



MORPHOLOGICAL AND MOLECULAR
SYSTEMATICS OF VERNONIEAE
(ASTERACEAE) IN THAILAND

MS. SUKHONTHIP BUNWONG

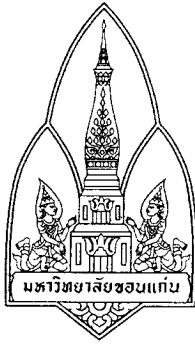
A THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
KHON KAEN UNIVERSITY

2010

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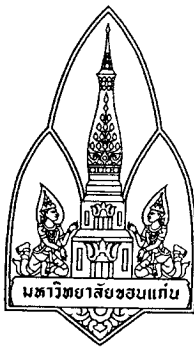
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**MORPHOLOGICAL AND MOLECULAR
SYSTEMATICS OF VERNONIEAE
(ASTERACEAE) IN THAILAND**

MS. SUKHONTHIP BUNWONG

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
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FOR
DOCTOR OF PHILOSOPHY
IN BIOLOGY

Thesis Title: Morphological and Molecular Systematics of Vernonieae
(Asteraceae) in Thailand

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สุคนธ์ทิพย์ บุญวงศ์. 2553. อนุกรมวิธานเชิงสัณฐานวิทยาและชีวโมเลกุลของพืชเผ่า Vernoniae (Asteraceae) ในประเทศไทย. วิทยานิพนธ์ปริญญาปรัชญาดุษฎีบัณฑิต

สาขาวิชาชีววิทยา บัณฑิตวิทยาลัย มหาวิทยาลัยขอนแก่น.

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บทคัดย่อ

ศึกษาอนุกรมวิธานของพืชเผ่า Vernoniae ในประเทศไทย พบพืช 51 แทกซา 48 ชนิด 16 สกุล และ 5 เผ่าย่อย ในจำนวนนี้เป็นพืชประจำถิ่นในประเทศไทย 14 แทกซา ได้แก่ *Acilepis chiangdaoensis*, *A. doichangensis*, *A. namnaoensis*, *A. ngaoensis*, *A. principis*, *A. sutepensis*, *A. pseudosutepensis*, *Camchaya pentagona*, *C. spinulifera*, *C. tenuiflora*, *Camchaya* sp., *Koyamasia calcarea*, *Vernonia curtisii* var. *tomentosa* และ *V. pseudobirmanica* พบพืชสกุลใหม่ของโลก 2 สกุล คือ *Iodocephalopsis* S.Bunwong & H.Rob. และ *Kurziella* H.Rob. & S.Bunwong การศึกษาครั้งนี้ได้ดำเนินการเปลี่ยนสถานะพืชจาก *Iodocephalus gracilis* มาเป็น *Camchaya gracilis* และเปลี่ยนจาก *Iodocephalus eberhardtii* มาเป็น *Iodocephalopsis eberhardtii* และมีพืชที่จัดเป็นพืชที่รายงานครั้งแรกในประเทศไทยจำนวน 2 ชนิด ได้แก่ *Camchaya gracilis* และ *Pseudelephantopus spicatus* นอกจากนี้ยังมีพืชที่คาดว่าจะจะเป็นพืชชนิดใหม่ของโลกในสกุล *Camchaya* จำนวน 1 ชนิด ได้สร้างรูปวิธานระบุสกุล ชนิด และพันธุ์ บรรยายลักษณะพืช บันทึกชื่อพื้นเมือง การกระจายพันธุ์ นิเวศวิทยา และภาพวาดลายเส้น

การวิเคราะห์ความสัมพันธ์ทางสัณฐานวิทยา (phenetics) ในพืชเผ่า Vernoniae ในประเทศไทย จำนวน 42 ชนิด โดยอาศัยลักษณะเชิงปริมาณและคุณภาพ จำนวน 46 ลักษณะ จากลักษณะวิสัย ใบ ดอก ผล และเรณู นำข้อมูลมาวิเคราะห์การจัดกลุ่มแบบ UPGMA ด้วยโปรแกรม PAUP* 4.0b10 ได้แผนภูมิเดนโดรแกรมที่แบ่งพืชออกเป็น 5 กลุ่ม ที่ระดับความห่าง 0.20 ซึ่งสอดคล้องกับการจัดกลุ่มพืชในแผนภูมิวิวัฒนาการ หรือ เคลดโดแกรม ที่ได้จากการวิเคราะห์ลำดับนิวคลีโอไทด์

การวิเคราะห์ความสัมพันธ์ทางวิวัฒนาการของพืชจำนวน 50 ตัวอย่าง จาก 35 ชนิด โดยอาศัยข้อมูลลำดับนิวคลีโอไทด์ในไรโบโซมดีเอ็นเอ บริเวณ internal transcribed spacer (ITS) และคลอโรพลาสต์ดีเอ็นเอ บริเวณยีน *ndhF* และตำแหน่ง *trnL-F* ด้วยวิธี Maximum Parsimony ด้วยโปรแกรม PAUP* 4.0b10 และ Bayesian Analysis ด้วยโปรแกรม MrBayes 3.0b4 และได้นำข้อมูลของลักษณะทางสัณฐานวิทยาจำนวน 46 ลักษณะมาวิเคราะห์ร่วมด้วย ผลการวิเคราะห์ พบว่า พืช

เผ่า *Vernonieae* ในประเทศไทยมีความสัมพันธ์แบบโมโนไฟเลติก เผ่าย่อยที่มีความสัมพันธ์ภายในเผ่าเป็นแบบโมโนไฟเลติกได้แก่ *Centrapalinae* และ *Elephantopinae* ส่วนเผ่าย่อยที่มีความสัมพันธ์แบบพอลิไฟเลติก คือ *Gymnantheminae* เผ่าย่อยที่มีความสัมพันธ์แบบพาราไฟเลติก คือ *Erlangeinae* นอกจากนี้ยังพบว่าความสัมพันธ์ของพืชภายในเคลดโคเกรมนีสอดคล้องกับการจัดกลุ่มพืชในเดนโดแกรมเป็นส่วนใหญ่ และยังสนับสนุนระบบการจำแนกพืชเผ่านี้ในปัจจุบันอีกด้วย

Sukhonthip Bunwong. 2010. **Morphological and molecular systematics of Vernonieae (Asteraceae) in Thailand.** Doctor of Philosophy

Thesis in Biology, Graduate School, Khon Kaen University.

Thesis Advisors: Prof. Dr. Pranom Chantaranothai, Prof. Dr. Sterling C. Keeley

ABSTRACT

The Vernonieae of Thailand are revised to include 51 taxa, 48 species, 16 genera, and five subtribes. Fourteen species are endemic including: *Acilepis Chiangdaoensis*, *A. doichangensis*, *A. namnaoensis*, *A. ngaoensis*, *A. principis*, *A. sutepensis*, *A. pseudosutepensis*, *Camchaya pentagona*, *C. spinulifera*, *C. tenuiflora*, *Camchaya* sp., *Koyamasia calcarea*, *Vernonia curtisii* var. *tomentosa* and *V. pseudobirmanica*. We also propose two new endemic genera, *Iodocephalopsis* S.Bunwong & H.Rob. and *Kurziella* H.Rob. & S.Bunwong. *Iodocephalus gracilis* is placed into synonymy under *Camchaya gracilis* and *Iodocephalus eberhardtii* is transferred to *Iodocephalopsis eberhardtii*. In addition, one undescribed species of *Camchaya* is likely new to science and further studies are underway to verify this. *Camchaya gracilis* and *Pseudelephantopus spicatus* are newly recorded for Thailand. Keys to genera, species and varieties, descriptions, vernacular names, ecological data and illustrations are provided. Phenetic analysis based on 46 characters of habit, leaf, flower, achene and pollen morphology were applied to 42 taxa using UPGMA. Analysis revealed five groups of taxa and a dendrogram congruent with the tree generated from the molecular data. Phylogenetic analyses of 50 accessions of 35 species were conducted using sequence data from the nuclear ribosomal internal transcribed spacer (ITS), the chloroplast DNA gene *ndhF* and the non-coding chloroplast region *trnLC-F*. Maximum parsimony and Bayesian analyses along with morphological characters revealed that, overall, the Thai Vernonieae are monophyletic, as are the subtribes Centrapalinae and Elephantopinae. The Gymnantheminae and Erlangeinae, as currently assigned are polyphyletic and paraphyly, however. Existing taxonomic assignments are unconfirmed, with the exceptions listed above.

This thesis is dedicated to parents and teachers

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CHAPTER I

INTRODUCTION

1. Introduction

The Compositae or Asteraceae are the largest flowering plant family with ca. 24,000 species divided into 12 subfamilies, and 1600-1700 genera (Funk *et al.*, 2009). The family is also among the most widespread with taxa on every continent except Antarctica and on many island chains throughout the world as well. Similarly, both habit and habitat are highly variable. Growth forms range from annual and perennial herbs < 5 cm to shrubs, vines and trees over 40 m tall. Species are found in nearly every type of habitat as well from aquatic to dry and from sea level to >3500 m. In general Compositae are most common in open areas, but there are also many shade tolerant species (Funk *et al.*, 2005).

The family also includes many economically important species. For example, lettuce, artichoke, and endive are widely consumed vegetables and sunflower and safflower seeds provide large quantities of oil. Additionally, chrysanthemums, marigolds, bachelor buttons, daisies and many other species are cultivated as garden ornamentals (Jansen and Palmer, 1987).

Along with their uses in food and for decoration some members of the family also produce a variety of defensive compounds. For example, one of the best known is pyrethrum a widely applied commercial insecticide. Other compounds known as sesquiterpene lactones are extremely bitter to the taste and have been shown to be effective against mammalian and insect herbivores, and, are often antifungal and cytotoxic; and some can even prevent insect larvae from reaching sexual maturity (Keeley and Robinson, 2009).

Many of these same compounds have medicinal value(s) for humans as well. Species of Vernoniaceae have been reported as sources of traditional medicine in many cultures (Keeley and Robinson, 2009). For example, the Yi in China use *Vernonia saligna* (Wall.) DC. in the treatment of sore throat, cough, tuberculosis and uterus prolapse (Huang *et al.*, 2003). In India *V. cinerea* Less. (now *Cyanthillium cinerium*

(Less.) H. Rob., *V. roxburghii* Less., *V. teres* Wall. and *Elephantopus scaber* L. to cure fevers and as a tonic for as well as a cure for stomachs (Kirtikar *et al.*, 1984). The book The Medicinal Plants of Thailand (Saralamp *et al.*, 1996) reports *V. elliptica* DC. (now *Tarlmounia elliptica* (DC.) H. Rob., S.C. Keeley, Skvarla & R. Chan) is useful for treating chronic gastro-intestinal ailments and ridding children of intestinal parasites (Saralamp *et al.*, 1996). Additionally, the crude extract and solvent fractions of the leaves and bark of *V. tenoreana* Oliv. showed broad spectrum activity against *Staphylococcus aureus*, *S. faecalis*, *Bacillus subtilis*, *B. cereus*, *Shigella dysenteriae* and *Klebsiella pneumonia* (Ogundare *et al.*, 2006). Antifungal activity of the compound zaluzanin D, from the aerial parts of *V. arborea* Buch.-Ham. (now *Strobocalyx arborea* (Buch.-Ham.) Sch. Bip) has also been found to be effective against six plant-pathogenic fungi (Krishna, 2003) and a steroidal saponin, vernonioside G (1), isolated from the roots of *V. cumingiana* Benth., is used in traditional Chinese medicines to anti-inflammatory activity (Liu *et al.*, 2005).

The Vernonieae are in the subfamily Cichorioideae which traditionally also includes the Liabeae, its sister tribe, the Cichorieae and the Arctitoidinae. Recent work by Funk *et al.* (2009) have expanded the subfamily to include several additional subtribes, however, there has been little actual change in phylogenetic relationships as most of the newly recognized subtribes are composed of genera that were previously included in one of the four original tribes of the subfamily. The Vernonieae originated in Madagascar/Africa and is now found widely throughout both the Old and New Worlds. The greatest concentration of taxa is in east Africa and Brazil, in their respective hemispheres. The tribe include ~130 genera and 1,300 species (Keeley & Robinson, 2009; and various recent papers by Robinson and collaborators (e.g., Robinson *et al.*, 2008; Robinson *et al.*, 2009; Robinson & Skvarla, 2009). However, until recently most species were within the large and morphologically complex genus *Vernonia* (e.g., Gleason, 1906; Ekman, 1914; Gleason, 1922; Gleason, 1923a; Jones, 1977; Keeley & Jones, 1977; Keeley & Jones, 1979; Jeffrey, 1988; Robinson and colleagues (1960-2010) and Keeley and colleagues (1979-2009)). Bremer (1994) summed up this situation as “the *Vernonia* problem” identifying it as the major stumbling block to understanding relationships within the tribe. Not only has it been difficult to distinguish taxa inside and outside of *Vernonia s.l.*, it has been

equally difficult to separate species from each other even within small geographically circumscribed areas, and conversely, to group taxa at higher levels to erect subtribes. It was not until DNA sequence data became available that it was possible to understand subtribal relationships (Keeley *et al.*, 2007; Keeley & Robinson, 2009). As a result of the refractory nature of the Vernonieae at every taxonomic level, it has been dubbed the “evil tribe” (Funk *et al.*, 2005; Keeley *et al.*, 2007).

Recent work by Robinson (1999b; 2007) and Keeley and Robinson (2009) based on molecular and morphological characters have resulted in substantial subtribal reorganization and the recognition of numerous (new) taxonomic entities. As of 2009, 20 subtribes were recognized on the basis of DNA sequence data, morphology, pollen type, chromosome number and to a lesser degree, secondary chemistry. The best understood and most clearly defined subtribes are those found in the New World. This is because various taxonomic groups such as that of North American *Vernonia* of North America (Gleason, 1906, 1922, 1923b) and studies like those of the West Indian Vernonieae (Ekman, 1914; Keeley & Jones, 1977; Keeley, 1978) are available and contain detailed information allowing them to be placed accurately within the framework. On the other hand, the number of the Old World subtribes are few and their delimitations less certain. This is due to lack of study of Vernonieae and many other plant groups throughout large areas of Africa and Asia. It is expected that the number of the Old World subtribes will increase as taxa are studied in greater depth (Robinson, *pers. comm.*).

The relationships among Vernonieae taxa of many Asian, Indo-Chinese and Malaysian Vernonieae lack any kind of treatment beyond the earliest naming and describing. That there are also >500 species in this region has made understanding the relationships among Vernonieae taxa extremely challenging as well. The present study is designed to address this deficiency for Thailand. Using morphological and molecular characters for the Vernonieae in Thailand it is possible to provide better and clearer species delimitations and to pursue other aspects, which may affect relationships at many levels within the tribe.

2. General morphology of *Vernonieae* (Keeley and Robinson, 2009)

2.1 Habits are annual or perennial herbs, shrubs, vines or trees. Stem and foliage are variously pubescent.

2.2 Leaves are usually entire and alternate, rarely opposite or whorled, sessile and petiolate, margins serrate or entire.

2.3 Capitulescences and secondary inflorescences are cymose with cymiform, corymbiform, paniculate occasionally reduced to solitary capitula (Figure 1.1).

2.4 Capitula are homogamous with 1 – 400 flowers, sessile or pedunculate. Florets are perfect (Figure 1.2). The flower colour is purple, pink or white. Corollas are actinomorphic and funnel form with lobe is longer than wide or rarely zygomorphic, then with unequal lobes. Involucres are campanulate to cylindrical, bracts are typically imbricate in 2–9 series; scarious or leafy, persistent or deciduous (Figure 1.3A). Receptacles are flat or convex, smooth or pitted, sometimes with pales, spines or partitions. Anthers are calcarate with a sagittate base, auricles obtuse or acute, frequently tailed, apical appendages acute, and with or without glands (Figure 1.4A). Style branches are spreading, semi-cylindrical, slender, tips acute or obtuse, sometimes recurved, outer surfaces pubescent with acute or blunt trichomes, inner surfaces with stigmatic papillae, but lacking other trichomes, base glabrous (Figure 1.4B).

2.5 Achenes are terete, angled or occasionally flattened, rarely dimorphic, typically with 3–20 ribs; outer surfaces glabrous or pubescent (Figure 1.3B). Pappus are persistent or deciduous, usually with capillary bristles, rarely coroniform, squamellose or with flattened or twisted segments, in two series typically the outer of short bristles or squamellae, the inner of long bristles; both series remain firmly attached at maturity.

2.6. Pollen are highly ornamented, lophate, sublophate, echinate or psilate (Figure 1.5).

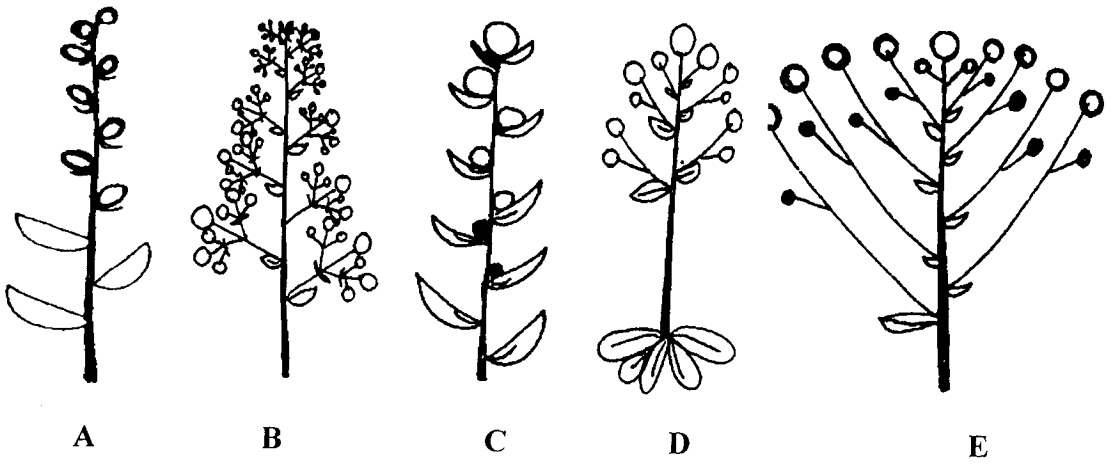


Figure 1.1 Capitulescences in Vernoniaeae; A. Spicate, B. Paniculiform, C. Solitary, D. Scapose, E. Corymbiform.

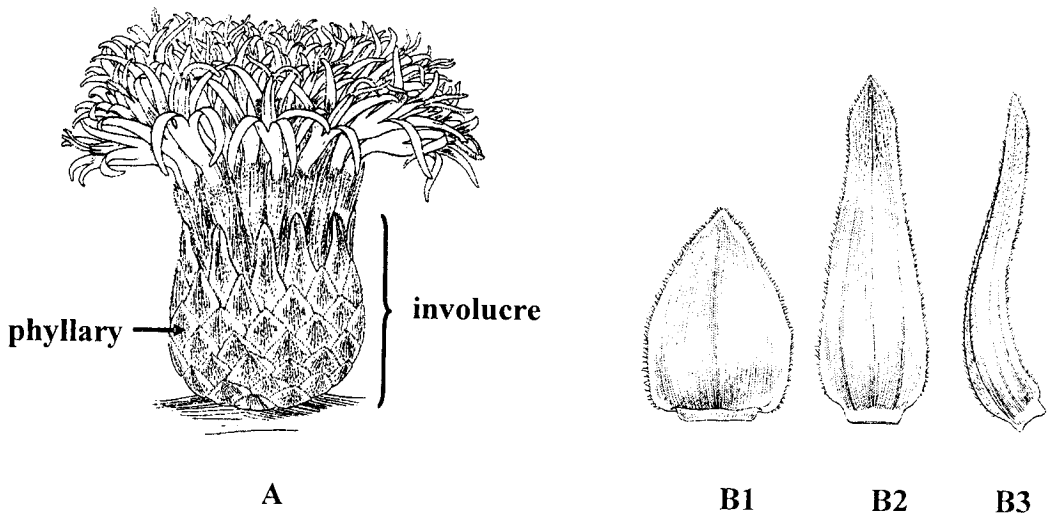


Figure 1.2 Capitula of Vernoniaeae; A. Discoide capitula, B1 – B3. Phyllaries.
(Modified from Robinson, 1999a).

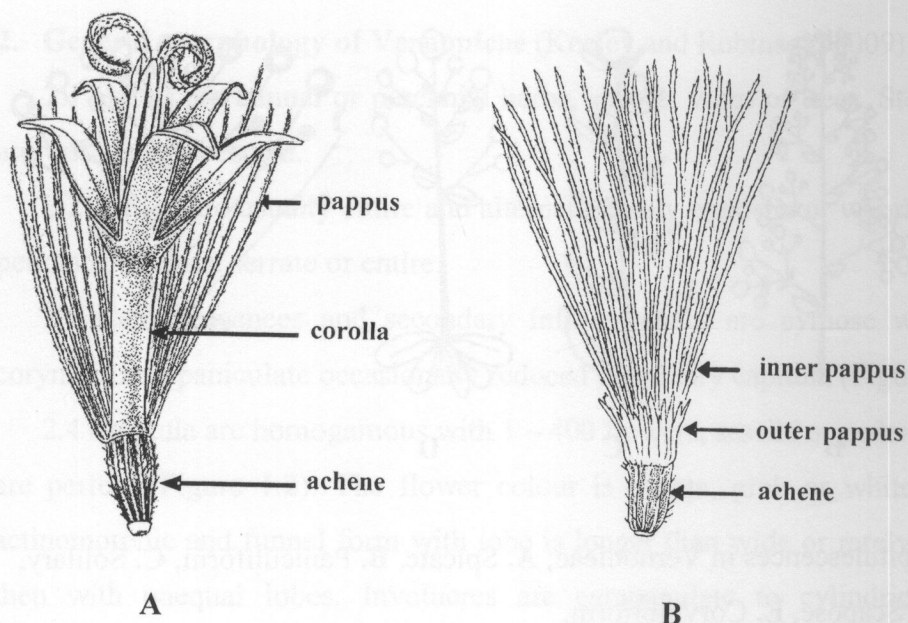


Figure 1.3 Floret and achene of Vernoniae **A.** Floret, **B.** Pappose achene
(Modified from Robinson, 1999a and Robinson and Skvarla, 2006).

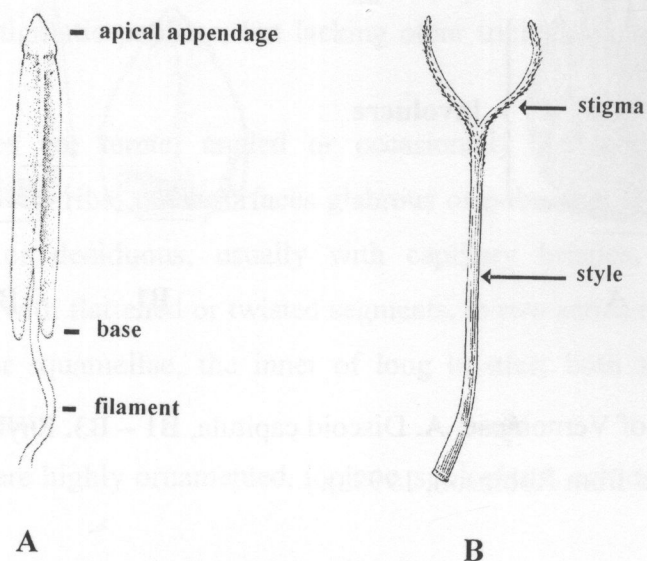


Figure 1.4 Stamen and pistil of Vernoniae; **A.** Stamen, **B.** Pistil
(Modified from Robinson, 1999a).

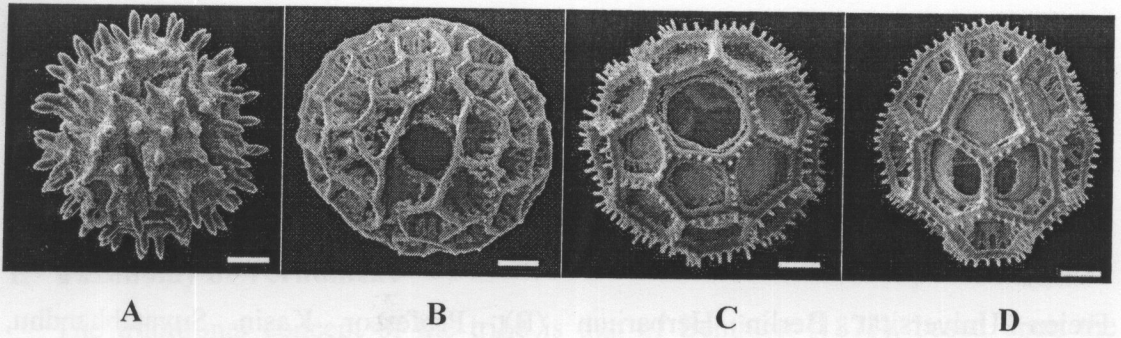


Figure 1.5 Pollen types of Vernonieae

A. Echininate 3-colporate

B. Lophate 3-colporate

C. Lophate 3-porate

D. Lophate 6-porate

(Applied from Bunwong and Chantaranothai, 2008).

3. Objectives

3.1 To enumerate the existing genera and species of Vernonieae in Thailand, construct taxonomic keys to them and record ecological and distributional data for each.

3.2 To examine the relationships within members of the tribe using morphometric analysis.

3.3 To construct a phylogeny of Thai Vernonieae using nuclear ribosomal internal transcribed spacer (ITS) and chloroplast DNA sequence data.

4. Scope of study

Morphological, ecological and distributional data for Vernonieae in Thailand were obtained from field collected specimens and herbaria. The studies were carried out between June 2007 and May 2010.

5. Anticipated benefits

This study will provide fundamental information on the tribe Vernonieae in Thailand using morphological and molecular data in a phylogenetic framework.

6. Institutional Resources

6.1 Morphological studies were carried out at the Department of Biology, Faculty of Science, Khon Kaen University. Specimens were obtained from field collections in Thailand and from herbarium specimens at the University of Aarhus (AAU), Botanischer Garten und Botanisches Museum Berlin-Dahlem, Zentraleinrichtung der Freien Universität Berlin Herbarium (B), Professor Kasin Suvatabhandhu, Chulalongkorn University (BCU), Department of Agriculture Bangkok (BK), Royal Forest Department Forest Herbarium (BKF), The Natural History Museum (BM), University of Copenhagen (C), Royal Botanic Garden Edinburgh (E), Conservatoire et Jardin botaniques de la Ville de Genève (G), Royal Botanic Gardens, Kew (K), Khon Kaen University (KKU), Nationaal Herbarium Nederland, Leiden University branch (L), Muséum National d'Histoire Naturelle Herbier National de Paris (P), Prince of Songkla University (PSU), Queen Sirikit Botanic Garden (QBG), and the Smithsonian Institution United States National Herbarium (US). The field collections are kept at KKU, QBG and US.

6.2 The molecular studies were investigated at the Botany Department, University of Hawaii at Manoa, Hawaii, USA.

CHAPTER II

TAXONOMIC TREATMENT

1. Taxonomy of Vernonieae

The traditional concept of the tribe is that of Bentham (1873), based upon the earlier work of Cassini (1819, 1828), Lessing (1832), and Candolle (1836). The biggest change in Bentham's tribal concept has come with the recent revisions of the Old and New World Vernonieae by Robinson (1999a, 1999b; 2007) based on morphological studies along with the molecular work of Keeley (Keeley & Jansen, 1994; Keeley *et al.*, 2007). Combining these findings has produced a new understanding of the Vernonieae (Keeley and Robinson, 2009, Ch. 28 in *The Systematics, Evolution and Biogeography of the Compositae* (Funk *et al.*, 2009)). In this treatment, 20 subtribes and 125 genera were recognized with more genera added since as a result of ongoing work by Robinson and colleagues within a phylogenetic context. Among the most important of Robinson's treatment (1999a) was the redefinition of the core genus, *Vernonia*. Historically, *Vernonia* was the name given to any taxon within the tribe that was not morphologically distinctive enough to be easily separated from other species. The taxonomic confusion resulting this dumping together of many different, but difficult to separate entities is in large part the reason for the Vernonieae's nickname, "the evil tribe" (Funk *et al.*, 2005; Keeley *et al.*, 2007). Robinson's revision of *Vernonia* reduced the number of species from >1000 distributed worldwide to <25 and those entirely restricted to the New World. As a consequence, all the Old World and many the New World taxa had to be placed in other genera and subtribes (Robinson, 1999a, 1999b, 2007; Keeley & Robinson, 2009). While work ongoing studies will no doubt produce changes, the basic structure of the tribe has been established (Keeley *et al.*, 2007; Keeley & Robinson, 2009) and new taxa can be placed within this framework with a reasonable degree of certainty, and new subtribes recognized as required to maintain monophyly. The tribe has been shown to be unequivocally monophyletic (Keeley & Jansen, 1994; Kim *et al.*, 1998; Keeley *et al.*, 2007; Funk *et al.*, 2009) and its constitution has remained relatively

constant over time. The few changes in tribal membership that have been made in the taxa historically assigned to the Vernonieae have resulted from molecular studies, primarily removal of *Pluchea*, *Eremothamnus*, *Corymbium* and the addition of *Distephanus*, summarized in Robinson (2007) and Keeley & Robinson (2009). Based on the work of Keeley and Jansen (1994), Kim *et al.* (1998) and Keeley *et al.* (2007) Madagascar/eastern Africa is the site of origin of the tribe. The tribe also is divided into two major lineages, one in the Old World, with a concentration of taxa in Africa, and the other New World, where the center of diversity is Brazil (Robinson, 1999a, 1999b; Keeley *et al.*, 2007). In general, there is little overlap between taxa from the two hemispheres; however work by Keeley *et al.* (2007) showed that trans-Atlantic dispersals have occurred in both directions. The status of inter-hemispheric relationships and the frequency of their occurrence is currently under investigation by Keeley and Robinson.

2. Morphological characters used in Vernonieae taxonomy

2.1 Trichomes

Trichome type and cellular structure have been used in Vernonieae taxonomy (Fig. 2.1), particularly to distinguish between species; *e.g.*, Faust & Jones (1973), Jones (1973), Narayana (1979), Isawumi (1996), and Robinson (1999a, 1999b) and unite genera; *e.g.*, stellate trichomes in *Piptocarpha* (Smith & Coile, 2007) and various other New World taxa (Robinson, 1999a). Isawumi (1984), Robinson (1999a, 1999b) and Adedeji & Jewoola (2008) also showed the value of trichome morphology at higher levels such as sections and subtribes. There are estimated 25-30 different types of trichomes recorded on stems, leaves, inflorescences, phyllaries, florets and styles providing a wide range of potentially useful characters. For example, Isawumi (1996) reported six different foliar trichome types in 61 species of West African *Vernonia* while Narayana (1979) found 18 different trichomes on leaves, stems and floral parts in south Indian Vernonieae. MacLeish (1987) Stutts & Muir (1981) and Stutts (1988) also observed additional trichome types bringing the number well above 25. Robinson (1999a, 1999b) has used style trichomes, in particular, to distinguish genera and subtribes.

2.2 Pollen

The pollen morphology of tribe Vernonieae is useful for generic, and sometimes for species delimitations (Keeley & Jones, 1977, 1979). *Vernonia* pollen morphology was originally described and illustrated as a potentially useful feature for *Vernonia* taxonomy by Wodehouse (1928, 1935) followed by Stix (1960). Keeley & Jones (1977, 1979) provided a system of classification for Vernonieae pollen types worldwide which continue to be used today. Additional studies, particularly those of Smith (1969), Kingham (1976), Robinson (1999a, 1999b), Robinson & Skvarla (2006, 2007, 2009) and Robinson *et al.* (2008) have made pollen morphology a fundamental character in distinguishing Vernonieae taxa. Pollen type is included in many recent species descriptions as well; *i.e.*, Skvarla *et al.* (2005), Bunwong & Chantaranothai (2008) and Dematteis & Pire (2008). Vernonieae pollen is variable in aperture number with 3-colporate, 3-porate and 6-porate forms and location in the tectum. The latter include echinate, subechinolophate, echinolophate and psilolophate. Most of paleotropical Vernonieae possess lophate 3-porate pollen.

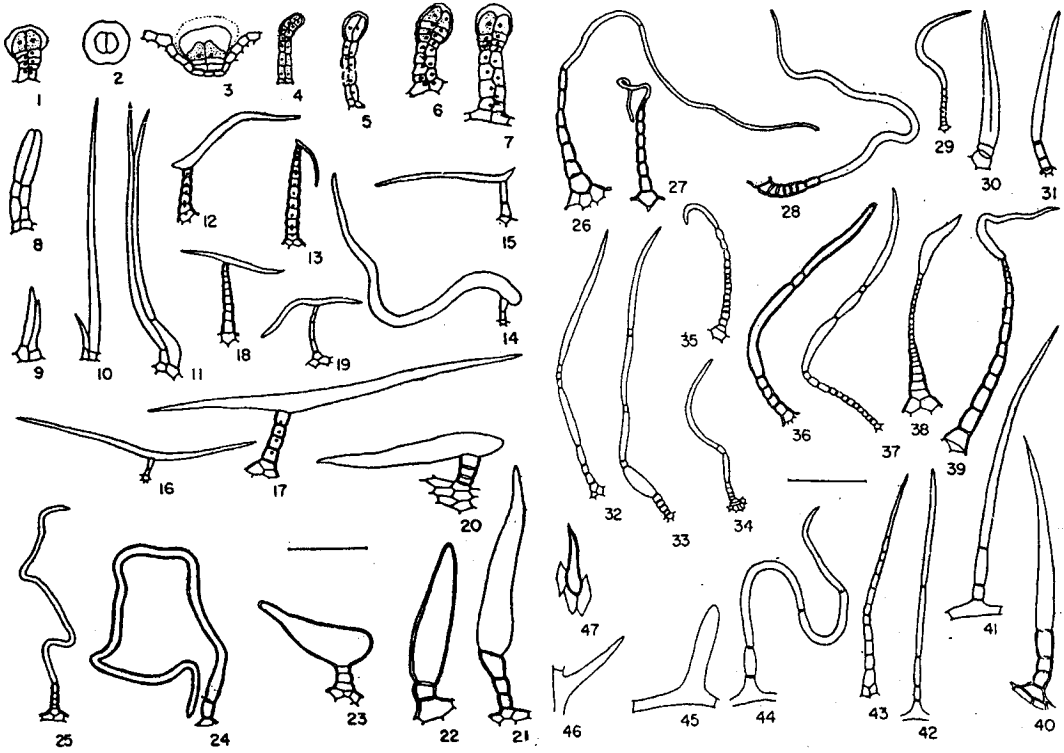


Figure 2.1 Type of Vernonieae trichome; 1 – 7. Glandular, 8 – 11. Biseriate or twin, 12 – 15. One armed, 16 – 19. T-shaped, 20 – 23. Swollen terminal celled, 24 – 25. Flagellate, 26 – 28. Whip-shaped, 29 – 31 and 45. Cylindrical, 32 – 44. Filiform, 46 – 47. Prickly.
(Applied from Narayana, 1979)

3. History of the Study of Vernonieae in Thailand

3.1 The first comprehensive work on Vernonieae in Thailand

Kerr (1936) in a treatment of Thai Compositae described 16 genera and 196 species overall. Twenty-eight of these were Vernonieae: *Camchaya kampotensis*, *C. loloana*, *Elephantopus scaber*, *E. scaber* var. *sinuata*, *Ethulia conyzoides*, *Vernonia andersonii*, *V. attenuata*, *V. cinerea*, *V. craibiana*, *V. cumingiana*, *V. curtisii*, *V. curtisii* var. *tomentosa*, *V. cylindriceps*, *V. divergens*, *V. elliptica*, *V. garrettiana*, *V. javanica*, *V. javanica* var. *mollissima*, *V. juncea*, *V. kerrii*, *V. kingii*, *V. parishii*, *V. patula*, *V. principis*, *V. roxburghii*, *V. rupicola*, *V. saligna*, *V. sangka*, *V. scandens*, *V. silhetensis*, *V. silhetensis* var. *sub serrata*, *V. solanifolia*, *V. squarrosa*, *V. sutepensis*, *V. volkameriifolia*, *V. volkameriifolia* var. *siamica* and *V. wallichii*. Suvatti (1978)

published the name of flowering plants in Thailand, two genera and 11 species of Vernonieae are found. They are *Elephantopus scaber*, *Vernonia cinerea*, *V. curtisii* var. *curtisii*, *V. curtisii* var. *tomentosum*, *V. elliptica*, *V. javanica*, *V. juncea*, *V. saligna*, *V. solanifolia*, *V. squarrosa*, *V. volkameriifolia* and *V. wallichii*.

3.2 Koyama and the revision of the Vernonieae in Thailand

Koyama visited Thailand between October and December 1979 for a botanical expedition throughout the country. More than 500 sheets of specimens were collected. He reported taxonomical studies in the Asteraceae of Thailand for the years 1981-2005, and the first enumeration of Vernonieae taxa was published in 1984. The genera *Camchaya*, *Elephantopus*, *Ethulia* and *Struchium* were described early on with the recommendation that *Iodocephalus eberhardtii* Gagnep. can be considered a species of *Camchaya*.

In 1993, Koyama recognized four species of woody climbers and two subshrub species as members of *Vernonia* section *Decaneurum* (DC.) Oliver, otherwise uncommon in the flora. These are *Vernonia andersonii* C.B. Clarke, *V. eberhardtii* Gagnep., *V. garrettiana* Craib, *V. scandens* DC., *V. divergens* (DC.) Edgew. and *V. saligna* DC., according to their involucral bracts. Later, in 1997, he considered five woody plants; *V. arborea* Buch.-Ham., *V. elliptica* DC., *V. parishii* Hook.f., *V. solanifolia* Benth. and *V. volkameriifolia* DC. belonging to section *Strobocalyx* Blume based on the features of achenes and pappus. After that, in 1998, *V. benguetensis* Elm. and *V. cinerea* (L.) Less. in section *Tephrodes* DC. and *V. patula* (Dryand) Merr. in section *Cyanopsis* Blume were examined.

In 2003, four taxa in *Vernonia* section *Calcarea* (Kitam.) H.Koyama; *V. birmanica* (Kuntze) Merr., *V. pseudobirmanica* H.Koyama, *V. curtisii* Craib and *V. calcarea* (Kitam.) H.Koyama) are confined to limestone areas were transferred from the genus *Camchaya* to *Vernonia*. These species are polyploid, based on 18 somatic chromosomes. Additionally, they have achenes with a caducous pappus. A year later, *V. doichangensis* H.Koyama, *V. namnaoensis* H.Koyama, *V. ngaoensis* H.Koyama, *V. pulicarioides* Gagnep., *V. roxburghii* Less., *V. silhetensis* (DC.) Craib and *V. squarrosa* (D. Don) Less. Were reported from mixed deciduous and dipterocarp forests.

Koyama’s work, most recent report “Taxonomic studies in the Asteraceae of Thailand” in 2005, seven species were described in section *Lepidaploa*, subsection *Paniculatae*: *Vernonia attenuata* DC., *V. chiangdaoensis* H.Koyama, *V. kingii* C.B.Clarke, *V. kradungensis* H.Koyama, *V. principis* Gagnep., *V. pseudosutepensis* H.Koyama and *V. sutepensis* Kerr. In addition, Koyama thought two species had affinities to *V. tonkinensis* Gagnep. because of the ovate involucrel phyllaries but the peduncles of the specimen are more slender than *V. tonkinensis*, and to *V. virgata* Gagnep. with subulate involucrel phyllaries but the immature achene was unable to be observed.

Forty-four species in total were reported for the Vernonieae of Thailand (Koyama, 1984, 1993, 1997, 1998, 2003, 2004, 2005). Further study is needed to clarify the concept of particular species because of the poor state of the available material.

3.3 Robinson and generic classification in paleotropical Vernonieae

In order to redefine the Paleotropical members of Vernonieae, Robinson (1990, 1999b), Robinson & Skvarla (2006, 2007, 2009) and Robinson *et al.* (2008) transferred some Thai *Vernonia* species to eight new or resurrected genera; *i.e.*, *Acilepis*, *Cyanthillium*, *Decaneuropsis*, *Gymnanthemum*, *Koyamasia*, *Monosis*, *Strobocalyx* and *Tarlmounia*. These are found in the five subtribes *Centrapalinae* H.Rob., *Elephantopinae* Less, *Erlangeinae* H.Rob., *Gymnantheminae* H.Rob. and *Vernoniinae* Cass. ex Demort. (Table 2.1).

Table 2.1 Subtribal and generic classification of Vernonieae in Thailand.

	Koyama's classification	Robinson's classification	Subtribe
1	<i>Camchaya kampotensis</i>	<i>Camchaya kampotensis</i>	Centrapalinae
2	<i>C. eberhardtii</i>	<i>C. eberhardtii</i>	Centrapalinae
3	<i>C. loloana</i>	<i>C. loloana</i>	Centrapalinae
4	<i>C. pentagona</i>	<i>C. pentagona</i>	Centrapalinae
5	<i>C. spinulifera</i>	<i>C. spinulifera</i>	Centrapalinae
7	<i>Elephantopus mollis</i>	<i>Elephantopus mollis</i>	Elephantopinae
8	<i>E. scaber</i>	<i>E. scaber</i>	Elephantopinae
9	<i>Ethulia conyzoides</i>	<i>Ethulia conyzoides</i>	Erlangeinae
10	<i>Struchium sparganophorum</i>	<i>Sparganophoros sparganophora</i>	Vernoniinae

Table 2.1 Subtribal and generic classification of Vernonieae in Thailand. (Cont.)

	Koyama's classification	Robinson's classification	Subtribe
11	<i>Vernonia</i> aff. <i>tonkinensis</i>	<i>Acilepis tonkinensis</i>	Erlangeinae
12	<i>V.</i> aff. <i>virgata</i>	<i>A. virgata</i>	Erlangeinae
13	<i>V. andersonii</i>	<i>Decaneuropsis andersonii</i>	Gymnantheminae
14	<i>V. arborea</i>	<i>Strobocalyx arborea</i>	Gymnantheminae
15	<i>V. attenuata</i>	<i>A. attenuata</i>	Erlangeinae
16	<i>V. benguetensis</i>	not revised	not revised
17	<i>V. birmanica</i>	not revised	not revised
18	<i>V. calcarea</i>	<i>Koyamasia calcarea</i>	unplaced
19	<i>V. chiangdaoensis</i>	<i>A. chiangdaoensis</i>	Erlangeinae
20	<i>V. cinerea</i>	<i>Cyanthillium cinereum</i>	Erlangeinae
21	<i>V. curtisii</i>	not revised	not revised
22	<i>V. divergens</i>	<i>A. divergens</i>	Erlangeinae
23	<i>V. doichangensis</i>	<i>A. doichangensis</i>	Erlangeinae
24	<i>V. eberhardtii</i>	<i>D. eberhardtii</i>	Gymnantheminae
25	<i>V. elliptica</i>	<i>Tarlmounia elliptica</i>	Gymnantheminae
26	<i>V. garrettiana</i>	<i>D. garrettiana</i>	Gymnantheminae
27	<i>V. kingii</i>	<i>A. kingii</i>	Erlangeinae
28	<i>V. kradungensis</i>	<i>A. peguensis</i>	Erlangeinae
29	<i>V. namnaoensis</i>	<i>A. namnaoensis</i>	Erlangeinae
30	<i>V. ngaoensis</i>	<i>A. ngaoensis</i>	Erlangeinae
31	<i>V. parishii</i>	<i>Monosis parishii</i>	Gymnantheminae
32	<i>V. patula</i>	<i>Cyanthillium hookerianum</i>	Erlangeinae
33	<i>V. principis</i>	<i>A. principis</i>	Erlangeinae
34	<i>V. pseudobirmanica</i>	not revised	not revised
35	<i>V. pseudosutepensis</i>	<i>A. pseudosutepensis</i>	Erlangeinae
36	<i>V. pulicarioides</i>	not revised	not revised
37	<i>V. roxburghii</i>	not revised	not revised
38	<i>V. saligna</i>	<i>A. saligna</i>	Erlangeinae
39	<i>V. scandens</i>	<i>D. vagans</i>	Gymnantheminae
40	<i>V. silhetensis</i>	<i>A. silhetensis</i>	Erlangeinae
41	<i>V. solanifolia</i>	<i>S. solanifolia</i>	Gymnantheminae
42	<i>V. squarrosa</i>	<i>A. squarrosa</i>	Erlangeinae
43	<i>V. sutepensis</i>	<i>A. sutepensis</i>	Erlangeinae
44	<i>V. volkameriifolia</i>	<i>M. volkameriifolia</i>	Gymnantheminae

4. Materials and methods

4.1 Specimens were obtained during fieldworks in Thailand and from AAU, B, BCU, BK, BKF, BM, C, E, G, K, KKU, L, P, PSU, QBG and US herbarium specimens. The field collections have been deposited at KKU, QBG and US. Information recorded from specimens included distribution and ecological data when provided and the vernacular name if noted.

4.2 Keys to genera, species and varieties are provided along with descriptions of the genera, species and varieties. Only mature vegetative and reproductive parts were measured or scored for these descriptions.

4.3 Macromorphology: measurements, presence/absence and specifics of surfaces and vestitures were obtained manually or with a light microscope.

4.4 Micromorphology: cleaned achenes, leaf surfaces and unacetolyzed pollen were observed with scanning electron microscopy (SEM).

5. Explanatory notes on descriptions; based on Roque *et al.* (2009)

Capitulescence: secondary inflorescence in which the floral units are heads, the clustering of heads in the Compositae.

Capitulum or *head*: a short, dense indeterminate inflorescence of sessile flowers attached to a common receptacle.

Carpopodium: basal abscission zone of the achenes, formed by one or more seriated of cells generally different from the ones in the achene wall, more or less hardened.

Coroniform pappus: a pappus composed of very short, distinct or connate elements that collectively form crown-like ring.

Cymiform: a simple or compound secondary inflorescence that develops in the pattern of a simple or compound cyme. Usually restricted in Compositae descriptions to secondary inflorescences that develop in a distinctly cymose pattern. Most Compositae secondary inflorescences are technically cymiform because they are wholly or in part determinate in their pattern of development.

Discoid head: homogamous head contains only disk florets.

Disk florets: perfect, or less commonly functionally staminate, or rarely sterile, more or less tubulose, (3 – 4) 5-lobed, radial corolla limb, less commonly the limb bilabiate.

Floret: a small flower characteristic of the Compositae.

Involucre: disk-like to cup-shaped, ovoid, or cylindric group of bracts in one or more seriated that collectively subtend or surround the florets in a head.

Panicate: more or less pyramidal compound secondary inflorescences with a central rachis and shorter side branches. The sequence of head initiation and maturation is determinate.

Pappus: modified calyx consisting of bristles, dry scales, and/or awns, characteristic of the Compositae.

Pappus bristle: flexible to stiff, more or less hair-like pappus element.

Phyllary: one of the bracts that forms the primary involucre in the Compositae.

Receptacle: basal part of head onto which are inserted phyllaries, florets, and often palea.

Ribbed achenes: bearing raised longitudinal ridges.

Solitary head: head that is not clustered with others in a secondary inflorescence.

Spiciform: more or less cylindrical secondary inflorescence with a central rachis and sessile or subsessile heads. The sequence of inflorescence development is usually determinate with distal heads maturing before proximal heads.

Style branches: the result of incomplete fusion of the distal most portions of connate carpels of a compound pistil in which the carpel tips are distinct.

Twin hairs: two-celled trichomes characteristic of the achenes of many Compositae.

6. Illustration of plant measurements

Plant measurements used in keys and descriptions.

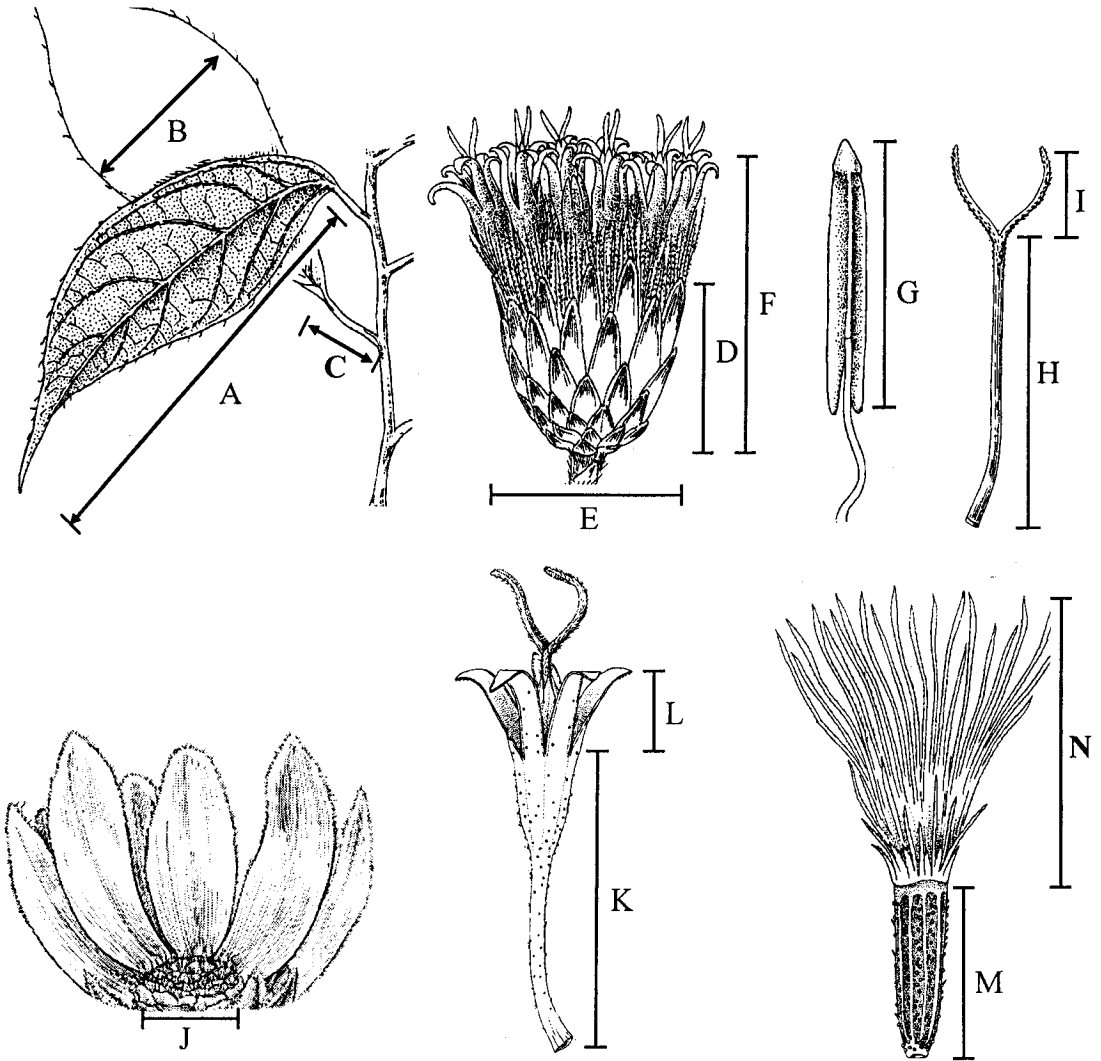


Figure 2.2 The illustrations of plant measurement were used in descriptions;

A. Leave length, B. Leave width, C. Petiole length, D. Involucral length, E. Involucral diameter, F. Capitula height, G. Anther length, H. Style length, I. Stigma length, J. Receptacle diameter, K. Corolla tube length, L. Corola lobe length, M. Achene length, N. Inner pappus length.

(Modified from Robinson, 1999a)

7. Results

Fifteen genera, 48 species and 51 taxa of Vernonieae are recognized in Thailand.

VERNONIEAE

Cassini in J. Phys. Chim. Hist. Nat. Arts 82: 132. 1816.

Type: *Vernonia noveboracensis* (L.) Willd., Sp. Pl., ed. 4, 3: 1632. 1803.

Serratula noveboracensis L., Sp.: 818. 1753.

Herbs, shrubs, vines or trees. *Stem* acaulescent or caulescent. *Leaves* simple, alternate or rosulate, petiolate or sessile; lamina ovate, obovate, lanceolate, oblanceolate or elliptic, pubescent, margins serrate or entire, apex rounded, acute or acuminate, base cuneate or attenuate, membranaceous, chartaceous or coriaceous. *Capitulescences* terminal or axillary, solitary, paniculate or corymbose with cymose branch, sometimes spicate. *Capitula* discoid, homogamous, pedunculate or sessile, florets bisexual and fertile. *Involucre* numerous, imbricate, persistent bracts. *Florets* purple to white, actinomorphic or zygomorphic, lobes 3 – 5, pubescent or glabrous. *Anthers* 5, purple to yellow or white, syngenesious. *Styles* purple to white, 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs. *Achenes* subterete, clavate or obovate, 3 – 10-ribbed, carpopodium present or absent. *Pappus* present or absent; if present bristly or coroniform, with 1 – 2-seriate, persistent or deciduous. *Pollen* echinate or lophate, 3-porate, 6-porate or 3-colporate, with or without micropuncta.

KEY TO THE GENERA

- | | |
|---|------------------------------|
| 1. Corolla strongly zygomorphic, liguliform with single deepest sinus | |
| 2. Pappus with straight apex | 5. Elephantopus |
| 2. Pappus with N-shaped apex | 12. Pseudelephantopus |
| 1. Corolla actinomorphic, without a single deepest sinus | |
| 3. Achenes without carpopodium | |
| 4. Pappus absent | |

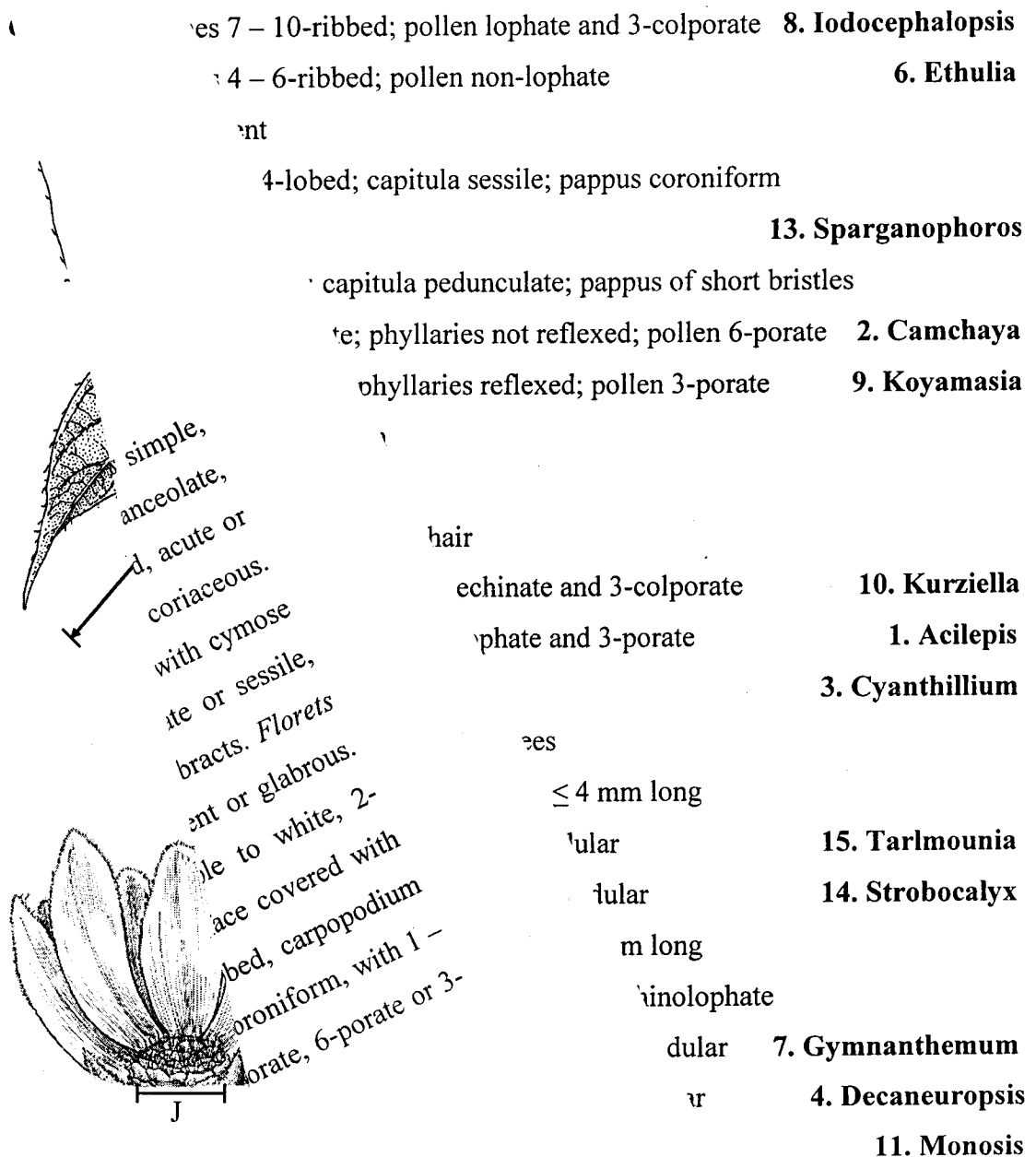


Figure 2.2 The illustra

- A. Leave lei
- E. Involucra_{est sinus}
- length, I. Stig
- L. Corola lobe
- (Modified from

alternate or
 gins serrate or
 attenuate, subcoriaceous.

- 5. Achenes 7 – 10-ribbed; pollen lophate and 3-colporate **8. Iodocephalopsis**
- 5. Achenes 4 – 6-ribbed; pollen non-lophate **6. Ethulia**
- 4. Pappus present
 - 6. Corolla 3 – 4-lobed; capitula sessile; pappus coroniform **13. Sparganophoros**
 - 6. Corolla 5-lobed; capitula pedunculate; pappus of short bristles
 - 7. Achenes obovate; phyllaries not reflexed; pollen 6-porate **2. Camchaya**
 - 7. Achenes oblong; phyllaries reflexed; pollen 3-porate **9. Koyamasia**
- 3. Achenes with carpopodium
 - 8. Herbs
 - 9. Leaves without T-shaped hair
 - 10. Pappus 1-seriate; pollen echinate and 3-colporate **10. Kurziella**
 - 10. Pappus 2-seriate; pollen lophate and 3-porate **1. Acilepis**
 - 9. Leaves with T-shaped hairs **3. Cyanthillium**
 - 8. Vines, erect or scandens shrubs or trees
 - 11. Achenes ≤ 2.5 mm long; involucre ≤ 4 mm long
 - 12. Achenes glabrous; involucre glandular **15. Tarlmounia**
 - 12. Achenes pubescent; involucre eglandular **14. Strobocalyx**
 - 11. Achenes > 2.5 mm long; involucre > 4 mm long
 - 13. Involucre 7 – 10 mm long; pollen subechinolophate
 - 14. Small trees; leaves serrate; achenes glandular **7. Gymnanthemum**
 - 14. Scandent; leaves entire; achenes eglandular **4. Decaneuropsis**
 - 13. Involucre 4 – 5 mm long; pollen psilolophate **11. Monosis**

1. Acilepis

D. Don, Prodr. Fl. Nepal.: 169. 1825.

Type: *Acilepis squarrosa* D. Don

Perennial herbs. *Stem* acaulescent or caulescent. *Leaves* simple, alternate or rosulate, petiolate, lamina ovate, obovate or elliptic, pubescent, margins serrate or entire, apex rounded, acute or acuminate, base cuneate or attenuate, subcoriaceous.

Capitulescences terminal or axillary, corymbose, paniculate, spiciform, scapose, solitary. *Capitula* discoid, homogamous, pedunculate or sessile, florets bisexual and fertile. *Involucre* herbaceous. *Florets* purple to white, actinomorphic, lobes 5. *Anthers* 5. *Styles* purple, 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs. *Achenes* subterete or obovate, usually 10-ribbed, carpopodium present. *Pappus* bristles, 2-seriate. *Pollen* lophate, 3-porate, with or without micropuncta.

Sixteen species are recognized in Thailand.

KEY TO THE SPECIES

1. Capitula more than 30 florets
 2. Phyllaries mostly reflexed
 3. Leaves acauline; corolla and achenes hairy **1. *A. attenuata***
 3. Leaves cauline; corolla and achenes without hairs **12. *A. silhetensis***
 2. Phyllaries not reflexed
 4. Capitula terminal, pedunculate
 5. Phyllaries with dense tomentum; peduncles subsessile **4. *A. doichangensis***
 5. Phyllaries with sparsely arachnoid hairs; peduncles elongated **7. *A. ngaoensis***
 4. Capitula axillary, sessile **13. *A. squarrosa***
1. Capitula < 30 florets
 6. Capitula pedunculate, involucre > 5 mm long
 7. Phyllaries herbaceous, apex mucronate or aristate
 8. Leaves chartaceous; achenes hairy
 9. Upper leaves elliptic, acute to acuminate; achenes glandular
 10. Leaves subsessile or with petioles up to 6 mm long
 11. Capitula with *ca.* 20 florets, pedunculate and cup-shaped, involucre with dense hairs **6. *A. namnaoensis***
 11. Capitula with 8 – 12 florets, pedunculate and oblong,

- involucre with sparse hairs **5. A. kingii**
10. Leaves petiolate, petioles up to 25 mm long
12. Corolla without hair; achenes 2 – 3.5 mm long
13. Inner pappus 8 – 9 mm long; involucre 8 – 10 mm long
14. Receptacle glabrous
15. Phyllaries and peduncles with densely villose; pappus
6 – 7 mm long; anthers purple **10. A. pseudosutepensis**
15. Phyllaries and peduncles with sparsely pilose;
pappus 8 – 9 mm long; anthers yellowish **14. A. sutepensis**
14. Receptacle pubescent **15. A. tonkinensis**
13. Inner pappus 6 – 7 mm long; involucre 6 – 7 mm long **16. A. virgata**
12. Corolla with sparse hairs; achenes 4 – 5 mm long **11. A. saligna**
9. Upper leaves linear-lanceolate to falcate, or caudate; achenes eglandular **9. A. principis**
8. Leaves membranaceous; achenes without hairs **8. A. peguensis**
7. Phyllaries scarious, spinose **2. A. chiangdaoensis**
6. Capitula subsessile, involucre ≤ 5 mm long **3. A. divergens**

1. Acilepis attenuata (DC.) H. Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2):

137. 2009. Type: India orient; *Wallich* 3020 (K!). Figures 2.16, 2.58 A. & B.

Conyza attenuata Wall., Numer. List [Wallich] no. 3020, comp. no. 130, *nom. nud.*

Vernonia attenuata DC., Prodr. 5: 33. 1836.

Perennial herbs 50 – 120 cm tall. *Stem* erect, conspicuously ribbed, puberulous. *Leaves* simple, rosulate, 9 – 22 by 2 – 8 cm, obovate to obovate-lanceolate or elliptic, margins entire or serrate, apex obtuse or acute, base cuneate or attenuate, subcoriaceous, upper surface scabrous and eglandular; lower surface scabrous with whip-shaped hairs and capitate glands; lateral veins 5 – 11-paired; petioles up to 5 mm long. *Capitulescences* terminal, scapose. *Capitula* campanulate, 15 – 18 mm long, pedunculate. *Receptacle* flat, 6 – 8 mm diam., glabrous. *Phyllaries*

6 – 7-seriate, herbaceous, campanulate, green with purple apex, 7 – 11 mm long, margins filiferous, outer surface arachnoid without glands; the outer and the middle ones ovate, apex apiculate, upper half reflexed; the inner ones ovate-lanceolate to oblong, apex acuminate. *Florets* 40 – 65, infundibular, purple, puberulous glandular; corolla tube 6 – 8.5 mm long; corolla lobes 2 – 3 mm long. *Anthers* 2.5 – 3 mm long, apical appendage acute, base obtuse. *Styles* purple, 7 – 10 mm long, branches 2.5 – 4 mm long, sweeping hairs on outside surface reaching below style bifurcation. *Achenes* subterete, 2.5 – 3 mm long, 10-ribbed, pubescent with twin hairs and capitate glands, carpodium present. *Pappus* bristles, 2-seriate, the inner ones 7 – 7.5 mm long, persistent. *Pollen* echinolophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai; NORTH-EASTERN: Nong Bua Lum Phu, Udon Thani, Sakon Nakhon; SOUTH-WESTERN: Kanchanaburi; PENINSULAR: Satun.

Distribution.— Myanmar, Thailand.

Ecology.— Dipterocarp or dry evergreen forest, alt. 50 – 780 m; flowering October to February.

Note.— *A. attenuata* is distinguished by reflexed phyllaries, rosulate leaves and spicate capitulescences with a conspicuous scape.

Specimens examined.— *S. Bunwong* 15 (KKU), 347 (KKU, US), 351 (KKU, US), 354 (KKU, US), 373 (KKU, US); *G. Congdon* 62 (AAU, PSU), s.n. (PSU); *B. Hansen & T. Smitinand* 12722 (C, E, K, L, P); *A.F.G. Kerr* 10147 (BK, BM, K); *J.F. Maxwell* 87-88 (E), 93-190 (L); *W. Nanakorn et al.* 5415 (QBG); *Pradit* 641 (BK); *S. Sutheesorn* 3589 (BK); *Th. Sørensen, K. Larsen & B. Hansen* 2439 (C).

2. *Acilepis chiangdaoensis* (H.Koyama) H.Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2): 140. 2009. Type: as *Vernonia chiangdaoensis* H.Koyama. Figures 2.17, 2.58 C. & D.

Vernonia chiangdaoensis H.Koyama, Bull. Natl. Sci. Mus., Tokyo, B. 31(2): 69. 2005. Type: Thailand, Chiang Mai, Doi Chiangdao, *M. Tagawa, K. Iwatsuki & N. Fukuoka* T-4038 (KYO!).

Perennial herbs, 1 – 2 m tall. *Stem* erect, conspicuously ribbed, villose. *Leaves* 10 – 30 by 4 – 10 cm, lanceolate, margins serrate, apex acuminate, base attenuate, subcoriaceous, upper surface scabrous and without glands; lower surface scabrous with whip-shaped hairs, cylindrical hairs and capitate glands; lateral veins 7 – 10-paired; petioles up to 3 cm long. *Capitulescences* terminal, paniculate. *Capitula* campanulate, 10 – 12 mm long, pedunculate. *Receptacle* flat, 2 – 2.5 mm diam., pubescent. *Phyllaries* 4 – 5-seriate, scarious, campanulate, green or purple apically, 8 – 10 mm long, margins filiferous, outer surface villose, glands capitate; the outer and the middle ones lanceolate, apex spinose; the inner lanceolate to oblong, apex acuminate. *Florets* 10 – 15, narrowly infundibular, purple or white, glandular; corolla tube 4 – 5 mm long; corolla lobes 2.5 – 3 mm long. *Anthers* 2.5 – 2.8 mm long, apical appendage acute, base obtuse. *Styles* purple, 4.5 – 6 mm long, branches 2.5 – 3 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* subterete, 2.5 – 3.5 mm long, 10-ribbed, pubescent with twin hairs and capitate glands, carpopodium present. *Pappus* bristles, 2 seriate, the inner ones 6 – 6.5 mm long, persistent. *Pollen* echinolophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Chiang Mai.

Distribution.— Endemic to Thailand.

Ecology.— Mixed deciduous or pine-oak forest, alt. 600 – 800 m; flowering December to February.

Vernacular.— Dok See Pa (ดอกสีฟ้า), DoK Doi Pa (ดอกดอยฟ้า).

Note.— *A. chiangdaoensis* is distinguished by the largest leaves within the genus and scarious apical spinose phyllaries.

Specimens examined.— *S. Bunwong* 77 (KKU, US); *J.F. Maxwell* 89-1585 (CMU, L), 89-1597 (QBG); *W. Nanakorn et al.* 209 (QBG), 10191 (QBG); *S. Sutheesorn* 2235 (K); *Th. Sørensen, K. Larsen & B. Hansen* 1073 (BKF, C, K); *M. Tagawa, K. Iwatsuki & N. Fukuoka* T-4038 (KYO).

3. *Acilepis divergens* (Edgew.) H.Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2): 140. 2009. Type: India; *Wallich* 3027A (K!). Figures 2.18, 2.59 A. & B.

Conyza divergens Wall., Numer. List [Wallich] no. 3027A, comp. no. 137, *nom. nud.*

Eupatorium divergens Roxb., Fl. Ind. 3: 414. 1832.

Vernonia divergens (Roxb.) Edgew., J. Asiat. Soc. Bengal 2: 172. 1853.

Shrubby herbs, 1 – 3 m tall. *Stem* erect, inconspicuously ribbed, pilose-villose or tomentose. *Leaves* 10 – 13 by 3 – 5 cm, ovate or elliptic, margins serrate, apex acute, base attenuate, subcoriaceous; both surfaces scabrous with whip-shaped hairs and capitate glands; lateral veins 6 – 10-paired; petioles up to 1 cm long. *Capitulescences* terminal and axillary, corymbose. *Capitula* narrowly campanulate, subsessile or shortly pedunculate, 9 – 10 mm long. *Receptacle* flat, *ca.* 1 mm diam., glabrous. *Phyllaries* 3 – 4-seriate, herbaceous, narrowly campanulate or slightly oblong-cylindrical, green or purple apically, 4 – 5 mm long, 3 – 3.5 mm diam., margins filiferous, outer surface arachnoid, glandular; the outer and the middle ones ovate, acuminate or apiculate; the inner ones lanceolate to oblong, apex acuminate. *Florets* 6 – 10, infundibular, purple, glandular; corolla tube 4 – 5 mm long; corolla lobes 2 – 2.5 mm long. *Anthers* 2 – 2.5 mm long, apical appendage acute, base obtuse. *Styles* purple, 5 – 6 mm long, branches 1.5 – 2 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* obovate, *ca.* 2 mm long, 10-ribbed, glandular, carpodium present. *Pappus* bristles, 2-seriate, the inner ones 4 – 5 mm long, persistent. *Pollen* echinolophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Chiang Mai, Phayao, Nan, Tak, Sukhothai; NORTH-EASTERN: Loei; SOUTH-WESTERN: Kanchanaburi.

Distribution.— China (Yunnan), India, Myanmar, Thailand, Laos, Cambodia, Vietnam.

Ecology.— Open deciduous and hill evergreen forests, alt. 300 – 1,850 m; flowering October to April.

Vernacular.— San Ngern (สารเงิน), Nat Foi (หนาดฟอย).

Note.— *A. divergens* is clearly distinguished by having a corymbose capitulescences with short pedicel and its capitula that are among the smallest *Acilepis* spp.

Specimens examined.— *Adisai* 1046 (BK); *Amporn* 15 (BKF); *K. Bunchuai* 102 (BKF, C, E, K, L, P); *S. Bunwong* 39 (KKU), 56 (KKU), 377 (KKU, US); *Charal* 431 (BKF); *N. Fukuoka & H. Koyama* T-62103 (BKF); *R. Geesink, P. Hiepko & C. Phengklai* 8027 (L), 8115 (BKF, C); *B. Hansen, G. Seidenfaden & T. Smitinand* 10796 (L), 10976 (BKF, C); *B. Hansen & T. Smitinand* 12926 (BKF, C, E, K, L); *A.F.G. Kerr* 524 (BM, K), 2918 (BM, K), 8747 (BK, K), 10227 (BK, K, BM); *F. Konta, C. Phengklai & S. Khao-iam* 4135 (BKF); *H. Koyama, S. Mitsuta & T. Yahara* T-39916 (BKF), T-48693 (BKF); *H. Koyama & C. Phengklai* T-39844 (BKF); *T. Koyama, C. Phengklai, C. Niyomdham, M. Tamura, H. Okada & P.J. O'connor* 15357 (QBG), 15371 (QBG); *H. Koyama, H. Terao & Th. Wongprasert* T-31991 (AAU, BKF, C, L), T-32172 (BKF), T-32264 (BKF), T-32267 (BKF), T-32350 (BKF), T-32455 (BKF), T-32634 (BKF), T-32797 (BKF), T-32813 (BKF), T-33188 (AAU), T-33293 (BKF), T-33379 (BKF), T-33524 (BKF), T-33533 (BKF), T-48693 (BKF); *K. Larsen* 9533 (K, L); *J.F. Maxwell* 90-156 (CMU, E, L), 91-18 (CMU, L), 91-72 (CMU, L), 91-117 (CMU, L), 93-94 (CMU, L), 95-45 (BKF, L), 95-185 (BKF, L), 95-1306 (L), 96-95 (BKF, CMU, L), 97-1502 (BKF, CMU, L), 01-113 (BKF, CMU); *W. Nanakorn et al.* 388 (QBG), 2859 (QBG), 5459 (QBG), 5501 (QBG), 5561 (QBG), 5778 (QBG); *Y. Paisooksantivatana* 1590-85 (BK), 1747-86 (BK); *O. Petrmitr* 200 (L); *C. Phengklai et al.* 3092 (C, L); *R. Pooma* 1004 (BKF); *Put* 4423 (BK, BM, K, L); *J. Sadakorn* 292 (BK); *T. Santisuk* 1082 (BKF), 1599 (BKF); *T. Smitinand* 8738 (BKF); *T. Soradet* 390 (BKF); *P. Srisanga* 2623 (QBG); *P. Srisanga, S. Sasirat, W. Pongamornkul, S. Sukiam & P. Panyachan* 2452 (QBG); *P. Suksathan* 1573 (QBG); *S. Sutheesorn* 3281 (BK); *Th. Sørensen, K. Larsen & B. Hansen* 1232 (C, BKF, K), 6571 (BKF, C, K, L); *B. Tantisewie & C. Phengklai* 714 (BKF, C, K,)

4. *Acilepis doichangensis* (H.Koyama) H.Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2): 140. 2009. Type: as *Vernonia doichangensis* H.Koyama. Figures 2.19, 2.59 C. & D.

Vernonia doichangensis H.Koyama, Bull. Natl. Sci. Mus. Tokyo, Ser. B. 30(1): 22. 2004. Type: Thailand, Chiang Mai, Mae Taeng District, Doi Chang; *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk* T-20693 (KYO!).

Shrubby herbs, rhizomatous, 0.5 – 2 m tall. *Stem* erect, conspicuously ribbed, puberulose. *Leaves* 7 – 15 by 2 – 6 cm, elliptic or oblanceolate, margins subentire or remotely serrulate, apex acute or acuminate, base cuneate, subcoriaceous; both surfaces scabrous with hairs and capitate glands; lateral veins 8 – 10-paired; petioles up to 5 mm long. *Capitulescences* terminal and axillary, paniculate. *Capitula* campanulate, subsessile or pedunculate. *Receptacle* flat, glabrous. *Phyllaries* 5 – 6-seriate, herbaceous, narrowly campanulate, 10 – 12 mm long, margins filiferous, outer surface tomentose, glandular; the outer and the middle ones ovate, acuminate; the inner ones lanceolate to oblong, apex acute. *Florets* ca. 35, infundibular, purple, glandular; corolla tube 4 – 5 mm long; corolla lobes 4 – 5 mm long. *Achenes* oblong, ca. 5 mm long, 10-ribbed, glabrous. *Pappus* bristles, 2-seriate, the inner ones ca. 8 mm long, persistent.

Thailand.— NORTHERN: Chiang Mai.

Distribution.— Endemic to Thailand.

Ecology.— Hill evergreen forest, alt. 1,000 – 1,300 m; flowering September to January.

Note.— *A. doichangensis* is distinguished from *A. attenuata* and *A. silhetensis* by its tomentose involucre and glabrous achenes.

Specimens examined.— *T. Shimitzu*, *H. Toyokuni*, *H. Koyama*, *T. Yahara* & *T. Santisuk* T-19059 (KYO), T-20678 (KYO), T-20693 (KYO).

5. *Acilepis kingii* (C.B.Clarke) H.Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2): 141. 2009. Type: as *Vernonia kingii* C.B.Clarke. Figures 2.20, 2.60 A. & B.

Vernonia kingii C.B.Clarke, Compos. Ind: 12. 1876. Type: Myanmar, Yomah Province, Pegu, Irrawaddy & Sittang Valley, *S. Kurz* s.n. (K!).

Perennial herbs, 1 – 1.5 m tall. *Stem* erect, conspicuously ribbed, puberulous. *Leaves* 10 – 20 by 4 – 8 cm, lanceolate, margins serrate, apex acuminate, base attenuate, subcoriaceous; both surfaces scabrous with whip-shaped hairs and capitate glands; lateral veins 9 – 10-paired; petioles up to 2.5 cm long. *Capitulescences*

terminal and axillary, paniculate. *Capitula* campanulate, 10 – 12 mm long, pedunculate. *Receptacle* flat, 2 – 2.5 mm diam., hairy. *Phyllaries* 4 – 5-seriate, herbaceous, narrowly campanulate, light green or purple apically, 5 – 6 mm long, 3 – 3.5 mm diam., margins filiferous, outer surface arachnoid, capitate glands; the outer and the middle ones ovate, apex obtuse and apiculate; the inner ones ovate-lanceolate to oblong, apex obtuse or apiculate. *Florets* 8 – 12, infundibular, purple or white, glandular; corolla tube 4 – 5 mm long; corolla lobes 2.5 – 3 mm long. *Anthers* yellowish, 2.5 – 3 mm long, apical appendage acute, base acute. *Styles* purple, 5 – 7 mm long, branches 2 – 3 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* subterete, 2.5 – 3.5 mm long, 10-ribbed, pubescent, glands capitate, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 6 – 6.5 mm long, persistent. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai, Chiang Rai.

Distribution.— China (Yunnan), India, Myanmar, Thailand, Laos.

Ecology.— Hill evergreen or pine-oak forest, alt. 1,000 – 1,800 m; flowering January to March.

Note.— *A. kingii* is recognized by obtuse and apiculate phyllaries and loose paniculate capitulescence.

Specimens examined.— *S. Bunwong* 78 (KKU, US); *S. Gardner* H172 (L); *R. Geesink*, *P. Hiepko* & *C. Phengklai* 8277 (BKF, C, K, L, P); *A.F.G. Kerr* 4729 (BK, BM, K); *J.F. Maxwell* 89-1442 (CMU, L), 97-157 (BKF); *W. Nanakorn et al.* 5683 (QBG); *Y. Paisooksantivatana* 840-82 (BKF).

