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SYSTEMATICS OF ERIOCAULACEAE IN THAILAND

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Thesis submitted in fulfillment for the Degree of Doctor of Philosophy

University of Dublin

Trinity College

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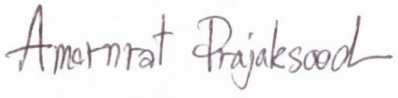

Amornrat Prajaksood

SUMMARY

This thesis aimed to provide a complete account of the family Eriocaulaceae for Thailand, to resolve the identity of unknown Thai taxa in the family and to investigate the relationship between Thai species using morphological, anatomical, and molecular approaches.

The morphological study was undertaken. Approximately 2,400 herbarium specimens from the 15 herbaria were examined. Field work took place in 21 Thai National Parks, two Wildlife Sanctuaries and 25 other Districts totaling 26 Provinces in Thailand between September and December 2002. The chapter provides a complete account of Eriocaulaceae in Thailand, 45 taxa, which comprises 35 species. The unknown Thai taxa which have been proved to be new to science comprise 15 taxa. Three new combinations and 27 new synonyms within 10 taxa were made. Full descriptions of genus and species, keys, synonyms, drawing and colour photographs were provided. The distribution and the morphological characters which were found to be useful for identification within *Eriocaulon* in Thailand were also given.

Anatomical study was undertaken. Full reviews of anatomical works in the family are provided. Permanent slides of transverse section of leaves and scapes from fresh material of 46 specimens, which comprises 34 taxa were prepared using the paraffin method adapted from Thammathaworn (1995). The sections were stained with toluidine blue and mounted permanently in DPX mountant for microscopy. The general aspects of and variation of anatomical characters within *Eriocaulon* were studied. The five anatomical characters which I believe to be of most taxonomic value are: the presence/absence of a hypodermis in leaves, the position of the vascular tissue in leaves, the presence/absence of homogenous mesophyll in leaves, the presence/absence of scapes and the presence of a chlorenchymatous band wider than the diameter of stele in scapes.

Phenetic and phylogenetic analyses were performed. 48 specimens were used in this study, two of which, *Xyris indica* L. (Xyridaceae) and *Syngonanthus* sp., were used as the outgroups and the remaining 46 specimens were representative of 34 taxa of *Eriocaulon*. Thirty binary state morphological and anatomical characters were phenetically analysed using the furthest neighbour (complete linkage) method and simple matching coefficient in combination with Homogeneity analysis. Six groups from the 34 taxa of *Eriocaulon* are recognised. The *trnL-F* region of the plastid genome was selected for phylogenetic analysis. Silica gel dried leaves and scapes were used for total DNA extraction. The entire *trnL-F* region (*trnL* intron and *trnL-F* intergenic specer) was amplified by the Polymerase Chain Reaction (PCR) using the forward primer c and f. The data was analysed using parsimony in PAUP version 4.0b6. The same morphological and anatomical dataset was imported into PAUP version 4.0b6 and subjected to combined analysis. Analysis of nucleotide sequence dataset resulted in three equally most parsimonious trees of length 2,590 steps whereas the analysis of combined dataset produced 16 equally most parsimonious trees of length 2,770 steps. The cladogram produced by the combined analysis showed only two clades different from the cladogram produced by

the molecular matrix analysis. The data from the *trnL-F* region were partially successful for studying relationships of 34 taxa within *Eriocaulon* as some groups were weakly supported by bootstrap values in the analysis. Therefore, five of six groups defined by phenetic analysis was neither supported or rejected, though the monophyly of group II, as defined by phenetic analysis, was also found in strict consensus trees of both phylogenetic analyses. There were only two clades in the consensus cladogram produced by the combined analysis which were different from those found in the molecular matrix analysis, even though the number of clades resolved in the consensus tree produced by the combined analysis was smaller than, and the bootstrap value was higher than, by the molecular matrix analysis.

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CHAPTER 1

GENERAL INTRODUCTION AND AIMS

1.1 Introduction

The Eriocaulaceae is a large family of perennial or occasionally annual herbaceous plants with usually grass-like leaves (Heywood, 1993). Stützel (1998) recognised 10 genera in the family, with around 1300 species. The family is mainly tropical, and subtropical in distribution, with most of the species found in South America and Africa. The genera are:

(1) *Paepalanthus* Kunth (including *Modenkeanthus* Morat) which is composed of about 600 species, mostly occuring in South America, with some in Central America, Africa, and Madagascar.

(2) *Eriocaulon* L. which is composed of 400 species in tropical and subtropical area of the world.

(3) *Syngonanthus* Ruhland (including *Comanthera* L.B. Smith and *Carptotepala* Mold.) which consists of about 250 species, mainly in South America but a few also in Africa and Madagascar.

(4) *Leiothrix* Ruhland which consists of about 37 species in South America, mainly Brazil.

(5) *Mesanthemum* Körn. which consists of 18 species in tropical and subtropical regions of Africa and 2 also in Madagascar; the records for South America are erroneous.

(6) *Lachnocaulon* Kunth which comprises about eight species in North America, Florida, and the Mississippi regions.

(7) *Blastocaulon* Ruhland which comprises about five species, all in Minas Gerais, Brazil.

(8) *Rondonanthus* Herzog (including *Wurdackia* Moldenke) which comprises five species restricted to the Guayana Shield in northern South America.

(9) *Philodice* C. Mart. which is composed of two species, *P. cuyabensis* Mart. and *P. hoffmannseggiii* Mart. according to The International Plant Names Index (2004) restricted to the basins of the Amazon and Orinoco rivers in tropical South America.

(10) *Tonina* Aubl. with only one species, *T. fluviatilis* Aubl., found in northern South America.

Recently, Sano (2004) proposed a new genus, *Actinophalus* (Körn.) Sano, containing 28 species. He analyzed morphology and plasticity, including large amounts of data obtained from intensive field studies of the section *Actinophalus* in *Paepalanthus* and finally concluded that *Actinophalus* can be distinguished from *Paepalanthus* based on the presence of an umbel-like inflorescence, distinct cytology, and cytochemistry and in having a geographic range restricted to Brazil.

Stützel (1998) reported general characteristics of the family and stated that the family mainly occurs on poor sandy soils, in marshy or boggy habitats, and in the mountains, even on rocks. Some species of *Eriocaulon*, *Paepalanthus*, *Leiothrix* and *Tonina* grow submerged in rivers, ponds, and temporarily flooded places. The family has no specialized hibernating organs such as bulbs or underground corms. They endure short dry periods with well developed green leaves. Several species are either annual or perennial according to climate and living conditions. Chromosome of *Eriocaulon* have base numbers of 8, 9, 15, 20 and 25 and may be diplo-, tetra- and hexaploids; the chromosomes are very small. The

family is insect-pollinated (entomophily) by flies (*Diptera*) and beetles (following field observation, I also found that ants visited the flowers). Stützel (1998) also stated that cross-pollination occur in the family due to the separate flowering periods of male and female flowers. However, he noticed that in *Eriocaulon* anthesis of each flower lasted several days. This means that male and female flowers could be fully functional at the same time on a single plant, thereby allowing for geitonogamous self - pollination. However, unless there is absolutely synchrony in flowering time between inflorescence on a single plant and/or plants in a population (for which I have no evidence), cross-pollination between plants remains possible. Pollen is dispersed as a single, spheroid to ellipsoid, grain 25-35 μm in diameter and spiraperturate (aperture runs around pollen grain), and the surface is echinate to echinulate; the spinulae are of different size (Stützel, 1998).

Prajaksood (2000) studied pollen morphology of 12 species in *Eriocaulon* from Northeast of Thailand with light and scanning electron microscopes. She showed the pollen to be simple, syncolplate, spiraperture with parallel spirals around the grain, spheroidal, 15-30 μm in diameter, with the sexine provided with echinae. Her description agreed with Stützel (1998). She stated that pollen ruptured into fragments after treatment by acetolysis and also concluded that pollen does not provided a robust evidence for classification within the genus (Figure 1.1). Therefore pollen morphology was not included in this thesis.

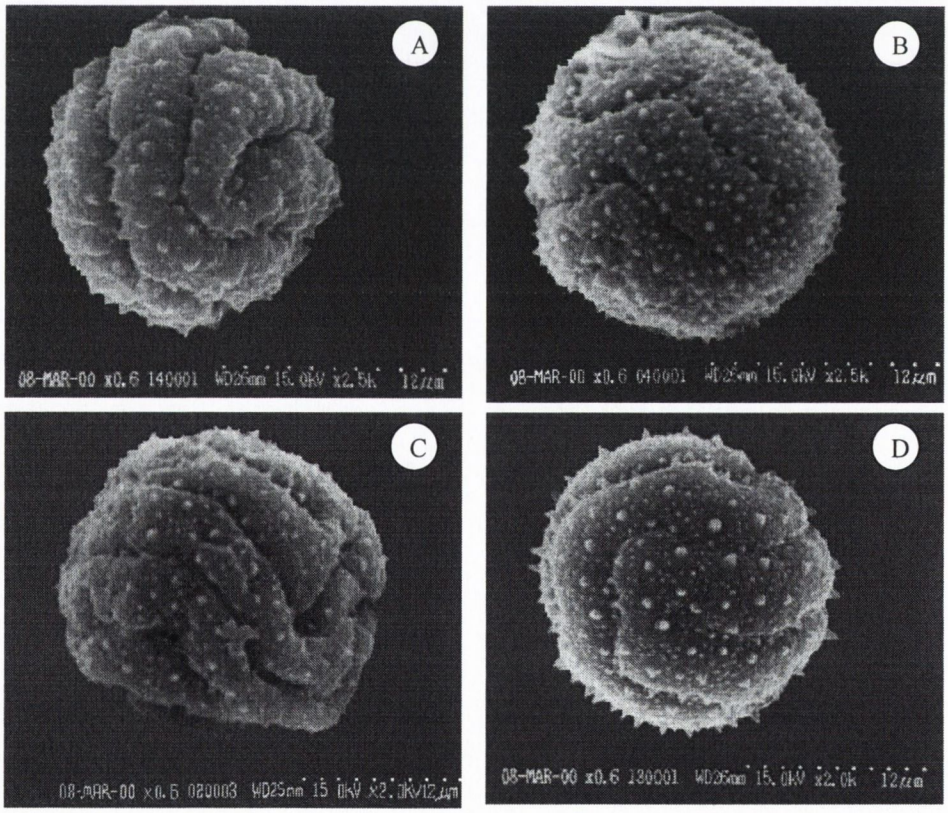

Figure 1.1 Pollen morphology in some species of *Eriocaulon*. (A) Pollen grain of *Eriocaulon infirmum* Steud. (*E. nakayense* sensu Prajaksood (2000)). (B) Pollen grain of *E. echinulatum* Mart. (C) Pollen grain of *E. nautiliforme* Lecomte. (D) Pollen grain of *E. smitinandii* Moldenke. Adapted from Prajaksood (2000).

In recent years seed surface morphology in the family has been recognized as a useful taxonomic aid (Nair, 1987; Giulietti *et al.*, 1988, Phillips, 1994). Seeds are ellipsoid or subglobose and their colour varies from yellow to a rich chestnut brown, the patterning often appearing as white flakes or striae against the background colour of the seed (Phillips, 1994). Seeds are characteristically sculptured (recticulate ot tuberculate— often called "Hairy") due to the anticlinal walls of the inner layer of the outer integument (Stützel, 1998). Phillips (1994) stated that seed surface morphology has been of great help in distinguishing species for the Ceylon Flora account of the Eriocaulaceae at species, or at least each species complex level. But she also stated that more work is required before broad generalizations at the generic level can be made with confidence. I noticed that in same inflorescence of species in *Eriocaulon*, seed sculpturing does vary. For example, sometime the sculpturing within a single species different when the seed is in the water from when it is not. However, because of the limits of time, seed morphology is not included in this study but will be carefully observed in the future.

The family seems to be very distinct, and placement in a separate order may well be justified (Stützel, 1998). The family still needs much intensive investigation because information on it is based on a few, very incomplete studies (Dahlgren *et al.*, 1985). *Eriocaulon* is the most widespread genus, with a great Asiatic concentration of species but rich representation also in Africa and South America (Dahlgren *et al.*, 1985). In Asia, there is only a single genus present, *Eriocaulon* (Phillips, 1997; Stützel, 1998). Consequently, in Thailand the family is represented by this genus.

1.2 Economic Value of Eriocaulaceae

The Eriocaulaceae are of little economic value. In Thailand, the rigid scapes along with their attached inflorescences are often dyed and sold as ornamental everlastings just as they are elsewhere in the world (Heywood, 1993). For example, in Central Brazil, the inflorescences of several species with their long peduncles are collected and dried for room decoration and the value of exported inflorescences has reached nearly 2 million US dollars (Stützel, 1998). Additionally, in China and Malaysia, they are used as medicinal plants, particularly for treatment of optical diseases. For example, 5-10 g of the entire plant of *E. cinereum* R.Br. is used for its antiphlogistic and ophthalmic properties (Hooper, 1929; Keys, 1976).

1.3 Eriocaulaceae and the Flora of Thailand Project

The study of the Flora of Thailand, with its estimated 11,000 vascular plant species, has been gathering momentum in the last few years and has now reached a well-advanced stage. The Flora of Thailand project, whose aim is to produce a complete floristic treatment of the entire vascular flora, was initiated in 1958 with Thai-Danish, Thai-Dutch and Thai-Japanese botanical expeditions (BKF, 2004).

In 1965, several botanists already working for decades on Thai flora decided to start more formal work on the Flora of Thailand project. The project was initiated by K. Larsen (Aarhus) in collaboration with J.E. Vidal (Paris), B.L. Burtt (Edinburgh), L.L. Forman (Kew), C. Phenklai (Bangkok), B. Hansen (Copenhagen), T. Smitinand (Bangkok), C.G.G.J. van Steenis (Leiden) and C.F. van Beusekom (Leiden). The Project was formally launched in 1967. The first part of the Flora was published in 1970 and additional parts have been produced regularly since then (BKF, 2004).

Nowadays, the Editorial Board of Flora of Thailand consists of representatives of principal herbaria, such as G. Argent (Edinburgh), J. Dransfield (Kew), K. Iwatsuki (Tokyo), K. Larsen (Aarhus), D. Middleton (Harvard), I. Nielsen (Aarhus), J. Parnell (Dublin), H. Pedersen (Copenhagen), C. Phengklai (Bangkok), M. Roos (Leiden) T. Santisuk (Bangkok) and J. Vidal (Paris) (Santisuk & Larsen, 2001). By August 2001, about 120,000 collections had been made for the project and seven volumes (in 21 parts) of the Flora had been published (BKF, 2004). Middleton (2003) has estimated the number of vascular plants in Thailand is 10,250 in 304 families. However, he highlights that only about 30% of the total number of species have so far been published or have been accepted for publication in the Flora of Thailand. The Eriocaulaceae is one of several small families in Thailand which have yet to be revised for the Flora of Thailand Project.

1.4 History of Species Diversity of Eriocaulaceae in Thailand

The first report of Eriocaulaceae species in Thailand is that of Schmidt (1904) who reported only *Eriocaulon quinquangulare* L. in the Flora of Koh Chang, Trat province. Later, Craib (1912) reported only *E. luzulaefolium* Mart. from Doi Sutep (Chiang Mai province) for the Flora of Siam and did not comment on Schmidt's earlier record.

Moldenke (1954) reported one new taxon from Phu Kradung, Loei province: *E. siamense* Moldenke. Five years later Moldenke (1959) reported another two new taxa from Chantaburi province: *E. smitinandii* Moldenke and *E. thailandicum* Moldenke. Twenty years later, Moldenke (1971) provided a list of Eriocaulaceae of the world and reported 32 taxa of the family in Thailand (Table 1.1).

Koyama (1955) reported three new taxa from Thailand: *E. lepidum* T.Koyama from Doi Sutep, Chiang Mai province; *E. nakayense* T.Koyama and *E. xenopodiun* T.Koyama both from Nakhon Phanom province (Table 1.1).

Hansen (1969) reported one new taxon from Thailand, *E. escape* Hansen, which was found on Phu Kradung, in Loei province (Table 1.1).

Satake (1974) reported that there were ten taxa of *Eriocaulon* in Thailand, seven of which were new to science (Table 1.1).

Smitinand (1975) reported that there were about 20 species of the genus in Thailand. However, he did not provide a list of names. Two years later, Smitinand (1977) reported that *E. henryanum* Ruhland was found in Khao Yai National Park, Nakhon Nayok province. In 1980, Smitinand reported 8 taxa of the genus in his Thai Plant Names book, *E. alatum* Lecomte, *E. echinulatum* Mart., *E. henryanum* Ruhland, *E. longifolium* Nees, *E. odoratum* Dalz., *E. sexangulare* L., *E. stellulatum* Körn. and *E. thailandicum* Moldenke. Recently, BKF (2001) revised the Tem Smitinand's book and reported 9 species more than Smitinand (1980) (Table 1.1).

It is noticeable that the species diversity of this family in Thailand is still poorly known. Many reports only list the names, with no descriptions or illustrations; therefore, it is difficult to recognize the plants, which could lead to under collection and misidentification of the specimens. The situation improved when Zhang (1999) worked on *Eriocaulon* in East Asia and reported 29 taxa in Thailand, including two new taxa which were endemic to Thailand (Table 1.1). This work provided a great deal of information on the family in East Asia.

In 2000, Prajaksood worked on a preliminary study of the family in NE Thailand and reported 21 taxa. 13 species potentially new to science were noticed, one of which was subsequently so reported in 2002: it is *E. pseudoescape* A.Prajaksood & Chantar. (Table 1.1).

Due to the minute flower parts which show a surprising degree of variation, the species are considered to be one of the most difficult groups to diagnose (Ansari and Balakrishnan, 1994; Phillips, 1997). However, between 1954 and 1974, 13 new taxa were reported from Thailand (Moldenke, 1954; Koyama, 1955; Moldenke, 1959; Hansen, 1969, Satake, 1974). Therefore, it is clear that much remains to be known in regard to the species diversity of Eriocaulaceae in Thailand (Table 1.1).

Table 1.1 Comparison of selected major works of Eriocaulaceae in Thailand. - = not reported, / = reported, ? = reported as synonym, * = endemic to Thailand, K = Koyama (1955), H = Hansen (1969), M = Moldenke (1971), S = Satake 1974, Z = Zhang (1999), P1= Prajaksood (2000), B = BKF (2001), P2 = Prajaksood (2002).

No.	Species	K	H	M	S	Z	P1	B	P2
1	*E. achiton* Körn.	-	-	/	-	-	-	-	-
2	*E. alatum* Lecomte	-	-	-	-	?	/	/	-
3	*E. alpestre* Hook.f. & Thoms.	-	-	/	-	-	-	-	-
4	*E. australe* R.Br.	-	-	-	-	/	-	-	-
5	*E. bassacense* Moldenke	-	-	-	-	-	/	-	-
6	*E. brownianum* Mart.	-	-	-	-	/	/	/	-
7	*E. christopheri* Fyson	-	-	-	-	-	/	-	-
8	*E. cinereum* R.Br.	-	-	/	-	/	/	/	-
9	*E. cristatum* Mart.	-	-	-	-	/	-	-	-
10	*E. dianae* Fyson	-	-	/	-	-	?	-	-
11	*E. dianae* var. *longibracteatum* Fyson	-	-	/	-	-	?	-	-
12	*E. dipsacoides* Satake	-	-	-	/*	/	?	-	-
13	*E. echinulatum* Mart.	-	-	/	-	/	/	/	-

Table 1.1 Continued

No.	Species	K	H	M	S	Z	P1	B	P2
14	*E. echinulatum* var. *tenue* Satake	-	-	-	/*	?	?	-	-
15	*E. eglandulatum* Z.X.Zhang	-	-	-	-	/*	-	-	-
16	*E. escape* Hansen	-	/*	-	-	-	/	/	-
17	*E. hamiltonianum* Mart.	-	-	/	-	/	?	-	-
18	*E. henryanum* Ruhland	-	-	/	-	-	-	/	-
19	*E. heterolepis* Steud.	-	-	-	-	-	/	-	-
20	*E. hookerianum* Stapf	-	-	/	-	-	/	/	-
21	*E. infirmum* Steud.	-	-	/	-	-	-	-	-
22	*E. intermedium* Körn.	-	-	/	/	?	?	-	-
23	*E. intermedium* var. *brevicaulae* Satake	-	-	-	/*	?	?	-	-
24	*E. intermedium* var. *glabrum* Satake	-	-	-	/*	?	-	-	-
25	*E. kathmanduense* Satake	-	-	-	-	-	/	-	-
26	*E. kradungense* Satake	-	-	-	/*	/	/	/	-
27	*E. lepidum* T.Koyama	/*	-	/	-	-	-	-	-
28	*E. longifolium* Nees	-	-	-	-	-	-	/	-
29	*E. luzulaefolium* Mart.	-	-	/	-	/	-	-	-
30	*E. minimum* Lam.	-	-	-	-	-	/		
31	*E. nakayense* T.Koyama	/*	-	/	-	-	/	-	-
32	*E. nautiliforme* Lecomte	-	-	-	-	/	/	/	-
33	*E. nepalense* Prescott ex Bong.	-	-	-	-	/	-	-	-
34	*E. odoratum* Dalz.	-	-	/	-	-	-	/	-
35	*E. oryzetorum* Mart.	-	-	/	-	/	-	-	-
36	*E. pseudoescape* A.Prajaksood & Chantar.	-	-	-	-	-	-	-	/*
37	*E. pseudonepalense* Satake	-	-	-	/*	/	/	-	-
38	*E. quinquangulare* L.	-	-	/	-	/	-	-	-
39	*E. redactum* Ruhland	-	-	/	-	-	?	-	-
40	*E. robusto-brownianum* Ruhland	-	-	/	-	-	-	-	-
41	*E. setaceum* L.	-	-	/	/	/	/	/	-
42	*E. sexangulare* L.	-	-	/	/	/	-	/	-
43	*E. siamense* Moldenke	-	-	/*	-	/	/	/	-
44	*E. siamense* var. *leiophyllum* Z.X.Zhang	-	-	-	-	/*	-	-	-
45	*E. smitinandii* Moldenke	-	-	/*	-	/	/	/	-
46	*E. sollyanum* Royle	-	-	/	-	-	-	-	-
47	*E. soucherei* Moldenke	-	-	/	-	-	-	-	-
48	*E. stellulatum* Körn.	-	-	/	-	-	-	/	-
49	*E. tagawae* Satake	-	-	-	/*	-	?	-	-
50	*E. thailandicum* Moldenke	-	-	/*	-	/	/	/	-
51	*E. tokinense* Ruhland	-	-	-	-	/	-	-	-
52	*E. truncatum* Ham.ex Mart.	-	-	/	-	/	/	-	-
53	*E. ubonense* H. Lecomte	-	-	/	-	-	-	-	-
54	*E. wightianum* Mart.	-	-	-	-	/	-	-	-
55	*E. willdenovianum* Moldenke	-	-	/	-	/	-	-	-
56	*E. xenopodium* T.Koyama	/*	-	/	-	/	/	-	-
57	*E. xeranthemum* Mart.	-	-	-	-	/	-	-	-
58	*E. zollingeranoides* Z.X.Zhang	-	-	-	-	/	-	-	-
59	*E. zollingerianum* Körn.	-	-	/	-	/	-	-	-
	Total (Taxa)	3	1	32	10	29	21	17	1

1.5 Historical Infrageneric Classification in *Eriocaulon* L. in East Asia

Fyson (1919-1922) revised the genus *Eriocaulon* in India and proposed eight sections within 51 species as follows:

(1) Section *Leucantherae* Fyson: Anthers white, consists of *E. breviscapon* Körn., *E. fluviatile* Trimen., *E. horsley-kundae* Fyson, *E. miserum* Körn., *E. rivulare* Dalz. and *E. sieoldianum* Sieb. & Zucc.

(2) Section *Setaceae* Fyson: Anthers black, submerged plants with capillary leaves, comprises *E. setaceum* L. and *E. intermedium* Körn.

(3) Section *Connatosepalae* Fyson: Anthers black, terrestial or swamp plants, female sepals connate, consists of *E. alpestre* Hook.f. & Thomson ex Körn.

(4) Section *Cristatosepalae* Fyson: Anthers black; terrestial or swamp plants; female sepals free; floral bracts scabrid or puberulous, pale; female sepals strongly boat-shaped and crested on the keel or at least enlarged, composed of *E. cuspidatum* Dalz., *E. echinulatum* Mart., *E. elenore* Fyson, *E. margaretae* Fyson, *E. minutum* Hook.f., *E. sexangulare* L. and *E. thomasi* Fyson

(5) Section *Scariosae* Fyson: Anthers black; terrestial or swamp plants; female sepals free; floral bracts scabrid or puberulous, pale; female sepals 3 or 2 narrow; comprises *E. edwardii* Fyson, *E. hamiltonianum* Mart. and *E. oryzetorum* Mart.

(6) Section *Simplices* Fyson: Anthers black, terrestial or swamp plants, female sepals free, floral bracts black with white hairs on the back, receptacle glabrous, consists of *E. achiton* Körn., *E. barba-caprae* Fyson, *E. collettii* Hook.f., *E. collium* Hook.f., *E. dianae* Fyson, *E. duthiei* Hook.f., *E. geoffreyi* Fyson, *E. gregatum* Körn., *E. luzulaefolium* Mart., *E. nepalense* Prescott ex Bong., *E. pumilio* Hook.f., *E. quinquangulare* L., *E. roseum* Fyson, *E. sedgwickii* Fyson, *E. thwaitsii* Körn., *E. trilobum* Buch.-Ham. ex Körn., *E. trimeni* Hook.f., *E. truncatum* Buch.-Ham. ex Mart. and *E. xeranthemum* Mart.

(7) Section *Hirsutae* Fyson: Anthers black; terrestial or swamp plants; female sepals free; floral bracts black with white hairs on the back, receptacle and involucral bracts hairy or also the scapes and leaves, male petals equal and small, consists of *E. brownianum* Mart., *E. gracile* Mart., *E. lanceolatum* Miq., *E. rhodae* Fyson, *E. robusto-brownianum* Ruhland and *E. wightianum* Mart.

(8) Section *Anisopetalae* Fyson: Anthers black; terrestial or swamp plants; female sepals free; floral bracts black with white hairs on the back, receptacle hairy, one male petal much enlarged and projecting so or to hide the floral bracts, comprises *E. atratum* Körn., *E. caulecens* Steud., *E. ceylanicum* Körn., *E. cristatum* Mart., *E. longicuspis* Hook.f., *E. odoratum* Dalz. and *E. polycephalum* Hook.f.

Satake (1940) studied the family in Japan and recognised two subgenera and five sections with 36 species, as follows:

Subgenus *Astole* Körn.

1. Section *Nasmythia* Mart. comprises *E. decemflorum* Maxim.

Subgenus *Trimeranthus* Nakai

2. Section *Heterochitoni* Ruhland consists of *E. miyagianum* Koidzumi

3. Section *Leucochephala* Nakai consists of *E. sieboldtinum* Sieb. & Zucc. ex Steud.

4. Section *Euriocaulon* Ruhland is composed of three series, series *Disepala* Satake (*E. suishaense* Hayata), series *Leptocaulon* Ruhland (*E. zyotanii* Satake) and series *Tmetopsis* Ruhland (*E. cauliferum* Makino, *E. nantoense* Hayata, *E. parvum* Körn., *E. senile* Honda and *E. trisectum* Satake)

5. Section *Spathopeplus* Nakai consists of two subsections as follows:

5.1 Subsection *Macropoda* Satake (*E. heleocharioides* Satake)

5.2 Subsection *Apoda* Satake comprises two series

5.2.1 Series *Miqueliana* Satake is composed of *E. buergerianum* Körn., *E. hondoense* Satake, *E. japonicum* Körn., *E. lutchuense* Koidzumi, *E. matsumurae* Nakai, *E. miquelianum* Körn., *E. monococcon* Nakai, *E. nudicuspe* Maxim., *E. perplexum* Satake, *E. piliphorum* Satake, *E. robustius*, *E. sikokianum* Maxim., *E. takae* Koidzumi and *E. tenussimum* Nakai, Makino

5.2.2 Series *Atra* Satake consists of *E. atroides* Satake, *E. atrum* Nakai, *E. hananoegoense* Masam., *E. kosiorense* Miyabe, *E. nakasimanum* Satake, *E. nanellum* Ohwi, *E. nosoriense* Ohwi, *E. pallenscens* Satake, *E. sachalinense* Miyabe, *E. sekimotoi* Honda and *E. sphagnicolum* Ohwi

In 1991, Ma studied *Eriocaulon* in China and proposed two subgenera, more or less similar to Satake (1940), however Ma recognized only three sections as follows:

Subgenus *Eriocaulon* L. consists of *E. decemflorum* Maxim.

Subgenus *Trimeranthus* Nakai comprises three sections

1. Section *Macrocaulon* Ruhland is composed of three series

1.1 Series *Tmetopsis* Ruhland (*E. acutinbracteatum* W.L.Ma, *E. angustulum* W.L.Ma, *E. australe* R.Br., *E. brownianum* Mart. var. *nilagirense* Fyson, *E. henryanum* Ruhland, *E. nantoense* Hayata var. *micropetalum* W.L.Ma, *E. nantoense* Hayata var. *parviceps* W.L.Ma, *E. pullum* T.Koyama, *E. rockianum* Hand.-Mazz. var. *latifolium* W.L.Ma, *E. senile* Honda, *E. setaceum* L., *E. sexangulare* L., *shochoanum* Hand.-Mazz., *E. sollyanum* Royle and *E. yaoshanense* Ruhland var. *brevicalyx* W.L.Ma,)

1.2. Series *Leiantha* W.L.Ma (*E. bilobatum* W.L.Ma, *E. leianthum* W.L.Ma and *E. zollingerianum* Körn.)

1.3. Series *Disepala* Satake (*E. merrillii* Ruhland var. *longibracteatum* W.L.Ma and *E. sclerophyllum* W.L.Ma)

2. Section *Leucocephala* Nakai (*E. cinereum* R.Br., *E. echinulatum* Mart. and *E. taichanense* F.Z.Li)

3. Section *Spathopeplus* Nakai consists of 3 series

3.1 Series *Miqueliana* Satake (*E. buergerianum* Körn. and *E. sikokianum* Maxim. var. *linanense* W.L.Ma)

3.2 Series *Robustiora* W.L.Ma (*E. alpestre* Hook.f. var. *sichuanense* W.L.Ma, *E. chinorossium* W.L.Ma, *E. glabripetalum* W.L.Ma, *E. robustius* (Maxim.) Makino and *E. minusculum* Moldenke)

3.3 Series *Mangshanensia* W.L.Ma (*E. faberi* Ruhland and *E. mangshanense* W.L.Ma)

Ansari and Balakrishnan (1994) who worked on the family in India for five years, described 65 species of *Eriocaulon* and recognized 12 informal sections formulated on the basis of the Indian species and based on a number of constant and contrasting features recognized for those species. The sections they recognised were:

Section I or section *Connatosepalae* Fyson, this section is represented by a single species, *E. alpestre* Hook.f. & Thomson ex Körn. which is restricted to the Himalayan region and also reported from China and Japan.

Section II or section *Hirsutae* Fyson, only two species are included in this section, *E. rhodae* Fyson is confined to Western Peninsular India and *E. helferi* Hook.f. extends its distribution to Andaman Islands whereas its allied species, *E. wightianum* Mart., is endemic to Burma.

Section III is composed of 19 species, 14 of which are endemic to Western Peninsular India (*E. ensiforme* C.E.C.Fisch., *E. heterolepis* Steud., *E. hookerianum* Stapf, *E. lanceolatum* Miq. ex Körn., *E. odoratum* Dalz., *E. parviflorum* (Fyson) Ansari & Balakr., *E. robusto-brownianum* Ruhland, *E. richardianum* (Fyson) Ansari & Balakr., *E. santapaui* Moldenke, *E. sivarajanii* Ansari & Balakr., *E. stellulatum* Körn., *E. thwaitesii* Körn., *E. trilobum* Buch.-Ham, ex Körn., *E. vasudevanii* Ansari & Balakr.), four of which are frequent in the northern part of India and extend to the neighbouring countries of the northeast region (*E. brownianum* Mart., *E. nepalense* Prescott ex Bong., *E. oryzetorum* Mart. and *E. xeranthemum* Mart.) and *E. sharmae* Ansari & Balakr. is endemic to India.

Section IV or section *Setaceae* Fyson, contains only *E. capillus-naiadis* Hook.f. which has a wider distribution outside the country and *E. setaceum* L. which is restricted to the Western Peninsular of India.

Section V comprises two species, *E. longifolium* Nees ex Kunth which is reported only from Andaman Islands, whereas *E. sexangulare* L. is restricted to the West coast of Peninsular region.

Section VI is composed of six species; most of them are endemic to Western Peninsular India, *E. achiton* Körn., *E. cuspidatum* Dalz., *E. duthei* Hook.f., *E. eurypeplon* Körn., *E. fysonii* Ansari & Balakr. and *E. sedgwickii* Fyson.

Section VII included 11 species, *E. cherrapunjianum* Ansari & Balakr., *E. conica* C.E.C.Fisch., *E. cristatum* Mart., *E. edwardii* Fyson, *E. hamiltonianum* Mart., *E. longicuspis* Hook.f., *E. martianum* Walla ex Körn., *E. palghatense* Ansari & Balakr., *E. quinquangulare* L., *E. ramnadense* Ansari & Balakr., and *E. truncatum* Ham. ex Mart.

Section VIII consists of three species. *E. collettii* Hook.f. is native to Burma, whereas *E. nairii* Chandrab. & Chandras. and *E. robustum* Steud. are endemic to the Western Peninsular of India.

Section IX comprises four species, which are all found in Western Peninsular India, namely *E. elenorae* Fyson, *E. margaretae* Fyson, *E. meeboldii* Ansari & Balakr. and *E. minutum* Hook.f.

Section X is composed of two species endemic to India, *E. pectinatum* Ruhland and *E. rajendrababui* Ansari & Balakr.

Section XI, only *E. tuberiferum* Kulkarni & Desai is included in this section.

Section XII or section *Leucoantherae* Fyson, consists of 12 species, *E. dalzellii* Körn., *E. barbeyanum* Ruhland, *E. miserum* Körn., *E. mitophyllum* Hook.f., *E. fluviatile* Trimen, *E. breviscapum* Körn., *E.*

panagudianum Ansari & Balakr., *E. leucomelas* Steud. *E. talbotii* Ansari & Balakr., *E. ritchieanum* Ruhland, *E. cinereum* R.Br. and *E. redactum* Ruhland.

They used the following key to separate plants into the sections.

Key to the sections of the genus

1a. Female sepals connate into a spathe	Section I
1b. Female sepals free	2.
2a. Female petals coriaceous, broad, with a distinct claw	Section II
2b. Female petals hyaline, narrow, not clawed or absent	3.
3a. Anthers black or dark brown	4.
3b. Anther white or pale yellow	11.
4a. Seed surface furnished with appendages or ridges	5.
4b. Seed surface without any appendages or ridges	10.
5a. Seed coat cells transversely or vertically elongated	6.
5b. Seed coat cells isodiametric	Section VIII
6a. Appendages of seeds ribbon-like or rectangular in structure or represented by ridges on the surface of seeds	Section VII
6b. Appendages of seeds setiform	7.
7a. Male sepals connate laterally at least at the base to form a closed or open spathe	8.
7b. Male sepals free	Section VI
8a. Spathe of male flower closed and tubular	Section V
8b. Spathe of male flower split on the abaxial side	9.
9a. Stem more than 10 cm long; leaves cauline, filiform	SectionIV
9b. Stem absent or less than 5 cm long; leaves caespitose, not filiform	Section III
10a. Seed coat cells isodiametric	Section IX
10b. Seed coat cells transversely elongated	Section X
11a. Seed surface furnished with ribbon-like appendages	SectionXI
11b. Seed surface without any appendages	Section XII

Certainly, according to Ansari and Balakrishnan (1994), it is not advisable to use such a classification based on plants from a limited geographic region in a wider context; the classification was constructed only as a general practical aid to the identification of species, though they admit that these groups may later help to form a natural classification.

Since then, Zhang (1999) produced the first monograph of the genus in East Asia. According to him, *Eriocaulon* has the highest variability within the family. The high intraspecific variability combined with sometimes limited interspecific differences makes the taxonomy of the genus sometimes very difficult. In order to establish a natural classification system for the genus, he studied morphology, anatomy and pollen morphology. His results show that the genus is in a phase of evolutionary differentiation. He described 74 species from eastern and southern Asia and established a new

infrageneric system within *Eriocaulon* based on the results of a cladistic analysis and classical taxonomy. Two subgenera were recognized, *Trimeranthus* Nakai including seven sections and 53 species, and *Spathopeplus* Körn. including three sections and 21 species, as follows:

Subgenus *Trimeranthus* Nakai, comprises seven sections; six of which were found in Thailand (Table 1.1).

1. Section *Macrocaulon* Ruhland consists of only one species, *E. setaceum* L. which is also found in Thailand (Table 1.1).

2. Section *Simplices* Fyson comprises 25 taxa: *E. achiton* Körn., *E. boni* Lecomte, *E. brownianum* Mart., *E. collinum* Hook.f., *E. eglandulatum* Z.X.Zhang, *E. ermeiense* W.L.Ma ex Z.X.Zhang, *E. heterolepis* Steud., *E. kunmingense* Z.X.Zhang, *E. laosense* Moldenke, *E. leianthum* W.L.Ma, *E. luzulaefolium* Mart., *E. nantoense* Hayata, *E. nepalense* Prescott ex Bong., *E. oryzetorum* Mart., *E. parvum* Körn., *E. pseudonepalense* Satake, *E. quinquangulare* L., *E. robusto-brownianum* Ruhland, *E. rockianum* Hand.-Mazz. var. *latifolium* W.L.Ma, *E. schochianum* Hand.-Mazz., *E. smitinandii* Moldenke, *E. thailandicum* Moldenke, *E. wightianum* Mart., *E. xenopodium* T.Koyama and *E. xeranthemum* Mart.; 12 of which were found in Thailand (Table 1.1).

3. Section *Anisopetalae* Fyson is composed of 10 taxa: *E. bassacense* Moldenke, *E. cristatum* Mart., *E. eberhardtii* Lecomte, *E. henryanum* Ruhland, *E. hookerianum* Stapf, *E. kradungense* Satake, *E. nautiliforme* Lecomte, *E. siamense* Moldenke, *E. siamense* Moldenke var. *leiophyllum* Z.X.Zhang, *E. tanakae* Ruhland; 5 of which were found in Thailand (Table 1.1).

4. Section *Heterochiton* Ruhland comprises three species, all of which were found in Thailand: *E. australe* R.Br., *E. sexangulare* L., *E. willdenovianum* Moldenke.

5. Section *Disepala* (Satake) Z.X.Zhang, is composed of 10 taxa: *E. dipsacoides* Satake, *E. echinulatum* Mart., *E. hamiltonianum* Mart., *E. nigrum* Lecomte, *E. pseudotruncatum* Z.X.Zhang, *E. thwaitesii* Körn., *E. truncatum* Buch.-Ham. ex Mart., *E. truncatum* Buch.-Ham. ex Mart. var. *florensense* Z.X.Zhang, *E. zollingerianoides* Z.X.Zhang, *E. zollingerianum* Körn.; 7 of which were found in Thailand (Table 1.1).

6. Section *Leucantherae* Fyson, comprises four species: *E. barbeyanum* Ruhland, *E. cinereum* R.Br., *E. taishanense* F.X.Li and *E. tonkinense* Ruhland; 2 of which were found in Thailand (Table 1.1).

7. Section *Nasmythia* Huds., is composed of only one species, *E. decemflorum* Maxim., which is not found in Thailand.

Subgenus *Spathopeplus* Körn., comprises three sections, none of which were found in Thailand.

1. Section *Apoda* (Satake) Z.X.Zhang, consists of 22 taxa: *E. alpestre* Hook.f. & Thomson, *E. atroides* Satake, *E. atrum* Nakai, *E. atrum* Nakai var. *kananoegoense* (Masam.) T.Koyama, *E. buergerianum* Körn., *E. faberi* Ruhland, *E. hondoense* Satake, *E. japonicum* Körn., *E. kusiroense* Miyabe & Kudô ex Satake, *E. liberisepalum* Z.X.Zhang, *E. minusculum* Moldenke, *E. miquelianum* Körn., *E. miquelianum* Körn. var. *matsumurae* (Nakai) Z.X.Zhang, *E. monococcon* Nakai, *E. nanellum* Ohwi, *E. nanellum* Ohwi var. nosoriense (Ohwi) Ohwi & T.Koyama, *E. sachalinense*

Miyabe & Nakai, *E. sekimotoi* Honda, *E. sphagnicolum* Ohwi, *E. takae* Koidz., *E. tenuissimum* Nakai, *E. zyotanii* Satake.

2. Section *Macrapoda* Z.X.Zhang, comprises only *E. heleocharioides* Satake

3. Section *Nudicuspa* Z.X.Zhang, consists of only *E. nudicuspe* Maxim.

Zhang (1999) examined the seed coat of 65 selected species by scanning electron microscopy (SEM) and realized that the seed coat was bitegmic, each integument consisting of two layers. He found that the heterogeneous surface structure of the seed coat was generally derived from the thickenings of anticlinal walls of the inner layer of the outer integument. He also found that this thickening of the cell walls provided distinctive features which he considered were more important taxonomically than the general shape of the seeds. Whether only a part of the anticlinal walls or all of them were thickened, or if the thickenings were completely absent, he also found to be of essential diagnostic value. The thickenings in the genus often occur on the anticlinal walls, rarely in the corners between transverse and longitudinal anticlinal walls. He found that seed morphology is of high value for the identification of *Eriocaulon* species and also at infrageneric level. Seed coat characters are uniform for section *Leucantherae* and section *Heterochiton* in subgenus *Trimeranthus* and all three sections in subgenus *Spathopeplus*.

Zhang (1999) studied the anatomy of the peduncle of 60 selected species and stated that the epidermis above the ribs displays important diagnostic characters for subgenera. For example, subgenus *Spathopeplus*, in which the cells of the epidermis above the ribs are distinctly smaller and thickened, contrasts with subgenus *Trimeranthus* where the cells of the epidermis of are neither small nor thickened. Additionally, Zhang (1999) reported that the stele (the central vascular cylinder) consists of two distinct whorls of vascular bundles and medulla (pit), with the outer bundles smaller than the inner ones. There is also a sclerenchyma band in the stele. The steles may be formed according to the following types:

Type I: the outer whorl is completely encircled by a sclerenchymatous band.
Type II: the sclerenchymatous band runs only between the outer and the inner bundles.
Type III: the outer and inner bundles are completely surrounded by sclerenchyma.
Type IV: there is no continuous sclerenchymatous band, but the sclerenchyma lies peripheral to the inner bundles.

He noticed that the structure of the vascular bundle is very variable and is only helpful for species determination, but seems not to be constant for sections or subgenera. Even though he found section *Nasmythia* shows the same anatomical characteristics of scape as subgenus *Spathopeplus* (the epidermis cells of the ribs area thickened and smaller than other epidermis cells), he assigned section *Nasmythia* to the subgenus *Trimeranthus*, because of the flower characteristics and seed morphology.

Zhang (1999) conducted a cladistic analysis of Asian *Eriocaulon* based on the morphological characters of flowers and seeds and selected the genus *Mesanthemum* to be an outgroup. He summarized the systematics and evolution of Asian *Eriocaulon* species and divided them into four groups. Group I, he distinguished by the large sepals of the female flowers. The synapomorphy for group II is the morphology of the median petal of the male flowers, which is much larger than the lateral petals, rising over the flowers and also extending beyond the capitula. Group III differs from the other groups in that the median sepal of the female flowers is much smaller than the lateral ones. Group IV is characterized by the sepals of female flowers being connate and forming a spathe. Based on this character, group IV is described as subgenus *Spathopeplus*.

1.6 Aims of Study

Based on the observation of the history of species diversity of Eriocaulaceae in Thailand (Table 1.1), 59 taxa have until now been found in Thailand. However, there is a little consistency about the species' occurrence. For example, only 11 of 32 taxa reported by Moldenke (1971) are also reported by BKF (2001) and therefore 6 of the taxa reported by BKF (2001) are not reported by Moldenke (1971). Especially, a large number of the taxa reported in Table 1.1 are considered to be synonyms by Zhang (1999) and Prajaksood (2000). The most up to date information was from Zhang (1999) and Prajaksood (2000). Zhang studied Thai species based on information from herbarium specimens which were held in herbaria from countries other than Thailand (neither **BK** nor **BKF**) and Prajaksood (2000) studied specimens which were found in the Northeast of Thailand. This means they could not complete the account of the family for Thailand. Therefore, the aim of this study was to:

1.6.1 Provide a complete account of Eriocaulaceae for the Flora of Thailand.

1.6.2 Resolve the identity of unknown Thai taxa in the family.

1.6.3 Investigate the relationships between Thai species using morphological, anatomical and molecular approaches.

CHAPTER 2

GENERAL MORPHOLOGY

2.1 Introduction

The general morphological characters described here are based mainly on the taxa studied in the taxonomic treatment chapter (Chapter 5). These taxa are from Thailand but also include taxa from other earlier works from other regions in Asia (*i.e.* Koyama (1984), Phillips (1997), Zhang (1999)) or from global studies (*i.e.* Heywood (1993), Stützel (1998)). Terms used, which are specific to the group of study, are explained herein and when appropriate some figures are provided to give more explanation.

2.2 Habit and vegetative parts

Eriocaulaceae are annual or perennial herbs. To recognize the habit, the stem is always used: annual herbs will have a very short stem, reduced to a basal disc or are corm-like (Figures 2.1 and 2.2); aquatic submerged plants will have an elongate stem (Figure 2.3). The term perennial herb is applied to plants with a rhizome; sometimes the rhizome is very short.

Roots are fibrous (Figures 2.1 and 2.2), the fenestrae which is the horizontal lines along the root can be easily observed and distinguish the family from the Poaceae or Cyperaceae.

Stems are normally unbranched (Figure 2.2), however branched stems can be found in submerged plants (Figure 2.3)

Leaves are simple, sessile, opaque to translucent, sometimes fenestrate, usually narrowly linear (Figures 2.1 and 2.2). Filiform or acicular leaves are found only in *Eriocaulon setaceum* L.; which is the only submerged aquatic species (Figure 2.3). Leaves are spirally arranged, mostly crowded into basal rosettes (Figure 2.2B) and dispersed along elongated stems in *E. setaceum* and some other species which grow in shallow water (Figure 2.3A). Their size is very variable but always has a significant value when combined with the other characters. The presence of hairs on the leaf surface is also useful for indentification. Papillate leaves are rarely found in the family, and papillae, if present, can be easily observed under the stereomicroscope or compound microscope (Figure 2.4). The apex of the leaves is acute, obtuse or 2-lobed; a hydrathode-like structure (pore at the end of apex) is always present.

2.3 Reproductive parts

The peduncles (scapes) are leafless and ribbed, few or numerous, slender and usually extend beyond the leaves, which may sheath them at the base (Figure 2.1); hairy scapes can be useful for identification. However, scapes are absent in some species in *Eriocaulon* species (*e.g. Eriocaulon escape* B.Hansen) (Figure 2.5).

Sheaths are loose, acute, obtuse or 2-3-lobed, often glabrous. The colour or surfaces of the sheaths are always similar to the leaves. Because the sheaths always surround the base of the scapes, they will be absent if the scapes absent.

The capitula are hemispherical or ovoid to globose, usually monoecious and composed of many small unisexual flowers on a central receptacle surrounded by one to several whorls of involucral bracts (Figure 2.6). The receptacle may be elongate or convex (Figure 2.6), often villus (Figure 2.6B). Each flower is itself subtended by enclosing floral bracts (Figures 2.6B and 2.10C-D). Within each capitulum the male and female flowers are mixed or the male flowers are in the center surrounded by female flowers (Figure 2.7). The capitula are different in size, shape and colour which are mostly easy to recognize (Figure 2.8). However, in some species, capitula are very similar, *e.g. Eriocaulon hamiltonianum* Mart. (Figure 2.8C) and *E. zollingerianum* Körn. (Figure 2.8I). Therefore, dissections under the stereomicroscope are required for identification.

Involucral bracts are mostly in 1-3 whorls and coriaceous (Figure 2.8A-C), rarely scarious (Figure 2.8 F and H). They are mostly brown in colour (Figure 2.8A); however, sometimes in the inner whorls, the upper parts can be black. When the term "whitish" involucral bracts is used, it means they are colourless or very light brown, the term "whitish" is also applied to the colour of floral bracts, sepals and petals in the same sense (Figure 2.8H). The length of the involucral bracts when cpmpared to the length of the capitula is useful as a means of recognizing the species, for example, *Eriocaulon truncatum* var. florensense Z.X.Zhang has the length of involucral bracts the same as the length of capitula (Figure 2.8F) whereas *E. xeranthemum* Mart. has the length of involucral bracts longer than its capitula (Figure 2.8H) (the habit of these two speices are more or less the same). The shape of the involucral bract varies from obovate to elliptic, and is rarely linear (Figure 2.11). The hairs are always on the outer face of the involucral bracts if present (Figure 2.11).

Floral bracts are mostly scarious (Figure 2.9B) and rarely coriaceous (Figure 2.10 C-D). Their colour varies from whitish (Figure 2.8A, D and E), brownish (Figure 2.8B-C, G-I) to blackish (Figure 2.8F), and can have taxonomic value. The floral bract size and shape is also varied; they are often oblanceolate or obovate (Figure 2.12). The shape of apex is very useful for identification as well as the presence of hairs on the outer face (Figure 2.12).

The perianth is usually composed of 2 distinct whorls (Figure 2.9D), though it is sometimes reduced or absent (Figure 2.9C).

The segments of the outer perianth (sepals) are mostly scarious, whitish (Figure 2.9D), the presence of blackish sepals or blackish in the upper part is also taxonomically important. However, their size varies (Figures 2.13 and 2.14) and is not taxonomically useful as it is dependant on the environment. The sepals are two or three in number and free (Figure 2.13A-D), united or partly united and sometime spathe-like especially in the male flowers (Figure 2.8E-N). In the female, they are usually free (Figure 2.14), and often navicular (boat-shaped) or oblanceolate (Figure 2.14 B-D) and sometimes winged (Figure 2.14L and P). The presence of hairs provides a significant value for identification, especially in the female flowers (Figure 2.14).

The inner series (petals) are more or less thicker than the sepals and always whitish if present. A comparison in size of the medial petalwith the lateral ones is taxonomically important (Figures 2.13 and 2.15). In *Eriocaulon*, petals may be exserted from the floral bracts, *e.g. Eriocaulon siamense* Moldenke (Figure 2.5) which makes the species easily distinguishable from others. The petals are two or three. The male petals are fused with the floral axis to form an infundibular structure topped by very small free lobes (Figures 2.9D and 2.13), one of which may be somewhat enlarged (Figure 2.13). Whereas the female petals are always free (Figure 2.15) or may be lacking altogether (Figure 2.10C). The subapical black nectar-glands are mostly conspicuous on the inner face (Figures 2.13 and 2.15). White-hairs are often found at the tip of the petals (Figures 2.13 and 2.15).

Male flowers have stamens as many, or twice as many (*e.g.* in *Eriocaulon*), as the petals and inserted on the inner perianth segments when there are present. The inner whorl of stamens is epipetalous. The anthers are loculicidally dehiscent, mostly black, however whitish or creamy anther are also found and also useful for identification. A vestigial gynoecium (black gland) is usually present in the center of the male flowers; the number of glands is as many as the locules (Figures 2.13).

Female flowers have a superior 2-3 (Figure 2.16) or 5-6-locular ovary (Figure 2.16F and J). The style is single, terminal and tipped with 2, 3 or 6 (Figure 2.16) elongate stigmas (as many as the locules). There is a solitary, orthothropous, pendulous ovule in each locule. The length of the stalk is useful in identification (Figure 2.16). The fruit is a membranous, loculicidally dehiscent capsule, each locule containing a single, ellipsoidal or ovoid seed (Figure 2.10C). The seeds contain copious floury endosperm and a small embryo. The seeds are yellow to reddish-brown, the seed coat is usually with cells transversely elongate. The appendages or tuberculae are mostly presnt from the middle of the transverse radial walls (called as papillate) or sometime the papillate absent.

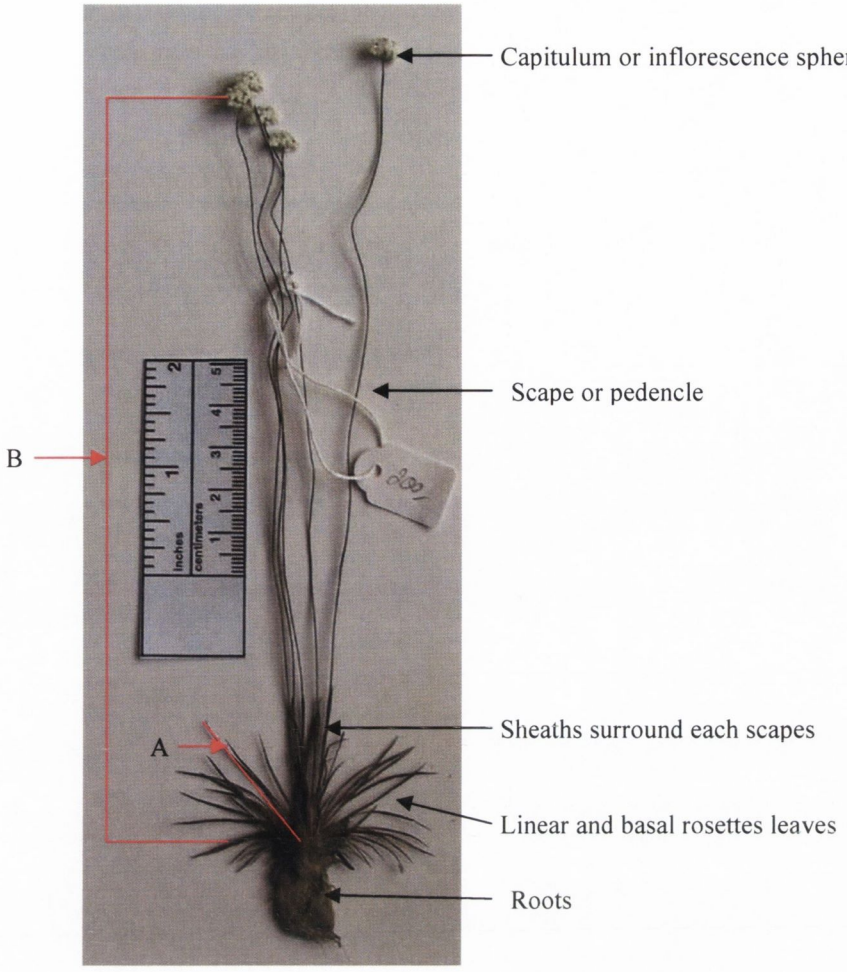

Figure 2.1 Habit of *Eriocaulon siamense* Moldenke. (A) The length of leaves, (B) The length of scapes.

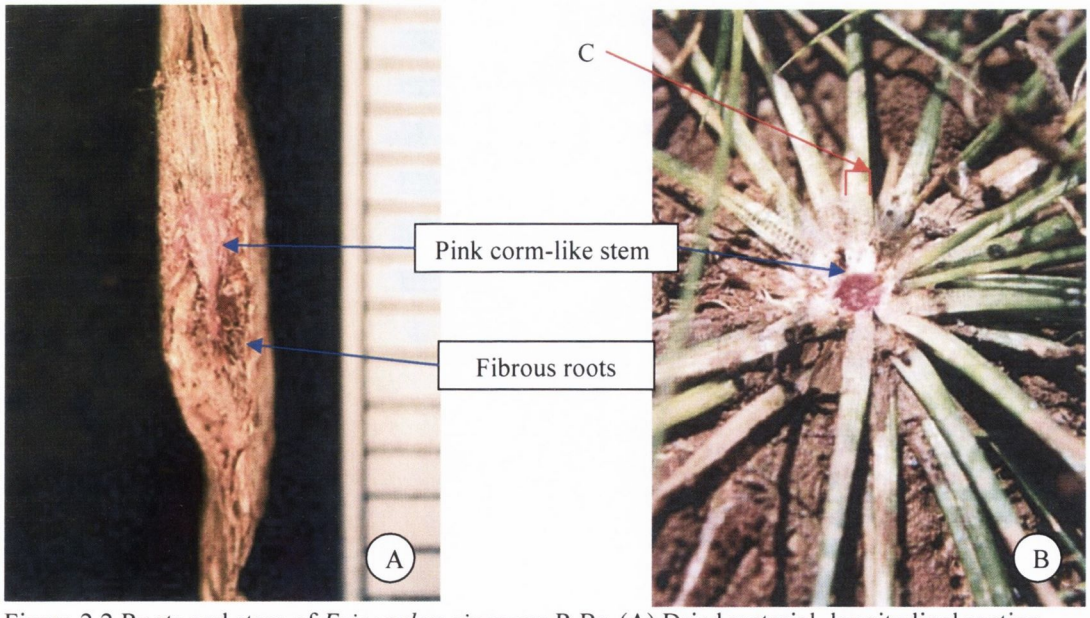

Figure 2.2 Roots and stem of *Eriocaulon cinereum* R.Br. (A) Dried material, longitudinal section stem. Scale = 1mm. (B) Fresh material, transverse section stem, (C) The width at the base of leaves.

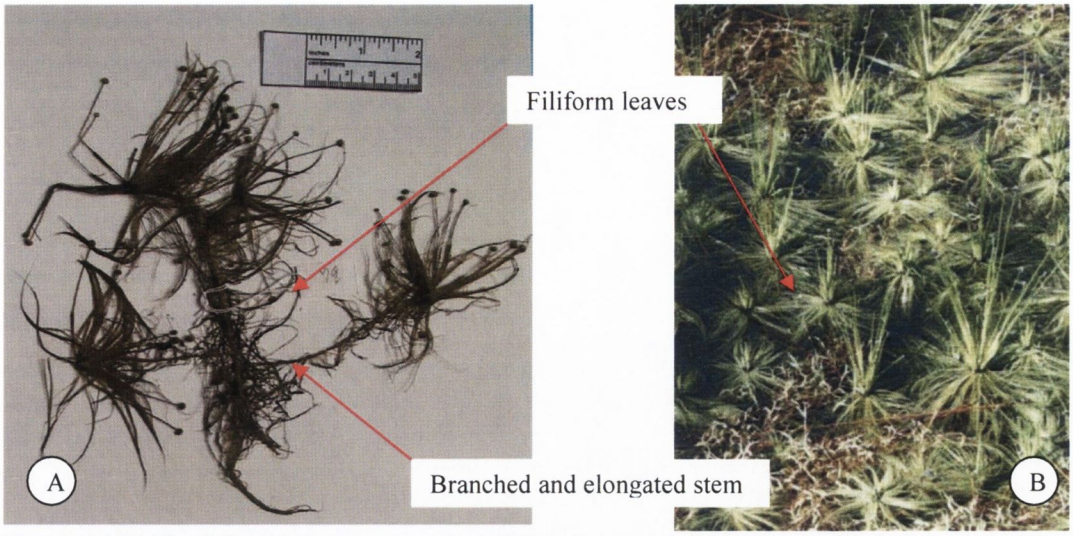

Figure 2.3 Habit of *Eriocaulon setaceum* L. (A) Dried material show branched and elongated stem, filiform leaves (B) Fresh material in stream show filiform leaves spread under water.

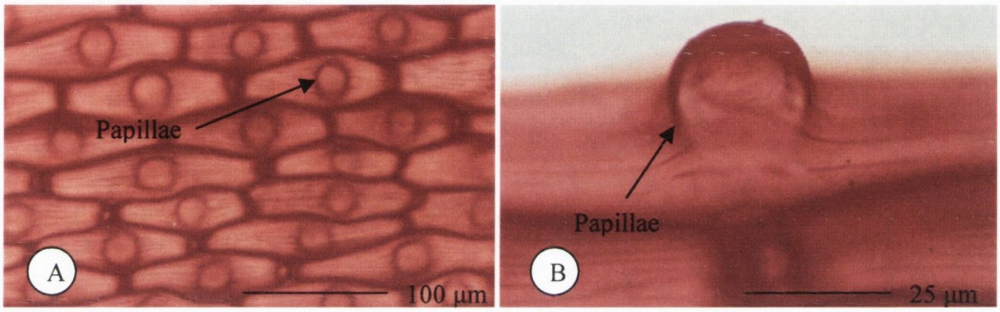

Figure 2.4 Papillae on leaf surface of *Eriocaulon echinulatum* Mart. Leaves stained with safranin and observed under compound microscope. (A) Top view of papillate epidermal cells. (B) Lateral view of papillate epidermal cell. Apated from Prajaksood (2000).

Figure 2.5 Character of inflorescence and the presence of scape within *Eriocaulon*. From right to left, inflorescence (capitulum) without scape in *Eriocaulon escape* B.Hansen; capitula with scape in *E. infirmum* Steud., *E. siamense* Moldenke and *E. echinulatum* Mart.

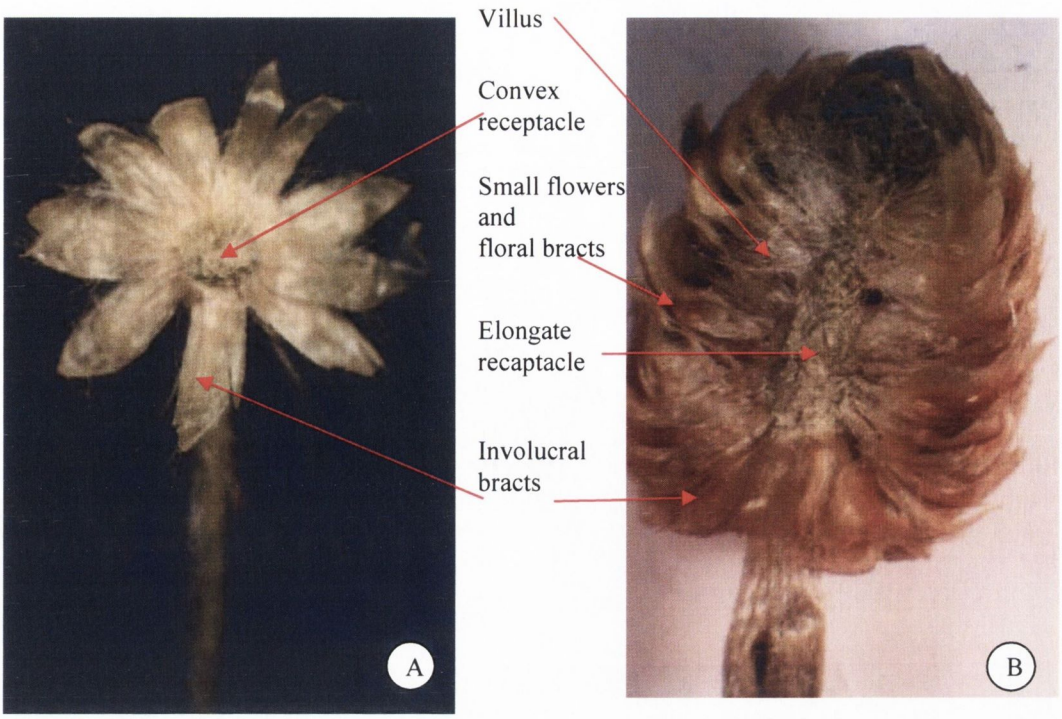

Figure 2.6 *Eriocaulon chantaranothai* A.Prajaksood & J.Parn (A) and *E. zollingerianum* Körn (B)

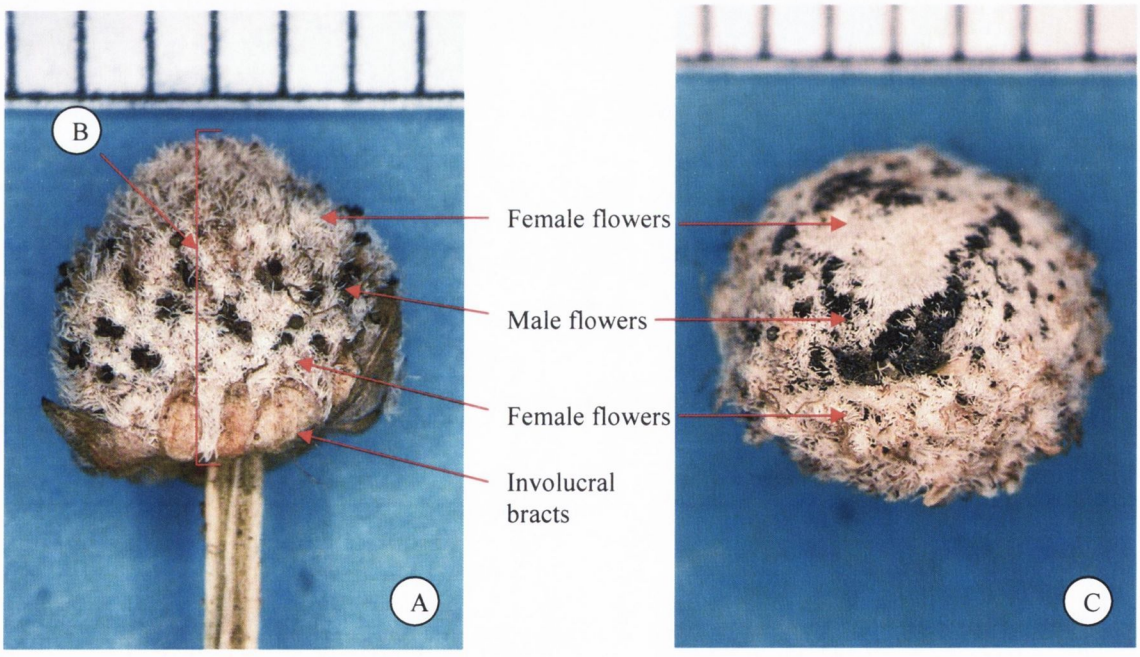

Figure 2.7 Capitulum of *Eriocaulon phuphanense* A.Prajaksood & J.Parn. (A) and the length of capitulum (B); and capitulum *E. xenopodium* T.Koyama (C).

