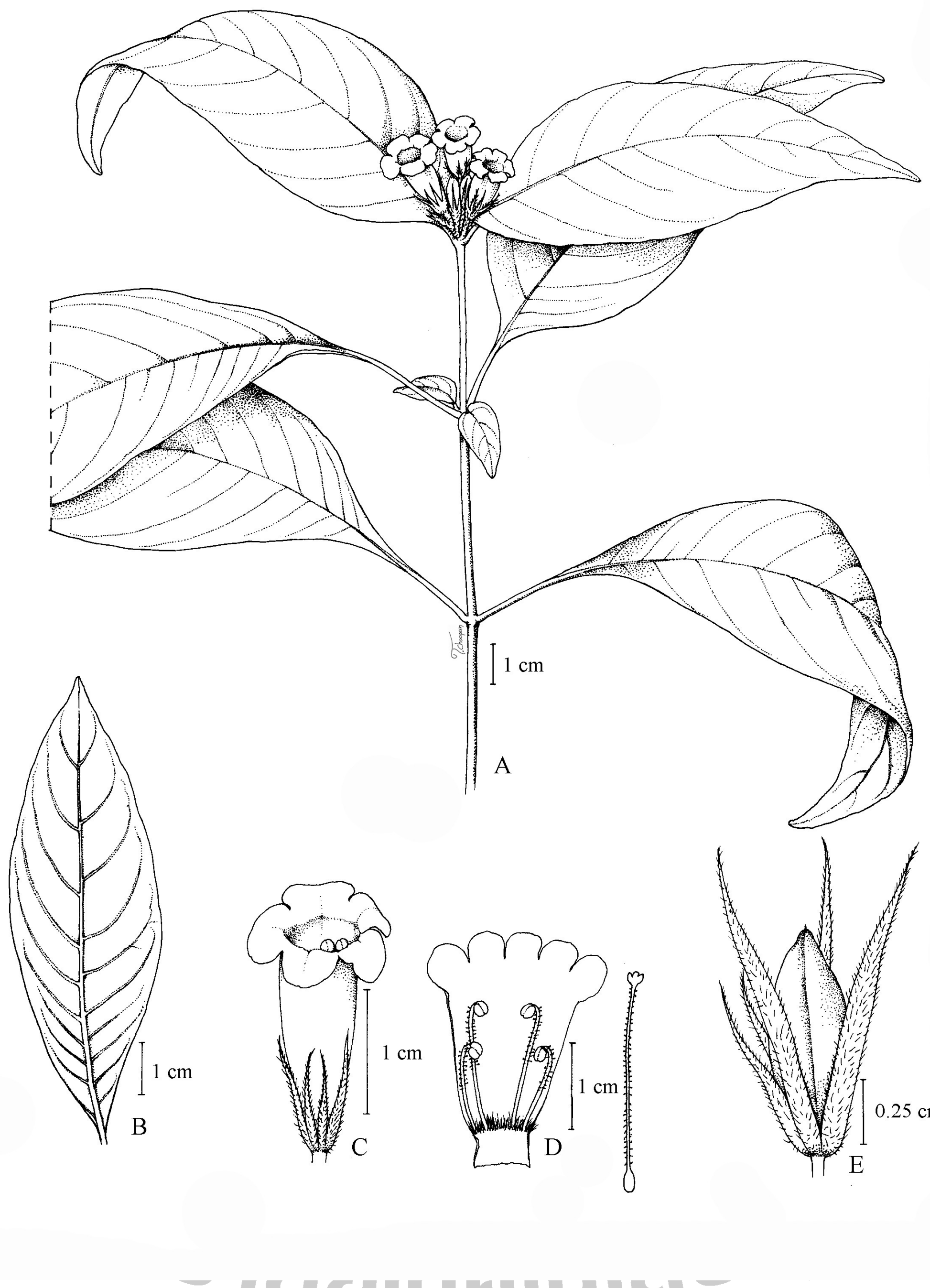


Figure 5.41 *Staurogyne argentea* Wall.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.42 *Staurogyne argentea* Wall.

A: habit, B: inflorescence with opened flowers.

20. *Staurogyne aristata* E. Hossain., Notes Roy. Bot. Gard. Edinburgh 31(3): 383. 1972, [Type: Thailand, Trang, Ton Nam Pliew, 14 November 1959; T. Smitinand & E.C. Abbe 6139 (holotype! K)]. Figures 5.43-5.44.

Herbs, up to 18 cm tall, erect, unbranched, puberulous. **Leaves** opposite-decussate; petioles 1-2.5 cm long; blade elliptic, 10-15 by 4-8 cm, apex acute or nearly obtuse, base cuneate or acute, puberulous on vein underneath, secondary veins 9-11 pairs, opposite or alternate. **Inflorescence** terminal capitate; bracts 2, elliptic or leaf-like, 3 by 1 cm, puberulous; pedicels 0.1-0.2 cm long, puberulous; bracteoles 2, linear, ca. 1.4 by 0.1-0.2 cm, puberulous. **Flowers** up to 2 by 1 cm, actinomorphic, tubular puberulous outside. **Calyx** lobes 5, unequal (2 short, 3 long), linear, 0.8-1.5 cm long, puberulous. **Corolla** lobes 5, white, elliptic, 0.4-0.5 by 0.3-0.4 cm, apex obtuse, puberulous. **Stamens** included, anthers globose, 0.15 cm in diameter, filaments, 0.8-1 cm long, with glandular hair; staminodes 1, 0.1-0.3 cm long. **Ovary** oblong, glabrous; style 2 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.55 cm long, 0.2 cm wide, puberulous. **Seeds** 24-28, brown, orbicular, ca. 0.1 cm in diameter.

Thailand.--- PENINSULAR: **Trang**, Ton Ngam Pliew, 22 Aug. 1955, P. Suvarnakoses 872 (**BKF**, **E**), 14 Nov. 1959; T. Smitinand & E.C. Abbe 6139 (**BKF**, holotype! **K**)].

Distribution.--- Endemic to Thailand.

Ecology.--- In shaded moist evergreen forest along stream, at 100-200 m altitude.

Vernacular.--- Krab Khon (กราบขน) (Researcher).

Notes.--- This species was distinguished from *S. argentea* by broader leaves with short hairs on vein underneath, bracts, bracteoles, calyx and corolla puberulous, the stigma 2-lobed, and the filaments with glandular hairs. Moreover, Hossain said that their leaves conspicuously present sclereids.

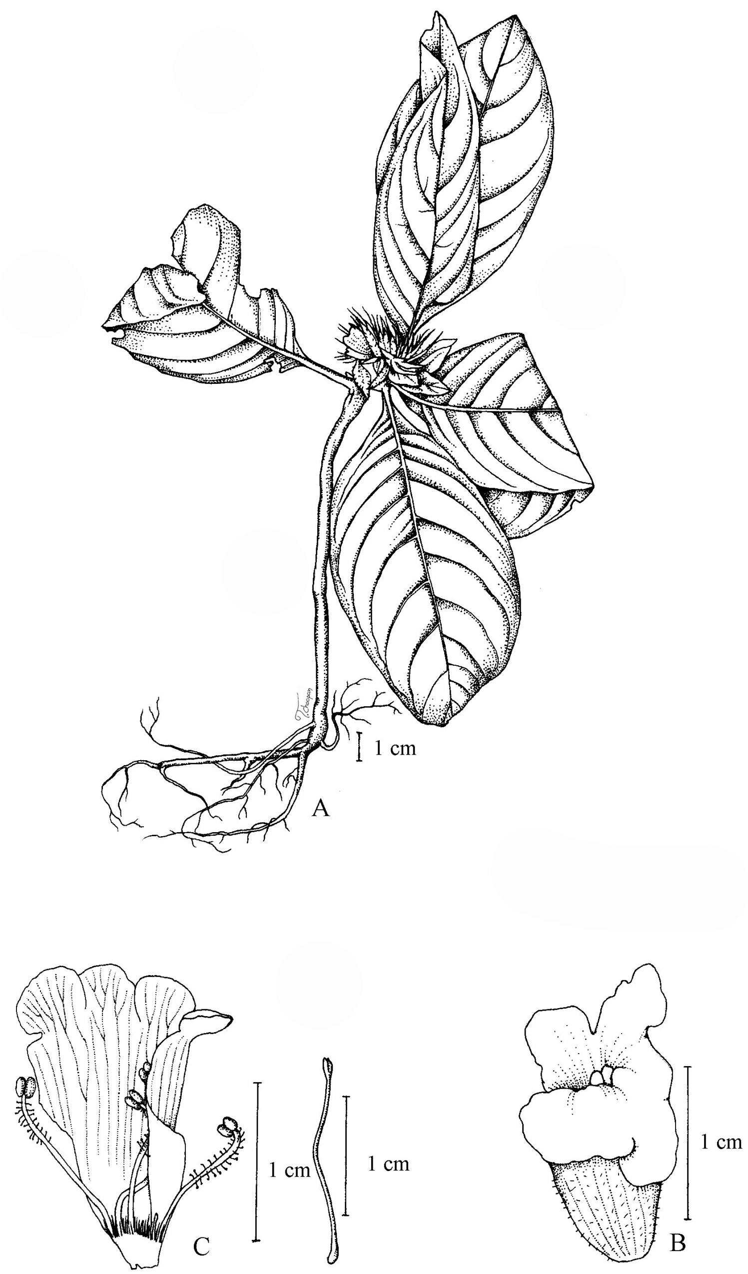


Figure 5.43 *Staurogyne aristata* E. Hossain.

A: habit, B: flower, C: pistil and stamens.

A

B

Figure 5.44 *Staurogyne aristata* E. Hossain.

A: herbarium sheet (type!), B: dried inflorescence with opened flowers.

21. *Staurogyne concinnula* (Hance) Kuntze, Rev. Gen. Pl. 2: 497. 1891, [Type: see *Ebermaiera concinnula*]; Chayamarit, Pl. Khao Yai Nat. Park 210. 2006; Deng, Gao, & Xia, Fl. Hong Kong 3: 163. 2009; Hu, Deng & Daniel in Wu et al., Fl. China 19: 375. 2011. Figures 5.45-5.46.

___*Ebermaiera concinnula* Hance, in Seemann, J. Bot. 6(70): 300-301. 1868, [Type: China, Cantoniensis, Tsui-ngam, Sai-chÜ-shan, Aril 1866; G. T. Sampson 13021 (BM, isotype! GH, K)].

___*Staurogyne concinnula* (Hance) Matsumura, Pl. Jap. 2: 581. 1912.

Staurogyne rosulata Bremek., Dansk Bot. Ark. 23: 198. 1965b, [Type: Thailand, Prachinburi, Khao Khieo, 20 July 1963; K. Larsen 10656 (AAU, isotype! C, E, K, L, U)].

Staurogyne subrosulata E. Hossain, Notes Roy. Bot. Gard. Edinburgh 31(3): 385. 1972 [Type: Thailand, Nakhon Nayok-Salika waterfall, 14 August 1968 K. Larsen, T. Suntisuk & E. Warncke 3398 (AAU)].

Herbs, very short, unbranched. **Leaves** rosette; petioles 0.5-2.3 cm long; blade oblanceolate or spathulate, 1.2-7 by 0.4-1.8 cm, apex obtuse, base cuneate or attenuate, puberulous, secondary veins 5-7 pairs, opposite or alternate. **Inflorescence** axillary racemes, up to 15 cm long; bracts 2, linear, 0.2-0.4 by 0.1-0.2 cm; pedicels 0.1-0.2 cm long; bracteoles 2, linear, ca. 0.2 cm long. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular funnel-form. **Calyx** lobes 5, linear, unequal, 0.5-0.6 cm long, puberulous. **Corolla** lobes 5, purple, elliptic, 0.3 by 0.1 cm, apex obtuse, glabrous.

Stamens included, anthers globose, 0.15 cm in diameter, filaments 0.25-0.5 cm long, with glandular hiars; staminode 1. **Ovary** oblong, glabrous; style 0.5 cm long, glabrous; stigma 3-lobed. **Fruits** capsule brown, up to 0.4-0.5 by 0.15 cm. **Seeds** 8-10, brown, orbicular, ca. 0.2 cm in diameter.

Thailand.--- EASTERN: **Nakhon Ratchsima**, Khao Yai NP, 11 Dec. 1962, C. Phengklai 446 (**BKF**), 6 Jan. 1963 C. Phengklai 696 (**BKF**, **K**, **L**), 22 Oct. 1969, C.F. van Beusekom & C. Charoenphol 1828 (**AAU**, **BKF**, **C**, **E**, **K**, **L**), 6 May 2011, 2 Dec. 1983, N. Fukuoka & M. Ito 34984 (**BKF**), 7 Jul. 1966, anonymous 54 (**BKF**), 4 May 1964, C. Harnlananda 179 (**BKF**), 6 Oct. 1962, T. Smitinand 7456 (**BKF**), 7 Oct. 1962, T. Smitinand 7514 (**BKF**, **L**), 18 Jul. 1973, G. Murata, N. Fukuoka & C. Phengklai 16249 (**BKF**, **L**), 19 Jul. 1973, G. Murata, N. Fukuoka & C. Phengklai 16313 (**AAU**, **BKF**, **L**), 16331 (**L**) & s.n. (**BKF**), 6 May 2011, T. Choopan 2011-217 (**BKF**, **SUT**), 18 Aug. 1964, S. Suthisorn 1 (**BK**), Kong Kaeo waterfall, 12 Aug. 1974, J.F. Maxwell 74-793 (**AAU**, **BK**, **L**), Orchid waterfall, 31 Oct. 1970, C. Charoenphol, K. Larsen & E. Warncke 4386 (**AAU**, **BKF**, **L**), Pak Chong, 20 Nov. 1982, H. Koyama, H. Terao, C. Niyomdham & T. Wongprasert 30126 (**BKF**, **C**, **L**), 18 Nov. 1982, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk 30014 (**BKF**, **C**, **L**);--- CENTRAL: **Nakhon Nayok**, Khao Yai NP, 8 Oct. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk 19554 (**BKF** 2 sheets, **L**) & 19578 (**BKF**, **C**, **L**), 9 Oct. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk 19726 (**BKF** 2 sheets, **C**, **L**), 10 Oct. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk 18127 (**BKF** 2 sheets, **L**), Pha Ta-Baek, 14 Oct. 1984, G. Murata, C. Phengklai, S. Mitsuta, H. Nagamasu & N. Nantasan 52385

(**BKF**), Pha Deo Dai, 14 Aug. 2000, J.F. Maxwell 00-402 (**L**), Sarika waterfall, 14 Aug. 1968, K. Larsen, T. Santisuk & W. Warncke 3398 (type! **AAU**);--- SOUTH-EASTERN: **Prachin Buri**, Khao Khieo, 20 Jul. 1963, K. Larsen 10656 (type! **AAU**, **C**, **E**, **K**, **L**), 8 Mar. 1964, B. Hansen, G. Seidenfaden & T. Smitinand 11380 (**BKF**, **C**), 7 Jul. 1966, K. Larsen, T. Smitinand & E. Warncke 22 (**AAU**) & 54 (**AAU**), 8 Jul. 1966, K. Larsen, T. Smitinand & E. Warncke 103 (**AAU**), 9 Jul. 1966, K. Larsen, T. Smitinand & E. Warncke 165 (**AAU**, **BKF**), 7 Sep. 2002, J.F. Maxwell 02-311 (**BKF**, **L**).

Distribution.--- China, Taiwan, Hongkong, Japan, Thailand, Vietnam.

Ecology.--- In shaded evergreen forest, at 500-1,100 m altitude. Flowering: July-September.

Vernacular.--- Butsaba Ngam (บุษบางาม).

Notes.--- This species is only distributed at Khao Yai areas.

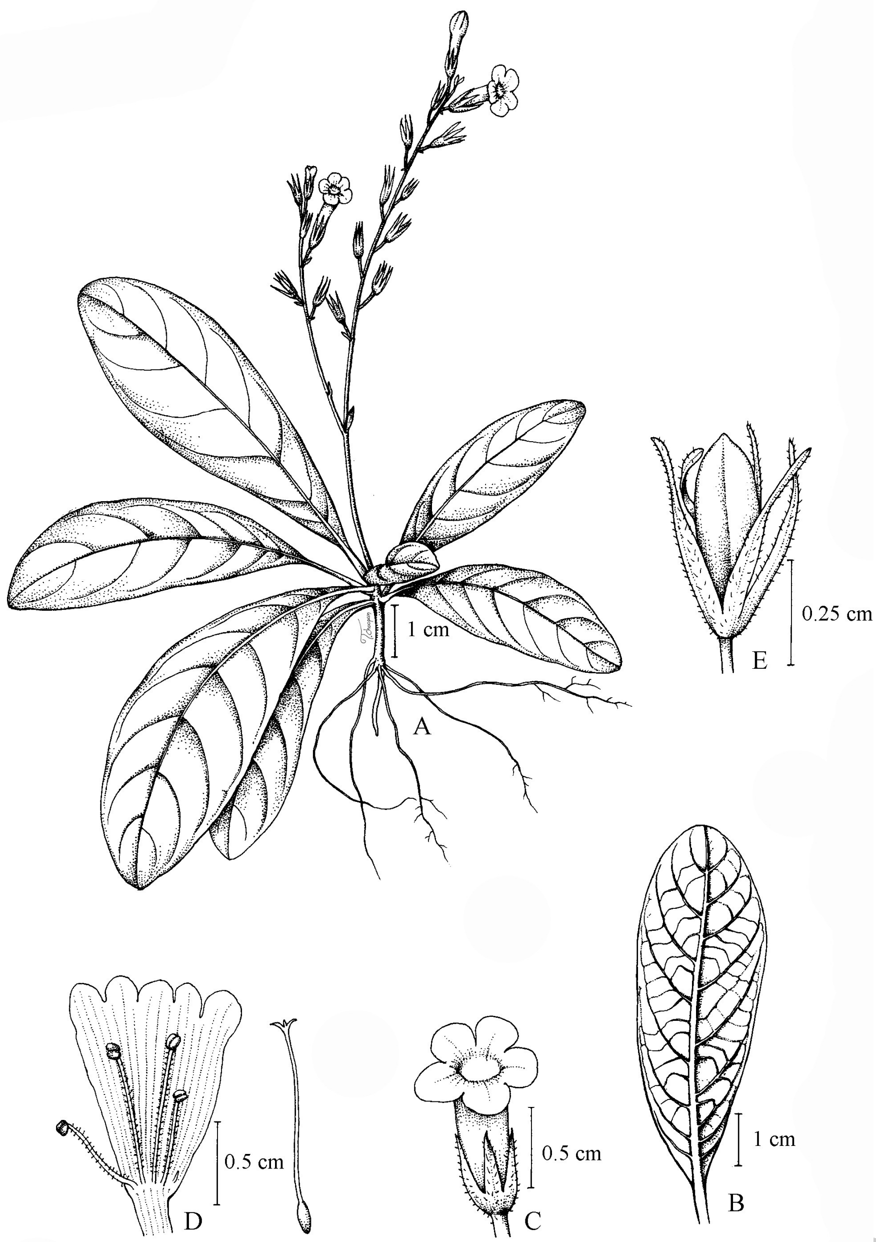


Figure 5.45 *Staurogyne concinnula* (Hance) Kuntze.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.46 *Staurogyne concinnula* (Hance) Kuntze.

A: habit, B: inflorescence with opened flower.

22. *Staurogyne cuneata* J. B. Imlay, Bull. Misc. Inform. Kew 1939: 110. 1939, [Type: Thailand, Chumphon-Khao Tong, 18 January 1927; A.F.G. Kerr 11534 (ABD, C 2 photo sheets, K)]. Figures 5.47-5.48.

Herbs, up to 25 cm tall, erect, unbranched, puberulous. **Leaves** opposite or decussate; petioles 1-2 cm long, puberulous; blade elliptic, 5-11 by 2-5 cm, apex acute or subacute, base acute or acuminate, glabrous, secondary veins 7-9 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes; bracts 1, ovate, 1-2 by 0.4-0.5 cm, puberulous; pedicels 0.1 cm long, glabrous; bracteole 2, linear, ca. 0.3 cm long. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, subequal, linear, 0.2-0.3 cm long, glabrous. **Corolla** lobes 5, pink or pale rose, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, glabrous. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 0.7 cm long, with glandular hairs; staminodes 0. **Ovary** oblong, glabrous; style 1 cm long, glabrous; stigma 3-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 10-12, brown, orbicular, ca. 0.06 cm in diameter.

Thailand.--- SOUTH-WESTERN: **Prachuap Khiri Khan**, Khao Luang, 4 Jul. 1926, A.F.G. Kerr 10811 (paratype! **ABD**, **BK**, **BM**, **C** 2 photo sheets, **K** 2 sheets);--- PENINSULAR: **Chumphon**, Khao Tong, 18 Jan. 1927, A.F.G. Kerr 11534 (type! **ABD**, **C** 2 photo sheets, **K**); **Ranong**, Khao Phota Luangkaeo, 11 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 26943 (**BKF** 2 sheets, **L**), 22 Jun. 1974, R. Geesink, T. Hattink, C.C. Charoenphol 7419 (**AAU**, **BKF**, **L**).

Distribution.--- Endemic to Thailand.

Ecology.--- In shaded evergreen forest, at 700-900 m altitude. Flowering: January-May.

Vernacular.--- Krab baipradap tai (กราบใบประดับใต้) (Researcher).

Notes.--- It can be distinguished from *S. dispar* by glabrous inflorescences, smaller rose flowers, and subequal sepals. Moreover, the leaves turned black when dried.

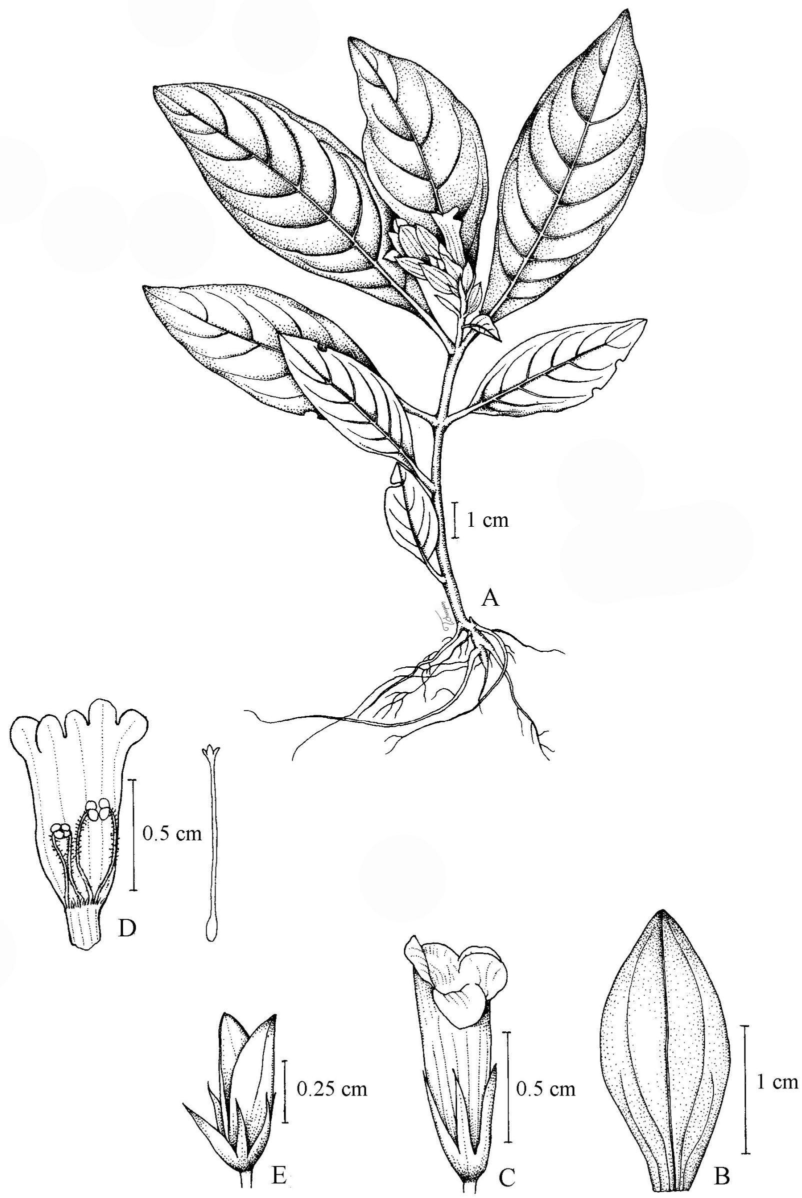
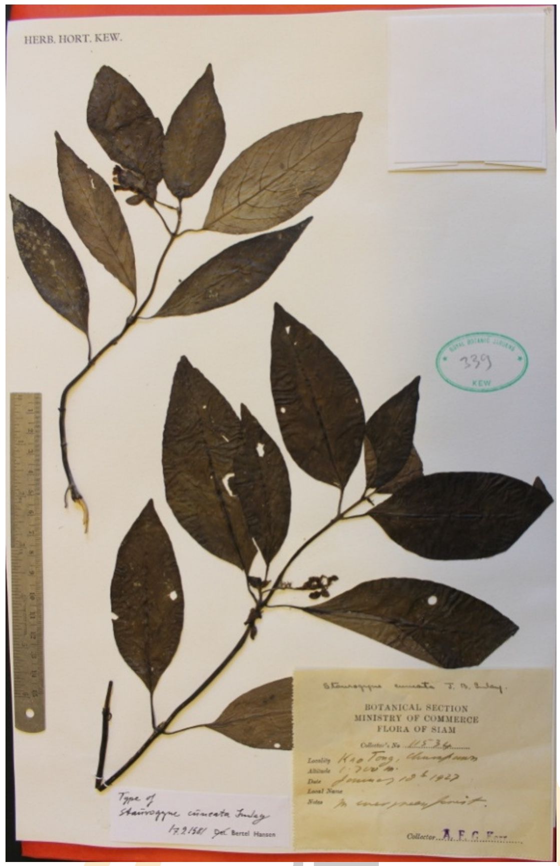


Figure 5.47 *Staurogyne cuneata* J. B. Imlay.

A: habit, B: bract, C: flower, D: pistil and stamens, E: fruit.



A

B

Figure 5.48 *Staurogyne cuneata* J. B. Imlay.

A: herbarium sheet (type!), B: dried inflorescence with opened flowers.

23. *Staurogyne densifolia* Bremek., Dansk Bot. Ark. 27: 75. 1969, [Type: Thailand, Phitsanulok, Thung Salaeng Luang, 25 July 1966; K. Larsen, T. Smitinand & E. Warncke 897 (holotype! AAU, U)]. Figures 5.49-5.50.

Herbs, short erect, rosulate, unbranched, dense puberulous. **Leaves** opposite or rosulata; petioles 1.5 cm long, puberulous; blade oblanceolate, 6.5-11 by 2-3 cm, puberulous underneath, apex obtuse, base acute, glabrous, secondary veins 6-8 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes; bract 1, ovate, 0.5-0.65 by 0.3-0.4 cm, glabrous; pedicels 0.2-0.3 cm long, puberulous; bracteoles 2, linear, ca. 0.2 cm long. **Flowers** up to 1.6 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal, linear, 1 posterior lobe 0.75 by 0.15 cm, 2 anterior lobes 0.7 by 0.12 cm, 2 lateral lobes 0.4 by 0.05 cm, glabrous. **Corolla** lobes 5, white, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, glabrous. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments, ca. 0.65-0.9 cm long, puberulous; staminode 1. **Ovary** oblong, glabrous; style 1.4 cm long, glabrous; stigma 3-lobed. **Fruits** not seen.

Thailand.--- NORTHERN: **Phitsanulok**, Thung Salaeng Luang, 25 Jul. 1966, K. Larsen, T. Smitinand & E. Warncke 897 (type! **AAU**, **C** photo sheet, **U** photo sheet).

Distribution.--- Endemic to Thailand.

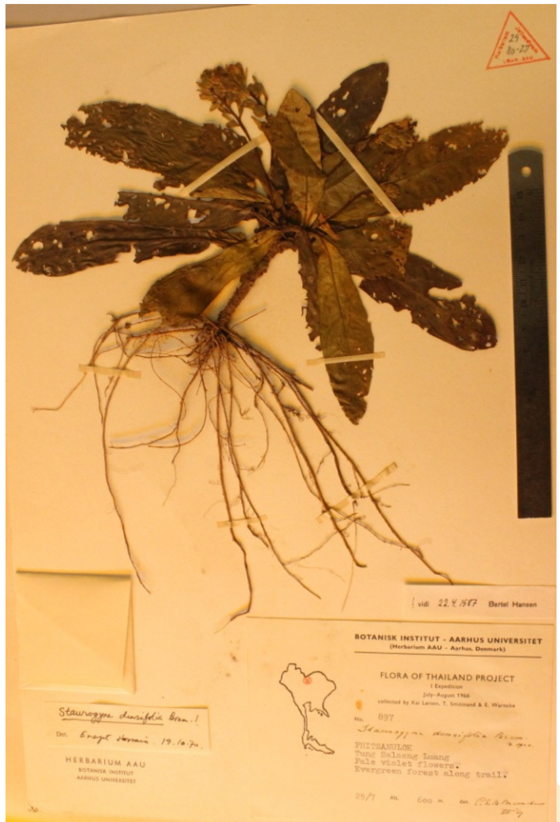
Ecology.--- In shaded evergreen forest, at 600 m altitude.

Vernacular.--- Krab Thung Salaeng Luang (กราบทุ่งแสลงหลวง) (Researcher).

Notes.--- This species resembles *S. helferi* in the comparatively large size of the bracts, of which the lower ones, moreover, are sterile and separated from each other by a much larger interval than the other ones. It shows, however, an entirely different habit, for *S. helferi* possess an ascending stem with comparatively long internodes and much larger leaves, which, moreover, on the upper side are densely though shortly pilose (instead of nearly entirely glabrous in *S. densifolia*). Furthermore, the nearest ally of this species is probably *S. rosulata* (Synonym of *S. concinnula*), a plant occurring in the central part of Thailand. It is distinguished by its on the upper side nearly glabrous and towards the base rather suddenly contracted leaf blade, by its wider bracts, and by plants provided with an inflorescence consisting of a simple raceme (instead of several racemes in *S. rosulata*).

Figure 5.49 *Staurogyne densifolia* Bremek.

A: habit, B: bract, C: pistil and stamens, D: calyx.



A

B

Figure 5.50 *Staurogyne densifolia* Bremek.

A: herbarium sheet (type!), B: dried inflorescence with opened flowers.

24. *Staurogyne dispar* J. B. Imlay, Bull. Misc. Inform. Kew 1939: 110. 1939, [Type: Thailand, Mae Hong Son-Doi Pepo, 29 June 1922; A.F.G. Kerr 6178 (BK, BM, K)]. Figures 5.51-5.52.

Herbs, up to 25 cm tall, erect, unbranched, puberulous. **Leaves** opposite or decussate; petioles 1.5-3 cm long, puberulous; blade lanceolata, 4-8 by 1.5-3 cm, apex acute or subacute, base acute or acuminate, glabrous, secondary veins 5-6 pairs, opposite or alternate. **Inflorescence** terminal racemes; bracts 1, elliptic, 1-2 by 0.4-0.5 cm, glabrous; pedicels 0.1 cm long, glabrous; bracteole 2, linear, ca. 0.4 cm long. **Flowers** up to 1.5 by 0.7 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (1 longer, 2 anterior middle, 2 lateral shorter), linear, 0.3, 0.6, 0.9 cm long, glabrous, **Corolla** lobes 5, white, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, glabrous. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 1 cm long, with glandular hairs; staminodes 0. **Ovary** oblong, glabrous; style 1.7 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 10-12, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- NORTHERN: **Mae Hong Son**, Doi Pepo, 29 Jun. 1922, A.F.G. Kerr 6178 (type! **BK**, **BM**, **K** 2 sheets); **Tak**, Doi Musor, 9 Dec. 1961, T. Smitinand 7070 (**BKF**), 31 Aug. 1967, M. Tagawa, K. Iwatsuki, H. Koyama & A. Chintayungkun 8642 (**BKF**, **C**, **L**), 23 Aug. 1961, C. Chermsirivathana 52 (**BK**), 25 Jul. 1959, F. Floto 7718 (**C**).

Distribution.--- Endemic to Thailand.

Ecology.--- In shaded evergreen forest, at 400-1,100 m altitude. Flowering: September-December.

Vernacular.--- Krab Musor (กราบมูเซอ), Krab baipradap nua (กราบใบประดับเหนือ) (Researcher).

Notes.--- It is distinguished from *S. cuneata* by puberulous inflorescences, larger white flowers, and by unequal sepals.

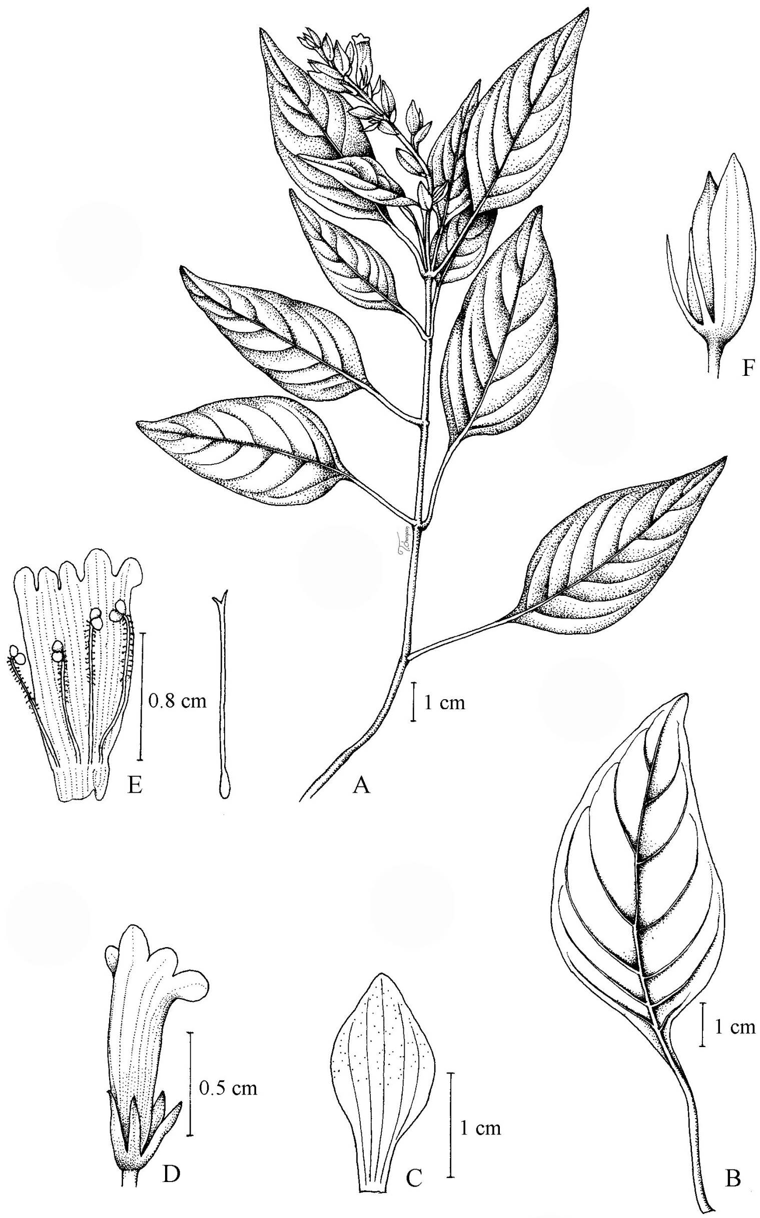


Figure 5.51 *Staurogyne dispar* J. B. Imlay.

A: habit, B: ventral leaf, C: bract, D: flower, E: pistil and stamens, F: fruit.

A

B

Figure 5.52 *Staurogyne dispar* J. B. Imlay.

A: herbarium sheet (type!), B: dried inflorescence with opened flower.

25. *Staurogyne filipes* E. Hossian, Notes Roy. Bot. Gard. Edinburgh 31(3): 383. 1972 [Type: Laos, Muang Huang, Wiengchan, 31 March 1932; A.F.G. Kerr 21771 (holotype! K); 29 March 1932; A.F.G. Kerr 20793 (BM, isotype! K)]. Figures 5.53-5.54.

Herbs, up to 35 cm tall, erect, branched or unbranched, puberulous. **Leaves** opposite or decussate; petioles 1-4.5 cm long, puberulous; blade elliptic or elliptic-lanceolata, 3-10 by 1-4 cm, apex nearly obtuse or acute, base acute, puberulous, secondary veins 7-9 pairs, opposite or alternate. **Inflorescence** terminal or axillary lax racemes, with glandular hairs; bract 1, linear or linear-lanceolate, 0.4-0.55 by 0.1 cm, with glandular hair; pedicels 0.6-0.8 cm long, with glandular hairs; bracteoles 2, linear, 0.3-0.5 cm long, with glandular hairs. **Flowers** up to 1.5 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3), 0.45-0.65 and 0.65-1.1 cm long, linear, with glandular hairs. **Corolla** lobes 5, white with purple line on throat, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, puberulous. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 0.7 cm long, with glandular hairs; staminode 1. **Ovary** oblong, glabrous; style 0.8 cm long, glabrous; stigma 3-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm, puberulous. **Seeds** 26-28, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- PENINSULAR: **Pattani**, Betong, 1 Aug. 1923, A.F.G. Kerr 7442 (**BK**, **BM**, **K**), 26 Aug. 1923, A.F.G. Kerr 7920 (**BK**, **BM**, **K**); **Yala**, Tan To, 9 Feb. 2004, D.J. Middleton, M. Phuphat, R. Pooma & K. Williams 2834 (**BKF**), Betong, 3 Mar. 1941, T. Premrasmi 136 (**BKF**).

Distribution.--- Thailand, Laos.

Ecology.--- In shaded evergreen forest, at 50-400 m altitude. Flowering: July-September.

Vernacular.--- Krab Pattani (กราบปัตตานี) (Researcher).

Notes.--- This species shows 2 distinct variants from type specimen of Laos i.e., pedicel 6-8 mm long (as type 2-6 mm long) and bracts linear-lanceolate 4-5.5 mm long (as type linear-acute 2.5 -3.5 mm long), which E. Hossain described in 2 varieties but they are not given any formal Latin names owing to the limited material.

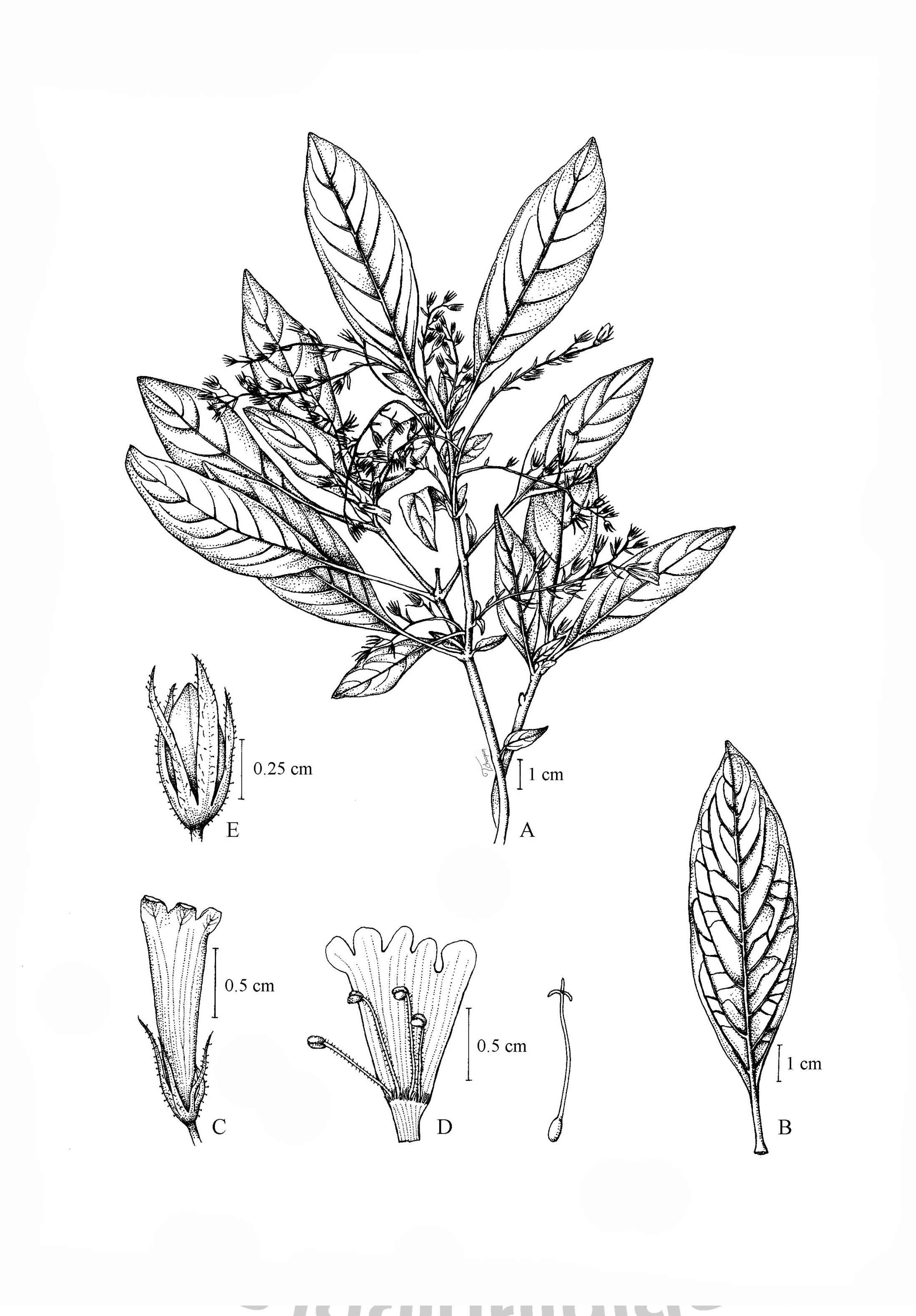
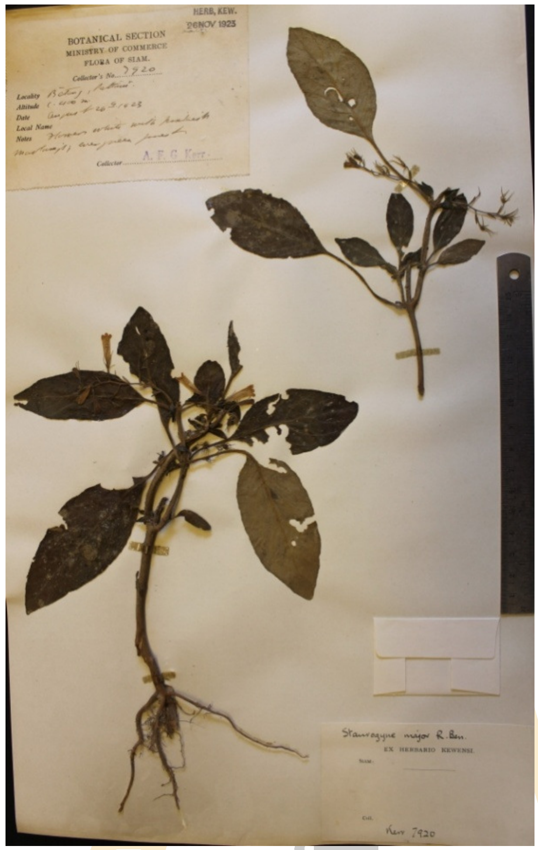


Figure 5.53 *Staurogyne filipes* E. Hossain.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.



A

B

Figure 5.54 *Staurogyne filipes* E. Hossain.

A: herbarium sheets, B: dried inflorescence with opened flower.

26. *Staurogyne glauca* (Nees) Kuntze, Rev. Gen. Pl. 2: 497. 1891, [Type: see *Ebermaiera glauca*]; Benoist in Lecomte, Fl. Indo-Chine 4: 624. 1935. Figures 5.55-5.56.

___*Ebermaiera glauca* Nees, in Candolle, Prodr. 11: 73-74. 1847a, [Type: India, W. Deccan peninsula and S. Madras, R. Wight cat. n. 1932 (holotype! E, K, P)]; Clarke in Hooker, Fl. Brit. India 4: 395. 1885; Anderson, J. Linn. Soc. Bot. 9: 450. 1867; Hô, Câyco Viêtnam 3(1): 76. 1993.

Staurogyne siamensis C. B. Clarke, in Lindhard, Bull. Herb. Boissier 5: 716. 1905 [Type: Thailand, Raheng, near Taposah, 8 January 1904; E. Lindhard s.n. (holotype! C, K, P)]; *Staurogyne glauca* var. *siamensis* R. Ben., Benoist, Bull. Soc. Bot. France 60: 267. 1913.

Staurogyne rivularis Merrill, Philippine J. Sci. 7: 248. 1912b, [Type: Philippines, Luzon, Manila, December 1910; Merrill 7396 (K, L)]; Merrill, Fl. Manila 441. 1912a; Bremekamp, Reinwardtia 3: 173. 1955.

Herbs, up to 20 cm tall, erect, branched. **Leaves** opposite or decussate; petioles 0.3-1.5 cm long; blade spathulate, 1-4 by 0.5-2 cm, apex obtuse, base decurrent, glabrous. secondary veins 6-8 pairs, opposite or alternate. **Inflorescence** axillary raceme; bract 1, spathulate or leaf-like, 1 by 0.3 cm, with glandular hairs; pedicels 0.1 cm long, with glandular hairs; bracteoles 2, linear, ca. 0.6 cm long, with glandular hairs. **Flowers** up to 0.8 by 0.4 cm, actinomorphic, tubular. **Calyx** lobes 5, subequal, linear, 0.6 cm long, glandular hairs. **Corolla** lobes 5, white with reddish purple line in throat, elliptic, 0.3 by 0.1 cm, apex obtuse and curved. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments, 0.4-0.5 cm long, glandular hairs; staminode 1. **Ovary** oblong, glabrous; style 0.5 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.45 by 0.1 cm. **Seeds** 20-24, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- Raheng-near Taposah, 8 Jan. 1904, E. Lindhard s.n. (holotype! **C**, **K**, **P**), 19 Feb. 1930, anonymous 18130 (**BK**),--- NORTHERN: **Chiang Mai**, Doi Suthep, 27 Dec. 1910, A.F.G. Kerr 1631 (**BM**), 4 Dec. 1911, A.F.G. Kerr 2270 (**BM**, **L**), Fang, 22 Feb. 1958, T. Smitinand 4305 (**BKF**) & 4313 (**BKF**), 12 Jan. 1988, Y. Paisooksantivatana, J. Sadakorn & P. Penchitra 2230-88 (**BK**), Thep Phanom hot spring, 21 Dec. 1989, J.F. Maxwell 89-1578 (**E**, **L**), Fang-hot spring park, 10 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33308 (**BKF**), Doi Chiang Dao WS, 10 Mar. 1990, J.F. Maxwell 90-307 (**E**); **Lampang**, Chae Son NP, 8 Jan. 1996, J.F. Maxwell 96-39 (**BKF**), 15 Jan. 2011, T. Choopan 2011-165 (**BKF**, **SUT**); **Phayao**, Chiang Kam, 29 Feb. 1912, A.F.G. Kerr 2468 (**E**, **K**);--- NORTH-EASTERN: **Phetchabun**, Nam Nao NP, 26 Dec. 1982, H. Koyama, H. Terao & T. Wongprasert 31733 (**BKF**) & 31764 (**BKF**); **Sakon Nakhon**, Phu Phan NP, 23 Jan. 1999, P. Chaikong 30/42 (**KKU**), 14 Dec. 1982, H. Koyama, H. Terao & T. Wongprasert 31041 (**BKF**, **C**, **L**), 13 Nov. 1984, G. Murata, C. Phengklai, S. Mitsuta, T. Yahara, H. Nagamasu & N. Nantasan 50610 (**BKF**), Sangklokao, 27 Dec. 1962, Adisai 256 (**BK**);--- EASTERN: **Chaiyaphum**, Phak Pang, 1 Feb. 1931, A.F.G. Kerr 19980 (**BK**, **BM**, **K**); **Nakhon Ratchasima**, Pak Thong Chai, 24 Dec. 1923, A.F.G. Kerr 8118 (**BK**, **BM**, **C**, **L**); **Yasothon**, Kheung Nai, 23 Jan. 1984, J. Sadakorn & Y.

Paisooksantivatana 1411-84 (**BK**);--- CENTRAL: **Angthong**, 30 Dec 1928, Put 2604 (**BM**); **Nakhon Nayok**, Khao Yai NP, Feb. 1966, C. Chermsirivathana 613 (**BK**); **Saraburi**, Sam Lan, 20 Nov. 1973, J.F. Maxwell 73-676 (**AAU**, **BK**); --- SOUTH-EASTERN: **Chanthaburi**, Khao Soi Dao, 15 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 351 (type! **C**); **Chonburi**, Sriracha, 5 Mar. 1920, A.F.G. Kerr 4039 (**BM**), Khao Khieo, 6 Dec. 1975, J.F. Maxwell 75-1106 (**AAU**, **BK**, **L**); **Prachin Buri**, Krabinburi, 4 Jan. 1925, A.F.G. Kerr 9838 (**BK**, **BM** 2 sheets, **C**);--- SOUTH-WESTERN: **Kanchanaburi**, Sai Yok, 25 Nov. 1971, C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan 3967 (**BKF**, **L**), 25 Dec. 1961, K. Larsen 8960 (**C**, **K**), 1 Jan. 1962, K. Larsen 9067 (**C**, **K**), Ban Kao-Ta Khien, 27 Nov. 1961, K. Larsen 8396 (**C** 2 sheets), Had Palom, K. Larsen 8854 (**C**);--- PENINSULAR: **Chumphon**, Thasae, 16 Jan. 1967, J.F. Maxwell 87-63 (**AAU**, **BKF**, **L** 2 sheets); **Surat Thani**, Khian Sa, 19 Feb. 1930, A.F.G. Kerr 18130 (**BK**, **BM**).

Distribution.--- India, Pakistan, Myanmar, Malaysia, Thailand, Cambodia, Vietnam, Philippines, Australia.

Ecology.--- In shaded mixed decidous forest along stream, at 400-600 m altitude. Flowering: October-December.

Vernacular.--- Ya Krab Hieo (หญ้ากรามเหี่ยว) (Angthong).

Notes.--- This species is distinguished from *S. spatulata* by the smaller spatulate leaves without long hairs, the shorter axillary raceme inflorescences, and by small white flowers with reflected lobes.

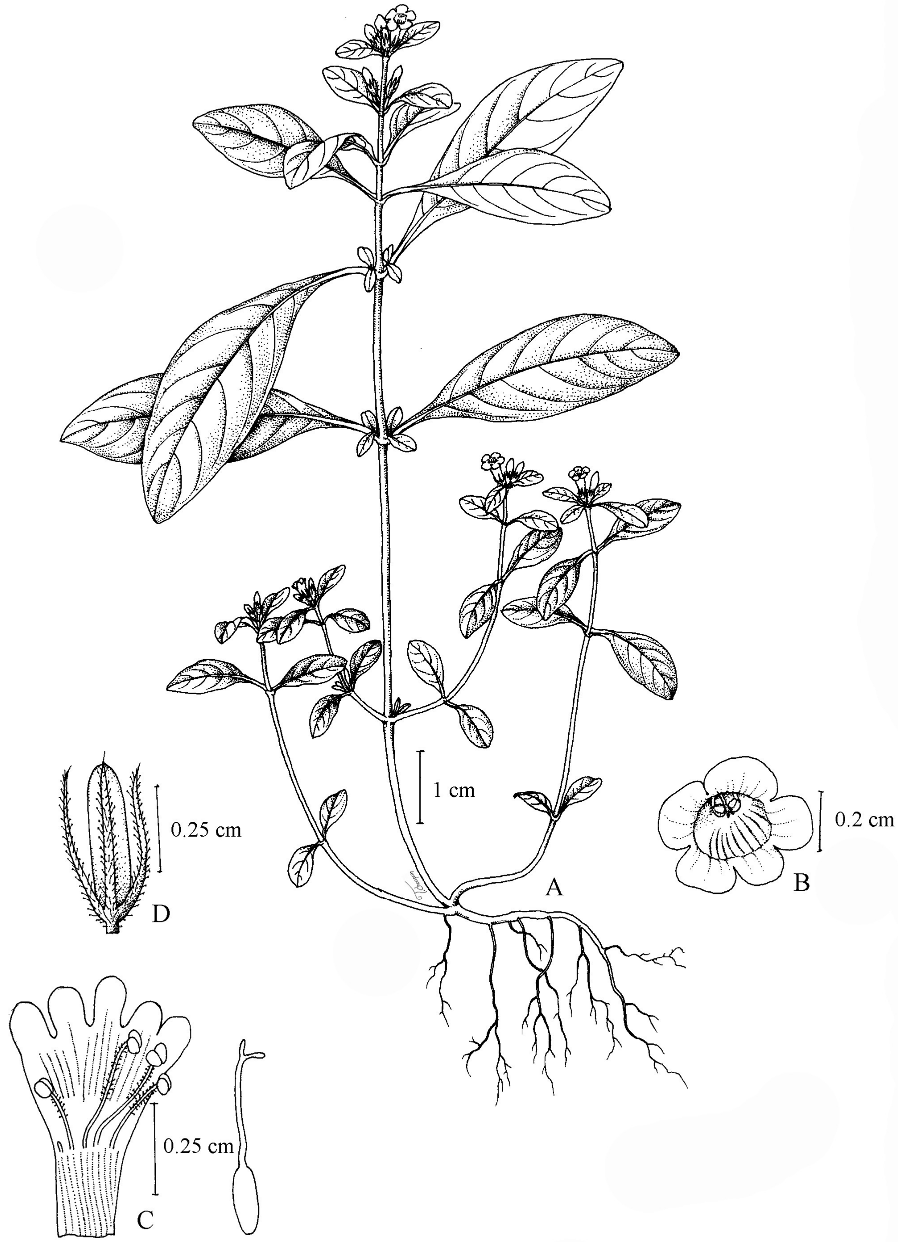


Figure 5.55 *Staurogyne glauca* Kuntze.