6. *Acilepis namnaoensis* (H.Koyama) H.Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2): 141. 2009. Type: as *Vernonia namnaoensis* H.Koyama. Figures 2.21, 2.60 C. & D.

Vernonia namnaoensis H.Koyama, Bull. Natl. Sci. Mus., Tokyo, B. 30(1): 22. 2004. Type: Thailand, Phetchabun, Nam Nao national park, *H. Koyama*, *H. Terao* & *Th. Wongprasert* T-311840 (KYO!).

Perennial herbs, 1 – 2 m tall. *Stem* erect, conspicuously ribbed, villose. *Leaves* 15 – 20 by 5 – 8 cm, obovate or oblanceolate, margins serrate, apex acuminate, base cuneate, subcoriaceous; both surfaces scabrous with whip-shaped hairs and capitate glands; lateral veins 6 – 8-paired; petioles up to 10 mm long. *Capitulescences* terminal and axillary, paniculate. *Capitula* campanulate, 12 – 15 mm long, pedunculate. *Receptacle* flat, 2 – 2.5 mm diam., hairy. *Phyllaries* 4 – 5-seriate, herbaceous, campanulate, light green, 7 – 8 mm long, 6 – 7 mm diam., margins filiferous, outer surface with densely arachnoid, glands capitate; the outer and the middle ones ovate, apex spinose; the inner ones ovate-lanceolate, apex apiculate. *Florets* ca. 20, infundibular, purple, glandular; corolla tube ca. 5 mm long; corolla lobes ca. 3 mm long. *Anthers* yellowish, ca. 3 mm long, apical appendage acute, base acute. *Styles* purple, 5 – 8 mm long, branches 1.5 – 2.5 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* subterete, 3.5 – 4 mm long, 10-ribbed, covered with sparse hairs and glands, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 6 – 7 mm long, persistent. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.– NORTH-EASTERN: Phetchabun; EASTERN: Chaiyaphum.

Distribution.– Endemic to Thailand.

Ecology.– Dry dipterocarp or dry evergreen forest, alt. 800 m; flowering November to December.

Note.– *A. namnaoensis* is characterized by its involucre is cup-shaped and phyllaries are spinose with whitish tomentose. Its specific epithet is derived from Nam Nao national park in Phetchabun province.

Specimens examined.– *S. Bunwong* 385 (KKU, US); *H. Koyama*, *H. Terao* & *Th. Wongprasert* T-311840 (KYO).

7. *Acilepis ngaoensis* (H.Koyama) H.Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2): 141. 2009. Type: as *Vernonia ngaoensis* H.Koyama. Figures 2.22, 2.61 A. & B.

Vernonia ngaoensis H.Koyama, Bull. Natl. Sci. Mus., Tokyo, B. 30(1): 25. 2004.
Type: Thailand, Ranong, Muang District, Ngao waterfall, T. Shimitzu, H. Toyokuni,
H. Koyama, T. Yahara & C. Niyomdham T-26543 (KYO!).

Perennial herbs, 0.6 – 1.2 m tall. *Stem* erect, conspicuously ribbed, puberulous. *Leaves* 10 – 20 by 2 – 5 cm, elliptic or oblanceolate, margins serrate, apex acuminate to acuminate, base cuneate, subcoriaceous; both surfaces scabrous with whip-shaped hairs and capitate glands; lateral veins 9 – 11-paired; petioles up to 10 mm long. *Capitulescences* terminal or axillary, solitary or loosely paniculate. *Capitula* campanulate, 10 – 20 mm long, pedunculate. *Receptacle* flat, hairy. *Phyllaries* 6 – 7-seriate, herbaceous, campanulate, light green or purple apically, 10 – 15 mm long, margins filiferous, outer surface arachnoid, glands capitate; the outer and the middle ones ovate or lanceolate, apex spinose; the inner ones lanceolate or oblong, apex apiculate. *Florets* ca. 80, infundibular, purple, glandular; corolla tube 7 – 8 mm long; corolla lobes 3 – 4 mm long. *Anthers* 3.5 – 4 mm long, apical appendage acute, base obtuse. *Styles* purple, 7 – 9 mm long, branches 3 – 3.5 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* subterete, 3 – 4 mm long, 10-ribbed, pubescent with twin hairs, and glands, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 8 – 9 mm long, persistent. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.– PENINSULAR: Ranong.

Distribution.– Endemic to Thailand.

Ecology.– Rocky dry dipterocarp, alt. 100 m; flowering December to January.

Note.– *A. ngaoensis* is recognized by having large capitula with a long peduncle, phyllaries are non reflexed and capitulescences are solitary or loosely paniculate. Its specific epithet is derived from Ngao waterfall national park in Ranong province.

Specimens examined.– S. Bunwong 386 (KKU, US); S. Indrapong 84 (BKF), 843 (K, L); J.F. Maxwell 87-88 (AAU, BKF, CMU, L, P, PSU); T. Santisuk 650 (BKF); T. Shimitzu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham T-26543 (KYO).

8. *Acilepis peguensis* (C.B.Clarke) H.Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2): 141. 2009. Type: as *Vernonia peguensis* C.B.Clarke. Figures 2.23, 2.61 C. & D.

Vernonia peguensis C.B.Clarke, Compos. Ind.: 13. 1876. Type: Myanmar, Yomah province, Pegu, *S. Kurz* 882 (K!).

Vernonia kradungensis H.Koyama, Bull. Natl. Sci. Mus., Tokyo, B. 30(2): 72. 2005. Type: Thailand, Loei, Phu Kradung national park; *H. Koyama, H. Terao & Th. Wongprasert* T-31211 (KYO!).

Perennial herbs, 0.5 – 1.5 m tall. *Stem* erect, conspicuously ribbed, sericeous. *Leaves* 10 – 20 by 3 – 6 cm, oblanceolate or obovate, margins serrate, apex acute or acuminate, base attenuate, chartaceous; both surfaces scabrous with whip-shaped hairs and capitate glands; lateral veins 4 – 8-paired; petioles up to 30 mm long. *Capitulescences* terminal or axillary, paniculate. *Capitula* campanulate, 10 – 12 mm long, pedunculate. *Receptacle* flat, 2 – 2.5 mm diam., hairy. *Phyllaries* 4 – 5-seriate, herbaceous, narrowly campanulate or slightly oblong-cylindrical, light green, 5 – 6 mm long, 3 – 4 mm diam., margins filiferous, outer surface arachnoid, glands capitate; the outer and the middle ones ovate, apex acuminate or aristate; the inner ones lanceolate to oblong, apex acuminate. *Florets* 10 – 15, infundibular, white or purple, glandular; corolla tube 4.5 – 5 mm long; corolla lobes 2.5 – 3 mm long. *Anthers* purple, 3 – 3.5 mm long, apical appendage acute, base obtuse. *Styles* purple, 6 – 7 mm long, branches 2 – 2.5 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* subterete, 2.5 – 3.5 mm long, 10-ribbed, glandular, carpodium present. *Pappus* bristles, 2-seriate, the inner ones 5.5 – 6 mm long, persistent. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTH-EASTERN: Loei.

Distribution.— Myanmar, Thailand.

Ecology.— Deciduous or dry evergreen forest, alt. 800 m; flowering November to December.

Vernacular.— Dok Khon Kai Noi (ดอกขนไก่น้อย).

Note.— The distinct features of *A. peguensis* are membranaceous leaves and achenes without hair.

Specimens examined.— *D. Bunpheng* 264 (K); *S. Bunwong* 372 (KKU, US); *H. Koyama, H. Terao & Th. Wongprasert* T-31211 (KYO); *G. Murata, C. Phengkklai, S. Mitsuta & T. Yahara* T-43083 (BKF, L, KYO); *H. Nagamasu & N. Nantasan* T-43024 (AAU, BKF, KYO, US).

9. *Acilepis principis* (Gagnep.) H. Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2): 143. 2009. Type: as *Vernonia principis* Gagnep. Figures 2.24, 2.62 A. & B.

Vernonia principis Gagnep., Bull. Mus. Hist. Nat. 25: 490. 1919. Type: Thailand, Molu, Prince H. d'Orleans s.n. (P!).

Perennial herbs, 0.5 – 2 m tall. *Stem* erect, conspicuously ribbed, puberulous. *Leaves* 10 – 25 by 3 – 8 cm, ovate-lanceolate or lanceolate, margins serrate, apex acute, base cuneate, subcoriaceous; upper surface scabrous without glands; lower surface scabrous with whip-shaped hairs and capitate glands, lateral veins 9 – 15-paired; petioles up to 10 mm long. *Capitulescences* terminal or axillary, paniculate. *Capitula* campanulate, 10 – 15 mm long, pedunculate. *Receptacle* flat, 2.5 – 3 mm diam., hairy. *Phyllaries* 5 – 6-seriate, herbaceous, campanulate, light green or purple apically, 7 – 8 mm long, 4 – 5 mm diam., margins filiferous, outer surface arachnoid, eglandular; the outer and the middle ones ovate, apex aristate or apiculate; the inner ones ovate-lanceolate, apex obtuse or apiculate. *Florets* 20 – 25, infundibular, purple or white, glabrous; corolla tube 5 – 6 mm long; corolla lobes 3 – 4 mm long. *Anthers* purple, 3 – 4 mm long, apical appendage acute, base obtuse. *Styles* purple, 8 – 9 mm long, branches 3 – 4 mm long, sweeping hairs on the outer surface reaching at style bifurcation. *Achenes* subterete, 2.5 – 3 mm long, 10-ribbed, pubescent with twin hairs, carpodium present. *Pappus* bristles, 2-seriate, the inner ones 7 – 8 mm long, persistent. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Chiang Rai, Nan, Lamphun, Lampang, Tak.

Distribution.— Endemic to Thailand.

Ecology.— Evergreen forest, alt. 600 – 1,400 m; flowering December to March.

Note.— This species is similar to *A. kingii* and *A. saligna* in capitula shape but differs in achenes without hair and the upper leaves lanceolate-oblong with caudate apex or falcate shape.

Specimens examined.— *S. Bunwong* 382 (KKU, US); *H.B.G Garrett* 855 (BKF, E, K, L, P); *B. Hansen, G. Seidenfaden & T. Smitinand* 10862 (C, K, L, P); *C.C. Hosseus* 328 (BM, K, L); *K. Iwatsuki & N. Fukuoka* T3464 (AAU, BKF), T3556 (KYO); *H. Koyama & C. Phengklai* T-39099 (AAU); T-39209 (AAU, KYO, US); *J.F. Maxwell* 91-123 (L), 93-1382 (L), 93-1563 (BKF, L), 96-22 (L), 97-1540 (L); *Put* 3449 (BM, K), 3454 (K); *P. Srisanga* 2392 (QBG); *P. Srisanga, S. Sasirat, W. Pongamornkul, S. Sukiam & P. Panyachan* 2483 (QBG); *S. Sutheesorn* 1557 (BKF); *Th. Wongprasert & S. Khao-iam* 212-43 (BKF).

10. *Acilepis pseudosutepensis* (H.Koyama) H.Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2): 143. 2009. Type: as *Vernonia pseudosutepensis* H.Koyama. Figures 2.25, 2.62 C. & D.

Vernonia pseudosutepensis H.Koyama, Bull. Natl. Sci. Mus. Tokyo, Ser. B. 31(2): 74. 2005. Type: Thailand, Uthai Thani, Huay Ka Kaeng, *J.F. Maxwell* 76-94 (AAU!, L!).

Perennial herbs, 60 – 150 cm tall. *Stem* erect, conspicuously ribbed, sericeous. *Leaves* simple, alternate at base, 10 – 14 by 4 – 7 cm, ovate-lanceolate or elliptic, margins serrate, apex acuminate, base cuneate or acuminate, subcoriaceous; upper surface scabrous without glands; lower surface scabrous with whip-shaped hairs and capitate glands; lateral veins 9 – 11-paired; petioles up to 10 mm long. *Capitulescences* terminal and axillary, paniculate. *Capitula* campanulate, 10 – 15 mm long, pedunculate. *Receptacle* flat, 1.5 – 3 mm diam., glabrous. *Phyllaries* 5 – 6-seriate, herbaceous, narrowly campanulate, light green or purple apically, 8 – 10 mm long, 3 – 4 mm diam., margins filiferous, outer surface densely arachnoid, capitate glands; the outer and the middle ones ovate or lanceolate, apex apiculate or aristate; the inner ones ovate-lanceolate to oblong, apex apiculate. *Florets* 10 – 15, infundibular, purple, glandular; corolla tube 7 – 8 mm long; corolla lobes 3 – 4 mm

long. *Anthems* 3.5 – 4 mm long, apical appendage acute, base obtuse. *Styles* purple, 7 – 9 mm long, branches 3 – 3.5 mm long, sweeping hairs on the outer surface reaching at style bifurcation. *Achenes* subterete, 2 – 3.5 mm long, 10-ribbed, pubescent with twin hairs and capitate glands, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 6 – 7 mm long, persistent. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Tak; SOUTH-WESTERN: Uthai Thani, Kanchanaburi.

Distribution.— Endemic to Thailand.

Ecology.— Limestone mountain or mixed evergreen forest, alt. 200 – 400 m; flowering December to February.

Vernacular.— Ka Ma Plong (กะมาพล่อง).

Note.— *A. pseudosutepensis* is recognized by leaves usually alternate at base, elongate peduncle, loose capitulescences, densely villose and scarious phyllaries.

Specimens examined.— *S. Bunwong* 388 (KKU, US); *K. Larsen* 8794 (C, L), 8990 (C, L); *J.F. Maxwell* 76-94 (AAU, BK, L), 94-41 (L); *Y. Paisooksantivatana* 1558-85 (BK); *C. Phengklay* 346 (BKF, L).

11. *Acilepis saligna* (DC.) H. Rob. Proc. Biol. Soc. Wash. 112(1): 226. 1999.
Type: India Orient, Silhet, *Wallich* 3061 (E!, G!, K!). Figures 2.26, 2.63 A. & B.

Conyza saligna Wall., Numer. List [Wallich] no. 3061, comp. no. 171, *nom. nud.*
Vernonia saligna DC., Prodr. 5: 33. 1836.

Perennial herbs, 2 – 2.5 m tall. *Stem* erect, conspicuously ribbed, sericeous. *Leaves* 10 – 15 by 3 – 6 cm, lanceolate or elliptic, margins serrate, apex acuminate, base cuneate, subcoriaceous; both surfaces scabrous with whip-shaped hairs and capitate glands; lateral veins 6 – 10-paired; petioles up to 6 mm long. *Capitulescences* terminal or axillary, paniculate. *Capitula* campanulate, 6 – 7 mm long, pedunculate. *Receptacle* flat, 2 – 2.5 mm diam., hairy. *Phyllaries* 5 – 6-seriate, herbaceous, campanulate, light green or purple apically, 6 – 7 mm long, 3.5 – 4.5 mm diam., margins filiferous, outer surface arachnoid, glands capitate; the outer and the middle

ones ovate, apex acuminate or cuspidate; the inner ones ovate-lanceolate to oblong, apex rounded or apiculate. *Florets* 10 – 15, infundibular, purple, puberulous glandular; corolla tube 6 – 7 mm long; corolla lobes 2 – 3 mm long. *Anthers* purple, 2.5 – 3 mm long, apical appendage acute, base obtuse. *Styles* purple, 5 – 7 mm long, branches 1.5 – 2 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* subterete, 3 – 3.5 mm long, 10-ribbed, pubescent with twin hairs and capitate glands, carpodium present. *Pappus* bristles, 2-seriate, the inner ones 6 – 7 mm long, persistent. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Chiang Mai.

Distribution.— China (Yunnan), India, Nepal, Bhuthan, Myanmar, Thailand, Laos, Vietnam.

Ecology.— Pine-oak forest, alt. 1,100 – 1,400 m; flowering November to December.

Note.— *A. saligna* is different from *A. kingii* by its sessile leaves and smaller capitula in a dense panicle.

Specimens examined.— *S. Bunwong* 357 (KKU, US); *E. Hennipman* 3220 (BKF, P).

12. *Acilepis silhetensis* (DC.) H. Rob., Proc. Biol. Soc. Wash. 112(1): 227. 1999.

Type: India, Silhet; *Wallich* 2921 (E!). Figures 2.27, 2.63 C. & D.

Vernonia bracteata Wall., Numer. List [Wallich] no. 2921, comp. no. 31, *nom. nud.*

Decaneurum silhetense DC., Prodr. 5: 67. 1836.

Vernonia silhetensis (DC.) Hand.— Mazz., Zymb. Sin. Pt. 7: 1084. 1936.

Perennial herbs, 1 – 3 m tall. *Stem* erect, inconspicuously ribbed, pilose. *Leaves* 7 – 12 by 2 – 4 cm, lanceolate or oblanceolate, margins serrate, apex acute or acuminate, base attenuate, subcoriaceous; both surfaces scabrous with whip-shaped hairs and capitate glands; lateral veins 5 – 10-paired; petioles up to 1 cm long. *Capitulescences* terminal, paniculate or solitary. *Capitula* campanulate, 15 – 20 mm long, pedunculate. *Receptacle* flat, 6 – 10 mm diam., hairy. *Phyllaries* 6 – 7-seriate,

herbaceous, campanulate, dark purple or green with purple apex, 11 – 18 mm long, 10 – 15 mm diam., margins filiferous, outer surface arachnoid lacking glands; the outer and the middle ones ovate, apex acuminate, upper half strongly reflexed; the inner ones ovate-lanceolate to oblong, apex acuminate or aristate. *Florets* 50 – 75, infundibular, purple, glandular; corolla tube 8 – 12 mm long; corolla lobes 3.5 – 5 mm long. *Anthers* 3.5 – 4.5 mm long, apical appendage acute, base obtuse. *Styles* purple, 10 – 12 mm long, branches 3.5 – 4.5 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* subterete, 4 – 5 mm long, 10-ribbed, glandular, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 6.5 – 8 mm long, persistent. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai, Lamphun, Lampang; NORTH-EASTERN: Phetchabun, Loei, Khon Kaen.

Distribution.— China, India, Bhutan, Myanmar, Thailand, Laos, Cambodia.

Ecology.— Dipterocarp or pine-oak forest, alt. 700 – 1,350 m; flowering August to January.

Vernacular.— Phak Phet Kao Kum (ผักเผ็ดข้าวท่า), Ya Klung (หญ้าคลัง), Ya Hang Nok Kiew (หญ้าทางนกเขียว), Hudsakuen (หุสคีน).

Note.— This species is distinguished by its strongly reflexed phyllaries and glandular achenes lacking trichomes.

Specimens examined.— *Adisai* 714 (BK); *K. Buchuai* 279 (AAU, BKF); *S. Bunwong* 19 (KKU), 49 (KKU), 364 (KKU, US); *C. Charoenpol*, *K. Larsen* & *E. Warncke* 4855 (BKF); *Dee* 159 (BKF), 195 (E); *Din* 125 (BKF); *N. Fukuoka* & *M. Ito* T-35208 (BKF); *C. Glamwaewwong* 45 (QBG); *C.C. Hosseus* 313a (BM, K); *A.F.G. Kerr* 828A (BM, K); *F. Konta*, *Th. Wongprasert* & *B. Sangkhachand* 29740 (BKF), 29741 (BKF); *H. Koyama* T-39781 (BKF, L), T-39884 (BKF, L), T-61104 (BKF); *H. Koyama*, *S. Mitsuta*, *T. Yahara* & *H. Nagamasu* T-39671 (BKF, L), T-39760 (L); *H. Koyama*, *T. Yahara*, *H. Nagamasu*, *W. Nanakorn* & *N. Nantasan* T-39710 (AAU, BKF, L), T-39736 (BKF, L); *H. Koyama* & *C. Phengklai* T-39197 (BKF, L); *H. Koyama*, *H. Terao* & *Th. Wongprasert* T-31330 (C, BKF), T-31340 (BKF); *J.F. Maxwell* 73-636 (AAU, BK, BKF), 95-1065 (CMU, BKF), 95-1227 (BKF, L); *S. Mitsuta*, *T. Yamada* & *H. Nagamazu* T-46454 (BKF); *G. Murata*, *K. Iwatsuki*, *C.*

Phengklai & C. Charoenpol T-15497 (BKF), T-15498 (BKF, P); *G. Murata, C. Phengklai, S. Mitsuta, H. Nagamasu & N. Nantasan* T-40224 (BKF); *W. Nanakorn et al.* 209 (QBG), 1920 (QBG), 5245 (QBG), 5302 (QBG), 9948 (QBG); *Native* 25 (BKF), 68 (BKF); *M. Norsangsri* 925 (QBG); *Y. Paisooksantivatana* 1645b-85 (BK); *R. Pooma* 43 (BKF), 62 (BKF); *Prayad* 1076 (BK); *Put* 311 (BK, BM, K), 4458 (BK, BM, K); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & T. Santisuk* T-18726 (BKF), T-20113 (BKF, L), T-22531 (BKF, L), T-22618 (BKF, L), T-22724 (BKF), T-22730 (BKF, L), T-22803 (BKF), T-22814 (BKF, L), T-22959 (BKF, L), T-22998 (BKF), T-23018 (BKF, L), T-23132 (BKF); *P. Sooksathan* 1930 (QBG), 2111 (QBG); *Th. Sørensen, K. Larsen & B. Hansen* 6227 (C, K); *M. Tagawa, K. Iwatsuki & N. Fuguoka* T-486 (BKF, K, L); *M. Tagawa, K. Iwatsuki, N. Fuguoka, A. Nalampoon & A. Chintaynhgkuh* 9099 (BKF); *H. Takahashi* T-60557 (BKF), T-63527 (BKF); *Vidal* 5337 (AAU, BKF, L, P).

13. *Acilepis squarrosa* D.Don, Prodr. Fl. Nepal.: 169. 1825. Type: Nepal, Hamilton s.n. Figures 2.28, 2.64 A. & B.

Vernonia teres Wall., Numer. List [Wallich] no. 2926, comp. no. 36, *nom. nud.*

Vernonia squarrosa Less., Linaea 6: 678. 1831.

Perennial herbs, 30 – 80 cm tall. *Stem* erect, inconspicuously ribbed, villose. *Leaves* 3 – 10 by 1 – 3 cm, oblanceolate, margins serrate, apex acute, base cuneate, coriaceous; both surfaces scabrous with whip-shaped hairs and capitate glands; lateral veins 5 – 10-paired; petioles up to 5 mm long. *Capitulescences* terminal and axillary, solitary. *Capitula* campanulate, 15 – 20 mm long, sessile or subsessile. *Receptacle* flat, 4.5 – 5.5 mm diam., glabrous. *Phyllaries* 12 – 13-seriate, light green or purple apically, herbaceous, campanulate, 15 – 20 mm long, 10 – 15 mm diam., margins filiferous, outer surface arachnoid lacking glands; the outer and the middle ones ovate or lanceolate, apex acuminate or apiculate; the inner ones ovate-lanceolate to oblong, apex acuminate or apiculate. *Florets* 50 – 80, infundibular, purple, puberulous, glands capitate; corolla tube 7 – 10 mm long; corolla lobes 4 – 6 mm long. *Anthers* 3 – 3.5 mm long, apical appendage acute, base obtuse. *Styles* purple, 9 – 11 mm long,

branches 2 – 3 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* subterete, 2.8 – 3.2 mm long, 10-ribbed, pubescent without glands, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 7 – 11 mm long, persistent. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai, Chiang Rai, Lamphun, Lampang, Tak; NORTH-EASTERN: Phetchabun, Loei, Sakon Nakhon, Mukdahan, Kalasin, Khon Kaen; EASTERN: Chaiyaphum, Nakhon Ratchasima, Surin; SOUTH-WESTERN: Uthai Thani, Kanchanaburi; CENTRAL: Lop Buri; SOUTH-EASTERN: Prachin Buri, Chon Buri.

Distribution.— China (Yunnan), India, Bhutan, Myanmar, Thailand, Laos.

Ecology.— Dipterocarp, deciduous, hill evergreen or pine-oak forest, alt. 10 – 1,200 m; flowering September to May.

Vernacular.— Kiang Pa Chang (เกียงพาช้าง), Nat Dhum (หนาดดู่), Nat Khum (หนาดคำ).

Note.— *A. squarrosa* is easily recognized by its large and sessile capitula (with more than 100 phyllaries) in the axils of the leaves.

Specimens examined.— *Adisai* 155 (BK); *M. Bult* 156 (BKF); *S. Bunwong* 14 (KKU), 20 (KKU), 374 (KKU, US); *Dee* 21 (BKF); *C. Glamwaewwong* 63 (QBG); *C.C. Hosseus* 50 (BM, C, E, G, K, L, P); *A.F.G. Kerr* 828 (BM, K), 19775 (B, BK, BM, E, K, L); *H. Koyama & C. Phengklai* T-39155 (BKF, L); *H. Koyama & H. Terao & Th. Wongprasert* T-1737 (BKF), T-30901 (BKF), T-30934 (BKF), T-31777 (BKF), T-32161 (BKF), T-32187 (BKF), T-32251 (BKF), T-32388 (BKF), T-32454 (BKF), T-32609 (BKF), T-32909 (BKF); *A. Marcan* 2768 (BM, K); *J.F. Maxwell* 73-630 (AAU, BK), 75-626 (AAU, BK, L), 87-1243 (BKF, CMU, L), 87-1313 (CMU, BK, BKF, L), 89-1254 (CMU, L), 91-806 (AAU, CMU, E, L, P), 93-1257 (CMU, L), 96-1329 (BK, BKF, CMU, L); *G. Murata, K. Iwatsuki, C. Phengklai & C. Charoenpol* T-15425 (BKF, P); *G. Murata & C. Phengklai* 50372 (BKF), 50415 (BKF), 50438 (BKF); *G. Murata, C. Phengklai, S. Mitsuta, H. Nagamasu & N. Nantasan* T-51568 (BKF); *W. Nanakorn et al.* 1515 (QBG), 4816 (QBG), 9823 (QBG), 10044 (QBG); *M. Norsangsri* 906 (QBG); *Y. Paisooksantivatana* 1780-86 (BK), 2306-89 (BK),

2548-89 (BK); *C. Phengklai et al.* 3595 (BKF), 3993 (BKF), 12315 (BKF); *Ploenchit* 1368 (BKF), 1938 (BKF); *W. Pongamornkul* 343 (QBG); *R. Pooma* 1301 (BKF); *Pradit* 523 (BK); *Prayad* 9 (BK), 44 (BK); *Put* 2059 (K), 2175 (BK, BM, K), 3111 (K), 4239 (AAU, B, BK, BM, K); *J. Sadakorn* 664 (BK); *W. Sakamethawee* 271 (BKF); *T. Santisuk* 6663 (BKF); *T. Shimitzu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham* T-21892 (BKF, L), T-22532 (BKF), T-22533 (BKF, L); *T. Shimitzu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk* T-18263 (BKF), T-18271 (BKF), T-18272 (BKF, L), T-19331 (BKF), T-20080 (BKF, L), T-20141 (BKF); *T. Smitinand* 12035 (BKF); *P. Srisanga* 2183 (QBG); *S. Sutheesorn* 3048 (BK), 3503 (BK); *Th. Sørensen, K. Larsen & B. Hansen* 1349 (K), 5392 (C), 5417 (C);); *C.F. van Beusekom & C. Phengklai* 2301 (AAU, L); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 3804 (BKF, C, K, L); *Winit* 1515 (BKF, K).

14. *Acilepis sutepensis* (Kerr) H. Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2): 144. 2009. Type: as *Vernonia sutepensis* Kerr. Figures 2.29, 2.64 C. & D.

Vernonia sutepensis Kerr, Bull. Misc. Inform., Kew. 1935: 329. 1935. Type: Thailand, Chiang Mai, Doi Sutep, *A.F.G. Kerr* 3561 (K!).

Perennial herbs, 60 – 150 cm tall. *Stem* erect, conspicuously ribbed, villose. *Leaves* rosulate, 10 – 14 by 4 – 7 cm, ovate-lanceolate or elliptic, margins serrate, apex acuminate, base cuneate or acuminate, subcoriaceous; both surfaces scabrous with whip-shaped hairs and capitate glands, lateral veins 9 – 11-paired; petioles up to 10 mm long. *Capitulescences* terminal and axillary, paniculate. *Capitula* campanulate, 10 – 15 mm long, pedunculate. *Receptacle* flat, 1.5 – 3 mm diam., glabrous. *Phyllaries* 5 – 6-seriate, herbaceous, narrowly campanulate, light green or purple apically, 8 – 10 mm long, 3 – 4 mm diam., margins filiferous, outer surface with sparsely arachnoid, capitate glands; the outer and the middle ones ovate or lanceolate, apex apiculate or aristate; the inner ones ovate-lanceolate to oblong, apex apiculate. *Florets* 13 – 20, infundibular, purple, glandular; corolla tube 7 – 8 mm long; corolla lobes 3 – 4 mm long. *Anthers* 3.5 – 4 mm long, apical appendage acute, base obtuse. *Styles* purple, 7 – 9 mm long, branches 3 – 3.5 mm long, sweeping hairs on the outer

surface reaching below style bifurcation. *Achenes* subterete, 2 – 3.5 mm long, 10-ribbed, pubescent with twin hairs and capitate glands, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 8 – 9 mm long, persistent. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Chiang Mai, Chiang Rai, Lamphun, Lampang.
Distribution.— Endemic to Thailand.

Ecology.— Hill evergreen or pine-oak forest, alt. 1,100 – 1,500 m; flowering November to March.

Note.— *A. sutepensis* is distinguished from *A. pseudosutepensis* by having larger capitula and sparse hairs on the phyllaries.

Specimens examined.— *S. Bunwong* 18 (KKU), 361 (KKU, US); *A.F.G. Kerr* 3561 (K); *H. Koyama & H. Nagamasu* T-40125 (L); *T. Koyama, C. Phengkklai, C. Niyomdham, H. Okada & P.J. O'Connor* 15599 (AAU, BKF); *T. Koyama, H. Terao & Th. Wongprasert* T-23692 (KYO); *J.F. Maxwell* 88-56 (CMU), 88-182 (AAU, CMU, BKF, L), 91-88 (CMU, L), 91-123 (AAU, CMU), 95-168 (BKF, CMU, L), 97-157 (CMU, L); *W. Nanakorn* 6015 (QBG), 6033 (QBG); *C. Niyomdham & R. Kubat* 1347 (AAU, BKF, C, E, K, L); *P. Suvarnakoset* 95 (E); *W. Ponggamornkul* 391 (QBG); *J. Sadakorn* 526 (BK); *C.H. & B. Sangkachand* 287 (BKF); *T. Smitinand* 152 (P); *T. Smitinand & P. Suvarnakoset* 152 (BKF); *P. Srisanga, S. Sasirat, W. Pongamornkul, S. Sukiam & P. Panyachan* 2477 (QBG); *B. Sukkri* 68 (BKF); *Th. Sørensen, K. Larsen & B. Hansen* 915 (BKF, C, K), 6903 (BKF, C, K); *Th. Wongprasert* s.n. (BKF).

15. *Acilepis tonkinensis* (Gagnep.) H. Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2): 144. 2009. Type: as *Vernonia tonkinensis* Gagnep. Figure 2.65 A. & B.
Vernonia tonkinensis Gagnep., Bull. Mus. Hist. Nat. 25: 492. 1919. Type: Vietnam, Tonkin, *Balansa* 3078 (P!).

Perennial herbs, 1 – 1.5 m tall. *Stem* erect, inconspicuously ribbed, villose. *Leaves* alternate, 5 – 10 by 1.5 – 4 cm, elliptic or obovate, margins serrate, apex acute, base cuneate or truncate, subcoriaceous; upper surface scabrous, lower surface pilose

glandular; lateral veins 6 – 11-paired; petioles up to 5 mm long. *Capitulescences* terminal, paniculate. *Capitula* campanulate, 9 – 12 mm long, pedunculate. *Receptacle* flat, hairy. *Phyllaries* 5 – 6-seriate, herbaceous, broadly campanulate, 8 – 10 mm long, outer surface arachnoid, glands capitate; the outer and the middle ones ovate, apex acute; the inner ones ovate-lanceolate to oblong, apex apiculate. *Florets* ca. 20, infundibular, purple, glandular; corolla tube ca. 5 mm long; corolla lobes ca. 4 mm long. *Achenes* subterete, ca. 3 mm long, 10-ribbed, pubescent with twin hairs and capitate glands, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 8 – 9 mm long, persistent.

Thailand.— NORTHERN: Chiang Mai.

Distribution.— Vietnam, Thailand.

Ecology.— Granite bedrock in dry dipterocarp forest, alt. 930 – 1,200 m; flowering January to February.

Note.— *A. tonkinensis* can be recognized by its pubescent receptacle and broadly ovate phyllaries with acute apices.

Specimens examined.— *H. Koyama*, *H. Terao* & *Th. Wongprasert* T-33577 (KYO); *J. Kubiniok* 392/6 (CMU).

16. *Acilepis virgata* (Gagnep.) H. Rob. & Skvarla, Proc. Biol. Soc. Wash. 122(2): 144. 2009. Type: as *Vernonia virgata* Gagnep. Figures 2.65 C. & D.

Vernonia virgata Gagnep., Bull. Mus. Hist. Nat. 25: 493. 1919. Type: Laos, Xieng-Kouang, *Spire* 1302 (type not seen).

Perennial herbs, ca. 1 m tall. *Stem* erect, conspicuously ribbed, pilose. *Leaves* cauline 8 – 10 by 2.5 – 3.5 cm, elliptic, margins serrate, apex acuminate, base cuneate, subcoriaceous; upper surface pilose along main and lateral veins; lower surface pilose glandular; lateral veins 7 – 10-paired; petioles up to 5 mm long. *Capitulescences* terminal, paniculate. *Capitula* campanulate, 7 – 10 mm long, pedunculate. *Receptacle* flat, hairy. *Phyllaries* 5 – 6-seriate, herbaceous, campanulate, ca. 6 mm long, outer surface arachnoid, glands capitate; the outer and the middle ones ovate-lanceolate,

apex acuminate; the inner ones ovate-lanceolate to oblong, apex acute. *Florets* ca. 20, infundibular, purple, glandular; corolla tube ca. 3 mm long; corolla ca. 4 mm long. *Achenes* subterete, ca. 2 mm long, 10-ribbed, pubescent with twin hairs and capitate glands, carpodium present. *Pappus* bristles, 2-seriate, the inner ones 6 – 7 mm long, persistent.

Thailand.— PENINSULAR: Surat Thani.

Distribution.— Thailand, Laos.

Ecology.— Evergreen forest, alt. 180 m; flowering March.

Note.— *A. virgata* is distinguished from *A. tonkinensis* by phyllaries are nearly scarious and capitula that are long pedunculate in loosely paniculate capitulescences.

Specimen examined.— *H. Koyama, H. Terao & Th. Wongprasert* T-33960 (KYO).

2. Camchaya

Gagnep., Notul. Syst. 4: 14. 1920.

Type: *Camchaya kampotensis* Gagnep.

Annual herbs. *Stem* erect, pubescent. *Leaves* simple, alternate, usually petiolate; lamina ovate to lanceolate, pubescent with hairs and glands, margins serrate, apex acute to acuminate, base attenuate, usually chartaceous. *Capitulescences* terminal or axillary, paniculate or corymbose. *Capitula* campanulate or hemispherical, pedunculate, homogamous; florets bisexual and fertile. *Involucre* imbricate, campanulate or hemispherical. Phyllaries persistent, the outer and the middle ones ovate or lanceolate, the inner ones linear-oblong, sometimes pubescent, glands capitate. *Florets* purple or white, narrowly infundibular, pubescent with hairs and/or capitate glands; lobes 5. *Anthers* apical appendage acute, base rounded. *Styles* purple, 2-branched, slender, acute, inner surface covered with stigmatic papillae, outer surface and shaft covered with sweeping hairs. *Achenes* obovate, usually 10-ribbed, carpodium absent. *Pappus* bristles, 1-seriate, often deciduous. *Pollen* echinolophate, 6-porate, without micropuncta.

Seven species are recognized in Thailand.

KEY TO THE SPECIES

- 1. Phyllaries broadly ovate without marginal spines
 - 2. Achenes 4 – 5-ribbed **1. *C. gracilis***
 - 2. Achenes 10-ribbed **7. *C. sp.***
- 1. Phyllaries broadly ovate with marginal spines
 - 3. Achenes 10-ribbed
 - 4. Phyllaries glandular, spines up to 5 mm
 - 5. Phyllaries aristate or apiculate; achenes 1.5 – 2 mm
 - 6. Leaves with T-shaped hairs; phyllaries spinose ≤ 1 mm long **3. *C. loloana***
 - 6. Leaves without T-shaped hairs; phyllaries spinose ≥ 1 mm long **6. *C. tenuiflora***
 - 5. Phyllaries acuminate; achenes 2.5 – 3 mm long **2. *C. kampoensis***
 - 4. Phyllaries without glands, spines up to 10 mm **5. *C. spinulifera***
 - 3. Achenes 5 (6 – 9)-ribbed **4. *C. pentagona***

1. *Camchaya gracilis* (Gagnep.) S. Bunwong & H. Rob., Proc. Biol. Soc. Wash. 122(3): 361. 2009. Type: as *Iodocephalus gracilis* Thorel ex Gagnep. Figures 2.30, 2.66 A. & B.

Iodocephalus gracilis Thorel ex Gagnep., Notul. Syst. (Paris) 4: 17. 1920. Type: Laos, Bassac, *Thorel* 2396 (P!).

Annual herbs, 50 – 100 cm tall. *Stem* erect, rounded, inconspicuously ribbed; villose with uniseriate hairs, T-shaped hairs and glands. *Leaves* alternate, elliptic-oblong, 3 – 6 by 0.3 – 1 cm, margins serrate or entire, apex acute, base attenuate, subcoriaceous; upper surface scabrous lacking glands, lower surface scabrous with whip-shaped hairs and capitate glands, lateral veins 8 – 10-paired; petioles up to 3

mm long. *Capitulescences* terminal and axillary, corymbose. *Capitula* campanulate, 8 – 10 mm long, pedunculate. *Receptacle* flat, 2 – 3 mm diam., glabrous. *Phyllaries* 4 – 5 seriate, imbricate, campanulate, light green or purple, 7 – 8 mm long, 6 – 7 mm diam., margins entire without spines, outer surface arachnoid, glandular; the outer one ovate, apex acute to acuminate; the inner ones ovate-lanceolate, apex acute to acuminate. *Florets* 50 – 70, infundibular, purple, puberulous, glands capitate; corolla tube 3 – 5 mm long; corolla lobe 2 – 3 mm long. *Anthers* ca. 2 mm long, apical appendage acute, base rounded. *Styles* purple, 5 – 7 mm long, branches 1.5 – 2 mm long; sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* obovate, ca. 2 mm long, puberulous with twin hairs and capitate glands, 4 – 5-ribbed, carpodium absent. *Pappus* bristles, 1 – 2 mm long, frequently deciduous or lacking, present in some floret with 1-rowed, deciduous. *Pollen* echinolophate, 6-porate, without micropuncta.

Thailand.— EASTERN: Ubon Ratchathani.

Distribution.— Thailand, Laos.

Ecology.— Dipterocarp forest, alt. 150 m; flowering October to December.

Note.— *C. gracilis* is characterized by phyllaries without marginal spines, *Achenes* with 4 – 5 ribs and leaves that are narrowly elliptic-oblong. This species is included in *Camchaya* as it shares 6-porate pollen found in no other genus.

Specimens examined.— *S. Bunwong* 33 (KKU), 45 (KKU), 346 (KKU, US); *R. Pooma*, *K. Phattanahirankanok* & *S. Sirimongkol* 4737 (AAU); *Th. Wongprasert et al.* s.n. (BKF).

2. *Camchaya kampfensis* Gagnep., Notul. Syst. 4: 14. 1920. Type: Cambodia, Kampot, *Geoffray* 331 (P!). Figures 2.66 C. & D.

Annual herbs 30 – 80 cm tall. *Stem* erect, rounded, inconspicuously ribbed, pubescent with T-shaped hairs and glands. *Leaves* lanceolate, 7 – 25 by 5 – 9 cm, margins serrate, apex acute, base attenuate, chartaceous; both surfaces puberulous glandular; petioles up to 7 mm long. *Capitulescences* terminal and axillary, paniculate or solitary. *Capitula* campanulate, 10 – 15 mm long, pedunculate. *Phyllaries* 6 – 7-

seriate, 9 – 12 mm long, margins with spines up to 5 mm long, outer surface puberulous, glands capitate; the outer and the inner ones lanceolate, apex acuminate; the inner ones lanceolate or linear-oblong, apex acute. *Florets* purple, puberulous, glands capitate. *Anthers* ca. 2 mm long, apical appendage acute, base rounded. *Styles* purple, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* obovate, 2.5 – 3 mm long, glabrous, 10-ribbed, carpopodium absent. *Pappus* bristles, 1-seriate, caducous or lacking. *Pollen* echinolophate, 6-porate, without micropuncta.

Thailand.— SOUTH-EASTERN: Chanthaburi.

Distribution.— Thailand, Cambodia.

Ecology.— Evergreen forest, alt. 700 – 900 m; flowering December.

Note.— *C. kampoensis* can be recognized by its acute to broadly acuminate phyllaries and its large achenes.

Specimens examined.— *A.F.G. Kerr* 17783 (BK, E, K, P); *T. Kira, K. Hozumi, K. Yoda & S. Kokawa* 102 (BKF); *M. Martin* 769 (L); *J.F. Maxwell* 99-624 (CMU); *T. Santisuk* s.n. (BKF); *J.E. Vidal* 4766 (L).

3. *Camchaya loloana* Kerr, Bull. Misc. Inform., Kew. 1935: 327. 1935. Type: Thailand, Chiang Mai, Chiangdao district; *A.F.G. Kerr* 6650 (BK!, BM!, K!, P!). Figures 2.67 A. & B.

Key to variety

1. Florets 65 – 100, corolla tube 7 – 9.5 mm long, corolla lobes 2.5 – 3 mm long

1. var. *loloana*

1. Florets 32 – 60, corolla tube 5.5 – 5.6 mm long, corolla lobes 1.5 – 2 mm long

2. var. *mukdahanensis*

3.1 var. *loloana*

Annual herbs, 30 – 70 cm tall. *Stem* erect, rounded, inconspicuously ribbed, pubescent with T-shaped hairs and glands. *Leaves* ovate, 3 – 10 by 2 – 4 cm, margins

serrate, apex acute or acuminate, base attenuate, chartaceous; both surfaces scabrous with whip-shaped hairs, cylindrical hairs and capitate glands; lateral veins 8 – 12-paired; petioles up to 10 mm long. *Capitulescences* terminal and axillary, paniculate. *Capitula* campanulate, 9 – 10 mm long, pedunculate. *Receptacle* convex, 3.5 – 4 mm diam., glabrous. *Phyllaries* 7 – 8-seriate, imbricate, campanulate, greenish with purple apex, 8 – 10 mm long, margins with spines up to 1 mm long, outer surface arachnoid, glands capitate; the outer lanceolate, apex spinose; the inner ones lanceolate or linear-oblong, apex acuminate. *Florets* 65 – 100, infundibular, purple rarely white, puberulous, glands capitate; corolla tube 7 – 9.5 mm long; corolla lobes 2.5 – 3 mm long. *Anthers* 1.8 – 2.5 mm long, apical appendage acute, base rounded. *Styles* purple, 7 – 11 mm long, branches *ca.* 2 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* obovate, 1.3 – 1.7 mm long, glabrous, 10-ribbed, carpodium absent. *Pappus* bristles, 1-seriate, 1.5 – 3 mm long, some florets absent, deciduous. *Pollen* echinolophate, 6-porate, without micropuncta.

Thailand.— NORTHERN: Chiang Mai, Lampang, Phitsanulok; NORTH-EASTERN: Khon Kaen; EASTERN: Nakhon Ratchasima, Ubon Ratchathani; SOUTH-WESTERN: Kanchanaburi; CENTRAL: Saraburi.

Distribution.— China (Yunnan), Thailand, Laos, Cambodia.

Ecology.— On limestone in dipterocarp, dry evergreen, and hill evergreen forests, alt. 400 – 1,500 m; flowering July to December.

Vernacular.— Dok Lea (ดอกเลา), Phu Muang (พุ่มวาง).

Note.— *C. loloana* is recognized by having short marginal spines on phyllaries, 10-ribbed achenes and leaves with T-shaped hairs.

Specimens examined.— *S. Bunwong* 25 (KKU), 330 (KKU, US), 339 (KKU, US); *R. Geesink* & *C. Phengklai* 6192 (AAU, BKF, E, L, P); *A.F.G. Kerr* 6650 (BM, K, P) & 7982 (BK, BM, K, P); *M.C. Lakshanakara* 286 (BK, BM, K); *K. Larsen, T. Santisuk* & *E. Warncke* 2862 (BKF, E); *J.F. Maxwell* 96-1215 (BKF); *W. Nanakorn et al.* 1626 (QBG), 1821 (QBG) & 8472 (QBG); *T. Santisuk* s.n. (BKF); *T. Shimizu, H. Toyokumi, H. Koyama, T. Yahara* & *T. Santisuk* 20639 (AAU, BKF, L); *S. Sutheesorn* 2637 (BK).

3.2 var. mukdahanensis H.Koyama, Acta Phytotax. Geobot. 35(1-3): 52. 1984. Type: Thailand, Mukdahan, Muang district, Dongman village, *H. Koyama et al.* T-30941 (KYO!). Figures 2.31, 2.67 C. & D.

Annual herbs, 10 – 70 cm tall. *Stem* erect, rounded, inconspicuously ribbed, scabrous with uniseriate hairs and T-shaped hairs. *Leaves* alternate, 5 – 11 by 2 – 5 cm, ovate or lanceolate, margins serrate or undulate, apex acute or acuminate, base attenuate, chartaceous; both surfaces scabrous with whip-shaped hairs, cylindrical hairs and capitate glands; lateral veins 5 – 9-paired; petioles up to 15 mm long. *Capitulescences* terminal and axillary, paniculate. *Capitula* campanulate, 9 – 10 mm long, pedunculate. *Receptacle* convex, 2 – 2.5 mm diam., glabrous. *Phyllaries* 5 – 6-seriate, campanulate, greenish with purple apex, 7 – 9 mm long, 4 – 6 mm diam., margins with spines up to 0.2 mm long, outer surface arachnoid, glands capitate; the outer lanceolate, apex spinose; the inner ones lanceolate to oblong, apex acuminate. *Florets* 30 – 70, infundibular, purple, puberulous, glands capitate; corolla tube *ca.* 5.5 mm long; corolla lobes 1.5 – 2 mm long. *Anthems* 1.5 – 2 mm long, apical appendage acute, base rounded. *Styles* purple, 5 – 6 mm long, branches *ca.* 2 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* obovate, 1.3 – 1.5 mm long, glabrous, 10-ribbed, carpopodium absent. *Pappus* bristles, 1-seriate, 1.5 – 2 mm long, some florets absent, deciduous. *Pollen* echinolophate, 6-porate, without micropuncta.

Thailand.— NORTH-EASTERN: Nong Khai, Mukdahan; EASTERN: Ubon Ratchathani.

Distribution.— Thailand, Laos.

Ecology.— Rocky area in dipterocarp forest, alt. 250 – 400 m; flowering August to January.

Vernacular.— Phu Muang (พุ่มง).

Note.— *C. loloana* var. *mukdahanensis* differs from the typical variety by having smaller capitula which is shorter involucre and the number of florets is less than the typical variety.

Specimens examined.— *S. Bunwong* 38 (KKU), 41 (KKU), 338 (KKU, US), 343 (KKU, US); *H. Koyama et al.* T-30941 (KYO); *H. Koyama, H. Terao & Th. Wongprasert* T-30662 (BKF, L), T-30866 (BKF), T-30904 (BKF, L), T-31137 (BKF, L); *M. Norsangsri* 1158 (QBG).

4. *Camchaya pentagona* H.Koyama, Acta Phytotax. Geobot. 35(1-3): 53. 1984.
Type: Thailand, Ubon Ratchathani, *H. Koyama, H. Terao & Th. Wongprasert* T-30791 (KYO!, AAU!, L!). Figures 2.32 A., 2.68 A.

Annual herbs, 20 – 60 cm tall. *Stem* erect, rounded, inconspicuously ribbed, scabrous with uniseriate and T-shaped hairs. *Leaves* alternate, ovate or lanceolate, 3 – 10 by 2 – 4 cm, margins serrate or sinuate, apex acute, base attenuate, chartaceous; both surfaces scabrous with whip-shaped hairs, cylindrical hairs and capitate glands; lateral veins 5 – 10-paired; petioles up to 2 cm long. *Capitulescences* terminal and axillary, paniculate. *Capitula* broadly campanulate or hemispherical, 13 – 15 mm long, pedunculate. *Receptacle* convex, 3.5 – 6 mm diam., glabrous. *Phyllaries* 8 – 9-seriate, imbricate, hemispherical, 11 – 12 mm long, margins with spines up to 0.5 mm long, outer surface arachnoid eglandular; the outer and the middle ones lanceolate, apex spinose; the inner ones lanceolate to oblong, apex acuminate. *Florets* 80 – 150, infundibular, purple, puberulous, glands capitate; corolla tube 6 – 7 mm long; corolla lobes 2 – 2.5 mm long. *Anthers* ca. 2 mm long, apical appendage acute, base rounded. *Styles* purple, 6 – 7.5 mm long, branches ca. 2 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* obovate, 1.7 – 2 mm long, glabrous, 5 (–6 – 9)-ribbed, carpopodium absent. *Pappus* bristles, 1-seriate, 2 – 3.5 mm long, some florets absent, deciduous. *Pollen* echinolophate, 6-porate, without micropuncta.

Thailand.— EASTERN: Ubon Ratchathani.

Distribution.— Endemic to Thailand.

Ecology.— Disturbed area in dipterocarp forest, alt. 220 – 300 m; flowering October to December.

Note.— *C. pentagona* is distinguished by its typically 5-ribbed achenes.

Specimens examined.— *S. Bunwong* 29 (KKU), 32 (KKU), 33 (KKU), 344 (KKU, US); *H. Koyama*, *H. Terao* & *Th. Wongprasert* T-30760 (L), T-30791 (KYO, AAU, L).

5. *Camchaya spinulifera* H.Koyama, Acta Phytotax. Geobot. 35(1-3): 54. 1984.

Type: Thailand, Mukdahan, Nikomkhamsoi district, Phu Moo forest park; *H. Koyama*, *H. Terao* & *Th. Wongprasert* T-30837 (KYO!, L!). Figures 2.32 B., 2.68 B. - D.

Annual herbs, 40 – 100 cm tall. *Stem* erect, rounded, inconspicuously ribbed, scabrous with uniseriate and T-shaped hairs. *Leaves* alternate, ovate to lanceolate, 4 – 10 by 1.5 – 4 cm, margins serrate, apex acute, base attenuate, chartaceous; both surfaces scabrous with whip-shaped hairs, cylindrical hairs, T-shaped hairs and capitate glands; lateral veins 5 – 13-paired; petioles up to 1 cm long. *Capitulescences* terminal and axillary, paniculate. *Capitula* campanulate or hemispherical, 10 – 15 mm long, pedunculate. *Receptacle* convex, 4.5 – 6.5 mm diam., glabrous. *Phyllaries* 8 – 9-seriate, imbricate, hemispherical, 10 – 15 mm long, 10 – 20 mm diam., margins with spines up to 10 mm long, outer surface arachnoid eglandular; the outer lanceolate, apex spinose; the inner ones lanceolate to oblong, apex acuminate. *Florets* 130 – 220, infundibular, purple, puberulous, glands capitate; corolla tube 7.5 – 9 mm long; corolla lobes 2.5 – 3 mm long. *Anthers* ca. 2 mm long, apical appendage acute, base rounded. *Styles* purple, 8 – 11 mm long, branches 2 – 2.5 mm long; sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* obovate, 1.3 – 1.5 mm long, glabrous, 10-ribbed, carpopodium absent. *Pappus* bristles, 1-seriate, 1.5 – 3 mm long, some florets absent, deciduous. *Pollen* echinolophate, 6-porate, without micropuncta.

Thailand.— NORTH-EASTERN: Nong Khai, Sakon Nakhon, Mukdahan, Kalasin; EASTERN: Chaiyaphum, Ubon Ratchathani.

Distribution.— Endemic to Thailand.

Ecology.— Rocky area in dipterocarp forest, alt. 200 – 300 m; flowering September to December.

Vernacular.— Phu Muang (ພູມາງ), Up-Pa-Kud (ຊຸປາກຸດ).

Note.— *C. spinulifera* is recognized by having the longest marginal spines on their phyllaries of any species, and the lack of glands on the phyllaries.

Specimens examined.— *S. Bunwong* 11 (KKU), 39 (KKU), 40 (KKU), 327 (KKU, US), 332 (KKU, US), 336 (KKU, US); *C. Chermisrivathana* 1596 (BK); *H. Koyama*, *H. Terao* & *Th. Wongprasert* T-30837 (AAU, BKF), T-30954 (BKF), T-31007 (L), T-31054 (BKF), T-31068 (BKF); *G. Murata* & *C. Phengklai* T-50396 (BKF); *G. Murata*, *C. Phengklai*, *S. Mitsuta*, *T. Yahara*, *H. Nagamasu* & *N. Nantasan* T-50638 (BKF) & T-51352 (BKF); *I.C. Nielsen*, *C. Niyomdham*, *T. Jonganurak*, *N. Hemrath* & *J. Rithipheth* 1628 (AAU); *C. Niyomdham* 4897 (BKF); *T. Smitinand* 10097 (BKF, L), s.n. (BKF); *S. Suddee* 6 (BKF); *S. Sutheesorn* 654 (BK), 3500 (BK), 3529 (BK); *P. Suvanakoses* 1947 (BKF); *Th. Wongprasert et al.* s.n. (BKF).

6. *Camchaya tenuiflora* Kerr, Bull. Misc. Inform., Kew. 1935: 327. 1935. Type: Thailand, Bangkok, *A.F.G. Kerr* 20563 (BK!, E!, K!, L!, P!). Figures 2.32 C., 2.69 A.-B.

Annual herbs, 20 – 70 cm tall. *Stem* erect, rounded, inconspicuously ribbed, scabrous with uniseriate and T-shaped hairs. *Leaves* alternate, ovate or lanceolate, 3 – 10 by 1.5 – 2.5 cm, margins serrate, apex acute, base attenuate, chartaceous; both surfaces scabrous with whip-shaped hairs, cylindrical hairs and capitate glands; lateral veins 5 – 10-paired; petioles up to 10 mm long. *Capitulescences* terminal and axillary, paniculate and solitary. *Capitula* campanulate, 8 – 10 mm long, pedunculate. *Receptacle* convex, 1.5 – 3 mm diam., glabrous. *Phyllaries* 6 – 7-seriate, imbricate, campanulate, light green with purple apex, 8 – 9 mm long, 6 – 10 mm diam., margins with spines up to 5 mm long, outer surface arachnoid glandular; the outer and the middle ones lanceolate, apex spinose; the inner ones lanceolate to oblong apex acuminate. *Florets* 40 – 60, infundibular, purple or white, puberulous, glands capitate; corolla tube 4 – 6 mm long; corolla lobes 1.5 – 2.5 mm long. *Anthers* ca. 2 mm long, apical appendage acute, base rounded. *Styles* purple, 4 – 7 mm long, branches 1.5 – 1.7 mm long; sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* obovate, 1.5 – 1.7 mm long, glabrous, 10-ribbed, carpopodium absent.

Pappus bristles, 1-seriate, 1 – 4 mm long, some florets absent, deciduous. *Pollen* echinolophate, 6-porate, without micropuncta.

Thailand.— NORTHERN: Chiang Mai, Chiang Rai; NORTH-EASTERN: Loei; EASTERN: Chaiyaphum, Nakhon Ratchasima.

Distribution.— Endemic to Thailand.

Ecology.— Open area in evergreen forest, alt. 700 m; flowering October to December.

Note.— *C. tenuiflora* differs from *C. loloana* by its longer marginal spine on phyllaries and leaf surfaces without T-shaped hair.

Specimens examined.— *S. Bunwong* 48 (KKU), 348 (KKU, US); *Put* 4264 (BK, E, K, P), *R. Pooma* 1231 (BKF).

7. *Camchaya* sp. Figures 2.33, 2.69 C.-D.

Annual herbs, 50 – 100 cm tall. *Stem* erect, rounded, inconspicuously ribbed; scabrous with uniseriate hairs, T-shaped hairs and glands. *Leaves* alternate, elliptic to oblong, 3 – 8 by 2 – 3 cm, margins serrate, apex acute, base attenuate, chartaceous; both surfaces puberulous with cylindrical hairs, T-shaped hairs and capitate glands; lateral veins 5 – 10-paired; petioles up to 2 cm long. *Capitulescences* terminal and axillary, corymbose. *Capitula* campanulate, 8 – 10 mm long, pedunculate. *Receptacle* convex, 2.5 – 3 mm diam., glabrous. *Phyllaries* 5 – 6-seriate, imbricate, broadly campanulate, light green with purple apex, 7 – 8 mm long, 5 – 6 mm diam., margins pale without spine, outer surface arachnoid glandular; the outer and the middle ones ovate, apex acuminate; the inner ones lanceolate to oblong, apex acuminate. *Florets* 50 – 70, infundibular, purple, puberulous, glands capitate; corolla tube 6 – 7 mm long; corolla lobe 2.5 – 3 mm long. *Anthers* ca. 2 mm long, apical appendage acute, base rounded. *Styles* purple, 6 – 7 mm long, branches 2 – 2.5 mm long; sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* obovate, ca. 1.5 mm long, glandular, 10-ribbed, carpopodium absent. *Pappus* bristles, 1-seriate, 1 – 2 mm long, some florets absent, deciduous. *Pollen* echinolophate, 6-porate, without micropuncta.

Thailand.— NORTH-EASTERN: Udon Thani.

Distribution.— Endemic to Thailand.

Ecology.— Rocky area in dipterocarp forest, alt. 300 m; flowering November to December

Note.— This species is similar to *V. gracilis* in having ovate phyllaries which its without marginal spine but differs in 10-ribbed achenes and broadly ovate leaf shape.

Specimens examined.— *S. Bunwong* 328 (KKU, US).

3. *Cyanthillium*

Blume, Bidjr.: 889. 1826.

Type: *Cyanthillium villosum* Blume.

Annual herbs. *Stem* erect, pubescent. *Leaves* simple, alternate, petiolate; lamina ovate, lanceolate, elliptic or rhombic, pubescent, margins serrate or undulate, apex acute or acuminate, base attenuate, chartaceous. *Capitulescences* terminal or axillary. *Capitula* discoid, homogamous, pedunculate, florets bisexual and fertile. *Involucre* imbricate, persistent. *Corolla* purple to white, actinomorphic, lobes 5. *Anthers* 5, syngenesious. *Styles* purple, 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs. *Achenes* clavate or turbinate, 5 – 10-ribbed, carpodium present. *Pappus* bristles, 1 – 2-seriate. *Pollen* echinolophate, 3-porate, with micropuncta.

Two species are recognized in Thailand.

KEY TO THE SPECIES

- | | |
|---|---------------------------------|
| 1. Pappus 2-seriate, achenes with indistinct ribs and dense hairs | 1. <i>C. cinereum</i> |
| 1. Pappus 1-seriate, achenes 5-ribbed, without hair | 2. <i>C. hookerianum</i> |

1. *Cyanthillium cinereum* (L.) H. Rob., Proc. Biol. Soc. Wash. 103(1): 252. 1990. Type: not located. Figures 2.70 A. & B.

Conyza cinerea L., Sp. Pl.: 862. 1753.

Vernonia cinerea (L.) Less., Linnaea 4: 291. 1829.

Annual herbs, 20 – 80 cm tall. *Stem* erect, conspicuously ribbed, sericeous. *Leaves* 3 – 5 by 2 – 3 cm, lanceolate or ovate to broadly ovate, margins undulate to serrate, apex acute to acuminate, base attenuate, chartaceous; upper surface sericeous without glands; lower surface sericeous with cylindrical hairs, T-shaped hairs and capitate glands, lateral veins 5 – 7-paired; petioles up to 2 cm long. *Capitulescences* terminal or axillary, paniculate. *Capitula* campanulate, 5 – 6 mm long, pedunculate. *Receptacle* flat, 2 – 2.5 mm diam., glabrous. *Phyllaries* 3 – 4-seriate, imbricate, campanulate, green with purple apex, 4 – 4.5 mm long, 2.5 – 3 mm diam., margins filiferous, outer surface sericeous glandular; the outer and the middle ones lanceolate, apex acute to acuminate; the inner ones lanceolate to oblong, apex acuminate. *Florets* 25 – 30, infundibular, purple or white, puberulous glandular; corolla tube 3 – 3.5 mm long; corolla lobes *ca.* 1 mm long. *Anthers* *ca.* 0.6 mm long, apical appendage acute, base obtuse. *Styles* purple, *ca.* 3 mm long, branches *ca.* 0.5 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* clavate, 1.5 – 1.8 mm long, rib inconspicuous, densely pubescent with twin hairs and capitate glands, carpodium present. *Pappus* bristles, 2-seriate, the inner ones 3 – 3.5 mm long, persistent. *Pollen* echinolophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai, Chiang Rai, Phitsanulok, Nakhon Sawan; NORTH-EASTERN: Phetchabun, Loei, Nong Bua Lum Phu, Udon Thani, Nong Khai, Sakon Nakhon, Nakhon Phanom, Mukdahan, Kalasin, Maha Sarakham, Khon Kaen; EASTERN: Chaiyaphum, Nakhon Ratchama, Ubon Ratchathani; SOUTH-WESTERN: Kanchanaburi; CENTRAL: Lop Buri, Saraburi, Nakhon Nayok, Bangkok; PENINSULAR: Chumphon, Ranong, Phangnga, Phuket.

Distribution.— Tropics and subtropics.

Ecology.— Open area or dipterocarp or dry evergreen forest, alt. 0 – 250 m; flowering January to December.

Vernacular.— Mor Noi (หมอน้อย), Kan Toop (ก้นตูป), Tua Haa Din (ถั่วแฮะดิน), Fa Rang Kok (ฝรั่งโคก), Suea Sam Kha (เสือสามขา), Ya Dok Kao (หญ้าดอกขาว), Ya La Ong (หญ้าละออง).

Note.— *C. cinereum* is a widespread weed of disturbed areas throughout the tropics. It is widely known by its former name, *Vernonia cinerea*. Its leaf shape and capitula size vary continuously therefore plants in dry areas frequently have small capitula and leaves while those in more mesic situations have larger heads and leaves.

Specimens examined.— *L.B. & E.C. Abbe & T. Smitinand* 2470 (BKF); *T. Boonkird* 66 (BK); *S. Bunwong* 22 (KKU), 24 (KKU), 25 (KKU), 52 (KKU), 55 (KKU), 56 (KKU); *G. Congdon* 36 (AAU), 327 (AAU); *N. Fukuoka & M. Ito* T-34854 (BKF); *Hamilton & G. Congdon* 36 (BKF); *K. Iwatsuki & N. Fukuoka* T3230 (L), T7313 (BKF, E); *K. Iwatsuki* T246 (BKF, E, K); *Kasem* 156 (BK); *A.F.G. Kerr* 2475 (BM, E), 3284 (BM), 3769 (BM), 5087 (BM, E, K), 6400 (BK, BM), 8344 (BM), 8366 (BM, K), 12838 (BK, BM, K), 16459 (BK, BM, K), 19650 (AAU, BK, BM, K), 21420 (BK, BM, E); *R.M. King* 5569 (L); *H. Koyama* T-33031 (BKF), T-61504 (BKF); *H. Koyama & H. Terao* T-32863 (BKF); *H. Koyama, H. Terao & Th. Wongprasert* T-30953 (BKF), T-31066 (BKF), T-31164 (BKF, C), T-31449 (BKF), T-31508 (BKF), T-31576 (BKF), T-31585 (BKF), T-32000 (BKF), T-32543 (BKF), T-32912 (BKF), T-33025 (BKF), T-33079 (BKF), T-33134 (BKF), T-33135 (BKF), T-33170 (BKF), T-33327 (BKF), T-34034 (BKF), T-34084 (BKF), T-33464 (BKF, C), T-33552 (BKF), T-33646 (BKF); *H. Koyama, H. Terao, C. Niyomdham & Th. Wongprasert* T-30059 (BKF), T-30220 (BKF), T-30330 (BKF), T-31889 (BKF), T-33956 (BKF); *W.R.S. Ladell* 257 (BK, K); *K. Larsen, T. Smitinand, E. Warncke* 189 (AAU); *J.F. Maxwell* 73-789 (AAU, BK), 74-8 (AAU), 87-1484 (CMU), 91-1088 (E); *G. Murata, N. Fuguoka* T-17330 (BKF); *G. Murata, N. Fuguoka & C. Phengklai* T-16634 (BKF, L), T-17537 (BKF, L); *G. Murata, K. Iwatsuki & D. Chaiglom* T-16634 (BKF); *G. Murata, K. Iwatsuki & C. Phengklai* T-14764 (AAU, BKF, P); *G. Murata, C. Phengklai, S. Mitsuta, H. Nagamasu & N. Nantasan* T-37036 (BKF), T-38672 (BKF), T-41774 (BKF), T-50999 (BKF), T-51995 (BKF), T-52587 (BKF); *M.F. Newman, T. Boonthavikoon, C. Hemrat & D.J. Middleton* 1142 (AAU, E); *Y. Paisooksantivatana* 495-81(BK), 521-81(BK), 548-81(BK), 843-82 (BK), 1181-82

(BK), 1887-86 (BK); *Parikarn* 11 (BK); *Parikarn & Prayad* 71 (BK), 95 (BK); *O. Petrmitr* 229 (L); *C. Phengkklai et al.* 12590 (BKF), 12928 (BKF), 14308 (BKF); *R. Pooma* 1003 (BKF); *Put* 2211 (AAU, BK, BM, K), s.n. (BK, BM); *J. Sadakorn* 287 (BK); *G. Seidenfaden* 2195 (C); *T. Shimizu, H. Koyama & N. Fukuoka* T-7550 (BKF); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & C. Niyomdham* T-21360 (BKF), T-26074 (BKF), T-26228 (BKF), T-27115 (BKF), T-27122 (BKF), T-27296 (BKF); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & D. Phanichapol* T-23255 (BKF), T-23453 (BKF); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & T. Santisuk* T-19409 (BKF), T-27668 (BKF); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & Th. Wongprasert* T-27576 (BKF); *T. Smitinand* 4930 (BKF), 6284 (BKF); *W. Somprasong* 112 (BK); *Th. Sørensen, K. Larsen & B. Hansen* 709 (C), 1848 (C), 6182 (K); *M. Tagawa, K. Iwatsuki & N. Fukuoka* T-1963 (BKF, E, L); *M. Tagawa, T. Shimizu, H. Koyama & A. Nalampoon* T-10630 (BKF); *Vacharee* 34 (BK); *C.F. van Beusekom, C. Phengkklai, R. Geesink & B. Wongwan* 3508 (BKF, C, K, L), 3651 (BKF, K); *Th. Wongprasert* 9912-05 (BKF); *R. Zimmermann* s.n. (G).

2. *Cyanthillium hookerianum* (Arn.) H. Rob., Proc. Biol. Soc. Wash. 112(1): 229. 1999. Type: Sri Lanka. Figures 2.34, 2.70 C. & D.

Vernonia hookeriana Arn., Nov. Act. Nat. Cur. 18(1): 346. 1836.

Conyza patula Ait., Hortus Kew. 3: 184. 1789.

Vernonia chinensis Less., Linnaea 6: 105, 674. 1831.

Annual herbs, 1 – 2 m tall. *Stem* erect, conspicuously ribbed, white sericeous. *Leaves* 3 – 10 by 2 – 5 cm, elliptic to ovate or slightly rhombic, margins serrate or slightly sinuate, apex acute or obtuse, base attenuate, chartaceous; upper surface puberulous glandular; lower surface sericeous with T-shaped hairs and capitate glands; lateral veins 4 – 8-paired; petioles up to 2 cm long. *Capitulescences* terminal or axillary, paniculate. *Capitula* broadly campanulate or subglobose, 7 – 10 mm long, pedunculate. *Receptacle* flat, 2 – 3 mm diam., glabrous. *Phyllaries* 4 – 5-seriate, imbricate, semispherical, light green, 6 – 7 mm long, 5 – 6 mm diam., margins filiferous, outer surface arachnoid glandular; the outer and the middle ones lanceolate,

apex acuminate or aristate; the inner ones lanceolate to oblong, apex acuminate. *Florets* 80 – 120, infundibular, purple or white, corolla tube 4 – 5 mm long; corolla lobes *ca.* 2 mm long. *Anthers* 1.5 – 2 mm long, apical appendage acute, base obtuse. *Styles* purple, 4 – 5 mm long, branches 1 – 1.5 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* turbinate, 1 – 1.5 mm long, 5-ribbed, glandular, carpodium present. *Pappus* bristles, 1-seriate, 2 – 3 mm long, deciduous. *Pollen* echinolophate, 3-porate, with prominent micropuncta.

Thailand.— NORTHERN: Nan, Sukhothai; NORTH-EASTERN: Mukdahan; EASTERN: Buri Ram; CENTRAL: Bangkok, Samut Prakan; SOUTH-EASTERN: Prachin Buri; PENINSULAR: Surat Thani.

Distribution.— China, India, Malay Peninsula, Thailand, Laos, Cambodia, Philippines, New Guinea.

Ecology.— Open area in dry evergreen forest or secondary forest, alt. 0 – 100 m; flowering August to February.

Note.— *C. hookerianum* differs from *C. cinereum* by having only a single series of pappus, a 5-ribbed achene without hair and a globose capitula.

Specimens examined.— *A.F.G. Kerr* 3892 (BM, K), 3983 (BM, K), s.n. (BM); *R.M. King* 5563 (L), 5564 (L); *H. Koyama, H. Terao & Th. Wongprasert* T-33138 (AAU, BKF, L); *M.C. Lakshnakara* 948 (BK, BM, K); *A. Marcan* 39 (BM), 416 (BM, K); *J.F. Maxwell* 70-19 (BK, L), 71-643 (BK, L); *Y. Paisooksantivatana* 1879-86 (BK); *C. Phengkklai et al.* 3392 (BKF); *R. Schomburgk* 1859 (K); *S. Sutheesorn* 1875 (BK); *Vanpruk* 1015 (BKF, K), 999 (K).

4. *Decaneuropsis*

H. Rob. & Skvarla, Proc. Biol. Soc. Wash. 120(3): 360. 2007.

Type: *Vernonia cumingiana* Benth.

Perennial shrubs. *Stem* scandent, young branches rounded, pubescent or glabrous. *Leaves* simple, alternate, petiolate, pubescent with uniseriate hairs; lamina ovate, lanceolate or elliptic; margins entire, apex acute or acuminate, base cuneate,

subcoriaceous. *Capitulescences* terminal or axillary. *Capitula* discoid, homogamous, pedunculate; florets bisexual and fertile. *Involucre* imbricate, 4 – 6-seriate, phyllaries 7 – 12 mm long, persistent, eglandular. *Florets* purple or white, actinomorphic; lobes 5. *Anthers* 5, syngenesious. *Styles* 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs reaching below style bifurcation. *Achenes* clavate or turbinate, 10-ribbed, hairy, eglandular, carpopodium present. *Pappus* bristles, 2-seriate. *Pollen* echinolophate, 3-colporate, with micropuncta.

Three species are recognized in Thailand.

KEY TO THE SPECIES

1. Phyllaries whitish puberulous

2. Phyllaries obtuse; leaves glandular

3. *D. garrettiana*

2. Phyllaries acute; leaves eglandular

2. *D. eberhardtii*

1. Phyllaries furruginous tomentose

1. *D. cumingiana*

1. *Decaneuropsis cumingiana* (Benth.) H. Rob. & Skvarla, Proc. Biol. Soc. Wash. 120(3): 364. 2007. Type: as *Vernonia cumingiana* Benth. Figures 2.35, 2.71 A. & B.

Vernonia cumingiana Benth. in Hook.f., Kew Journ. 4: 232. 1852. Type: Philippines, M. Cuming 1092 (G!).

Vernonia sangka Kerr, Bull. Misc. Inform., Kew 1935, 329. 1935. Type: Thailand, Kanchanaburi, Sangka, A.F.G. Kerr 8302 (K!).

Climbing or scandent shrubs, 3 – 10 m tall. *Stem* sprawling, young branches rounded, inconspicuously ribbed, ferruginous tomentose. *Leaves* 7 – 10 by 3 – 4 cm, elliptic to oblong-elliptic, margins entire, apex acute, base cuneate, subcoriaceous; upper surfaces puberulous with glands, lower surface sericeous with whip-shaped hairs, cylindrical hairs and capitate glands; lateral veins 5 – 6-paired; petioles up to 1 cm long. *Capitulescences* terminal and axillary, paniculate. *Capitula* campanulate, 12 – 15 mm long, pedunculate. *Receptacle* flat, 4 – 4.5 mm diam., hairy. *Phyllaries* 5 –

6-seriate, imbricate, campanulate, dull green, 7 – 8 mm long, 6 – 7 mm diam., margins filiferous, outer surface ferruginous tomentose, glands capitate; the outer and the middle ones ovate, apex acute; the inner ones lanceolate to oblong, apex acute. *Florets* 20 – 30, infundibular, purple, glandular, corolla tube 5 – 6.5 mm long; corolla lobes *ca.* 2 mm long. *Anthems* 2.8 – 3 mm long, apical appendage acute, base obtuse. *Styles* purple, 7 – 7.5 mm long, branches 3.5 – 4 mm long. *Achenes* clavate, 3 – 3.5 mm long, 10-ribbed, puberulous without glands, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 9 – 9.5 mm long, persistent. *Pollen* echinolophate, 3-colporate, with micropuncta.

Thailand.– NORTHERN: Chiang Mai, Nan, Lampang; NORTH-EASTERN: Phetchabun; SOUTH-WESTERN: Kanchanaburi; CENTRAL: Phra Nakhon Si Ayutthaya, Saraburi, Nakhon Nayok; PENINSULAR: Yala.

Distribution.– Hong Kong, India, Thailand, Laos, Cambodia, Vietnam, Philippines, New Guinea.

Ecology.– Evergreen or pine-oak forest, alt. 200 – 850 m; flowering November to April.

Vernacular.– Phaya Rak Pa (พญารักป่า), Pan Sieng (พันเชียง).

Note.– *D. cumingiana* is recognized by its leaf surface and phyllaries are ferruginous tomentose.

Specimens examined.– *S. Bunwong* 74 (KKU); *A.F.G. Kerr* 1114 (BK, BM, K), 8302 (BM, K, P); *A. Marcan* 1844 (BK, BM, K); *J.F. Maxwell* 02-27 (BKF); *C. Phengkhai* 562 (K); *B. Sangkhachand* 1409 (BKF); *P. Srisanga* 1315 (QBG); *Th. Sørensen, K. Larsen & B. Hansen* 6942 (C, K); *Winit* 1287 (BK, BKF, K), 1916 (K).

2. *Decaneuropsis eberhardtii* (Gagnep.) H. Rob. & Skvarla, Proc. Biol. Soc. Wash. 120(3): 365. 2007. Type: as *Vernonia eberhardtii* Gagnep. Figures 2.36, 2.71 C. & D.

Vernonia eberhardtii Gagnep., Bull. Mus. Natl. Hist. Nat.: 489. 1919. Type: Vietnam, Tonkin, *Eberhardt* 4230 (P!).

Vernonia craibiana Kerr, Bull. Misc. Inform., Kew 1935: 328. 1935. Type: Thailand, A.F.G. Kerr 9969 (K!, L!, P!).

Climbing or scandent shrubs. *Stem* sprawling, young branches inconspicuously ribbed, puberulous. *Leaves* 10 – 15 by 5 – 7 cm, elliptic or obovate, margins entire, apex acute, base cuneate, subcoriaceous; both surfaces puberulous with cylindrical hairs, lateral veins 5 – 7-paired; petioles up to 1 cm long. *Capitulescences* terminal and axillary, paniculate. *Capitula* campanulate, 10 – 15 mm long, pedunculate. *Receptacle* flat, 2 – 3 mm diam., hairy. *Phyllaries* 4 – 5-seriate, imbricate, campanulate, dark green or purple apically, 7 – 8 mm long, 4 – 5 mm diam., margins filiferous, outer surface puberulous without gland; the outer and the middle ones ovate, acute or apiculate; the inner ones ovate or ovate-lanceolate, apex acute or obtuse. *Florets* 11 – 13, infundibular, purple, glabrous; corolla tube 5 – 5.5 mm long; corolla lobes 2 – 2.5 mm long. *Anthers* 3 – 3.5 mm long, apical appendage acute, base acute. *Styles* purple, 6 – 6.5 mm long, branches 4 – 5 mm long. *Achenes* turbinate, 2.5 – 3 mm long, 10-ribbed, covered with dense hairs, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 6 – 7 mm long, persistent. *Pollen* echinolophate, 3-colporate, with micropuncta.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai; NORTH-EASTERN: Phetchabun; EASTERN: Chaityaphum; SOUTH-WESTERN: Kanchanaburi.

Distribution.— Thailand, Cambodia, Vietnam.

Ecology.— Dry evergreen forest, alt. 500 – 800 m; flowering December to February.

Vernacular.— Ya Kae Krua (ยามแก่เครือ).

Note.— *D. eberhardtii* differs from *D. cumingiana* by having nearly glabrous leaves and phyllaries.

Specimens examined.— *S. Bunwong* 67 (KKU), 376 (KKU, US), 384 (KKU, US); *H.B.G. Garrett* 1483 (K, L, P); *A.F.G. Kerr* 6413 (K, P), 9969 (BM, E, K, L, P); *F. Konta & S. Khao-iem* 11451 (BKF); *H. Koyama, F. Konta & W. Nanakorn* T-48974 (BKF); *J.F. Maxwell* 75-1122 (AAU, BK, L), 76-681 (AAU, BK), 92-129 (E, L), 96-466 (BKF), 97-101 (BKF), 02-21 (BKF, CMU); *C. Phengkklai* 562 (BKF); *Put*

3553 (BK, BM, E, K, P); *J. Sadakorn* 531 (BK); *B. Sangkhachand* 3064 (BKF); *T. Santisuk* 1122 (BKF); *T. Smitinand* 871 (BKF); *Vacharapong* 370 (BK); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 3774 (BKF, C, K, L, P), 4459 (BKF, C, K, L); *Th. Wongprasert & S. Khao-iem* 041-31 (BKF).