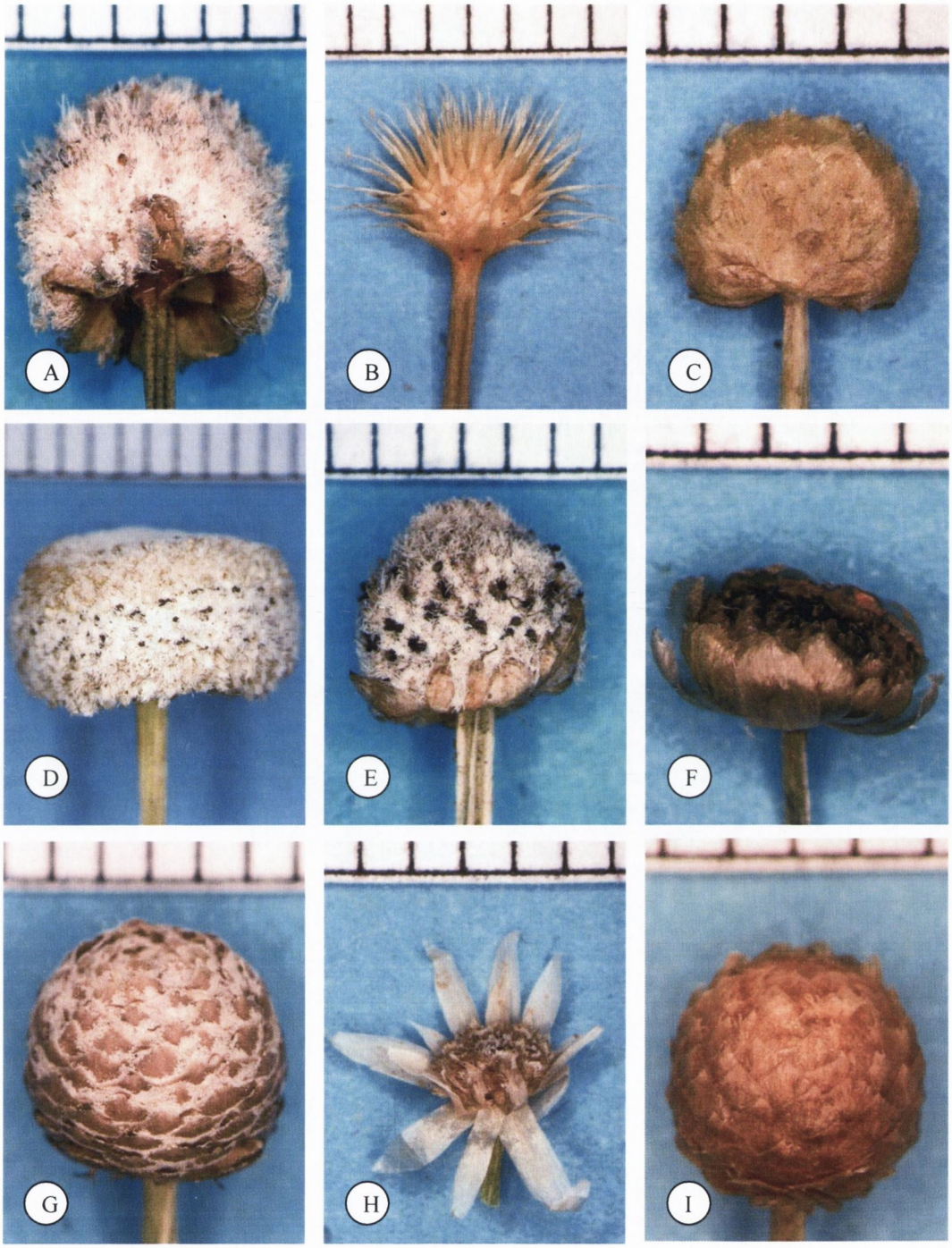

Figure 2.8 Variation of capitulum in *Eriocaulon* L. (A) *Eriocaulon chiangmaiense* ssp. *leucanthemum* A.Prajaksood & J.Parn., (B) *E. echinulatum* Mart., (C) *E. hamiltonianum* Mart., (D) *E. kradungense* f. *kradungense* (Satake) A.Prajaksood & J.Parn., (E) *E. phuphanense* A.Prajaksood & J.Parn., (F) *E. truncatum* var. *florensense* Z.X.Zhang, (G) *E. willdenovianum* Moldenke (H) *E. xeranthemum* Mart., and (I) *E. zollingerianum* Körn. Scale = 1 mm.

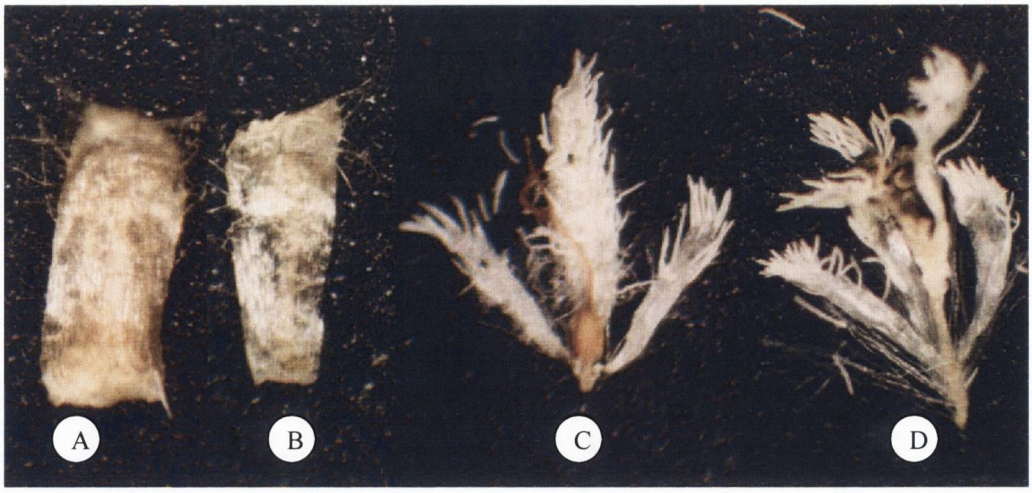

Figure 2.9 *Eriocaulon chantaranithai* A.Prajaksood & J.Parn. (A) Involucral bract. (B) Floral bract. (C) Female flower. (D) Male flower.

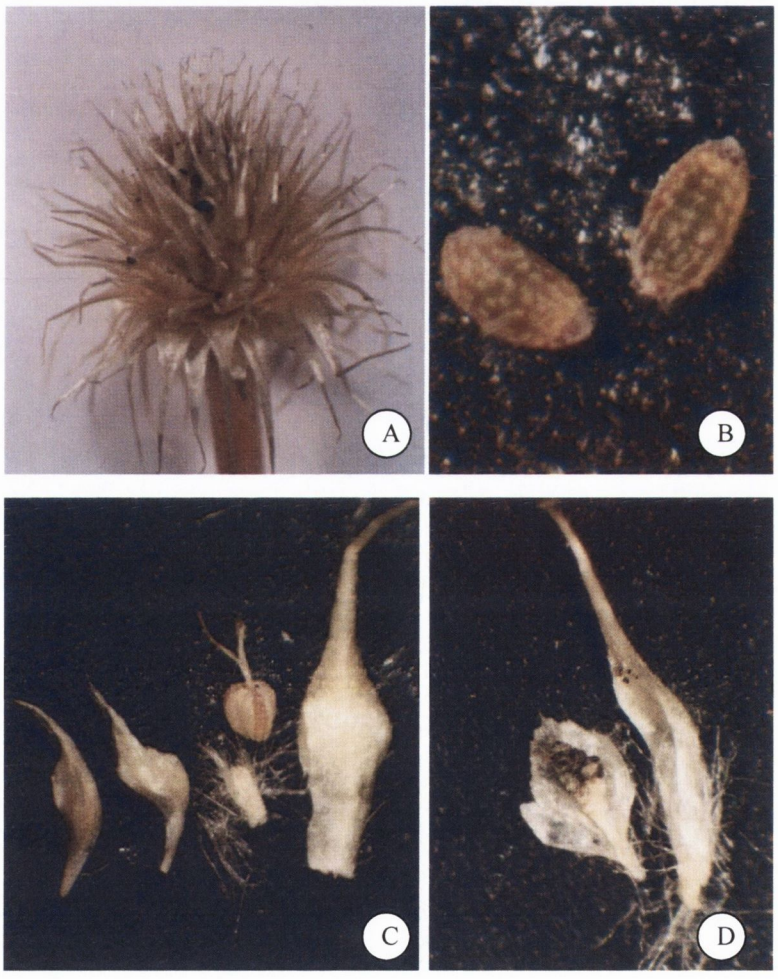

Figure 2.10 *Eriocaulon echinulatum* Mart. (A) Capitulum. (B) Seeds. (C) Female parts and floral bracts. (D) Male parts and floral bract.

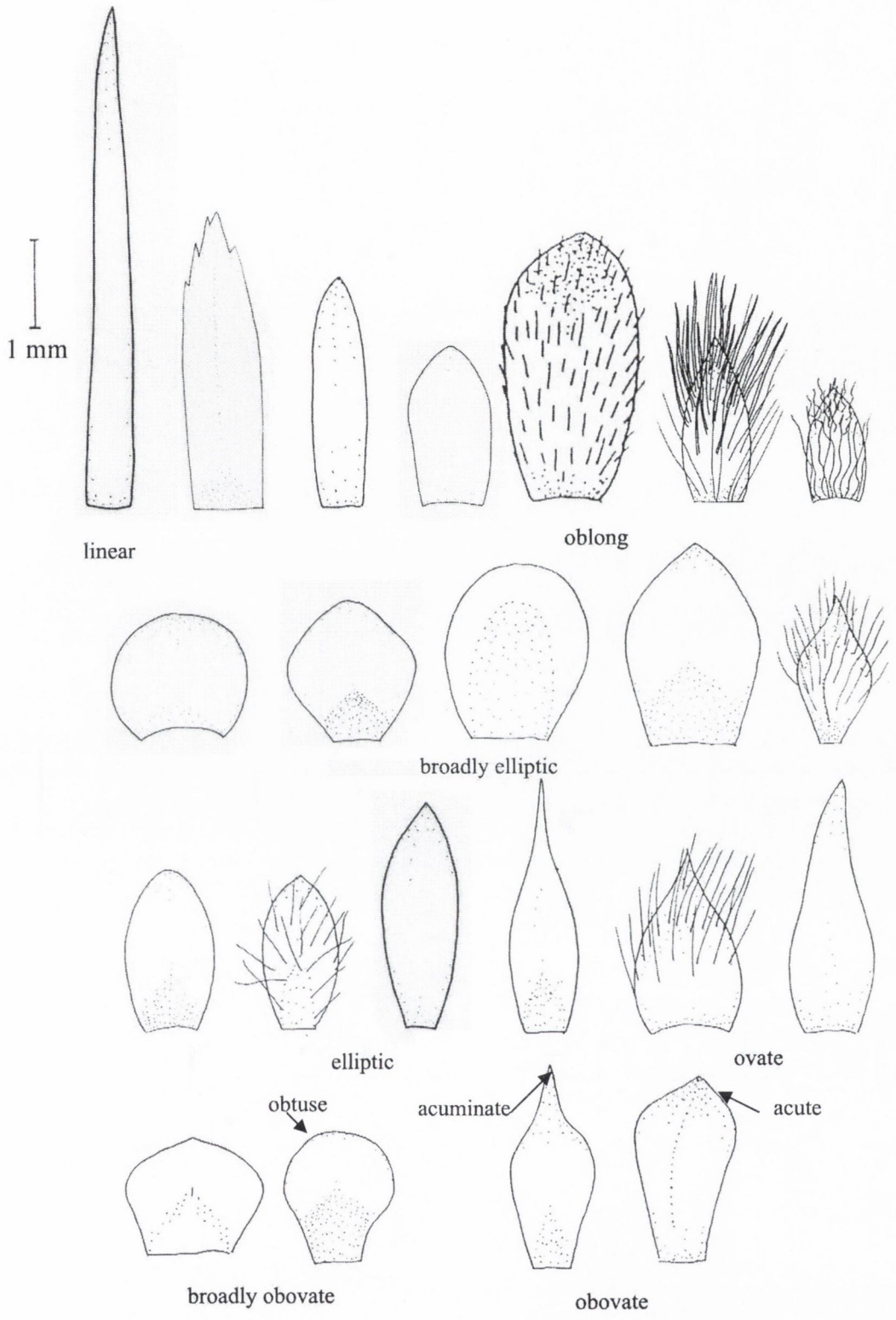

Figure 2.11 Variation of involucral bracts in *Eriocaulon*. Drawn by A. Prajaksood.

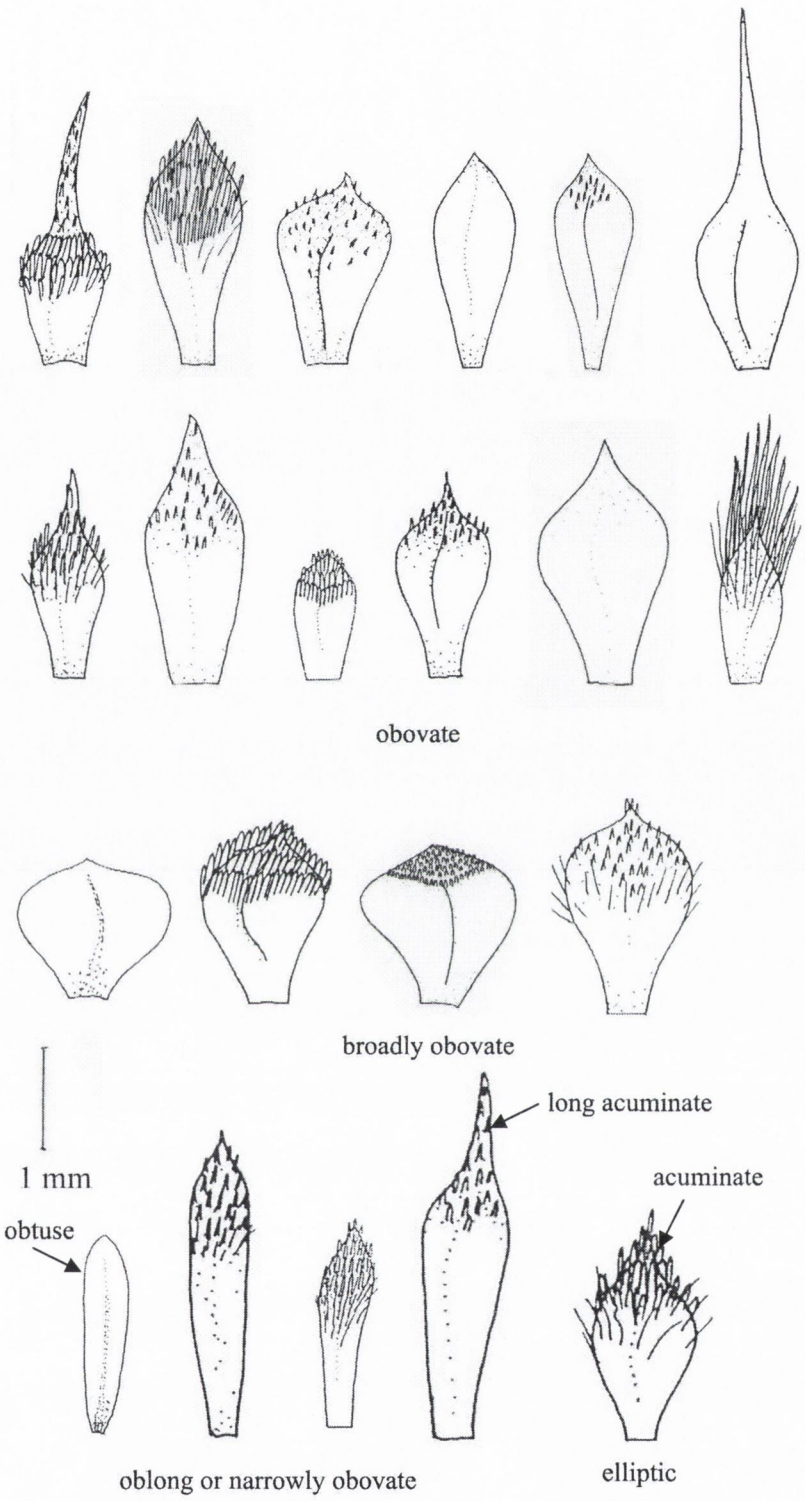

Figure 2.12 Variation of floral bracts in *Eriocaulon*. Drawn by A. Prajaksood.

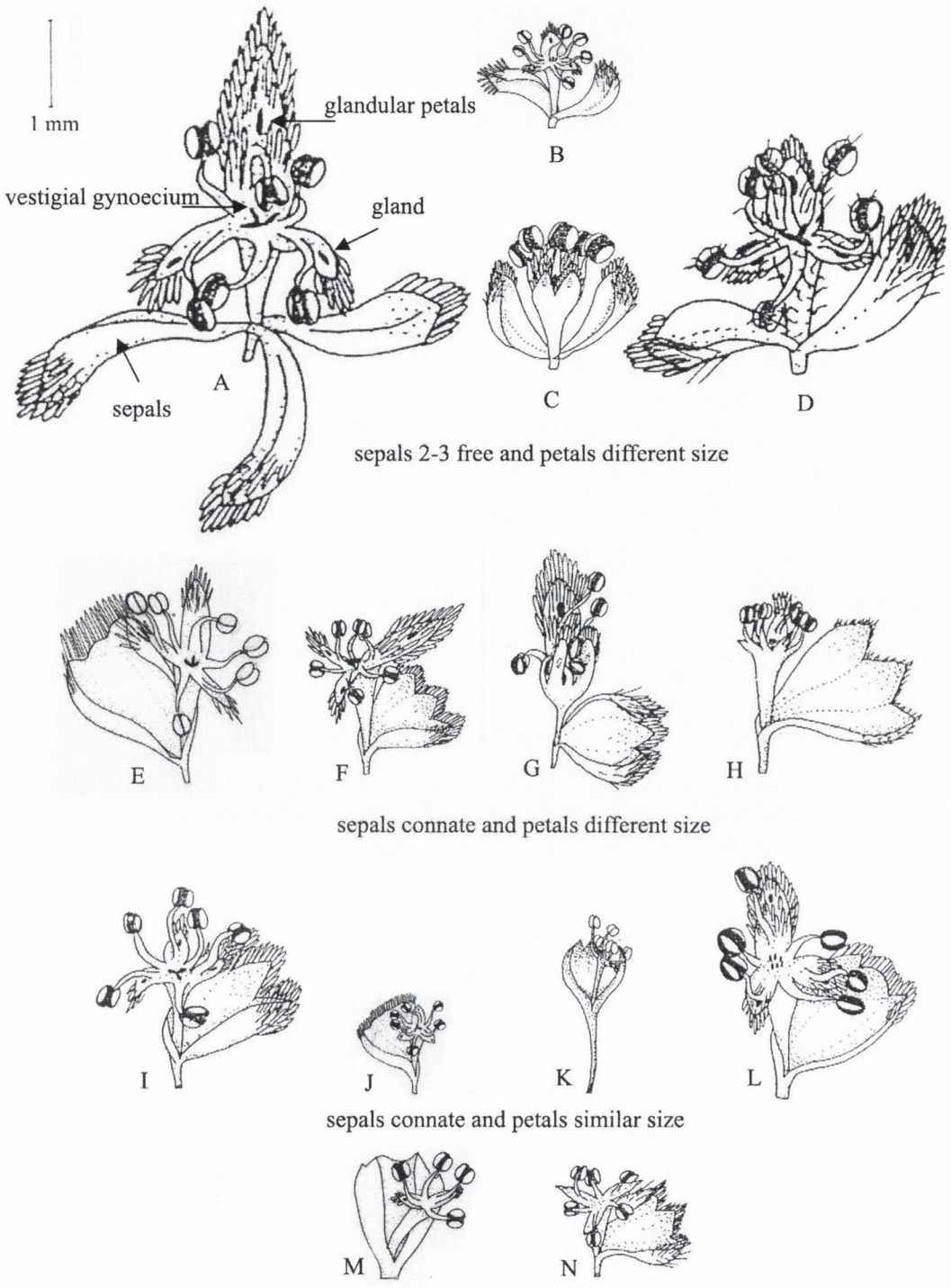

Figure 2.13 Variation of male flowers in *Eriocaulon*. (A) *Eriocaulon nautiliforme* Lecomte, (B) *E. phuphanoides* A.Prajaksood & J.Parn., (C) *E. phatamense* A.Prajaksood & Chantar., (D) *E. phuphanense* A.Prajaksood & J.Parn., (E) *E. chiangmaiense* ssp. *leucanthemum* A.Prajaksood & J.Parn., (F) *E. siamense* Moldenke, (G) *E. chantaranothai* A.Prajaksood & J.Parn., (H) *E. nepalense* var. *luzulaefolium* (Mart.) A.Prajaksood & J.Parn., (I) *E. nautiliformoides* A.Prajaksood & J.Parn., (J) *E. xeranthemum* Mart., (K) *E. cinereum* R.Br., (L) *E. ubonense* var. *hexagynum* A.Prajaksood & Chantar., (M) *E. willdenovianum* Moldenke and (N) *E. thailandicum* Moldenke. Drawn by A. Prajaksood.

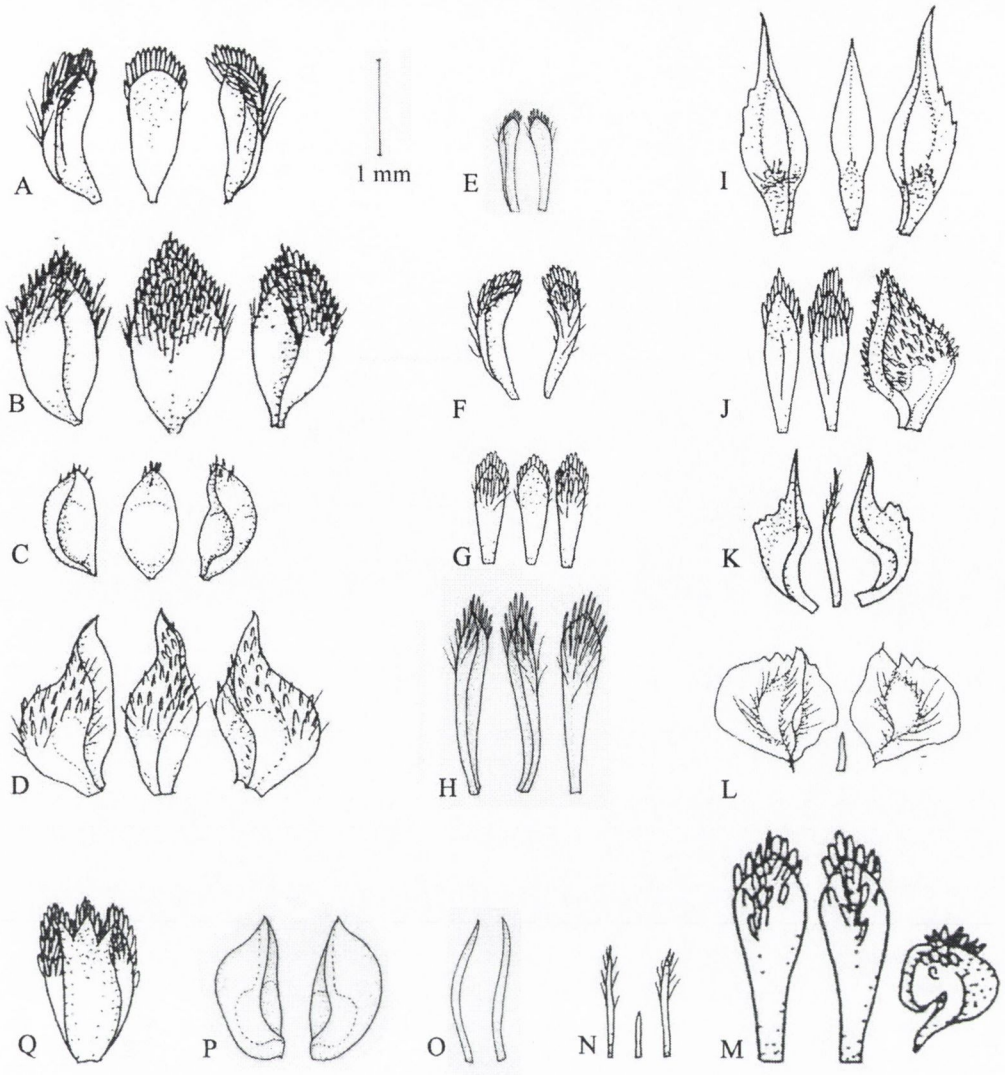

Figure 2.14 Variation of female sepals in *Eriocaulon*. (A) Broadly oblanceolate in *Eriocaulon xenopodium* T.Koyama. (B)-(D) Boat-shaped sepals, (B) *E. henryanum* Ruhland, (C) *E. setaceum* L. and (D) *E. parnellii* A.Prajaksood & J.Parn. (E)-(H) Oblanceolate sepals, (E) *E. xeranthemum* Mart., (F) *E. phatamense* A.Prajaksood & Chantar., (G) *E. laosense* Moldenke and (H) *E. chiangmaiense* ssp. *leucanthemum* A.Prajaksood & J.Parn. (I)-(M) Dimorphic sepals, (I) *E. escape* B.Hansen, (J) *E. nautiliformoides* A.Prajaksood & J.Parn., (K) *E.echinulatum* Mart., (L) *E. zollingerianum* Körn. and (M) *E. nautiliforme* Lecomte. (N)-(O) Filiform sepals, (N) *E. chantaranothai* A.Prajaksood & J.Parn. and (O) *E. hamiltonianum* Mart. (P) Keeled sepals in *E. willdenovianum* Moldenke. (Q) United sepals in *E. phuchongense* A.Prajaksood & Chantar. Drawn by A. Prajaksood.

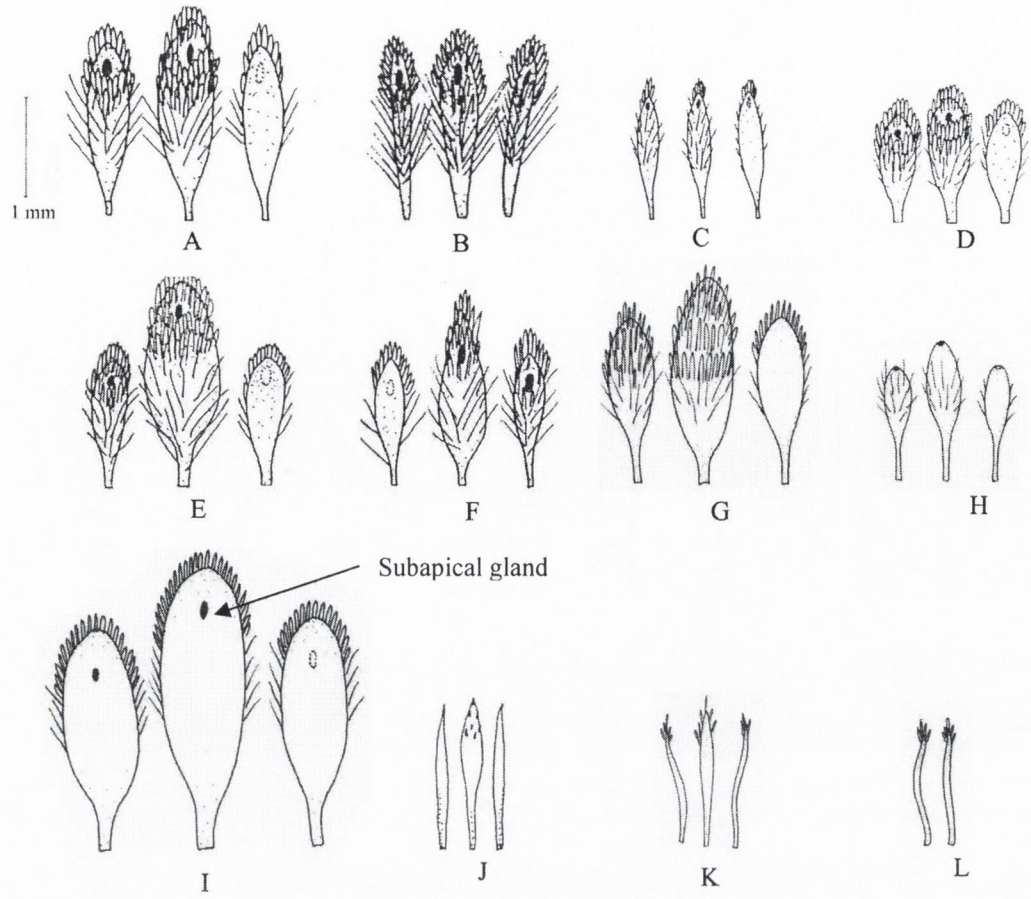

Figure 2.15 Variation of female petals in *Eriocaulon*. (A)-(D) More or less same size petals, (A) Elliptic, attenuate petals in *Eriocaulon xenopodium*, (B) Narrowly oblanceolate *E. henryanum* Ruhland, (C) *E. truncatum* Buch.-Ham. ex Mart. and (D) Elliptic, attenuate petals in *E. laosense* Moldenke. (E)-(H) Different size petals, (E) *E. phatamense*, (F) *E. chantaranothai*, (G) Subapical glands absent in petals of *E.* chiangmaiense *ssp. leucanthemum* and (H) *E. truncatum* var. *florensense*, (I) Hairy only on the margin of petals in *E. wightianum* Mart. (J)-(L) Filiform petals, (J) *E. zollingerianum*, (K) *E. hamiltonianum* and (L) *E. willdenovianum*. Drawn by A. Prajaksood.

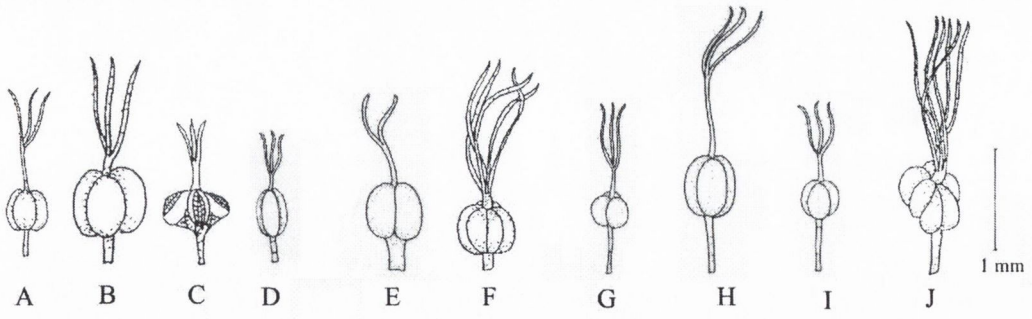

Figure 2.16 Variation of ovary in *Eriocaulon*. (A)-(F) Short stalk ovary, (A) *Eriocaulon truncatum*, (B) *E. xenopodium*, (C) *E. zollingerianum*, (D) *E. xeranthemum*, (E) *E. willdenovianum*, (F) *E. nautiliformoides* var. *hexagynum*. (G)-(J) Long stalked ovary, (G) *E. hamiltonianum*, (H) *E. chiangmaiense* ssp. *leucanthemum*, (I) *E. truncatum* var. *florensense* and (J) *E. ubonense* var. hexagynum. Drawn by A. Prajaksood.

2.4 Conclusions

The morphological characters which were found to be useful for identification within *Eriocaulon* in Thailand are as follows:

(1) The presence of underground stems (rhizome or corm)*
(2) The width at the base of leaves (as shown in Figure 2.2C)
(3) The length of leaves*(as shown in Figure 2.1A)
(4) The presence of hairy leaves*
(5) The presence of papillate leaves*
(6) The presence of obtuse leaf apex*
(7) The presence of reddish leaves*
(8) The presence of papillate leaf margin
(9) The presence of scapes*
(10) The presence of hairy scape
(11) The length of scapes (as shown in Figure 2.1B)
(12) The presence of hairy leaf sheaths
(13) The length of capitula (as shown in Figure 2.7B)
(14) The colour of capitula
(15) The presence of hairy receptacle*
(16) The presence of involucral bracts as long as or longer than the length of capitula*
(17) The shape of involucral bracts (as classified and shown in Figure 2.11)
(18) The presence of papery involucral bracts*
(19) The presence of hairy involucral bracts*
(20) The shape of involucral bract apex* (as classified and shown in Figure 2.11)
(21) The shape of floral bracts (as classified and shown in Figure 2.12)
(22) The colour of floral bracts*
(23) The presence of hairy floral bracts*
(24) The shape of floral bract apex* (as classified and shown in Figure 2.12)
(25) The number of male sepals*
(26) The colour of male sepals*
(27) The presence of equal male petals*
(28) The presence of longest male petals exserted beyond the floral bracts*
(29) The presence of hairy male petals*
(30) The presence of black gland on male petals*
(31) The presence of white anthers
(32) The number of female sepals
(33) The presence of connate female sepals
(34) The presence of dimorphic female sepals*
(35) The shape of female sepals* (as classified and shown in Figure 2.14)
(36) The colour of female sepals*
(37) The presence of female petals*

(38) The shape of female petals (as classified and shown in Figure 2.15)
(39) The presence of longest female petals exserted beyond the floral bracts
(40) The presence of black gland on female petals
(41) The presence of penta or hexagynoecious*
(42) The presence of papillate seeds*

The calyx and corolla are the most importance characters for identification. However, the underground stems, leaves, involucral bracts and floral bracts are additional characters which can be taxonomically important and can aid species identification during the field work. Seed coat patterns are interesting characters which need to be confirmed if they are constant in each species, though this character are also applied for recognized the species from the others.

Only 27 morphological characters were found to be useful for phenetic analysis (indicated by *). Records of these for 33 taxa of *Eriocaulon* were transferred to a dataset (Appendix 4) for an analysis designed to investigate the relationship between Thai species using morphological, anatomical and molecular approaches (see Chapter 4).

Most of the characters which were found to be useful for identification in this chapter were also used in the earlier identification keys, *i.e.* Hooker (1894), Fyson (1919-1922), Cook (1996), Phillips (1997) Zhang (1999) and Prajaksood (2000). Some characters used to be usedful for their earlier identification keys but I found that they are not constant and not useful for identification, *i.e.* Zhang (1999) used characters of male sepals free or united, the presence of dorsal pressed male sepals; hairy on female sepals; the texture of floral bract and involucral bracts (thick or thin), the present of hydrathode in leaf apex (absent in setaceum), the shape of male petals (eeg shape or lanceolate), the colour of seeds, the lenght of sheath comparison with the length of leaves, the presence of hairy male sepals, the shape of seeds (ovater elliptic/elliptic), the numer of carpels (one or three carpels).

CHAPTER 3

ANATOMICAL STUDY

3.1 General Introduction

Characteristics related to the anatomical features of plants have been employed for systematic purposes for over 150 years and they are useful in both practical identification and determination of phylogenetic relationships (Judd *et al.*, 2002).

Vegetative anatomical characters have been used with more regularity than floral ones. This is probably due to the view point that if additional data are believed desirable to solve a taxonomic problem, then looking inside the leaves, stems and roots could potentially yield different information than that from reproductive organs (Stuessy, 1990).

Leaves, for example, are extremely varied anatomically and provide numerous systematically significant characters (Carlquist, 1961; Dickison, 1975). The epidermis varies in the number of cell layers, the size and shape of individual cells, the thickness of cell walls and the occurrence of papillae or the various kind of hairs. Some leaves have a hypodermis, which is formed from one or more differentiated layers of cells beneath the epidermis. The cuticle is a waxy coating over the epidermis and it varies in thickness and surface texture (Judd *et al.*, 2002). As shown in Figure 3.1, stomatal types are distinctive of certain families such as the Ranunculaceae (anomocytic), the Brassicaceae (anisocytic), the Caryophyllaceae (diacytic) and the Rubiaceae (paracytic). The closely related families Acanthaceae and Scrophulariaceae are distinguished by the presence of diacytic stomata in the former as against anomocytic in the latter (Singh, 1999).

Characters relating to the internal tissues of leaves are also important. The mesophyll may be differentiated into palisade and spongy layers and the number of cell layers in each may vary. The distribution and shape of mesophyll cells and the presence or absence of intercellular spaces may also be diagnostic (Judd *et al.*, 2002).

Secretory structures, especially crystals, are common in vascular plants, are usually located in cells, are variously shaped and are usually composed of calcium oxalate, calcium carbonate, or silica. Druses (spherical groups of crystals), raphides (needle-like crystals) and crystal sand are the most common types (Figure 3.2). Silica bodies are often taxonomically important in monocots (Judd *et al.*, 2002).

Trichome characters are very variable as shown in Figure 3.3 (Metcalfe and Chalk, 1950) and the structure of trichomes is very useful taxonomically some taxa including in the large genus *Astragalus* L. (Fabaceae) (with more than 2000 species) and in *Hedera* L. (Araliaceae) when the Himalayan

species *Hedera nepalensis* K.Koch is distinguished from its European relative *H. helix* L. in having scaly trichomes as against stellate (Singh, 1999).

3.2 Historical Review of Anatomical Study in the Eriocaulaceae

As earlier stated the Eriocaulaceae is a predominantly pantropical family of 11 genera and 1300 species (Stützel, 1998; Sano, 2004) containing (1) *Paepalanthus* Kunth with about 600 species, (2) *Eriocaulon* L. with about 400 species, (3) *Syngonanthus* Ruhl. with about 250 species, (4) *Leiothrix* Ruhl. with about 37 species, (5) *Actinocephalus* Sano with 28 species, (6) *Mesanthemum* Körn. with about 18 species, (7) *Lachnocaulon* Kunth with about 8 species, (8) *Blastocaulon* Ruhl. comprising about 5 species, (9) *Rondonanthus* Herzog with 5 species, (10) *Philodice* C. Mart. with 2 species and (11) *Tonina* Aubl. with only one species, *T. fluviatilis* Aubl. (see Chapter 1).

3.2.1 Overview of Anatomical Study in the Eriocaulaceae

van Tieghem (1887) studied the root anatomy of *Eriocaulon septangulare* With, *Lachnocaulon michauxii* Kunth, *Philodice hoffmannseggii* Mart. and *Tonina fluviatilis*. He reported that the pericycle in the root of the Eriocaulaceae is typically interrupted by protoxylem elements lying next to the endodermis. This seems to be a feature characteristic of the family and van Tieghem (1887) also indicated that the number of protoxylem poles was a diagnostic feature of the family.

Poulsen (1888) studied the anatomy of all vegetative parts (leaf, leaf sheath, stem, scape and root) of *Eriocaulon helichrysoides* Bong., *Paepalanthus caulescens* Kunth, *Pae. consanguines* Körn., *Pae. freyreissii* Körn., *Pae. itatiaiae* Körn., *Pae. minutulus* Mart., *Pae. nitens* Kunth., *Pae. plantagineus* Körn., *Pae. polyanthus* Kunth., *Pae. schenckii* Pouls., *Pae. schraderi* Körn., *Pae. tortilis* Körn., *Pae.* sp. and *Tonina fluviatilis*. He stated that transverse veins in the leaf could occasionally be found; that abnormal double stomata are found in *Pae. tortilis*; that the extra-axillary scape in *Tonina* was truly lateral and he found a bi-concentric vascular bundle type in the stem of *Pae. polyanthus*.

Holm (1901) studied the anatomy of all parts of *Eriocaulon decangulare* L. and described the root as either (a) thick, white, mostly unbranched with few root-hairs or (b) less white, thinner, longer with many lateral rootlets and root-hairs and that the stele in the stem showed an endodermoid layer (without Casparian strips).

Ruhland (1903) claimed to have studied "all species of *Paepalanthoideae*", although his account was only a preliminary study and a subsequent detailed account never appearing. He studied the anatomy of all vegetative parts of *Eriocaulon crassiscapum* Bong., *Leiothrix crassifolia* (Bong.) Ruhl; *Leiothrix* luxurians (Körn.) Ruhl., *Lei. pedunculosa* Ruhl. and 35 species of *Paepalanthus*.

Lecomte (1907) stated that the scape anatomy was basically identical throughout the family but that it varied in quantitative ways, which might be diagnostic.

Malmanche (1919) studied selected parts of the anatomy of 32 species of *Eriocaulon*; 4 species of *Lachnocaulon*; 6 species of *Mesanthemum*; 33 species of *Paepalanthus*; *Philodice hoffmannseggii*; and *Tonina fluviatilis*. His work was the most important summarizing the anatomy of the family until that of Tomlinson (1969) and Stützel (1998).

Arber (1922) studied the leaf anatomy of *Eriocaulon cuspitadum* Dalz., *E. septangulare*, *E. setaceum* L., *E. wallichianum* Mart. f. *submersa* and *Paepalanthus speciosus* Gardn. She reported that the leaf apex in some *Eriocaulon* spp. developed a hydrathode-like organ.

Solereder and Meyer (1929) also studied the anatomy of the family, in particular the leaf and scape of *Eriocaulon decangulare* and all vegetative parts of *E. septangulare*; the stem of *Paepalanthus falcifolius* Körn.; the leaf and scape of *Syngonanthus niveus* Ruhl. and the leaf and stem of *Tonina fluviatilis*.

Solomon (1931) studied the anatomy of stem and root of *Eriocaulon septangulare*.

Hare (1950) studied the structure and development of *Eriocaulon septangulare* and stated that the root-hairs were absent, that the stele in the stem showed an endodermoid layer and described the scape as radially symmetrical.

Tomlinson studied the anatomy of all parts of *Paepalanthus alsinoides* Wright in 1965 and in 1969, he studied all vegetative parts of 8 species of *Eriocaulon,* 3 species of *Lachnocaulon*, *Leiothrix turbinata* Gleas., 4 species of *Paepalanthus*, 2 species of *Syngonanthus* and *Tonina flavidulus.* He also studied the root of *Blastocaulon rupestre* (Gardn.) Ruhl., 23 species of *Eriocaulon,* 8 species of *Leiothrix*, *Mesanthemum radicans* Körn., 17 species of *Paepalanthus*, *Philodice hoffmannseggii* and *Syngonanthus caulescens* (Poir.) Ruhl. and summarized previous studies of the anatomy of the Eriocaulaceae based on the work of earlier authors and his own studies.

Dahlgren (1985) reported that the vessels are present in the vascular strands of roots, stems and leaves and that the air spaces in mesophyll alternate with lamellae of chlorenchyma causing the fenestration of the leaves. The stomata are paracytic. He also found that the hairs are sometimes present and are either short and three-celled or long and uniseriate and that the druses, needle-like or prismatic oxalate crystals sometimes occur.

Stützel (1998) summarized the vegetative anatomy of the family based on Poulsen (1888) and Malmanche (1919).

Zhang (1999) studied the anatomy of the scape of 58 species of *Eriocaulon* in East Asia. He reported that the structure of the vascular bundle was very variable and that though helpful for species determination, it seemed not to be constant for sections or subgenera.

Prajaksood (2000) studied the anatomy of leaves and scapes of 8 species of *Eriocaulon* and first reported the anatomical characters of *Eriocaulon kradungense* Satake, *E. minimum* Lam. and *E. nakayense* T. Koyama. She made the first report of the papillose epidermal characters in the family as found in *E. alatum* Lec., *E. echinulatum* Mart., *E. minimum, E. nakayense* and *E. xenopodion* T. Koyama; and the first report of sinous anticlinal walled cells in *Eriocaulon* as found in *E. alatum, E. kradungense, E. minimum, E. nakayense, E. xenopodion.* She stated that the outline of the outer tangential wall of the epidermis, the type of trichomes, the arrangement of the mesophyll, the type of cells in the bundle sheath of the scape and the number of buttresses in the scape are useful as interspecific discriminates.

Recently, Scatena *et al.* (2005) studied anatomy of roots, stems, leaves and scapes of 47 taxa of Brazilian Eriocaulaceae, including one species of *Actinocephalus,* three species of *Blastocaulon,* nine species of *Eriocaulon,* three species of *Leiothrix,* 13 species of *Paepalanthus* and one species of *Philodice,* 17 taxa of *Syngonanthus* and one species of *Tonina.* According to the correlation of anatomical characters between taxa and the habitats where the species occur using multivariate analyses, they concluded that root and stem anatomical charaters seem to be more affected by environmental factors and seem of little value for delimiting major taxonomic groups within the family. Other characters in the leaves, such as epidermis with thickened wall cells, compartmented substomatal chambers, mesophyll with hypodermis, compact chlorenchyma, collenchymatous bundle sheath extensions and numerous vascular bundles, were shown to be important for defining species clusters in *Leiothrix, Syngonanthus* and *Paepalanthus* subg. *Platycaulon.* Similarly, loosely aggregated chlorenchyma caused *Blastocaulon, Eriocaulon, Philodice, Syngonanthus* sect. *carpocephalus, S.* sect. *Syngonanthus,* and *Tonina*, genera from humid environments, to cluster. Additionally, scape characters appear to be more informative in discriminating groups.

3.2.2 Anatomy of the Eriocaulaceae

Summarizing available literature reveals the following structures within 9 of the 10 genera in the family. So far there are no data on the anatomy of *Rondonanthus*. This section is largely based on the observations of Tomlinson (1969), supplemented by Dahlgren (1985), Stützel (1998), Zhang (1999) and Prajaksood (2000), where additional information is given, references are cited.

Hairs on Vegetative Organs

Hairs are basically of three main types: filamentous uniseriate hairs present in many species, three-celled glandular hairs present in almost all species and multicellular capitate glandular hairs present infrequently. All hairs with 2, essentially similar, basal cells (Figure 3.4 C-D, Figure 3.5 C-E, Figure

3.8 E): **a basal cell** (or foot-cell as stated by Stützel (1998)) either included within the epidermis (filamentous hairs) or superficial (glandular hairs) and a short usually more or less globose cutinized **collar-cell** (or basal cell as stated by Stützel (1998)). The collar-cell often persisting on the older parts of the plant when the rest of indumentum has been lost (Stützel, 1998). The distal part of the filamentous hairs consisting of a long, uniseriate, usually pointed, multicellular filament. The distal part of the three-celled glandular hairs consisting of an ephemeral, usually thin-walled cell with densely staining contents. The distal part of the multicellular capitate glandular hairs consisting of a short, usually 3-celled filament ending in an inflated cell.

(1) Filamentous hairs (Figure 3.4 and Figure 3.8 G)

Most typically arising early in the leaf axils, notably in rosette-leaves, forming dense beard-like protective tufts. Otherwise not uncommon on the leaf margin as, *e.g.*, *Paepalanthus alsinoides, Pae. brachypus* Kunth, *Pae. domingensis* Ruhl. (Figure 3.4 D-E), *Pae. flaccidus* (Bong.) Kunth; *Lac. engeli* Ruhl.; *Tonina fluviatilis* (Figure 3.4 A-C); when more widely distributed forming a conspicuous silvery or woolly indumentum (*Pae. argenteus* (Bong.) Körn. and *Pae. macrorrhizus* (Bong) Kunth). Basal cell wedged into epidermis and usually much smaller than unmodified epidermal cells. Collar-cell almost invariably present, usually cutinized and staining intensely with safranin. Distal filament usually persistent, long, pointed, septate, the smooth wall slightly thickened at the thin septa, as shown in some *Eriocaulon* species (Figure 3.8 G). Distal filament rarely finely spinulose (*Pae. distichophyllus,* Figure 3.4 F) in a manner recalling certain glandular hairs, or only the terminal cell spinulose (*Syngonanthus nitens* Ruhl.). Filamentous hairs short and producing a powdery indumentum on the upper surface in *S. cirninatusi* and *S. imbricatus*. Filamentous hairs in leaf axils in *Pae. williamsii* Mold. commonly irregular and slightly inflated.

(2) Three-celled glandular hairs (Figures 3.5-3.8)

Occurring on surface of lamina and inflorescence axis of all species with possible exception of *Eriocaulon gracile* Mart. and *Paepalanthus weddellianus* Körn.. Best revealed in fresh material by staining with methylene blue. Sometimes uniformly distributed, but commonly less frequent on adaxial than abaxial surface (*e.g. Pae. domingensis, Pae. tuerckheimii* Ruhl.; *Lachnocaulon engleri* Ruhl.), on abaxial surface typically restricted to costal regions. Differences in distribution of leaf hairs in various species of *Eriocaulon* stressed as a diagnostic feature by Malmanche. Hairs initial in *E. helichrysoides,* according to Malmanche, arising by oblique division at one end of as elongated epidermis cell, subsequently dividing twice by transverse divisions and displaced into a superficial position above the end wall of 2 contiguous long cells. Hairs usually very regularly distributed in cell files of abaxial costal regions (*e.g.* Figure 3.5 B), rarely on adaxial surface (*e.g.* Figure 3.5 A) between each pair of long epidermal cells. Two most proximal cells usually persistent, densely staining distal cell usually ephemeral. Basal cell short, scarcely penetrating epidermis; collar-cell always present (Figure 3.5 C-E, Figure 3.8 E and H), often obliquely orientated. There are two types of glandular cell which are largely distinguished by shape of distal cell:

(a) Unbranched glandular hairs (Figure 3.6 and Figure 3.8 H) with a smooth, elliptical, usually short distal cell, either continuous with the axis of the hair base or commonly adpressed against the leaf surface. Hairs in *Pae. scytophyllus* Ruhl. very short (Figure 3.6 F), with a single conical distal cell (Ruhland, 1903). Length of distal cell fairly constant and characteristic for a species although adaxial may be somewhat longer than abaxial hairs on the same leaf. Distal cells less than 10 μm long characteristic of some *Eriocaulon* spp., *e.g. Eriocaulon articulatum* Morong (= *E. septangulare* With.) (Figure 3.6 E), *E. decangulare, E. ravenelii* Chapm., *E. scariosum* Smith (= *E. smithii* R.Br.) (Figure 3.6 D), *E. septangulare* (Figure 3.6 A-C); distal cells 10-20 μm long characterize other species, *e.g. E. compressum* Lam.; *Lachnocaulon engleri, Lac. minus* (Chapm.) Small (Figure 3.6 H); *Tonina fluviatilis* (Figure 3.6 G); distal cells over 20 μm long present in *Paepalanthus* spp., *e.g. Paepalanthus brachypus, Pae. claussenianus* Körn., *Pae. hirsutus* Kunth, *Pae. oerstedianus* Körn., *Pae. ramosus* Kunth and are usually associated with branched glandular hairs. Distal cell < 100 μm long present in *E. alatum, E. echinulatum, E. kradungense, E. minimum, E. nakayense* and *E. xenopodion*; distal cell 100-200 μm long in some *Eriocaulon* as shown in Figure 3.8 H (Prajaksood, 2000).

(b) Branched glandular hairs (T-shaped or bi-branched called "Malpighian" hairs) (Figure 3.7): distal cell 2-armed, the arms extending parallel to the leaf surface along the longitudinal axis of the leaf. Hairs as whole then T-shaped, or the distal cell itself T-shaped with a very short basal cells. Arms of the T either almost equally long and producing symmetrical hairs (*e.g. Leiothrix turbinata; Paepalanthus alsinoides* (Figure 3.7 C), *Pae. flaccidus, Pae. freyreissii, Pae. minutulus; Syngonanthus caulescens, S. flavidulus* (Michx.) Ruhl. (Figure 3.7 B), *S. nitens*) or very unequal and producing asymmetrical hairs (*e.g. Pae. elegans* Kunth, *Pae. elongatus* Körn. according to Ruhland's illustration (1903) (Figure 3.7 D), *Pae. plantagineus, Pae. tortilis; S. appressus* Ruhl.), the terminal cell with a slightly inflated, irregularly lobed and somewhat T-shaped distal cell in *Pae. ciliolatus* as shown in Ruhland's illustration (1903) (Figure 3.7 E). Symmetry of hairs often constant for a given species but symmetrical and asymmetrical hairs sometimes present in same species (*e.g. Pae. umbellatus* Kunth, *Pae. williamsii* as shown in Figure 3.7 A and F). Distal cell of T-shaped hairs commonly smooth and scarcely thick-walled (*e.g. Lei. turbinata; Pae. alsinoides, Pae. elongatus, Pae. williamsii*), but sometimes thicker-walled and finely spinulose (*e.g. Pae. caulescens, Pae. umbellatus; S. flavidulus, S. nitens*), or with both smooth and occasional spinulose hairs together in *S. reflexus* Gleas.

Both branched and unbranched hairs occur together in some species of *Paepalanthus*, *e.g. Paepalanthus nitens* and *Pae. ramosus*. Early stages in development of T by lateral swelling of adpressed distal cell recorded for *Pae. warmingianus*. Transitional hair with adpressed and irregularly lobed distal cell recorded for *Pae. schenckii*.

Prajaksood (2000) noted that in some *Eriocaulon* species such as *Eriocaulon nakayense* found only two-celled glandular hairs without a distal cell could be found and she suggested that two-celled

glandular hairs may be a distinct type of glandular hairs and not just the three-celled glandular hairs lacking the distal cell.

(3) Multicellular capitate glandular hairs (Figure 3.7 G-J)
Normally with two proximal cells extending into a usually 3-celled stalk and capped by an inflated distal cell recorded for *Paepalanthus acanthophyllus* Ruhl. (Figure 3.7 J), *Pae. compactus* Gardn.(Figure 3.7 G) and *Pae. gyrotrichus* Ruhl. (Figure 3.7 H) as shown in Ruhland's illustration (1903); *Pae. curvifolius* Kunth and *Pae. flavescens* Körn.; resembling those on reproductive organs of some *Syngonanthus* spp.

Leaf (Vegetative foliage)

Dorsiventral (bifacial), rarely ribbed as in *Paepalanthus homomallus* (Bong.) Mart. and *Pae. macrorrhizus*. Cuticle thin, finely striated longitudinally in certain *Eriocaulon* spp. (Figure 3.8 C-E), *e.g. Eriocaulon alatum, E. articulatum, E. australe* R.Br., *E. compressum, E. decangulare, E. echinulatum, E. kradungense, E. minimum, E. nakayense, E. scariosum, E. sexangulare* L., *E. xenopodion*.

The appearance of leaf in transverse section (Figure 3.9) determined largely by the extent to which chlorenchymatous mesophyll is interrupted by the parenchymatous bundle sheath extension (buttresses) and the lateral extension of buttresses to form colorless hypodermis layers. Size of buttresses and their association with surface layer changes continuously from base to apex of leaf.

Epidermis (Figures 3.8-3.10) cells rectangularly, longitudinally extended or shorter, wider and somewhat hexagonal. Periclinal walls in surface view papillate in some *Eriocaulon* as firstly noted by Prajaksood (2000) in *Eriocaulon alatum, E. echinulatum* (Figure 3.8 A, C), *E. minimum, E. nakayense* and *E. xenopodion*. Anticlinal walls in surface view typically non-sinous, but sometimes slightly sinous in *Tonina fluviatilis* (Figure 3.10 D); cutinized middle lamella of anticlinal walls distinctly sinous in *Paepalanthus alsinoides* (Figure 3.11 A) and *Pae. minutulus*, however, anticlinal walls in transverse section sinous in *Eriocaulon* as shown in *E. alatum, E. kradungense, E. minimum, E. nakayense, E. xenopodion* (Prajaksood, 2000).

Epidermal walls remaining thin in more hydrophytic or shade-loving species (*e.g.* most *Eriocaulon* spp.; *Paepalanthus caulescens, Pae. flavescens, Pae. nitens*) but otherwise uniformly thickened to form a mechanical epidermis, the lumen often much occluded in more xerophytic or sun-loving forms, *e.g. Pae. alsinoides* (Figure 3.11), *Pae. brachypus, Pae. claussenianus, Pae. elongatus; S. niveus* Ruhl., *S. reflexus*; thickened walls often distinctly lamellate (Figure 3.11 B and Figure 3.13 G). Epidermis sometimes not uniformly thickened, but outer thicker than remaining walls as in *Pae. ramosus* and *Pae. weddellianus*. Abaxial epidermis in *Leiothrix turbinata* with walls not uniformly thickened, in contrast to uniformly thickened adaxial cells. Partially occluded cell lumen in *Pae. alsinoides* (Figure 3.11 C) slightly enlarged at end of each cell. Secondary wall substance in *Pae.*

alsinoides deposited externally above and below anticlinal walls (Figure 3.11 B) but almost obvious around partially occluded substomatal chambers (Figure 3.13 H). Adaxial epidermis sometimes appearing irregularly biseriate in transverse section owing to oblique overlapping end walls as in *Pae. domingensis, Pae. falcifolius, Pae. polyanthus, Pae. senaeanus* Ruhl., *Pae. tortilis, Pae. tuerckheimii*; similar epidermis in *Lei. turbinata* also occasionally genuinely biseriate.

Epidermal cells typically large, adaxial usually somewhat larger than abaxial cells (Figure 3.12 A-C); costal abaxial often larger than intercostal abaxial cells (the reverse of the usual monocotyledonous construction) especially in many *Eriocaulon* spp. Inward enlargement of abaxial costal cells marked in *Paepalanthus elongatus* and *Pae. schraderi* and especially in *Pae. compactus* with very deep epidermis (up to two-thirds total depth of lamina).

Adaxial epidermis (Figure 3.10 A-C and Figure 3.11 B-C) usually uniform or rarely with indistinct costal bands of narrow cells above veins. Files of epidermis in surface view apparently regularly or more commonly irregularly divided into long- and short-cells. Short-cells produced by late division of long-cells (Figure 3.10 B-C), giving rise to hairs (Figure 3.10 A) and usually displaced into a superficial position above common end wall of two contiguous long-cells.

In contrast, the abaxial epidermis (Figure 3.10 D-F and Figure 3.11 A) is sometimes uniform but mostly with distinct or indistinct stomata-free bands below veins pectinating with usually broader intercostal stomata-bearing bands (Figure 3.10 E-F). Hairs commonly restricted to costal bands (*e.g.* Figure 3.10 F).

Abaxial epidermis and sometimes adaxial in many *Paepalanthus* spp. with large inwardly growing protuberances penetrating deeply into the mesophyll, either singly from the middle of relatively short cells, or in pairs one from each end of longer cells, the cells then appearing somewhat n-shaped in longitudinal section. Alternatively with 3 or more lobes from longer cells as in *Paepalanthus applanatus* Ruhl. (Figure 3.9 G), *Pae. claussenianus, Pae. domingensis, Pae. falcifolius, Pae. flaccidus, Pae. hilairei* Körn. (Figure 3.9 E), *Pae. macrocephalus* var. *pachyphylla* Ruhl., *Pae. polyanthus, Pae. speciosus,* and *Pae. tuerckheimii*. In *Pae. falcifolius* internal lobes, as seen in surface view, collectively forming regular transverse files. Further towards interior of leaf, compact mesophyll cells conform to irregular contours produced by epidermal unevenness or protuberances, forming points of attachment to cells of loose mesophyll, Slight epidermal lobing of latter kind also noted in *Eriocaulon australe* and *Leiothrix turbinata*. In transverse section sometimes it is difficult to distinguish localized inward epidermal lobes of this kind from inward protrusion of entire cells (as in *Pae. compactus* and *Pae. elongatus*).

Hypodermis of colorless cells sometimes developed, largely as lateral extension of uppermost and lowermost parts of buttresses. Adaxial hypodermis forming a more or less continuous layer in *Eriocaulon humboldtii* Kunth; *Paepalanthus amoenus* Körn., *Pae. claussenianus, Pae. consanguineus*

Körn., *Pae. elegans, Pae. elongatus, Pae. warmingianus, Pae. weddellianus, Pae. williamsii* (Figure 3.12 A, G), *Pae. xeranthemoides* Mart.; *Syngonanthus niveus, S. reflexus*, the layer often multiseriate, especially in the median part of semi-terete leaves, *e.g.* up to 8 cells deep in *Pae. elegans*. Adaxial hypodermis discontinuous in *E. decangulare* (Figure 3.12 B). Abaxial hypodermis less well developed, usually forming narrow costal bands as lateral extension of buttresses, interrupted by intercostal chlorenchyma, rarely forming a more or less continuous abaxial layer as in *Pae. warmingianus* and *Pae. xeranthemoides* except for interruption above stomata. Hypodermis in *Pae. claussenianus* differentiated into outer slightly thick-walled hypodermis cells and larger, inner thin-walled cells, the latter continuous with buttresses. Isolated bands of hypodermal cells, above or below bundles, common in distal parts of leaves but becoming continuous with bundle sheath in proximal parts (*e.g. Pae. alsinoides; S. flavidulus*).

Stomata (Figure 3.8-3.10 and Figure 3.13) always superficial, with 2 shallow thin-walled lateral subsidiary cells, paracytic (the grass type), usually restricted to abaxial surface (hypostomatic) but not uncommon adaxially (amphistomatic as found both surfaces) in distal parts of lamina of some *Eriocaulon* spp. (*Eriocaulon helichrysoides* and *E. septangulare*); otherwise restricted to abaxial intercostal regions and often with each epidermal file composed of regularly alternating stomata and long epidermal cells. In some aquatic species stomata are lacking as stated by Stützel (1998). Stomatal apparatus always shallower than rest of epidermis, situated superficially or slightly elevated (Figure 3.13 E, G), even in xerophytic types, the substomatal chamber thus largely enclosed by epidermal cells. Substomatal chamber in *Paepalanthus alsinoides* partially occluded by additional uneven wall deposits (Figure 3.13 G-H). Terminal subsidiary cells not developed. Two shallow thin-walled lateral subsidiary cells parallel to and slightly longer than guard cells accompanying each stoma (Figure 3.13 A-B).

Guard cells from 36 μm (*Paepalanthus nivenus*) to 75 μm (*Pae. falcifolius*) long, each with a single prominent outer ledge producing a characteristic beak-like structure in transverse section. Possible slightly developed inner ledge for guard cells of *Eriocaulon* spp. suggested by Solereder and Mayer. Guard cells thin-walled in hydrophytic species becoming thicker-walled in more xerophytic species (Figure 3.13 E, G), the lumen constricted most in equatorial regions, more or less circular in transverse section. Abnormal double stomata recorded for *Pae. bifidus* Kunth and *Pae. tortilis* by Poulsen.

Mesophyll (Figure 3.8 J-N and Figure 3.9 A-B, E, G) between veins consisting of an assimilatory tissue, either restricted to longitudinal bands in many species with well-developed buttress or continuous above and below veins (*e.g.* Figure 3.8 K), in many species without complete buttress (Figure 3.8 J and Figure 3.9 B).

One-2 adaxial layers of palisade tissue sometimes distinct as in *Eriocaulon alatum* (Figure 3.8 L), *E. echinulatum* (Figure 3.8 J), *E. kradungense*, *E. minimum* (Figure 3.8 M), *E. nakayense*, *E.*

xenopodion, Lachnocaulon minus; Leiothrix pedunculosa, Lei. turbinata; Paepalanthus alsinoides, Pae. domingensis, Pae. hilairei (Figure 3.9 E), *Pae. tuerckheimii; Tonina fluviatilis*. Adaxial assimilatory layer otherwise compact with cells scarcely anticlinally extended but distinct from looser abaxial mesophyll, or difference between "palisade" and " spongy mesophyll" expressed largely by differences in number of chloroplasts, the palisade with a high number of chloroplasts. Adaxial mesophyll layer of more hydrophytic species often represented by elongated and not anticlinally extended cells (*e.g. E. septangulare*). Some species palisade is absent (Stützel, 1998).
Abaxial mesophyll between veins represented by isodiametric cells, scarcely lobed in xerophytic species, becoming looser and more prominently lobed in more hydrophytic species, sometimes radiately arranged around veins (*e.g. Eriocaulon australe; Lachnocaulon engleri, Lac. minus; Paepalanthus alsinoides*); in most extreme hydrophytes replaced by air-lacunae, but degree of development of lacunae within a single individual much influenced by wetness of habitat.

Vein (vascular bundles) (Figures 3.8-3.9 and Figure 3.12) always arranged in a single series, somewhat alternately large and small, more or less equidistant from each surface, but closest to adaxial surface in some *Eriocaulon* spp. (*e.g. Eriocaulon alatum, E. annamense* Lec., *E. banani* Lec., *E. buergerianum* Körn., *E. crassiscapum, E. dregei* Hochst., *E. fenestratum* Boj., *E. henryanum* Ruhl., *E. kouroussense* Lec., *E. modestum* Kunth). Bundles rarely forming a few irregular series at different levels (*Paepalanthus polyanthus*).

Number of veins in a leaf often fairly constant in narrow-leaved species, *e.g.* 1 in *Eriocaulon setaceum; Paepalanthus capillaceus* Klotsch.; 3 in *Pae. curvifolius, Pae. elegans*; 5 in *Syngonanthus flavidulus, S. nitens*; 8 in *E. alatum*; several to many and less constant in number in broader-leaved species.

Veins immediately surrounded by parenchymatous outer sheath extended above and below as buttresses. Sclerotic inner sheath immediately surrounding veins either distinct as a single layer of fibre-like cells (sometimes biseriate) as in larger leaved species of *Mesanthemum* and in *Paepalanthus brachypus, Pae. curvifolius, Pae. elegans, Pae. xeranthemoides*; sometime only distinct around phloem (*e.g. Pae. alsinoides* and *Pae. elongatus*). Longitudinal section in hydrophytic species less distinct and cells scarcely thick-walled (Figure 3.12 J-K) *e.g.* most *Eriocaulon* spp. Vascular tissue of larger veins usually including a distinct protoxylem lacuna, remains of annular wall thickening of disrupted elements persisting within the lacuna. Metaxylem in larger leaved species of *Eriocaulon* including 2 wide vessels; metaxylem in *Paepalanthus* often represented by an upside down of v-shaped (in transverse section) strand of angular and narrower elements enclosing the phloem. Phloem always represented by a single, non-sclerotic strand. Smaller veins or all veins in smaller leaved species with less regularly arranged and often reduced vascular tissue.

Transverse veins few but not absent as suggested by Poulsen, sheathed by colorless parenchyma; restricted to transverse diaphragms in fenestrate leaves of hydrophytes, otherwise often forming incipient diaphragms in many species with loose mesophyll (*e.g. Eriocaulon australe*)

Buttresses usually parenchymatous; commonly I-shaped in transverse section, the horizontal part of adjacent girders tending to become united into a continuous hypodermis. Buttressed usually equally tall above and below each vein but in *Eriocaulon alatum* and related species listed above the abaxial buttresses are much taller than adaxial buttresses, therefore, the vein is closer to the adaxial than the abaxial surface. Buttresses either uniseriate (least common and typical only in tall buttresses) or more usually bi- to multi-seriate especially in terete-leaved species. (*e.g. Paepalanthus curvifolius, Pae. elegans; Syngonanthus flavidulus* (Figure 3.12 H), *S. reflexus*). Buttress cells (and associated hypodermal cells) sometimes collenchymatous (*e.g. E. australe, E. decangulare; Leiothrix beckii* Ruhl.*; Pae. curvifolius, Pae. schenckii*) or even fibre-like (*e.g. Pae. niveus*; abaxial but not adaxial buttress cells in *Pae. elegans*). In *S. reflexus* outermost buttress cells sometimes thicker-walled than those elsewhere.

Veins buttressed to each surface in the leaf base become isolated from one or both surfaces in the distal part of the leaf. "Vestiges" of buttresses may be represented by narrow isolated hypodermal strands above and below veins (*e.g. Paepalanthus alsinoides*). The following summarizes the general distribution of vascular bundles in transverse section:

(1) Almost all vein buttressed to each surface (except for a few minor or marginal veins in some species): *Eriocaulon alatum, E. annamense, E. banani, E. buergerianum, E. crassiscapum, E. decangulare* (Figure 3.12 B), *E. dregei, E. fenestratum, E. helichrysoides, E. henryanum, E. humboldtii, E. kouroussense, E. modestum, E. ravenelii* Chapm.*; Paepalanthus amoenus, Pae. caulescens, Pae. claussenianus, Pae. curvifolius, Pae. elegans, Pae. flaccidus, Pae. nitens; Syngonanthus reflexus*. In some species of *Eriocaulon, e.g. E. septangulare*, buttresses separated from each epidermis by only one compact chlorenchyma layer and therefore belonging to this category.

(2) Only largest veins buttressed to each surface. Minor veins buttressed in one of the three following ways. (a) Wholly independent of surface layers, *e.g. Eriocaulon australe* (Figure 3.12 C)*; Leiothrix turbinata; Paepalanthus williamsii* (Figure 3.12 A)*; Tonina fluviatilis* (the buttresses in this species uniseriate and very shallow). (b) Frequently or wholly attached to adaxial surface only, *e.g. E. australe, E. sexangulare; Mesanthemum pubescens* Körn., *M. radicans* Körn., *M. rutenbergianum* Körn., *M. tuberosum* Lec.*; Pae. brachypus, Pae. compactus, Pae. elongatus, Pae. falcifolius, Pae. flavescens, Pae. ramosus, Pae. tuerckheimii, Pae. weddellianus, Pae. xeranthemoides*. (c) Most frequently attached to abaxial epidermis, *e.g. Syngonanthus flavidulus* (Figure 3.12 H).