A: habit, B: flower, C: pistil and stamens, D: fruit.

A

B

Figure 5.56 *Staurogyne glauca* Kuntze.

A: habit, B: inflorescence with opened flower.

27. *Staurogyne griffithiana* [Nees] (T. And.) Kuntze, Rev. Gen. Pl. 2: 497. 1891, [Type: see *Erythracanthus griffithianus*]; Clarke, J. Asiat. Soc. Bengal 74(30): 640. 1908; Ridley, Fl. Malay Penin. 2: 561. 1923; Bremekamp, Reinwardtia 3: 181. 1955. Figures 5.57-5.58.

___*Erythracanthus griffithianus* Nees, in Candolle, Prodr. 11: 78. 1847a. [Type: Malaysia, Malacca; W. Griffith s.n.-Kew Distrib. 6078 (GZU, K)].

___*Ebermaiera griffithiana* (Nees) T. Anders, J. Linn. Soc. Bot. 9: 452. 1867; Clarke in Hooker, Fl. Brit. India 4: 400. 1885.

Herbs, up to 15 cm tall, short, branched, puberulous. **Leaves** opposite or decussate; petioles 1.5-4 cm long, puberulous; blade elliptic, 5-12 by 3.5-5 cm, apex obtuse, base obtuse, puberulous, secondary veins 9-11 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes; bract 1, elliptic, 1 by 0.2-0.3 cm, puberulous; pedicels 0.5 cm long, puberulous; bracteoles 2, elliptic, ca. 0.8 cm long. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3), linear, 0.7-1.2 cm long, puberulous. **Corolla** lobes 5, white, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, puberulous. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 0.8-1.0 cm long, glabrous; staminode 1. **Ovary** oblong, glabrous; style 1.0 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 20-24, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- PENINSULAR: **Chumphon**, Lang Suan, 6 Feb. 1927, A.F.G. Kerr 11846 (**BK**, **BM**, **K**); **Narathiwat**, Nikom Waeng, 14 Sep. 1966, B. Sangkhachand & B. Nimanong 1364 (**BKF**, **C**, **L**), 7 Oct. 1966, P. Sangkhachand 497

(**BK**, **L**), 24 Apr. 1968, Prayad 1319 (**BK**), Chatwarin waterfall, 18 Oct. 1970, C. Charoenphol, K. Larsen & E. Warncke 3988 (**AAU**), 15 Aug. 1995, K. Larsen, S.S. Larsen, C. Tange, R. Moran, T. Niyomdham & P. Puudjaa 45581 (**AAU**), Ban Bala, 16 Aug. 1995, K. Larsen, S.S. Larsen, C. Tange, R. Moran, T. Niyomdham & P. Puudjaa 45658 (**AAU**); **Pattani**, Betong,9 Aug. 1923, A.F.G. Kerr 7897 (**K**), 26 Aug. 1923, A.F.G. Kerr 7674 (**BK**, **BM**, **K**); **Phangnga**, Khao Lumpee, 14 Sep. 1994, P.C. Boyce 949 (**K**); **Satun**, 11 Mar. 1928, A.F.G. Kerr 14467 (**BK**, **BM**); **Surat Thani**, 25 Oct. 1990, K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa 40909 (**AAU**).

Distribution.--- Malaysia, Singapore, Thailand, Indonesia.

Ecology.--- In shaded moist evergreen forest, at 50-500 m altitude. Flowering: February-April.

Vernacular.--- Krab Nara (กราบนรา) (Researcher).

Notes.--- This species is distinguished from *S. obtusa* by the leaves thick, elliptic or ovate with distinctly more reticulated veins underneath, and the unbranched raceme inflorescences with showy bracts.

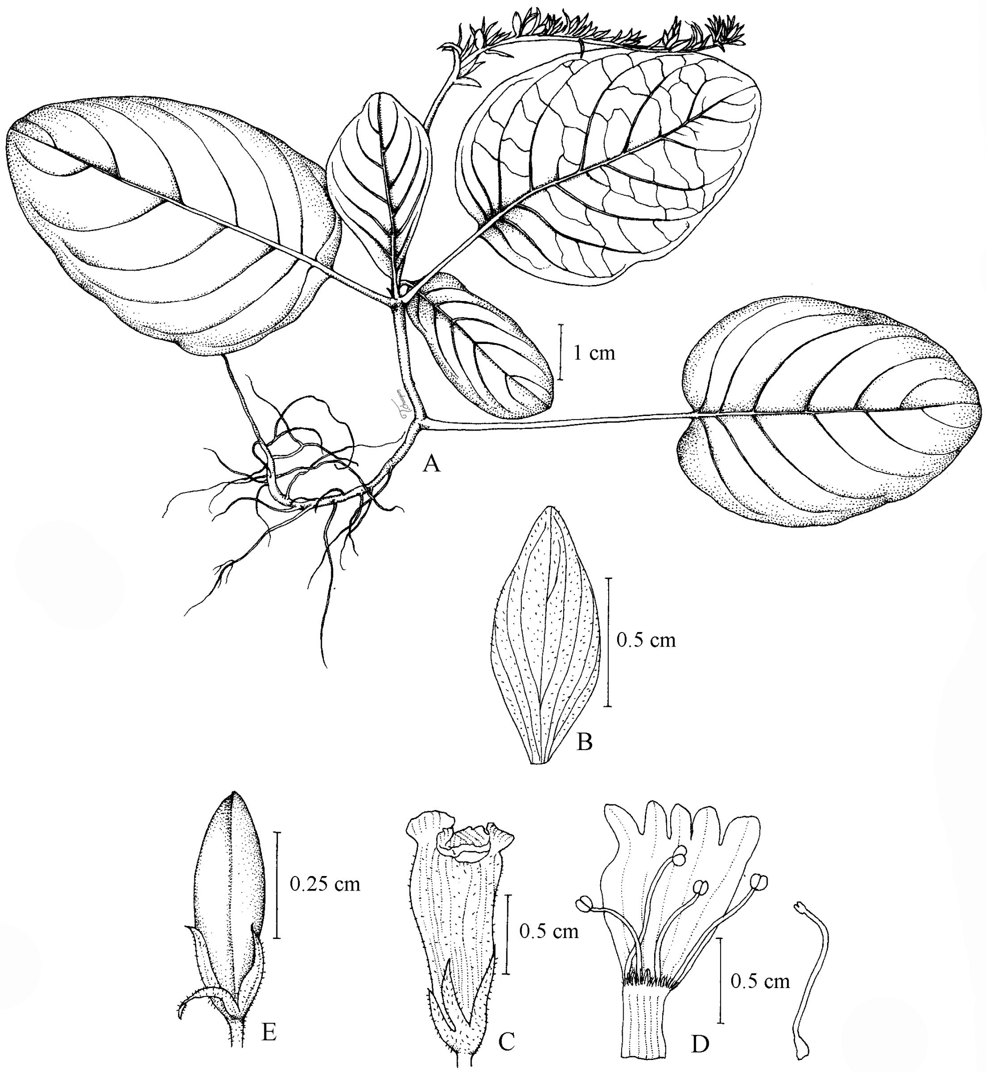
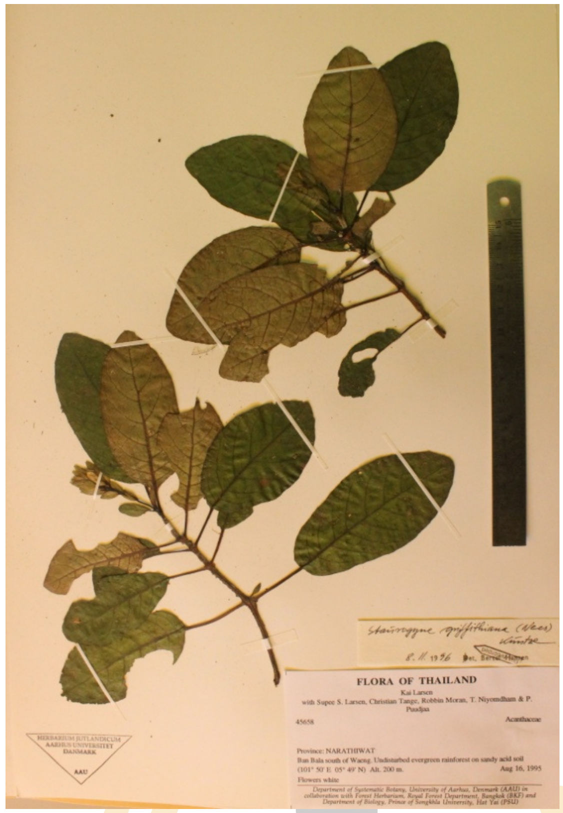


Figure 5.57 *Staurogyne griffithiana* (Nees) Kuntze.

A: habit, B: bract, C: flower, D: pistil and stamens, E: fruit.



A

B

Figure 5.58 *Staurogyne griffithiana* (Nees) Kuntze.

A: herbarium sheet, B: dried inflorescence with opened flowers.

28. *Staurogyne helferi* (T. Anders.) Kuntze, Rev. Gen. Pl. 2: 497. 1891, [Type: see *Ebermaiera helferi*]. Figures 5.59-5.60.

___*Ebermaiera helferi* T. Anders., J. Linn. Soc. Bot. 9: 452. 1867, [Type: Burma: Tenasserim, Attaran; Helfer 51-Kew Distrib. n. 6076 (K)]; Clarke in Hooker, Fl. Brit. India 4: 399. 1885.

Staurogyne latifolia Bremek., Dansk Bot. Ark. 27: 76. 1969, [Type: Thailand, Phangnga, foothills of Khao Phra Mi, 7 January 1966; B. Hansen & T. Smitinand 11828 (isotype! BKF, C)].

Herbs, very short, unbranched. **Leaves** rosette; petioles 0.5 cm long; blade oblanceolate or spathulate, 8-15 by5-8 cm, apex obtuse, base attenuate, secondary veins 6-8 pairs, opposite or alternate. **Inflorescence** terminal racemes; bract 1, ovate, 1.0 by 0.8 cm, puberulous; pedicels 0.1-0.2 cm long; bracteoles 2, linear, ca. 0.6 cm long, puberulous. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, subequal, linear, 0.5-0.6 cm long, glabrous. **Corolla** lobes 5, white, elliptic, 0.3 by 0.1 cm, apex obtuse. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments 0.6-0.8 cm long, with glandular hairs; staminodes 0. **Ovary** oblong, glabrous; style 0.8 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 10-12, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- PENINSULAR: **Phangnga**, Klong Saeng WS, 11 Sep. 1984, N. Fukuoka & W. Nanakhon 36104 (**BKF**, **L**), 11 Sep. 1984, anonymous 722 (**BKF**), Khao Phra Mi, 7 Jan. 1966, B. Hansen & T. Smitinand 11828 (isotype! **BKF**, **C**);

Ranong, Klong Naka WS, 24 Nov. 1974, R. Geesink, P. Hiepko, C. Charoenphol 7522 (**BKF**, **C**, **L**), 11 Sep. 1982, T. Shimizu, F. Konta, T. Wongprasert & B. Sangkhachand 29286 (**BKF**), 16 May 2011, T. Choopan 2011-249a (**BKF**, **SUT**), Khao Phota Luangkaeo-Kaper, 20 Nov. 1973, T. Santisuk 634 (**BKF** 2 sheets), 11 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 27007 (**BKF**) & 27022 (**BKF** 2 sheets), 27 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33802 (**BKF**); **Surat Thani**, 25 Oct. 1990, K. Larsen & S.S. Larsen & A.S. Barfod & W. Nanakorn & W. Ueachirakan & P Sirirugsa 40866 (**AAU**) & 40901 (**C**).

Distribution.--- Myanmar, Thailand.

Ecology.--- In shaded moist evergreen forest, at. 100-500 m altitude. Flowering: January-March.

Vernacular.--- Krab Klong Naka (กราบคลองนาคา) (Researcher).

Notes.--- This species shows more reticulated veins in oblanceolate leaves and the showy bracts ovate shaped.

Figure 5.59 *Staurogyne helferi* (T. Anders.) Kuntze.

A: habit, B: ventral leaf, C: bract and calyx, D: pistil, E: fruit.

A

B

Figure 5.60 *Staurogyne helferi* (T. Anders.) Kuntze.

A: habit, B: dried inflorescences.

29. *Staurogyne incana* (Blume) O. Kuntze, Rev. Gen. Pl. 2: 497. 1891, [Type: see *Adenosma incanum*]; Bremekamp, Reinwardtia 3: 191. 1955. Figures 5.75-5.76.

___*Adenosma incanum* (Bl.) Blume, Bijdr. Fl. Ned. Ind. 756. 1826 [Type: Java, Bogor (Buitenzorg), Nanggung, Blume s.n. (L)].

___*Ebermaiera incana* Hassk., in Teijsmann & Binnendijk, Hort. Bog. 149. 1866 [Type: Java]; Nees in Candolle, Prodr. 11: 76. 1847a; Clarke in Hooker, Fl. Brit. India 4: 397. 1885.

Staurogyne multiflora Bremek., Dansk Bot. Ark. 27(1): 76. 1969, [Type: Thailand, Phangnga, foothills of Khao Phra Mi, 7 January 1966; B. Hansen & T. Smitinand 11825 (BKF, C, U)].

Ebermaiera velutina Nees, in Candolle, Prodr. 11: 76. 1847a [Type:Mergui, Griffith s.n. (GZU)]; Anderson, J. Linn. Soc. Bot. 9: 452. 1867.

Herbs, up to 10 cm tall, decumbent ascending, branched, puberulous. **Leaves** opposite or decussate; petioles 1-3 cm long, puberulous; blade elliptic, 5-11 by 3-5 cm, apex obtuse, base obtuse, puberulous, secondary veins 7-9 pairs, opposite or alternate. **Inflorescence** terminal racemes; bract 1, lanceolate, 0.5 by 0.1-0.2 cm; pedicels 0.1 cm long, puberulous; bracteoles 2, linear, ca. 0.4 cm long. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3), linear 4 and lanceolate 1, 0.3-0.5 cm long, puberulous. **Corolla** lobes 5, white with pinkish purple in 3 lobes, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, puberulous. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments 0.5-0.7 cm long, with glandular hairs; staminode 1. **Ovary** oblong, glabrous; style 0.8 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 4-8, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- PENINSULAR: **Chumphon**, Tasae, 5 Nov. 1919, C.B. Kloss 6911 (**K**), 23 Dec. 1928, A.F.G. Kerr 16303 (**BK**, **BM**, **K**); **Phangnga**, foothills of Khao Phra Mi, 7 Jan. 1966; B. Hansen & T. Smitinand 11825 (type! **BKF**, **C**, **K**, **L**, **U** image), Bangwan stream-Kuraburi, 27 Sep. 2006, T. Muadsub 124 (**BKF**); **Ranong**, Khao Phota Luangkaeo, 11 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 27010 (**BKF** 2 sheets) & 27053 (**BKF**), Klong Naka WS, 28 Jan. 2003, V. Chamchumroon, N. Koonkhunthod, K. Phattaranakhirankanok, N. Tetsana 1843 (**BKF**), 16 Nov. 1973, T. Santisuk 576 (**BKF** 2 sheets), 8 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 26468 (**BKF** 2 sheets, **L**), 24 Nov. 1974, R. Geesink, P. Hiepko & C. Phengklai 7568 (**BKF**, **C**, **K**, **L**), Thung Raya-Na Sak WS, 30 Jan. 2004, D. Middleton, R. Namdang, R. Pooma, S. Suddee, S. Suwanachat & K. Williams 2673 (**BKF**), 25 May 2011, T. Choopan 2011-310 (**BKF**, **SUT**), Kaper, 20 Nov. 1965, B. Sangkhachand 1149 (**BKF**, **C**, **K** 2 sheets), Pak Chan, 28 Jan. 1927, A.F.G. Kerr 11678 (**BK**, **BM**, **K**); **Surat Thani**, Nasan, 8 Oct. 1955, S. Thavorn 486 (**BKF**, **K**); **Trang**, Khao Chong, 31 Jul. 1975, S. Suthisorn 3372 (**BK**).

Distribution.--- Myanmar, Thailand.

Ecology.--- In shaded moist evergreen forest, at 50-200 m altitude. Flowering: March-May.

Vernacular.--- Krab Thung Raya (กราบทุ่งระยะ) (Researcher).

Notes.--- This species was distinguished by the white flowers with pinkish purple in 3 lobes and the leaves with distinct white puberulous hairs on both surfaces.

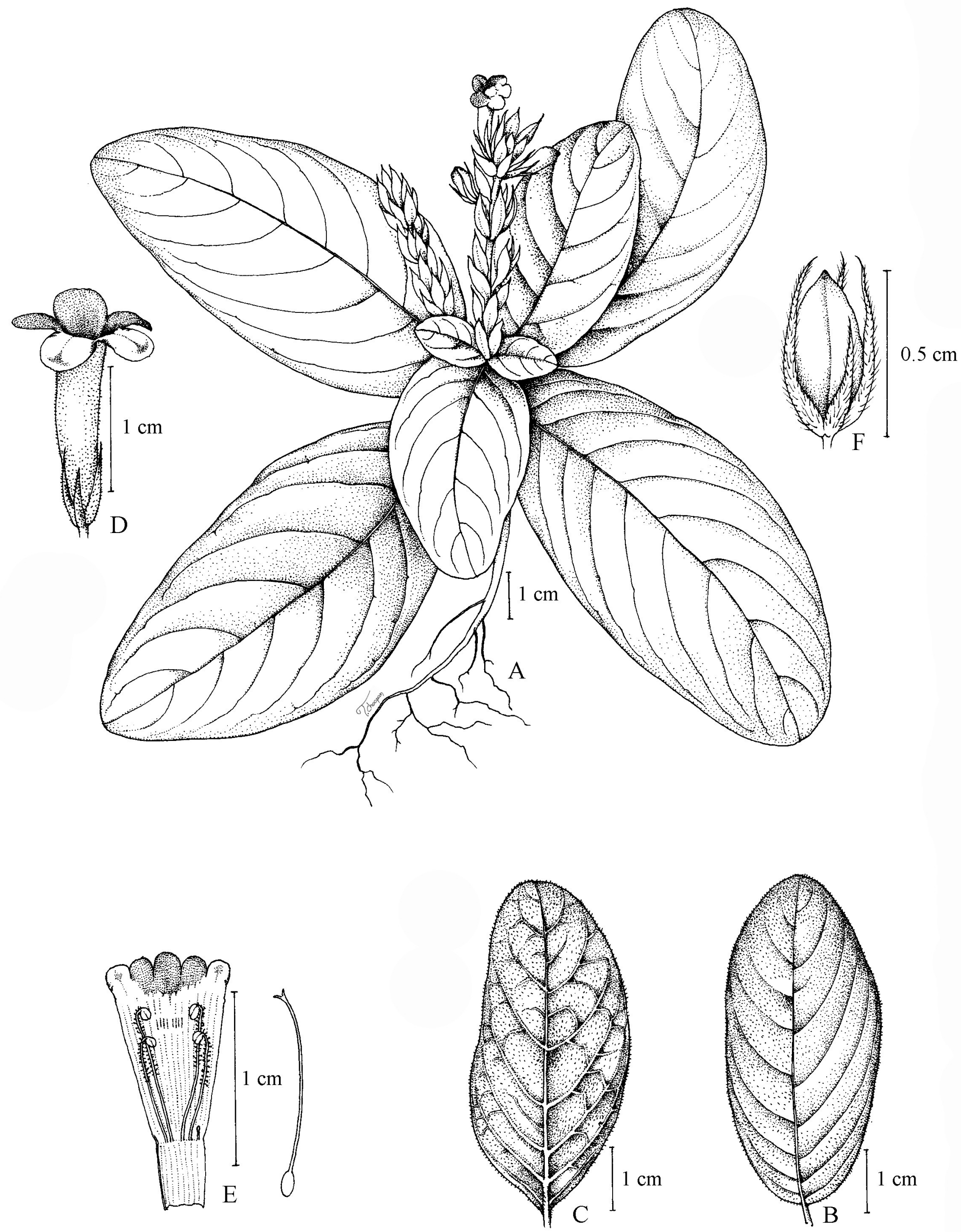


Figure 5.61 *Staurogyne incana* (Blume) O. Kuntze.

A: habit, B: dorsal leaf, C: ventral leaf, D: flower, E: pistil and stamens, F: fruit.

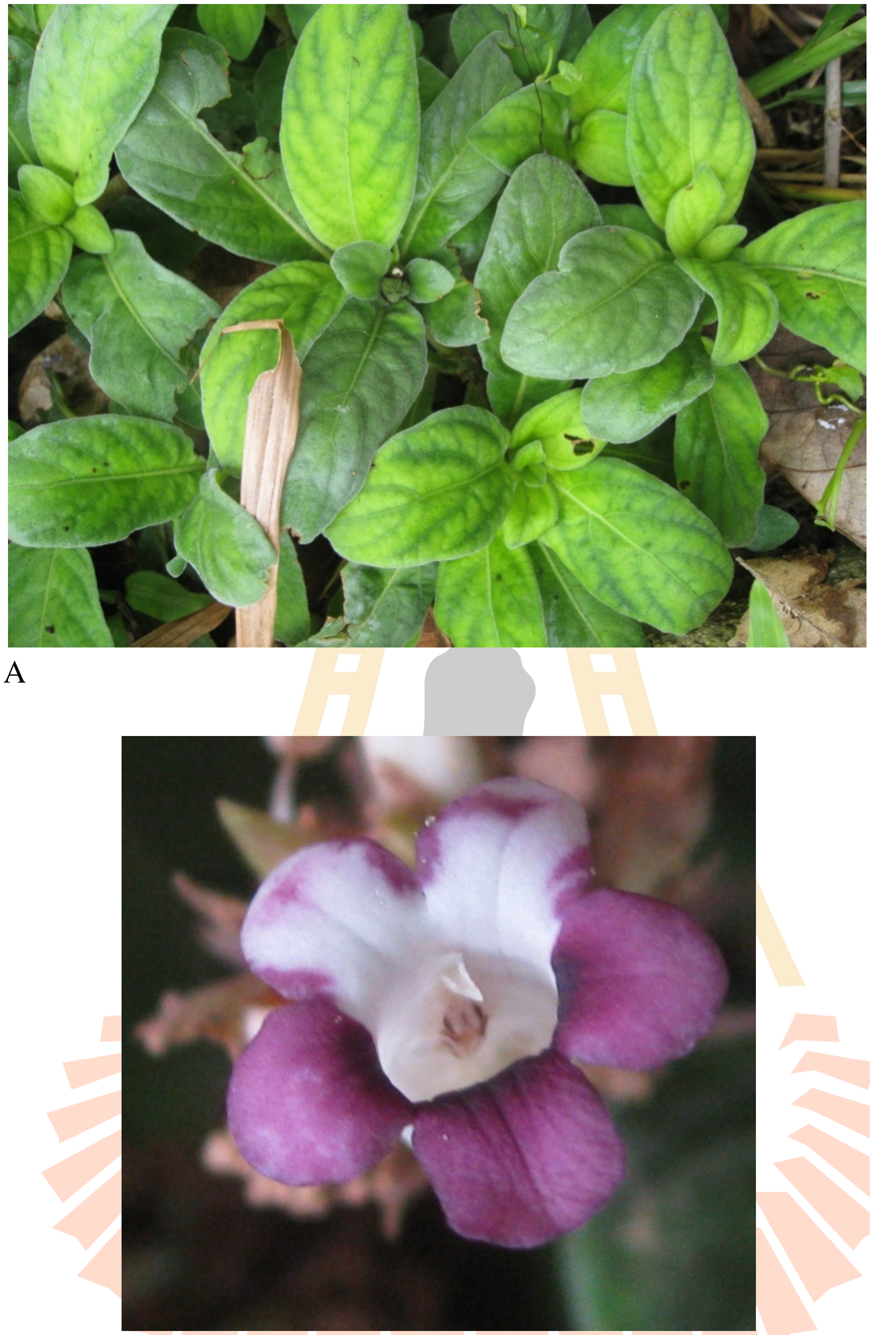

A
B

Figure 5.62 *Staurogyne incana* (Blume) O. Kuntze.

A: habit, B: inflorescence with opened flower.

30. *Staurogyne kingiana* C. B. Clarke, J. Asiat. Soc. Bengal 74(3): 637. 1908, [Type: Malaysia, Perak, on lime stone hills; King's collector 10704 (K) & Goenong, Mt. Panti; King's collector 208 (paratype! K)]; Ridley, Fl. Malay Penin. 2: 560. 1923; Bremekamp, Reinwardtia 3: 193. 1955, [Type: Malaysia, Johore, Mt. Panti, 5 December 1936; Corner 32542 (K, A)]. Figures 5.61-5.62.

Staurogyne setisepala C. B. Clarke ex S. Moore, J. Bot. 63 (suppl.): 77. 1925, [Type: Indonesia, Sumatra, Palembang, 3054a (BM, L)].

Shrubs, up to 100 cm tall, erect, branched, pubescent. **Leaves** opposite or decussate; petioles 2-4.5 cm long, puberulous; blade elliptic, 10-18 by 3-6 cm, apex acute, base acute or acuminate (narrow at base), glabrous, secondary veins 12-15 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes; bract 1, lanceolate, 1.7 by 0.1-0.2 cm, glabrous; pedicels 0.1 cm long, puberulous; bracteoles 2, linear, ca. 2 cm long, puberulous. **Flowers** up to 2.0 by 1 cm, actinomorphic, tubular. **Calyx** lobes 5, subequal, linear, 1.8-2 cm long, puberulous on margin,. **Corolla** lobes 5, yellowish-white with pale red on lower lip, elliptic, 0.7 by 0.3-0.4 cm, apex obtuse, glabrous. **Stamens** 4 included, anthers globose, 0.1 cm in diameter, filaments ca. 1.0-1.3 cm long, glabrous; staminode 1. **Ovary** oblong, glabrous; style 1.5 cm long, glabrous; stigma 2-lobed. **Fruits** capsule dark brown, up to ca. 0.6 by 0.25 cm. **Seeds** 12-18, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- PENINSULAR: **Narathiwat**, Janae, 17 Mar. 1985, C. Niyomdham 865 (**AAU**, **BKF**, **C**, **K**), Waeng, 20 Nov. 1962, B. Sangkhachand 863

(**BKF**), 29 Jun. 1972, P. Nitrasirirak 114 (**BKF**, **L**), Hala-Bala WS, 21 Jul. 2004, R. Pooma, K. Phattarahirankanok, S. Sirimongkol, M. Poopath & S. Sangrit 4512 (**BKF**); **Pattani**, Betong, 9 Aug. 1923, A.F.G. Kerr s.n. (**BM**), 13 Aug. 1923, A.F.G. Kerr 7618 (**BM**).

Distribution.--- Malaysia, Singapore, Thailand, Indonesia.

Ecology.--- In shaded evergreen forest, at 100-800 m altitude. Flowering: March-May.

Vernacular.--- Krab Hala-Bala (กราบฮาลา-บาลา) (Researcher).

Notes.--- This species is distinguished from other taxa within the same genus by the long raceme inflorescences with long calyx and long bracts.

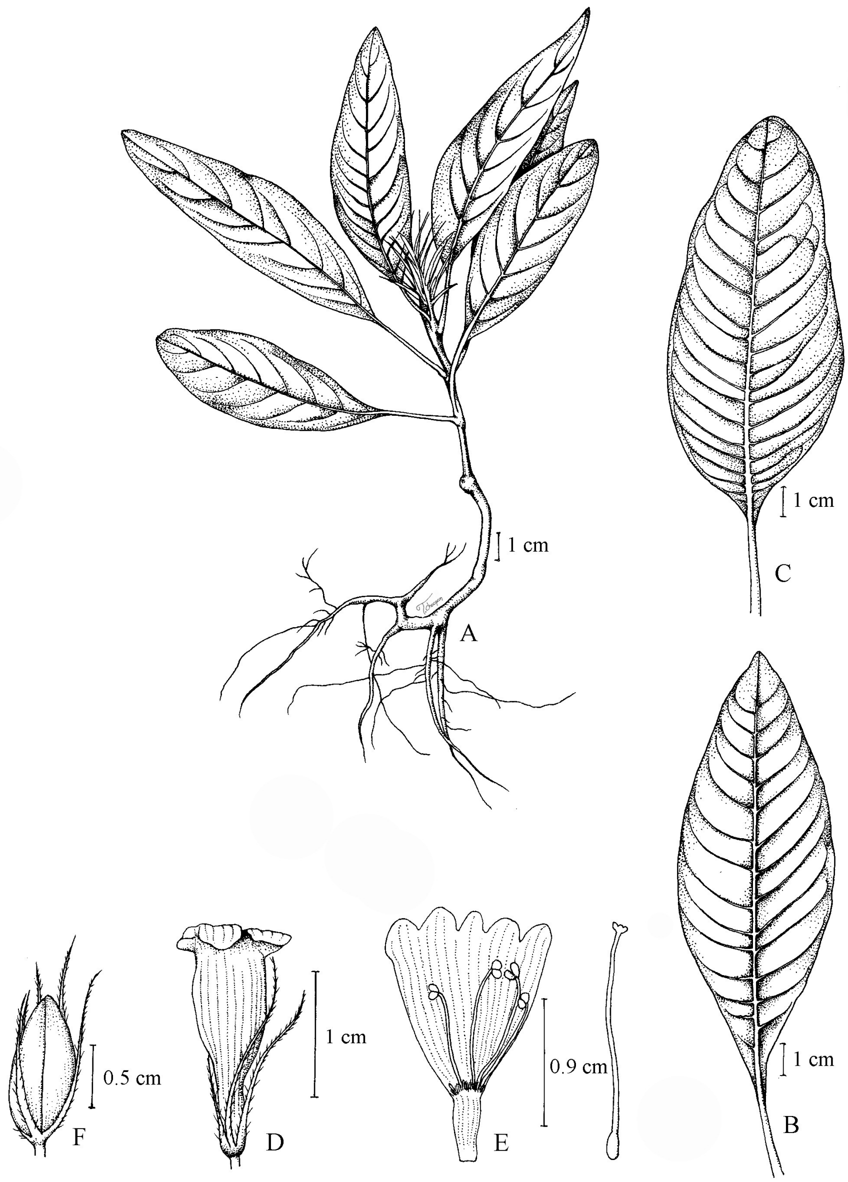


Figure 5.63 *Staurogyne kingiana* C. B. Clarke.

A: habit, B: dorsal leaf, C: ventral leaf, D: flower, E: pistil and stamens, F: fruit.

A

B

Figure 5.64 *Staurogyne kingiana* C. B. Clarke.

A: herbarium sheet, B: dried inflorescence with opened flowers.

31. *Staurogyne lanceolata* (Hassk) Kuntze, Rev. Gen. Pl. 2: 497. 1891; non Clarke, J. Asiat. Soc. Bengal 74(3): 636. 1908; nec Ridley, Fl. Malay Penin. 2: 559. 1923; Benoist in Lecomte, Fl. Indo-Chine. 4: 627. 1935; Bremekamp, Reinwardtia 3: 207. 1955. [Type: Java, Djakarta (Batavia), Tjikao; Blume 1208 (L)]. Figures 5.65-5.66.

___*Adenosma lanceolatum* Blume, Bijdr. Fl. Ned. Ind. 757, 1826. [Type: Java, Tjanjor, Tjikao].

___*Ebermaiera lanceolata* (Blume) Hassk., Hort. Bogor. 147. 1844 n.v., [Type: Java, Zollinger 593]; Miquel, Fl. Ind. Bat. 2: 774. 1856; Clarke in Hooker, Fl. Brit. India 4: 397. 1885.

___*Ebermaiera lanceolata* (Hassk) Nees, in Candolle, Prodr. 11: 76. 1847a.

Herbs, up to 10 cm tall, erect, rarely branched. **Leaves** opposite or decussate; petioles 1-1.5 cm long; blade lanceolate, 3-6 by 2-3 cm, apex obtuse, base acuminate, puberulous, secondary veins 8-10 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes; bract 1, lanceolate or narrow elliptic, 1.0 by 0.1 cm, puberulous; pedicels 0.1 cm long; bracteoles 2, linear, ca. 0.8 cm long, puberulous. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3), linear, 0.4-0.8 cm long, with short and long hairs. **Corolla** lobes 5, white with pinkish purple lobes, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, puberulous**. Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 0.3-0.5 cm long, puberulous; staminodes 0. **Ovary** oblong, glabrous; style 0.6 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 10-14, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- NORTH-EASTERN: **Sakon Nakhon**, Phu Phan NP, 13 Oct. 1999, P. Chaikong 31/42 (**KKU**), 23 Dec. 2010, T. Choopan 2010-099 (**BKF**, **SUT**);--- CENTRAL: **Nakhon Nayok**, Khao Yai NP, 16 Oct. 1999, S. Chongko 35 (**BKF**);--- EASTERN: **Nakhon Ratchasima**, Khao Yai NP, 7 Oct. 1962, T. Smitinand 7549 (**BKF**), 21 Nov. 1982, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk 30215 (**BKF**, **L**), 22 Oct. 1969, C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan 1820 (**AAU**, **BKF**, **C**, **E**), 19 Oct. 2001, J.F. Maxwell 01-534 (**L**), Ban Rai, 29 Nov. 1924, A.F.G. Kerr 9493 (**BK**); **Si Sa Ket**, Khao Phra Vihan NP, 21 Dec. 2005, R. Pooma, K. Phattarahirankanok, S. Sirimongkol & M. Poopath 6043 (**BKF**); **Surin**, 2 Dec. 1976, C. Phengklai et al. 3548 (**BKF**); **Ubon Ratchathani**, Phu Chong-Na Yoy NP, 21 Dec. 2010, T. Choopan 2010-084 (**BKF**, **SUT**);--- SOUTH-EASTERN: **Chanthaburi**, 1936, A. Vesterdal 14D (**C**), Khao Chamao-Khao Wong NP, 24 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & D. Phanichaphol 23468 (**BKF**), Khao Khitchakut NP, 15 Nov. 2010, T. Choopan 2010-023 (**BKF**, **SUT**), Khao Sabap, 18 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 515 (**C**), Krathing waterfall, 21 Oct. 1972, J.F. Maxwell 72-481 (**AAU**); **Chonburi**, Khao Khieo, 28 Aug. 1976, J.F. Maxwell 76-621 (**L**), Hoop Bon-Siracha, 25 Oct. 1927, D.J. Collins 1672 (**BK**); **Prachin Buri**, Krabinburi, 8 Nov. 1930, A. Marcan 2549 (**BM**); **Sa Kaeo**, Pang Sida NP, 13 Nov. 2010, T. Choopan 2010-006 (**BKF**, **SUT**); **Trat**, Chang Island, 26 Sep. 1924, A.F.G. Kerr 9178 (**BK**, **BM**, **K**), 29 Sep. 1924, A.F.G. Kerr 9493 (**K**), Kut Island, 20 Oct. 2000, C. Phengklai 13099 (**BKF** 2 sheets), 20 Nov. 1970, C. Charoenphol, K. Larsen & E. Warncke 5071 (**AAU**), Pong Song Salung, 5 Nov. 1964, P. Suvarnakoses 2202 (**BKF**, **L**), Namtok Phliew NP, 17 Oct. 1971, J.F. Maxwell 71-589 (**AAU**), 16 Nov. 2010, T. Choopan

2010-026 (**BKF**, **SUT**), Ban Saphan Hin, 8 Nov. 1993, K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Ueachirakan 44305 (**AAU**);--- SOUTH-WESTERN: **Kanchanaburi**, Sai Yok, 16 Dec. 1961, K. Larsen 8747 (**K**);--- PENINSULAR: **Krabi**, 8 Nov. 1930, A. Marcan 2549 (**K**), Nai Chong, 17 Dec. 1965, Umpai 216 (**BK**); **Nakhon Si Thammarat**, Kiriwong, 28 Apr. 1928, A.F.G. Kerr 15422 (**BK**, **BM**, **K**), Namtok Yong NP, 3 Dec. 1972, anonymous s.n. (**BKF**), 22 May 2011, T. Choopan 2011-289 (**BKF**, **SUT**), Khao Luang NP, 25 Oct. 1991, K. Larsen, S.S. Larsen, C. Niyomdham, W. Ueachirakan & P. Sirirugsa 42570 (**AAU**, **C**), 23 May 2011, T. Choopan 2011-296 (**BKF**, **SUT**); **Narathiwat**, Nikom Waeng, 1 Mar. 1974, K. Larsen, S.S. Larsen 32775 (**BKF**), Chatwarin waterfall, 22 Dec. 1993, N. Fukuoka & H. Koyama 61988 (**BKF**); **Phangnga**, Khao Nangting, 8 May 1967, S. Sutheesorn 2553 (**BK**); **Phatthalung**, Plai Wan waterfall, 19 Nov. 1990, K. Larsen, S.S. Larsen, C. Niyomdham, W. Ueachirakan & P. Sirirugsa 41602 (**AAU**); **Ranong**, Lam Liang, 2 Feb. 1927, A.F.G. Kerr 11775 (**BK**, **BM**, **K**), Muang Len, 2 Jan. 1966, B. Hansen & T. Smitinand 11874 (**BKF**, **C**, **E**, **K**, **L**), Klong Naka WS, 8 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 26471 (**BKF** 2 sheets), Klong Bang Bon, 24 Nov. 1974, S. Indrapong 47 (**BKF**), Kraburi, A.F.G. Kerr 16357 (**BK**); **Satun**, Ton Pliew, 28 Oct. 1993, K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Uerchirakan 44087 (**AAU**, **BKF**), Kuan Kalong, 15 Oct. 1970, C. Charoenphol, K. Larsen & E. Warncke 3845 (**AAU**, **BKF**, **K**, **L**), Ya Roy waterfall, 6 Nov. 1990, K. Larsen, S.S. Larsen, C. Niyomdham, W. Ueachirakan & P. Sirirugsa 41171 (**AAU**); **Songkhla**, 21 Dec. 1978, Hamilton & Congdon 105 (**BKF**), Ko Hong Hill, 15 Dec. 1984, J.F. Maxwell 84-523 (**BKF**), 9 Nov. 1988, P. Sirirugsa 1183 (**C**), Ton Nga Chang WS, 21 May 2011, T. Choopan

2011-288 (**BKF**, **SUT**); **Surat Thani**, Soa Um-Krut, 8 Jan. 1935, G. Seidenfaden 2244 (**C**), Ban Rai-Krut, 29 Nov. 1924, A.F.G. Kerr 9493 (**BK**, **BM**); **Trang**, Khao Chong, 17 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk 27458 (**BKF** 2 sheets) & 27465 (**BKF** 2 sheets), Ton The waterfall, 14 Nov. 1990, K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P Sirirugsa 41370 (**AAU**, **C**), Thalae Song Hong, 27 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 745 (**C**), South Peninsular BG, 20 May 2011, T. Choopan 2011-277 (**BKF**, **SUT**).

Distribution.--- Myanmar, Malaysia, Singapore, Thailand, Laos, Indonesia.

Ecology.--- In shaded mixed deciduous forest and evergreen forest with sandy soil, at 50-400 m altitude. Flowering: November-January.

Vernacular.--- Ya sam chun (หญ้าสามชั้น).

Notes.--- This species was distinguished from *S. setigera* by non-glandular hairs on bracts and white corolla with pinkish-purple lobes.

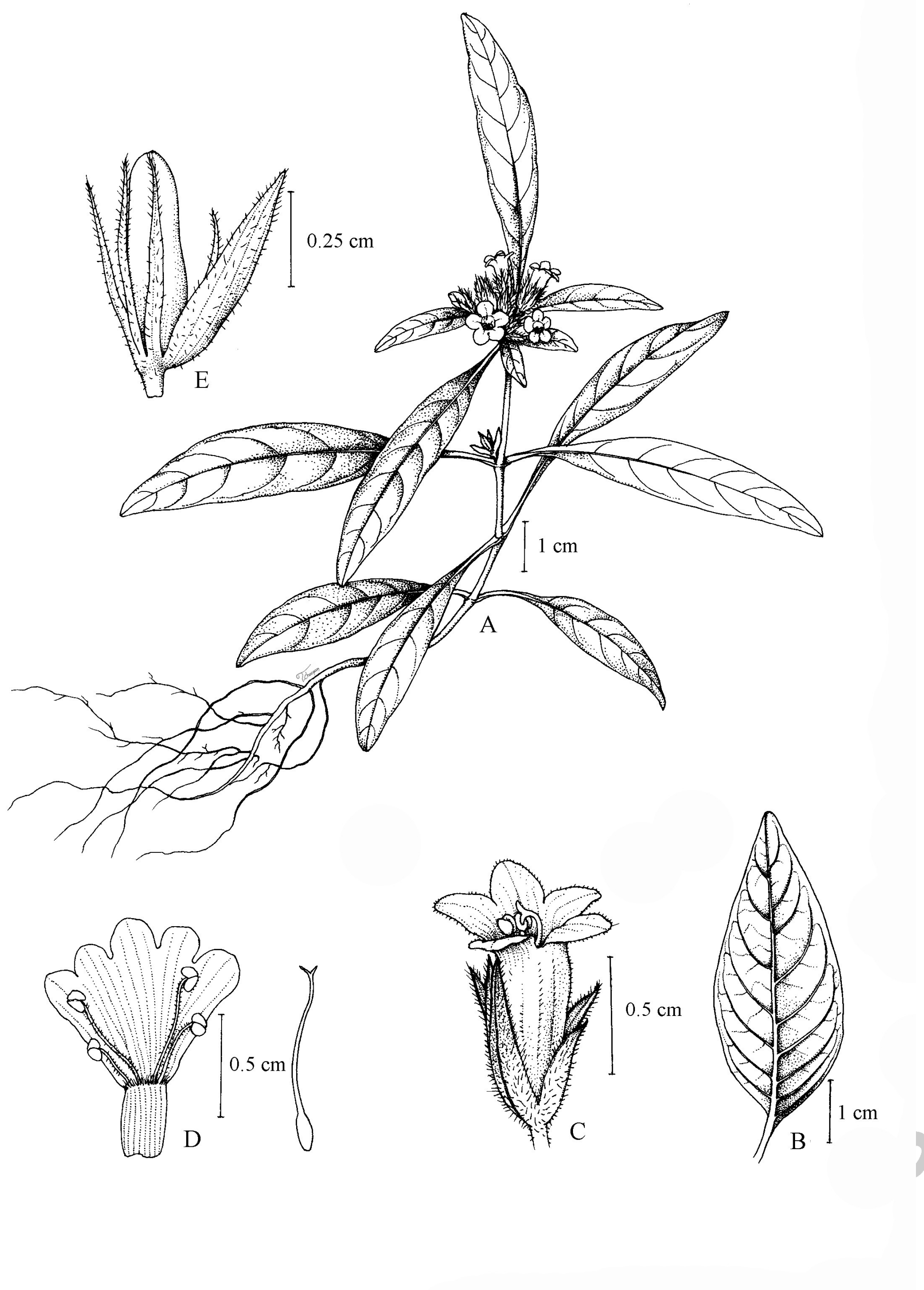


Figure 5.65 *Staurogyne lanceolata* (Hassk) Kuntze.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.66 *Staurogyne lanceolata* (Hassk) Kuntze.

A: habit, B: inflorescence with opened flower.

32. *Staurogyne lasiobotrys* (Nees) Kuntze, Rev. Gen. Pl. 2: 497. 1891, [Type: see *Ebermaiera lasiobotrys*]; Clarke, J. Asiat. Soc. Bengal 74(30): 639. 1908; Ridley, J. Straits Branch Roy. Asiat. Soc. 59: 147. 1911; Ridley, Fl. Malay Penin. 2: 561. 1923; Bremekamp, Reinwardtia 3: 195. 1955. Figures 5.67-5.68.

___*Ebermaiera lasiobotrys* Nees, in Candolle, Prodr. 11: 721. 1847a. [Type: Burma, Tenasserim, Chappedong hills; Wallich cat. 9084 (K)]; Anderson, J. Linn. Soc. Bot. 9: 452. 1867; Clarke in Hooker, Fl. Brit. India 4: 400. 1885.

Staurogyne expansa Bremek., Dansk Bot. Ark. 20: 57. 1961, [Type: Thailand, Trang, 28 January 1958; T. Sørensen, K. Larsen & B. Hansen 770 (holotype! C, U)].

Herbs, up to 10 cm tall, erect, unbranched. **Leaves** opposite or decussate; petioles 0.5-1.5 cm long; blade green with white or paler areas along midvein, elliptic, 1.5-7 by 1-3.5 cm, apex obtuse, base acuminate, glabrous, secondary veins 6-8 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes; bract 1, lanceolate, 0.25 by 0.1 cm, with long hairs; pedicels 0.1 cm long, puberulous; bracteoles 2, linear, ca. 0.25 cm long, with long hairs. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3), linear, 0.5-0.7 cm long, with long glandular hairs. **Corolla** lobes 5, reddish purple with white in 2 lobes and the tip of 1 lobe, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments 0.6-0.8 cm long, puberulous; staminodes 0. **Ovary** oblong, glabrous; style 1.1 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 10-14, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- PENINSULAR: 14 Dec. 1928, anonymous 4038 (**BM**) **Chumphon**, Tha Ngam, 16 Jan. 1927, A.F.G. Kerr 11481 (**BK**, **BM**, **K**), Langsuan, 14 Feb. 1927, A.F.G. Kerr 11946 (**BK**, **BM**, **C**, **K**, **L**); **Krabi**, Nai Chong, 18 Jan. 1966, B. Hansen & T. Smitinand 11982 (**BKF**, **C**, **K**, **L**), 17 Dec. 1965, Umpai 214 (**BK**), 25 Feb. 1969, Umpai s.n. (**BK**); **Nakhon Si Thammarat**, Lang Suan, 14 Feb. 1927, A.F.G. Kerr 11946 (**K**); **Narathiwat**, Nikom Waeng, Su-ngai Kolok, 3 Mar. 1974, K. Larsen & S.S. Larsen 32885 (**AAU**, **BKF**, **K**, **L**), Waeng, Apr. 1968, S. Phusomsaeng 434 (**BKF**, **K**, **L**), 25 Apr. 1968, P. Sangkhachand 1322 (**BK**), Sirindhorn waterfall, 29 Mar. 1987, J.F. Maxwell 87-276 (**L**), 11 Feb. 1997, P. Puudjaa 343 (**BKF**), Hala-Bala WS, 10 Feb. 1996, C. Niyomdham 4572 (**BKF**); **Pattani**, Betong, 1 Aug. 1928, A.F.G. Kerr 7442 (**K**); **Phangnga**, Thapput, 4 Mar. 1930, A.F.G. Kerr 18357 (**BK**, **BM**, **K**), 5 Mar. 1930, A.F.G. Kerr 18385 (**BK**, **BM**, **C**, **K**), Laemson NP, 22 Feb. 1994, A.S. Barford, C. Niyomdham, W. Ueachirakan, A.B. Pedersen & T. Burholt 45240 (**AAU**, **BKF**, **C**), Ko Ra-Kuraburi, 30 Jan. 2009, S. Watthana 2969 (**BKF**, **QBG**), Khao Dan, 19 Apr. 1928, A.F.G. Kerr 15314 (**L**); **Phatthalung,** Khao Den, 19 Apr. 1928, A.F.G. Kerr 15314 (**BK**, **BM**, **C**, **K**, **L**); **Phuket**, Kamala, 10 Mar. 1929, A.F.G. Kerr 17427 (**BK**, **BM**, **C**, **K**, **L**), Khao Phathaew NHA, 14 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 27186 (**BKF**) & 27325 (**BKF**), 3 Feb. 2003, V. Chamchumroon, N. Koonkhunthod, K. Phattaranakhirankanok, N. Tetsana 1897 (**BKF**), 17 May 2011, T. Choopan 2011-261 (**BKF**, **SUT**), Khao Phara, 25 Jan. 1966, E. Hennipma 3728 (**BKF**, **L**), Sirinath NP, 18 May 2011, T. Choopan 2011-264 (**BKF**, **SUT**), Mueang, 12 Dec. 1978, Hamilton & G. Congdon 74 (**AAU**, **BKF**); **Ranong**, La-Un, 1 Jan. 1929, A.F.G. Kerr 16474 (**BK**, **BM**, **K**), Ban Hin Song-Kraburi, 17 Jan. 1987, J.F.

Maxwell 87-82 (**AAU**, **BKF**, **E**, **L**), Klong Naka WS, 1 Mar. 1983, H. Koyama, H. Terao & T. Wongprasert 33907 (**BKF**), Phato, 2 May 1974, K. Larsen & S.S. Larsen 33583 (**AAU**); **Satun**, Kuan Don, 10 Mar. 1928, A.F.G. Kerr 14434 (**BK**, **BM**, **K**), Khao Khieo Range, 12 Mar. 1928, A.F.G. Kerr 14511 (**BK**, **BM**, **C**, **K**), Tarutao Island, 18 Jan. 1928, A.F.G. Kerr 14159 (**BK**, **BM**, **C**, **K**), 8 Feb. 1981, G. Congdon 1168 (**AAU**), Kuan Ka Long, 7 Jan. 1985, J.F. Maxwell 85-53 (**BKF**); **Surat Thani**, Klong Saeng WS, 15 Feb. 1994, J.F. Maxwell 94-193 (**BKF**), Khao Sok NP, 20 Feb 2001, K. Chayamarit, R. Pooma, V. Chamchaumroon & K. Phattarahirankanok & D.J. Milldleton 2584 (**BKF**) & 2585 (**BKF**); **Trang**, 28 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 770 (holotype! **C**), Khao Chong, 26 Jan. 1966, M. Tagawa, K. Iwatsuki & N. Fukuoka 6741 (**BKF**, **L**).

Distribution.--- India, Myanmar, Malaysia, Singapore, Thailand.

Ecology.--- In shaded evergreen forest, at 50-200 m altitude. Flowering: February-May.

Vernacular.--- Krab Phuket (กราบภูเก็ต) (Researcher).

Notes.--- This species was distinguished from other taxa within the same genus by the flowers reddish purple with white in 2 lobes and the tip of 1 lobe. The leaves show white or paler areas along midvein.