3. *Decaneuropsis garrettiana* (Craib) H. Rob. & Skvarla, Proc. Biol. Soc. Wash. 120(3): 365. 2007. Type: as *Vernonia garrettiana* Craib. Figures 2.37, 2.72 A. & B.

Vernonia garrettiana Craib, Bull. Misc. Inform., Kew. 1915: 431. 1915. Type: Thailand, *A.F.G. Kerr* 2341 (BM!, E!, K!).

Climbing or scandent shrubs, young branches rounded, inconspicuously ribbed, puberulous. *Leaves* 9 – 25 by 4 – 15 cm, elliptic or obovate, margins entire, apex acute, base cuneate, chartaceous; upper surfaces puberulous without glands; lower surface puberulous with whip-shaped hairs, cylindrical hairs and capitate glands, lateral veins 4 – 11-paired; petioles up to 3.5 cm long. *Capitulescences* terminal and axillary, paniculate. *Capitula* campanulate, 12 – 15 mm long, pedunculate. *Receptacle* flat, 5 – 5.5 mm diam., hairy. *Phyllaries* 5 – 6-seriate, imbricate, campanulate, totally green, 10 – 12 mm long, 8 – 8.5 mm diam., margins filiferous, outer surface puberulous without glands; the outer and the middle ones ovate or ovate-lanceolate, obtuse; the inner ones obovate-lanceolate, apex obtuse. *Florets* 20 – 30, infundibular, dark purple, glandular; corolla tube 7 – 8 mm long; corolla lobes *ca.* 2 mm long. *Anthers* 3 – 3.5 mm long, apical appendage acute, base acute. *Styles* white, 7 – 7.5 mm long, branches 3.5 – 4 mm long. *Achenes* subterete, 2.8 – 3 mm long, 10-ribbed, covered with dense hairs without glands, carpodium present. *Pappus* bristles, 2-seriate, the inner ones 6.5 – 8.5 mm long, persistent. *Pollen* subechinolophate, 3-colporate, with micropuncta.

Thailand.— NORTHERN: Chiang Mai, Chiang Rai, Lampang, Phrae; SOUTH-WESTERN: Kanchanaburina.

Distribution.— Myanmar, Thailand.

Ecology.— Mixed deciduous, evergreen or pine-oak forest, alt. 400 – 800 m; flowering November to February.

Note.— *D. garrettiana* is distinguished from *D. cumingiana* and *D. eberhardtii* by its obtuse phyllaries.

Specimens examined.— *S. Bunwong* 75 (KKU), *H.B.G. Garrett* 130 (BK, BKF, K); *B. Hansen, G. Siedenfaden & T. Smitinand* 11049 (BKF, C, K, P); *A.F.G. Kerr* 2341 (BM, E, K) & 10216 (BK, BM, K); *K. Larsen* 9339 (C, K); *J.F. Maxwell* 93-1437 (CMU, L), 93-1481 (CMU), 96-65 (CMU, L); *W. Nanakorn et al.* 5337 (QBG), 6156 (QBG); *S. Phusomseang* 66 (BKF, K, L); *W. Pongamornkul* 23 (QBG), 48 (QBG); *R. Pooma* 386 (BKF); *S. Sutheesorn* 1639 (BK), 2287 (BK); *C.F. van Beusekom & C. Phengklai* 2316 (AAU, BKF, C, E, L, P).

5. *Elephantopus*

L., Sp. Pl.: 814. 1753.

Type: *Elephantopus scaber* L.

Annual or perennial herbs. *Stem* rosulate or caulescent, pubescent. *Leaves* simple, alternate or rosette, usually petiolate; lamina obovate, oblanceolate, elliptic, pilose-villose glandular; margins crenate, dentate or serrate; apex acute or obtuse, base attenuate, usually chartaceous. *Capitulescences* terminal or axillary, scapose or paniculate. *Capitula* discoid, tubular; clusters subtended by secondary foliose bracts, homogamous; florets bisexual and fertile. *Phyllaries* 8, in 2 seriate, decussate, persistent, oblong, outer surface puberulous or pilose-villose, glands capitate. *Florets* purple or white, glabrous or glandular, zygomorphic; corolla tube slender; corolla lobes 5, *Anthers* 5, syngenesious, apical appendage acute. *Styles* purple or white, 2 – 3-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs. *Achenes* usually clavate, 10-ribbed, pubescent, carpopodium present. *Pappus* bristles, 1-seriate. *Pollen* lophate, 3-porate, without micropuncta.

Two species are recognized in Thailand.

KEY TO THE SPECIES

- | | |
|--|----------------------------|
| 1. Leaves cauline; capitulescences terminal and axillary | 1. <i>E. mollis</i> |
| 1. Leaves rosulate; capitulescences scapiform | 2. <i>E. scaber</i> |

1. *Elephantopus mollis* Kunth, Nov. Gen. Sp. [H.B.K.] 4: 26. 1820. Type: Venezuela, Caracas, *Humboldt & Bonpland* 627 (P!). Figures 2.38, 2.72 C. & D.

Elephantopus tomentosus Koster, Blumea 1: 464. 1935, non L.

Perennial herbs, 50 – 200 cm tall. *Stem* caulescent, erect or procumbent, rounded, inconspicuously ribbed, pilose. *Leaves* alternate, 10 – 20 by 3 – 5 cm, elliptic or oblong, margins crenate, apex acute, base attenuate, subcoriaceous; both surfaces sparsely pilose with filiform hairs, cylindrical hairs and capitate glands; lateral veins 10 – 16-paired; petioles up to 10 mm long. *Capitulescences* terminal and axillary, paniculate. *Foliose bracts* 3, deltoid. *Capitula* tubular, 7 – 8 mm long. *Receptacle* flat, ca. 1 mm diam., glabrous. *Phyllaries* 8, 2-seriate, decussate, tubular, light green, 6.5 – 8 mm long, 3 – 4 mm diam., margins entire, outer surface puberulous, without glands; the outer ovate, apex acute; the inner ones lanceolate, apex acuminate. *Florets* 4, white, zygomorphic, glabrous; corolla tube slender, 3 – 5 mm long; corolla lobes bilabiate, 1.5 – 2 mm long. *Anthers* ca. 1 mm long, apical appendage acute, base rounded. *Styles* white, 4 – 5 mm long, branches ca. 1 mm long; sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* clavate, 2.5 – 3 mm long, pubescent densely covered with twin hairs, eglandular, inconspicuously ribbed, carpodium present. *Pappus* bristles, dilated at base, 1-seriate, 4 – 6 by 2.5 – 4.5 mm long. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— EASTERN: Nakhon Ratchasima; Ubon Ratchathani;
PENINSULAR: Satun, Songkhla.

Distribution.— Pantropics.

Ecology.— Evergreen forest, alt. 0 – 100 m; flowering October to December.

Vernacular.— Doo Mai Ru Lom (โด้ไม้รูลอม), Hun Huay (หุนหวาย).

Note.— *E. mollis* is recognized by its cauline leaves and completely white flowers.

Specimens examined.— *S. Bunwong* 34 (KKU), 50 (KKU), 340 (KKU, US); *D.J. Collins* 451 (BM); *J.F. Maxwell* 86-47 (BKU, CMU, L); *C. Phengkhai* 10667 (BKF); *Put* 2205 (BM); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & C. Niyomdham* T-27159 (BKF); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & T. Santisuk* T-27555 (AAU, BKF); *T. Smitinand* 7194 (BKF).

2. *Elephantopus scaber* L., Sp. Pl.: 814. 1753. Type: India. Figures 2.39, 2.73 A. & B.

Two varieties are recognized in Thailand.

KEY TO THE VARIETIES

- | | |
|---|------------------------------------|
| 1. Leaves and inflorescences densely pilose-tomentose | 1. var. <i>penicillatus</i> |
| 1. Leaves and inflorescences sparsely pilose | 2. var. <i>scaber</i> |

2.1 var. *penicillatus* Gagnep., Fl. Indo-Chine [M.H. Lecomte *et al.*] 3: 503. 1924. Type: Laos, Chedom, *Thorel* 1407 (K!). Figures 2.40, 2.73 C. & D.

Perennial herbs, 40 – 100 m tall. *Stem* acaulescent except inflorescence scapose, erect, rounded, inconspicuously ribbed and pilose-villose. *Leaves* rosette at base, 6 – 20 by 6 – 10 cm, obovate, obovate-lanceolate, elliptic, margins crenate to serrate, apex obtuse, base attenuate, subcoriaceous; upper surface sparsely pilose, without glands; lower surface densely pilose, with filiform cylindrical hairs and capitate glands; lateral veins 7 – 16-paired; petioles up to 6 cm long. *Capitulescences* terminal, scapose. *Foliose bracts* 3, deltoid. *Capitula* tubular, 7 – 9 mm long. *Receptacle* flat, ca. 1 mm diam., glabrous. *Phyllaries* 8, distichous, decussate, tubular, 6.5 – 8 mm long, 3 – 4 mm diam., margins entire, outer surface puberulous, glands capitate; the outer ovate-lanceolate, apex acuminate; the inner ones lanceolate or oblong, apex acuminate. *Florets* 4, salverform, white or purple, zygomorphic,

glabrous or rarely hairy; corolla tube 4 – 6 mm long; corolla lobe, 2.5 – 3.5 mm long. *Anthers* ca. 2 mm long, apical appendage acute, base rounded. *Styles* purple, 6 – 8 mm long, branches ca. 1 mm long; sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* clavate, 2 – 2.5 mm long, pubescent with a dense covering of twin hairs, without glands, 10-ribbed, carpodium present. *Pappus* bristles 5, ca. 3 mm long, 1-seriate, dilated at base. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTH-EASTERN: Loei, Sakon Nakhon; EASTERN: Nakhon Ratchasima; Ubon Ratchathani; SOUTH-EASTERN: Chon Buri.

Distribution.— Thailand, Laos, Vietnam.

Ecology.— Dipterocarp or dry evergreen forest, alt. 100 – 400 m; flowering August to January.

Vernacular.— Doo Mai Ru Lom (โด้ไม้รูลุ่ม), Kee Fai Nok Khum (จีไฟนอกลุ่ม).

Note.— *E. scaber* var. *penicillatus* differs from the typical variety in having large capitula and whitish pilose-tomentose leaf surface and involucres.

Specimens examined.— *S. Bunwong* 10 (KKU), 326 (KKU, US), 333 (KKU, US), 345 (KKU, US); *C. Charoenpol*, *K. Larsen* & *E. Warncke* 4933 (AAU, BKF, K, L); *Damrongsak* 447 (BKF); *Dee* 20 (BKF), 444 (BKF); *Din* 174 (BKF); *N. Fukuoka* & *M. Ito* T-34864 (L); *H. Koyama* T-31316 (BKF, L); *H. Koyama*, *H. Terao* & *Th. Wongprasert* T-31019 (BKF) & T-31139 (BKF); *J.F. Maxwell* 75-1040 (AAU, BK, BKF); *G. Murata*, *C. Phengklae*, *S. Mitsuta*, *T. Yahara*, *H. Nagamasu* & *N. Nantasan* T-37463 (BKF), T-50689 (BKF), T-51129 (BKF); *C. Niyomdham* 5582 (BKF); *Put* 4216 (BM, BK, K, L); *B. Sangkhachand* & *S. Sutheesorn* 3528 (BK).

2.2 var. *scaber*

Perennial herbs, 10 – 40 cm tall. *Stem* acaulescent, erect, rounded, inconspicuously ribbed, sericeous. *Leaves* rosette at base, 8 – 20 by 3 – 5 cm, obovate or obovate-lanceolate, margins crenate or serrate, apex obtuse or acute, base attenuate, subcoriaceous; upper surface sparsely pilose without glands, lower surface densely pilose with filiform and cylindrical hairs and capitate glands; lateral veins 12 – 15-

paired; petioles up to 2 cm long. *Capitulescences* terminal, scapose. *Foliose bracts* 3, deltoid. *Capitula* tubular, 8 – 10 mm long. *Receptacle* flat, ca. 0.5 mm diam., glabrous. *Phyllaries* 8, 2-seriate, decussate, green with purple apex, 7 – 10 mm long, 2 – 3 mm diam., margins entire or filiferous, outer surface pilose, without glands; the outer lanceolate, apex acuminate to acuminate; the inner ones oblong, apex acuminate. *Florets* 4, salverform, purple, zygomorphic, glabrous; corolla tube 3 – 3.5 mm long; corolla lobes, 1.5 – 2 mm long. *Anthers* ca. 2 mm long, apical appendage acute, base acute. *Styles* purple, 7 – 8 mm long, branches ca. 0.5 mm long; sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* clavate, 2.5 – 3 mm long, pubescent with dense twin hairs, eglandular, inconspicuously ribbed, carpodium present. *Pappus* bristles 5, 1-seriate, dilateat bases. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai, Chiang Rai, Nan, Lampang, Sukhothai, Phitsanulok; NORTH-EASTERN: Phetchabun, Loei, Nong Khai, Sakon Nakhon, Mukdahan, Kalasin, Maha Sarakham, Khon Kaen; EASTERN: Chaiyaphum, Nakhon Ratchasima, Buri Ram, Surin, Ubon Ratchathani; SOUTH-WESTERN: Kanchanaburi, Prachuap Khiri Khan; SOUTH-EASTERN: Chon Buri, Chanthaburi, Trat; PENINSULAR: Chumphon, Ranong, Phangnga, Phuket, Nakhon Si Thammarat, Trang, Satun, Songkhla.

Distribution.— Pantropics.

Ecology.— Open area in dipterocarp, evergreen or pine-oak forest, alt. 0 – 300 m; flowering August to January.

Vernacular.— Doo Mai Ru Lom (โตไม่รู้ล้ม), Kee Fai Nok Khum (ชี้โพนกุ่ม), Ya Kai Nok Khum (หญ้าโพนกุ่ม), Ya Prab (หญ้าปราบ), Ya Sam Sib Song Hab (หญ้าสามสิบสองหาบ), Nat Pha (หนาดผา), Ta Che Go Wa (ตะชีโกวะ), Nat Mee Klan (หนาดมีนคลน).

Note.— This plant is characterized by having rosette leaves and spiciform capitulescence with conspicuous scape and variable leaf shape.

Specimens examined.— *E.F. Anderson* 5534 (CMU), 5545 (CMU), 6125 (CMU); *M. Balick & W. Nanakorn* 3468 (L); *S. Bunwong* 22 (KKU), 23 (KKU), 36 (KKU), 58 (KKU), 325 (KKU, US), 334 (KKU, US), 349 (KKU, US); *D.J. Collins*

2024 (K); *G. Congdon* 52 (AAU), 179 (AAU), 345 (AAU); *Dee* 138 (BKF); *N. Fukuoka & M. Ito* T-35664 (BKF); *H.B.G. Garrett* 242 (BM, E, K); *Hamilton & G. Congdon* 52 (BKF); *K. Iwatsuki & N. Fukuoka* T3562 (BKF, L); *A.F.G. Kerr* 11418 (BK, BM), 13792 (BK, BM, K), 1619B (BM, K); *H. Koyama* T-39867 (BKF); *H. Koyama, H. Terao, C. Niyomdham & Th. Wongprasert* T-30363 (BKF), T-30518 (AAU, BKF), T-30910 (BKF), T-31745 (BKF), T-32168 (BKF); *A. Marcan* 545 (BM), 1849 (BM); *J.F. Maxwell* 71-687 (AAU, BK, BKF), 72-493 (BK), 87-1404 (BK, CMU, L), 93-1106 (BKF, L), 96-1380 (BKF), 97-1207 (BKF); *J.F. Maxwell, S. Suttajit, W. Pannavalee & P. Tantipathananandh* 83 (CMU, L); *Morakot* 41 (QBG); *G. Murata, C. Phengklai, S. Mitsuta, T. Yahara, H. Nagamasu & N. Nantasan* T-37560 (AAU, BKF), T-38186 (BKF), T-38633 (BKF), T-43075 (BKF); *W. Nanakorn & H.T. Beck* 88104 (K); *W. Nanakorn et al.* 165 (QBG), 1393 (QBG), 4154 (QBG), 8171 (QBG), 9751 (QBG), 10062 (QBG); *Y. Paisooksantivatana* 375-80 (BK); *Y. Paisooksantivatana & S. Sutheesorn* 959-82 (BK); *C. Phengklai* 228 (BKF, L), 13153 (BKF), 46446 (K), s.n. (BKF); *W. Pongamornkul* 325 (QBG), 345 (QBG), 563 (QBG); *Pradit* 601 (BK); *Put* 2203 (BK); *B. Sangkhachand* 78 (BK), 1085 (BK), 1182 (BKF), 1560 (BK), 1762 (BK), 2218 (BK), 45577 (BKF, K); *B. Sangkhachand & T. Smitinand* 260 (L, P); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & T. Santisuk* T-18383 (BKF, L), T-19054 (BKF, L), T-19344 (BKF), T-27466 (BKF), T-27548 (BKF, L), T-27555 (AAU, BKF, L); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & C. Niyomdham* T-21350 (BKF), T-22264 (BKF), T-22566 (BK), T-26209 (BKF, L), T-26213 (BKF), T-26304 (BKF, L), T-26397 (BKF), T-26474 (BKF), T-26519 (BK), T-26547 (BKF, L), T-26562 (BKF), T-27152 (BKF), T-27305 (BKF, L); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & D. Phanichaphol* T-23949 (BKF), T-26028 (BKF, L); *S. Sutheesorn* 259 (BK), 697 (BK), 2794 (BK); *Th. Sørensen, K. Larsen & B. Hansen* 648 (BKF), 5668 (K); *T. Smitinand* s.n. (BKF); *P. Srisanga* 2618 (QBG); *J. Supapol* 119 (CMU); *S. Suwannaratana* 19 (L); *M. Tagawa, K. Iwatsuki & N. Fukuoka* T-2297 (BKF), T-5382 (BKF); *Umpai* 236 (BK); *C.F. van Beusekom & C. Phengklai* 2007 (AAU, E, L, P); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 3478 (BKF, K, L, P); *J.E. Vidal* 5291 (P); *L. Williams* 17010 (K); *Th. Wongprasert et al.* s.n. (BKF).

6. *Ethulia*

L.f., Dec. Pl. Hort. Upsal.: 1. 1762.

Type: *Ethulia conyzoides* L.

Annual herbs. *Stem* erect. *Leaves* simple, alternate, petiolate; lamina ovate, lanceolate, elliptic, pubescent, margins serrate, apex acute to acuminate, base attenuate, chartaceous. *Capitulescences* terminal or axillary, corymbose. *Capitula* discoid, pedunculate, homogamous; florets bisexual and fertile. *Involucre* imbricate. *Corolla* purple, infundibular, glandular; lobes 5, actinomorphic. *Anthers* 5, syngenesious, apical appendage acute, base obtuse. *Styles* white, 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs. *Achenes* turbinate, 6-ribbed, glandular. *Pappus* absent.

One species is recognized in Thailand.

1. *Ethulia conyzoides* L., Sp. Pl.: 1171. 1763. Type: Egypt, *P. Forsskal* 1387 (K!). Figures 2.41, 2.74 A. & B.

Annual herbs, 50 – 150 cm tall. *Stem* erect, conspicuously ribbed, puberulous. *Leaves* alternate, 5 – 8 by 1 – 2 cm, elliptic or lanceolate, margins serrate, apex acuminate or acute, base attenuate, chartaceous; both surfaces ferrugineous puberulous with unicellular hairs and capitate glands, shortly petiolate. *Capitulescences* terminal and axillary, corymbose. *Capitula* hemispherical, 3 – 4 mm long. *Receptacle* ca. 1.5 mm diam., glabrous. *Phyllaries* 3 – 4-seriate, imbricate, semispherical, green with purple apex, 1.5 – 2 mm long, 1 – 2 mm diam., margins filiferous, outer surface puberulous, glands capitate; the outer and the middle ones ovate to lanceolate, apex acute; the inner ones lanceolate to oblong, apex acute. *Florets* 20 – 30, infundibular, corolla purple, glandular; corolla tube 0.5 – 1 mm long; corolla lobes ca. 1 mm long. *Anthers* 1.5 – 2 mm long, apical appendage acute, base obtuse. *Styles* purple, inner surface covered with stigmatic papillae, sweeping hairs.

Achenes turbinate, 1.5 – 2 mm long, glandular, 6-ribbed, carpopodium absent. *Pappus* absent.

Thailand.— NORTHERN: Chiang Mai, Chiang Rai; NORTH-EASTERN: Nakhon Phanom.

Distribution.— Tropics.

Ecology.— Open area along river bank in evergreen forest, alt. 200 – 400 m; flowering May to September.

Note.— *E. conyzoides* is distinguished by achenes having 4 – 6 ribs, pappus and carpopodium are absent.

Specimens examined.— *H.B.G. Garrett* 227 (BKF, BM, K); *A.F.G. Kerr* 21396 (BK, BM, K), 21809 (K).

7. *Gymnanthemum*

Cass., Bull. Soc. Philom. Paris 1: 10. 1817.

Type: *Gymnanthemum cupulare* Cass.

Small trees. *Stem* caulescent. *Leaves* simple, alternate, petiolate; lamina ovate, or elliptic, pubescent, margins serrate, apex acuminate, base attenuate, chartaceous. *Capitulescences* terminal or axillary, corymbose. *Capitula* discoid, homogamous, pedunculate. *Florets* bisexual and fertile. *Involucre* herbaceous, persistent, apex obtuse. *Corolla* purple to white, actinomorphic; lobes 5. *Anthers* 5, syngenesious. *Styles* purple, 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs. *Achenes* subterete or obovate, usually 10-ribbed, carpopodium present. *Pappus* bristles, 2-seriate. *Pollen* lophate, 3-porate, with or without micropuncta.

One species is recognized in Thailand.

1. ***Gymnanthemum cylindriceps*** (C.B.Clarke) H.Rob., Proc. Biol. Soc. Wash. 112(1): 241. 1999. Type as *Vernonia cylindriceps* C.B.Clarke. Figures 2.42, 2.75 A. & B.

Vernonia cylindriceps C.B.Clarke, J. Linn. Soc. Bot. 25: 35. 1880. Type: India, Hartook Mekong, C.B. Clarke 42109 (K!).

Shrubs or subshrubs 2 – 6 m tall. *Stem* caulescent, young branches inconspicuously ribbed, white puberulous. *Leaves* 7 – 13 by 2 – 4 cm, oblanceolate, margins serrate, apex acute, base attenuate, chartaceous; upper surface puberulous, without glands; lower surface puberulous with whip-shaped hairs, cylindrical hairs and capitate glands; lateral veins 7 – 12-paired; petioles up to 1 cm long. *Capitulescences* terminal, corymbose. *Capitula* narrowly campanulate, 14 – 16 mm long, pedunculate. *Receptacle* convex, 1 – 1.5 mm diam., hairy. *Phyllaries* 5 – 6-seriate, imbricate, slightly oblong-cylindrical, green, 8 – 10 mm long, 3 – 4 mm diam., margins filiferous, outer surface arachnoid without glands; the outer and the middle ones, ovate, apex obtuse; the inner ones lanceolate or ovate-lanceolate, apex obtuse or rounded. *Florets* 5 – 10, infundibular, purple or white, glandular, corolla tube 6 – 7 mm long; corolla lobes 4 – 4.5 mm long. *Anthers* 4 – 4.5 mm long, apical appendage acute, base obtuse. *Styles* purple, 9 – 10 mm long, branches 2, 4 – 5 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* turbinate, 3 – 3.5 mm long, 10-ribbed, covered with dense hairs and capitate glands, carpodium present. *Pappus* bristles, 2-seriate, the inner ones 8.5 – 9 mm long. *Pollen* subechinolophate, 3-colporate, with prominent micropuncta.

Thailand.— NORTHERN: Chiang Mai, Chiang Rai.

Distribution.— China (Yunnan), India, Nepal, Myanmar, Thailand.

Ecology.— Evergreen or pine-oak forest, alt. 1,000 – 2,000 m; flowering December to April.

Note.— This species is characterized by distinctly sweet smell, shrubs or subshrubs and obtuse phyllaries.

Specimens examined.— *S. Bunwong* 76 (KKU), 378 (KKU, US); *H.B.G. Garrett* 629 (BKF, BM, K, P); *F. Konta & S. Khao-iam* 10846 (BKF), 10949 (BKF); *F. Konta & C. Phengkklai* 3950 (BKF), 3998 (BKF); *F. Konta, C. Phengkklai & S. Khao-iam* 4200 (BKF); *H. Koyama, H. Terao & Th. Wongprasert* T-33185 (BKF), T-33345 (BKF), T-33458 (BKF), T-33515 (BKF); *H. Koyama, T. Yahara & W. Nanakorn* T-32726 (BKF, L), T-39717 (BKF); *T. Koyama, C. Phengkklai, C. Niyomdham, M. Tamura, H. Okada & R.J. O'Connor* 15558 (AAU); *B. Løjtnant & C. Niyomdham* 155 (AAU, K); *C. Maknoi* 651 (QBG); *W. Nanakorn et al.* 2916 (QBG), 5760 (QBG), 5858 (QBG), 8629 (QBG); *R. Pooma* 382 (BKF), 932 (BKF); *J. Sadakorn* 435 (BK); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & T. Santisuk* 20608 (BKF); *T. Smitinand et al.* 6628 (BK, BM, K), 10280 (BK, BKF, K, L, P); *Th. Wongprasert* 5012-60 (BKF); *Worawoot* 95 (BKF).

8. *Iodocephalopsis*

S. Bunwong & H. Rob., Proc. Biol. Soc. Wash. 122(3): 358. 2009.

Type: *Iodocephalopsis eberhardtii* (Gagnep.) *S. Bunwong & H. Rob.*

Erect perennial herbs. *Stem* erect, pubescent with T-shaped hairs. *Leaves* simple, alternate, petiolate; lamina ovate, pubescent. *Capitulescences* laxly cymose with capitula solitary and 2-3 in a group. *Capitula* discoid, campanulate, pedunculate, homogamous; florets fertile. *Involucre* imbricate, hairy, phyllaries with entire margins. *Florets* purplish or whitish, infundibular; lobes 5. *Anthers* 5, purplish or yellowish, syngenesious, exerted. *Styles* purple, 2-branched, without enlarged basal node, inner surface covered with stigmatic papillae, outer surface and lower style shaft covered with sweeping hairs. *Achenes* 7 – 10-ribbed, glandular, with vermicular seriate of idioblasts on the surface; achene walls with distinct fibrous layer inside, without raphids, base without carpopodium. *Pappus* absent. *Pollen* echinolophate, 3-colporate, pores in short colpus formed of two partially fused lacunae.

One species is recognized in Thailand.

1. *Iodocephalopsis eberhardtii* (Gagnep.) S.Bunwong & H.Rob., Proc. Biol. Soc. Wash. 122(3): 358. 2009. Type: as *Iodocephalus eberhardtii* Gagnep. Figures 2.43, 2.74 C. & D.

Iodocephalus eberhardtii Gagnep., Notul. Syst. (Paris) 4: 18. 1920. Type: Vietnam, Lang-bian, *Eberhardt* 1711 (P!).

Iodocephalus glandulosus Kerr, Bull. Misc. Inform., Kew.: 326. 1935. Type: Thailand, Chiang Mai, Doi Sutep, *Kerr* 789 (BM!).

Camchaya eberhardtii (Gagnep.) Kitam. Acta Phytotax. Geobot. 23: 71. 1968.

Perennial herbs, 0.5 – 1 m tall. *Stem* erect, rounded, inconspicuously ribbed, puberulous with T-shaped hairs and glands. *Leaves* alternate, obovate-lanceolate, 4 – 10 by 1 – 4 cm, margins serrate or entire, apex acute, base attenuate, chartaceous; both surfaces puberulous with whip-shaped hairs, cylindrical hairs and capitate glands; lateral veins 5 – 8-paired; petioles up to 3 mm long. *Capitulescences* terminal or axillary, corymbose or solitary. *Capitula* campanulate, 8 – 10 mm long, pedunculate. *Receptacle* convex, 2.5 – 4 mm diam., glabrous. *Phyllaries* 3 – 4-seriate, imbricate, campanulate, dull green, 6 – 7 mm long, margins filiferous, outer surface arachnoid, glandular; the outer and the middle ones ovate, apex acute to acuminate; the inner ones ovate-lanceolate, apex acute to acuminate. *Florets* 15 – 25, infundibular, purple or white, puberulous, glands capitate; corolla tube 2.5 – 4 mm long; corolla lobes 2 – 2.5 mm long. *Anthers* ca. 2 mm long, apical appendage acute, base rounded. *Styles* purple, 3 – 5 mm long, branches 1 – 2 mm long; sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* turbinate, 3 – 5 mm long, glandular, 7 – 10-ribbed, carpodium and pappus absent. *Pollen* echinolophate, 3-colporate, without micropuncta.

Thailand.– NORTHERN: Chiang Mai, Chiang Rai, Nan, Phitsanulok; NORTH-EASTERN: Loei, Khon Kaen; EASTERN: Nakhon Ratchasima; SOUTH-WESTERN: Phetchaburi; CENTRAL: Nakhon Nayok.

Distribution.– Thailand, Laos, Cambodia.

Ecology.— Edge of evergreen and pine-oak forests, alt. 700 – 1700 m; flowering August to December.

Note.— *I. eberhardtii* is different from other *Camchaya* spp. by having 3-colporate pollen, pappus is absent and phyllaries are without marginal spine.

Specimens examined.— *S. Bunwong* 12 (KKU), 335 (KKU, US); *B.L. Burt* 5602 (E); *T. Boonkird* 24 (BK); *C. Charoenphol*, *K. Larsen* & *E. Warncke* 4223 (L); *Din* 6 (P), 249 (BKF, P); *N. Fukuoka* & *M. Ito* T-34597 (L); *A.F.G. Kerr* 199 (K), 789 (BM), 1619 (BM); *H. Koyama* T-61475 (L); *H. Koyama*, *H. Terao*, *Th. Wongprasert* T-30837 (BKF), T-31570 (BKF, L), T-31637 (L); *K. Larsen*, *T. Santisuk* & *E. Warncke* 969 (K, L, P), 2792 (K); *J.F. Maxwell* 74-808 (BK), 87-1492 (CMU, L), 91-770 (E, P); *D.J. Middleton*, *S. Suddee*, *S.J. Davies* & *C. Hemrat* 996 (K); *S. Mitsuta*, *H. Nagamasu*, *T. Yahara* & *N. Nantasan* T-42260 (BKF); *G. Murata*, *K. Iwatsuki*, *C. Phengklai* & *C. Charenphol* T-15328 (K, L), 41669 (BKF); *G. Murata*, *C. Phengklai*, *S. Mitsuta*, *T. Yahara*, *H. Nagamasu* & *N. Nantasan* T-42599 (L); *P. Palee* 228 (L); *W. Pongamornkul* 334 (QBG); *Y. Paisooksantivatana* 1857-86 (BK), 2469-89 (BK); *T. Shimizu*, *H. Toyokuni*, *H. Koyama*, *T. Yahama* & *C. Niyomdham* T-23017 (L); *T. Shimizu*, *H. Toyokuni*, *H. Koyama*, *T. Yahama* & *T. Santisuk* T-18098 (AAU, L), T-18595 (AAU, L), T-18670 (L); *P. Srisanga* 949 (QBG), 1125 (QBG); *Th. Sørensen*, *K. Larsen* & *B. Hansen* 4060 (K); *H. Tagahashi* & *M.N. Tamura* T-63301 (AAU, BKF); *Th. Wongprasert s.n.* (BKF).

9. *Koyamasia*

H. Rob., Proc. Biol. Soc. Wash. 112(1): 234. 1999.

Type: *Camchaya calcarea* Kitam.

Perennial herbs. *Stem* erect, pubescent. *Leaves* simple, alternate, petiolate; lamina ovate or elliptic, margins serrate, apex acute or acuminate, base attenuate, subcoriaceous. *Capitulescences* terminal, solitary. *Capitula* discoid, homogamous; pedunculate, florets bisexual and fertile. *Involucre* imbricate, reflexed. *Florets* purplish or white, actinomorphic; lobes 5. *Anthers* 5, syngenesious. *Styles* 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping

hairs. *Achenes* subterete, 10-ribbed, carpopodium absent. *Pappus* bristles, 1-seriate, deciduous. *Pollen* echinolophate, 3-porate, without micropuncta.

One species is recognized in Thailand.

1. *Koyamasia calcarea* (Kitam.) H. Rob., Proc. Biol. Soc. Wash. 112(1): 235. 1999. Type: as *Camchaya calcarea* Kitam. Figures 2.44, 2.76 A. & B.

Camchaya calcarea Kitam., Acta Phytotax. Geobot. 23: 71. 1968. Type: Thailand, Chiang Mai, Doi Chiangdao, T. Shimizu, H. Koyama & A. Nalampoon T-10011 (KYO!).

Vernonia calcarea (Kitam.) H. Koyama, Bull. Natn. Sci. Mus., Tokyo, Ser. B, 29(1): 20. 2003.

Perennial herbs, 20 – 80 m tall. *Stem* erect, conspicuously ribbed, puberulous with glands. *Leaves* 10 – 30 by 3 – 6 cm, ovate or elliptic, margins serrate, apex acute to acuminate, base attenuate, subcoriaceous, upper surface scabrous without glands, lower surface scabrous with whip-shaped hairs, and capitate glands, lateral veins 7 – 10-paired; petioles up to 6 cm long. *Capitulescences* terminal, solitary. *Capitula* broadly campanulate, 1.5 – 3 cm long, pedunculate. *Receptacle* glabrous. *Phyllaries* 6 – 7 seriate, imbricate, hemispherical, green or purple, 15 – 20 mm long, 15 – 20 mm diam., margins entire, outer surface puberulous glandular; the outer and the middle ones ovate to lanceolate, acuminate or aristate, upper half strongly reflexed; the inner ones ovate-lanceolate, apex acute. *Florets* more than 80, infundibular, purple or white, glandular; corolla tube 5 – 6 mm long; corolla lobes 2 – 3 mm long. *Anthers* 3 – 4 mm long, apical appendage acute, base obtuse. *Styles* purple, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* subterete, 3.5 – 4.5 mm long, 10-ribbed, glabrous, carpopodium absent. *Pappus* bristles, 1-seriate, 1 – 3 mm long, deciduous. *Pollen* echinolophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Chiang Mai.

Distribution.— Endemic to Thailand.

Ecology.— Limestone mountain, alt. *ca.* 1,300 m; flowering October to December.

Note.— *C. calcarea* differs from the other species of *Camchaya* by having oblong achenes, 3-porate pollen and reflexed phyllaries.

Specimens examined.— *Adisai* 611 (BK), *A.F.G. Kerr* 6548 (BM, BK, K); *H. Koyama*, *H. Nagamasu* & *W. Nanakorn* T-39755 (AAU); *Put* 373 (BK, BM, K); *T. Shimitzu*, *H. Toyokuni*, *H. Koyama*, *T. Yahara*, *T. Santisuk* & *C. Niyomdham* T-21121 (L), T-21128 (L), T-21181 (L); *T. Smitinand* & *E.C. Abbe* 6246 (US); *T. Smitinand* & *W. Nanakorn* T-39755 (AAU, L); *P. Suksathan* 2169 (QBG), 2847 (QBG).

10. *Kurziella*

H. Rob & S. Bunwong, *Proc. Biol. Soc. Wash.* 123(2): 174. 2010.

Type: *Vernonia gymnoclada* Collett & Hemsl.

Perennial herbs. *Stem* erect, young branches angled, puberulous. *Leaves* simple, alternate, subsessile, pubescent, glands capitate, subcoriaceous. *Capitulescences* axillary, spicate or solitary. *Capitula* discoid, homogamous, sessile or subsessile. *Florets* bisexual and fertile. *Involucre* imbricate, persistent, eglandular. *Corolla* purple, actinomorphic, lobes 5. *Anthers* 5, syngenesious. *Styles* 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs. *Achenes* terete, carpopodium present, hairy without glands. *Pappus* bristles, 1-seriate. *Pollen* echinate, 3-colporate, with micropuncta.

One species is recognized in Thailand.

1. *Kurziella gymnoclada* (Collett & Hemsl.) H. Rob & S. Bunwong, *Proc. Biol. Soc. Wash.* 123(2): 174. 2010. Type: as *Vernonia gymnoclada* Collett & Hemsl. Figures 2.45, 2.75 C. & D.

Vernonia gymnoclada Collett & Hemsl., *J. Linn. Soc., Bot.* 28: 70. 1890. Type: Myanmar, Meiktila, S.N. (K!).

Vernonia juncea Hook.f., Fl. Br. Ind. 3: 231. 1881, *nom. nud.*

Perennial herbs, up to 1 m tall. *Stem* erect, conspicuously ribbed, puberulous. *Leaves* 1 – 3 by 1 – 2 cm, obovate, margins serrate, apex obtuse or truncate, base cuneate, subcoriaceous, both surfaces scabrous with whip-shaped hairs and capitate glands, lateral veins 2 – 3-paired; petioles up to 5 mm long. *Capitulescences* terminal and axillary, spicate or solitary. *Capitula* campanulate, 10 – 13 mm long, subsessile or shortly pedunculate. *Receptacle* flat, 1.5 – 2 mm diam. *Phyllaries* 5 – 6-seriate, imbricate, campanulate, green or purple apically, 8 – 10 mm long, 4 – 5 mm diam., margins filiferous, outer surface puberulous without glands; the outer and the middle ones ovate or lanceolate, acute; the inner ones lanceolate to oblong, apex acute. *Florets* 15 – 20, infundibular, purple, glabrous; corolla tube 8 – 10 mm long; corolla lobes 3 – 3.5 mm long. *Anthers* 2 – 2.5 mm long, apical appendage acute, base obtuse. *Styles* purple, 7 – 8 mm long, branches 2 – 2.5 mm long, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* 2 – 3 mm long, *ca.* 5-ribbed, covered with dense hairs, carpodium present. *Pappus* bristles, 1-seriate, 9 – 10 mm long. *Pollen* echinate, 3-colporate, with micropuncta.

Thailand.— NORTHERN: Kamphaeng Phet; EASTERN: Nakhon Ratchasima; SOUTH-WESTERN: Kanchanaburi, Ratchaburi, Phetchaburi, Prachuap Khiri Khan; CENTRAL: Chai Nat, Saraburi, Bangkok.

Distribution.— Myanmar, Thailand.

Ecology.— Dipterocarp forest, alt. 40 – 200 m; flowering November to March.

Vernacular.— Yoong Pad Mae Mai (หูกปีดแม่ไม).

Note.— *K. gymnoclada* is distinguished by a single row of persistent pappus, deciduous leaves and sessile or subsessile capitula in axillary leaves.

Specimens examined.— *S. Bunwong* 391 (KKU, US); *A.F.G. Kerr* 7029 (AAU, BK, BM, E, K), 8037 (BK, BM, C, E, K, L, P), 10618 (BK, BM, C, E, K), 10670 (AAU, BM, BK, K), 19911 (AAU, BK, BM, E, K); *A. Marcan* 595 (BM, K); *Put* 1980 (K), 2273 (AAU, BK, BM, E, K), 2654 (BK, BM, E, L, K); *ST. Santisuk* s.n. (BKF); *T. Smitinand* 11398 (BKF); *Sutheesorn* 478 (BK), 479 (BK); *Th. Sørensen*, *K. Larsen & B. Hansen* 1013 (BKF), 2161 (BKF, C, K), 2166 (BKF, C, K), 3611 (K).

11. Monosis

DC. in Wight, Contrib. Bot. Ind.: 5. 1834.

Type: *Monosis wightiana* DC.

Perennial plants. *Stem* small trees or shrubs, young branches rounded, tomentose. *Leaves* simple, alternate, petiolate, pubescent with flagellate hairs; lamina ovate, obovate, oblanceolate or elliptic, margins serrate, apex acute, base attenuate or cuneate, subcoriaceous. *Capitulescences* terminal, thyrsoïd paniculate. *Capitula* discoid, homogamous, pedunculate, florets bisexual and fertile. *Involucre* imbricate, 4 – 5-seriate, 4 – 5 mm long, persistent, eglandular. *Florets* purple, actinomorphic, lobes 5. *Anthers* 5, syngenesious. *Styles* 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* turbinate, 10-ribbed, carpopodium present, hairy with glands. *Pappus* bristles, 2-seriate. *Pollen* psilolophate, 3-colporate, without micropuncta.

Two species are recognized in Thailand.

KEY TO THE SPECIES

- 1. Shrubs; lower leaf surface and young shoot ferruginous tomentose;
 achenes 2.5 – 3.5 mm long **1. *M. parishii***
- 1. Small tree; lower leaf surface and young shoot whitish puberulous;
 achenes 4 – 5 mm long **2. *M. volkameriifolia***

1. *Monosis parishii* (Hook.f.) H.Rob. & Skvarla, Proc. Biol. Soc. Wash. 119(4): 605. 2006. Type: as *Vernonia parishii* Hook.f. Figures 2.46, 2.76 C. & D.

Vernonia parishii Hook.f., Fl. Br. Ind. 3: 240. 1882. Type: Myanmar, Attran, *Parish* 103 (K!).

Shrubs or subshrubs, 1 – 3 m tall. *Stem* erect, young branches inconspicuously ribbed, ferruginous tomentose. *Leaves* 10 – 26 by 3 – 11 cm, ovate or elliptic, margins serrate, apex acute, base attenuate, coriaceous; upper surface ferruginous puberulous without glands; lower surface ferruginous tomentose with flagellate hairs and capitate glands; lateral veins 11 – 13-paired; petioles up to 3 cm long. *Capitulescences* terminal, thyrsoïd paniculate. *Capitula* narrowly campanulate or slightly oblong-cylindrical, 6 – 7 mm long, subsessile or pedunculate. *Receptacle* flat, 2 – 3 mm diam., glabrous. *Phyllaries* 4 – 5-seriate, imbricate, narrowly campanulate, purple or green with purple apex, 4 – 5 mm long, 2.5 – 3 mm diam., margins filiferous, outer surface arachnoid without glands; the outer and the middle ones ovate, apex acute or obtuse; the inner ones lanceolate or oblong, apex acute. *Florets* 7 – 9, infundibular, purple, glandular; corolla tube 4 – 5 mm long; corolla lobes 2 – 2.5 mm long. *Anthers* 3 – 3.5 mm long, apical appendage acute, base obtuse. *Styles* purple, 4 – 5.5 mm long, branches 2, 2 – 2.5 mm long. *Achenes* turbinate, 2.5 – 3.5 mm long, 10-ribbed, covered with sparse hairs and capitate glands, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 5 – 6 mm long, persistent. *Pollen* psilolophate, 3-colporate, without micropuncta.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai, Chiang Rai, Lampang, Sukhothai; SOUTH-WESTERN: Kanchanaburi.

Distribution.— China (Yunnan), India, Myanmar, Thailand, Laos.

Ecology.— Hill evergreen or pine-oak forest, alt. 250 – 800 m; flowering December to April.

Vernacular.— Khang Hang Lek (ขางหางเล็ก), Tree Cha Wa (ตรีชะวา), Nat Ngern (หนาดเงิน).

Note.— *M. parishii* is recognized by leaf surface which is ferruginous tomentose and it is a shrub.

Specimens examined.— *S. Bunwong* 66 (KKU), 72 (KKU), 394 (KKU, US); *C. Chermsirivathana* 416 (BK); *C.C. Hosseus* 458 (BM, C, E, G, K, L); *L.K. Juaton* 126 (BK); *F. Konta*, *C. Niyomdham* & *S. Khao-iam* 4108 (BKF), 4347 (BKF); *H. Koyama*, *C. Phengklai* T-39152 (BKF); *H. Koyama*, *S. Mitsuta* & *H. Nagamasu* T-39776 (BKF); *T. Koyama*, *C. Phengklai*, *C. Niyomdham*, *H. Okada* & *P.J. O'Connor*

T-15579 (AAU, BKF); *H. Koyama, H. Terao & Th. Wongprasert* T-32677 (BKF), T-33472 (BKF), T-33630 (BKF, L); *K. Larsen* 8570 (C); *J.F. Maxwell* 88-226 (AAU, BKF, CMU, L), 89-487 (BKF, L), 90-238 (CMU, E, L), 94-287 (CMU, L), 94-348, (CMU, L), 95-225 (CMU, BKF, L), 96-197 (CMU, BKF, L), 97-265 (BKF), 98-367 (BKF), 98-390 (BKF), 01-80 (BKF); *J.F. Maxwell, S. Suttajit, W. Pannavalee & U. Sangsorn* 153 (CMU); *S. Mitsuta, T. Yahara & H. Nagamasu* 46455 (BKF); *W. Nanakorn et al.* 598 (QBG), 610 (QBG); *C. Niyomdham* 5311 (BKF); *B. Nimanong & S. Phusomsaeng* 1729 (BKF, PSU); *M. Panatkool* 99 (L); *Parikarn & Prayad* 168 (BK); *C. Phengklai* 215 (BKF), 303 (BKF); *A. Phuakam* 1 (CMU, L); *Put* 3830 (BK, BM, K), 4527 (BK, BM, E, K, L, P); *J. Sadakorn* 231 (BK); *T. Santisuk* 1067 (PSU), s.n. (BKF); *T. Smitinand* 3769 (BKF); *P. Srisanga, S. Sasirat, W. Pongamornkul, S. Sukiam & P. Panyachan* 2457 (QBG); *S. Sutheesorn* 1634 (BK), 2272 (BK), 2337 (BK); *M. Tagawa & I. Yamada* T-13 (BKF); *Th. Sørensen, K. Larsen & B. Hansen* 7067 (C); *S. Thalamphai* (QBG); *S. Watthana & W. Pongamornkul* 230 (QBG); *Th. Wongprasert* 043-62 (BKF); *Th. Wongprasert & S. Khao-iam* 033-02 (BKF); *Worawoot* 4 (BKF).

2. *Monosis volkameriifolia* (DC.) H. Rob. & Skvarla, Proc. Biol. Soc. Wash. 119(4): 606. 2006. Type: Nepal, *Wallich* 3001 (K!). Figures 2.47, 2.77 A. & B.

Conyza volkameriifolia Wall., Numer. List [Wallich] no. 3001, comp. no. 111, *nom. nud.*

Vernonia volkameriifolia DC., Prodr. 5: 32. 1836.

Small trees, 3 – 6 m tall. *Stem* erect, bark grey, young branches inconspicuously ribbed, white tomentose. *Leaves* alternate, 10 – 50 by 5 – 20 cm, obovate or oblanceolate, margins serrate, apex acute, base cuneate, coriaceous; upper surface whitish puberulous, eglandular; lower surface whitish puberulous with flagellate hairs and capitate glands; lateral veins 10 – 20-paired; petioles up to 3 cm long. *Capitulescences* terminal, thyrsoid paniculate. *Capitula* campanulate, 9 – 10 mm long, subsessile or shortly pedunculate. *Receptacle* flat, 1.5 – 2 mm diam., glabrous, *Phyllaries* 4 – 5-seriate, imbricate, narrowly campanulate or slightly oblong-

cylindrical, light green or purple apically, 4 – 5 mm long, 2 – 3 mm diam., margins filiferous or entire, outer surface white arachnoid without glands; the outer and the middle ones ovate, apex acute; the inner ones ovate or lanceolate, apex acute. *Florets* 8 – 10, purple, corolla campanulate, glandular; corolla tube 5.5 – 6 mm long; corolla lobes 2 – 3 mm long. *Anthers* 3 – 3.5 mm long, apical appendage acute, base acute. *Styles* purple, 5 – 7 mm long, branches 2, 3 – 4 mm long. *Achenes* turbinate, 4 – 5 mm long, 10-ribbed, covered with dense twin hairs and capitate glands, carpodium present. *Pappus* bristles, 2-seriate, the inner ones 7 – 8 mm long. *Pollen* psilolophate, 3-colporate, without micropuncta.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai, Lamphun, Lampang.

Distribution.— China (Yunnan), India, Bhutan, Myanmar, Thailand, Vietnam.

Ecology.— Hill evergreen or pine-oak forest, alt. 500 – 1,750 m; flowering November to March.

Vernacular.— Kla Po Pha Du (กะโปพะดู), Ya Kaa (หญ้าแก), Ma Hok Ton (มะโหทดัน), Yarn (หยาน).

Note.— *M. volkameriifolia* is similar to *M. parisii* in capitula and leaf shape but differs in tree habits and whitish puberulous leaves surfaces.

Specimens examined.— *K. Bunchuai* 110 (BKF), 1397 (BKF, K, L, P); *S. Bunwong* 17 (KKU), 60 (KKU), 362 (KKU, US), 393 (KKU, US); *H.B.G. Garrett* 617 (AAU, BKF, K, L, P); *R. Geesink, P. Hiepko & C. Phengkklai* 8160 (AAU, BKF, L); *C.C. Hosseus* 227 (BM, G, K, L); *A.F.G. Kerr* 523 (BM, K, P), 1329 (K); *F. Konta, C. Phengkklai & S. Khao-iam* 4164 (BKF); *H. Koyama, S. Mitsuta, T. Yahara & H. Nagamasu* T-49522 (BKF); *H. Koyama & C. Phengkklai* T-39091 (BKF, L), T-39196 (AAU, BKF, L); *H. Koyama, H. Terao & Th. Wongprasert* T-32615 (BKF), T-32617 (BKF), T-33277 (BKF), T-33284 (AAU), T-33373 (BKF), T-33452 (BKF), T-33616 (BKF); *K. Larsen, S.S. Larsen, Chr.T. Nøgaard, K. Pharsen, P. Puudjaa & W. Ueachirakan* 44912 (AAU); *C. Maknoi* 645 (QBG); *J.F. Maxwell* 88-71 (BKF), 95-212 (BKF, L); *W. Nanakorn* 1125 (A, AU); *W. Nanakorn et al.* 1775 (QBG), 1965 (QBG), 5474 (QBG), 5539 (QBG), 8925 (QBG); *C. Phengkklai, C. Niyomdham, M. Tamura, H. Okada & P.J. O'Connor* 15595 (BKF, US); *J.F. Rock* 410 (US); *R. Pooma* 378 (BKF); *R. Pooma & J.F. Maxwell* 75-327 (AAU), 88-71 (CMU, L), 89-

487 (CMU), 94-150 (L); *T. Santisuk* 1067 (BKF); *T. Shimitzu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk* T-18605 (BKF, L), T-20140 (BKF, L), T-20886 (BKF, L); *T. Shimitzu, H. Toyokuni, H. Koyama, T. Yahara, T. Santisuk & C. Niyomdham* T-20886 (BKF); *Soraded* 344 (US); *P. Srisanga* 458 (QBG), 1229 (QBG), 2681 (QBG); *Th. Sørensen, K. Larsen & B. Hansen* 1578 (C, BKF, K), 6041 (C, K), 6042 (C, K), 6604 (BKF, C, K), 6905 (BKF, C, K); *B. Tantisewie & C. Phengklai* 701 (BKF, C, K, L); *Th. Wongprasert et al.* 043-11 (BKF), 043-40 (BKF), 043-76 (BKF); *Th. Wongprasert & S. Khao-iam* 033-27 (BKF); *Winit* 1329 (BK, K).

12. *Pseudelephantopus*

Rohr, Skkrift. Nat. Selsk. Kiobenl. 2: 214. 1792.

Type: *Pseudelephantopus spicatus* (Aubl.) C.F.Baker

Perennial herbs. *Stem* erect, surface pilose-villose. *Leaves* simple, alternate or rosette, sessile or petiolate; lamina obovate, oblanceolate, puberulous glandular; margins crenate, slightly serrate, dentate to entire; apex acute or obtuse, base cuneate to attenuate, chartaceous. *Capitulescences* terminal and axillary, spicate. *Capitula* discoid, tubular, clusters supported by foliaceous bracts, homogamous, florets bisexual and fertile. *Phyllaries* 8, 2-seriate, decussate, persistent, oblong, outer surface puberulous. *Florets* white, glabrous, lobes 5, zygomorphic. *Anthems* 5, syngenesious, apical appendage acute. *Styles* white, 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs. *Achenes* usually clavate, 10-ribbed, pubescent, carpopodium present. *Pappus* unequal bristles, apex N-shaped. *Pollen* lophate, 3-porate, without micropuncta.

One species is recognized in Thailand.

1. *Pseudelephantopus spicatus* (Aubl.) C.F.Baker, Trans. Acad. Sci. St. Louis 12: 45, 55 & 56. 1902. Type: not ascertained. Figures 2.48, 2.77 C. & D.

Pseudelephantopus spicatus Rohr, Skrifl. Nat. Selsk. Kiobenh. 2: 216. 1792.

Elephantopus spicatus Jussien ex Aublet, Pl. Guiana 2: 808. 1932.

Perennial herbs, 10 – 40 cm tall. *Stem* erect, inconspicuously ribbed, puberulous. *Leaves* simple, rosulate or alternate at bases, 5 – 15 by 1.5 – 5 cm, obovate or oblanceolate, margins slightly serrate to entire, apex obtuse or rounded, base cuneate or attenuate, subcoriaceous; upper surface puberulous without glands, lower surface puberulous with filiform hairs and capitate glands; lateral veins 9 – 15-paired; petioles up to 2 cm long. *Capitulescences* terminal and axillary, 1 – 4. *Capitula* 14 – 17 mm long, aggregated in clusters supported by foliaceous bracts, clusters arranged in spicate. *Receptacle* flat, 1 – 1.5 mm diam., glabrous. *Florets* bisexual and fertile. *Phyllaries* 8, 2-seriate, decussate, oblong, light green, 10 – 11 mm long, margins entire or filiferous, outer surface pilose without glands; the outer lanceolate, apex acute; the inner ones obovate-lanceolate or oblong, apices acute. *Florets* 4, salverform, white, zygomorphic, glabrous; corolla tube 5 – 9 mm long; corolla lobes 2.5 – 2.8 mm long. *Anthers* 1.5 – 2 mm long, apical appendage acute, base acute. *Styles* white, 5 – 9 mm long, branches ca. 2 mm long, inner surface covered with stigmatic papillae, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* clavate, 4 – 5 mm long, pubescent with densely twin hairs, without glands, 10-ribbed, carpopodium present. *Pappus* bristles, 1-seriate, often of two sizes and apex N-shaped, 6 – 9, 2 – 6 mm long. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Chiang Rai; NORTH-EASTERN: Nakhon Phanom; EASTERN: Ubon Ratchathani.

Distribution.— Tropics.

Ecology.— Open area in dipterocarp forest or river bank, alt. 100 – 400 m; flowering October to December.

Vernacular.— Doo La Doo (โด่ลาโด่), Ton Tai Din (ต้นใต้ดิน).

Note.— *P. spicatus* is distinguished from *Elephantopus* by having spicate capitulescences and N-shaped apex.

Specimens examined.— *S. Bunwong* 42 (KKU), 80 (KKU), 81 (KKU), 352 (KKU, US); *Th. Wongprasert et al.* 032-17 (BKF).

13. *Sparganophoros*

Vaill., Königl. Akad. Wiss. Paris Phys. Abh. 5: 368. 1754.

Type: *Sparganophoros vaillantii* Crantz

Annual herbs. *Stem* caulescent, erect or decumbent, puberulous. *Leaves* simple, alternate, usually petiolate; lamina elliptic, pubescent, margins serrate, apex acute, base attenuate, chartaceous. *Capitulescences* axillary, clusters. *Capitula* discoid, homogamous, hemispherical, sessile, florets bisexual and fertile. *Involucre* imbricate. *Florets* purple to white, actinomorphic, glandular, lobes 3 – 4. *Anthers* 5, syngenesious. *Styles* purple, 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs. *Achenes* turbinate, 3 – 4-angular, usually 3 – 5-ribbed, carpopodium absent. *Pappus* coroniform, thick, 1-seriate, persistent. *Pollen* echinolophate, 3-porate, without micropuncta.

One species is recognized in Thailand.

1. *Sparganophoros sparganophora* (L.) C. Jeffrey, Kew Bull. 43: 272. 1988.

Type: *Vaillanz* s.n. (P!). Figures 2.49, 2.79 A. & B.

Ethulia sparganophora L., Sp. Pl.: 1171. 1763.

Sparganophoros vaillantii Crantz, Inst. Rei. Herb. 1: 261. 1766.

Struchium sparganophorum (L.) Kuntze, Revis. Gen. Pl. 1: 366. 1891.

Annual, 20 – 50 cm tall. *Stem* erect, inconspicuously ribbed, puberulous. *Leaves* 4 – 12 by 2 – 15 cm, elliptic, pubescent, margins serrate, apex acute, base attenuate, chartaceous; both surfaces puberulous with cylindrical hairs and capitate glands; lateral veins 7 – 11-paired; petioles up to 12 mm long. *Capitulescences* axillary, solitary or clustered. *Capitula* hemispherical, sessile, 4 – 6 mm diam. *Receptacle* convex, 2 – 2.5 mm diam., glabrous. *Phyllaries* 3 – 4 seriate, imbricate, hemispherical, light green, 3 – 4 mm long, margins filiferous, outer surface puberulous without glands; the outer ovate to lanceolate, apex acute to acuminate; the

inner ones obovate-lanceolate, apex acuminate. *Florets* 50 – 70, infundibular, white, glandular; corolla tube 1 – 1.5 mm long; corolla lobes 3 – 4, 0.5 – 1 mm long. *Anthers* ca. 1 mm long, apical appendage acute, base acute. *Styles* purple, ca. 2 mm long, branches 1 – 1.5 mm long, inner surface covered with stigmatic papillae, sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* turbinate, 3 – 4-angular, 1 – 1.5 mm long, 3 – 5-ribbed, glandular, carpopodium absent. *Pappus* corona 3 – 4, ca. 1 mm long, whitish. *Pollen* echinolophate, 3-porate, grains covered with net-like pattern.

Thailand.— NORTHERN: Lamphun; NORTH-EASTERN: Nakhon Phanom; SOUTH-WESTERN: Kanchanaburi; CENTRAL: Bangkok; PENINSULAR: Ranong, Phangnga, Krabi, Trang, Songkhla, Yala.

Distribution.— Tropics.

Ecology.— Open sandy grassland or secondary evergreen forest, alt. 50 – 400 m; flowering August to April.

Note.— Distinct characters of *S. sparganophora* are sessile capitula in axillary head, achenes has coroniform pappus and florets have 3 – 4 corolla lobes.

Specimens examined.— *S. Bunwong* 28 (KKU); *C. Chermisrivathana* 1266 (BK, L); *G. Congdon* 868 (AAU); *A.F.G. Kerr* 8393 (BM, K); *K. Larsen & S.S. Larsen* 33266 (L); *K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa* 41462 (AAU); *A. Marcan* 45 (BM); *J.F. Maxwell* 71-107 (AAU, BK, L), 75-824 (AAU, BK, L), 86-636 (AUU, BKF, L), 86-911 (BKF, L); *D.J. Middleton, V. Chamchamroon, S. Lindsay, M. Phuphat & R. Pooma* 3463 (E); *Y. Paisooksantivatana* 1433-84 (BK); *P. Palee* 265 (BKF, CMU, L); *T. Piyakownclana* s.n. (BK); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & C. Niyomdham* 26302 (AAU, BKF, L); *Th. Sørensen, K. Larsen & B. Hansen* 436 (K), *E. Smith* 171 (BK); *J. Supapol* 164 (L); *S. Sutheesorn* 2275 (BK); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 3927 (L).

14. Strobocalyx

Type: *Strobocalyx arborea* Sch.Bip.

Perennial plants. *Habit* arborescent or scandent. *Leaves* simple, alternate, usually petiolate; lamina elliptic or oblong, pubescent with uniseriate or flagellate hairs, margins serrate or entire, apex acute or acuminate, base cuneate, coriaceous. *Capitulescences* terminal or axillary. *Capitula* discoid, homogamous, pedunculate or sessile, florets bisexual and fertile. *Involucre* imbricate, 2 – 4 seriate, 2 – 4 mm long, hairy without glands. *Florets* purple to white, actinomorphic, lobes 5. *Anthers* 5, syngenesious. *Styles* purple, 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* turbinate, usually 10-ribbed, ca. 2 mm long, hairy with glands, carpopodium present. *Pappus* 2 seriate of bristles. *Pollen* echinate, subechinolophate or echinolophate, 3-colporate, with micropuncta.

Two species are recognized in Thailand.

KEY TO THE SPECIES

1. Tree; capitulescences thyrsoid paniculate; achenes with 3 – 4 angles

1. *S. arborea*

1. Scandent or shrub; capitulescences corymbose; achenes with 10 ribs

2. *S. solanifolia*

1. *Strobocalyx arborea* (Buch.-Ham.) Sch.Bip., Jahresber. Pollichia 18: 171. 1861. Type: as *Vernonia arborea* Buch.-Ham., Figures 2.50, 2.78 A. & B.

Conyza arborea Wall. List [Wallich] no. 2. *nom. nud.*

Vernonia arborea Buch.-Ham., Trans. Linn. Soc. 14: 218. 1825. Type: Nepal, *S.N.* (E!).

Vernonia javanica DC., Prodr. 5: 22. 1836.

Tree, 5 – 20 m tall. *Stem* arborescent, rounded, inconspicuously ribbed, branches ferruginous pubescent. *Leaves* 8 – 20 by 4 – 10 cm, elliptic to oblong, margins entire, apex acuminate or caudate, base cuneate or oblique, coriaceous; both surfaces puberulous with filiform hairs and capitate glands; lateral veins 10 – 15-paired; petioles up to 3 cm long. *Capitulescences* terminal or axillary, thyrsoid paniculate. *Capitula* narrowly campanulate, shortly pedunculate. *Receptacle* flat, glabrous. *Phyllaries* 3 – 4-seriate, imbricate, narrowly campanulate or slightly oblong-cylindrical, green or purple, 2 – 3 mm long, margins filiferous, outer surface puberulous without glands; the outer ovate, apex obtuse or rounded; the inner ones ovate-lanceolate or oblong, apex obtuse. *Florets* 3 – 6, infundibular, purple to white, glandular; corolla tube 6 – 7 mm long; corolla lobes *ca.* 2 mm long. *Anthers* *ca.* 2.5 mm long, apical appendage acute, base obtuse. *Styles* purple. *Achenes* turbinate, *ca.* 2 mm long, 3 – 4-angled and inconspicuously ribbed, pubescent with twin hairs and capitate glands, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 6 – 7 mm long. *Pollen* subechinolophate, 3-colporate, with micropuncta.

Thailand.— NORTHERN: Nan; NORTH-EASTERN: Loei; PENINSULAR: Ranong, Surat Thani, Phangnga, Phuket, Krabi, Nakhon Si Thammarat, Phatthalung, Trang, Satun, Songkhla, Pattani, Yala, Narathiwat.

Distribution.— India, Sri Lanka, Myanmar, Thailand, Malay Peninsula, Vietnam, New Guinea.

Ecology.— Evergreen forest, alt. 50 – 300 m; flowering July to February.

Vernacular.— Ka Ton Rok (กะท้อนรอก), Ka Puam Ma Prao (กะพวมมะพร้าว), Kra Phee Kao (กระพีขาว), Ko Ta Ba Ru (โกตาบารู), Kee Aon (ชีอัน), Torn Lor (ตอนเลาะ), Baa Hor (แบหอ), Smong Kung (สมองกุง), Ai Nieaw Maa (้ายเหนียวหมา), Ta Kuam (ตะกวม), Nuang Chang (งวงช้าง).

Note.— *S. arborea* is distinguished by its big tree, 3 – 4-angled achenes and obtuse phyllaries.

Specimens examined.— *A.F.G. Kerr* 7276 (BM, K, L), 13034 (AAU, BK, BM, K, L), 15847 (BK, BM, K), 16477 (BK, BM, K); *K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa* 40943 (AAU, BKF, P, PSU), 41268

(AAU, BKF, PSU); *K. Larsen, S.S. Larsen, I. Nielsen & T. Santisuk* 30935 (AAU, BKF, K, L); *J.F. Maxwell* 75-739 (AAU, BK, L), 84-176 (BKF, PSU), 86-520 (BKF, CMU, L, P, PSU), 86-681 (BKF, CMU, L, PSU); *W. Nanakorn et al.* 7163 (QBG); *C. Niyomdham et al.* 358 (AAU, BKF, E, K, L, P), 5137 (BKF); *M. Norsangsri* 1052 (QBG); *Pochanart* 427 (BKF, K, P); *D. Prapat* 54 (AAU, BKF, L), s.n. (BKF); *Prayad* 494 (BK, US); *Put* 3655 (BK, BM, E, K); *P. Puudjaa* 311 (BKF); *Rabil* 188 (BK, BM, E, K); *Sanan* 333 (US), 768 (BKF, US); *B. Sangkhachand* 885 (BKF, K, L, P), 886 (BKF), 1010 (K), 1300 (BKF); *B. Sangkhachand & B. Nimanong* 1306 (BKF); *B. Sangkhachand & T. Smitinand* 1010 (BKF, L), 11936 (PSU); *T. Santisuk* 1249 (BKF, PSU); *T. Shimizu, N. Fuguoka & A. Nalampoon* T-8176 (BKF); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & C. Niyomdham* T-26360 (BKF, L), T-26501 (BKF), T-26502 (BKF), T-26503 (BKF); *T. Smitinand* 1722 (BKF), 2860 (BKF, US); *P. Suvarnakoset* 271 (BKF), 865 (BKF, US); *Th. Wongprasert* 997-72 (BKF).

2. *Strobocalyx solanifolia* Sch.Bip., Jahresber. Pollichia 18-19: 171. 1861. Type: as *Vernonia solanifolia* Benth., Figures 2.51, 2.78 C. & D.

Vernonia solanifolia Benth., Lond. Journ. Bot. 1: 486. 1842. Type: Hong Kong: *Hinds* s.n. (K!).

Climbing shrubs or scandents, 2 – 10 m tall. *Stem* nconspicuously ribbed, ferruginous tomentose. *Leaves* 8 – 20 by 4 – 10 cm, ovate or elliptic, margins serrate or entire, apex acute or acuminate, base cuneate, subcoriaceous; upper surface puberulous without glands; lower surface tomentose with filiform hairs, flagellate hairs and capitate glands; lateral veins 5 – 7-paired; petioles up to 3.5 cm long. *Capitulescences* terminal and axillary, thyrsoide panicle. *Capitula* narrowly campanulate, 8 – 10 mm long, pedunculate. *Receptacle* flat, 2 – 2.5 mm diam., hairy. *Phyllaries* 2 – 3 seriate, imbricate, narrowly campanulate or slightly oblong-cylindrical, 3.5 – 4 mm long, 3 – 4 mm diam., margins filiferous, outer surface tomentose without glands; the outer and the middle ones ovate, apex obtuse; the inner ones obovate, apex obtuse. *Florets* 5 – 7, infundibular, purple, puberulous, glands

capitates; corolla tube 4.5 – 6 mm long; corolla lobes 1.5 – 2.5 mm long. *Anthers* 2 – 2.5 mm long, apical appendage acute, base acute. *Styles* purple, 5 – 6.5 mm long, branches 2 – 2.5 mm long. *Achenes* turbinate, ca. 2 mm long, 10-ribbed, covered with sparse hairs and capitate glands, carpopodium present. *Pappus* 2 seriate of bristles, the inner ones 5 – 6 mm long. *Pollen* echinate, 3-colporate, with prominent micropuncta.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai, Nan, Lampang, Phitsanulok; NORTH-EASTERN: Phetchabun, Loei, Sakon Nakhon; EASTERN: Chaiyaphum, Nakhon Ratchasima; SOUTH-WESTERN: Kanchanaburi; CENTRAL: Nakhon Nayok.

Distribution.— Hong Kong, Myanmar, Thailand, Vietnam, Laos, Cambodia.

Ecology.— Hill evergreen or pine-oak forest, alt. 900 – 1,250 m; flowering February to May.

Vernacular.— Cha Kua (ชะเคือ จ้าเขือ).

Note.— *S. solanifolia* is distinguished by scandent habits, corymbose capitulescences and tomentose leaf surfaces.

Specimens examined.— *Adisai* 382 (BK); *A. Boonkongchart* 47 (BKF, CMU); *S. Bunwong* 68 (KKU), 70 (KKU); *P. Chantaranothai*, *J. Parnell*, *D. Middleton* & *D. Simpson* 1079 (BKF); *Kasem* 444 (BK, US); *A.F.G. Kerr* 4982 (BK, BM, K), 8816 (BK, BM, E, K), 20129 (BK, BM, K, L), 20226 (BK, BM, K); *W. Nanakorn* 391 (BKF); *B. Nimanong* & *S. Phusomsaeng* 1813 (BKF, PSU); *Pradit* 846 (BK); *P. Puudjaa* 198 (BKF); *T. Smitinand* 1152 (BKF), 2495 (US), 2639 (BKF); *P. Srisanga* 572 (QBG); *Winit* 1262 (BK, BKF, K).

14. *Tarlmounia*

H.Rob., S.C.Keeley, Skvarla & R.Chan., Proc. Biol. Soc. Wash. 121(1): 31. 2008.

Type: *Vernonia elliptica* DC.

Perennial plants. *Stem* rounded, white, sericeous. *Leaves* simple, alternate, petiolate, sericeous with long horn-shaped hairs, lamina elliptic, margins entire or serrate, apex acute rounded, base rounded, subcoriaceous. *Capitulescences* terminal or

axillary. *Capitula* discoid, homogamous, pedunculate, florets bisexual and fertile. *Involucre* imbricate, 3 – 4 seriate, 3 – 4 mm long, glandular without hairs. *Florets* purple to white, actinomorphic, lobes 5. *Anthers* 5, syngenesious. *Styles* 2-branched, inner surface covered with stigmatic papillae, outer surface covered with sweeping hairs on the outer surface reaching below style bifurcation. *Achenes* turbinate, 4 – 7-ribbed, ca. 2 mm long, glandular without hair, carpopodium present. *Pappus* bristles, 2-seriate. *Pollen* echinate, 3-colporate, with micropuncta.

One species is recognized in Thailand.

1. *Tarlmounia elliptica* (DC.) H.Rob., S.C.Keeley, Skvarla & R.Chan, Proc. Biol. Soc. Wash. 121(1): 32. 2008. Type: as *Vernonia elliptica* DC. Figures 2.52, 2.79 C. & D.

Vernonia elliptica DC. in Wight, Contrib. Bot. Ind. 5. 1834. Type: India, Nilgherry, Wight 1377 (E!).

Vernonia elaeagnifolia DC., Prod. 5: 22. 1836.

Climbing shrubs or scandents. *Stem* caulescent, young branches inconspicuously ribbed, white sericeous. *Leaves* 5 – 12 by 3 – 6 cm, elliptic, margins entire or serrate, apex acute or obtuse, base rounded, subcoriaceous; upper surface puberulous without glands; lower surface sericeous with T-shaped hairs; lateral veins 7 – 11-paired; petioles up to 1 cm long. *Capitulescences* terminal and axillary, thyrsoide panicle. *Capitula* narrowly campanulate, 10 – 15 mm long. *Receptacle* convex, ca. 1 mm diam., glabrous. *Phyllaries* 3 – 4-seriate, imbricate, narrowly campanulate or slightly oblong-cylindrical, green or purple apically, 3 – 4 mm long, ca. 3 mm diam., margins filiferous, outer surface arachnoid glandular; the outer and the middle ones ovate, obtuse to rounded; the inner ones obovate, apex acute or obtuse. *Florets* 4 – 5, infundibular, purple or white, glandular, corolla tube 4.5 – 5.5 mm long; corolla lobes 2 – 3 mm long. *Anthers* 3 – 3.5 mm long, apical appendage acute, base obtuse. *Styles* purple, 5.5 – 7 mm long, branches ca. 2 mm long. *Achenes* turbinate, ca. 2 mm long, 4 – 7-ribbed, covered with sparse hairs and capitate glands,

carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 5 – 6 mm long, persistent. *Pollen* echinate, 3-colporate, with prominent micropuncta.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai, Phitsanulok; NORTH-EASTERN: Loei, Nong Bua Lum Phu, Udon Thani; ESTERN: Chaiyaphum, Nakhon Ratchasima, Roi Et, Si Sa Ket; SOUTH-WESTERN: Ratchaburi, Phetchaburi; CENTRAL: Saraburi, Phra Nakhon Si Ayutthaya, Nakhon Nayok, Nonthaburi, Bangkok; SOUTH-EASTERN: Prachin Buri, Chon Buri, Rayong, Chanthaburi, Trat; PENINSULAR: Chumphon, Surat Thani, Nakhon Si Thammarat.

Distribution.— America, Africa, Asia.

Ecology.— Open area in wetland, alt. 0 – 100 m; flowering October to May.

Vernacular.— Kiew Darn (เขี้ยวดาน), Sar Muk Lord (ซำหมักหลอด), Tanmon (ตานหมอน), Tao Kee Tao (เตาชีเต้า), Lee Kuan Yuu (ลิควนยู), Tao Wan Lek (เตาวัลย์เหล็ก), Khud Mon (คึดมอญ), Tarlmoun (ตาลหม่น).

Note.— *T. elliptica* is characterized by having appressed T-shaped hairs on leaf surfaces, scandent habits and involucre without glands.

Specimens examined.— *Adisai* 123 (BK); *S. Bunwong* 69 (KKU), 390 (KKU, US); *D.J. Collins* 80 (E, K), 325 (K), 1769 (BK, K); *Dee* 34 (BKF); *Din* s.n. (BKF); *P. Gupatvanija* 26 (BK); *K. Iwatzuki & N. Fukuoka* T-7314 (BKF), T-7373 (BKF); *T. Jonganuruk* 288 (BCU); *A.F.G. Kerr* 1693 (AAU, BM, C, K, L), 4010 (BM, K), 12344 (BK, BM, K), 19950 (BK, BM, E, K); *F. Konta, W. Nanakorn & Th. Wongprasert* 49085 (BKF, K, L); *H. Koyama & H. Terao* T-32866 (C, BKF), T-33716 (BKF), T-33717 (BKF); *M.C. Lakshanakara* 308 (AAU, BK, K), s.n. (BK); *A. Marcan* 62 (BM), 2462 (BK, BM); *J.F. Maxwell* 71-162 (AAU, BK, L), 75-152 (AAU, BK, L), 92-57 (E); *C. Niyomdham* 531 (BKF); *Y. Paisooksantivatana* 1182-82 (BK); *P. Prasomsuke* s.n. (BCU); *Prayad* 228 (BK, US); *C. Prosakha* 16 (BCU); *Put* 2771 (BK, BM, E, K), s.n. (BM); *Sanan* 13 (E, BKF, US), 180 (BKF, US), 1002 (BKF, US); *B. Sangkhachand* 417 (BKF, US); *J. Schmidt* 481 (C); *R. Schomburgk* 1859 (K); *P. Sirirugsa* 173 (PSU); *E. Smith* 268 (BK), 298 (BK, BM); *P. Suvarnakoset* 1300 (BKF, US); *Th. Sørensen, K. Larsen & B. Hansen* 531 (C, K), 2164 (BKF, C, K); *S. Sutheesorn* 371 (BK, US), 2980 (BK); *Vacharapong* 8 (BK,

US); *K. Wangwasit*, *M. Norsaengsri* & *C. Lakoet* 70320-25 (QBG); *K. Wertsawang* 179 (QBG); *Th. Wongprasert* s.n. (BKF); *R. Zimmermann* 1899 (B, BM, G, K, L, P, US).

Uncertain species

1. *Vernonia birmanica* (O.Ktz.) Merr., *Brittonia* 2: 200. 1936. Type: Myanmar, Moulmein, *O. Kuntze* 6271 (K!). Figures 2.53, 2.80 A. & B.

Cacalia birmanica O.Ktz., *Rev. Gen.* P1. 323. 1891.

Annual, 1 – 2 m tall. *Stem* erect, inconspicuously ribbed, puberulous. *Leaves* cauline, 5 – 20 by 1 – 5 cm, lanceolate, margins serrate, apex acuminate, base attenuate, chartaceous; upper surface scabrous, lower surface puberulous, lateral veins 8 – 12-paired; petioles up to 2 cm long. *Capitulescences* terminal, loosely paniculate. *Capitula* campanulate, 10 – 12 mm long, pedunculate. *Receptacle* convex, glabrous. *Phyllaries* 4 – 5-seriate, imbricate, subglobular, *ca.* 7 mm long, outer surface arachnoid; the outer and the middle ones ovate or elliptic, apex obtuse; the inner ones broadly oblong, apex obtuse. *Florets* *ca.* 55, infundibular, white or purple, puberulous without glands. *Achenes* subterete, *ca.* 4 mm long, 10-ribbed, aculeate between ribs, carpodium absent. *Pappus* bristles, 2-seriate, the inner ones *ca.* 7 mm long, persistent.

Thailand.— NORTHERN: Lampang; SOUTH-WESTERN: Kanchanaburi.

Distribution.— Myanmar, Thailand.

Ecology.— Under dense canopy on the top of limestone mountain, alt. 650 – 1,000 m; flowering September to December.

Note.— *V. birmanica* is distinguished by its long and slender pedicel in a loose panicle, phyllaries are mostly obtuse with thickened tips and cup-shaped involucre.

Specimens examined.— *K. Larsen* 8492 (K), *J.F. Maxwell* 96-1490 (BKF).

2. *Vernonia cinerea* var. *montana* (C.B. Clarke) Koster, Blumea 1: 416. 1935.

Type: Assam, Khasia hill (not located). Figures 2.54, 2.80 C. & D.