(3) Vein buttressed only to abaxial surface, *e.g. Paepalanthus schenckii; Syngonanthus nitens*.

(4) Vein wholly independent of surface layers, *e.g. Eriocaulon articulatum, E. compressum, E. septangulare, E. scariosum* (Figure 3.12 E) (the buttresses often capped above and below by a single layer of chlorenchyma); *Lachnocaulon anceps* Benth. et Hook., *Lac. engleri, Lac. minus*

(Figure 3.12 F); *Paepalanthus alsinoides* (Figure 3.12 D), *Pae. bifidus*. Independent said by Ruhland to be supported by a compact chlorenchyma, at least in *Paepalanthus*.

Categories (1)-(4) are only partly reliable for diagnostic purposes since all of them can sometimes be seen in transverse section taken at different levels in a single leaf.

Air-lacunae recorded in *Eriocaulon alatum, E. articulatum, E. compressum, E. crassiscapum, E. decangulare, E. echinulatum, E. kradungense, E. minimum, E. nakayense, E. ravenelii, E. scariosum, E. septangulare, E. sexangulare, E. xenopodion* and group of species described by Malmanche with adaxially situated veins, *e.g. E. alatum, E. annamense, E. banani, E. buergerianum, E. crassiscapum, E. decangulare, E. dregei, E. fenestratum, E. helichrysoides, E. henryanum, E. humboldtii, E. kouroussense, E. modestum, E. ravenelii; Paepalanthus amoenus, Pae. caulescens, Pae. claussenianus, Pae. curvifolius, Pae. elegans, Pae. flaccidus, Pae. nitens; Syngonanthus reflexus*. Lacunae present in leaf base tending to be replaced distally by a continuous loose mesophyll (*e.g. E. decangulare*). Lacunae not usually developed in other genera, but has been observed in *Pae. williamsii*. Air-lacunae lined by one or more assimilatory layers, the lining cells often elongated, especially towards leaf base. Transverse uniseriate diaphragms of chlorophyll-rich, stellate chlorenchyma cells segmenting lacunae at regular intervals, air spaces alternating with layer of chlorenchyma producing regular fenestrate (Figure 3.9 A, B, F) or articulated leaves of more hydrophytic species of *Eriocaulon* (*e.g. E. septangulare* described by Hare). The diaphragm cells usually regularly stellate.

Leaf margin rounded or flattened, its variation of some diagnostic significance. Marginal cells commonly slightly thicker-walled and narrower than remaining epidermal cells, *e.g.* in *Eriocaulon decangulare* and *E. humboldtii*; especially *Paepalanthus oerstedianus*; the thick-walled marginal cells in *Lachnocaulon minus* forming a distinct biseriate wing. Leaf margin in a few *Paepalanthus* spp. (*e.g. Pae. amoenus, Pae. williamsii* (Figure 3.12 G)) including a massive subepidermal strand of fibers.

Leaf apex in some *Eriocaulon* spp. developing a hydrathode-like organ, as suggested by Arber, with the convergent veins terminating in a mass of tracheal tissue below a discontinuous epidermis (*e.g. Eriocaulon septangulare*).

Leaf base differing from distal parts of lamina largely in greater development of colorless hypodermal and buttressing tissues, the buttresses frequently continuous with each surface although discontinuous distally.

Leaf sheath (Inflorescence Leaf or Spathe)

Closed, tubular, sheathing organ at the base of the scape; enclosing the immature scape. Leaf sheath essentially equivalent to a wide rolled foliage leaf with opposite margins fused; outer epidermis

anatomically resembling abaxial, inner epidermis resembling adaxial epidermis of foliage leaf, although anastomosing bundles are more common as stated by Stützel (1998). Internal anatomy corresponding to that of foliage leaf except: (a) palisade-like layer restricted to outer (adaxial) surface; (b) all veins equivalent and buttressed to each surface. Continuous hypodermis commonly developed below outer surface.

Stem

Leafy, vegetative, aerial stem developed only in more robust species *e.g.* of *Paepalanthus, Leiothrix*. Stem then erect, tall, sometimes sparingly branched (*e.g. Paepalanthus amoenus*). Axis otherwise usually reduced to a congested rhizome with terminal leafy rosette (most *Eriocaulon* spp.) and only rarely with and elongated but decumbent aerial stem (*e.g. Tonina fluviatilis;* some aquatic *Eriocaulon* spp. such as *Eriocaulon capillus-najadis* Hook., *E. melanocephalum* var. *longipes* Griseb., *E. setaceum*). There is little or no pith, according to Stützel (1998), the biconcentric, leptocentric, or collateral bundles may have tracheids and vessels of the spiral type and net type. Both scalariform and simple perforations occur. In aquatic species, the xylem is reduced and vessels may be lacking (*e.g. Tonina fluviatilis*). A cortex is generally well developed, especially in the basal part of the stem.

Aerial axis (Figure 3.14) with two types: well-developed stems and reduced stems.

(1) Aerial axis with well-developed stems

The following account refers initially to well-developed aerial stems of *Paapalanthus* spp. Ways in which other species with relatively reduced stems differ are described later. Surface occasionally slightly ridged below leaf insertion. **Epidermis** uniform or with stomata, glandular and filamentous hairs as on lamina. **Cortex** always narrow, uniformly parenchymatous, rarely including a narrow chlorenchymatous zone as in *Paepalanthus tuerckheimii* (Figure 3.14 D). Specialized cortical vascular system not developed apart from transient leaf traces. Leaf traces mostly collateral but amphicribal in *Pae. polyanthus* according to Poulsen, thus recalling amphicribal bundles observed by Malmanche in rhizome of *Pae. xeranthemoides*. Cortex described by Malmanche as becoming lacunose by breakdown of tangential walls of cortical cells in *Eriocaulon bifistulosum* van Huerck *et* Muell*; Pae. caulescens; Philodice hoffmannseggii* and by Solereder and Meyer as lysigenously lacunose in *Syngonanthus caulescens*. **Central cylinder** always wide in proportion to cortex (Figure 3.14 A), delimited externally by a single endodermoid layer (Figure 3.14 B) of usually thick-walled cells, the cells often with lumen almost occluded by wall thickening (*e.g. Pae. alsinoides*) but apparently never suberized or with Casparian strips although described as an endodermis by Solereder and Meyer and earlier authors. Endodermoid cells with uneven wall thickenings, U-shaped in transverse section in *Pae. dasynema* Ruhl., *Pae. freyreissii, Pae. minutulus, Pae. plumosus* Körn., *Pae. schenckii, Pae. warmingianus*. Ground parenchyma at periphery of central cylinder thick-walled, sclerotic, forming distinct mechanical layer with gradual transition internally to thin-walled parenchymatous medulla; medulla hollow in *Pae. densiflorus* Körn. **Vascular bundles** narrow, congested within peripheral mechanical zone; becoming wider, more diffuse centrally (Figure 3.14 A); medulla often devoid of

vascular tissue. Peripheral veins (Figure 3.14 B) often irregular because of frequent tangential anastomoses. Large central vein, or most veins amphivasal (Figure 3.14 C), xylem an irregular series of angular elements more or less surrounding and enclosing central phloem strand; largest bundles each with a distinct protoxylem lacuna towards stem center, next to widest metaxylem elements. Smaller and peripheral veins without distinct protoxylem, irregularly collateral, xylem U- or V-shaped in transverse section and only partly enclosing phloem. Bi-concentric veins (the central lignified cells within the phloem may represent part of the phloem itself which has become sclerotic. If this is so, these cells are not tracheal elements, so the veins may not be truly bi-concentric) consisting of 2 series of xylem elements separated by a single cylinder of phloem recorded by Poulsen for *Pae. polyanthus*, by Ruhland for *Pae. incanus* (Bong.) Körn., by Solereder and Meyer for *Pae. falcifolius* and by Malmanche (occasionally) for *Pae. densiflorus*. Veins commonly sheathed completely or incompletely by fibrous tissue as in *Pae. elongatus* and *Pae. falcifolius* or sheathing tissues parenchymatous as in *Pae. polyanthus*. Fibrous sheathing tissues of individual veins becoming continuous with peripheral mechanical ground tissue. Vascular tissue in *Pae. alsinoides* not arranged in discrete bundles but united to form irregular tracheal strands with or without associated protoxylem, the phloem being scattered without reference to the xylem. Irregular vascular masses, apparently formed by similar fusion, recorded for *Pae. bifidus, Pae. schenckii, Pae. tortilis*.

(2) Aerial axis with reduced stems

Tonina fluviatilis: Cuticle papillose. Cortex of 4-6 layers of colorless parenchyma without vascular tissues. Central cylinder delimited by single layer of thick-walled cells. Vascular bundles restricted to a single series immediately within the sclerotic layer, enclosed by narrow, slightly thick-walled cells. Individual veins essentially amphivasal and each typically including several wide outer tracheal elements, smaller inner elements in an indistinct cylinder enclosing phloem, inner xylem of largest veins represented by a distinct protoxylem lacuna.

Paepalanthus minutulus, Pae. scandens Ruhl., *Pae. tuerckheimii* (Figure 3.14 D); *Philodice hoffmannseggii*, with a similar single peripheral series of veins. Medullary parenchyma rarely disorganized to produce a central lacuna as in *Pae. scandens*.

Eriocaulon bifistulosum (aquatic), endodermoid layer thin-walled, indistinct, stele narrow with single peripheral series of veins.

E. setaceum (floating aquatic), epidermis cutinized only above largest veins. Peripheral ground tissue chlorenchymatous. Cortex and central cylinder not distinctly delimited. Vascular bundles in a single series, alternately large and small; each large veins attached to epidermis by lignified buttress; small veins independent of surface cells. Medulla including wide lacuna. Peripheral layer including large inflated cells, described by Malmanche as internal hairs, each originating by internal enlargement of an epidermal cells, becoming filled with yellowish material and apparently functioning as flotation organ.

Rhizome

Epidermis usually thin-walled, large-celled, uniform except for indumentum of persistent filamentous hairs in leaf axils. **Cortex** wide with a narrow hypodermal region of compact, sometimes slightly ligno-syberized cells and wide middle region of loose, mostly starch-filled cells. Middle cortex wide in many *Eriocaulon* spp. *e.g. Eriocaulon articulatum, E. compressum, E. decangulare, E. helichrysoides, E. septangulare;* in *Leiothrix. beckii* and *Syngonanthus nitens*, consisting of isodiametric or (*e.g. E. septangulare*) elongated cells with numerous interconnecting peg-like protrusions. Few inner cortical layers sometimes somewhat more compact than rest of cortex, rarely slightly thick-walled as in *E. scariosum*. Cortical cells wholly smooth and not lobed in *Lachnocaulon* spp. Cortex without distinct vascular tissues except for numerous leaf traces and intracauline portion of roots. Cortical part of leaf traces in *Paepalanthus xeranthemoides* amphicribal, according to Malmanche, each trace with a complete well-developed fibrous sheath, the sclerotic sheath cells continuous with peripheral sclerotic tissue of central cylinder. **Stele** relatively narrow, delimited from cortex either by a distinct I-layered thin-walled endodermis, or the equivalent layer without Casparian strips as in *E. decangulare* according to Holm, or *E. septangulare* according to Hare and replaced by slightly sclerotic biseriate endodermoid layer. Indistinct, mostly uniseriate pericycle commonly present within the endodermis. Peripheral vascular tissues a represented either by a plexus of irregular xylem and phloem strands not arranged in distinct veins (*e.g. Eriocaulon* spp.) or by indistinctly amphivasal strands. Central region including discrete, diffusely distributed mostly irregular amphivasal veins. Parenchymatous medulla free of vascular tissue in *Lachnocaulon* spp. Veins in *E. septangulare* more or less collateral, xylem reduced to spirally thickened, feebly lignified vessels.

Scape (Inflorescence Axis)

Scape anatomy basically identical throughout family but varying in quantitative ways much emphasized as diagnostic features, according to Lecomte, Malmanche, Stützel (1998) and Zhang (1999). Surface usually ribbed, the ribs related in a direct way to internal structures. Number of ribs constant of each species within quite narrow limits and emphasized as a diagnostic feature (reflected in specific name, *e.g. Eriocaulon decangulare, E. septangulare, E. sexangulare*). The following description refers to the family generally; detailed features which distinguish genera and species are listed later (Figures 3.15-3.17).

Hairs on scape essentially similar to those of lamina or more rarely resembling those of inflorescence and unlike those on vegetative parts. **Epidermis** resembling that of lamina closely; differentiated into costal bands including abundant stomata within furrows, as in all *Eriocaulon* and *Lachnocaulon* spp. as well as in many *Paepalanthus* spp. Situation reversed in some *Leiothrix, Paepalanthus, Syngonanthus* spp. with stomatal bands occupying ribs and non-stomatal bands in furrows. **Cortex** wide, 2-3 times diameter of stele in many *Eriocaulon* spp., divided into distinct chlorenchymatous bands (usually below furrows, Figure 3.17 A; chlor.) alternating with colorless, usually broad parenchymatous buttresses (Figure 3.17 A; but.) extending from epidermis to stele. Buttresses usually

corresponding to external ribs (Figure 3.15 and 3.17 A), rarely extending only part-way across cortex (Figure 3.17 L). Cortex of scape suggested by Lecomte to represent fused adpressed leaves. **Stele** not usually delimited clearly from cortex except by an indistinct **endodermoid layer** (Figure 3.17 A; end.), described as "endodermis" by earlier authors in acceptance of Lecomte's analysis, but cells of layer without typical Casparian strips although showing other specialized staining properties, according to Malmanche; as "sclerenchyma band" by Zhang (1999). Stele usually a parenchymatous cylinder continuous externally with cortical buttresses, including a single series of alternately large and small veins. Large veins always opposite buttresses, small veins opposite chlorenchymatous bands; relative position of bundle changing slightly throughout scape, distally almost in two distinct series, larger bundle innermost, described as 2 series of concentric or biconcentric vascular bundle by Stützel (1998). Medulla almost invariably of uniform parenchyma. Rigidity of scape often increased by mechanical specialization of outer layers of buttresses and stele (Figure 3.17 G, J). Endodermoid layer, when distinct, a fluted cylinder running outside large but inside small veins. **Vascular bundles** almost always related constantly to number of buttresses and hence of ribs according to formula: number of ribs = buttresses = large veins = small veins; or total number of veins = 2 x number of buttresses or ribs (Figure 3.17 A-B). Large veins commonly resembling those of lamina, each with two wide metaxylem vessels flanking phloem and well-developed protoxylem lacuna. Metaxylem less commonly irregular or represented by distinct strand of vessels, more or less V-shaped in transverse section and enclosing phloem. Small veins with reduced vascular tissues; xylem not arranged regularly, rarely absent, each bundle then including only a small phloem strand (*e.g. Eriocaulon septangulare*). As recorded by Stützel (1998), the bundles contain spiral tracheids with scalariform perforations. **Medulla** parenchymatous (Stützel, 1998)

The following details the scape structure for each genus; this structure is constant often diagnostic for individual species.

***Eriocaulon*:**

Scape somewhat flattened, with bilateral symmetry in *Eriocaulon alpestre* Hook *et* Thoms., *E. benthamii* Schldl., *E. dregei, E. eberhardtii* Lec., *E. fluviatile* Trim., *E. gibbosum* Körn., *E. longipedunculatum* Lec., *E. septangulare* according to Malmanche (possibly Malmanche's record for *E. septangulare* is based on an artifact, since the scape of this species is described as radially symmetrical by other authors, *e.g.* Hare). Bilateral symmetry more evident in *E. longipedunculatum* and *E. pancheri* Lec. with slightly winged scape and cortical lacunae enlarged below wings. **Hairs** as on lamina typically restricted to costal regions, length of distal cell of glandular hairs emphasized as diagnostic feature by Malmanche. **Epidermis** thin-walled, resembling closely that of lamina. Epidermal costal bands situated above buttresses on slight to prominent ribs usually with slightly smaller, thicker-walled cells than intercostal bands but larger-celled in *E. crassiscapum*. According to Zhang (1999), 2 subgenera have been defined within the genus as the epidermis above the ribs displays one of the most important diagnostic characters, there are two types, as follows. Type I: subgenus *Trimeranthus* (Figure 3.18 A-G), in which the cells of the epidermis above the ribs are

neither smaller nor more thickened than in other areas (*e.g. E. brownianum* Mart., *E. collinum* Hook.f., *E. kradungense, E. schochianum* Hand.-Mazz., *E. sexangulare, E. wighteanum* Mart.). In contrast, type II: subgenera *Spathopeplus* (Figure 3.18 H-M) (*e.g. E. cristatum* Mart., *E. eglandulatum* Z.X.Zhang, *E. hondoense* Satake, *E. miquelianum* Körn., *E. nudicuspe* Maxim.), in which the cells are distinctly smaller and more thickened than in other areas. **Stomata** restricted to furrows and thus directly above assimilating bands. Stomatal frequency in *E. septangulare* increasing from base to apex of scape, distal stomata 10 times more frequent per unit area on scape than lamina, a feature associated with assimilating function of the scape (according to Hare). Stomata absent from scape base where enclosed by leaf sheath. **Cortex** usually much wider than stele. Chlorenchyma corresponding generally to that of lamina, either represented by uniform tissue, or becoming loosely reticulated (*e.g. E. decangulare*), but replaced in more hydrophytic species by wide lacunae delimited by buttresses (Figure 3.17 F, K; air-lac.). Each lacuna lined more or less completely by a single compact layer of chlorenchyma (discontinuous on inner surface) and segmented regularly by uniseriate diaphragms of stellate chlorophyll-rich cells producing a distinctly fenestrate scape (*e.g. E. banami, E. fenestratum, E. septangulare*). Chlorenchyma in *E. longifolium* Nees reduced to narrow tangential bands by massive enlargement of buttresses. Parenchymatous buttresses continuous across cortex (Figure 3.15), occasionally discontinuous in *E. scariosum* (Figure 3.17 L), enlarged tangentially to become more or less T- or Y- shaped in transverse section, hypodermal extensions sometimes almost continuous tangentially. Outermost part of buttress in *E. buergerianum, E. hondoense* and *E. nudicuspe* (Figure 3.18) of thick-walled cells as recorded by Zhang (1999). Innermost part of buttress in hydrophytic species sometimes only bi- or uniseriate (*e.g. E. banani, E. crassiscapum* and *E. echinulatum* (Prajaksood (2000), Figure 3.15 B)). Inner part of buttress, continuous with central tissue, parenchymatous, large-celled, thin-walled, remaining large-celled externally or becoming small-celled in more hydrophytic species. (*e.g. E. banani*; *E. cinereum* R.Br. and *E. truncatum* Buch.-Ham. ex Mart., according to Zhang (1999)). Outermost buttress cells slightly think-walled (*e.g. E. australe, E. bromelioideum* Lec., *E. brownianum, E. decangulare, E. gracile, E. humboldtii, E. longifolium*) or even slightly sclerotic in more rigid scapes (*e.g. E. buergerianum, E. cristatum, E. flavidulum* Michx., *E. helichrysoides, E. henryanum, E. kunthii* Körn.; *E. siamense* Mold. and *E. sexangulare*, according to Zhang (1999)), but in any one scape mechanical tissues always most pronounced distally. Collenchyma-like wall thickening sometimes observed (*e.g. E. compressum* and *E. decangulare*), but true collenchyma recorded by Malmanche only in *E. modestum*; otherwise collenchymatous appearance possibly a stage in development of thicker walls. The cells are noticeable collenchymatous or sclerenchymatous in buttress areas and the triangular intercellular space is quite visible (Zhang, 1999). **Stele** represented by a parenchymatous cylinder not clearly demarcated from cortex. The cylinder consists of two series of vascular bundles and pith. **Endodermoid layer** rarely distinct, its recognition by Malmanche (as an endodermis) in many species of *Eriocaulon* being rather arbitrary and determined by staining properties different from those of a true suberized endodermis. Endodermoid layer with slightly thickened cell walls recorded by Malmanche in *E. alatum, E. decangulare, E. longipedunculatum, E. miquelianum, E. modestum, E. neocaledonicum* Schl.. Wall thickening U-shaped in transverse section in *E. alatum, E. echinulatum*

(Prajaksood, 2000), *E. longipedunculatum, E. modestum*; *E. nakayense* and *E. xenopodion* (Prajaksood, 2000). Cells of endodermoid layer markedly sclerotic in *E. cristatum, E. helichrysoides, E. henryanum, E. kunthii* and correlated with narrow stele. Endodermoid layer described by Malmanche as passing both inside and outside small veins in *E. decangulare*, however, four types of endodermoid layer termed a sclerenchyma band in a central cylinder were observed by Zhang (1999) (Figure 3.16, Table 3.1) as follows. Type I: the outer whorl is completely encircled by endodermoid layers (*e.g. E. collinum* (Figure 3.16 A)). Type II: the endodermoid layer runs only between the outer and the inner bundles (*e.g. E. kradungense* (Figure 3.16 B), *E. nautiliforme* Lec. (Figure 3.16 C)). Type III: the outer and inner bundles are completely surrounded by the endodermoid layer (*e.g. E. miquelianum* (Figure 3.16 D), *E. nudicuspe* (Figure 3.16 E). Type IV: the endodermoid layer lies only peripheral to the inner bundles (*e.g. E. wighteanum* (Figure 3.16 F)). **Vascular bundles** usually enclosed by uniform, small-celled parenchyma. The outer series of vascular bundle are collateral, in contrast, the inner series show biconcentric type (Zhang, 1999). **Medulla (pith)** is distinct, thin-walled cells in *E. sexangulare, E. siamense, E. willdenovianum* Mold.; a few thick-walled cells in *E. eglandulatum*; all thick-walled cells in *E. buergerianum, E. hondoense, E. nudicuspe* (Zhang, 1999).

Number of buttresses (or number of ribs) varies between 3 and 14, though most often it is 4-5 (Zhang, 1999). Since the number of buttress can vary within a species, the following may be accepted only as a rough guide to the numbers that are to be found in each species.

3 buttresses in *Eriocaulon* sp.13 (Prajaksood, 2000)

4 buttresses in *E. alatum* (Prajaksood, 2000), *E. alpestre; E. minimum, E. nakayense* (Prajaksood, 2000; Figure 3.15 D); *E. nudicuspe* (Zhang,1999).

5 buttresses in *E. alatum, E. australe* (Figure 3.17 K), *E. benthamii, E. bifistulosum, E. brownianum, E. buchananii* Schldl., *E. echinulatum, E. gibbosum, E. henryanum, E. kouroussense, E. miquelianum, E. sexangulare* (Zhang, 1999), *E. xenopodion* (Prajaksood, 2000). Superficially 10 ribs in *E. bifistulosum* because of supplementary ribs opposite chlorenchymatous bands (Figure 3.17 E).

6 buttresses in *E. cristatum, E. gracile, E. modestum, E. sexangulare* (5-6), *E. siamense* (Zhang, 1999).

7 buttresses in *E. bromelioideum, E. buergerianum, E. crassiscapum* (6-7), *E. kradungense* (7-8) (Zhang, (1999) and Prajaksood, (2000; Figure 3.15 C), *E. longipedunculatum, E. pancheri, E. septangulare, E. ubonense* Lec. (7-9).

8 buttresses in *E. fluviatile*.

9 buttresses in *E. helichrysoides*.

10 buttresses in *E. banani, E. decangulare* (9-14), *E. dregei, E. fenestratum* (10-11), *E. neocaledonicum*.

11 buttresses in *E. humboldtii, E. kunthii*.

***Lachnocaulon*:**

With 3 or rarely 4 ribs, ribs opposite buttresses in all species examined. Epidermis thick-walled in *Lachnocaulon glabrum* Körn.. Chlorenchyma often loose, spongy buy never lacunose or septate.

Endodermoid layer slightly thickened. Smaller veins sometimes represented by irregular groups of vascular tissue rather than by typical single bundle.

***Leiothrix*:**

More xerophytic, approaching *Paepalanthus* more than *Eriocaulon*. Ribs 3-7 in *Leiothrix beckii*, up to 10 in *Lei. turbinata* (Figure 3.17 G); corresponding to assimilating bands and not buttresses. Chlorenchyma neither lacunose nor septate. Buttresses distinctly sclerotic. Stele with distinctly sclerotic peripheral layers surrounding veins in *Lei. turbinata*.

***Mesanthemum*:**

Ribs not corresponding to buttresses; opposite chlorenchyma in *Mesanthemum albidum* Lec., *M. auratum* Lec. (Figure 3.17 C), in other species twice as many ribs as buttresses, the ribs situated above radial junction between chlorenchyma and buttress (Figure 3.17 D). Number of ribs, buttresses or large veins in individual species as follows:

4 ribs in *M. albidum*
6 ribs in *M. auratum*
10 ribs in *M. pubescens, M. radicans, M. rutenbergianum, M. tuberosum*.

Buttresses typically sclerotic, especially in distal part of old scapes. Chlorenchyma spongy, with somewhat stellately-lobed cells, especially in *M. rutenbergianum*, but never lacunose or septate. Stele wide, up to 6 times diameter of cortex; medulla hollow in *M. radicans*. Endodermoid layer thickened in all species studied. Veins sclerotic in *M. rutenbergianum*.

***Paepalanthus*:**

Scape structure always more xerophytic than *Eriocaulon*. Scape sometimes smooth as in *Paepalanthus bifidus, Pae. brachypus, Pae. compactus, Pae. falcifolius, Pae. polyanthus*; otherwise ribs complementary to cortical buttresses, rarely with additional ribs, each major divided into 2 minor ribs as in *Pae. elegans, Pae hirsutus, Pae. xeranthemoides*. Number of ribs, buttresses or large veins in individual species as follows:

2 ribs in *Pae. spixianus* Mart..
3 ribs in *Pae. alsinoides* (Figure 3.17 M), *Pae. bongardii* Kunth, *Pae. brachypus, Pae. caespititius* Mart., *Pae. caulescens, Pae. claussenianus, Pae. elegans, Pae. freyreissii, Pae. hilairei, Pae. minutulus, Pae. neglectus* Körn., *Pae. nitens, Pae. oerstedianus, Pae. plantagineus, Pae. polyanthus, Pae. ramosus, Pae. tortilis, Pae. xeranthemoides*.
4 ribs in *Pae. bifidus* (4-5), *Pae. falcifolius, Pae. flaccidus, Pae. flagellaris* Kunth, *Pae. polyanthus* (4-5 or 6), *Pae. schenckii, Pae. viviparus* Mart.
5 ribs in *Pae. compactus, Pae. hirsutus, Pae. spathulatus* Körn., *Pae. warmingianus*.
6 ribs in *Pae. amoenus, Pae. ensifolius* Kunth, *Pae. langsdorffii* Körn., *Pae. plumosus*.

7 ribs in *Pae. blepharocnemis* Mart., *Pae. flavescens*.

8 ribs in *Pae. consanguineus* (8-10), *Pae. curvifolius, Pae. densiflorus, Pae. elongatus, Pae. weddellianus, Pae. williamsii*.

Bilaterally symmetrical scape, recorded by Malmanche for *Pae. ensifolius, Pae. langsdorffii, Pae. neglectus*, possibly artifacts; *Pae. spixianus* with 2 buttresses probably genuinely bilateral. Ribs typically above buttresses, as in *Eriocaulon,* but above chlorenchyma (Figure 3.17 C) in many species as in *Pae. blepharocnemis, Pae. caespititius, Pae. consanguineus, Pae. curvifolius, Pae. ensifolius, Pae. flagellaris, Pae. flavescens, Pae. freyreissii, Pae. hirsutus, Pae. langsdorffii, Pae. neglectus, Pae. nitens, Pae. plantagineus, Pae. plumosus* and *Pae. warmingianus*. **Epidermis** typically thicker-walled than in *Eriocaulon*, sometimes markedly so (*e.g. Pae. alsinoides*); epidermal cells enlarged anticlinally in *Pae. ramosus* and *Pae. polyanthus* in a manner recalling that to be seen in lamina, but epidermis not otherwise specialized to same degree as that of lamina. **Cortex** unique in *Pae. compactus*, because it is uniformly parenchymatous, without distinction between buttresses and assimilating bands, Chlorenchyma usually compact or at most slightly spongy, never lacunose or septate; sometimes restricted to narrow strands almost wholly enclosed by sclerenchyma of buttress, as in *Pae. elegans*. Scape emphasized as a major assimilating organ by Ruhland in *Pae. argyrolinon* Körn. and *Pae. dasynema*. **Buttresses** wholly or almost wholly of sclerenchyma in *Pae. amoenus, Pae. bongardii, Pae. brachypus, Pae. claussenianus, Pae. curvifolius, Pae. densiflorus, Pae. elegans, Pae. elongatus, Pae. flaccidus, Pae. flagellaris, Pae. flavescens, Pae. hirsutus, Pae. nitens, Pae. polyanthus, Pae. viviparus, Pae. weddellianus, Pae. williamsii*. Other species with thin-walled buttress cells, probably shade-dwellers according to Malmanche. Buttresses incomplete in *Pae. alsinoides* (Figure 3.17 M), represented by hypodermal strands of sclerenchyma opposite large veins. **Endodermoid layer** thin-walled in *Pae. bongardii, Pae. brachypus, Pae. claussenianus, Pae. falcifolius, Pae. hilairei, Pae. polyanthus, Pae. ramosus, Pae. spathulatus*, according to Malmanche and said to be sclerotic in remaining species studied, but this interpretation perhaps artificial owing to the difficulty of distinguishing the endodermoid layer from sclerotic ground tissue of stele. Peripheral stelar tissue around veins often sclerotic, sometimes markedly so. Large veins more usually with an irregular strands of tracheal elements than in *Eriocaulon*; V-shaped in transverse section (*e.g.* Figure 3.17 N). *Pae. consanguineus* unique in possessing medullary bundles in addition to normal peripheral stelar bundles.

***Philodice*:**

Ribs 5 in *Philodice hoffmannseggii*. Hairs with basal cell often elongated, bottled-shaped; collar-cell elongated, unlike corresponding cell in other Eriocaulaceae. Chlorenchyma compact, scarcely spongy; endodermoid layer thickened. Ground tissue of stele thick-walled in contract to thin-walled parenchymatous buttresses.

Syngonanthus

Ribs correspond to buttresses in *Syngonanthus caulescens* and *S. nitens*, but more or less to assimilating bands in *S. niveus* and *S. reflexus*, major ribs themselves each somewhat divided into 2 minor ribs. Epidermis markedly thick-walled in *S. reflexus*. Buttresses sclerotic, massive in *S. reflexus*, chlorenchyma then reduced to narrow bands. Endodermoid layer not usually distinct. Stelar peripheral cells surrounding veins somewhat thick-walled, especially in *S. reflexus*. Number of ribs, buttresses or large veins in individual species as follows:

3 ribs in *S. caulescens, S. nitens, S. niveus.*
5 ribs in *S. flavidulus* (Figure 3.17 H).
10 ribs in *S. reflexus*.

Tonina

Surface irregularly ribbed, without regular correspondence between ribs, buttresses, or veins. Buttresses 3, unequal. Chlorenchyma compact, scarcely spongy, not septate. Endodermoid layer and outermost cells of stele somewhat thick-walled. Veins 5 large and 5 small.

In the diagnostic characters of scape emphasized by Malmanche of the Eriocaulaceae as a whole include the following:

(a) Variations in size and shape of distal cell of glandular hairs and in thickness of cell walls of epidermis
(b) Variations in the number of ribs and their corresponding buttresses and large veins.
(c) Differences in position of ribs in relation to buttresses.
(d) Presence or absence of septate lacunae in cortical assimilating bands and degree of sponginess of chlorenchyma.
(e) Amount of wall thickening in endodermoid layer (although it is doubtful if this layer is a consistent morphological entity).
(f) Degree of sclerification of buttresses and outer layers of stele.

Root

Adventitious, of two fairly distinct types, either (a) vermiform or articulate, due to distinct cortical diaphragms as in almost all species of *Eriocaulon*, or (b) uniform, non-vermiform, without cortical diaphragms as in most species of remaining genera. Former type usually spongy white in external appearance, latter compact and brown, according to Malmanche. Roots in *E. decangulare* described by Holm as either (a) thick, white, mostly unbranched, with few root hairs or (b) less white, thinner, longer with many lateral rootlets and root-hairs. This difference refers only to external appearance and may possibly be an expression of age since internal structure of roots of both types is identical.

Piliferous layer usually differentiated into long-cells and short-cells, the latter producing hairs (Figure 3.19). Root-hairs apparently absent from some samples of *E. australe* and from *E. septangulare* according to Hare. Root-hairs commonly irregular groups of 2 or more (*e.g.* Figure 3.19

E, G) as *e.g.* in *Paepalanthus acuminatus* var. *longipilosus* Mold., *Pae. bahiensis* (Bong.) Kunth, *Pae. compactus, Pae. rigidus* (Bong.) Kunth; most typically in pairs (Figure 3.19 C, D, H and Figure 3.20 C), the paired cell side by side (*e.g.* in many species of *Eriocaulon* and *Lachnocaulon*) or sometimes one above the other (*e.g.* in *Leiothrix turbinata*). Paired and solitary root-hairs sometimes in more or less equal numbers (*e.g.* in *Lachnocaulon engleri*), or root-hairs mostly single with occasional pairs (*e.g.* in *Syngonanthus reflexus*). Malmanche's illustration of continuous vertical series of root-hairs in *Pae. brachypus* possibly incorrect. Individual root-hairs typically inflated below root surface, their bases overarched by adjacent long-cells (Figure 3.19 A, G, H). Clustered root-hairs commonly thicker-walled and less ephemeral than solitary or paired root-hairs.

Cortex usually with regular radial seriation of cells, especially in innermost layers; divided into three fairly distinct zones: (1) outer cortex, (2) middle cortex, (3) inner cortex, especially in more specialized roots.

(1) Outer cortex usually of one compact layer of thin-walled or at most slightly thick-walled, slightly ligno-suberized cells; 2-layered and forming a fairly distinct in some species of *Syngonanthus*. Outermost cortical layer in *Paepalanthus williamsii, Philodice hoffmannseggii,* and especially in *Syngonanthus, e.g. Syngonanthus caulescens, S. flavidulus, S. nitens*, discontinuous, represented by a single series of narrow, slightly thick-walled cells below anticlinal walls of piliferous layer, the remaining space occupied by enlarged cortical cells abutting directly on piliferous layer (Figure 3.20 C). Small cells of outer cortex connected by tangential protrusions usually meeting below pairs of root-hairs, the whole system forming an interconnected reticulum between middle cortex and piliferous layer (Figure 3.20 D).

(2) Middle cortex varying throughout the family as a whole, but quite constant for each species; divided into three types, as follows:

(a) Unspecialized cortex usually narrow in proportion to stele (*e.g.* Figure 3.21 C and Figure 3.22 A), as little as 2-4 cells wide in *Paepalanthus bifidus, Pae. minutulus*, consisting of uniformly long cells, thin-walled externally, usually with gradual or sharp transition to thicker-walled cells of inner cortex. Unspecialized cortex observed in, *e.g.*, *Blastocaulon rupestre* (Gardn.) Ruhl.; *Eriocaulon caulinum, E. nigrum* var. *suishaense* Hals., *E. seemanii* Mold. and possibly *E. melanocephalum* var. *longipes; Lachnocaulon engleri, Lac. minus; Leiothrix nubigena* (Ruhl.) Kunth, *Lei. turbinata; Pae. acuminatus, Pae. amoenus, Pae. bahiensis, Pae. balansae* var. *densiflorus* Mold., *Pae. brittonii* Mold., *Pae. capillaceus* var. *proliferus* Gleason, *Pae. compactus, Pae. lamarckii* Kunth, *Pae. rigidus, Pae. seslerioides* Griseb., *Pae. tuerckheimii; Tonina fluviatilis*.

(b) Slightly specialized cortex showing features transitional to highly specialized condition. Early stage in *Pae. duidae* Gleason with middle cortex differentiated into vertical files of more or less alternate long-cells and short-cells, with regular outline, independent of one another. Short-cells in this and subsequently more specialized types, apparently derived by an equal transverse division of a cortical mother cell with subsequent elongation of only one daughter cell, not by unequal division of a

mother cell. In somewhat more specialized roots, originally contiguous short-cells, despite elongation of long-cells, retain continuity in two directions, vertically and horizontally. **Vertically**, by extensions maintaining contact by growth at same rate as over-all root elongation (Figure 3.20 A), the short-cells thus forming an irregular reticulum in the intercellular system between long-cells (Figure 3.23 K, N), as in the following species: *Eriocaulon alpestre, E. australe, E. benthamii. E. caesium* Griseb, *E. formosanum* Hayata., *E. heterodoxum* Mold., *E. longifolium; Leiothrix curvifolia, Lei. dielsii* Ruhl., *Lei. echinulata, Lei. flavescens, Lei. fulgida* Ruhl., *Lei. pilulifera* (Körn.) Ruhl.; *Mesanthemum radicans, M. rutenbergianum; Pae. williamsii; Syngonanthus caulescens*; with a slightly tendency, especially in *Eriocaulon* spp., for cells to be arranged in regular horizontal series. **Horizontally**, by irregular lateral protrusions developed between adjacent short-cells at the same level (Figure 3.20 B).

(c) Specialized cortex developed by restriction of short-cells to **transverse diaphragms**, separated by a single whorl of long-cells, as in all species of *Eriocaulon* except those mentions above. Diaphragms sometimes somewhat irregular, as in *Eriocaulon compressum*, but otherwise sufficiently regular so as to produce characteristic vermiform appearance. Diaphragms rare in other genera (as in *Syngonanthus flavidulus* and *Philodice hoffmannseggii*) and exceptional for the genera *Leiothrix* (in *Leiothrix arechavaletae* Ruhl.) and *Paepalanthus* (in *Pae. nitens* and *Pae. xeranthemoides*). Less highly organized diaphragms include those recorded by Malmanche with relatively smooth short-cells, not in lateral contact, as in *E. australe* (Figure 3.23 G-J), *E. brownianum, E. longifolium; Pae. curvifolius, Pae. flavescens, Pae. hirsutus*. Short-cells otherwise lobed horizontally. Lobes relatively few and simple, *e.g.* in *S. flavidulus*, but in most *Eriocaulon* spp., short-cells lobed and complex and characteristic manner as recorded by Hare (Figure 3.23 A-F). Each short-cell essentially cubical, but elaborately lobed to form numerous peg-like contacts with adjacent short-cells, the pegs maintaining local continuity despite over-all expansion; rarely some of finer protrusions losing contact and ending blindly. Each short-cell with several major lobes, themselves subdivided into minor lobes or the minor lobes arising directly from main cell body. Major lobe sometimes in vertical pairs on each tangential wall, accompanied by four on radial walls, more or less one at each corner and extending horizontally. Upper and lower surfaces of the short-cell smooth and somewhat concave due to pressure of long-cells above and below (Figure 3.23 L-M). Major lobes alternatively subdivided into numerous fine protrusions making minor lobes. Other, numerous, minor lobes directly from main cell body between major lobes. Minor lobes making contact with similar lobes either from a different or, commonly, from the same cell (Figure 3.23 C-F). Short-cells commonly slightly thicker-walled than long-cells and often slightly lignified, the nodal diaphragms then much more rigid than the intervening long-celled internodal regions. Lacunae described by Malmanche in some species (*e.g. E. buergerianum*) said to be formed by breakdown of tangential walls of cortical cells, but probably an artifact.

(3) Inner cortex of radially and concentrically seriated layers one or more cells thick, usually differing from the middle cortex (*e.g.* Figure 3.21 B, D, F, K and Figure 3.22 B, D, G, H). Inner cortical layers often flattened tangentially (*e.g.* Figure 3.21 D, K), commonly with slight to pronounce wall thickening, the thickening usually uniformly distributed, the number of modified inner cortical layers usually constant for each species. Inner cortex of mechanical significance in more hydrophytic

species, *e.g.* most *Eriocaulon* spp., supplementing and often closely resembling endodermis (Figure 3.22 G-H); but in more xerophytic species, *e.g.* most *Paepalanthus* spp., although often thicker-walled and more pronounce than in *Eriocaulon*, mechanically less significant in view of massive endodermis (*e.g.* Figure 3.21 D). Innermost cortical cells in many *Eriocaulon* spp. (*e.g. Eriocaulon septangulare*) with numerous peg-like outgrowths (Figure 3.22 E) making contact with each other and especially with the enlarged short-cells forming innermost limit of each diaphragm (Figure 3.23 L). Surface in contact with endodermis usually smooth.

Endodermis usually uniseriate, arising from same mother cells as inner cortical layers; occasionally biseriate in *Paepalanthus. albo-vaginatus* Alv.Silv.; multiseriate, up to 5-layered some species of *Syngonanthus* (Figure 3.21 B). Falsely biseriate endodermis developed from radial overlapping of markedly oblique end walls of short endodermal cells (Figure 3.21 F), the tapering end walls sometimes as long a s non-overlapping walls (Figure 3.21 G), *e.g.* in *Blastocaulon rupestre; Leiothrix arechavaletae, Lei. echinulata* Mold.*; Mesanthemum radicans; Pae. albo-vaginatus, Pae. balansae, Pae. brachypus, Pae. compactus, Pae. williamsii*; frequently of this pseudo-biseriation depending on obliqueness of end walls in relation to length of endodermal cell (Figure 3.21 F-J). Endodermal cells in *Eriocaulon* typically long and with truncate ends. Degree and distribution of wall thickening in mature endodermal cells very constant and of some diagnostic value for each species; more hydrophytic species (*e.g. Eriocaulon*) including a narrow, thin-walled endodermis not well differentiated from inner cortex except for suberin deposits (Figure 3.22 H); more xerophytic species (*e.g. Leiothrix, Paepalanthus*) including a wide, thick-walled and mechanically significant endodermis abruptly differentiated from inner cortex and pericycle (Figure 3.21 B, D, F, K), the unspecialized cortex typically associated with this mechanical endodermis usually sloughing early.

The three types of endodermis and their distribution are:

(1) Cells of endodermis uniformly thin-walled, or walls at most slightly thickened. *Eriocaulon arechavaletae, E. australe* (slightly thickening), *E. benthamii, E. buergerianum, E. caesium, E. capillus-najadis, E. compressum, E. crassiscapum, E. cristatum, E. formosanum, E. fuliginosum* Wright, *E. helichrysoides, E. heterodoxum, E. longifolium, E. longipedunculatum, E. nigrum, E. nipponicum* Max., *E. ovoideum* Britt. *et* Small, *E. tropicanum* Mold., *E. truncatum* Ham.*; Philodice hoffmannseggii; Syngonanthus caulescens*. somewhat thicker-walled endodermis, transitional to next class in *E. decangulare, E. kurtzii, E. melanocephalum, E. panamaense* Mold. In *E. benthamii, E. melanocephalum* (Figure 3.22 J) endodermis forms sole mechanical tissue of root.

(2) Cells of endodermis uniformly thickened, but extent of wall thickening quite variable, massive and often distinctly lamellate in many species marked (*). *Eriocaulon brownianum, E. longifolium, E. seemanii; Leiothrix arechavaletae, Lei. curvifolius* (*), *Lei. dielsii, Lei. echinulata* (*), *Lei. flavescens, Lei. fulgida* (*), *Lei. pilulifera, Lei. turbinata* (*)*; Mesanthemum auratum, M. radicans, M. rutenbergianum; Paepalanthus amoenus, Pae. bahiensis, Pae. brachypus, Pae. brittonii, Pae. compactus* (*), *Pae. curvifolius, Pae. duidae, Pae. elegans* (*), *Pae flavescens, Pae. hirsutus* (*),

Pae. nitens, Pae. rigidus, Pae. vaginatus, Pae. weddellianus (*), *Pae. williamsii; Syngonanthus flavidulus* (*).

(3) Cells of endodermis unevenly thickened, the inner tangential thicker than remaining walls, appearing more or less U-shaped in transverse section. Walls relatively slightly thickened, as in *Eriocaulon alpestre*, some samples of *E. australe* and *Paepalanthus lamarckii*, but walls more usually thick, often distinctly lamellate as in *Blastocaulon rupestre; E. caulinum; Lachnocaulon engleri, Lac. glabrum, Lac. minus; Leiothrix nubigena; Pae. acuminatus, albo-vaginatus, Pae. alsinoides, Pae. balansae, Pae. lamarckii, Pae. seslerioides, Pae. tuerckheimii*. In massive-walled endodermis, cell lumen often almost occluded, frequently conspicuously pitted. Mechanical significance of thick-walled endodermal cells frequently indicated by their radial extension (Figure 3.21 D, F, K), thereby in creasing thickness of endodermis as in *B. rupestre; Lei. curvifolia, Lei. echinulata, Lei. nubigena, Lei. turbinata; Mesanthemum radicans; Pae. albo-vaginatus, Pae. brachypus, Pae. brittonii, Pae. compactus, Pae. curvifolius, Pae. elegans, Pae. weddellianus.*

Pericycle usually uniseriate, thin-walled, inconspicuous, but locally or continuously bi-or tri-seriate in *Leiothrix curvifolia; Paepalanthus brittonii, Pae. compactus, Pae. xeranthemoides*; lignified and appreciably thick-walled in *Lei. nubigena* (Figure 3.21 K)*; Pae. claussenianus, Pae. compactus, Pae. falcifolius, Pae. ramosus, Pae. weddellianus*. Pericycle typically interrupted by protoxylem elements lying next to endodermis (Figure 3.21 H and Figure 3.22 B, D, G, H), a feature characteristic of the family according to van Tieghem, but sometimes not seen in roots with wide steles as in, *e.g.*, *Lei. curvifolia; Pae. balansae, Pae. brittonii, Pae. claussenianus, Pae. compactus, Pae. falcifolius, Pae. rigidus*. Number of protoxylem poles emphasized as a diagnostic feature by van Tieghem, but shown by subsequent authors to be somewhat variable within a single species.

Stele varying in complexity, from oligarch large in proportion to diameter (polyarch of Stützel (1998)). Wide steles including several to many wide metaxylem vessels scattered more or less uniformly throughout medullary parenchyma. Peripheral metaxylem elements somewhat narrower and not arranged in distinct radial series (Figure 3.21 C) in *Blastocaulon rupestre; Eriocaulon arechavaletae, E. caulinum, E. fenestratum, E. helichrysoides, E. humboldtii. E. kunthii, E. kurtzii; Leiothrix curvifolia, Lei. nubigena, Lei. turbinata; Mesanthemum radicans; Paepalanthus albo-vaginatus, Pae. amoenus, Pae. balansae, Pae. brachypus, Pae. brittonii, Pae. claussenianus, Pae. compactus, Pae. curvifolius, Pae. elongatus, Pae. falcifolius, Pae. hilairei, Pae. ramosus, Pae. rigidus, Pae. tuerckheimii, Pae. vaginatus, Pae. weddellianus, Pae. williamsii*. Stele transitional to more simple type in *Lachnocaulon* (*e.g. Lachnocaulon engleri, Lei. glabrum*); *Tonina fluviatilis* (with 3-5 wide central vessels themselves often in direct contact with endodermis, a condition approached by *Pae. tuerckheimii*). Stele in more hydrophytic species narrow (Figure 3.22 F) and relatively simple, the xylem consisting only of a solitary wide central vessel and a fairly constant number of narrow, pericycle protoxylem elements (Figure 3.22 G, H) as in all *Eriocaulon* spp. not listed above; in most *Leiothrix* spp. except those listed above; in *M. auratum, M. rutenbergianum; Pae. alsinoides, Pae. caulescens, Pae. duidae, Pae. elegans, Pae. flaccidus, Pae. flavescens, Pae. lamarckii, Pae. nitens,*

Pae. xeranthemoides; Philodice. hoffmannseggii. Narrow steles often including only one conjunctive layer between central vessel and pericycle as in *E. scariosum*. Stele in *E. melanocephalum* very narrow, xylem elements mostly vestigial (Figure 3.22 J). Pith parenchymatous (Stützel, 1998).

Phloem in wider steles sometimes in strands uniformly distributed throughout central ground parenchyma, between scattered vessels (Figure 3.21 E), as in *Blastocaulon rupestre; Eriocaulon caulinum, E. kurtzii; Leiothrix curvifolia, Lei. nubigena; Paepalanthus albo-vaginatus, Pae. brittonii, Pae. claussenianus, Pae. compactus, Pae. falcifolius, Pae. ramosus*, the phloem strands often reduced to a single sieve-tube, but more typically restricted to a peripheral position, alternating with the protoxylem elements but never situated in pericycle. Phloem strands small and often inconspicuous, more obvious in many species with thick-walled conjunctive parenchyma, such as *Lei. fulgida; Pae. falcifolius, Pae. weddellianus*.

Secretory, Storage and Conducting Elements

Crystals: Calcium oxalate common as prismatic, rhombohedral and often needle-like crystals associated with assimilating tissue; druse-like aggregates occasional (Figure 3.2).

Starch: mostly restricted to cortex of rhizome and colourless tissues of leaf base; grains small, mostly simple, irregularly spherical.

Xylem: Vessels in metaxylem of all parts, with mostly simple, more or less transverse perforation plates, less commonly scalariform with few thickening bars in leaf and scape. Elements in stem of *T. fluviatilis* with long, scalariform perforation plates on very oblique end walls. Elements in root usually long with pitted walls, thickening least developed in roots of hydrophytic species, often represented by annular thickenings connected by frequent vertical bars. Elements in rhizome short, irregular; end wall often irregularly oblique. Tracheids are always present as recorded by Stützel (1998).

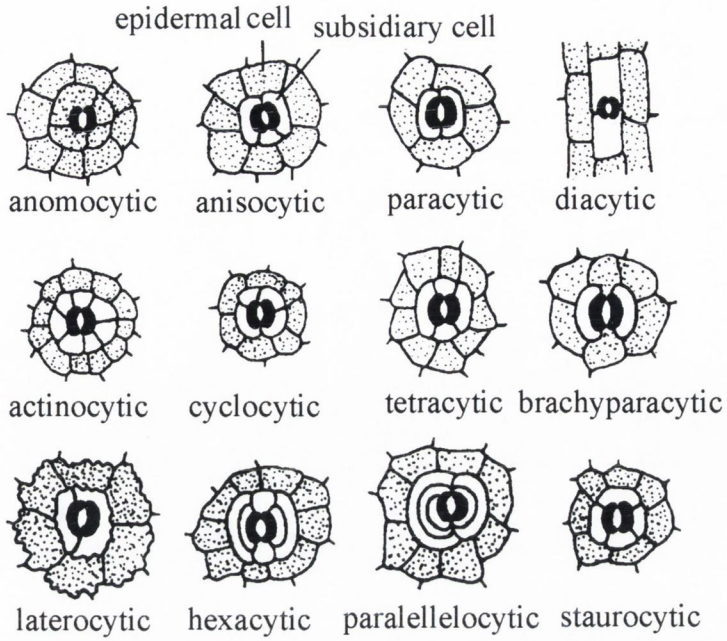

Figure 3.1 Stomatal types. Adapted from Khomgrid (1999).

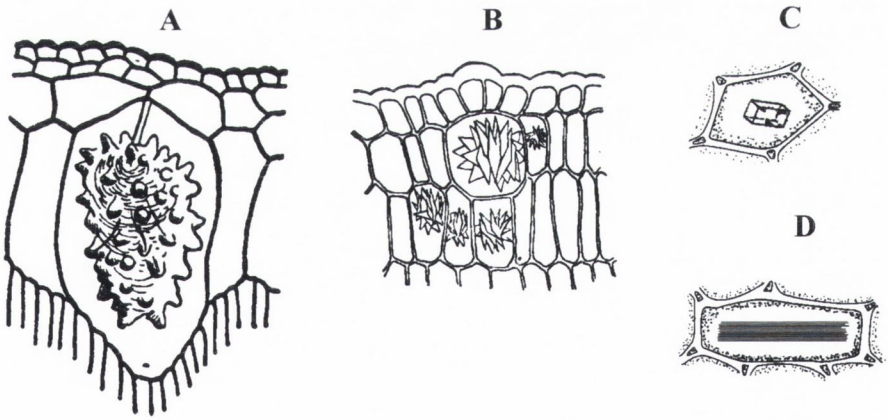

Figure 3.2 Secretory structures. (A) Cystolith. (B) Druse-like crystals. (C) Prismatic crystal. (D) Raphide crystal. (A)-(B) Adapted from Metcalfe and Chalk (1950), (C)-(D) adapted from Judd *et al.*(2002).

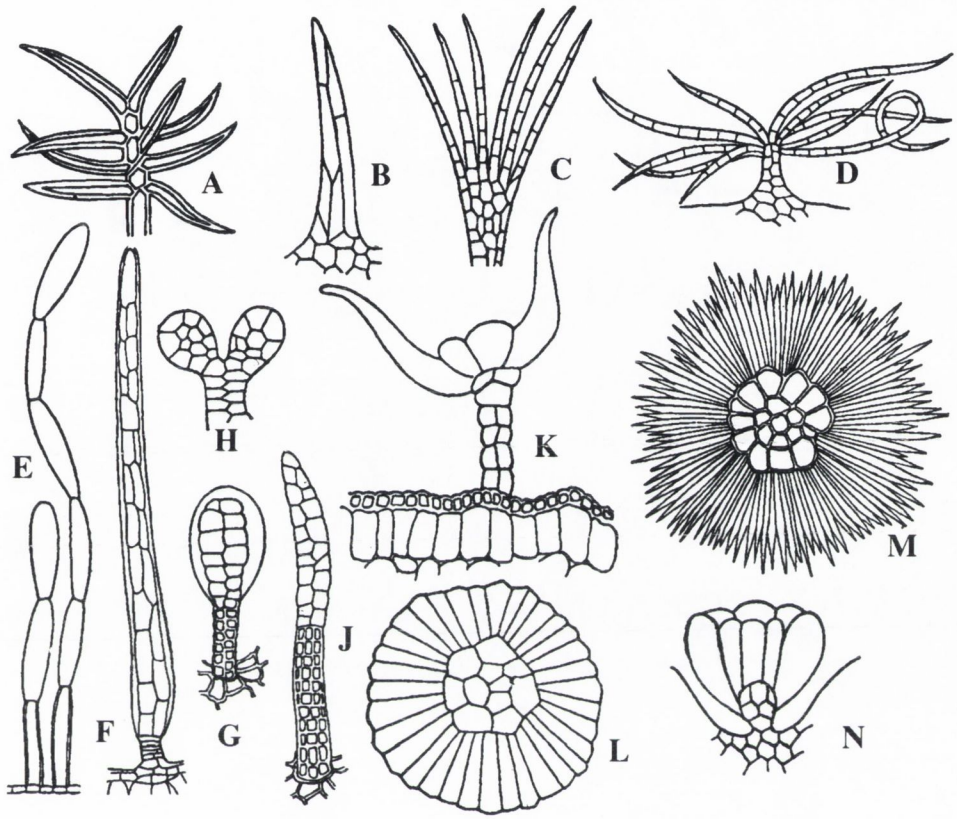

Figure 3.3 Various trichomes in Ericaceae. (A) Abietiform hair. (B) Shaggy hair. (C) Broom-shaped shaggy hair. (D) Stellate shaggy hair. (E)-(G) External glands. (H) Double glandular hair. (J) Glandular hair. (K) Cup-shaped peltate hair. (L)-(M) Peltate hairs. (N) Bud-shaped peltate hair. Adapted from Metcalfe and Chalk (1950)

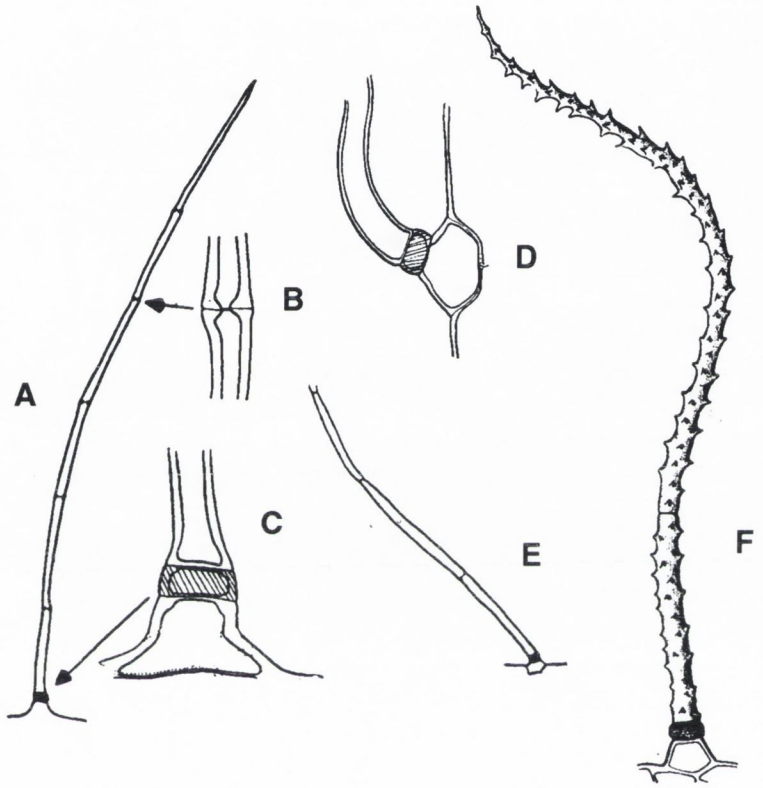

Figure 3.4 Filamentous hairs in some species of Eriocaulaceae. (A)–(C) *Tonina fluviatilis* lamina, (A) Entire hair (x50). (B) Details of distal septum (x230). (C) Details of base (x230). (D)-(E) *Paepalanthus domingensis*, (D) Base of hair from leaf margin (x210). (E) Hair from leaf margin, distal cells omitted (x65). (F) Hair of margin of leaf base of *Paepalanthus distichophyllus*. (A)–(E) Adapted from Tomlinson (1969), (F) adapted from Ruhland (1903).

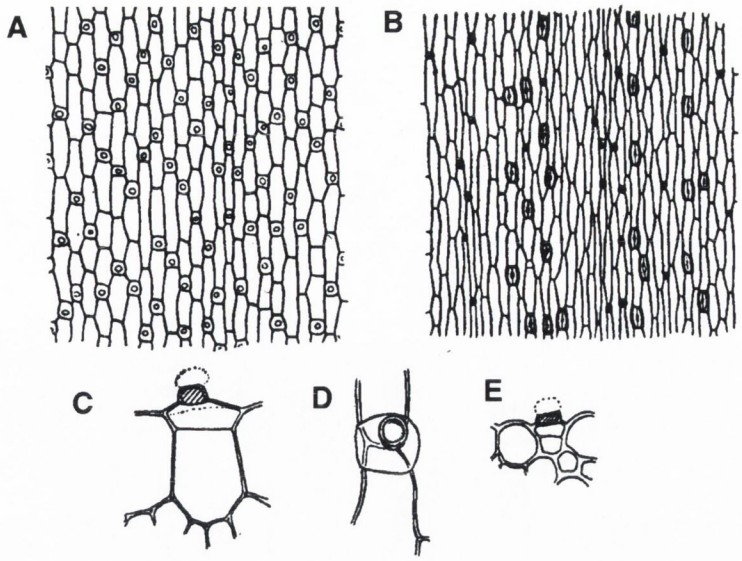

Figure 3.5 Lamina of *Paepalanthus williamsii*. (A) Adaxial epidermis, surface view (x50). (B) Abaxial epidermis, surface view (x50). (C) Transverse section adaxial epidermis including hair base, distal cell detached (x230). (D) Hair base, adaxial surface, distal cell detached (x230). (E) Transverse section base abaxial hair, distal cell detached (x230). Adapted from Tomlinson (1969).

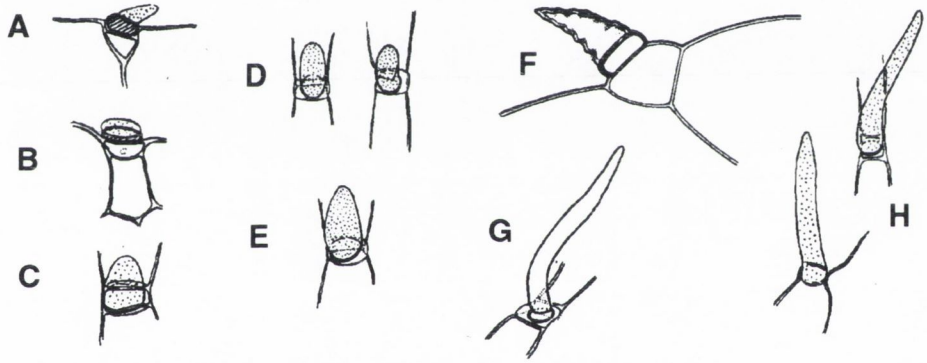

Figure 3.6 Unbranched three-celled glandular hairs on lamina in some species of Eriocaulaceae. (A)-(C) Adaxial hairs of *Eriocaulon septangulare* (x230), (A) longitudinal section. (B) Transverse section. (C) Surface view. (D) Hairs of *E. scariosum*, surface view (x230). (E) Hairs of *E. articulatum*, surface view (x230). (F) Hair of *Paepalanthus scytophyllus*, longitudinal section. (G) Hair of *Tonina fluviatilis*, surface view (x230). (H) Hair of *Lachnocaulon minus*, surface view (x230). (A)-(E), (G) and (H) Adapted from Tomlinson (1969), (F) adapted from Ruhland (1903).

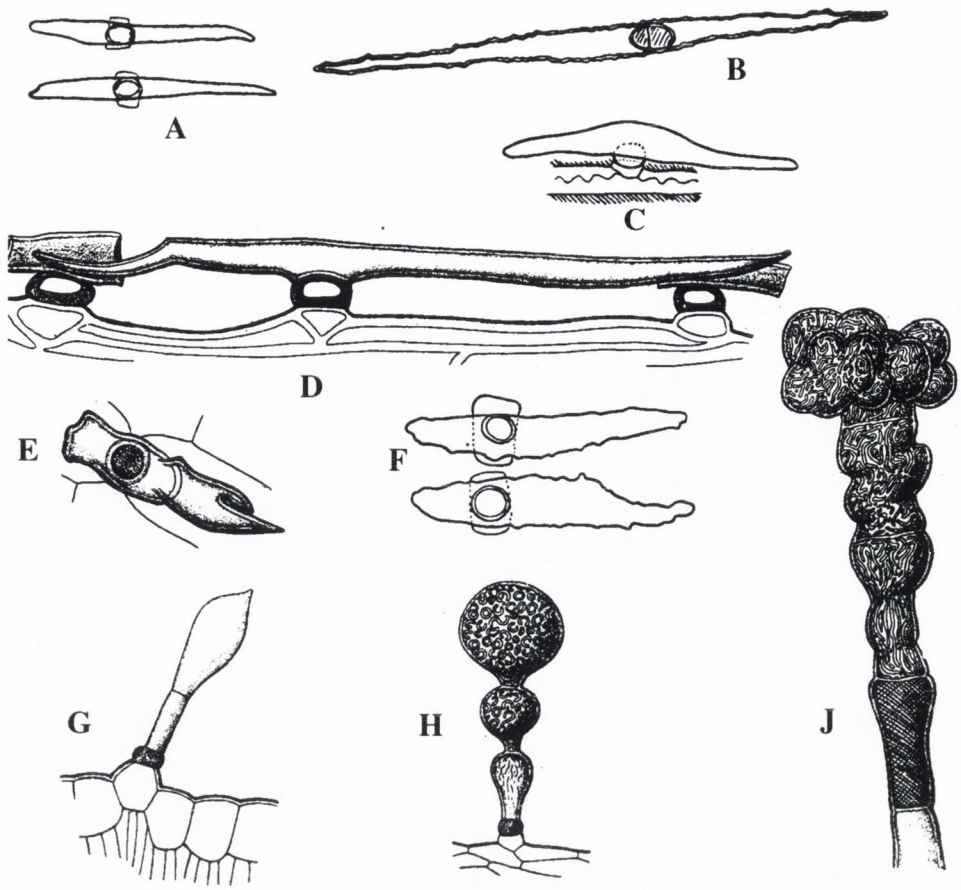

Figure 3.7 Branched three-celled glandular hairs (A-F) and multicellular capitate glandular hairs (G-J) in some species of Eriocaulaceae. (A)-(C) Arms of T-shaped cell almost equal or equal, (A) Adaxial, almost equal, hairs on lamina of *Paepalanthus williamsii*, surface view, distal cell attached (x230). (B) Surface view of glandular hair, branched, equally T-shaped on lamina of *Syngonanthus flavidulus*, distal cell attached (x230). (C) Surface view of hair with persistent distal cell from costal region of abaxial leaf epidermis of *Pae. alsinoides* (x260). (D)-(F) Arms of T-shaped cells unequal, (D) Hairs on scape of *Pae. elongatus*, longitudinal section. (E) Hair on adaxial leaf epidermis of *Pae. ciliolatus*, surface view. (F) Hairs on adaxial leaf epidermis of *Pae. williamsii*, surface view (x230). (G) Hair on Adaxial leaf epidermis of *Paepalanthus compactus* Gardn. (H) Hair of *Pae. gyrotrichus* Ruhl. (J) Hair of *Pae. acanthophyllus* Ruhl. (A)-(C) and (F) Adapted from Tomlinson (1969), (D)-(E) and (G)-(J) adapted from Ruhland (1903).

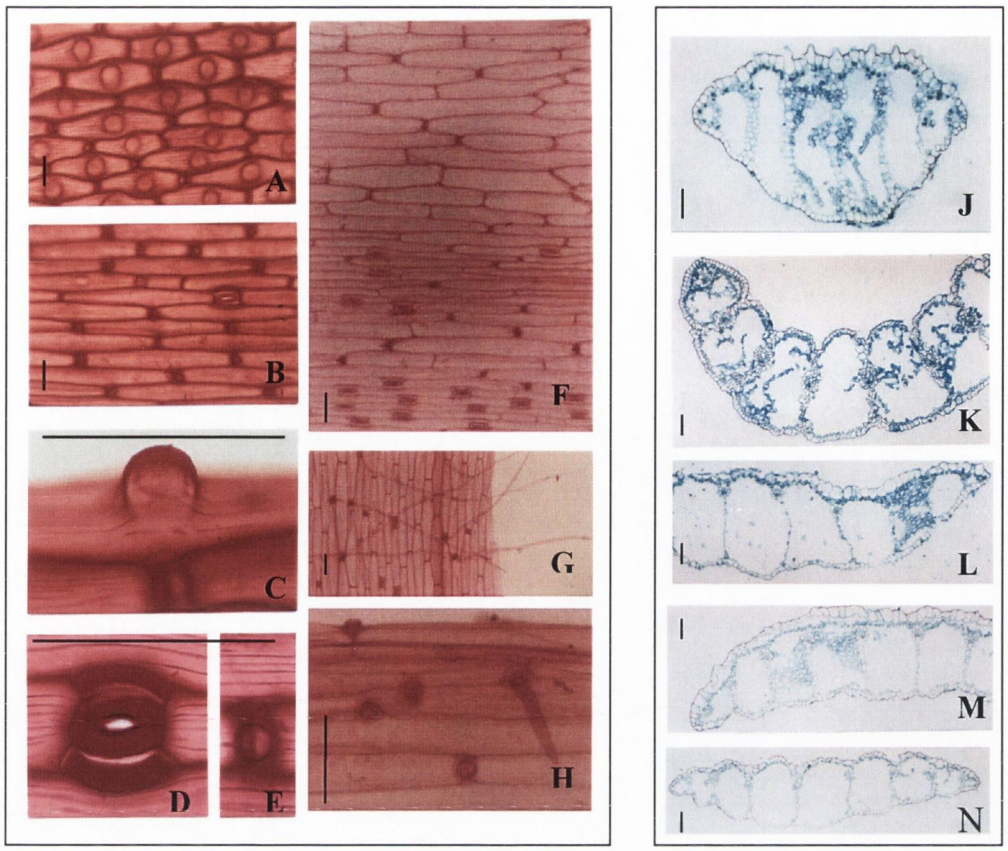

Figure 3.8 Leaf anatomy of some species of *Eriocaulon*. (A)-(H) Epidermis surface view, (A)-(E) *Eriocaulon echinulatum*, (A) papillose adaxial epidermis. (B) Abaxial epidermis. (C) Papillose and cutinized epidermal cell. (D) Paracytic stoma with two subsidiary cells and cutinized on abaxial surface. (E) Trichome on abaxial surface. (F) Typical adaxial (above) and abaxial (below) epidermis of *Eriocaulon* sp.13 (the number following Prajaksood (2000)). (G)-(H) *Eriocaulon* sp.5 (the number following Prajaksood (2000)), (G) multicellular filament trichomes on abaxial epidermis. (H). Three-celled glandular hairs with distal cells detached and attached. (J)-(N) Transverse section of leaf, (J) leaf margin straight and mostly discontinuous buttresses in *E. echinulatum*. (K) Leaf margin upward and continuous buttresses in *Eriocaulon* sp.13. (L) Distinct diaphragm of stellate parenchyma and discontinuous buttresses in *E. alatum*. (M) Leaf margin downward in *E. minimum*. (N) Leaf margin straight in *Eriocaulon* sp.5. Scale = 100 μm. Adapted from Prajaksood (2000).