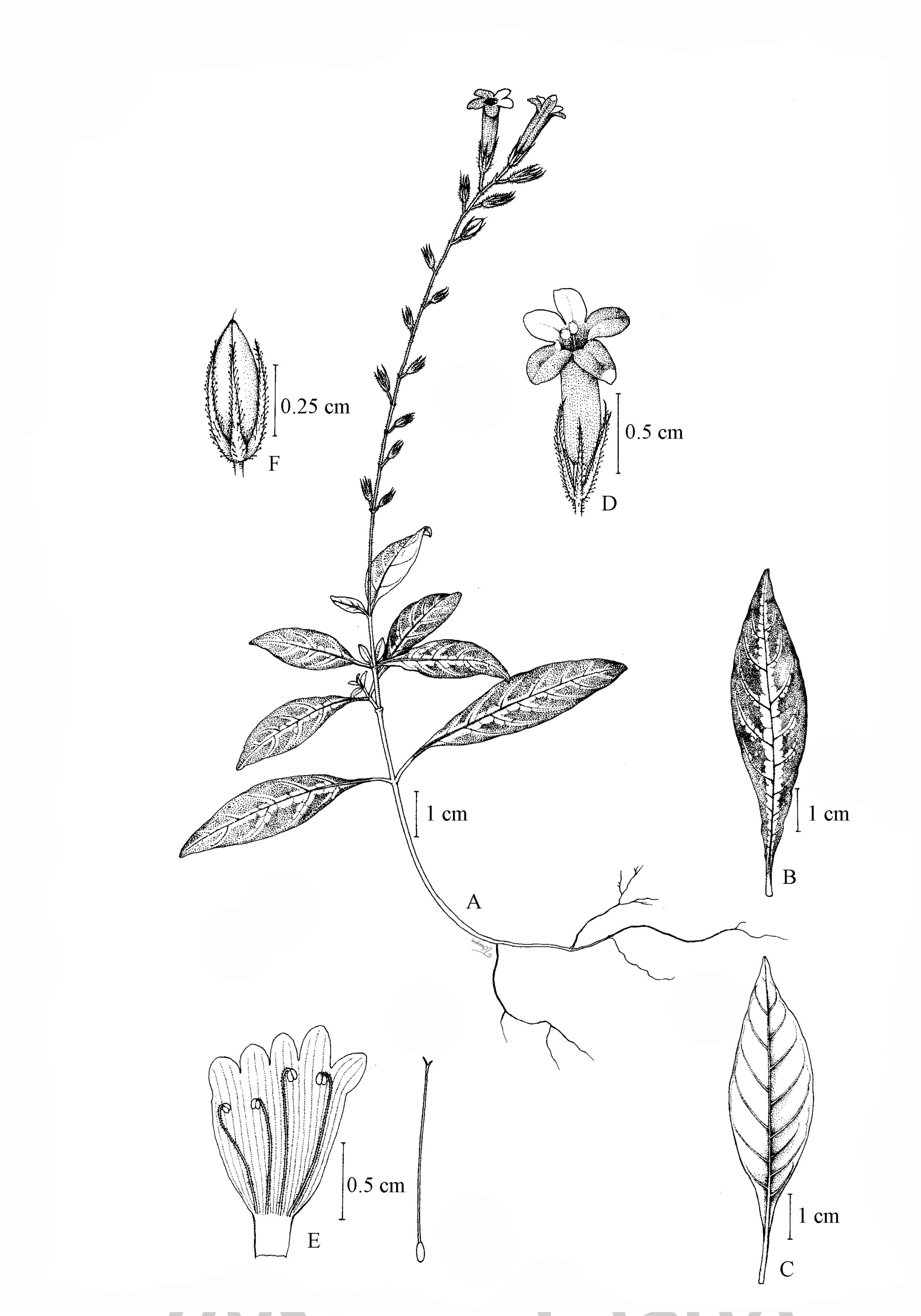


Figure 5.67 *Staurogyne lasiobotrys* (Nees) Kuntze.

A: habit, B: dorsal leaf, C: ventral leaf, D: flower, E: pistil and stamens, F: fruit.

A

B

Figure 5.68 *Staurogyne lasiobotrys* (Nees) Kuntze

A: habit, B: inflorescence with opened flower.

33. *Staurogyne longeciliata* Bremek., Dansk Bot. Ark. 20: 60. 1961, [Type: Thailand, Nakhon Si Thammarat, Khao Island, 26 January 1958; T. Sørensen, K. Larsen & B. Hansen 699 (BKF, C, U)]; Hansen, Nordic J. Bot. 15: 587-590. 1995. Figures 5.69-5.70.

Herbs, up to 25 cm tall, erect, branched. **Leaves** opposite or decussate; petioles 1.5-4 cm long; blade lanceolate or spatulate, 4-7 by 2-3 cm, apex obtuse, base acuminate, puberulous, secondary veins 8-10 pairs, opposite or alternate. **Inflorescence** terminal or axillary raceme; bract 1, lanceolate or narrow elliptic, 1.0 by 0.2 cm, puberulous; pedicels 0.1 cm long; bracteoles 2, linear, ca. 0.8 cm long, puberulous. **Flowers** up to 1.1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3), linear, 0.5-0.7 cm long, with long hairs and short glandular hairs. **Corolla** lobes 5, white, elliptic, 0.2 by 0.1-0.2 cm, apex obtuse, with glandular hairs. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 0.3-0.45 cm long, puberulous; staminode 1. **Ovary** oblong, glabrous; style 0.6 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 10-14, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- PENINSULAR: **Nakhon Si Thammarat**, Khao Island, 26 Jan. 1958; T. Sørensen, K. Larsen & B. Hansen 699 (type! **BKF**, **C**); **Phuket,** Khao Phataew WS, 14 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 27216 (**BKF** 2 sheets, **C** 2 sheets, **K**, **L**), 17 May 2011, T. Choopan 2011-263 (**SUT**); **Satun**, Kuan Don, 30 Dec. 1927, A.F.G. Kerr 13752 (**BK**, **BM**), 20

May 2011, T. Choopan 2011-281 (**SUT**); **Yala**, Nikom Kue Long, 11 Dec. 1972, T. Santisuk 371 (**BKF**, **K**, **L**).

Distribution.--- Endemic to Thailand.

Ecology.--- In shaded moist evergreen forest with sandy soil, at 50-400 m altitude. Flowering: November-January.

Vernacular.--- Krab Pha Taeo (กราบพะแทว) (Researcher).

Notes.--- This species was distinguished from *S. lanceolata* with height up to 25 cm with branched, thinner leaf texture, narrower bract with more dense and longer hairs and showing long hairs on midvein and margin of bracts (*S. lanceolata* only on margin), leaf blade color only green, leaf shape lanceolate to spatulate, more leaf venation, and longer petioles.

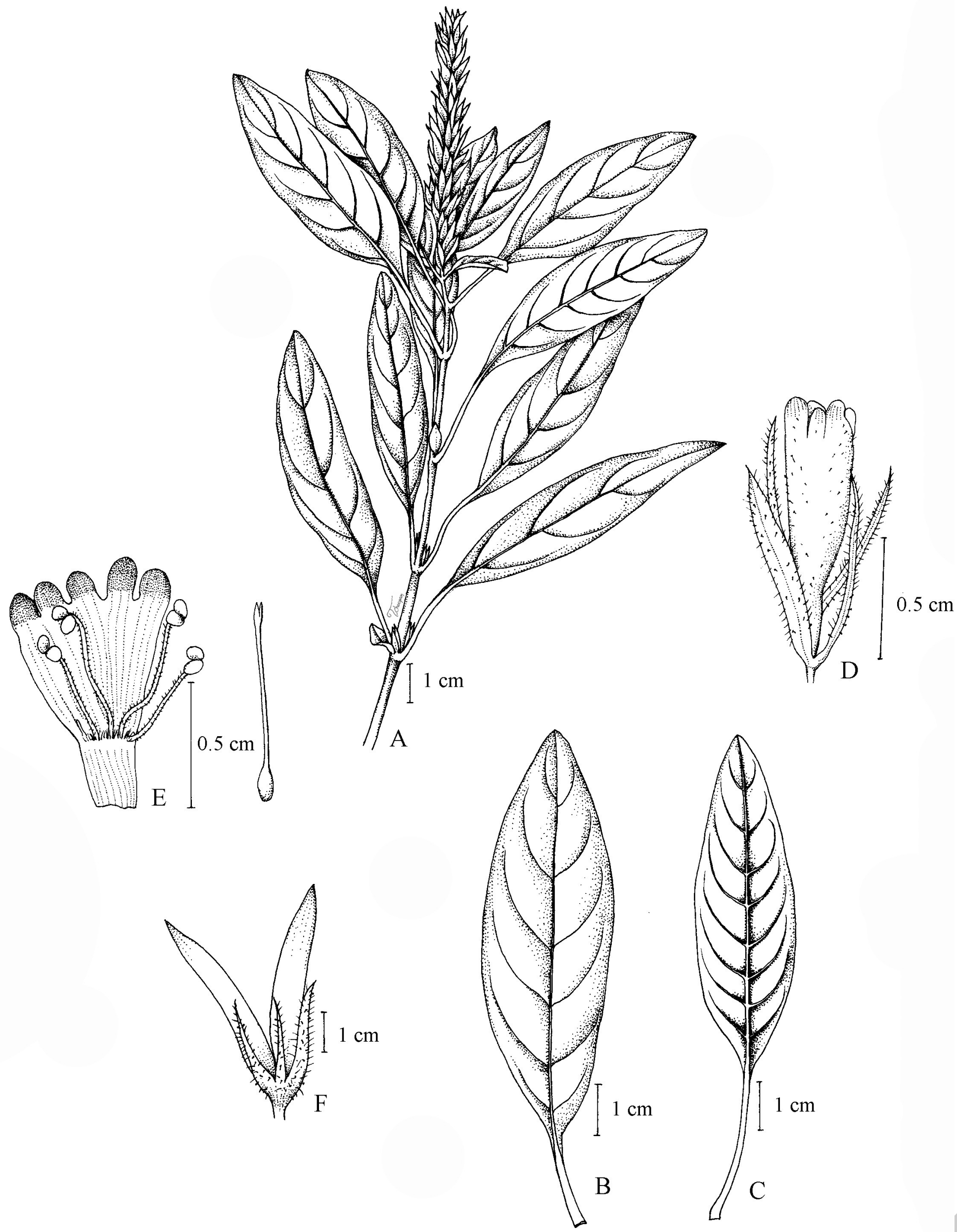


Figure 5.69 *Staurogyne longeciliata* Bremek.

A: habit, B: dorsal leaf, C: ventral leaf, D: flower, E: pistil and stamens, F: fruit.

A

B

Figure 5.70 *Staurogyne longeciliata* Bremek.

A: habit, B: dried inflorescence with open flower.

34. *Staurogyne major* Benoist, Bull. Mus. Hist. Nat. 171. 1933, [Type: Tonkin, Cho chu; Eberhardt 3981, Dinh Ca; Eberhardt 3902 (paratype! P) n.v.; Vietnamese, Annam, Mont Bani, July 1927; J. Clemens 3883 (syntype! C, P)]; Benoist in Lecomte, Fl. Indo-Chine 4: 634. 1935; Hô, Câyco Viêtnam 3(1): 31. 1993. Figures 5.71-5.72.

Staurogyne atropurpurea E. Hossain, Notes Roy. Bot. Gard. Edinburgh 31(3): 382. 1972, [Type: Thailand, Song Khaw, 1 February 1962; K. Larsen 9457 (C)].

___*Staurogyne lasiobotrys* (Nees) Kuntze var. *atropurpurea* (E. Hossain) B. Hansen, Flora Malesiana Bulletin. 38: 173-178. 1985.

Herbs, up to 100 cm tall, erect, branched. **Leaves** opposite or decussate; petioles 2-5 cm long; blade elliptic, 5-15 by 2-7 cm, apex acute, base acute, glabrous except on nerves and margin, secondary veins 6-9 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes, densely puberulous; bracts 1, lanceolate or linear, 0.5-0.6 by 0.1-0.15 cm, long puberulous; pedicels 0.1 cm long, puberulous; bracteole 2, linear, ca. 0.5 cm long, long puberulous. **Flowers** up to 2.5 by 1.2 cm, actinomorphic, tubular. **Calyx** lobes 5, subequal, linear, 1 cm long, with long glandular hairs,. **Corolla** lobes 5, reddish purple, elliptic, 0.5 by 0.3-0.5 cm, apex obtuse, with glandular hairs outside. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 1.5 cm long, puberulous; staminode 1. **Ovary** oblong, glabrous; style 2 cm long, glabrous; stigma 3-lobed. **Fruits** capsule brown, up to ca. 0.7 by 0.2 cm. **Seeds** 12-16, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- NORTHERN, **Tak**, Khun Pha Wor, 25 Mar. 2011, T. Choopan 2011-203 (**BKF**, **SUT**); SOUTH-WESTERN: **Kanchanaburi**, Bo Noi, 18 Jan. 1926, A.F.G. Kerr 10264 (**BK**, **BM**, **C**, **K**, **L**), E-Tong, 21 Feb. 1967, C. Chermsirivathana 671 (**BK** 2 sheets), Pilog-Thong Pha Phum, 11 Dec. 1969, C. Chermsirivathana 1592 (**BK**), Song Khaw, 1 Feb. 1962, K. Larsen 9457 (type! **C**).

Distribution.--- Myanmar, Thailand, Vietnam.

Ecology.--- In shaded evergreen forest along stream, at 400-800 m altitude. Flowering: December-February.

Vernacular.--- Krab Khun Pha Wor (กราบขุนพะวอ) (Researcher).

Notes.--- This species was distinguished from other taxa within the same genus by the large reddish purple flowers and long calyx with long glandular hairs.

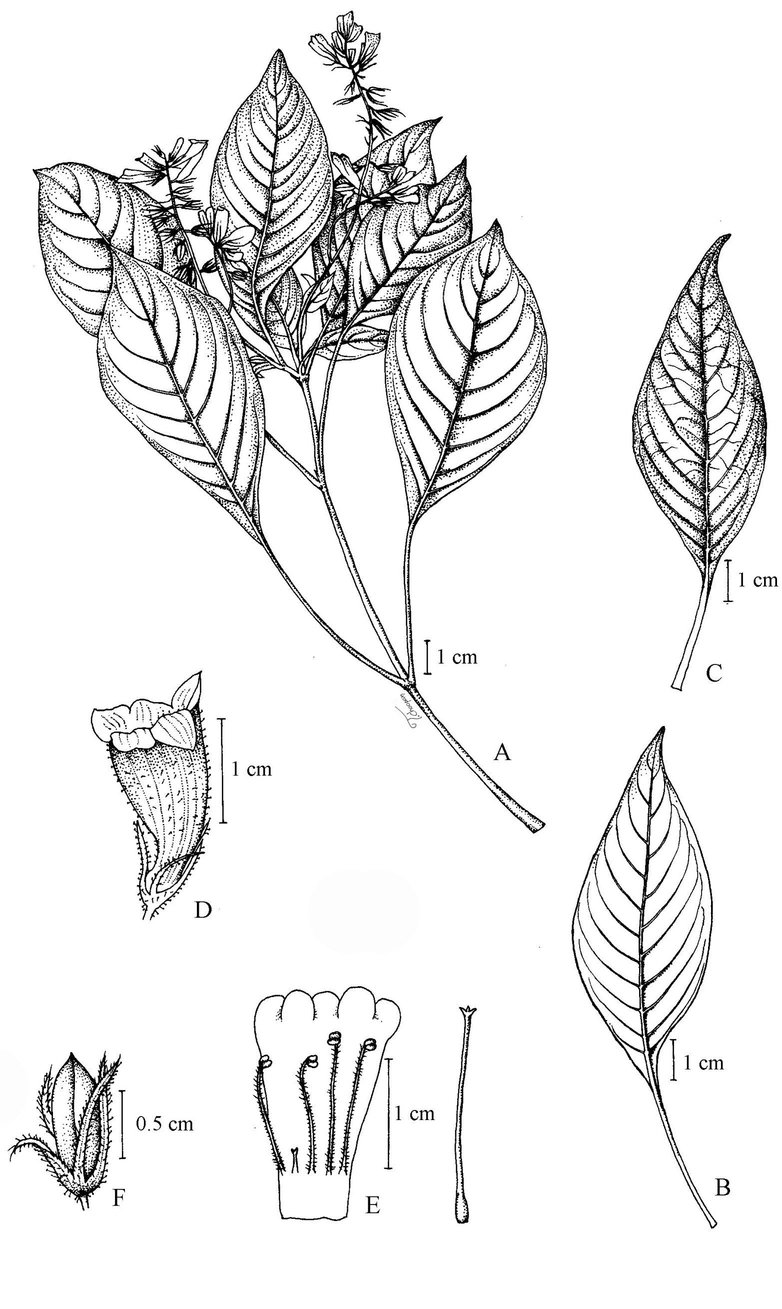


Figure 5.71 *Staurogyne major* Benoist.

A: habit, B: dorsal leaf, C: ventral leaf, D: flower, E: pistil and stamens, F: fruit.

A

B

Figure 5.72 *Staurogyne major* Benoist.

A: habit, B: dried inflorescence with opened flowers.

35. *Staurogyne merguensis* (T. Anders.) Kuntze, Rev. Gen. Pl. 2: 497. 1891, [Type: see *Ebermaiera merguensis*]; Clarke, J. Asiat. Soc. Bengal 74(3): 641. 1908; Ridley, J. Straits Branch Roy. Asiat. Soc. 59: 148. 1911; Ridley, Fl. Malay Penin. 2: 562. 1923; Bremekamp, Reinwardtia 3: 226. 1955. Figures 5.73-5.74.

___*Ebermaiera merguensis* T. Anders., J. Linn. Soc. Bot. 9: 452. 1867, [Type: Burma, Tenasserim, Mergui; Helfer 398-Kew Distrib. 6081 (K)]; Clarke in Hooker, Fl. Brit. India 4: 402. 1885.

Herbs, up to 10 cm tall, erect ascending, branched, puberulous. **Leaves** opposite or decussate; **petioles** 2-7 cm long, puberulous; blade purplish green, elliptic or oblong, 7-13 by 3-8 cm, apex obtuse, base obtuse or cordate, glabrous, puberulous on vein underneath, secondary veins 9-11 pairs, opposite or alternate. **Inflorescence** terminal racemes; **bract** 1, lanceolate, 0.2 by 0.1 cm; **pedicels** 0.1 cm long, puberulous; **bracteoles** 2, linear, ca. 0.2 cm long. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3), linear, 0.2-0.3 cm long, puberulous. **Corolla** lobes 5, white with reddish purple in 3 lobes, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse. **Stamens** included, **anthers** globose, 0.2 cm in diameter, filaments ca. 0.1 cm long, puberulous; **staminode** 1. **Ovary** oblong, glabrous; **style** 0.8 cm long, glabrous; **stigma** 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 4-8, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- SOUTH-EASTERN: **Trat**, Khlong Kaeo NP, 7 Jan. 2009, D.J. Middleton, P. Karaket, S. Lindsay, T. Phutthai & S. Suddee 4635 (**E**), Khao Ban Tad-Khao Saming, 20 Sep. 1946, D. Bunpheng 143 (**BKF**);--- PENINSULAR:

Chumphon, Phato-Pah Island, 8 Dec. 1897, anonymous 2068 (**K**), Phato, 2 May 1974, K. Larsen & S.S. Larsen 33573 (**AAU**); **Krabi**, Khao Pra Bangkram WS, 14 Feb. 1991, C. Niyomdham 2091 (**BKF**), 2 Oct. 2005, J.F. Maxwell 05-522 (**BKF**), 6 Mar. 2006, D. Middleton, S. Lindsay, K. Pattarahirankanok & S. Sirimongkol 4076 (**BKF**, **E**), Nai Chong, 17 Dec. 1965, Umpai 215 (**BK**); **Nakhon Si Thammarat**, Namtok Yong NP, 22 May 2011, T. Choopan 2011-294 (**BKF**, **SUT**), Khao Luang, 12 Feb. 2005, K. Williams, R. Pooma, M. Poopath & V. Chamchumroon 1412 (**BKF**, **E**); **Pattani**, Bannang Sta, 31 Jul. 1923, A.F.G. Kerr 7421 (**BK**, **BM**, **C**, **K**); **Phangnga**, 6 Dec. 1928, anonymous 3861 (**K**), Khao Lam Phi, 13 Sep. 1994, P.C. Boyce 924 (**K**), Kuraburi, 28 Dec. 2006, T. Muadsub 186 (**BKF**); **Phatthalung**, Tha Mot, 5 Oct. 1986, P. Sirirugsa 1028 (**BKF**), 5 Oct. 1991, K. Larsen, S.S. Larsen, C. Niyomdham, W. Ueachirakan & P. Sirirugsa 42153 (**AAU**, **BKF**), 24 Oct. 1993, K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Ueachirakan 43949 (**AAU**), Klong Hin Khao, 18 Apr. 1928, A.F.G. Kerr 15287 (**K**); **Ranong**, 18 Sep. 1968, C. Phengklai 1304 (**BKF**), Bei, 23 Mar. 1971, Bogner 421 (**K**), Hot spring park-Mueang, 5 Jul. 1992, K. Larsen, S.S. Larsen, C. Niyomdham, P. Sirirugsa, D.D. Tirvengadum & C.T. Nørgaard 43120 (**AAU**, **C**), 6 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 26196 (**BKF** 2 sheets) & 26218 (**BKF** 2 sheets), Khao Pho Ta Luangkaeo, 11 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 26948 (**BKF** 2 sheets) & 26996 (**BKF** 2 sheets, **C**, **L**), 27013 (**BKF** 2 sheets), 27019 (**BKF** 2 sheets, **C**, **L**) & 27052 (**BKF**), Klong Naka WS, 17 Nov. 1973, T. Santisuk 587 (**BKF** 2 sheets), 24 Dec. 1983, N. Fukuoka & M. Ito 35455 (**BKF**), 7 Sep. 1984, anonymous 652 (**BKF**), 8 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 26151 (**BKF**), 26411 (**BKF**), 26425 (**BKF**) & 26487 (**BKF**), 11 Sep. 1982, T. Shimizu, F. Konta, T. Wongprasert & B. Sangkhachand 29298 (**C**), Ngao waterfall NP, 15 May 2011, T. Choopan 2011-239 (**BKF**, **SUT**), Thung Raya-Na Sak WS, 30 Jan. 2004, D. Middleton, R. Namdang, R. Pooma, S. Suddee, S. Suwanachat & K. Williams 2678 (**BKF**), 17 Jan. 1987, J.F. Maxwell 87-76 (**AAU**, **L**) & 87-86 (**BKF**), 25 May 2011, T. Choopan 2011-317 (**BKF**, **SUT**); **Satun**, Thung Wa, 4 Jan. 1928, A.F.G. Kerr 13873 (**BM**), Kuan Kalong, 7 Jan. 1985, J.F. Maxwell 85-52 (**BKF**); **Surat Thani**, Baw Rai-Krut, 28 Nov. 1924, A.F.G. Kerr 9457 (**BK**, **BM**, **C**, **K**, **L**), Khao Sok NP, 25 Oct. 1991, K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa 40867 (**AAU**) & 40907 (**AAU**); **Trang**, Chawng, 14 Apr. 1928, A.F.G. Kerr s.n. (**BK**), 24 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 5836 (**C**), Khao Chong, 9 Oct. 1970, C. Charoenphol, K. Larsen & E. Warncke 3486 (**AAU**, **BKF**, **K**, **L**), 24 Jan. 1958, T. Smitinand 4091 (**BKF**), 26 Jan. 1966, M. Tagawa, K. Iwatsuki & N. Fukuoka 6739 (**BKF**, **L**), 30 Oct. 1984, J.F. Maxwell 84-377 (**BKF**), 13 Nov. 1990, K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa 41303 (**AAU**, **C**), 2 Dec. 1969, S. Phusomsaeng & S. Pinnin 323 (**BKF**, **C**, **L** 2 sheets); Chong waterfall, 14 Sep. 1933, D.J. Collins 2370 (**BM**), Talibong Island, 10 Feb. 1966, B. Hansen & T. Smitinand 12208 (**C**); **Yala**, 3 Mar. 1941, T. Premrasmi s.n. (**BKF**).

Distribution.--- Myanmar, Malaysia, Singapore, Thailand.

Ecology.--- In shaded moist evergreen forest, at 50-200 m altitude. Flowering: March-May.

Uses.--- It is used in Kedah “by Chinese as a specific for cough,” and an unknown collector told that the dried leaves are chewed with sirih (or betel).

Vernacular.--- Tan Oi (ตานอ้อย), Mai wan (ไม้หวาน).

Notes.--- *Staurogyne merguensis* and *Staurogyne tenuispica* are doubtless near allies. The inflorescence of *S. merguensis* is less strongly ramified, its peduncle and rachis are less slender and they are puberulous instead of glandular-hirtellous; the flowers, on the other hand, are larger. A few inflorescences with more than two branchlets were noted.

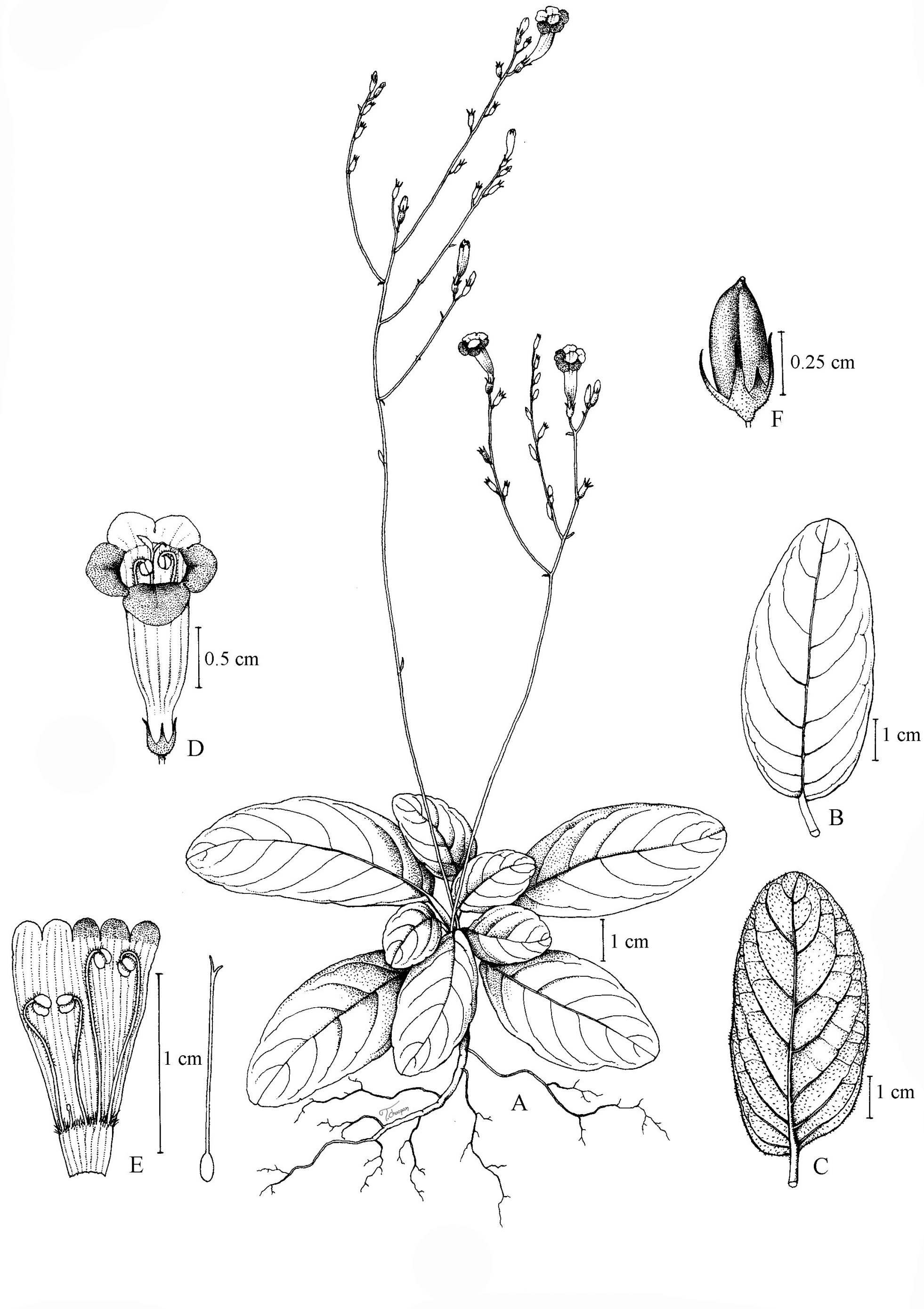


Figure 5.73 *Staurogyne merguensis* (T. Anders.) Kuntze.

A: habit, B: dorsal leaf, C: ventral leaf, D: flower, E: pistil and stamens, F: fruit.

A

B

Figure 5.74 *Staurogyne merguensis* (T. Anders.) Kuntze.

A: habit, B: inflorescence with opened flower.

36. *Staurogyne obtusa* (Nees) Kuntze, Rev. Gen. Pl. 2: 497. 1891, [Type: see *Erythracanthus obtusus*]; Benoist in Lecomte, Fl. Indo-Chine. 4: 631. 1935; Maxwell & Elliott, Fl. Doi Sutep-Pui Nat. Park 109. 2001. Figures 5.77-5.78.

___*Erythracanthus obtusus* Nees, in Candolle, Prodr. 11: 78. 1847a, [Type: Mergui; Griffith s.n.-Kew Distrib. 6083 (GZU, K)].

___*Ebermaiera obtusa* T. Anders., J. Linn. Soc. Bot. 9: 453. 1867; Clarke in Hooker, Fl. Brit. India 4: 401. 1885.

Herbs, up to 10 cm tall, short, subtomentose. **Leaves** opposite or decussate; **petioles** 3-10 cm long, puberulous; blade elliptic, 4-14 by 2-7.5 cm, apex obtuse, base obtuse or sometimes subcordate, glabrous, secondary veins 7-9 pairs, opposite or alternate. **Inflorescence** terminal or axillary lax racemes, puberulous; **bract** 1, elliptic, 0.3 by 0.1 cm, puberulous; **pedicels** 0.2 cm long, with glandular hairs; **bracteoles** 2, linear, ca. 0.2 cm long, puberulous. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, subequal, linear, 0.5-0.6 cm long, with glandular hairs. **Corolla** lobes 5, white, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, puberulous. **Stamens** included, **anthers** globose, 0.1 cm in diameter, filaments ca. 0.7 cm long, puberulous; **staminode** 1. **Ovary** oblong, glabrous; **style** 0.9 cm long, glabrous; **stigma** 3-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 12-16, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- NORTHERN: **Chiang Mai**, Doi Chiang Dao, 8 Mar. 1910, A.F.G. Kerr 1054 (**BM**, **K**), 30 Jan. 1913, A.F.G. Kerr s.n. (**BK**, **BM**), 12 Oct. 1926, Put 295 (**BK**, **BM**, **C**, **K**, **L**), 19 Dec. 1931, Put 4406 (**BK**, **BM**, **C**, **L**) & 4409 (**K**), 28

May 1906, C.C. Hosseus 464 (**K**), 1 Dec. 1961, K. Bunpan 32 (**BKF**), 5 Nov. 1989, J.F. Maxwell 89-1360 (**E**, **L**), 8 Feb. 1999, K. Larsen & S.S. Larsen 47304 (**AAU**), Fang, 12 Feb. 1959, T. Smitinand 3758 (**BKF**), Doi Suthep, 14 Jan. 1989, J.F. Maxwell 89-37 (**AAU**, **BKF**, **L**), 26 Mar. 1990, J.F. Maxwell 90-362 (**E**, **L**), Doi Wao, 23 Feb. 1912, A.F.G. Kerr 2436 (**BM**, **E**, **K**); **Chiang Rai**, Chiang Saen, 27 Mar. 1921, A.F.G. Kerr 5149 (**BK**, **BM**, **K**); **Nan**, Ban Huai Dong, 20 Nov. 1993, K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Ueachirakan 44640 (**AAU**); **Phitsanulok**, Thung Salaeng Luang, 18 Feb. 1964, B. Hansen , G. Seidenfaden & T. Smitinand 11192 (**BKF**, **C**, **K**);--- NORTH-EASTERN: **Loei**, Phu Suan Sai NP, 17 Jan. 2008, C. Maknoi 1953 (**BKF**, **QBG**); **Phetchabun**, 5 Jan. 1960, T. Smitinand 6296 (**BKF**, **K**);--- CENTRAL: **Nakhon Nayok**, Salika waterfall, 24 Nov. 1953, K. Suvatabandha 491 (**BK**);--- SOUTH-WESTERN: **Phetchaburi**, Kaeng Krachan NP, 26 Dec. 2007, P. Phonsena, W. Chausook, W. Loetsombunsuk & N. Loetsombunsuk 5767 (**BKF**);--- PENINSULAR: **Chumphon**, Pha To, 26 Jan. 2002, T. Wongprasert 021-2 (**BKF**); **Phangnga**, Kho Khao Island, 7 Dec. 1965, B. Sangkhachand 1191 (**BKF**, **C**, **E**, **K**, **L**); **Ranong**, 1 Feb. 1927, A.F.G. Kerr 11740 (**BK**, **BM**, **K**), Kaper, 17 Jan. 1929, A.F.G. Kerr 16694 (**BK**, **BM**, **C**, **K**, **L**); **Surat Thani**, 5 Dec. 1975, D. Prapat 107 (**BKF**, **K**), Khao Sok, 25 Oct. 1991, K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa 40863 (**AAU** 2 sheets, **C**), 26 Feb. 2006, D.J. Middleton, C. Hemrat, S. Lindsay, S. Suddee & S. Suwanachat 4016 (**BKF**, **E**), Klong Saeng WS, 18 Feb. 1994, J.F. Maxwell 94-254 (**BKF**).

Distribution.--- Myanmar, Thailand, Vietnam.

Ecology.--- In shaded evergreen forest, at 50-200 m altitude. Flowering: September-December.

Vernacular.--- Krab Cho Khanaeng (กราบช่อแขนง) (Researcher).

Notes.--- This species was distinguished from *S. griffithina* by thin ovate leaves and the well-branched lax raceme inflorescences with non-showy bracts.

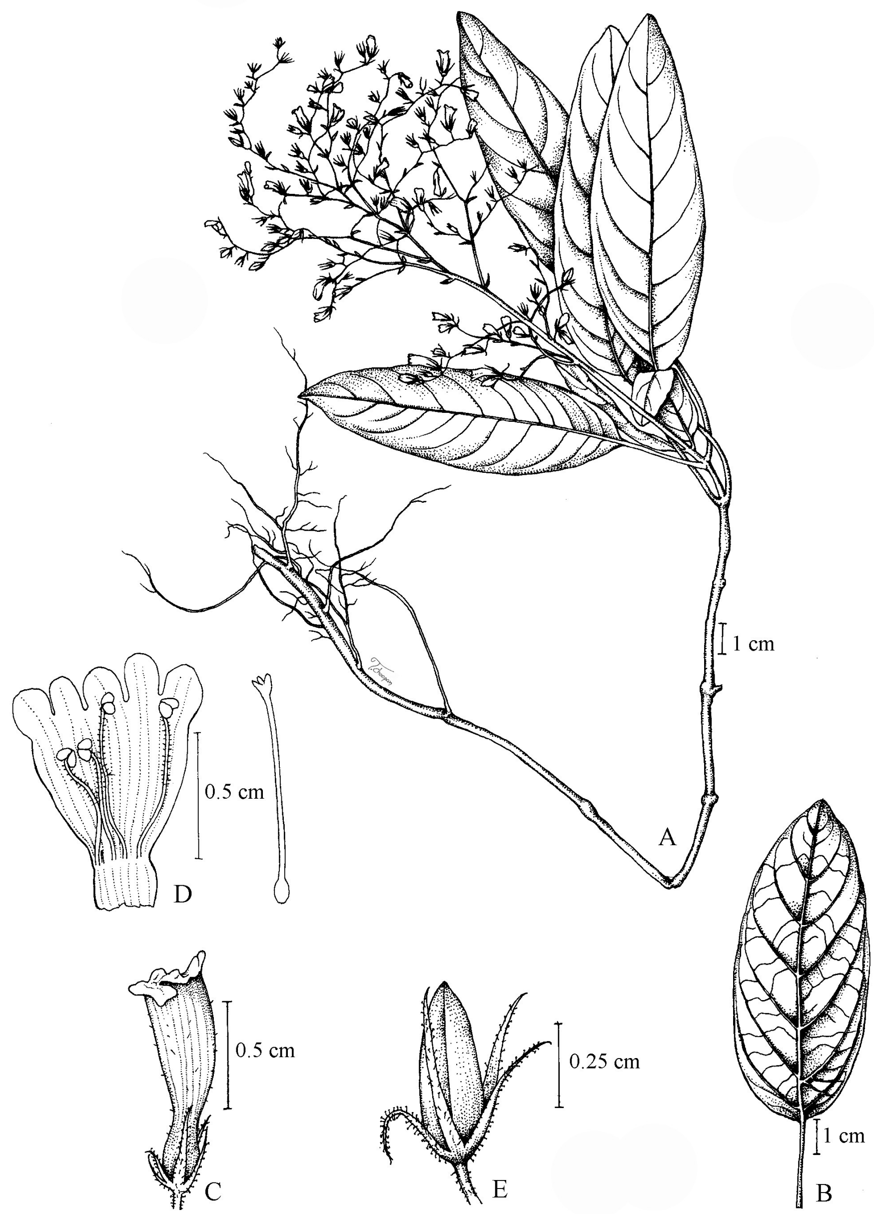
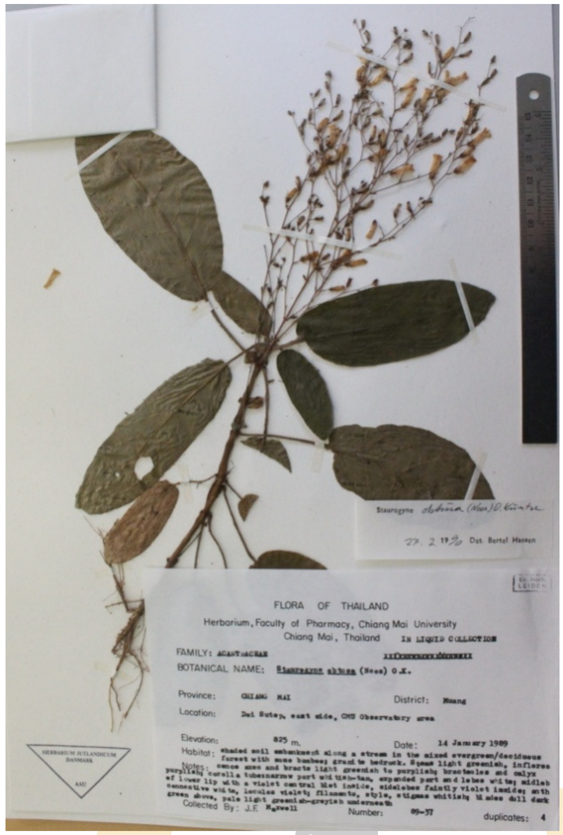


Figure 5.75 *Staurogyne obtusa* (Nees) Kuntze.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.



A

B

Figure 5.76 *Staurogyne obtusa* (Nees) Kuntze.

A: herbarium sheet, B: dried inflorescence with opened flowers.

37. *Staurogyne parvicaulis* B. Hansen, Nordic J. Bot. 15: 585-586. 1995, [Type: Thailand, Nong Khai, 15 December 1982, H. Koyama, H. Terao & T. Wongprasert 31078 (BKF, holotype! C)]. Figures 5.79-5.80.

Herbs, up to 10 cm tall, unbranched, much contracted. **Leaves** subrosulate; petioles 0.3-0.8 cm long, pubescent; blade lanceolate, 4-6 by 1-1.8 cm, apex obtuse, base attenuate, pubescent on nerve, secondary veins 7-9 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes, glandular hairs; bract 1, lanceolate, 0.6 by 0.2 cm, with glandular hairs; pedicels 0.2-0.3 cm long, puberulous; bracteoles 2, linear, ca. 0.6 cm long, with glandular hairs. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3), posterior lobe lanceolate, the other lobes linear-lanceolate, 0.2-0.3 cm long, with densely stalked-glandular hairs. **Corolla** lobes 5, pale purple, elliptic, 0.35 by 0.3 cm, apex obtuse, with glandular hairs outside. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments 0.5-0.6 cm long, densely puberulous; staminode 1. **Ovary** oblong, glabrous; style 0.7 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 10-14, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- NORTH-EASTERN: **Nong Khai**, Si Chiang Mai, 15 Dec. 1982, H. Koyama, H. Terao & T. Wongprasert 31078 (**BKF**, holotype! **C**);--- EASTERN: **Nakhon Ratchasima**, Pi Mai, 16 Mar. 1958, T. Sørensen, K. Larsen & B. Hansen 2154 (**C** 2 sheets).

Distribution.--- Endemic to Thailand.

Ecology.--- Open grassy fields, at 100-400 m altitude.

Vernacular.--- Krab Si Chiang Mai (กราบศรีเชียงใหม่) (Researcher).

Notes.--- Resembling *Staurogyne concinnula* but distinguished by being stalked-glandular puberulous in floral parts and by its leaf-like lower bracts.

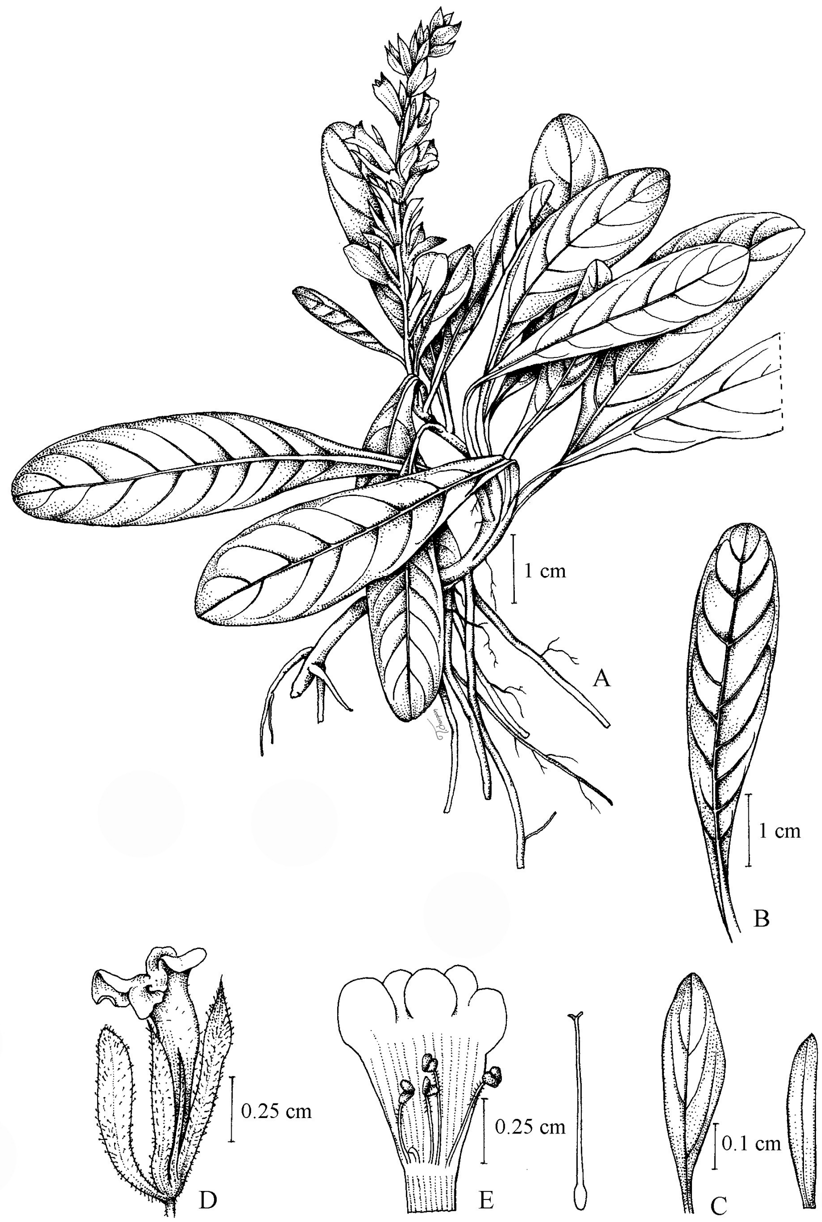


Figure 5.77 *Staurogyne parvicaulis* B. Hansen.

A: habit, B: ventral leaf, C: bracts, D: flower, E: pistil and stamens.

A

B

Figure 5.78 *Staurogyne parvicaulis* B. Hansen.

A: herbarium sheet (type!), B: dried inflorescence with opened flowers.

38. *Staurogyne punctata* J. B. Imlay, Bull. Misc. Inform. Kew 1939(3): 109. 1939 [Type: Thailand, Phu Kradueng, 11 February 1931, A.F.G. Kerr 20094 (BK, BM, K)]. Figures 5.63-5.64.

Staurogyne kradengensis Bremek., Dansk Bot. Ark. 20: 59. 1961, [Type: Thailand, Phu Kradueng, 7 July 1959; T. Sørensen, K. Larsen & B. Hansen 7412 (BKF, holotype! C, E, U,)].

Perennial herbs or subshrubs, up to 30 cm tall, erect, rarely branched. **Leaves** opposite or decussate; petioles 0.8-1 cm long, puberulous; blade narrow elliptic, 5-8 by 1-2 cm, apex acute, base acute, glabrous, secondary veins 8-10 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes, puberulous; bract 1, lanceolate or elliptic, 0.6 by 0.1 cm; pedicels reddish purple, 0.1-0.2 cm long; bracteoles 2, linear, ca. 0.4 cm long. **Flowers** up to 1.5 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3), linear, 0.3-0.5 cm long, glabrous. **Corolla** lobes 5, white, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, glabrous. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 0.5-0.7 cm long, with glandular hairs; staminode 1. **Ovary** oblong, glabrous; style 0.9 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.15 cm. **Seeds** 16-24, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- NORTH-EASTERN: **Loei**, Phu Kradueng, 11 Feb. 1931, A.F.G. Kerr 20094 (type! **BK**, **BM**, **K**), 19 Mar. 1958, T. Sørensen, K. Larsen & B. Hansen 2271 (**C**), 7 Jul. 1959; T. Sørensen, K. Larsen & B. Hansen 7412 (**BKF**, holotype! **C**,

E), 31 Oct. 1984, S. Mitsuta, H. Nagamasu, T. Yahara & N. Nantasan 42262 (**BKF**) 42343 (**BKF**), 15 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 22735 (**BKF**) & 22819 (**BKF** 2 sheets), 16 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 23084 (**BKF** 2 sheets, **C**, **L**), 23131 (**BKF**) & 23184 (**BKF** 2 sheets, **L**), 2 Sep. 1988, M.N. Tamura 60504 (**BKF**), 1 Nov. 1984, G. Murata, C. Phengklai, S. Mitsuta, T. Yahara, H. Nagamasu & N. Nantasan 42505 (**BKF**, **L**) & 42542 (**BKF**, **L**), 28 Nov. 1965, M. Tagawa, K. Iwatsuki & N. Fukuoka 466 (**AAU**, **BKF**, **K**, **L**), 14 Dec. 1963, Umpai 90 (**BK**), 29 Mar. 1948, K. Suvatabandha 191 (**BK**, **K**), 18 Dec. 1982, H. Koyama, H. Terao & T. Wongprasert 31221 (**BKF**, **C**, **L**), 19 Dec. 1982, H. Koyama, H. Terao & T. Wongprasert 31302 (**BKF**), 31 Aug. 1988, H. Takahashi & M.N. Tamura 63293 (**BKF**), 13 Sep. 1990, P. Chantaranothai, J. Parnell, D. Simpson & K. Sridit 90/173 (**K**), 14 Sep. 1990, P. Chantaranothai, J. Parnell, D. Simpson & K. Sridit 90/210 (**K**), 29 Dec. 1971, C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan 4539 (**BKF**, **L**), 26 Dec. 2010, T. Choopan 2010-113 (**BKF**, **SUT**), Phu Luang, 4 Dec. 1965, M. Tagawa, K. Iwatsuki & N. Fukuoka 1220 (**BKF**, **C**, **L**), 16 Jun. 2004, S. Bunwong 291 (**KKU**), 25 Nov. 2010, T. Choopan 2010-065 (**BKF**, **SUT**); Wang Saphung, 19 Jan. 1948, Din 10 (**BKF**), 12 Jul. 1948, D. Bunpheng 84 (**BKF**).

Distribution.--- Thailand.

Ecology.--- In shaded hill evergreen forest with *Pinus* along stream, at 1,100-1,300 m altitude. Flowering: September-December.

Vernacular.--- Kok kai (กกไค), Mai Phuay Nam (ไม้เฟือยน้ำ).

Notes.--- This species is distinguished from *S. subglabra* by their narrow lanceolate leaves mostly clustered on the top of branches, staminode 1. It normally grows on moist rock along river banks of high mountains (hill forest or pine evergreen forest).

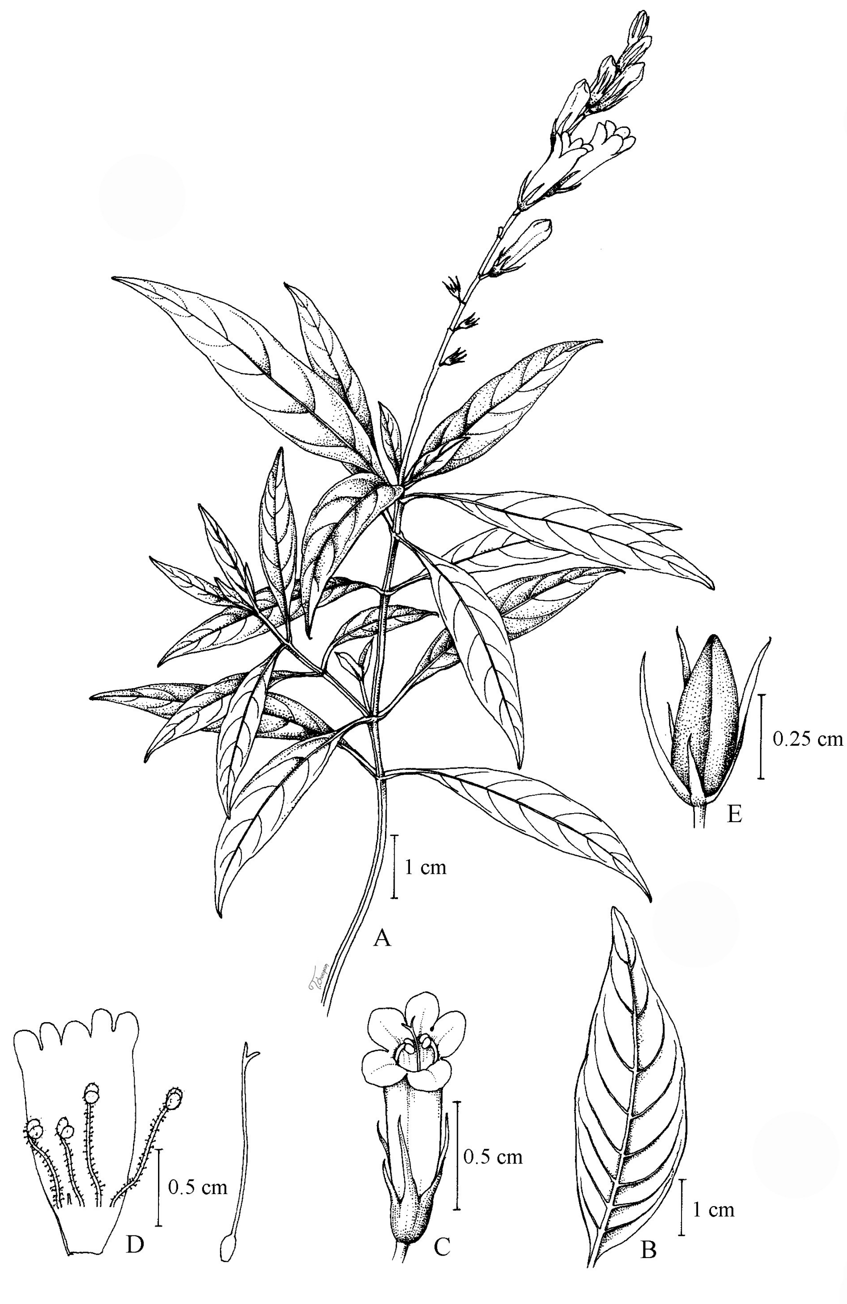


Figure 5.79 *Staurogyne punctata* J. B. Imlay.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.80 *Staurogyne punctata* J. B. Imlay.

A: habit, B: inflorescence with opened flowers.

39. *Staurogyne racemosa* [Wall] (Miq) Kuntze, Rev. Gen. Pl. 2: 497. 1891, [Type: see *Erythracanthus racemosus*]; Clarke, J. Asiat. Soc. Bengal 74(3): 641. 1908; Ridley, Fl. Malay Penin. 2: 562. 1923; Benoist in Lecomte, Fl. Indo-Chine. 4: 633. 1935; Bremekamp, Reinwardtia 3: 232. 1955. Figures 5.81-5.82.

___*Erythracanthus racemosus* Nees, in Wallich, Pl. Asiat. Rar. 3: 80. 1832. [Type: Malaysia, Penang, 1830, N. Wallich cat. no. 2336 (K, P)]; Nees in Candolle, Prodr. 11: 78. 1847a.

___*Ebermaiera racemosa* Miq., Fl. Ind. Bat. 2: 775. 1856; [Type: Penang, Wallich]; Clarke in Hooker, Fl. Brit. India 4: 401. 1885.

___*Ebermaiera racemosa* T. Anders., J. Linn. Soc. Bot. 9: 452. 1867.

Ruellia racemosa Roxb., Fl. Ind. 3: 472. 1874 [Type: Wallich s.n. (PH)].