Annual, 1 – 2 m tall. *Stem* erect, conspicuously ribbed, pilose-villose. *Leaves* 7 – 8 by 2 – 4 cm, ovate or ovate-lanceolate, margins serrate or dentate, apex acute, base attenuate, chartaceous; upper surface puberulous glandular; lower surface villose with whip-shaped hairs, T-shaped hairs and capitate glands; lateral veins 5 – 7-paired; petioles up to 2 cm long. *Capitulescences* terminal or axillary, paniculate. *Capitula* narrowly campanulate, 5 – 7 mm long, pedunculate. *Receptacle* flat, 2 – 2.5 mm diam., glabrous. *Phyllaries* 3 – 4 seriate, imbricate, narrowly campanulate, 5 – 6 mm long, 3 – 4 mm diam., margins filiferous, outer surface hirsute without glands; the outer and the middle ones lanceolate, acuminate; the inner ones lanceolate to oblong, apex acuminate. *Florets* 20 – 30, infundibular, purple, corolla tube 4 – 5 mm long; corolla lobes *ca.* 2 mm long. *Anthers* 0.5 – 2 mm long, apical appendage acute, base obtuse. *Styles* purple, 5 – 6 mm long, branches 1 – 2 mm long. *Achenes* clavate, 1.5 – 2 mm long, 5 – 8-ribbed, densely pubescent with twin hairs and capitate glands, carpodium present. *Pappus* 2 seriate of bristles, the inner ones 5 – 6 mm long. *Pollen* echinolophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Chiang Mai, Nan; NORTH-EASTERN: Loei, Khon Kaen; EASTERN: Nakhon Ratchasima, Ubon Ratchathani.

Distribution.— Thailand, Laos, Cambodia, Vietnam, Sumatra.

Ecology.— Hill evergreen or pine-oak forest, alt. 500 – 1000 m; flowering October to March.

Note.— *V. cinerea* var. *montana* should be transferred to a species of *Cyanthillium*

Specimens examined.— *S. Bunwong* 16, (KKU), 62 (KKU), 371 (KKU, US); *C. Chermisrivathana* 56 (BKF), 437 (BK); *H.B.G. Garrett* 922 (AAU, BKF E, L, P); *B. Hansen, G. Siedenfaden & T. Smitinand* 11001 (C); *A.F.G. Kerr* 8848 (AAU, BM); *H. Koyama, S. Mitsuta & H. Nagamasu* T-39848 (BKF); *H. Koyama & C. Phengklai* T-40069 (BKF, L); *H. Koyama, H. Terao & Th. Wongprasert* T-31213 (BKF), T-31565 (BKF), T-31743 (BKF), T-31749 (BKF), T-32285 (BKF), T-32307 (BKF), T-

32820 (BKF), T-33275 (BKF), T-33614 (AAU, BKF), T-32800 (BKF) ; *J.F. Maxwell* 88-31 (CMU), 88-213 (CMU), 90-10 (CMU, E, L), 95-202 (BKF, L), 96-172 (BKF, L); *W. Nanakorn et al.* 1616 (QBG), 8087 (QBG); *P. Palee* 171 (L); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & C. Niyomdham* T-22031 (BKF), T-22617 (BKF); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahama & T. Santisuk* T-20676 (BKF); *P. Srisanga* 2621 (QBG); *P. Srisanga, S. Sasirat, W. Pongamornkul, S. Sukiam & P. Panyachan* 2486 (QBG); *S. Sukkri* 90 (L); *Th. Sørensen, K. Larsen & B. Hansen* 1783 (C), 3704 (C), 3736 (C), 6588 (C) ; *H. Takahashi & M.N. Tamura* T-63331 (BKF).

3. *Vernonia curtisii* Craib et Hutchinson, Bull. Misc. Inform., Kew 1910: 22. 1910. Type: Malay Peninsula, Kedah, Langawi, *Curtis* 2127 (K!). Figures 2.55, 2.81 A. & B.

KEY TO THE VARIETIES

1. Lower surface of leaves puberulous

1. var. *curtisii*

1. Lower surface of leaves tomentose

2. var. *tomentosa*

3.1 var. *curtisii*

Succulent herbs, 20 – 100 cm tall. *Stem* erect, conspicuously ribbed, puberulous with glands. *Leaves* 5 – 15 by 2 – 7 cm, ovate or elliptic, margins serrate, apex acute to acuminate, base attenuate, chartaceous; both surfaces puberulous with whip-shaped hairs and capitate glands; lateral veins 7 – 12-paired; petioles up to 4 cm long. *Capitulescences* terminal, solitary or loosely paniculate. *Capitula* campanulate, 15 – 20 mm long, pedunculate. *Receptacle* flat, glabrous. *Phyllaries* 6 – 7-seriate, imbricate, campanulate, light green or purple apex, 7 – 10 mm long, 8 – 15 mm diam., margins entire, outer surface puberulous; the outer and the middle ones ovate to lanceolate, apex acuminate with reflexed, the inner ones lanceolate to oblong, apex caudate. *Florets* ca. 60, infundibular, purple, pubescent with soft hairs and capitate glands; corolla tube 7 – 10 mm long; corolla lobes 2 – 3 mm long. *Anthers* 2.8 – 3 mm long, apical appendage acute, base obtuse. *Styles* purple, sweeping hairs on the

outer surface reaching below style bifurcation. *Achenes* clavate, 3 – 3.5 mm long, 10-ribbed, sparsely glandular, carpopodium absent. *Pappus* bristles, 1-seriate, the inner ones 2 – 8 mm long, deciduous. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Lampang; NORTH-EASTERN: Phetchabun; SOUTH-WESTERN: Kanchanaburi; CENTRAL: Saraburi; PENINSULAR: Patthalung, Trang, Satun, Songkla.

Distribution.— India, Thailand, Laos, Cambodia, Vietnam, Malay Peninsula, Malay islands.

Ecology.— Limestone mountain, alt. 100 – 500 m; flowering November to April.

Vernacular.— Chang Nga Pha (ช้างนาผา).

Note.— *V. curtisii* is similar to *Koyamasia calcarea* in having solitary or loosely paniculate capitulescences and reflexed phyllaries but differs in a small capitula and pappus. Both of them are found on limestone mountain.

Specimens examined.— *Adisai* 965 (BK); *C. Chermisrivathana* 1477 (BK, L); *G. Congdon* 44 (AAU, PSU); *Kasem* 548 (BK); *A.F.G. Kerr* 3612 (BM, K); *F. Konta, Th. Wongprasert & B. Sangkhachand* T-29668 (BKF, L); *A. Marcan* 2348 (BM, K, P); *J.F. Maxwell* 87-24 (CMU, L, PSU); *G. Murata, K. Iwatsuki & C. Phengkklai* T-14893 (L); *Put* 1780 (AAU, BK, K, L, P), 1877 (BK), 1879 (AAU, BK, BM, E, K, P), 4019 (AAU, BK, BM, K, P); *Rabil* 310 (BK, BM, K); *T. Smitinand & H. Sleumer* 1372 (K, L); *Winit* 757 (K).

3.2 var. *tomentosa* Kerr, Fl. Siam. Enum. 2(3): 238. 1936. Type: Thailand, *A.F.G. Kerr* 8997 (BK!, BM!, K!). Figures 2.81 C. & D.

Succulent herbs, 20 – 100 cm tall. *Stem* erect, conspicuously ribbed, tomentose or villose. *Leaves* 5 – 10 by 2 – 6 cm, ovate or elliptic, margins serrate, apex acute to acuminate, base attenuate, chartaceous; upper surface scabrous; lower surface tomentose; lateral veins 7 – 12-paired; petioles up to 4 cm long. *Capitulescences* terminal, solitary or paniculate. *Capitula* campanulate, 11 – 13 mm long, pedunculate. *Receptacle* flat, glabrous. *Phyllaries* 6 – 7-seriate, imbricate, campanulate, green with

purple apex, 7 – 8 mm long, 8 – 10 mm diam., margins filiferous, outer surface puberulous; the outer and the middle ones ovate to lanceolate, caudate, upper half strongly reflexed; the inner ones lanceolate to oblong, apex acute to acuminate. *Florets* ca. 60, infundibular, purple; corolla tube 7 – 8 mm long; corolla lobes 2 – 2.5 mm long. *Anthems* 2.8 – 3 mm long, apical appendage acute, base obtuse. *Styles* purple. *Achenes* clavate, 3 – 3.5 mm long, 10-ribbed, sparsely glandular, carpopodium absent. *Pappus* bristles, 2-seriate, the inner ones 5 – 6 mm long, deciduous. *Pollen* lophate, 3-porate, without micropuncta.

Thailand.— NORTHERN: Chiang Rai; SOUTH-WESTERN: Kanchanaburi, Ratchaburi.

Distribution.— Endemic to Thailand.

Ecology.— Limestone mountain, alt. 200 – 1,600 m; flowering June to August.

Vernacular.— Hua Chai Wai Yarap (หัวไชยธารา).

Note.— This plant differs from the typical variety by having dense hairs on the lower leaf surfaces.

Specimens examined.— *H. Banziger* 702 (CMU); *C. Phengkklai*, *B. Sangkhachand* & *B. Nimanong* 2986 (K); *A. Marcan* 1736 (BM); *J.F. Maxwell* 86-396 (CMU, PSU); *S. Pumicong* 443 (QBG); *S. Watthana* 875 (AAU, QBG).

4. ***Vernonia kerrii*** Craib, Bull. Misc. Inform., Kew 1914: 7. 1914. Type: Thailand, Nan, Sop Ngao, *Kerr* 2404 (K!, BM!). Figures 2.82 A. & B.

Perennial herbs, ca. 30 cm tall. *Stem* erect, basal branching, inconspicuously ribbed, puberulous. *Leaves* cauline, 4 – 6 by 1 – 2.5 cm, oblanceolate or elliptic, margins slightly serrate, apex acute or obtuse, base cuneate, chartaceous; both surfaces pubescent; lateral veins 7 – 10-paired; petioles up to 3 mm long. *Capitulescences* terminal or axillary, solitary or in loose panicle. *Capitula* campanulate, 10 – 11 mm long, subsessile or pedunculate. *Phyllaries* 4 – 5-seriate, imbricate, campanulate, 7 – 8 mm long, margins filiferous, outer surface nearly glabrous; the outer and the middle ones ovate, apex acute; the inner ones ovate-lanceolate, apex acute. *Florets* 20 – 25, infundibular, purple, glandular, corolla tube

6.5 – 7 mm long; corolla lobes 2 – 3 mm long. *Achenes* narrowly turbinate, *ca.* 3 mm long, 10-ribbed, puberulous, carpopodium present. *Pappus* bristles, 2-seriate, the inner ones 6 – 7 mm long.

Thailand.– NORTHERN: Chiang Mai, Nan.

Distribution.– Endemic to Thailand

Ecology.– Rock cliff by river in hill evergreen forest, alt. 700 – 1,400 m; flowering February.

Note.– *V. kerrii* is similar to *Acilepis* spp. Its distinct character is the subsessile capitula in axillary leaves.

Specimens examined.– *Kerr* 2404 (K, BM); *Th. Sørensen, K. Larsen & B. Hansen* 1602 (K).

5. *Vernonia pseudobirmanica* H.Koyama, Bull. Natl. Sci. Mus., Tokyo, B. 29(1): 16. 2003. Type: Thailand, Tak, Khao Phra War, *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk* T-18505-bis (KYO!). Figures 2.56, 2.82 C. & D.

Perennial herbs, 20 – 40 cm tall. *Stem* erect, conspicuously ribbed, puberulous. *Leaves* cauline, 3 – 12 by 1 – 3 cm, elliptic or obovate, margins serrate, apex acuminate, base attenuate, chartaceous; upper surface glabrate or scabrous; lower surface glabrate or pubescent; lateral veins 7 – 12-paired; petioles up to 1 cm long. *Capitulescences* terminal, loosely corymbose. *Capitula* broadly campanulate, 5 – 6 mm long, pedunculate. *Receptacle* glabrous. *Phyllaries* 4 – 5-seriate, imbricate, broadly campanulate, *ca.* 5 mm long, margins filiferous, outer surface nearly glabrous; the outer and the middle ones linear-oblong, apex acute; the inner ones ovate-lanceolate to oblong, apex obtuse. *Florets* *ca.* 20, infundibular, purple, glabrous. *Achenes* fusiform, *ca.* 3 mm long, 10-ribbed, glabrous, carpopodium absent. *Pappus* bristles, 2-seriate, the inner ones *ca.* 5 mm long.

Thailand.– NORTHERN: Tak; SOUTH-WESTERN: Kanchanaburi.

Distribution.– Endemic to Thailand.

Ecology.– Limestone mountain, alt. 700 – 900 m; flowering November to December.

Note.— *V. pseudobirmanica* differs from *V. birmanica* by its smaller capitula with approximately 20 florets. Its phyllaries margins are filiferous and the outer surfaces are nearly glabrous.

Specimens examined.— *K. Larsen* 8794 (E, K), 8890 (K); *C. Phengkai* 346 (K); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk* T-18505-bis (KYO); *C.F. van Beusekom, C. Phengkai, R. Geesink & B. Wongwan* 3746 (BKF, K, L, P).

6. *Vernonia pulicarioides* Gagnep., Fl. Indo-Chine 3: 482. 1924. Type: Annam (not located). Figures 2.57, 2.83 A. & B.

Pulicaria annamica Gagnep., Bull. Soc. Bot France. 68: 121. 1921.

Perennial herbs, 20 – 40 cm tall. *Stem* erect, conspicuously ribbed, villose. *Leaves* 5 – 10 by 1.5 – 2 cm, oblong or oblanceolate, margins subentire, apex acute or truncate, base cuneate, subcoriaceous; upper surface scabrous without glands; lower surface scabrous with whip-shaped hairs and capitate glands; lateral veins 4 – 8-paired; petioles sessile. *Capitulescences* terminal, solitary or few. *Capitula* hemispherical, 10 – 15 mm long, pedunculate. *Receptacle* glabrous. *Phyllaries* 5 – 6-seriate, imbricate, hemispherical, green or purple apically, 10 – 15 mm long, 10 – 15 mm diam., margins filiferous, outer surface sericeous without glands; the outer and the middle ones lanceolate, apex acuminate; the inner ones lanceolate, apex acuminate or aristate. *Florets* ca. 70, narrowly infundibular, purple, pubescent with hairs and glands; corolla tube 6 – 7 mm long; corolla lobes 2 – 2.5 mm long. *Anthers* 3.5 – 4 mm long, apical appendage acute, base acute. *Styles* purple, 6 – 6.5 mm long, branches 2 – 2.5 mm long, sweeping hairs on the outer surface reaching at style bifurcation. *Achenes* subterete, 2 – 2.5 mm long, inconspicuously ribbed, pubescent with densely twin hairs without glands, carpodium present. *Pappus* bristles, 2-seriate, the inner ones 8 – 9 mm long. *Pollen* lophate, without micropuncta.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai.

Distribution.— Myanmar, Thailand, Laos, Vietnam.

Ecology.— Evergreen forest, alt. 780 – 1600 m; flowering October to February.

Note.— This species is distinguished by having hemispherical capitula, sericeous phyllaries without glands and lophate pollen with small lacuna and indistinct apertures.

Specimens examined.— *P. Suksathan* 1932 (QBG).

8. Conclusion

8.1 Taxonomy and distribution

8.1.1 Subtribal classification

The tribe Vernoniae studying in Thailand consists of 16 genera and 48 species in five subtribes (Table 2.2). The subtribal classifications based on Robinson (1999b) are as follows:

Subtribe Centrapalinae H.Rob. Seven species of *Camchaya* and one variety: *C. gracilis*, *C. kampotensis*, *C. loloana*, *C. loloana* var. *mukdahanensis*, *C. pentagona*, *C. spinulifera*, *C. tenuiflora* and *Camchaya* sp.

Subtribe Elephantopinae Less. Two species of *Elephantopus* and one variety: *E. mollis*, *E. scaber*, *E. scaber* var. *penicillatus* and one species of *Pseudelphantopus*: *P. spicatus*.

Subtribe Erlangeinae H.Rob. Sixteen species of *Acilepis*, two *Cyanthillium* and one each of *Ethulia*, *Iodocephalopsis* and *Koyamasia*: *A. attenuata*, *A. Chiangdaoensis*, *A. divergens*, *A. doichangensis*, *A. kingii*, *A. namnaoensis*, *A. ngaoensis*, *A. peguensis*, *A. principis*, *A. pseudosutepensis*, *A. saligna*, *A. silhetensis*, *A. squarrosa*, *A. sutepensis*, *A. tonkinensis*, *A. virgata*, *C. cinereum*, *C. hookerianum*, *E. conyzoides*, *I. eberhardtii* and *K. calcarea*.

Subtribe Gymnantheminae H.Rob. Three species of *Decaneuropsis*: *D. cumingiana*, *D. eberhardtii* and *D. garrettiana*; two each of *Monosis* and *Strobocalyx*: *M. parishii*, *M. volkameriifolia*, *S. arborea* and *S. solanifolia*, and one each of *Gymnanthemum* and *Tarlmounia*: *G. cylindriceps* and *T. elliptica*.

Subtribe Vernoniinae Cass. ex Dumort. One species, *Sparganophoros sparganophora*.

Uncertain species; the remaining seven taxa are unrevised and therefore can not be placed into any of the known subtribes of Robinson (1999b). These are *Kuerziella gymnoclada*, *Vernonia birmanica*, *V. cinerea* var. *montana*, *V. curtisii*, *V. curtisii* var. *tomentosa*, *V. pseudobirmanica* and *V. pulicarioides*.

8.1.2 Taxonomic notes

One of the species, *Camchaya gracilis*, is a new record for Thailand (Bunwong *et al.*, 2009). It is otherwise known elsewhere within Indo-China, (Gagnepain, 1924). Another species, *Pseudelephantopus spicatus*, is also newly reported from northern, northeastern and eastern Thailand in those provinces close to the Me Khong River. It is often found in open areas in dry dipterocarp forest or along the main rivers. In addition, this species has never been recorded in any of the neighboring countries, i.e., Myanmar, Cambodia and Laos except Java (Backer & Bakhuizen, 1965). There are 15 species of endemic Thai Vernonieae (Koyama, 1984, 1993, 1997, 1998, 2003, 2004, 2005). These are *Acilepis chiangdaoensis*, *A. doichangensis*, *A. namnaoensis*, *A. ngaoensis*, *A. principis*, *A. pseudosutepensis*, *A. sutepensis*, *Camchaya pentagona*, *C. spinulifera*, *C. tenuiflora*, *C. sp.*, *Koyamasia calcarea*, *Vernonia curtisii* var. *tomentosa*, *V. kerii* and *V. pseudobirmanica*. Two new genera, *Iodocephalopsis* S.Bunwong & H.Rob. (Bunwong *et al.*, 2009), and *Kurziella* H.Rob. & S.Bunwong (Robinson *et al.*, 2010), are described as well as the transfer of *Iodocephalus gracilis* Gagnep. to *Camchaya gracilis* (Gagnep.) S.Bunwong & H.Rob.

The new taxa described by Bunwong and Robinson, and included in this treatment were originally described as species of *Iodocephalus* Gagnep. (Gagnepain, 1920). However, they are not congeneric as the type of the genus is here reduced to synonymy with *Camchaya* Gagnep. Hence the new combination *Camchaya gracilis* (Gagnep.) S.Bunwong & H.Rob. is proposed. A new genus, *Iodocephalopsis* S.Bunwong & H.Rob., was also established for the second species originally placed in *Iodocephalus*, with both *Iodocephalus glandulosus* Kerr and *Camchaya eberhardtii* (Gagnep.) Kitam. were placed in synonymy with the name *Iodocephalopsis eberhardtii* (Gagnep.) S. Bunwong & H. Rob. Additionally, a new genus, *Kurziella*, is named to accommodate in Myanmar and Thailand. *Vernonia gymnoclada* Coll. & Hemsl., a species often identified in herbaria as *Vernonia juncea* Kurz, nom. nud., is

reduced to a basionym of the new combination, *Kurziella gymnoclada* (Coll. & Hemsl.) H. Rob. & S. Bunwong (Robinson *et al.*, 2010).

8.1.3 Habitat and Distribution

The largest number of Vernonieae species in Thailand is found in the northern and northeastern parts of the country. Taxa are typically found in open areas within dipterocarp, deciduous, evergreen and pine-oak forests, from sea level to over 2,000 m (Figures 2.84–2.88). Five endemic taxa, *Acilepis pseudosutepensis*, *Koyamasia calcarea*, *Vernonia birmanica*, *V. curtisii* var. *tomentosa* and *V. pseudobirmanica*, are restricted to limestone rock in evergreen forests. Overall, the greatest numbers of endemic species are found across the Indo-Burma and Indo-China regions. A few, however, such as *Cyanthillium cinereum*, *Elephantopus scaber*, *E. mollis*, *Ethulia conyzoides*, *Pseudelephantopus spicatus*, *Sparganophoros sparganophora* are found widely throughout the tropics. Only five other species are also widespread and they are found distributed through Malay Peninsula. These are *Cyanthillium hookerianum*, *Decaneuropsis cumingiana*, *Strobocalyx arborea*, *Vernonia cinerea* var. *montana* and *V. curtisii*.

8.2 Key characters

8.2.1 Habit. Thai Vernonieae includes annual and perennial herbs, scandent and upright shrubs and trees. *Acilepis*, *Camchaya*, *Cyanthillium*, *Elephantopus*, *Ethulia*, *Iodocephalopsis*, *Koyamasia*, *Kurziella* and *Sparganophoros* are herbaceous while *Gymnanthemum*, *Monosis* and *Strobocalyx* are upright shrubs and trees. The scandent habit is found in *Decaneuropsis* and one species each in *Strobocalyx* and *Tarlmounia*. These differences are useful in broad generic separations, particularly at the subtribal level.

8.2.2 Leaves. Diverse in shape, texture, indumentum and length of petiole, leaves offer some of the most useful taxonomic characters. Among these is the chartaceous versus subcoriaceous character of the leaves, the latter particularly common in *Monosis*, *Strobocalyx*, *Decaneuropsis*, *Tarlmounia* and some species of *Acilepis*. This character also seems to be related to the woody habit of these taxa. Trichome type, combinations and density are also informative at both the genus and species levels. The six types of trichomes found on Thai Vernonieae leaves are:

whip-shape (Figures 2.3, 2.4A), cylindric (Figures 2.4, 2.5A), T-shaped (Figures 2.5B, 2.6), flagellate (Figures 2.7, 2.8), filiform (Figures 2.9) and capitate gland. Whip-shaped hairs are common in many taxa, but T-shaped hairs are restricted to *Camchaya*, *Cyanthillium* and *Tarlmounia*. Flagellate trichomes, on the other hand, are restricted to *Acilepis attenuata*, *A. pseudosutepensis*, *Monosis* spp. and *Strobocalyx solanifolia* and cylindrical hairs are present only in *Iodocephalopsis* and *Acilepis saligna*. Similarly, filiform hairs are unique to *Elephantopus* spp. among Thai Vernoniaeae. The amount of tomentum can also be diagnostic as only a few taxa are densely pilose, villose or tomentose, i.e., *Decaneuropsis cumingiana*, *Elephantopus* spp., *Monosis parishii*, *Strobocalyx solanifolia*, *Tarlmounia elliptica*, *Vernonia cinerea* var. *montana* and *V. curtisii* var. *tomentosa*.

8.2.3 Capitulescence. These are terminal or found in the axils of leaves, characteristic placements found throughout the tribe. However, the differences among genera allow this feature to be useful in separating taxa. The simplest arrangement is a cymose branch which can form compound cymiform (*Acilepis* and *Camchaya*), corymbiform (*Iodocephalopsis* and *Gymnanthemum*), paniculate (*Monosis*) inflorescences while others may reduced to solitary capitula, i.e. *Acilepis squarrosa*. Added to other reproductive characters capitulescence can provide sufficient information to discriminate between individual species.

8.2.4 Phyllaries. The apex of the phyllaries is reflexed only in *Acilepis attenuata*, *A. silhetensis*, *Koyamasia calcarea* and *Vernonia curtisii*, making this character while not widely applicable, a good discriminator for specific taxa. Phyllary seriate, on the other hand is largely useful in distinguishing *Elephantopus* and *Pseudelephantopus* from all other genera. In the former genus there are two distichous seriate while in the others they are imbricate in several to many seriate. Tomentum and shape are also variable, but must be used in combination with other characters to distinguish one taxon from the next.

8.2.5 Florets. The number of florets varies from as few as four to >100 correlated with this is the gradually increasing size of the capitulum. If there are a small number of florets, the capitulum is usually small and narrow. Conversely, a large number of florets occur in large, broad campanulate or globose shaped capitula.

Pink and purple florets dominate in the Thai Vernonieae, with only *Elephantopus mollis* and *Pseudelephantopus spicatus* having white florets.

8.2.6 Achenes. Rib number is a significant character for separating taxa. For example, 10-ribbed achenes are the most common. Those few species with a lower number, i.e., *Camchaya gracilis*, *C. pentagona*, *Ethulia conyzoides*, *Sparganophoros sparganophora* and *Strobocalyx arborea* can be easily separated from all others and then distinguished from each other on the basis of other characters such as tomentum and capitulescence morphology. Usually the achene surfaces are also differentiated and these differences can be used to separate taxa. Glabrous achenes are found only *Camchaya* and *Koyamasia calcarea*, for example. Additionally, the carpodium is important for generic classification. It is prominent in *Acilepis* (Figure 2.10), *Cyanthillium* (Figures 2.11 G.-H.), *Decaneuropsis* (Figures 2.12 A.-C.), *Elephantopus* (Figures 2.12 D.-E.), *Gymnanthemum* (Figure 2.12 F.), *Kurziella* (Figure 2.13 A.), *Monosis* (Figures 2.13 B.-C.), *Pseudelephantopus* and *Tarlmounia* (Figure 2.13 F.), but it is inconspicuous in *Camchaya* (Figures 2.11 A.-F.), *Ethulia*, *Iodocephalopsis* (Figure 2.12 G.), *Koyamasia* (Figure 2.12 H.) and *Sparganophoros* (Figure 2.13 D.).

8.2.7 Pappus. Typically the pappus is formed of bristles in one or two seriate, the exception being *Sparganophoros* with a coroniform pappus. When there is a double seriate the outer one is shorter than the inner one and is typically more likely to be deciduous than the inner one. A single seriate pappus is known only from *Camchaya*, *Cyanthillium hookerianum*, *Elephantopus*, *Koyamasia*, *Kurziella*, *Pseudelephantopus*, *Sparganophoros* and *Vernonia curtisii*.

8.2.8 Pollen morphology. Thai Vernonieae have pollen of four main types; 1) echinate or subechinolophate 3-colporate, 2) lophate 3-colporate, 3) lophate 3-porate and 4) lophate 6-porate pollen (Figures 2.14, 2.15). Echinate or subechinolophate 3-colporate pollen (Figure 2.15 D.) is characteristic of woody taxa such as *Decaneuropsis*, *Strobocalyx* and *Tarlmounia*. The similarly woody *Monosis* has lophate 3-colporate pollen. The 3-porate pollens (Figures 2.14 A.-F.; 2.15 A., C., E.) are found in most annual other genera except for *Camchaya* which have distinct 6-porate pollen (Figure 2.15 B). These pollen morphologies correlate well with other characters that distinguish genera and species from each other.

Table 2.2 Ecological and distributional data of Thai Vernoniaeae. Key to abbreviations; 1. Endemic to Thailand, 2. Pantropics,

3. China and Japan, 4. India and Myanmar, 5. Indo-China, 6. Peninsular Malay, 7. Top of Limstone moutain,

8. Open area, dipterocarp or deciduous forest, 9. Evergreen forest, 10. Pine-oak forest, N. Northern, NE. North-eastern,

E. Eastern, SW. South-western, C. Central, SE. South-eastern and PEN. Peninsular.

Current taxon	Geographical distribution						Flowering period	Ecology				Altitude (m)	Distribution in Thailand					
	1	2	3	4	5	6		7	8	9	10		N	NE	E	SW	C	SE
<i>Acilepis attenuata</i>	-	-	-	✓	-	-	Oct - Feb	-	✓	-	50 – 780	✓	✓	-	✓	-	-	✓
<i>A. chiangdaoensis</i>	✓	-	-	-	-	-	Dec - Feb	-	✓	✓	600 – 800	✓	-	-	-	-	-	-
<i>A. divergens</i>	-	-	✓	✓	✓	-	Oct - Apr	-	✓	-	300 – 1850	✓	✓	-	✓	-	-	-
<i>A. doichangensis</i>	✓	-	-	-	-	-	Sep - Jan	-	-	-	1000 – 1300	✓	-	-	-	-	-	-
<i>A. kingii</i>	-	-	✓	✓	✓	-	Jan - Mar	-	-	✓	1000 – 1800	✓	-	-	-	-	-	-
<i>A. namnaoensis</i>	✓	-	-	-	-	-	Nov - Dec	-	✓	-	ca. 800	-	✓	✓	-	-	-	-
<i>A. ngaoensis</i>	✓	-	-	-	-	-	Dec - Jan	-	✓	-	ca. 100	-	-	-	-	-	-	✓
<i>A. peguensis</i>	-	-	-	✓	✓	-	Nov - Dec	-	✓	-	ca. 800	-	✓	-	-	-	-	-
<i>A. principis</i>	✓	-	-	-	-	-	Dec - Mar	-	-	✓	600 – 1400	✓	-	-	-	-	-	-
<i>A. pseudosuteupensis</i>	✓	-	-	-	-	-	Dec - Feb	✓	-	✓	200 – 400	✓	-	-	✓	-	-	-
<i>A. saligna</i>	-	-	✓	✓	✓	-	Nov - Dec	-	-	-	1100 – 1400	✓	✓	-	-	-	-	-
<i>A. silhetensis</i>	-	-	✓	✓	✓	-	Aug - Jan	-	✓	✓	700 – 1350	✓	✓	-	-	-	-	-

Table 2.2 Ecological and distributional data of Thai Vernonieae. Key to abbreviations; 1. Endemic to Thailand, 2. Pantropics, 3. China and Japan, 4. India and Myanmar, 5. Indo-China, 6. Peninsular Malay, 7. Top of Limstone moutain, 8. Open area, dipterocarp or deciduous forest, 9. Evergreen forest, 10. Pine-oak forest, N. Northern, NE. North-eastern, E. Eastern, SW. South-western, C. Central, SE. South-eastern and PEN. Peninsular. (Cont.)

Current taxon	Geographical distribution						Flowering period	Ecology				Altitude (m)	Distribution in Thailand						
	1	2	3	4	5	6		7	8	9	10		N	NE	E	SW	C	SE	PEN
<i>A. squarrosa</i>	-	-	✓	✓	✓	-	Sep - May	-	✓	✓	✓	10 – 1200	✓	✓	✓	✓	-	-	
<i>A. sutepensis</i>	✓	-	-	-	-	-	Nov - Mar	-	-	✓	✓	1100 – 1500	✓	-	-	-	-	-	
<i>A. tonkinensis</i>	-	-	-	-	✓	-	Jan - Feb	-	✓	-	-	930 – 1200	✓	-	-	-	-	-	
<i>A. virgata</i>	-	-	-	-	✓	-	Mar	-	-	✓	-	ca. 180	-	-	-	-	-	✓	
<i>Camchaya gracilis</i>	-	-	-	-	✓	-	Oct - Dec	-	✓	-	-	ca. 150	-	✓	-	-	-	-	
<i>C. kampotensis</i>	-	-	-	-	✓	-	Dec	-	-	✓	-	700 – 900	-	-	✓	-	-	-	
<i>C. loloana</i>	-	-	✓	-	✓	-	Jul - Dec	✓	✓	✓	✓	400 – 1500	✓	✓	✓	✓	-	-	
<i>C. loloana</i> var. <i>mukdahanensis</i>	-	-	-	-	✓	-	Aug - Jan	-	✓	-	-	250 – 400	-	✓	✓	-	-	-	
<i>C. pentagona</i>	✓	-	-	-	-	-	Oct - Dec	-	✓	-	-	220 – 300	-	-	✓	-	-	-	
<i>C. spinulifera</i>	✓	-	-	-	-	-	Sep - Dec	-	✓	-	-	200 – 300	-	✓	✓	-	-	-	
<i>C. tenuiflora</i>	✓	-	-	-	-	-	Oct - Dec	-	-	✓	-	ca. 700	✓	✓	✓	-	-	-	
<i>C. sp.</i>	✓	-	-	-	-	-	Nov - Dec	-	✓	-	-	ca. 300	-	✓	-	-	-	-	

Table 2.2 Ecological and distributional data of Thai Vernoniaeae. Key to abbreviations; 1. Endemic to Thailand, 2. Pantropics, 3. China and Japan, 4. India and Myanmar, 5. Indo-China, 6. Peninsular Malay, 7. Top of Limstone moutain, 8. Open area, dipterocarp or deciduous forest, 9. Evergreen forest, 10. Pine-oak forest, N. Northern, NE. North-eastern, E. Eastern, SW. South-western, C. Central, SE. South-eastern and PEN. Peninsular. (Cont.)

Current taxon	Geographical distribution						Flowering period	Ecology				Altitude (m)	Distribution in Thailand						
	1	2	3	4	5	6		7	8	9	10		N	NE	E	SW	C	SE	PEN
<i>Cyanthillium cinereum</i>	-	✓	-	-	-	-	Jan - Dec	-	✓	✓	-	0 - 250	✓	✓	✓	-	✓	✓	
<i>C. hookerianum</i>	-	-	✓	✓	✓	✓	Aug - Feb	-	-	✓	-	0 - 100	✓	✓	-	✓	-	✓	
<i>Decaneuropsis cumingiana</i>	-	-	✓	✓	✓	✓	Nov - Apr	-	-	✓	✓	200 - 850	✓	✓	✓	-	-	✓	
<i>D. eberhardtii</i>	-	-	-	-	✓	-	Dec - Feb	-	-	✓	-	500 - 800	✓	✓	✓	-	-	-	
<i>D. garrettiana</i>	-	-	-	✓	-	-	Nov - Feb	-	✓	✓	✓	400 - 800	✓	-	-	-	-	-	
<i>Elephantopus mollis</i>	-	✓	-	-	-	-	Oct - Dec	-	-	✓	-	0 - 100	-	-	-	-	-	✓	
<i>E. scaber</i>	-	✓	-	-	-	-	Aug - Jan	-	✓	✓	✓	0 - 400	✓	✓	✓	✓	✓	✓	
<i>E. scaber</i> var. <i>penicillatus</i>	-	-	-	-	✓	-	Aug - Jan	-	✓	✓	-	100 - 400	-	✓	-	✓	-	-	
<i>Ethulia conyzoides</i>	-	✓	-	-	-	-	May - Sep	-	-	✓	-	200 - 400	✓	✓	-	-	-	-	
<i>Gymnanthemum cylindriceps</i>	-	-	✓	✓	-	-	Dec - Apr	-	-	✓	✓	1000 - 2000	✓	-	-	-	-	-	
<i>Iodocephalopsis eberhardtii</i>	-	-	-	-	✓	-	Aug - Dec	-	-	✓	✓	700 - 1700	✓	✓	✓	-	-	-	
<i>Koyamasia calcarea</i>	✓	-	-	-	-	-	Oct - Dec	✓	-	-	-	ca. 1300	✓	-	-	-	-	-	

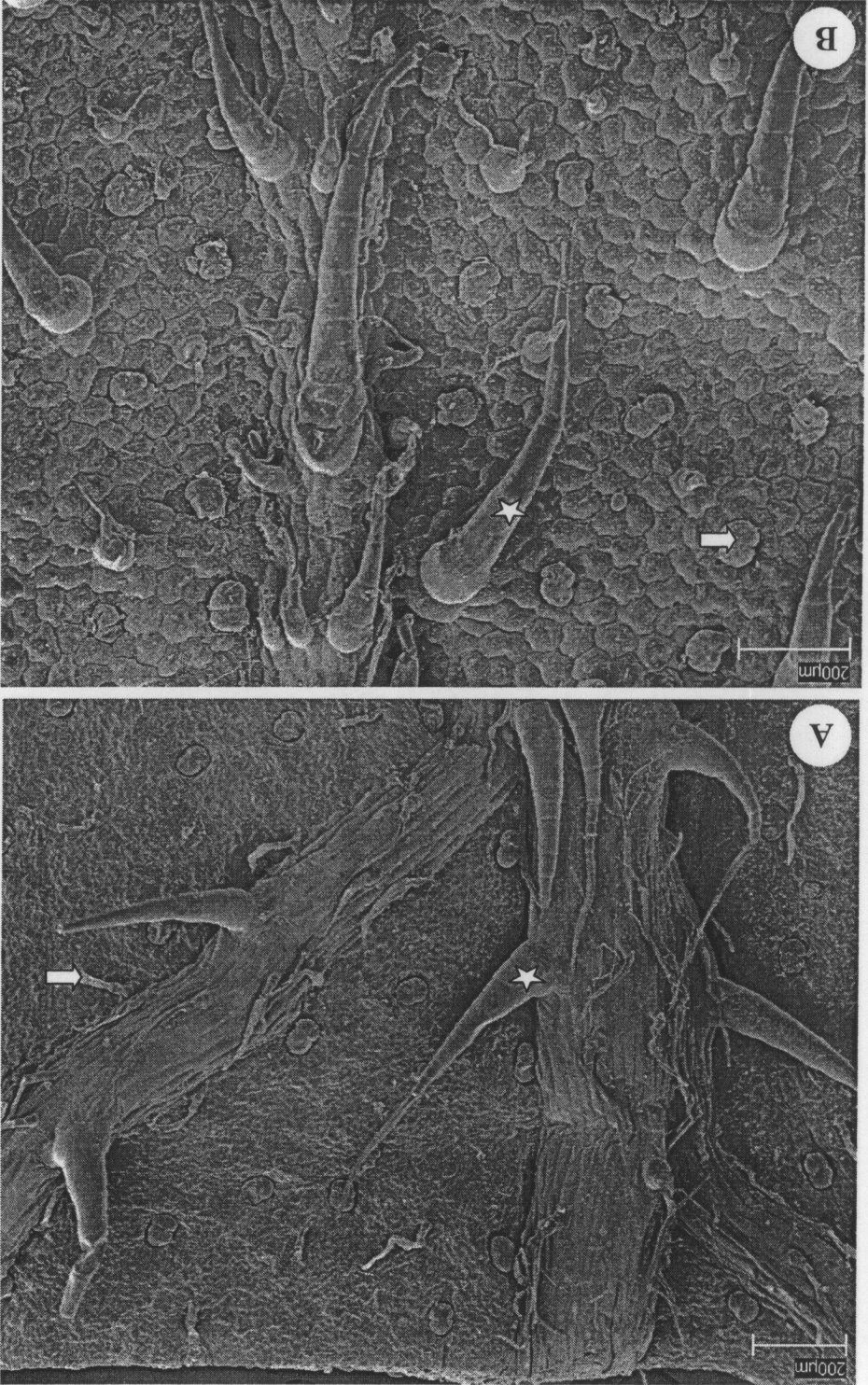
Table 2.2 Ecological and distributional data of Thai Veroniceae. Key to abbreviations; 1. Endemic to Thailand, 2. Pantropics, 3. China and Japan, 4. India and Myanmar, 5. Indo-China, 6. Peninsular Malay, 7. Top of limestone mountain, 8. Open area, dipterocarp or deciduous forest, 9. Evergreen forest, 10. Pine-oak forest, N. Northern, NE. North-eastern, E. Eastern, SW. South-western, C. Central, SE. South-eastern and PEN. Peninsular. (Cont.)

Current taxon	Geographical distribution						Flowering period		ecology				Altitude (m)		Distribution in Thailand						
	1	2	3	4	5	6			7	8	9	10			N	NE	E	SW	C	SE	PEN
<i>Kurziella gymnoclada</i>	-	-	-	✓	-	-	Nov - Mar	-	✓	-	-	-	40 – 200	✓	✓	-	✓	✓	✓	✓	-
<i>Monosis parishii</i>	-	-	✓	✓	✓	-	Dec - Apr	-	-	✓	✓	✓	250 – 800	✓	✓	-	-	✓	-	-	-
<i>M. volkameriifolia</i>	-	-	✓	✓	✓	-	Nov - Mar	-	-	✓	✓	✓	500 – 1750	✓	✓	-	-	-	-	-	-
<i>Pseudelephantopus spicatus</i>	-	✓	-	-	-	-	Oct - Dec	-	✓	✓	-	-	100 – 400	✓	✓	✓	✓	-	-	-	-
<i>Sparganophoros sparganophora</i>	-	✓	-	-	-	-	Aug - Apr	-	✓	✓	✓	-	50 – 400	✓	✓	✓	-	✓	✓	-	✓
<i>Strobocalyx arborea</i>	-	-	✓	✓	✓	✓	July - Feb	-	-	✓	✓	-	50 – 300	✓	✓	✓	-	-	-	-	✓
<i>S. solanifolia</i>	-	-	✓	✓	✓	-	Feb - May	-	-	✓	✓	✓	900 – 1250	✓	✓	✓	✓	✓	✓	-	-
<i>Tarlmounia elliptica</i>	-	✓	-	-	-	-	Oct - May	-	✓	-	-	-	0 – 100	✓	✓	✓	✓	✓	✓	✓	✓
<i>Vernonia birmanica</i>	-	-	-	✓	-	-	Sep - Dec	✓	✓	-	-	-	650 – 1000	✓	✓	-	-	✓	-	-	-
<i>V. cinerea</i> var. <i>montana</i>	-	-	-	-	✓	✓	Oct - Mar	-	-	✓	✓	✓	500 – 1000	✓	✓	✓	✓	-	-	-	-
<i>V. curtisii</i>	-	-	-	✓	✓	✓	Nov - Apr	✓	✓	-	-	-	100 – 500	✓	✓	✓	✓	✓	✓	-	✓
<i>V. curtisii</i> var. <i>tomentosa</i>	✓	-	-	-	-	-	Jun - Aug	✓	✓	-	-	-	200 – 1600	✓	✓	-	-	✓	-	-	-

Table 2.2 Ecological and distributional data of Thai Veronieae. Key to abbreviations; 1. Endemic to Thailand, 2. Pantropics, 3. China and Japan, 4. India and Myanmar, 5. Indo-China, 6. Peninsular Malay, 7. Top of Limestone mountain, 8. Open area, dipterocarp or deciduous forest, 9. Evergreen forest, 10. Pine-oak forest, N. Northern, NE. North-eastern, E. Eastern, SW. South-western, C. Central, SE. South-eastern and PEN. Peninsular. (Cont.)

Current taxon	Geographical distribution						Flowering period	ecology				Altitude (m)	Distribution in Thailand						
	1	2	3	4	5	6		7	8	9	10		N	NE	E	SW	C	SE	PEN
<i>V. kerii</i>	✓	-	-	-	-	-	Feb	-	-	✓	-	700 – 1400	✓	-	-	-	-	-	-
<i>V. pseudobirmanica</i>	✓	-	-	-	-	-	Nov - Dec	✓	-	-	-	700 – 900	✓	-	-	✓	-	-	-
<i>V. pulicarioides</i>	-	-	-	✓	✓	-	Oct - Feb	-	-	✓	-	780 – 1600	✓	-	-	-	-	-	-

Figure 2.3 Scanning electron micrographs of leaf surfaces of *Camchaya*.
A. Whip-shaped hairs (star), cylindrical hairs (arrow) and capitulate glands of *C. lolana* var. *mukdahanensis*.
B. Whip-shaped hairs (star) and capitulate glands (arrow) of *Camchaya* sp.



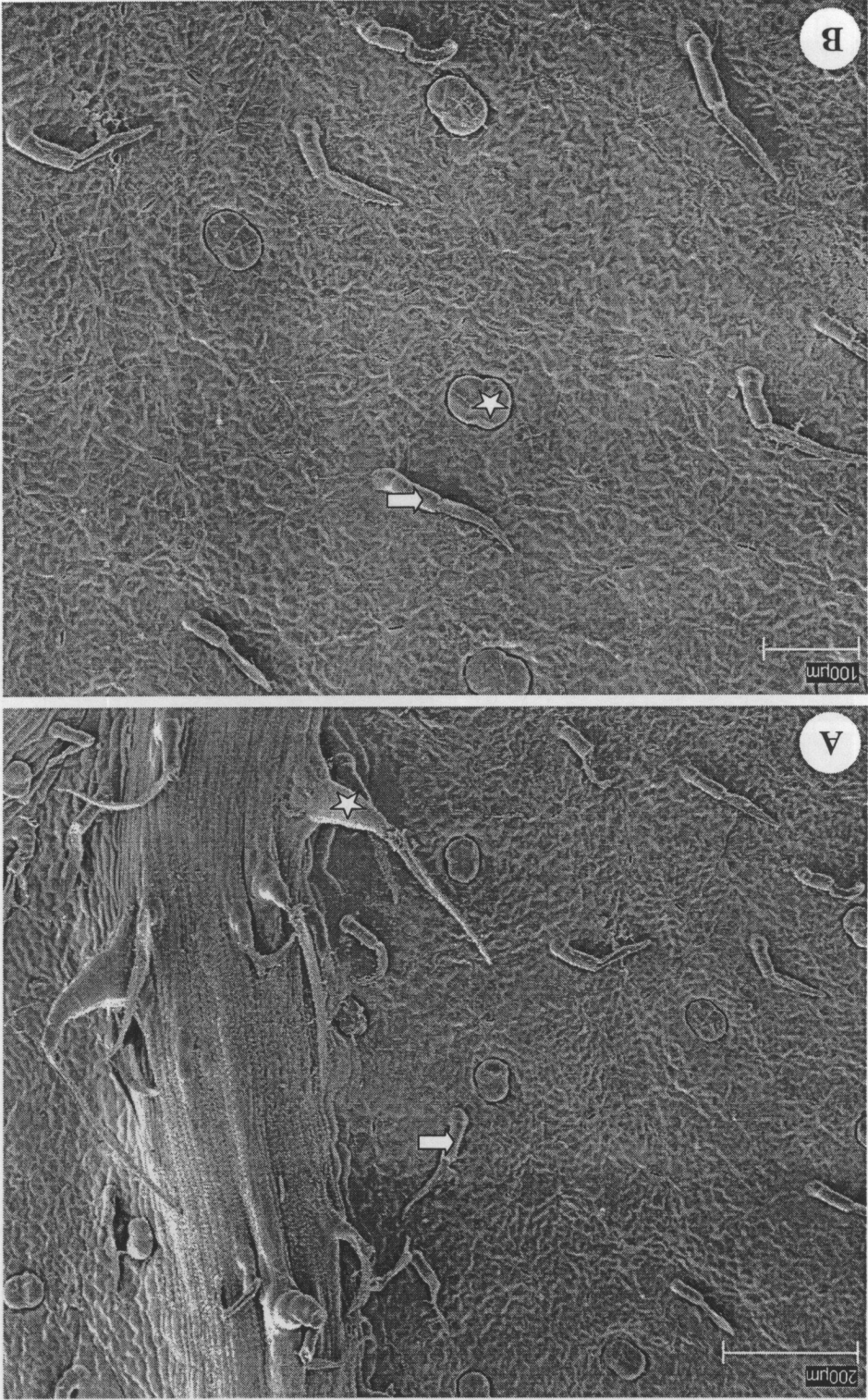


Figure 2.4 Scanning electron micrographs of leaf surfaces of *Iodocephalopsis*.
A. Whip-shaped hairs (star), cylindrical hairs (arrow) and capitate glands of *I. eberhardtii*.
B. Cylindrical hairs (arrow) and capitate glands (star) of *I. eberhardtii*.

Figure 2.5 Scanning electron micrographs of leaf surfaces of *Acilepis* and *Tarlmounia*.
A. Cylindrical hairs (arrow) and capitate glands (star) of *A. saligna*.
B. T-shaped hairs of *Tarlmounia elliptica*.

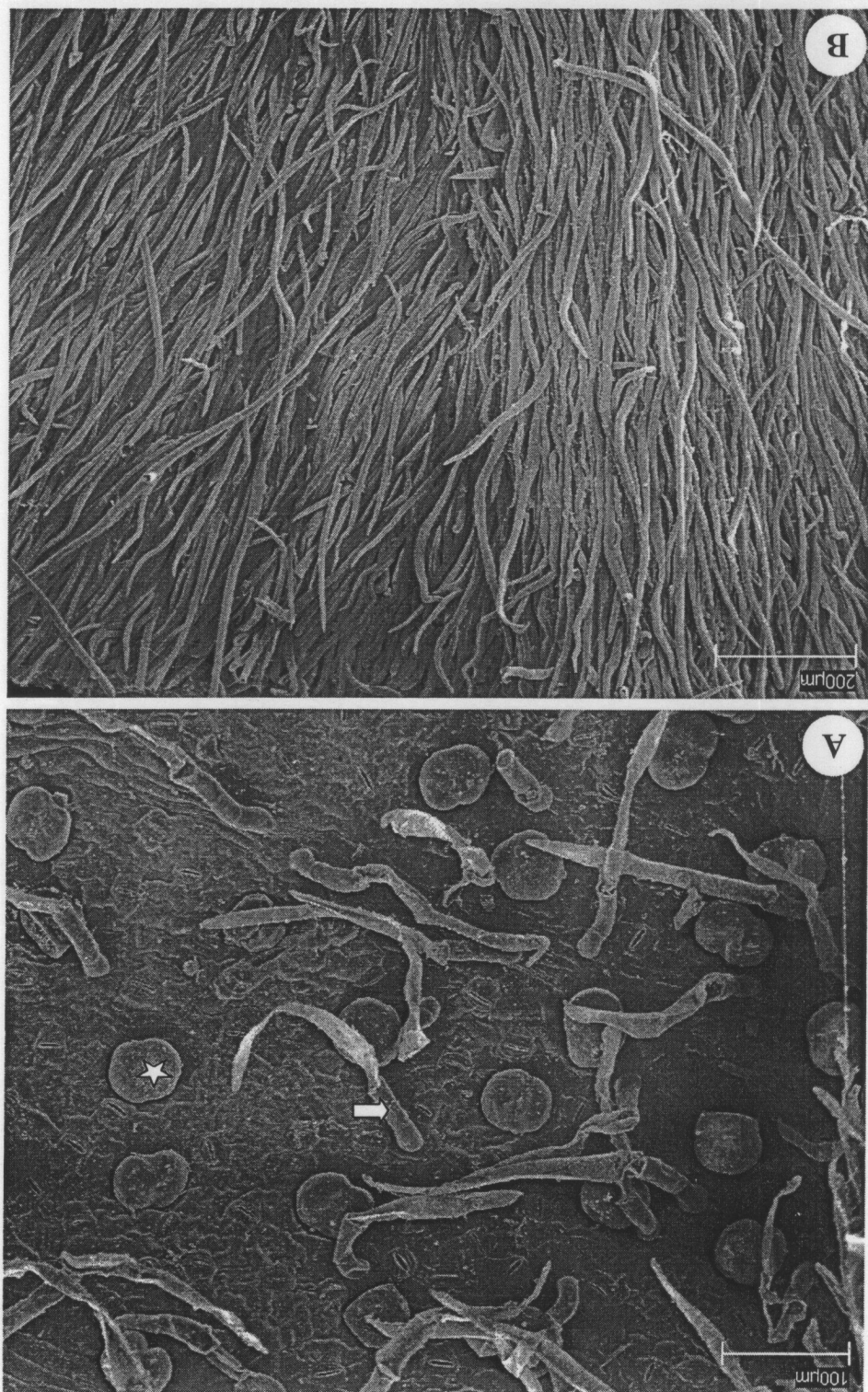
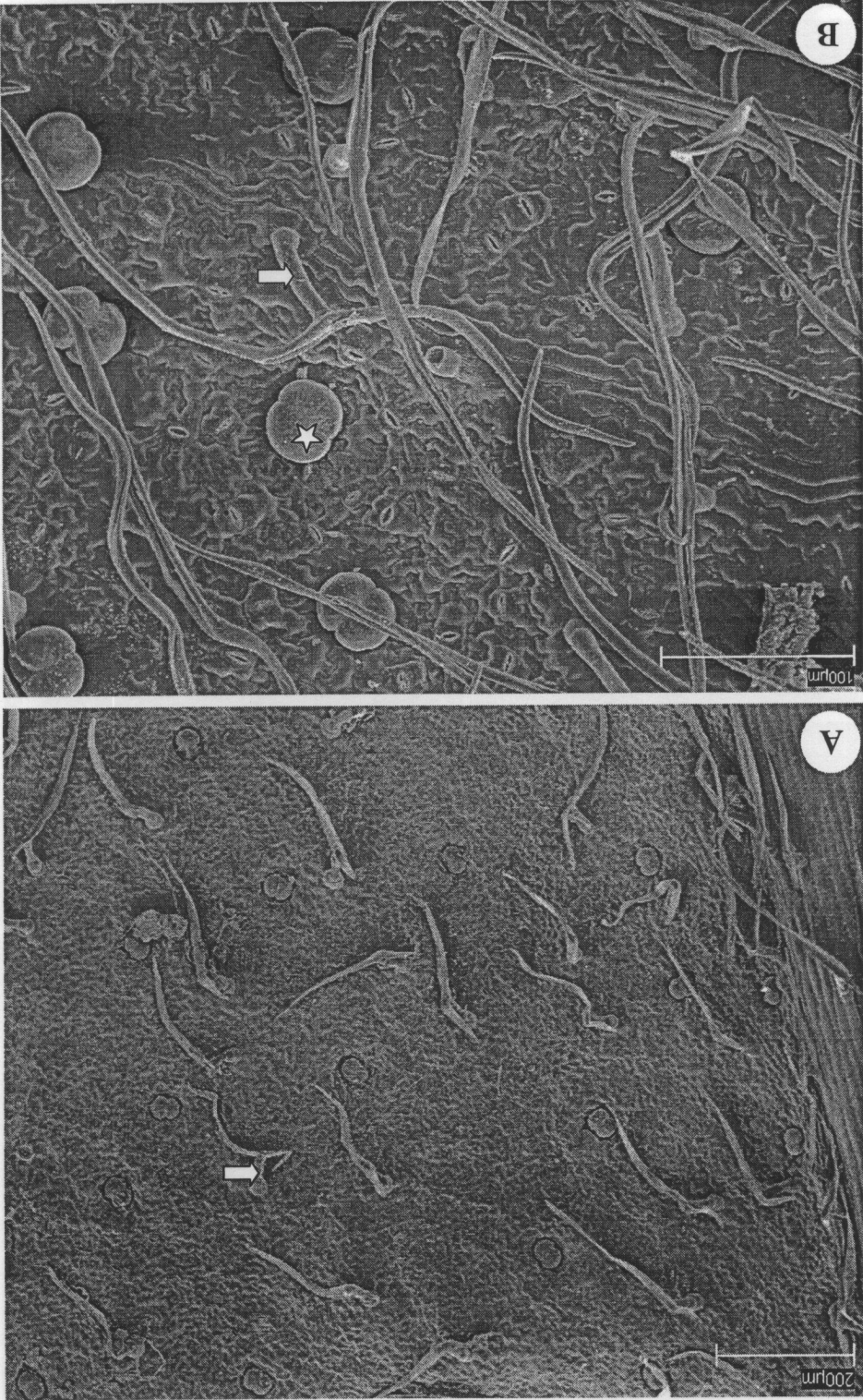


Figure 2.6 Scanning electron micrographs of leaf surfaces of *Cyanthillium*.

A. T-shaped hairs (arrow) and capitate glands of *C. cinereum*.

B. T-shaped hairs (arrow) and capitate glands (star) of *C. hookerianum*.



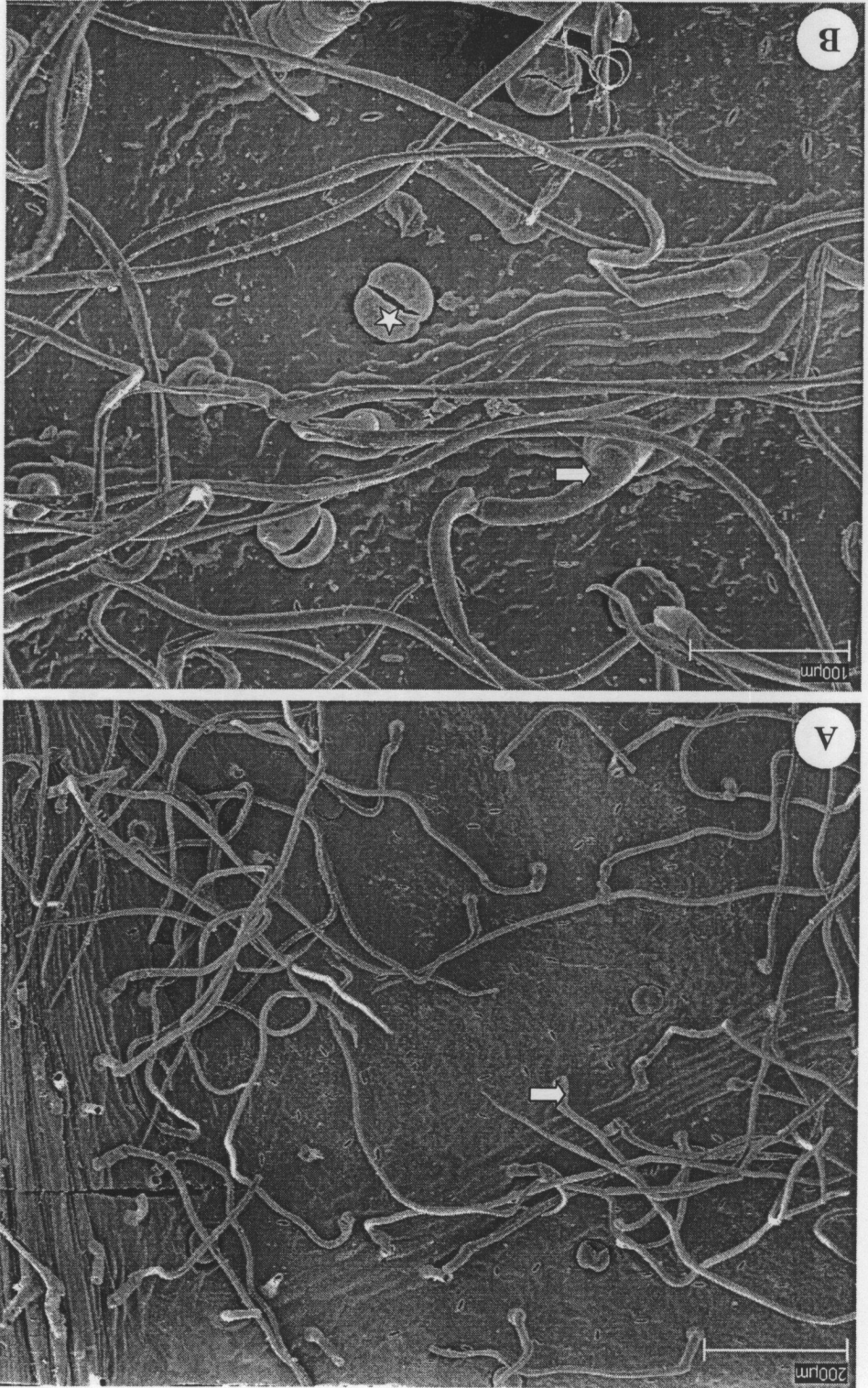


Figure 2.7 Scanning electron micrographs of leaf surfaces of *Acilepis*.
A. Flagellate hairs (arrow) and capitate glands of *A. attenuata*.
B. Flagellate hairs (arrow) and capitate glands (star) of *A. pseudosutepensis*.

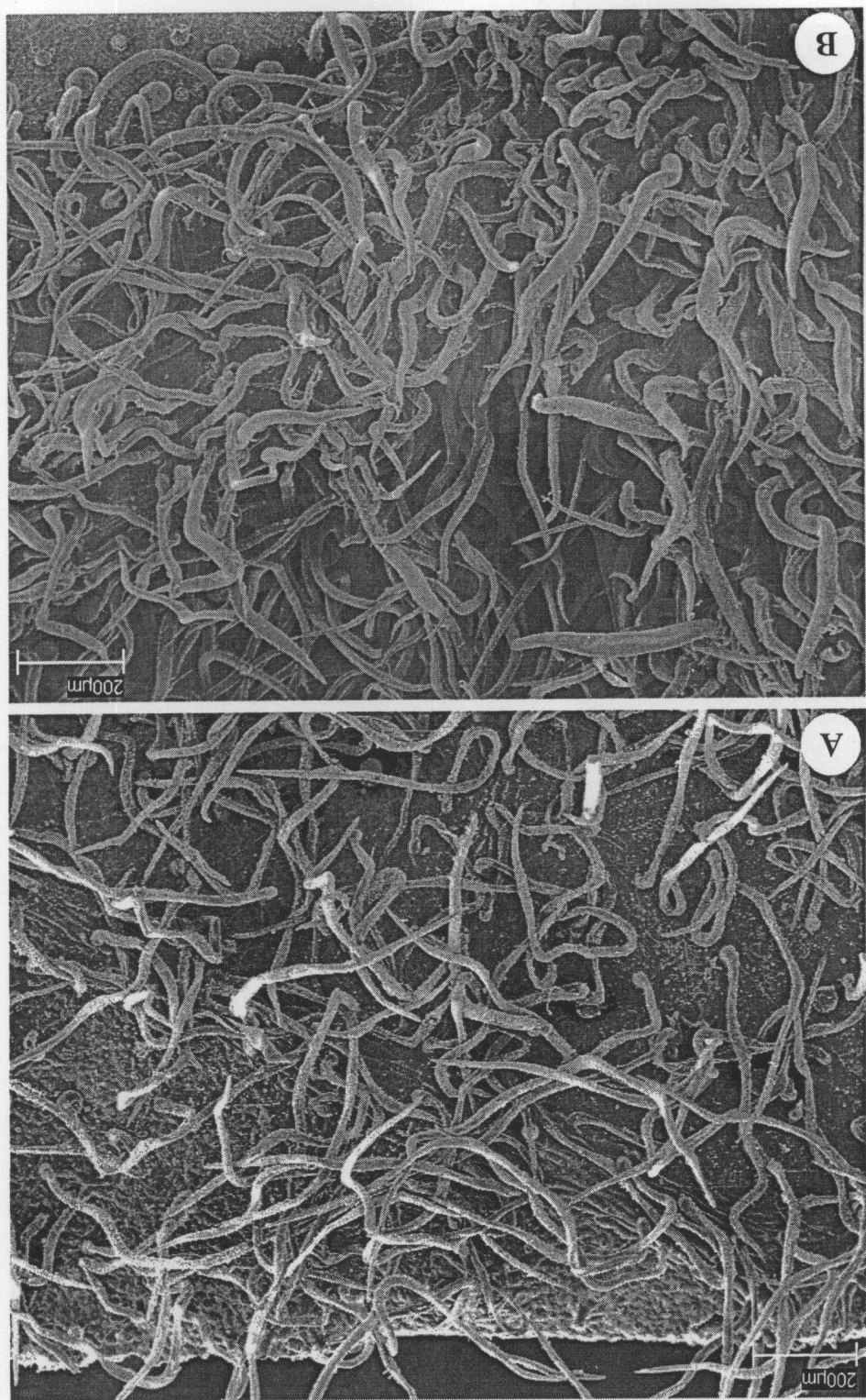
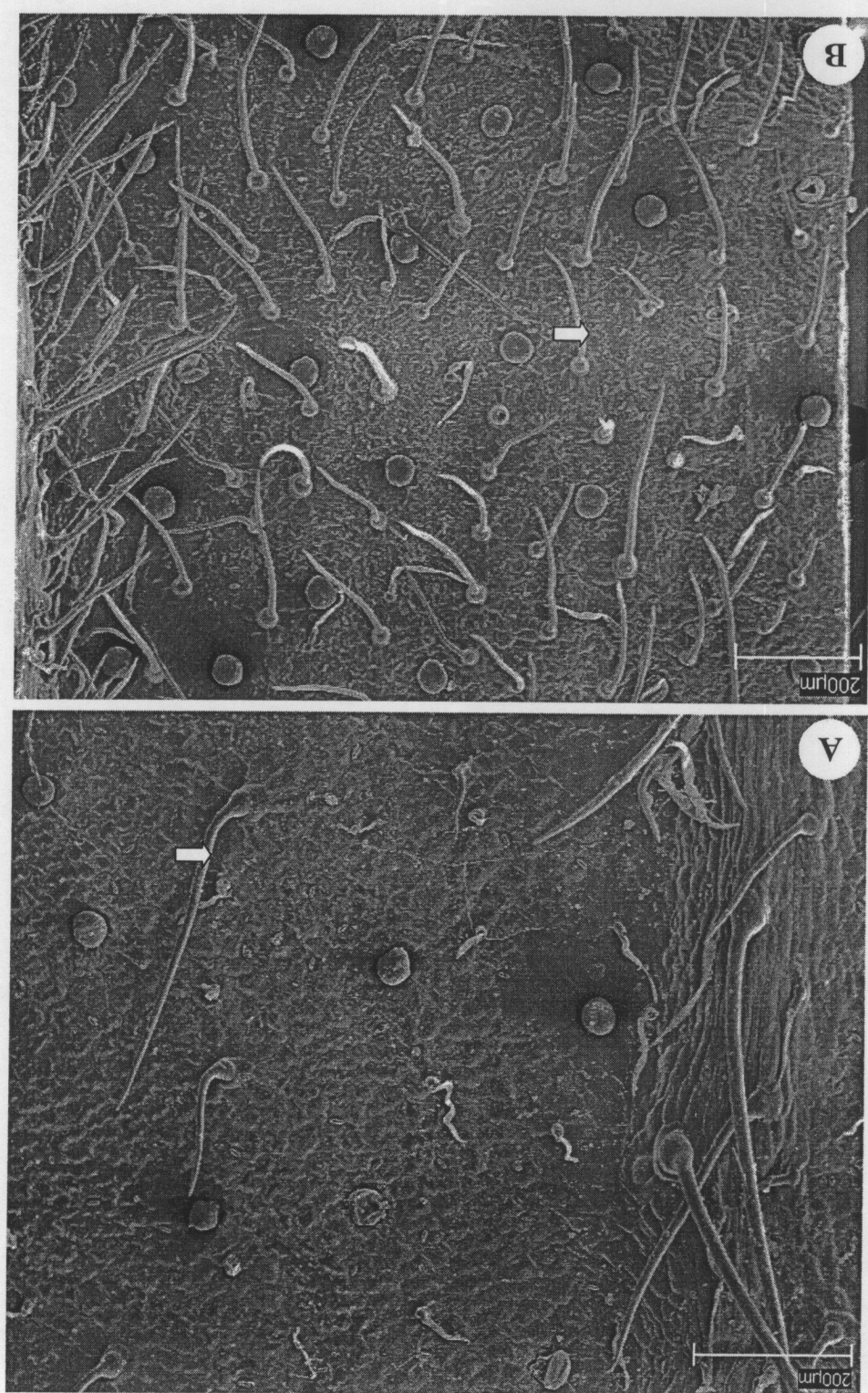


Figure 2.8 Scanning electron micrographs of leaf surfaces of *Monosis* and *Strobocalyx*.
A. Flagellate hairs and capitate glands of *M. parishii*.
B. Flagellate hairs and capitate glands of *S. solanifolia*.

E. mollis.

A. & B. Filiform hairs (arrow), cylindrical hairs and capitate glands of

Figure 2.9 Scanning electron micrographs of leaf surfaces of *Elephantopus*.



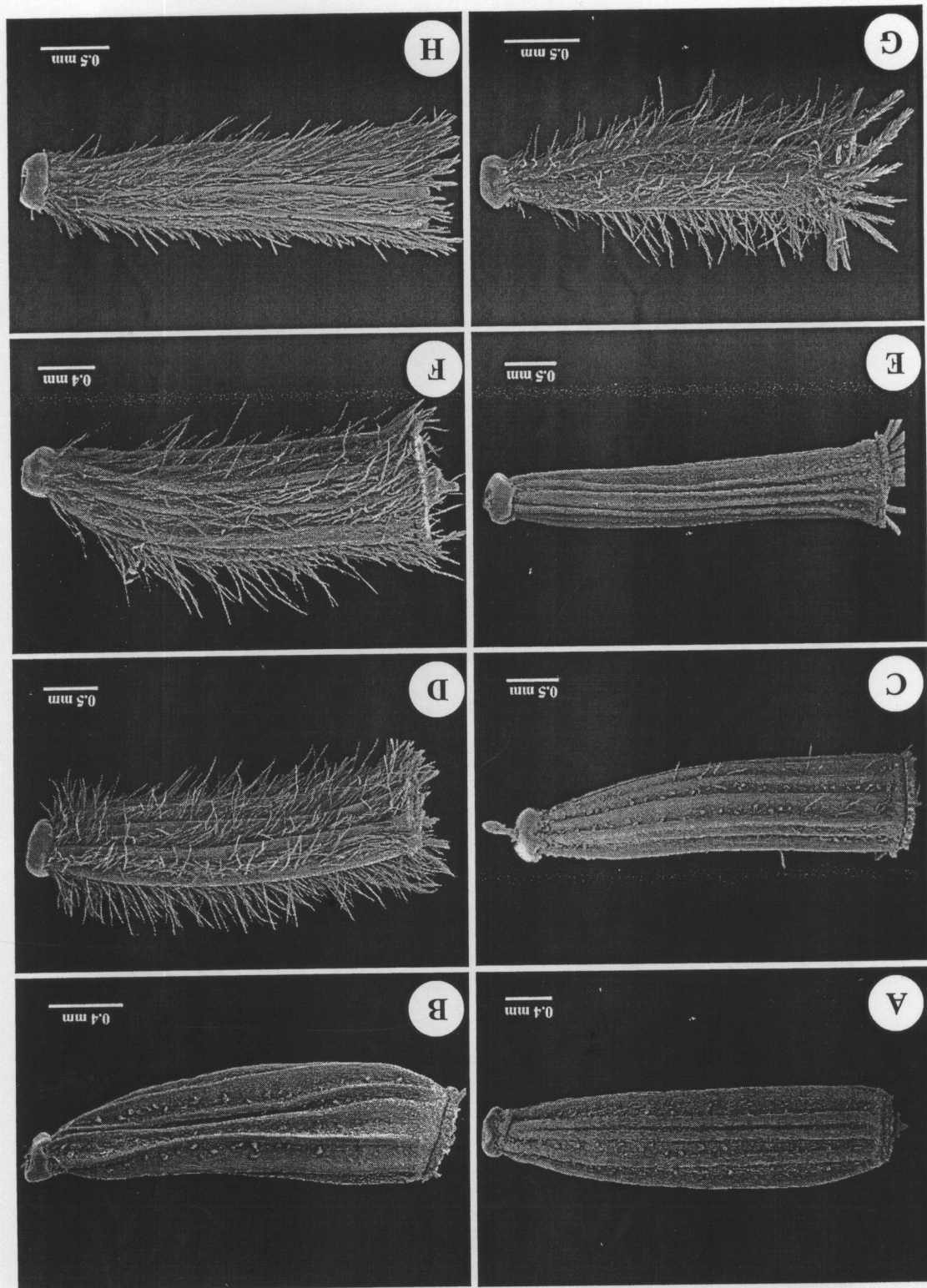


Figure 2.10 Achenes of *Acilepis*
A. *A. chiangdaoensis*
D. *A. ngaensis*
G. *A. pseudosutepensis*
B. *A. divergens*
E. *A. peguensis*
H. *A. squarrosa*
C. *A. namnaensis*
F. *A. principis*

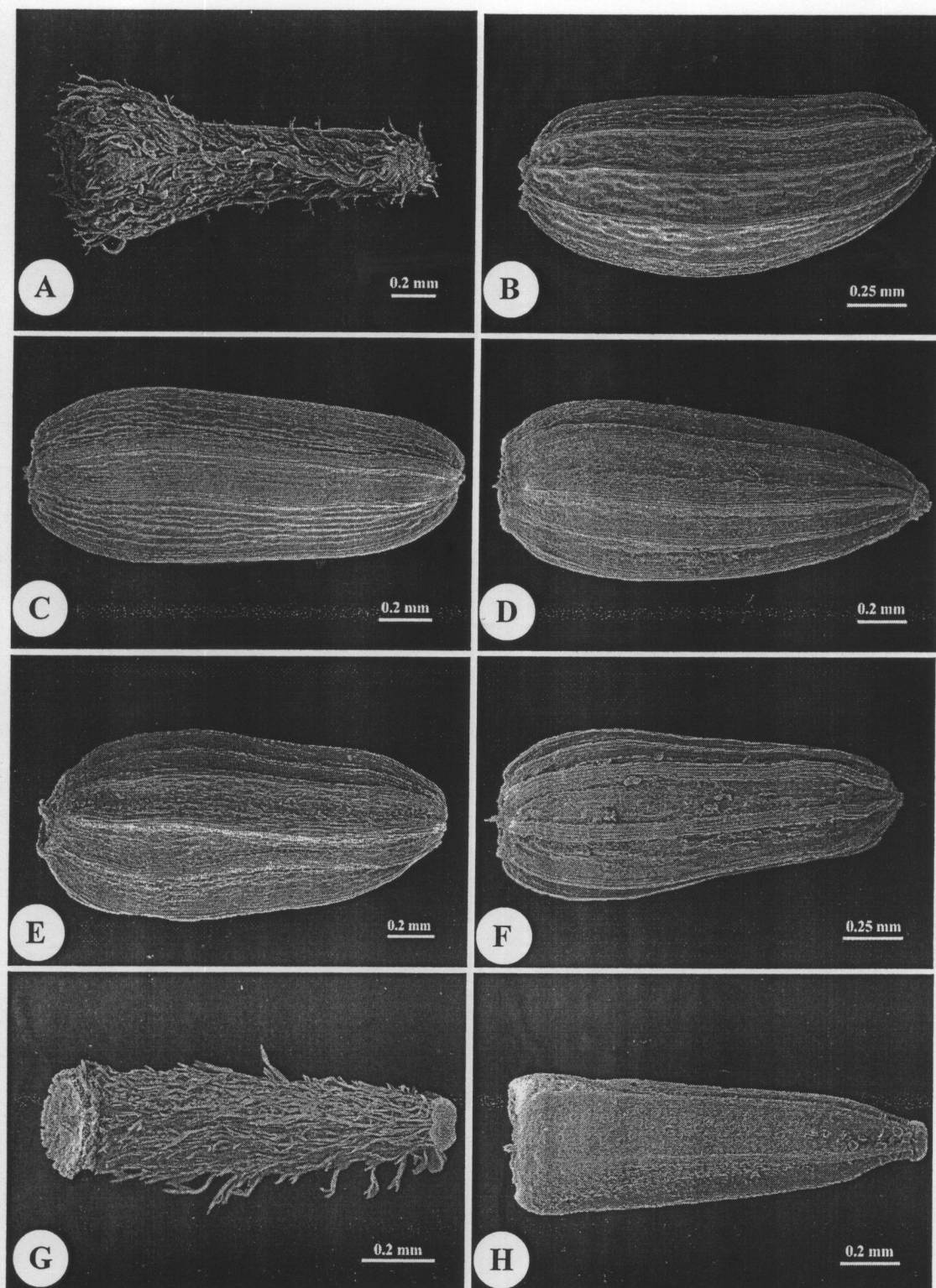


Figure 2.11 Achenes of *Camchaya* and *Cyanthillium*

A. *C. gracilis*

B. *C. loloana*

C. *C. pentagona*

D. *C. spinulifera*

E. *C. tenuiflora*

F. *Camchaya* sp.

G. *Cyanthillium cinereum*

H. *Cyanthillium hookerianum*

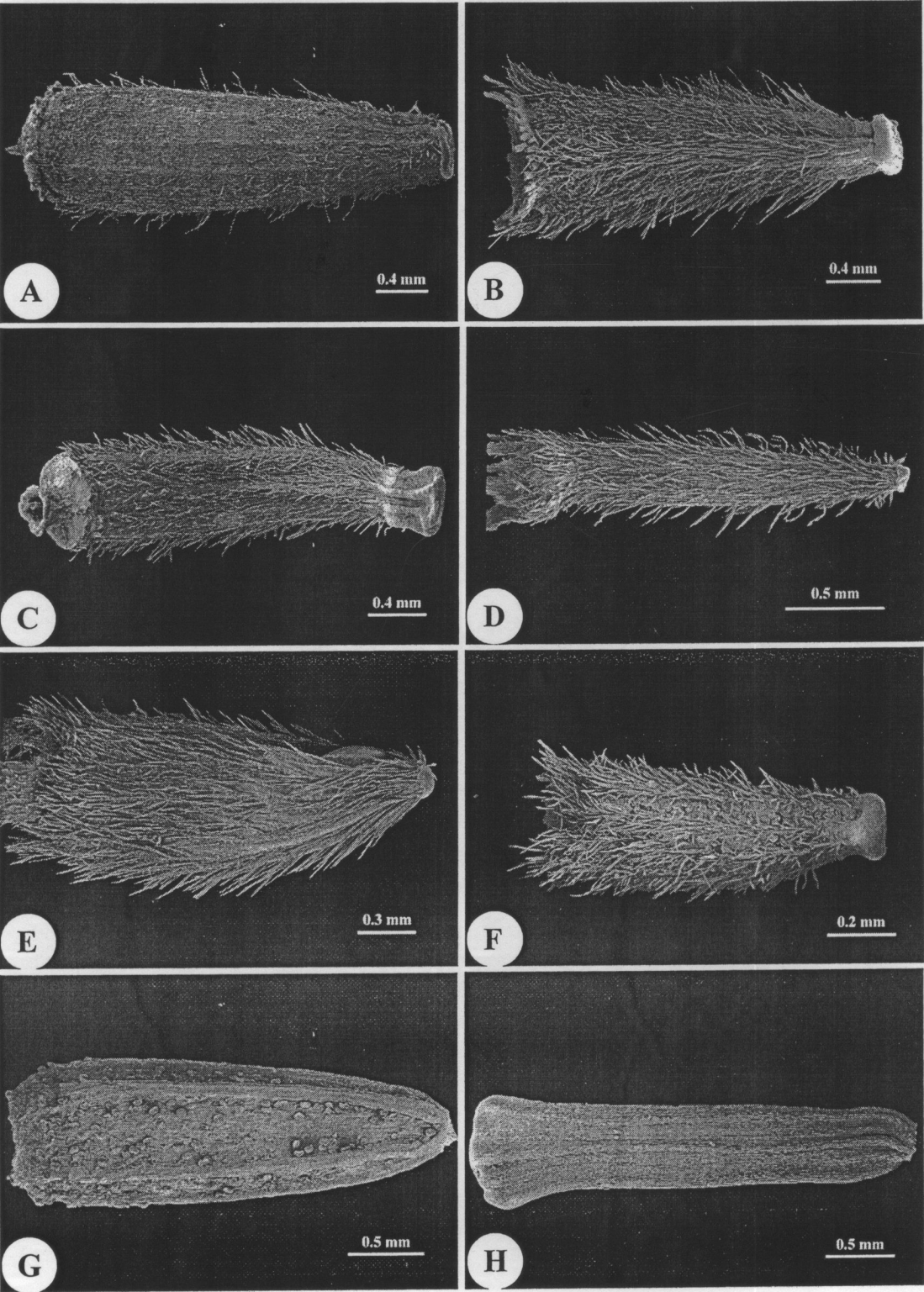


Figure 2.12 Achenes of *Decaneuropsis*, *Elephantopus*, *Gymnanthemum*, *Iodocephalopsis* and *Koyamasia*.
A. *D. cumingiana* B. *D. eberhardtii* C. *D. garrettiana*
D. *E. mollis* E. *E. scaber* var. *penicillatus*
F. *G. cylindriceps* G. *I. eberhardtii* H. *K. calcarea*

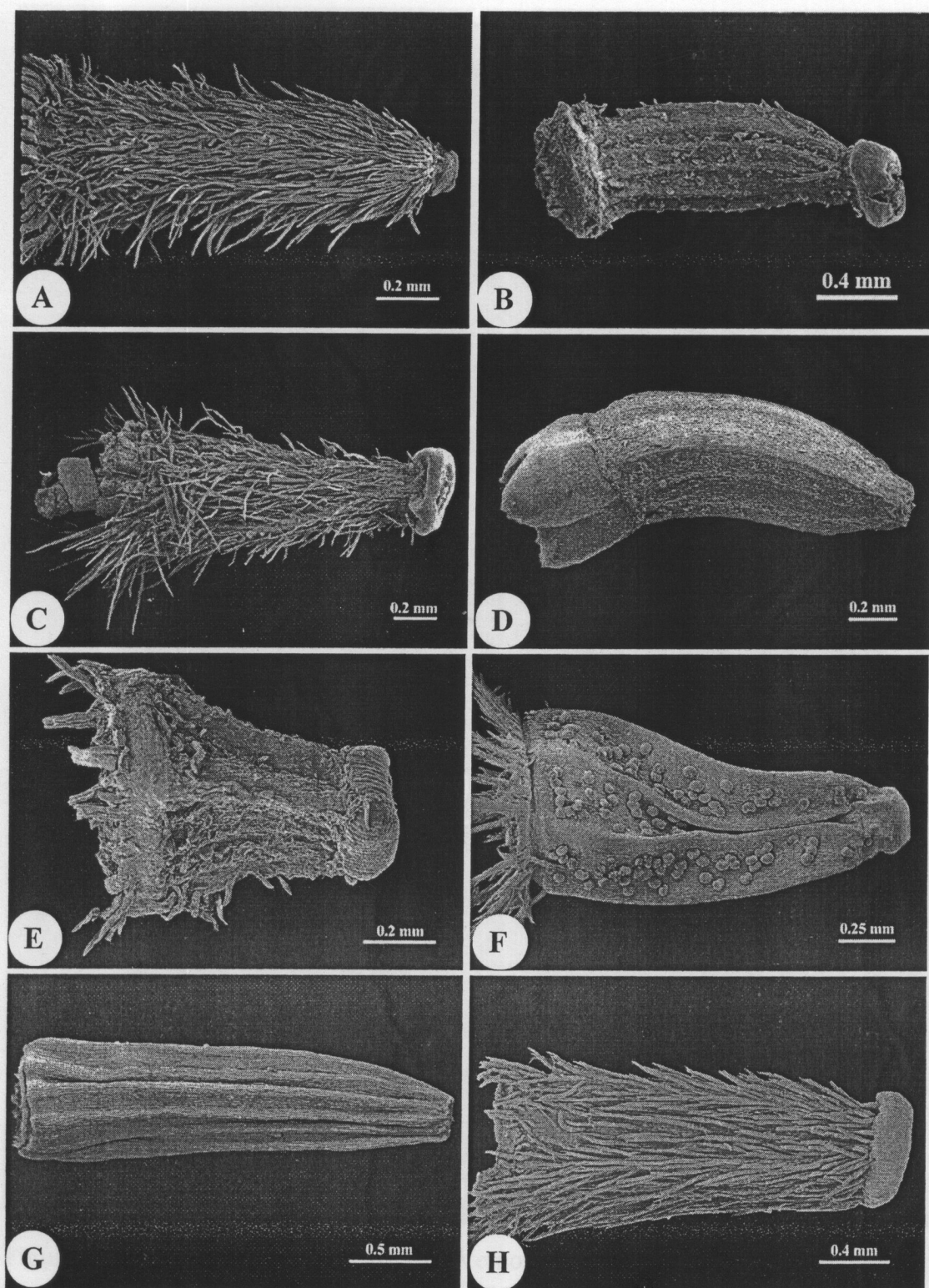


Figure 2.13 Achenes of *Kurziella*, *Monosis*, *Sparganophoros*, *Strobocalyx*, *Tarlmounia* and uncertain species.