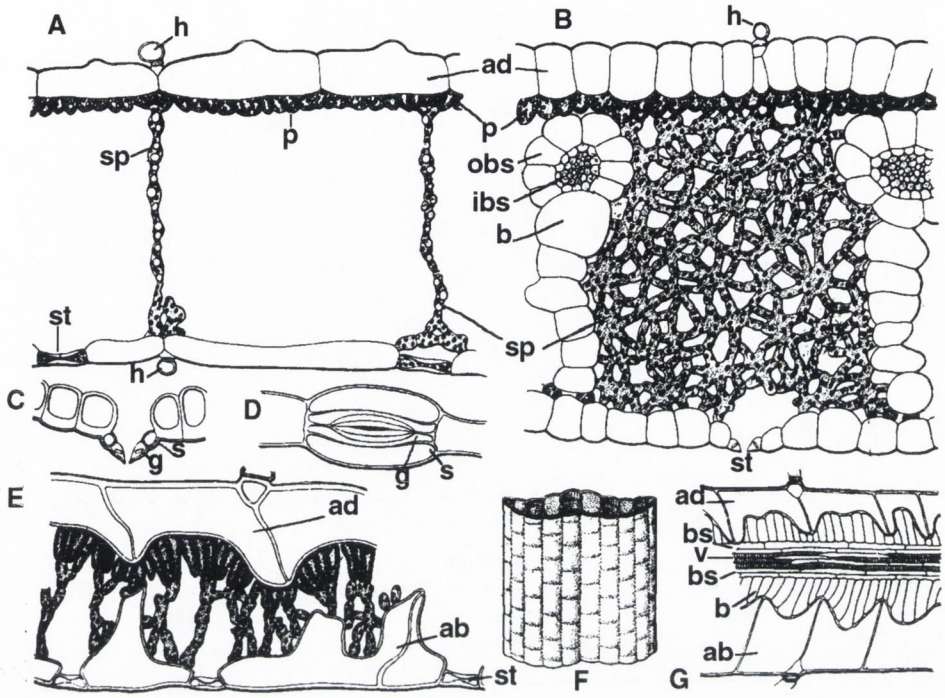

Figure 3.9 Appearance of the leaf in some species of Eriocaulaceae. (A) Longitudinal section of leaf, shows stellate diaphragms. (B) Transverse section of leaf. (C)-(D) Opened stoma of *Paepalanthus camptophyllus* Ruhl., (C) transverse section. (D) Surface view. (E) Longitudinal section of leaf in *Pae. hilairei* Körn. (F) Lamina of *Eriocaulon crassiscapum* Bong., shows fenestration of lacunose structure (x10). (G) Longitudinal section of leaf in *Pae. applanatus* Ruhl. ab = abaxial epidermis, ad = adaxial epidermis, b = buttress, bs = bundle sheath, g = guard cell, h = hair, ibs = inner bundle sheath, obs = outer bundle sheath, p = palisade cell, s = subsidiary cell, sp = stellate parenchyma, st = stoma, v = vascular bundle. Adapted from Ruhland (1903).

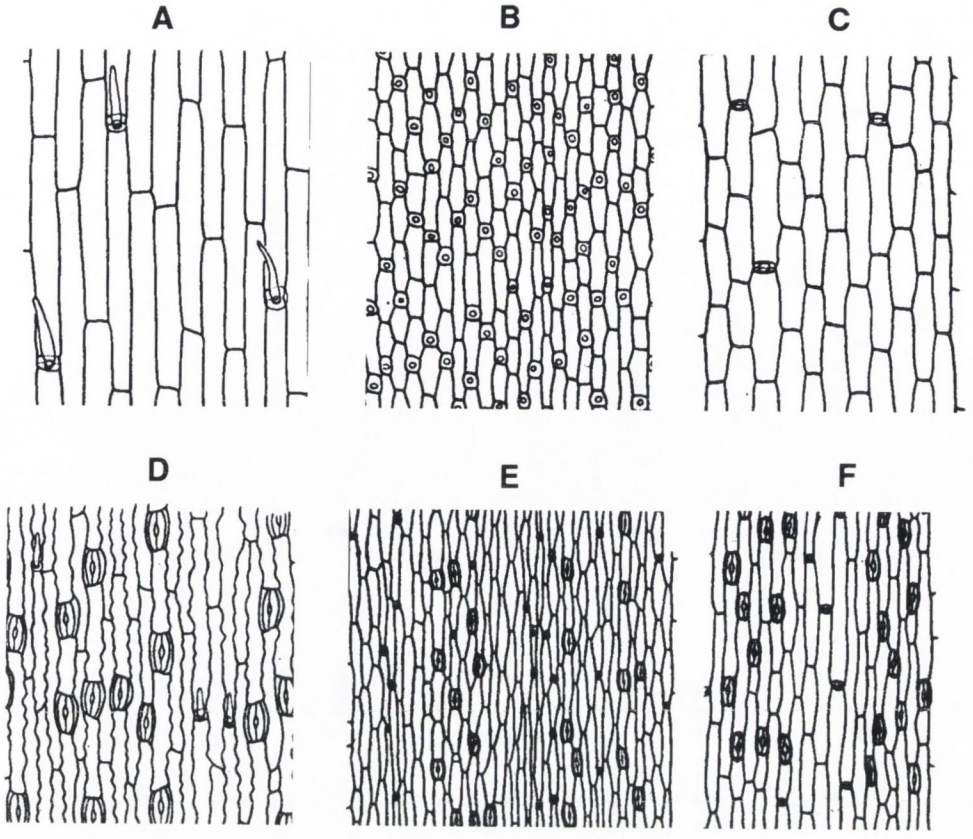

Figure 3.10 Surface view of leaf epidermis in some species of Eriocaulaceae. (A)-(C) Adaxial epidermis. (D)-(F) Abaxial epidermis. (A) and (D) *Tonina fluviatilis* (x50). (B) and (E) *Paepalanthus williamsii* (x50). (C) and (F) *Eriocaulon decangulare* (x50). Adapted from Tomlinson (1969).

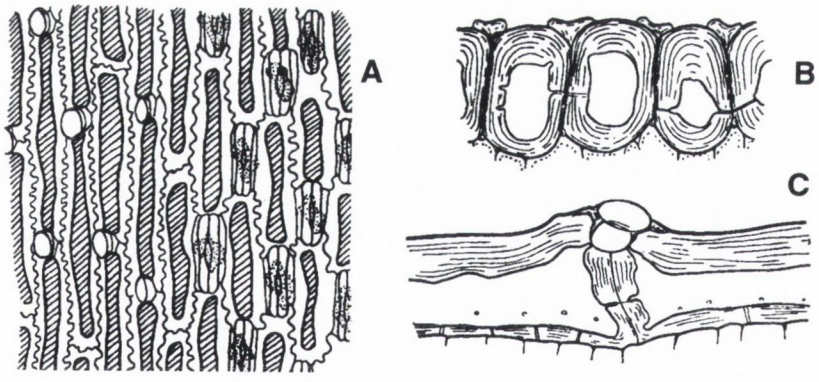

Figure 3.11 Epidermis of *Paepalanthus alsinoides*. (A) Abaxial epidermis, surface view, costal band to left; intercostal band to right (x70). (B) Transverse section adaxial epidermis (x320). (C) Longitudinal section adaxial epidermis with persistent hair base (x320). Adapted from Tomlinson (1969).

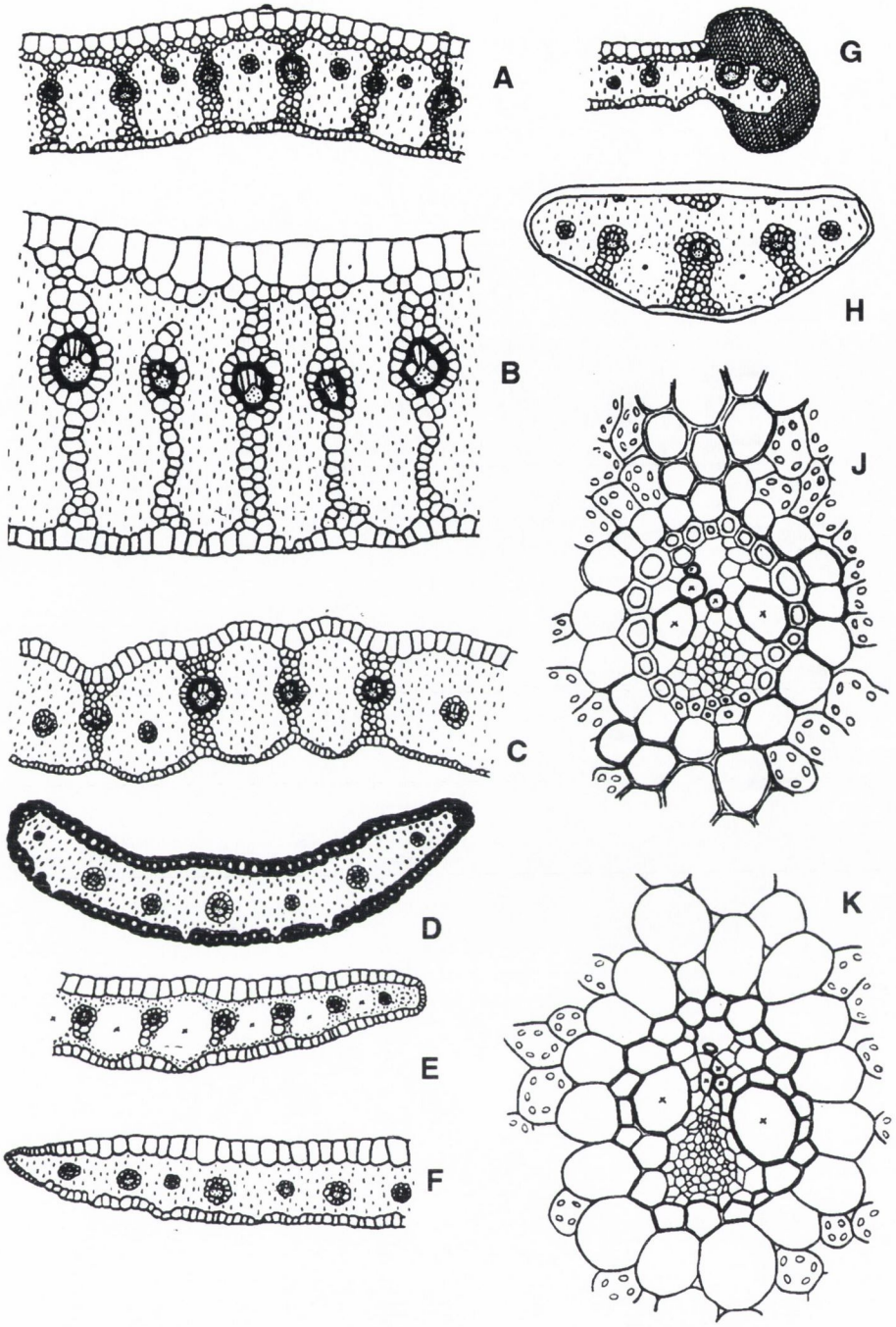

Figure 3.12 Lamina and veins in transverse section of some species of Eriocaulaceae. (A) *Paepalanthus williamsii* (x50). (B) *Eriocaulon decangulare* (x50). (C) *E. australe* (x50). (D) *Pae. alsinoides* (x60). (E) *E. scariosum* (x50). (F) *Lachnocaulon minus* (x50). (G) Margin lamina in *Pae. williamsii* (x50). (H) *Syngonanthus flavidulus* (x50). (J) Major vascular bundle in *Pae. williamsii* (x460). (K) Major vascular bundle in *E. decangulare* (x230). Adapted from Tomlinson (1969).

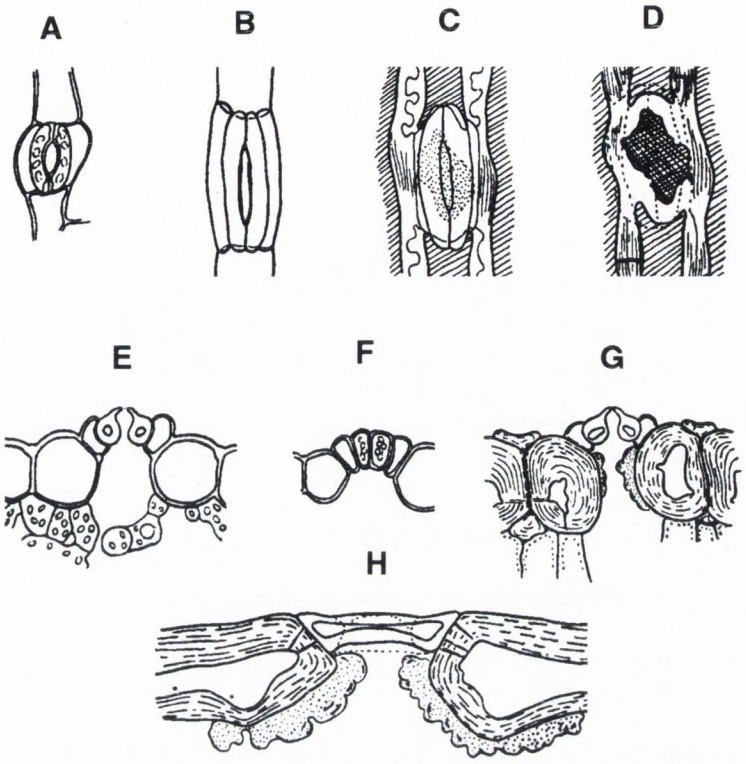

Figure 3.13 Stomata on abaxial epidermis in some species of Eriocaulaceae. (A) Surface view in *Tonina fluviatilis* (x230). (B) Surface view in *Eriocaulon decangulare* (x230). (C)-(D) Surface view in *Paepalanthus alsinoides* (x320), (C) high focal level. (D) Low focal level. (E)-(F) Transverse section in *Pae. williamsii* (x230), (E) equatorial level. (F) Polar level. (G)-(H) *Pae. alsinoides* (x320), (G) transverse section. (H) Longitudinal section. Adapted from Tomlinson (1969).

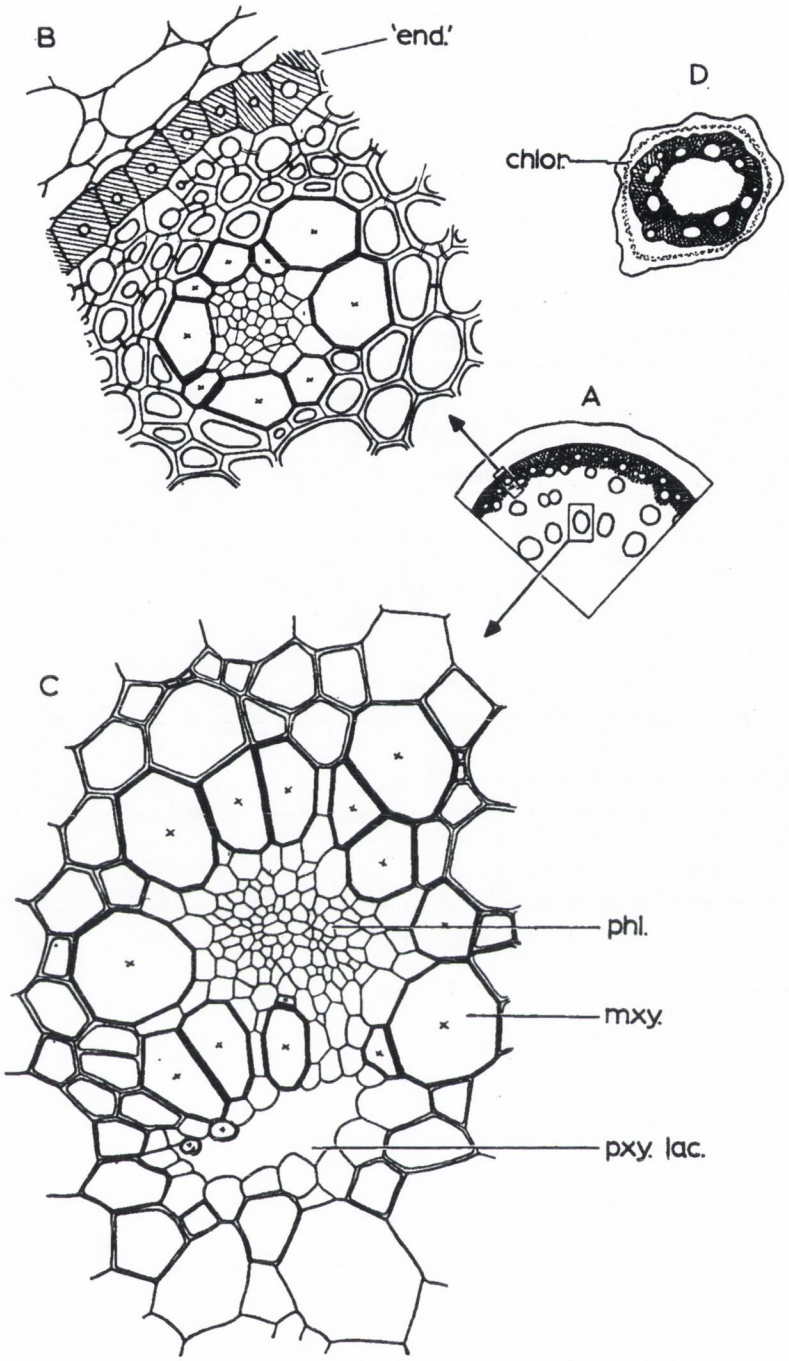

Figure 3.14 Leafy aerial stem of some species of Eriocaulaceae. (A)-(C) *Paepalanthus williamsii*, (A) transverse section of stem sector (x20). (B) Transverse section amphivasal vein from periphery of central cylinder (x460). (C) Transverse section amphivasal vein from center of central cylinder (x460). (D) *Pae. tuerckheimii*, transverse section of stem (x20). end. = endodermoid layer, chlor. = chlorenchyma, phl. = phloem, mxy. = metaxylem, pxy. lac. = protoxylem lacuna. Adapted from Tomlinson (1969).

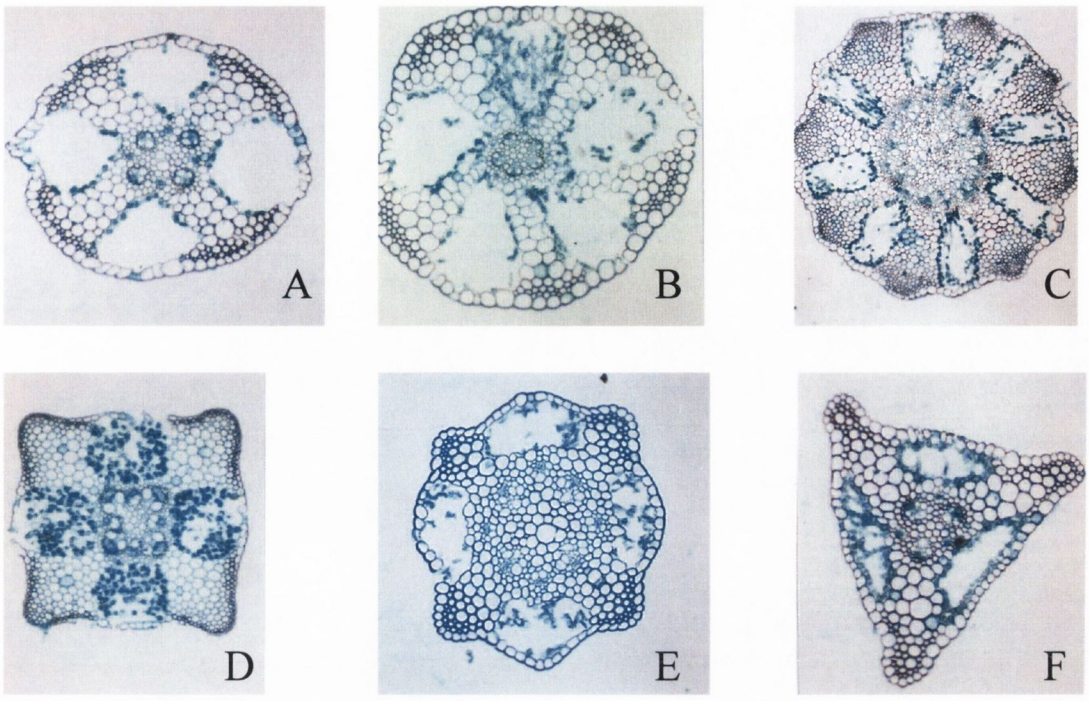

Figure 3.15 Transverse section of scapes in some species of *Eriocaulon*. (A) *E. alatum*. (B) *E.* echinulatum. (C) *E. kradungense* (D) *E.* nakayense. (E) *Eriocaulon* sp.5 (the number following Prajaksood (2000)). (F) *Eriocaulon* sp.13. (the number following Prajaksood (2000)). Adapted from Prajaksood (2000).

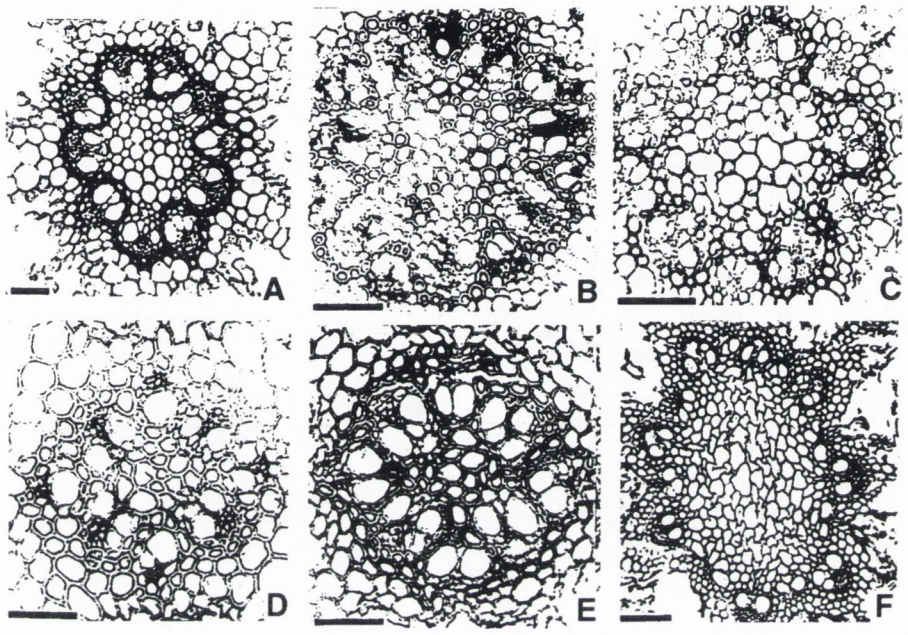

Figure 3.16 Four types of endodermoid layers in transverse section of scape in some species of *Eriocaulon*. (A) Type I: *E. collinum*. (B)-(C) Type II: (B) *E. kradungense*; (C) *E. nautiliforme*. (D)-(E) Type III: (D) *E. miquelianum*, (E) *E. nudicuspe*. (F) Type IV: *E. wighteanum*. Scale = 0.05 mm. Adapted from Zhang (1999).

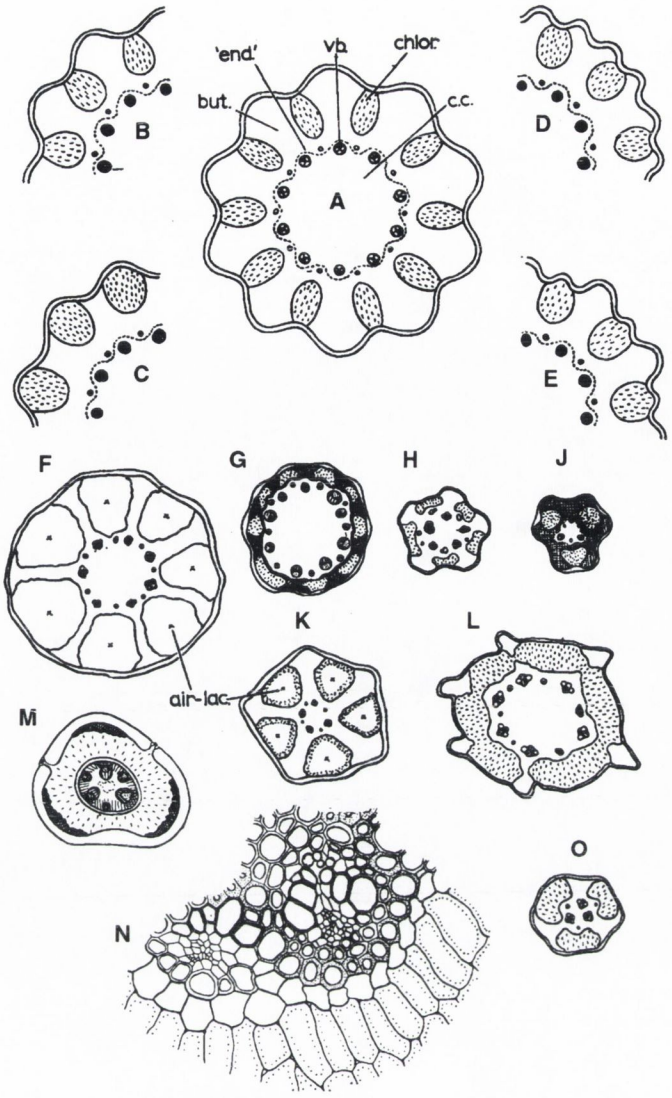

Figure 3.17 Scape and endodermoid layer types in transverse section of some species of Eriocaulaceae. (A)-(B) *Eriocaulon decangulare* (x20), (A) basic construction of the Eriocaulaceous scape. (B) Periphery of scape. (C)-(E) Common variants (x20), (C) large veins and buttresses opposite furrows, ribs corresponding to the chlorenchyma bands. (D) Ribs fluted. (E) Minor ribs opposite chlorenchyma bands. (F) *E. articulatum* (x20). (G) *Leiothrix turbinata* (x20). (H) *Syngonanthus flavidulus* (x20). (J) *Paepalanthus tuerckheimii* (x20). (K) *E. australe* (x20). (L) *E. scariosum* (x20). (M)-(N) *Pae. alsinoides*, (M) x20. (N) outer part of stele (x260). (O) *Lachnocaulon engleri* (x20). Adapted from Tomlinson (1969). but. = buttresses, end. = endodermoid layer, vb. = vascular bundle, chlor. = chlorenchyma band, c.c. = central cylinder, air-lac. = air lacunae.

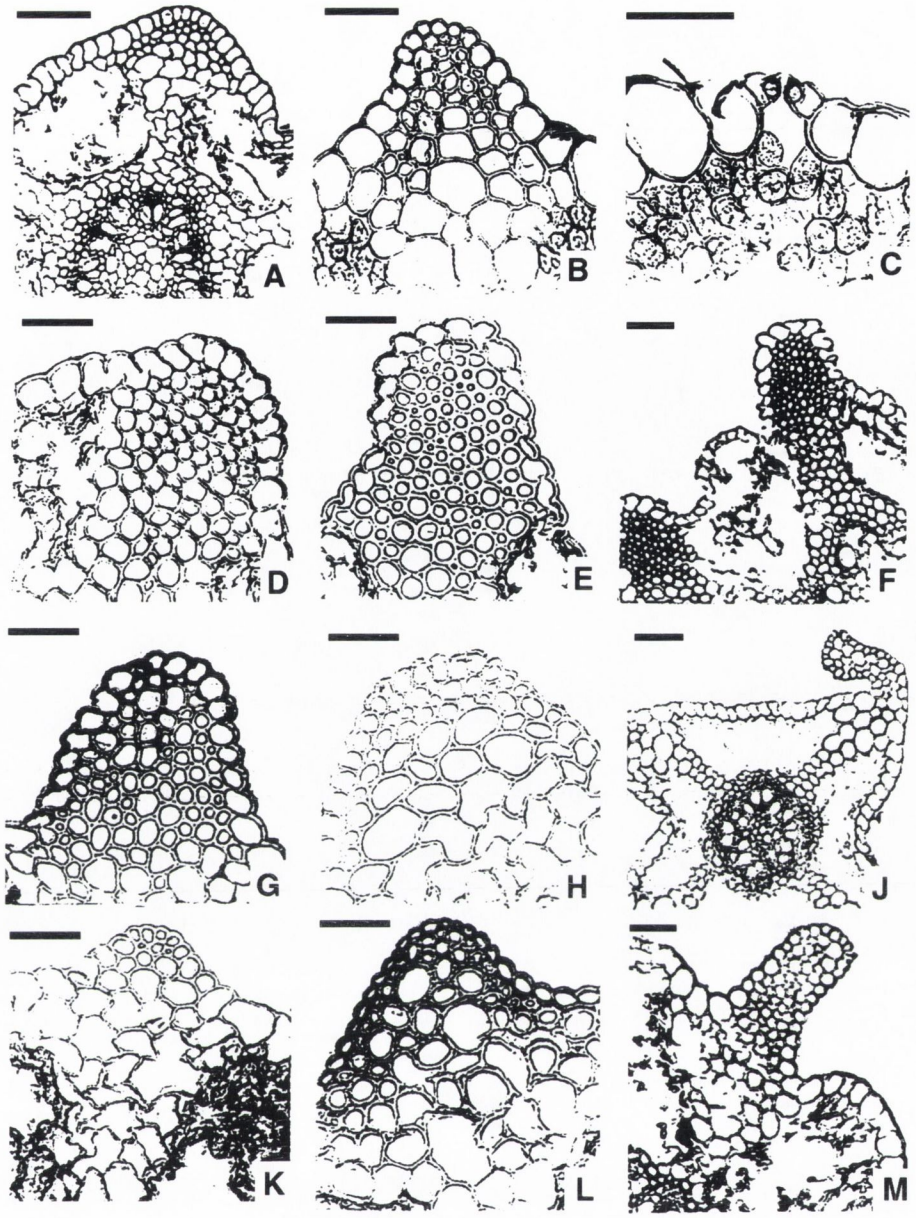

Figure 3.18 Epidermal cells above ribs in transverse section of scapes in some species of *Eriocaulon*. (A)-(G) Epidermal cells above the ribs in subgenus *Trimeranthus* are almost neither smaller nor thickened than other areas, (A) *E. schochianum*. (B) *E. collinum*. (C) stoma in *E. collinum*. (D) *E. brownianum*. (E) *E. kradungense*. (F) *E. sexangulare*. (G) *E. wighteanum*. (H)-(M) Epidermal cells above the ribs in subgenera *Spathopeplus* are distinctly smaller and thickened than other areas, (H) *E. miquelianum*. (J) *E. nudicuspe*. (K) *E. hondoense*. (L) *E. eglandulatum*. (M) *E. cristatum*. (A), (G), (J) and (M) scale = 0.1 mm; (B)-(F), (H), (K) and (L) scale = 0.05 mm. Adapted from Zhang (1999).

Table 3.1 List of species in each type of endodermoid layer in scape. Four types of endodermoid layer and two types of epidermal cells above ribs see details in "Scape of *Eriocaulon*". ? = lacking data. Subg. I = subgenus *Trimeranthus*, Subg. II = subgenus *Spathopeplus*. I > II = mostly I or a few II. Adapted from Zhang (1999).

Taxon	Classification (Zhang,1999)	Ribs	Epidermal cells above ribs	Endodermoid layer types
E. setaceum	Subg. I, Sect. I	6	II	II
E. achiton	Subg. I, Sect.II	5	II	I
E. boni	Subg. I, Sect.II	3	II	II
E. brownianum	Subg. I, Sect.II	6	II	II
E. collinum	Subg. I, Sect.II	5	II	I
E. eglandulatum	Subg. I, Sect.II	5	II	I
E. ermeiense	Subg. I, Sect.II	4	II	II
E. heterolepis	Subg. I, Sect.II	5	II	I
E. kunmingense	Subg. I, Sect.II	4	II	II
E. laosense	Subg. I, Sect.II	3	II	?
E. leianthum	Subg. I, Sect.II	?	?	?
E. luzulaefolium	Subg. I, Sect.II	4	II	I
E. nantoense	Subg. I, Sect.II	5	II	II
E. nepalense	Subg. I, Sect.II	6	II	II
E. oryzetorum	Subg. I, Sect.II	4	II	II
E. parvum	Subg. I, Sect.II	6	I	II
E. pseudonepalense	Subg. I, Sect.II	4	II	II
E. quinquangulare	Subg. I, Sect.II	5	I>II	I
E. robusto-brownianum	Subg. I, Sect.II	6	II	II
E. rockianum	Subg. I, Sect.II	4	I>II	II
E. schochianum	Subg. I, Sect.II	5	II	I
E. smitinandii	Subg. I, Sect.II	4	II	I, II
E. thailandicum	Subg. I, Sect.II	4	II	II
E. wighteanum	Subg. I, Sect.II	8	II	IV
E. xenopodium	Subg. I, Sect.II	7	II	I
E. xeranthemum	Subg. I, Sect.II	5	I	?
E. bassacense	Subg. I, Sect.III	6	II	II
E. cristatum	Subg. I, Sect.III	6	II	I
E. eberhardtii	Subg. I, Sect.III	6	?	?
E. henryanum	Subg. I, Sect.III	4-5	II	II
E. hookerianum	Subg. I, Sect.III	6	II	I, II

Table 3.1 Continued.

Taxon	Classification (Zhang,1999)	Ribs	Epidermal cells above ribs	Endodermoid layer types
E. kradungense	Subg. I, Sect.III	7	II	I
E. nautiliforme	Subg. I, Sect.III	5	II	II
E. siamense	Subg. I, Sect.III	5-6	II	II
E. tanakae	Subg. I, Sect.III	?	?	?
E. australe	Subg. I, Sect.IV	5	II	II
E. sexangulare	Subg. I, Sect.IV	4-5	II	II
E. willdenovianum	Subg. I, Sect.IV	5	II	II
E. escape (E. dipsacoides)	Subg. I, Sect.V	?	?	?
E. echinulatum	Subg. I, Sect.V	4	I>II	II
E. hamiltonianum	Subg. I, Sect.V	4-5	II	I, II
E. nigrum	Subg. I, Sect.V	5	I>II	II
E. pseudotruncatum	Subg. I, Sect.V	9	?	?
E. thwaitesii	Subg. I, Sect.V	5	II	I
E. truncatum	Subg. I, Sect.V	5-6	I	II
E. zollingerianoides	Subg. I, Sect.V	4	I	I
E. zollingerianum	Subg. I, Sect.V	5	II>I	I, II
E. barbeyanum	Subg. I, Sect.VI	?	?	?
E. cinereum	Subg. I, Sect.VI	5	I>II	II
E. taishanense	Subg. I, Sect.VI	?	?	?
E. tonkinense	Subg. I, Sect.VI	8	II	II
E. decemflorum	Subg. I, Sect.VII	4	I>II	II
E. alpestre	Subg. II, Sect.I	4	I>II	II
E. atroides	Subg. II, Sect.I	4	II	II
E. atrum	Subg. II, Sect.I	3	I>II	IV
E. buergerianum	Subg. II, Sect.I	5	II	II
E. faberi	Subg. II, Sect.I	5	II	I
E. hondoense	Subg. II, Sect.I	5	II	II
E. japonicum	Subg. II, Sect.I	5	II	II
E. kusiroense	Subg. II, Sect.I	?	?	?
E. liberisepalum	Subg. II, Sect.I	5	I>II	II
E. minusculum	Subg. II, Sect.I	3	I	III
E. miquelianum	Subg. II, Sect.I	4	II	II
E. monococcon	Subg. II, Sect.I	4	II	II
E. nanellum var. nosoriense	Subg. II, Sect.I	3	II	II
E. sachalinense	Subg. II, Sect.I	?	?	?

Table 3.1 Continued.

Taxon	Classification (Zhang,1999)	Ribs	Epidermal cells above ribs	Endodermoid layer types
E. sekimotoi	Subg. II, Sect.I	4	II	II
E. sphagnicolum	Subg. II, Sect.I	3	?	?
E. takae	Subg. II, Sect.I	?	?	?
E. tenuissimum	Subg. II, Sect.I	4	II	I
E. zyotanii	Subg. II, Sect.I	4	I>II	II
E. heleocharioides	Subg. II, Sect.II	9	?	II
E. nudicuspe	Subg. II, Sect.III	4	II	III

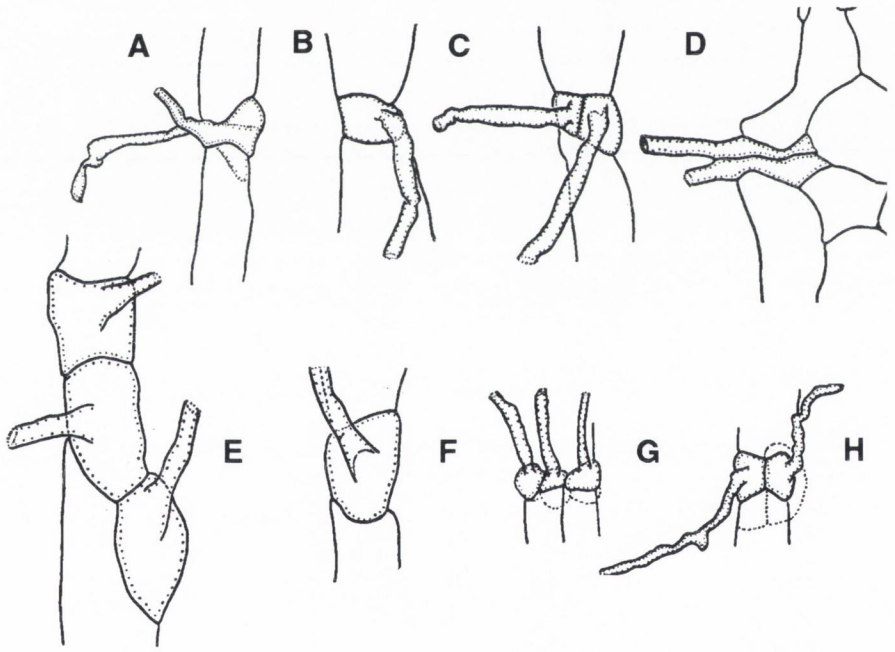

Figure 3.19 Root-hairs in some species of Eriocaulaceae. (A) *Eriocaulon scariosum*, optical longitudinal section of twin root-hairs. (B)-(D) *E. decangulare*, (B) solitary root-hairs, surface view. (C) Twin root-hair, surface view. (D) Transverse section, periphery of root with twin root-hairs. (E)-(F) *Leiothrix turbinata*, (E) triplet of root-hairs in vertical series. (F) Solitary root-hairs, surface view. (G)-(H) *Lachnocaulon minus*, (G) triplet of root-hairs, surface view. (H) Twin root-hairs surface view. All x290. Adapted from Tomlinson (1969).

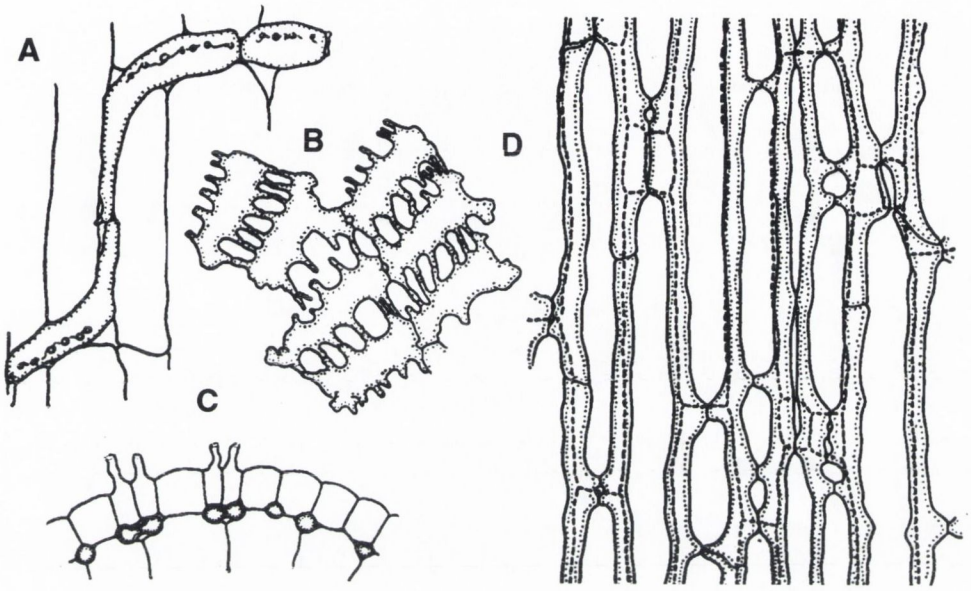

Figure 3.20 Cortex of root in *Syngonanthus flavidulus*. (A) Vertical connection between two adjacent diaphragm from longitudinal section (x290). (B) Portion of diaphragms from transverse section (x290). (C) Diagrammatic transverse section peripheral layers (not to scale). (D) Surface layers, surface view, at focal plane of hypodermis, piliferous layer with dotted outline (x230). Adapted from Tomlinson (1969).

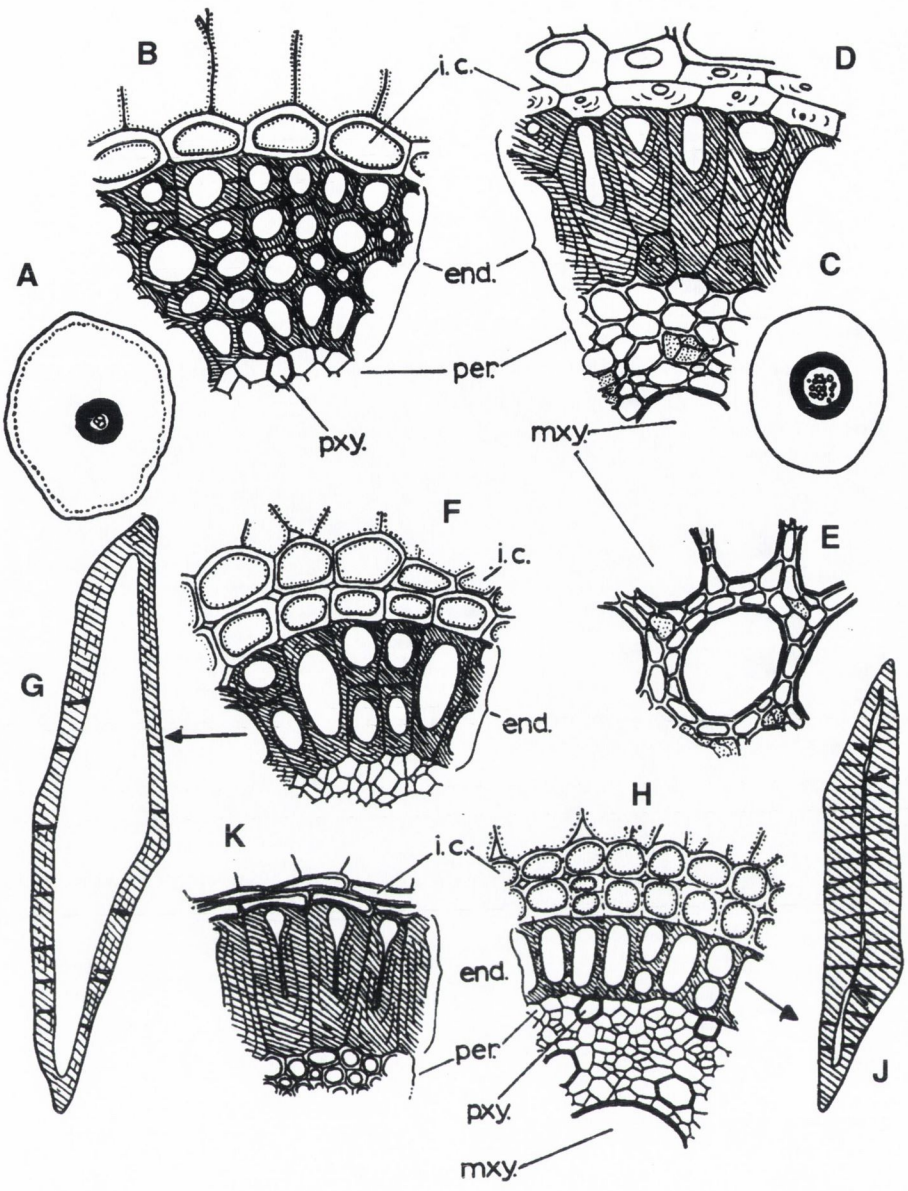

Figure 3.21 Roots in some species of Eriocaulaceae. (A)-(B) *Syngonanthus* (*Carptotepala*) *jenmanii*, (A) transverse section (x17). (B) Endodermal region (x290). (C)-(E) *Paepalanthus albo-vaginatus*, transverse section. (C) x17. (D) Endodermal region (x290). (E) Central part of stele (x290). (F)-(G) *Mesanthemum radicans* (x290), (F) transverse section, endodermal region. (G) Isolated endodermal cell. (H)-(J) *Pae. williamsii* (x290), (H) endodermal region. (J) Isolated endodermal cell. (K) *Leiothrix nubigena*, endodermal region (x290). Adapted from Tomlinson (1969). i.c. = inner cortex, end. = endodermis, per. = pericycle, pxy. = protoxylem, mxy. = metaxylem.

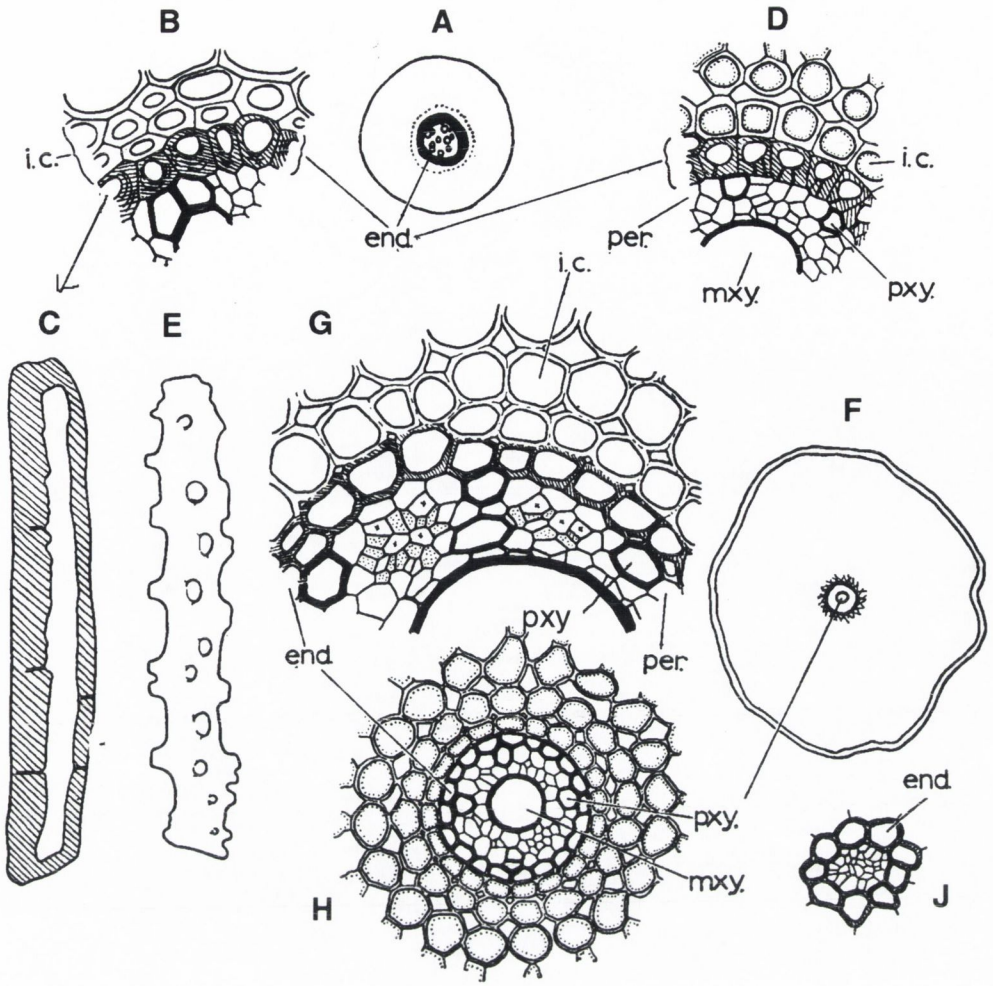

Figure 3.22 Roots in some species of *Eriocaulon*. (A)-(C) *E. caulinum*, (A) transverse section (x40). (B) Transverse section, endodermal region (x290). (C) Isolated endodermal cell (x290). (D) *E. australe*, transverse section, endodermal region (x290). (E) *E. arechavaletae*, isolated lobed inner cortical cell (x290). (F)-(G) *E. decangulare*, (F) transverse section (x17). (G) Transverse section, endodermal region (x290). (H) *E. compressum*, transverse section, complete stele (x290). (J) *E. melanocephalum*, transverse section, complete stele (x290). Adapted from Tomlinson (1969). i.c. = inner cortex, end. = endodermis, per. = pericycle, pxy. = protoxylem, mxy. = metaxylem.

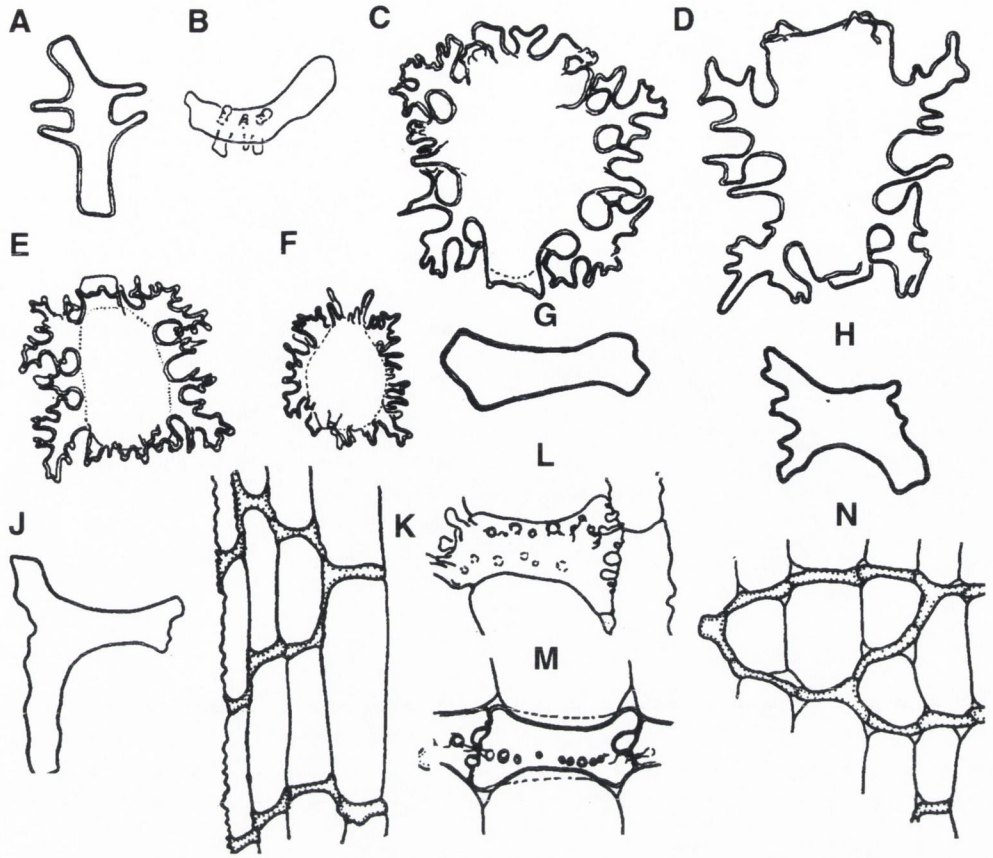

Figure 3.23 Short-cells from the middle cortex in some species of Eriocaulaceae. (A)-(B) *Paepalanthus williamsii*, (A) transverse section. (B) Obliquely horizontal view of isolated cell. (C)-(F) Transverse section of root, (C) *Eriocaulon decangulare*. (D) *E. scariosum*. (E) *E. compressum*. (F) *E. articulatum*. (G)-(K) *E.* australe, (G) simple outline, optical longitudinal section. (H) short-cell lobed, optical longitudinal section. (J) Short-cell next to innermost cortical layers, optical longitudinal section. (K) Longitudinal section middle cortex, short-cell arranged in incipient diaphragms. (L)-(M) *E. compressum*, (L) radial longitudinal section, short-cell next to innermost cortical layers. (M) Short-cell from radial longitudinal section. (N) *Leiothrix flavescens*, radial longitudinal section with reticulum of short-cells. All x 290, except (K) and (N) x100. Adapted from Tomlinson (1969).

3.3 Aims of Study

This chapter is based on work using Thai species which are representative of Asian *Eriocaulon*, which aimed to find anatomical characters within *Eriocaulon* for descriptive and phenetic/phylogenetic analyses and to assess the use of anatomical characters in the taxonomy and systematics of *Eriocaulon*. Useful information in regard to the anatomical characters was transferred to a dataset (Appendix 4) for an analysis designed to investigate the relationships between Thai species using morphological, anatomical and molecular approaches (see Chapter 4).

3.4 Materials and Methods

Permanent slides of transverse section of leaves and scapes from fresh material of forty-six specimens which had been collected from 26 Provinces in Thailand between September and December 2002. were examined (this comprises 34 taxa (see Appendix 2)). Material was prepared using the paraffin method adapted from Thammathaworn (1995) (see Appendix 3). Portions of fresh leaves and scapes were fixed for 24 hours in 70% FAA. Following dehydration in a graded TBA alcohol series, section of paraffin embedded materials were cut on the Leica SM 2000R sliding microtome with the Feather disposable microtome blade (S35) and holder No. 240D, at 10-15 μm thickness. The sections were fixed to slides using 0.5% aqueous gelatin. The sections were then stained with toluidine blue (Giulietti *et al.*, 1995) (0.5 % in water) for two hours and mounted permanently in DPX mountant for microscopy.

More than 40 sections of scapes and leaves of each species were examined. Descriptions and photographs were made using a Olympus BX60 compound microscope fitted with a Olympus Camedia C-5060 digital camera, using Olympus DP-Soft software.

The slides representative of each species were deposited in the Herbarium of Trinity College, Dublin, Ireland (**TCD**) and Herbarium of Khon Kaen University, Khon Kaen, Thailand (**KKU**).

3.5 Results

The transverse sections of leaves and scapes (inflorescence axis) of the representative species are shown in Figures 3.24-3.72

3.5.1 General anatomical description

Leaves dorsiventral.

Outline: adaxial surface of the median lamina varying from concave (Figure 3.70 A) to flat or convex (Figure 3.55 A), abaxial surface varying from convex (Figure 3.70 A) to flat or concave (Figure 3.55 A). *Leaf margin*: varying from upward (Figure 3.70 A) to straight or downward (Figure 3.55 A); rounded (Figure 3.65 A), acute (Figure 3.38 A) or acuminate (Figure 3.61 A); cells commonly thicker-walled and narrower than remaining epidermal cells.

Epidermis: cells typically large, adaxial usually somewhat larger than abaxial cells (Figure 3.24 C), rarely of similar size, costal often larger than intercostal cells, rarely of similar size. Hypodermis present (Figure 3.70 B) adaxially or absent. Adaxial and abaxial: cells circular or rectangular; periclinal wall of cells thinly and finely striated longitudinally cutinized (Figure 2.24 A) or not cutinized, papillae present (Figure 3.58 D) or absent; anticlinal wall of cells typically non-sinous. Stomata: hypostomatic (confined to abaxial surface), mostly superficial or slightly raised; guard cells usually with prominent outer ledge (Figure 3.24 B), rarely inner ledge present. Trichomes: mostly present on adaxial surface but always present on abaxial surface (Figure 3.24 A).

Vascular tissue: collateral vascular bundles, more or less alternately large and small (Figure 3.24 E), mostly closest to adaxial surface (Figure 3.24 D), equidistant (Figure 3.24 E) from each surface in the distal part of the leaf, always arranged in a single series, a protoxylem lacuna distinct in large bundle. Rarely transverse veins present (Figure 3.24 F) Bundle sheath in major bundles two layers; outer sheath parenchymatous; inner sheath sclerotic parenchymatous, mostly thickened-wall absent (Figure 3.25 D), rarely thickened-wall present, mostly thickened-wall cells surrounding vein as a single layer (Figure 3.25 A), rarely only distinct around phloem (Figure 3.25 C) or around xylem (Figure 3.25 B).

Buttresses (bundle-sheath extensions): usually parenchymatous (Figure 3.24 E), sometime adaxial and/or abaxial buttress cells collenchymatous (Figure 3.24 C); either uniseriate (Figure 3.24 D) or bi (Figure 3.24 E)-to multi-seriate (Figure 3.24 C); all major or large veins buttressed; buttress of major vein at median lamina usually continuous with each surface (Figure 3.24 C, E), rarely buttress discontinuous (Figure 3.24 D).

Mesophyll: air lacunae present, mostly differentiated into palisade and spongy mesophyll (Figure 3.24 C-E), homogeneous without stellate cells in the distal part of the leaf or the narrow leaf (Figure 3.57

B). Palisade on the adaxial (Figure 3.24 C) or both sides (Figure 3.24 D), 1-2 layers, cells compact, varying from isodiametric to elongated. Spongy: loose, cells stellate and prominently lobed (Figure 3.24 D-E) or scarcely lobed (Figure 3.24 C).

Crystal: prismatic, rarely present.

Scapes usually present, surface usually ribbed, number of ribs varying from 3 to 10.

Epidermis: cells circular or rectangular, periclinal wall of cells thinly and finely striated longitudinally cutinized, papillae absent; anticlinal wall of cells typically non-sinous. Hypodermis absent. Stomata: superficial or slightly raised (Figure 3.26 A); guard cells usually with prominent outer ledge, rarely inner ledge present (Figure 3.26 B). Trichomes: present (Figure 3.26 A).

Cortex: mostly divided into distinct chlorenchymatous bands alternating with buttresses extending usually from epidermis to stele. Chlorenchymatous band: air lacunae present, usually narrower than diameter of stele; cells varying from isodiametric, elongated, irregularly shaped (scarcely extended but not stellate shaped) to stellate and scarcely lobed or stellate and prominently lobed. Buttresses: usually corresponding to external ribs, continuous across cortex (Figure 3.70 C), rarely extending only part-way to support the ribs (discontinuous) (Figure 3.50 C); outermost (near epidermis) mostly lacunar collenchymatous, multi-seriate (Figure 3.26 A); innermost (near stele) parenchymatous (Figure 3.26 A) or lacunar collenchymatous (Figure 3.59 D), either uniseriate or bi-to multi-seriate.

Stele: represented by a parenchymatous cylinder continuous externally with cortical buttresses, including a single series of alternately large and small collateral vascular bundles, a protoxylem lacuna distinct in large bundle (Figure 3.26 C). Large bundles always opposite buttresses, small bundles opposite chlorenchymatous bands. Vascular bundles: number of large bundles almost always same as small bundles and number of buttresses, varying from 3 to 10 bundles. Endodermoid layer: indistinct (slightly thickened cell walls) (Figure 3.27 A, C) or distinct (thickenings U-shape cell walls); running outside large but inside small bundles (Figure 3.27 B, D) or passing both sides of small bundles (Figure 3.26 C). Medulla (pith): uniform typical parenchymatous (Figure 3.27 A-B) and/or sclerotic parenchymatous (Figure 3.27 C-D).

Crystal: prismatic (Figure 3.26 D), rarely present.

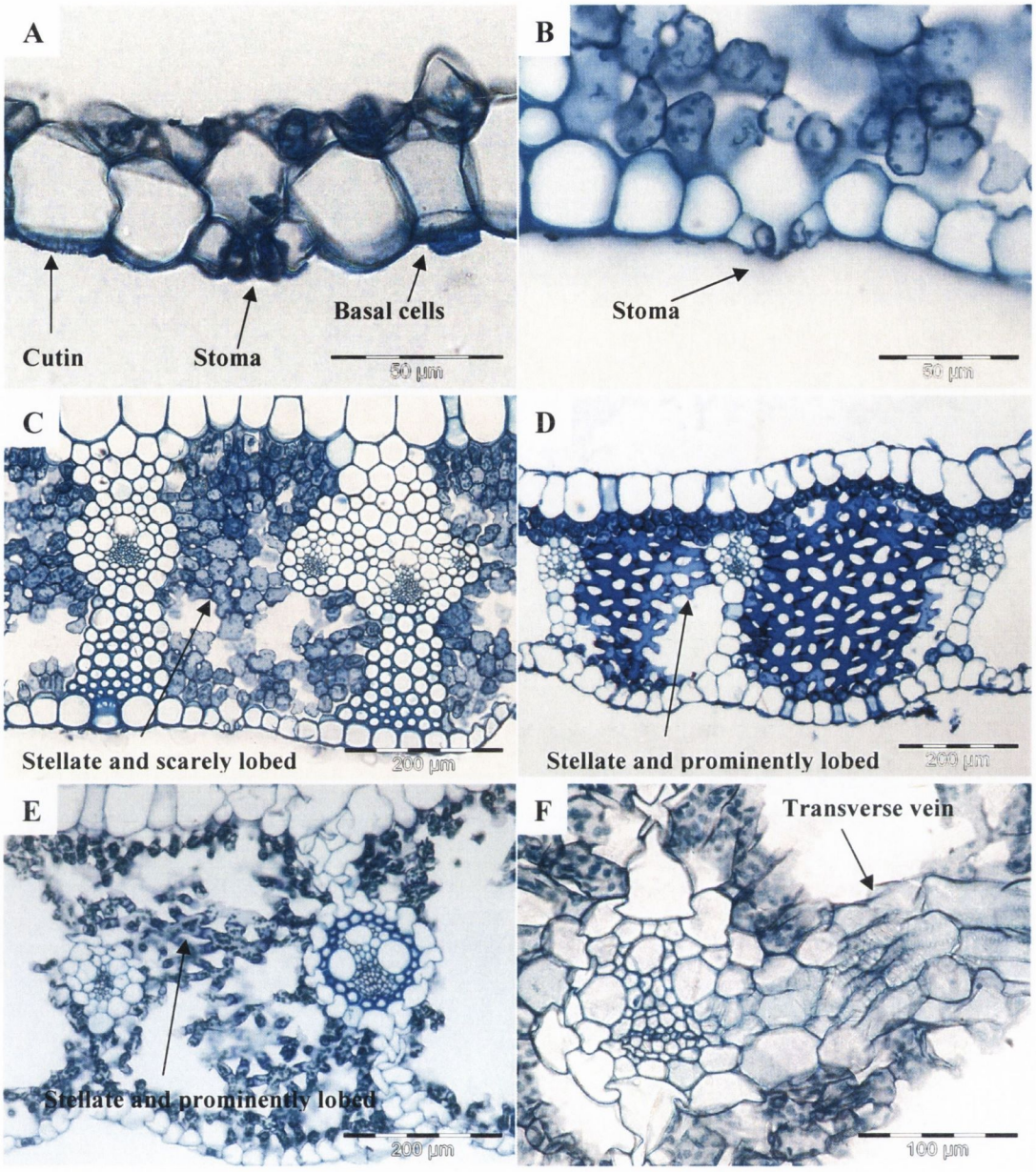

Figure 3.24 Epidermis and mesophyll in leaf. (A) *Eriocaulon xeranthemum*, finely striated longitudinally cutinized on abaxial epidermis. (B)-(C) *E. siamense* var. *macrophyllum*, (B) guard cells with prominent outer ledge on abaxial epidermis. (C) Continuous buttresses and stellate and scarcely lobed. (D) *E. infirmum*, discontinuous buttresses and stellate and prominently lobed. (E) *E. willdenovianum*, stellate and prominently lobed. (F) *E. nautiliforme*, transverse vein present.

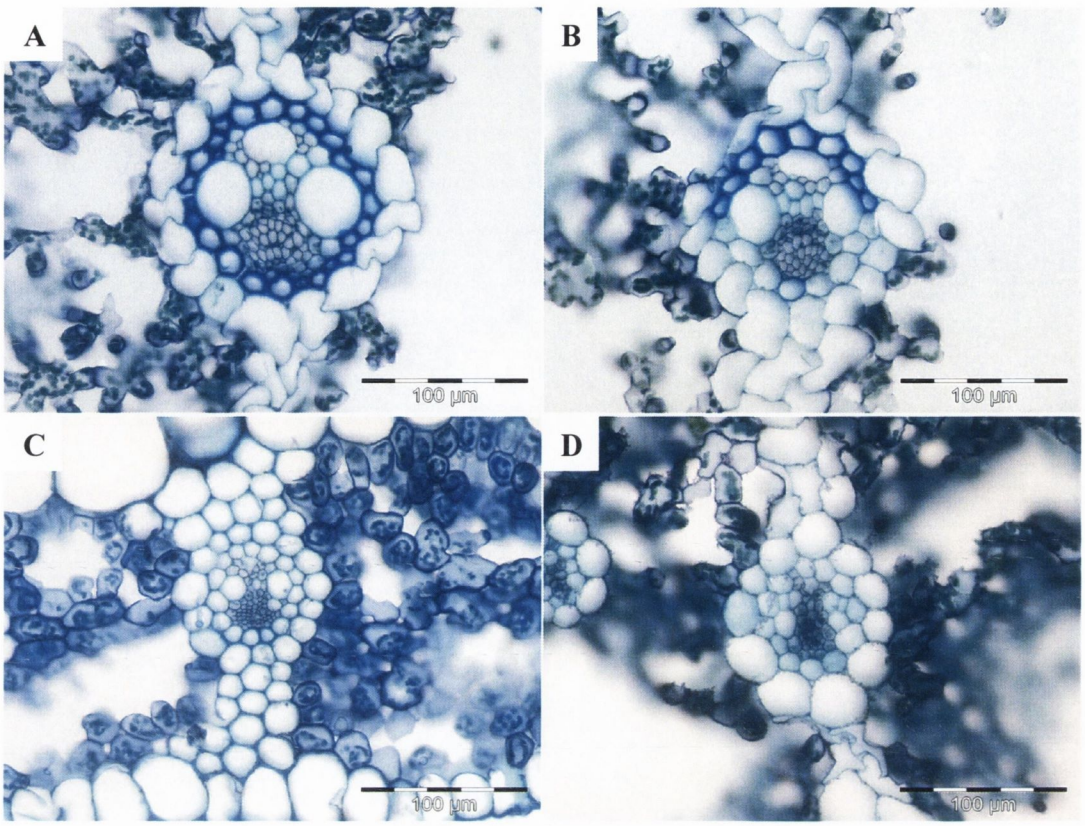

Figure 3.25 Types of inner bundle sheath in leaf. (A)-(B) *Eriocaulon willdenovianum*, (A) Thickened-wall cells surrounding vein. (B) Thickened-wall cells only distinct around xylem. (C) Thickened-wall cells only distinct around phloem in *E. siamense* var. *macrophyllum*. (D) Thickened-wall cells absent in *E. ubonense* f. *kradungense*.