Herbs, up to 80 cm tall, erect, branched, glabrous. **Leaves** opposite or decussate; petioles 1.5-3 cm long, glabrous; blade elliptic, 5-10 by 3-4.5 cm, apex obtuse or acute, base acute, glabrous except margin puberulous, secondary veins 6-7 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes, puberulous; bracts 2, linear, 0.4-0.5 by 0.1-0.2 cm; pedicels 0.1 cm long, puberulous; bracteoles 2, linear, ca. 0.3 cm long, puberulous. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, subequal, purple, linear, 0.4-0.5 cm long, with glandular hairs. **Corolla** lobes 5, reddish purple, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, glabrous. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 0.7 cm long, with glandular hairs; staminode 1. **Ovary** oblong, glabrous; style 0.7 cm long, glabrous; stigma 3-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 4-8, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- SOUTH-WESTERN: **Phetchaburi**, Kaeng Krachan NP, 14 Dec. 2002, D. J. Middleton, S.Suddee & C. Hemrat 1663 (**BKF**), 25 Aug. 2004, I.C. Nielsen, S. Suddee, N. Hemrath & J. Rithipheth 1919 (**BKF**);--- PENINSULAR: **Surat Thani**, Khao Kuap-Krut, 23 May 1930, Put 2966 (**BK**, **C**, **K**).

Distribution.--- Myanmar, Malaysia, Singapore, Thailand, Indonesia.

Ecology.--- In shaded evergreen forest, at 900-1,000 m altitude. Flowering: September-December.

Vernacular.--- Krab Kleep Muang (กราบกลีบม่วง) (Researcher).

Notes.--- This species was distinguished from others within the same genus by the reddish purple flower but smaller than in *S. major* and the shorter purple calyx with shorter puberulous, instead of green ones.

Figure 5.81 *Staurogyne racemosa* (Miq) Kuntze.

A: habit, B: flower, C: pistil and stamens.

A

B

Figure 5.82 *Staurogyne racemosa* (Miq) Kuntze.

A: herbarium sheet, B: inflorescence with opened flowers.

40. *Staurogyne setigera* (Nees) Kuntze, Rev. Gen. Pl. 2: 497. 1891, [Type: see *Ebermaiera setigera*]; Clarke, J. Asiat. Soc. Bengal 74(3): 635. 1908; [Type: Philippines, Balabac Island, Katakupan, November 1927; M. Ramos & G. E. Edano 49718 (isotype! A)]; Ridley, Fl. Malay Penin. 2: 559. 1923; Benoist in Lecomte, Fl. Indo-Chine 4: 626. 1935; Bremekamp, Reinwardtia 3: 187. 1955; Maxwell, Fl. Ko Hong Hill 241. 2006. Figures 5.83-5.84.

___*Ebermaiera setigera* Nees, in Candolle, Prodr. 11: 76. 1847a, [Type: Malaysia, Malacca, Cuming, Griffith 2355 (K)]; Miquel, Fl. Ind. Bat. 2: 774. 1856; Anderson, J. Linn. Soc. Bot. 9: 451. 1867; Clarke in Hooker, Fl. Brit. India 4: 398. 1885.

Ebermaiera subcapitata C. B. Clarke, in Rosenvinge, Bot. Tidsskr. 24: 348. 1902b, [Type: Thailand, Trat, Chang Island-Klong Munse, 18 January 1900; J. Schmidt 122 & 271 (syntype! C)]; Clarke in Schmidt, Fl. Koh Chang 6: 198. 1902a.

Staurogyne malaccensis C. B. Clarke, J. Asiat. Soc. Bengal 74(3): 636. 1908, [Type: Malay Peninsula, Malacca, Griffith 189 (K)]; Ridley, J. Straits Branch Roy. Asiat. Soc. 59: 147. 1911; Ridley, Fl. Malay Penin. 2: 559. 1923; non Benoist in Lecomte, Fl. Indo-Chine 4: 626. 1935; Bremekamp, Reinwardtia 3: 204. 1955.

Herbs, up to 10 cm tall, erect ascending, branched, puberulous. **Leaves** opposite or decussate; petioles purplish green, 1-2 cm long, puberulous; blade elliptic, 3-8 by 2-3.5 cm, apex obtuse, base obtuse, puberulous, secondary veins 7-9 pairs, opposite or alternate. **Inflorescence** terminal ovoid dense spikes; bracts 1, lanceolate, 0.5 by 0.1-0.2 cm, with long hairs and short glandular hairs; pedicels 0.1 cm long, puberulous; bracteoles 2, linear, ca. 0.5 cm long. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3), linear or lanceolate, 0.5-0.8 cm long, with long hairs and short glandular hairs. **Corolla** lobes 5, white with red lines in throat and basal lobes area, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 0.6 cm long, puberulous; staminodes 0. **Ovary** oblong, glabrous; style 0.8 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 10-12, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- SOUTH-EASTERN: **Trat**, Chang Island, 9 Jan. 1900, J. Schmidt 122 (type! **C**), 18 Jan. 1900, J. Schmidt 271 (syntype! **C**, **K**);--- PENINSULAR: 5 Nov. 1919, C.B. Kloss 6920 (**K**), 30 Mar. 1911, J. Schmidt 271 (**K**); **Narathiwat**, Hala-Bala WS, 26 Dec. 1999, C. Phengklai et al. 14837 (**BKF**), Sungai Kolok-Nikom Waeng, 1 Mar. 1974, K. Larsen & S.S. Larsen 32775 (**AAU**, **L**); **Phangnga**, 6 Dec. 1928, anonymous 3860 (**K**); **Phatthalung**, Khao Pu-Khao Ya NP, 19 May 2011, T. Choopan 2011-272 (**BKF**, **SUT**); **Ranong**, Kraburi, 25 Dec. 1928, A.F.G.Kerr 16357 (**BM**), Muang Len, 11 Jan. 1966, B. Hansen & T. Smitinand 11874 (**K**); **Songkhla**, Ton Nga Chang WS, 17 Aug. 1995, K. Larsen, S.S. Larsen, C. Tange, R. Moran, T. Niyomdham & P. Puudjaa 45735 (**BKF**); **Trang**, Khao Chong, 13 Oct. 1985, J.F. Maxwell 85-971 (**AAU**, **BKF**, **E**, **L**).

Distribution.--- Malaysia, Singapore, Thailand, Vietnam, Indonesia.

Ecology.--- In shaded moist evergreen forest, at 100-400 m altitude. Flowering: March-May.

Vernacular.--- Krab Pu Ya (กราบปู่ย่า) (Researcher).

Notes.--- This species was distinguished from *S. lanceolata* by glandular hairs and non-glandular hairs on bracts, white corolla with reddish-purple lines inside corolla tube, and capitate inflorescences.

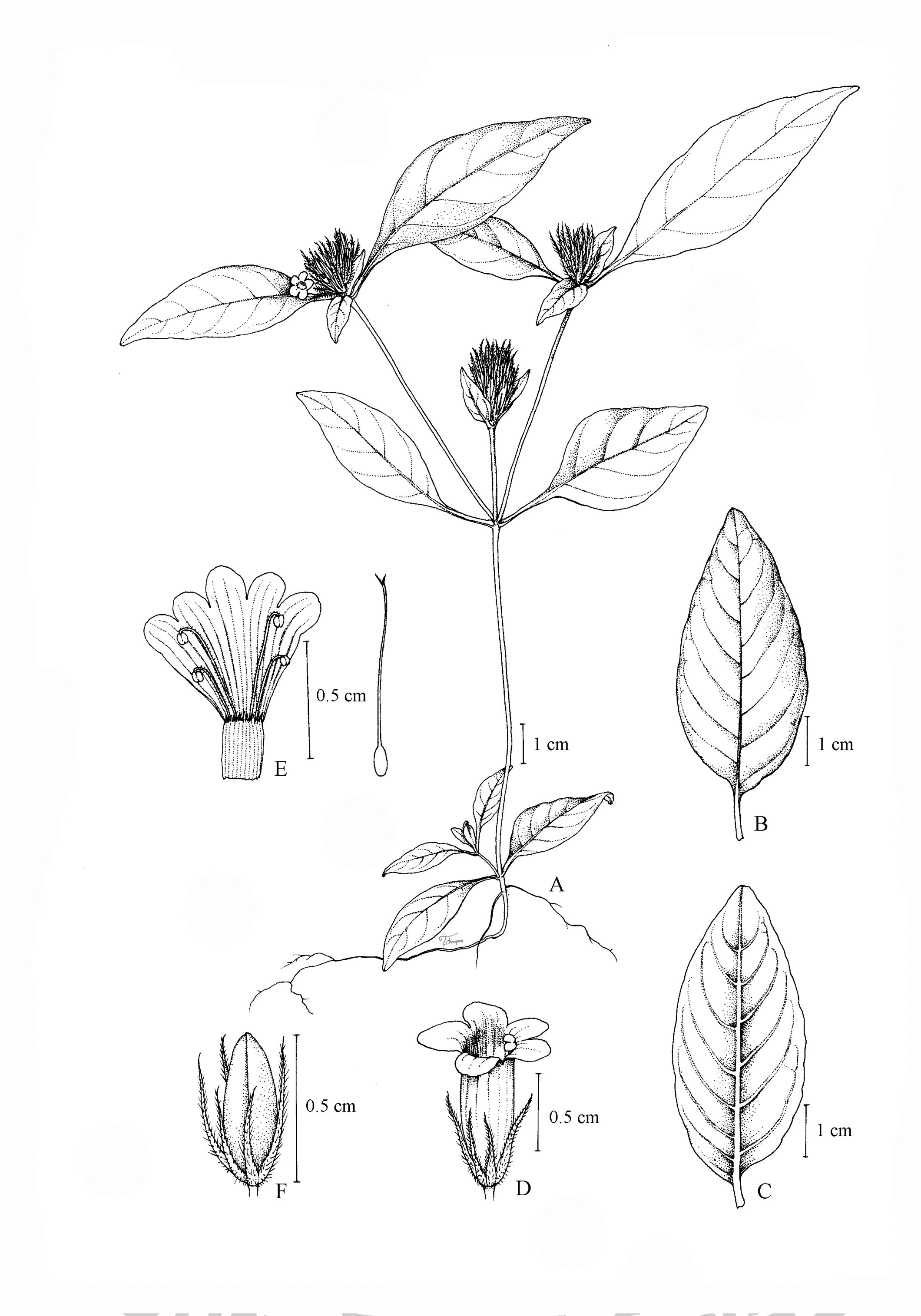


Figure 5.83 *Staurogyne setigera* (Nees) Kuntze.

A: habit, B: dorsal leaf, C: ventral leaf, D: flower, E: pistil and stamens, F: fruit.

A

B

Figure 5.84 *Staurogyne setigera* (Nees) Kuntze.

A: habit, B: inflorescence with opened flower.

41. *Staurogyne singularis* Bremek., Dansk Bot. Ark. 27: 77. 1969, [Type: Thailand, Phitsanulok, Phu Mieng, 27 July 1966; K. Larsen, T. Smitinand & E. Warncke 935 (holotype! AAU, isotype! BKF, isotype! U)]. Figures 5.85-5.86.

Staurogyne bella Bremek. var. *longipedicellata* Bremek., Dansk Bot. Ark. 27: 74. 1969, [Type: Thailand, Phu Mieng mountain, 27 July 1966; K. Larsen, T. Smitinand & E. Warncke 933 (isotype! AAU, isotype! BKF, isotype! U)]; *Staurogyne singularis* Bremek. var. *longipedicellata* (Bremek.) E. Hossain, comb. nov., Hossain, Notes Roy. Bot. Gard. Edinburgh 31(3): 387. 1972.

Staurogyne inaequalis E. Hossain, Notes Roy. Bot. Gard. Edinburgh 31(3): 381. 1972 [Type: Thailand, Phitsanulok, Phu Mieng mountain, 27 July 1966; K. Larsen, T. Smitinand & E. Warncke 929 (holotype! AAU, isotype! BKF, isotype! U)].

Herbs, up to 10 cm tall, decumbent-ascending, branched at upper part, puberulous. **Leaves** opposite or decussate; petioles 0.5-2 cm long, puberulous; blade lanceolate, 3-7 by 1-2.5 cm, apex obtuse or nearly obtuse, base acute, puberulous underneath, secondary veins 7-8 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes, puberulous; bract 1, linear, 0.3-0.5 by 0.1 cm; pedicels 0.5-0.7 cm long, puberulous; bracteoles 2, filiform, ca. 0.2 cm long. **Flowers** up to 2 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, linear, unequal, 1 posterior lobe 0.6 cm long, 2 anterior lobes 0.7 cm long, 2 lateral lobes 0.5 cm long, puberulous. **Corolla** lobes 5, white with pink-rose lobes, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, puberulous. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 0.6-

0.8 cm long, puberulous; staminode 1. **Ovary** oblong, glabrous; style 0.9 cm long, glabrous; stigma 3-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 10-12, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- NORTHERN: **Nan,** Doi Phuka NP, 6 Jul. 2001, P. Srisanga 1948 (**QBG**), 14 Nov. 2001, P. Srisanga 2261 (**BKF**, **QBG**); **Phitsanulok**, Phu Miang, 27 Jul. 1966 K. Larsen, T. Smitinand & E. Warncke 929 (holotype! **AAU**, isotype! **BKF**) & 933 (holotype! **AAU**, isotype! **BKF**) & 935 (holotype! **AAU**, isotype! **BKF**), 5 Oct. 1967, T. Shimizu, K. Iwatsuki, N. Fukuoka, M. Hutoh, D. Chaiglom & A. Nalampoon 11756 (**AAU**);--- NORTH-EASTERN: **Loei**, Phu Suan Sai NP-Nahaeo, 21 Jun. 1995, W. Nanakorn 3858 (**QBG**), 20 Oct. 2012, T. Choopan 2012-331 (**BKF**, **SUT**).

Distribution.--- Endemic to Thailand.

Ecology.--- In shaded hill evergreen forest, at 600-1,300 m altitude. Flowering: July-September.

Vernacular.--- Krab Phu Miang (กราบภูเมี่ยง) (Researcher).

Notes.--- This species was distinguished from *S. subglabra* by the greater number of inflorescences, which, moreover, are much shorter and consist of a much smaller number of flowers, corolla lobes pink-rose with hairs at point of adnation (filament & corolla) inside corolla tube, and also by the narrower bracts and calyx lobes.

Figure 5.85 *Staurogyne singularis* Bremek.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.86 *Staurogyne singularis* Bremek.

A: habit, B: inflorescence with opened flower.

42. *Staurogyne spatulata* (Blume) Koord., Exkursionsfl. Java 3: 211. 1912 n.v., [Type: Java, Djakarta (Batavia); Blume s.n. (holotype! L)]; Koorders, Exkursionsfl. Java 147. 1914; Bremekamp, Reinwardtia 3: 170. 1955. Figures 5.87-5.88.

___*Adenosma spatulatum* Blume, Bijdr. Fl. Ned. Ind. 757. 1826. [Type: Bataviae].

___*Ebermaiera spatulata* (Blume) Hassk., in Teijsmann & Binnendijk, Hort. Bog. 149. 1866 [Type: Java]; Nees in Candolle, Prodr. 11: 74. 1847a; Miquel, Fl. Ind. Bat. 2: 772. 1856.

Ebermaiera glauca Nees var. *spatulata* (Blume) Clarke, in Hooker, Fl. Brit. India 4: 396. 1885.

Staurogyne polycaulis Bremek., Dansk Bot. Ark. 20: 60. 1961, [Type: Thailand, Nakhon Si Thammarat, Koh Khao, 29 January 1958; T. Sørensen, K. Larsen & B. Hansen 811 (holotype! C, U)].

Staurogyne flexicaulis Bremek., Dansk Bot. Ark. 20: 58. 1961, [Type: Thailand, Chanthaburi, Soi Dao, 15 January 1958; T. Sørensen, K. Larsen & B. Hansen 351 (holotype! C)].

Herbs, up to 30 cm tall, erect ascending, branched, puberulous. **Leaves** opposite or decussate; petioles 2-4 cm long, puberulous; blade elliptic, 4-9 by 2-3.5 cm, apex obtuse or acute, base acute, puberulous, secondary veins 9-11 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes, up to 6 by 2 cm; bract 1, lanceolate, 1-1.0 by 0.2 cm, with glandular hairs; pedicels 0.1 cm long, puberulous; bracteoles 2, linear, ca. 1.0 cm long, with glandular hairs. **Flowers** up to 0.8 by 0.4 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3 with one wider), linear, 0.7-1.0 cm long, with glandular hairs. **Corolla** lobes 5, white with pinkish purple lines in throat, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, puberulous. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 0.7 cm long, puberulous; staminode 1. **Ovary** oblong, glabrous; style 0.6 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.3 by 0.2 cm. **Seeds** 4-8, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- NORTHERN: **Chiang Mai**, Jan. 1981, C. Chermsirivathana s.n. (**BK**), Doi Suthep, 4 Dec. 1911, A.F.G. Kerr 2270 (**K**), Chiang Dao, 8 Mar. 1965, C. Chermsirivathana 307 (**BK**, **BKF**), Omkoi, 10 Jan. 1983, H. Koyama, H. Terao & T. Wongprasert 32219 (**BKF**), Mae Taeng, 20 Jan. 1992, J.F. Maxwell 92-43 (**E**, **L**); **Lampang**, Doi Khun Tan NP, 16 Feb. 1995, J.F. Maxwell 95-112 (**BKF**, **L**), Chae Son NP, 15 Jan. 2011, T. Choopan 2011-164 (**BKF**, **SUT**); **Nan**, Doi Phuka NP, 13 Jan. 2011, T. Choopan 2011-141 (**BKF**, **SUT**); **Phitsanulok**, Thung Salaeng Luang NP, 1 Mar. 1974, S. Sutheesorn 2968 (**BK**); **Phrae**, Huai Khamin, 10 Feb. 1912, A.F.G. Kerr 2350 (**BM**, **E**, **K**); **Sukhothai**, Ramkhamhaeng NP, 28 Jan. 1995, J.F. Maxwell 95-37 (**BKF**, **L**); **Tak**, Maetak, 2 Mar. 1958, T. Sørensen, K. Larsen, B. Hansen 1813 (**BKF**, **E**);--- NORTH-EASTERN: **Loei**, Phu Ruea NP, 26 Nov. 2010, T. Choopan 2010-069 (**BKF**, **SUT**); **Phetchabun**, Mueang, 27 Mar. 1922, A.F.G. Kerr 5692 (**BK**, **BM**, **K**); **Sakon Nakhon**, 17 Feb. 1924, A.F.G. Kerr 8478 (**BM**, **K**), Phu Phan NP, 14 Dec. 1982, H. Koyama, H. Terao & T. Wongprasert 31025 (**BKF**), 10 Nov. 2001, P. Chaikong 53/44 (**KKU**);--- EASTERN: **Chaiyaphum**, Thung

Kamung, 15 Dec. 1971, C.F. Beusekom, C. Phengklai, R. Geesink & B. Wongwan 4296 (**BKF**); **Nakhon Ratchasima**, Huai Thalaeng, 25 Dec. 1928, Put 2245 (**BK**, **BM**, **K**), Pak Thong Chai, 26 Dec. 1923, A.F.G. Kerr 8118 (**K**), Pak Chong, 29 Dec. 1923, A. Marcan 1574 (**BK**, **BM**, **K**); **Ubon Ratchathani**, 24 Feb. 1961, Chirayupin 176 (**BK**), Phu Phralan, 18 Dec. 2008, P. Puudjaa & C. Hemrat 1503 (**BKF**);--- CENTRAL: **Ang Thong**, 30 Dec. 1929, Put 2604 (**BK**, **K**), 7 Mar. 1971, J.F. Maxwell 71-133 (**AAU**, **BK**), 11 Dec. 1971, J.F. Maxwell 71-783 (**AAU**, **BK**); **Nakhon Nayok**, Khao Daeng, 23 Dec. 1966, S & J 1934 (**BK**), Sarika waterfall, 22 Nov. 1982, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk 30241 (**BKF**); **Saraburi**, Sam Lan, 5 Jan. 1974, J.F. Maxwell 74-3 (**AAU**, **BK**, **BKF**), 25 Jan. 1976, J.F. Maxwell 76-38 (**AAU**, **BK**, **L** 2 sheets);--- SOUTH-EASTERN: **Chachoengsao**, Khao Ang Rue Nai WS, 14 Nov. 2010, T. Choopan 2010-011 (**BKF**, **SUT**); **Chanthaburi**, Khao Chamao-Khao Wong NP, 23 Nov. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & D. Phanichaphol 23406 (**BKF** 2 sheets), Soi Dao, 14 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 7259 (**C**), 15 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 351 (**C**); **Chonburi**, Sriracha, 5 Mar. 1920, A.F.G. Kerr 4039 (**K**), Khao Khieo, 16 Jan. 1976, J.F. Maxwell 76-7 (**AAU**, **BK**, **L**);--- SOUTH-WESTERN: **Kanchanaburi**, Sai Yok, 7 Dec. 1961, K. Larsen 8577 (**C**), 14 Dec. 1961, K. Larsen 8725 (**C**), 16 Dec. 1961, K. Larsen 8747 (**C**), 25 Dec. 1961, K. Larsen 8960 (**K**), Thung Yai Naresuan WS, 16 Jan. 1994, J.F. Maxwell, 94-76 (**BKF**, **L** 2 sheets), Sangklaburi, 10 Feb. 1960, K. Bunpan 26 (**BKF**), Song Thaw, 2 Feb. 1962, K. Larsen 9496 (**C**), Greung Gavia, 5 Feb. 1962, K. Larsen 9575 (**C**); **Ratchaburi**, Ban Rai, 1 Mar. 1965, S. Suthisorn 430 (**BK**);--- PENINSULAR: **Chumphon**, Ta Sae, 22 Dec. 1928, A.F.G. Kerr 17498 (**K**); **Nakhon Si Thammarat**, Kao Island, 29 Jan. 1958, T. Sørensen, K. Larsen & B. Hansen 811 (**C**), Nabon, 19 Jan. 1971, Umpai 420 (**BK** 2 sheets); **Phangnga**, Thap Put, 24 Feb. 1971, J. Sadakorn 223 (**BK**); **Surat Thani**, 19 Feb. 1930, A.F.G. Kerr 18130 (**K**).

Distribution.--- India, Nepal, Pakistan, Myanmar, Thailand, Vietnam, Indonesia.

Ecology.--- In shaded mixed deciduous forest and evergreen forest, at 100-1000 m altitude. Flowering: September-December.

Vernacular.--- Krab Bai Khon (กราบใบขน) (Researcher).

Notes.--- This species was distinguished from orther species within the same genus by being distinctly hairy in all parts of plants. It was separated from *S. glauca* by large hairy spatulate leaves, mostly terminal long raceme inflorescences, and white corolla with straight lobes.

Figure 5.87 *Staurogyne spathulata* (Blume) Koord.

A: habit, B: flower, C: pistil and stamens, D: fruit.

A

B

Figure 5.88 *Staurogyne spathulata* (Blume) Koord.

A: habit, B: inflorescence with opened flower.

43. *Staurogyne subglabra* C. B. Clarke, J. Asiat. Soc. Bengal 74(3): 640. 1908, [Type: Malaysia, Perak, Taiping hills King's collector 8427 (K)]; Ridley, Fl. Malay Penin. 2: 562. 1923; Bremekamp, Reinwardtia 3: 199. 1955. Figures 5.89-5.90.

Staurogyne bella Bremek., Dansk Bot. Ark. 27: 74. 1969, [Type: Thailand, Phu Mieng mountain, 27 July 1966; K. Larsen, T. Smitinand & E. Warncke 931 (holotype! AAU, isotype! BKF, isotype! U)]

Herbs, up to 40 cm tall, erect, unbranched, glabrous. **Leaves** opposite or decussate; petioles 1-2 cm long, glabrous; blade elliptic, 4-9 by 2-3.5 cm, apex obtuse or acute, base acute, glabrous, secondary veins 9-11 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes, up to 15 cm long; bract 1, lanceolate, 0.5 by 0.1 cm, glabrous; pedicels 0.15 cm long, puberulous; bracteoles 2, linear, ca. 0.5 cm long. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3), linear, 0.6-0.9 cm long, glabrous. **Corolla** lobes 5, white, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, glabrous. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 0.5-0.7 cm long, puberulous; staminodes 0. **Ovary** oblong, glabrous; style 0.9 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 16-20, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- NORTHERN: **Phitsanulok**, Phu Mieng, 27 Jul. 1966, K. Larsen, T. Smitinand, E. Warncke 929 (isotype! **BKF**), 931 (holotype! **AAU**, isotype! **BKF**), Phu Hin Rong Kla NP, 30 Oct. 2001, S. Watthana & P. Suksathan 1632 (**QBG**), 10 Jan. 1011, T. Choopan 2011-117 (**BKF**, **SUT**), Phu Soi Dao, 10 May 1999, P.

Suksathan 1692 (**QBG**) & 2704 (**QBG**);--- NORTH-EASTERN: **Loei**, Phu Suan Sai NP, 23 Aug. 2006, C. Maknoi 1039 (**QBG**), 5 Nov. 1995, W. Nanakorn et al. 5129 (**QBG**), 17 Feb. 2010, T. Choopan 2010-010 (**BKF**, **SUT**).

Distribution.--- Malaysia, Singapore, Thailand, Vietnam.

Ecology.--- In shaded hill evergreen forest, at 1000-1300 m altitude. Flowering: September-December.

Vernacular.--- Krab Phu (กราบภู) (Researcher).

Notes.--- This species was distinguished from *S. kradengensis* by their broader elliptic leaves with glabrous petioles, more distict veinlets, scattered from base to top of stem, no staminodes. It normally grows on moist or shaded soils on high mountains (hill evergreen forest without pine).

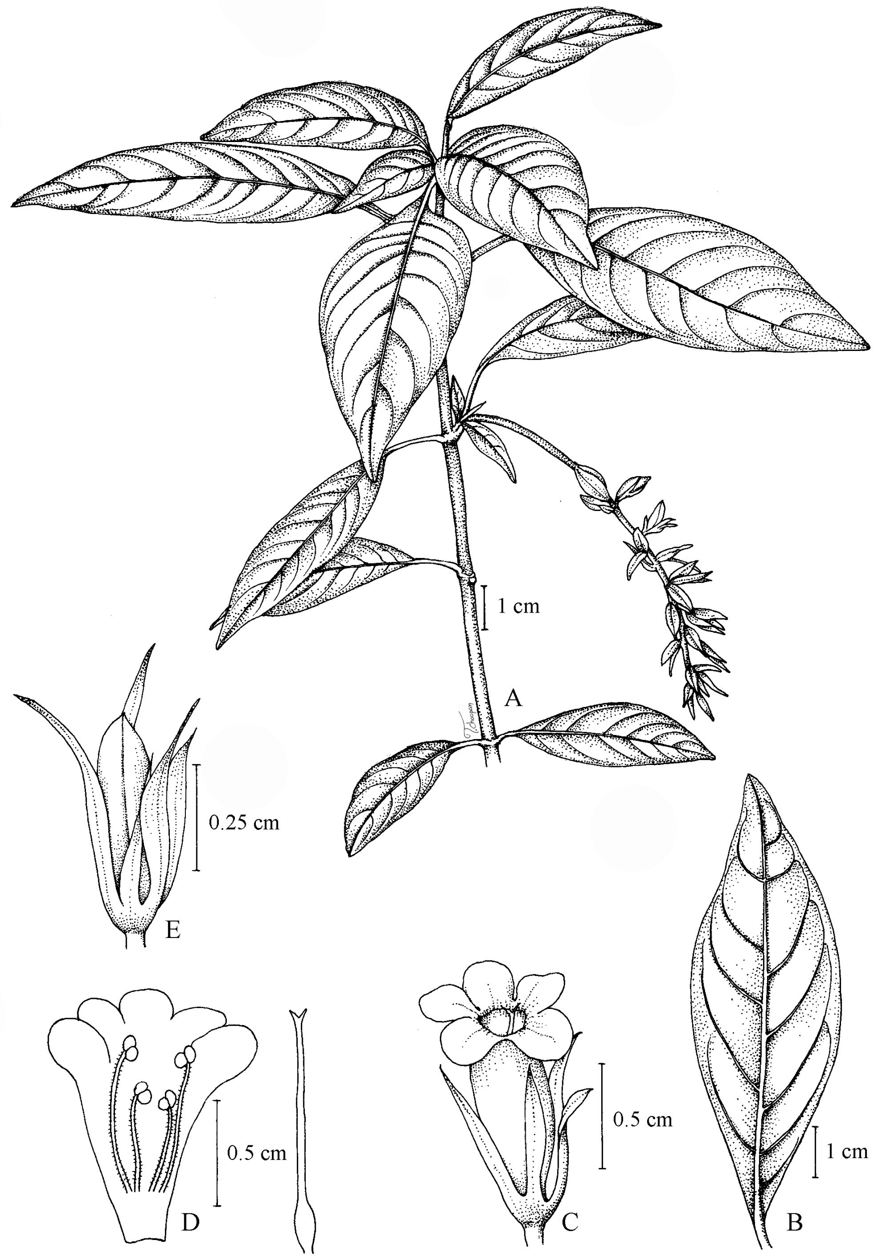


Figure 5.89 *Staurogyne subglabra* C. B. Clarke.

A: habit, B: ventral leaf, C: flower, D: pistil and stamens, E: fruit.

A

B

Figure 5.90 *Staurogyne subglabra* C. B. Clarke.

A: habit, B: inflorescence with opened flowers.

44. *Staurogyne tenuispica* Bremek., Reinwardtia 3: 227. 1955, [Type: Thailand, Chumphon, Tasan, 5 November 1919; C.B. Kloss 6974 (K)]. Figures 5.91-5.92.

Staurogyne kerrii E. Hossain, Notes Roy. Bot. Gard. Edinburgh 31(3): 386. 1972, [Type: Thailand, Chumphon, Tasan, 23 December 1928; A.F.G. Kerr 16307 (BK, holotype! BM, isotype! C, K, L) & Phatthalung, Klong Hai Khao, 18 Apr. 1928, A.F.G. Kerr 15287 (BK, paratype! BM)].

Herbs, up to 20-25 cm tall, decumbent ascending, unbranched, puberulous. **Leaves** subrobulate; petioles purplish green, 1-3.5 cm long, puberulous; blade oblong, 5-8.5 by 2.5-3.5 cm, apex obtuse, base cordate, puberulous on veins, secondary veins 6-8 pairs, opposite or alternate. **Inflorescence** terminal racemes, with glandular hairs; bracts 2, lanceolate or leaf-like, 0.15-0.25 by 0.1-0.2 cm, puberulous; pedicels 0.1 cm long, with glandular hairs; bracteole 1, linear, ca. 0.1 cm long, puberulous. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, unequal (short 2, long 3), linear, 0.2-0.25 cm long, with glandular hairs. **Corolla** lobes 5, white with reddish purple in 3 lobes, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, with glandular hairs. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 1.2-1.6 cm long, with glandular hairs; staminode 1. **Ovary** oblong, glabrous; style 1 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 14-16, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- PENINSULAR: **Chumphon**, Tasae, 5 Nov. 1919, C.B. Kloss 6974 (type! **K**) & 6984 (**K**), 28 Jan. 1927, A.F.G. Kerr 11667 (**BK**, **BM**, **K**), 22 Dec.

1928, A.F.G. Kerr 16279 (**BK**, **BM**, **K**) & 17500 (**K**), 23 Dec. 1928, A.F.G. Kerr 16307 (type! **BK**, holotype! **BM**, isotype! **C**, **K**, **L**), Hot spring forest park, 26 Feb. 1983, H. Koyama, H. Terao & T. Wongprasert 33742 (**BKF**, **C** 2 sheets, **K** 2 sheets, **L**); **Phangnga**, Khao Phra Mai, 7 Jan. 1966, B. Hansen & T. Smitinand 11824 (**BKF**, **C**, **E**, **K**); **Phatthalung**, Klong Hai Khao, 18 Apr. 1928, A.F.G. Kerr 15287 (**BK**, paratype! **BM**); Lanmoonjui, 23 Aug. 1996, W. Nanakorn et al. 7292 (**QBG**); **Ranong**, Hot spring park-Mueang, 6 Dec. 1979, T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham 26210 (**BKF**, **C**, **L**), Mueang Len, 12 Jan. 1966, B. Hansen & T. Smitinand 11922 (**BKF**, **C**, **K**), Boonyaparn waterfall, 6 Dec. 1999, T. Wongprasert s.n. (**BKF** 2 sheets); **Satun**, Thung Wa, 4 Jan. 1928, A.F.G. Kerr 13873 (**BK**, **K**); **Trang**, 15 Nov. 1969, P. Sangkhachand 2151 (**BK**), Khao Chong, 12 Aug. 1975, J.F. Maxwell 75-799 (**AAU**, **BK**, **L**).

Distribution.--- Endemic to Thailand.

Ecology.--- In shaded moist evergreen forest, at 50-200 m altitude. Flowering: December-February.

Vernacular.--- Krab Namphuron (กราบน้ำพุร้อน) (Researcher).

Notes.--- This species is doubtless a very near ally of *S. merguensis*, but the difference between the latter and the plant described above seem to be of sufficient importance to justify the distinction of two species. The paniculiform, glandular-hirtellous inflorescence of *S. tenuispica* resembles that of *S. obtusa*, but the leaf base of the latter is not emarginated, and its bracts and calyx lobes are distinctly longer.

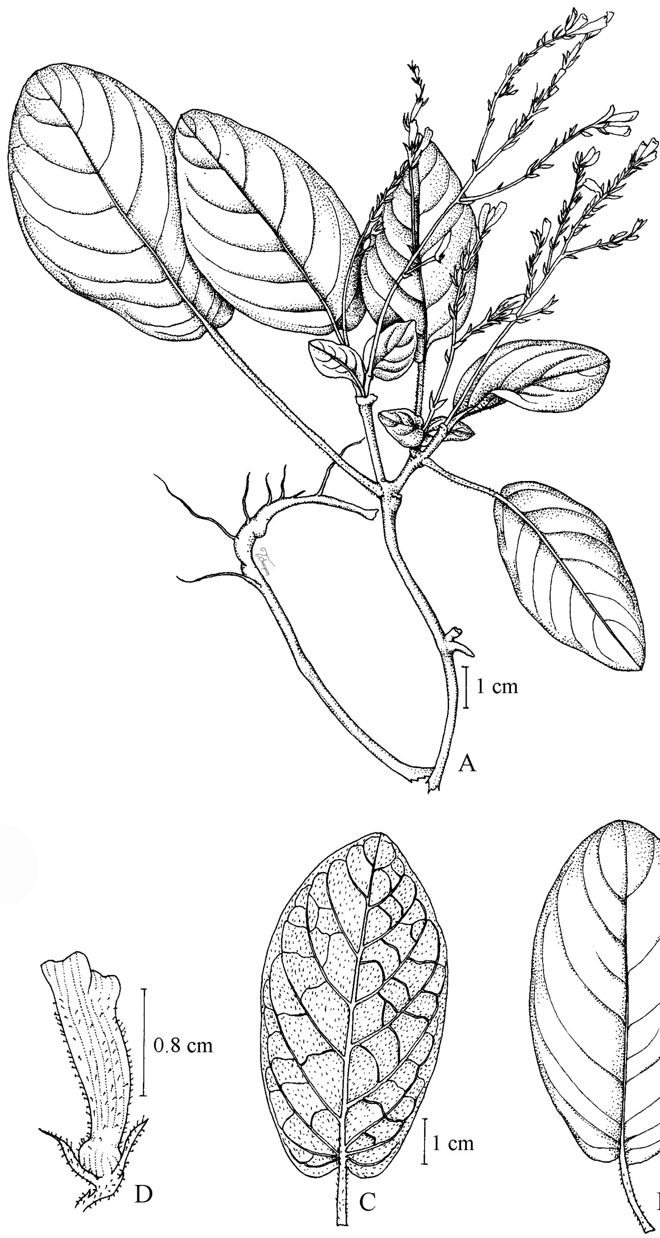


Figure 5.91 *Staurogyne tenuispica* Bremek.

A: habit, B: dorsal leaf, C: ventral leaf, D: flower.

A

B

Figure 5.92 *Staurogyne tenuispica* Bremek.

A: herbarium sheet (type!), B: dried inflorescence with opened flowers.

45. *Staurogyne* sp3. Figures 5.93-5.94.

Herbs, up to 50 cm tall, erect, branched, glabrous. **Leaves** opposite or decussate; petioles 2-3 cm long, glabrous; blade elliptic or lanceolate, 5-11 by 3-4.5 cm, apex acute or attenuate, base acute, glabrous, secondary veins 9-11 pairs, opposite or alternate. **Inflorescence** terminal or axillary racemes, up to 15 cm long; bracts 2, linear, 0.15 cm long, with glandular hairs; pedicels 0.2 cm long, with glandular hairs; bracteole 1, linear, ca. 0.15 cm long, with glandular hairs. **Flowers** up to 1 by 0.5 cm, actinomorphic, tubular. **Calyx** lobes 5, subequal, linear, 0.2 cm long, with glandular hairs. **Corolla** lobes 5, purple, elliptic, 0.5 by 0.1-0.2 cm, apex obtuse, with glandular hairs. **Stamens** included, anthers globose, 0.1 cm in diameter, filaments ca. 0.7 cm long, puberulous; staminode 1. **Ovary** oblong, glabrous; style 0.8 cm long, glabrous; stigma 2-lobed. **Fruits** capsule brown, up to ca. 0.5 by 0.2 cm. **Seeds** 8-10, brown, orbicular, ca. 0.05 cm in diameter.

Thailand.--- SOUTHWESTERN: **Phetchaburi**, Kaeng Krachan NP, 13 Dec. 2002, D.J. Middleton, S. Suddee & C. Hemrat 1610 (**BKF**), 24 Jan. 2005, K. Williams, S. Suddee, J. Hemrat, N. Rithphet & S. Polphan 1061 (**BKF**).

Distribution.--- Known from Thailand only.

Ecology.--- In shaded hill evergreen forest, at 900-1200 m altitude. Flowering: October-December.

Vernacular.--- Krab Kaeng Krachan (กราบแก่งกระจาน) (Researcher).

Notes.--- This species was distinguished from *S. racemosa* by glabrous rachis instead of puberulous, glandular hairs on pedicels and calyx, much longer pedicels, and by narrower bracts. Moreover, it was separated from *S. lasiobotrys* by an inflorescence with several racemes, floral parts covered with shorter glandular hairs, and by glabrous rachis (instead of distinct long glandular hairs in *S. lasiobotrys*)

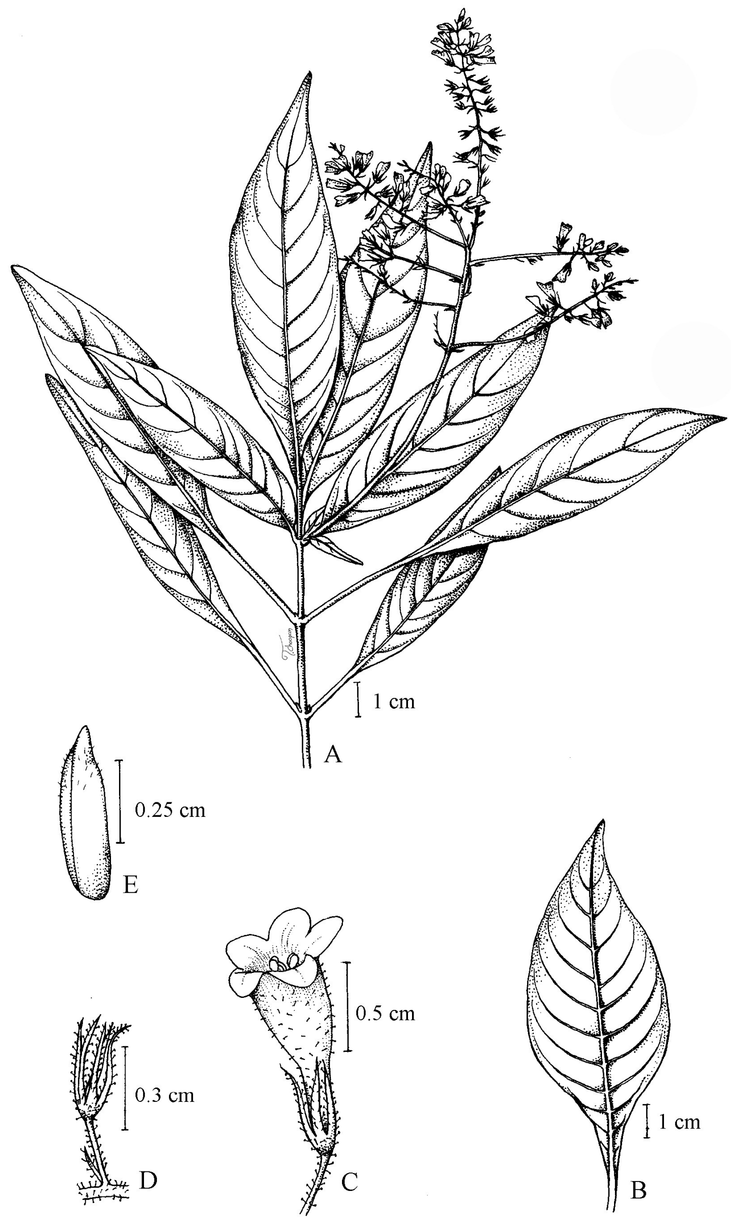


Figure 5.93 *Staurogyne* sp3.

A: habit, B: ventral leaf, C: flower, D: calyx, E: fruit.

A

B

Figure 5.94 *Staurogyne* sp3.

A: herbarium sheet, B: inflorescence with opened flowers.

5.5 Conclusions and Discussion

As the result of taxonomic study, 4 genera, and 45 species of *Pseuderanthemum*, *Nelsonia*, *Ophiorrhiziphyllon*, and *Staurogyne* were found throughout Thailand including cultivated species. There were 3 unidentified species, i.e., *Pseuderanthemum* sp1, *Pseuderanthemum* sp2, and *Staurogyne* sp3, which are expected to be species new to science. In the past, Imlay (1938) studied the taxonomy of Siamese Acanthaceae for her thesis. She reported on 16 species of *Pseuderanthemum*, 1 species of *Nelsonia*, 2 species of *Ophiorrhiziphyllon*, and 18 species of *Staurogyne*, but sometimes at different ranks as compared to this research. After that, Hansen (1985) listed the species number in the genus of Acanthaceae in Thailand, that there were 8 species of *Pseuderanthemum*, 1 species each of *Nelsonia* and *Ophiorrhiziphyllon*, and 25 species of *Staurogyne*. He also commented on some reductions in *Staurogyne* where, in his opinion, Bremekamp (1961, 1965b, 1969) raised too many species and Enayet Hossain (1972) also overdid it and said that there were some difficulties with the specific delimitation in *Pseuderanthemum*.

In this study, there were different morphological characters in each genus, which led to more easy to identify. As a result, the morphological characters of the studied group in Thailand were concluded as follows:

Pseuderanthemum

Sixteen taxa were found, i.e., *P. axillare*, *P. bracteatum*, *P. carruthersii*, *P. crenulatum*, *P. glomeratum*, *P. graciliflorum*, *P. latifolium*, *P. laxiflorum*, *P. longistylum*, *P. metallicum*, *P.* “*palatiferum*”, *P. parishii*, *P. reticulatum*, *P. siamense*, *P*. sp1, and *P*. sp2. Their morphological characters and ecology were analyzed as follows:

Habit.--- Plants are herbs or small shrubs in 10 taxa of *P. axillare*, *P. bracteatum*, *P. crenulatum*, *P. glomeratum*, *P. latifolium*, *P. longistylum*, *P. parishii*, *P. siamense*, *P*. sp1, and *P*. sp2, and shrubs in 6 species of *P. carruthersii*, *P. graciliflorum*, *P. laxiflorum*, *P. metallicum*, *P*. "*palatiferum*", and *P. reticulatum*.

Stem.--- Their stems are erect with white or brown bark. Puberulous stems were observed in 11 taxa, excluding *P. carruthersii*, *P. latifolium*, *P. metallicum*, *P. reticulatum*, and *P*. sp2.

Hair.--- Different type of hairs were investigated, i.e., glandular haris, puberulous, and pubescent. Hairs were observed in almost parts of plants. This character was used as a taxonomic tool to separate *P. longistylum* and *P*. sp2, with glabrous leaves and pubescent leaves, respectively.

Petiole.--- The shortest petiole (less than 1 cm long) was observed in *P. axillare* and *P. bracteatum*, while the longest one (4-6.5 cm long) in *P. graciliflorum*.

Leaf blade.--- The leaves are simple, opposite or decussate, apex acute, base acuminate. Several shapes of leaf were found such as elliptic, lanceolate, ovate, linear, or oblong. This character could be used as a taxonomic tool in *P. axillare*, which was distinguished from other species in the same genus by the presence of linear or narrowly oblong leaves. Herbaceous (leathery) leaves were found in *P. carruthersii*, *P. latifolium*, *P. metallicum*, *P. reticulatum*, and *P*. sp2. *P. carruthersii* and *P. reticulatum* showed 2 leathery leaf shapes, i.e., symmetric ovate leaves and asymmetric elliptic leaves. They were separated from each other by the color, reddish purple in *P. carruthersii* and yellowish green or grayish green in *P. reticulatum*. The color of the leaf underside was a distinct character of *P. siamense* and *P.* sp2, with reddish purple along veins and deep purple on the whole surface, respectively.

Leaf venation.--- Leaf veins were arranged in an opposite or alternate pattern. The number of secondary veins depended on the length of leaf. Leaf veins presented more hairs than the leaf blade.

Inflorescence.--- Plants showed terminal or axillary cyme inflorescences. *P. graciliflorum* showed dense cyme. *P. carruthersii* and *P. reticulatum* revealed branched or compound cyme. Long inflorescences were found in *P. glomeratum*, *P. latifolium*, *P. longistylum*, *P. parishii*, *P.* sp1, and *P.* sp2.

Bracts.--- Bracts could be lanceolate, oblong, or leaf-like. *P. bracteatum* was distictly represent with leaf-like bracts 2-3 cm long, which were used as a taxonomic homologue.

Bracteoles.--- Bracteoles could be lanceolate or linear, dense puberulous, 1-4 mm long.

Calyx.---The calyx was fused at base and divided into 5 lobes, less than 1 cm long, linear or lanceolate with glandular hairs or pubescent.

Corolla.---Corolla fused as a narrow long tube at base and divided into 5 lobes, white, pink, or purple in color. Two upper lobes were fused (most of this genus) or separated (*P. bracteatum* and *P. parishii*). The corolla tube longer than corolla lobes was found in *P. graciliflorum*, *P. latifolium*, *P. laxiflorum*, *P. longislylum*, and *P.* sp1, while *P. carruthersii*, *P. metallicum*, and *P. reticulatum* had tubes as long as lobes. Most of this genus showed corolla lobes with reddish purple dots, except *P. crenulatum*, *P. laxiflorum*, and *P. parishii*.

Stamens.---Plants revealed 2 fertile stamens and 2 staminodes. Anthers were 2-thecate with longitudinal dehiscence. Inserted stamens were found in *P. axillare* and *P. crenulatum*, distinctly exserted stamens in *P. parishii*, and slightly exserted stamen in *P. bracteatum*, *P. carruthersii*, *P. glomeratum*, *P. graciliflorum*, *P. latifolium*, *P. laxilfloum*, *P. longistylum*, *P.* "*palatiferum*", *P. reticulatum*, and *P.* sp1.

Pistil.---The ovary is cylindrical with 4 ovules. The style is long, glabrous or puberulous at base. The stigma is divided into 2 lobes. *P. axillare*, *P. carruthersii*, *P. crenulatum*, *P. reticulatum* presented 1-2 cm-long style while the others 3-4.5 cm long.

Fruits.---Their fruits formed as capsules with 2-4 seeds. Capsule surface was glabrous or puberulous. *P. graciliflorum* showed the largest capsule (up to 3 cm) while the rest of the native species presented the same size (between 1.5-2.2 cm long). Fruits of ornamental plants did not develop or were rarely found: *P. carruthersii*, *P. metallicum*, *P. laxiflorum*, and *P. reticulatum*.

Ecology.--- Plants were collected from different areas such as dry evergreen forest (*P. graciliflorum*, *P. longistylum*, *P.* sp1), hill evergreen forest (*P. glomeratum*, *P. latifolium*, *P. parishii*, *P. siamense*), moist evergreen forest (*P. graciliflorum*, *P. crenulatum*, *P.* sp2), mixed deciduous forest (*P. axillare*), and dry dipterocarp forest (*P. bracteatum*). Their habitat varies from dry to moisture, shaded to opened, or low to high altitude, including some introduced species for ornamentals, i.e., *P. carruthersii*, *P. laxiflorum*, *P. metallicum*, and *P. reticulatum*, and medicinal purposes, i.e., *P.* "*palatiferum*".

Nelsonia*, *Ophiorrhiziphyllon*, and *Staurogyne

Only one species was found for the genus *Nelsonia* and *Ophiorrhiziphyllon*, i.e., *Nelsonia canescens* and *Ophiorrhiziphyllon macrobtryum*, respectively. Twenty-seven species were found for *Staurogyne*, i.e., *S. argentea*, *S. aristata*, *S. concinnula*, *S. cuneata*, *S. densifolia*, *S. dispar*, *S. filipes*, *S. glauca*, *S. griffithiana*, *S. helferi*, *S. incana*, *S. kingiana*, *S. lanceolata*, *S. lasiobotrys*, *S. longeciliata*, *S. major*, *S. merguensis*, *S. obtusa*, *S. parvicaulis*, *S. punctata*, *S. racemosa*, *S. setigera*, *S. singularis*, *S. spathulata*, *S. subglabra*, *S. tenuispica*, and *S.* sp3. Their morphological characters and ecology were analyzed as follows:

Habit.--- Plants are herbs (almost all) or small shrubs.

Stem.--- The puberulous stems are ascending in *Nelsonia* and erect in *Ophiorrhiziphyllon* and *Staurogyne*. Brown bark was found in small shrubs: *O. macrobotryum*, *S. punctata*, *S. racemosa*, *S. subglabra*, and *S.* sp3.

Hair.--- Indumentum was investigated in all of species. Hairs were presented in almost parts of plants. This character was used as a taxonomic homologue to distinguish several species from each other, i.e., *S. argentea* and *S. aristata*, with glabrous corolla and puberulous corolla, *S. tenuispica* and *S. merguensis*, with floral parts with glandular hairs and puberulous, *S. lanceolata* and *S. setigera*, with bracts with glandular-puberulous hairs and only puberulous, respectively.

Petiole.--- Short petioles were found in *S. helferi*, *S. parvicaulis* which about 0.5 cm long. In contrast, *S. merguensis* and *S. obtusa* represented quite long petioles which can be up to 7 and 10 cm, respectively.

Leaf blade.--- The leaves are simple, opposite or decussate (rarely alternate only in upper part of stem in *S. glauca*), apex acute or obtuse, base acuminate, obtuse, or cordate. Several shapes of leaf were found, such as elliptic, lanceolate, ovate, spatulate, or oblong. This character could be used as a taxonomic tool in *S. merguensis* and *S. tenuispica*, which was distinguished from other species in the same genus by being cordate at base of leaves and leathery leaf texture. *S. punctata* was distinguished from *S. subglabra* by narrower lanceolate leaves densely arranged at the top of stem.

Leaf venation.--- Leaf veins are arranged in an opposite or alternate pattern. The number of secondary veins depended on the length of leaf. Leaf veins represented more hairs than the leaf blade. The vein ending formed loops. *S. merguensis* and *S. tenuispica* were distinguished from other species in the same genus by showing distinctly reticulate veins.

Inflorescence.--- Plants showed spike inflorescence in *Nelsonia*, terminal or axillary raceme inflorescence in *Ophiorrhiziphyllon* and *Staurogyne*. Dense racemes were observed in *S. incana*, *S. kingiana*, *S. lanceolata*, and *S. spatulata*. Lax racemes were found in *O. macrobotryum*, *S. concinnula*, *S. filipes*, *S. lasiobotrys*, *S. merguensis*, *S. obtusa*, *S. punctata*, *S. racemosa*, *S. singularis*, *S. subglabra*, *S. tenuispica*, *S.* sp3. Raceme with distinctly broad bracts were represented in *S. cuneata*, *S. densifolia*, *S. dispar*, *S. griffithiana*, and *S. helferi*. Capitate inflorescence was found in *S. argentea*, *S. aristata*, and *S. setigera*.

Bracts.--- Bracts could be lanceolate, linear, or leaf-like. *S. cuneata*, *S. densifolia*, *S. dispar*, *S. griffithiana*, and *S. helferi* distictly presented broad bracts (2 cm wide), which was used as a taxonomic homologue.

Bracteole.--- There was no bracteole in *Nelsonia*. Two bracteoles could be lanceolate or linear, puberulous, in *Ophiorrhiziphyllon* and *Staurogyne*.