A. *K. gymnoclada* B. *M. parishii*
 D. *Sparganophoros sparganophora*
 F. *T. elliptica* G. *V. curtisii*

C. *M. volkameriifolia*
 E. *Strobocalyx arborea*
 H. *V. pulicarioides*

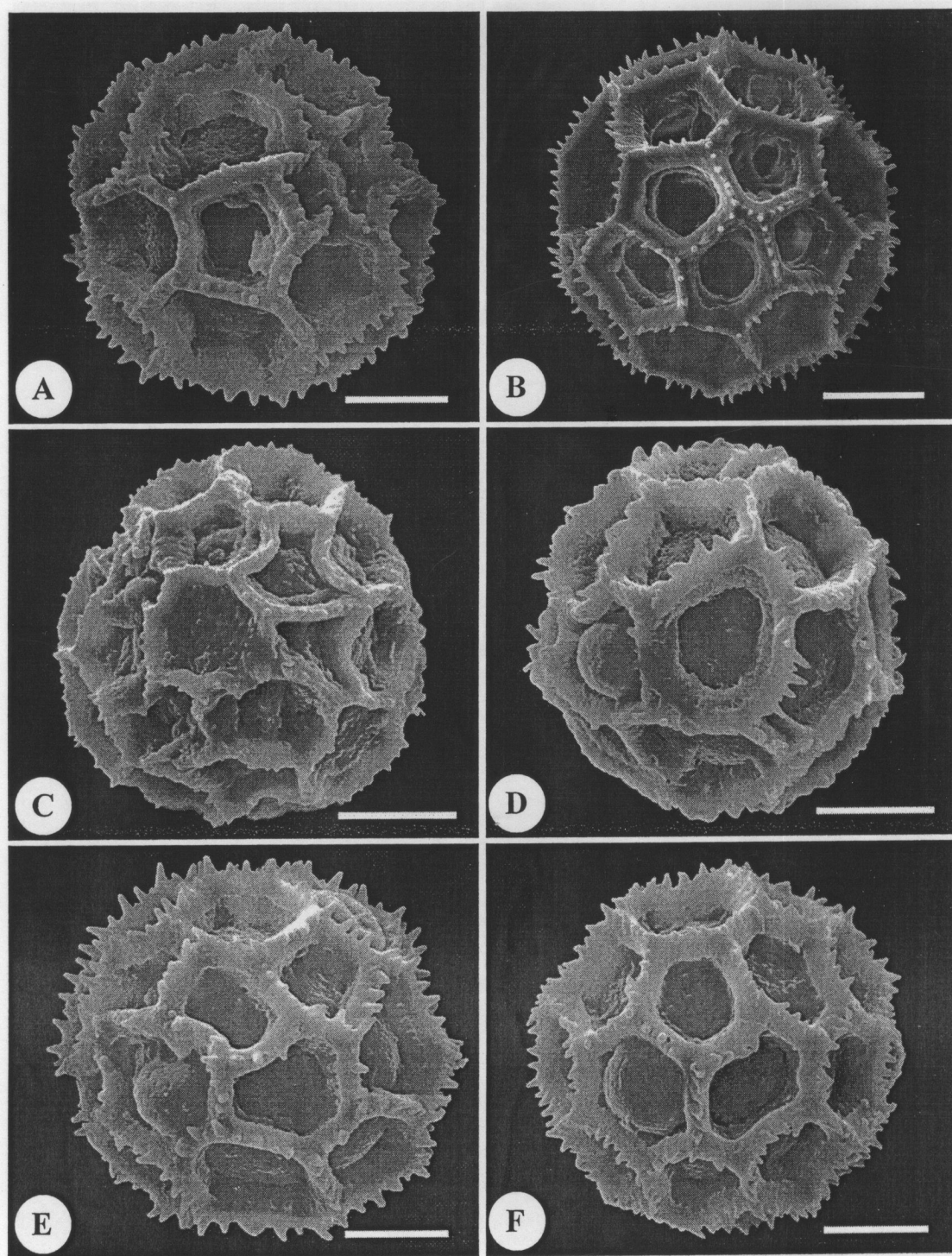


Figure 2.14 Unacetolyzed pollen of Thai Vernoniaeae; adding to Bunwong & Chantaranothai (2008). Scale bar = 10 μ m.

A. *Acilepis chiangdaoensis*

B. *A. namnaoensis*

C. *A. ngaoensis*

D. *A. peguensis*

E. *A. principis*

F. *A. pseudosutepensis*

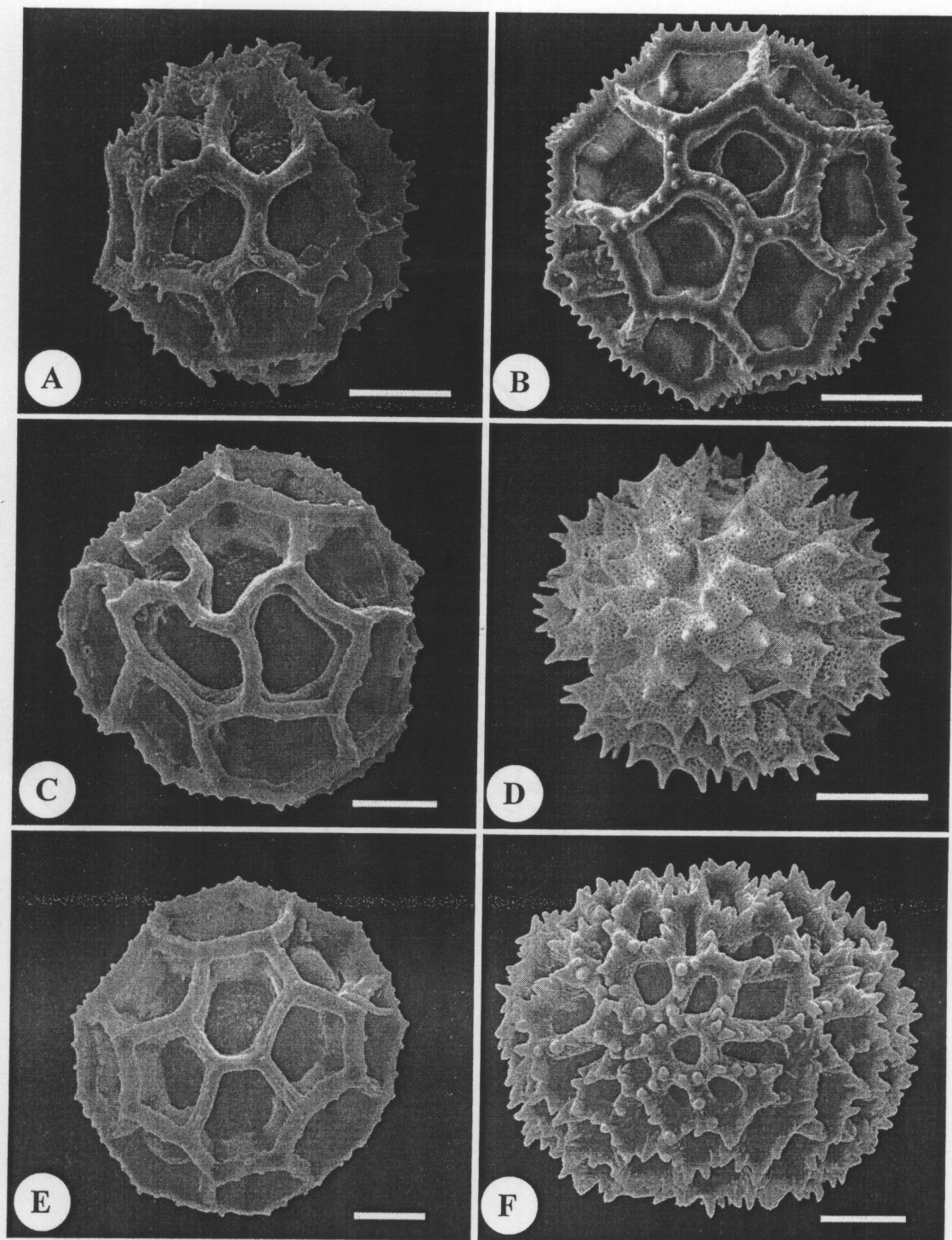


Figure 2.15 Unacetolyzed pollen of Thai Vernonieae; adding to Bunwong & Chantaranothai (2008). Scale bar = 10 μ m.