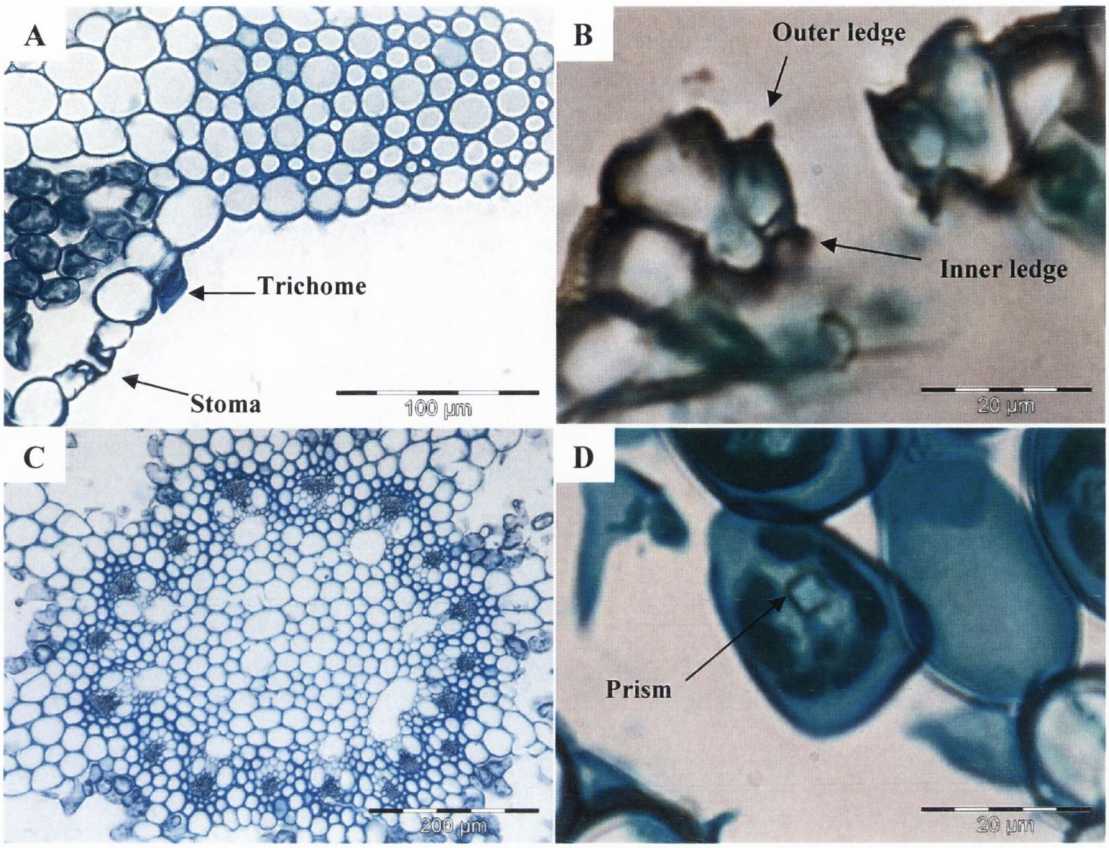

Figure 3.26 Scape and prismatic crystal. (A) Epidermis and cortex with outermost buttress collenchymatous cells in *Eriocaulon siamense*. (B) Guard cells with prominent outer and inner ledge in *E. siamense* ssp. *hexagynum*. (C) Endodermoid layer in scape distinct, running outside large but passing both sides of small bundles with parenchymatous pith in *E. siamense* var. *macrophyllum*. (D) Prism in chlorenchyma cell in *E. escape*.

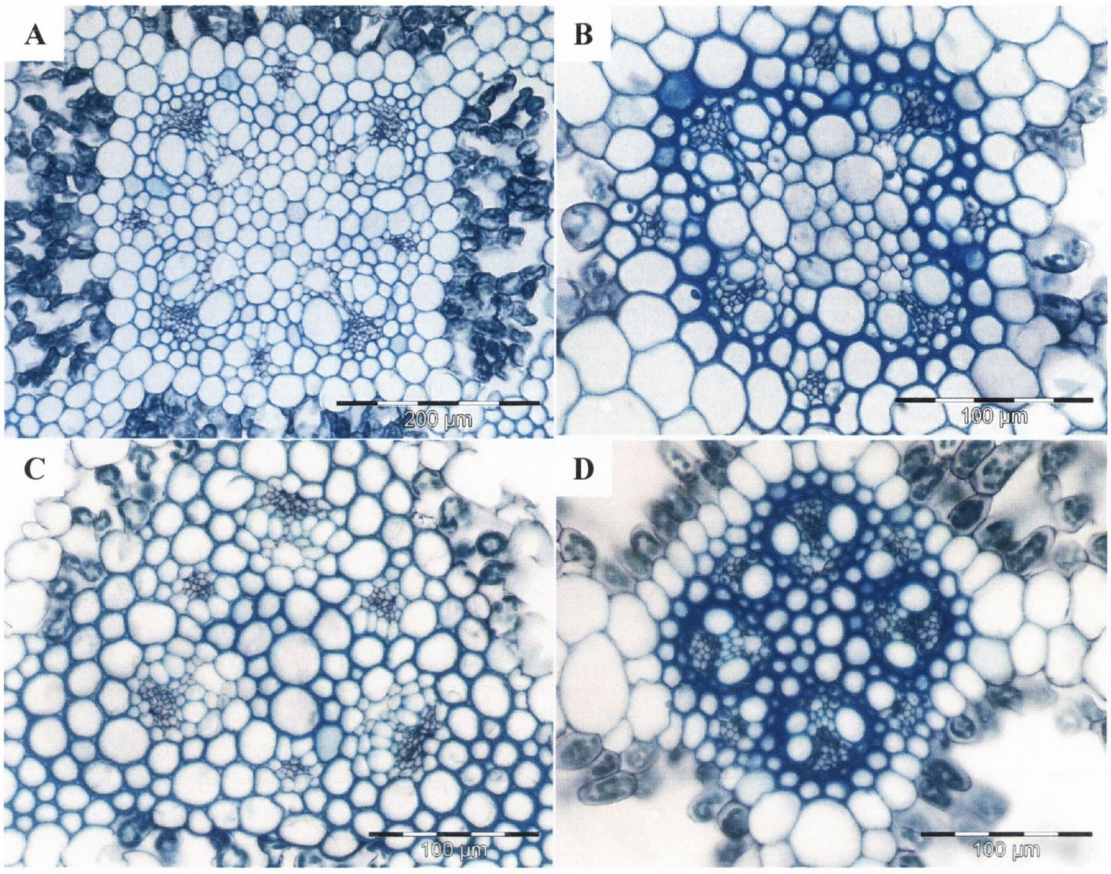

Figure 3.27 Types of endodermoid layer and pith in stele of scape. (A) Endodermoid layer indistinct with parenchymatous pith in *Eriocaulon siamense*. (B) Endodermoid layer distinct running outside large but inside small bundles with parenchymatous pith in *E. quinquangulare* var. *longibracteatum*. (C) Endodermoid layer indistinct with sclerotic parenchymatous pith in *E. phatamense*. (D) Endodermoid layer distinct with sclerotic parenchymatous pith in *E. echinulatum*.

3.5.2 Anatomical description of species

Characters of individual species are noted when they differ from the general state as described above (Figures 3.28-3.72).

***E. brownianum* Mart.**

Specimens examined: *A.Prajaksood & S.Suddee* 201

Leaves (Figure 3.28 A-B)

Outline: adaxial surface of the median lamina concave, abaxial surface convex. *Leaf margin*: upward, rounded.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: equidistant from each surface. Bundle sheath: inner sheath thickened-wall present, thickened-wall cells surrounding vein, a single layer.

Buttresses: collenchymatous; multi-seriate; buttress of major vein at median lamina continuous with each surface.

Mesophyll: palisade on the adaxial side, cells elongated. Spongy cells stellate and scarcely lobed.

Crystal: absent.

Scapes (Figure 3.28 C-D) 7 ribs.

Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.

Cortex: Chlorenchymatous band: narrower than diameter of stele, cells elongated or stellate and prominently lobed. Buttresses: 7 buttresses, continuous across cortex; lacunar collenchymatous, multi-seriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: distinct, running outside large but inside small bundles. Medulla: parenchymatous.

Crystal: absent.

***E. chantaranothai* A.Prajaksood & J.Parn.**

Specimens examined: *A.Prajaksood & S.Suddee* 310 (leaves not fresh) and 321.

Leaves (Figures 3.29 A-B and 3.30 A-B)

Outline: adaxial surface of the median lamina flat, abaxial surface convex or flat. *Leaf margin*: downward, acute or rounded.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.
Buttresses: parenchymatous, either uniseriate or bi-seriate, buttress of major vein at median lamina continuous with each surface.
Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figures 3.29 C-D and 3.30 C-D) rib absent or 4 ribs.
Epidermis: anticlinal wall of cells either sinous or not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or irregularly shaped. Buttresses: 4 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, bi- to multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: either indistinct or distinct, running outside large but inside small bundles. Medulla: either parenchymatous or sclerotic parenchymatous.
Crystal: absent.

***E. cinereum* R.Br.**

Specimens examined: *A.Prajaksood & S.Suddee* 339

Leaves (Figure 3.31 A-B)
Outline: adaxial surface of the median lamina convex or flat, abaxial surface concave or flat. *Leaf margin*: downward or straight, rounded.
Epidermis: adaxial same size as abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.
Vascular tissue: closest to adaxial surface, in the distal part of the leaf equidistant from each surface. Bundle sheath: inner sheath thickened-wall absent.
Buttresses: parenchymatous, bi-seriate; buttress of major vein at median lamina discontinuous.
Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figure 3.31 C-D) rib absent.
Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge present.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or stellate and scarcely lobed. Buttresses: 4 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: distinct, running outside large but inside small bundles. Medulla: sclerotic parenchymatous.
Crystal: absent.

***E. echinulatum* Mart.**

Specimens examined: *A.Prajaksood & S.Suddee* 174

Leaves (Figure 3.32 A-B)

Outline: adaxial surface of the median lamina concave to flat, abaxial surface convex to flat. *Leaf margin*: upward or straight, rounded.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial: periclinal wall of cells cutinized, papillae present; anticlinal wall of cells sinous. Abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall present, thickened-wall cells surrounding vein, a single layer.

Buttresses: parenchymatous, either uniseriate or bi-seriate; buttress of major vein at median lamina continuous with each surface.

Mesophyll: palisade on the adaxial side, cells isodiametric. Spongy cells stellate and prominently lobed.

Crystal: absent.

Scapes (Figure 3.32 C-D) rib absent.

Epidermis: anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent.

Cortex: Chlorenchymatous band: wider than diameter of stele, cells isodiametric, elongated, or stellate and scarcely lobed. Buttresses: 4 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, bi-to multi-seriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: distinct, running outside large but inside small bundles. Medulla: sclerotic parenchymatous.

Crystal: absent.

***E. escape* B.Hansen**

Specimens examined: *A.Prajaksood & S.Suddee* 240

Leaves (Figure 3.33 C-F)

Outline: adaxial surface of the median lamina convex, abaxial surface concave or convex. *Leaf margin*: straight or downward, rounded or acute.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.

Buttresses: parenchymatous, either uniseriate or bi-seriate; buttress of major vein at median lamina discontinuous, rarely continuous.
Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: prismatic.

Scapes absent.

***E. hamiltonianum* Mart.**

Specimens examined: *A.Prajaksood & S.Suddee* 250, 314 and 324

Leaves (Figures 3.34 A-B, 3.35 A-B and 3.36 A-B)
Outline: adaxial surface of the median lamina concave, flat or convex, abaxial surface convex, flat or concave. *Leaf margin*: upward, straight or downward; rounded or acuminate in the basal part of the leaf.
Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.
Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall present, thickened-wall cells either surrounding vein as a single layer or only distinct around phloem, in the distal part of the leaf the thickened-wall absent.
Buttresses: parenchymatous, uniseriate, buttress of major vein at median lamina either discontinuous or continuous.
Mesophyll: palisade on either the adaxial side or both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: prismatic.

Scapes (Figures 3.34 C-D, 3.35 C-D and 3.36 C-D) rib absent.
Epidermis: anticlinal wall of cells either sinous or not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: wider than diameter of stele, cells isodiametric, elongated or stellate and scarcely or prominently lobed. Buttresses: 4 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, bi-to multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: either indistinct or distinct, running outside large but inside small bundles. Medulla: parenchymatous and sclerotic parenchymatous.
Crystal: prismatic.

***E. hamiltonianum* Mart. var. *acuminatum* A.Prajaksood & J.Parn.**

Specimens examined: *A.Prajaksood & S.Suddee* 318

Leaves (Figure 3.37 A-B)

Outline: adaxial surface of the median lamina convex or flat, abaxial surface convex or flat. *Leaf margin*: straight or downward, rounded.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae present; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.

Buttresses: parenchymatous, uniseriate, buttress of major vein at median lamina discontinuous.

Mesophyll: palisade on the adaxial side, cells isodiametric. Spongy cells stellate and prominently lobed.

Crystal: absent.

Scapes (Figure 3.37 C-D) rib absent.

Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.

Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or irregularly shaped. Buttresses: 4 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, multi-seriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: indistinct. Medulla: parenchymatous.

Crystal: absent.

***E. infirmum* Steud.**

Specimens examined: *A.Prajaksood & S.Suddee* 189

Leaves (Figure 3.38 A-B)

Outline: adaxial surface of the median lamina convex or flat, abaxial surface convex or flat. *Leaf margin*: downward or straight, rounded or acute.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial: periclinal wall of cells not cutinized, papillae present; anticlinal wall of cells sinous. Abaxial: periclinal wall of cells not cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.

Buttresses: parenchymatous, either uniseriate or bi-seriate; buttress of major vein at median lamina discontinuous.

Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.

Crystal: absent.

Scapes (Figure 3.38 C-D) rib absent.

Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.

Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or irregularly shaped. Buttresses: 5 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: indistinct. Medulla: parenchymatous.
Crystal: absent.

***E. laosense* Moldenke**

Specimens examined: *A.Prajaksood & S.Suddee* 257, 259 and 293

Leaves (Figures 3.39 A-B, 3.40 A-B and 3.41 A-B)
Outline: adaxial surface of the median lamina concave, flat or convex; abaxial surface convex or concave. *Leaf margin*: upward or downward; rounded or acute.
Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.
Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.
Buttresses: parenchymatous, uniseriate to tri-seriate, buttress of major vein at median lamina continuous with each surface.
Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figures 3.39 C-D, 3.40 C-D and 3.41 C-D) 3 or 4 ribs.
Epidermis: anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric, elongated or irregularly shaped. Buttresses: 3 or 4 buttresses, continuous across cortex; lacunar collenchymatous and/or parenchymatous, outermost multi-seriate and innermost uniseriate or bi- to multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: either indistinct or distinct, running outside large but inside small bundles. Medulla: parenchymatous and/or sclerotic parenchymatous.
Crystal: absent.

***E. nautiliforme* Lecomte**

Specimens examined: *A.Prajaksood & S.Suddee* 169

Leaves (Figure 3.42 A-B)
Outline: adaxial surface of the median lamina convex, abaxial surface concave. *Leaf margin*: downward, rounded.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells not cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.
Vascular tissue: equidistant from each surface. Transverse veins present. Bundle sheath: inner sheath thickened-wall absent.
Buttresses: parenchymatous, uniseriate, buttress of major vein at median lamina continuous with each surface.
Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figure 3.42 C-D) 5 ribs.
Epidermis: anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric, elongated or irregularly shaped. Buttresses: 5 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, bi-to multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: indistinct. Medulla: parenchymatous.
Crystal: absent.

***E. nautiliformoides* A.Prajaksood & J.Parn.**

Specimens examined: *A.Prajaksood & S.Suddee* 264

Leaves (Figure 3.43 A-C)
Outline: adaxial surface of the median lamina concave, abaxial surface convex. *Leaf margin*: upward, rounded.
Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells not cutinized, papillae present; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.
Vascular tissue: closest to adaxial surface but in the distal part of the leaf equidistant from each surface. Bundle sheath: inner sheath thickened-wall absent.
Buttresses: parenchymatous, either uniseriate or bi-seriate, buttress of major vein at median lamina continuous with each surface.
Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figure 3.43 D-E) rib absent.
Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or irregularly shaped. Buttresses: 6 buttresses, continuous across cortex; lacunar collenchymatous, multi-seriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: indistinct. Medulla: parenchymatous and sclerotic parenchymatous.
Crystal: absent.

***E. nautiliformoides* var. *hexagynum* A.Prajaksood & Chantar.**

Specimens examined: *A.Prajaksood & S.Suddee* 265

Leaves (Figure 3.44 A-B)
Outline: adaxial surface of the median lamina concave or flat, abaxial surface convex or flat. *Leaf margin*: upward or straight, rounded.
Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells not cutinized, papillae present; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.
Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.
Buttresses: parenchymatous, either uniseriate or bi-seriate, buttress of major vein at median lamina continuous with each surface.
Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figure 3.44 C-D) 6 ribs.
Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric, elongated or irregularly shaped. Buttresses: 6 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, bi-to multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: distinct, running outside large but inside small bundles. Medulla: parenchymatous and sclerotic parenchymatous.
Crystal: absent.

***E. nepalense* Prescott ex Bong. var. *luzulaefolium* (Mart.) A.Prajaksood & J.Parn.**

Specimens examined: *A.Prajaksood & S.Suddee* 161 and 208

Leaves (Figures 3.45 A-B and 3.46 A-B)
Outline: adaxial surface of the median lamina convex or concave, abaxial surface concave or convex.
Leaf margin: downward or upward, rounded.
Epidermis: adaxial either larger than or same size as abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae present or absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall either absent or present, thickened-wall cells surrounding vein as a single layer.
Buttresses: parenchymatous, either uniseriate or bi-seriate; buttress of major vein at median lamina continuous with each surface.
Mesophyll: palisade either on both sides or only the adaxial side, cells isodiametric. Spongy cells stellate and scarcely or prominently lobed.
Crystal: absent.

Scapes (Figures 3.45 C-D and 3.46 C-D) 5 ribs.
Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric, elongated or irregularly shaped. Buttresses: 5 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: indistinct. Medulla: parenchymatous.
Crystal: absent.

***E. parnellii* A.Prajaksood & Chantar.**

Specimens examined: *A.Prajaksood & S.Suddee* 242

Leaves (Figure 3.47 A-B)
Outline: adaxial surface of the median lamina convex or flat, abaxial surface convex or flat. *Leaf margin*: straight, rounded.
Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells not cutinized, papillae absent; anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent. Trichomes: present only on abaxial surface.
Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.
Buttresses: parenchymatous, uniseriate; buttress of major vein at median lamina discontinuous.
Mesophyll: homogenous, cells irregularly shaped.
Crystal: absent.

Scapes (Figure 3.47 C-D) 4 ribs.
Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or elongated. Buttresses: 4 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: distinct, running outside large but inside small bundles. Medulla: parenchymatous and sclerotic parenchymatous.
Crystal: absent.

***E. phatamense* A.Prajaksood & Chantar.**

Specimens examined: *A.Prajaksood & S.Suddee* 289

Leaves (Figure 3.48 A-B)

Outline: adaxial surface of the median lamina concave or flat, abaxial surface convex or flat. *Leaf margin*: upward or straight, rounded.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells not cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.

Buttresses: parenchymatous, either uniseriate or bi-seriate, buttress of major vein at median lamina continuous with each surface.

Mesophyll: palisade on the adaxial side, cells isodiametric. Spongy cells stellate and prominently lobed.

Crystal: absent.

Scapes (Figure 3.48 C-D) 3 ribs.

Epidermis: anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent.

Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric. Buttresses: 3 buttresses, continuous across cortex; lacunar collenchymatous, multi-seriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: indistinct. Medulla: sclerotic parenchymatous.

Crystal: absent.

***E. phuchongense* A.Prajaksood & Chantar.**

Specimens examined: *A.Prajaksood & S.Suddee* 260, 276 and 285

Leaves (Figures 3.49 A-B, 3.50 A-B and 3.51 A-B)

Outline: adaxial surface of the median lamina concave or flat, abaxial surface convex or flat. *Leaf margin*: upward or straight; rounded or acute.

Epidermis: adaxial either larger than or same size as abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial: periclinal wall of cells cutinized, papillae present; anticlinal wall of cells sinous. Abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells either sinous or not sinous. Stomata: guard cells inner ledge absent. Trichomes: present either only on abaxial surface or both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent or present, thickened-wall cells surrounding vein as a single layer.

Buttresses: parenchymatous, either uniseriate or bi-seriate, buttress of major vein at median lamina discontinuous or continuous.

Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figures 3.49 C-D, 3.50 C-D and 3.51 C-D) 3 or 4 ribs.
Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent or present.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or elongated. Buttresses: 3 or 4 buttresses, either discontinuous or continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous or lacunar collenchymatous, bi-to multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: either indistinct or distinct, running outside large but inside small bundles. Medulla: parenchymatous or sclerotic parenchymatous.
Crystal: absent.

***E. phuphanoides* A.Prajaksood & J.Parn.**

Specimens examined: *A.Prajaksood & S.Suddee* 299 (leaves and scapes not fresh), 320 and 345

Leaves (Figures 3.52 A-B, 3.53 A-B and 3.54 A-B)
Outline: adaxial surface of the median lamina concave or flat, abaxial surface convex or flat. *Leaf margin*: upward or straight, rounded.
Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present either only on abaxial surface or both surfaces.
Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.
Buttresses: parenchymatous, either uniseriate or bi-seriate; buttress of major vein at median lamina continuous with each surface.
Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figures 3.52 C-D, 3.53 C-D and 3.54 C-D) 3 or 4 ribs.
Epidermis: anticlinal wall of cells sinous or not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric, elongated or irregularly shaped. Buttresses: 3 or 4 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous or lacunar collenchymatous, bi-to multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: either indistinct or distinct, running outside large but inside small bundles. Medulla: parenchymatous or sclerotic parenchymatous.
Crystal: absent

***E. pseudoescape* A.Prajaksood & Chantar.**

Specimens examined: *A.Prajaksood & S.Suddee* 239

Leaves (Figure 3.33 A-B)

Outline: adaxial surface of the median lamina concave, abaxial surface convex. *Leaf margin*: upward, rounded or acute.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.

Buttresses: parenchymatous, either uniseriate or bi-seriate; buttress of major vein at median lamina continuous with each surface.

Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.

Crystal: absent.

Scapes absent.

***E. quinquangulare* L. var. *longibracteatum* A.Prajaksood & J.Parn.**

Specimens examined: *A.Prajaksood & S.Suddee* 317

Leaves (Figure 3.55 A-B)

Outline: adaxial surface of the median lamina concave, abaxial surface convex. *Leaf margin*: upward, rounded.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae present; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall present, thickened-wall cells only distinct around phloem.

Buttresses: parenchymatous, either uniseriate or bi-seriate, buttress of major vein at median lamina continuous with each surface.

Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.

Crystal: absent.

Scapes (Figure 3.55 C-D) 4 ribs.

Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.

Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or irregularly shaped. Buttresses: 4 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, multi-seriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: distinct, running outside large but inside small bundles. Medulla: parenchymatous.
Crystal: prismatic.

***E. setaceum* L.**

Specimens examined: *A.Prajaksood & S.Suddee* 243

Leaves (Figure 3.56 A)
Outline: adaxial surface of the median lamina convex, abaxial surface convex. *Leaf margin*: straight, rounded.
Epidermis: adaxial same size as or larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells not cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.
Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall present, thickened-wall cells surrounding vein, a single layer.
Buttresses: parenchymatous, bi-seriate; buttress of major vein at median lamina discontinuous.
Mesophyll: palisade on the adaxial side, cells isodiametric. Spongy cells stellate and scarcely lobed.
Crystal: absent.

Scapes (Figure 3.56 B-C) 4 ribs.
Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or irregularly shaped. Buttresses: 4 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, bi-to multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: indistinct. Medulla: parenchymatous.
Crystal: absent.

***E. siamense* Moldenke**

Specimens examined: *A.Prajaksood & S.Suddee* 200 and 258

Leaves (Figures 3.57 A-B and 3.58 A-B)
Outline: adaxial surface of the median lamina concave or flat, abaxial surface convex or flat. *Leaf margin*: upward or straight, rounded.
Epidermis: adaxial larger than abaxial cells, costal often larger than intercostal cells, rarely similar size. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent or

present; anticlinal wall of cells either sinous or not sinous. Stomata: guard cells inner ledge absent or present. Trichomes: present either only on abaxial surface or both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent or present, thickened-wall cells surrounding vein as a single layer.

Buttresses: parenchymatous, either uniseriate or bi-seriate; buttress of major vein at median lamina discontinuous or continuous.

Mesophyll: palisade on both sides, cells isodiametric or elongated. Spongy cells stellate and scarcely or prominently lobed.

Crystal: absent.

Scapes (Figures 3.57 C-D and 3.58 C-D) 4 or 5 ribs.

Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent or present.

Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric, elongated or irregularly shaped. Buttresses: 4 or 5 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous or lacunar collenchymatous, bi-to multi-seriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: either indistinct or distinct, running outside large but passing both sides of small bundles. Medulla: parenchymatous.

Crystal: absent.

***E. siamense* Moldenke var. *macrophyllum* A.Prajaksood & J.Parn.**

Specimens examined: *A.Prajaksood & S.Suddee* 203 and 241

Leaves (Figures 3.59 A-B and 3.60 A-B)

Outline: adaxial surface of the median lamina concave, abaxial surface convex. *Leaf margin*: upward; rounded, acute or acuminate.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: present adaxially. Adaxial: periclinal wall of cells cutinized, papillae absent or present; anticlinal wall of cells sinous or not sinous. Abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: equidistant from each surface. Bundle sheath: inner sheath thickened-wall absent or present, thickened-wall cells only distinct around phloem.

Buttresses: adaxial buttress cells parenchymatous but abaxial buttress cells collenchymatous, bi- to multi-seriate; buttress of major vein at median lamina continuous with each surface.

Mesophyll: palisade on the adaxial side, cells isodiametric or elongated. Spongy cells stellate and scarcely lobed.

Crystal: absent.

Scapes (Figures 3.59 C-D and 3.60 C-D) 8 ribs.

Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric, irregularly shaped or stellate and scarcely lobed. Buttresses: 8 buttresses, continuous across cortex; outermost lacunar collenchymatous and innermost parenchymatous or lacunar collenchymatous; multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses, or 9 large bundles and 9 small bundles. Endodermoid layer: indistinct or distinct, running outside large but passing both sides of small bundles. Medulla: parenchymatous.
Crystal: absent.

***E. siamense* Moldenke ssp. *hexagynum* A.Prajaksood & Chantar.**

Specimens examined: *A.Prajaksood & S.Suddee* 281

Leaves (Figure 3.61 A-B)
Outline: adaxial surface of the median lamina concave, abaxial surface convex. *Leaf margin*: upward, acuminate.
Epidermis: adaxial larger than or same size as abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial: periclinal wall of cells not cutinized, papillae present, anticlinal wall of cells sinous. Abaxial: periclinal wall of cells cutinized, papillae present; anticlinal wall of cells sinous. Stomata: guard cells inner ledge present. Trichomes: present on both surfaces.
Vascular tissue: equidistant from each surface. Bundle sheath: inner sheath thickened-wall present, thickened-wall cells surrounding vein, a single layer.
Buttresses: parenchymatous, either uniseriate or bi-seriate, buttress of major vein at median lamina continuous with each surface.
Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figure 3.61 C-D) 5 ribs.
Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge present.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric. Buttresses: 5 buttresses, continuous across cortex; lacunar collenchymatous, multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: indistinct. Medulla: parenchymatous and sclerotic parenchymatous.
Crystal: absent.

***E. smitinandii* Moldenke**

Specimens examined: *A.Prajaksood & S.Suddee* 205

Leaves (Figure 3.62 A-B)
Outline: adaxial and abaxial surfaces of the median lamina flat. *Leaf margin*: straight, rounded.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells not cutinized, papillae absent; anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.
Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.
Buttresses: parenchymatous, uniseriate to tri-seriate; buttress of major vein at median lamina continuous with each surface.
Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figure 3.62 C-D) rib absent.
Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or irregularly shaped. Buttresses: 5 buttresses, continuous across cortex; lacunar collenchymatous, multi-seriate.
Stele: Vascular bundles: number of large bundles same as buttresses but 4 of small bundles. Endodermoid layer: indistinct. Medulla: parenchymatous and sclerotic parenchymatous.
Crystal: absent.

***E. thailandicum* Moldenke**

Specimens examined: *A.Prajaksood & S.Suddee* 252

Leaves (Figure 3.63 A-B)
Outline: adaxial surface of the median lamina concave or flat, abaxial surface convex or flat. *Leaf margin*: upward or straight, rounded.
Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.
Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.
Buttresses: parenchymatous, either uniseriate or bi-seriate, buttress of major vein at median lamina continuous with each surface.
Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figure 3.63 C-D) 5 ribs.
Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or elongated. Buttresses: 5 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, uniseriate or bi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: distinct, running outside large but inside small bundles. Medulla: sclerotic parenchymatous.

Crystal: absent.

***E. truncatum* Buch.-Ham. ex Mart.**

Specimens examined: *A.Prajaksood & S.Suddee* 245

Leaves (Figure 3.64 A-B)

Outline: adaxial surface of the median lamina concave, abaxial surface convex. *Leaf margin*: upward, rounded.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.

Buttresses: parenchymatous, either uniseriate or bi-seriate; buttress of major vein at median lamina continuous with each surface.

Mesophyll: palisade on both sides, cells isodiametric or elongated. Spongy cells stellate and prominently lobed.

Crystal: absent.

Scapes (Figure 3.64 C-D) 6 ribs.

Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.

Cortex: Chlorenchymatous band: wider than diameter of stele, cells isodiametric, elongated or stellate and scarcely lobed. Buttresses: 6 buttresses, continuous across cortex; parenchymatous, outermost multi-seriate and innermost bi-to multi-seriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: distinct, running outside large but inside small bundles. Medulla: parenchymatous.

Crystal: absent.

***E. truncatum* Buch.-Ham. ex Mart. var. *florensense* Z.X.Zhang**

Specimens examined: *A.Prajaksood & S.Suddee* 162

Leaves (Figure 3.65 A-B)

Outline: adaxial surface of the median lamina concave, abaxial surface convex. *Leaf margin*: upward, rounded.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: equidistant from each surface. Transverse veins present. Bundle sheath: inner sheath thickened-wall absent.

Buttresses: parenchymatous, bi-seriate; buttress of major vein at median lamina continuous with each surface.

Mesophyll: palisade on both sides, cells isodiametric or elongated. Spongy cells stellate and prominently lobed.

Crystal: absent.

Scapes (Figure 3.65 C-D) 6 ribs.

Epidermis: anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent.

Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or stellate and prominently lobed. Buttresses: 6 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, bi-to multi-seriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: indistinct. Medulla: parenchymatous.

Crystal: absent.

***E. ubonense* Lecomte and *E. ubonense* Lecomte f. *kradungense* (Satake) A.Prajaksood & J.Parn.**

Specimens examined: *A.Prajaksood & S.Suddee* 202 and 238

Leaves (Figures 3.66 A-B and 3.67 A-B)

Outline: adaxial surface of the median lamina concave or flat, abaxial surface convex. *Leaf margin*: upward or straight, rounded.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous or not sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: equidistant from each surface. Bundle sheath: inner sheath thickened-wall absent.

Buttresses: mostly parenchymatous, some adaxial buttress cells collenchymatous; uniseriate or bi-to multi-seriate; buttress of major vein at median lamina continuous with each surface.

Mesophyll: palisade on the adaxial side, cells isodiametric or elongated. Spongy cells stellate and scarcely lobed.

Crystal: absent.

Scapes (Figures 3.66 C-D and 3.67 C-D) 7 or 10 ribs.

Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.

Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric, irregularly shaped or stellate and scarcely lobed. Buttresses: 7 or 10 buttresses, continuous across cortex; outermost lacunar collenchymatous and innermost parenchymatous or lacunar collenchymatous; multi-seriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: distinct, running outside large but inside small bundles. Medulla: parenchymatous and sclerotic parenchymatous.

Crystal: absent.

***E. wightianum* Mart.**

Specimens examined: *A.Prajaksood & S.Suddee* 176

Leaves (Figure 3.68 A-B)

Outline: adaxial surface of the median lamina concave, abaxial surface convex. *Leaf margin*: upward, rounded or acute.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: equidistant from each surface. Transverse veins present. Bundle sheath: inner sheath thickened-wall present, thickened-wall cells surrounding vein, a single layer.

Buttresses: parenchymatous, uniseriate to tri-seriate; buttress of major vein at median lamina continuous with each surface.

Mesophyll: homogenous, cells stellate and prominently lobed.

Crystal: prismatic.

Scapes (Figure 3.68 C-D) 7 ribs.

Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.

Cortex: Chlorenchymatous band: narrower than diameter of stele, cells elongated or irregularly shaped. Buttresses: 7 buttresses, continuous across cortex, lacunar collenchymatous, multi-seriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: indistinct. Medulla: parenchymatous.

Crystal: absent.

***E. willdenovianum* Moldenke**

Specimens examined: *A.Prajaksood & S.Suddee* 170

Leaves (Figure 3.69 A-B)

Outline: adaxial surface of the median lamina concave, abaxial surface convex. *Leaf margin*: upward, rounded.

Epidermis: adaxial larger than abaxial cells, costal often larger than intercostal cells, rarely of similar size. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: equidistant from each surface. Bundle sheath: inner sheath thickened-wall present, thickened-wall cells surrounding vein, a single layer, rarely distinct only around xylem.

Buttresses: parenchymatous, uniseriate to tri-seriate; buttress of major vein at median lamina continuous with each surface.
Mesophyll: homogeneous, cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figure 3.69 C-D) 5 ribs.
Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric or stellate and scarcely lobed. Buttresses: 5 buttresses, continuous across cortex, lacunar collenchymatous, multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: indistinct. Medulla: parenchymatous.
Crystal: absent.

***E. xenopodium* T.Koyama**

Specimens examined: *A.Prajaksood & S.Suddee* 158

Leaves (Figure 3.70 A-B)
Outline: adaxial surface of the median lamina concave, abaxial surface convex. *Leaf margin*: upward, rounded.
Epidermis: adaxial larger than abaxial cells, costal similar size with intercostal cells. Hypodermis: present adaxially. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.
Vascular tissue: equidistant from each surface. Bundle sheath: inner sheath thickened-wall present, thickened-wall cells surrounding vein, a single layer.
Buttresses: mostly parenchymatous, some abaxial buttress cells collenchymatous; either uniseriate or bi-to multi-seriate; buttress of major vein at median lamina continuous with each surface.
Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.
Crystal: absent.

Scapes (Figure 3.70 C-D) 7 ribs.
Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.
Cortex: Chlorenchymatous band: narrower than diameter of stele, cells isodiametric, elongated or stellate and prominently lobed. Buttresses: 7 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, bi-to multi-seriate.
Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: distinct, running outside large but passing both sides of small bundles. Medulla: parenchymatous.
Crystal: absent.

***E. xeranthemum* Mart.**

Specimens examined: *A.Prajaksood & S.Suddee* 166

Leaves (Figure 3.71 A-B)

Outline: adaxial surface of the median lamina concave, abaxial surface convex. *Leaf margin*: upward or straight, rounded or acute.

Epidermis: adaxial larger than abaxial cells, costal similar size with intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall present, thickened-wall cells surrounding vein, a single layer.

Buttresses: parenchymatous, uniseriate, buttress of major vein at median lamina continuous.

Mesophyll: palisade on both sides, cells isodiametric. Spongy cells stellate and prominently lobed.

Crystal: absent.

Scapes (Figure 3.71 C-D) 4 ribs.

Epidermis: anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent.

Cortex: Chlorenchymatous band: wider than diameter of stele, cells isodiametric or stellate and prominently lobed. Buttresses: 4 buttresses, continuous across cortex, parenchymatous, outermost multi-seriate and innermost uniseriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: indistinct. Medulla: parenchymatous.

Crystal: absent.

***E. zollingerianum* Körn.**

Specimens examined: *A.Prajaksood & S.Suddee* 165

Leaves (Figure 3.72 A-B)

Outline: adaxial surface of the median lamina slightly concave, abaxial surface convex. *Leaf margin*: downward, rounded.

Epidermis: adaxial larger than abaxial cells, costal larger than intercostal cells. Hypodermis: absent. Adaxial and abaxial: periclinal wall of cells cutinized, papillae absent; anticlinal wall of cells sinous. Stomata: guard cells inner ledge absent. Trichomes: present on both surfaces.

Vascular tissue: closest to adaxial surface. Bundle sheath: inner sheath thickened-wall absent.

Buttresses: parenchymatous, uniseriate, buttress of major vein at median lamina discontinuous.

Mesophyll: palisade on the adaxial side, cells isodiametric. Spongy cells stellate and prominently lobed.

Crystal: prismatic.

Scapes (Figure 3.72 C-D) rib absent.

Epidermis: anticlinal wall of cells not sinous. Stomata: guard cells inner ledge absent.

Cortex: Chlorenchymatous band: wider than diameter of stele, cells isodiametric, elongated or stellate and scarcely lobed. Buttresses: 5 buttresses, continuous across cortex; outermost lacunar collenchymatous, multi-seriate and innermost parenchymatous, bi-seriate.

Stele: Vascular bundles: number of large bundles same as small bundles and number of buttresses. Endodermoid layer: distinct, running outside large but inside small bundles. Medulla: sclerotic parenchymatous.

Crystal: absent.

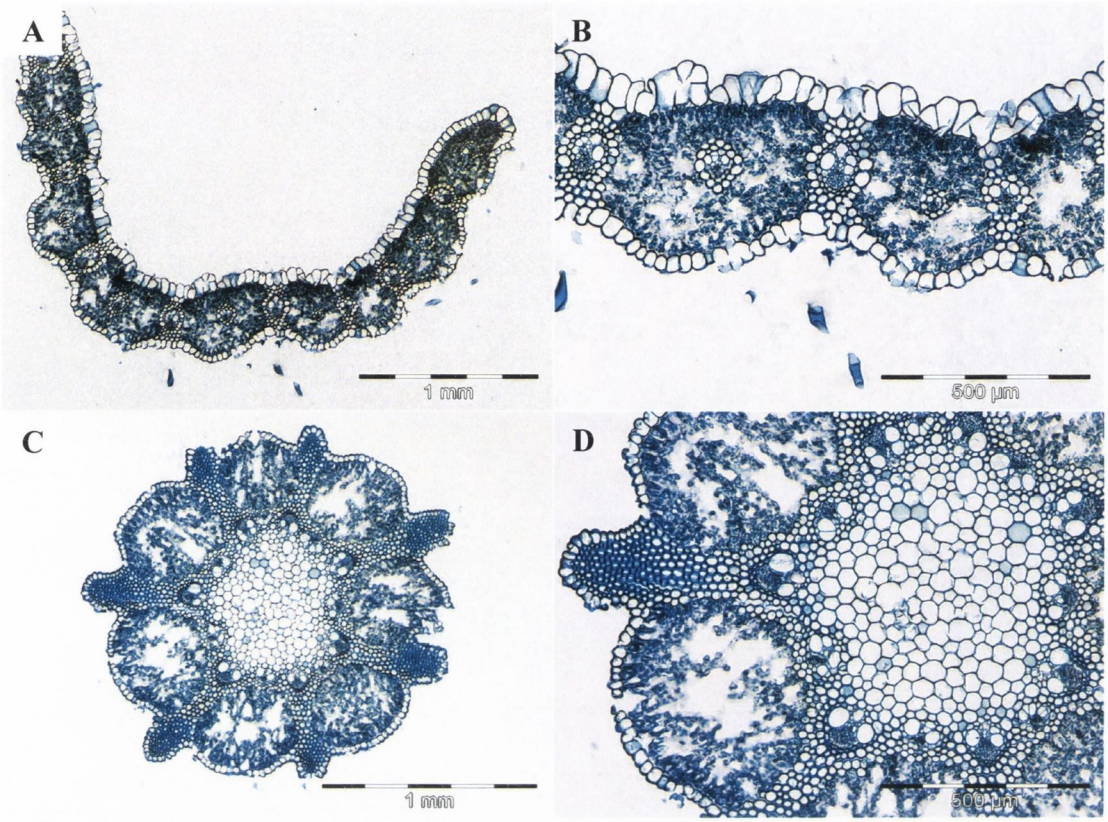

Figure 3.28 Anatomy of leaf and scape of *Eriocaulon brownianum* from *A.Prajaksood & S.Suddee* 201.

(A) Leaf margin upward.

(B) Inner sheath thickened-wall present surrounding vein, stellate and scarcely lobed..

(C) Scape seven ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, stellate and prominently lobed.

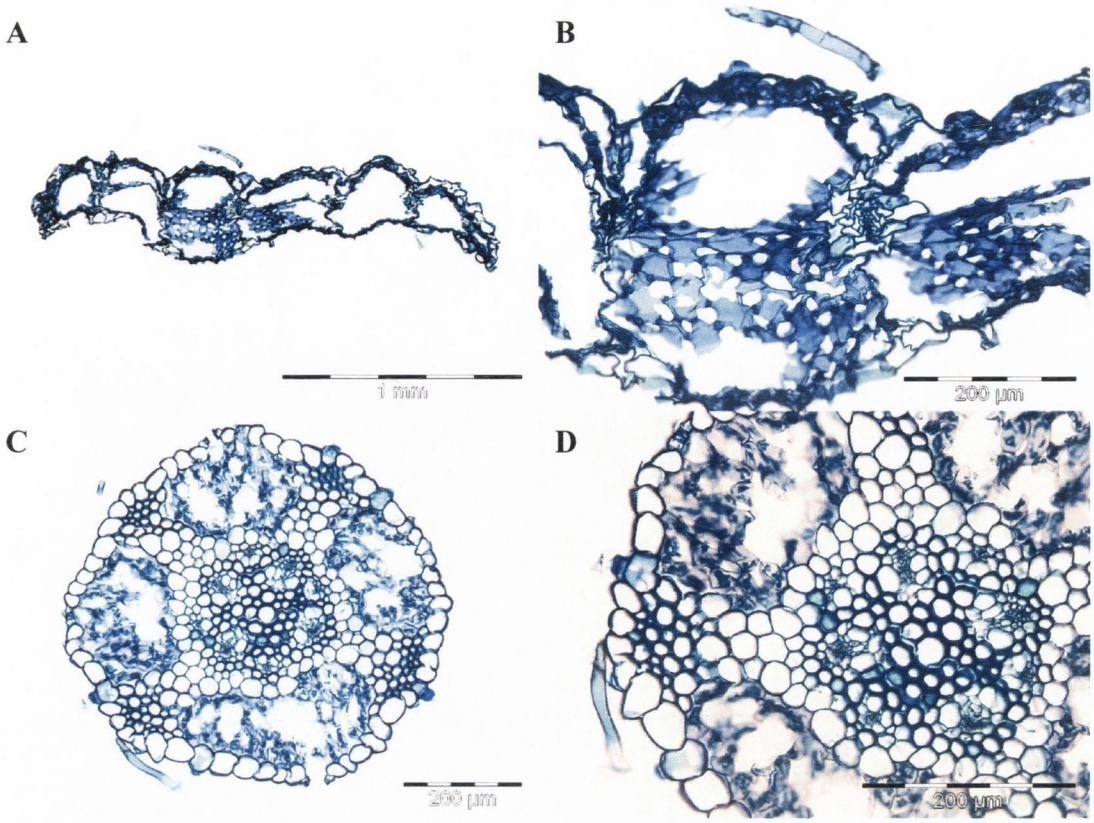

Figure 3.29 Anatomy of leaf and scape of *Eriocaulon chantaranothai* from *A.Prajaksood & S.Suddee* 310 (leaves not fresh).

(A) Leaf margin downward.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape four ribs.

(D) Endodermoid layer in scape indistinct, irregularly shaped cells in chlorenchymatous band, sclerotic parenchymatous pith.

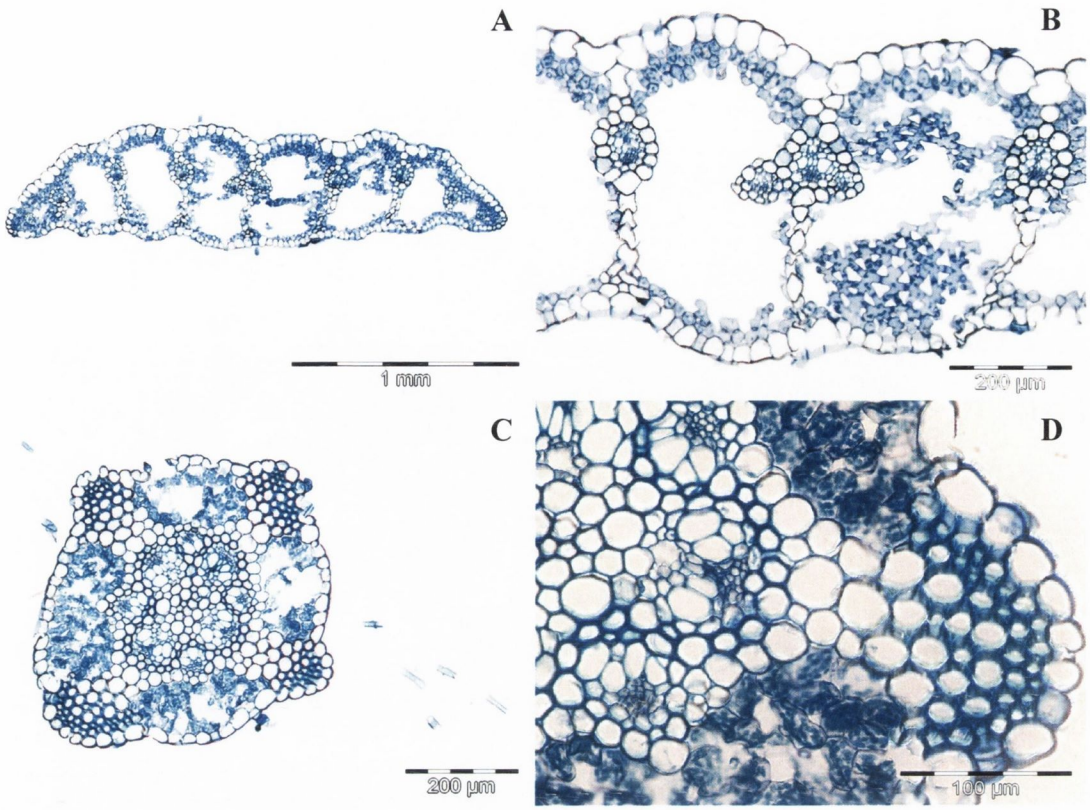

Figure 3.30 Anatomy of leaf and scape of *Eriocaulon chantaranothai* from *A.Prajaksood & S.Suddee* 321.

(A) Leaf margin downward.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape four ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, irregularly shaped cells in chlorenchymatous band.

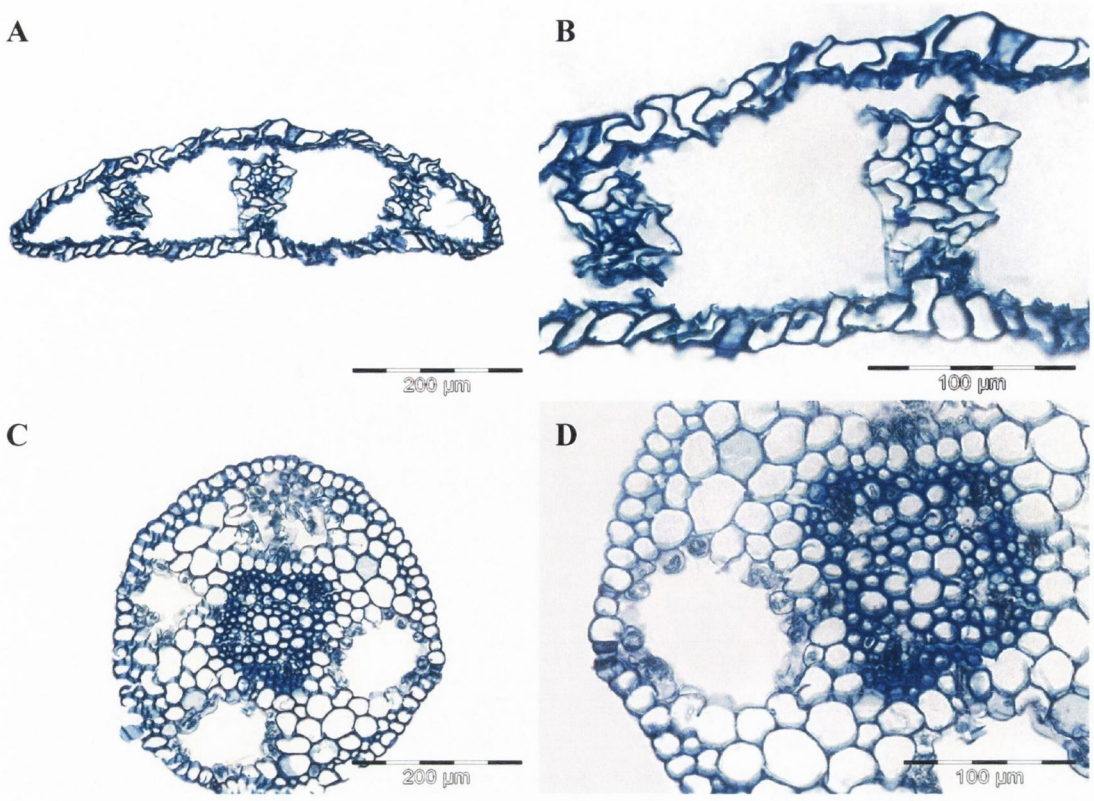

Figure 3.31 Anatomy of leaf and scape of *Eriocaulon cinereum* from *A.Prajaksood & S.Suddee* 339.

(A) Leaf margin straight.

(B) Inner sheath thickened-wall absent, discontinuous buttresses.

(C) Scape no ribs with four buttresses, stellate and scarcely lobed.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, sclerotic parenchymatous pith.

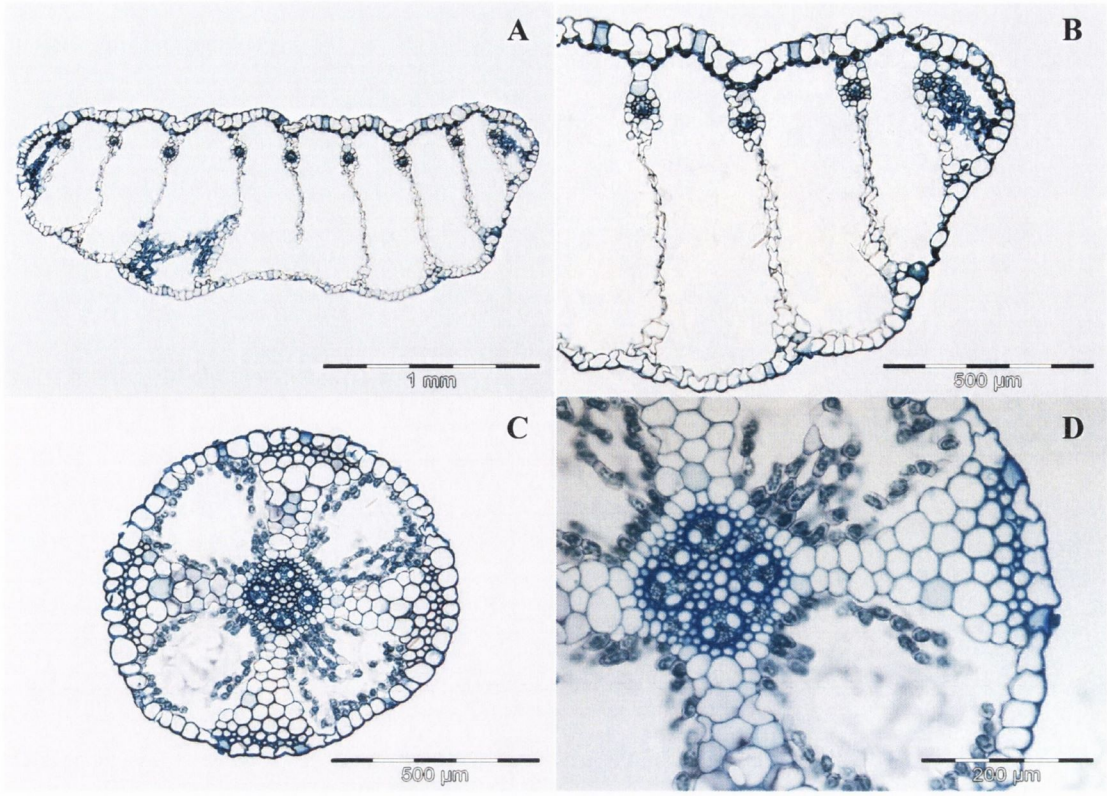

Figure 3.32 Anatomy of leaf and scape of *Eriocaulon echinulatum* from *A.Prajaksood & S.Suddee* 174.

(A) Leaf margin straight.

(B) Inner sheath thickened-wall present surrounding vein, stellate and prominently lobed, papillose adaxial epidermis.

(C) Scape no ribs with four buttresses.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, stellate and scarcely lobed, sclerotic parenchymatous pith.

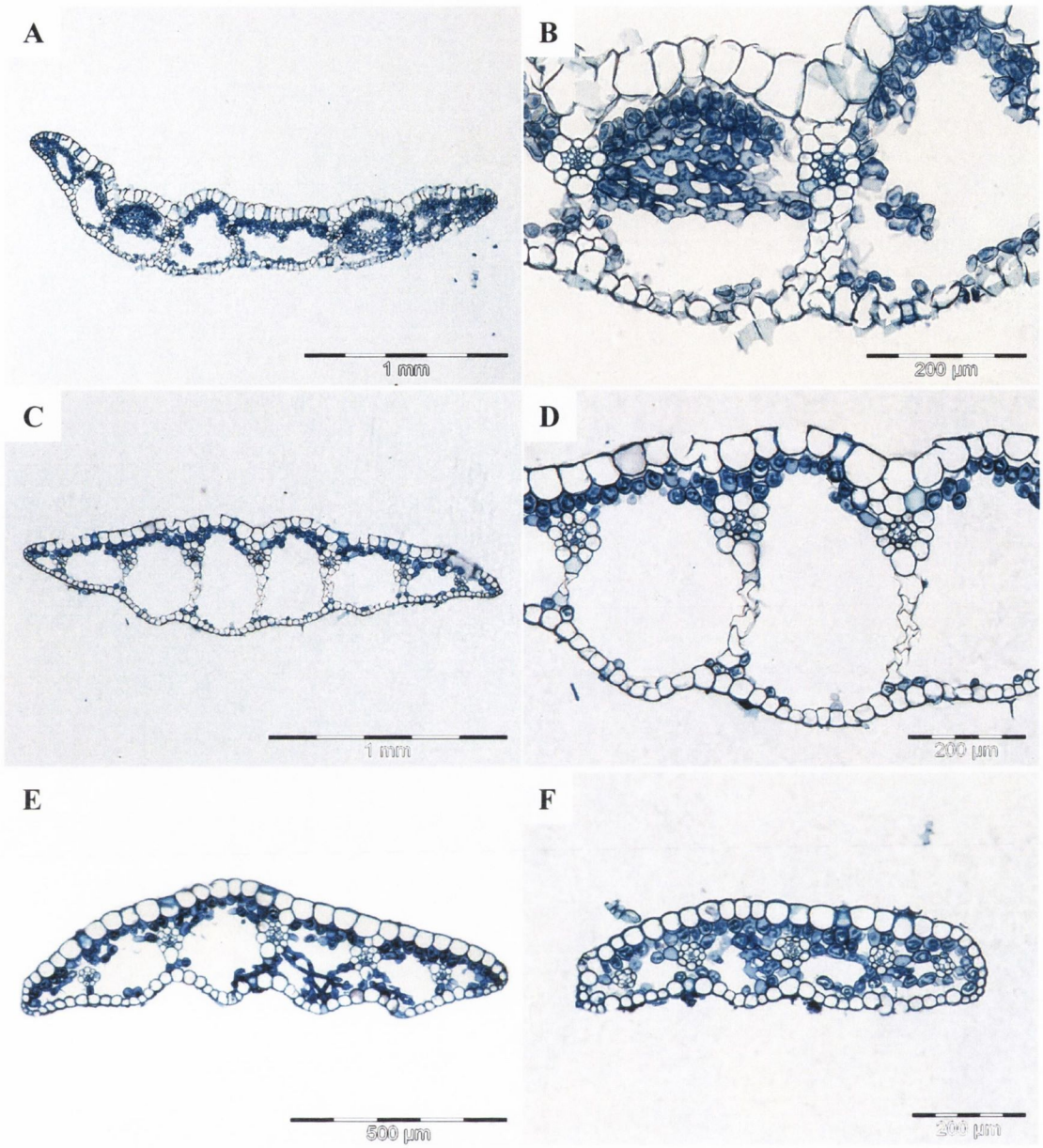

Figure 3.33 Anatomy of leaf and scape of *Eriocaulon pseudoescape* and *E. escape*.

(A)-(B) *E. pseudoescape* from *A.Prajaksood & S.Suddee* 239, (A) leaf margin upward.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C)-(F) *E. escape* from *A.Prajaksood & S.Suddee* 240, (C) leaf margin straight.

(D) Inner sheath thickened-wall absent.

(E) Leaf margin downward, stellate and prominently lobed.

(F) No buttressed vein in distal part of the leaf.

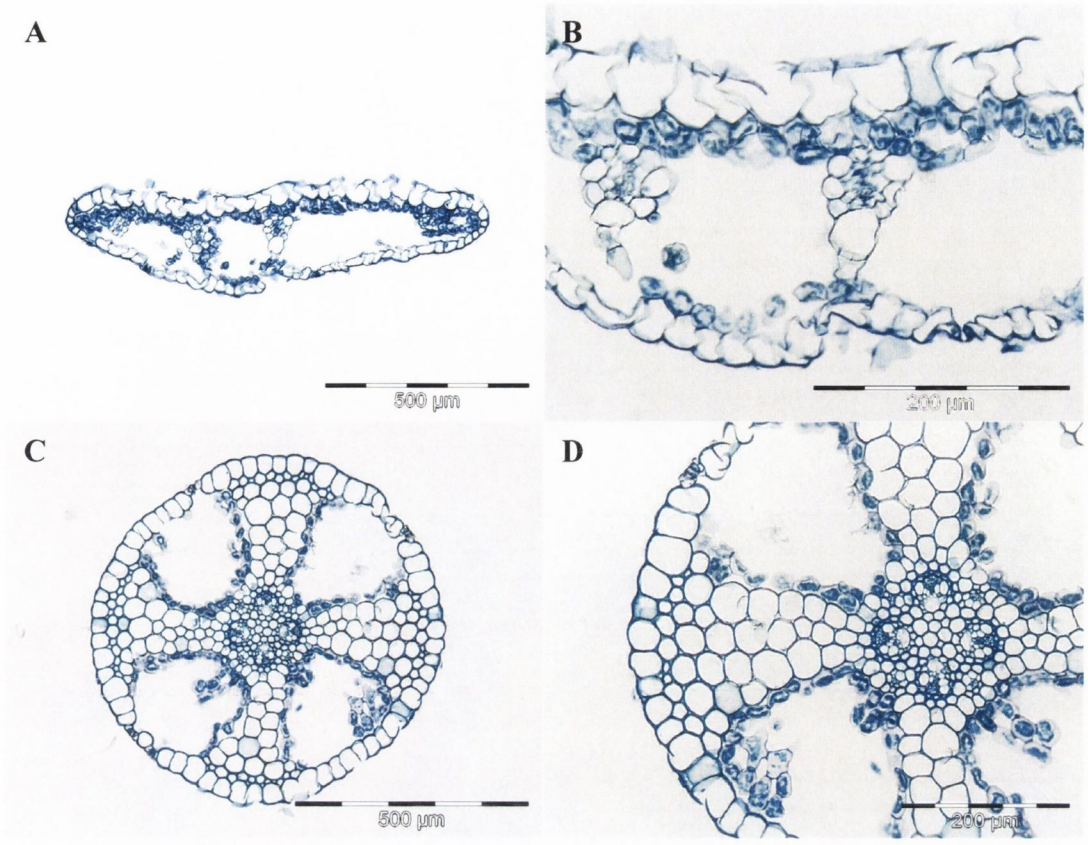

Figure 3.34 Anatomy of leaf and scape of *Eriocaulon hamiltonianum* from *A.Prajaksood & S.Suddee* 250.

(A) Leaf margin straight.

(B) Inner sheath thickened-wall present surrounding vein, stellate and prominently lobed.

(C) Scape no ribs with four buttresses.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, stellate and scarcely lobed, parenchymatous and sclerotic parenchymatous pith.

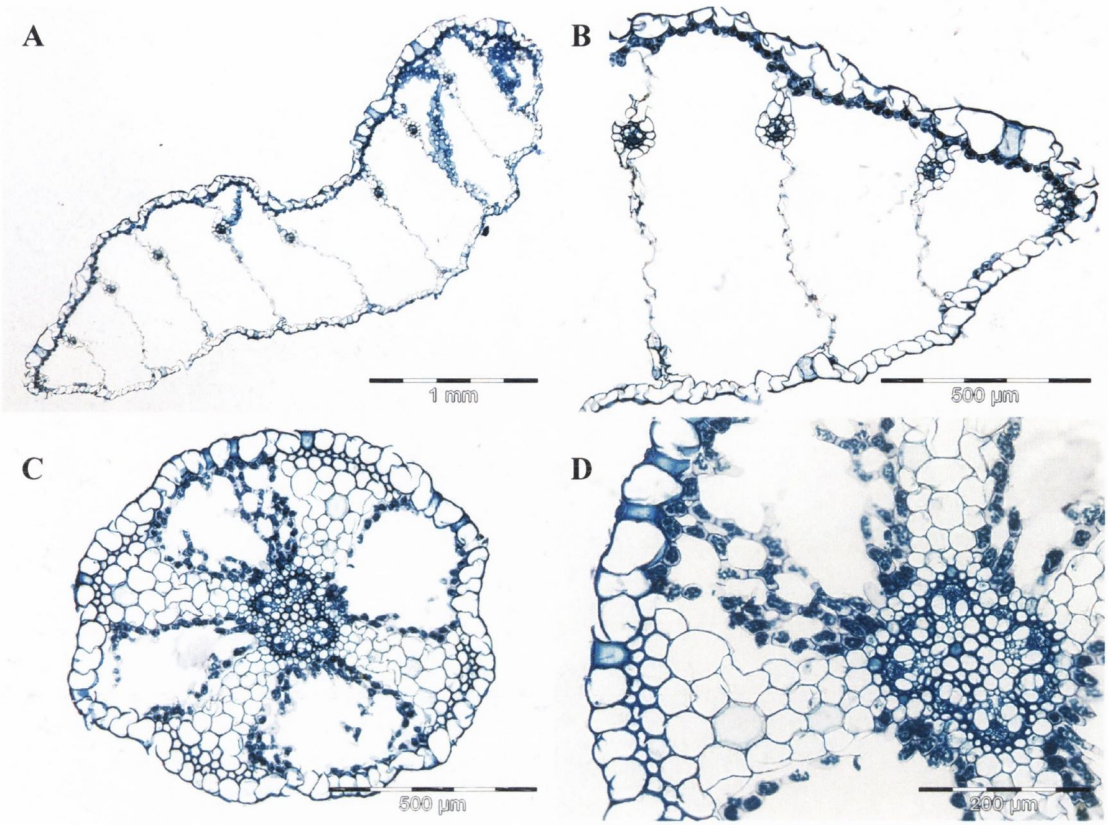

Figure 3.35 Anatomy of leaf and scape of *Eriocaulon hamiltonianum* from *A.Prajaksood & S.Suddee* 314.

(A) Leaf margin straight, stellate and prominently lobed.

(B) Inner sheath thickened-wall present surrounding vein.

(C) Scape four ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, stellate and prominently lobed, parenchymatous and sclerotic parenchymatous pith.

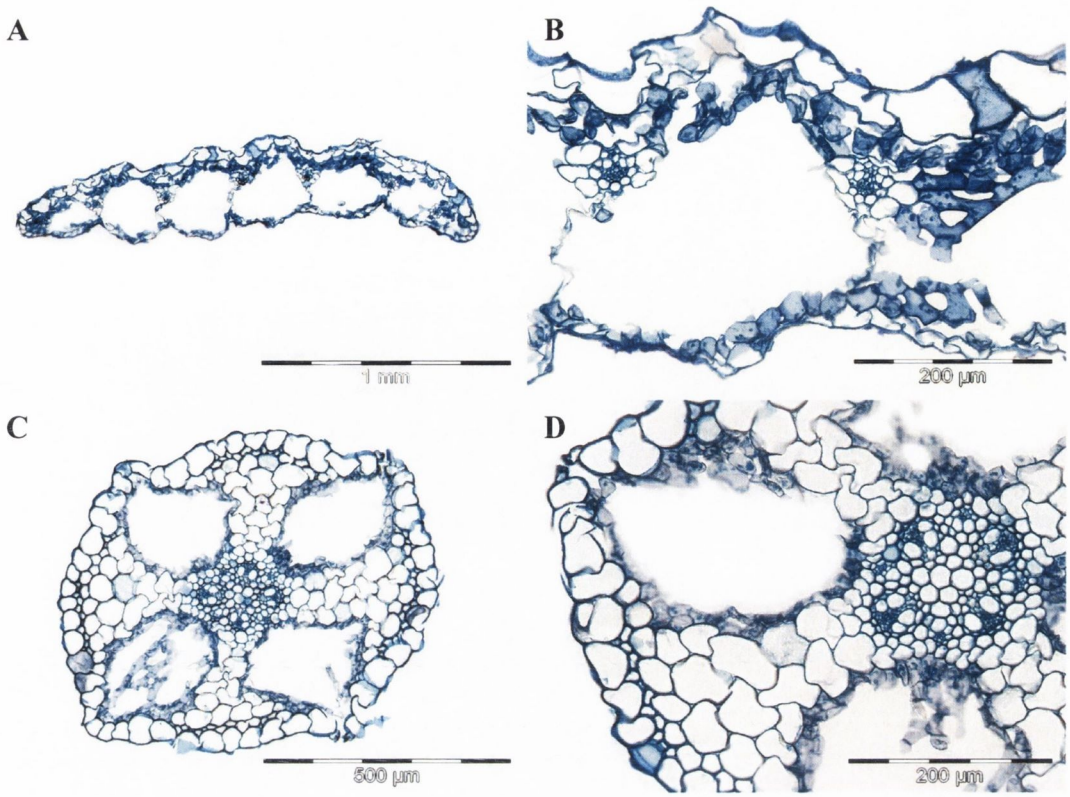

Figure 3.36 Anatomy of leaf and scape of *Eriocaulon hamiltonianum* from *A.Prajaksood & S.Suddee* 324.