Calyx.--- Calyx is fused at base and divided into 4 lobes in *Nelsonia*, or 5 lobes in *Ophiorrhiziphyllon* and *Staurogyne*, linear or lanceolate with glandular hairs or pubescent.

Corolla.--- The corolla is fused as a tube at base and divided into 5 lobes, white, purplish red, or purple in color. The corolla is formed as 2-lipped in *Nelsonia* and *Ophiorrhiziphyllon*, or nearly actinomorphic in *Staurogyne*. *S. major* was easily distinguished from the others by large, deep purplish red flowers.

Stamens.--- Plants revealed 2 fertile stamens but no staminode in *Nelsonia*, 2 fertile stamens with 2 staminodes in *Ophiorrhiziphyllon*, and 4 fertile stamens with 0-1 staminode in *Staurogyne*. Exserted stamens and oblong anthers with longitudinal dehiscence presented in *Ophiorrhiziphyllon*, while inserted stamens and globose anthers were found in *Nelsonia* and *Staurogyne*.

Pistil.--- The ovary is cylindrical with many ovules. The style is long, glabrous or puberulous at base. The stigma is divided into 2-3 lobes.

Fruit.--- Their fruits formed as capsules with 8-20 seeds, 0.3-0.6 cm long. Capsule surface was glabrous or puberulous.

Ecology.--- *Nelsonia* was collected from open areas along the edge of dry or moist evergreen forest and open area of mixed deciduous forest. *Ophiorrhiziphyllon* was obsereved in hill evergreen forest along the streams of nothern Thailand. *Staurogyne*'s habitat varies from dry to moist, shaded to opened, or low to high altitude including dry evergreen forest in northeast and east, moist evergreen forest in south peninsular, and hill evergreen forest in northern and western Thailand.

Morphological Characters Consideration for Identification

In the genus level, several morphological characters were used as a taxonomic tool, i.e, the presence of retinacula in explosive capsules, inflorescence type, number of fertile stamen, stamen position, and number of calyx lobe. Moreover, several characters could be used to identify the genus as follows:

Ovule.--- Ovary showed 2-4 ovules in *Pseuderanthemum*, but 8 – many in *Nelsonia*, *Ophiorrhiziphyllon*, and *Staurogyne*.

Fruit. --- The length of capsule in *Pseuderanthemum* were 1-3 cm, while 0.3-0.6 cm in *Nelsonia*, *Ophiorrhiziphyllon*, and *Staurogyne*.

Anther.--- Shape of anthers were oblong in *Pseuderanthemum* and *Ophiorrhiziphyllon*, but globose in *Nelsonia* and *Staurogyne*.

Bracteole.--- There were bracteoles in *Pseuderanthemum*, *Ophiorrhiziphyllon*, and *Staurogyne* but absent in *Nelsonia*.

Staminode.--- There were 2 staminodes in *Pseuderanthemum* and *Ophiorrhiziphyllon*, 0-1 staminode in *Staurogyne*, and absent in *Nelsonia*.

Pseuderanthemum

Morphological characters using for species identification were the connate of upper lobes, the length of corolla tube compare to which of corolla lobes, fruit length, the presence of hairs on capsule surface, leaf shape and color, stamen position, dots on corolla lobes.

Nelsonia*, *Ophiorrhiziphyllon*, and *Staurogyne

Morphological characters using for species identification were the present of hairs on floral parts, inflorescence type, number of fertile stamens and staminodes, leaf shape and arrangement, stamen position, dehiscence of anthers, corolla color including marks and lines.

CHAPTER VI

PHYLOGENETIC AND EVOLUTIONARY STUDIES

6.1 Introduction

Phylogeny is the evolutionary development and history of organismal lineages as they change through time. It implies that different species arise from previous forms via descent. Evidence from morphological, biochemical, and gene sequence data suggest that all organisms on earth are genetically related and genealogical relationships of living things can be represented by a vast evolutionary tree, the tree of life. The organisms that are alive today are but the leaves of this giant tree, and if we could trace their history back down the branches of the tree of life, we would encounter their ancestor, which lived thousands or millions or hundreds of millions of years ago. Organisms have evolved through the ages from ancestral forms into more derived forms. New lineages generally retain many of their ancestral features, which are then gradually modified and supplemented with novel traits that help them to better adjust to the environment they live in. Studying the phylogeny of organisms can help us explain similarity and differences among plants, animals, and microorganisms. The tree of life thus provides a rigorous framework to guide research in all biological subdisciplines, and it is therefore an ideal model for the organization of biological knowledge (Steven, 2001 onwards, Soltis et al., 2005; Simpson, 2010).

6.2 Literature Review

A limited systematic value on phylogeny has been recognized for vegetative features, especially within families and genera, and they have been used, usually as adjunct features, in the construction of taxonomic keys. However, no meaningful application has ever been made of vegetative morphology to the systematic consideration of angiosperm phylogeny at the higher taxonomic levels.

As mentioned above, there remain several reasons why a full generic cladistic analysis of morphological data is not possible such as (1) the monophyly of many genera is questionable, (2) some genera constitute approximately 50% of the species-level diversity within Acanthaceae and are extremely heterogeneous for many characters, making any exemplar taxon approach problematic, (3) many genera are insufficiently known, due to lack of material, (4) there is a lack of critical comparative anatomical studies across a broad enough range of genera within Acanthaceae, and (5) character coding of complex morphological variation is difficult from a transformational perspective as there are many distinct ways to code morphological variation (Hawkins, 2000; Scotland and Vollesen, 2000).

In the absence of a phylogeny estimate based on morphology, morphological data could be discussed in narrative form relative to an accepted phylogeny based on molecular data (McDade and Moody, 1999; McDade et al., 2000). Such an approach suffers from the lack of a corroborated accurate phylogeny even in the presence of high bootstrap values and reduces morphology to a subsidiary role in classification. The incongruent morphological characters are interpreted as a simple model of character evolution – plesiomorphy, synapomorphy and convergence – and a molecular phylogeny still need more analysis to discover a procedure. Other approaches such as combined analysis of morphological and molecular data remain controversial (Klung and Wolfe, 1993; Miyamoto and Fitch, 1995; Nixon and Carpenter, 1996) and are cautioned against because of a lack of critical detail on anatomy. Poorly circumscribed morphological characters combined with molecular data are unlikely to provide a clearer understanding of phylogeny. Recently, there have been several critical studies of particular morphological structures that have increased our understanding of phylogenetic issues (Scotland et al., 1994; Schönenberger and Endress, 1998; Manktelow, 2000)

The subfamily Nelsonioideae is characterized by the following morphological traits: lack of cystoliths (symplesiomorphy), lack of retinacula (symplesiomorphy), relatively large number of ovules (symplesiomorphy), and descending-cochlear aestivation pattern of the corolla lobes (synapomorphy). Although usually treated within Acanthaceae, this assemblage of genera has also been treated as a tribe of Scrophulariaceae (Bremekamp, 1955, 1965b) and as a distinct family (Sreemadhavan, 1977; Lu, 1990).

There have been molecular systematic studies addressing the higher level systematics of Acanthaceae (Hedren et al., 1995; Scotland et al., 1995; McDade and Moody, 1999; McDade et al., 2000). The genes used for these studies were rbcL, ndhF, trnL-F, and trnL-F combined with ITS. Phylogenetic relationships based on a combination of nuclear and chloroplast DNA sequence data have been studied in numerous genera in each subfamily but very seldom in Nelsonioideae (Wenk and Daniel, 2009). Based on a limited sampling of genera, Nelsonioideae have been shown to be basal to all other lineages of Acanthaceae (Scotland et al., 1995; McDade et al., 2000, 2008).

6.3 Materials and Methods

6.3.1 Morphological and Anatomical Characters Selection

Several distinct morphological and anatomical characters were selected to develop a phylogenetic tree for the studied taxa (Table 6.1).

Table 6.1 Characters of studied taxa used in analysis.

No	Homologues	No	Homologues
1.	Shrub	17.	Brochidodromous leaf venation
2.	Retinacula	18.	Two-upper lobes connate
3.	Asymmetric leaves	19.	Corolla tube > 1 cm long, narrow
4.	Cystoliths	20.	Calyx 5-partite
5.	Glandular trichomes	21.	Glabrous leaves
6.	Bracteole	22.	Seeds > 4 per capsule
7.	Fertile stamens = 4	23.	Ascending-cochlear aestivation
8.	Fertile stamens = 2	24.	Spike inflorescence
9.	Staminode	25.	Cyme inflorescence
10.	Inserted anthers	26.	Raceme inflorescence
11.	Elongated thecae	27.	Capitate inflorescence
12.	Spotted corolla lobes	28.	Dense inflorescence
13.	Stripes in throat	29.	Purplish-green leaves
14.	Two-lipped corolla	30.	Capsule > 0.8 cm long
15.	Crispy leaves	31.	Leaves > 2 cm wide
16.	Monothecous stamens	32.	Corolla > 2 cm diameter

Some traits have been offered as evidence for tribal and subfamilial taxa within Acanthaceae. Some characters are briefly discussed. A phylogeny was developed of the taxa based on morphological characters with appropriate data analysis, using PAUP*4.0b10 (Swofford, 2002). Character evolution was analyzed based on morphological characters with appropriate data analysis, using Mesquite (Maddison and Maddison, 2011).

Selected homologues were analyzed in the context of a data matrix that included the studied taxa, treating each homologue (code 1) as a hypothesis of a group.

6.3.2 Molecular Study

Sixty-three samples were represented the studied taxa and outgroup of researcher. Five putative outgroup species (*Justicia* spp. from Thailand) were also selected for covering a wide range of vegetative and reproductive morphology. The list of plant samples with voucher information and accession number is provided in Table 6.2. The samples focused on Thai species collected during fieldwork in Thailand. DNA was extracted from leaf tissue in silica-gel. Outgroup DNA of *Justicia* was obtained from DNA Bank. This work was conducted in the Jodrell Laboratory, the Royal Botanic Gardens, Kew, United Kingdom.

Table 6.2 List of samples with voucher information and accession number.

No	Species	RBG, Kew DnaBank Voucher	RBG, Kew DnaBank number
1.	*Pseuderanthemum crenulatum* 1	T. Choopan 2011-306 (SUT)	41754
2.	*Staurogyne lanceolata* 1	T. Choopan 2011-289 (SUT)	41755
3.	*Nelsonia canescens* 1	T. Choopan 2011-315 (SUT)	41756
4.	*Staurogyne lasiobotrys*	T. Choopan 2011-264 (SUT)	41757
5.	*Pseuderanthemum reticulatum*-B	T. Choopan 2011-321 (SUT)	41758
6.	*Pseuderanthemum carruthersii*-B	T. Choopan 2011-323 (SUT)	41759
7.	*Pseuderanthemum laxiflorum*	T. Choopan 2011-324 (SUT)	41760
8.	*Staurogyne glauca*	T. Choopan 2011-165 (SUT)	41761
9.	*Ophiorrhiziphyllon macrobotryum*	T. Choopan 2011-135 (SUT)	41762
10.	*Staurogyne lanceolata* 2	T. Choopan 2011-327 (SUT)	41763
11.	*Pseuderanthemum* sp2	T. Choopan 2011-316 (SUT)	41764
12.	*Staurogyne punctata* 1	T. Choopan 2010-113 (SUT)	41776
13.	*Staurogyne helferi*	T. Choopan 2011-249 (SUT)	41777
14.	*Pseuderanthemum metallicum*	T. Choopan 2011-329 (SUT)	41778
15.	*Pseuderanthemum graciliflorum* 3	T. Choopan 2011-169 (SUT)	41779
16.	*Pseuderanthemum "palatiferum"*	T. Choopan 2011-328 (SUT)	41780
17.	*Staurogyne argentea*	T. Choopan 2011-257 (SUT)	41781
18.	*Staurogyne spatulata* 1	T. Choopan 2010-069 (SUT)	41782
19.	*Staurogyne incana*	T. Choopan 2011-310 (SUT)	41783
20.	*Pseuderanthemum reticulatum*-A	T. Choopan 2011-320 (SUT)	41784
21.	*Pseuderanthemum parishii* 1	T. Choopan 2010-111 (SUT)	41785
22.	*Pseuderanthemum axillare*	T. Choopan 2011-326 (SUT)	41786
23.	*Pseuderanthemum bracteatum* 1	T. Choopan 2010-083 (SUT)	41798
24.	*Pseuderanthemum carruthersii*-A	T. Choopan 2011-322 (SUT)	41799

Table 6.2 (Continued).

No	Species	RBG, Kew DnaBank Voucher	RBG, Kew DnaBank number
25.	*Pseuderanthemum graciliflorum* 1	T. Choopan 2010-037 (SUT)	41800
26.	*Pseuderanthemum latifolium* 1	T. Choopan 2011-210 (SUT)	41801
27.	*Staurogyne concinnula*	T. Choopan 2011-217 (SUT)	41802
28.	*Staurogyne merguensis*	T. Choopan 2011-317 (SUT)	41803
29.	*Staurogyne major*	T. Choopan 2011-203 (SUT)	41804
30.	*Staurogyne setigera*	T. Choopan 2011-272 (SUT)	41805
31.	*Pseuderanthemum longistylum* 1	T. Choopan 2010-048 (SUT)	41806
32.	*Pseuderanthemum* sp1 (1)	T. Choopan 2010-036 (SUT)	41807
33.	*Pseuderanthemum parishii* 3	T. Choopan 2011-182 (SUT)	41808
34.	*Pseuderanthemum parishii* 2	T. Choopan 2011-162 (SUT)	41820
35.	Unknown 1	T. Choopan 2011-166 (SUT)	41821
36.	*Staurogyne punctata* 2	T. Choopan 2010-066 (SUT)	41822
37.	*Pseuderanthemum graciliflorum* 4	T. Choopan 2011-242 (SUT)	41823
38.	*Pseuderanthemum siamense*	T. Choopan 2011-118 (SUT)	41824
39.	*Pseuderanthemum latifolium* 2	T. Choopan 2011-180 (SUT)	41825
40.	*Pseuderanthemum crenulatum* 2	T. Choopan 2011-270 (SUT)	41826
41.	*Pseuderanthemum bracteatum* 2	T. Choopan 2010-078 (SUT)	41827
42.	*Staurogyne subglabra*	T. Choopan 2011-117 (SUT)	41828
43.	*Staurogyne lanceolata* 3	T. Choopan 2010-026 (SUT)	41829
44.	*Staurogyne spatulata* 2	T. Choopan 2010-042 (SUT)	41830
45.	*Nelsonia canescens* 2	T. Choopan 2010-100 (SUT)	41842
46.	*Pseuderanthemum crenulatum* 3	T. Choopan 2011-297 (SUT)	41843
47.	*Pseuderanthemum* sp1 (2)	T. Choopan 2010-027 (SUT)	41844
48.	*Staurogyne lanceolata* 4	T. Choopan 2011-222 (SUT)	41845

Table 6.2 (Continued).

No	Species	RBG, Kew DnaBank Voucher	RBG, Kew DnaBank number
49.	*Pseuderanthemum parishii* 4	T. Choopan 2010-058 (SUT)	41846
50.	*Staurogyne longeciliata* 1	T. Choopan 2011-245 (SUT)	41847
51.	*Staurogyne longeciliata* 2	T. Choopan 2011-281 (SUT)	41848
52.	*Staurogyne longeciliata* 3	T. Choopan 2011-246 (SUT)	41849
53.	Unknown 2	T. Choopan 2011-312 (SUT)	41850
54.	*Eranthemum nervosum* (outgroup)	T. Choopan 2011-183 (SUT)	41851
55.	*Barleria lupulina* (outgroup)	T. Choopan 2011-330 (SUT)	41852
56.	*Justicia* sp. (outgroup)	T. Choopan 2011-298 (SUT)	41864
57.	*Pseuderanthemum graciliflorum* 2	T. Choopan 2011-295 (SUT)	41865
58.	*Pseuderanthemum longistylum*	T. Choopan 2011-232 (SUT)	41866
59.	*Justicia gendarussa* (outgroup)	T. Choopan 2011-331 (SUT)	41867
60.	Unknown 3	T. Choopan 2011-274 (SUT)	41868
61.	*Justicia* sp. (outgroup)	T. Choopan 2011-314 (SUT)	41869
62.	*Pseuderanthemum latifolium* 3	T. Choopan 2011-187 (SUT)	41870
63.	*Nelsonia canescens* 3	T. Choopan 2010-002 (SUT)	41871
64.	*Justicia vasculosa* (outgroup)	K. Ruengsawang (KKU)	41769
65.	*Justicia fragilis* (outgroup)	K. Ruengsawang (KKU)	41770
66.	*Justicia decumbens* (outgroup)	K. Ruengsawang (KKU)	41771
67.	*Justicia vagabunda* (outgroup)	K. Ruengsawang (KKU)	41772

DNA Extraction

Total DNA was extracted from about 0.3 g of silica dried leaf tissue, using the 2X CTAB buffer (Hexadecyltrimethylammonium bromide) method of Doyle and Doyle (1987). Before precipitation, an aliquot of 150 µl was purified using QIAquick PCR purification kit (Qiagen GmbH, Hilden, Germany) with the NucleoSpin® Extract II columns (Macherey-Nagel GmbH & Co., KG, Germany) following the manufacturer's instructions. DNA levels were checked on the 1% agarose gel (Dutscher Scientific, Essex, UK) and then stored at -20°C or -80°C. The remainder of DNA was precipitated in 2X volume of -20°C ethanol. DNA samples were then purified using a caesium chloride-ethidium bromide (CsCl-EtBr) gradient (1.55 g/ml density). The exact method is described in Appendix D.

PCR Amplification

For PCR amplification, DNA was amplified in 25-µl reactions using an Applied Biosystems GeneAmp PCR System 9700 thermocycler. A small number of studied taxa were not obtained due to amplification problems. One region of nuclear DNA and 4 regions of chloroplast DNA were applied as follows:

(1) The ITS nuclear region was amplified by using a combination of the universal primers AB101 and AB102 (Sun et al., 1994). For some taxa, the ITS1 and ITS2 regions were amplified separately using internal primers ITS2, ITS3, ITS4, and ITS5 (White et al., 1990). Details of the reaction mixture and PCR program are provided in Appendix E.

(2) The trnL-F plastid region was amplified by using a combination of the universal primers trnC and trnF. For some taxa, the intron and spacer regions were

amplified separately using internal primers trnE and trnD (Taberlet et al., 1991). Details of the reaction mixture and PCR program are provided in Appendix F.

(3) The ndhF-rpl32R region was amplified by using a combination of the universal primers ndhF and rpl32R (Olmstead and Sweere, 1994). Details of the reaction mixture and PCR program are provided in Appendix G.

(4) The psaI-accD region was amplified by using a combination of the universal primers psaI and accD (Small et al., 1998). Details of the reaction mixture and PCR program are provided in Appendix G.

(5) The trnQ-rps16x1 region was amplified by using a combination of the universal primers trnQ and rps16x1 (Shaw et al., 2005, 2007). Details of the reaction mixture and PCR program are provided in Appendix G.

PCR products were viewed on a 1% agarose gel (Dutscher Scientific, Essex, UK), to check if the reactions had been successful, and then cleaned using a PCR purification kit (Qiagen GmbH, Hilden, Germany) with columns following the manufacturer's instructions.

Cycle Sequencing

Cycle sequencing reactions (for protocol see Appendix H) were performed using the cycle sequencing with BigDye® Terminator Kit v3.1 (Applied Biosystems, AB, USA). The amplifications were performed in 5-µl volumes on an Eppendorf Flexlid Mastercycler Nexus. Cycle sequencing products were cleaned using MagneSil® Green (Promega Corporation, Madison, USA) on a Beckman Coulter robot (Biomek® NX S8, Buckinghamshire, UK) following the manufacturer's instructions. Cleaned products were then sequenced on an Applied Biosystems 3730 DNA Analyzer following the manufacturer's instructions.

Sequence Alignment

Sequences were manually edited and assembled in Sequencher version 4.5 (Gene Codes Corporation, Ann Arbor, Michigan, USA). They were further aligned by eye in MacClade 3.05 (Maddison and Maddison, 1995). The molecular data matrix from 5 regions did not show.

Phylogenetic Analysis

A total of 10 different analyses were carried out: (1) morphological-anatomical character data, (2) nrITS sequence data, (3) trnL-F sequence data, (4) ndhF-rpl32R sequence data, (5) psaI-accD sequence data, (6) trnQ-rps16x1, (7) combined 4 plastid sequence data, (8) combined morphological-anatomical characters and 5 sequence data, (9) combined 5 sequence data, and (10) combined molecular phylogeny to evaluate the distribution of morphological data.

Maximum parsimony (MP) analyses were performed on the molecular data sets (gaps scored as missing data), using the program PAUP*4.0b10 (Swofford, 2002). All characters were unordered and analysed with equal weights. Heuristic searches were conducted with 1,000 random addition replicated searches of equally weighted (EW) characters (Fitch, 1971), tree bisection-reconnection (TBR) branch swapping with MULTREES in effect but saving no more than 5 trees at each step. These trees were also used to reweight the characters according to the best fit of their rescaled consistency indices (Farris, 1989), and new searches as described above were performed using the successive weight (SW) until the length of the tree did not change in two successive rounds; this approach in tree search reduces the disturbing effect, if any, of unstable taxa (Farris, 1969). Sequences of ITS for 39, trnL-F for 1, psaI-accD for 15, and trnQ-rps16 for 5 of the taxa could not be obtained, possibly due to the low quality of DNA or the ambiguity of their sequence. However, because of their importance to this analysis, they were included in the combined data sets with all of these data coded as missing.

Bootstrap (BS) support values (Felsenstein, 1985) were obtained from 1,000 replicates of sampling characters with EW and SW using TBR swapping but holding only 10 trees per bootstrap replicate. Simple addition sequence was used to build trees, with groups having frequencies greater than 50% being shown in the final bootstrap consensus tree. The following categories were used to describe the levels of bootstrap support: weak = 50-74%, moderate = 75-84%, and strong = 85-100% (van Bank et al., 2002). The consistency index (CI), retention index (RI), and rescaled consistency index (RC) were also calculated using PAUP*4.0b10 (Swofford, 2002) to measure the amount of homoplasy in data and character fit in the analyses.

For Bayesian analyses, MrModeltest 2.2 (Nylander et al., 2004; Posada, 1998) was used to find the best fit model of nucleotide substitution. Bayesian analyses were performed using MrBayes 3.2 (Huelsenbeck and Ronquist, 2001; Ronquist and Huelsenbeck, 2003; Ronquist et al., 2012). A separate best-fit model was used to represent each DNA region, then the data sets were combined, and all models were implemented by partitioning the data. Markov chain Monte Carlo (MCMC) runs were performed, each with one cold chain and three heated chains for 5,000,000 generations, saving a tree every 1,000 generations. Clades with Bayesian Posterior

Probabilities > 95% were considered to have strong support, 90-95% moderate support, and < 90% weak support.

Morphological data were also optimized on Bayesian trees produced from the analysis of all combined DNA regions using Mesquite 2.75 (Maddison and Maddison, 2011). Individual characters were traced on the tree to identify morphological synapomorphies and to examine the relationship between molecular and morphological characters.

6.4 Results

Sixty-three accessions representing the studied taxa and 5 putative outgroup taxa (*Justicia*) in Thailand were designed to study the phylogenetic analysis based on morphological-anatomical characters, chloroplast DNA (trnL-F, ndhF-rpl32R, psaI-accD, trnQ-rps16x1), and nuclear ribosomal DNA (nrITS) sequences. The results are summarized as follows:

1. Analysis of morphological-anatomical characters

For the character matrix of the morphological and anatomical features, 32 characters were included. Heuristic parsimony searches of the character data set revealed 380 equally most parsimonious trees (not show). Sixty-three taxa were analyzed including the outgroups of *Justicia*, *Barleria* and *Eranthemum* from the researcher's collection. The studied taxa were separated into 2 distinct groups but not clearly and with no well supported incongruence. This analysis was just tried to see the trend of characters before combination with sequence data.

2. Analysis of separate nuclear ribosomal DNA (nrITS) and chloroplast DNA (trnL-F, ndhF-rpl32R, psaI-accD, trnQ-rps16x1) sequence data

For the aligned sequences of the nrITS, 906 sites were found. Heuristic parsimony searches of the nuclear ribosomal ITS data set revealed 88 equally most parsimonious trees. One of these trees is shown in Figure 6.1. Twenty-four taxa were analyzed including 3 outgroups of *Stachys sylvatica*, *Nepeta cataria*, and *Buddleja saligna* from GenBank (National Center for Biotechnology Information (NCBI), National Library of Medicine, Bethesda MD, USA). Studied taxa were separated into 4 distinct groups but a few number of samples were added in analysis.

From the sequences of trnL-F, 1,095 sites were included in the analysis. The gene trnL-F provided 755 constant, 177 parsimony-informative characters along with 163 variable but uninformative characters. Heuristic parsimony searches of the chloroplast trnL-F data set revealed 4,720 equally most parsimonious trees. One of these trees is shown in Figure 6.2. Sixty-two taxa were analyzed including outgroups of *Justicia* from DNA Bank and the researcher's collection, *Barleria* and *Eranthemum* from the researcher's collection. Studied taxa were separated into 5 distinct groups (including 2 outgroup clades) but not clearly in the group of *P. metallicum*-*P.* sp2-*P. laxiflorum* and *S. helferi*-*S. lasiobotrys*-*S. glauca*-*S. major*-*S. merguensis*.

From the sequences of ndhF-rpl32R, 805 sites were included in the analysis. Heuristic parsimony searches of the chloroplast ndhF-rpl32R data set revealed 110 equally most parsimonious trees. One of these trees is shown in Figure 6.3. Sixty-three taxa were analyzed including outgroups of *Justicia*, *Barleria* and *Eranthemum* from the researcher's collection. Studied taxa were separated into 3 main groups (excluding the outgroup clades) but still not clearly in the group of *S. helferi*-*S.* l*asiobotrys*-*S. glauca*-*S. concinnula*-*S. major*-*S. merguensis*-*S. argentea*-*S. setigera*.

From the sequences of psaI-accD, 1,070 sites were included in the analysis. Heuristic parsimony searches of the chloroplast psaI-accD data set revealed 2,470 equally most parsimonious trees. One of these trees is shown in Figure 6.4. Forty-eight taxa were analyzed including outgroups of *Justicia*, *Barleria* and *Eranthemum* from the researcher's collection. Studied taxa were separated into 3 main groups (excluding the outgroup clades) but also not clearly in the group of *Pseuderanthemum* and *Staurogyne*-*Ophiorrhiziphyllon*.

From the sequences of trnQ-rps16x1, 1,476 sites were included in the analysis. Heuristic parsimony searches of the chloroplast trnQ-rps16x1 data set revealed 220 equally most parsimonious trees. One of these trees is shown in Figure 6.5. Fifty-eight taxa were analyzed including outgroups of *Justicia*, *Barleria* and *Eranthemum* from the researcher's collection. Studied taxa were separated into 4 main groups (excluding the outgroup clades) but remained not clear in the group of *P. metallicum*-*P. crenulatum, S. lasiobotrys*-*S. major*-*S. incana*, and *S. lanceolata*-*S. glauca*-*S. concinnula*-*S. punctata*.

As there was no well supported incongruence between the separated analyses, sequence data from the regions were combined.

3. Analysis of combined plastid trnL-F, ndhF-rpl32R, psaI-accD, and trnQ-rps16x1 sequence data

The combined data comprise 4,453 sites of aligned sequence. The Maximum Parsimony (MP) analysis of the combined data with characters equally weighted (EW) produced many equally most parsimony trees. Bootstrap consensus of these trees is shown in Figure 6.6. Studied taxa of 4 plastid regions were analyzed including outgroups of *Justicia* from DNA Bank and the researcher's collection, and *Barleria* and *Eranthemum* from the researcher's collection. Studied taxa were separated into 5 main groups (excluding 2 outgroup clades) but remained unclear in groups of *P. metallicum*-*P.* "*palatiferum*"-*P. laxiflorum* and *S.* l*asiobotrys*-*S. glauca*-*S. major*-*S. argentea*-*S. incana*-*S. setigera*.

4. Analysis of combined 5 molecular sequence data and morphological-anatomical characters

The combined data comprise 5,395 sites of aligned sequence plus morphological-anatomical characters. The Maximum Parsimony (MP) analysis of the combined data with character equally weighted (EW) produced 1,500 equally most parsimony trees. One of these trees and bootstrap consensus are shown in Figures 6.7-6.8. Studied taxa of 4 plastid regions, 1 nuclear region, and 32 morphological-anatomical characters were analyzed including outgroups of *Justicia* from DNA Bank and the researcher's collection, and *Barleria* and *Eranthemum* from the researcher's collection. Studied taxa were separated into 5 main groups (excluding 2 outgroup clades) but remained unclear in the group of *S. helferi*-*S.* l*asiobotrys*-*S. glauca*-*S. concinnula*-*S. major*-*S. merguensis*-*S. argentea*-*S. incana*-*S. setigera*.

5. Analysis of combined trnL-F, ndhF-rpl32R, psaI-accD, trnQ-rps16x1, and nrITS sequence data

The combined data comprise 5,359 sites of aligned sequence. The outgroup was *Justicia decumbens* (no. 41771). Range of character set from 1-1102 was trnL-F data, 1103-2578 was trnQ-rps16x1 data, 2579-3383 was ndhF-rpl32R data, 3384-4453 was psaI-accD data, 4454-5359 was nrITS data, of which some sites were excluded from analyses because the alignment was ambiguous. The Maximum Parsimony (MP) analysis of the combined sequence data with characters equally weighted (EW) was just tried to see the trend before Bayesian analysis for more accurate and reliable. Bayesian trees are shown in Figures 6.9-6.10. Studied taxa of 4 plastid regions and 1 nuclear region were analyzed including outgroups of *Justicia* from DNA Bank and the researcher's collection, and *Barleria* and *Eranthemum* from the researcher's collection. The tree revealed the studied taxa more clearly in groups than the other analyses. This tree then was used for optimizing morphological characters.

6. Optimization of morphological characters onto the phylogeny

Five selected characters of studied taxa were optimized on Bayesian tree of combined data of nrITS, trnL-F, ndhF-rpl32R, psaI-accD, and trnQ-rps16x1, i.e., the exsertion of filaments, corolla form, leaf venation pattern, number of staminodes, and inflorescence type (Table 6.3). Some traced characters are homoplastic which they represented in several studied taxa and evolved independently such as "long exserted" filament, staminode "absent" and "head" inflorescence type (Figures 6.11-6.15).

Table 6.3 Characters and coding used in the analysis and mapping characters to the phylogeny in combined Bayesian analysis.

Characters	States
1. Exsertion of filaments	inserted (0), only anthers exserted (1), shortly exserted (2), long exserted (3)
2. Corolla form	nearly actinomorphic (0), slightly 2-lipped (1), distinctly 2-lipped (2)
3. Leaf venation pattern	Eucamptodromous (0), Brochidodromous (1)
4. Number of staminode	Staminode absent (0), staminode 1 (1), staminode 2 (2)
5. Inflorescence type	Spike (0), cyme (1), raceme (2), head (3)

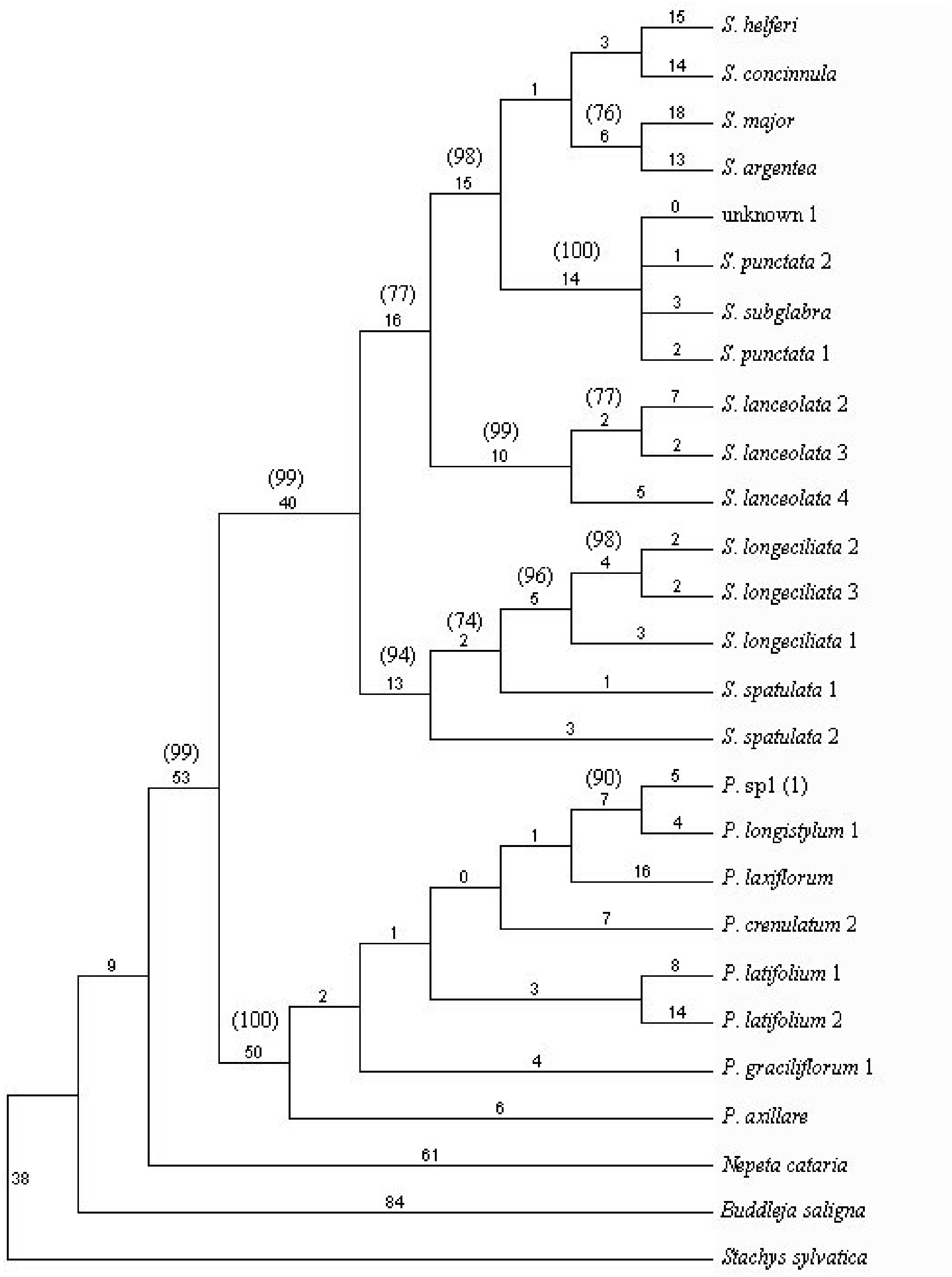


Figure 6.1 Most parsimonious tree resulting from nrITS analysis. Values at nodes (in parenthesis) indicate bootstrap support > 70%. Values above lines indicate number of change.

P.: *Pseuderanthemum*, *S.*: *Staurogyne*

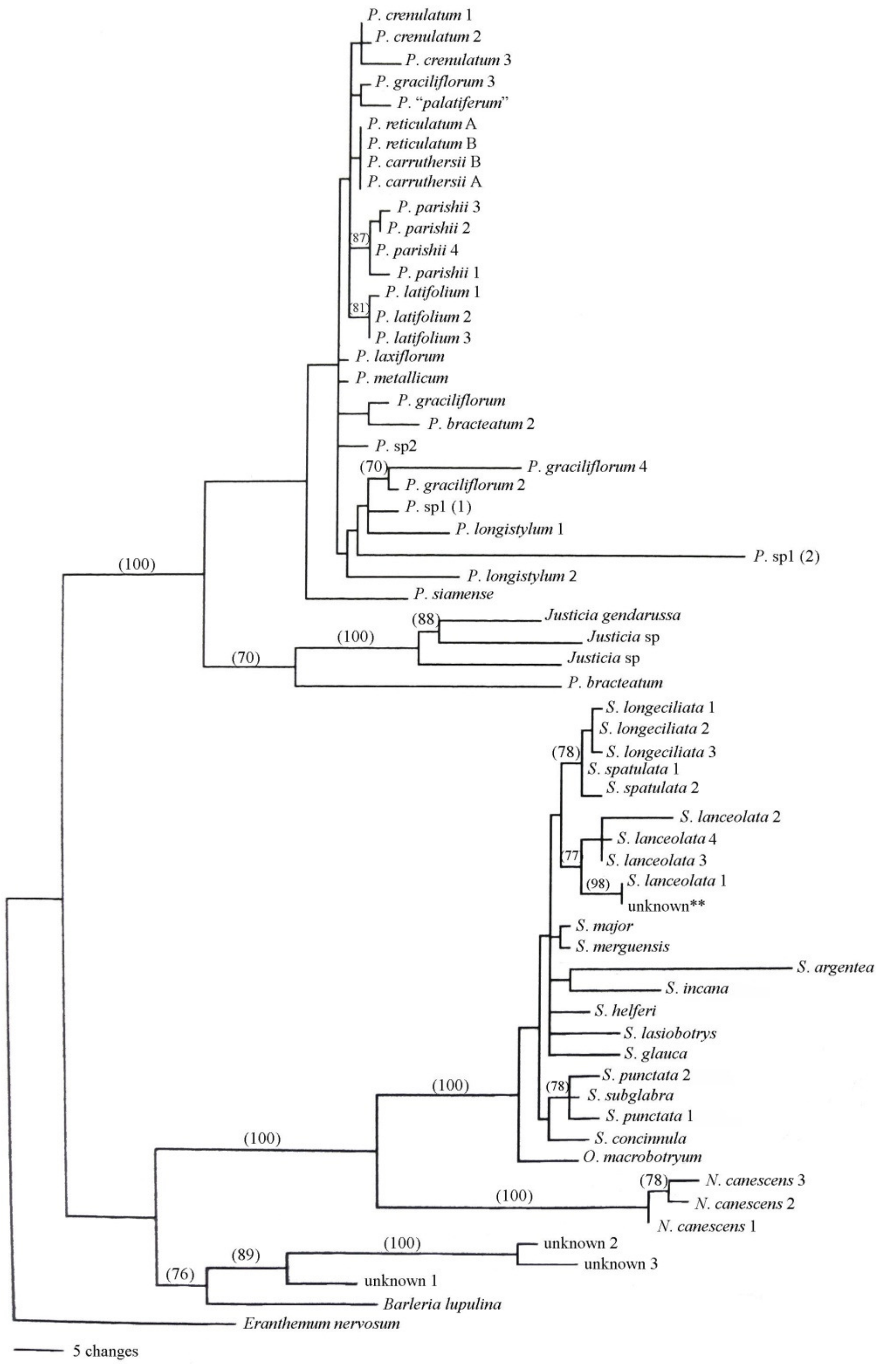


Figure 6.2 Most parsimonious tree resulting from trnL-F analysis. Values at nodes indicate bootstrap support > 70%.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

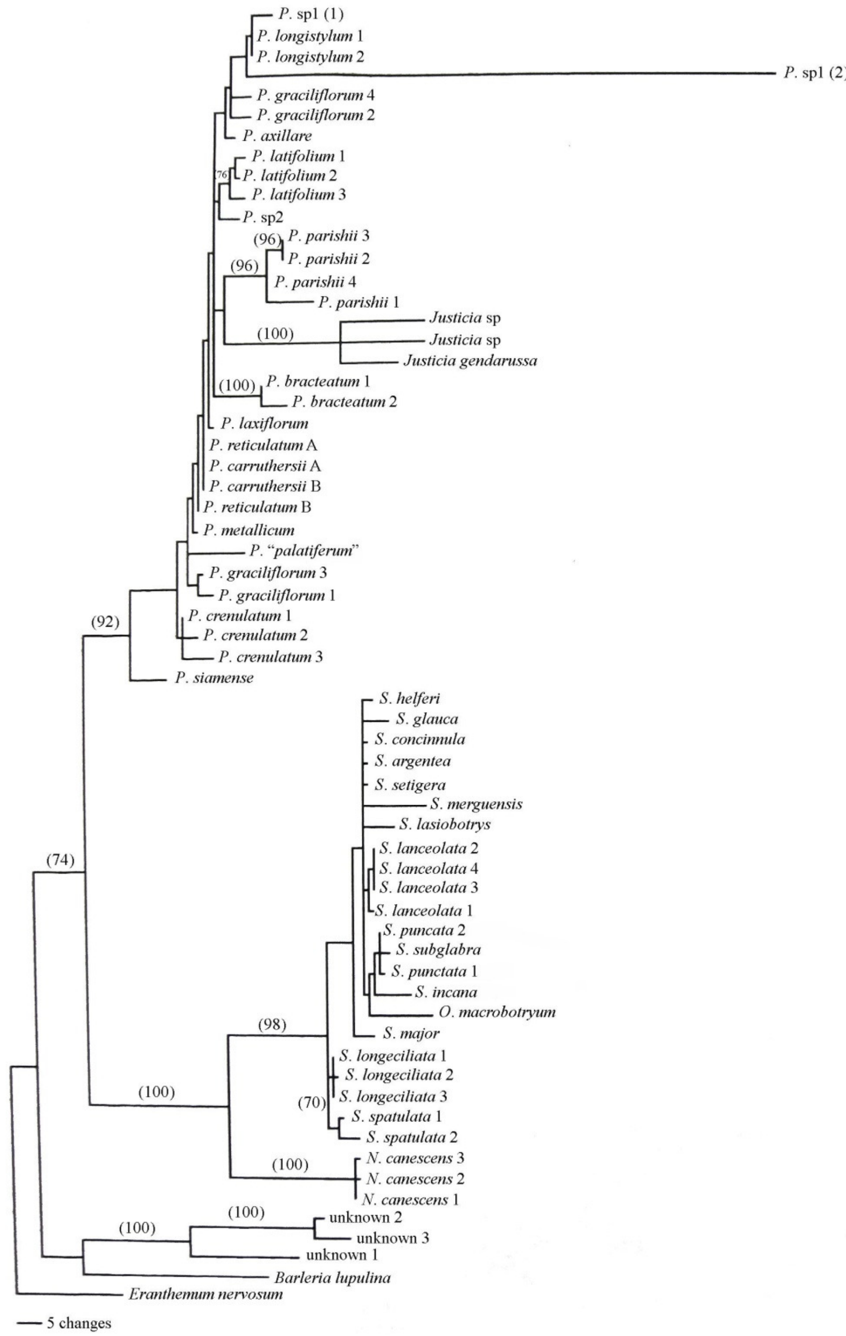


Figure 6.3 Most parsimonious tree resulting from ndhF-rpl32R analysis. Values at nodes indicate bootstrap support > 70%.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum, S.*: *Staurogyne*

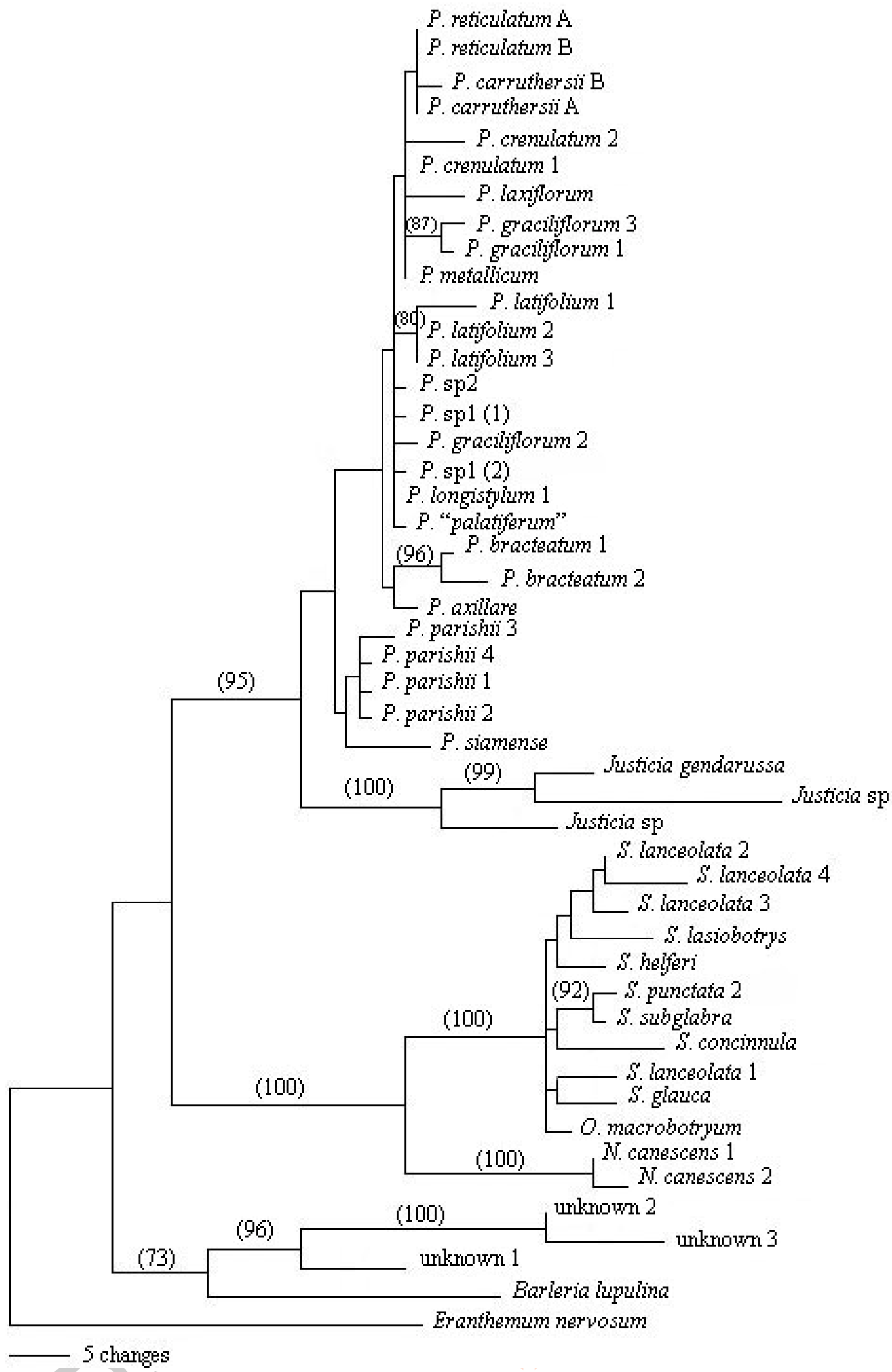


Figure 6.4 Most parsimonious tree resulting from psaI-accD analysis. Values at nodes indicate bootstrap support > 70%.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

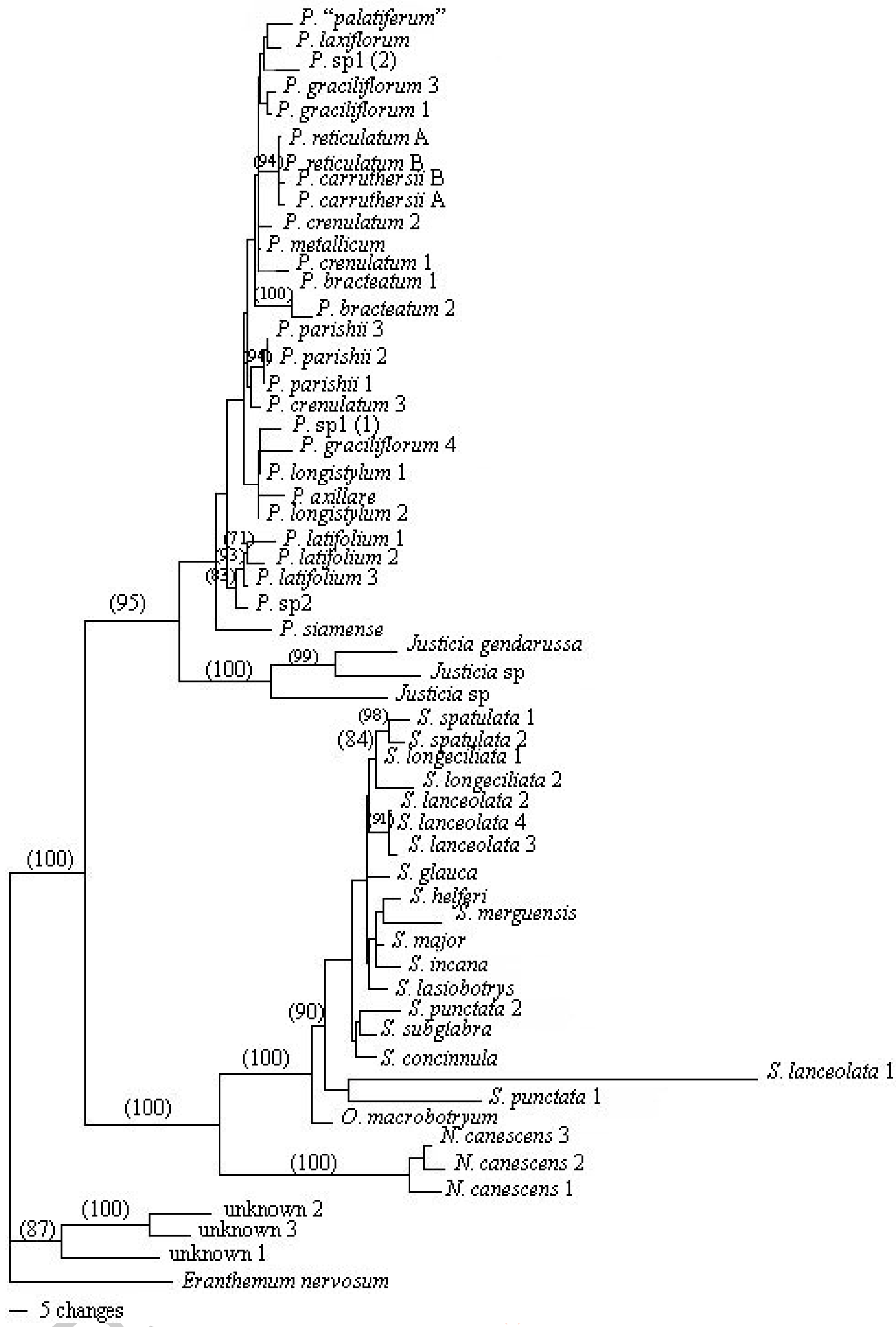


Figure 6.5 Most parsimonious tree resulting from trnQ-rps16x1 analysis. Values at nodes indicate bootstrap support > 70%.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

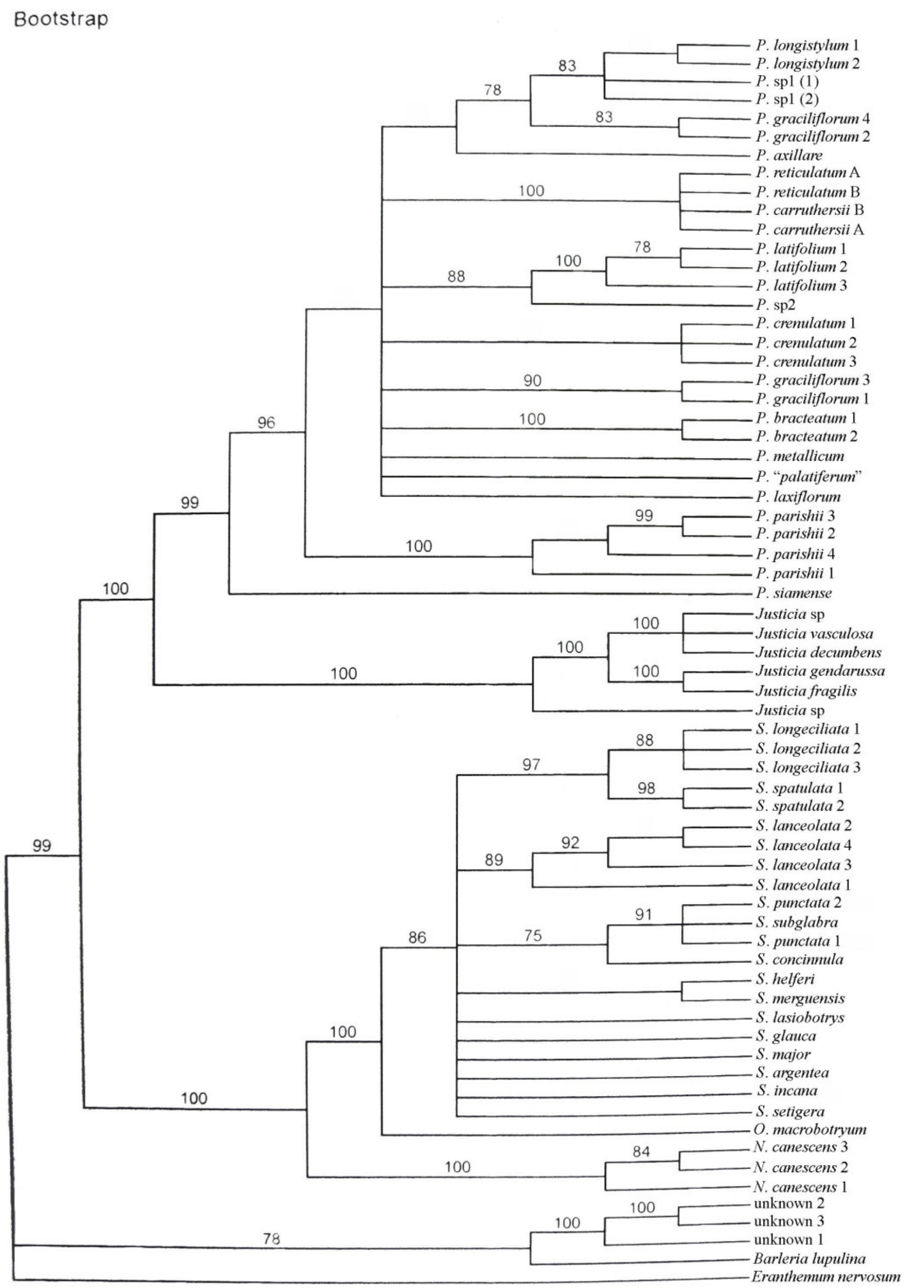


Figure 6.6 Bootstrap consensus of most parsimonious tree from a combined plastid trnL-F, ndhF-rpl32R, psaI-accD, and trnQ-rps16x1 heuristic analysis. Values at nodes indicate bootstrap support > 70%.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