A. *Acilepis saligna*

C. *Koyamasia calcarea*

E. *Vernonia curtisii*

B. *Camchaya* sp.

D. *Kurziella gymnoclada*

F. *V. pulicarioides*

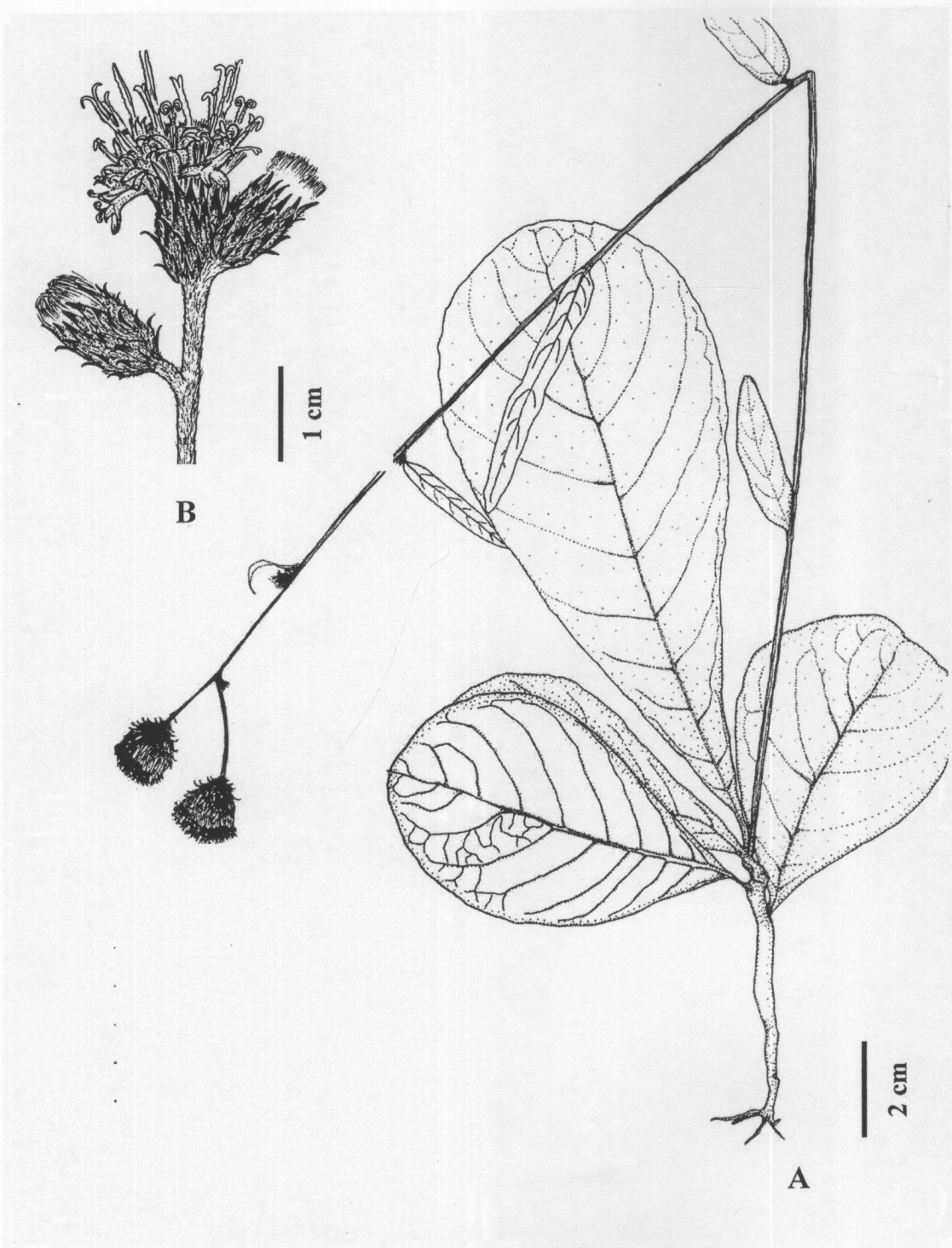


Figure 2.16 *Acilepis attenuata* A. habit B. capitula



Figure 2.17 *Acilepis chiangdaoensis*



Figure 2.18 *Acilepis divergens*



Figure 2.19 *Acilepis doichangensis*

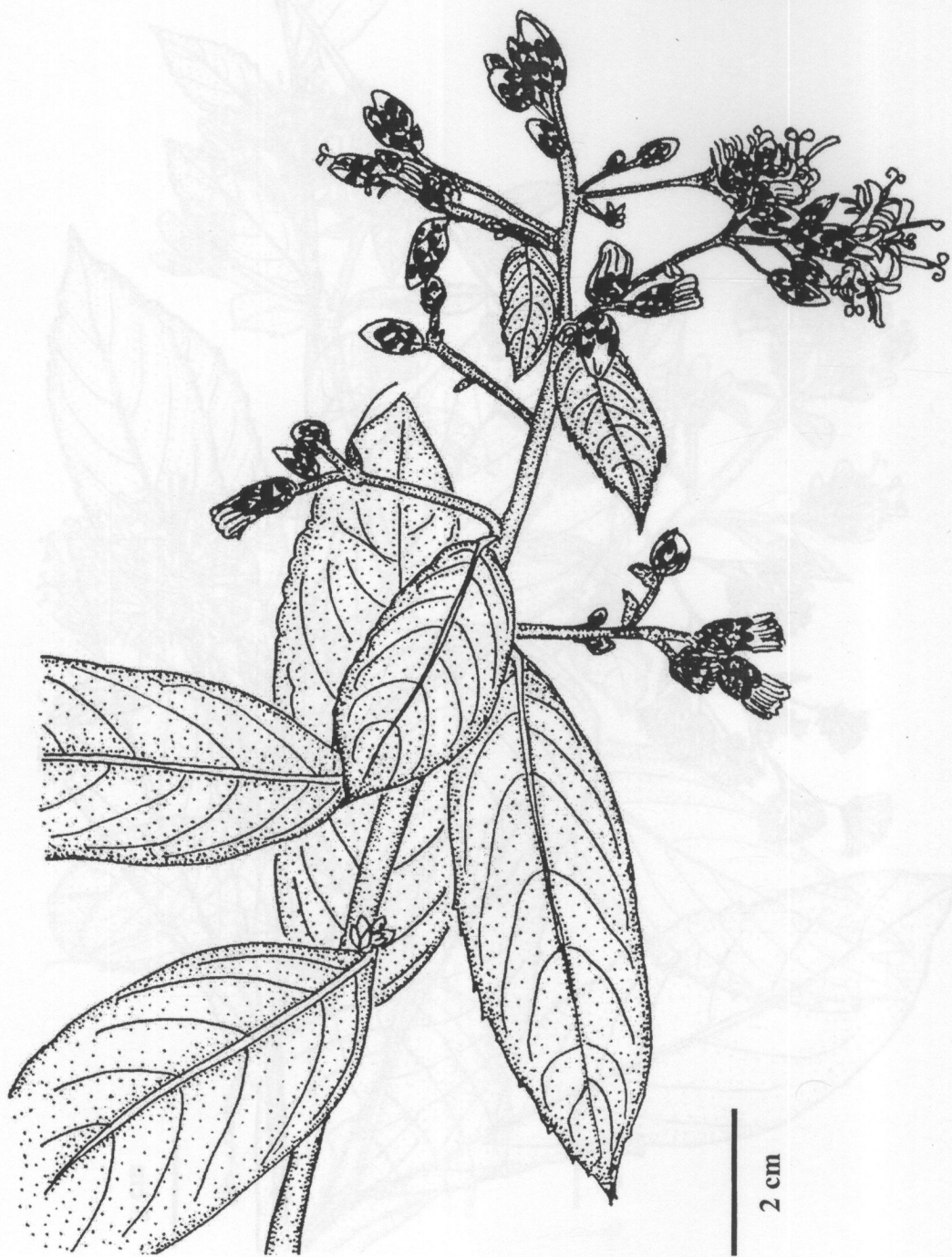


Figure 2.20 *Acilepis kingii*



Figure 2.21 *Acilepis namnaoensis*

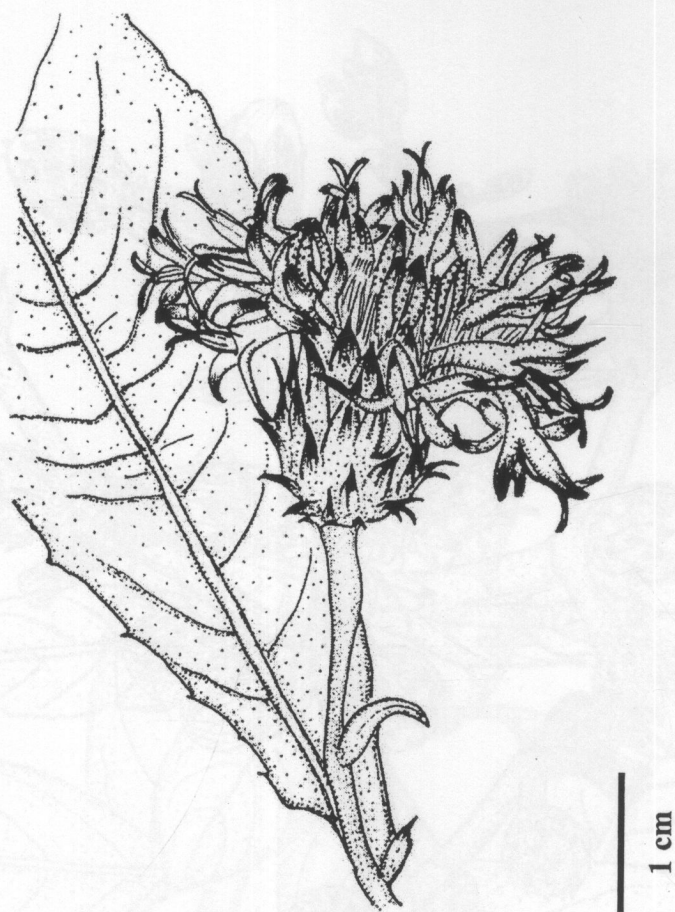


Figure 2.22 *Acilepis ngaoensis*

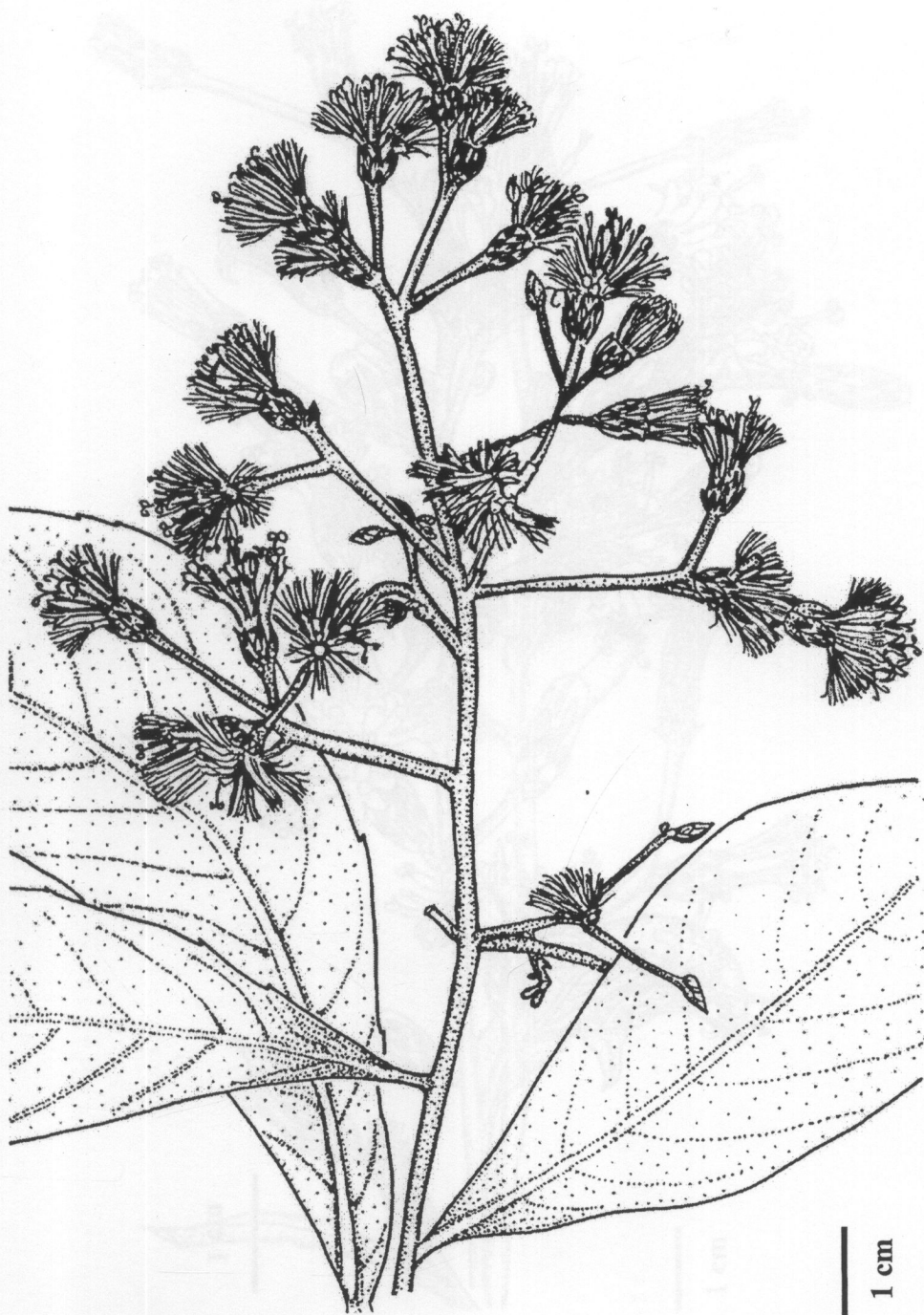


Figure 2.23 *Acilepis peguensis*

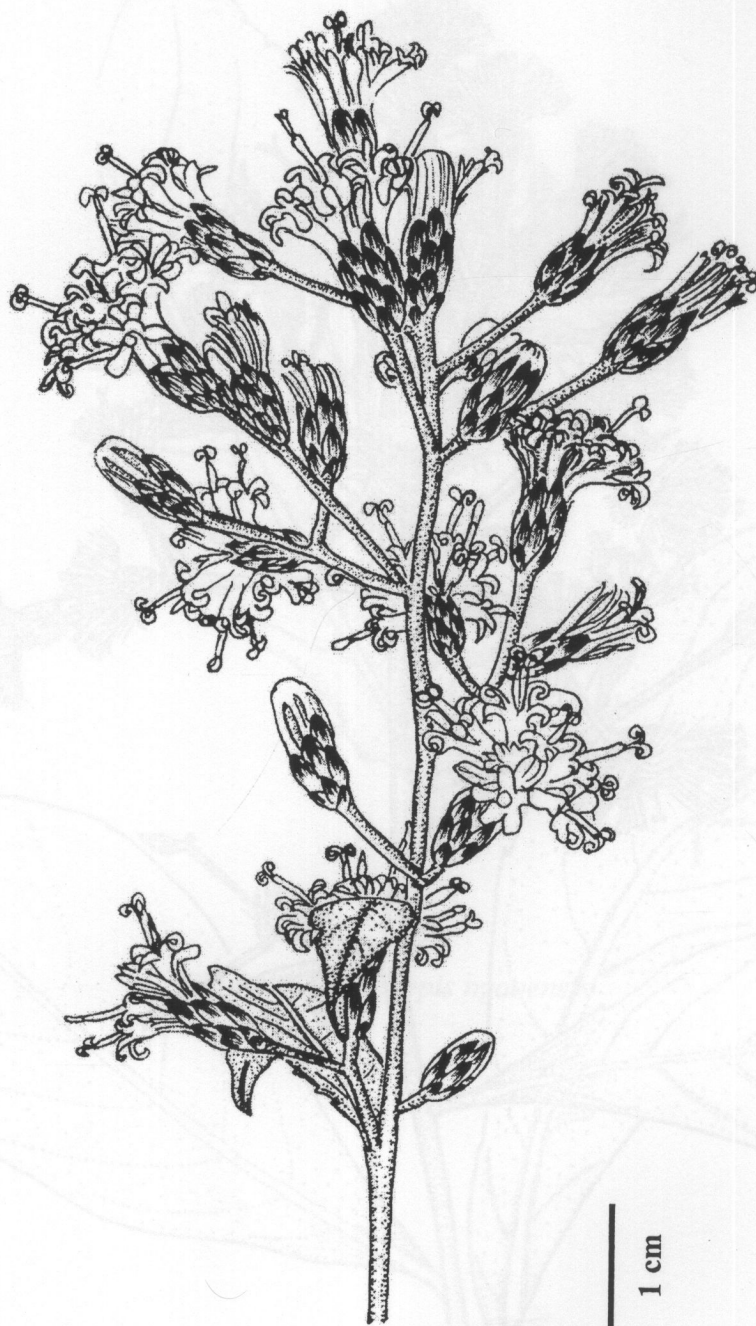


Figure 2.24 *Acilepis principis*



Figure 2.25 *Acilepis pseudosutepensis*



Figure 2.26 *Acilepis saligna*

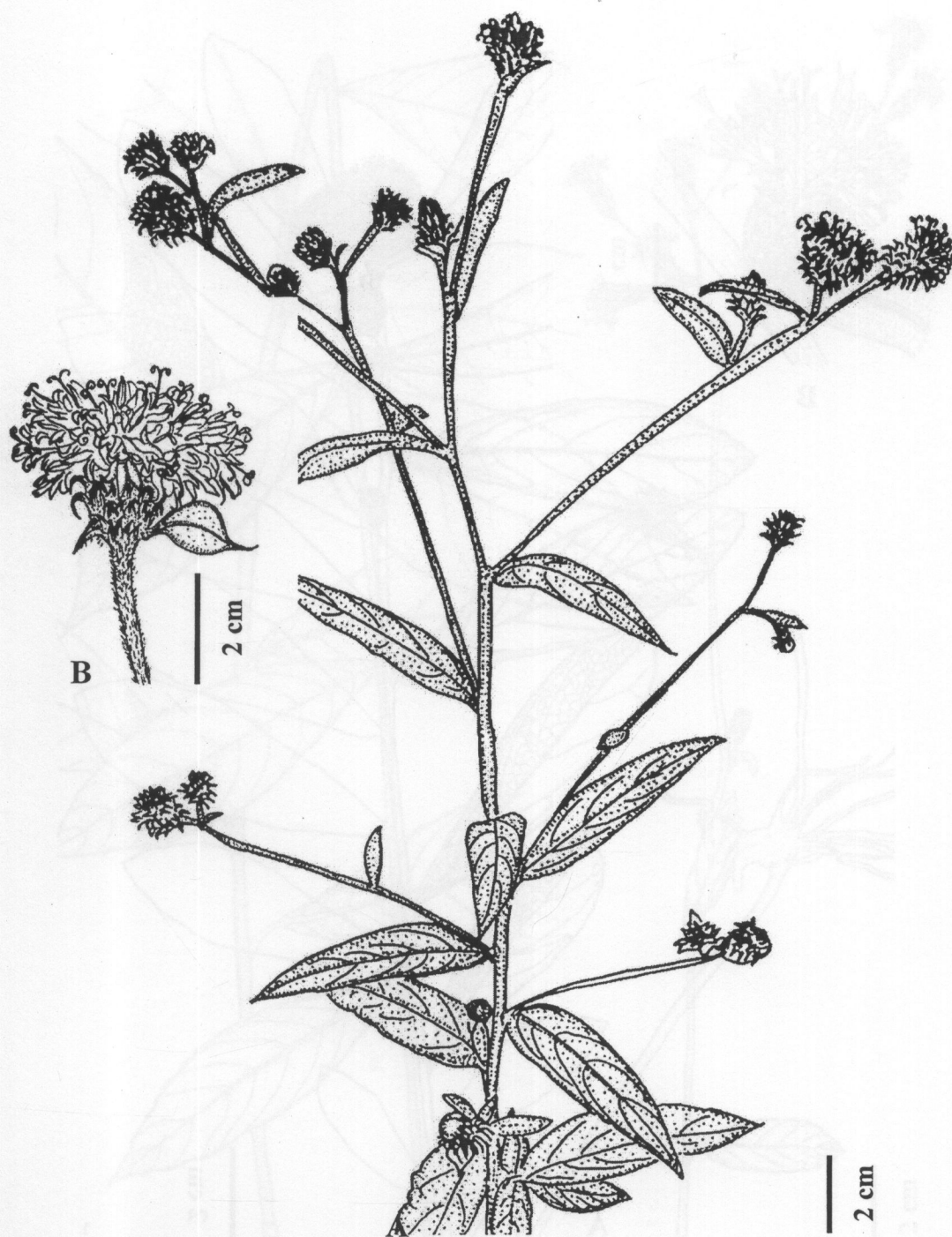


Figure 2.27 *Acilepis silhetensis*; A. habit B. capitulum

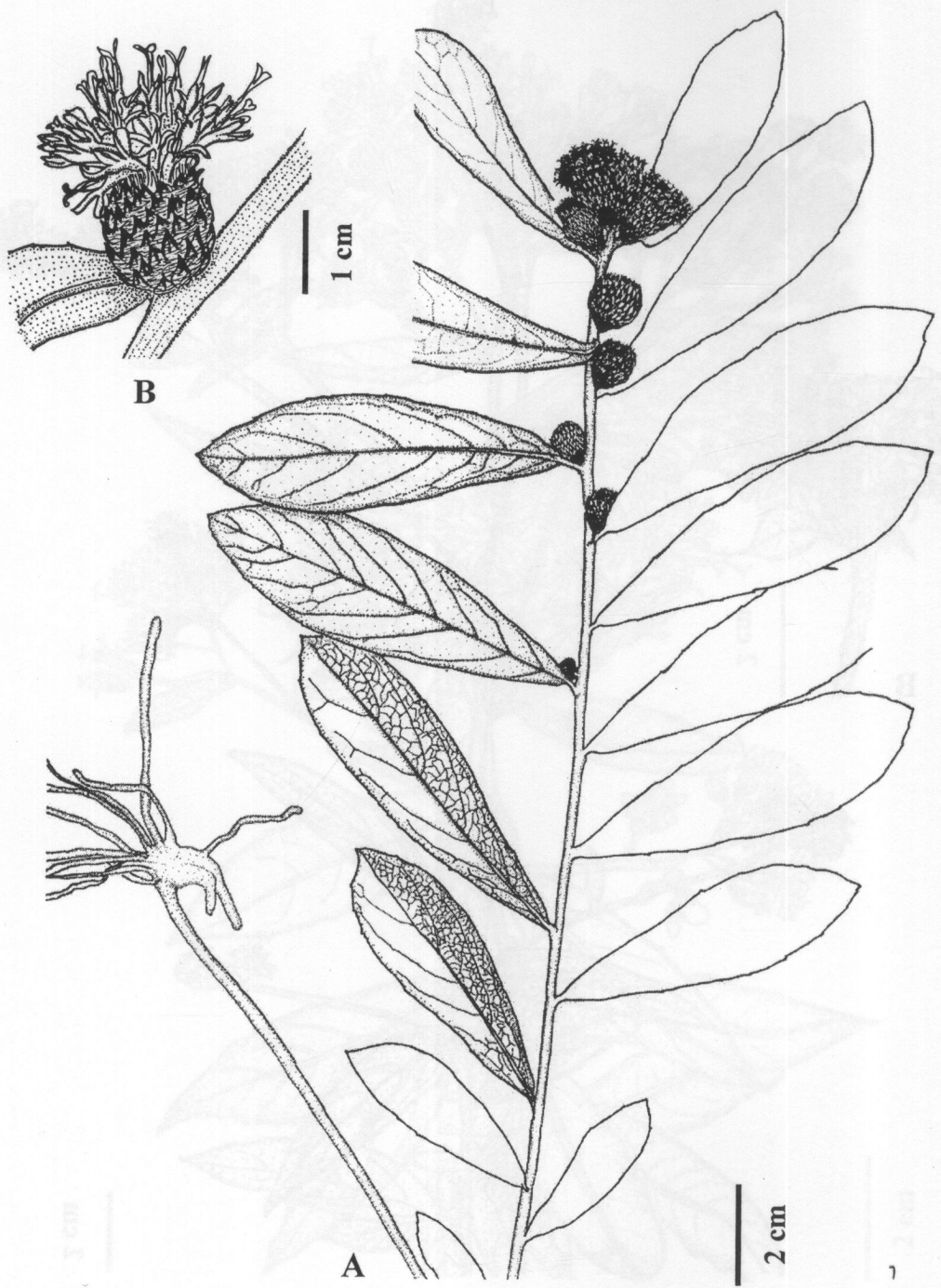


Figure 2.28 *Acilepis squarrosa*; A. habit B. capitulum

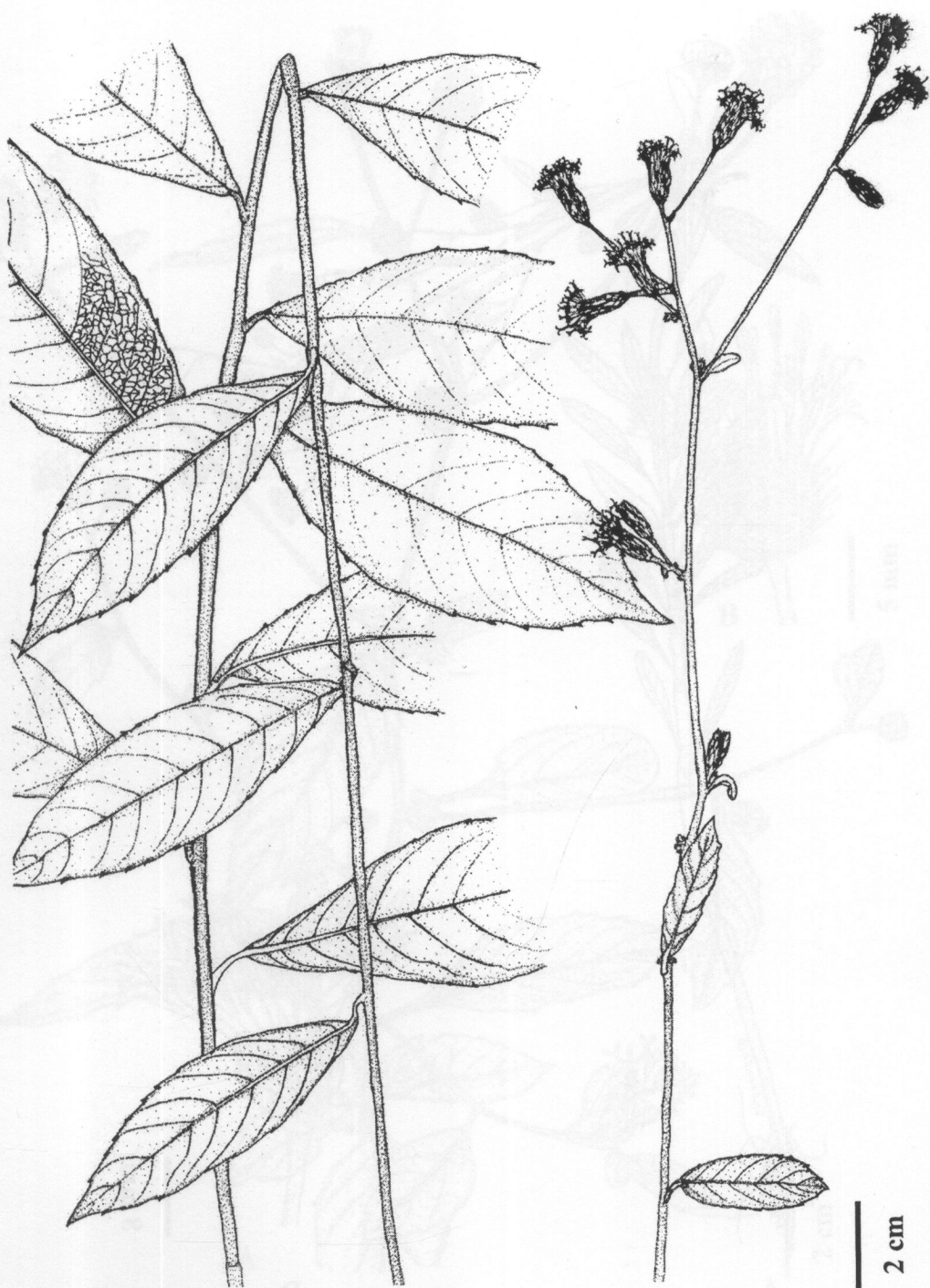


Figure 2.29 *Acilepis sutepensis*



Figure 2.30 *Camchaya gracilis*; A. habit B. capitulum

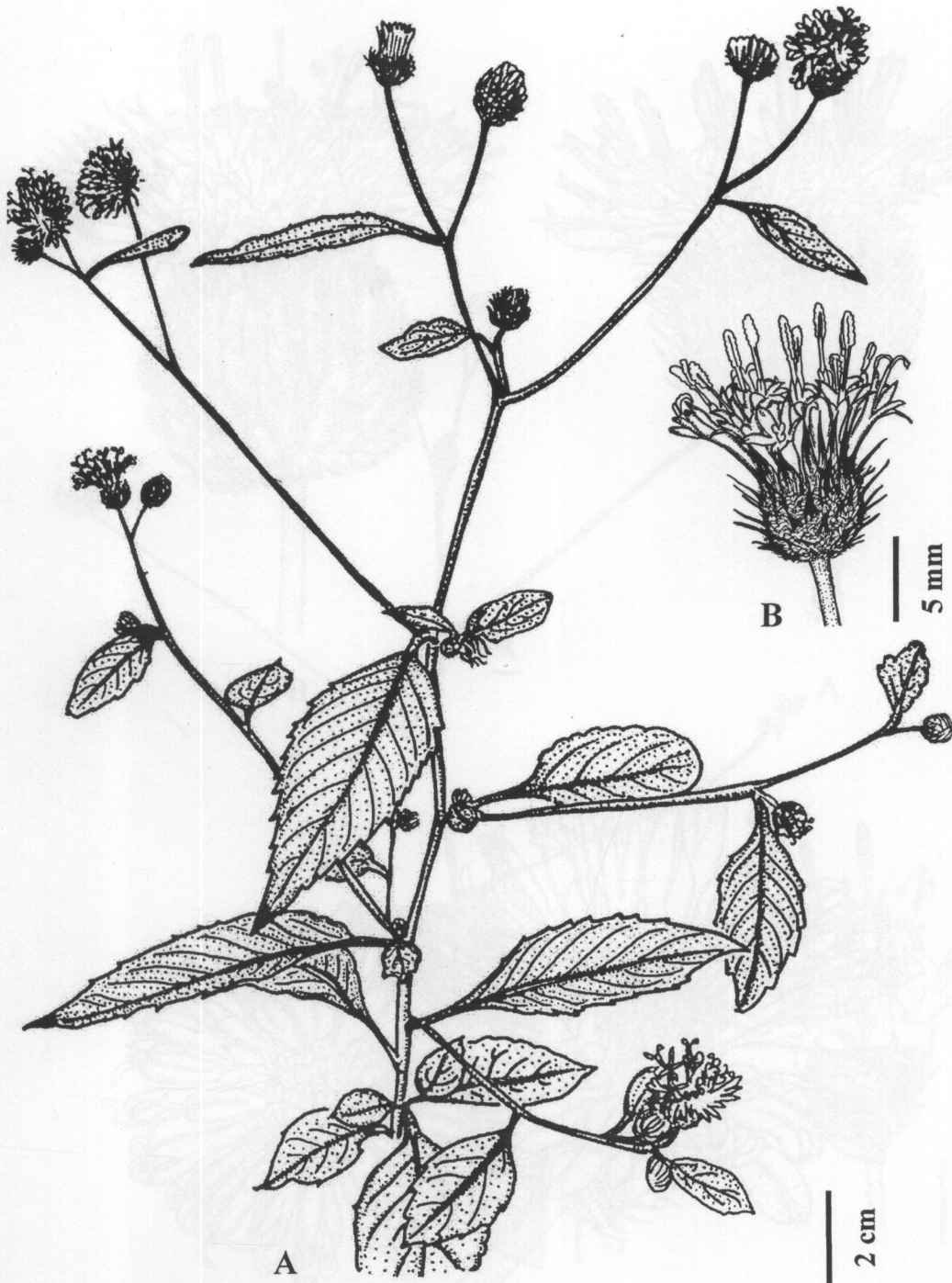


Figure 2.31 *Camchaya loloana* var. *mukdahanensis* A. habit B. capitulum

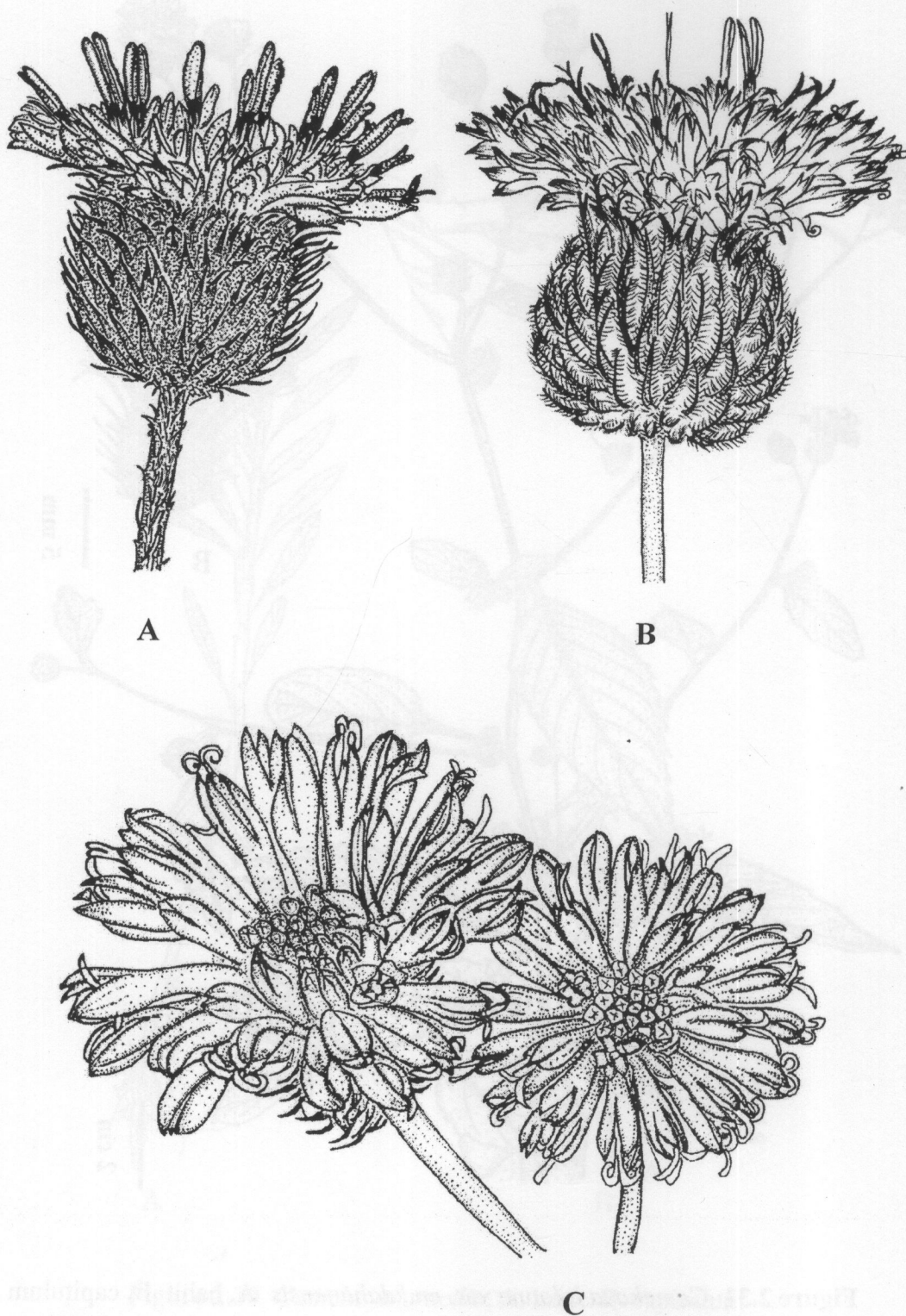


Figure 2.32 A. *Camchaya pentagona* B. *C. spinulifera* C. *C. tenuiflora*

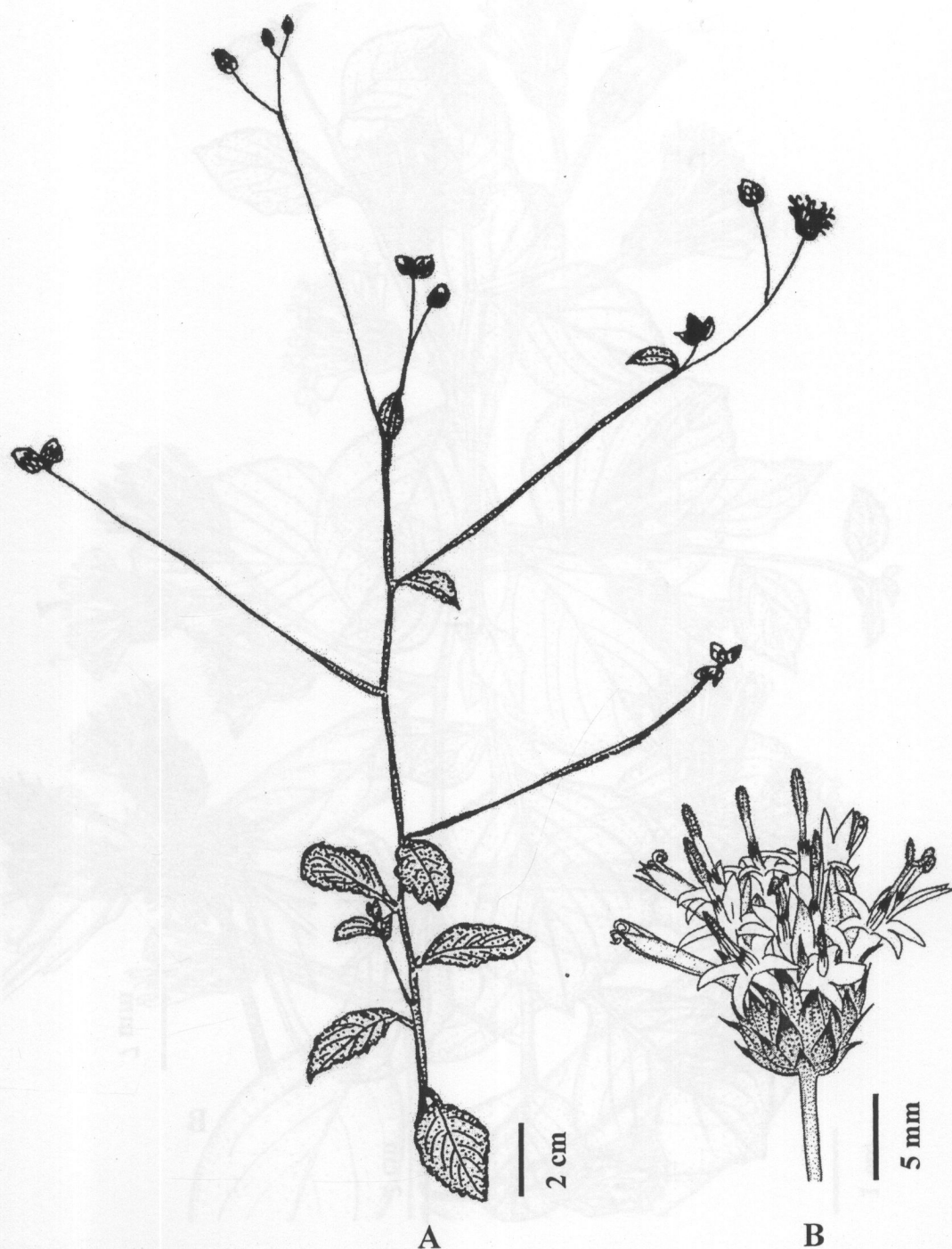


Figure 2.33 *Camchaya* sp. A. habit B. capitulum

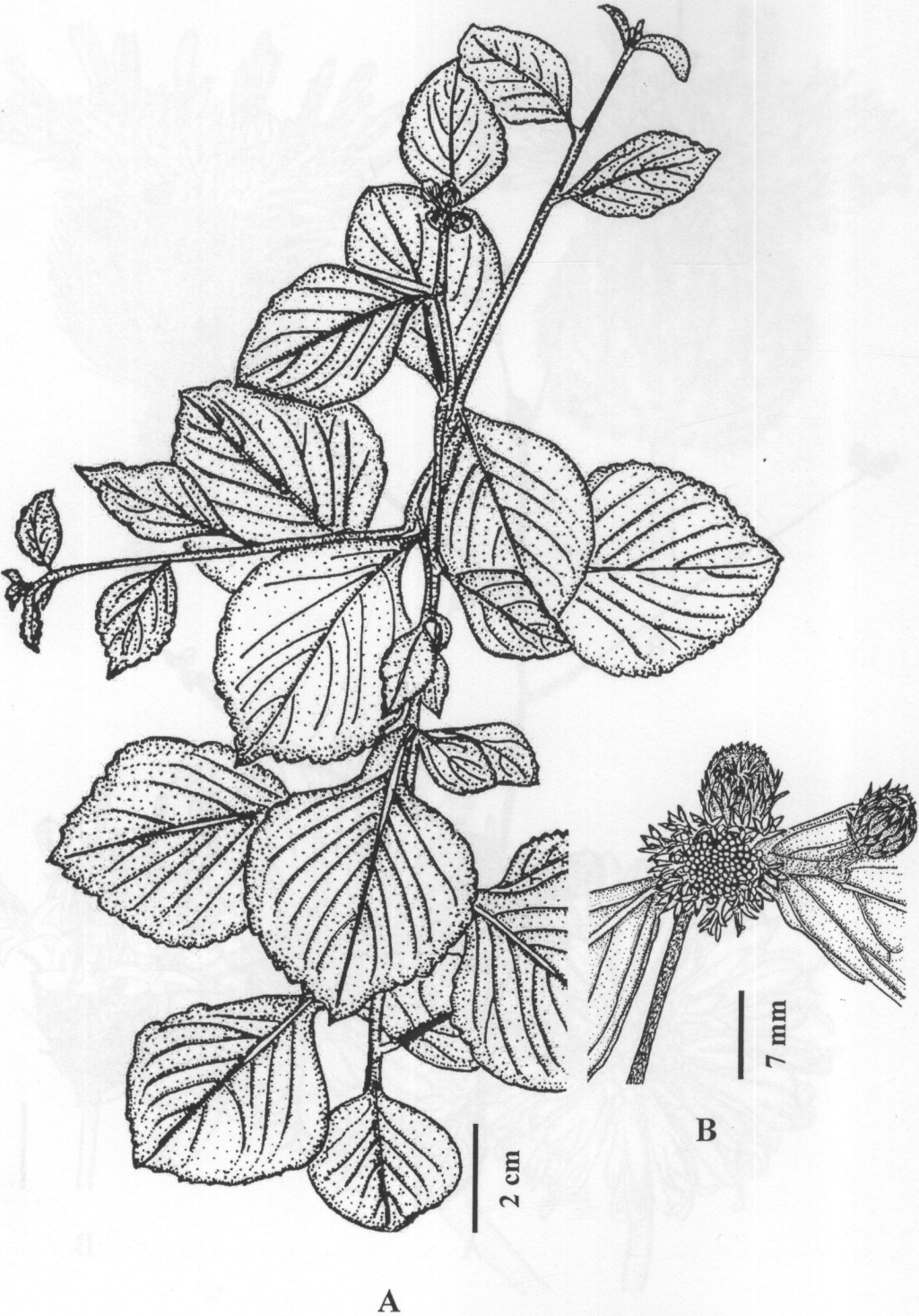


Figure 2.34 *Cyanthillium hookerianum* A. habit B. capitulum

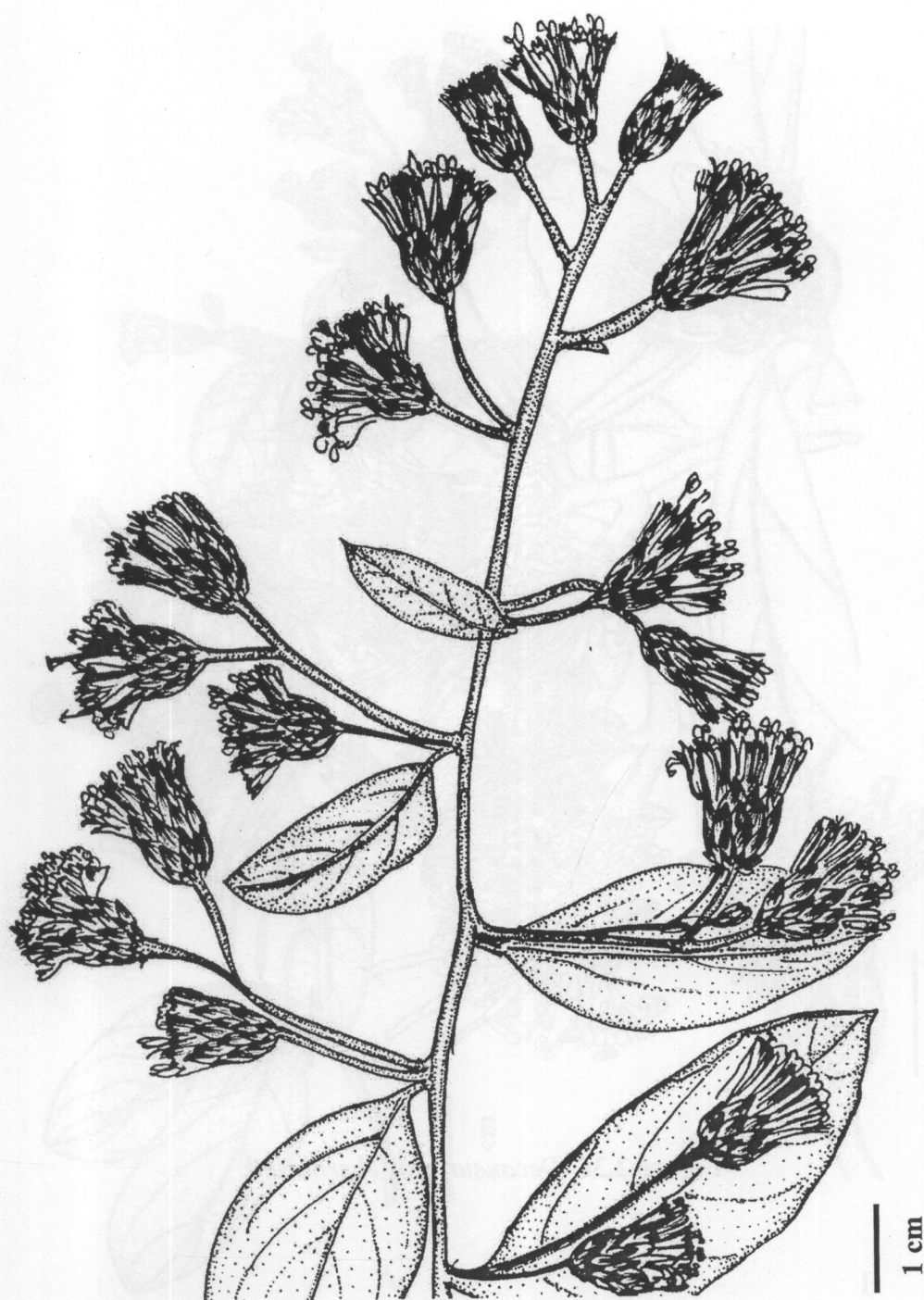


Figure 2.35 *Decaneuropsis cumiagiana*

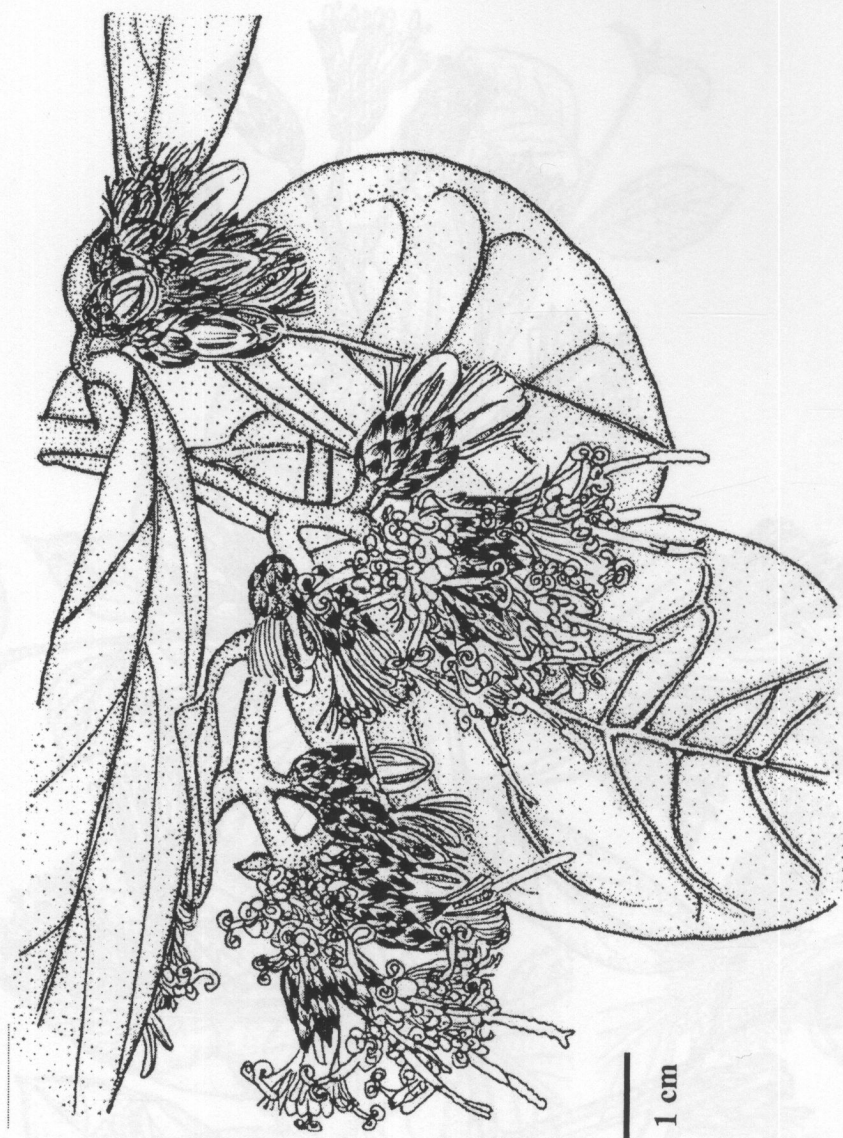


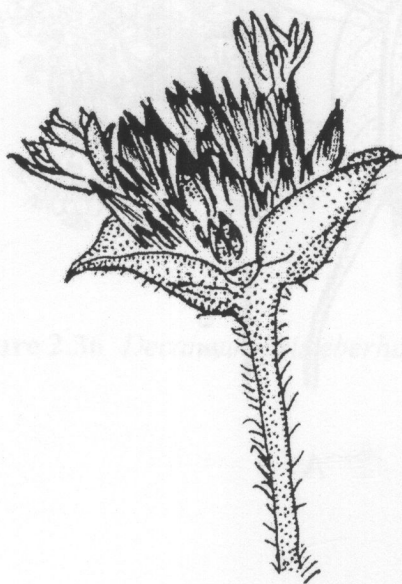
Figure 2.36 *Decaneuropsis eberhardtii*



Figure 2.37 *Decaneuropsis garrettiana*; A. habit B. capitulum



A



B

Figure 2.38 *Elephantopus mollis*; A. habit B. capitulum



Figure 2.39 *Elephantopus scaber*

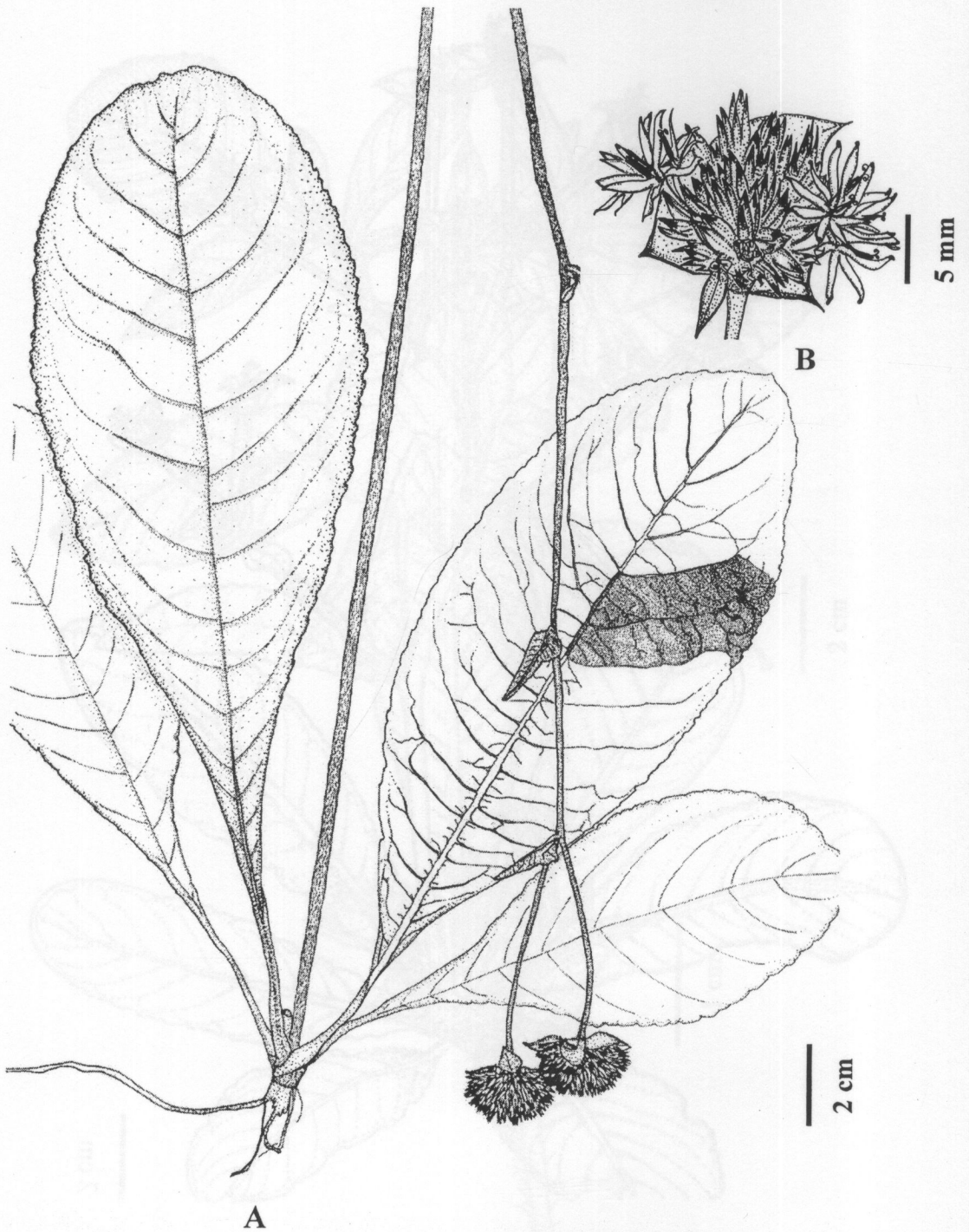


Figure 2.40 *Elephantopus scaber* var. *penicillatus*; A. habit B. capitulum



Figure 2.41 *Ethulia conyzoides*



Figure 2.42 *Gymnanthemum cylindriceps*



Figure 2.43 *Iodocephalopsis eberhardtii*



Figure 2.44 *Koyamasia calcarea*

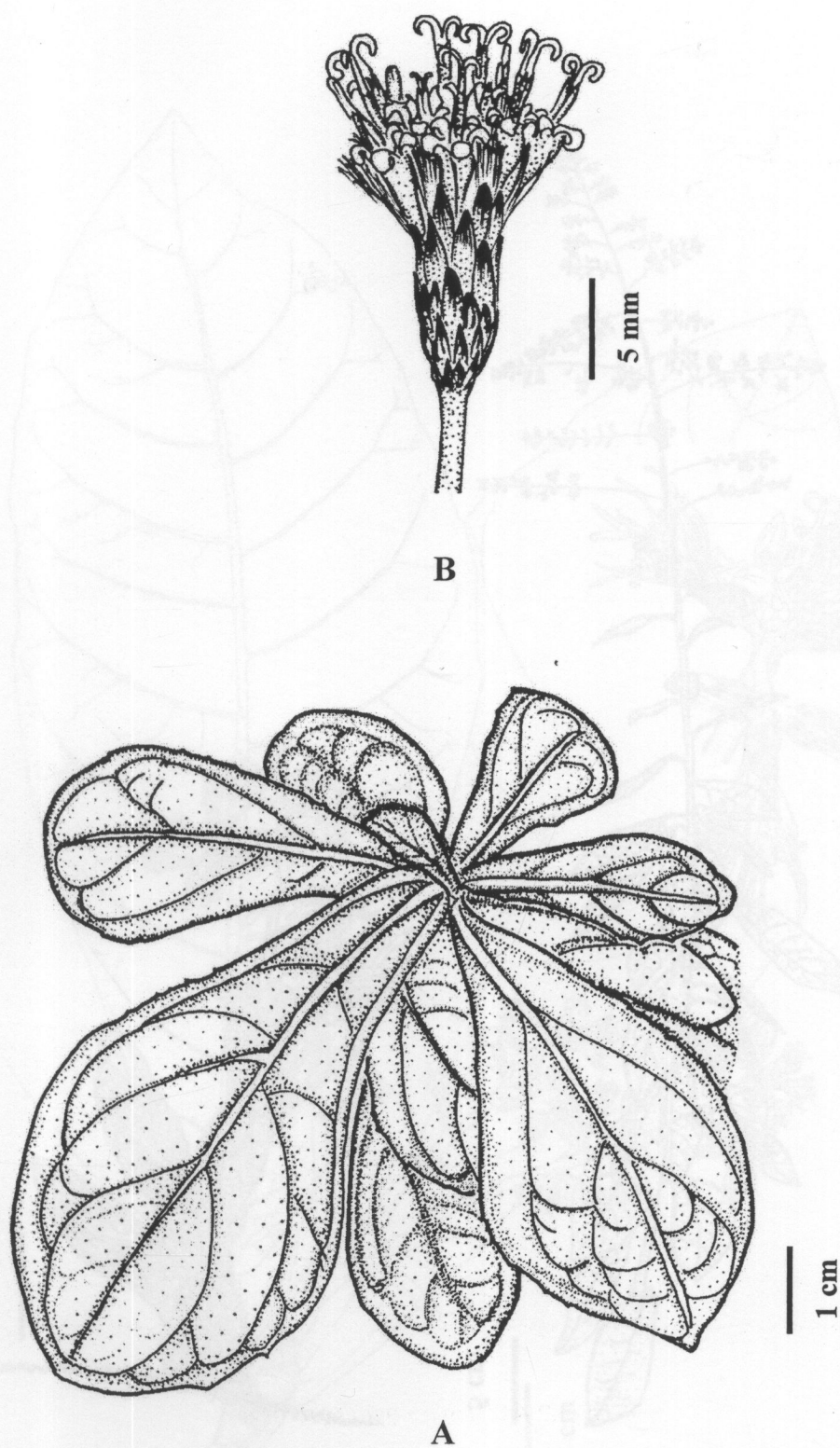


Figure 2.45 *Kurziella gymnoclada*; A. habit B. capitulum



Figure 2.46 *Monosis parishii*; A. habit B. capitulum

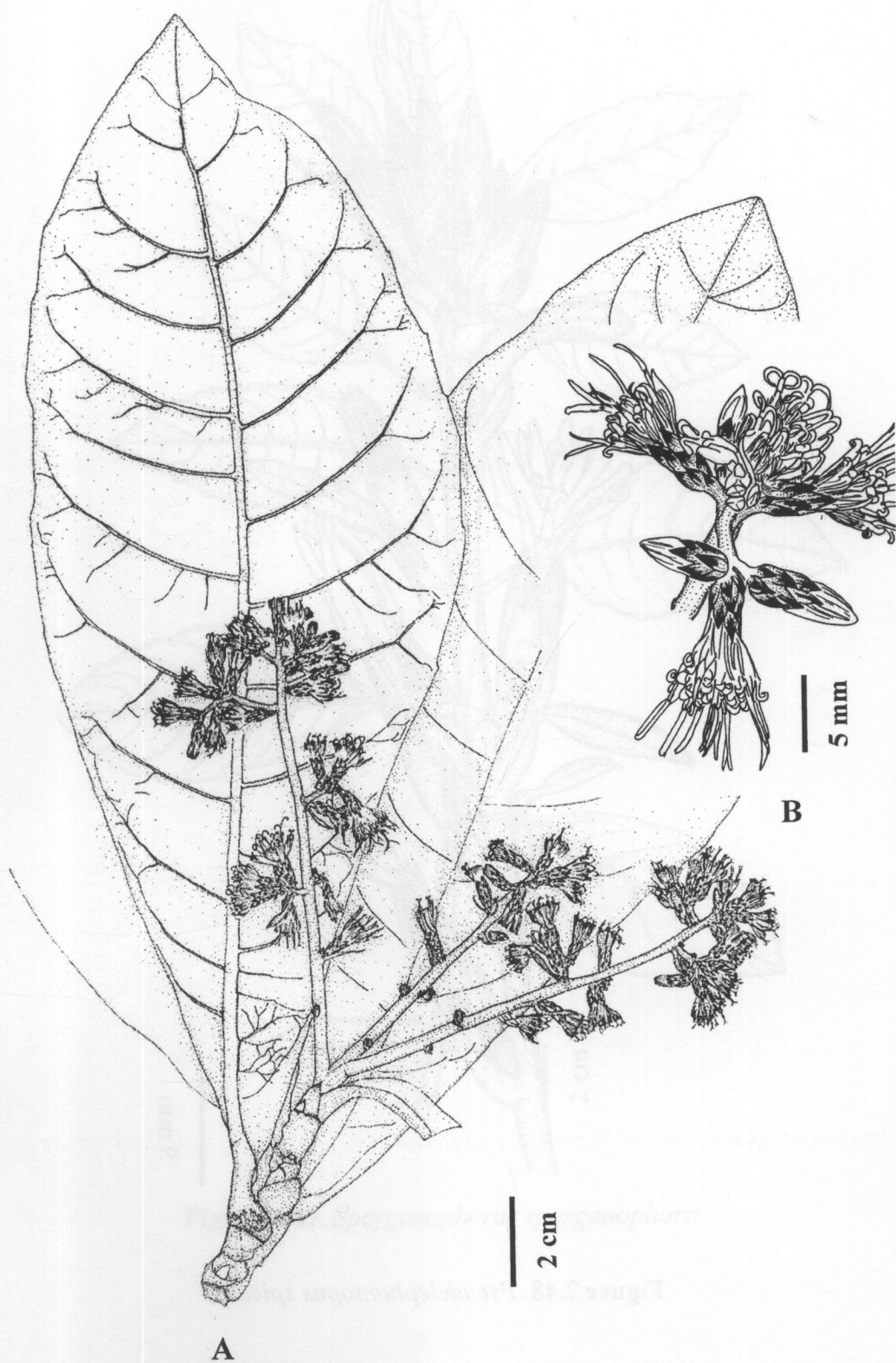


Figure 2.47 *Monosis volkameriifolia*; A. habit B. capitulum

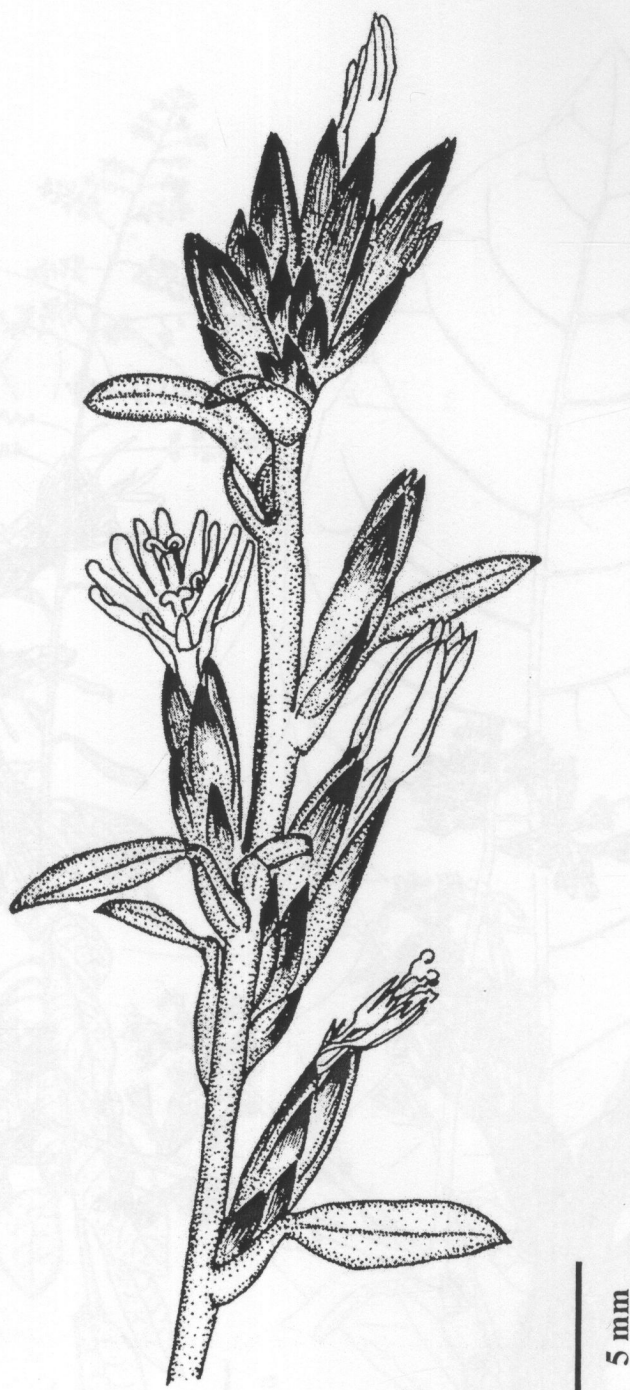


Figure 2.48 *Pseudelephantopus spicatus*

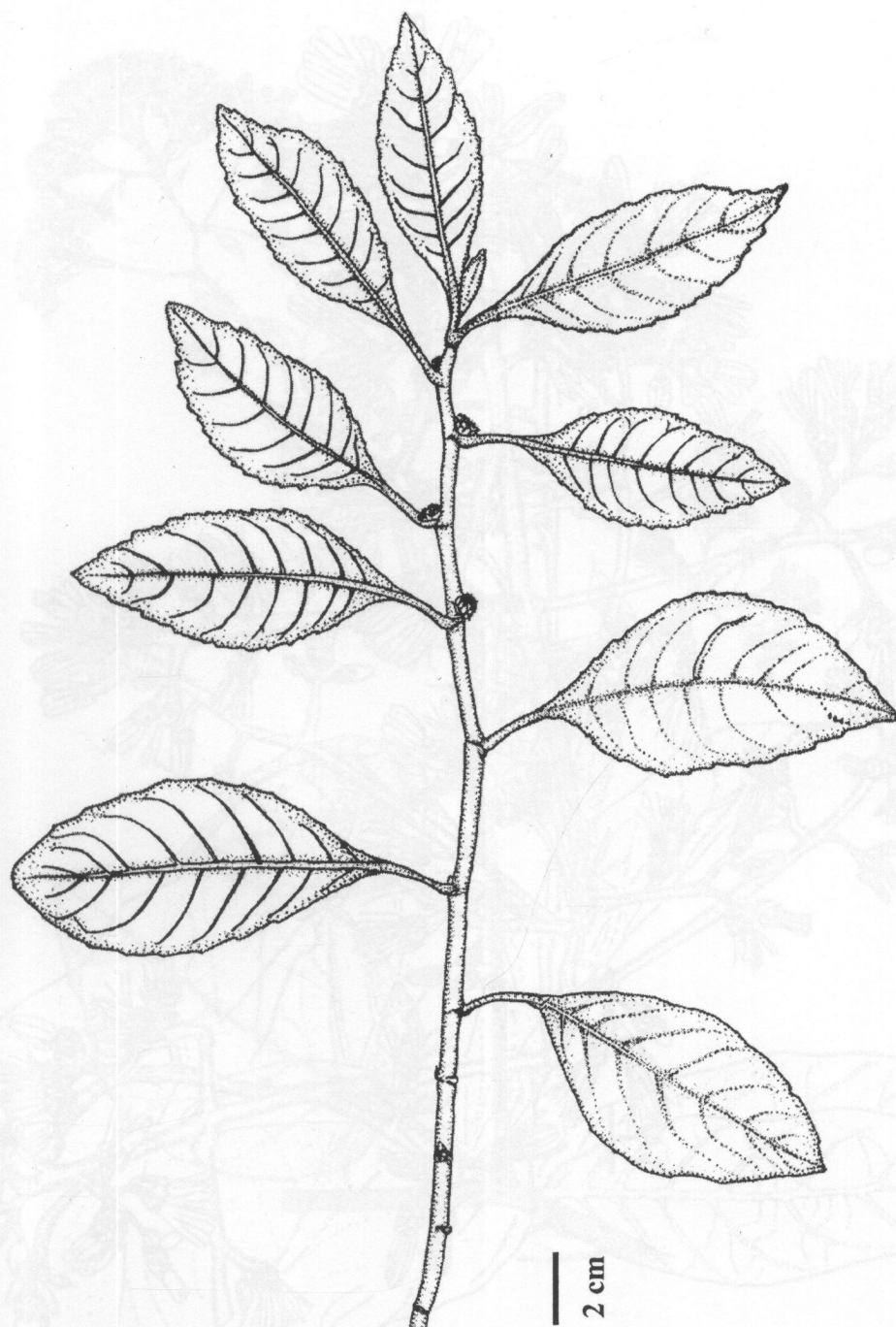


Figure 2.49 *Sparganophoros sparganophora*



Figure 2.50 *Strobocalyx arborea*

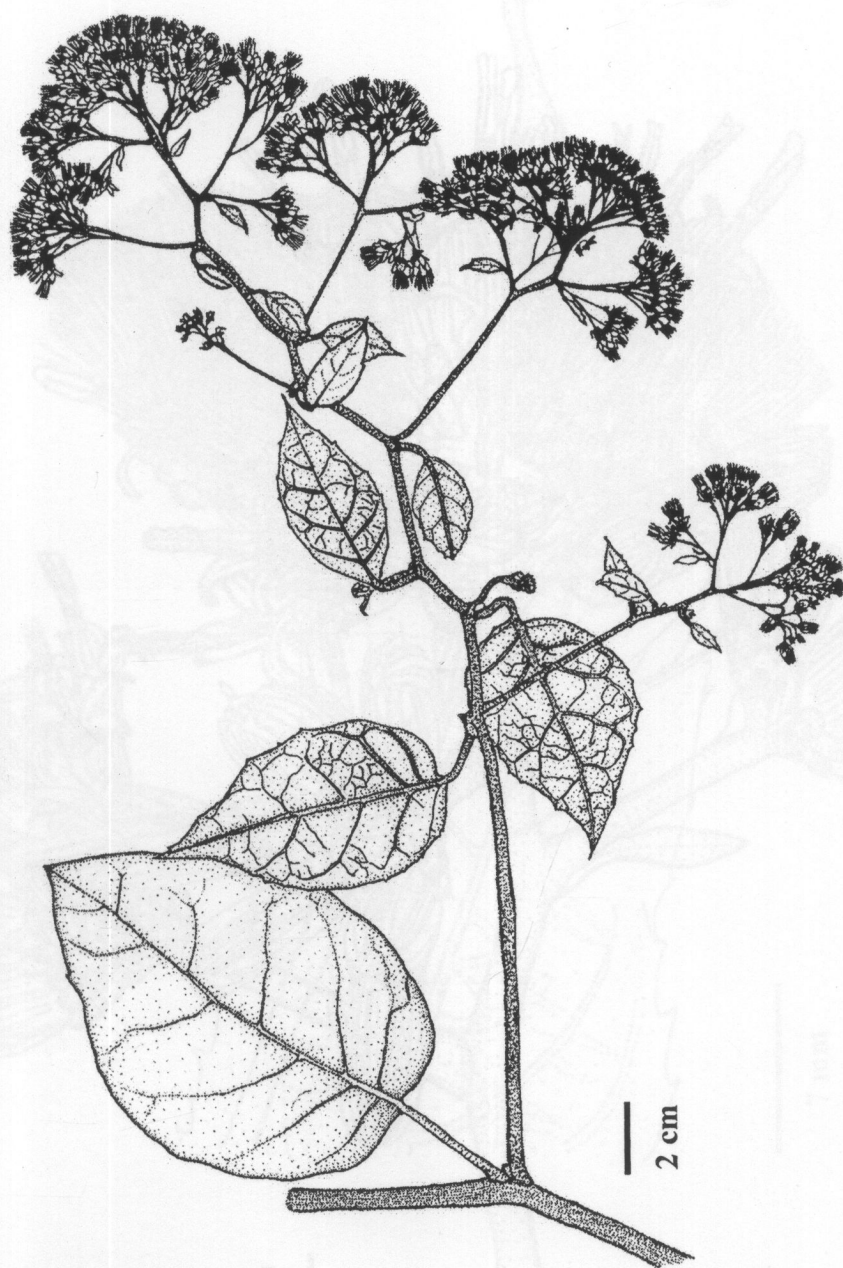


Figure 2.51 *Strobocalyx solanifolia*

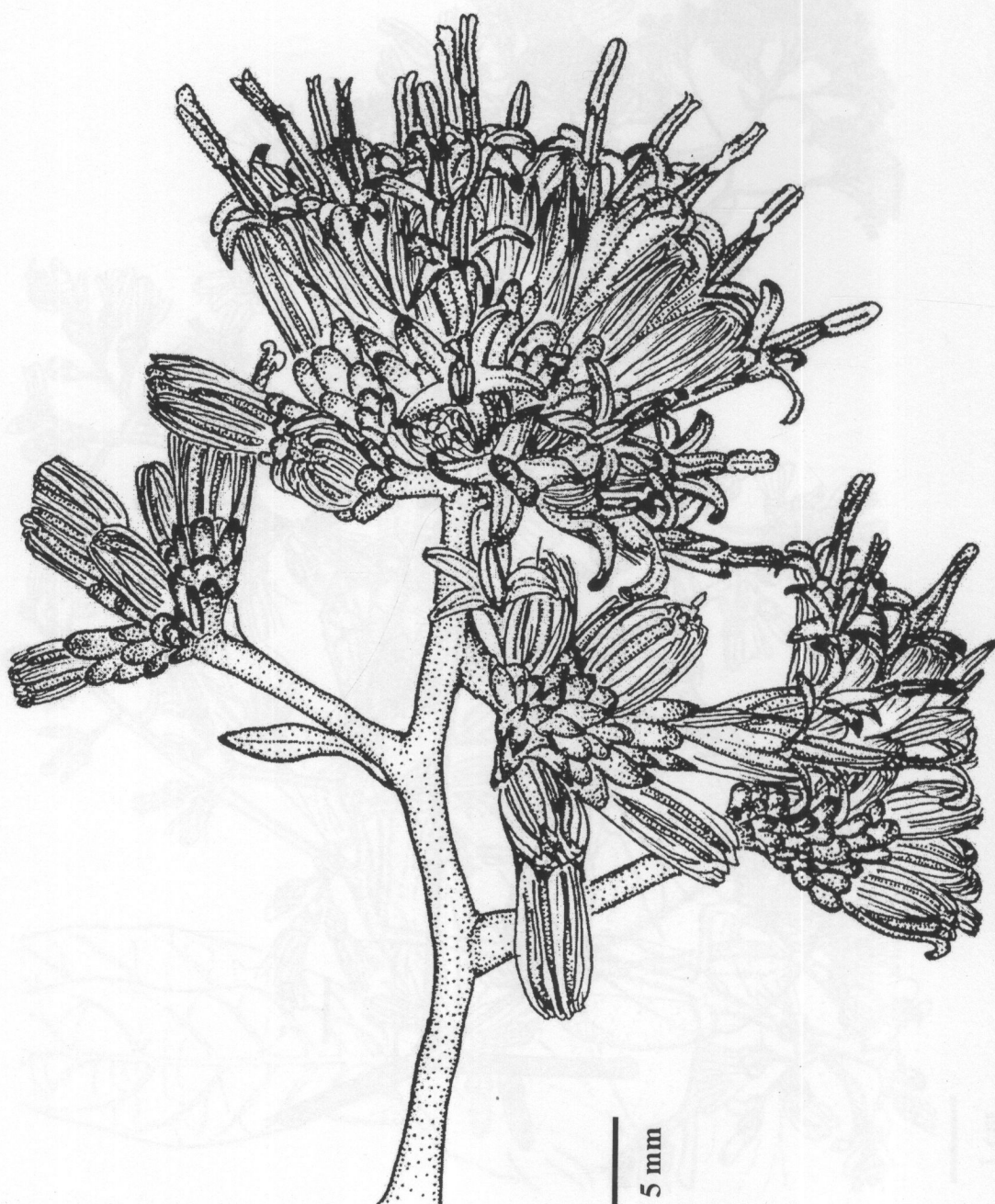


Figure 2.52 *Tarlmounia elliptica*

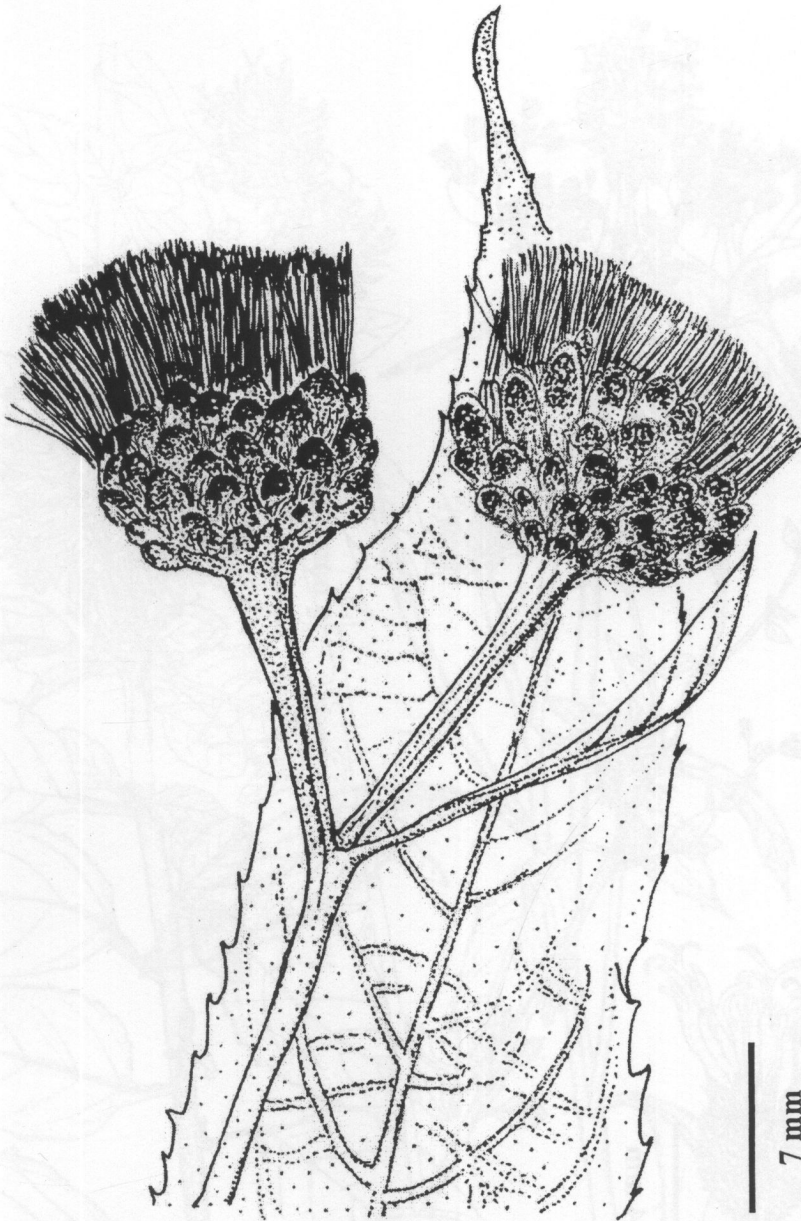


Figure 2.53 *Vernonia birmanica*



Figure 2.54 *Vernonia cinerea* var. *montana*; A. habit B. capitulum

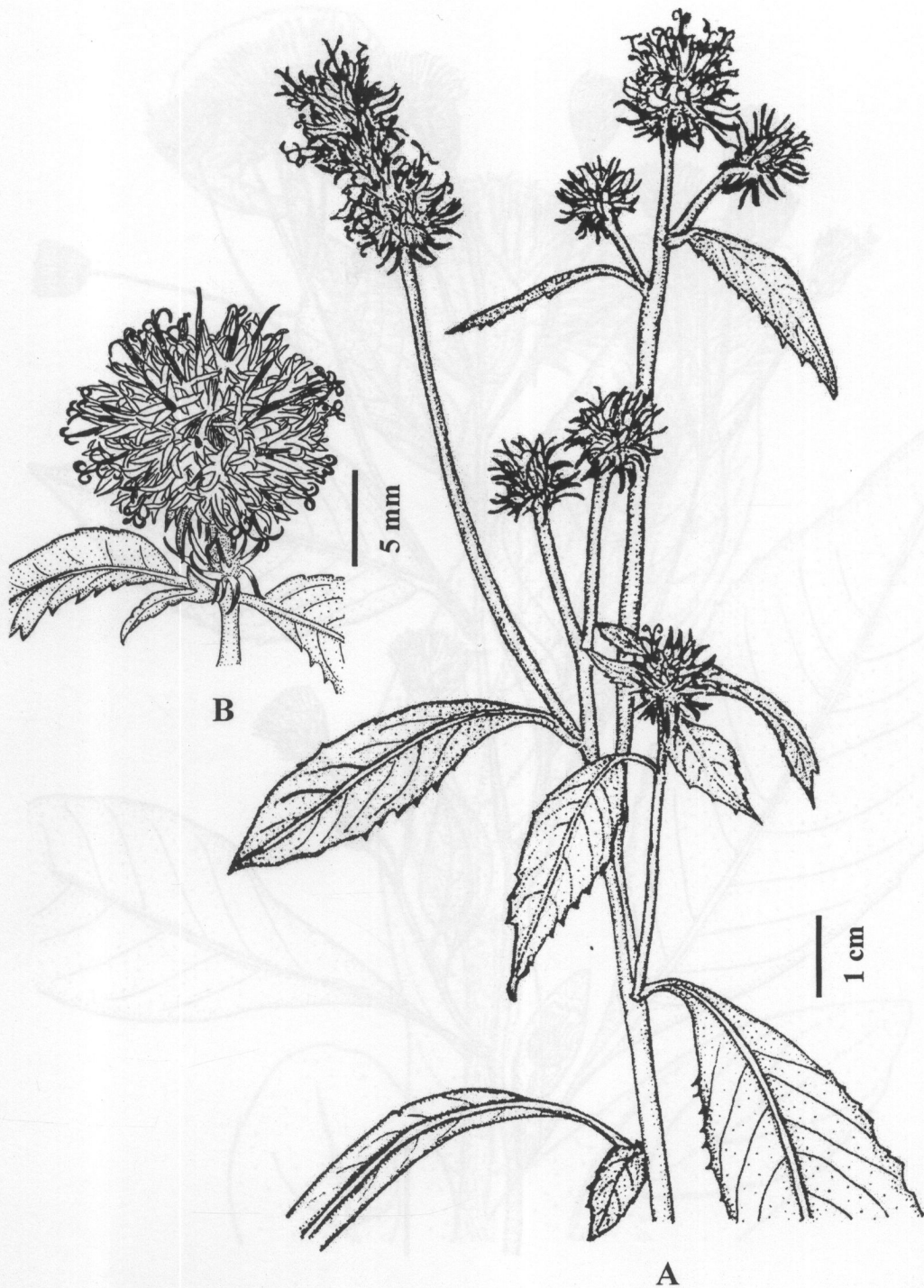


Figure 2.55 *Vernonia curtisii*; A. habit B. capitulum

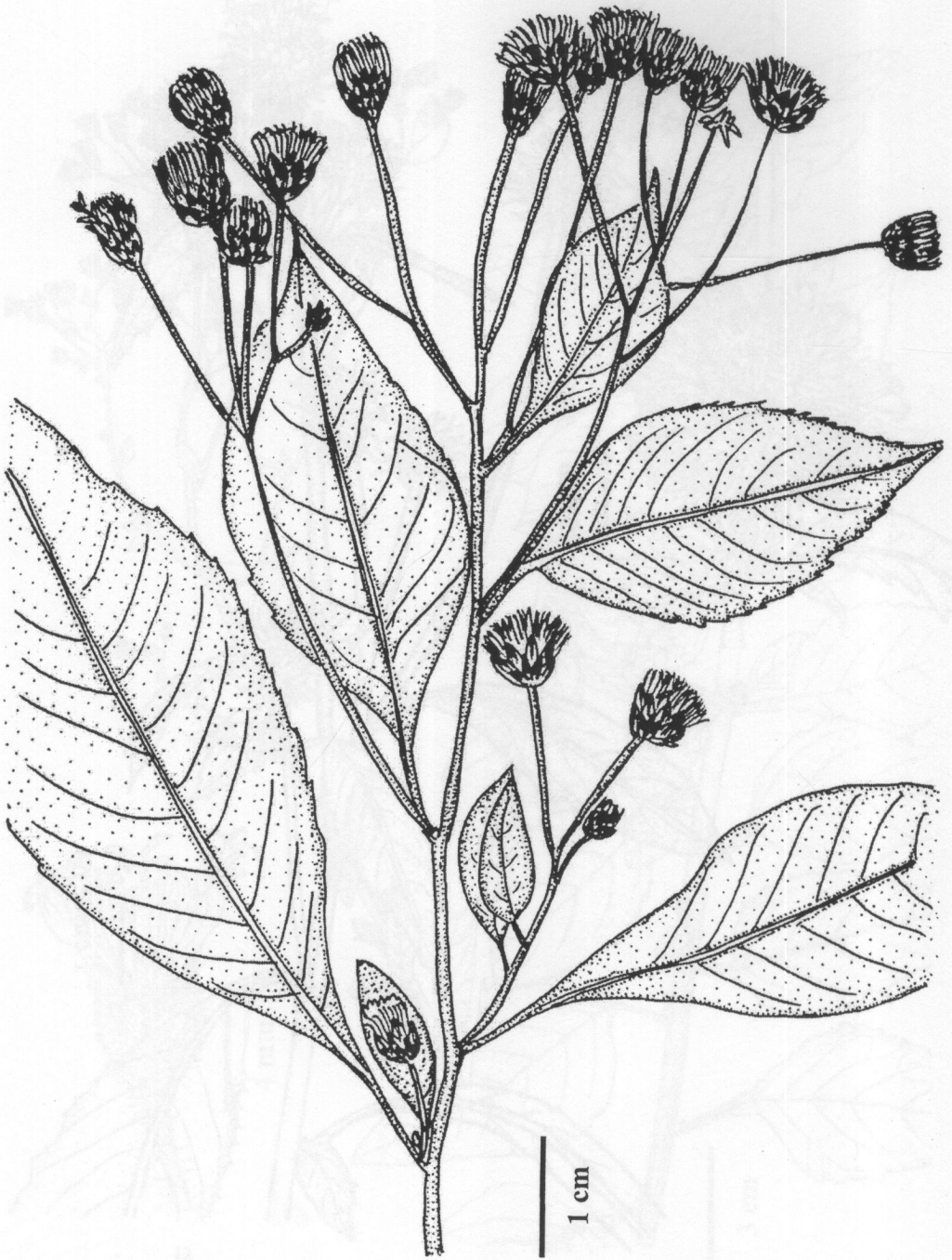


Figure 2.56 *Vernonia pseudobirmanica*

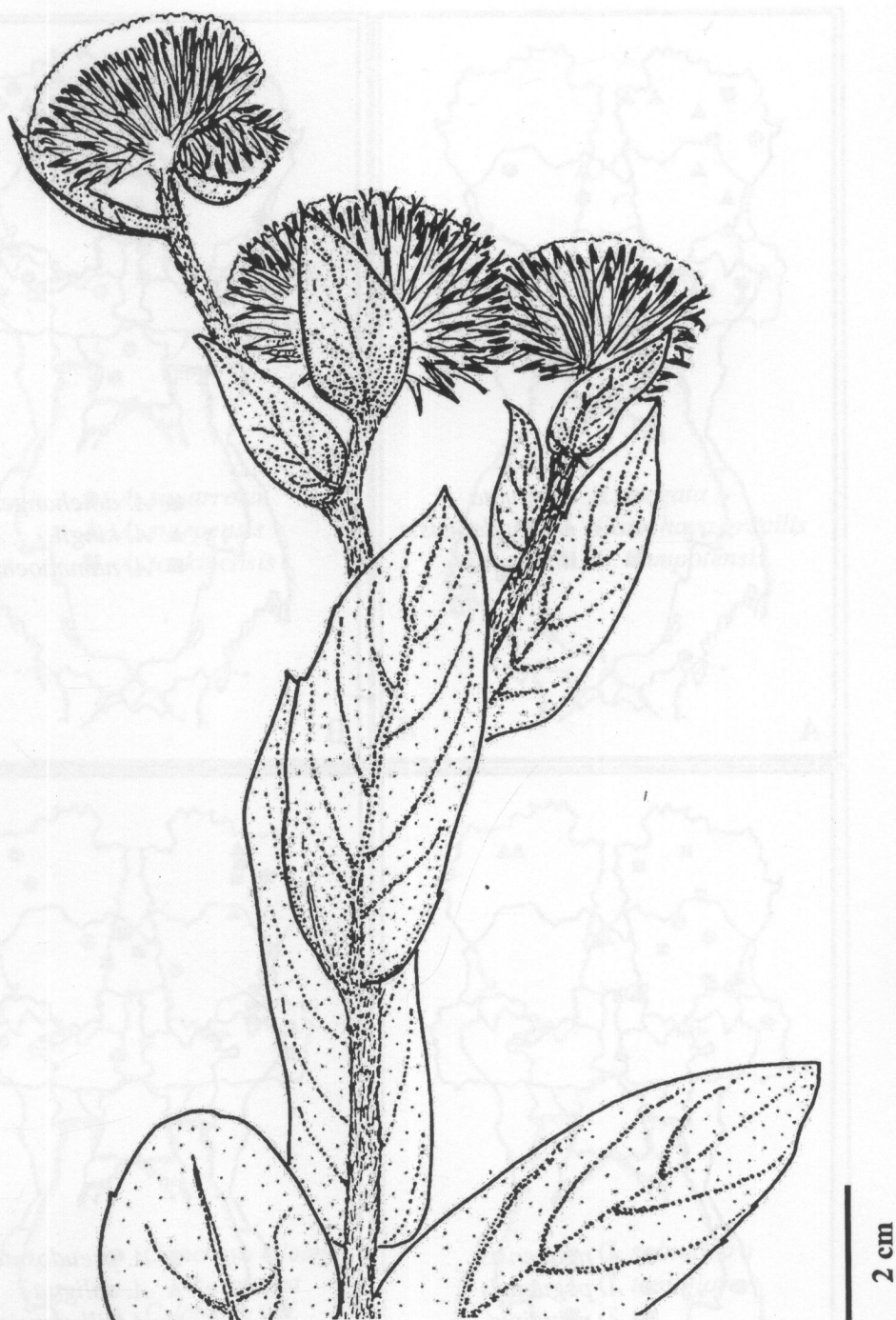


Figure 2.57 *Vernonia pulicarioides*

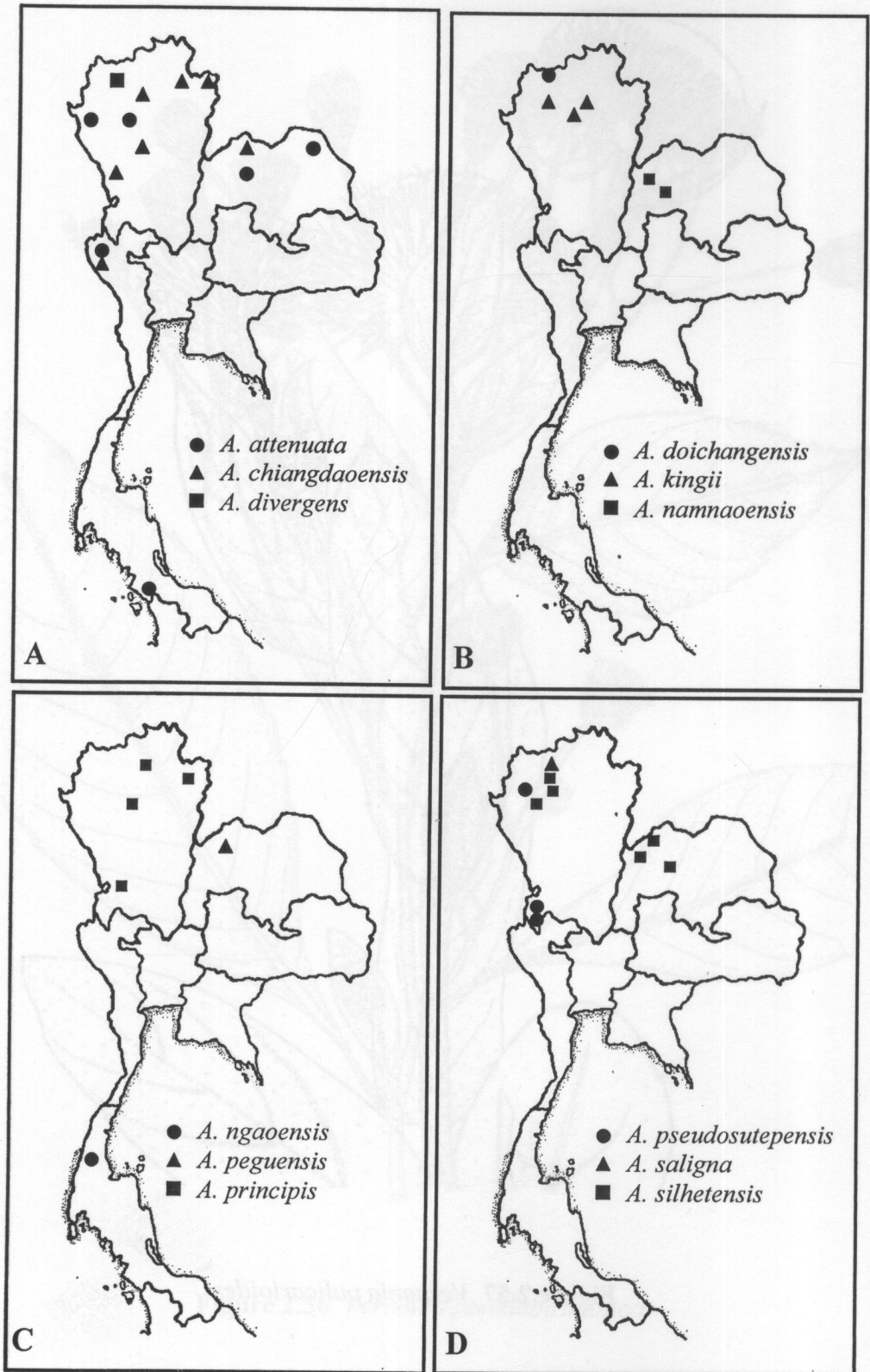


Figure 2.58 Distributional maps of *Acilepis*.

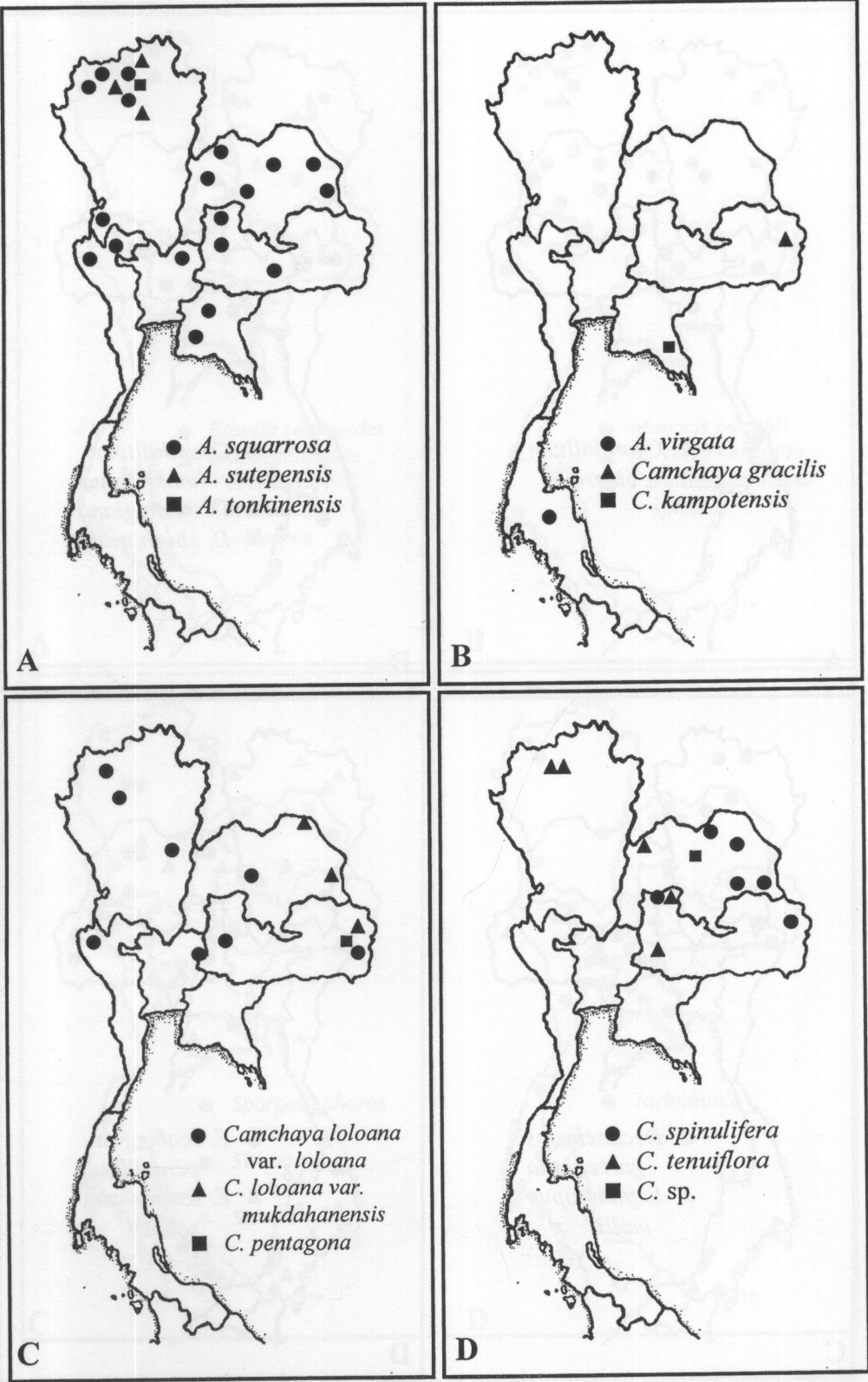


Figure 2.59 Distributional maps of *Acilepis* and *Camchaya*.

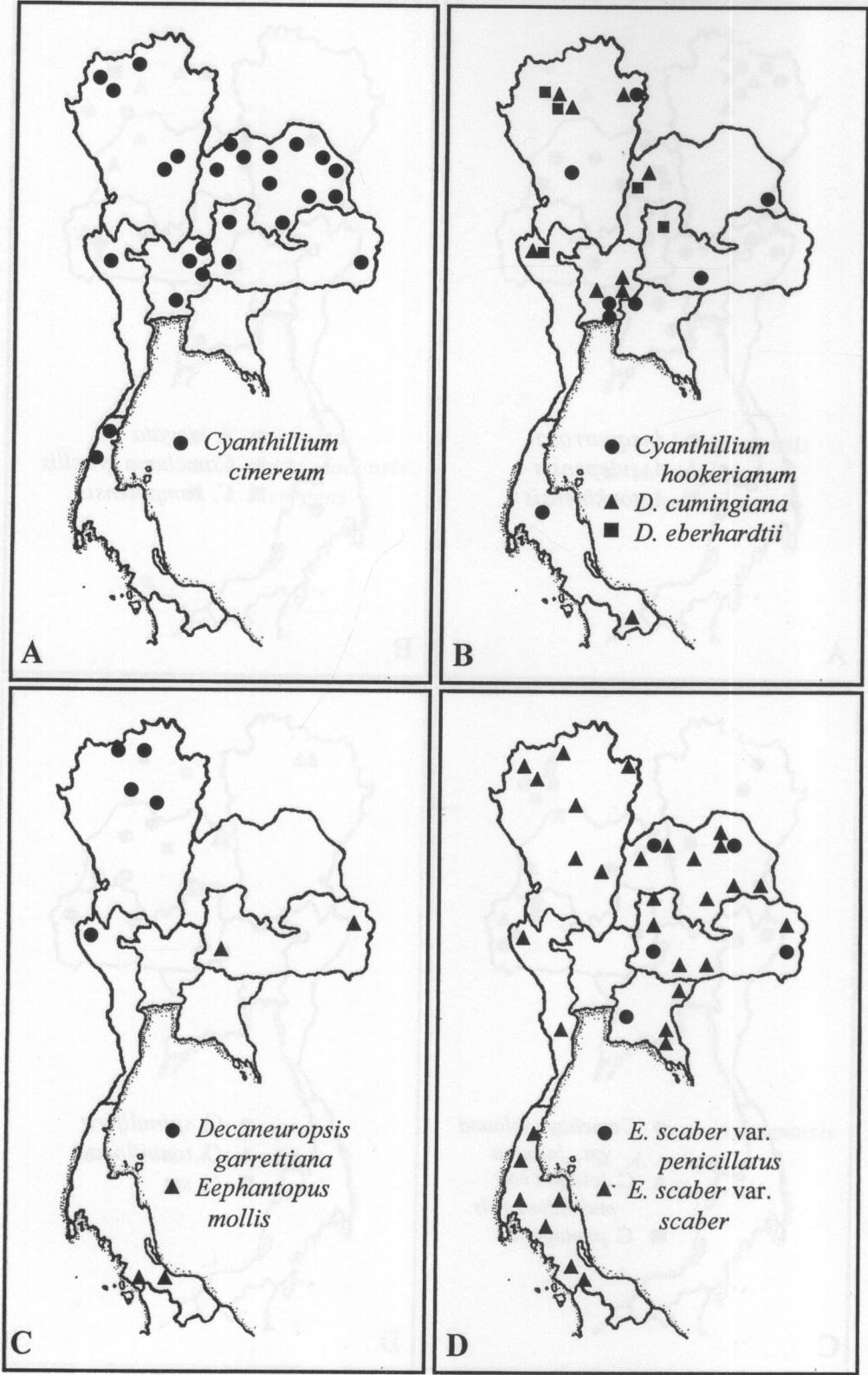


Figure 2.60 Distributional maps of *Cyanthillium*, *Decaneuropsis* and *Elephantopus*.

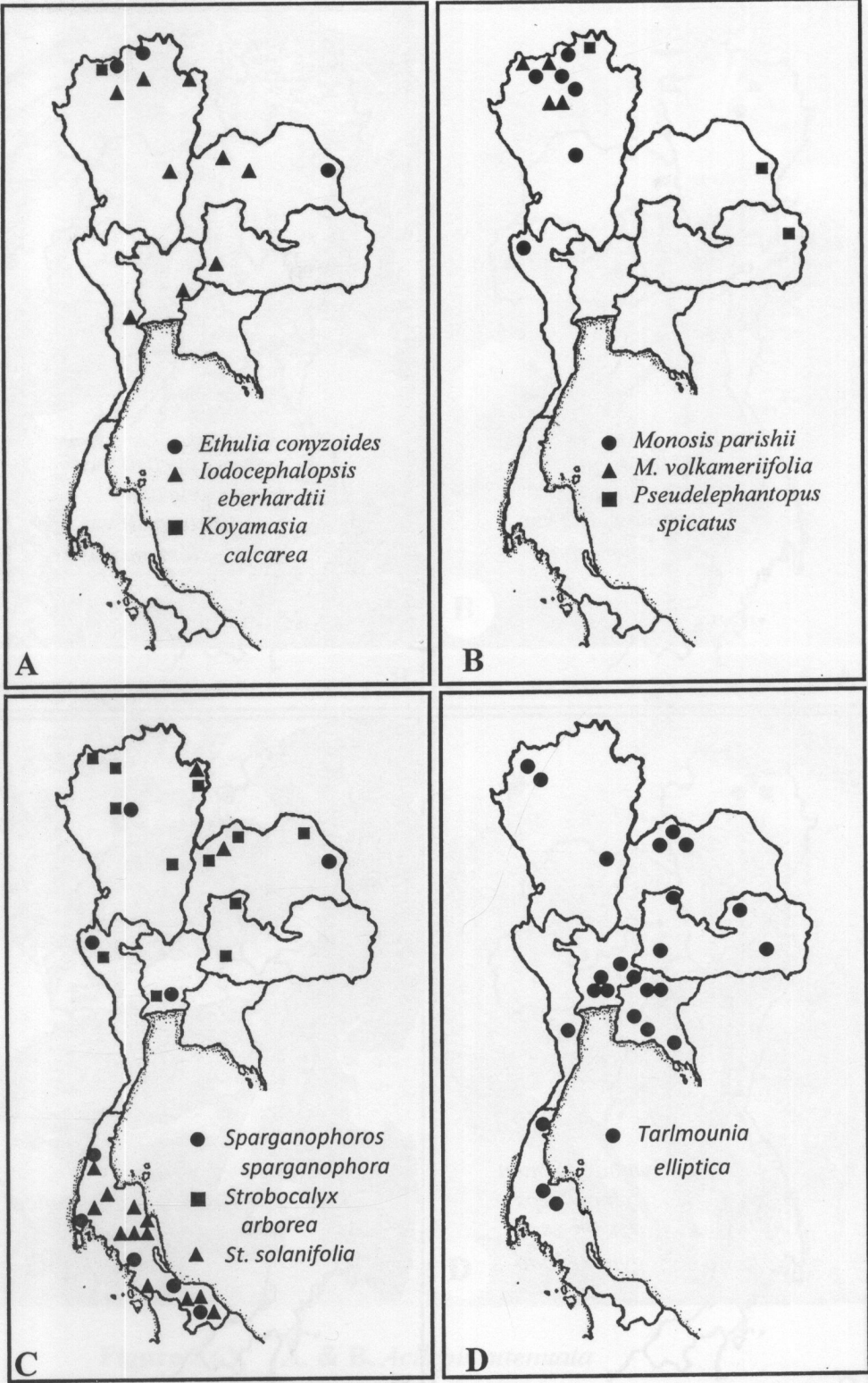


Figure 2.61 Distributional maps of *Ethulia*, *Iodocephalopsis*, *Koyamasia*, *Monosis*, *Pseudelephantopus*, *Sparganophoros*, *Strobocalyx* and *Tarlmounia*.

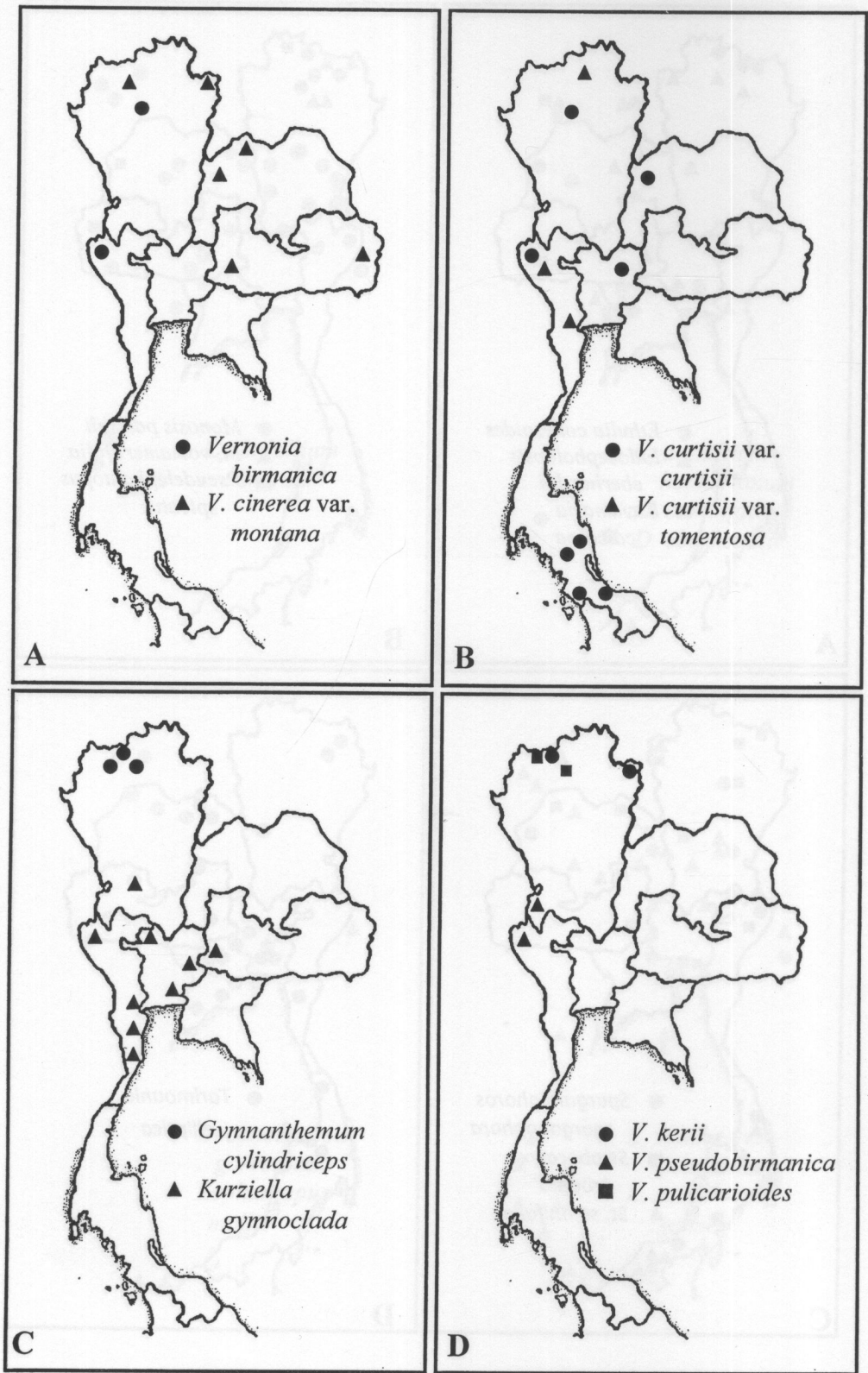


Figure 2.62 Distributional maps of *Gymnanthemum*, *Kurziella* and *Vernonia*.