(A) Leaf margin downward.

(B) Inner sheath thickened-wall present only distinct around phloem, stellate and prominently lobed.

(C) Scape no ribs with four buttresses, stellate and prominently lobed in chlorenchymatous band.

(D) Endodermoid layer in scape indistinct.

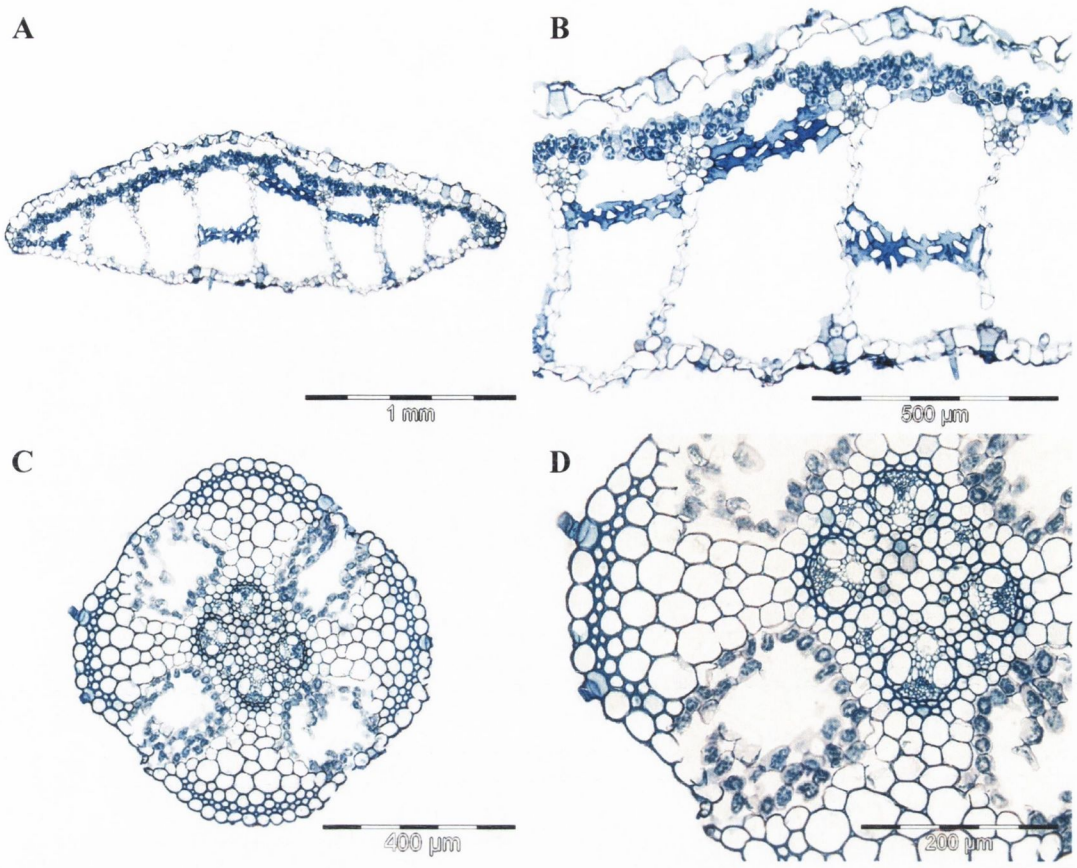

Figure 3.37 Anatomy of leaf and scape of *Eriocaulon hamiltonianum* var. *acuminatum* from *A.Prajaksood & S.Suddee* 318.

(A) Leaf margin straight.

(B) Inner sheath thickened-wall absent, discontinuous buttresses, stellate and prominently lobed, papillose epidermis.

(C) Scape no ribs with four buttresses.

(D) Endodermoid layer in scape indistinct, irregularly shaped cells in chlorenchymatous band.

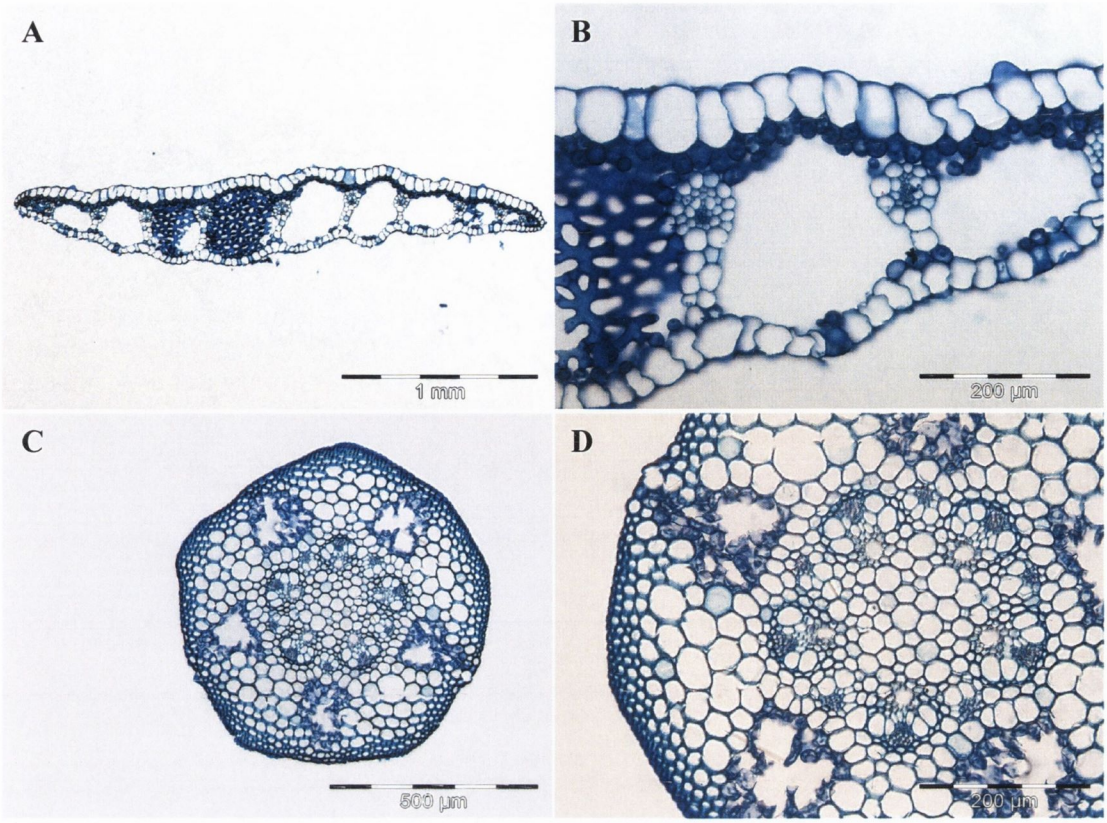

Figure 3.38 Anatomy of leaf and scape of *Eriocaulon infirmum* from *A.Prajaksood & S.Suddee* 189.

(A) Leaf margin straight.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed, papillose epidermis.

(C) Scape no ribs with five buttresses.

(D) Endodermoid layer in scape indistinct, irregularly shaped cells in chlorenchymatous band.

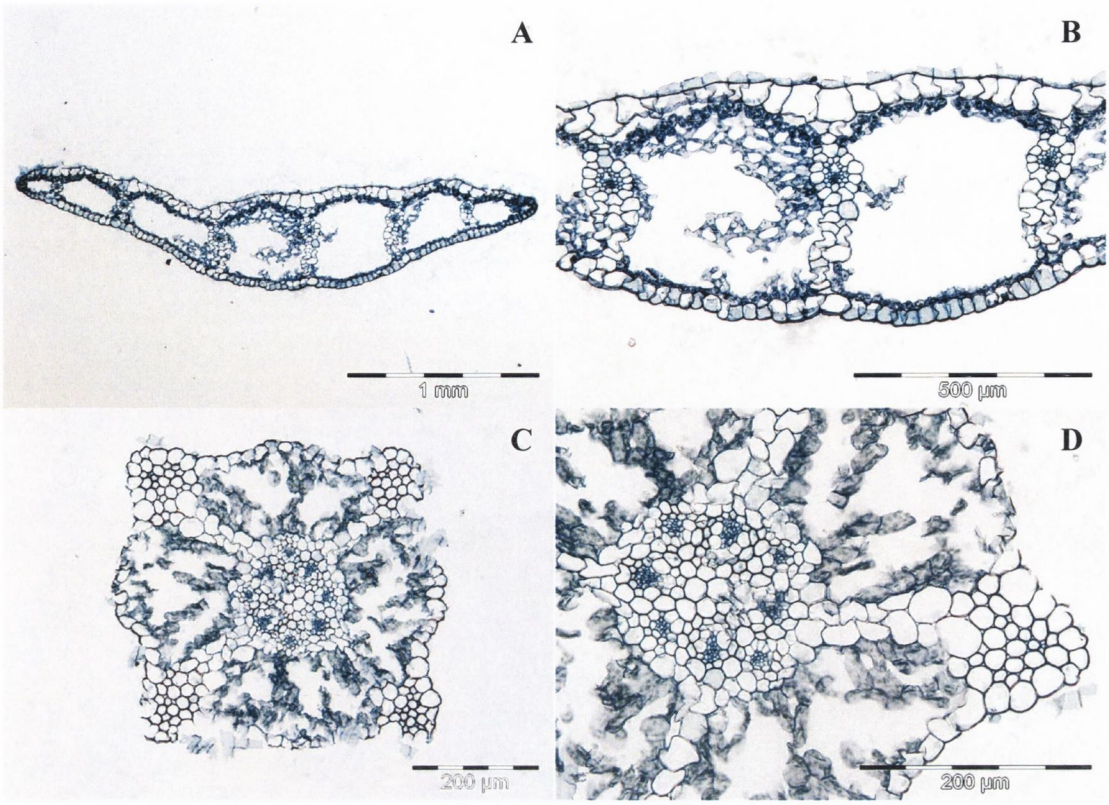

Figure 3.39 Anatomy of leaf and scape of *Eriocaulon laosense* from *A.Prajaksood & S.Suddee* 257.

(A) Leaf margin upward.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape four ribs.

(D) Endodermoid layer in scape indistinct, elongated or irregularly shaped cells in chlorenchymatous band.

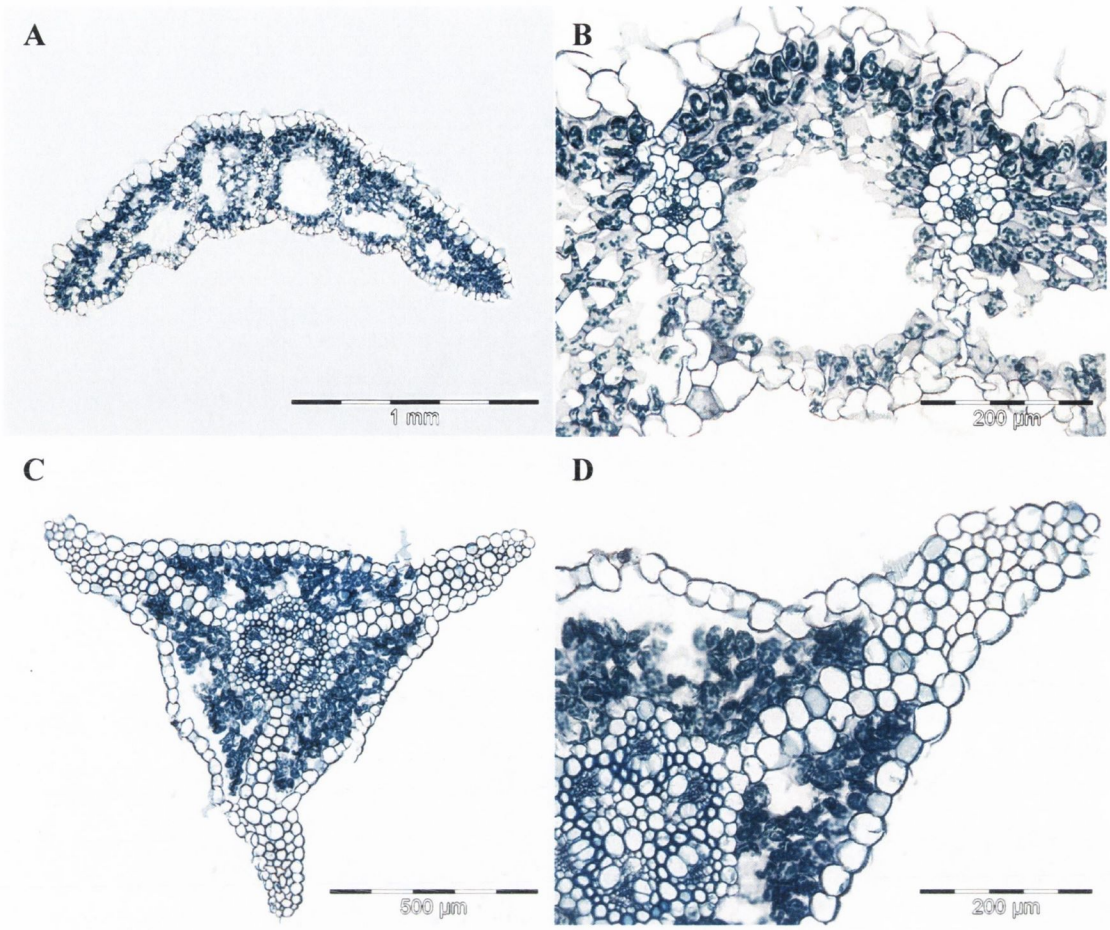

Figure 3.40 Anatomy of leaf and scape of *Eriocaulon laosense* from *A.Prajaksood & S.Suddee* 259.

(A) Leaf margin downward, papillose epidermis.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape three ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, isodiametric or elongated cells in chlorenchymatous band, parenchymatous and sclerotic parenchymatous pith.

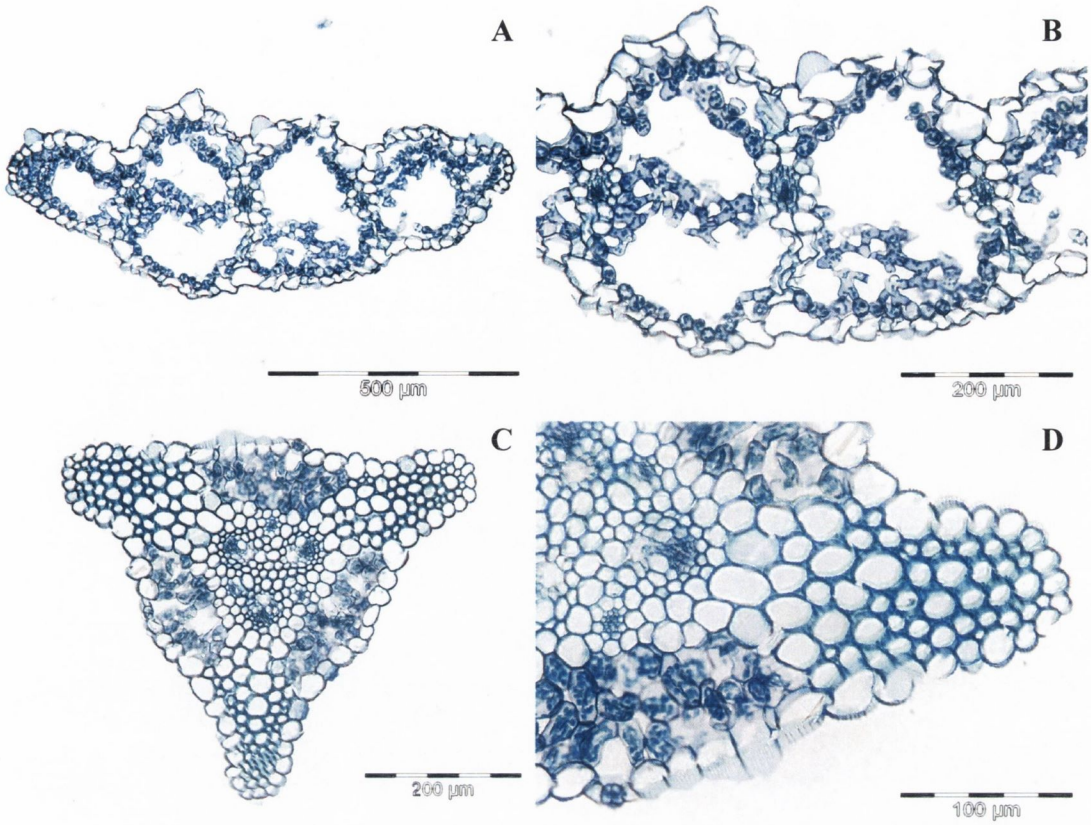

Figure 3.41 Anatomy of leaf and scape of *Eriocaulon laosense* from *A.Prajaksood & S.Suddee* 293.

(A) Leaf margin upward, papillose epidermis.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape three ribs.

(D) Endodermoid layer in scape indistinct, isodiametric or elongated cells in chlorenchymatous band, sclerotic parenchymatous pith.

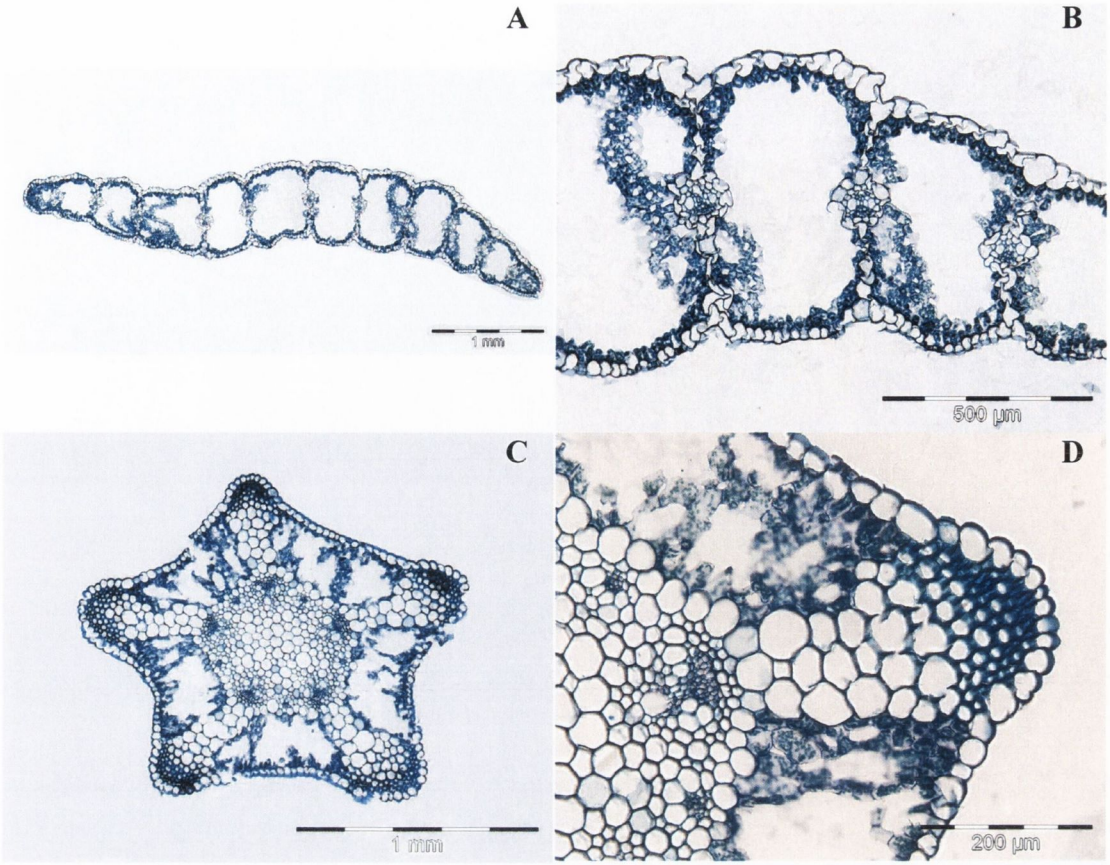

Figure 3.42 Anatomy of leaf and scape of *Eriocaulon nautiliforme* from *A.Prajaksood & S.Suddee* 169.

(A) Leaf margin downward.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

C) Scape five ribs.

(D) Endodermoid layer in scape indistinct, irregularly shaped cells in chlorenchymatous band.

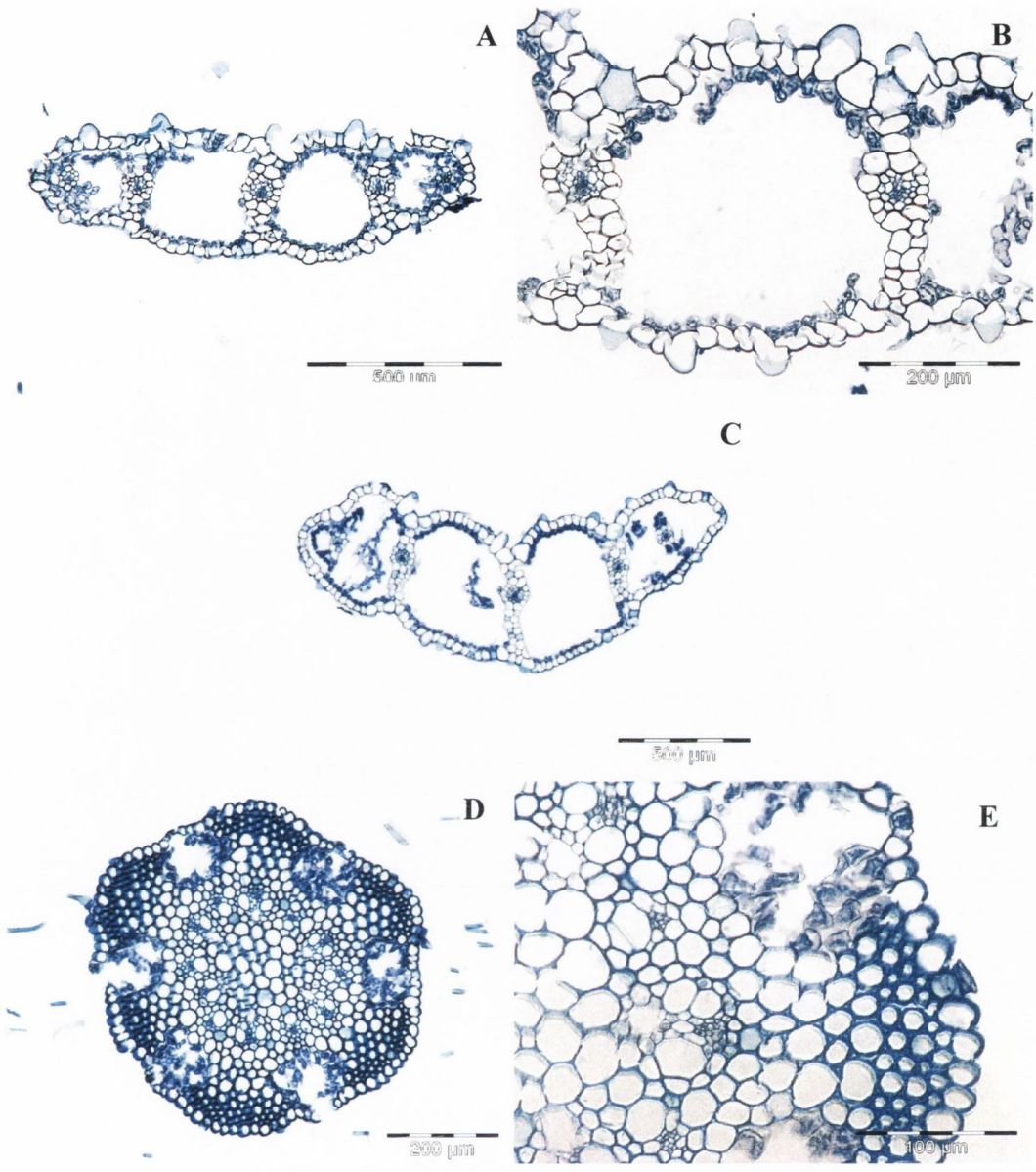

Figure 3.43 Anatomy of leaf and scape of *Eriocaulon nautiliformoides* from *A.Prajaksood & S.Suddee* 264.

(A) Leaf margin straight in distal part.

(B) Inner sheath thickened-wall absent, papillose epidermis.

(C) Papillose epidermis in basal part with stellate and prominently lobed.

(D) Scape no ribs with six buttresses.

(E) Endodermoid layer in scape indistinct, irregularly shaped cells in chlorenchymatous band, parenchymatous and sclerotic parenchymatous pith.

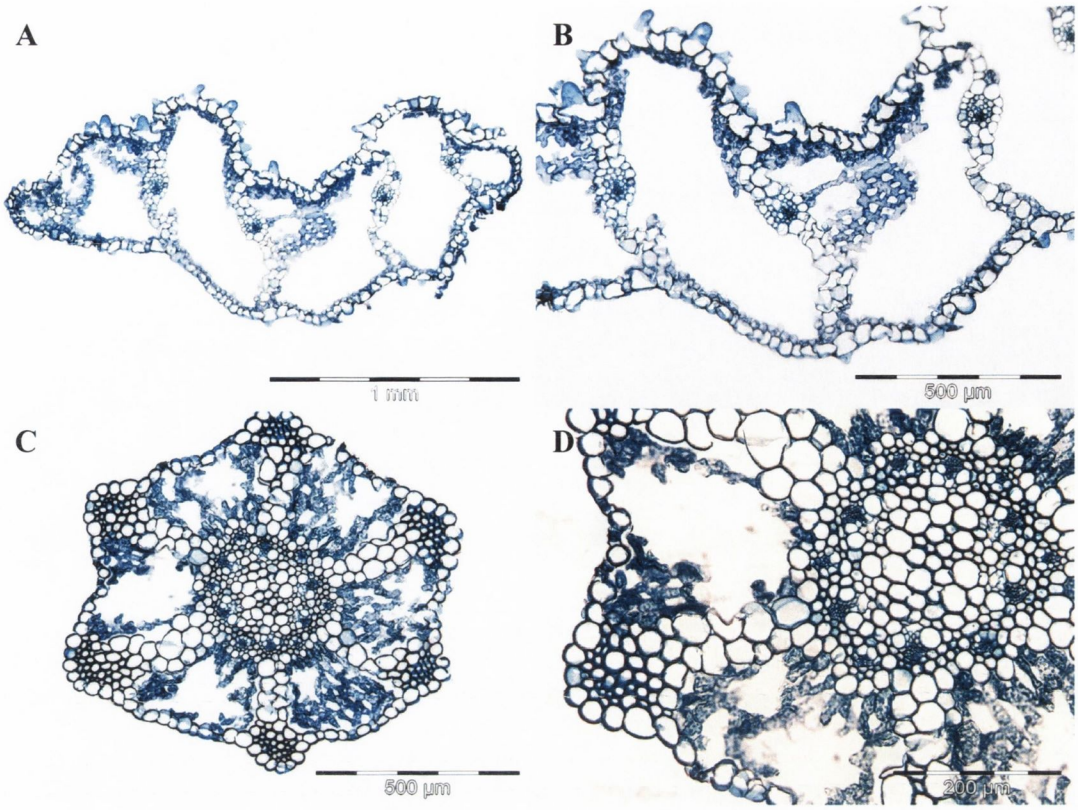

Figure 3.44 Anatomy of leaf and scape of *Eriocaulon nautiliformoides* var. *hexagynum* from *A.Prajaksood & S.Suddee* 265.

(A) Leaf margin upward, papillose epidermis.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape six ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, irregularly shaped cells in chlorenchymatous band, parenchymatous and sclerotic parenchymatous pith.

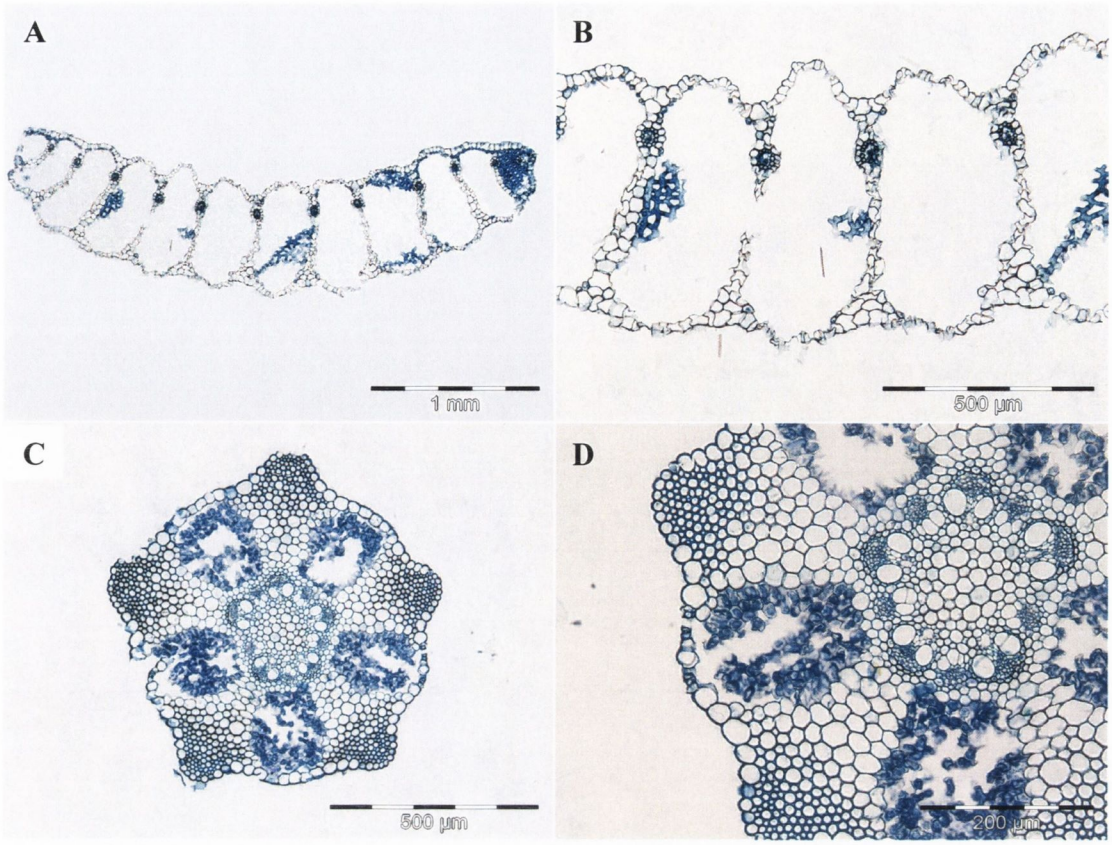

Figure 3.45 Anatomy of leaf and scape of *Eriocaulon nepalense* var. *luzulaefolium* from *A.Prajaksood & S.Suddee* 161.

(A) Leaf margin upward.

(B) Inner sheath thickened-wall present surrounding vein, stellate and prominently lobed.

(C) Scape five ribs.

(D) Endodermoid layer in scape indistinct, irregularly shaped cells in chlorenchymatous band.

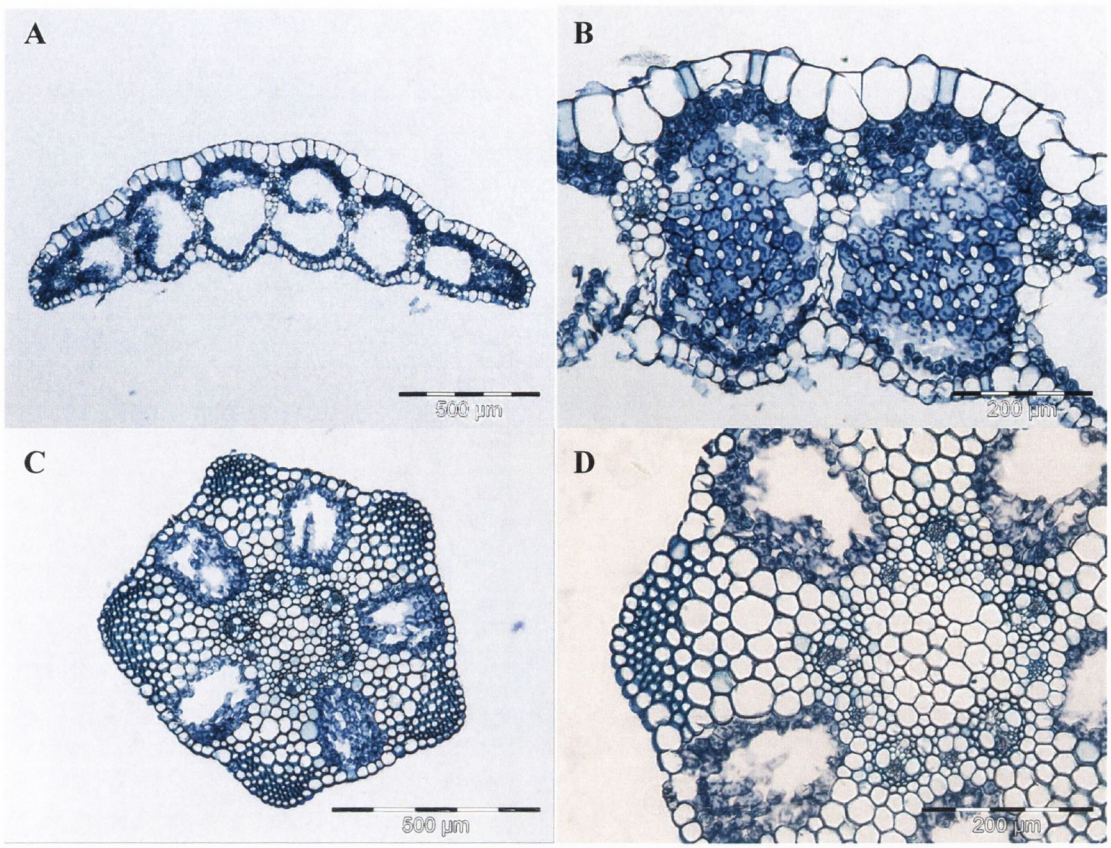

Figure 3.46 Anatomy of leaf and scape of *Eriocaulon nepalense* var. *luzulaefolium* from *A.Prajaksood & S.Suddee* 208.

(A) Leaf margin downward.

(B) Inner sheath thickened-wall absent, stellate and scarcely lobed, papillose epidermis.

(C) Scape five ribs.

(D) Endodermoid layer in scape indistinct, isodiametric or elongated cells in chlorenchymatous band.

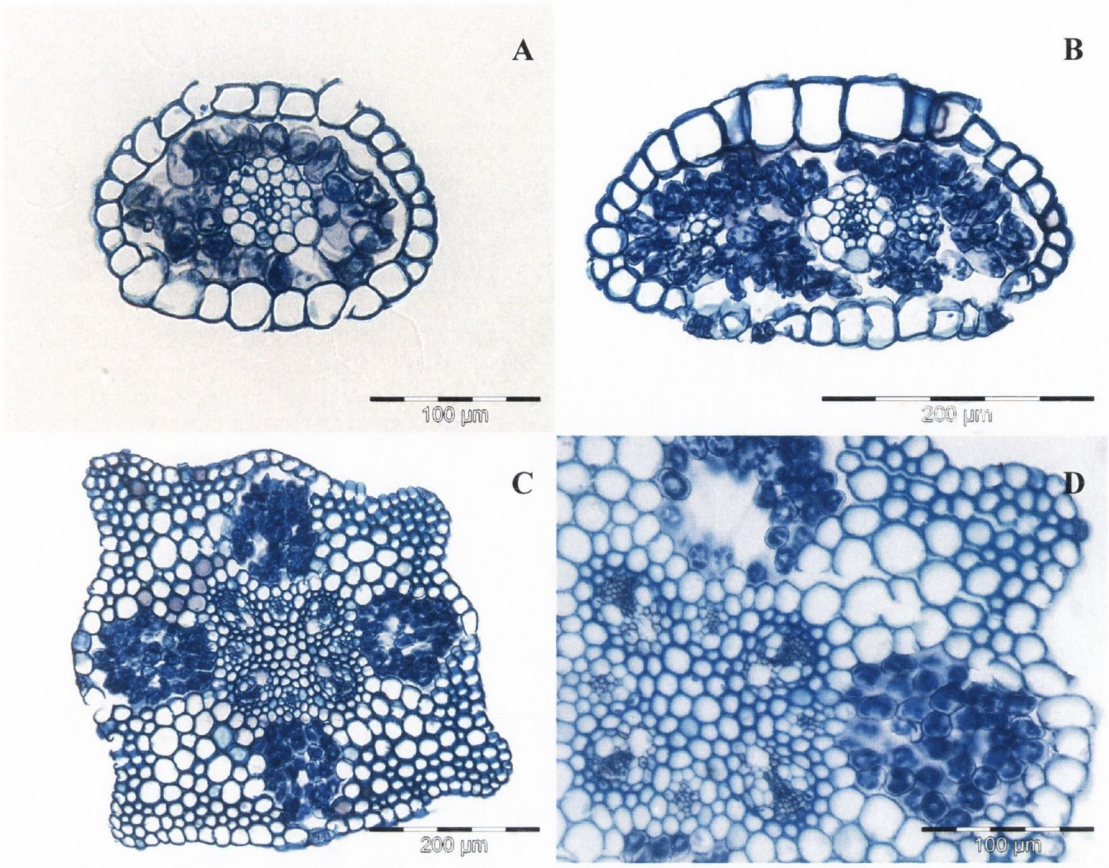

Figure 3.47 Anatomy of leaf and scape of *Eriocaulon parnellii* from *A.Prajaksood & S.Suddee* 242.

(A) Leaf margin straight.

(B) Inner sheath thickened-wall absent, homogenous mesophyll.

(C) Scape four ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, isodiametric or elongated cells in chlorenchymatous band, parenchymatous and sclerotic parenchymatous pith.

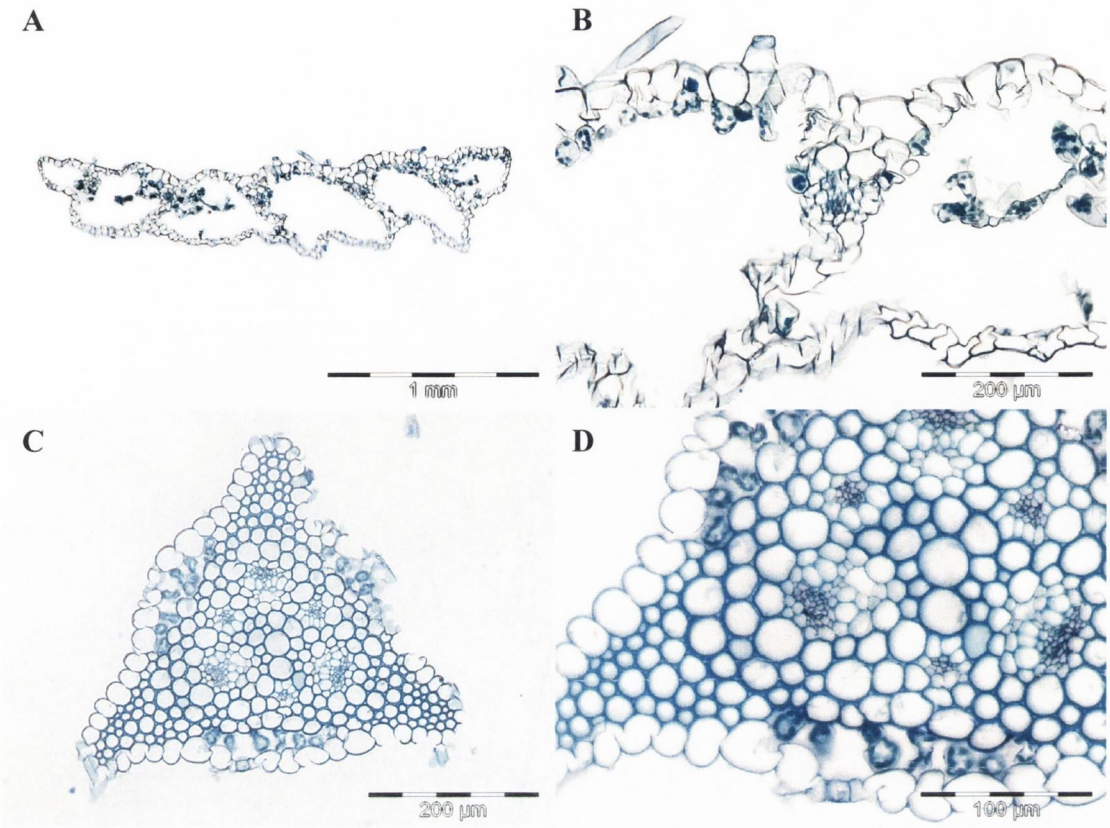

Figure 3.48 Anatomy of leaf and scape of *Eriocaulon phatamense* from *A.Prajaksood & S.Suddee* 289.

(A) Leaf margin upward, stellate and prominently lobed.

(B) Inner sheath thickened-wall absent.

(C) Scape three ribs.

(D) Endodermoid layer in scape indistinct, isodiametric cells in chlorenchymatous band, sclerotic parenchymatous pith.

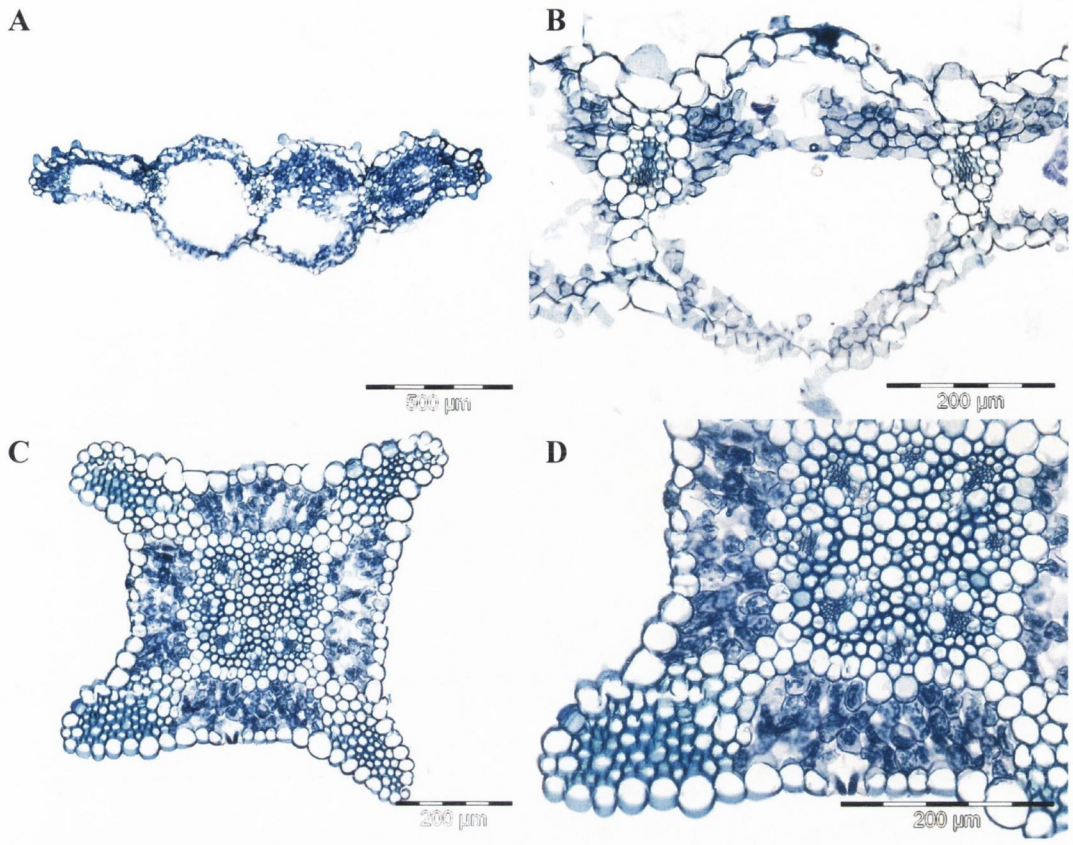

Figure 3.49 Anatomy of leaf and scape of *Eriocaulon phuchongense* from *A.Prajaksood & S.Suddee* 260.

(A) Leaf margin straight, papillose epidermis in adaxially.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape four ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, isodiametric or elongated cells in chlorenchymatous band, sclerotic parenchymatous pith.

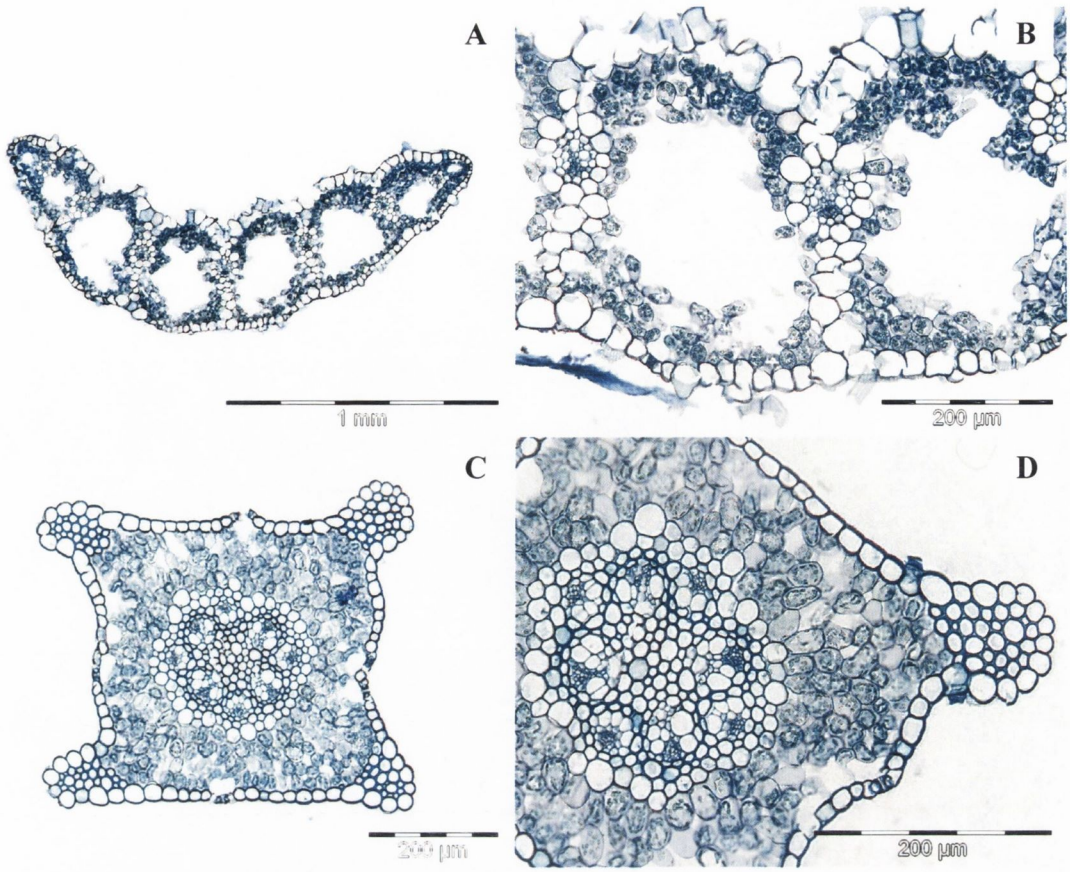

Figure 3.50 Anatomy of leaf and scape of *Eriocaulon phuchongense* from *A.Prajaksood & S.Suddee* 276.

(A) Leaf margin upward, papillose epidermis.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape four ribs with discontinuous buttresses.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, isodiametric or elongated cells in chlorenchymatous band, sclerotic parenchymatous pith.

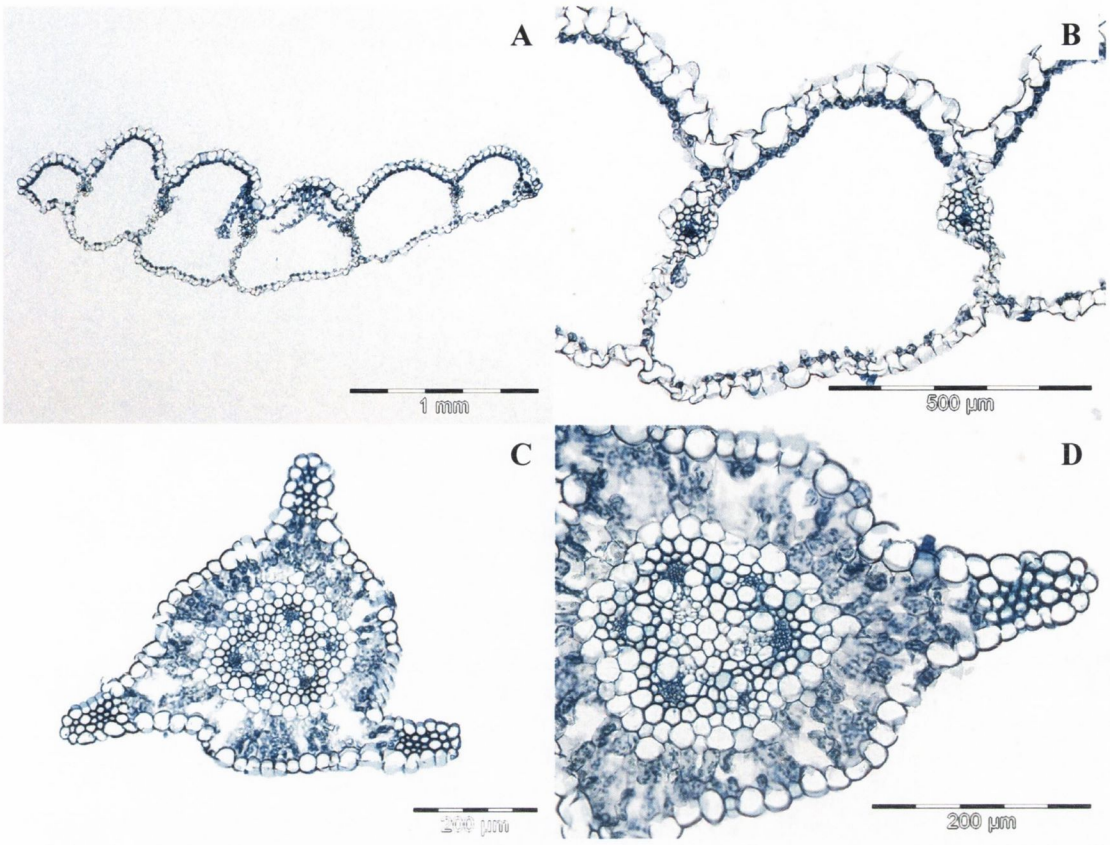

Figure 3.51 Anatomy of leaf and scape of *Eriocaulon phuchongense* from *A.Prajaksood & S.Suddee* 285.

(A) Leaf margin upward, stellate and prominently lobed.

(B) Inner sheath thickened-wall present surrounding vein, papillose epidermis.

(C) Scape three ribs with discontinuous buttresses.

(D) Endodermoid layer in scape indistinct, isodiametric or elongated cells in chlorenchymatous band.

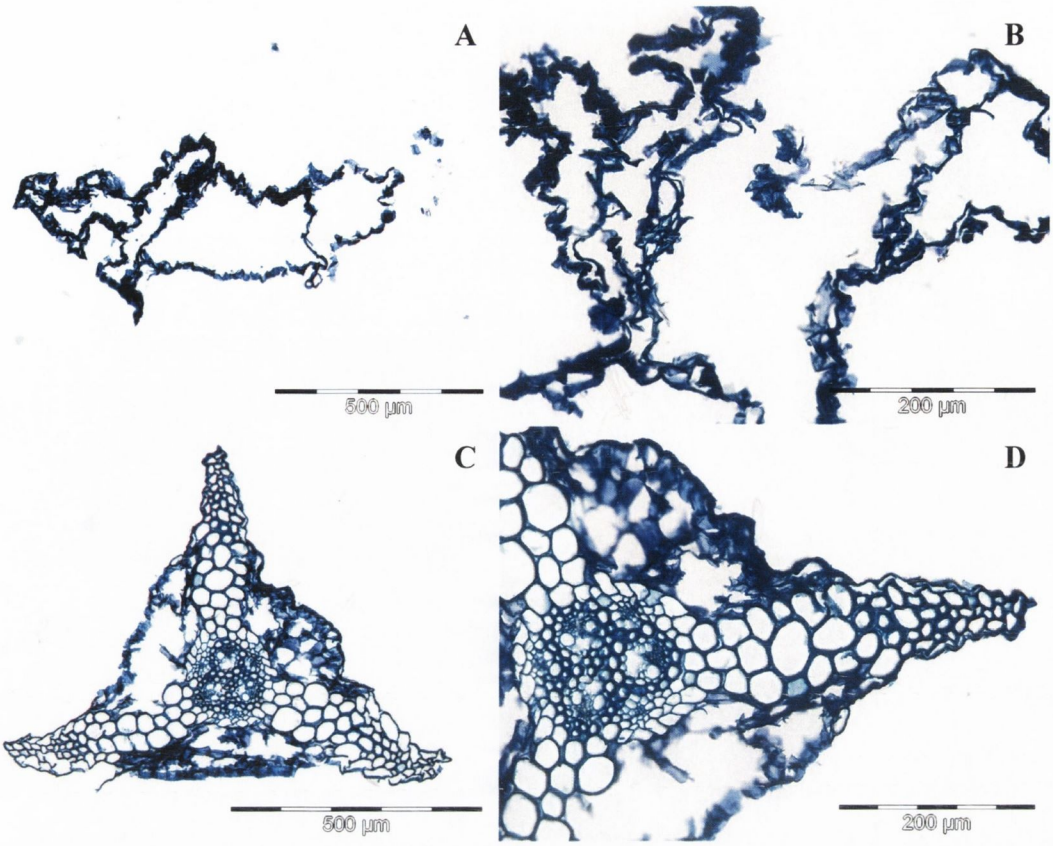

Figure 3.52 Anatomy of leaf and scape of *Eriocaulon phuphanoides* from *A.Prajaksood & S.Suddee* 299.

(A) Leaf margin upward.

(B) No detail of leaf anatomy.

(C) Scape three ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, isodiametric or elongated cells in chlorenchymatous band, lacunar collenchymatous buttresses, sclerotic parenchymatous pith.

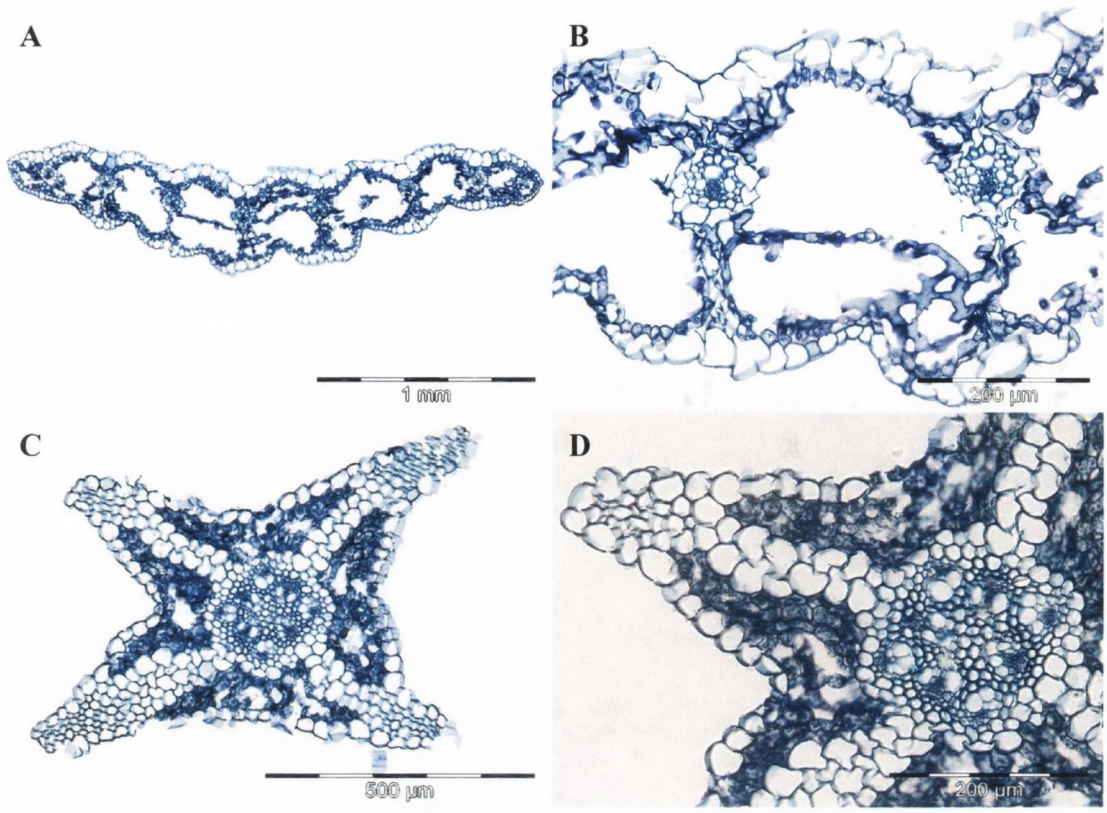

Figure 3.53 Anatomy of leaf and scape of *Eriocaulon phuphanoides* from *A.Prajaksood & S.Suddee* 320.

(A) Leaf margin upward.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape four ribs.

(D) Endodermoid layer in scape indistinct, isodiametric or elongated cells in chlorenchymatous band.

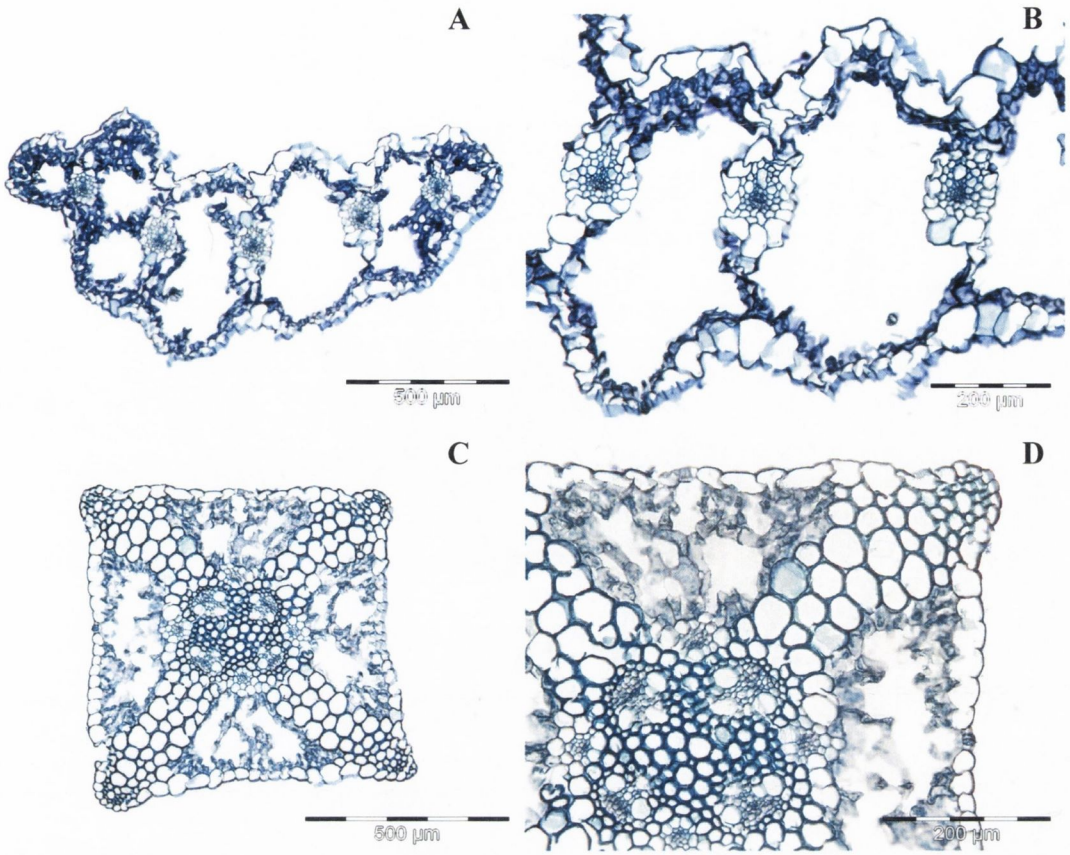

Figure 3.54 Anatomy of leaf and scape of *Eriocaulon phuphanoides* from *A.Prajaksood & S.Suddee* 345.

(A) Leaf margin upward.

(B) Inner sheath thickened-wall absent, continuous buttresses.

(C) Scape four ribs.

(D) Endodermoid layer in scape indistinct, irregular shaped cells in chlorenchymatous band, sclerotic parenchymatous pith.

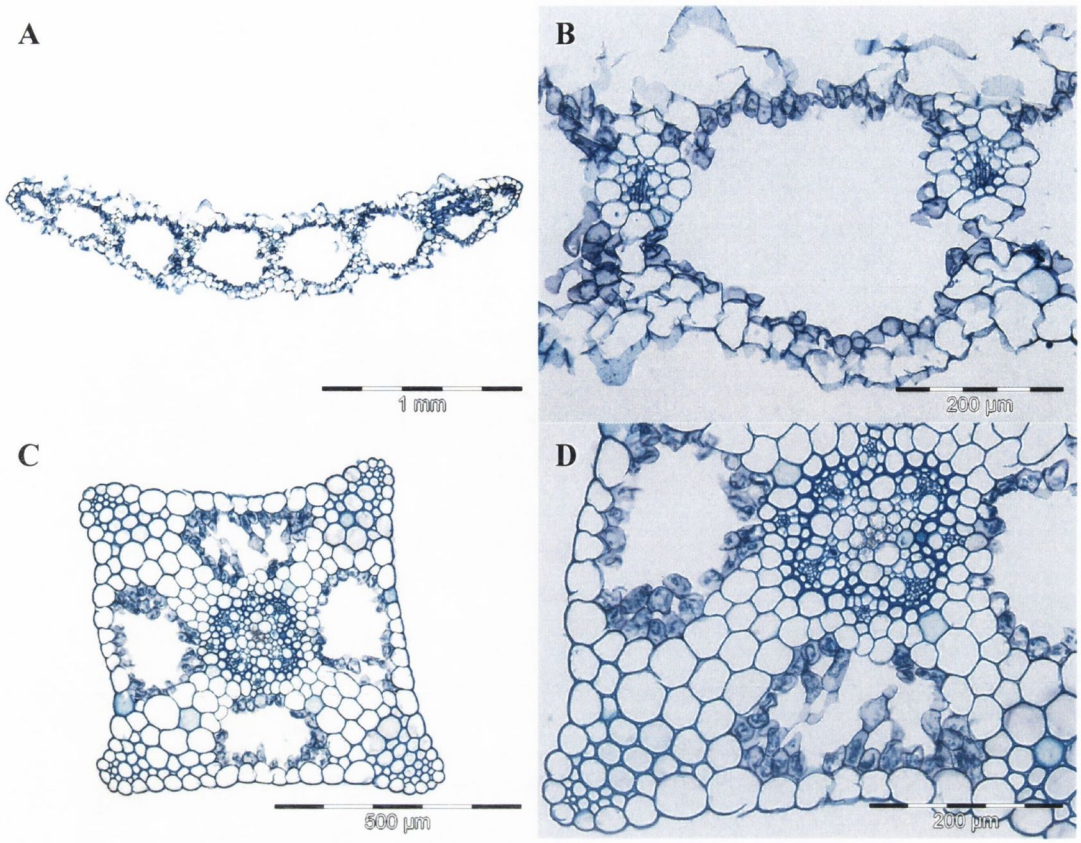

Figure 3.55 Anatomy of leaf and scape of *Eriocaulon quinquangulare* var. *longibracteatum* from *A.Prajaksood & S.Suddee* 317.

(A) Leaf margin upward, papillose epidermis, stellate and prominently lobed.

(B) Inner sheath thickened-wall present only distinct around phloem.

(C) Scape four ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, irregular shaped cells in chlorenchymatous band.

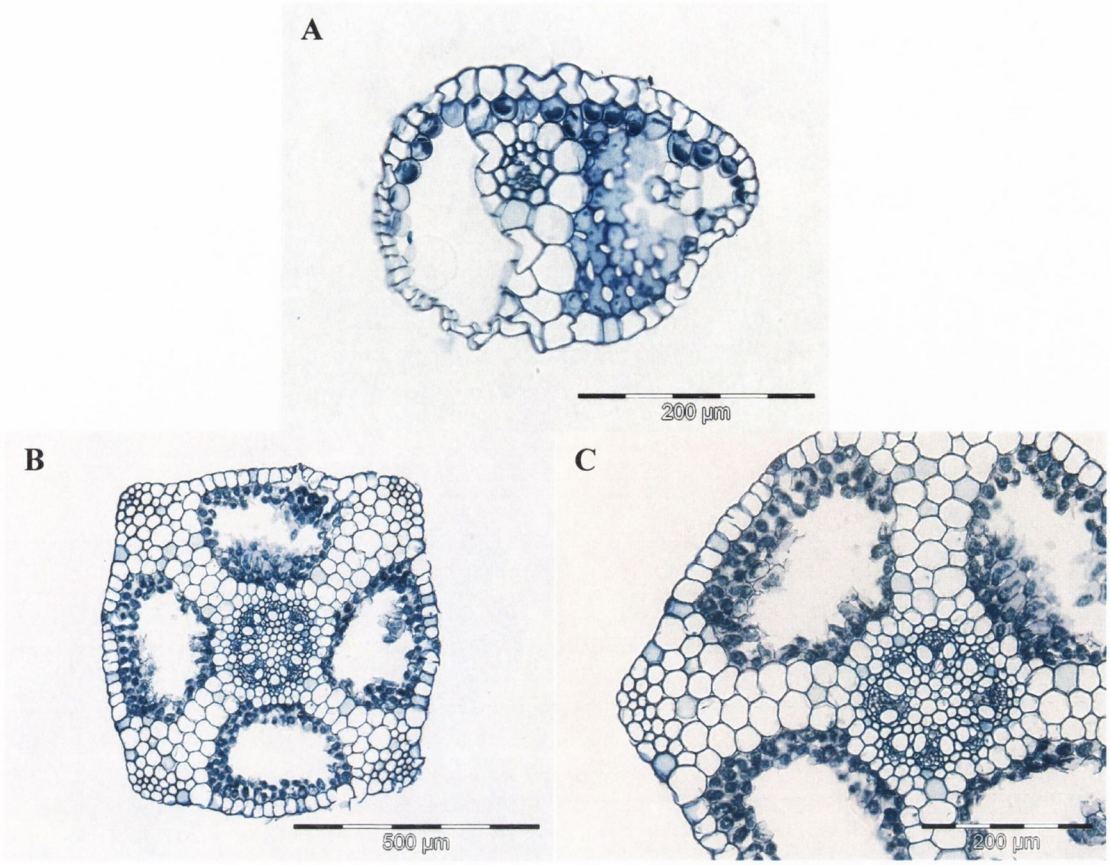

Figure 3.56 Anatomy of leaf and scape of *Eriocaulon setaceum* from *A.Prajaksood & S.Suddee* 243.

(A) Leaf margin straight, inner sheath thickened-wall present surrounding vein, stellate and scarcely lobed.

(B) Scape four ribs.

(C) Endodermoid layer in scape indistinct, isodiametric or irregularly shaped cells in chlorenchymatous band.