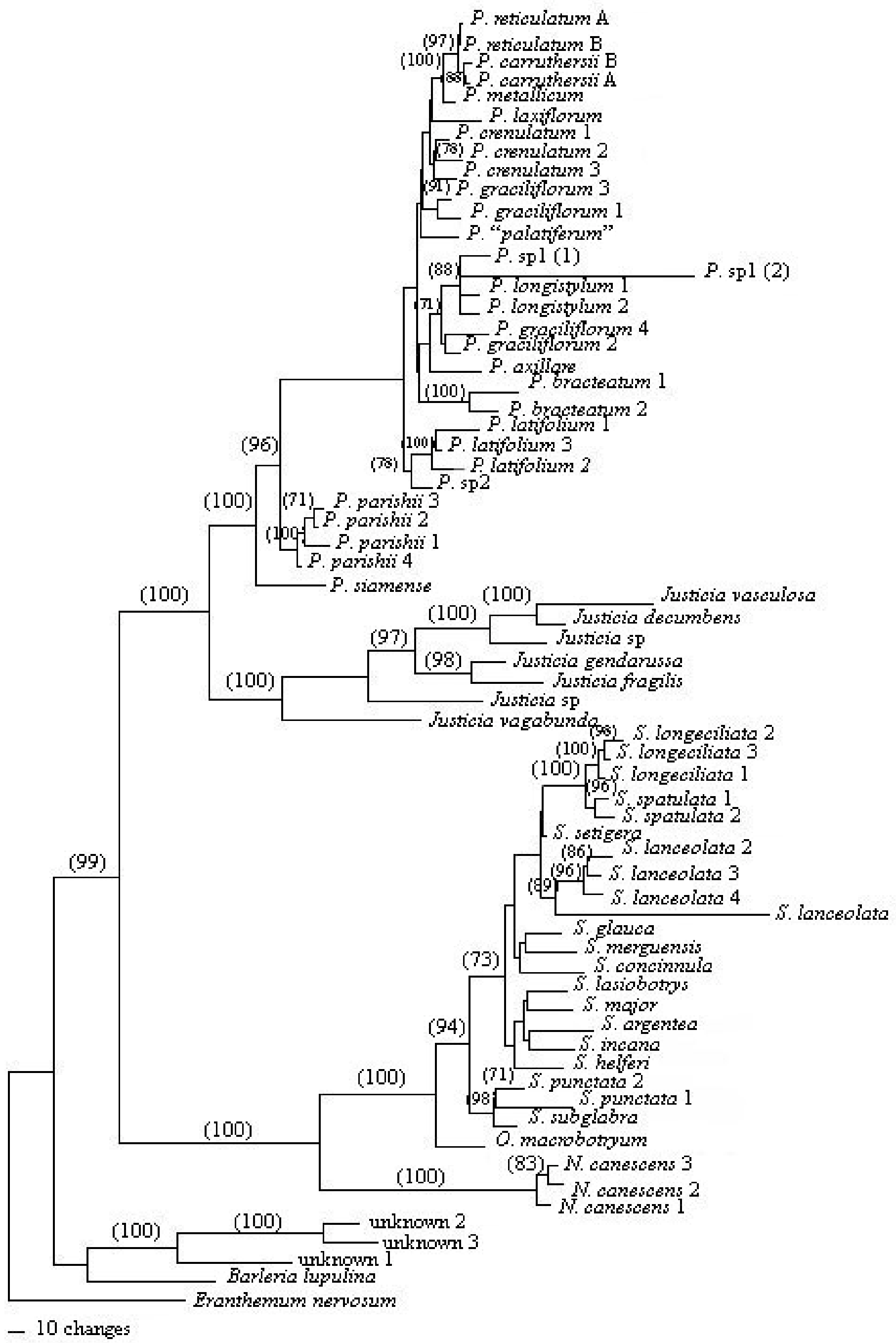


Figure 6.7 Most parsimonious tree from a combined nrITS, trnL-F, ndhF-rpl32R, psaI-accD, trnQ-rps16x1, and morphological-anatomical characters analysis. Values at nodes indicate bootstrap support > 70%.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

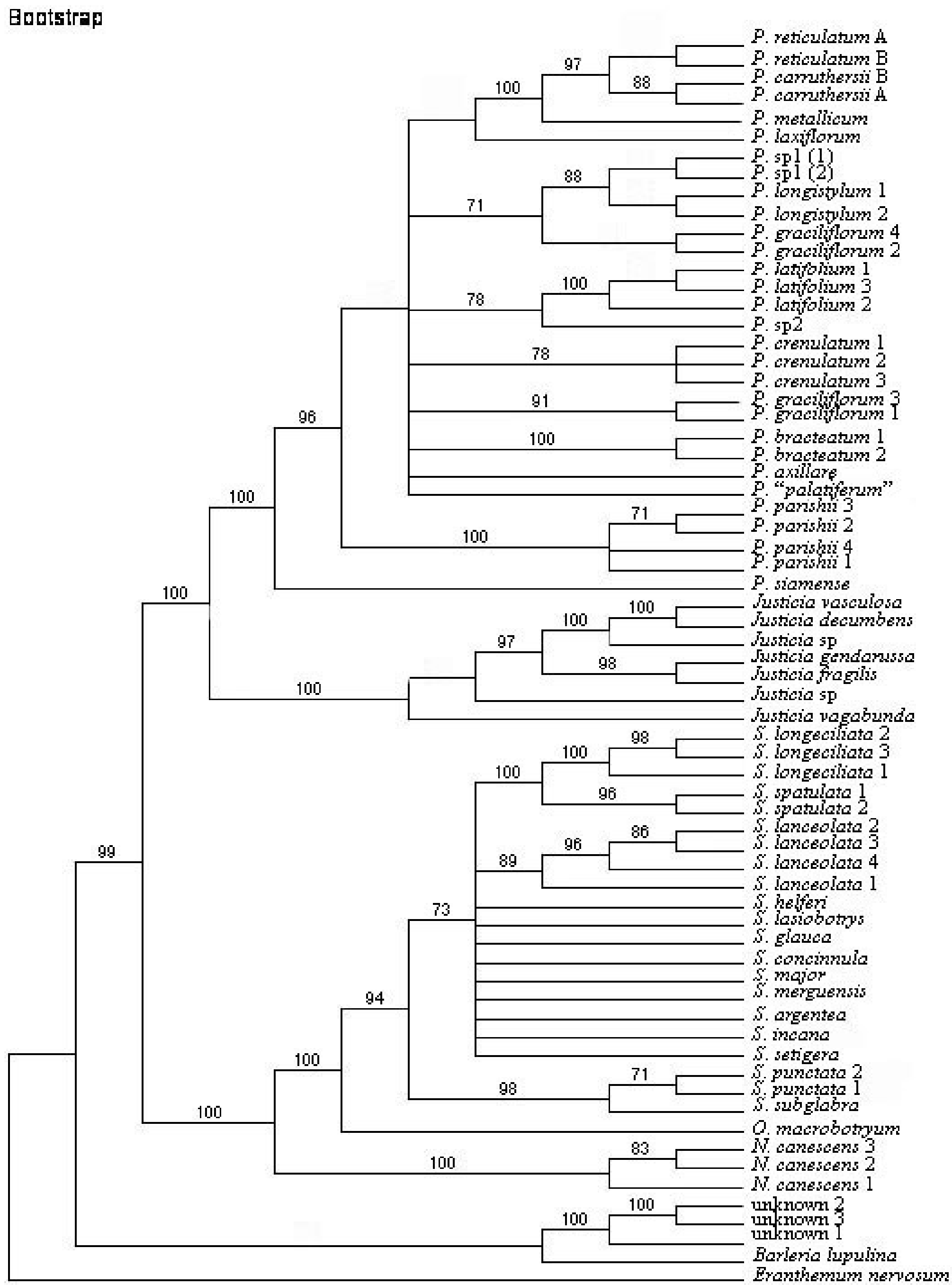


Figure 6.8 Bootstrap consensus of most parsimonious trees from a combined nrITS, trnL-F, ndhF-rpl32R, psaI-accD, trnQ-rps16x1, and morphological-anatomical characters analysis. Values at nodes indicate bootstrap support > 70%.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

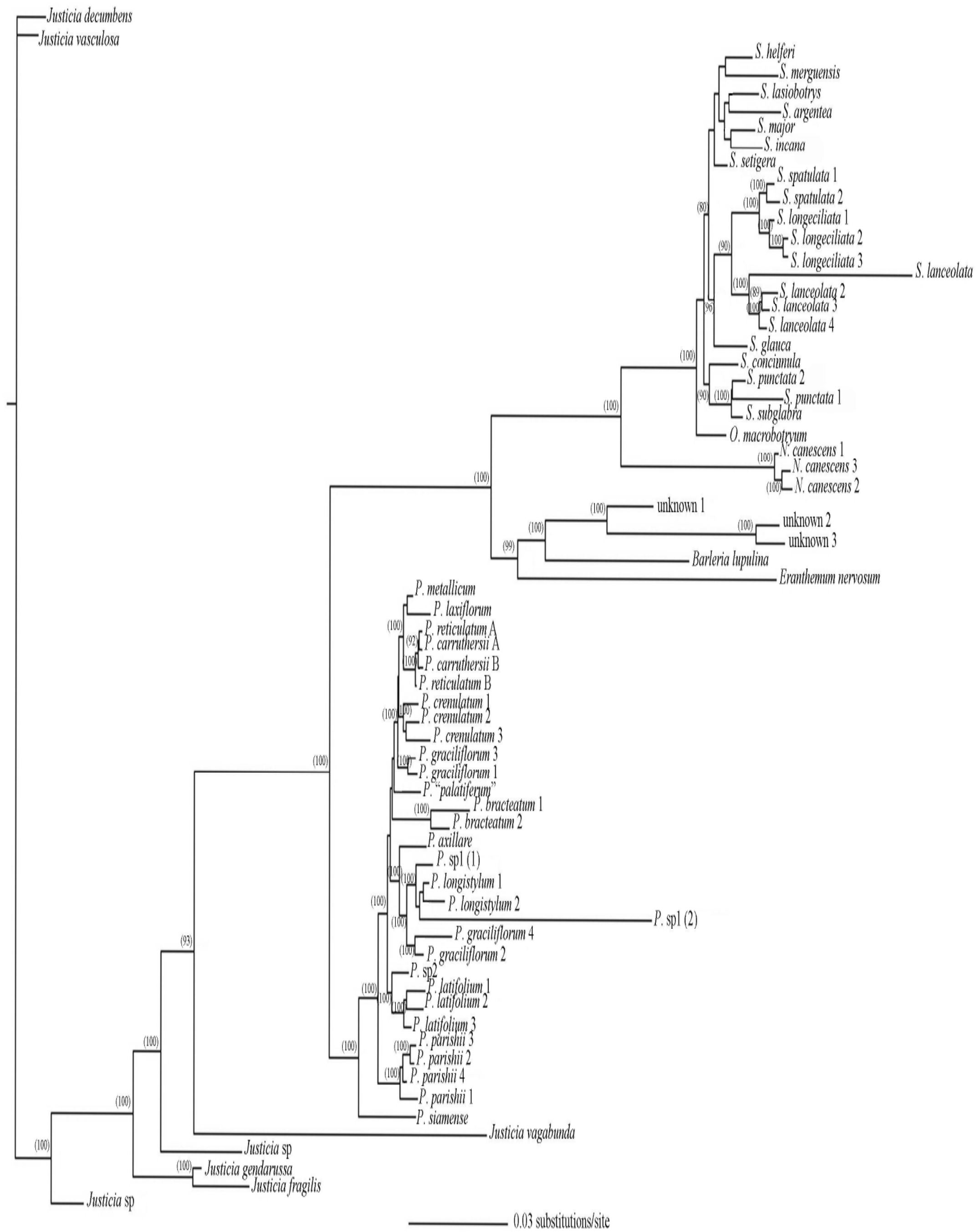


Figure 6.9 Bayesian tree based on a combined nrITS, trnL-F, ndhF-rpl32R, psaI-accD, and trnQ-rps16x1 analysis. Values at nodes indicate Bayesian posterior probabilities > 89%.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

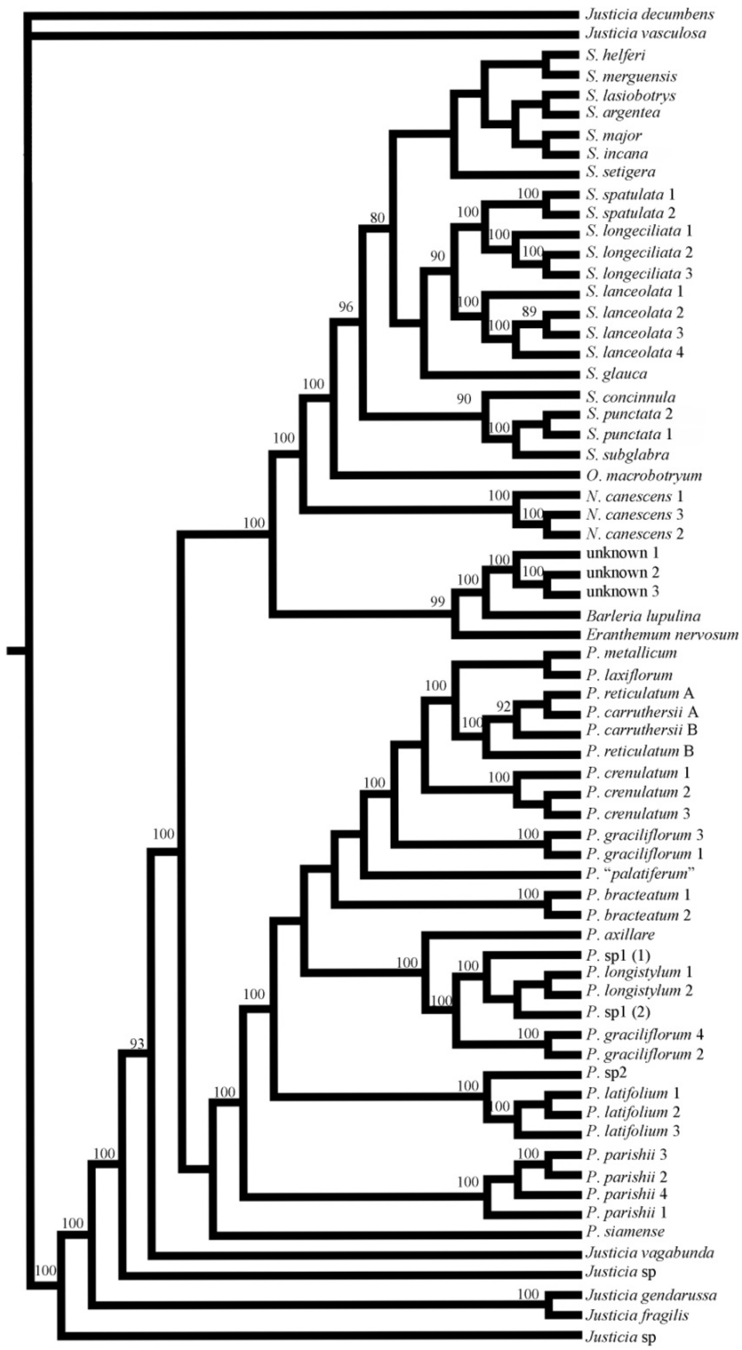


Figure 6.10 Bayesian consensus tree based on a combined nrITS, trnL-F, ndhF-rpl32R, psaI-accD, and trnQ-rps16x1 analysis. Values at nodes indicate Bayesian posterior probabilities > 89%.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

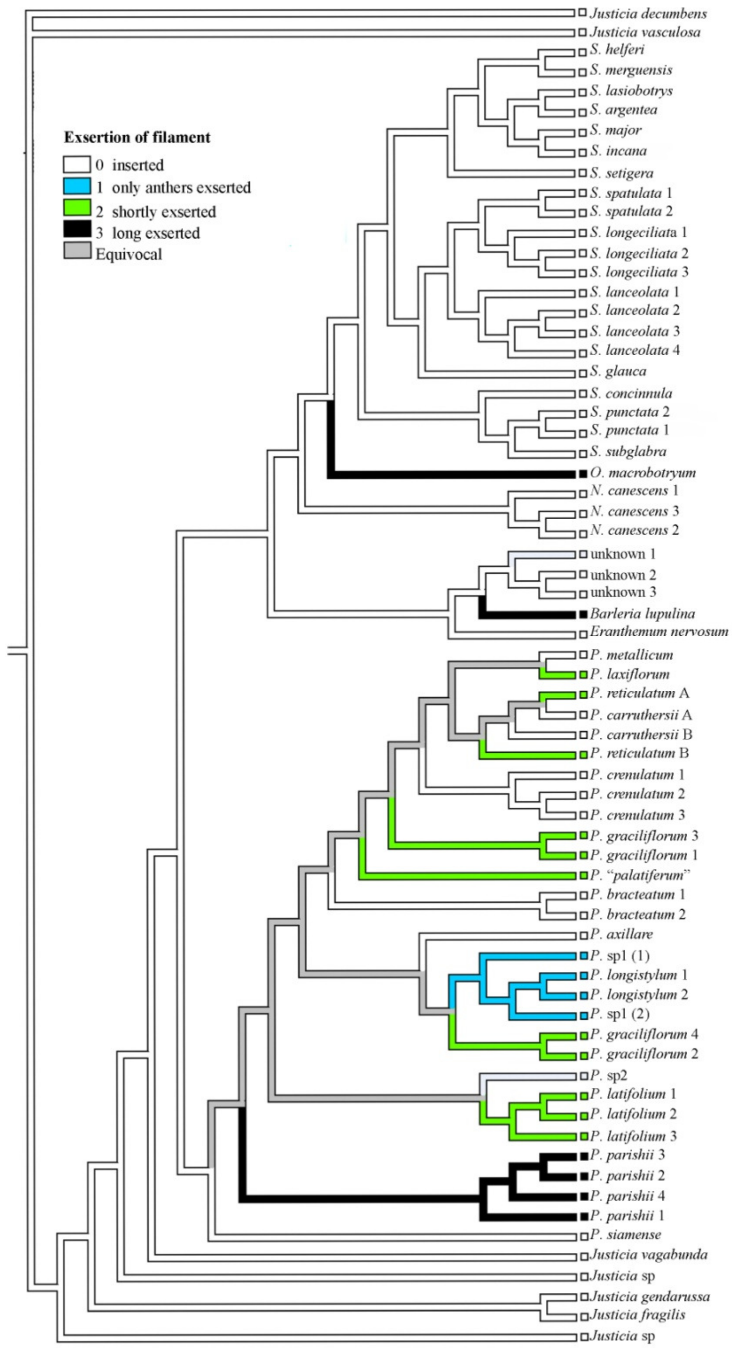


Figure 6.11 Bayesian tree of combined data of nrITS, trnL-F, ndhF-rpl32R, psaI-accD, and trnQ-rps16x1 optimized with the character "exsertion of filament" using Mesquite.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

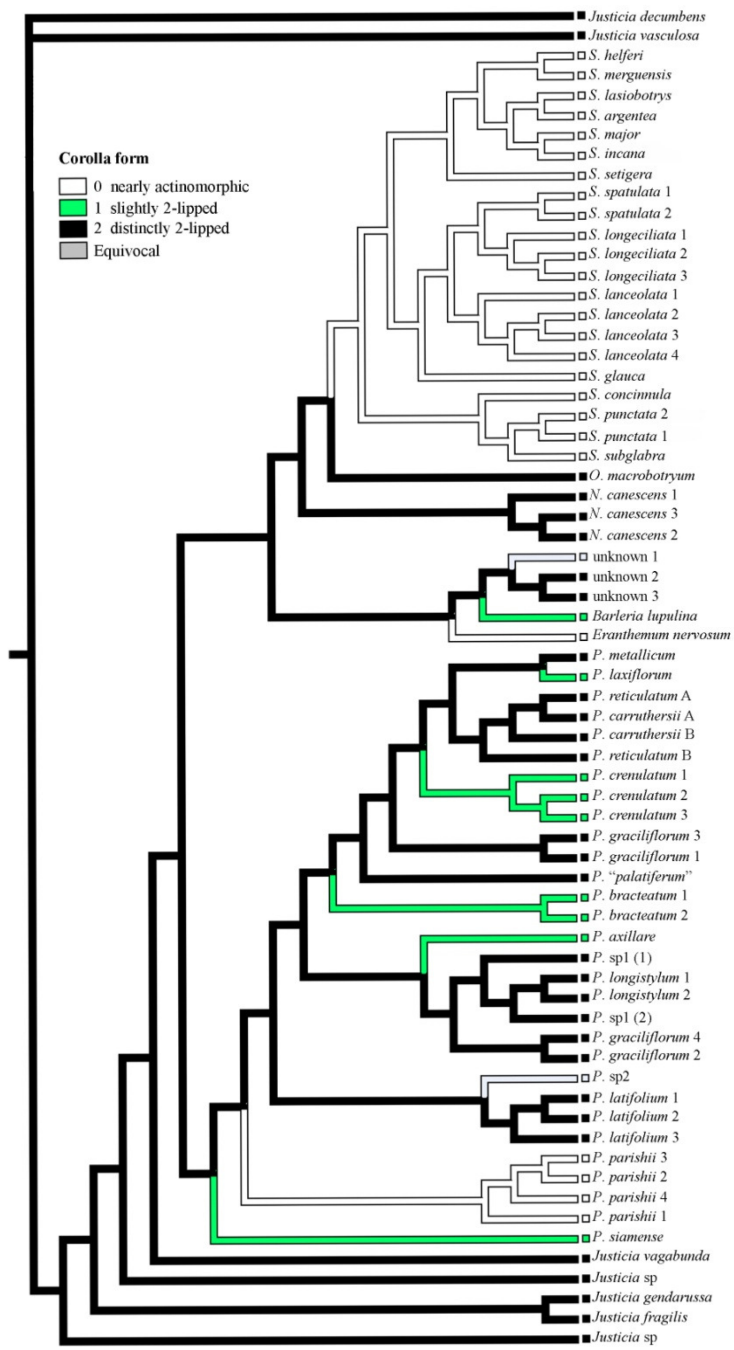


Figure 6.12 Bayesian tree of combined data of nrITS, trnL-F, ndhF-rpl32R, psaI-accD, and trnQ-rps16x1 optimized with the character "corolla form" using Mesquite.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

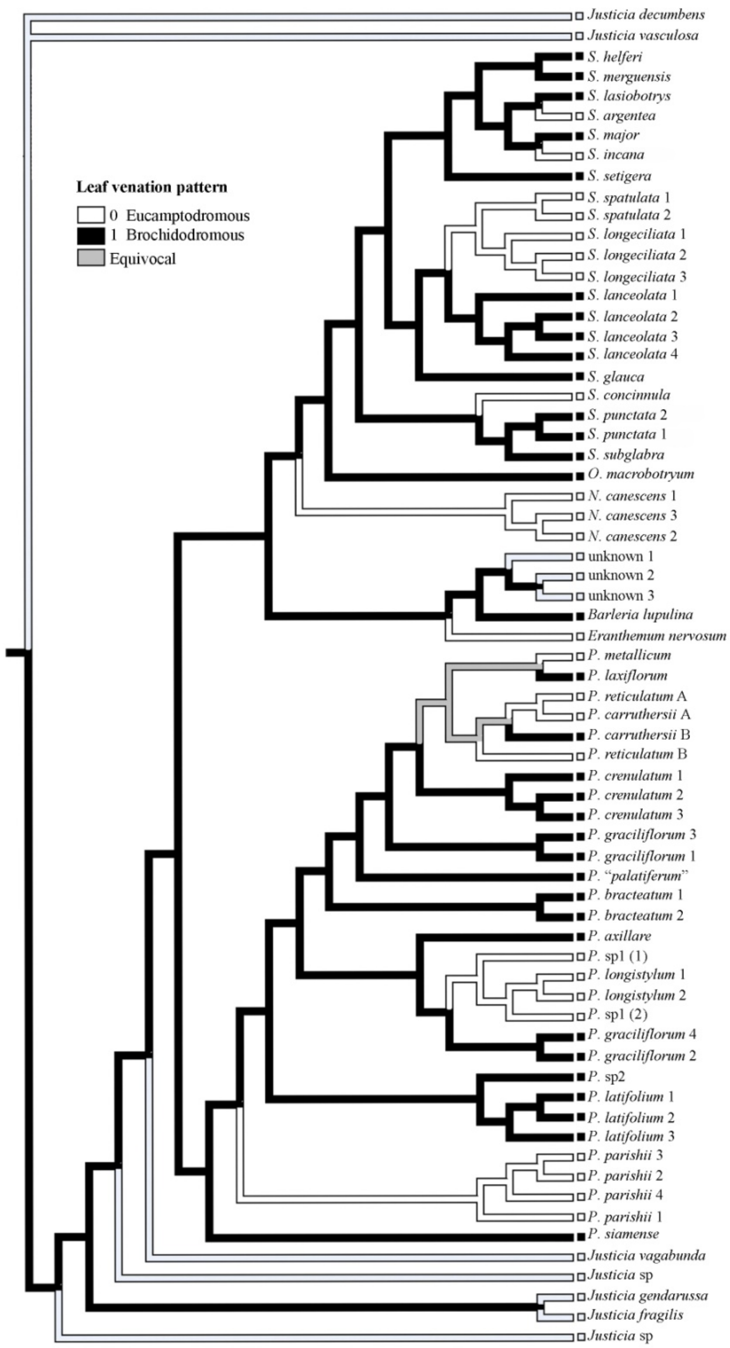


Figure 6.13 Bayesian tree of combined data of nrITS, trnL-F, ndhF-rpl32R, psaI-accD, and trnQ-rps16x1 optimized with the character "leaf venation pattern" using Mesquite.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

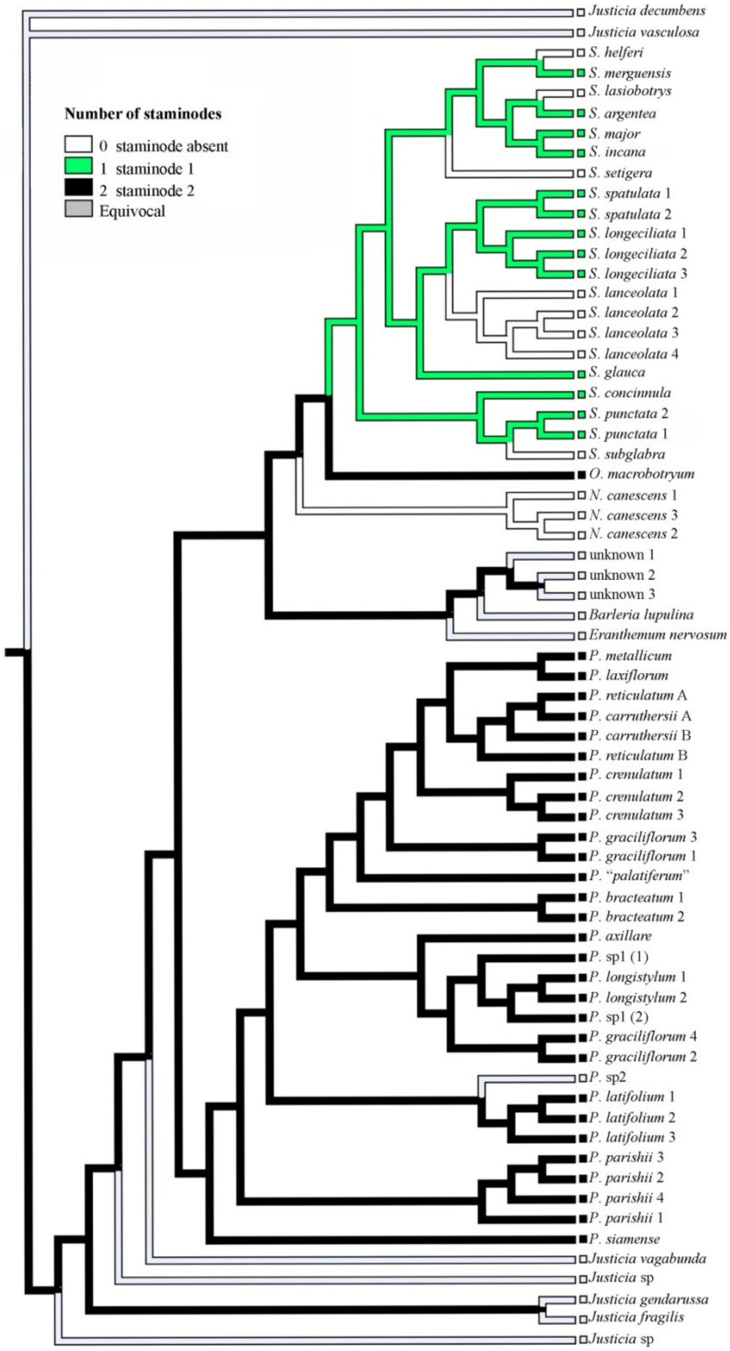


Figure 6.14 Bayesian tree of combined data of nrITS, trnL-F, ndhF-rpl32R, psaI-accD, and trnQ-rps16x1 optimized with the character "number of staminodes" using Mesquite.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

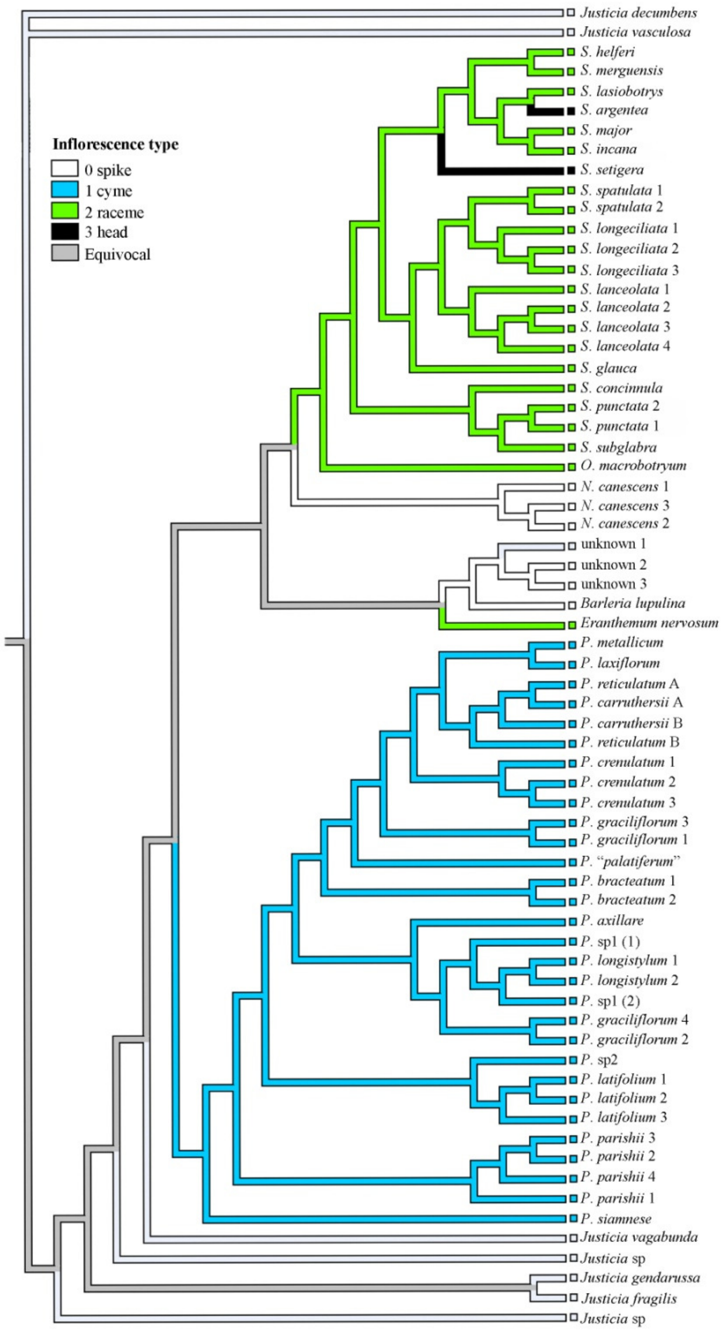


Figure 6.15 Bayesian tree of combined data of nrITS, trnL-F, ndhF-rpl32R, psaI-accD, and trnQ-rps16x1 optimized with the character "inflorescence type" using Mesquite.

N.: *Nelsonia, O.*: *Ophiorrhiziphyllon, P.*: *Pseuderanthemum*, *S.*: *Staurogyne*

6.5 Conclusions and Discussion

Phylogenetic analyses of 4 genera were conducted based on the ITS sequence of the nuclear ribosomal and the trnL-F, ndhF-rpl32R, psaI-accD, trnQ-rps16x1 of the chloroplast loci. Sixty-three taxa were used in this analysis.

There were so many problems in the analysis of nrITS sequence data; because of ambiguity, the sequences were difficult to align and the DNA could not be amplified. For several taxa, the ITS1 and ITS2 regions were amplified separately using internal primers ITS2, ITS3, ITS4, and ITS5. Unfortunately, their DNA bands did not show or their sequences were still messy. So, more than a half of the samples were excluded from this analysis and only 24 samples were analyzed. However, the limited analysis from this region showed the tree support quite well, and it further was necessary to include this region in a combined analysis. In this analysis, 3 samples of *Staurogyne longeciliata* were mentioned because they were clearly distinguished from *S. lanceolata*, although Hansen (1995) had included the 2 species together using hairs on bracts, but they differ in leaf texture and shape, inflorescence, and leaf hairs. So, this result led to the decision to separate them in this research when comparison on other regions and combined analyses were made. Moreover, *Pseuderanthemum longistylum* and *P.* sp1 were separated by strong support (BS = 90%), which is used to confirm giving a new species in the future work, beside the difference in some morphological characters, i.e., hairs on leaf surfaces and spots distribution on corolla lobes.

In the analysis of trnL-F sequence data, 62 samples were included but *P. axillare* were placed on a wrong clade in the first analysis. It might have been caused by contamination during processing. Then, new amplification and alignment were made for this sample. The new sequence data were added in the combined analysis after that and the result revealed strong support. Moreover, the intron and spacer regions were amplified separately using internal primers trnE and trnD in some taxa. So, most of the samples were used in the analysis. In the tree, *P. parishii* and *Nelsonia canescens* were separated by strong support (BS = 87% and 100% respectively). *P. latifolium*, *S. longeciliata*-*S. spatulata* clade, *S. lanceolata*, and *S. punctata*-*S. subglabra* clade were supported by 81%, 78%, 77%, and 78% moderate bootstrap values, respectively. Nevertheless, there were unclear groups in both *Pseuderanthemum* and *Staurogenoid*, which led to trying 3 more regions for this study.

In the ndhF-rpl32R sequence data analysis, all of 63 taxa were analyzed, even only 1 nucleotide direction in the sample of *P.* sp1 (2). The sequence from this region was very clear but quite short and consistent when aligned. Nevertheless, it might be useful for combined analysis to support high bootstrap values. In the tree, *P. parishii*, *P. bracteatum*, and *N. canescens* were separated by strong support (BS = 96%, 100%, and 100% respectively). *P. latifolium* was supported by 76% moderate bootstrap value. This region analysis conformed to the trnL-F in almost all cases.

There were 48 taxa (including 4 taxa of only one direction; *P.* sp1 (1), *P. bracteatum* 2, unknown 2, and unknown 3) in the analysis of psaI-accD sequence data. Some taxa and some directions of sequence showed an ambiguous sequence, for which they were excluded from the analysis. The sequence data of this region were long and showed more variation. In the tree, *P. bracteatum*, *P. graciliflorum*, *S. punctata*-*S. subglabra* clade, and *N. canescens* were separated by strong support (BS = 96%, 87%, 92%, and 100% respectively). *P. latifolium* was supported by 80%

moderate bootstrap value. This region analysis agreed with the trnL-F and ndhF-rpl32R in almost all cases.

Fifty-four taxa of both directions and 4 taxa of one direction (*P. axillare*, *P. crenulatum* 1, *P. crenulatum* 3, and *P.* sp1 (2)) were included in the analysis of trnQ-rps16x1 sequence data. This region was added to try a new useful region for Acanthaceae identification. As the result, long sequence data showed more variation useful to separate some more taxa from the others but was still unclear in some group. In the analysis, *P. reticulatum*-*P. carruthersii* clade, *P. latifolium*, *P. parishii*, *P. bracteatum*, *S. spatulata*, *S. lanceolata*, *O. macrobotryum*, and *N. canescens* were separated by strong support (BS = 94%, 93%, 94%, 100%, 98%, 91%, 100%, and 100%, respectively). *P.* sp2 was separated from *P. latifolium* by 83%, which was used to confirm for giving a new species in the future work, beside the distinct morphological characters, i.e., color of leaf lower surface, leaf texture, and habitat. *S. longeciliata* was distinguished from *S. spatulata* by 84% moderate bootstrap value and was also clearly separated from *S. lanceolata* which confirmed its location. This region analysis showed more separated groups than the others.

In the separate analyses of each region, the sequence data showed less or more variation depending on the region. Nuclear ribosomal DNA tended to present more variation, allowing easy to separation of taxa, than plastid DNA, but it always difficult to study due to the sequence normally being hard to align. Longer sequence data also revealed more variation; however, it difficult to align as well. For a single analysis, the sequence data could be used to separate some taxa, especially at genus level, but was still not clear enough in some groups. Therefore, phylogenetic analyses of combined sequence data provided the best phylogenetic reconstruction of studied taxa.

In combined plastid analysis, *P. reticulatum-P. carruthersii* clade, *P. latifolium*, *P. graciliflorum* 1-3, *P. bracteatum*, *P. parishii*, *P. siamense*, *S. longeciliata*, *S. spatulata*, *S. lanceolata*, *S. punctata-S. subglabra* clade, *O. macrobotryum*, and *N. canescens* were separated by strong support (BS = 100%, 100%, 90%, 100%, 100%, 100%, 88%, 98%, 89%, 91%, 100%, and 100%, respectively), which was useful to especially provide support for *S. longeciliata* classification. *P. longistylum-P.* sp1 clade and *P. graciliflorum* 2-4 were supportd by 83% moderate bootstrap values. *P.* sp2 was separated from *P. latifolium*, as in trnQ-rps16x1 regions, by 88% strong BS, and *S. concinnula* was distinguished from *S. punctata-S. subglabra* clade by 75% moderate BS.

When 4 plastid regions, 1 nuclear region, and morphological-anatomical characters were combined for analysis, *P. carruthersii*, *P. longistylum-P.* sp1 clade, *P. latifolium*, *P. graciliflorum* 1-3, *P. bracteatum*, *P. parishii*, *P. siamense*, *S. longeciliata*, *S. spatulata*, *S. lanceolata*, *S. punctata-S. subglabra* clade, *O. macrobotryum*, and *N. canescens* were separated by strong support (BS = 88%, 88%, 100%, 91%, 100%, 100%, 100%, 100%, 96%, 89%, 98%, 100%, and 100% respectively). Moreover, *P. crenulatum* was supported by 78% moderate Bootstrap values. *P.* sp2 was separated from *P. latifolium* by 78% moderate BS. So, the combined analysis revealed more distinct separation between genera and even species.

Based on combined DNA analysis, studied taxa could be divided into 2 main clades. Clade I (Nelsonioideae) can be diagnosed by presenting numerous seeds, descending cochlear aestivation, and glandular trichomes. Clade II (Acanthoideae) can be uniquely diagnosed by having retinacula, cystoliths, 2 staminodes, and ascending cochlear aestivation. Clade I, it could also be separated into 3 sub-clades. Sub-clade 1 (*Nelsonia canescens*) has autapomorphic characters, such as having spike inflorescence, 4-partite calyx, and no bracteole. Sub-clade 2 (*Ophiorrhiziphyllon macrobotryum*) can be diagnosed by having 2 exserted stamens with elongated thecae. Sub-clade 3 (*Staurogyne*) can be distinguished by showing 4 fertile stamens (didynamous). In more detail, *S. longeciliata* can be distinguished from *S. lanceolata* by moderate support (BPP = 90%) and was separated from *S. spatulat*a by strong support (BPP = 100%). *S. punctata* was separated from *S. subglabra* by 100% BPP. In clade II, *P. longistylum* and *P.* sp1 (1) were separated by 100% BPP. *P.* sp2 showed a distinct position on the tree and was separated from *P. latifolium* by 100%BPP. These results were useful in supporting the classification in this research and giving a new species in the future work. *P. carruthersii* and *P. reticulatum* came out in the same clade with strong support (BPP = 100%) by having the same of leaf texture, 2-forms of leaves, habit and inflorescences. Moreover, *P. siamense* came out as a sister group to all of the other *Pseuderanthemum* by 100% BPP with having unbranched inflorescence with subsessile flowers.

In the character evolution study, some traced characters are homoplastic when optimized on a Bayesian tree of combined analysis of ITS, trnL-F, ndhF-rpl32R, psaI-accD, and trnQ-rps16x1. Character 1 (exsertion of filament), character 2 (corolla form), character 3 (leaf venation pattern), character 4 (number of staminodes), and character 5 (inflorescence type) varied in several studied taxa. However, some research has been reported that presence of cystoliths and retinacula are synapomorphies for *Pseuderanthemum* taxa. Numerous seeds occurrence is a symplesiomorphy for Nelsonioideae taxa. Descending cochlear corolla aestivation is a synapomorphy for Nelsonioideae taxa (Wenk and Daniel, 2009).

Nevertheless, the result from this analysis suggested that some morphological and anatomical characters are variable in some taxa of the studied group. Therefore, using additional characters, such as more gene regions, more taxa from various geographic regions, pollen size and type, pollen sculpture, distributional and ecological data, and even more detail of further morphological (glandular hairs, flower or inflorescence size, morphometrics) and anatomical (cystolith size and type, fine leaf venation pattern) studies may support more accurate or correct identification.

Selection of homologues (characters/character state) is an important part of any systematic study. The researcher attempted to employ homologues that are discrete and can be scored for a number of species with a high degree of confidence based on direct observation. There is a tendency in morphological studies to assume that more characters are better. Phylogenetic accuracy can be improved by increasing the number of characters for a given problem and high bootstrap values also have a direct relationship to an increased character/taxon ratio. For both reasons many morphological studies attempt to include as many characters as possible. However, including poorly understood or badly circumscribed homologues in an analysis will add little if anything to the resulting topology.

In conclusion, the results from phylogenetic analyses demonstrate that character variation within species and clades causes difficulty in determining unambiguously diagnostic groups by morphological characters investigated here. The molecular data has provided insufficient information for resolving the relationship of 45 taxa within the studied group.

CHAPTER VII

BIOGEOGRAPHICAL AND BIODIVERSITY STUDIES

7.1 Geography of Thailand

Thailand is situated on the Indochinese peninsula in the heart of the Southeast Asian mainland and continues far to the south, linking its south peninsula with Malaysia. Its geographical location is from latitude 20° 25′ 30″ N at Mae Sai, Chiang Rai in the North to 5° 37′ N at Be Tong, Yala in the South and longitude 97° 22′ E at Mae La Noi, Mae Hong Son in the West to 105° 37′ 30″ E at Phibun Mangsahan, Ubon Ratchathani in the East. It is located between the equator and the Tropic of Cancer, covering an area of 511, 937 km^2. The map of Thailand is axe shaped whose upper part is very wide. The narrowest part of the country measures 12 km at Huai Yang in Prachuap Khiri Khan while the Isthmus of Kra in Ranong is the narrowest part of the peninsula, connecting the Indochinese Peninsula and the Malay Peninsula.

Thailand borders Laos and Myanmar to the north, Cambodia and the Gulf of Thailand to the east, Myanmar and the Andaman Sea to the west, and Malaysia to the south. Thailand has maximum dimensions of approximately 2,500 km north to south and 1,250 km east to west, with a coastline of approximately 1,840 km on the Gulf of Thailand and 865 km along the Andaman Sea (LePoer, 1989).

7.2 Floristic Regions of Thailand

The topography and drainage of Thailand define the country as four widely recognized geographical regions: the North (N), Northeast (NE), Center (C), and South (S). The four regions have no administrative significance, but each differs from the others in population, basic resources, natural features, and level of social and economic development. Thailand is administratively divided into 77 provinces. Botanically, Thailand is included in the Indochinese subdivision of the continental southeast Asiatic region according to the recent floristic divisions of the earth (Good, 1974). Thailand can be divided into 7 floristic regions (Figure 7.1). The followings are descriptions of floristic features of each division, including provinces (Smitinand, 1958; The Forest Herbarium, 2011, Santisuk, 2012).

1. NORTHERN (N): This division is under the Indo-Myanmaran floristic tendency. The region is rich in high mountains, having the highest peak (Doi Inthanon, altitude 2,576 m) in Thailand. The geological formation is generally of sandstone or granite. Types of forests range from dry dipterocarp forest below 500 m, dry evergreen forest between 500 to 1000 m, and to hill evergreen forests above 1000 m. The division includes 15 provinces: (1) Mae Hong Son, (2) Chiang Mai, (3) Chiang Rai, (4) Phayao, (5) Nan, (6) Lamphun, (7) Lampang, (8) Phrae, (9) Uttaradit, (10) Tak, (11) Sukhothai, (12) Phitsanulok, (13) Kamphaeng Phet, (14) Phichit, and (15) Nakhon Sawan.

2. NORTH-EASTERN (NE): This region corresponds to the Indochinese flora, but the Indo-Myanmaran elements can also be found here. Floristic affinities are close to southwestern China as well. The region is the high plateau of Thailand. Types of forests are from dry deciduous to mixed deciduous forests with large tracts of dry

evergreen forests growing intermittently. Pine forests are present from above 1000 metre. Dipterocarp forests are the common feature of the region. This division includes 12 provinces: (16) Phetchabun, (17) Loei, (18) Nong Bua Lam Phu, (19) Udon Thani, (20) Nong Khai, (21) Bueng Kan, (22) Sakon Nakhon, (23) Nakhon Phanom, (24) Mukdahan, (25) Kalasin, (26) Maha Sarakham, and (27) Khon Kaen.

3. EASTERN (E): This region is under the influence of the central and southern Indochinese flora. Dry dipterocarp forests are the main feature of the region. Savannas are also common. Pine forests can be seen side by side or mixed with dry dipterocarp forests. No significant bryophyte collections have been made from this region. This division includes 9 provinces: (28) Chaiyaphum, (29) Nakhon Ratchasima, (30) Buri Ram, (31) Surin, (32) Roi Et, (33) Yasothon, (34) Amnat Charoen, (35) Si Sa Ket, and (36) Ubon Ratchathani.

4. SOUTH-WESTERN (SW): This region is predominated by limestone formations and corresponds with the Lower Myanmaran flora. Evergreen forests are usually present in remote parts of the region near the border between Myanmar and Thailand. Bamboo forests and savanna scrubs are the common features of the plains. The bamboo forests often gradually change into mixed deciduous and dry dipterocarp forests. This division includes 5 provinces: (37) Uthai Thani, (38) Kanchanaburi, (39) Ratchaburi, (40) Phetchaburi, and (41) Prachuap Khiri Khan.

5. CENTRAL (C): This division corresponds with the southern half of Bangkok plain or central valley. The region is mostly under cultivation. Virgin forests have almost disappeared. The dipterocarps, once forming the evergreen forests in the region, are scattered here and there at present. The division includes 15 provinces: (42) Chai Nat, (43) Sing Buri, (44) Lop Buri, (45) Suphan Buri, (46) Ang Thong, (47)

Phra Nakhon Si Ayutthaya, (48) Saraburi, (49) Nakhon Pathom, (50) Pathum Thani, (51) Nakhon Nayok, (52) Nonthaburi, (53) Bangkok (Krung Thep Maha Nakhon), (54) Samut Prakan, (55) Samut Songkhram, and (56) Samut Sakhon.

6. SOUTH-EASTERN (SE): This region is under the influence of both southern Vietnamese and Malayan floras. The dipterocarps and savannas are also widespread in the plains. The common low shrub species in the area is *Dillenia hookeri*, which grows in common, scattered clumps. Rich mangrove swamps and tidal forests are the dominant feature of the coastal line and along the estuaries of the main rivers. The division includes 7 provinces: (57) Sa Kaeo, (58) Prachin Buri, (59) Chachoengsao, (60) Chon Buri, (61) Rayong, (62) Chanthaburi, and (63) Trat.

7. PENINSULAR (PEN): This region is mostly under the influence of the Malayan flora. The Malayan elements are fairly common in the region although in the northern part of the region Myanmaran and Malayan elements are notably joined together. The forests are mainly of the evergreen forest type and are made up of many dipterocarp species. Mangrove swamps in the region are very rich and are the main mangrove-forests of the country. The division includes 14 provinces: (64) Chumphon, (65) Ranong, (66) Surat Thani, (67) Phangnga, (68) Phuket, (69) Krabi, (70) Nakhon Si Thammarat, (71) Phatthalung, (72) Trang, (73) Satun, (74) Songkhla, (75)Pattani, (76) Yala, and (77) Narathiwat.

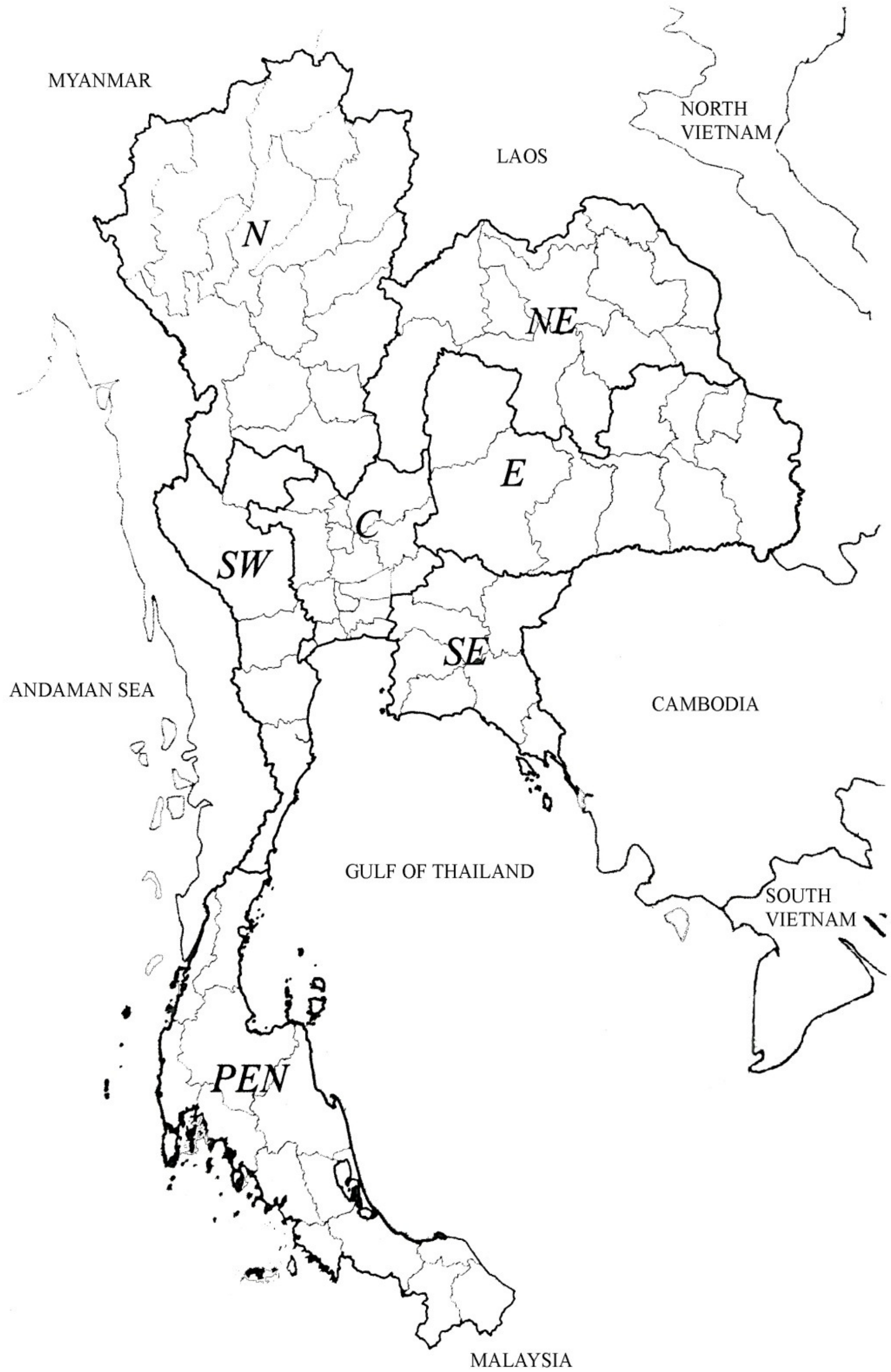


Figure 7.1 Seven Floristic Regions of Thailand (Thai Forest Herbarium, 2011).