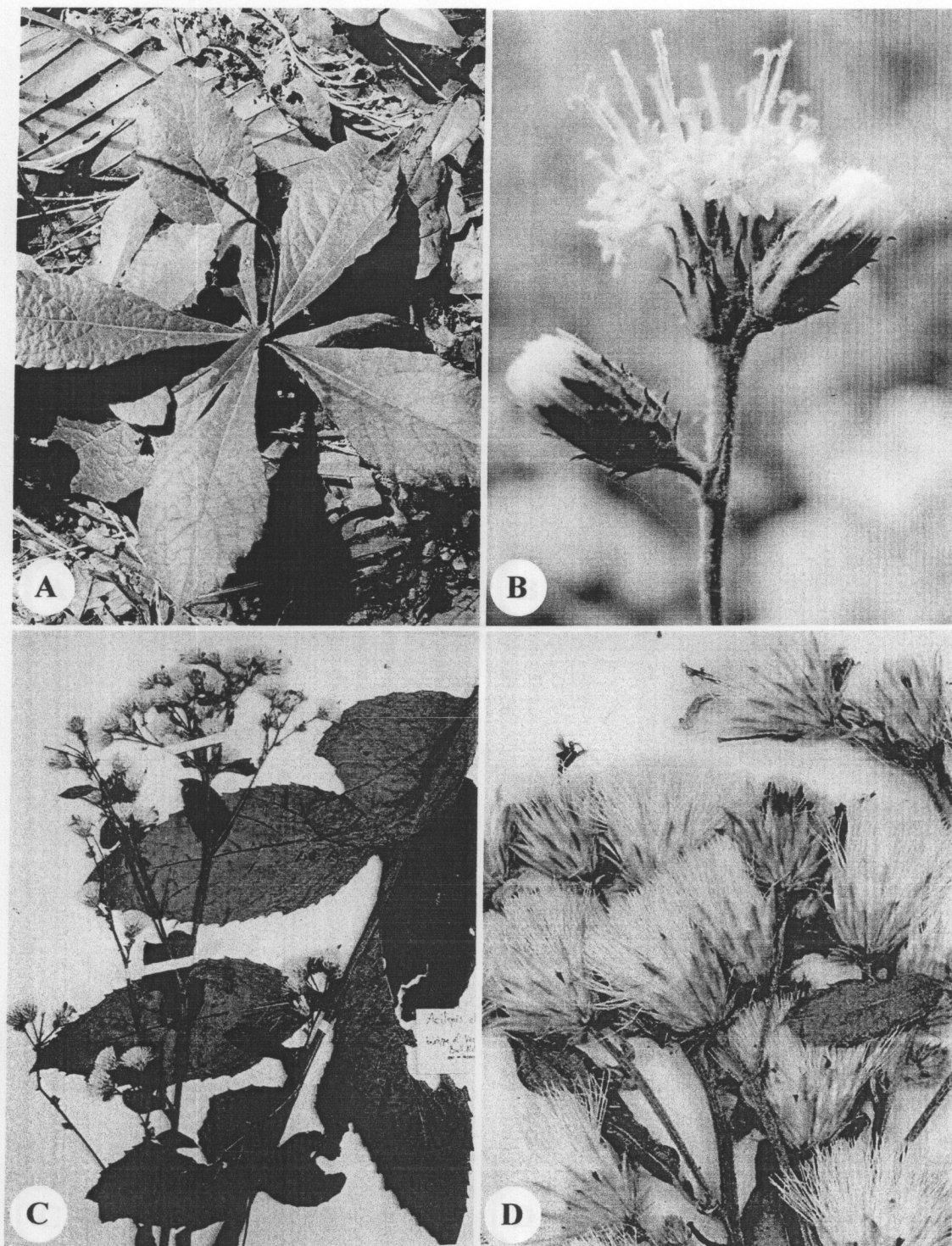


Figure 2.63 A. & B. *Acilepis attenuata*

 C. & D. *Acilepis chiangdaoensis*

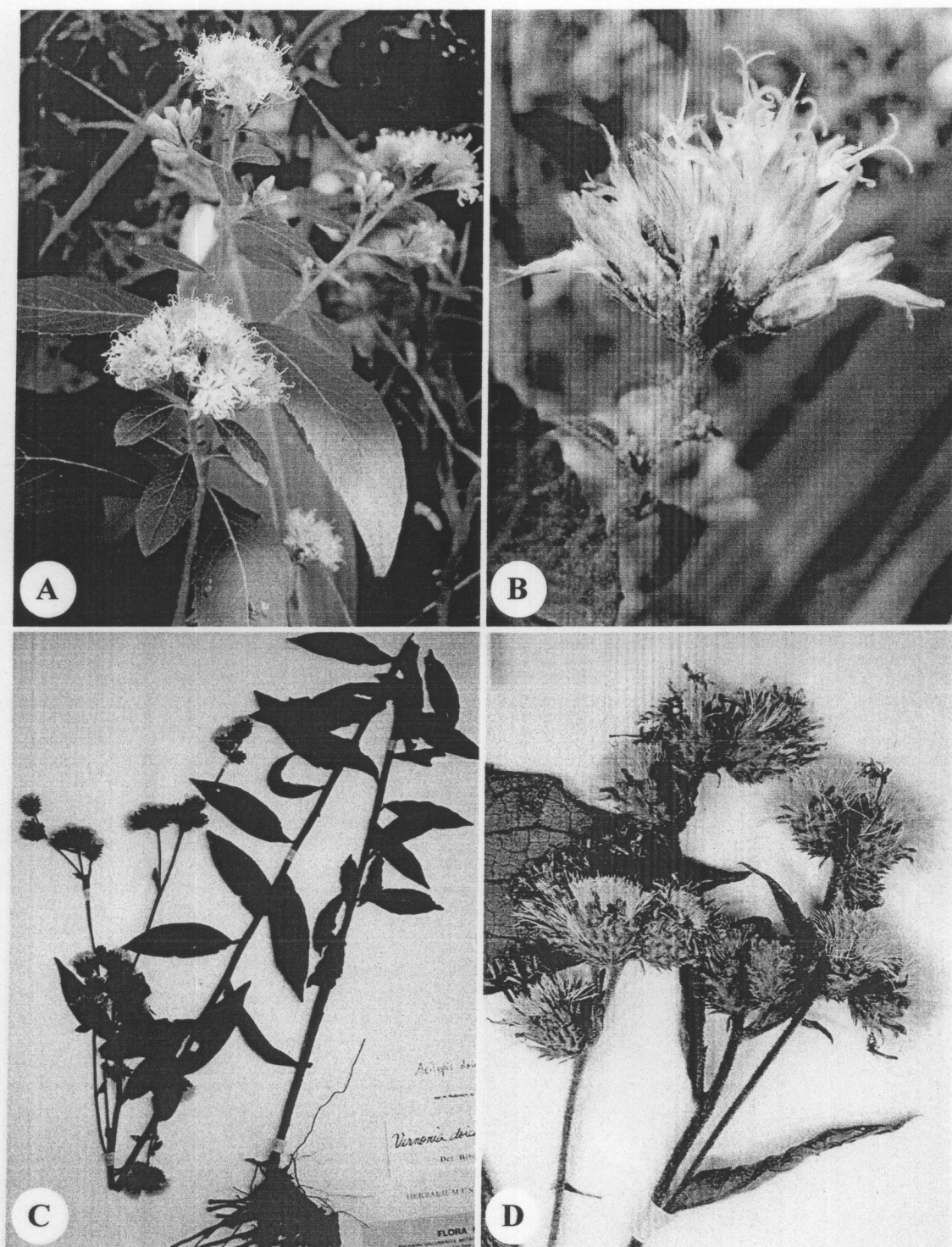


Figure 2.64 A. & B. *Acilepis divergens*

C. & D. *Acilepis doichangensis*

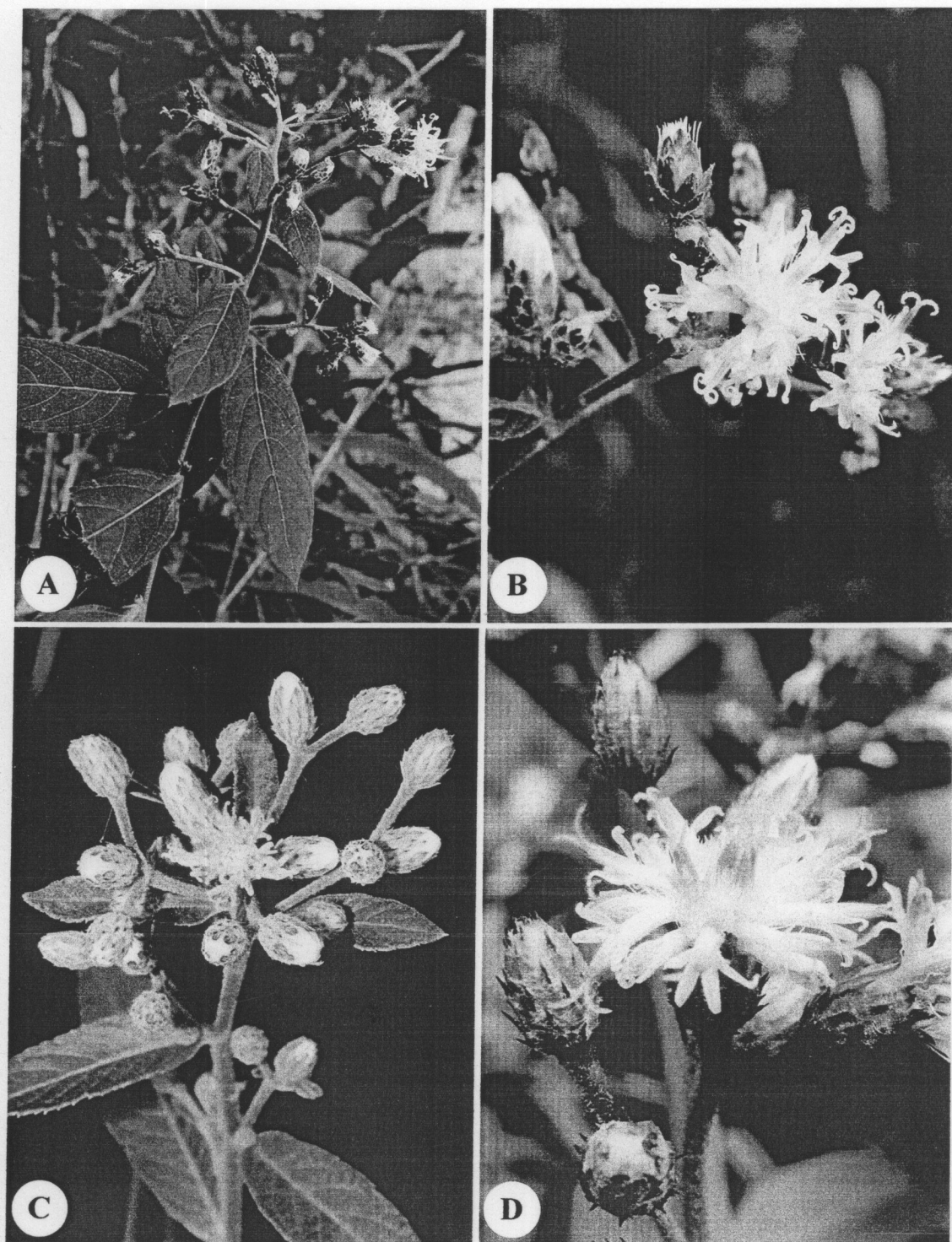


Figure 2.65 A. & B. *Acilepis kingii*

C. & D. *Acilepis namnaoensis*

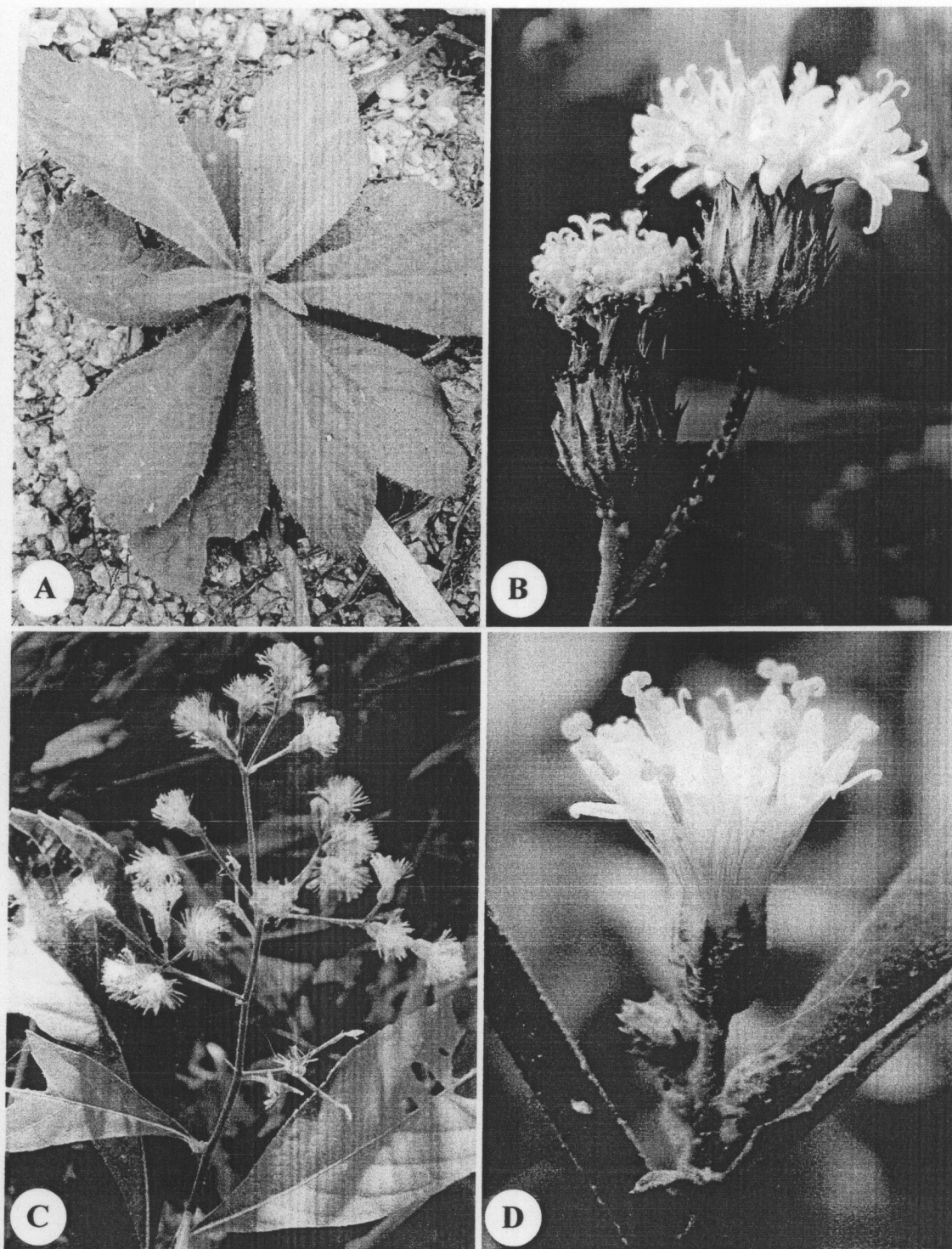


Figure 2.66 A. & B. *Acilepis ngaoensis*

C. & D. *Acilepis peguensis*

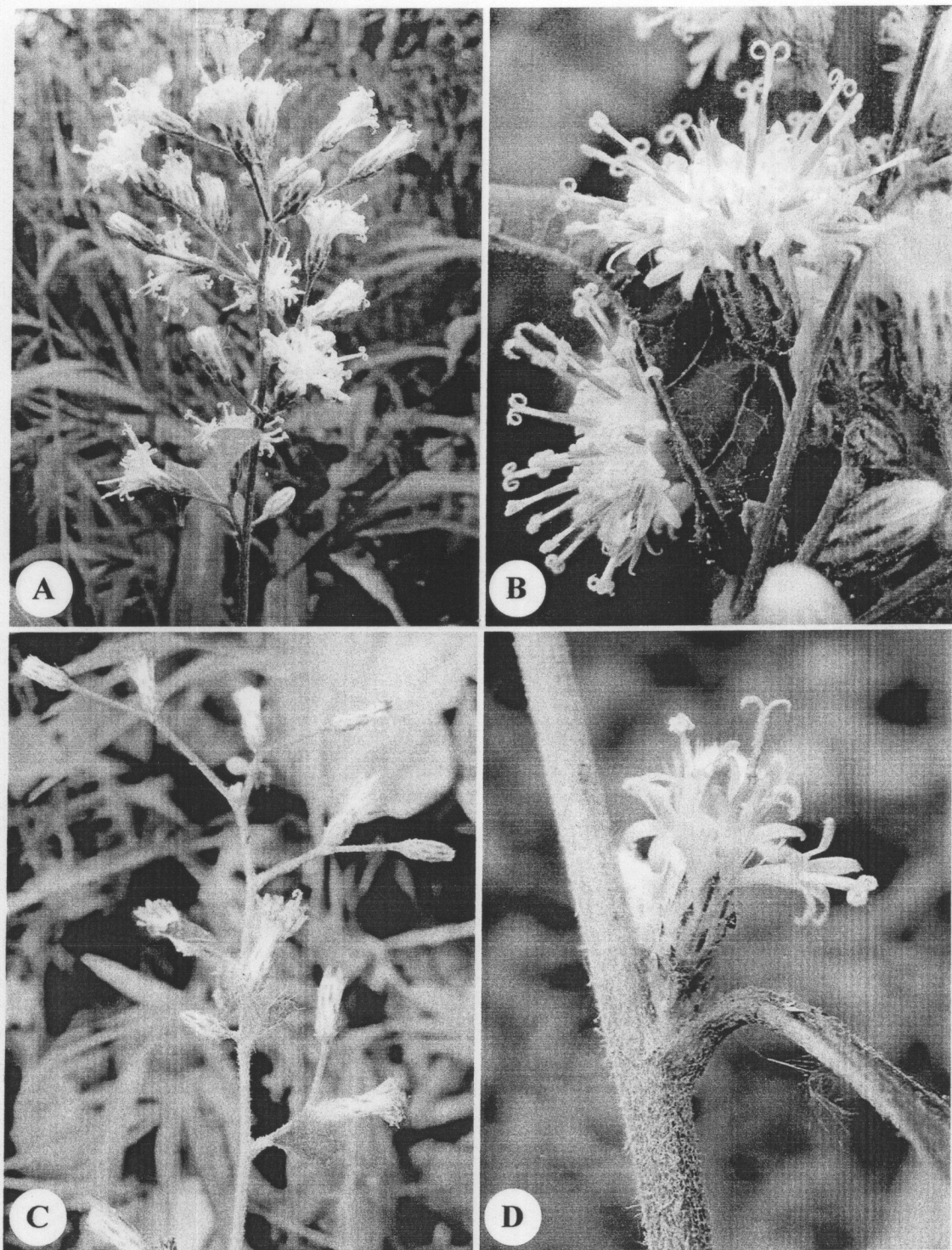


Figure 2.67 A. & B. *Acilepis principis*

C. & D. *Acilepis pseudosutepensis*

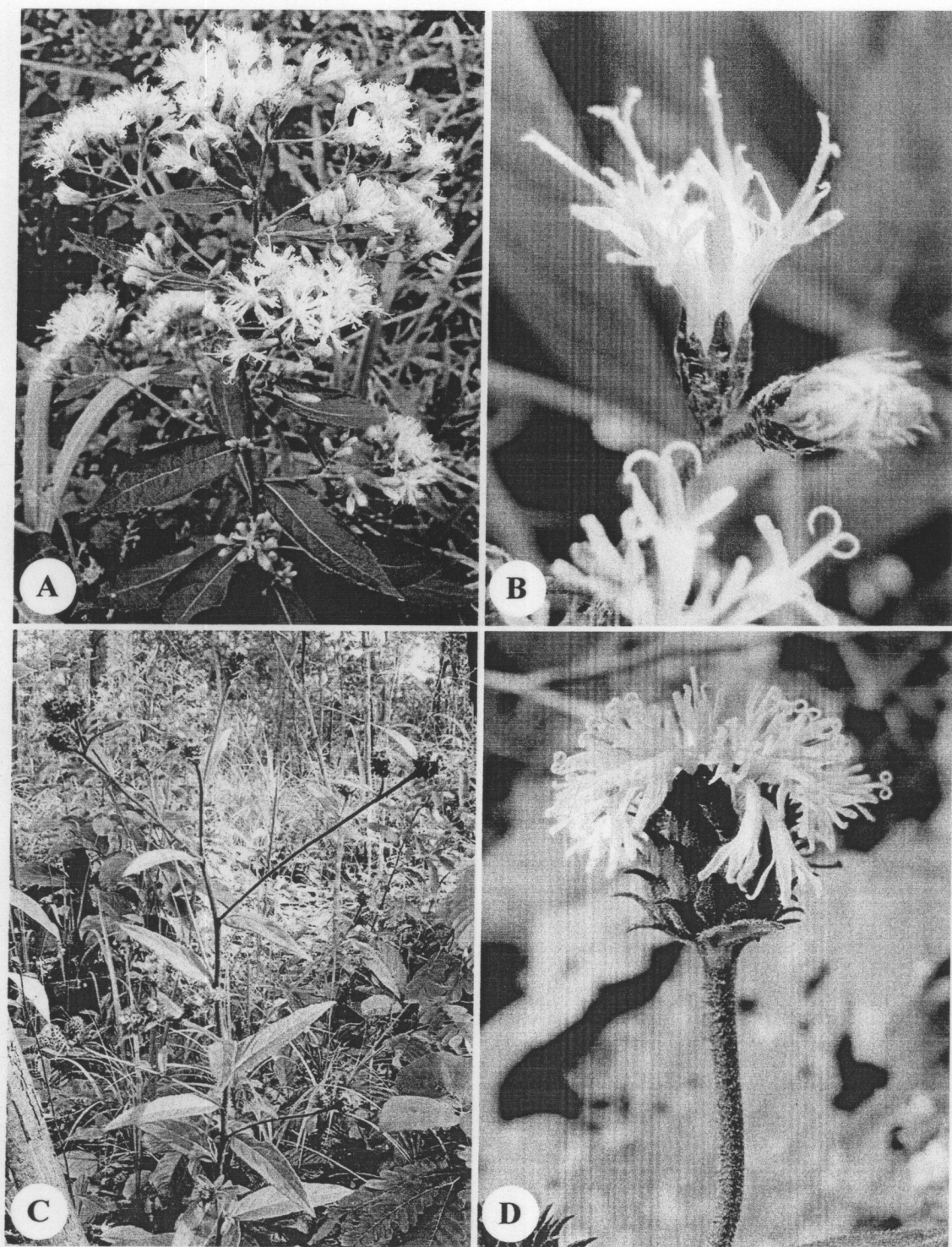


Figure 2.68 A. & B. *Acilepis saligna*

C. & D. *Acilepis silhetensis*

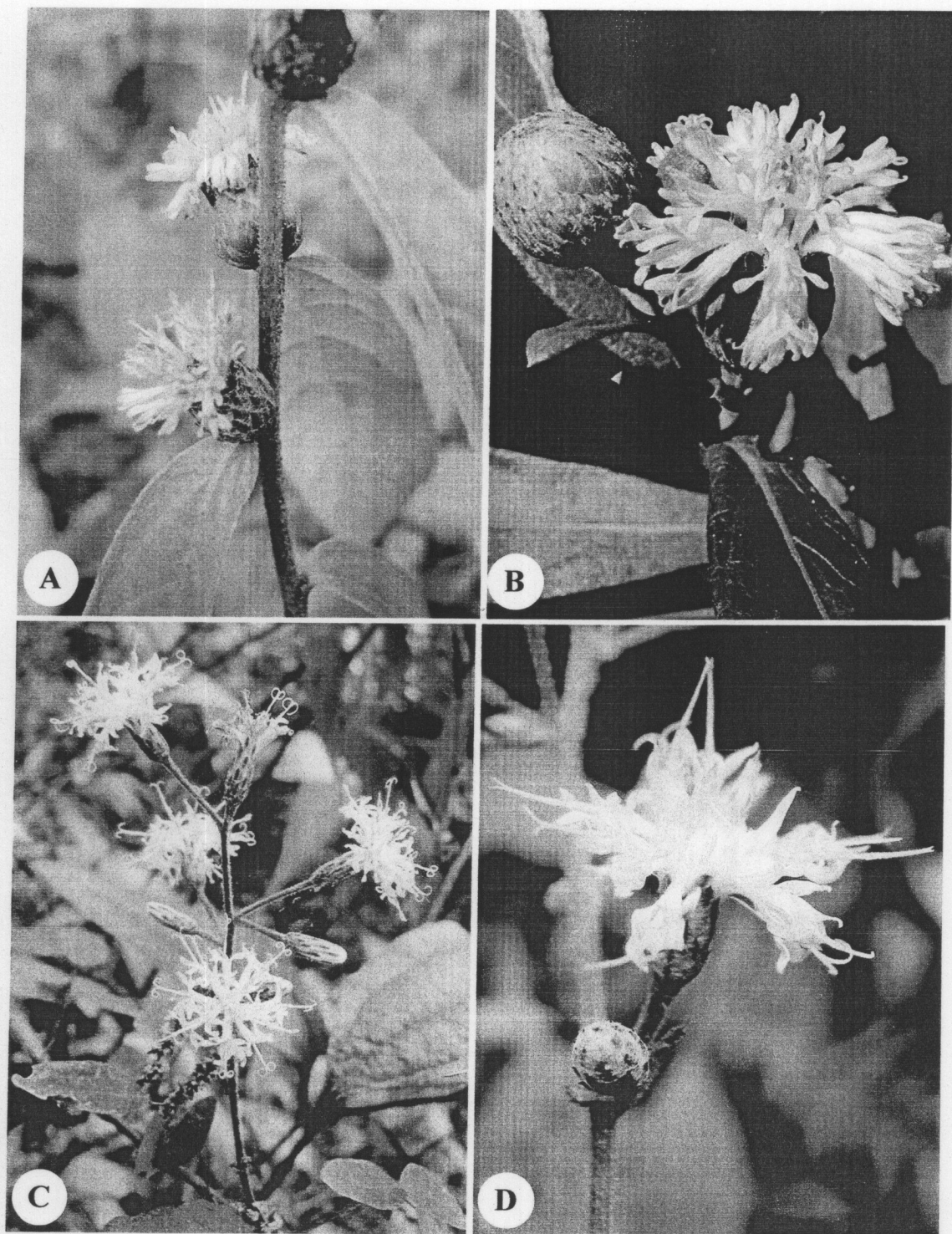


Figure 2.69 A. & B. *Acilepis squarrosa*

C. & D. *Acilepis sutepensis*

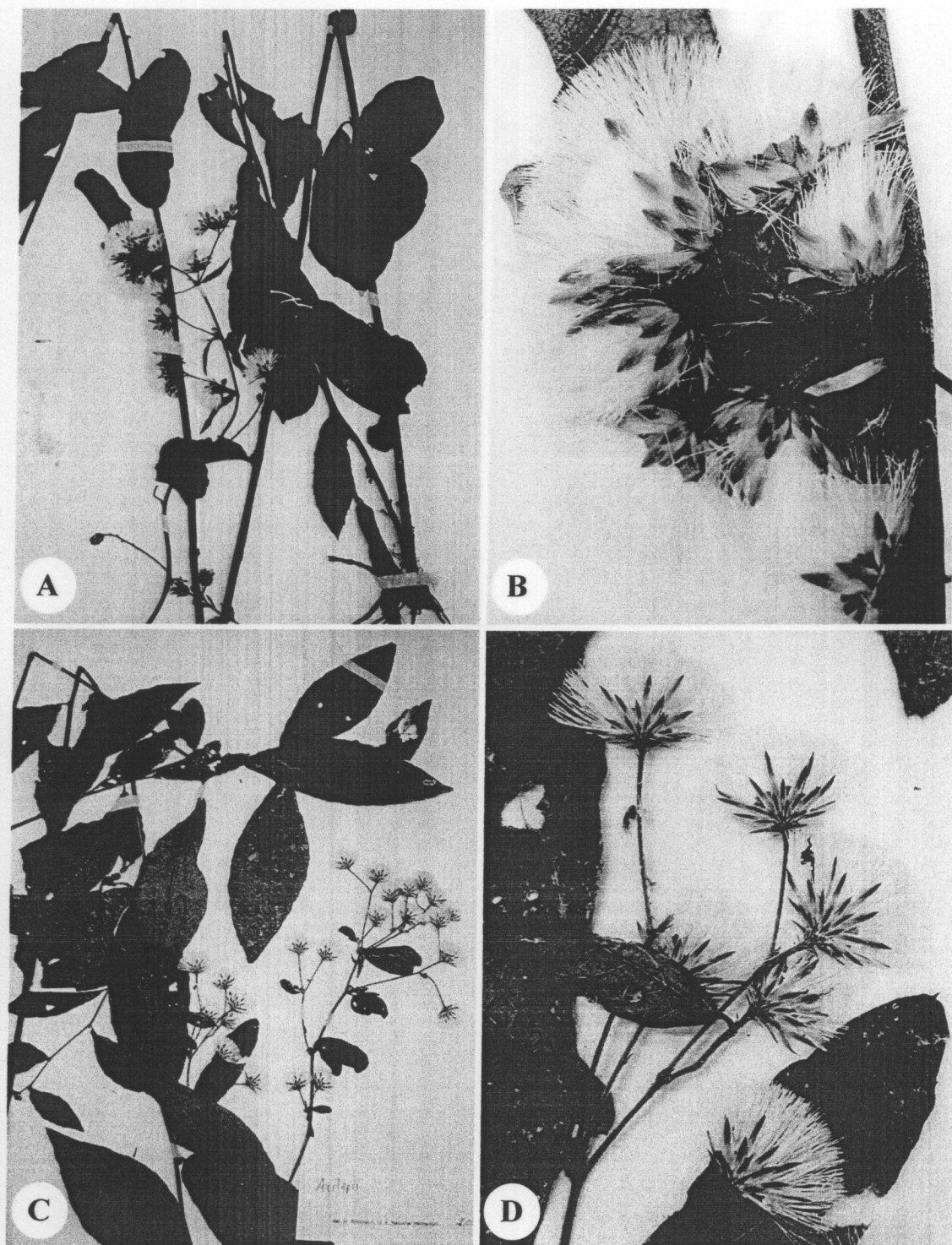


Figure 2.70 A. & B. *Acilepis tonkinensis*

C. & D. *Acilepis virgata*

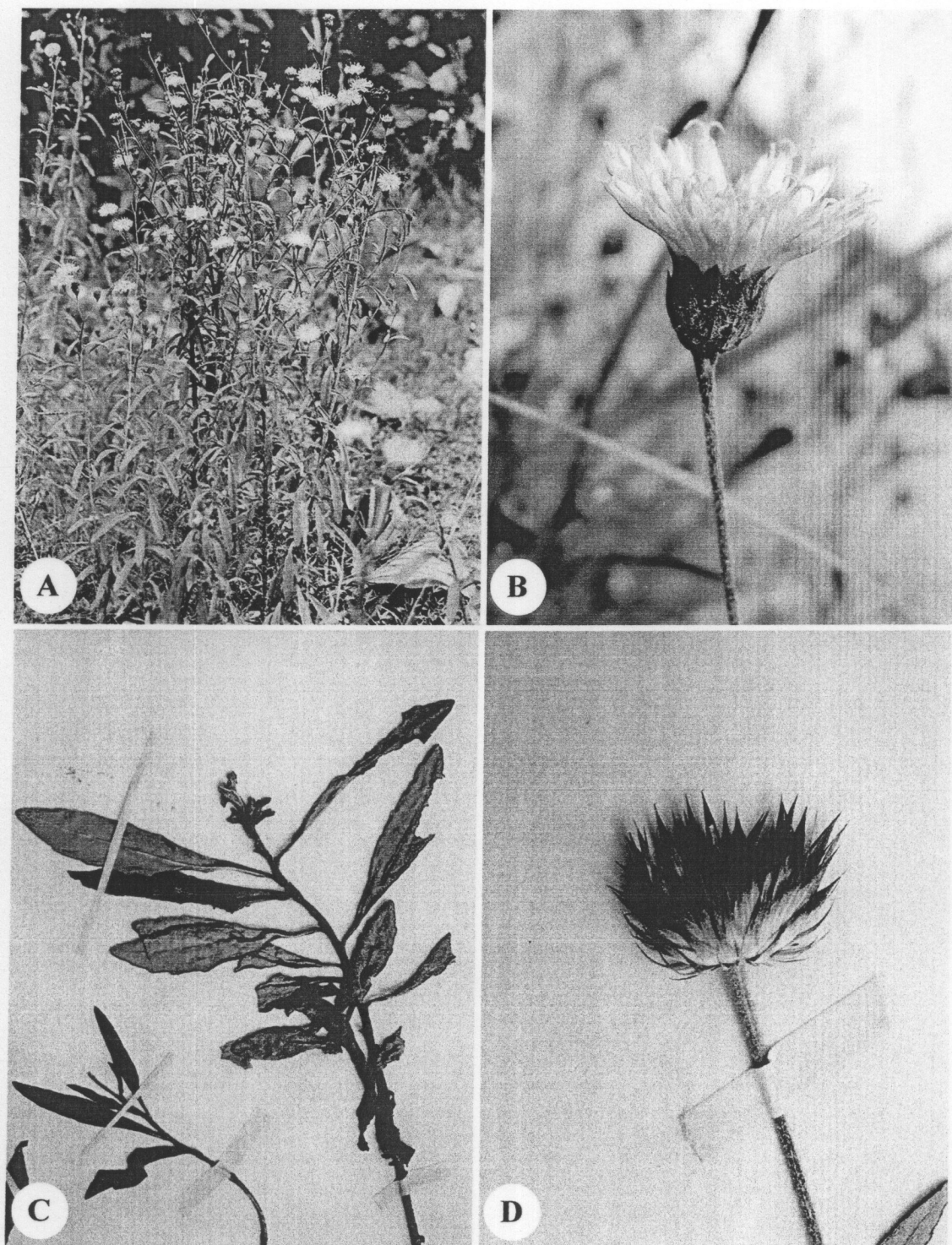


Figure 2.71 A. & B. *Camchaya gracilis*

C. & D. *Camchaya kampotensis*

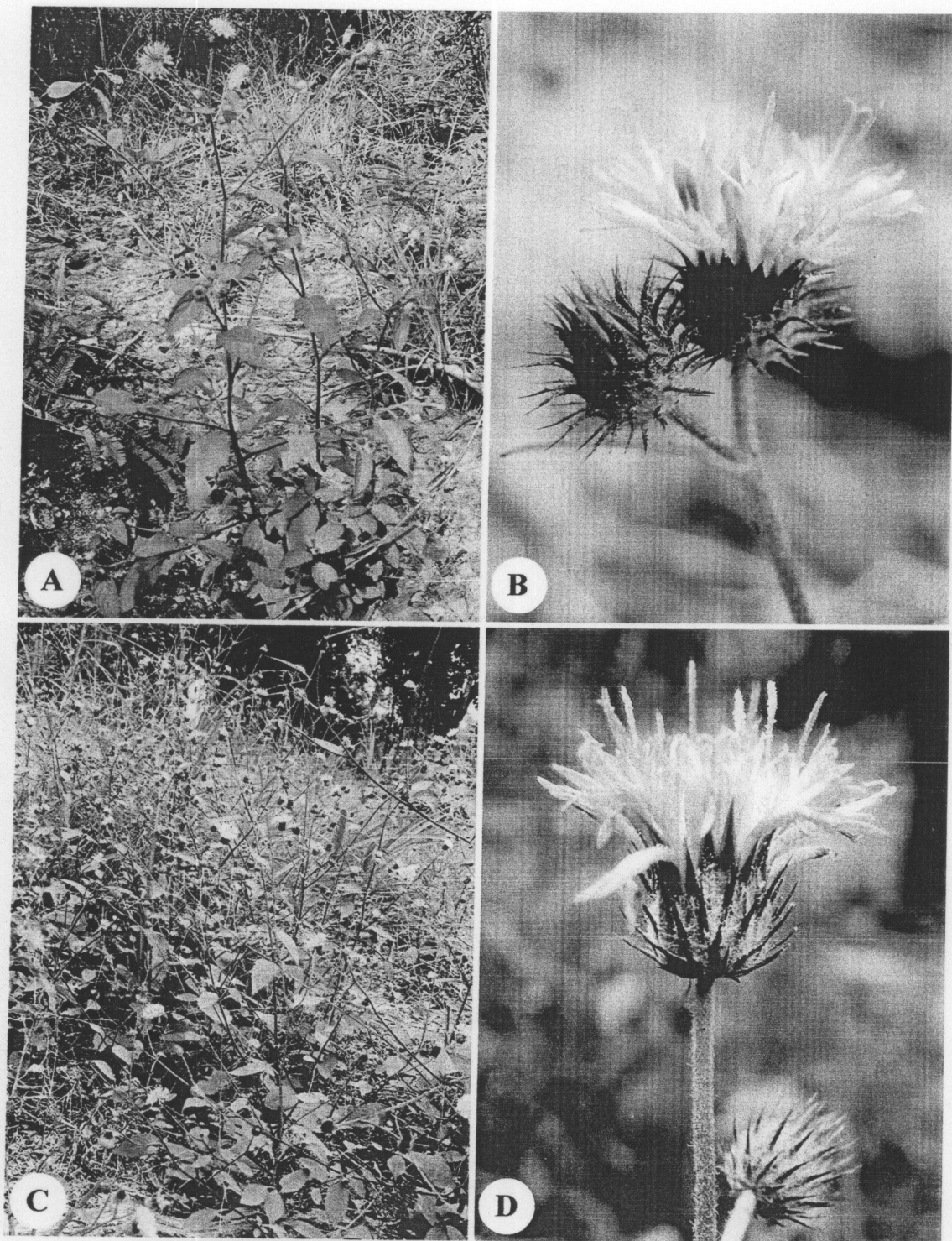


Figure 2.72 A. & B. *Camchaya loloana* var. *loloana*

C. & D. *Camchaya loloana* var. *mukdahanensis*

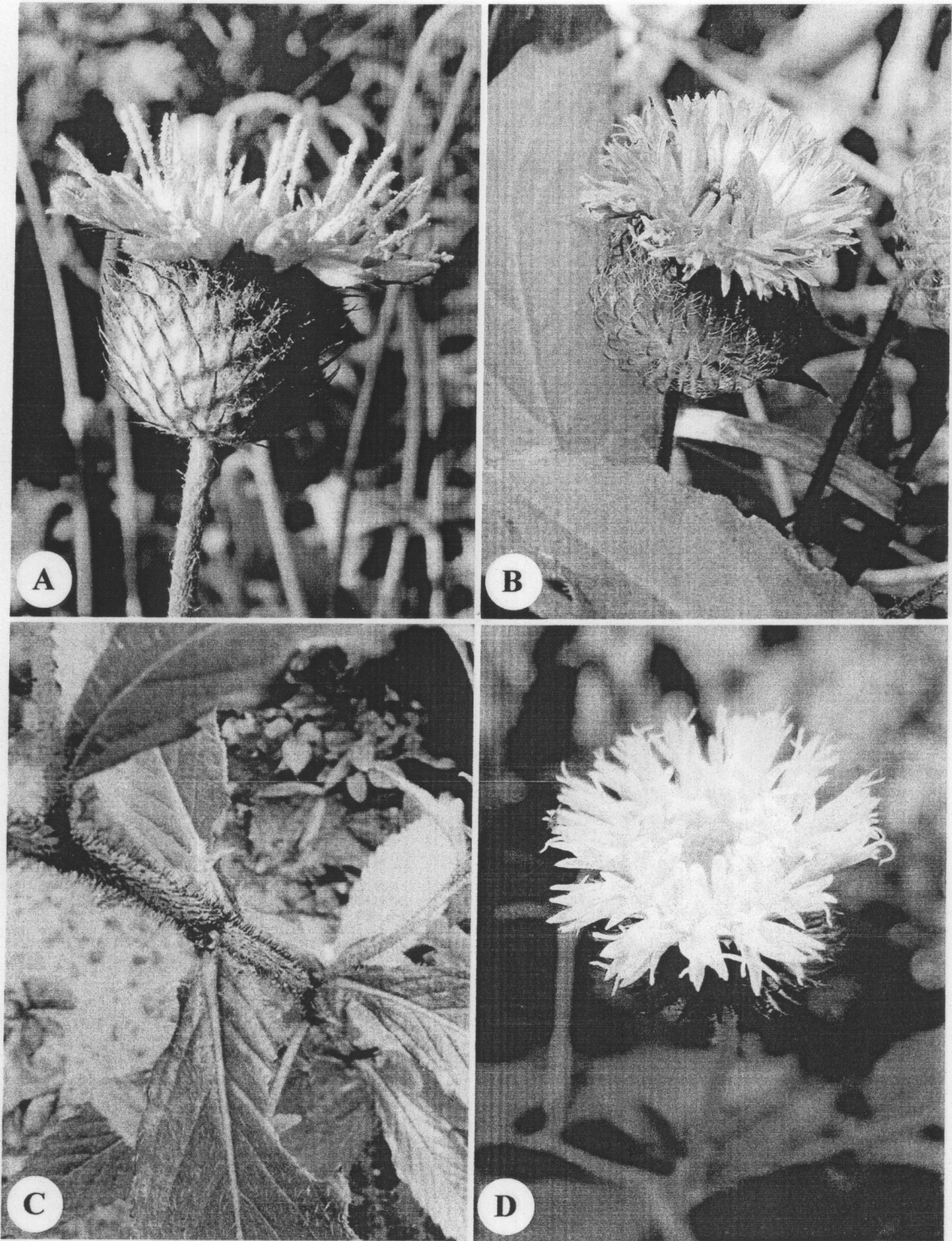


Figure 2.73 A. *Camchaya pentagona*

B. - D. *Camchaya spinulifera*

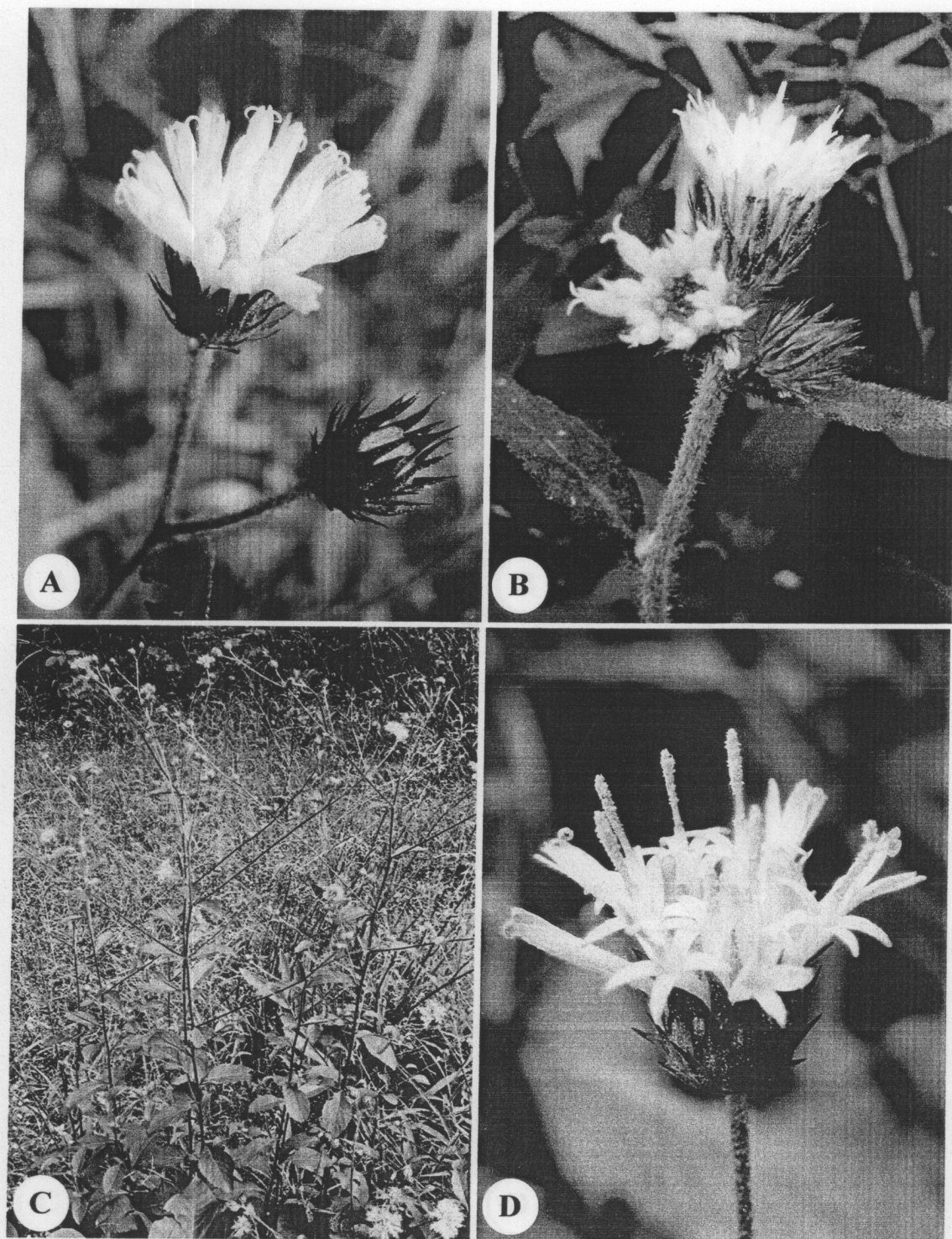


Figure 2.74 A. & B. *Camchaya tenuiflora*

C. & D. *Camchaya* sp.

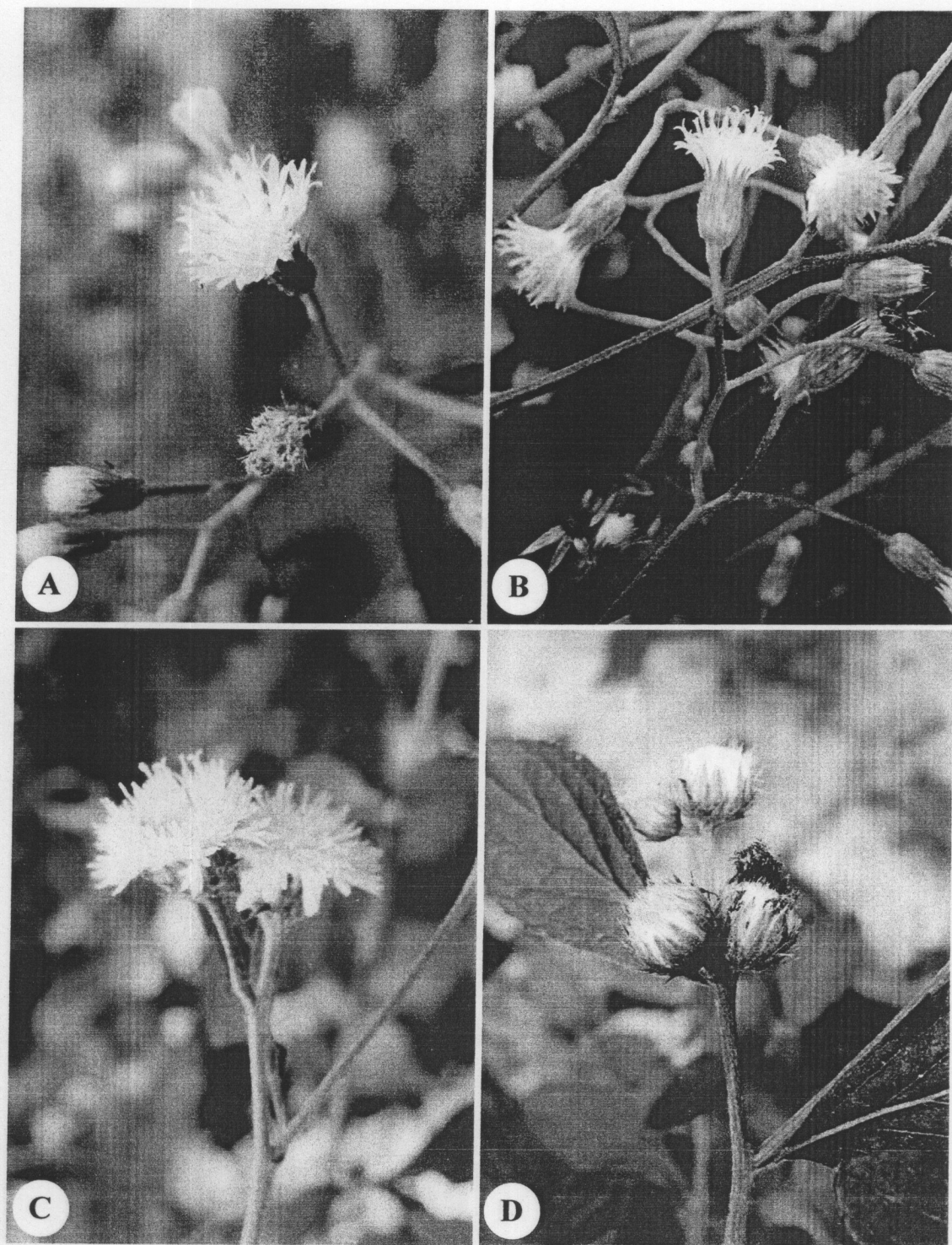


Figure 2.75 A. & B. *Cyanthillium cinereum*

C. & D. *Cyanthillium hookerianum*

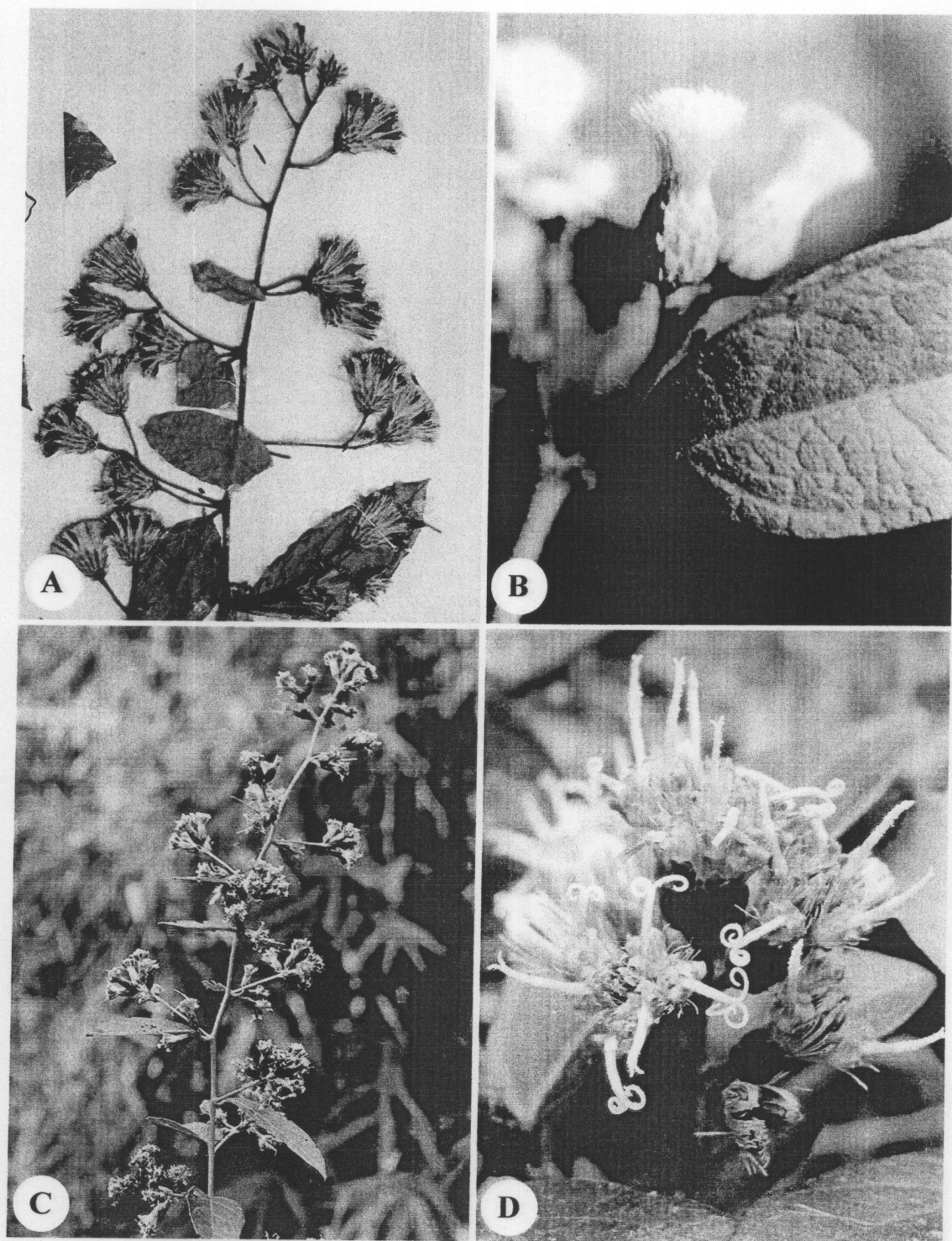


Figure 2.76 A. & B. *Decaneuropsis cumingiana*

C. & D. *Decaneuropsis eberhardtii*

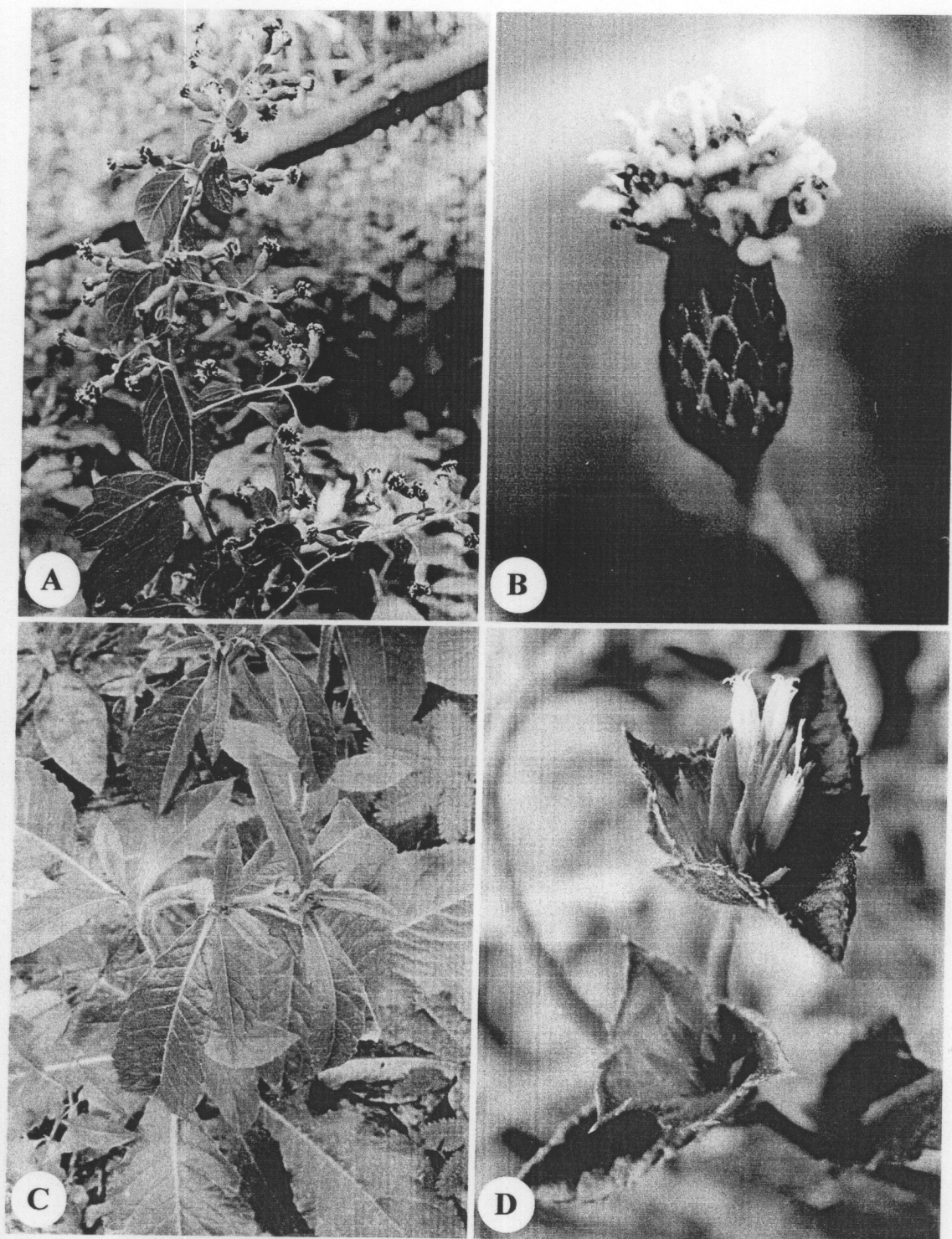


Figure 2.77 A. & B. *Decaneuropsis garrettiana*

C. & D. *Elephantopus mollis*

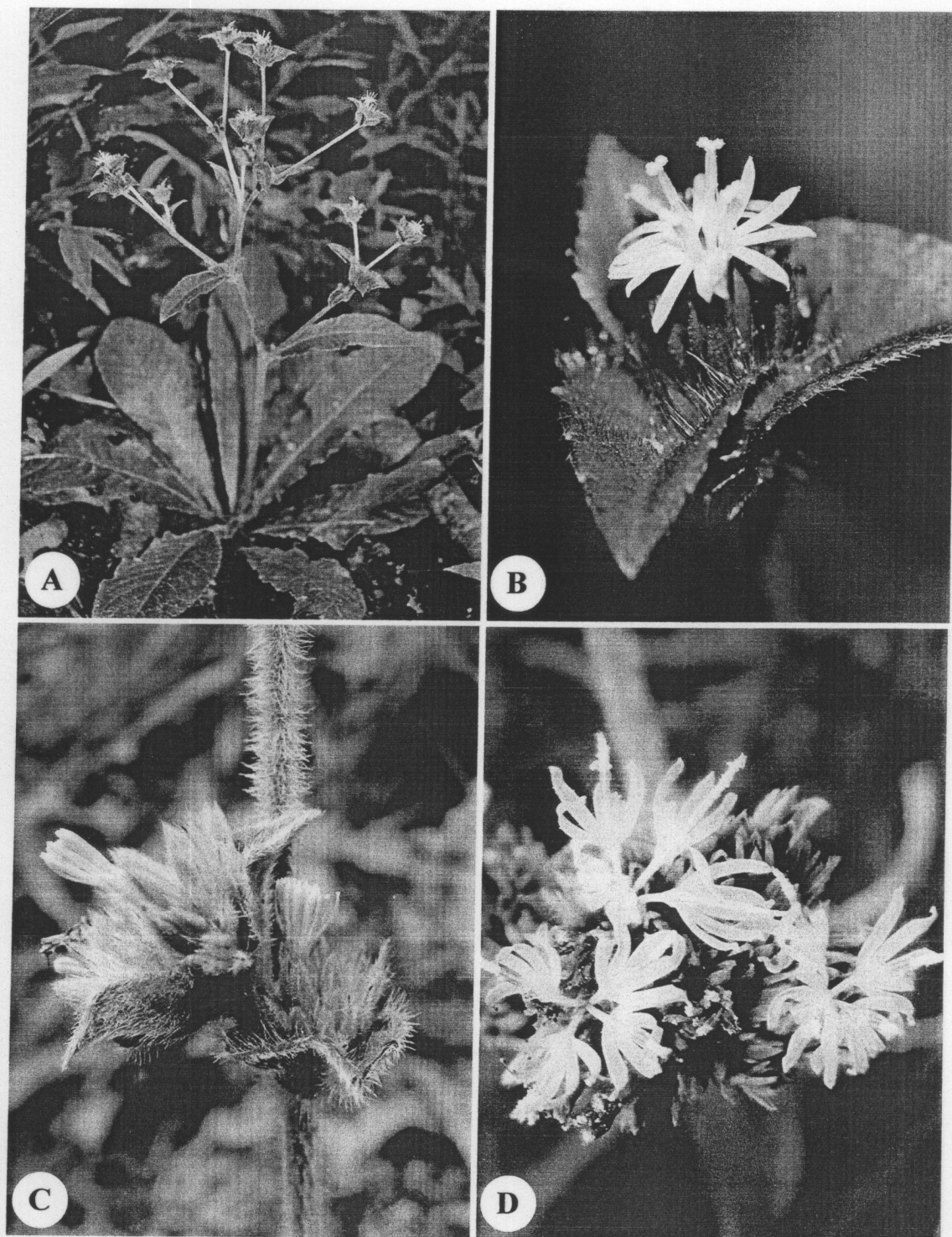


Figure 2.78 A. & B. *Elephantopus scaber* var. *scaber*

C. & D. *Elephantopus scaber* var. *penicillatus*

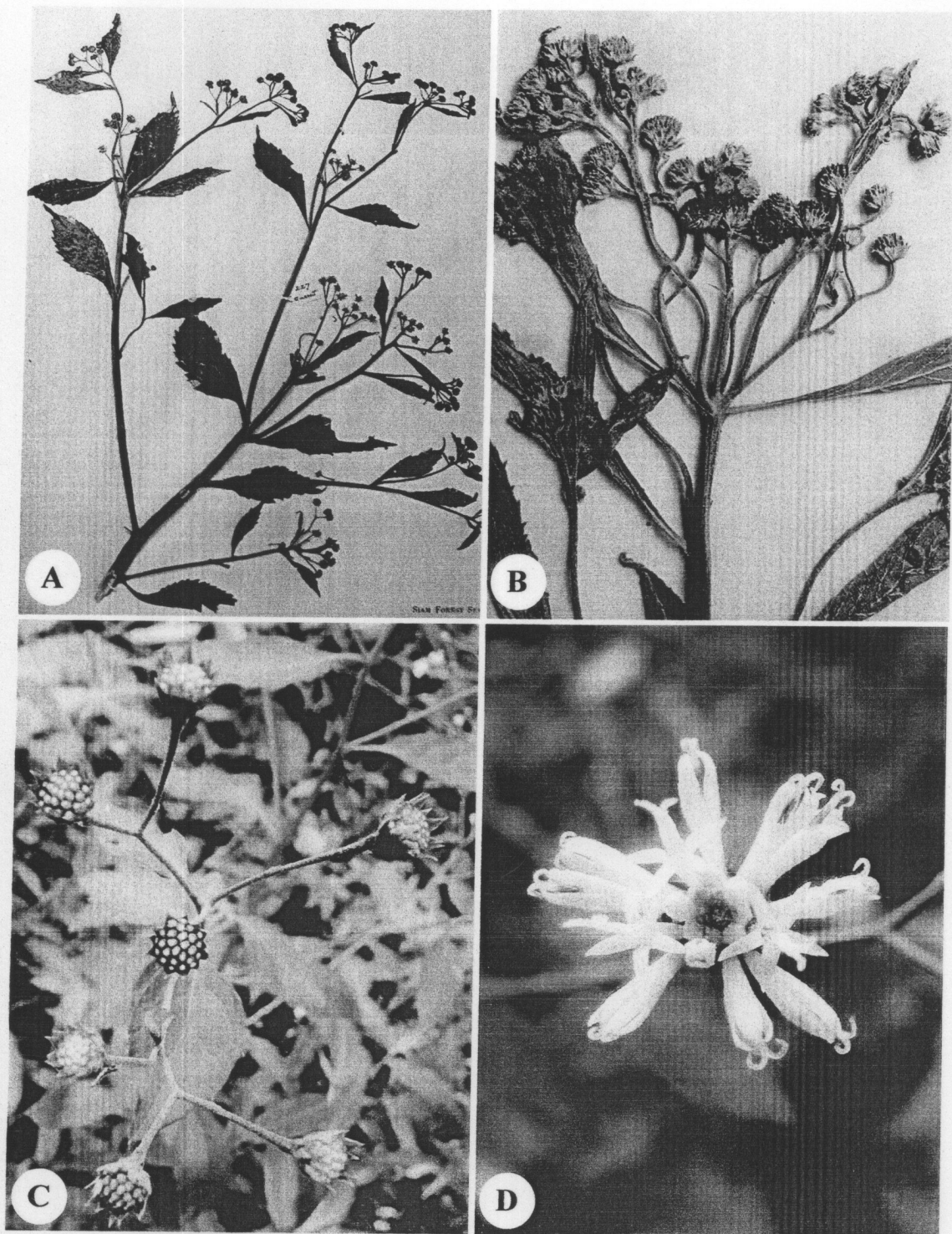


Figure 2.79 A. & B. *Ethulia cornizoides*
C. & D. *Iodocephalopsis eberhardtii*

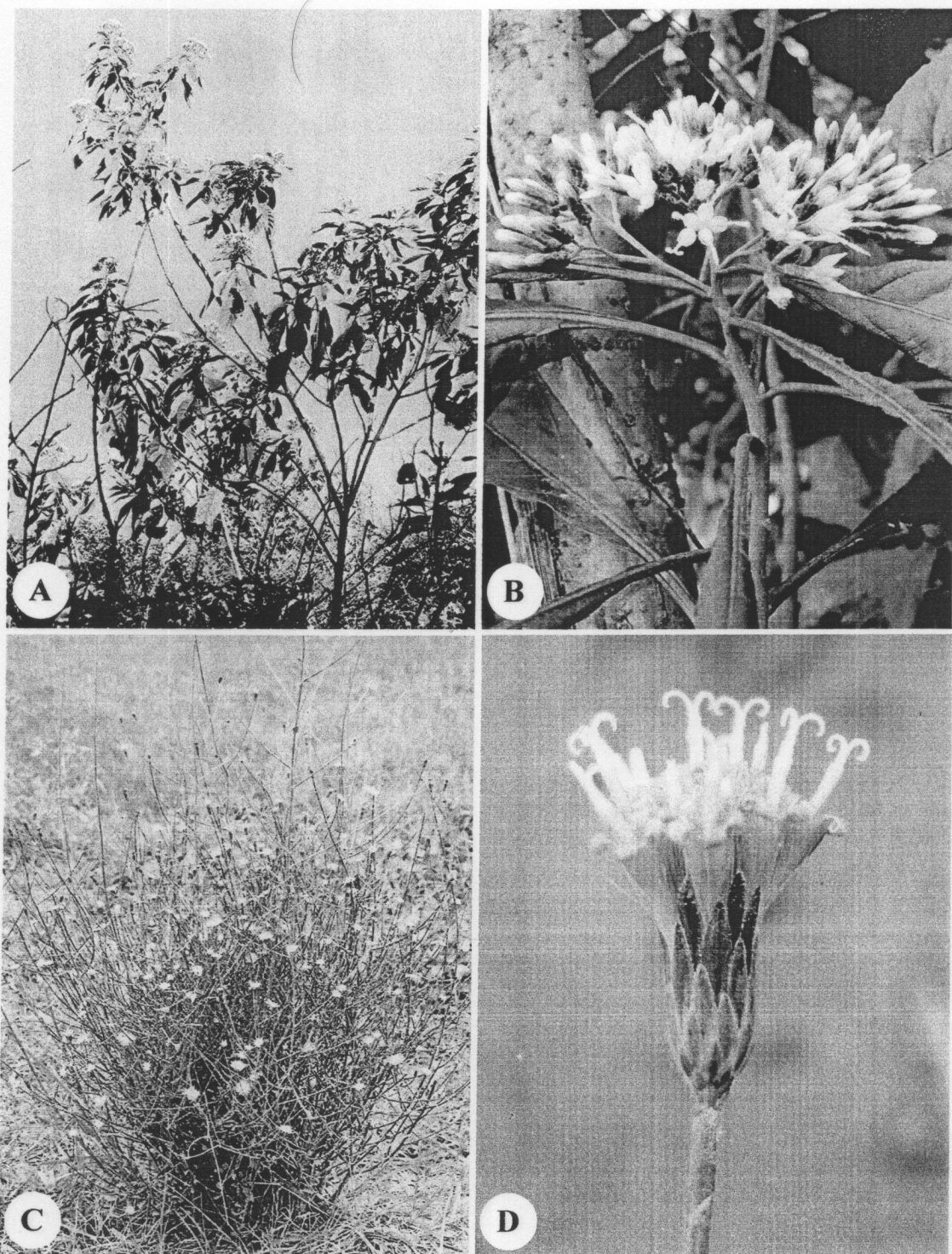


Figure 2.80 A. & B. *Gymnanthemum cylindriceps*

C. & D. *Kurziella gymnoclada*

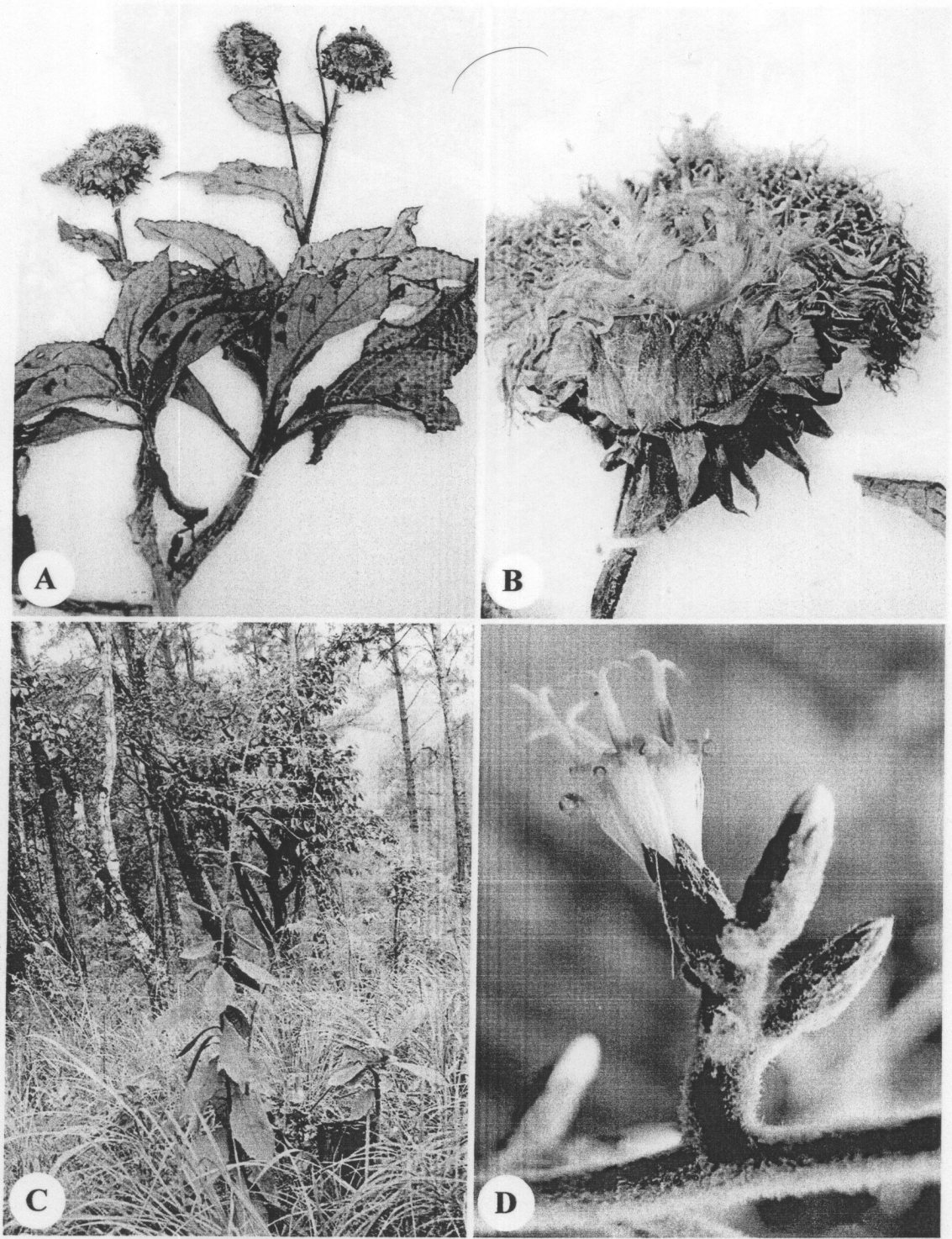


Figure 2.81 A. & B. *Koyamasia calcarea*

C. & D. *Monosis parishii*

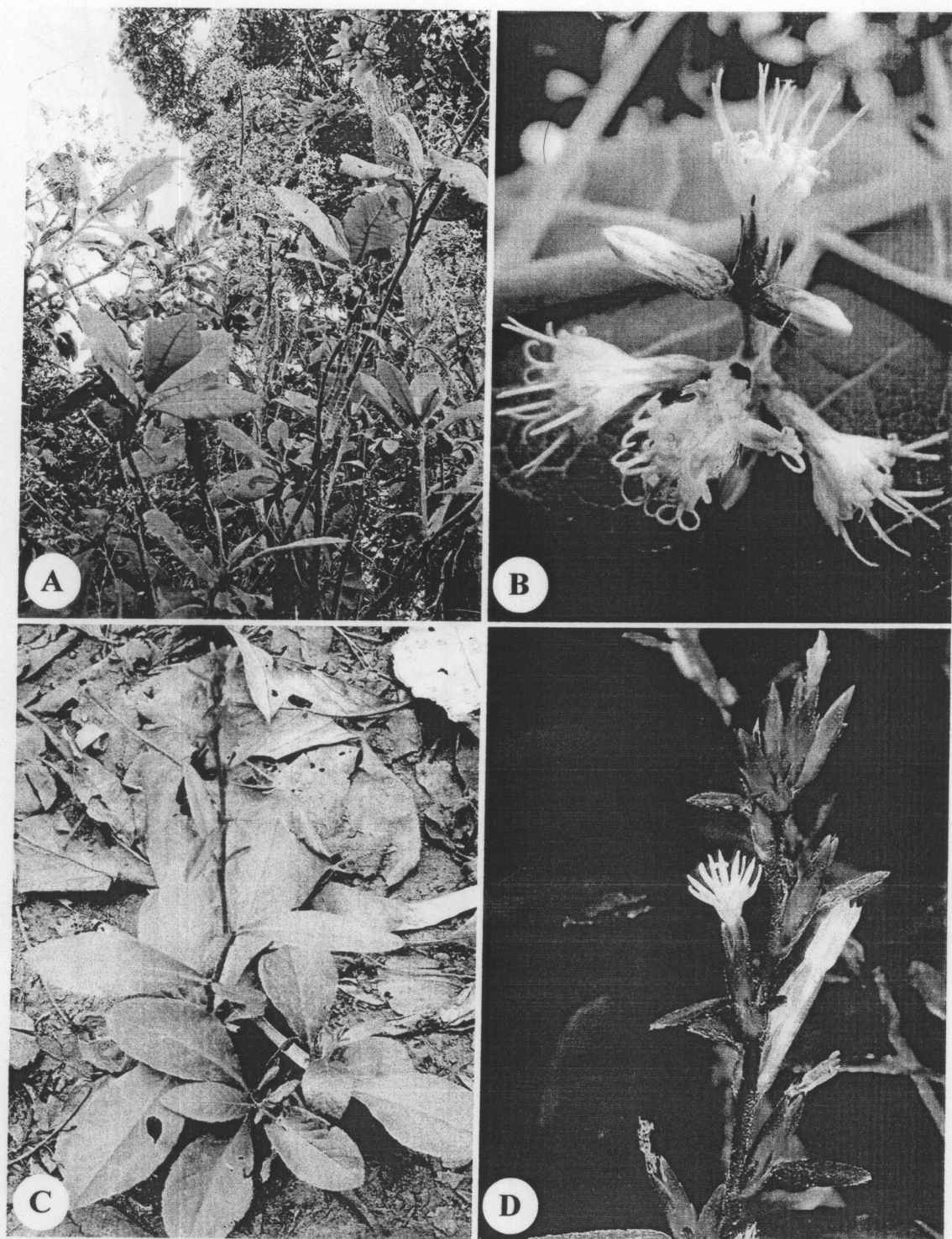


Figure 2.82 A. & B. *Monosis volkameriifolia*

C. & D. *Pseudelephantopus spicatus*

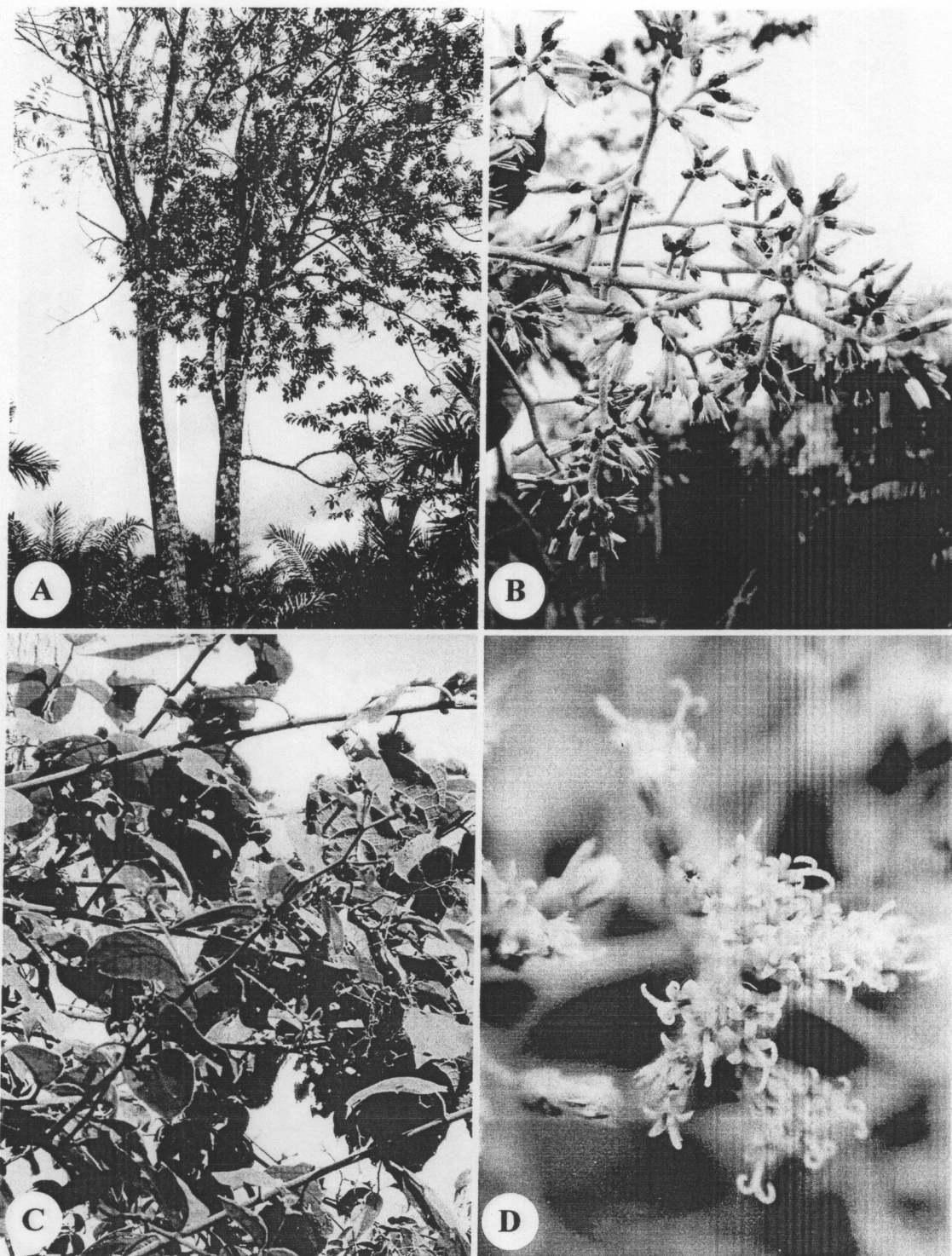


Figure 2.83 A. & B. *Strobocalyx arborea*

C. & D. *Strobocalyx solanifolia*

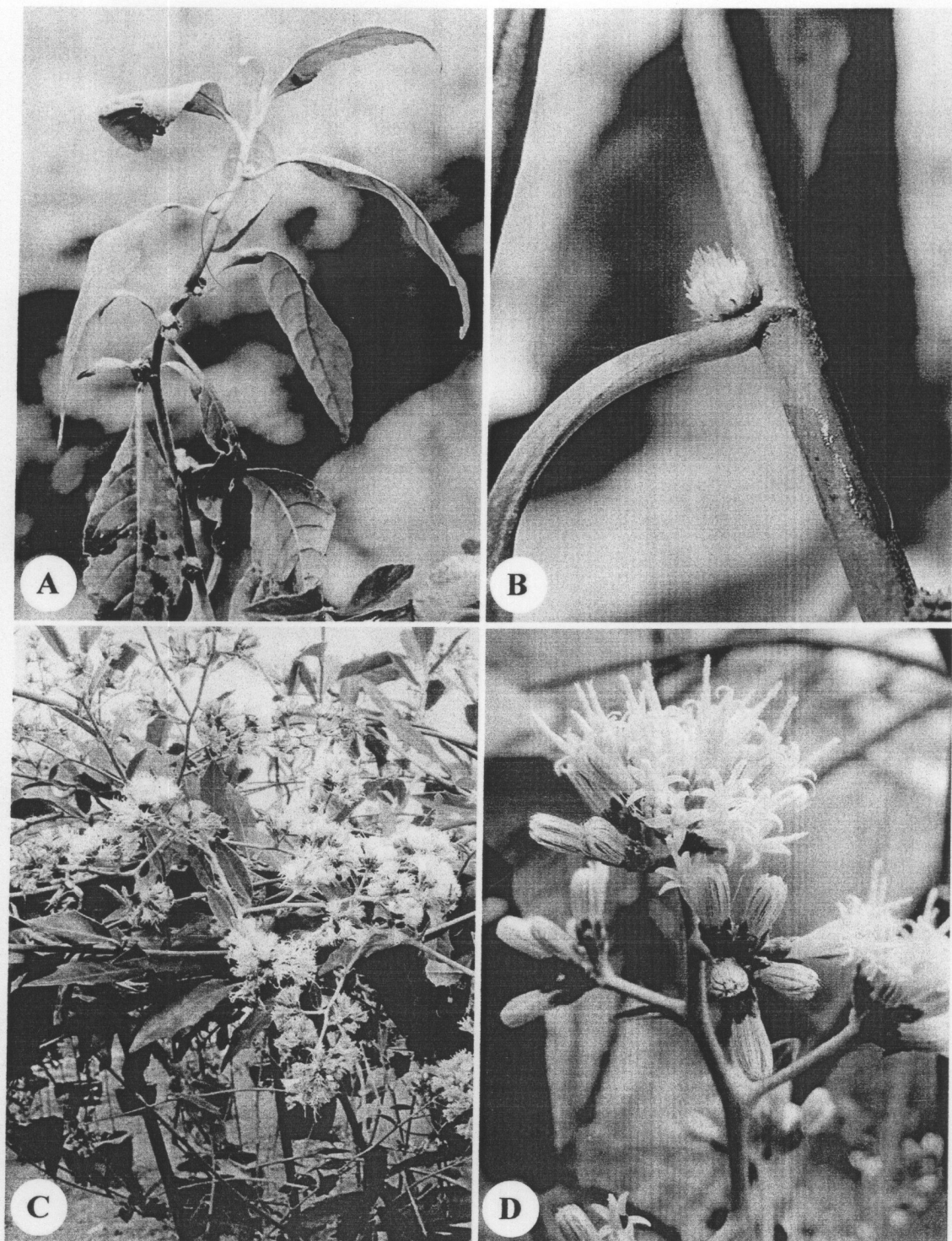


Figure 2.84 A. & B. *Sparganophoros sparganophora*

C. & D. *Tarlmounia elliptica*

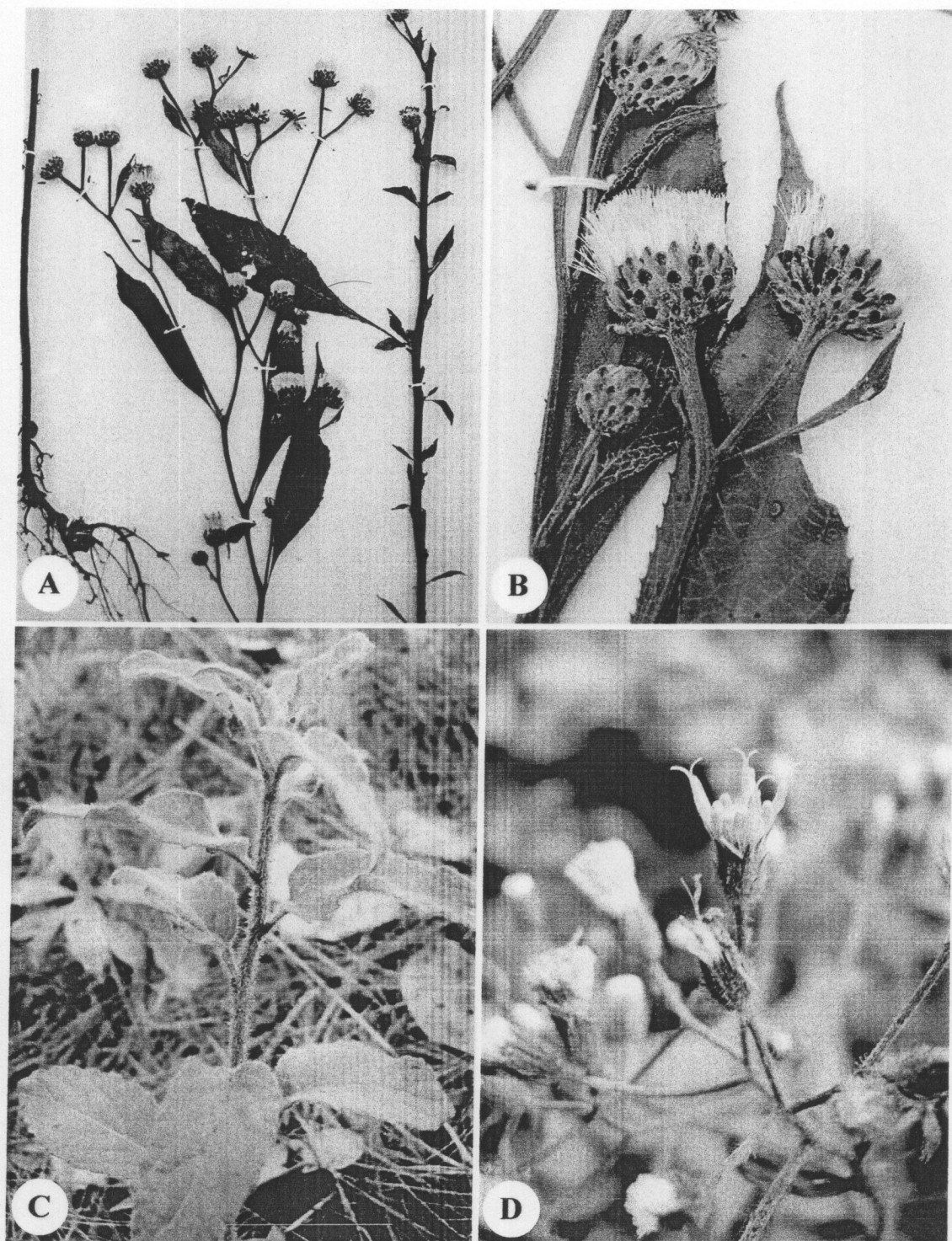


Figure 2.85 A. & B. *Vernonia birmanica*

C. & D. *Vernonia cinerea* var. *montana*

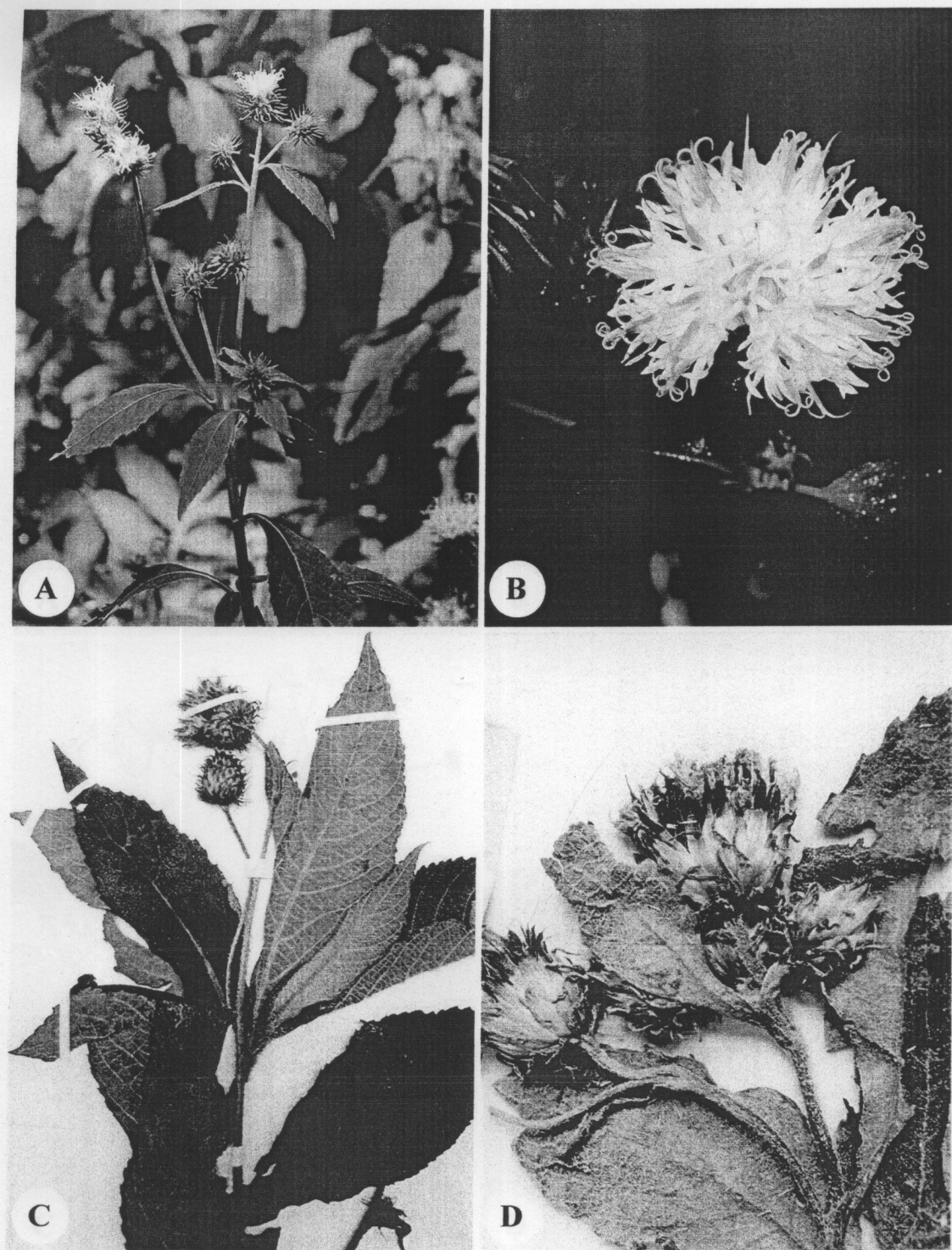


Figure 2.86 A. & B. *Vernonia curtisii* var. *curtisii*

C. & D. *Vernonia curtisii* var. *tomentosa*

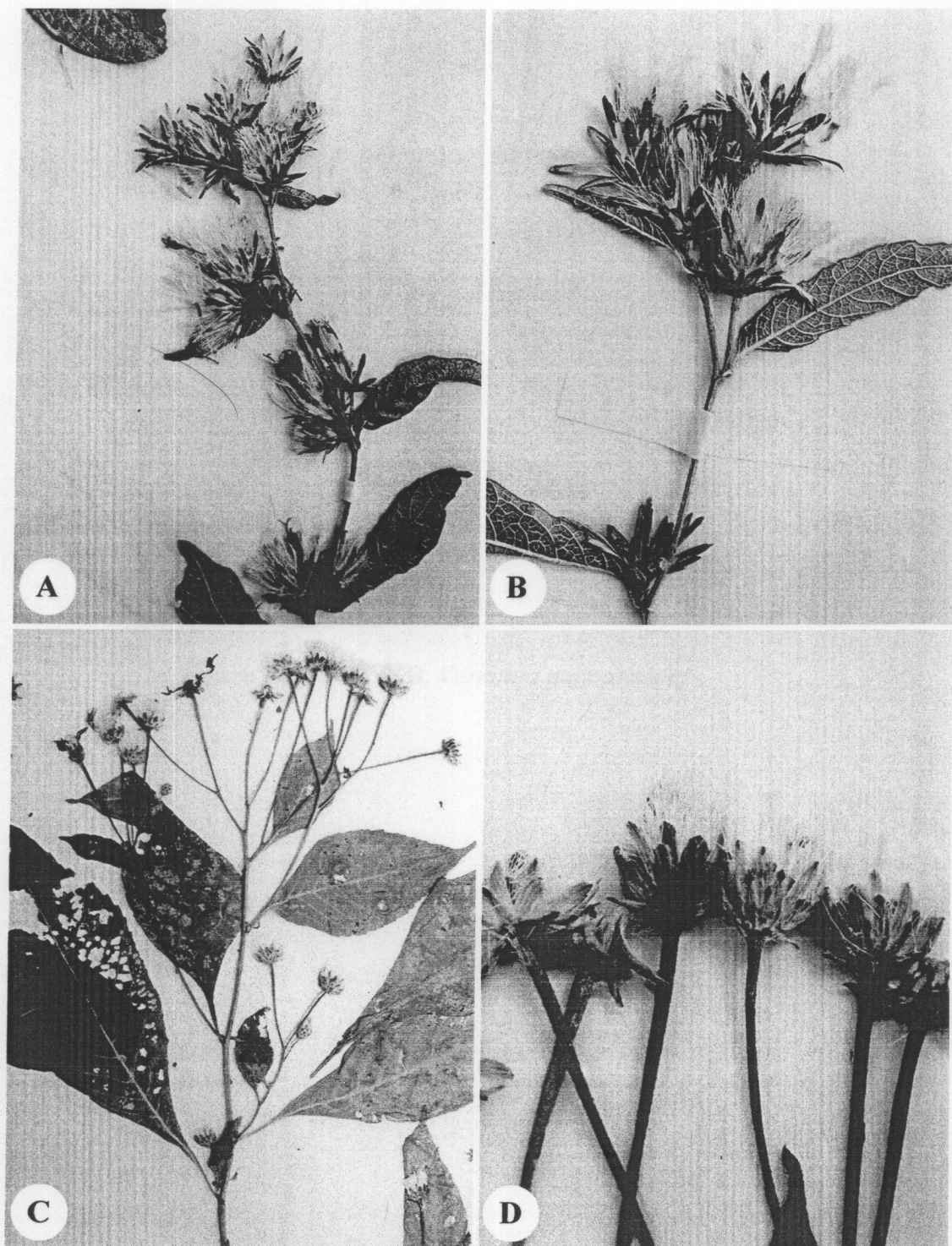


Figure 2.87 A. & B. *Vernonia kerrii*

C. & D. *Vernonia pseudobirmanica*

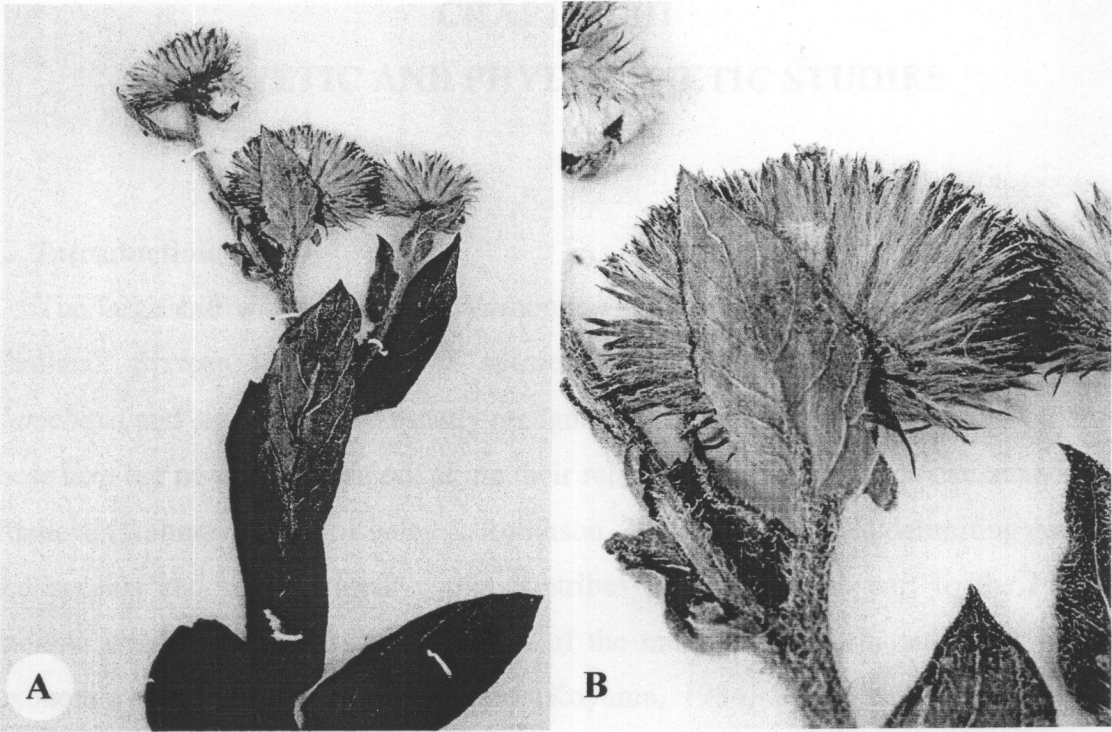


Figure 2.88 A. & B. *Vernonia pulicarioides*

CHAPTER III

PHENETIC AND PHYLOGENETIC STUDIES

1. Introduction

The large and widespread tribe Vernonieae (Compositae) are well represented in Thailand. Sixteen genera and 48 species, including many endemic species in *Camchaya* and *Acilepis*, are currently recognized. However, the relationships among these taxa are poorly understood, as are their relationships with Vernonieae outside of Thailand (Robinson, 2007; Keeley & Robinson, 2009). Difficulty in delimiting genera and species and placing them within subtribes is due in large part to the highly variable and overlapping nature of many of the morphological characters on which taxonomic treatments have been based (Koyama, 1984, 1993, 1997, 1998, 2003, 2004, 2005; Robinson, 1999a, 1999b; Keeley *et al.*, 2007; Robinson & Skvarla, 2006, 2007, 2009). Molecular studies using chloroplast and nuclear DNA (cpDNA and nDNA) have overcome many of these limitations, clarifying subtribal relationships, and when coupled with morphology provide clear characters to define genera and species in monophyletic groups (Keeley & collaborators, 1994, 2007, 2009; Robinson 1999a, 1999b; Robinson *et al.*, 2008). In 2007, Keeley *et al.* provided the first phylogeny for the tribe worldwide and clearly demonstrated the monophyly of the Vernonieae. The tribal phylogeny also showed that the Old and New World subtribal lineages were almost entirely distinct from each other with the Old World taxa basal to the New World taxa. The tribe originated in Madagascar/east Africa (Keeley *et al.*, 1994, 2007) as well. Two closely related southeast Asian taxa (*Strobocalyx arborea*, *Tarlounia elliptica*) did show a cross-hemispheric relationship, however. They were most closely related to a small American group of taxa in subtribes Leiboldiinae and Stokesiinae. For the most part, however, the two hemispheres have distinct and separate evolutionary lines.

Robinson (1999a, 1999b) revised the subtribes and genera of the Old and New World Vernonieae in separate treatments. This work was based on studies of pollen, morphological characters and combined with existing data on secondary chemistry

and chromosome numbers (Keeley & Robinson, 2009). Of greatest significance in Robinson's 1999 treatment was the new concept of the core genus, *Vernonia*. Of the >1000 species originally placed in *Vernonia* ("the *Vernonia* problem" of Bremer, 1994) fewer than 30 species remain. The genus now includes only the New World species, primarily from eastern North America where the type species, *V. noveboracensis*, is found (Robinson, 1999b), plus a small number of species in Mexico and South America (Keeley & Robinson, 2009). Since the New World species were much better studied and detailed taxonomic treatments available for most areas it was possible to erect robust new subtribes and genera in this hemisphere. The same is not true for the Old World, however, and many treatments are considered preliminary and subject to change (Robinson, 1999b; 2007, Keeley & Robinson, 2009). Thus even though the name *Vernonia* is still applied to species in Africa, India, Asia and Malaysia they must eventually be better studied and then placed in other genera (Keeley & Robinson, 2009). Since taxonomic treatments of the Old World species are lacking for many areas, however, it may be some time before new generic reassignments can be made with confidence.

It was the purpose of this study to establish a phylogeny for the Vernoniae of Thailand using information from cpDNA and nDNA sequences, morphology and palynology. Morphology and palynology used alone, and sequence data used alone failed to resolve generic and species relationships.

2. Materials and methods

2.1 Phenetic analysis

Twenty-six binary and 20 multistate characters for 42 species were obtained from studies of morphology, micro-hairs and pollen (Table 3.1). At least 15 specimens per taxon were examined. A number of these characters had previously been shown to be phylogenetically informative by Bunwong & Chantaranonthai (2008) and thus their results were included in the final data matrix. The data were analyzed using MacClade 4.03 (Maddison & Maddison, 2001) and imported into PAUP* 4.0b10 (Swofford, 2002) for UPGMA cluster analysis.

Table 3.1 Morphological characters and character states included in the study.

No.	Characters and character states
1	Habit; erect herb (0), scandent (1), shrub (2), tree (3)
2	Stem; acauline (0), cauline (1)
3	Stem rib; absent (0), present (1)
4	Stem vestiture; puberulous (0), tomentose (1), villose-pilose (2), sericeous (3)
5	Petiole length; 0-1 mm (0), > 1 mm (1)
6	Leaf shape; ovate or lanceolate (0), obovate or oblanceolate (1), elliptic or oblong (2)
7	Leaf margin; crenate (0), serrate (1), entire or undulate (2)
8	Leaf apex; obtuse or rounded (0), acute or acuminate (1), apiculate or cuspidate (2), caudate or aristate (3)
9	Leaf base; attenuate (0), cuneate or obtuse (1)
10	Leaf texture; coriaceous (0), chartaceous (1)
11	Leaf hair: whip-shaped with long terminal cell; absent (0), present (1)
12	Leaf hair: whip-shaped with short terminal cell; absent (0), present (1)
13	Leaf hair: filiform; absent (0), present (1)
14	Leaf hair: flagellate; absent (0), present (1)
15	Leaf hair: cylindrical; absent (0), present (1)
16	Leaf hair: T-shaped; absent (0), present (1)
17	Vestiture on upper leaf surface; puberulous (0), tomentose (1), villose-pilose (2), sericeous (3), scabrous (4)
18	Vestiture on lower leaf surface; puberulous (0), tomentose (1), villose-pilose (2), sericeous (3), scabrous (4)
19	Gland on upper leaf surface; absent (0), present (1)
20	Gland on lower leaf surface; absent (0), present (1)
21	Capitulescence type; spicate (0), paniculate (1), solitary (2), scapose (3), corymbose (4)
22	Phyllary rows; 1-2 (0), 3-5 (1), > 5 (2)
23	Phyllary arrangement; decussate (0), imbricate (1)
24	The middle phyllary shape; ovate (0), lanceolate (1), oblong (2)
25	The outer and the middle phyllary apex; obtuse (0), acute or acuminate (1), apiculate or aristate (2), spinose (3)
26	The outer and the middle phyllary with reflexed apex; absent (0), present (1)
27	Phyllary margin; ciliate (0), filiferous (1), spinulose (2), entire (3)
28	Phyllary vestiture; puberulous (0), tomentose (1), villose-pilose (2), arachnoid (3), sericeous (4)
29	Capitate gland on phyllaries; absent (0), present (1)
30	Number of floret per a capitulescence; 1-4 (0), 5-30 (1), >30 (2)
31	Corolla symmetry; actinomorphic (0), zygomorphic (1)
33	Corolla hairs; absent (0), present (1)
34	Pollen type; echinate (0), sublophate (1), lophate (2)
35	Pollen furrow; absent (0), present (1)
36	Pollen pore shape; circular (0), semicircular (1)
37	Number of pollen pore; 3 pores (0), 6 pores (1)

Table 3.1 Morphological characters and character states included in the study. (Cont.)

38	Pollen spine length; 0 μ m (0), >0-5 μ m (1), >5 μ m (2)
39	Pollen columella; prominent (0), inconspicuous (1)
40	Pollen micropuncta; absent (0), present (1)
41	Achene shape; turbinate (0), clavate (1), terete (2)
42	Achene hairs; absent (0), present (1)
43	Achene glands; absent (0), present (1)
44	Number of achene rib; 1-9 (0), $\geq$ 10 (1)
45	Carpopodium; absent (0), present (1)
46	Pappus; absent (0), present in every floret (1), present in some florets (2)

Table 3.2 Thai Vernoniaceae sequenced in this study. Collection localities, voucher information and GenBank accession numbers follow each taxon. S. Bunwong's collections are deposited in KKU, QBG and US, those of other collectors in QBG.

Species	Locality (Province)	Voucher information	GenBank Accession Number		
			ITS	ndhF	trnL
<i>Acilepis attenuata</i> (I)	Udon Thani	S. Bunwong 347	HQ158368	HQ158470	HQ15841
<i>A. attenuata</i> (II)	Khon Kaen	S. Bunwong 351	HQ158369	HQ158471	HQ15841
<i>A. attenuata</i> (III)	Loei	S. Bunwong 373	HQ158370	HQ158472	HQ15842
<i>A. attenuata</i> (IV)	Sakon Nakhon	S. Bunwong 354	HQ158371	HQ158473	HQ15842
<i>A. chiangdaoensis</i>	Chiang Mai	S. Bunwong 78	-	HQ158474	HQ15842
<i>A. divergens</i> (I)	Chiang Mai	S. Bunwong 366	HQ158372	HQ158475	HQ15842
<i>A. divergens</i> (II)	Ciang Mai	S. Bunwong 377	HQ158373	HQ158476	HQ15842
<i>A. kingii</i>	Chiang Mai	S. Bunwong 77	HQ158374	HQ158477	HQ15842
<i>A. namnaoensis</i>	Chaiyaphum	S. Bunwong 385	HQ158375	HQ158478	HQ15842
<i>A. ngaoensis</i>	Ranong	S. Bunwong 386	HQ158376	HQ158479	HQ15842
<i>A. peguensis</i>	Loei	S. Bunwong 372	HQ158377	HQ158480	HQ15842
<i>A. pseudosutepensis</i>	Tak	S. Bunwong 388	HQ158378	HQ158481	HQ15842
<i>A. saligna</i>	Mae Hong Son	S. Bunwong 357	HQ158379	HQ158482	HQ15843
<i>A. silhetensis</i>	Chiang Mai	S. Bunwong 364	HQ158380	HQ158483	HQ15843
<i>A. sutepensis</i> (I)	Chiang Mai	S. Bunwong 361	HQ158381	HQ158484	HQ15843
<i>A. sutepensis</i> (II)	Chiang Mai	S. Bunwong 367	HQ158382	HQ158485	HQ15843
<i>Camchaya gracilis</i>	Ubon Ratchathani	S. Bunwong 346	HQ158383	HQ158486	HQ15843
<i>C. loloana</i> (I)	Khon Kaen	S. Bunwong 330	HQ158384	HQ158487	HQ15843
<i>C. loloana</i> (II)	Ubon Ratchathani	S. Bunwong 339	HQ158385	HQ158488	HQ15843
<i>C. loloana</i> var. <i>mukdahanensis</i> (I)	Mukdahan	S. Bunwong 338	HQ158386	HQ158489	HQ15843
<i>C. loloana</i> var. <i>mukdahanensis</i> (II)	Ubon Ratchathani	S. Bunwong 343	HQ158387	HQ158490	HQ15843
<i>C. pentagona</i>	Ubon Ratchathani	S. Bunwong 344	HQ158388	HQ158491	HQ15843
<i>C. spinulifera</i> (I)	Udon Thani	S. Bunwong 327	HQ158389	HQ158492	HQ15844
<i>C. spinulifera</i> (II)	Sakon Nakhon	S. Bunwong 332	HQ158390	HQ158493	HQ15844
<i>C. spinulifera</i> (III)	Nong Khai	S. Bunwong 336	HQ158391	HQ158494	HQ15844
<i>C. tenuiflora</i>	Loei	S. Bunwong 348	HQ158392	HQ158495	HQ15844
<i>Camchaya</i> sp.1	Udon Thani	S. Bunwong 328	HQ158393	HQ158496	HQ15844

Table 3.2 Thai Vernoniaceae sequenced in this study. Collection localities, voucher information and GenBank accession numbers follow each taxon. S. Bunwong's collections are deposited in KKU, QBG and US, those of other collectors in QBG. (Cont.)

Species	Locality (Province)	Voucher information	GenBank Accession Number		
			ITS	ndhF	trnL
<i>Cyanthillium cinereum</i>	Loei	S. Bunwong 350	HQ158470	HQ158497	HQ158445
<i>Cyanthillium hookerianum</i>	Unon Ratchathani	S. Bunwong 341	HQ158471	HQ158498	HQ158446
<i>Decaneuropsis cumingiana</i>	Petchaboon	S. Bunwong 74	HQ158472	HQ158499	HQ158447
<i>D. eberhardtii</i>	Chaiyaphum	S. Bunwong 384	HQ158473	HQ158500	HQ158448
<i>D. garrettiana</i>	Chiang Mai	S. Bunwong 75	HQ158474	HQ158501	HQ158449
<i>Elephantopus mollis</i>	Ubon Ratchathani	S. Bunwong 340	HQ158475	HQ158504	HQ158452
<i>E. scaber</i> (I)	Udon Thani	S. Bunwong 325	HQ158476	HQ158505	HQ158453
<i>E. scaber</i> (II)	Sakon Nakhon	S. Bunwong 334	HQ158477	HQ158506	HQ158454
<i>E. scaber</i> var. <i>penicillatus</i>	Ubon Ratchathani	S. Bunwong 345	HQ158478	HQ158507	HQ158455
<i>Gymnanthemum cylindriceps</i>	Chiang Mai	S. Bunwong 378	HQ158479	HQ158508	HQ158456
<i>Iodocephalopsis eberhardtii</i>	Chiang Mai	S. Bunwong 335	HQ158480	HQ158509	HQ158457
<i>Koyamasia calcarea</i>	Chiang Mai	P. Suksathan 2847	HQ158481	HQ158510	HQ158458
<i>Kurziella gymnoclada</i>	Khon Kaen	S. Bunwong 391	HQ158407	HQ158511	HQ158459
<i>Monosis volkameriifolia</i>	Chiang Mai	S. Bunwong 362	HQ158408	HQ158512	HQ158460
<i>Pseudelephantopus spicatus</i> (I)	Ubon Ratchathani	S. Bunwong 342	HQ158409	HQ158513	HQ158461
<i>P. spicatus</i> (II)	Chiang Rai	S. Bunwong 352	HQ158410	HQ158514	HQ158462
<i>Strobocalyx arborea</i>	Loei	M. Norsangsri 1052	HQ158411	HQ158515	HQ158463
<i>S. solanifolia</i>	Loei	S. Bunwong 395	HQ158412	HQ158516	HQ158464
<i>Tarlmounia elliptica</i> (I)	Khon Kaen	S. Bunwong 390	HQ158413	HQ158517	HQ158465
<i>T. elliptica</i> (II)	Khon Kaen	S. Bunwong 392	HQ158414	HQ158518	HQ158466
<i>Vernonia cinerea</i> var. <i>montana</i> (I)	Mae Hong Son	S. Bunwong 356	HQ158415	HQ158519	HQ158467
<i>V. cinerea</i> var. <i>montana</i> (II)	Chiang Mai	S. Bunwong 371	HQ158416	HQ158520	HQ158468
<i>V. curtisii</i>	Chiang Rai	S. Watthana 875	HQ158417	HQ158521	HQ158469

Table 3.3 Morphological data matrix of 44 species of Thai Vernoniaeae. The Asterisk (*) indicates species not included in the molecular study.