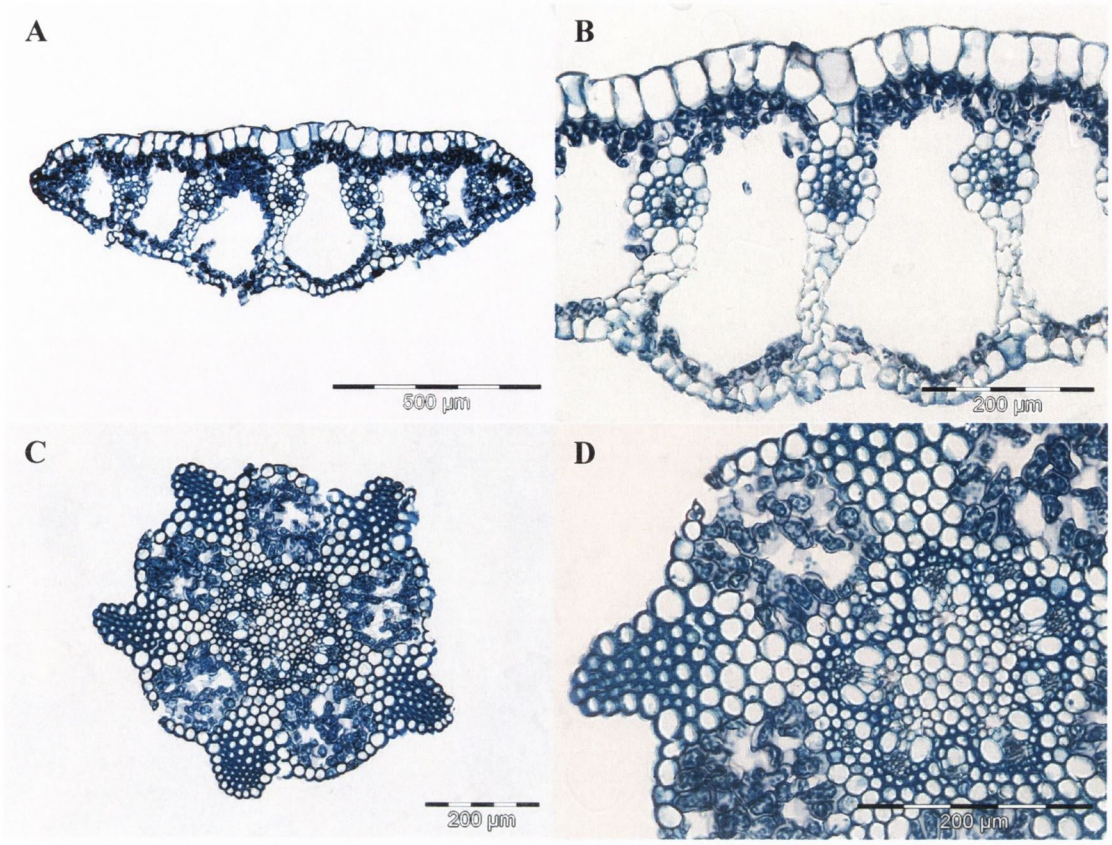

Figure 3.57 Anatomy of leaf and scape of *Eriocaulon siamense* from *A.Prajaksood & S.Suddee* 200.

(A) Leaf margin straight, stellate and scarcely lobed.

(B) Inner sheath thickened-wall present surrounding vein.

(C) Scape five ribs.

(D) Endodermoid layer in scape distinct, running outside large but passing both sides of small bundles, irregularly shaped cells in chlorenchymatous band.

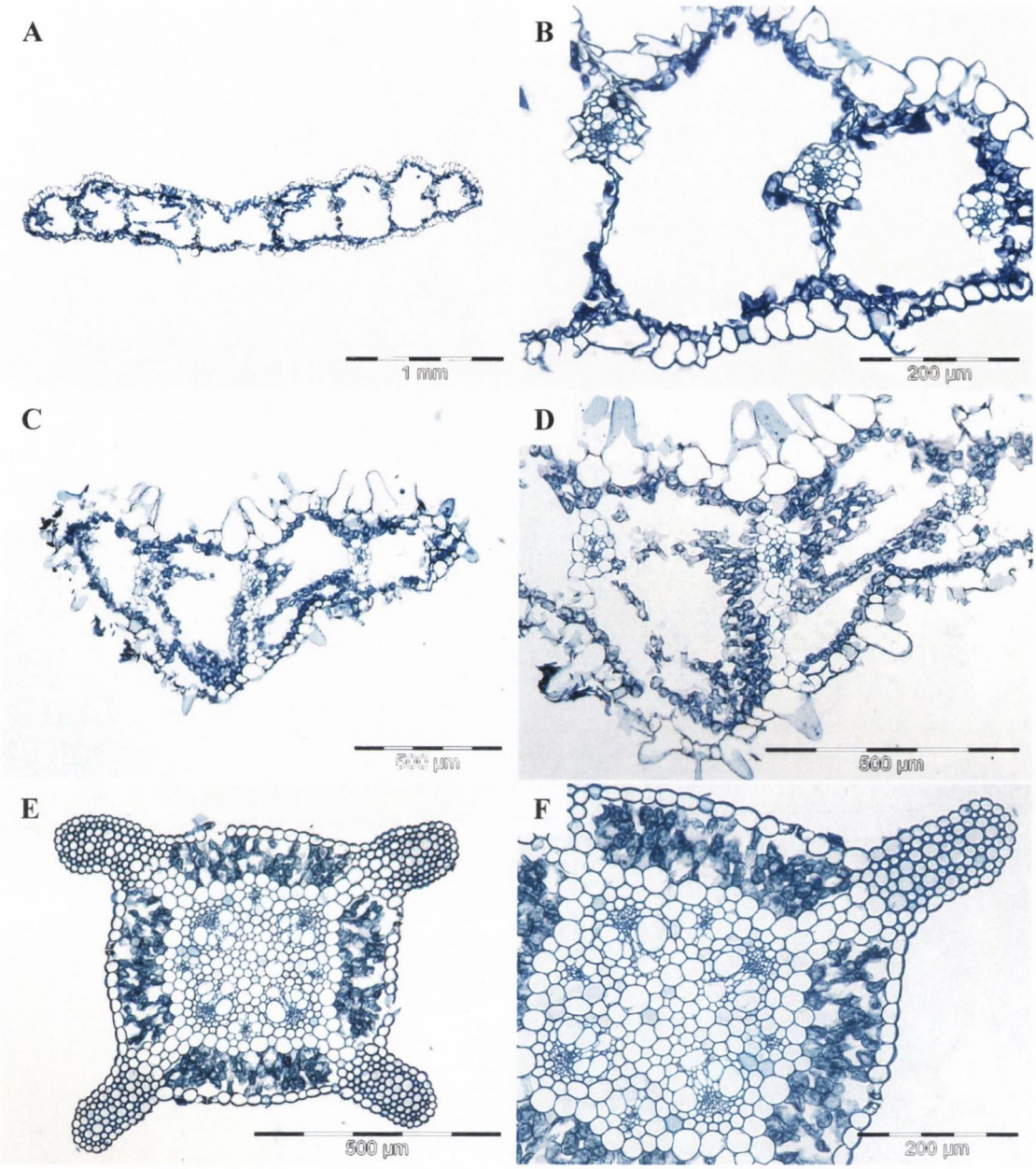

Figure 3.58 Anatomy of leaf and scape of *Eriocaulon siamense* from *A.Prajaksood & S.Suddee* 258.

(A) Leaf margin straight.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed, papillose epidermis.

(C) Leaf margin upward in distal part.

(D) Distinct papillose epidermis in distal part of the leaf.

(E) Scape four ribs.

(F) Endodermoid layer in scape indistinct, isodiametric or elongated cells in chlorenchymatous band.

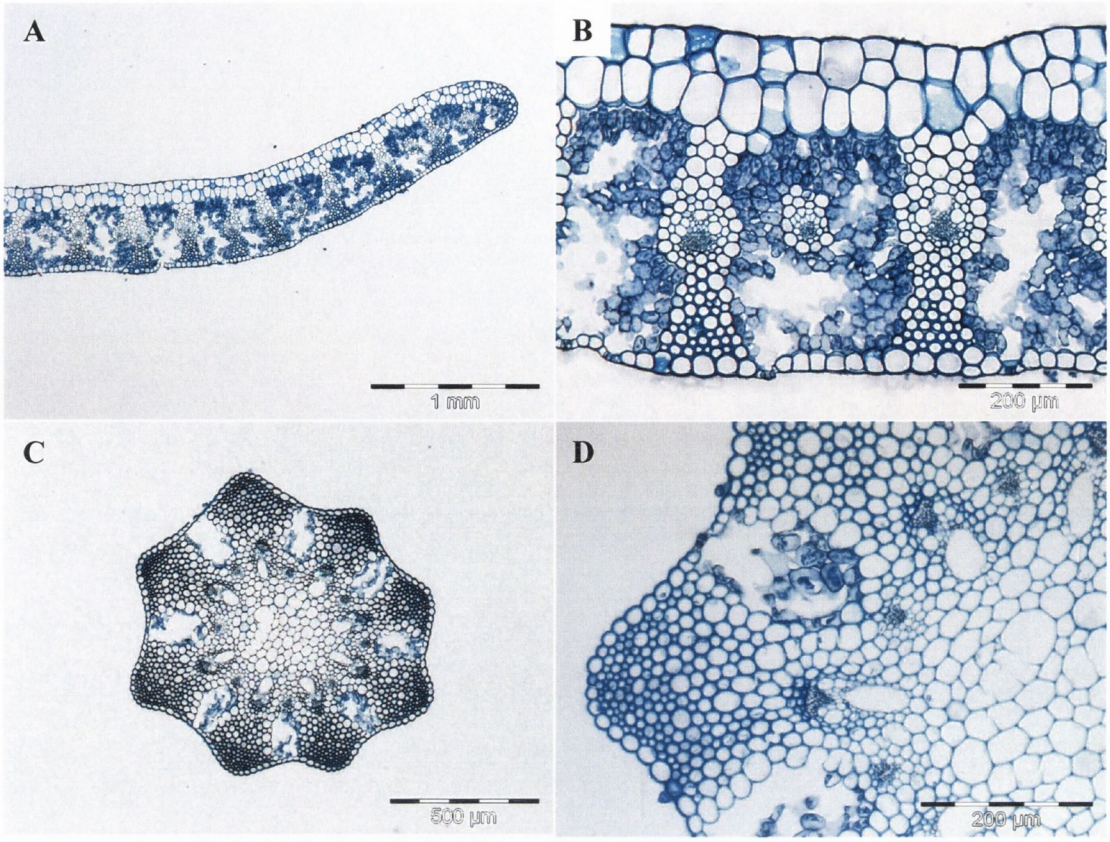

Figure 3.59 Anatomy of leaf and scape of *Eriocaulon siamense* var. *macrophyllum* from *A.Prajaksood & S.Suddee* 203.

(A) Leaf margin upward, hypodermis present in adaxially.

(B) Inner sheath thickened-wall absent, stellate and scarcely lobed.

(C) Scape eight ribs.

(D) Endodermoid layer in scape indistinct, isodiametric or irregularly shaped cells in chlorenchymatous band.

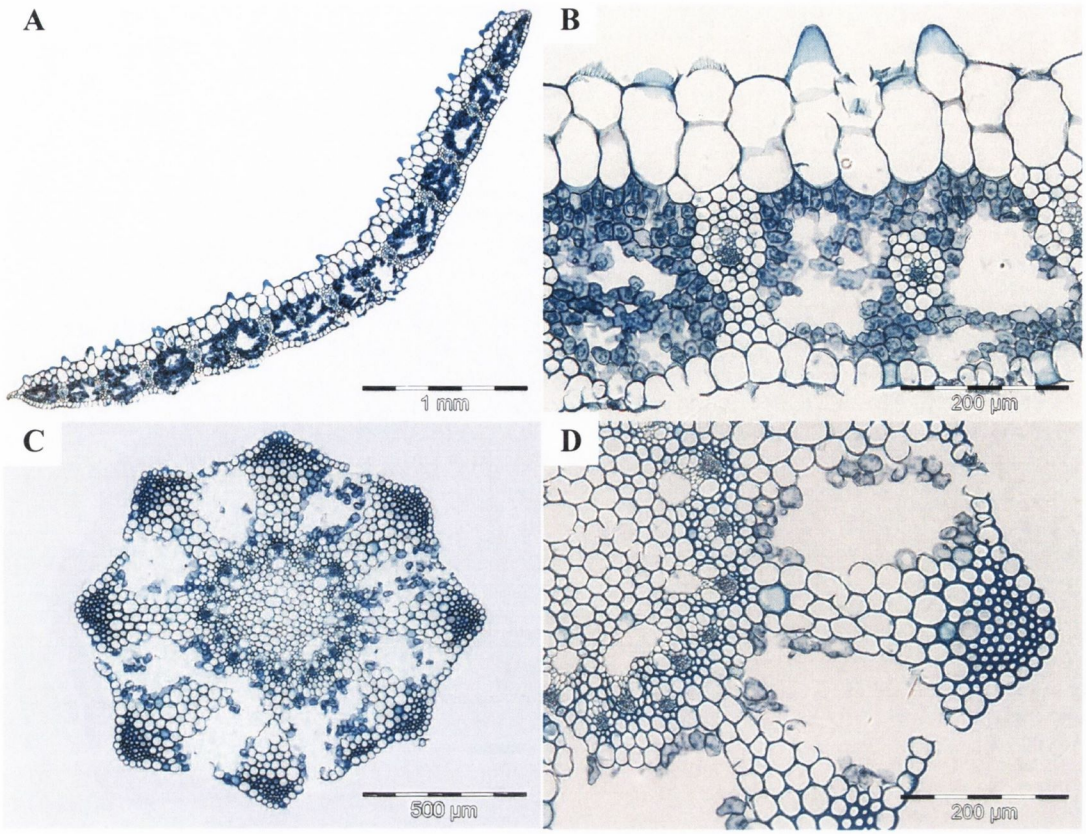

Figure 3.60 Anatomy of leaf and scape of *siamense* var. *macrophyllum* from *A.Prajaksood & S.Suddee* 241.

(A) Leaf margin upward, papillose epidermis and hypodermis present in adaxially.

(B) Inner sheath thickened-wall present only distinct around phloem, stellate and scarcely lobed.

(C) Scape eight ribs.

(D) Endodermoid layer in scape distinct, running outside large but passing both sides of small bundles, stellate and scarcely lobed.

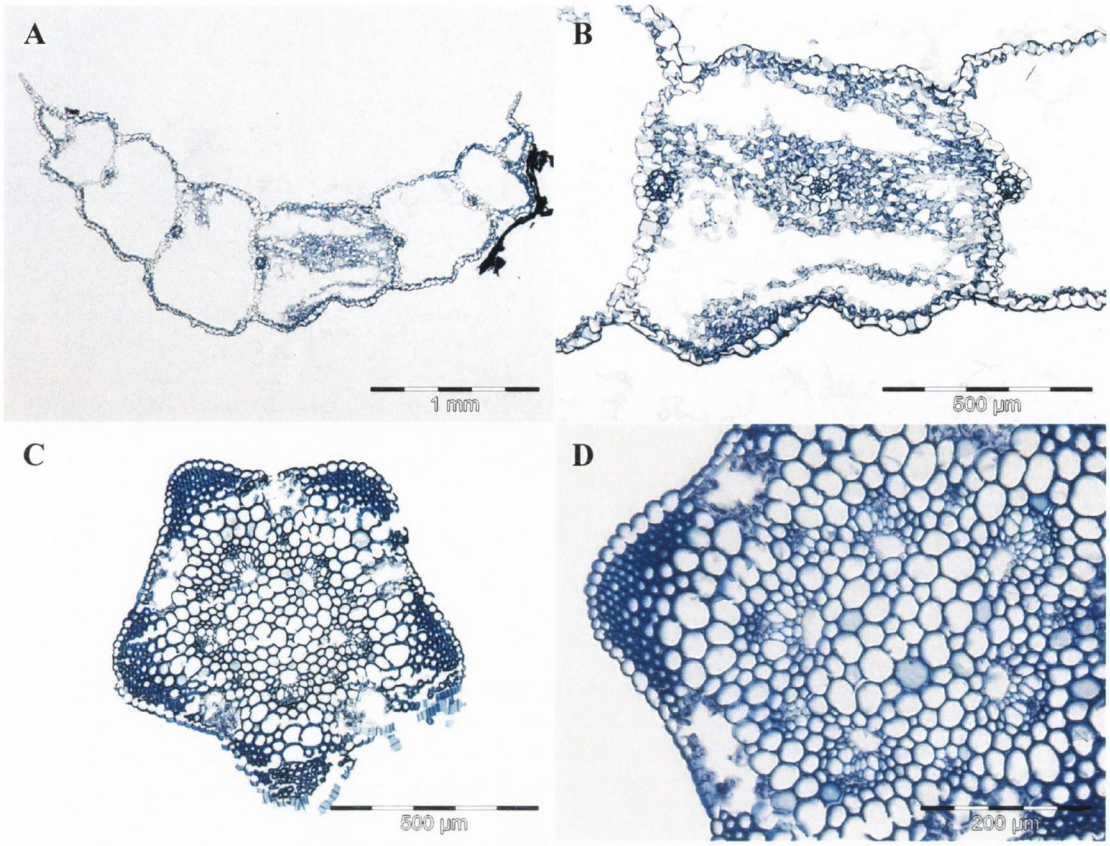

Figure 3.61 Anatomy of leaf and scape of *Eriocaulon siamense* Moldenke ssp. *hexagynum* from *A.Prajaksood & S.Suddee* 281.

(A) Leaf margin upward, acuminate.

(B) Inner sheath thickened-wall present surrounding vein, stellate and prominently lobed.

(C) Scape five ribs.

(D) Endodermoid layer in scape indistinct, isodiametric cells in chlorenchymatous band, parenchymatous and sclerotic parenchymatous pith.

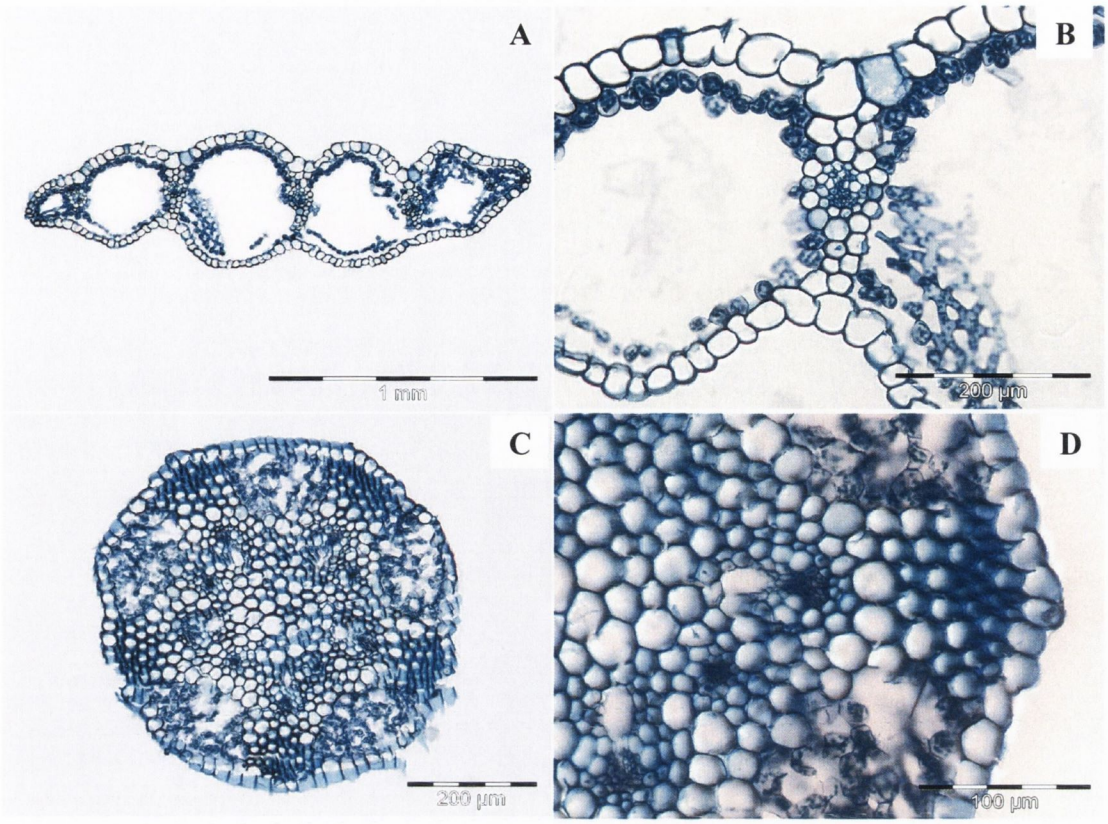

Figure 3.62 Anatomy of leaf and scape of *Eriocaulon smitinandii* from *A.Prajaksood & S.Suddee* 205.

(A) Leaf margin straight.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape no ribs with five buttresses.

(D) Endodermoid layer in scape indistinct, irregularly shaped cells in chlorenchymatous band, parenchymatous and sclerotic parenchymatous pith.

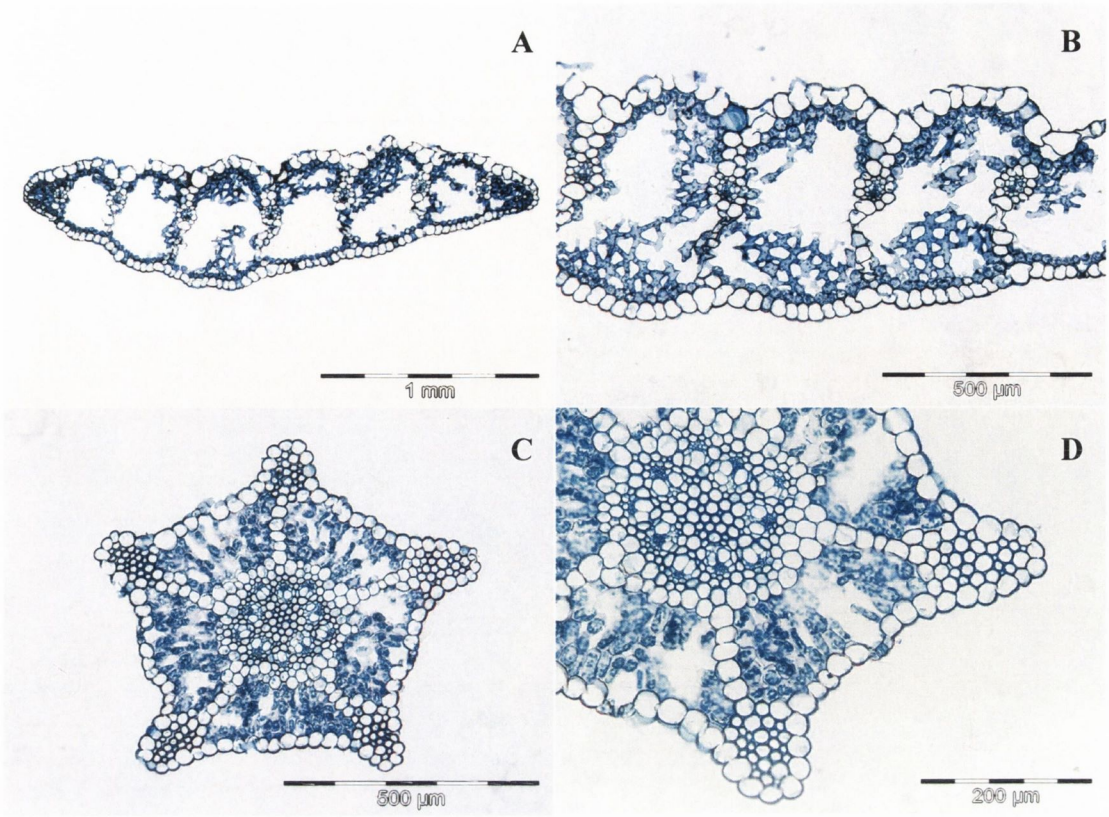

Figure 3.63 Anatomy of leaf and scape of *Eriocaulon thailandicum* from *A.Prajaksood & S.Suddee* 252.

(A) Leaf margin straight.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape five ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, isodiametric or elongated cells in chlorenchymatous band, sclerotic parenchymatous pith.

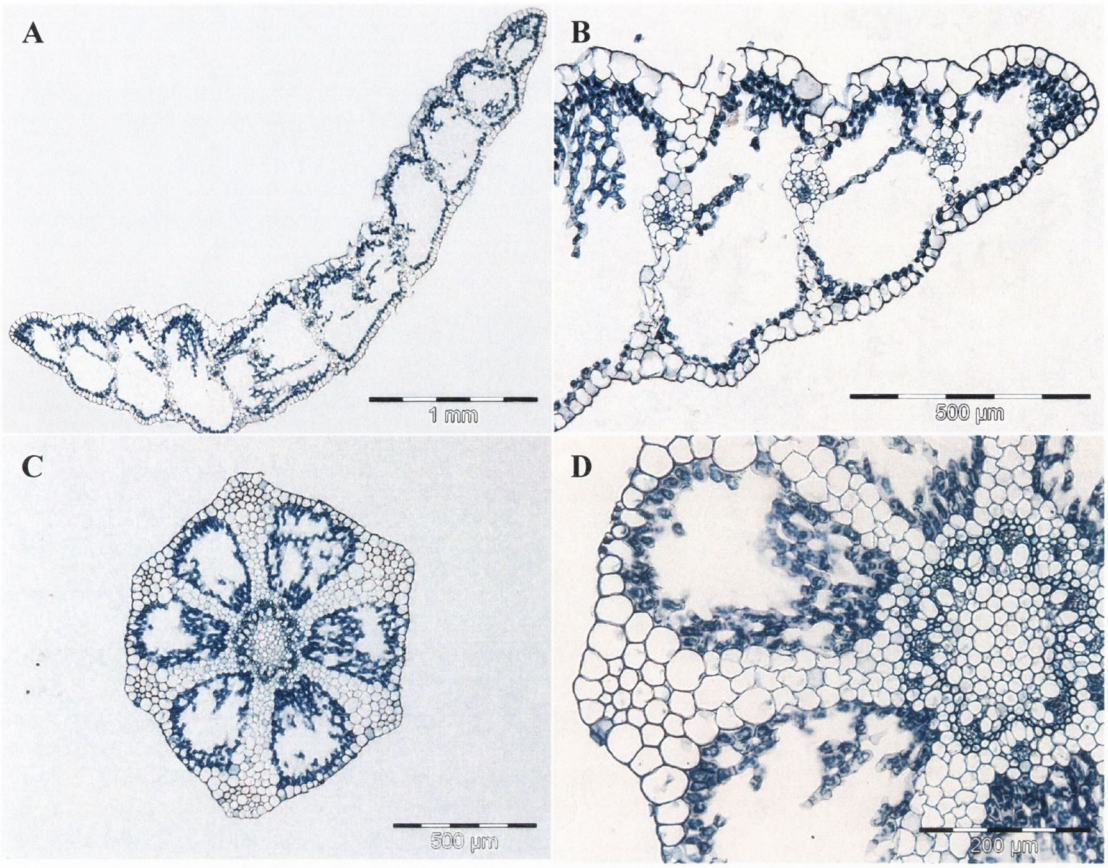

Figure 3.64 Anatomy of leaf and scape of *Eriocaulon truncatum* from *A.Prajaksood & S.Suddee* 245.

(A) Leaf margin upward.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape six ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, stellate and scarcely lobed.

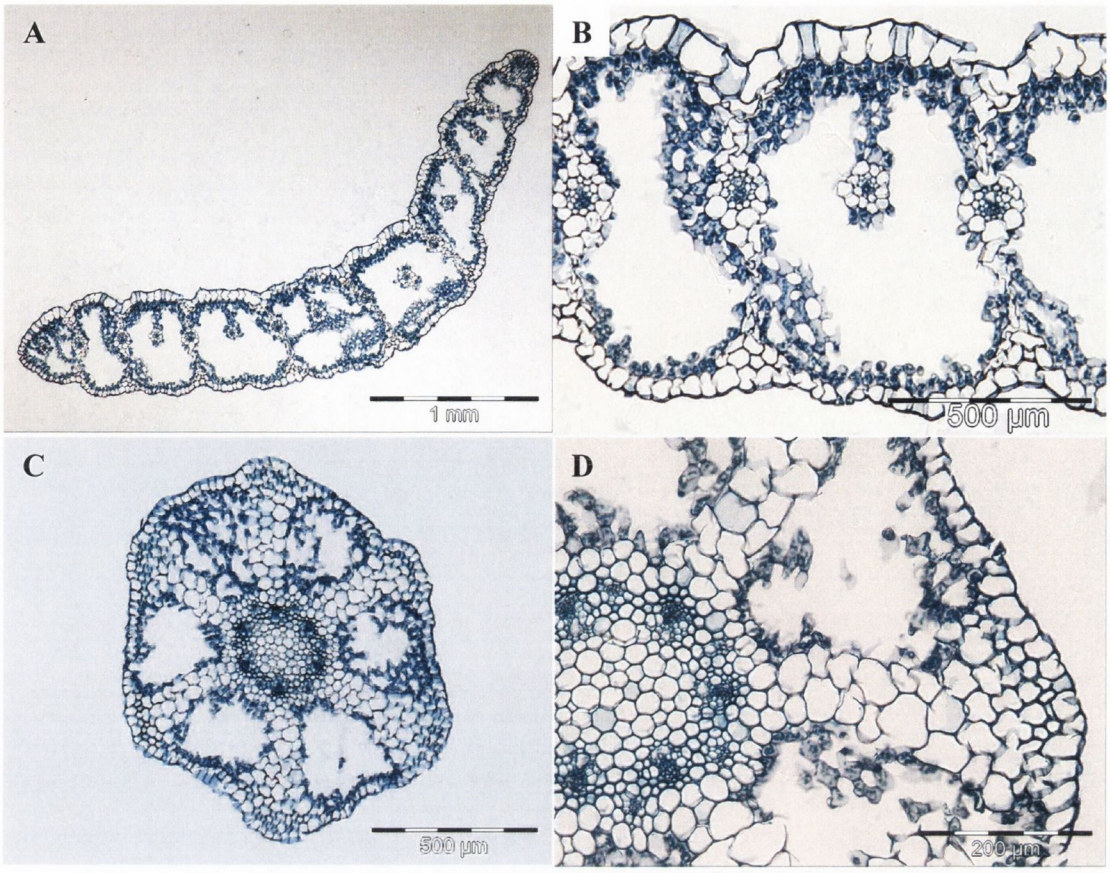

Figure 3.65 Anatomy of leaf and scape of *Eriocaulon truncatum* var. *florensense* from *A.Prajaksood & S.Suddee* 162.

(A) Leaf margin upward.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape six ribs.

(D) Endodermoid layer in scape indistinct, stellate and prominently lobed.

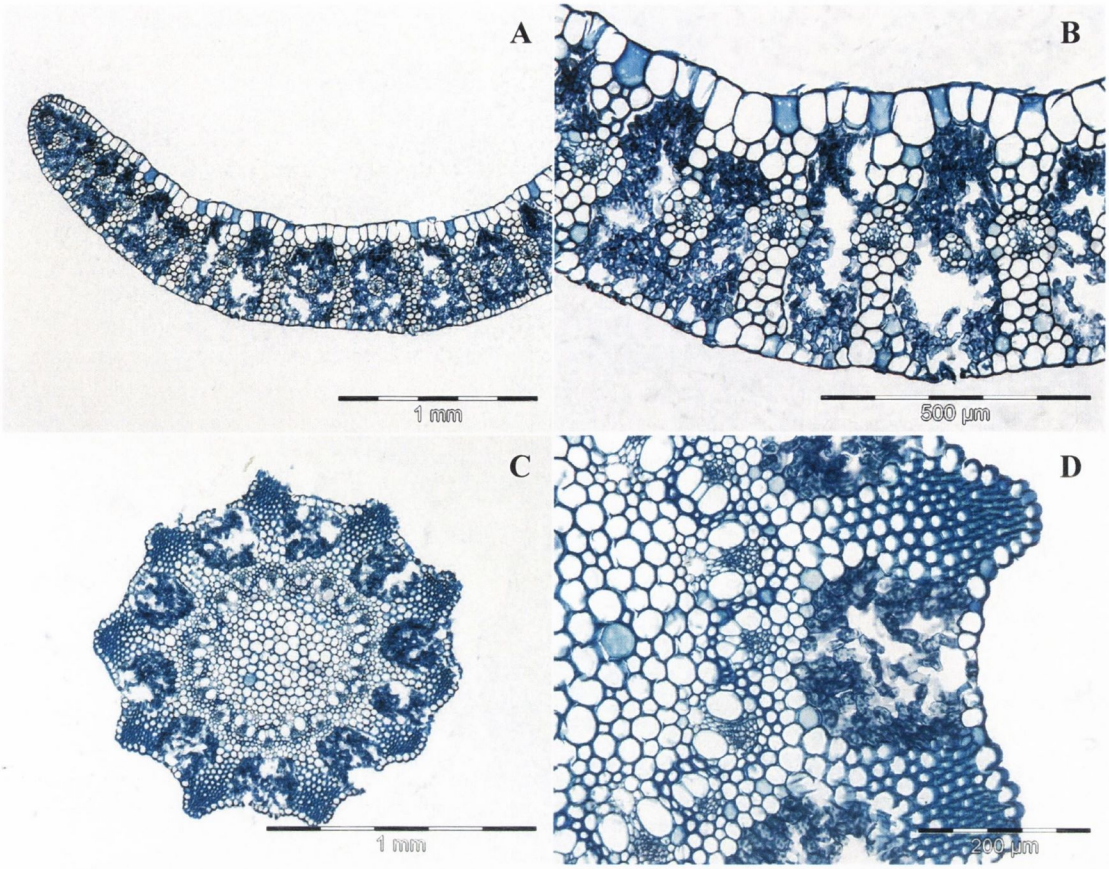

Figure 3.66 Anatomy of leaf and scape of *Eriocaulon ubonense* f. *kradungense* from *A.Prajaksood & S.Suddee* 202.

(A) Leaf margin upward.

(B) Inner sheath thickened-wall absent, stellate and scarcely lobed.

(C) Scape ten ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, irregularly shaped cells in chlorenchymatous band, parenchymatous and sclerotic parenchymatous pith.

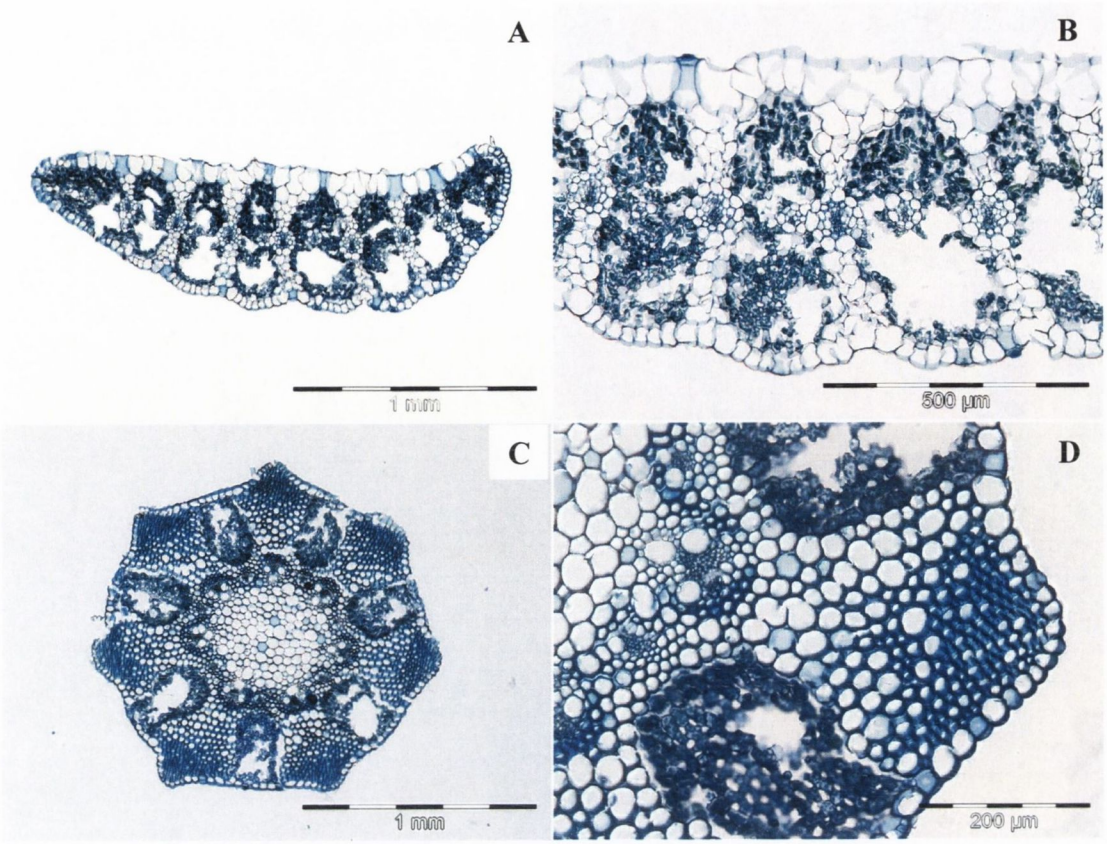

Figure 3.67 Anatomy of leaf and scape of *Eriocaulon ubonense* from *A.Prajaksood & S.Suddee* 238.

(A) Leaf margin upward.

(B) Inner sheath thickened-wall absent, stellate and scarcely lobed.

(C) Scape seven ribs.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, stellate and scarcely lobed.

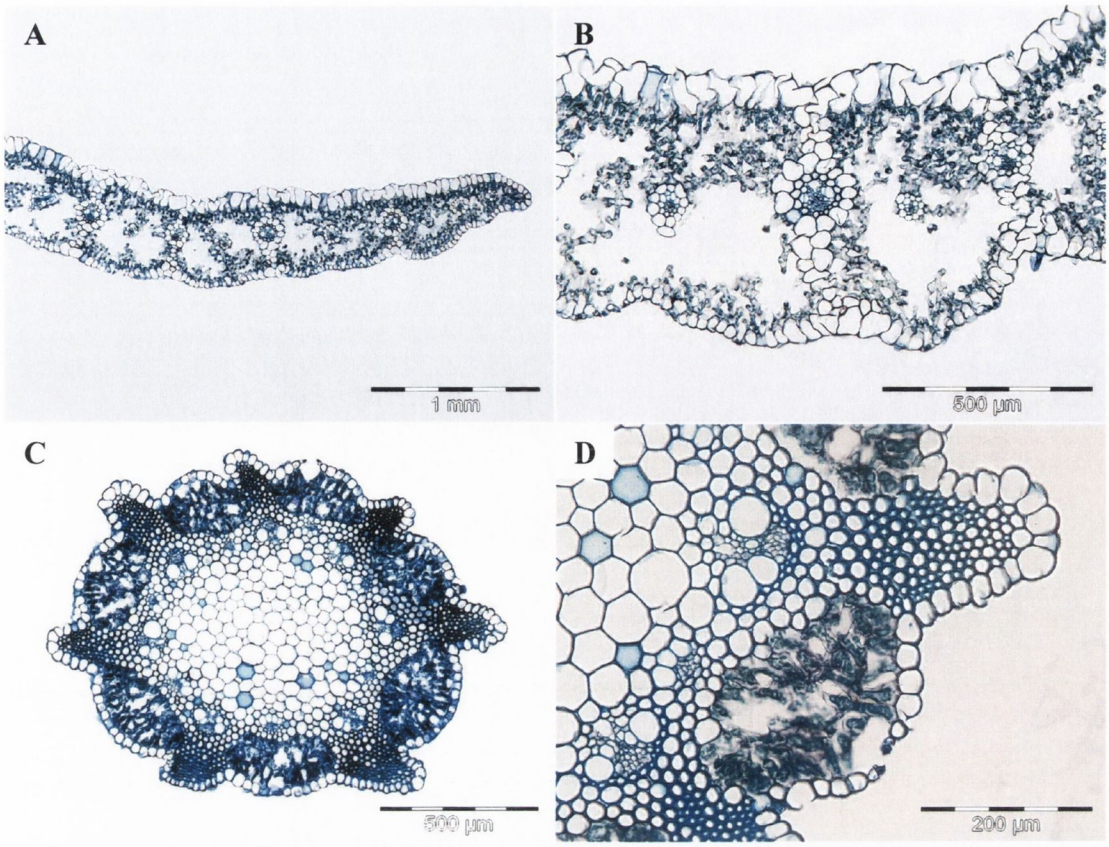

Figure 3.68 Anatomy of leaf and scape of *Eriocaulon wightianum* from *A.Prajaksood & S.Suddee* 176.

(A) Leaf margin upward.

(B) Inner sheath thickened-wall present surrounding vein, stellate and prominently lobed.

(C) Scape seven ribs.

(D) Endodermoid layer in scape indistinct, irregularly shaped cells in chlorenchymatous band.

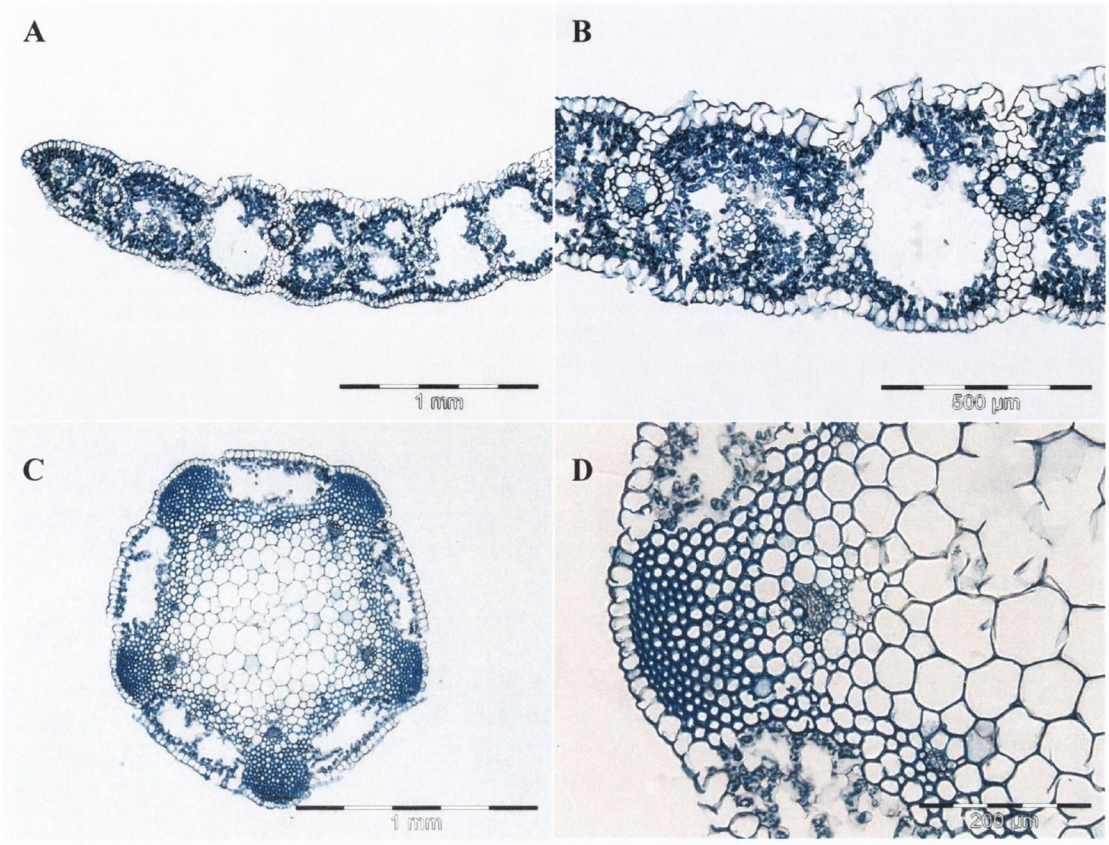

Figure 3.69 Anatomy of leaf and scape of *Eriocaulon willdenovianum* from *A.Prajaksood & S.Suddee* 170.

(A) Leaf margin upward.

(B) Inner sheath thickened-wall present surrounding vein, stellate and prominently lobed.

(C) Scape five ribs.

(D) Endodermoid layer in scape indistinct, stellate and scarcely lobed.

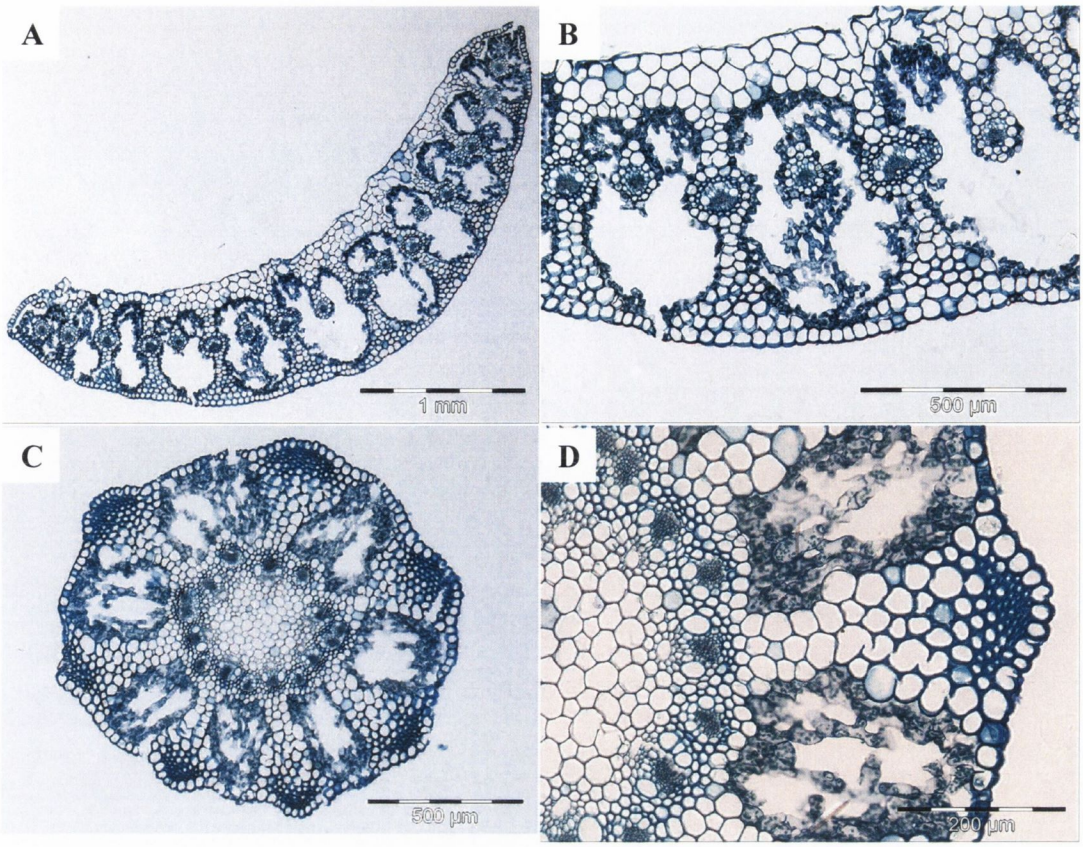

Figure 3.70 Anatomy of leaf and scape of *Eriocaulon xenopodium* from *A.Prajaksood & S.Suddee* 158.

(A) Leaf margin upward, hypodermis present in adaxially.

(B) Inner sheath thickened-wall present surrounding vein, stellate and prominently lobed.

(C) Scape seven ribs.

(D) Endodermoid layer in scape distinct, running outside large but passing both sides of small bundles, stellate and prominently lobed.

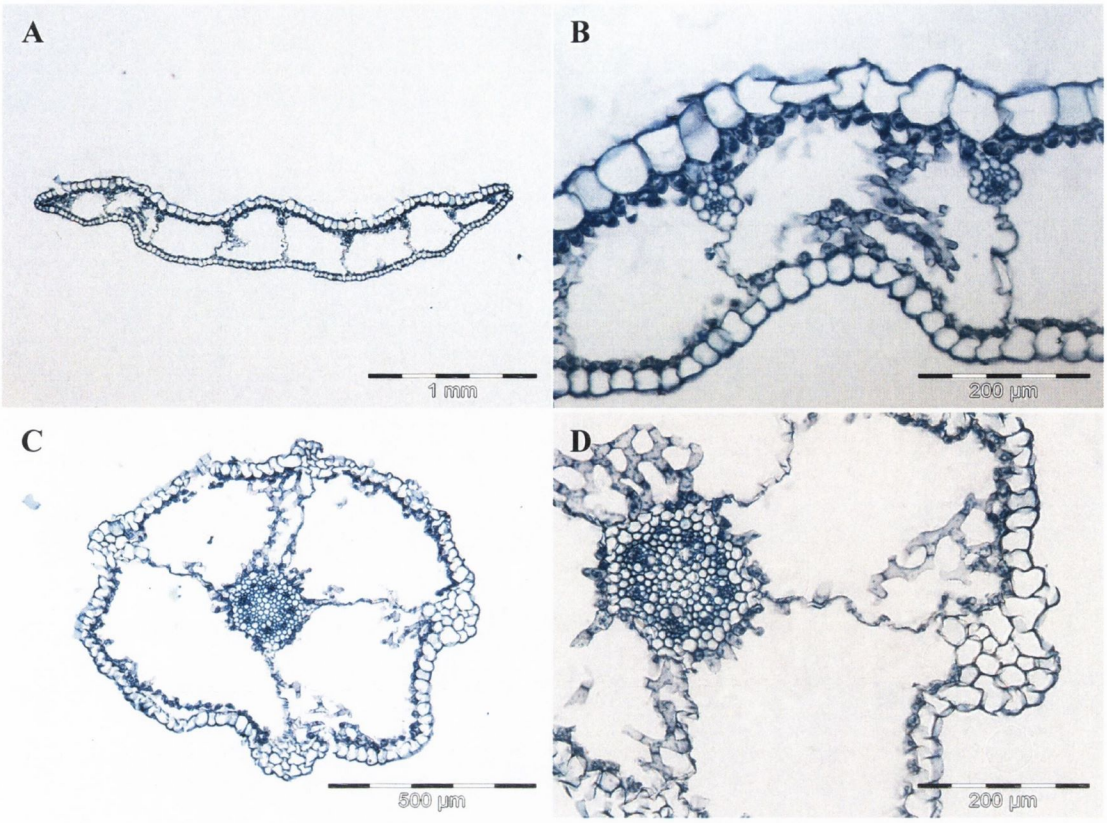

Figure 3.71 Anatomy of leaf and scape of *Eriocaulon xeranthemum* from *A.Prajaksood & S.Suddee* 166.

(A) Leaf margin upward.

(B) Inner sheath thickened-wall present surrounding vein, stellate and prominently lobed.

(C) Scape four ribs.

(D) Endodermoid layer in scape indistinct, stellate and prominently lobed.

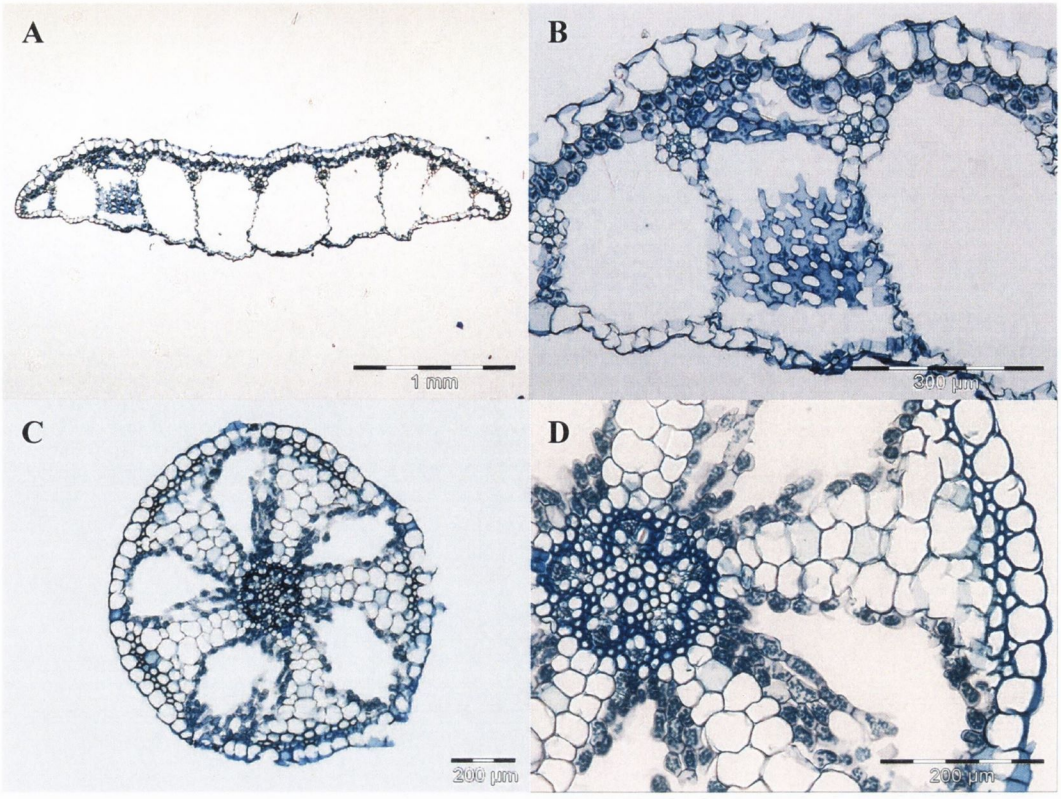

Figure 3.72 Anatomy of leaf and scape of *Eriocaulon zollingerianum* from *A.Prajaksood & S.Suddee* 165.

(A) Leaf margin downward.

(B) Inner sheath thickened-wall absent, stellate and prominently lobed.

(C) Scape no ribs with five buttresses.

(D) Endodermoid layer in scape distinct, running outside large but inside small bundles, stellate and scarcely lobed, sclerotic parenchymatous pith.

3.6 Discussion

Most earlier anatomical studies in the family were based on material which was not Asian, *e.g.* the studies by van Tieghem (1887), Poulsen (1888), Holm (1901), Ruhland (1903), Solereder and Meyer (1929), Solomon (1931) and Hare (1950). However, Prajaksood (2000) is the most similar in environment and specimens examined to the current work. However, it concentrated exclusively on the Northeast of Thailand. Following field work, I found that the environment has a great impact on morphology. It should be noted that it is possible that anatomical differences found between this and previous studies may be due to the environment. The anatomical characters of *Eriocaulon* are hydrophilic as they grow in wet or moist environments; therefore most of the characters found in this study agreed with the previous studies.

3.6.1 Hairs on the vegetative organs

The hairs are filamentous uniseriate with a basal cell and a collar cell as earlier studies (Tomlinson, 1969) (Figures 3.4A-E and 3.37D). The unbranched three-celled glandular hairs (Figure 3.6) were not easily to recognized from the transverse section in this study, however, they were found in *Eriocaulon* in Thailand (Figure 3.8H) (Prajaksood, 2000). Branched three-celled glandular hairs (Figure 3.7A-F) and multicellular capitate glandular hairs (Figure 3.7G-J) have not been reported in the genus.

3.6.2 Leaves

The common leaf characters in *Eriocaulon* which agreed with previous studies (Tomlinson, 1969) were the dorsiventral structure (as found common in the family) and thin and finely striated longitudinally cuticle (Figure 3.24A).

Epidermis:

The outline of the leaves has not been reported previously, and is not taxonomically important because it varies within a species. For example, the adaxial surface of the median lamina varies from concave to convex and the abaxial surface varies from convex to concave, *e.g. Eriocaulon nepalense* var. *luzulaefolium* (Figures 3.45 A and 3.46 A); or the adaxial surface of the median lamina varies from flat to concave and the abaxial surface varies from flat to convex, *e.g. E. phuchongense* (Figures 3.49 A and 3.50 A).

The epidermal cells were either: (a) adaxial cells usually larger than abaxial cells— a similar finding to Tomlinson (1969), however, similar sized cells are also found in the same species, *e.g. E. nepalense* var. *luzulaefolium* (Figures 3.45 B and 3.46 B); or (b) costal often larger than intercostal cells (Tomlinson, 1969), however, similar sized cells are also found in the same species, for example *E. siamense* (Figure 3.57 B) or *E. willdenovianum* (Figure 3.69 B).

In most species in *Eriocaulon*, papillae are absent; the presence of a papillate epidermis was useful for recognizing species (Prajaksood, 2000), however, it is noted that they may be absent or present in some species, for example in *E. nepalense* var. *luzulaefolium* (Figures 3.45 B and 3.46 B), in *E. siamense* (Figures 3.57 B, 3.58 A and C). Additionally, Prajaksood (2000) reported a papillate epidermis in *E. zollingerianum* (*E. alatum* sensu Prajaksood, 2000) in the specimens collected from Phu Phan National Park, Sakon Nakhon (Northeast floristic region) but these papillae were absent from specimens collected from Makham, Chantaburi (Southeast floristic region). Similarly, a papillate epidermis was present in *E. hamiltoniamum* (*E. minimum* sensu Prajaksood, 2000), specimens collected in Phu Phan National Park, Sakon Nakhon (Prajaksood, 2000) but absent from material in Pribueng, Si Sa Ket (Eastern floristic region, collector number 250) and in Phu Phan National Park, Sakon Nakhon (collector numbers 314 and 324). These observations prove that this character varies in the same species even within the same area. *E. echinulatum* from Phu Phan National Park, Sakon Nakhon and from Muang, Trat (Southeast floristic region) also have papillate epidermis. *E. infirmum* (*E. nakayense* sensu Prajaksood, 2000).

The sinous anticlinal wall was first recognized in the family by Prajaksood (2000). Most species in this study have non-sinous walls, however, this character varies in some species, for example it may be absent or present in *E. siamense* (Figures 3.57 B and 3.58 D); therefore this character is not useful for identification. The presence of sinous anticlinal wall in *E. zollingerianum, E. hamiltonianum, E. infirmum* and *E. ubonense* f. *kradungense* (*E. kradungense* sensu Prajaksood, 2000) (Prajaksood, 2000) was confirmed.

A hypodermis was reported as present in some species of *Paepalanthus, Syngonanthus* and some American *Eriocaulon* species, *i.e. E. humboldtii* and *E. decangulare* (Tomlinson, 1969). This character was absent in most *Eriocaulon* examined, however, this character is taxonomically important and this study may be the first report of a hypodermis found in Asian species (see Appendix 4, Table A, character number 28).

Stomata were paracytic (the grass type) and hypostomatic (confined to adaxial surface) (therefore agreeing with previous studies). Guard cells with both an outer and inner ledge were found (agreeing with Solereder and Mayer, 1929), however, the inner ledge was rarely present. Therefore, the character of stomata is not taxonomically valuable. The density of guard cells per unit area has never been studied. However, I noted that this varies from the basal to distal part of the leaves and depends on the width of the leaves which in itself is dependant on habitat.

Vascular tissue:

The veins (vascular bundles) are arranged in a single series. The position of the veins compared with the surface is taxonomically valuable, *e.g. E. zollingerianum* (*E. alatum* sensu Tomlinson, 1969) has the bundles closest to adaxial surface. Tomlinson (1969) stated that the number of veins is constant in narrow-leaved species but less constant in broader-leaved species. However, I noted that the width of

the leaves varies dependant on the environment; therefore, there is no consistency in the number of veins in the leaves. For example, Tomlinson (1969) reported that *E. zollingerianum* always has 8 veins but I found 9 veins. I believe that this difference arises from a difference in position of the section along the leaves and environment. However, in *E. setaceum* which has filiform leaves, the number of veins is always constant and this species always has only 1 vein. The vascular tissue of the larger veins showed a distinct protoxylem lacuna and metaxylem including two wide vessels in *Eriocaulon* as similar to the observation by Tomlinson (1969). Transvese veins were also found (as reported by Poulsen, 1888).

Buttresses:

Buttresses are usually parenchymatous, however, collenchymatous buttresses were also found in *Eriocaulon* (Tomlinson, 1969). Tomlinson (1969) grouped the vascular bundles in transverse section into 4 categories using the character-buttresses. However, my study confirmed his observation that all of the categories can be seen in transverse sections taken at different levels in a single leaf.

Mesophyll:

Air-lacunae (air space) were always seen in *Eriocaulon* as reported by Tomlinson (1969) and Prajaksood (2000). Transverse uniseriate diaphragms of stellate chlorenchymase cells were also seen to produce a regular fenestrate structure in leaves as stated by Tomlinson (1969) (Figure 3.24D).

3.6.3 Scapes

The anatomy of scapes (inflorescence axis) was interesting as previous researchers (Lecomte,1907; Malmanche, 1919; Stützel, 1998 and Zhang, 1999) stated that they were diagnostic features. Additionally, Scatena *et al.* (2005) concluded that scape characters appear to be more informative in discriminating groups within the family. Radially symmetric scapes were found in this study for the first time; bilateral symmetry being thought previously to be universal.

Epidermis:

I noted that the number of ribs is constant in each species within quite narrow limits as stated by Tomlinson (1969). However, I also found that they were not constant in some species, *e.g.* there were 7 to 10 ribs in *E. ubonense* (Figures 3.66 and 3.67). Maybe the number of ribs depends on the environmental conditions. Zhang (1999) recognized 2 subgenera of Eriocaulaceae using the comparative size of epidermis above the ribs and other areas; subgenus *Trimeranthus* (*e.g. E. brownianum, E. ubonense* f. *kradungense*, *E. sexangulare* and *E. wightianum*) has the epidermal cells above the ribs neither smaller nor more thickened than in others areas. In contrast, subgenus *Spathopeplus*, *e.g. E. infirmum* (*E. eglandulatum* sensu Zhang, 1999), has cells distinctly smaller and more thickened than in other areas. However, I found that my results agreed with Zhang (1999) for *E brownianum* and *E. wightianum* but not for *E. ubonense* f. *kradungense* and *E. infirmum*. Therefore, I consider this character not to be useful for identification.

Cortex:

Previous studies showed the cortex to be usually much wider than the stele (Tomlinson, 1969). I noticed that the comparative radial width of a chlorenchymatous band with the diameter of stele was of taxonomic value.

The innermost buttresses of *E. echinulatum* were not only uni- or bi-seriate (Prajaksood, 2000) but also multi-seriate. The sizes of the parenchymatous cells were larger and thinner in hydrophytic species (*e.g. E. cinereum* and *E. truncatum*) as shown by Zhang (1999).

In the outermost buttresses, the cells are thick-walled, *e.g. E. brownianum* and *E. infirmum* (*E. gracile* sensu Zhang, 1999) or sclerotic in more rigid scapes (*e.g. E. siamense*) as shown by Zhang (1999).

Stele:

Zhang (1999) proposed there to be four types of endodermoid layer based on the layout of thick-walled cells in the stele, *e.g. E. ubonense* f. *kradungense* and *E. nautiliforme* were of type II (endodermoid layer runs only between the outer and the inner bundles). My results agreed with Zhang (1999) for *E. ubonense* f. *kradungense,* whereas I found that the endodermoid layer was indistinct in *E. nautiliforme* (Figure 3.42C-D) and also found that the presence of an endodermoid layer varied from indistinct to distinct in, for example, *E. hamiltonianum* (Figures 3.35 D and 3.36 D) and in *E. laosense* (Figures 3.39 D and 3.40 D). Therefore, this character should not be used for identification.

My results agreed with Zhang (1999) in that the medulla (pith) of *E. siamense* and *E. willdenovianum* were thin-walled cells; where as Zhang (1999) reported a few thick-walled cells in *E. infirmum* but I found no thick-walled cells. Therefore, this character must not be used for identification.

3.6.4 Crystal

The presence of crystals which may be prism-like, needle-like or druse-like was reported by Tomlinson (19690 and Prajaksood (2000). However, this study found prism-like crystals only. Maybe the presence of other crystal types depends on the habitat as well.

3.7 Conclusion

According to the results of the anatomical study of 46 specimens examined within 34 taxa of Eriocaulaceae in Thailand, the following summary can be constructed:

3.7.1 The general anatomical characters within *Eriocaulon*

The anatomical characters which were found in every specimen examined, are listed below:

Leaves

1. Shape of epidermal cells: circular or rectangular
2. Stomata superficial or slightly raised, present only in lower epidermis
3. Collateral vascular tissue
4. Two-layered bundle sheath
5. Air space in mesophyll
6. Trichomes present

Scapes

7. Shape of epidermal cells: circular or rectangular
8. Stomata superficial or slightly raised
9. Periclinal wall cutinized epidermis
10. Non papillae periclinal wall epidermis
11. Hypodermis absent
12. Trichome present
13. Stomata present
14. Large vascular bundles opposite buttresses and small vascular bundles opposite chlorenchymatous band

3.7.2 The variation of anatomical characters within *Eriocaulon*

Ruhland (1903) noted that *Eriocaulon* seems very specialized in its anatomy. However, its anatomy is quite diverse as I found that most of anatomical characters in this genus are variable as described in the discussion and listed below:

Leaves

1. Outline (see details in the discussion).

2. Leaf margin: varying from upward to downward, for example in *E. nepalense* var. *luzulaefolium* (Figures 3.45 A and 3.46); or upward to straight, for example in *E. siamense* (Figures 3.57 A and 3.58 A). Leaf margin varying from rounded to acuminate, for example *E. siamense* var. *macrophyllum* (Figures 3.59 A and 3.60 A).

3. Comparative size of epidermal cells (see details in the discussion).

4. Shape of epidermal cells: varying from circular or rectangular, for example *E. escape* (Figure 3.33 E and F); periclinal wall of cells finely striated longitudinally, cutinized or not cutinized, for example in *E. chantaranothaii* or in *E. nepalense* var. *luzulaefolium*.

5. The presence of papillate epidermis (see details in the discussion).

6. The presence of sinous anticlinal wall cells (see details in the discussion).

7. The presence of thickened-wall cells in the inner sheath of the major vascular bundle: (a) varying from absent to present, for example in *E. nepalense* var. *luzulaefolium* (Figures 3.45 B and 3.46 B); (b) present and forming a single layer or present only around the xylem as in *E. willdenovianum* (Figure 3.25 A-B); (c) present as a single layer or only around the phloem as in *E. hamiltonianum* (Figures 3.35 B and 3.36 B).

8. The presence of collenchymatous buttress cells vary from absent to present, for example in *E. ubonense* f. *kradungense* (Figures 3.66 B and 3.67 B).

9. The mesophyll buttresses vary from uniseriate to multi-seriate, for example in *E. ubonense* f. *kradungense* (Figures 3.66 B and 3.67 B).

10. The presence of continuous buttresses vary from continuous to discontinuous, for example in *E. hamiltonianum* (Figures 3.35 A and 3.3.6 A) or in *E. siamense* (Figures 3.57 A and 3.58 B, D).

11. The shape of chlorenchymatous cells: (a) palisade cells vary from isodiametric, to elongated shaped, for example in *E. ubonense* f. *kradungense* (Figures 3.66 B and 3.67 B); (b) spongy cells vary from stellate and scarcely lobed to stellate and prominently lobed, for example in *E. siamense* (Figures 3.57 A and 3.58 D), in *E. nepalense* var. *luzulaefolium* (Figures 3.45 B and 3.46 B).

Scapes

12. The presence of ribs: varies from absent to present as in *E. chantaranothai* (Figures 3.29 C and 3.30 C).

13. The number of ribs: (a) varies between 3 or 4 ribs as in *E. laosense* (Figures 3.39 C and 3.40 C), *E. phuchongense* (Figures 3.49 C and 3.51 C) and *E. phuphanoides* (Figures 3.52 C and 3.54 C); (b) or 4 or 5 ribs as in *E. siamense* (Figures 3.57 C and 3.58 C); (c) or 7 or 10 ribs as in *E. ubonense* (Figures 3.66 C and 3.67 C).