7.3 Biodiversity of Acanthaceae

The Acanthaceae is distributed mainly in tropical and subtropical regions and is well represented in the New World, tropical Africa, Madagascar, and tropical Asia, but rather less so in Australia, and extends less into temperate regions. The family is characteristic of both moist forest and arid regions with a great variety of habits, including aquatic plants and xerophytes.

In Thailand, many species commonly grow in the forest, and are cultivated as ornamental and medicinal plants. Several introduced species have been used as ornamental plants in gardens. Moreover, some species have been used as medicinal plants (Chayamarit, 2002, 2007; Areekul et al., 2009; Padee and Nualkaew, 2009).

Pseuderanthemum is a genus in the subfamily Acanthoideae, tribe Ruellieae, subtribe Justiciinae. The ecology of the genus is very diverse. The genus occurs in different habitats. The genus widely distributed from Asia, Australia, Africa, to America.

Nelsonia, *Ophiorrhiziphyllon*, and *Staurogyne* are genera in the subfamily Nelsonioideae. The ecology of *Nelsonia* is open areas with moisture and sandy soil. It is also distributed in Asia, Australia, Africa, and tropical America. The habitat of *Ophiorrhiziphyllon* is in shaded hill evergreen forest with moist areas or along streams. It is restrictedly distributed in China, Myanmar, Laos, Vietnam, and Thailand. For *Staurogyne*, it normally grows in moist areas or along streams of evergreen forest. It is distributed in Asia, Australia, and Africa.

7.4 Materials and Methods

A location map was created based on the natural geographical distribution of Thai species and included the cultivated species using a global positioning system with ArcGIS 9.3 (Environmental Systems Research Institute [ESRI], 2009). An overview of the distribution of each species in these taxa within the genus was made from labels on Thai materials, and ecological observations were made during collection in natural habitats. The forest types followed the *Forests of Thailand* (Santisuk, 2012).

7.5 Results

Fifty-six national parks, 18 wildlife sanctuaries, 2 botanical gardens, 1 no hunting area, 1 arboretum, 1 forest park and other sites including cultivated species were selected to represent the distribution of Thai species. They were divided into 7 groups based on floristic regions of Thailand as follows (Figure 7.2):

1. Northern division (N): This division included 23 conserved areas, i.e., Salawin NP, Doi Wiang La WS, Doi Fahhompok NP, Chiang Dao WS, Haui Nam Dang NP, Queen Sirikit BG, Doi Suthep - Pui NP, Doi Inthanon NP, Doi Luang NP, Khun Jae NP, Phu Sang NP, Doi Phukha NP, Mae Ping NP, Doi Khun Tan NP, Chae Son NP, Mae Yom NP, Wiang Kosai NP, Khun Pha Wor NP, Lan Sang NP, Umphang WS, Thung Yai Naresuan WS, Thung Salaeng Luang NP, and Phu Hin Rong Kla NP.

2. Northeastern division (NE): This division included 11 conserved areas, i.e., Phu Suan Sai NP, Phu Ruea NP, Phu Luang WS, Phu Kradueng NP, Phu Wua WS,

Phu Phan NP, Phu Sithan WS, Phu Pha Man NP, Phu Wiang NP, Phu Paek AR, and Phu Pha Lom FP.

3. Eastern division (E): This division included 7 conserved areas, i.e., Tat Ton NP, Sai Thong NP, Khao Yai NP, Huai Thapthan – Huai Samran WS, Pha Taem NP, Phu Chong – Na Yoi NP, and Yod Dom WS.

4. Central division (C): This division included 2 conserved areas, i.e., Sap Lang Ka WS and Namtok Samlan NP.

5. Southeastern division (SE): This division included 8 conserved areas, i.e., Pang Sida NP, Thap Lan NP, Khao Ang Rue Nai WS, Khao Chamao-Khao Wong NP, Khao Khitchakut NP, Khao Soi Dao WS, Namtok Phlio NP, and Ko Chang NP.

6. Southwestern division (SW): This division included 9 conserved areas, i.e., Huai Kha Khaeng WS, Khuean Srinakarin NP, Khao Laem NP, Thong Pha Phum NP, Sai Yok NP, Erawan NP, Kaeng Krachan NP, Kui Buri NP, and Namtok Huai Yang NP.

7. The peninsular division (PEN): This division included 19 conserved areas, i.e., Thung Raya – Nasak WS, Namtok Ngao NP, Khlong Nakha WS, Khlong Yun WS, Khao Sok NP, Sirinath NP, Khao Phra Thaeo NHA, Than Bok Khorani NP, Khao Nan NP, Khao Luang NP, Namtok Yong NP, Khao Pu-Khao Ya NP, Peninsular BG (Thung Khai), Tarutao NP, Thale Ban NP, Ton Nga Chang WS, Bang Lang NP, Budo - Su Ngai Padi NP, and Hala Bala WS.

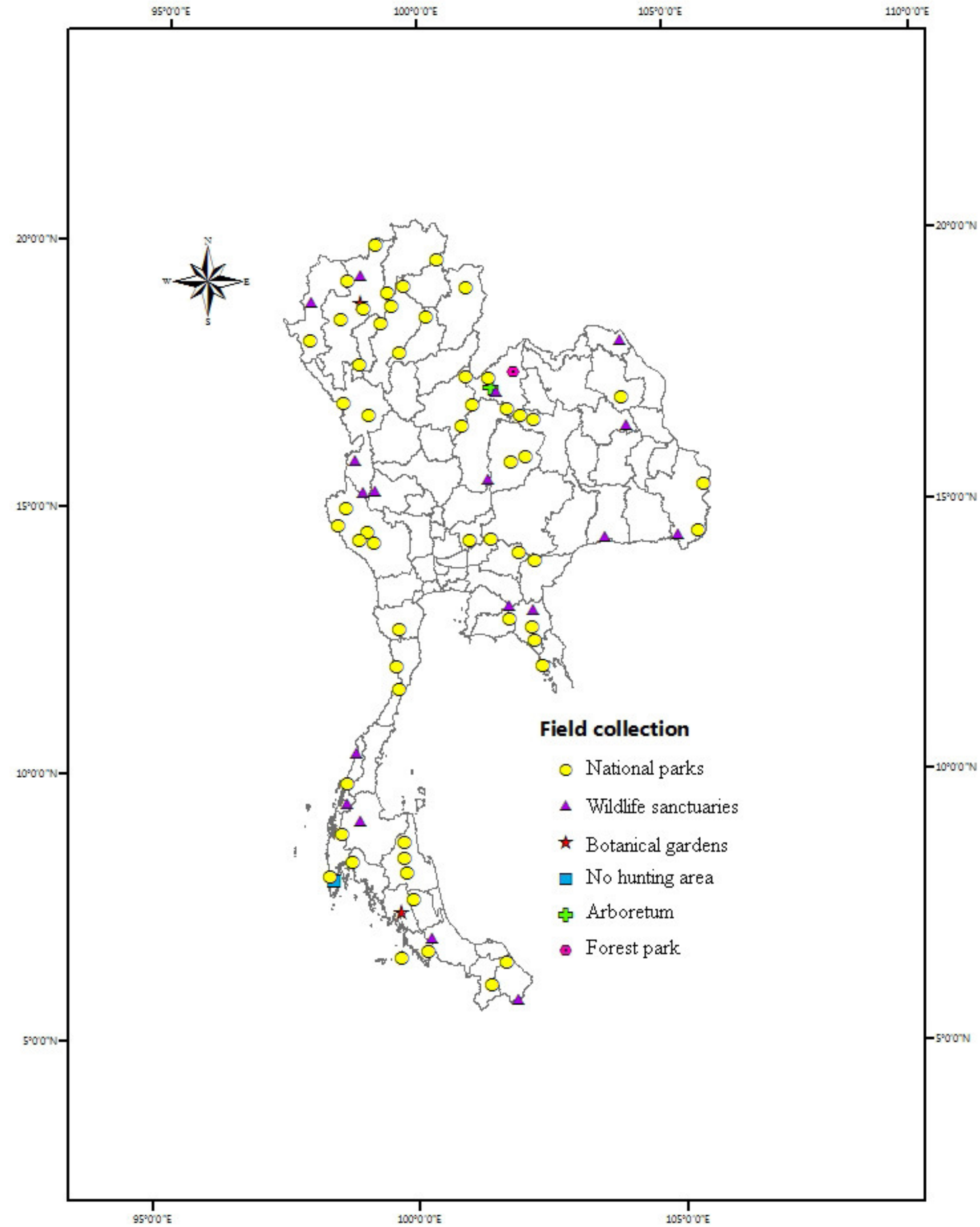


Figure 7.2 Seventy-nine field collection areas in Thailand.

From 45 taxa which were investigated throughout Thailand, five taxa were widely found in almost all floristic regions, i.e., *Pseuderanthemum graciliflorum*, *P. longistylum*, *Nelsonia canescens*, *Staurogyne lanceolata*, and *S. spatulata*, not including cultivated species. All taxa normally grow in low altitude forest. Eight taxa were found rarely in some areas, based on field collection, i.e., *P. axillare* in mixed deciduous forest at Pha Taem National Park, *Ophiorrhiziphyllon macrobotryum* in hill evergreen forest at Doi Phu kha National Park, *S. concinnula* in hill evergreen forest at Khao Yai National Park, *S. helferi* in moist evergreen forest at Khlong Nakha Wildlife Sanctuary, *S. punctata* along streams in pine hill forest at Loei and Phitsanulok, *S. major* in hill evergreen forest at Khun Phawo National Park, *S. singularis* in hill evergreen forest at Phu Suan Sai National Park, and *S. subglabra* in hill evergreen forest at Loei and Phitsanulok. Moreover, some taxa were only investigated from the herbaria and the habitat was shown to be distinctly limited, i.e., *P. glomeratum* at Doi Wao, *S. aristata* at Ton Nam Plio, *S. cuneata* at Ranong and Prachuap Khiri Khan, *S. densifolia* at Thung Salaeng Luang National Park, *S. dispar* at Tak, *S. filipes* at Yala, *S. kingiana* at Narathiwat, *S. parvicaulis* at Srichiangmai-Nongkhai, and *S.* sp3 at Kaeng Krachan National Park (Figures 7.3-7.47).

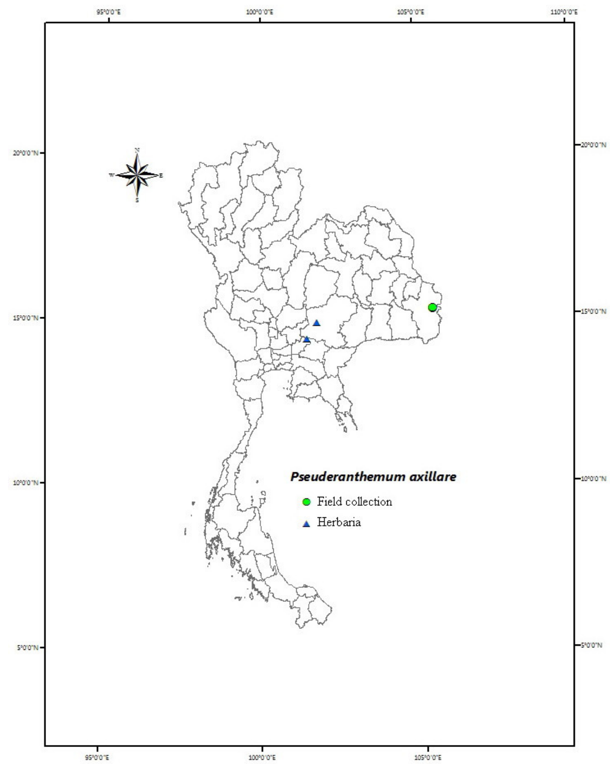


Figure 7.3 Distribution of *Pseuderanthemum axillare* in Thailand.

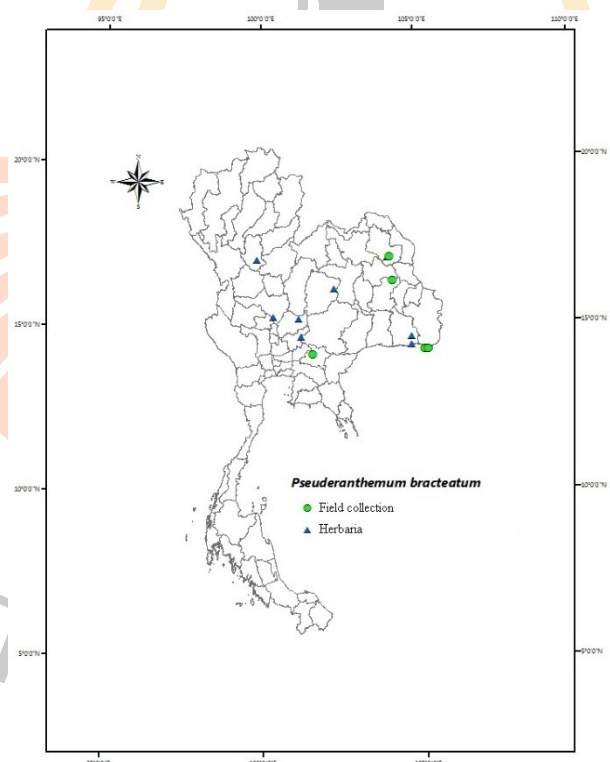


Figure 7.4 Distribution of *Pseuderanthemum bracteatum* in Thailand.

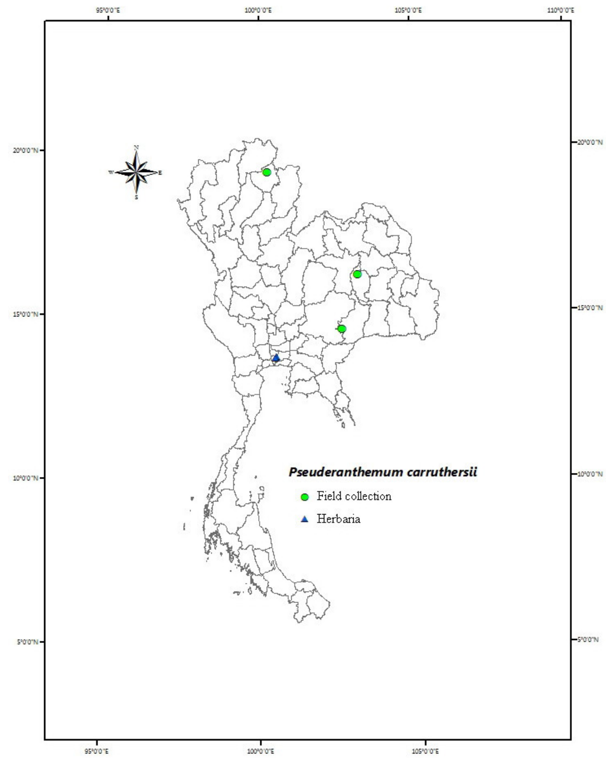


Figure 7.5 Distribution of *Pseuderanthemum carruthersii* in Thailand.

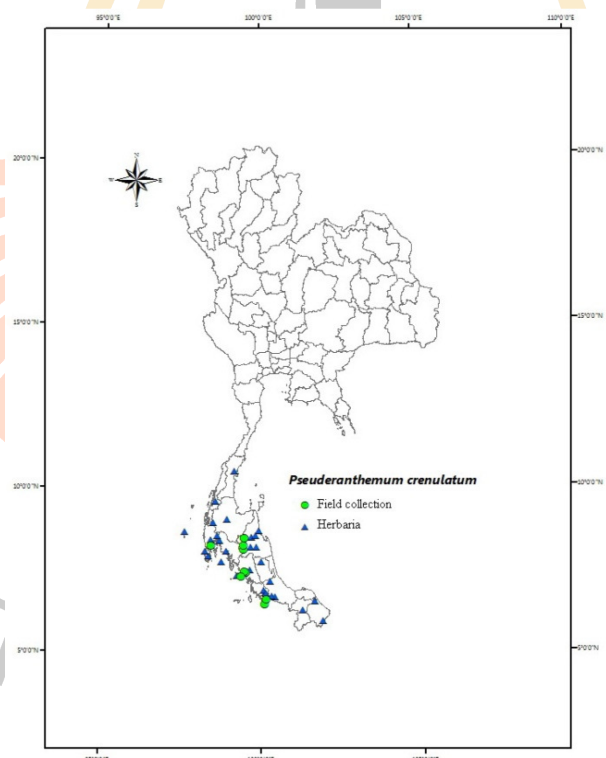


Figure 7.6 Distribution of *Pseuderanthemum crenulatum* in Thailand.

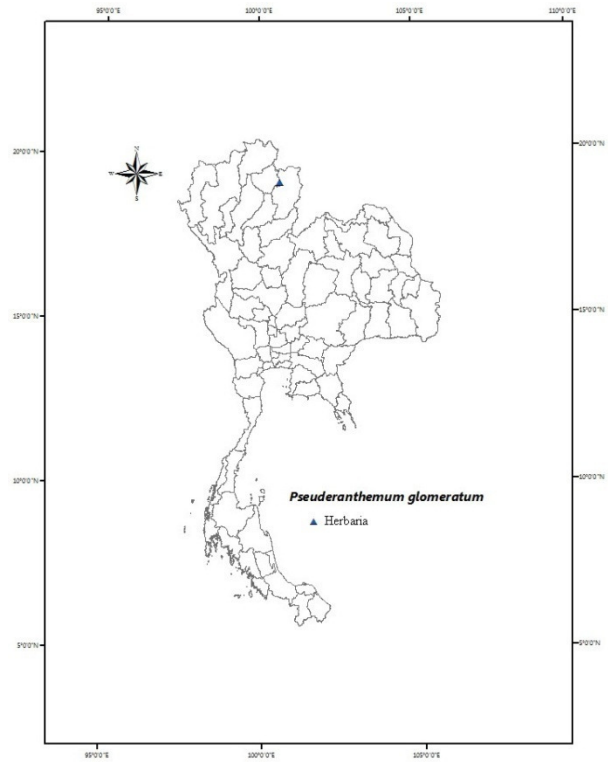


Figure 7.7 Distribution of *Pseuderanthemum glomeratum* in Thailand.

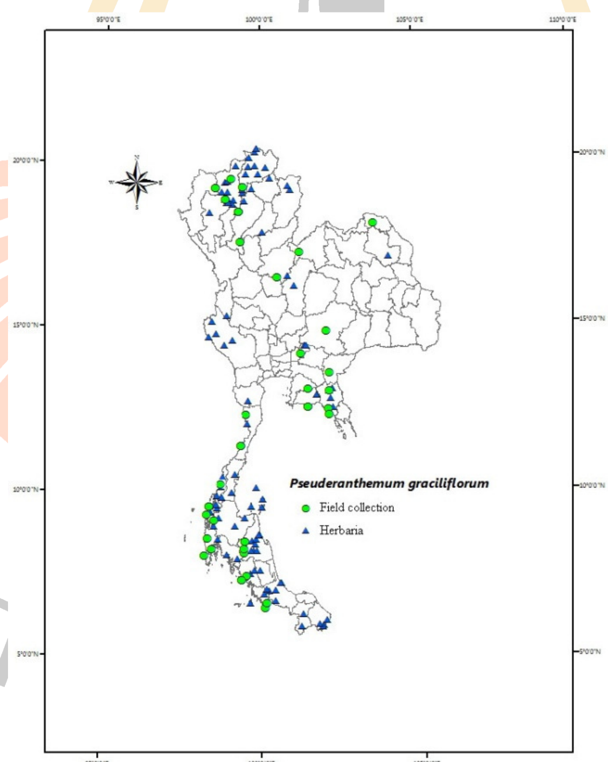


Figure 7.8 Distribution of *Pseuderanthemum graciliflorum* in Thailand.

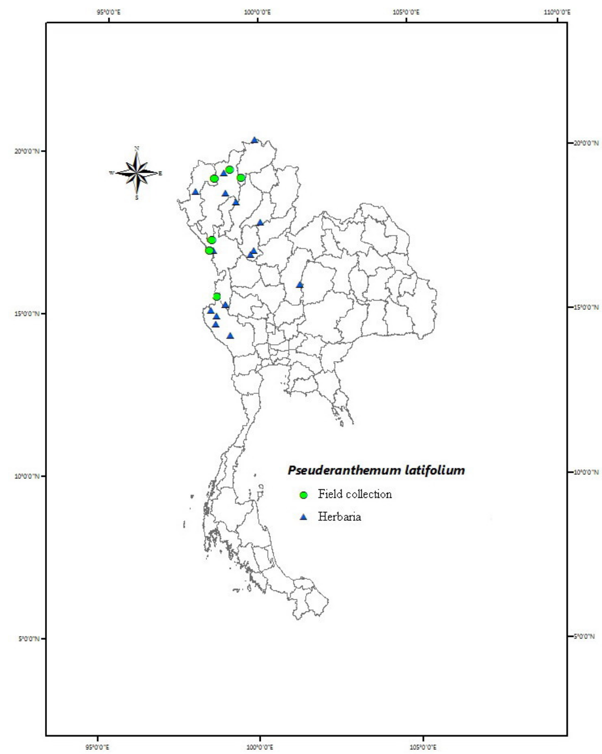


Figure 7.9 Distribution of *Pseuderanthemum latifolium* in Thailand.

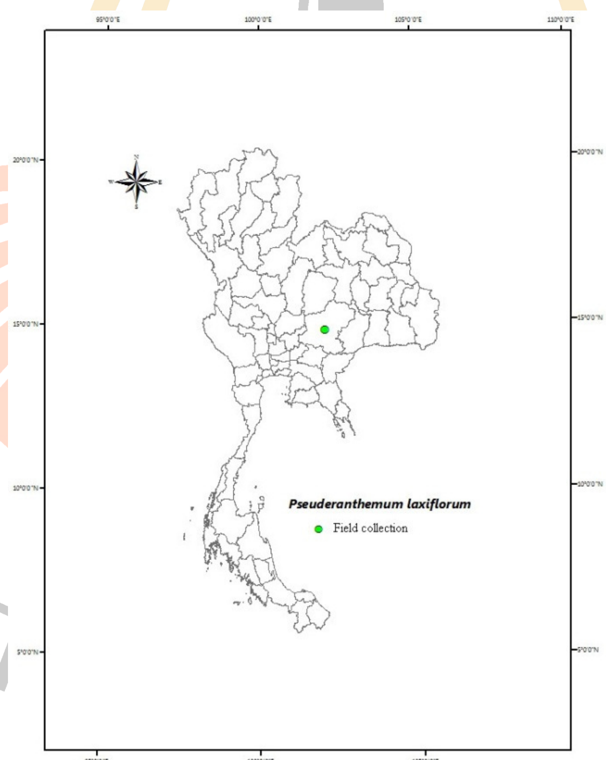


Figure 7.10 Distribution of *Pseuderanthemum laxiflorum* in Thailand.

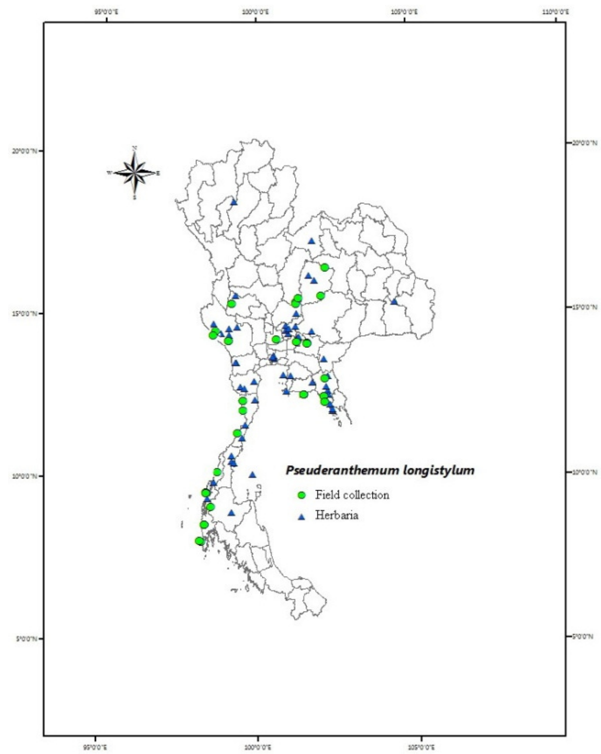


Figure 7.11 Distribution of *Pseuderanthemum longistylum* in Thailand.

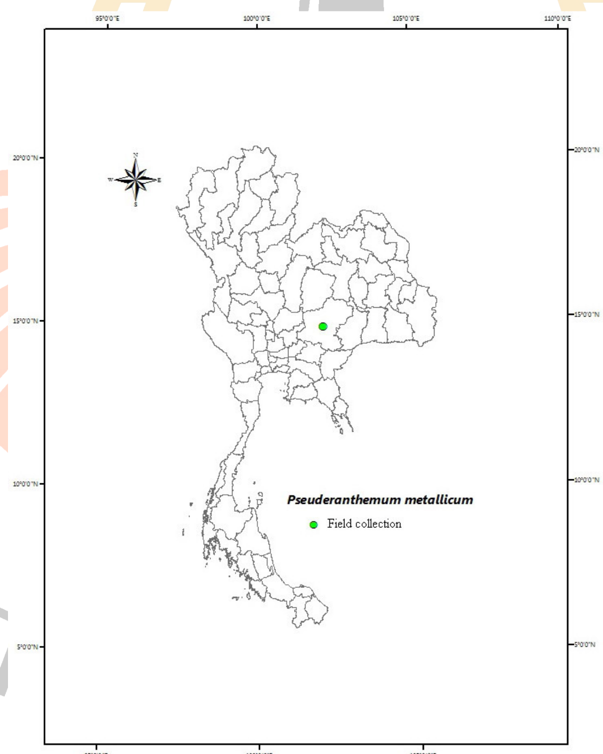


Figure 7.12 Distribution of *Pseuderanthemum metallicum* in Thailand.

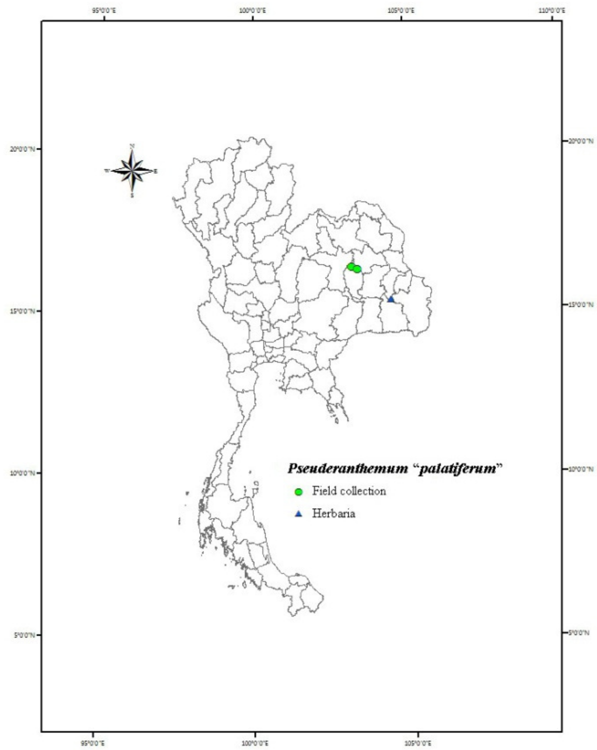


Figure 7.13 Distribution of *Pseuderanthemum* "*palatiferum*" in Thailand.

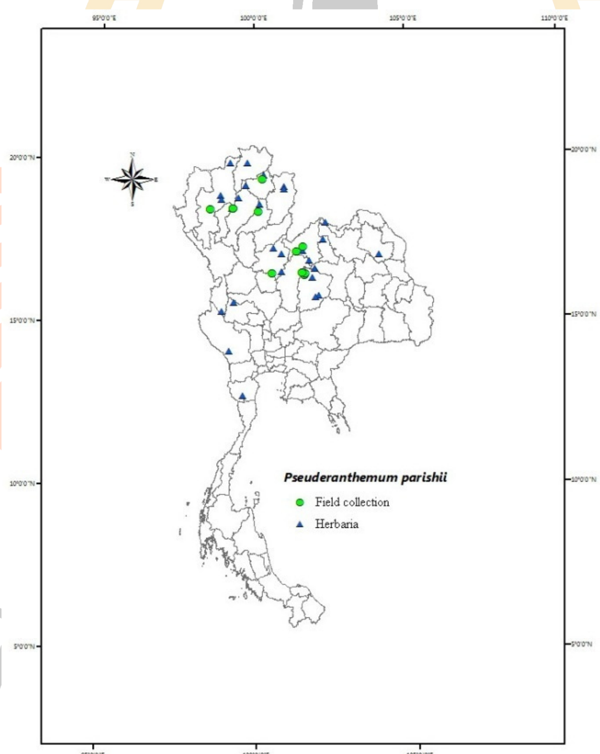


Figure 7.14 Distribution of *Pseuderanthemum parishii* in Thailand.

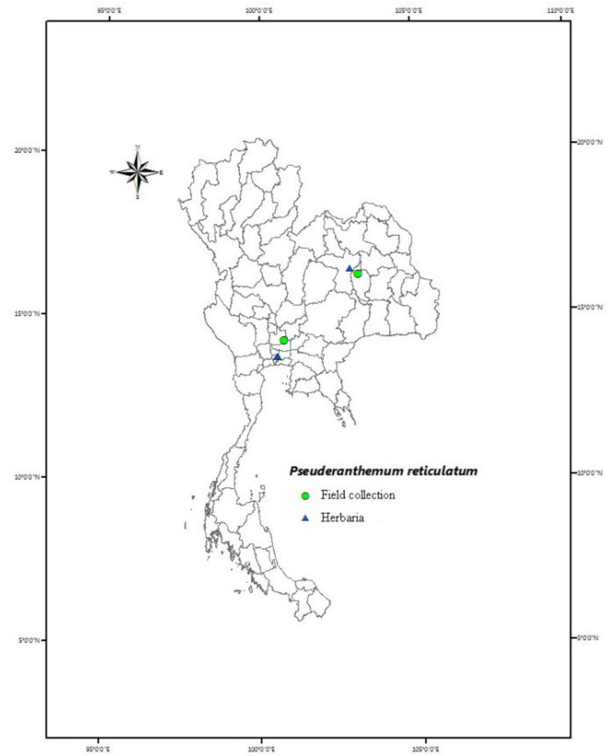


Figure 7.15 Distribution of *Pseuderanthemum reticulatum* in Thailand.

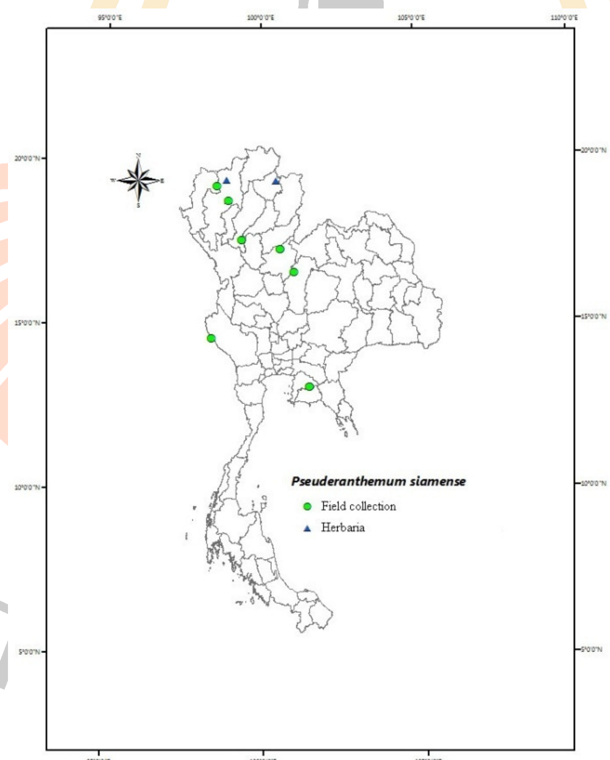


Figure 7.16 Distribution of *Pseuderanthemum siamense* in Thailand.

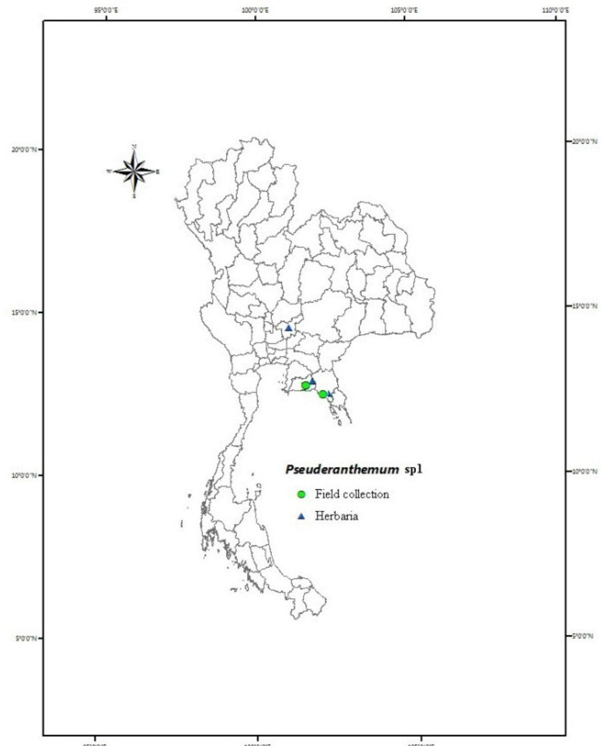


Figure 7.17 Distribution of *Pseuderanthemum* sp1 in Thailand.

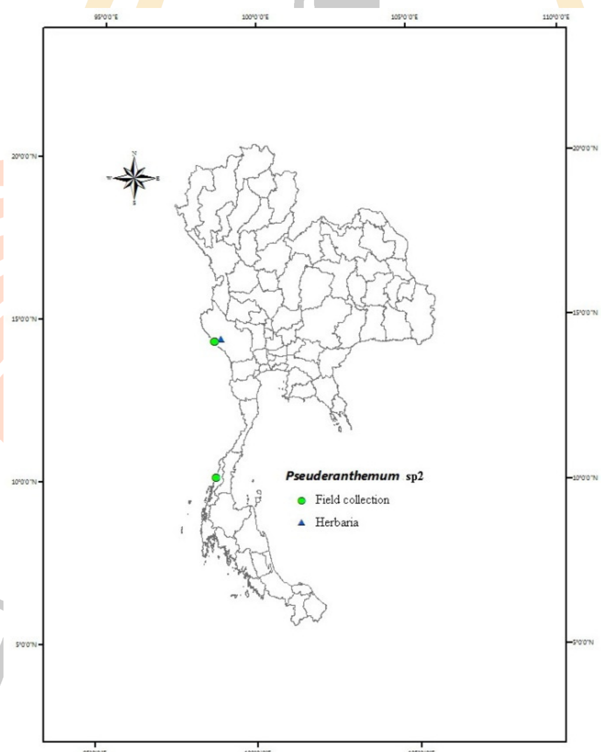


Figure 7.18 Distribution of *Pseuderanthemum* sp2 in Thailand.

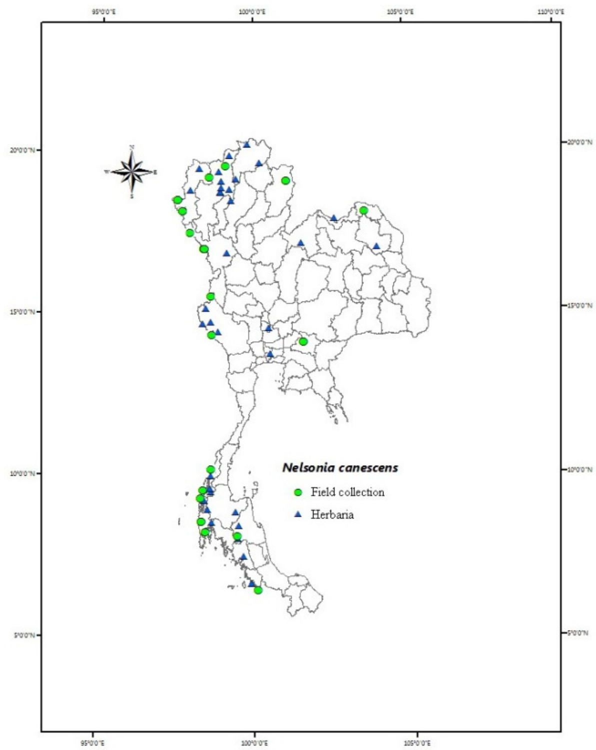


Figure 7.19 Distribution of *Nelsonia canescens* in Thailand.

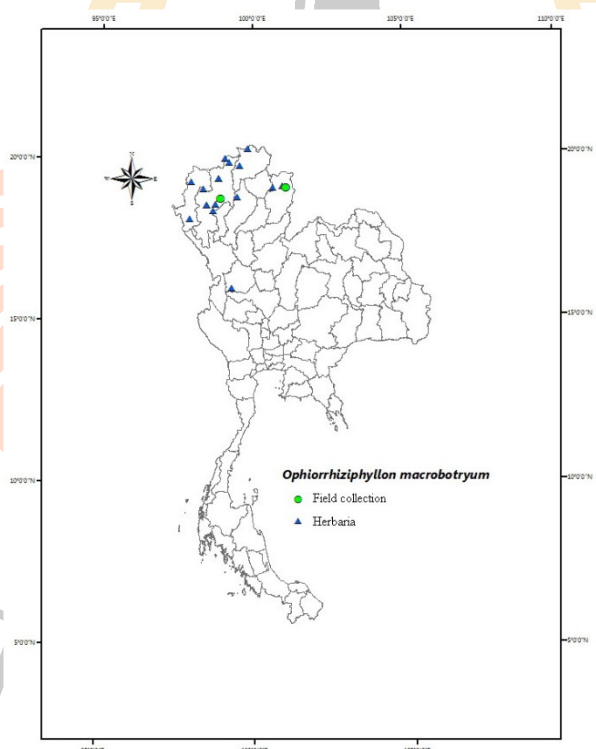


Figure 7.20 Distribution of *Ophiorrhiziphyllon macrobotryum* in Thailand.

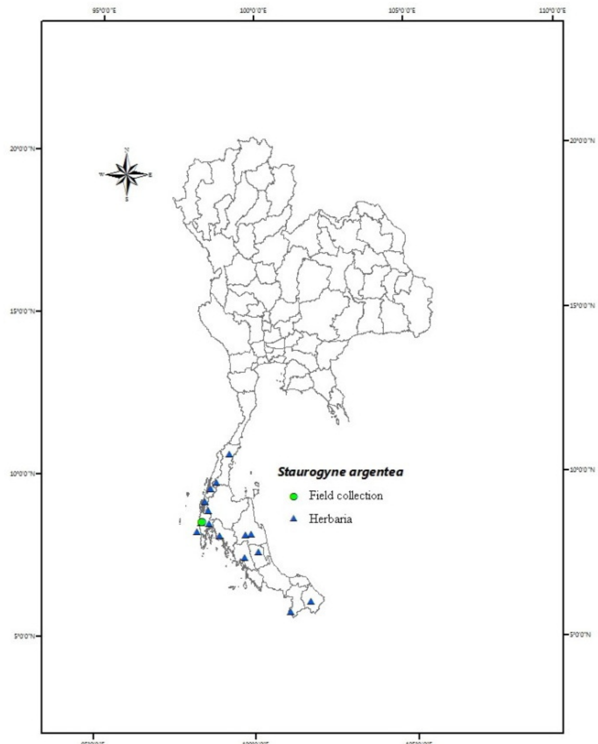


Figure 7.21 Distribution of *Staurogyne argentea* in Thailand.

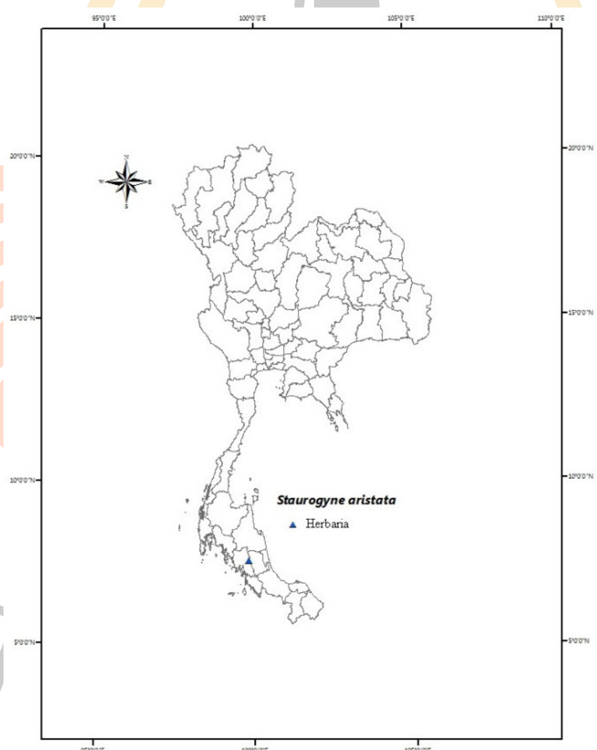


Figure 7.22 Distribution of *Staurogyne aristata* in Thailand.

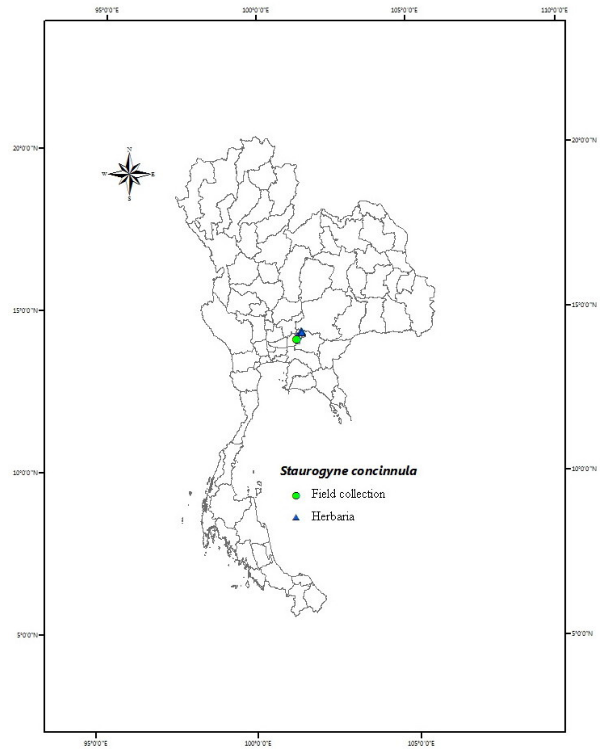


Figure 7.23 Distribution of *Staurogyne concinnula* in Thailand.

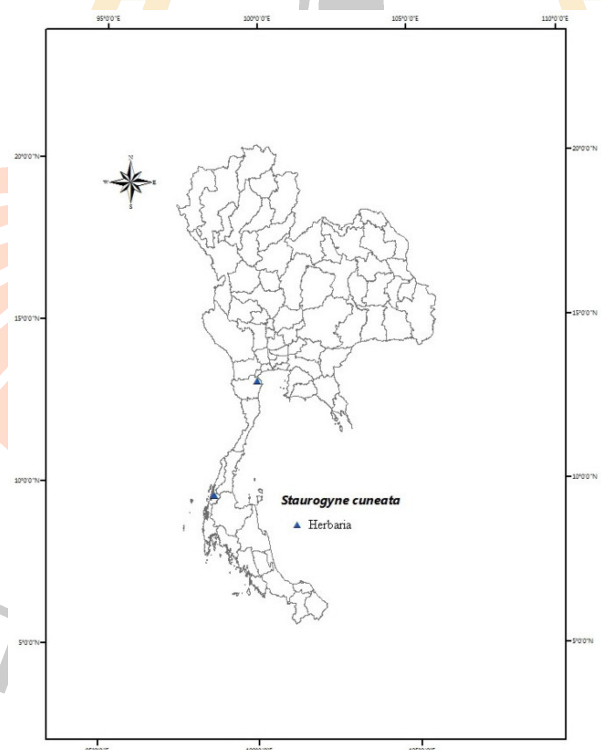


Figure 7.24 Distribution of *Staurogyne cuneata* in Thailand.

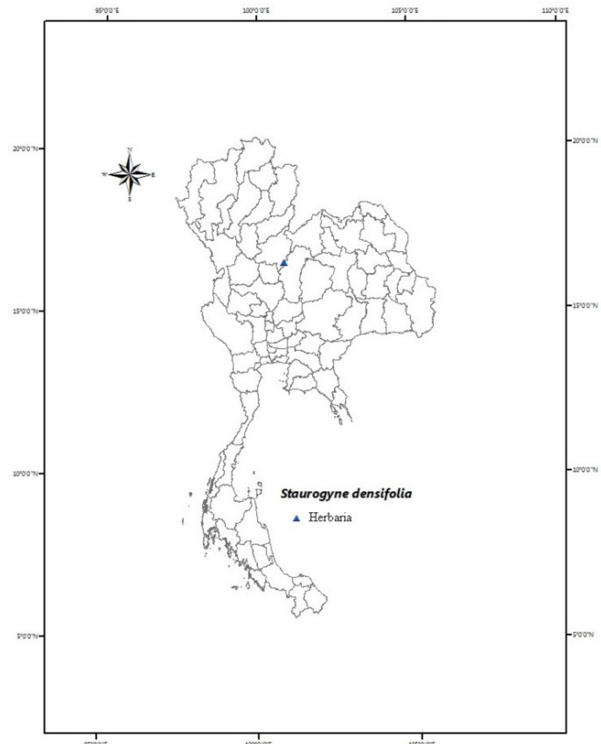


Figure 7.25 Distribution of *Staurogyne densifolia* in Thailand.

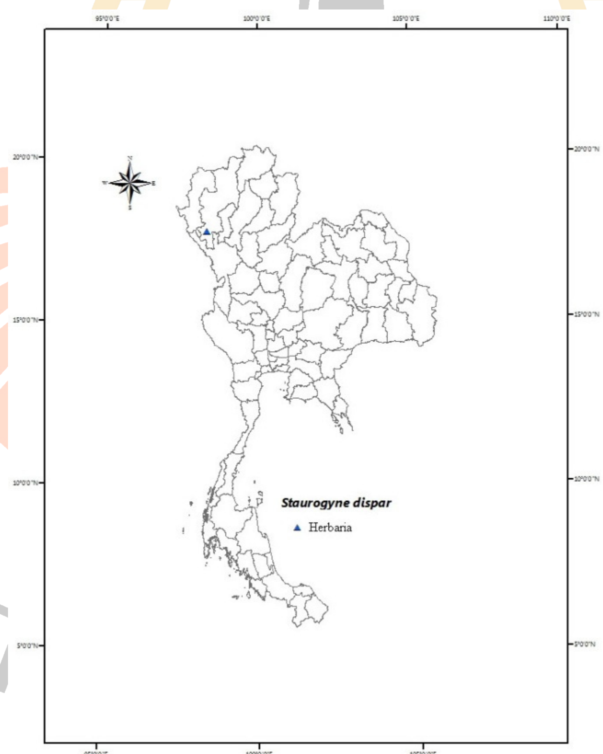


Figure 7.26 Distribution of *Staurogyne dispar* in Thailand.

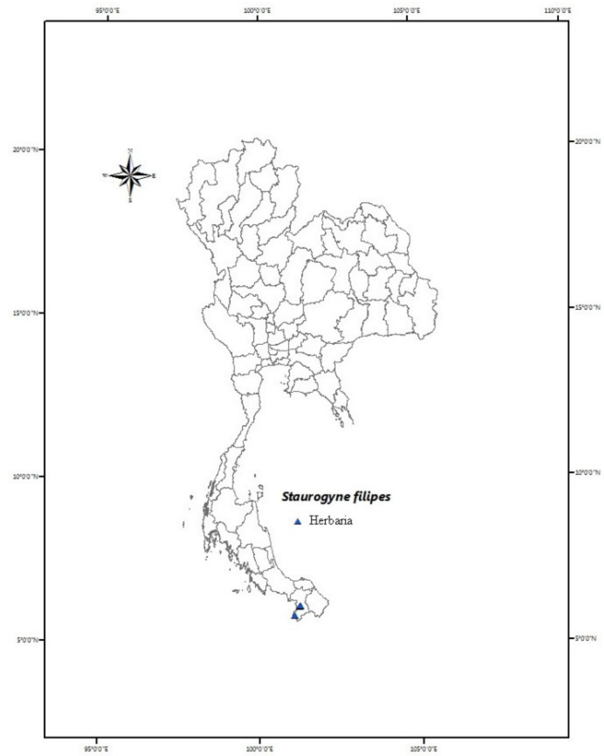


Figure 7.27 Distribution of *Staurogyne filipes* in Thailand.

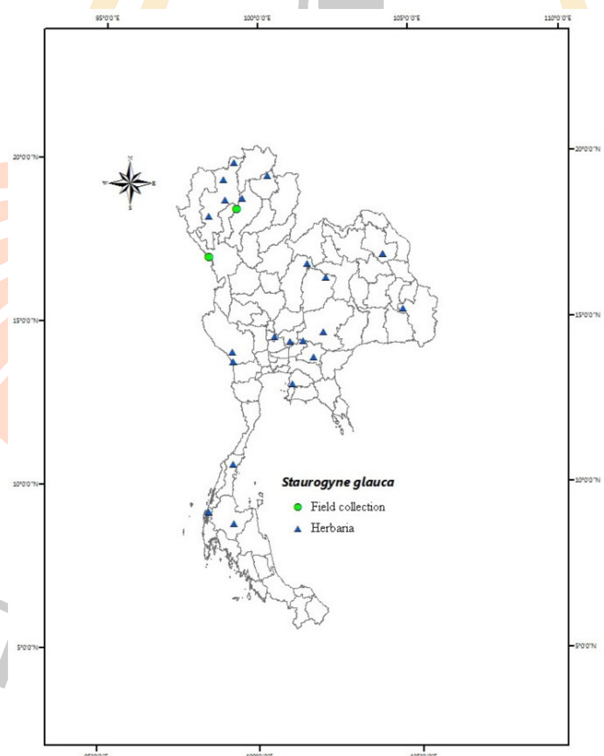


Figure 7.28 Distribution of *Staurogyne glauca* in Thailand.

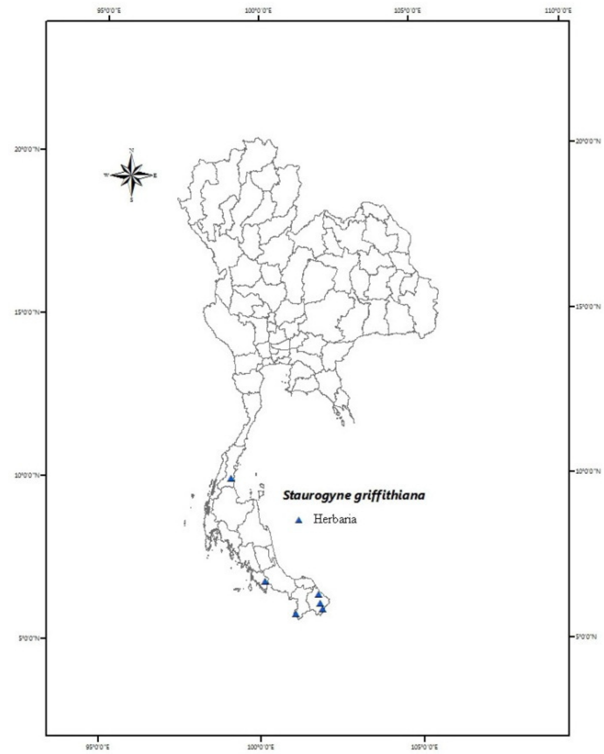


Figure 7.29 Distribution of *Staurogyne griffithiana* in Thailand.