	1111111111222222222233333333334444444
Taxon/Node	1234567890123456789012345678901234567890123456
<i>Acilepis attenuata</i>	0010111110100000440132103113020112000111011111
<i>A. chiagdaoensis</i>	011210111001001044011112013110102000111111111
<i>A. divergens</i>	0112101110010000441141100013110102000110101111
<i>A. kingii</i>	0110101110010000441111100013010112000110011111
<i>A. namnaoensis</i>	0112111110010000441111103013110102000100011111
<i>A. ngaoensis</i>	0110111110010000441122103013010102000100211111
<i>A. peguensis</i>	0113111100010000441111101013110102000100001111
<i>A. principis*</i>	0110101110010000440111102013010102000100010111
<i>A. pseudosutepensis</i>	0113111110100000440111101013110102000100011111
<i>A. saligna</i>	0113001110010000441111102013010112000110011111
<i>A. silhetensis</i>	0112011110010000441142101113020102000110001011
<i>A. squarrosa*</i>	0112011010010000441122101013020112000110010111
<i>A. sutepensis</i>	011200101001000044??11101013110102000111011111
<i>Camchaya gracilis</i>	0102022000010000440141101033110112011110111000
<i>C. loloana</i>	0102001001010010441111113123120112011110300102
<i>C. loloana</i> var. <i>mukdahanensis</i>	0102001001010010441111113023120112011110300102
<i>C. pentagona</i>	0102101001010010441112113023120112011110300002
<i>C. sp.</i>	0100121001000011001141101030120112011110300102
<i>C. spinulifera</i>	0102001001010011441122113023020112011110300102
<i>C. tenuiflora</i>	0102101001010010441111113023120112011110301102
<i>Cyanthillium cinereum</i>	0113101101000011330111111013110112000101111111
<i>Cy. hookerianum</i>	0113121001000001031111113013120112000101001011
<i>Decaneuropsis cumingiana</i>	1101122110010010031111101011010112100201110111
<i>D. eberhardtii</i>	1100122110000010000011101010010002100201010111
<i>D. garrettiana</i>	1100122111010010000112110010010101100210310111
<i>Elephantopus mollis</i>	0102120101001010221110021012001002100110110111
<i>El. scaber</i> var. <i>penicillatus</i>	0002110000001010220130021012101002000110310111
<i>El. scaber</i> var. <i>scaber</i>	0003110001001010220130021012001002000110110111
<i>Gymnanthemum cylindriceps</i>	3100111101010010000142100010010101100201011111
<i>Iodocephalopsis eberhardtii</i>	0100121101010010001141101013110112100211001100
<i>Koyamasia calcarea</i>	0100001101010000440121101030120102011110100102
<i>Kurziella gymnoclada</i>	0110011011010000441101110010010000100201010011
<i>Monosis parishii</i>	2101121100000100010111101013010102100010011111
<i>M. volkameriifolia</i>	3102111100000100000111101013010102100010011111
<i>Pseudelephantopus spicatus</i>	0000111000001000000100021030000002000110110111
<i>Sparganophoros sparganophora</i>	0100121101000010001121101010020102000101001001
<i>Strobocalyx arborea</i>	3100122310001000001111100010010100100201011011
<i>St. solanifolia</i>	1101101111001100010111100011010110100201011111
<i>Tarlmounia elliptica</i>	1103121110000001030011100013110100100201001011
<i>Vernonia curtisii</i>	0100101101010000001122111130020112000110101111
<i>V. cinerea</i> var. <i>montana</i>	0112101101010001021111111012010002000101011111
<i>V. pulicarioides*</i>	0112021110010000440122111014020112003100010011

2.2 Molecular Data

2.2.1 Taxon sampling and nomenclature

Thirty-five species in 16 genera of Thai Vernonieae were sampled using herbarium and silica gel preserved specimens (Table 3.2). Nomenclature is based on that of Robinson (1990, 1999b), Robinson & Skvarla (2006, 2007, 2009) and Robinson *et al.* (2008). Two species of *Distephanus* Cass. were chosen as the outgroup following the work of Keeley & Jansen (1994) and Keeley *et al.* (2007).

2.2.2 DNA extraction, amplification and sequencing

Total genomic DNA was extracted using Qiagen DNeasy Plant Mini Kits following the instructions supplied. Primer ITS5A (Downie & Katz-Downie, 1996). Primers used to amplify and sequence the trnL-F region of cpDNA were designed by Taberlet *et al.* (1991) and those used for the 3' end of the ndhF region were designed by Jansen (1992). All primer sequences are given in Table 3.3. For the PCR amplification reactions, each 25 µl PCR reaction cocktail contained 14 µl of sterile water, 2.5 µl of 10x NH₄ PCR reaction buffer (Bioline), 2 µl of 20 mM dNTPs (Promega) in an equimolar ratio, 1.25 µl of 50 mM magnesium chloride, 0.5 µl of 10 mg/ml Bovine Serum Albumin (Sigma), 1 µl of a 10 mM concentration of the forward primer, 1 µl of a 10 mM concentration of the reverse primer, 0.25 µl of Biolase Red DNA polymerase enzyme (1 unit/µl from Bioline), and 2.5 µl of template DNA. The amount of template DNA was adjusted when necessary to generate sufficient PCR products for DNA sequencing.

The amplification reactions were conducted in a PTC-100 thermal cycler (MJ Research, USA). The PCR profile consisted of an initial preheating at 94 °C for 2 minutes followed by 35 cycles of 1 min at 94 °C, followed by 1 minute at 48 °C (54 °C for cpDNA) and 2 minutes at 72 °C. Primer extension time was increased by 4 second (7 second for cpDNA) for each subsequent reaction cycle. An additional seven minutes extension at 72 °C was added for completion of unfinished DNA strands. All PCR products were quantified by agarose gel electrophoresis in comparison to an aliquot of product with a known quantity of a HyperladderII (Bioline; Ohio, USA). The remainder was stored at 4 °C until utilized. PCR products were purified for sequencing using a mixture of Shrimp alkaline phosphatase and exonuclease (ExoSap) following recommendations from the manufacturer. The cycle

presequencing reactions were done using PTC-100 thermal cycler (MJ Research, USA), incubation at 37 °C for 15 minutes and enzymatic inactivation at 80 °C for 15 minutes. The purified products were sequenced on ABI 3730XL capillary-based DNA sequencers at the center of Advanced Studies in Genomics, Proteomics and Bioinformatics (ASGPB), University of Hawaii at Manoa.

Table 3.4 Primer sequences used for PCR and cycle sequencing

Name	Sequence (5'-3')
ITS5A	GGA AGG AGA AGT CGT AAC AAG G
ITS4	TCC TCC GCT TAT TGA TAT GC
trnL C	CGA AAT CGG TAG ACG CTA CG
trnL F	ATT TGA ACT GGT GAC ACG AG
ndhF 1603	CCT YAT GAA TCG GAC AAT ACT ATG C
ndhF +607	CCT YAT GAA TCG GAC AAT ACT ATG C

2.2.3 Sequence alignment

For each accession, contiguous sequences were compiled with Sequencer 4.8 (Gene Codes, Ann Arbor, Michigan, USA) and edited manually. All sequences were deposited in GenBank (Table 3.2). Sequence alignments were generated by the program MUSCLE, Multiple Sequence Comparison by Log-Expectation, version 3.7 (Edgar, 2004) and adjusted manually in Se-Al sequence alignment editor (Rambaut, 1996).

2.2.4 Phylogenetic analyses

Data sets were analyzed individually and in combination. Similarly, the morphological data were analyzed separately and then in combination with the combined (concatenated) sequences. Analyses were conducted using Maximum Parsimony (MP) and Bayesian Analysis (BA) criteria as employed in PAUP* 4.0b10 (Swofford, 2002) and MrBayes 3.0b4 (Ronquist & Huelsenbeck, 2003), respectively. MP trees were generated with the following conditions; gaps treated as missing data, full heuristic search, tree-bisection-and-reconnection (TBR), 1000 random additions, one tree held at each step, and 1000 bootstrap replicates (Felsenstein, 1985). Bayesian

analysis was performed using the General Time Reversible model (GTR) using Markov Chain Monte Carlo (MCMC) simulations (Geyer, 1991) with four heated chains for one million generations. Four runs were conducted and each run was sampled every 100th generation. The first 1250 trees were discarded as the burn-in period, the number determined by generations to convergence. All trees saved from the independent runs (excluding burn-in) were used to construct 50% majority-rule consensus trees. Trees were drawn in PAUP*4.01b.10 (Swofford, 2002) or with the program MEGA 3.0 (Molecular Evolutionary Genetics Analysis) (Kumar *et al.*, 2004).

3. Results

3.1 Phenetic analysis

UPGMA analysis of the 46 characters scored for external morphological characters and for pollen revealed five clusters (Figure 3.1):

Group I. Subtribe Elephantopinae; *Elephantopus scaber*, *E. mollis* and *Pseudelephantopus spicatus*.

Group II. Subtribe Centrapalinae; *Camchaya gracilis*, *C. loloana*, *C. pentagona*, *C. spinulifera*, *C. tenuiflora*, *C. sp.*, and *Koyamasia calcarea*.

Group III. Subtribe Gymnantheminae; *Decaneuropsis cumingiana*, *D. eberhardtii*, *D. garrettiana*, *Gymnanthemum cylindriceps*, *Monosis parishii*, *M. volkameriifolia*, *Strobocalyx arborea*, *S. solanifolia* and *Tarlmounia elliptica*.

Group IV. Uncertain placement; *Iodocephalopsis eberhardtii*, *Sparganophoros sparganophora* and *Vernonia curtisii*.

Group V. Subtribe Erlangeinae; *Acilepis attenuata*, *A. chiangdaoensis*, *A. divergens*, *A. kingii*, *A. namnaoensis*, *A. ngaoensis*, *A. peguensis*, *A. principis*, *A. pseudosutepensis*, *A. saligna*, *A. silhetensis*, *A. squarrosa*, *A. sutepensis*, *Cyanthillium cinereum*, *C. hookerianum*, *Vernonia cinerea* var. *montana*, *Kurziella gymnoclada* and *Vernonia pulicarioides*.

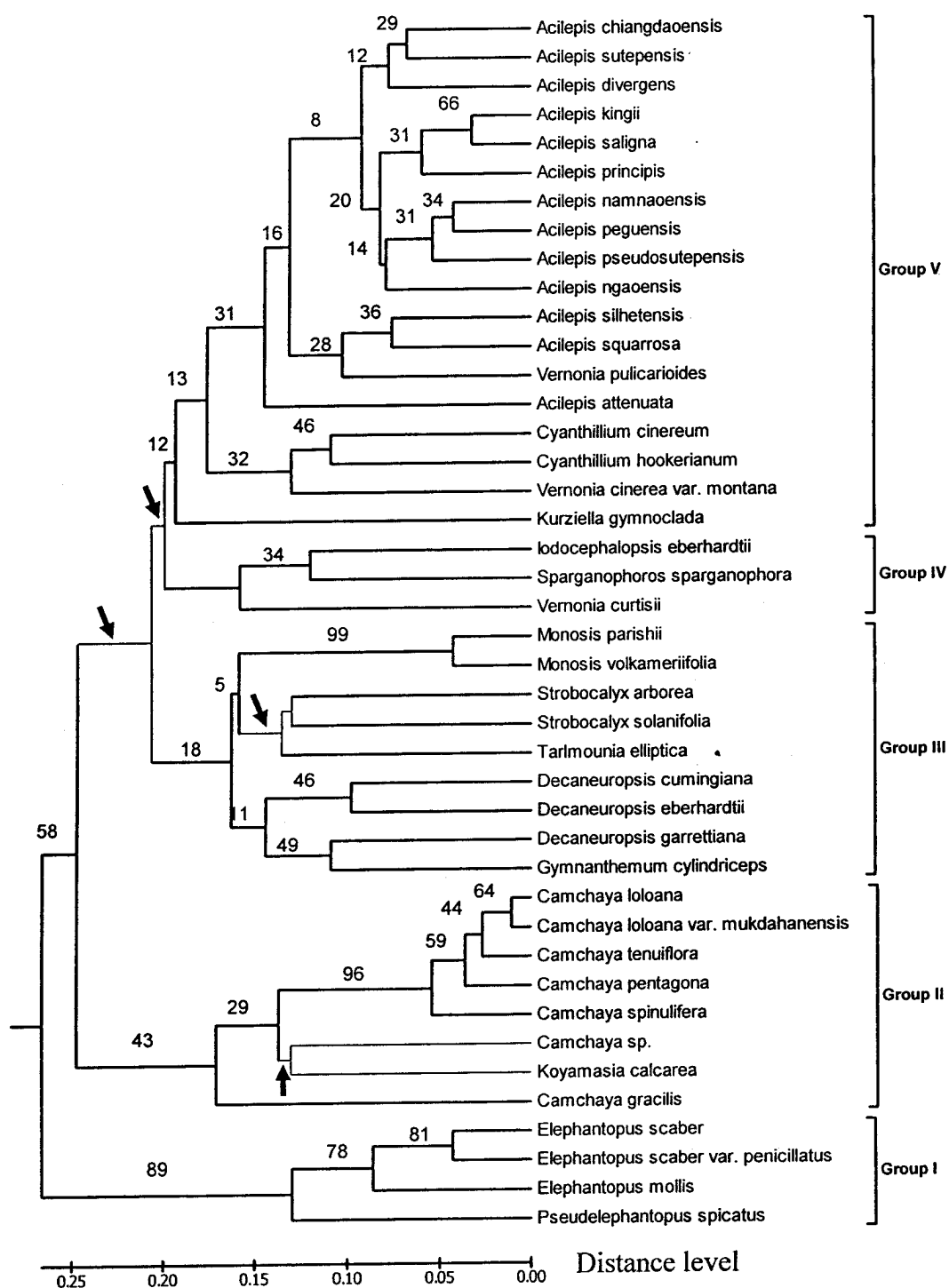


Figure 3.1 UPGMA tree of 42 Thai Vernoniaceae based on morphological characters. Numbers above the lines indicate bootstrap support (1000 replications). Arrows indicate that line lack of support in the bootstrap consensus tree.

3.2 Phylogeny

3.2.1 Maximum Parsimony analyses

The results of the MP analyses of the individual and the combined data sets (ITS, ndhF, trnL, morphological characters) show only slight differences between taxa. Multiple polytomies also prevent understanding of the larger scale subtribal relationships. This is especially true for the tree generated from trnL-F sequences alone and the tree resulting from morphological characters alone (Table 3.5, Figure 3.2). Even with the better resolved clades of the individual ITS and ndhF trees (Figures 3.2; A, B) and those produced by analyzing all the data sets in combination (Figure 3.3) relationships among the clades shown by MP remain unclear. Moderately- to well-supported monophyletic groups recognized in the latter combined analysis included *Acilepis/Koyamasia/Vernonia curtisii*, *Camchaya*, *Decaneuropsis*, *Elephantopus*, *Tarlmounia/Strobocalyx* and *Cyanthillium/Vernonia*, respectively. These generic groupings are consistent with those recognized in recent revisionary treatments by Robinson & Skvarla, 2006, 2007, 2009; Robinson *et al.* 2008)

Table 3.5 Summary of statistics for each and combined data sets resulting from MP analyses.

Partition	Aligned length	Informative character	% of informative character	Tree length	CI	RI
ITS	769	408	53.06	1461	0.548	0.845
ndhF	900	98	10.89	317	0.868	0.903
trnL-F	997	82	8.22	335	0.558	0.668
Morphology	46	46	100	261	0.287	0.728
ITS + ndhF + trnL-F	2666	588	22.05	2254	0.506	0.808
Molecular + Morphology	2712	634	23.38	2562	0.522	0.791

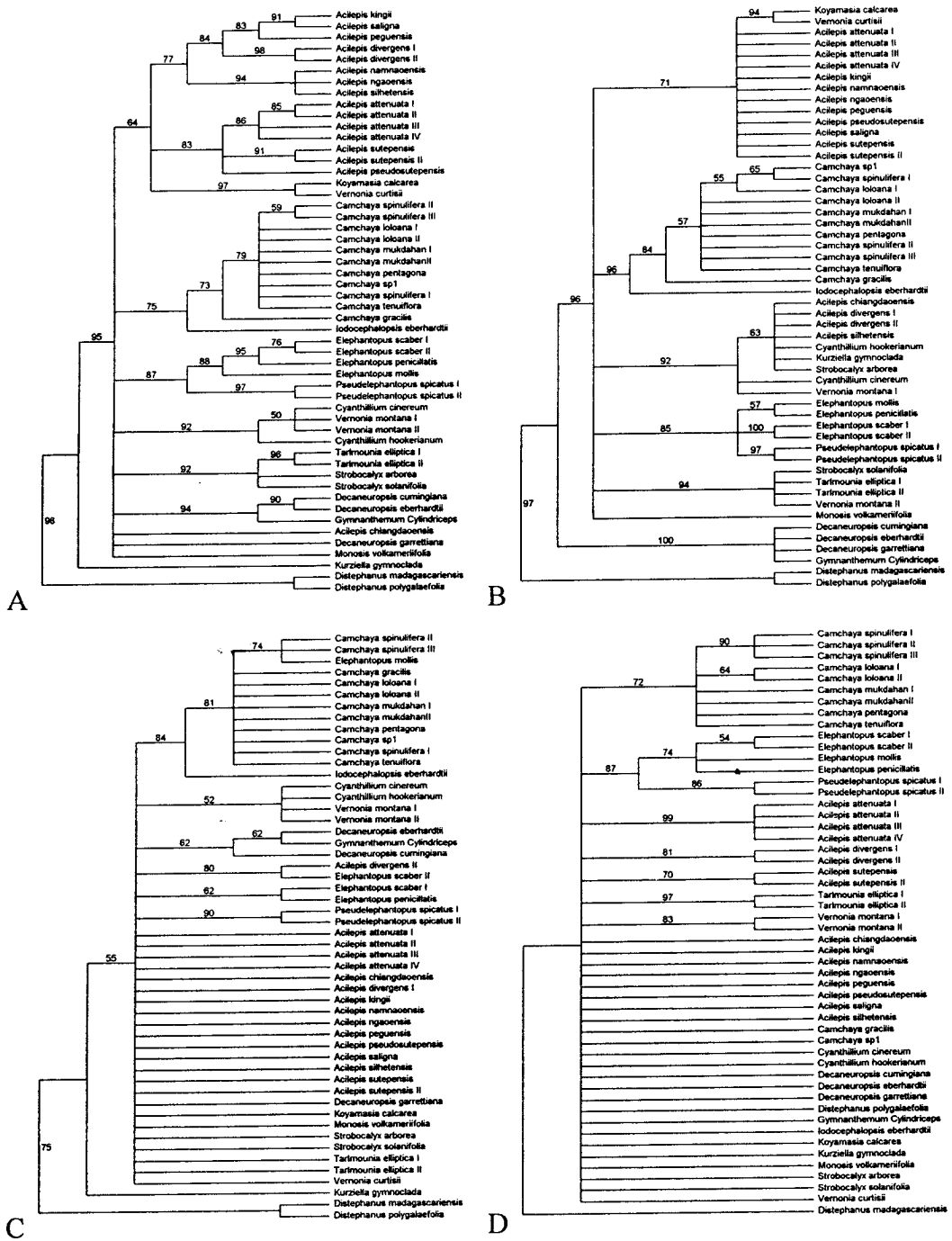


Figure 3.2 Consensus trees of MP analyses from single data sets: A. ITS, tree length 1461, CI 0.548, RI 0.845; B. ndhF, tree length 317, CI 0.868, RI 0.903; C. trnL-F, tree length 335, CI 0.558, RI 0.668; D. Morphology tree length 261, CI 0.287, RI 0.728. Numbers above the branches are bootstrap support > 50% (1000 replicates).

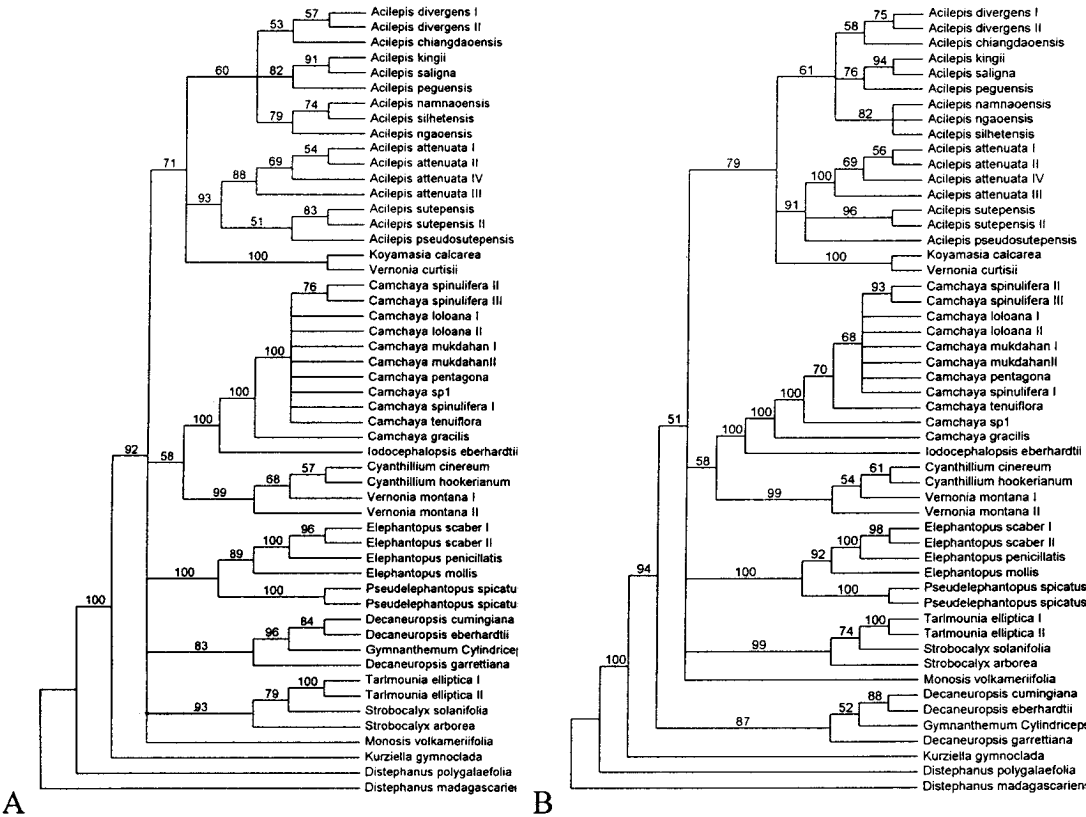


Figure 3.3 Consensus trees of the MP analyses: A. Concatenated molecular sequences (ITS + ndhF + trnL), tree length 2254, CI 0.506, RI 0.808; B. Combined molecular and morphological data sets, tree length 2562, CI 0.522, RI 0.791. The numbers above the branches are >50% bootstrap support (1000 replicates).

3.2.2 Bayesian Analysis

Fully resolved trees were obtained using BA with the combined data sets (Figure 3.4); the same monophyletic groups and genera (above) were identified as were shown in the MP analyses (Figure 3.3). *Kurziella gymnoclada*, a taxon not yet assigned to tribe, was basal to all other Thai Vernoneae, as was the case with the combined-data-sets MP trees. The most significant results of the BA analyses were the paraphyly of both the Gymnantheminae and the Erlangeinae. *Decaneuropsis* and *Tarlmounia/Strobocalyx*, subtribe Gymnantheminae (Robinson & Skvarla, 2007; Robinson *et al.*, 2008), are not closely related to each other as would be expected if they were, in fact, members of the same subtribe (Figure 3.4). Similarly, the

Erlangeinae is also paraphyletic with most members in the *Acilepis* group (Erlangeinae I) while *Cyanthillium* spp. and *Vernonia cinerea* var. *montana*, also thought to belong to the Erlangeinae, are more closely related to taxa in the subtribe Centrapalinae (Figure 3.4). *Monosis volkameriifolia* is sister to both the Erlangeinae (I & II) and the Centrapalinae. *Decaneuropsis*, on the other hand, holds a basal position similar to that of the African *Gymnantheminae* in Keeley *et al.*, 2007. The taxonomic implications of these relationships are discussed below.

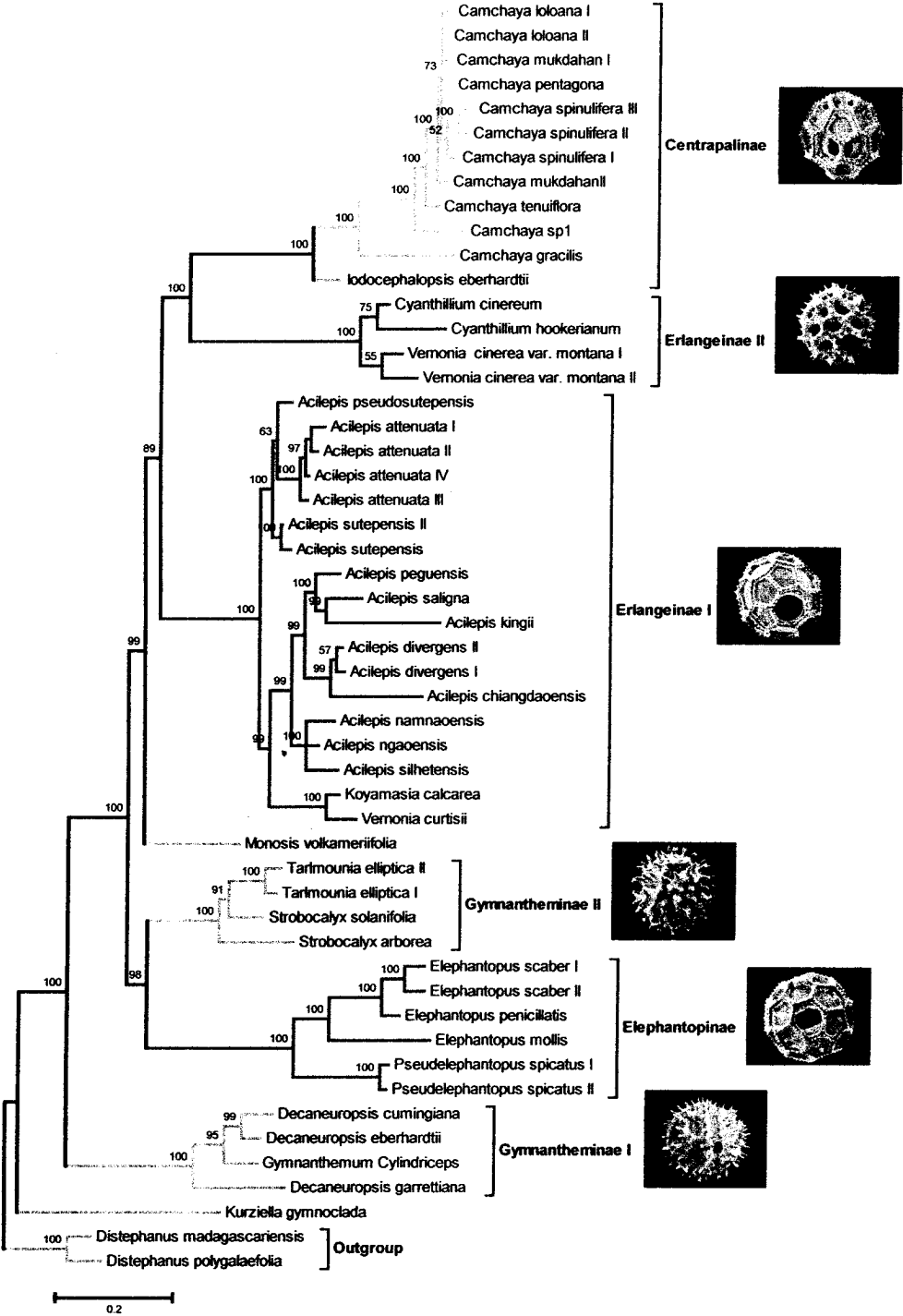


Figure 3.4 Consensus tree of BA analysis from a combined molecular and morphological data sets; run for 1×10^6 generations, model GTR, log-likelihood score -17253. Posterior probability values are given above lines. Color of lines indicate type of pollen; Blue = 3-colporate, Green = 3-porate, Purple = 6-porate.

4. Discussion

4.1 Taxonomic implications

The six clades identified in the combined data MP and BA analyses (Figures 3.3, 3.4) and the five groups revealed by UPGMA (Figure 3.1) are highly congruent. However, the paraphyly of both the Gymnantheminae and the Erlangeinae make new subtribal assignments likely, especially if relationships seen here are confirmed within the framework of a global tribal analysis such as that of Keeley *et al.* (2007). The lack of modern taxonomic treatments for the majority of the Old World Vernoniae is the principal reason for tribal misassignments as data on which to place taxa are sparse. As a result, it is inevitable that there will be (major) changes in subtribal boundaries among Old World taxa, and in the circumscription of genera and species within them. A tantalizing aspect to the relationships shown in this study, however, is the likelihood that there are separate (south/east) Asia-centered and Africa-centered Vernoniae lineages. These would derive from different sources/areas and likely evolved in isolation from each other. Several different lineages have also been identified within the New World species (Keeley *et al.*, 2007), but such smaller monophyletic divisions were not apparent among Old World species until now.

4.1.1 Subtribe Centrapalinae

On the basis of both morphology and DNA sequence data the genus *Camchaya* (Centrapalinae) is well supported. The genus is characterized by an annual habit, erect stems with cauline leaves, achenes without a carpopodium, a deciduous pappus, and echinolophate six-porate pollen. Bunwong *et al.* (2009) distinguished the genus *Iodocephalopsis* from *Camchaya* based on the absence of a spine at the tip of the involucre bracts, differences in bract shape, and on the tricolporate pollen of *Iodocephalopsis* rather than the six-porate grains of *Camchaya*. Such a distinction is strongly supported (p.p. 100%) by the phylogenetic relationships revealed in the BA tree. Although both genera are clearly within a monophyletic Thai Centrapalinae Robinson (pers. comm.) expressed doubt about the existence of true Centrapalinae in Thailand because the taxa are morphologically different from those in Africa. As a result, Thai genera will need to be put into an analysis in combination with African Centrapalinae taxa from before a final decision can be made as to whether *Camchaya* and *Iodocephalopsis* belong in this subtribe or another possibly a new one.

4.1.2 Subtribe Elephantopinae

The subtribe Elephantopinae is clearly monophyletic like the Centrapalinae. *Elephantopus* and *Pseudelephantopus* are also strongly supported as distinct from each other (Figures 3.1, 3.3, 3.4). The taxa in the Elephantopinae are characterized by an annual to biennial herbaceous/subshrubby habit, liguliform zygomorphic corollas, capitula clustered within foliose bracts, filiform hairs on the leaf surfaces and echinolophate triporate pollen. Keeley *et al.* (2007) found that *Elephantopus* is New World in origin. There are multiple species of *Elephantopus* in eastern North America and Brazil, but little is known of Old World taxa. Additionally, *Elephantopus mollis* and *E. scaber*, as well as *Pseudelephantopus spicatus*, are found widely across tropical regions worldwide as weeds of disturbed areas. In the analyses conducted in this study the Elephantopinae are sister to two southeast Asian/Malayasian Gymnantheminae, *Tarlmounia elliptica*, a monotypic genus with a shrubby, scandent habit, and *Strobocalyx arborea*, a timber tree up to 30 m tall (Keeley *et al.*, 2007, Robinson *et al.*, 2008). These findings differ substantially from those of Keeley *et al.* (2007), however. In the latter study, *Tarlmounia* and *Strobocalyx* together were sister to the relict American subtribes Stokesiinae and Leiboldiinae. The Elephantopinae, on the other hand, were in a separate distantly related clade with a sister group whose numerous taxa are much more widespread throughout the Americas (the subtribe Lepidaploinae). The close relationship of *Tarlmounia/Strobocalyx* to taxa in the Leiboldiinae and Stokesiinae supports a connection between Old and New World Vernoniaceae as proposed by Keeley *et al.* (2007) to represent a transatlantic dispersal from the Old to the New World. However, the ultimate phylogenetic position of the Elephantopinae remains to be confirmed as there are putatively six other species in east Asia and Malaysia that have not yet been sequenced. Adding these to geographically inclusive analyses may alter currently perceived relationships within and between hemispheres.

4.1.3 Subtribe Gymnantheminae

The constitution of the Gymnantheminae has been in flux since the initial establishment of the subtribe by Robinson in 1999. In a number of cases new taxa such as *Decaneuropsis* and *Tarlmounia* have been added, (*i.e.*, Robinson, 2007; Robinson *et al.*, 2007, 2008) and equally, some have been removed and placed in their

own subtribes *i.e.*, *Distephanus*, subtribe Distephaneae (Keeley & Robinson, 2009). The Gymnantheminae is well represented in Africa and are among the basal members of the tribe (Keeley *et al.*, 2007). In addition to the large tree species of the Old World, *i.e.*, *Strobocalyx arborea*, there are also shrubs/treelets, and less commonly, herbs in this subtribe. Taxa frequently have deciduous involucre bracts and are characterized by blunt sweeping hairs on the style, an indurate appendage on the anthers, reflexed and deeply divided corolla lobes and tricolporate, non-lophate pollen (Robinson, 2007; Robinson *et al.*, 2008; Keeley & Robinson, 2009).

There are two distinct clades of Thai Gymnantheminae, making the subtribe as now constituted paraphyletic (Figure 3.4). The Gymnantheminae I is composed of species of the recently erected genus, *Decaneuropsis*, (Robinson & Skvarla, 2007) plus one species of *Vernonia* that has yet to be transferred into it. *Decaneuropsis* also holds a basal position within the Thai Vernonieae, similar to the position of the African Gymnantheminae species in the tribal phylogeny (Keeley *et al.*, 2007). *Decaneuropsis* differs from African Gymnantheminae, however, in that it is characterized by a low-growing scandent habit, differences in corolla morphology and has thrysiform rather than corymbiform inflorescences (Robinson *et al.*, 2007). Whether this genus should be placed in a separate tribe from the other Gymnantheminae will depend on the results of analyses that include putative members of both this subtribes in Thailand and Africa.

The Gymnantheminae II taxa (Figure 3.4) may also need to be recognized as a separate subtribe. In the study by Keeley *et al.* (2007) *Strobocalyx arborea* and *Tarlmounia elliptica* plus the New World subtribes Stokesiinae and Leiboldiinae formed a clade sister to all other New World Vernonieae (Keeley *et al.*, 2007, Figure 2) or, alternatively, were included within the New World clades (their Figure 3). In both cases *Strobocalyx/Tarlmounia* plus Stokesiinae/Leiboldiinae were distant from the (basal) African Gymnantheminae. More analyses with New and Old World Vernonieae will be needed in order to establish the correct position of these taxa, however.

4.1.4 Subtribe Erlangeinae

The Erlangeinae, like the Gymnantheminae, are paraphyletic (Figure 3.4). Also like the Gymnantheminae, no African taxa were included in analyses

performed during this study and hence the relationships to other members of the subtribe, including the African type genus *Erlangea*, are unknown. There are 21 genera in the Erlangeinae, all of which occur in Africa; only two (those included in this study) have ranges that extend beyond Africa (Keeley *et al.*, 2007). It seems highly likely that Thai taxa may not belong to the Erlangeinae, but rather to a tribe of their own.

Within the Thai Erlangeinae, as presently classified, (Figure 3.4) are two paraphyletic subclades. One includes the genus *Acilepis* + (*Koyamasia calcarea* and *Vernonia curtisii* (Erlangeinae I)) and the other *Cyanthillium* + (*Vernonia cinerea* var. *montana* (Erlangeinae II)). The Erlangeinae I is strongly monophyletic and because of this does not support maintaining *Koyamasia* as a separate genus, but rather transferring it to *Acilepis*. Supporting this conclusion are low rates of sequence divergence (Table 3.5) that are well within the range found for other Compositae genera. Additionally, if *Koyamasia* is retained as a separate genus it will force *Acilepis* to be paraphyletic, an untenable solution (Keeley *et al.*, 2007; Funk *et al.*, 2009). *Koyamasia calcarea* and *V. curtisii* are morphologically distinct from most other *Acilepis*, the likely result of their limestone soil-restricted distribution in the mountains of Thailand. It may be that a lineage of limestone-adapted taxa evolved within *Acilepis* in specific areas where this soil type predominates and where soil types more common in the rest of Thailand are not found.

The subtribal position of *Cyanthillium* is also unclear, especially as it relates to the otherwise African Erlangeinae (II) (Figure 3.4). If the sister group relationship of *Cyanthillium* and *Camchaya/Iodocephalopsis* holds up when other New and Old World taxa are added to the analysis then it would be more logical to either a) create a new subtribe for *Cyanthillium* or b) to include it in the Centrapalinae. Which of these approaches is best overall will depend on any further evidence of paraphyly or its lack among *Cyanthillium* species in the New World, as well as refining subtribal concepts for Thai Vernonieae overall. At this point final decisions must, as in many of the other cases, wait on information yet to be obtained.

5. Conclusions

Neither molecular nor morphological data alone can provide a resolved phylogeny for the Thai Vernonieae. Instead all the data must be used together. Additionally, it is only BA that provides a resolved phylogeny (*i.e.*, Figures 3.2, 3.3 versus Figure 3.4), similar to the results of Keeley *et al.* (2007). It is also clear that for Thai Vernonieae some subtribal assignments are in need of clarification, especially for the Erlangeinae and the Gymnantheminae. *Cyanthillium* is not closely related to *Acilepis*, both of which are currently assigned to the Erlangeinae (Robinson, 2007), and in the Gymnantheminae, *Decaneuropsis* is only distantly related to *Tarlmounia* and *Strobocalyx*. Additionally, the latter two taxa were found to be most closely related to the New World not the Old World species by Keeley *et al.* (2007). Given that the Erlangeinae, the Gymnantheminae, and the Centrapalinae are found predominantly in Africa, but are also distributed elsewhere in the Old World, the location of the closest relatives of Thai taxa is as yet unknown. It is equally unclear if there are any true Gymnantheminae in Thailand (Robinson, pers. comm.). This makes it likely that new subtribes will need to be created to reflect the monophyly of the Thai species groups and their differences from African taxa, for example. *Kurziella gymnoclada*, currently unplaced, will also need to be included in a broader analysis of Vernonieae within the Old World in order to ascertain its affinities.

Despite current gaps in our knowledge of relationships within the tribe it is an exciting time for research in the Vernonieae of southeast Asia. There is now a regional phylogeny where none existed before that will allow for testing of hypotheses of relationships over a wider geographic area (the Old World). Of particular interest are the relationships of taxa now putatively in the same subtribe, but found in different areas of Asia and Africa. Thailand is important in tracing these relationships because it is located at the crossroads of biotic migrations westward from Malaysia and eastward from India and Africa. Understanding these historical pathways of dispersal will tell us much about the evolution and radiation of the Vernonieae in the Old World.

CHAPTER IV

GENERAL CONCLUSION AND DISCUSSIONS

Systematic study of tribe Vernonieae in Thailand was conducted based on morphology and on molecular techniques. The first publications, specimen examinations, descriptions with distinguishing characters are illustrated and habitat and distribution maps provided. The results show that there are 51 taxa in five subtribes, 16 genera and 48 species. Fourteen species are endemic to Thailand; seven in *Acilepis*, *A. chiangdaoensis*, *A. doichangensis*, *A. namnaoensis*, *A. ngaoensis*, *A. principis*, *A. sutepensis* and *A. pseudosutepensis*, four in *Camchaya*, *C. pentagona*, *C. spinulifera*, *C. tenuiflora* and *C. sp.* and three not yet placed in any subtribe, *Koyamasia calcarea*, *Vernonia curtisii* var. *tomentosa* and *V. pseudobirmanica*. Moreover, two new genera are published here. The first genus is the monotypic *Iodocephalopsis* formerly in the genus *Iodocephalus*. The second one, *Kurziella*, is also monotypic and was formerly *Vernonia gymnoclada*. Both of them are primarily found in Myanmar and Indo-China. In addition, one new combination is proposed; *Iodocephalus gracilis* Gagnep is now *Camchaya gracilis*. *Camchaya* is the only genus with 6-porate pollen, a feature found in the former *Iodocephalus gracilis* and therefore wrongly placed in that genus. Two species are also newly recorded for Thailand. They are *C. gracilis* previously reported only in the neighbouring countries, Laos and Cambodia, and *Pseudelephantopus spicatus* which is never previously been collected in Thailand or any of its neighbouring countries. Finally, one species of genus *Camchaya* (*C. sp.*) is likely new to science and further studies are underway to verify this.

Members of the Vernonieae grow in many different forest types from low (0 m) up to high (2,000 m) elevations. Most species are found in northern and northeastern floristic regions, while only a few species occur elsewhere (*i.e.* east and southwest). Most species are found at high elevation in open areas within dipterocarp, pine-oak and hill evergreen forests. Some species are restricted to limestone such as *Koyamasia calcarea*, *Vernonia birmanica* and *V. curtisii*, while others grow in lowland saline

soil, i.e. *Kurziella gymnoclada* and *Tarlmounia elliptica*. Eight species are described on the basis of only a small number of field collections. This is due to their rarity, restricted habitats, and poor distributional information. These are *Acilepis doichangensis*, *A. tonkinensis*, *A. virgata*, *Camchaya kampoensis*, *Etulia conyzoides*, *Vernonia birmanica*, *V. pseudobirmanica* and *V. pulicarioides*.

Phenetic groupings based on 46 morphological characters for the 42 species in this study were established based on habit, leaf, flower, achene and pollen. The results, shown in the UPGMA phenogram (Fig. 3.1) are five groups which correlate with the Vernoniae subtribal classification of Keeley and Robinson (2009) and are also similar to those clades identified in the phylogenetic trees of the combined molecular and morphological data sets (Fig 3.3, 3.4). These phenetic groups are approximately equivalent to the following clades:

- Group I = Elephantopinae
- Group II = Centrapalinae
- Group II = Gymnantheminae I & II
- Group IV and V = Erlangeinae I & II and Centrapalinae

The phylogenetic analyses of combined ITS, ndhF, trnL sequences and the morphological data set gave the best resolved trees whereas no single partition alone was sufficient to provide a fully resolved phylogeny. BA shows better resolution and higher support values than MP analyses. The phylogenetic trees reveal that the Thai Vernoniae are monophyletic. However, not all of the subtribes are similarly monophyletic, at least as currently placed to subtribe. For example, Gymnantheminae is polyphyletic and the Erlangeinae is paraphyletic. Others, such as the Centrapalinae and Elephantopinae are monophyletic, but may not be if analyzed with African members (Robinson, pers. comm.), something that remains to be investigated. *Koyamasia gymnoclada* is basal to the rest of the Thai Vernoniae in the BA as are woody species in general. Despite the presence of the two species *Iodocephalopsis eberhardtii* and *Camchaya gracilis* which are newly recognized, the subtribe Centrapalinae remains clearly monophyletic. Similarly, *Elephantopus* and *Pseudelephantopus* in subtribe Elephantopinae are monophyletic and do not change any previous results (summarized in Keeley & Robinson, 2009). On the other hand,

Monosis volkameriifolia is not part of any other clade or subtribe despite having a prior assignment in the *Gymnantheminae* and must be transferred to a different subtribe.

Name changes will be required for *Gymnanthemum cylindriceps* which is clearly a member of *Decaneuropsis* and for *Vernonia cinerea* var. *montana*. The latter taxon is putatively a variety of *V. cinerea*, placed in the genus *Cyanthillium* (as *C. cinereum*) by Robinson (1999b). However, this variety is more closely related to *C. hookerianum* than *V. cinerea* var. *montana* indicating that the current nomenclature does not reflect the correct relationship and requires revising the generic nomenclature and correcting its subtribal placement. Similarly, *Vernonia curtisii* is not only closely related to *Koyamasia calcarea* but also shares with it restriction to the same limestone habitat and morphological characters of a short bristly and caducous pappus, reflexed phyllaries and echinolophate 3-porate pollen type. To ensure monophyly both taxa will need to be placed in the same genus. Finally, the subtribal placement of three species, *Vernonia birmanica*, *V. pseudobirmanica* and *V. pulicarioides*, remains to be determined. They each have characters in common with some of the other Thai taxa, but will require further study to determine the best placement within the tribe.

Thai Vernonieae have geographically limited distributions and high endemism. These features strongly suggest a distinct evolutionary line for the Thai Vernonieae within the Old World members of the tribe. Further studies will likely result in the recognition of subtribes or sections for these taxa.

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APPENDICES

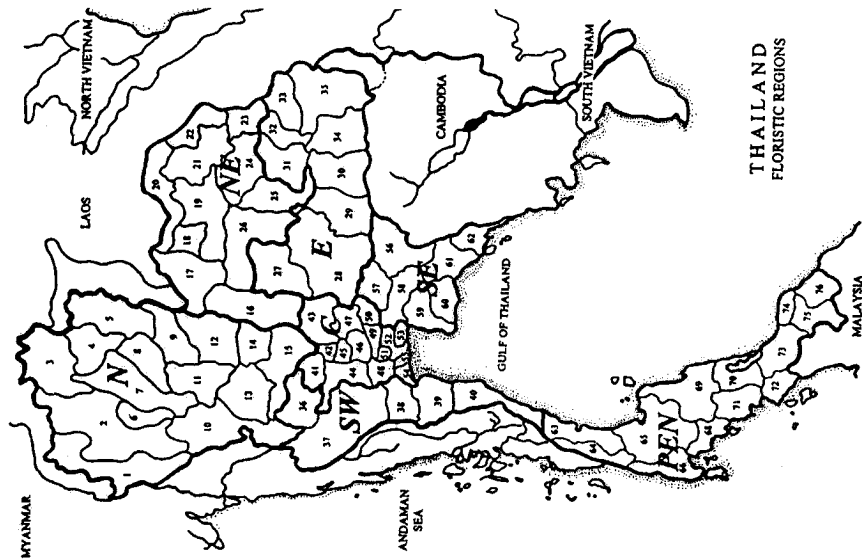
APPENDIX A

The floristic regions and provinces map of Thailand

The floristic regions and provinces map of Thailand (Applied from Flora of Thailand, Cyperaceae, vol. 6, part 4)

FLORISTIC REGIONS AND PROVINCES OF THAILAND

- | | |
|--------------------------|-------------------------------------|
| N (NORTHERN) | 39 Phetchaburi |
| 1 Mae Hong Son | 40 Prachuap Khiri Khan |
| 2 Chiang Mai | C (CENTRAL) |
| 3 Chiang Rai | 41 Chai Nat |
| 4 Phayao | 42 Sing Buri |
| 5 Nan | 43 Lop Buri |
| 6 Lamphun | 44 Suphan Buri |
| 7 Lampang | 45 Ang Thong |
| 8 Phrae | 46 Phra Nakhon Si Ayutthaya |
| 9 Utharadit | 47 Saraburi |
| 10 Tak | 48 Nakhon Pathom |
| 11 Sukhothai | 49 Pathum Thani |
| 12 Phitsanulok | 50 Nakhon Nayok |
| 13 Kamphaeng Phet | 51 Nonthaburi |
| 14 Phichit | 52 Krung Thep Maha Nakhon (Bangkok) |
| 15 Nakhon Sawan | 53 Samut Prakan |
| NE (NORTHEASTERN) | 54 Samut Songkhram |
| 16 Phetchabun | 55 Samut Sakhon |
| 17 Loei | 56 Sa Kaeo |
| 18 Nong Bua Lum Phu | 57 Prachin Buri |
| 19 Udon Thani | 58 Chachoengsao |
| 20 Nong Khai | 59 Chon Buri |
| 21 Sakon Nakhon | 60 Rayong |
| 22 Nakhon Phanom | 61 Chanthaburi |
| 23 Mukdahan | 62 Trat |
| 24 Kalasin | PEN (PENINSULAR) |
| 25 Maha Sarakham | 63 Chumphon |
| 26 Khon Kaen | 64 Ranong |
| E (EASTERN) | 65 Surat Thani |
| 27 Chaiyaphum | 66 Phangnga |
| 28 Nakhon Ratchasima | 67 Phuket |
| 29 Burirum | 68 Krabi |
| 30 Surin | 69 Nakhon Si Thammarat |
| 31 Roi Et | 70 Phatthalung |
| 32 Yasothon | 71 Trang |
| 33 Annap Chaoen | 72 Satun |
| 34 Si Sa Ket | 73 Songkhla |
| 35 Ubon Ratchathani | 74 Pattani |
| SW (SOUTHWESTERN) | 75 Yala |
| 36 Uthai Thani | 76 Narathiwat |
| 37 Kanchanaburi | |
| 38 Ratchaburi | |



APPENDIX B

Molecular and morphological data set for phylogenetic study

Taxon/Node	Sequence
Acilepis attenua	ACCACCAATAGTCATGTATCAATCG-AAAAGG-ACCTTTCATTTTAGCCAACCACACC--ATT-GGCATGGGA
Acilepis attenua	ACCACCAATAGTCATGTATCAATCG-AAAAGG-ACCTTTCATTTTAGCCAACCACACC--ATT-GGCATGGGA
Acilepis attenua	ACCACCAATAGTCATGTATCAATCG-AAAAGG-ACCTTTCATTTTAGCCAACCACACC--ATT-GGCATGGGA
Acilepis chiangd	??
Acilepis diverge	ACCACCAACAGTCATGTATCAATCGAAAAAGA-AGTTTCTTTT TAGCCAACCACACC--ATTGGGCATGGGA
Acilepis diverge	ACCACCAACAGTCATGTATCAATCGAAAAAGA-AGTTTCTTTT TAGCCAACCACACC--ATTGGGCATGGGA
Acilepis kingii	ACCACCAACAGTCATGCTTCAGTCGTAAAAAA-ACCTTCTTTT TAGCCAACCATACC--ATTGGGCATGGGA
Acilepis namnaoe	ACCACCAATAGTCATGTTTCAATCGAAAAATA-ACCTTCTTTT TAGCCAACCACACC--ATTGGGCATGGGA
Acilepis ngaons	ACCACCAATAGTCATGTTTCAATCGAAAAATA-ACCTTCTTTT TAGCCAACCACACC--ATTGGGCATGGGA
Acilepis peguens	ACCACCAACAGTCATGTATCAATCGATAAAGA-ACCTTCTTTT TAGCCAACCATACC--ATTGGGCATGGGA
Acilepis pseudos	ACCACCAATAGTCATGTATCAATCG-AAAAGG-ACCTTTCATTTTAGCCAACCACACC--ATT-GGCATGGGA
Acilepis saligna	ACCACCAACAGTCATGTATCAATCGTAAAAAA-ACCTTCTTTT TAGCCAACCATACC--ATTGGGCATGGGA
Acilepis silhete	ACCACCAATAGTCATGTTTCAATCGAAAAATA-ACCTTCTTTT TAGCCAACCACACC--ATTGGGCATGGGA
Acilepis sutepen	ACCACCAATAGTCATGTATCAATCG-AAAAGG-ACCTTTCATTTTAGCCAACCACACC--ATT-GGCATGGGA
Acilepis sutepen	ACCACCAATAGTCATGTATCAATCG-AAAAGG-ACCTTTCATTTTAGCCAACCACACC--ATT-GGCATGGGA
Camchaya gracili	ACCACCAATAGTCATGTATCAATCG-TGAAGG-ACTTCCATTTAGGCCAACCATACC--ATG-AGCACAGGA
Camchaya loloana	ACCACCAACAGTCATGCATCAATCT-TAAAGG-ACTTCCATTTAGGCCAACCATACC--ATA-GGCACAGGA
Camchaya loloana	ACCACCAACAGTCATGCATCAATCT-TAAAGG-ACTTCCATTTAGGCCAACCATACC--ATA-GGCACAGGA
Camchaya mukdaha	ACCACCAACAGTCATGCATCAATCT-TAAAGG-ACTTCCATTTAGGCCAACCATACC--ATA-GGCACAGGA
Camchaya mukdaha	ACCACCAACAGTCATGCATCAATCT-TAAAGG-ACTTCCATTTAGGCCAACCATACC--ATA-GGCACAGGA
Camchaya pentago	ACCACCAACAGTCATGCATCAATCT-TAAAGG-ACTTCCATTTAGGCCAACCATACC--ATA-GGCACAGGA
Camchaya spl	ACCACCAACAGTCATGCATCAATCT-TAAAGG-ACTTCCATTTAGGCCAACCATACC--ATA-GGCACAGGA
Camchaya spinuli	ACCACCAACAGTCATGCATCAATCT-TAAAGG-ACTTCCATTTAGGCCAACCATACC--ATA-GGCACAGGA
Camchaya spinuli	ACCACCAACAGTCATGCATCAATCT-TAAAGG-ACTTCCATTTAGGCCAACCATACC--ATA-GGCACAGGA
Camchaya spinuli	ACCACCAACAGTCATGCATCAATCT-TAAAGG-ACTTCCATTTAGGCCAACCATACC--ATA-GGCACAGGA
Camchaya tenuifl	ACCACCAACAGTCATGCATCAATCT-TAAAGG-ACTTCCATTTAGGCCAACCATACC--ATA-GGCACAGGA
Cyanthillium cin	ACCACCTTAGTATAGGCATCAATCA---AAGG-ACTAATATTTAGACAAACCACACC--ATG-GGCATGGGA
Cyanthillium hoo	ACCACCTTAGTATAGGCATCAATCA---AAGG-ACTAATTTTAGACAAACCACACC--ATG-GGCATGGGA
Decaneuropsis cu	ACCACCACTAGTCATGCATCCACCG-ATAAGG-ACTTACGTTTAGGCCAACCCACACC--ATG-AACATGGGA
Decaneuropsis eb	ACCACCACTAGTCATGCATCCACCG-ACAAGG-ACTTACGTTTAGGCCAACCCACCATGAT-AGCATGGGA
Decaneuropsis ga	??
Distephanus mada	ACCACCACTAGCCGTGCGTCCACCG-AAGGGG-ACTTCAGTTTGGGCCAACCCGACC--ATT-GGAACGGGA
Distephanus poly	ACCACCACTAGCCGTGCGTCCACCG-AAGGGG-ACTTCAGTTTGGGCCAACCCGACC--ATT-GGAACGGGA
Elephantopus mol	ACCACCAATAGTCATGTGCGCAATCA-AGGCGG-CCTTCAATTTTGGGCCAACCCACACAAA--GGCATGGGA
Elephantopus sca	ACCACCAATAGTCATGTGCGCAATCA-AGGCGG-CCTTCAATTTTGGGCCAACCCACACGCGAC--GGCATGGGA
Elephantopus sca	ACCACCAATAGTCATGTGCGCAATCA-AGGCGG-CCTTCAATTTTGGGCCAACCCACACGCGAC--GGCATGGGA
Elephantopus pen	ACCACCAATAGTCATGTGCGCAATCA-AGGCGG-CCTTCAATTTTGGGCCAACCCACACGCGAC--GGCATGGGA
Gymnanthemum Cyl	ACCACCACTAGTCATGCATCCACCG-AAAAGG-ACTTGCCTTTTAGGCCAACCCACACC--ATC-AGCATGGGA
Iodocephalopsis	ACCACCAATAGTCATGTATCAATCG-TAAAGG-ACTTCCATTTTAGGCCAACCATGCC--ATG-GGCACAGGA
Koyomasia calcar	ACCACCAATAGTCGTGTATCAATTA-AAAAGG-AATTCATTTTAGGCCAACCCACACC--ATTAGGCATGGGA

Kurziella gymnoc	ACCACCACTAGTCGTGCGCTCCGCTGCAAGGGGACCTGTGTTGGGGCAACCGCACC--ATG-GGCACGGGA
Monosis volkamer	ACCACCTATAGTCGTGCTTCAAATCG-AAAAGG-ACTTCTATTTAGGCCAACCCACACC--ATG-GGCACGGGA
Pseudelephantopu	ACCACCAACAGCCGCTGTGCCATGCA-AAGAGG-CCATAGTTTTTGGGGCAACCATGTCACGAG--GGCATGGGA
Pseudelephantopu	ACCACCAACAGCCGCTGTGCCATGCA-AAGAGG-CCATAGTTTTTGGGGCAACCATGTCACGAG--GGCATGGGA
Strobocalyx arbo	ACCACCAATAGTCGTGCATCAATCG-AAGAGG-ACTTCTATTTAGGGCAACCCACACC--ATA-AGCATGGGA
Strobocalyx sola	ACCACCAATAGTCGTGCATCAATCG-AAGAGG-ACTTCTATTTAGGGCAACCCACACC--ATG-GGCATGGGA
Tarlounia ellip	ACCACCAATAGTCGTGCATCAATCG-AAGAGG-ACTTCTATTTAGGGCAACCCACACC--ATA-AGCATGGGA
Tarlounia ellip	ACCACCAATAGTCGTGCATCAATCG-AAGAGG-ACTTCTATTTAGGGCAACCCACACC--GTG-GGCATGGGA
Vernonia montana	ACCACCTACAGTCAGGCATCAATCA---AAGG-ACTAATATTTAGACAAACCACACC--ATG-GGCATGGGA
Vernonia montana	ACCACCTATAGTCAGGCATCAATCA---AAGG-ACTAATATTTAGACAAACCACACC--ATG-GGCATGGGA
Vernonia curtisi	ACCACCAATAGTCGTGTATCAATTA-AAAAGG-ACTTCTATTTAGGCCAACCCACACC--ATTAGGCATGGGA

Input data matrix (continued):

[illegible]

Input data matrix (continued):

[illegible]

[illegible]

[illegible]

2. ndhF set

Input data matrix:

Taxon/Node	Sequence
Acilepis attenua	-----CTTATATTGATTCTATTTACTTTGTTTCGTTGGATTCTTAGGAAATTCCTTT-
Acilepis attenua	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Acilepis attenua	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Acilepis attenua	TACTATGCTA-TCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Acilepis chiangd	-----GATCCTTAGG--ATTCCCTTT-
Acilepis diverge	-----GATTCTTAGG--ATTCCCTTT-
Acilepis diverge	-----G-TTCGTTGGATTCTTAGG-AATTCCTTT-
Acilepis kingii	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Acilepis namnaoe	-----CTTTG-TTCGTTGGATTCTTAGGAAATTCCTTT-
Acilepis ngaoens	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Acilepis peguens	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Acilepis pseudos	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Acilepis saligna	TACTATGCTATTCCCAAACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Acilepis silhete	-----GGATTCCTTAGG--ATTCCCTTT-
Acilepis sutepen	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Acilepis sutepen	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Camchaya gracili	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Camchaya loloana	-----GATTCAATTAC-TTG-TTGTGTTGATTCTTAGG-AATTCCTTT-
Camchaya loloana	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTGTGTTGATTCTTAGG-AATTCCTTT-
Camchaya mukdaha	-----TTG-TTGTGTTGATTCTTAGG-AATTCCTTT-
Camchaya mukdaha	-----CGATGCACCTTTG-TTGTGTTGATTCTTAGG-AATTCCTTT-
Camchaya pentago	-----GCATTCT--GG-GATTCTTT-
Camchaya spl	-----GGATTCCTTAGG-AATTCCTTT-
Camchaya spinuli	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTGTGTTGATTCTTAGG-AATTCCTTT-
Camchaya spinuli	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTGTGTTGATTCTTAGG-AATTCCTTT-
Camchaya spinuli	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTGTGTTGATTCTTAGG-AATTCCTTT-
Camchaya tenuifl	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTGTGTTGATTCTTAGG-AATTCCTTT-
Cyanthillium cin	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Cyanthillium hoo	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Decaneuropsis cu	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Decaneuropsis eb	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Decaneuropsis ga	---CTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Distephanus mada	-----ACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Distephanus poly	-----CTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Elephantopus mol	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Elephantopus sca	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Elephantopus sca	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Elephantopus pen	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Gymnanthemum Cyl	---TATGCTATTCCCAACTACT-ATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Iodocephalopsis	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Koyamasia calcar	-----TCTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Kurziella gymnoc	-----GGATC--GGAGATTCTTTG
Monosis volkamer	-----GATTCTATTACTTTGTTTCGTTGGATTCTTAGG-AATTCCTTT-
Pseudelephantopu	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Pseudelephantopu	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Strobocalyx arbo	-----ATTACATG-AGTTCCTTT-
Strobocalyx sola	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Tarlounia ellip	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Tarlounia ellip	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Vernonia montana	TACTATGCTATTCCCAAACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Vernonia montana	TACTATGCTATTCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-
Vernonia curtisi	-ACTATGCTA-TCCCAACTACTTATATTGATTCTATTACTTTG-TTCGTTGGATTCTTAGG-AATTCCTTT-

Input data matrix (continued):

Taxon/Node	
Acilepis attenua	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis attenua	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis attenua	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis attenua	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis Chiangd	CAATCAGACA-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis diverge	C-ATCAGACA-TGGAT-GTATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis diverge	CAATCAGACA-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis kingii	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis namnao	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis ngaoens	CAATCAGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis peguens	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis pseudos	CAATCAGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAGAATTC-
Acilepis saligna	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis silhete	C-ATCAGACA-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-
Acilepis sutenep	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC-

<i>Acilepis</i>	<i>sutepen</i>	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Camchaya</i>	<i>gracili</i>	AAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Camchaya</i>	<i>loloana</i>	CAATCACGACG-TGGGG-ATATTAAACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Camchaya</i>	<i>loloana</i>	CAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Camchaya</i>	<i>mukdaha</i>	CAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Camchaya</i>	<i>mukdaha</i>	CAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATGAATCTTTTACATAAAAAATTC
<i>Camchaya</i>	<i>pentago</i>	C-ATCACAACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Camchaya</i>	<i>spl</i>	CAATCACGACGTTGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Camchaya</i>	<i>spinuli</i>	CAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Camchaya</i>	<i>spinuli</i>	CAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Camchaya</i>	<i>spinuli</i>	CAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Camchaya</i>	<i>tenuifl</i>	CAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Cyanthillium</i>	<i>cin</i>	CAATCACGACA-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Cyanthillium</i>	<i>hoo</i>	CAATCACGACA-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Decaneuropsis</i>	<i>cu</i>	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATCAATCTTTTACATAAAAAATTC
<i>Decaneuropsis</i>	<i>eb</i>	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATCAATCTTTTACATAAAAAATTC
<i>Decaneuropsis</i>	<i>ga</i>	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATCAATCTTTTACATAAAAAATTC
<i>Distephanus</i>	<i>mada</i>	CAATCAAGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Distephanus</i>	<i>poly</i>	CAATCAAGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Elephantopus</i>	<i>mol</i>	CAATCACGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Elephantopus</i>	<i>sca</i>	CAATCACGATG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Elephantopus</i>	<i>sca</i>	CAATCACGATG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Elephantopus</i>	<i>pen</i>	CAATCACGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Gymnanthemum</i>	<i>Cyl</i>	CAATCATGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATCAATCTTTTACATAAAAAATTC
<i>Iodymecephalopsis</i>		CAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Koyamasia</i>	<i>calcar</i>	CAATCACGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Kurziella</i>	<i>gymnoc</i>	C-GTCAGAAG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Monosis</i>	<i>volkamer</i>	CAATCACGACG-TGGATAATATT-AACCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Pseudelephantopu</i>		CAATCACGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Pseudelephantopu</i>		CAATCACGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Strobocalyx</i>	<i>arbo</i>	CAATCACGACA-TGGTA-TTATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Strobocalyx</i>	<i>sola</i>	CAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Tarlmounia</i>	<i>ellip</i>	CAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Tarlmounia</i>	<i>ellip</i>	CAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Vernonia</i>	<i>montana</i>	CAATCACGACA-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TAGAAATCTTTTACATAAAAAATTC
<i>Vernonia</i>	<i>montana</i>	CAATCACGACG-TGGAT-ATATT--AACCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC
<i>Vernonia</i>	<i>curtisi</i>	CAATCACGACG-TGGAT-ATATT--ATCCAAATGGTTAACCCCGTC-TATAAATCTTTTACATAAAAAATTC

Input data matrix (continued):

[illegible]

Tarlounia ellip ATTTTTTTGATAGACGAATAATTGATGCAATTCCAAATGGGGTTGGTCTTATGAGTTTTTTGG-TAGCAGAG
Vernonia montana ATTTTTTTGATAGACGAATAATTGATGCAATTCCAAATGGGGTTGGTCTTATGAGTTTTTTGG-TAGCAGAG
Vernonia montana ATTTTTTTGATAGACGAATAATTGATGCAATTCCAAATGGGGTTGGTCTTATGAGTTTTTTGG-TAGCAGAG
Vernonia curtsi ATTTTTTTGATAGACGAATAATTGATGCAATTCCAAATGGGGTTGGTCTTATGAGTTTTTTGG-TAGCAGAG

Input data matrix (continued):

[illegible]

Input data matrix (continued):

[illegible]

Camchaya mukdaha	GTTGCATCGAAACAT-AAAAATG-TTGACTAATC---
Camchaya pentago	-----
Camchaya spl	-----
Camchaya spinuli	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG
Camchaya spinuli	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG
Camchaya spinuli	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG
Camchaya tenuifl	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG
Cyanthillium cin	GTTGCATCGAAACATCAAAATG-TTGACTAATCTCG
Cyanthillium hoo	GTTGCATCGAAACAT-CAAAATG-TTGACTAATCTCG
Decaneuropsis cu	GTTGTATCGAAACATAAAAAATG-TTGACTAATCTCG
Decaneuropsis eb	GTTGTATCGAAACATAAAAAATG-TTGACTAATCTCG
Decaneuropsis ga	GTTGTATCGAAACATAAAAAATG-TTGACTAATCTC-
Distephanus mada	GTTGCATCG-----
Distephanus poly	GTTGCATCG-----
Elephantopus mol	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG
Elephantopus sca	ATTGCGTCGAAAAA-AAAAATC-TTGAGTAATCC--
Elephantopus sca	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG
Elephantopus pen	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG
Gymnanthemum Cyl	GTTGTATCGAAACATCAAAATG-TTGACTAATCTC-
Iodocephalopsis	G-----
Koyamasia calcar	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG
Kurziella gymnoc	GTTGCATCGAAACATCAAAATG-TTGACTAATCTCG
Monosis volkamer	G-TGCATC-----
Pseudelephantopu	GTTGCATCG-AACATAAAAAATG-TTGACTAATCTCG
Pseudelephantopu	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG
Strobocalyx arbo	-----
Strobocalyx sola	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG
Tarlmounia ellip	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG
Tarlmounia ellip	GTTGCATCGAAACATAAAAAATG-TTGACT-----
Vernonia montana	GTTGCTTCGAAACATCAAAT---GTGACTAACCTCG
Vernonia montana	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG
Vernonia curtisi	GTTGCATCGAAACATAAAAAATG-TTGACTAATCTCG

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Taxon/Node		4567890123456789012345678901234567890123456789012345678901234567890123456789012345
Acilepis attenua	GTTTCAG-AAAGCAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCTGGGTCTTA	
Acilepis attenua	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis attenua	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis attenua	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis chiangd	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis diverge	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis diverge	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis kingii	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis namnao	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis ngoaes	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis peguens	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis pseudos	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis saligna	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis silhet	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis sutepen	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Acilepis sutepen	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	
Camchaya gracili	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Camchaya loloana	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Camchaya loloana	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Camchaya mukdah	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Camchaya mukdah	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Camchaya pentago	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Camchaya spl	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Camchaya spinuli	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Camchaya spinuli	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Camchaya spinuli	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Camchaya tenuifl	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Cyanthillium cin	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Cyanthillium hoo	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Decaneuropsis cu	GTTTCAG-AAAGCGAA-----AATCAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Decaneuropsis eb	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Decaneuropsis ga	GTTTCAG-AAAGCGAA-----AATAAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Distephanus mada	GTTTCAG-AAAGCGAA-----AATCAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Distephanus poly	GTTTCAG-AAAGCGAA-----AATCAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Elephantopus mol	GTTTCAG-AAAGCGAA-----AAGAIAAAA--GGATAGTGCAGAGACTCGATGGAAGCT--GTTCTA	
Elephantopus sca	GTTTCAG-AAAGCGAAAGAGAAAAAGGAGAAAAAGGATAGGTCGACAGACTCGATGGAAGCT--GTTCTA	

[illegible]

[illegible]

[illegible]

Input data matrix (continued):

[illegible]

Input data matrix (continued):

[illegible]

[illegible]

Acilepis attenua AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGAAGAGCAAAGACTGAAA-
 Acilepis attenua AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAAAGCCGA-GACTGAA-
 Acilepis attenua AGGATGAGACATCAGGAATAGTCGGGGA-AGC-TCAGT-TGGTAGAGCAGA-GACTGAAA-
 Acilepis attenua AGGATGAGACATCAGGAATAGTCGGGAT-AGCTTCAGT-TGGTAAAGCAAA-GACTGAAAT
 Acilepis chiangd AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCCTTT-T-----
 Acilepis diverge AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGGAAAGCAAAGAAATGAAAA
 Acilepis diverge AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTCT-----
 Acilepis kingii AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TTTTT-GGGGGG-----
 Acilepis namnaoe AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCATT-TGGAAAAAGCAGAGACTGAAAT
 Acilepis ngaoens AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAAA-GAATGAAA-
 Acilepis peguens AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAAAAGAAATGAAA-
 Acilepis pseudos AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-T-GTAGAGCAGA-GACTGAAA-
 Acilepis saligna AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-T-GTAGAGCAGA-GACTGAAA-
 Acilepis silhete AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAGA-GACTGAAA
 Acilepis sutepen AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAAA-GACTGAA-
 Acilepis sutepen AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAGGAGACTGAA-
 Camchaya gracili AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAAA-GACTGAAA
 Camchaya loloana AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGAAAGAGCAAAGGACTGAAA-
 Camchaya loloana AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAGA-GACTGAAA
 Camchaya mukdaha AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCA-----
 Camchaya mukdaha AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-----
 Camchaya pentago AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAGA-GACTGAA--
 Camchaya spl AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCACT-TGGGAAAGCAGAAGACTGAAA-
 Camchaya spinuli AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGAAAGCAGAGGACTGAAAT
 Camchaya spinuli AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGAAAGCAGA-GACTGAAA
 Camchaya spinuli AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCACTTGGGAAAGCAGAGGACTGAAA-
 Camchaya tenuifl AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGGAGAGCAAA-GACTAAATC
 Cyanthillium cin AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAAAAGACTGAAA-
 Decaneuropsis cu AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCACTGTAGAAAAAATAAATGAATC
 Decaneuropsis eb AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAAA-GACTGAAAT
 Decaneuropsis ga AGGATGAGACATCAGCAATAGTCGGGAT-AGC-TCAAT-TGGTAGAGCAAA-GACTGAAAT
 Distephanus mada AGGATGAGACATCAGGAATAGTCGGGAT-AGTA-----
 Distephanus poly AGGATGAGACATCAGGAATAGTCGGGAT-AGC-----
 Elephantopus mol AGGATGAGACATCAGGAATAGTCGGGATAGC-TCAGT-TGGAAAGAGGAGA-GACTGAAA-
 Elephantopus sca AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCACT-TGGAAAAGCAAA-GACTGAAA-
 Elephantopus sca AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTC-----
 Elephantopus pen AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCCTCT-TGGGAAAGCAAA-GACTAAAA-
 Gymnanthemum Cyl AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-----GTAGC-----
 Iodocephalopsis AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-T-----

Koyamasia calcar	AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAGAGGACTGAAA-
Kurziella gymnoc	AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAGAGGACTGAAAT
Monosis volkamer	AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGAAAAGCAAA-GACTGAAAT
Pseudelephantopu	AGGAGGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAA--GACTGAA--
Pseudelephantopu	AGGAGGAGACATCAGGAATAGTCGGGAT-AGC-TCAAT-TGGAAAAGCAGAGGACTGAAAT
Strobocalyx arbo	AGGATGAGACATCAGGAATAGTC-----
Strobocalyx sola	AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAAA-GACTGAAA-
Tarlmounia ellip	AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAAGAAGACTGAAAA
Tarlmounia ellip	AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAAA-GACTAAAAAT
Vernonia montana	AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAAAGGACTGAAA-
Vernonia montana	AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAGAGCAGAGGACTGAAAA
Vernonia curtisi	AGGATGAGACATCAGGAATAGTCGGGAT-AGC-TCAGT-TGGTAAAGCAGA-GAATGAAAT

RESEARCH PUBLICATIONS

1. Bunwong, S. and Chantaranothai, P. 2008. Pollen Morphology of the Tribe Vernonieae (Compositae) in Thailand. **The Natural History Journal of Chulalongkorn University** 8(1): 45-55.
2. Bunwong S., Robinson, H. & Chantaranothai, P. 2009. Taxonomic notes on *Camchaya* and *Iodocephalus* (Vernonieae: Asteraceae), and a new genus *Iodocephalopsis*. **Proceedings of the Biological Society of Washington** 122(3): 357-363.
3. Robinson, H., Bunwong, S. & Chantaranothai, P. 2010. A new genus, *Kurziella* from Thailand (Vernonieae: Asteraceae). **Proceedings of the Biological Society of Washington**. 123(2):174–178.
4. Bunwong, S. and Chantaranothai, P. 2010. A new record of *Pseudelephantopus spicatus* C.F.Baker (Asteraceae) from Thailand. **Thai Forest Bulletin (Botany)**. (In press)
5. Bunwong, S., Keeley, S.C. and Chantaranothai, P. Phylogenetic relationships in Vernonieae (Asteraceae) in Thailand based on DNA sequence data from the nuclear rDNA ITS region and chloroplast regions *ndhF* and *trnL*. **Systematic Botany**. (submitted)

Oral presentation:

1. Bunwong, S. and Chantaranothai, P. 2008. Morphological Taxonomy of *Vernonia* (Asteraceae) in Thailand. In: **The 14th Flora of Thailand Meeting 18th–21st August**, The Carlsberg Academy, Copenhagen, Denmark.
2. Keeley, S.C. and Bunwong, S. 2010. The relationships of Vernonieae (Compositae) from Thailand to those in Africa, Madagascar and Asia. In: **Botany 2010, July 31 – August 4, Rhode Island, USA**. Available Source: <http://2010.botanyconference.org/engine/search/index.php?func=detail&aid=2>
11. June 9, 2010.
3. Bunwong, S. and Chantaranothai, P. 2010. Revision of Tribe Vernonieae (Asteraceae) in Thailand. In: **The 2nd Symposium of the “Flore du**

Cambodge, du Laos et du Viêtname” 6th – 8th December 2010, Hanoi, Vietnam. (Accepted).

Poster presentations:

1. Keeley, S.C. and Bunwong, S. 2008. Preliminary Phylogenetic relationships in Thai Vernonieae (Compositae). In: **Botany 2008: Botany without Borders**, University of British Columbia, Vancouver, BC, 26th – 30th July.
2. Bunwong, S., Chantaranothai, P. and Keeley, S.C. 2008. A preliminary study of phylogenetic relationships in Thai Vernonieae (Asteraceae). In: **Abstracts: Research and Thesis 2008**. V. Baimai and R. Tanthalekha (Eds.), p. 112. BRT program, Bangkok.
3. Bunwong, S., Chantaranothai, P. and Keeley, S.C. 2009. Molecular taxonomy of tribe Vernonieae (Asteraceae) in Thailand. In: **Abstract of Research and Thesis 2009**. V. Baimai and R. Tanthalekha (Eds.), p. 81. BRT program, Bangkok.
4. Bunwong, S. and Chantaranothai, P. 2010. Generic revision of Vernonieae (Asteraceae) in Thailand. In: **The 4th Symposium of the Botany in Thailand 24th – 26th March**, p. 150. Chiang Mai.

Awards:

1. Popular vote for poster presentation at 13th BRT Annual Meeting, Holiday Inn, Chiang Mai, Thailand, 12th – 14th October 2009.
2. The Excellent award for poster presentation at the 4th Symposium of the Botany in Thailand, Chiang Mai, 24th – 26th March 2010.

VITAE

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2001-2003 Master Degree of Science (Biology), Khon Kaen University, Khon Kaen, Thailand.

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Publications

1. Bunwong, S., Chantaranothai, P. and Thammathaworn, A. 2004. Taxonomy of Tribe Vernonieae (Asteraceae) in Thailand. **KKU Research Journal (Graduate Studies)** 4: 1-11.
2. Pornpongrungreung, P., Vanijajiva, O. and Bunwong, S. 2006. A historical study of Thai Asteraceae. In: **Proceedings of the International Compositae Alliance (TICA-Deep Achene)**. Barcelona, Spain.

Awards

1. The excellent award for oral presentation of research and thesis presentation of the 6th Graduate School, Khon Kaen University conference, 2003.
2. The excellent award in poster presentation of research and thesis presentation of the 7th BRT annual conference (Taxonomy of tribe Vernonieae (Compositae) in Thailand), 2003.
3. The excellent award in poster presentation of research and thesis presentation of the 8th BRT annual conference (Palynology of tribe Vernonieae (Compositae) in Thailand), 2004.