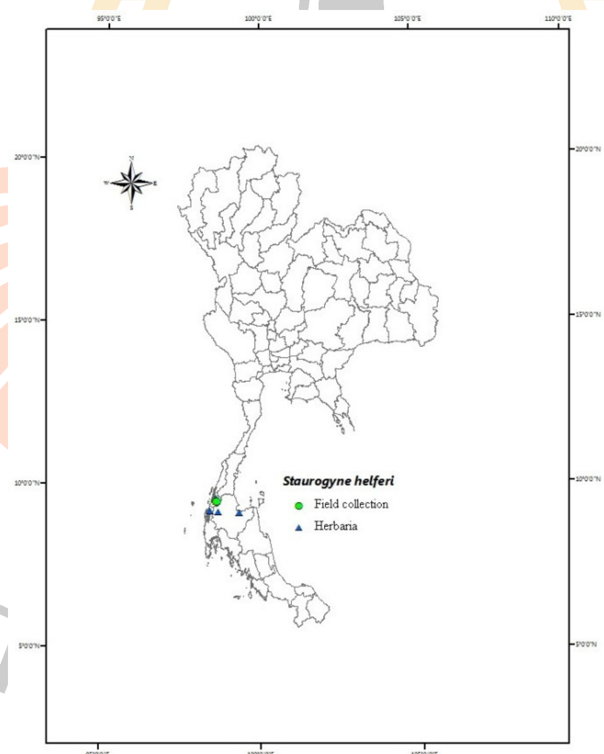


Figure 7.30 Distribution of *Staurogyne helferi* in Thailand.

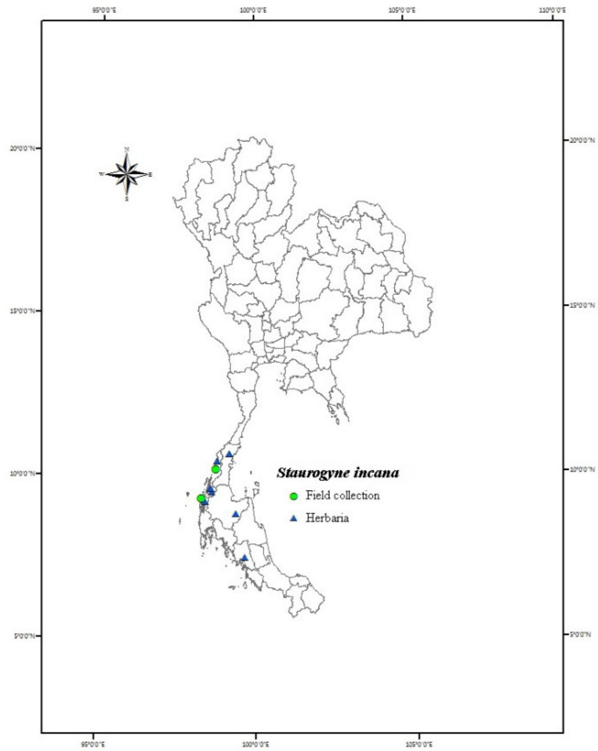


Figure 7.31 Distribution of *Staurogyne incana* in Thailand.

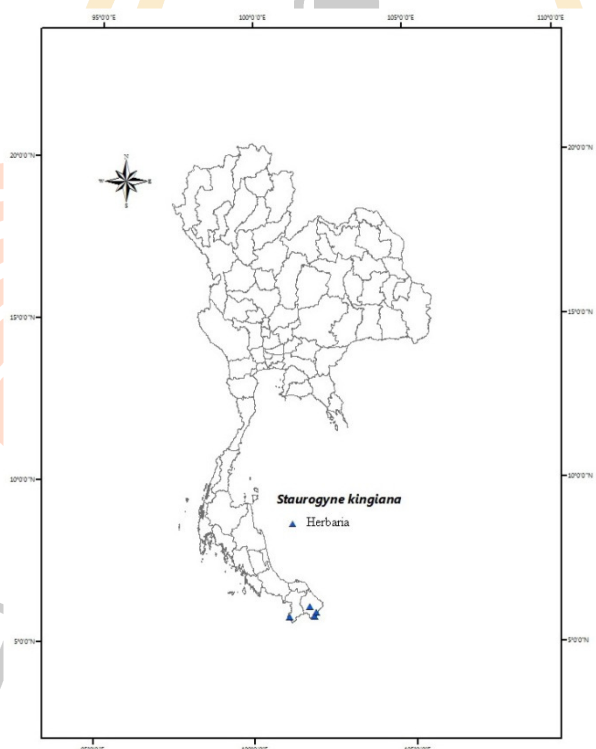


Figure 7.32 Distribution of *Staurogyne kingiana* in Thailand.

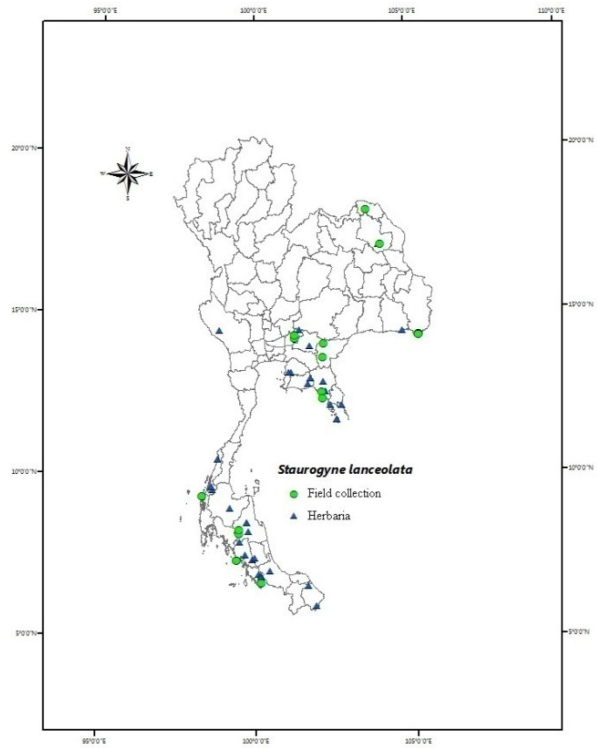


Figure 7.33 Distribution of *Staurogyne lanceolata* in Thailand.

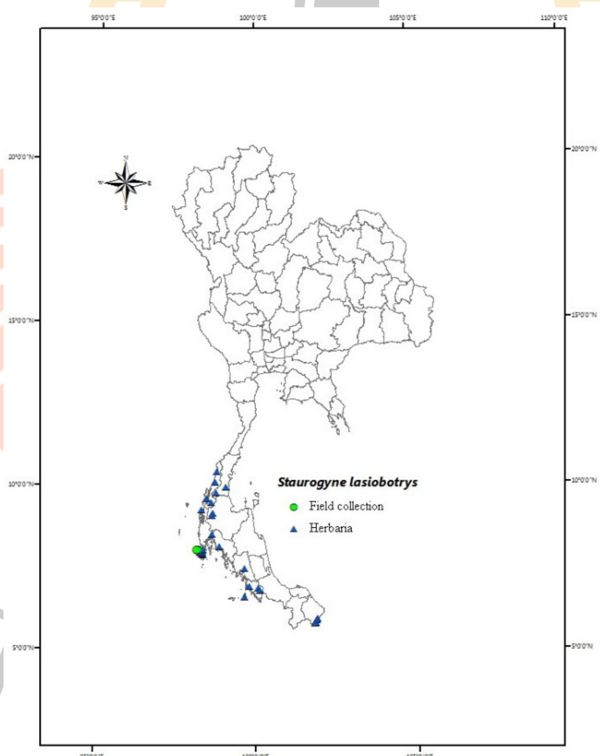


Figure 7.34 Distribution of *Staurogyne lasiobotrys* in Thailand.

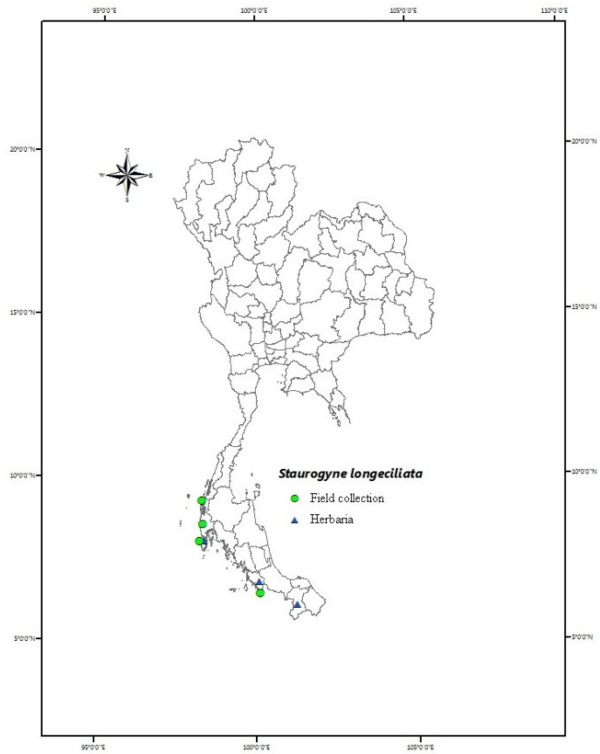


Figure 7.35 Distribution of *Staurogyne longeciliata* in Thailand.

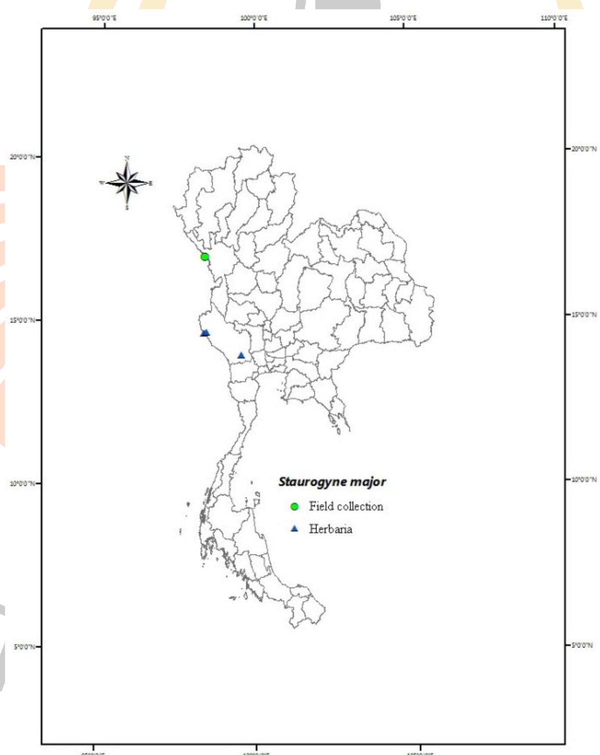


Figure 7.36 Distribution of *Staurogyne major* in Thailand.

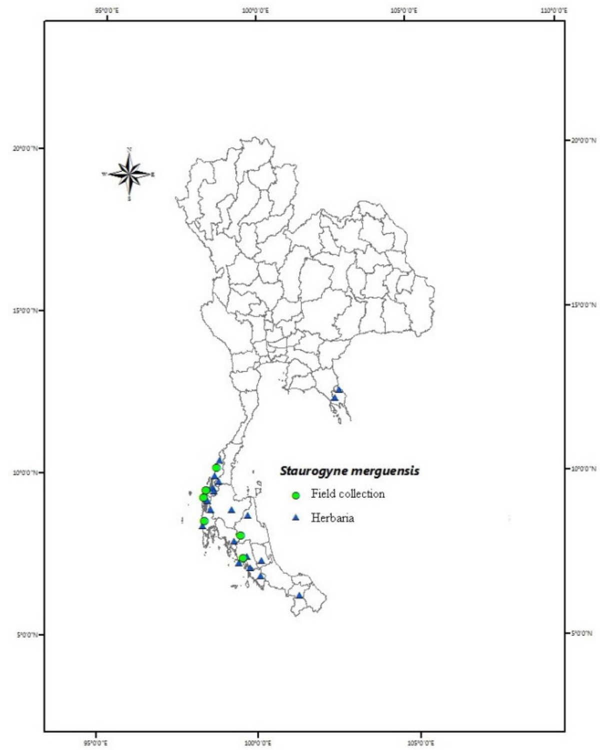


Figure 7.37 Distribution of *Staurogyne merguensis* in Thailand.

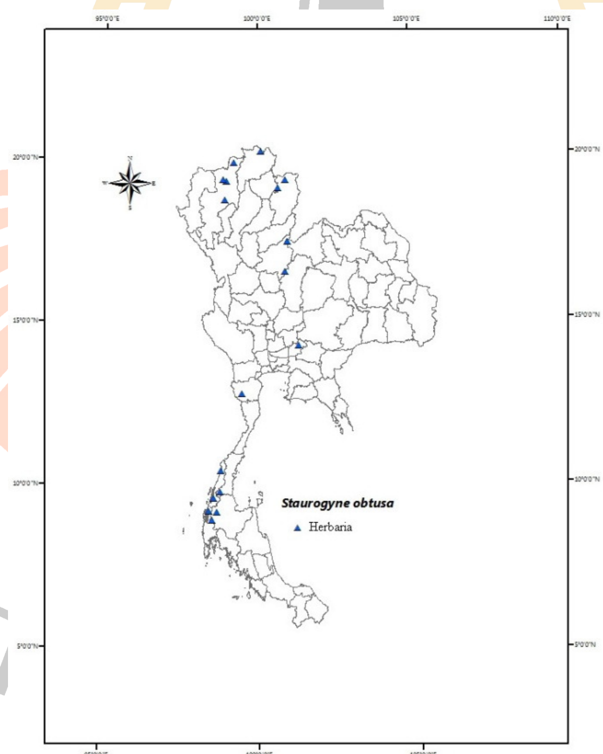


Figure 7.38 Distribution of *Staurogyne obtusa* in Thailand.

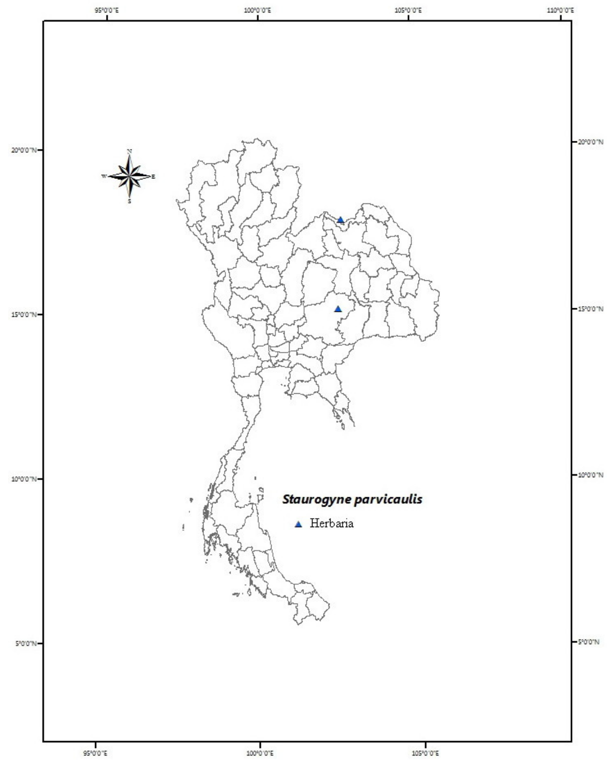


Figure 7.39 Distribution of *Staurogyne parvicaulis* in Thailand.

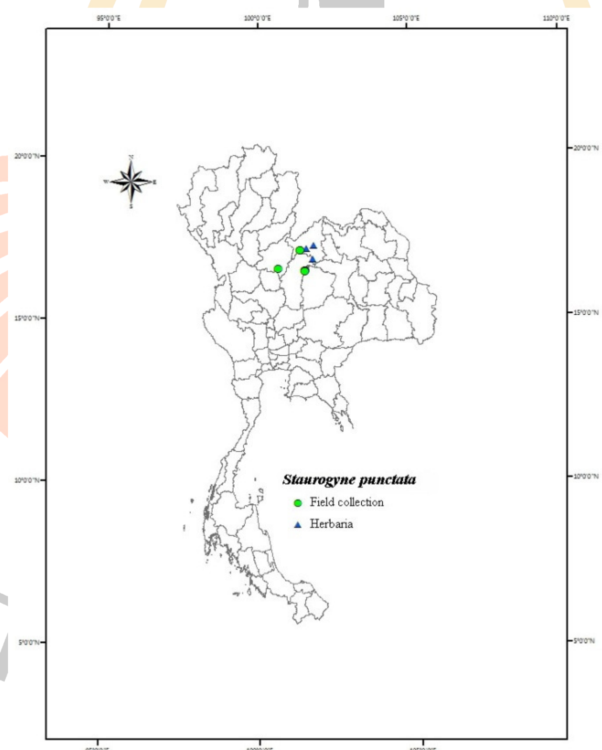


Figure 7.40 Distribution of *Staurogyne punctata* in Thailand.

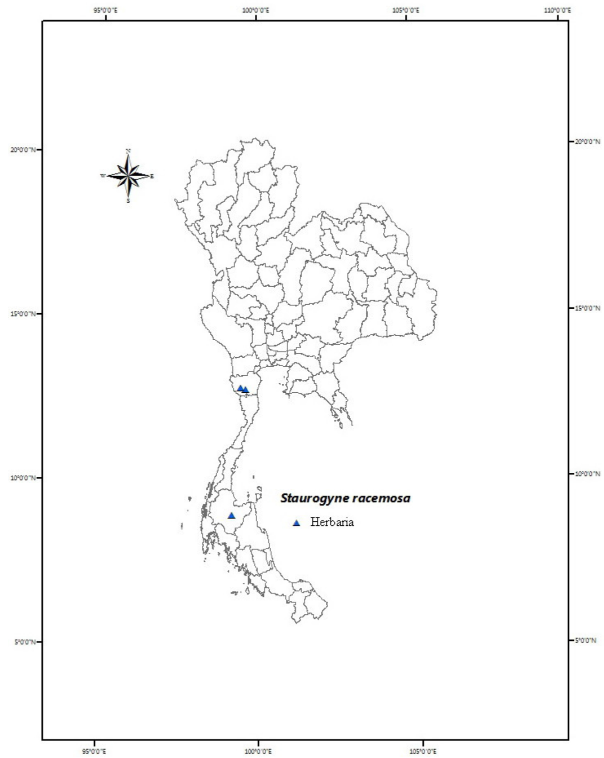


Figure 7.41 Distribution of *Staurogyne racemosa* in Thailand.

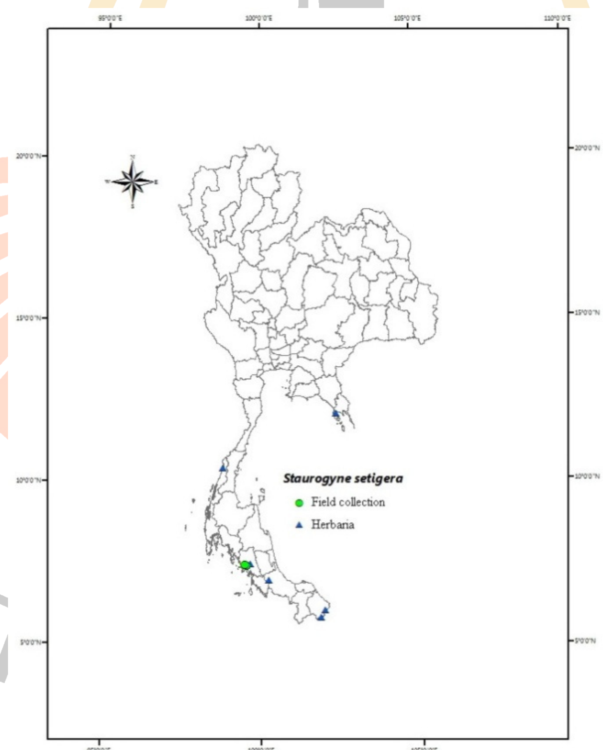


Figure 7.42 Distribution of *Staurogyne setigera* in Thailand.

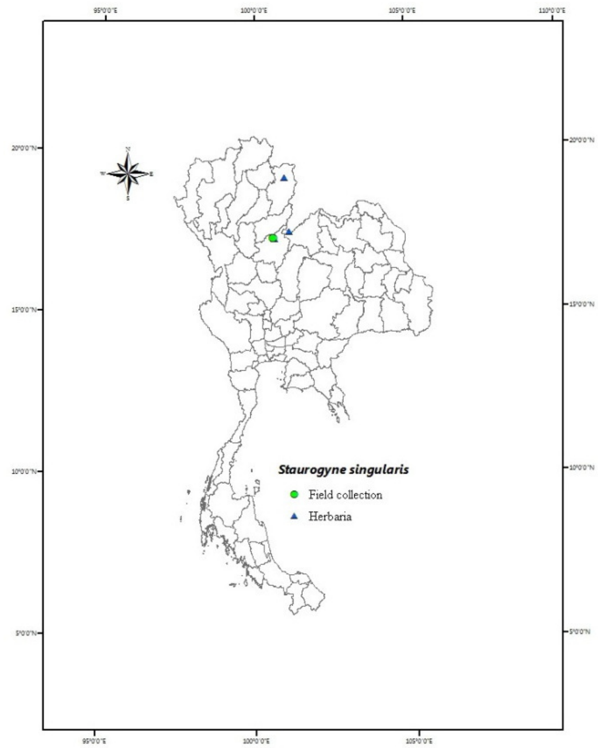


Figure 7.43 Distribution of *Staurogyne singularis* in Thailand.

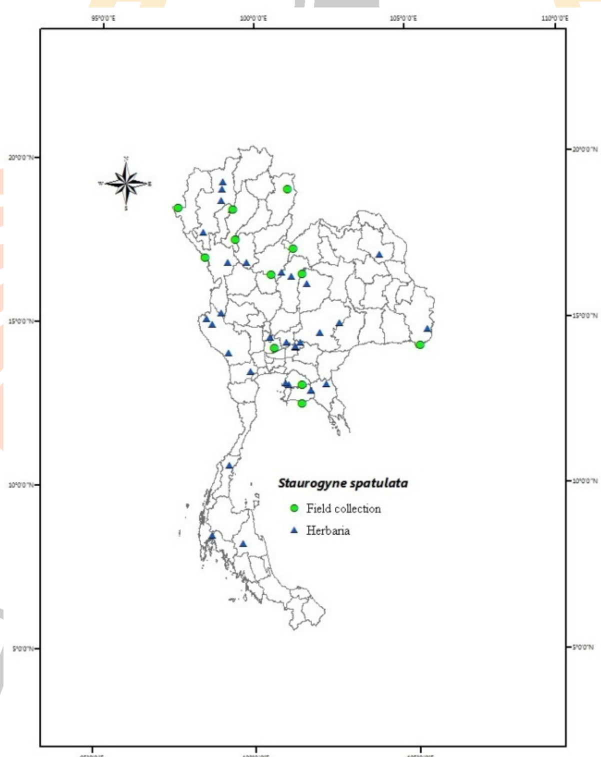


Figure 7.44 Distribution of *Staurogyne spatulata* in Thailand.

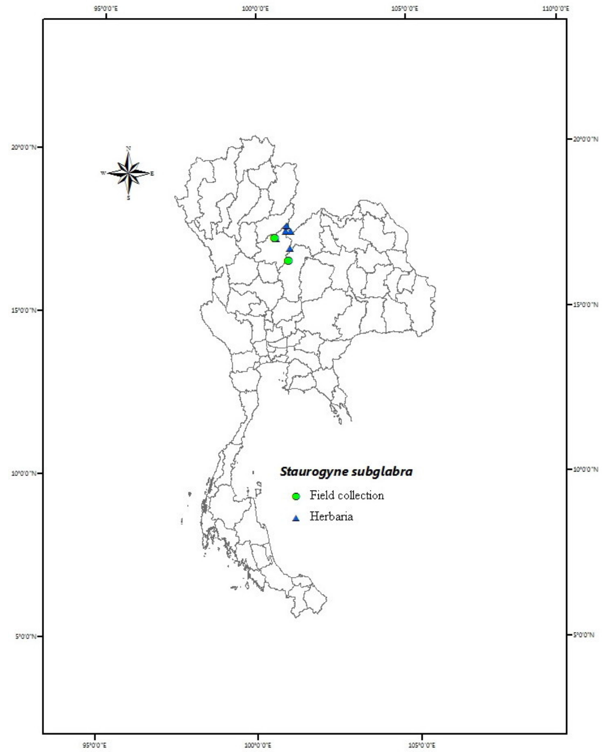


Figure 7.45 Distribution of *Staurogyne subglabra* in Thailand.

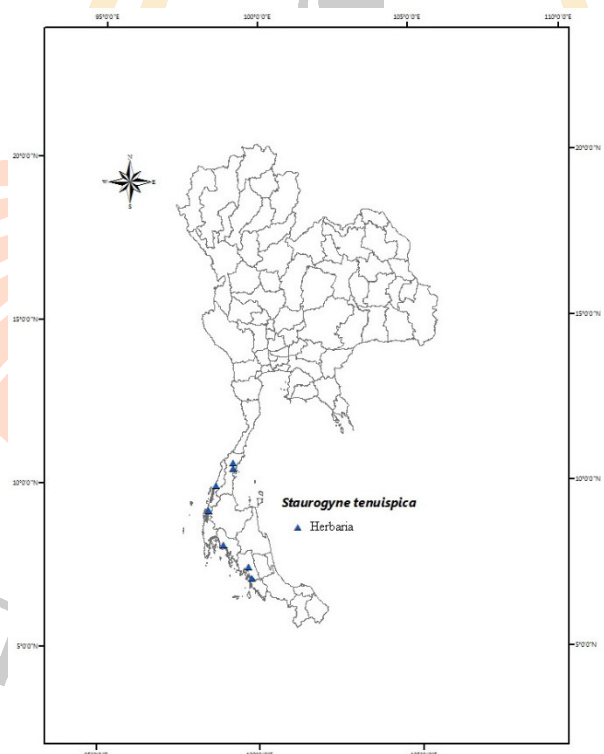


Figure 7.46 Distribution of *Staurogyne tenuispica* in Thailand.

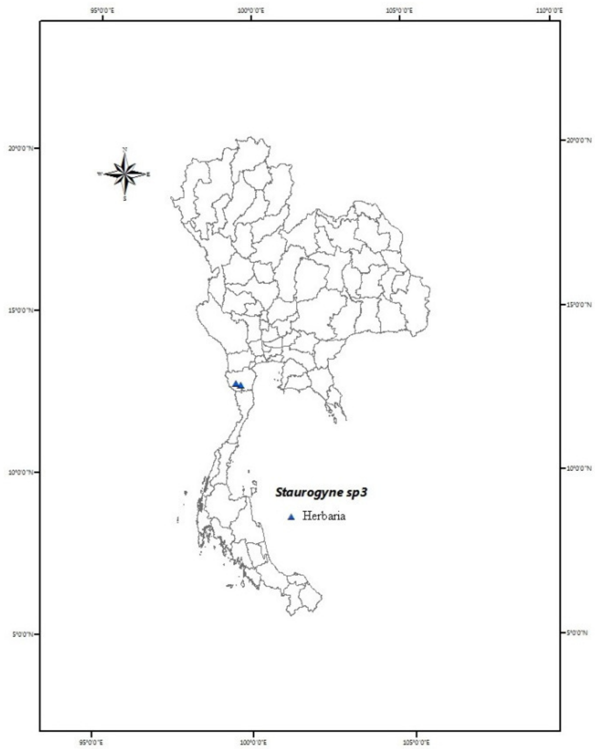


Figure 7.47 Distribution of *Staurogyne* sp3 in Thailand.

7.6 Conclusions and Discussion

In conclusion, 45 taxa in 4 genera were investigated throughout Thailand. They varied in form both within the genus and within the species. Five taxa, which normally grow in the lowland forest, were found in almost all Thailand floristic regions. Their environment is not more restricted, then they can grow in diverse habitats. Eight studied taxa were found in restricted areas based on field collection. The differences in environmental conditions may affect their growth, so if their habitat is lost or changed, they may die out. From this study some taxa are not resistant to drought and hot weather. Moreover, some taxa were only investigated from herbaria and the habitat was shown to be distinctly limited. These taxa have a risk to disappear easily. The researcher or even other observers did not have more chances to see them in nature. And unfortunately, a few taxa were found only as one specimen from Thailand, that is the type specimen, i.e., *P. glomeratum*, *S. aristata*, *S. densifolia*, and *S. parvicaulis*. At present, these taxa may already be lost or extinct. The climate change may cause them to disappear from nature.

From the present study, the number of species is 45 taxa which make it diverse country in equator region, especially in tropical and subtropical of Asia and Africa. The ecology of *Pseuderanthemum* is very diverse, dry to wet. The genus occurs in different habitats: hill evergreen forest, mixed deciduous forest, dry dipterocarp forest, and moist evergreen forest. So, more taxa were taken to be ornamental plants because they can stand and tolerate conditions outside the forest. The habitat of *Nelsonia* is open areas with moisture or wet fields and sandy soil. Sometime, it was evaluated as a weed in the field, but also has been used to control others weeds in the garden. *Ophiorrhiziphyllon* grows in shaded hill evergreen forest with wet conditions or along streams. *Staurogyne* normally grows in moist areas or along the stream of dry, hill, and rain evergreen forest.

The specific habitat which is appropriate to plant growth depends on many factors. A bioclimatic area results from a combination of temperature and humidity (Vidal, 1979). Most studied taxa are herbs or small shrubs, which appear during the rainy season. The distribution of each taxa depends on a niche. The appropriate environment is necessary to support their life cycle. Furthermore, geological patterns, such as type of soil and rock, could either inhibit or encourage the distribution of each taxa.

CHAPTER VIII

CONCLUSIONS AND DISCUSSIONS

In the present research, 4 genera and 45 taxa of subfamilies Nelsonioideae and Acanthoideae in Thailand were investigated in several parts. The taxonomic study was revised as an important part. The anatomical features were analyzed to provide additional knowledge and data of the studied taxa concerning leaf venation pattern, cystoliths, and leaf epidermal cells. The use of anatomical observation did not seem to be useful for identification or classification within the genus but was still helpful among genera. The palynological study was helpful to confirm the division of genera, even if it was not very useful for species identification. The modified technique was tried to keep the pollen shape from collapsing and avoid using the special controlled substance as acetic anhydride. In different plant groups, the technique should be modified depending on plant species and their pollen characters. The phylogenetic and evolutionary studies are very useful for identifying unknown taxa and confirming the determination of new taxa in the future, since some species were only found as vegetative parts in the field collection. They are helpful for looking for patterns of character evolution of each representative taxa. The samples were dried in silica gel. This research did not use dried specimens from herbaria because of the difficulty in amplifying DNA and the loss of grant funding without obtaining good results. However, herbarium specimens were used for palynology. The biogeography and biodiversity studies of each taxa were interpreted in each forest type and each part of the country. They are useful for seeking out the status of each taxa in nature to enable planning for conservation on sustainable basis.

Sixteen taxa of *Pseuderanthemum*, 1 of each taxa of *Ophiorrhiziphyllon* and *Nelsonia*, and 27 taxa of *Staurogyne* in Thailand are recognized here and an artificial key to them was constructed. The number of taxa adequately shows the diversity of the genera *Pseuderanthemum* and *Staurogyne*. Moreover, they are very useful to refine the definition, description and biodiversity among taxa and species within the genus. The taxonomic revision has provided type specimen, publications, descriptions, specimen examination in the country, and other useful notes. Every name was consulted at least by the description from the first publication. Although some type specimens have not been seen, the new descriptions concluded here so far match with their first and the following references.

The genus *Pseuderanthemum* is widely distributed throughout the country in almost every kind of forest, from moist evergreen forest near sea level to higher altitudes in dry evergreen, deciduous, bamboo, and hill evergreen forest. The number of taxa in each forest type varies because some species spread over a wide area while many species are restricted to a small area. The number and characteristics of plants vary in terms of their evolution and their distribution. The geographical mappings are available for considering the pattern of distribution and for relating to other species in areas outside Thailand. Moreover, because of their showy inflorescences and distinct leaf characters, several taxa have a potential to be cultivated plants. From the revision, the name of *P*. "*palatiferum*" (Wall.) Radlkofer is a synonym of *P. latifolium* (Vahl) B. Hansen with consideration of their type specimens. So, the plants using this name do not have a legitimate name, even considering more type specimens within this genus or seeking the publication in its originality as Vietnam. It is an important thing to make a decision to give a new name of this plant soon. Furthermore, the present study shows 2 unidentified taxa of the genus. *P*. sp1 is quite similar to *P. longistylum*, and they were also collected from the same area of south-eastern Thailand. However, *P*. sp1 shows dense pubescence on the leaf surfaces and is dotted in all five lobes of the petal instead of having glabrous leaves and being dotted in 3 lower lobes. *P*. sp2 was found in south-western and peninsular Thailand. Its characteristics do not match any species in the genus, but the reproductive parts are still not complete. Both of them are preliminarily considered as new taxa and need to be determined as new species in the future.

Nelsonia canescens was normally found in open areas with sandy soil of mixed deciduous and evergreen forest. It distributed in every part of the country and was evaluated as a weed in some areas. However, it has been used as a medicinal plant to treat pain (in general) and also cultivated for controlling other weeds and keeping moisture in orchards.

Ophiorrhiziphyllon macrobotryum only grows in high altitude, moist areas or along streams of hill evergreen forest in the north. Its habitat was restricted and risks disappearing if their environment change. Because of being a monotypic genus in the country, considering to protect them is an urgent need.

The plants in the genus *Staurogyne* are mostly found in moist evergreen forest of the peninsular region. However, a few taxa are distributed in almost all parts of the country. Some taxa grow in specific habitats such as along streams in pine forest, i.e., *Staurogyne punctata*, in the shade of hill evergreen forest, i.e., *Staurogyne subglabra* and *S. singularis*, and in moist evergreen forest in more southern part of the peninsular region, i.e., *Staurogyne filipes* and *S. kingiana*. Almost a half of them were described from herbaria and some taxa were represented by only a few specimen, i.e., *Staurogyne aristata*, *S. cuneata*, *S. densifolia*, *S. dispar*, and *S. parvicaulis*. From this case, it can be interpreted that they are quite hard to see or rare in nature, and there is concern whether they still exist or are already lost or locally extinct. From the revision, *Staurogyne longeciliata* was separated from *S. lanceolata* as Hansen (1995) had reduced using similarity of hairs on bracts. Both of them were collected in nature in the present study. They are quite different in leaf texture and shape, flower bracts, and inflorescence when closely investigated. *S.* sp3 is an unidentified taxon of this genus. The specimens were collected from Kaeng Krachan National Park and kept at the BKF a few years ago. Its characteristics do not match with any type specimen of the genus. So, the present study exposes a new taxon that must be determined to a new species soon.

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APPENDICES

APPENDIX A

CLASSIFICATION OF ACANTHACEAE BY LINDAU 1895

Acanthaceae

Subfamily Nelsonioideae

Subfamily Thunbergioideae

Subfamily Mendoncioideae

Subfamily Acanthoideae

Tribe Contortae

Subtribe Trichanthereae

Louteridieae

Hygrophileae

Petalideae

Strobilantheae

Ruellieae

Barlerieae

Tribe Imbricatae

Acantheae

Aphelandreae

Andrographideae

Asystasieae

Graptophylleae

Pseuderanthemeae

Diclipterineae

Odontonemineae

Monothecineae

Porphyrocomineae

Isoglossineae

Justicieae

APPENDIX B

CLASSIFICATION OF ACANTHACEAE BY BREMEKAMP 1965

Acanthaceae

- Subfamily Acanthoideae
  - Subtribe Haselhoffieae
    - Rhombochlamydeae
    - Stenandriopsideae
    - Aphelandreae
    - Acantheae
- Subfamily Ruellioideae
  - Tribe Trichanthereae
  - Tribe Whitfieldieae
  - Tribe Louteridieae
  - Tribe Ruellieae
    - Subtribe Blechinae
      - Ruelliinae
      - Barleriinae
      - Strobilanthidinae
      - Petalidiinae
      - Hygrophylinae
  - Tribe Lepidagathideae
    - Subtribe Lepidagathinae
      - Chroesthidinae
      - Borneacanthinae
  - Tribe Andrographideae
  - Tribe Justicieae
    - Subtribe Odonteminae
      - Rhytiglossininae
      - Justiciinae

APPENDIX C

CLASSIFICATION OF ACANTHACEAE BY SCOTLAND AND VOLLESEN 2000

Acanthaceae Juss.

Subfamily Nelsonioideae Pfeiff.

Subfamily Thunbergioideae Kostel.

Subfamily Acanthoideae Link

Tribe Acantheae Dumort.

Tribe Ruellieae Dumort.

Subtribe Ruelliinae Nees

Subtribe Andrographiinae Nees

Subtribe Justiciinae Nees

Subtribe Barleriinae Nees

Nelsonioideae [retinacula absent, cystoliths absent, descending cochlear aestivation]

Anisosepalum E. Hossain

Elytraria Michx.

Gynocraterium Bremek.

Nelsonia R. Br.

Ophiorrhiziphyllon Kurz

Saintpauliopsis Staner

Staurogyne Wall.

Thunbergioideae: including *Mendoncia* [Primarily lianas, bristled anthers, poricidal opening of thecae, capsules or drupes]

Anomacanthus R. D. Good

Mendoncia Vell. ex Vand.

Meyenia Nees

Pseudocalyx Radlk.

Thunbergia Retz.

Acanthoideae [retinacula and explosive capsules]

Tribe Acantheae [cystoliths absent, colpate pollen, 4 monothecate anthers]

Acanthopsis Harv.

Acanthus L.

Achyrocalyx Benoist

Aphelandra R. Br.

Blepharis Juss.

Crossandra Salisb.

Crossandrella C. B. Clarke

Cynarospermum Vollesen

Cyphacanthus Leonard

Encephalosphaera Lindau

Geissomeria Lindl.

Holographis Nees

Neriacanthus Benth.

Orophochilus Lindau

Rhombochlamys Lindau

Salpixantha Hook.

Sclerochiton Harv.

Stenandrium Nees

Streptosiphon Mildbr.

Strobilacanthus Griseb.

Xantheranthemum Lindau

Tribe Ruellieae [cystoliths]

Subtribe Ruelliinae [left-contorted aestivation and filament curtain]

Acanthopale C. B. Clarke

Aechmanthera Nees

Heteradelphia Lindau

Hygrophila R. Br.

Apassalus Kobuski

Benoicanthus Heine & A. Raynal

Blechum P. Brown

Bravaisia DC.

Brillantaisia P. Beauv.

Brunoniella Bremek.

Calacanthus T. Anders. ex Benth.

Clarkeasia J. R. I. Wood

Dischistocalyx T Anders. ex Benth.

Duosperma Dayton

Dyschoriste Nees

Echinacanthus Nees

Epiclastopelma Lindau

Eranthemum L.

Eremomastax Lindau

Eusiphon Benoist

Hemigraphis Nees

Sautiera Decne.

Spirostigma Nees

Stenosiphonium Nees

Stenothyrsus C. B. Clarke

Strobilanthes Blume

Ionacanthus Benoist

Kosmosiphon Lindau

Leptosiphonium F. Muell.

Louteridium S. Watson

Lychniothyrsus Lindau

Mellera S. Moore

Mimulopsis Schweinf.

Pararuellia Bremek.

Petalidium Nees

Phaulopsis Willd.

Physacanthus Benth.

Polylychnis Bremek.

Pseudoruellia Benoist

Ruellia L.

Ruelliospis C. B. Clarke

Sanchezia Ruiz & Pav.

Satanocrater Schweinf.

Strobilanthopsis S. Moore

Suessenguthia Merm.

Trichanthera Kunth

Trichosanchezia Mildbr.

Zygoruellia Baill.

Subtribe Andrographinae [Daubenpollen, ascending cochlear aestivation, usually many ovules]

Andrographis Wall. ex Nees

Cystacanthus T. Anderson

Diotacanthus Benth.

Graphandra J. B. Imlay

Gymnostachyum Nees

Haplanthodes Kuntze

Indoneesiella Sreem.

Phlogacanthus Nees

Subtribe Justiciinae [ascending cochlear aestivation, 2-4 ovules, Rhamen/ Spangen/Knötchen/Gürtel pollen]

Afrofittonia Lindau

Ambongia Benoist

Ancistranthus Lindau

Angkalanthus Balf. f.

Anisacanthus Nees

Anisotes Nees

Calycacanthus K. Schum.

Carlowrightia A. Gray

Celerina Benoist

Centrilla Lindau

Cephalacanthus Lindau

Chalarothyrsus Lindau

Chamaeranthemum Nees

Chileranthemum Oerst.

Chlamydocardia Lindau

Chlamydostachya Mildbr.

Anthacanthus Nees

Aphanosperma T.F. Daniel

Ascotheca Heine

Asystasia Blume

Ballochia Balf. f.

Brachystephanus Nees

Dicladanthera F. Muell.

Dicliptera Juss.

Ecbolium Kurz

Filetia Miq.

Fittonia Coem.

Forcipella Baill.

Glossochilus Nees

Graptophyllum Nees

Gypsacanthus Lott, Jar. & Rze.

Harpochilus Nees

Chorisochora Vollesen

Clinacanthus Nees

Clistax Mart.

Codonacanthus Nees

Conocalyx Benoist

Cosmianthemum Bremek.

Cyclacanthus S. Moore

Cylindrosolenium Lindau

Danguya Benoist

Dasytropis Urb.

Dichazothece Lindau

Linariantha B.L. Burtt & R.M. Sm.

Mackaya Harv.

Marcania J. B. Imlay

Megalochlamys Lindau

Megalostoma Leonard

Megaskepasma Lindau

Mellitacanthus S. Moore

Metarungia Baden

Mexacanthus T. F. Daniel

Mirandea Rzed.

Monechma Hochst.

Monothecium Hochst.

Odontonema Nees

Henrya Nees

Herpetacanthus Nees

Hoverdenia Nees

Hypoestes Sol. ex R. Br.

Ichtyostoma Hedr. & Vollesen

Isoglossa Oerst.

Isotheca Turrill

Jadunia Lindau

Juruasia Lindau

Justicia L.

Kalbreyeriella Lindau

Populina Baill.

Pranceacanthus Wassh.

Pseuderanthemum Radlk.

Pseudodicliptera Benoist

Psilanthele Lindau

Ptyssiglottis T. Anderson

Pulchranthus Bau, Rev.&Now.

Razisea Oerst.

Rhinacanthus Nees

Ritonia Benoist

Rungia Nees

Ruspolia Lindau

Ruttya Harv.

Oplonia Raf.

Oreacanthus Benth.

Pachystachys Nees

Pelecostemon Leonard

Peristrophe Nees

Phialacanthus Benth.

Podorungia Baill.

Poikilacanthus Lindau

Tessmanniacanthus Mildbr.

Tetramerium Nees

Thysanostigma J. B. Imlay

Trichaulax Vollesen

Samuelssonia Urb. & Ekman

Sapphoa Urb.

Schaueria Nees

Sebastiano-Schaueria Nees

Spathacanthus Baill.

Sphinctacanthus Benth.

Stenostephanus Nees

Streblacanthus Nees

Trichocalyx Balf. f.

Xerothamnella C. T. White

Yeatesia Small

Subtribe Barleriinae [Quincuncial aestivation]

Barleria L.

Barleriola Oerst.

Borneacanthus Bremek.

Boutonia DC.

Chroesthes Benoist

Crabbea Harv.

Hulemacanthus S. Moore

Lepidagathis Willd.

Lophostachys Pohl

Unplaced within Acanthoideae

Acanthostelma Bidgood & Brummitt

Acanthura Lindau

Aphelandrella Mildbr.

Camarotea Scott Elliot

Chlamydacanthus Lindau

Kudoacanthus Hosok.

Lankesteria Lindl.

Lasiocladus Bojer ex Nees

Leandriella Benoist

Morsacanthus Rizzini

Dolichostachys Benoist

Golaea Chiov.

Idiacanthus Leonard

Sphacanthus Benoist

Vavara Benoist

Neuracanthus Nees

Perenideboles Ram. Goyena

Pericalypta Benoist

Vindasia Benoist

Whitfieldia Hook.

Excluded genera

Thomandersia Baill.

APPENDIX D

DNA EXTRACTION PROTOCOL

(MODIFIED FROM DOYLE & DOYLE, 1987)

Ten ml of 2X CTAB buffer (2% hexadecyltrimethylammonium bromide Sigma H-5882, 1.4 M NaCl, 20 mM EDTA, 100 mM Tris-HCl pH 8.0) with 40 µl beta-mercaptoethanol were put into a 50 ml capped centrifuge tube per sample and preheated at 65°C in a waterbath. About 0.3 g of silica dried leaf tissue was ground in a motar and pestle, preheated to 65°C, with a small amout of sterile sand added as an abrasive, using a small portion of isolation buffer (c. ¼ volume). The remainder of the buffer was then added, and the leaf tissue was ground further, and swirled to suspend the slurry. The slurry was then returned to the capped centrifuge tube and immediately incubated at 60-65°C for 15-20 minutes with occasional gentle swirling and mixing.

An equal volume (10 ml) of SEVAG (Chloroform-Isoamyl alcohol 24:1 v/v) was added to each sample, and ensuring the lid was secure, the contents of the tube were mixed gently but thoroughly by shaking 4 or 5 times to obtain a momentary single phase. The tubes were then transferred to the orbital shaker and shaken on minimum speed for up to 1 hour for slimy or mucilaginous samples. The caps were opened slightly to release gas before racking.

The tubes were then centrifuged at 8,000 or 9,000 rpm at 25°C for 5-10 minutes to separate the layers. The aqueous (top) phase containing DNA was removed with a plastic transfer pipette and transferred to a 50 ml falcon cap tube, and 2X volume of -20°C ethanol (if using herbarium material use 2/3 volume of isopropanol) was added and inverted gently to precipitate DNA. The tube was then kept in a -20°C freezer for 1-2 weeks to precipitate DNA.

Tubes were then spun at 3,000 rpm for 5 minutes to collect the precipitate. The supernatant was poured off after spinning and 3 ml of wash buffer (70% ethanol) was added and rocked gently to dislodge the pellet from the bottom. The tubes were spun again at 3,200-4,000 rpm for 3 minutes and the liquid poured off being careful not to lose the pellet and the tubes were left on their sides for up to a day in the fume cupboard to allow the alcohol to evaporate completely. The pellet was then resuspended in 3 ml of 1.5 g/ml caesium chloride-ethidium bromide (CsCl-EtBr) solution. The samples were covered in foil or kept dark to prevent EtBr from degrading in sunlight at room temperature until the pellet dissolved. This can take from 8-10 hours overnight to several days.

The DNA was further purified by CsCl gradient centrifugation at 45,000 rpm overnight or 58,000 rpm for 5 hours and followed by dialysis (following the standard protocol of the Jodrell Laboratory). The DNA was then removed from the solution in a band area with a pipette to a transparent tube using a UV light box (a concentrated solution of caesium chloride formed a density gradient after a few hours of high-speed centrifugation, where compounds were separated according to their density, DNA was concentrated as a distinct band within the gradient). An equal volume of butanol was added to each sample. The tubes were shaked and left for 15 minutes to remove ethidium bromide (two layers were seen in the tube, the top layer was the butanol with the ethidium bromide and the bottom layer was the DNA). A 5 l beaker was rinsed with distilled water and filled to 4 l with milli-Q water. A 800 ml container was rinsed and half filled with milli-Q water. Dialysis tubing was cut into 15 cm strips and rinsed in the 800 ml container. The lower end of each tubing piece was clamped with the appropriately numbered lower clamp (water could not get in and contaminate the samples). The corresponding sample was pipetted into the tubing using a transfer pipette. The top end of tubing was clamped making sure there were no bubbles or ethidium bromide in the sample, and the clamp was tightened on the sample, thereby increasing the pressure. Samples were placed in a 5 l beaker containing milli-Q water up to 4 hours making sure the samples were kept underwater and that the water was stirred with a magnetic stirrer. The samples were concentrated by transferring to a tray and adding sugar. The samples were then left 20-40 minutes. The upper clamps were tightened and the samples were placed into a 5 l beaker containing 4 l of milli-Q water with 50 ml of dialysis buffer (80X dilution). The samples were then left overnight ensuring that they were kept underwater and stirred as before. The samples were then transferred to new 80X solution and left for 4 hours. DNA levels were checked on the 1% agarose gel then stored at -20°C (or -80°C for long periods).

QIAquick purification of total DNA (QIAGEN)

Seven hundred and fifty µl of Buffer PB (Binding buffer) and 150 µl of the total DNA (5:1) were added and mixed in a column with a 2 ml cut-lid tube. The tube with column was then spun at 10,000 rpm for 1 minute. Any liquid at the bottom tube was discarded. Seven hundred and fifty µl of Buffer PE (Wash buffer) were added to wash the total DNA and then spun 2 times at 10,000 rpm for 1 minute to discard solution and remove residual EtOH (PE Buffer). The columns were transferred to 1.5

ml collection tubes and 50 μl of Buffer EB (Elution buffer) were added. The tubes were left for 10 minutes and then spun at 13,000 rpm for 1 minute to elude DNA to the collection tube.

APPENDIX E

POLYMERASE CHAIN REACTION (PCR) PROTOCOL FOR ITS

The following quantities of reagents were added to each 25 µl reaction:

ReddyMix PCR Master Mix* (conc. 1.1x)	22.5 µl
BSA (Bovine serum albumen)	0.5 µl
10 ng/µl Primer 1	0.5 µl
10 ng/µl Primer 2	0.5 µl
DNA template	1.0 µl

(* product of Thermo Scientific, Leicestershire, UK)

The samples were run on a PCR machine (an Applied Biosystems GeneAmp PCR System 9700 thermocycler) using the following conditions:

94°C for 2 minutes

94°C for 1 minute
48°C for 1 minute } 30 cycles
72°C for 1.5 minutes

72°C for 4 minutes

4°C hold

APPENDIX F

POLYMERASE CHAIN REACTION (PCR) PROTOCOL FOR TRNL-F

The following quantities of reagents were added to each 25 µl reaction:

ReddyMix PCR Master Mix* (conc. 1.1x)	22.5 µl
BSA (Bovine serum albumen)	0.5 µl
10 ng/µl Primer 1	0.5 µl
10 ng/µl Primer 2	0.5 µl
DNA template	1.0 µl

(* product of Thermo Scientific, Leicestershire, UK)

The samples were run on a PCR machine (an Applied Biosystems GeneAmp PCR System 9700 thermocycler) using the following conditions:

94°C for 2 minutes		80°C for 5 minutes **
94°C for 1 minute		95°C for 1 minute
50°C for 1 minute	30 (35) cycles	49°C for 1 minute
72°C for 1.5 minutes		65°C for 5 minutes
72°C for 4 minutes		65°C for 4 minutes
4°C hold		4°C hold

**Long and Cold PCR process was used in case DNA was hard to amplify.

APPENDIX G

PCR PROTOCOL FOR

NDHF-RPL32R, PSAI-ACCD, TRNQ-RPS16X1

The following quantities of reagents were added to each 25 µl reaction:

ReddyMix PCR Master Mix* (conc. 1.1x)	22.5 µl
BSA (Bovine serum albumen)	0.5 µl
10 ng/µl Primer 1	0.5 µl
10 ng/µl Primer 2	0.5 µl
DNA template	1.0 µl

(* product of Thermo Scientific, Leicestershire, UK)

The samples were run on a PCR machine (an Applied Biosystems GeneAmp PCR System 9700 thermocycler) using the following conditions:

80°C for 5 minutes **

95°C for 1 minute
49°C for 1 minute
65°C for 5 minutes
} 35 cycles

65°C for 4 minutes

4°C hold

**Long and Cold PCR process was used in case DNA was hard to amplify.

APPENDIX H

CYCLE SEQUENCING REACTION

The following quantities of reagents were added to each 5 µl reaction:

Premix* (BigDye® Terminator Kit v3.1)	0.25 µl
SB (Sequencing buffer)	1.5 µl
1 ng/µl Primer (1/10 dilution from PCR dilution)	1.0 µl
Double distilled water	1.25 µl
DMSO (only in ITS region)	0.3 µl
DNA template	1.0 µl

(*product of Applied Biosystems, AB, USA)

The samples were run on a machine (an Eppendorf Flexlid Mastercycler Nexus) using the following conditions:

96°C for 1 minute

96°C for 10 seconds

50°C for 5 seconds — 26 cycles

60°C for 4 minutes

4°C hold

CURRICULUM VITAE

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