14. The presence of sinous anticlinal wall cells: most species are non-sinous, however, in *E. phuphanoides* they may or may not be sinous (Figures 3.53 C and 3.54 C).

15. The shape of chlorenchymatous cells: (a) varies from isodiametric to elongated or irregularly shaped, for example in *E. nepalense* var. *luzulaefolium* (Figures 3.45 D and 3.46 D); (b) varies from isodiametric, elongated, stellate and scarcely lobed to stellate and prominently lobed, for example in *E. hamiltonianum* (Figures 3.34 C and 3.35 C).

16. The number of buttresses varies with and is the same as, the number of ribs.

17. The presence of continuous buttresses: in most species, the continuous buttresses are present, however, in *E. phuchongense* both continuous and discontinuous buttresses (Figures 3.49 C and 3.50 C) are found.

18. The presence of outermost collenchymatous buttresses: may be absent or present as found in *E. laosense* (Figures 3.39 D and 3.41 D).

19. The presence of innermost collenchymatous buttresses: may be absent or present as found in *E. siamense* (Figures 3.57 D and 3.58 F), *E. siamense* var. *macrophyllum* (Figures 3.59 D and 3.60 D).

20. The number of rows of seriate cells in the innermost buttresses: varies from uni-to multi-seriate as in *E. laosense* (Figures 3.39 D and 3.41 D).

21. The comparative number of large vascular bundles, small vascular bundles and buttresses: most of species have the same number, except in *E. siamense* var. *macrophyllum*, where the number of large vascular bundles equals the number of small vascular bundles (9 bundles) but is less than the number of buttresses (8 buttresses) (Figure 3.60 C) and in *E. smitinandii*, the number of buttresses (5 buttresses) equals the number large vascular bundles (5 bundles) and is more than the number of small vascular bundles (4 bundles) (Figure 3.62 C).

22. The presence of an endodermoid layer (see details in the discussion).

23. The type of cells in medulla: varies from parenchymatous to sclerotic parenchymatous, for example in *E. laosense* (Figures 3.39 D and 3.41 D), in *E. phuchongense* (Figures 3.50 D and 3.51 D).

3.7.3 The taxonomic value of anatomical characters within *Eriocaulon*

The anatomical characters that were believed to be of most taxonomic value, because they were relatively invariable and appeared to offer a potential for grouping of species, are listed below:

Leaves

1. The presence/absence of a hypodermis
2. The position of the vascular tissue
3. The presence/absence of homogenous mesophyll

Scapes

4. The presence/absence of scapes
5. The presence of a chlorenchymatous band wider than the diameter of stele

However, there are only three anatomical characters of the leaves which were found to be useful for phenetic analysis. The records of these for 33 taxa of *Eriocaulon* were included into the dataset of morphological characters (Appendix 4) for an analysis designed to investigate the relationships between Thai species using morphological, anatomical and molecular approaches (see Chapter 4).

CHAPTER 4

PHENETIC AND PHYLOGENETIC ANALYSES

4.1 Introduction

Taxonomy aims at developing classifications reflective of evolutionary history and based on different criteria. Often distinct methodologies are employed for analysis of data. Data handling for establishing relationships between organisms often use either phylogenetic methods and/or phenetic methods (Singh, 1999).

Phylogenetic methods aim at developing a classification based on an analysis of phylogenetic data: a typical output is cladogram. Hennig (1950) was among the first to propose the methods to be used, then Mayr (1969) named this methodology "Cladistics". Often cladistics is based on the principle of parsimony according to which the most likely evolutionary route is the shortest hypothetical pathway of changes that explains the pattern under observation (Singh, 1999). The advantage of molecular data for phylogenetic reconstruction is that DNA sequences often evolve in a much more regular manner than do morphological and physiological characters and they are often much more amenable to quantitative treatments than morphological data. Moreover, molecular data are abundant whereas a limited number of morphological or physiological characters are available for phylogenetic studies (Li, 1942). Over the past decade, botanists have produced several thousand phylogenetic analyses based on molecular data, with particular emphasis on analyses based on *rbc*L sequence data (Savolainen and Chase, 2003).

The order Commelinales consists of five families: Commelinaceae, Mayacaceae, Rapateaceae, Xyridaceae and Eriocaulaceae, and is considered to be monophyletic on the basis of morphological characters. Certainly, the monophyly of the order has been supported in morphology-based cladistic analyses (Dahlgren *et al.*, 1985; Stevenson and Loconte, 1995). Based on cladistic analyses of *rbc*L (ribulose 1,5-bisphosphate carboxylase large subunit) chloroplast DNA (cpDNA) sequence and morphological data, Linder and Kellogg (1995) concluded that a combined data set produced the most resolved and robust results. However, in their analyses the Commelinales were not retrieved as a monophyletic group. *Lachnocaulon* (Eriocaulaceae) was found to share characters with both the Xyridaceae in the Commelinineae as well as with the Restionineae (poalean clade). Although the position of Eriocaulaceae in the combined data analysis did not optimize the distribution of these characters, it is consistent with the hypothsis that the Eriocaulaceae is related to the poalean clade. Even though *rbc*L provides many interesting insights, it did not fully resolve phylogenetic relationships within the commelinid monocots (Linder and Kellogg, 1995). Chase *et al.* (1995) added *rbc*L data for the Eriocaulaceae (1 sequence) to infer that it is sister to Cyperaceae, Juncaceae and Thurniaceae. Hahn *et al.* (1995) showed that only the Eriocaulaceae and Xyridaceae in the Commelinales share deletions in ORF 2280 within the chloroplast inverted repeat; such deletions also characterize the Cyperaceae, Juncaceae, Poaceae, Joinvilleaceae, Restionaceae, Flagellariaceae and

Typhaceae. However, Davis (1995) argued that the Commelinaceae, Eriocaulaceae, Xyridaceae and Cyperaceae form a clade which is sister to the Zingiberales, with Pontederiaceae, Philydraceae and Haemodoraceae as close relatives, based on restriction-site variation in the inverted repeat region of the chloroplast genome.

The phylogenetic relationships of the five families of the Commelinales remains an area of deep uncertainty in higher-level monocot systematics, despite intensive morphological and anatomical study. Based on cladistic analyses of *rbc*L sequences, the subclass Commelinidae is paraphyletic (Givnish *et al*, 1999): however, the order Commelinales-*sensu lato* or *sensu stricto*- is polyphyletic. This unnatural grouping consists of three different clades, including (1) Eriocaulaceae (*Eriocaulon septangulare* and *Tonina aquatica*) and Xyridaceae (*Orectanthe* and *Xyris*) sister to the grass alliance (Poaceae, Joinvilleaceae, Restionaceae and Flagellariaceae); (2) Rapateaceae which is sister to the Bromeliaceae and Mayacaceae; and (3) Commelinaceae which is sister to the monogeneric Hanguanaceae (Figure 4.1). Based on these data, Givnish *et al.* (1999) suggested the segregation of the Eriocaulales including the Eriocaulaceae and the Xyridaceae (Figure 4.2). However, explanation of the phylogenetic relationships among the Poaceae and related families in the Commelinids using combined data of morphology, inversions in the plastid genome, and sequence data from the mitochondrial and plastid genomes recognized the Rapateaceae-Xyridaceae-Eriocaulaceae (*Eriocaulon humboldtii* and *Tonina fluviatilis*)-Mayacaceae-Hydatellaceae clade as forming the same order (Figure 4.3) (Michelangeli *et al.*, 2003).

Few molecular data on the Eriocaulaceae have been gathered. According to the National Center for Biotechnology Information (NCBI) database GenBank (NCBI, accessed July, 2005), there are only 27 nucleotide sequences reported within the family, covering 6 out of 10 genera, including *Eriocaulon* [9 reports for *E. aquaticum* (F1-ATPase alpha subunit or *atp*A gene), *E. compressum* (NADH dehydrogenase subunit F or *ndh*F gene), *E. decangulare* (26S ribosomal RNA gene), *E. humboldtii* (ATPase F1 alpha subunit or *atp*1 gene, *rbc*L gene), *E. microcephalum* (*rbc*L gene) and *E. septangulare* (18S ribosomal RNA gene, tRNA-Lys or *trn*K and maturase K or *mat*K gene, *rbc*L gene)]; *Lachnocaulon* [5 reports for *L. anceps* (*atp*B gene for ATP syntase beta subunit, *rbc*L gene, *atp*A gene and cytochrome oxidase subunit I gene)]; *Mesanthemum* [4 reports for *M. radicans* (*rbc*L gene, *atp*B gene) and *M.* sp. (*rbc*L gene, *atp*B gene)]; *Paepalanthus* [2 reports for *P. fasciculatus* (*rbc*L gene, *atp*B gene)]; *Syngonanthus* [3 reports for *S. flavidulus* (*rbc*L gene, *atp*A gene), *S. yacumbensis* (*rbc*L gene)] and *Tonina* [4 reports for *T. aquatica* (*rbc*L gene), *T. fluviatilis* (*rbc*L gene, *atp*1 gene, *ndh*F gene)].

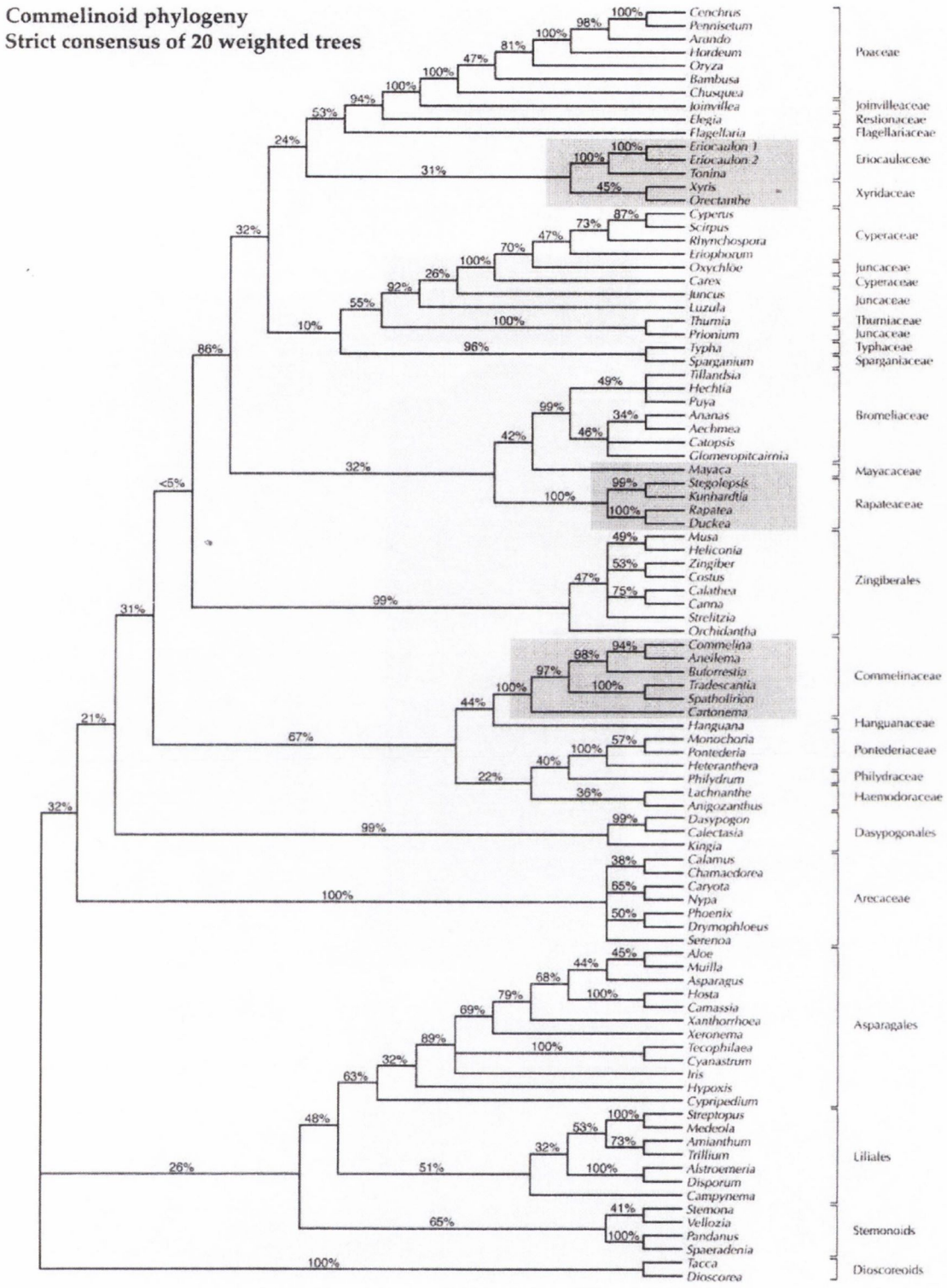

Figure 4.1 Strict consensus of the 20 shortest trees for 95 taxa based on codon-weighted parsimony for the Commelinoid phylogeny. Parsimony jackknife values are shown as percentage. Grey boxes indicate families of the former Commelinales sensu Dahlgren *et al.* (1985). From Givnish *et al.* (1999).

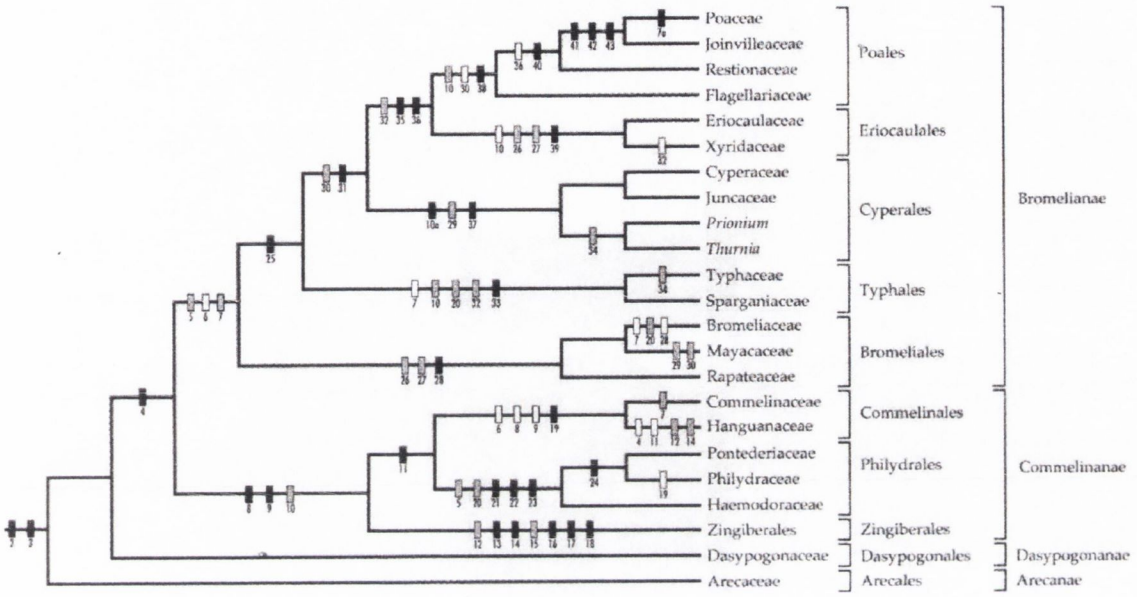

Figure 4.2 Summary of morphological, anatomical, chemical and genomic character states supporting the *rbc*L phylogeny of the revised subclass Commelinidae. Proposed orders and superorders indicated at right. From Givnish *et al.* (1999).

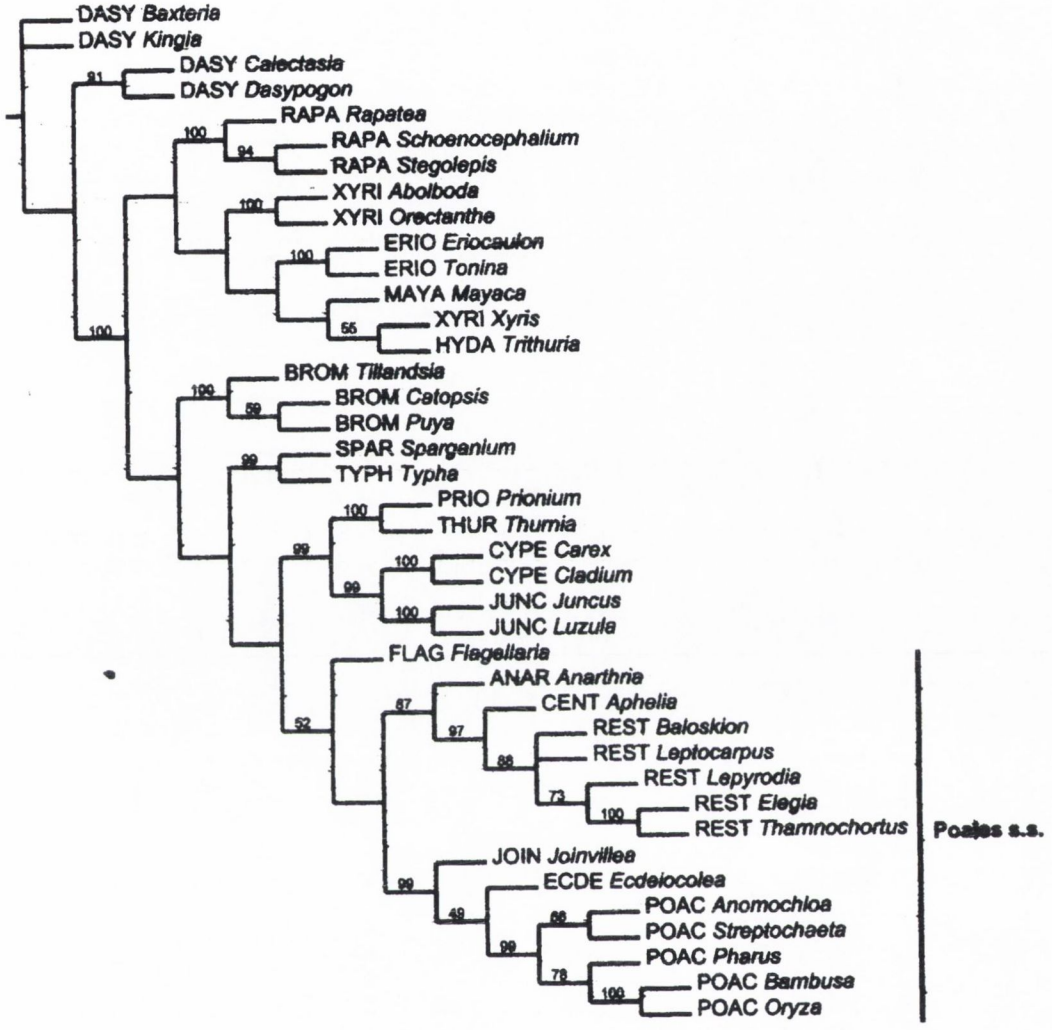

Figure 4.3 Strict consensus of the combined analysis of three character sets (morphology, *atp*B and *rbc*L) of Poaceae and related families. Numbers above the branches are jackknife support values for groups with score ≥ 50%. From Michelangeli *et al.* (2003).

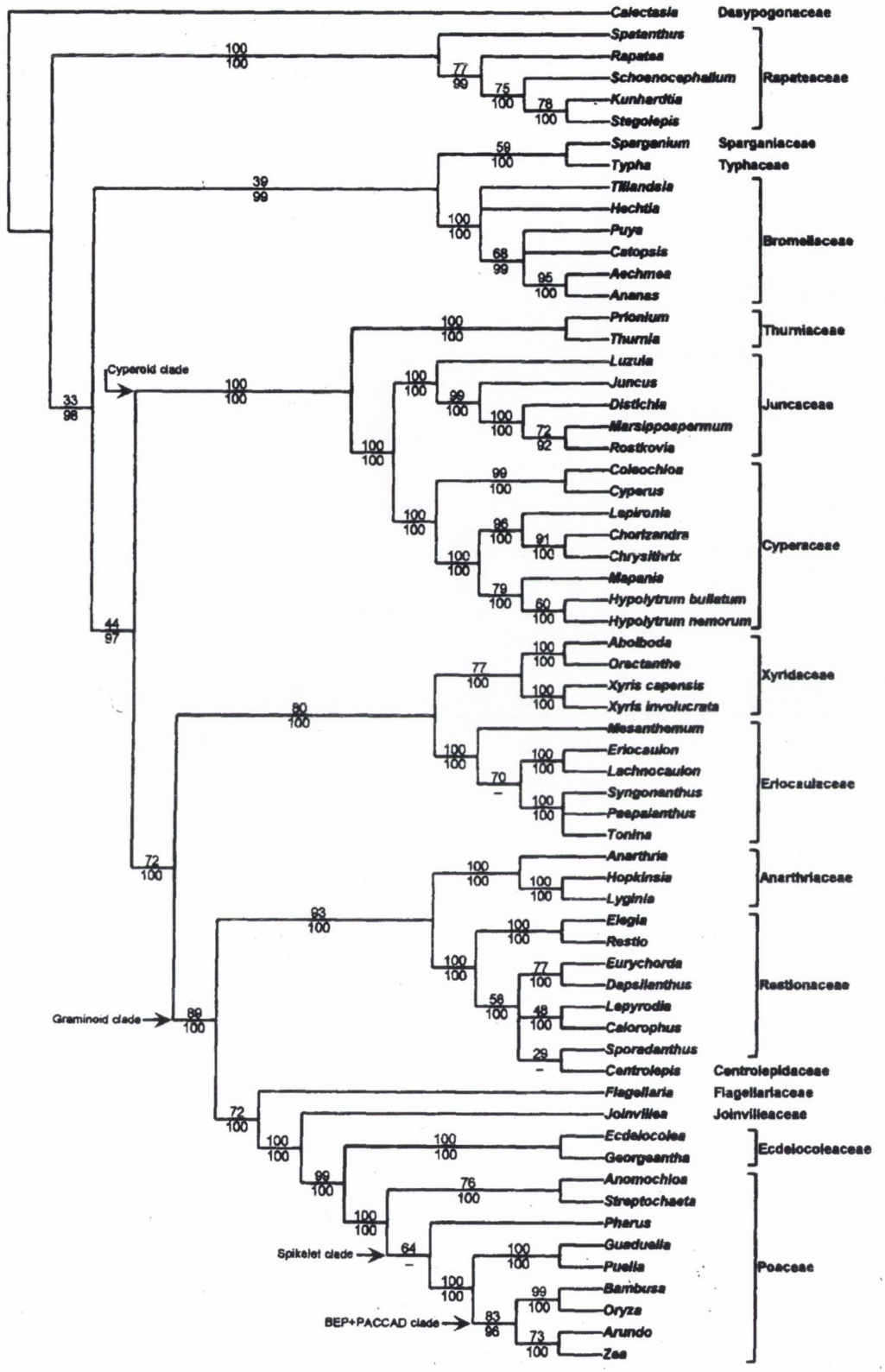

Figure 4.4 Strict consensus tree of 12 most parsimonious trees found from analysis of Poales *rbc*L and *atp*B sequences. Jackknife supported values and Bayesian posterior probabilities are shown above and below the branches, respectively. From Bremer (2002).

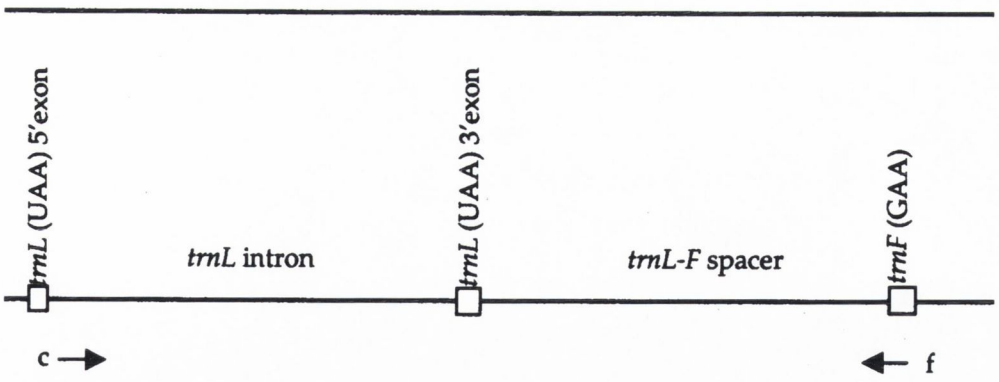

Figure 4.5 Diagram illustrating the entire *trnL-F* region between *trn*L (UAA) 5' exon and *trn*F (GAA) on which the primer c (5'-CGAAATCGGTAGACGCTACG-3') and primer f (5'-ATTTGAACTGGTGACACGAG-3') were use for amplification. From Taberlet *et al.* (1991).

The evolutionary relationships among the 6 genera of the Eriocaulaceae (*Eriocaulon microcephalum, Lachnocaulon anceps, Mesanthemum* sp., *Paepalanthus fasciculatus, Syngonanthus yacumbensis* and *Tonina fluviatilis*) were included in a study of the phylogenetic interrelationships among 18 families of Poales, assessed by cladistic analysis of cpDNA *rbc*L and *atp*B sequences (Bremer, 2002). The Eriocaulaceae and the Xyridaceae were moderately supported as sister groups, in agreement with some earlier studies. Bayesian inference with strong Jackknife support showed that *Eriocaulon* and *Lachnocaulon* were sister to other Eriocaulaceae including *Mesanthemum* (Figure 4.4). Biogeographic analysis indicated that the Xyridaceae and the Eriocaulaceae-Xyridaceae clade are both originally South American. However, the ancestral distribution of Eriocaulaceae remains unknown, and the result is also dependent on the sampling of the taxa (Bremer, 2002).

Although cpDNA sequence variations are now widely used to investigate interspecific relationships among angiosperms, the gene *rbc*L has been the preferred gene for inferring phylogeny at the family level and above, especially, in early 1990s, when most molecular phylogenetic studies relied on *rbc*L sequences (Soltis *et al.*, 1998). However, the non-coding regions often display the highest frequency of mutations and can be useful for assessing taxonomic relationships of more closely related taxa (Taberlet *et al.*, 1991).

It is noted that the phylogenetic relationships within *Eriocaulon*, which is one of the widespread genera within the family and the only genus in Asia and Europe, has not yet been researched. To address this issue, a preliminary study of phylogenetic relationships within the genus was undertaken in this thesis. I based my work on the sequencing of the *trn*L (UAA) intron and the intergenic spacer between the *trn*L (UAA) 3'exon and the *trn*F (GAA) gene, namely the entire *trnL-F* region (Figure 4.5). The entire *trnL-F* region, to the best of my knowledge, has never been used in phylogenetic studies of the Eriocaulaceae. Sequences of these regions have phylogenetic potential at the species,

generic and family levels in many plant groups (Soltis *et al.*, 1998) and these regions are easily amplified and sequenced (Taberlet *et al.*, 1991).

Realization that a complete phylogenetic analysis of all plants has not been achieved and is not likely to be achieved in the foreseeable future, has led many taxonomists to believe that we should, after all, try to produce a sound workable phenetic classification. This reflects a general belief that a perfect phenetic system would also be a perfect phylogenetic one. Additionally, because we have not been able to unravel with any degree of certainty or detail the major phylogenetic pathways of plants, a classification based on purely phenetic criteria often broadly agrees with those which are based on phylogeny (Stace, 1980). This realization coincided with the concept of numerical taxonomy by Sneath (1957), who first introduced numerical taxonomy for classification. Later, Sokal and Sneath (1963) published "Principles of Numerical Taxonomy" and Sneath and Sokal (1973) published the expanded and updated version "Numerical Taxonomy". Numerical taxonomy seeks to base classifications on a great number of characters from many sets of data in an effort to produced an entirely phenetic classification of maximum predictivity that could help in better understanding of relationships, and is also known as "Phenetic methods or cluster analysis". The results of cluster analysis are commonly presented as dendrograms known as phenograms (Singh, 1999). Phenetic analysis was included in this study.

4.2 Aims of Study

This chapter aims to study the relationships within *Eriocaulon* Thai species using phenetic methods: the characters are taken from morphological and anatomical information (from Chapters 2 and 3) and to compare the results from phenetic analysis compared with three categories of phylogenetic method using (1) the characters from *trn*L-F sequences only, (2) the characters from morphological and anatomical information (from Chapters 2 and 3) only and (3) the characters from combined data of *trnL-F* sequences and morphological and anatomical information.

4.3 Materials and Methods

Forty-eight specimens were used in this study, two of which, *Xyris indica* L. (Xyridaceae) and *Syngonanthus* sp., were used as the outgroups and the remaining forty-six specimens examined were representative of 34 taxa of *Eriocaulon*. Information regarding the names and sources of the respective specimens are provided in Appendix 2.

Isolation of genomic DNA

Total DNA was extracted from 0.03- 0.2 grams of silica gel dried leaf and scape material (Appendix 2) using a modified hexadecyltrimethyl ammonium bromide (CTAB) method from Doyle & Doyle (1990) (Appendix 5.1). The crude total DNA sample was then purified using the JETQUICK PCR Purification Spin Kit, namely Spin Column Technique and the purified total DNA stored at -20°C or -

80°C (Appendix 5.3). Each crude total DNA extract was then quantified using gel electrophoresis (Appendix 5.2).

Amplification of target DNA regions

The entire *trnL-F* region from purified total DNA was amplified using the Polymerase Chain Reaction (PCR) (Appendix 5.4). The reactions were carried out using a GeneAmp PCR System 9700 thermocycler. The amplified PCR products were quantified using gel electrophoresis (Appendix 5.2) and then purified using the JETQUICK PCR Purification Spin Kit (Appendix 5.3) before being stored at -20°C or -80°C.

Cycle Sequencing of amplified PCR products

Cycle sequence reactions were carried out on the amplified PCR products using the Big Dye Terminator sequence mix of Applied Biosystems™. All cycle sequence reactions were carried out using a GeneAmp PCR System 9700 thermocycler (Appendix 5.5). The sequenced samples were then purified (Appendix 5.6). Subsequently, the cycle sequenced samples were denatured (Appendix 4.7) and run on 310 Genetic Analyser, using the ABI Prism™ 310 module SEQ POP6 (1.0-mL)E or the ABI Prism™ 310 module SEQ POP6 RAPID (1.0-mL)E run files, at the Department of Botany, University of Dublin, Trinity College. The sequences were then processed using ABI Prism™ DNA Sequencing Analysis Software, v 2.1.1.

Sequence assembly, Alignment and DNA Analysis

The electropherograms from automated sequencing were edited and assembled using AutoAssembler version 2.1. The sequences were then imported into PAUP version 4.0b10 (PPC) (Swofford, 2002) and aligned using MacClade version 4.0 PPC, ClustralX and Se-Al version v2.0a8 then finally aligned by eye. The resulting matrix was then subjected to parsimony analysis.

Morphological and Anatomical Dataset

The 30 binary state invariable characters of the morphological and anatomical dataset (Appendix 4 Table A) from the studies in chapter 2 and chapter 3 of 48 taxa was initially compiled using Excel in Microsoft version 10. In order to compare the phenetic and cladistic analyses using the same matrix, the dataset was imported into PAUP version 4.0b10 (Swofford, 2002). The matrix was then subjected to combined phylogenetic analyses. To be able to compare the result of phenetic and phylogenetic methods, the 30 dataset was used.

Phenetic analyses

The dataset was imported into and analysed using SPSS 12.0.1 for Windows. I used the furthest neighbour (complete linkage) agglomerative clustering to delineate clusters with clear discontinuities (it produces maximally linked clusters (Legendre and Legendre, 1998)) and a simple matching

coefficient as they give equal weight to matches and mismatches (Sokal and Sneath, 1963). Homogeneity analysis is a basic technique in nonlinear multivariate analysis which is similar to multidimensional scaling (Bond and Michailidis, 1996), this technique is also known as optimal scaling of categorical variables, dual scaling, multi correspondence analysis and principle component analysis for categorical data. The analysis using SPSS 12.0.1 for Windows, was performed using an ordination technique designed for binary state data. The results from the analysis were used to access support for the groupings in the dendrogram from phenetic analysis. Therefore, all characters used in this phenetic analysis were binary state data.

Phylogenetic analyses

Optimal trees were obtained using maximum parsimony. The parsimony analysis employed a heuristic search (1,000 replicates). Starting trees were obtained using random stepwise addition (1,000 replicates), holding 1 tree at each step during stepwise addition. The branch-swapping algorithm used was tree bisection-reconnection (TBR); no more than 100 trees of score (length) greater than or equal to 10 were saved in each replicate. All characters were unordered and had equal weight. Gaps treated as missing data. Character-state optimization was Accelerated transformation (ACCTRAN). To access relative clade support, bootstrap analyses (Felsenstein, 1985) were also obtained via 1,000 bootstrap replicates. The search parameters employed in estimating bootstrap support were identical to those employed in the parsimony analysis except that stepwise addition was set to SIMPLE. Only branches supported above 50% bootstrap were shown. The consistency index (CI) (Kluge and Farris, 1969), retention index (RI) (Farris, 1989) and rescaled consistency index (RC) (Farris, 1989) were also calculated using PAUP to measure the amount of homoplasy in data. All resulting trees were rooted using both species of *Syngonanthus* sp. (Eriocaulaceae) and *Xyris indica* (Xyridaceae) as the outgroups because they are sufficiently closely related to *Eriocaulon* spp. (Eriocaulaceae) to allow alignment. "Strong" bootstrap support is defined here as values above 80% whereas "weak" bootstrap support is defined as values less than 80%.

4.4 Results

4.4.1 Phenetic analyses

The dendrogram from the analysis is shown in Figure 4.6 and was found to be fairly stable. Stability was assessed by changing one element of the data in the matrix [changing the character state of the presence of rhizome or corm in *Eriocaulon nautiliformoides* 264 from absent (0) to present (1)] and finding that this change did not cause any changes in the dendrogram.

Homogeneity analysis was performed using three dimensions as the solution (dimensions 4 and 5 had eigenvalues less than 0.1) (Figure 4.7).

By combining the information from the dendrogram (Figure 4.6) and the scatter diagram of the object scores labelled by taxon in three dimensions from the homogeneity analysis (Figure 4.8), I was able to

recognize six groups from the 34 taxa of *Eriocaulon*. Recognizing different groupings in the dendrogram is, in essence, an arbitrary process. The shared characters within the six groups (Table 4.1) and the details of each group are described as follows.

Group I

This group is composed of two species, *E. willdenovianum* and *E. wightianum*. From the data matrix, there are 25 shared characters within the group, consisting of character numbers 2, 3, 4, 5, 6, 7, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 24, 25, 26, 27, 28, 29 and 30 (see Table 4.1 and the description of these character in Appendix 4). The unique characters within the group are leaf length equal or longer than 10 cm (character number 2 or #2), leaf apex obtuse (#5), involucral bracts leathery (#10), seed papillate (#27), vascular tissue equidistant (#29) and mesophyll homogenous in leaf (#30) (Table 4.1).

As can be seen from the homogeneity analysis (Figure 4.8), these taxa do not plot near to the taxa in group II. Therefore, in part, recognition of the cut-point for the dendrogram is defined by the necessity of delimiting these groups.

Group II

This group consists of three taxa, *E. truncatum*, *E. truncatum* var. *florensense* and *E. xeranthemum*. From the data matrix, there are 25 shared characters, composed of character numbers 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 28 and 30. The unique characters within the group are receptacle glabrous (#8), involucral bracts papery (#10) and the presence of a hypodermis in leaf (#28).

Within this group, *E. xeranthemum* and *E. truncatum* are closely related with only 3 different characters, (character numbers 9, 16 and 27), with *E. truncatum* var. *florensense* differing in character numbers 9, 14 and 29.

Group III

This group comprises six taxa, *E. echinulatum, E. escape, E. hamiltonianum, E. hamiltonianum* var. *acuminatum, E. thailandicum* and *E. zollingerianum*. From the data matrix, there are 17 shared characters among the group, consisting of character numbers 1, 2, 3, 4, 5, 6, 8, 11, 13, 17, 19, 20, 21, 26, 28, 29 and 30. The only unique character within the group is male petals eglandular (#21). *E. echinulatum, E. escape*, and *E. zollingerianum* are closely related as they have female lateral sepals with winged-keels (#22).

Group IV

This group is composed of eight taxa, *E. brownianum, E. nautiliforme, E. siamense, E. siamense* ssp. *hexagynum, E. siamense* var. *macrophyllum, E. xenopodium, E. ubonense* and *E. ubonense* f. *kradungense*. From the data matrix, there are 11 shared characters among the group, comprising character numbers 7, 8, 9, 12, 13, 14, 16, 20, 21, 25 and 30. The presence of blackish floral bracts was found only in this group and group V.

It is noted that *E. siamense, E. siamense* ssp. *hexagynum* and *E. siamense* var. *macrophyllum* are closely related with only three different characters (character numbers 10, 11 and 25).

Group V

This group consists of seven taxa, *E. cinereum, E. infirmum, E. nepalense* var. *luzulaefolium, E. parnellii, E. pseudoescape, E. quinquangulare* and *E. setaceum*. From the data matrix, there are 18 shared characters within the group, composed of character numbers 1, 2, 3, 4, 5, 9, 12, 13, 15, 16, 17, 19, 22, 23, 24, 26, 28 and 29.

According to the homogeneity analysis (Figure 4.8), these taxa do not plot near to the taxa in group VI. Therefore, in part, recognition of the cut-point for the dendrogram is defined by the necessity of delimity of these groups.
It is noted that *E. pseudoescape* is more closely related to *E. nepalense* var. *luzulaefolium* than to *E. escape* (group III) because *E. pseudoescape* and *E. nepalense* var. *luzulaefolium* share 29 characters from the data matrix, and only differ in the presence or absence of a scape. Whereas there are 19 characters shared between *E. pseudoescape* and *E. escape* from the data matrix,. The new species, *E. parnellii* is closely related to *E. setaceum* as there are only two different characters (the presence of unequal male petals and the presence of hairy male petals).

Group VI

This group comprises the remaining eight taxa, *E. chantaranothaii, E. laosense, E. nautiliformoides, E. nautiliformoides* var. *hexagynum, E. phatamense, E. phuchongense, E. phuphanoides* and *E. smitinandii*; six of these taxa are new to science. From the data matrix, there are 21 shared characters within the group, consisting of character numbers 1, 2, 4, 5, 6, 7, 8, 9, 12, 13, 14, 17, 20, 21, 22, 24, 25, 27, 28, 29 and 30. The unique character within this group is the non-papillate seed.

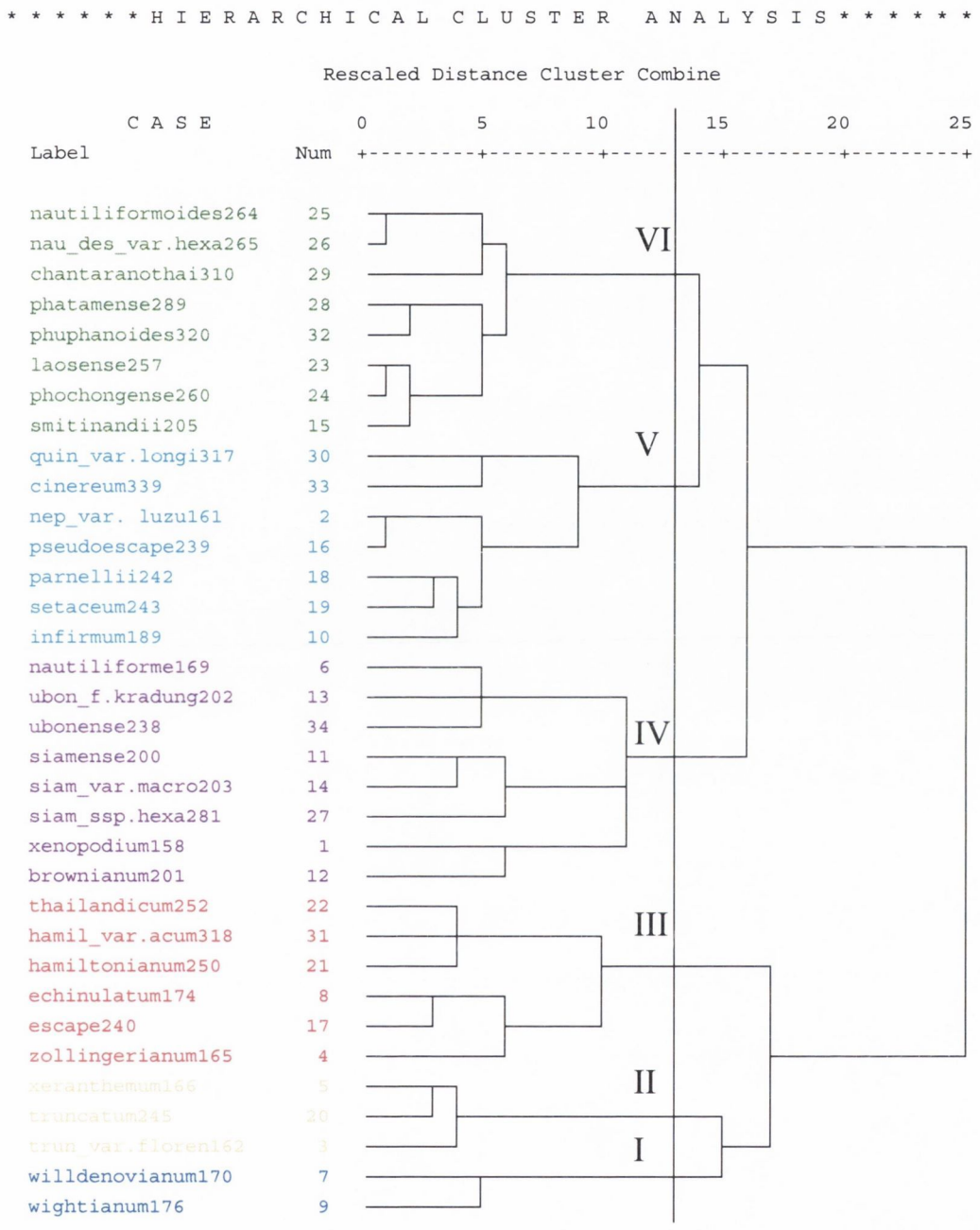

Figure 4.6 Dendrogram using the complete linkage and simple matching method of 34 taxa shows possible six groups (I, II, III, IV, V and VI).

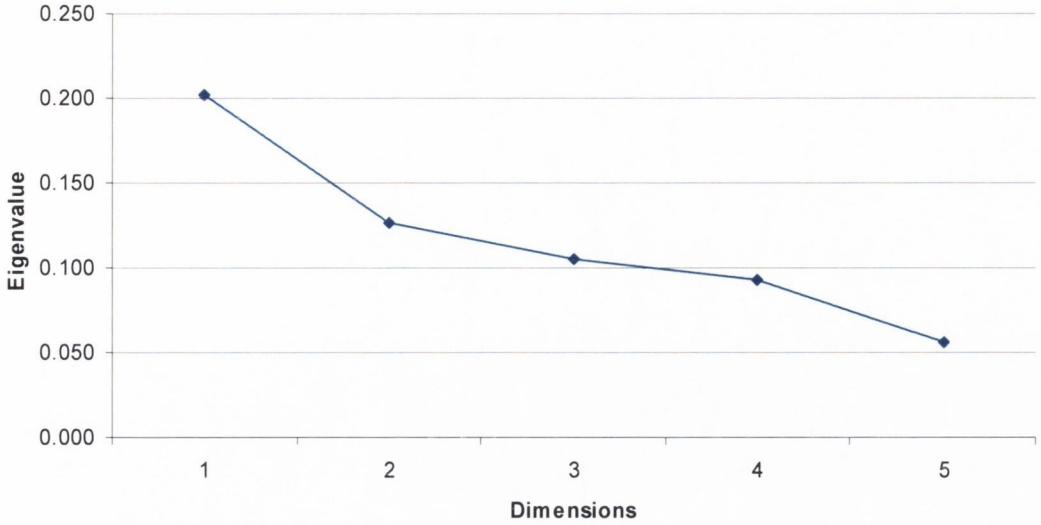

Figure 4.7 Eigenvalue of five dimensions from homogeneity analysis of 34 taxa.

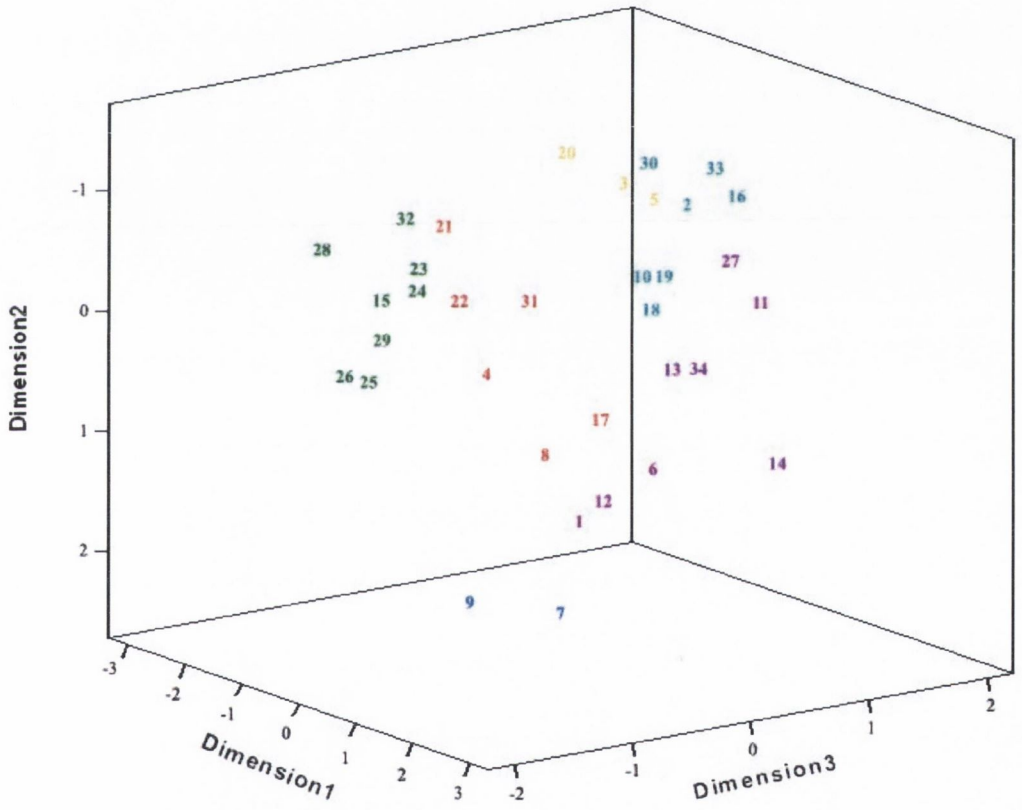

Figure 4.8 Homogeneity analyses of 34 taxa using three dimensions dataset, the object scores labeled by taxon, cases weighted by number of objects. The numbers indicate the numbers in the dendrogram in Figure 4.6. Blue = group I, Yellow = group II, Red = group III, Purple = group IV, Light blue = group V and Green = group VI in the dendrogram.

Table 4.1 Relation of shared characters among the six groups. "√"means shared presence character, "X" means shared absence character and "-"means not shared character within the group.

Characters	Groups					
	I	II	III	IV	V	VI
#1 stem rhizome or corm	-	X	X	-	X	X
#2 leaf length equal or longer than 10 cm	√	X	X	-	X	X
#3 leaf hairy	X	X	X	-	X	-
#4 leaf papillate	X	X	X	-	X	X
#5 leaf apex obtuse	√	X	X	-	X	X
#6 leaf reddish	X	X	X	-	-	X
#7 scape	√	√	-	√	-	√
#8 receptacle hairy	-	X	√	√	-	√
#9 involucral bracts as long as or longer than the length of capitula	X	-	-	X	X	X
#10 involucral bracts papery	X	√	-	-	-	-
#11 involucral bracts hairy	-	X	X	-	-	-
#12 involucral bracts apex long acuminate	X	X	-	X	X	X
#13 floral bracts blackish	X	X	X	√	√	X
#14 floral bracts hairy	√	-	-	√	-	√
#15 floral bracts apex long acuminate	X	X	-	-	X	-
#16 male flowers 2 sepals	X	-	-	X	X	-
#17 male flowers blackish sepals	X	√	X	-	√	X
#18 male flowers unequal petals	X	X	-	-	-	-
#19 male flowers petals exserted beyond the floral bracts	X	X	X	-	X	-
#20 male flowers petals hairy	X	X	X	√	-	√
#21 male flowers glandular petals	√	√	X	√	-	√
#22 female flowers lateral sepal winged-keeled	-	X	-	-	X	X
#23 female flowers dimorphic sepals	-	X	-	-	X	-
#24 female flowers blackish sepals	X	√	-	-	√	X
#25 female flowers petals	√	√	-	√	-	√
#26 ovary 5-6 locules	X	X	X	-	X	-
#27 seed papillate	√	-	-	-	-	X
#28 leaf, hypodermis	X	√	X	-	X	X
#29 leaf, vascular tissue equidistant	√	-	X	-	X	X
#30 leaf, mesophyll homogeneous	√	X	X	X	-	X
Total number of shared characters	25	25	17	11	18	21

4.4.2 Phylogenetic analyses

4.4.2.1 Anatomical and morphological trees

Analysis of the 30 binary state characters from the morphological (27 characters) and anatomical (three characters) matrixes (Appendix 4, Table A) produced 16,040 equally most parsimonious trees of length 97 steps with CI = 0.31, RI = 0.75 and RC = 0.23. One of the 16,040 cladograms with consensus and bootstrap support is given in Figure 4.9. There were only eight nodes common to all equally most parsimonious trees (39 nodes were different). There were eight bootstrap values greater than 50% support, five of which supported the consensus resolved nodes. The statistical values (CI, RI and RC) for 30 anatomical and morphological characters are shown in Table 4.2.

4.4.2.2 Molecular trees

Analysis of the 1357 nucleotide sequence data set (with 326 variable and 545 parsimony-informative characters) from the entire *trnL-F* region without coded gaps (293 characters) (Appendix 5.8) resulted in three equally most parsimonious trees of length 2,590 steps with CI = 0.57, RI = 0.50 and RC = 0.29. One of these three cladograms with consensus and bootstrap support is shown in Figure 4.10. There were 45 nodes common to all equally most parsimonious trees, 20 of which have bootstrap values greater than 50% support.

4.4.2.3 Combined trees

The combined data set included 326 variable and 575 parsimony-informative characters (545 of which are nucleotide sequence characters from the entire *trnL-F* region without coded gaps and the remaining 30 binary state characters from the morphological (27 characters) and anatomical (three characters) matrixes (Appendix 5.8). The parsimony analysis of the combined data matrix produced 16 equally most parsimonious trees of length 2,770 steps with CI = 0.55, RI = 0.50 and RC = 0.27. One of these 16 cladograms with consensus and bootstrap support is shown in Figure 4.11. There were 36 nodes common to all equally most parsimonious trees. There were 23 bootstrap values greater than 50% support, 19 of which supported the consensus resolved nodes. Additionally, the strict consensus of the 16 cladograms with bootstrap support is shown in Figure 4.12, it showed that there were only 2 major nodes different from the consensus of the molecular data only matrix analysis (red arrowed branches). The statistical values (CI, RI and RC) for 30 anatomical and morphological characters are shown in Table 4.3.

4.4.2.5 Grouping

The cladograms from the anatomical and morphological data matrix showed small numbers of nodes resolved by the consensus tree (8 nodes) and of nodes supported by bootstrap value (8 nodes) (Figure 4.9). Only three of eight bootstrap values were strong support (value higher than 80%), however, these values supported only the terminal nodes and only one node comprised of different species (node *E.*

*echinulatum*174 and *E. escape*240), the remaining were for the same species. Therefore, this grouping should not be considered using this analysis.

The cladograms from the molecular data only matrix (Figure 4.10) suggested that there were possibly 4 clades within 46 taxa (Clades A, B, C and D) in relation to the consensus agreement and the number of steps. However, it is noted that there was high bootstrap support only for group D (100%).

The cladograms from the combined analysis showed a smaller number of nodes common to all equally most parsimonious trees than the molecular data only matrix; but the bootstrap values are generally higher than in analysis of molecular alone. Furthermore, the analysis showed not only that the major clades (Clades A, B, C and D) were similar to the cladograms from the only molecular data matrix (Figures 4.11 and 4.12) but also showed that there was bootstrap support for group C (53%) and group D (57%). Within the remaining taxa in the combined cladogram, two further groupings (A and B) could be recognized; though these did not receive bootstrap support above 50%.

Therefore, the groups A, B C and D were discussed in relation to the distribution of the anatomical and morphological characters and compared to the groupings indicated by phenetic analysis as follows (Figure 4.13):

Group C:

From the data matrix (Appendix 4 Table A), there were five shared characters within the group (Figure 4.13), consisting of leaves less than 10 cm long (character number 2 or #2 in Appendix 4 Table A), glabrous leaves (#3), hairy receptacle (#8), involucral bracts shorter than the length of capitula (#9) and the 2-3 locular ovary (#26). Group C, is therefore a clade comprising of 13 taxa; *E. quinquangulare* var. *longibracteatum* (collector number 317), *E. phuphanoides* (collector number 320), *E. hamiltonianum* (collector numbers 250, 314 and 324), *E. zollingerianum* (collector number 165), *E. echinulatum* (collector number 174), *E. hamiltonianum* var. *acuminatum* (collector number 318), *E. nepalense* var. *luzulaefolium* (collector numbers 157, 161 and 208), *E. pseudoescape* (collector number 239), *E. parnellii* (collector number 242), *E. setaceum* (collector number 243), *E. siamense* (collector number 200), *E. siamense* var. *macrophyllum* (collector numbers 203 and 241) and *E. infirmum* (collector number 189).

Within Clade C, *E. siamense* (collector number 200), *E. siamense* var. *macrophyllum* (collector numbers 203 and 241) have 100% bootstrap support as a group. Unsurprisingly from the data matrix, there were only four anatomical and morphological characters different between them, comprising the apex of the leaf (#5), the colour of the leaf (#6), the presence/absence of hypodermis (#28) and the position of vascular tissue in the mesophyll (#29).

Within Clade C, *E. hamiltonianum* (collector number 314), *E. quinquangulare* var. *longibracteatum* (collector number 317) and *E. phuphanoides* (collector number 320) also form a group with 100%

bootstrap support. However, the data matrix indicates that there were nine anatomical and morphological characters different within the group; that is the colour of the leaves (#6), the colour of the floral bracts (#13), the presence /absence of hairs on the floral bracts (#14), the number of male sepals (#16), the colour of the male sepals (#17), the presence/absence of unequal male petals (#18), the presence /absence of hairs on the male petals (#20), the presence /absence of glandular male petals (#21) and the colour of the female sepals (#24).

Group D:

From the data matrix, there was only one shared character within the group (Figure 4.13), consisting of the glabrous receptacle (#8), which separates it from the other 3 groups (Groups A, B and C). Group D, is therefore a clade comprising 3 taxa which were the same as group II produced by the phenetic analysis; *E. truncatum* (collector number 245), *E. truncatum* var. *florensense* (collector number 162) and *E. xeranthemum* (collector number 166). Within the clade, *E. truncatum* (collector number 162) and *E. truncatum* var. *florensense* (collector number 245) are closely related with 93-94% bootstrap support. From the data matrix, there were only three anatomical and morphological characters different within the group; the length of involucral bracts in comparison with the length of capitula (#9), the presence/absence of hairs on the floral bracts (#14) and the position of vascular tissue in the mesophyll (#29).

Group A:

From the data matrix, there were eight shared characters within the group (Figure 4.13), consisting of scape present (#7), receptacle hairy(#8), involucral bracts shorter than the length of capitula (#9), floral bracts hairy (#14), absence of winged-keeled lateral female sepals (#22), presence of female petals (#25), absence of hypodermis in the leaves (#28) and the absence of homogeneous mesophyll (#30). Group A, therefore a group comprises 11 taxa; *E. laosense* (collector numbers 257 and 259), *E. phuchongense* (collector numbers 260, 276, 285 and 293), *E. thailandicum* (collector number 252), *E. siamense* (collector number 258), *E. siamense* ssp. *hexagynum* (collector number 281), *E. nautiliforme* (collector number 169), *E. phuphanoides* (collector numbers 299 and 345), *E. ubonense* f. *kradungense* (collector number 202), *E. smitinandii* (collector number 205), *E. chantaranothaii* (collector numbers 310 and 321) and *E. nautiliformoides* var. *hexagynum* (collector number 265).

Within this group, *E. laosense* (collector numbers 257 and 259), and *E. phuchongense* (collector numbers 260, 276, 285 and 293) form a group with 81-83% bootstrap support. This shows that there were variations in the *trnL-F* region within *E. phuchongense* and that *E. laosense* is similar to it. From the data matrix, the only difference is that the apex of the floral bracts is different within the 2 species.

Within this group, *E. siamense* (collector number 258) and *E. siamense* ssp. *hexagynum* (collector number 281) form a group with 71-95% bootstrap support. From the data matrix, there were six anatomical and morphological characters different within the group, presence/absence of rhizome or corm (#1), colour of the leaves (#6), texture of the involucral bracts (#10), presence /absence of hairs

on the involucral bracts (#11), the number of locules in the ovary (#26) and the position of vascular tissue in the mesophyll (# 29).

Group B:

From the data matrix, there were six shared characters within the group (Figure 4.13), composed of the leaves non papillate (#4), the green leaves (#6), the receptacle hairy (#8), the male petals non-exserted beyond the floral bracts (#19), the 2-3-locular ovary (#26) and the absence of homogenous mesophyll (#30). Group B, is there for a group consisting of four taxa; *E. ubonense* (collector number 238), *E. escape* (collector number 240), *E. xenopodium* (collector number 158) and *E. phatamense* (collector number 289).

Within Clade B, *E. ubonense* (collector number 238) and *E. escape* (collector number 240) have 100% bootstrap support as group. However, from the data matrix, there were 17 anatomical and morphological characters different within the group consisting of the presence/absence of rhizome or corm (#1), the apex of leaves (#5), the presence/absence of scape (#7), the length of involucral bracts comparison with the length of capitula (#9), the presence /absence of hairs on the involucral bracts (#11), the colour of floral bracts (#13), the presence /absence of hairs on the floral bracts (#14), the apex of floral bracts (#15), the colour of male sepals (#17), the presence/absence of unequal male petals (#18), the presence /absence of hairs on the male petals (#20), the presence /absence of glandular male petals (#21), the presence /absence of winged-keeled lateral female sepals (#22), the presence /absence of dimorphic female sepals (#23), the colour of female sepals (#24), the presence /absence of female petals (#25) and the position of vascular tissue in the mesophyll (# 29).

Series of lineages:

The remaining five taxa are the series of lineages that split off at deep nodes in the cladogram (Figure 4.13), *E. cinereum* (collector number 339), *E. wightianum* (collector number 176), *E. brownianum* (collector number 201), *E. willdenovianum* (collector number 170) and *E. nautiliformoides* (collector number 264).

Within this series, *E. wightianum* (collector number 176) and *E. brownianum* (collector number 201) form a clade with 100% bootstrap support. However, surprisingly the data matrix shows that there were 10 anatomical and morphological characters different within the clade, consisting of the presence/absence of rhizome or corm (#1), the presence /absence of hairs on the leaves (#3), the apex of leaves (#5), the colour of floral bracts (#13), the colour of male sepals (#17), the presence /absence of hairs on the male petals (#20), the presence /absence of winged-keeled lateral female sepals (#22), the presence /absence of dimorphic female sepals (#23), the colour of female sepals (#24) and the presence /absence of homogenous mesophyll (#30).

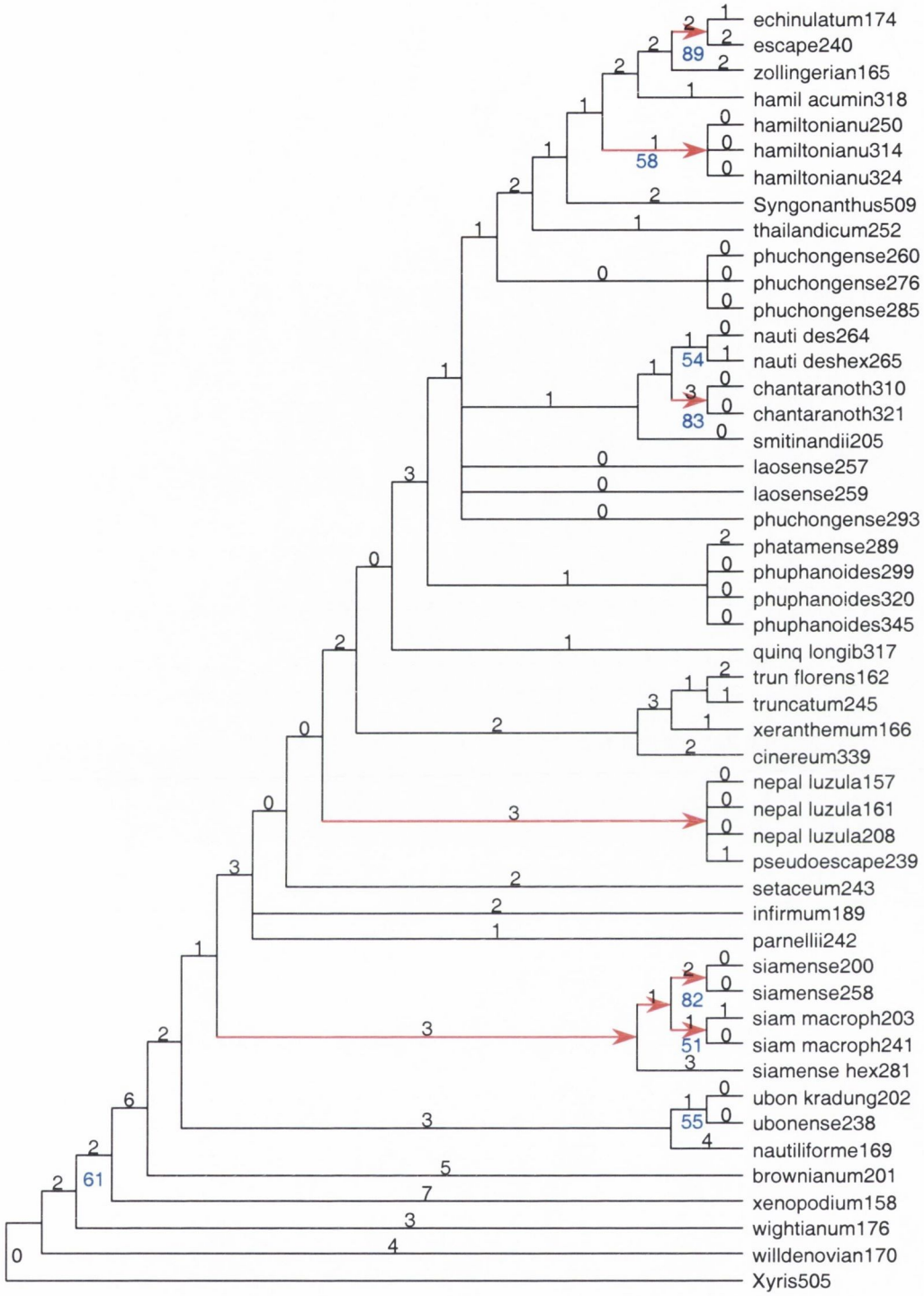

Figure 4.9 One of 16,040 equally most parsimonious trees for 46 samples in 34 taxa of *Eriocaulon* and two outgroup taxa, based on equally weighted parsimony analysis of the anatomical and morphological data. Length = 97, CI = 0.31, RI = 0.75, RC = 0.23. Values above branches are steps. Bootstrap percentages greater than 50% (1,000 replicates) are shown below the branches. Arrowed branches are consensus resolved.

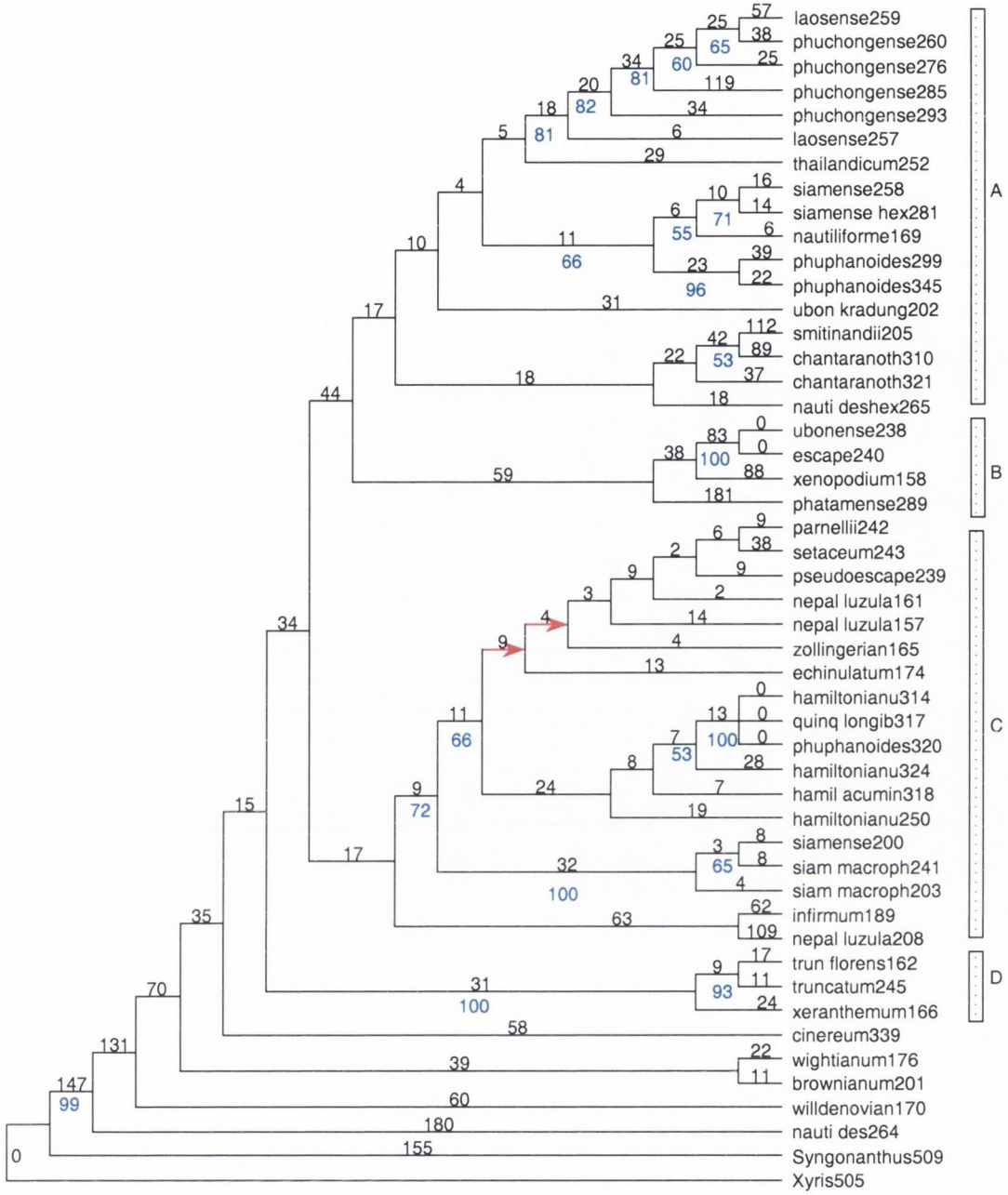

Figure 4.10 One of three equally most parsimonious trees for 46 samples in 34 taxa of *Eriocaulon* and two outgroup taxa, based on equally weighted parsimony analysis of the entire *trnL-F* sequence data (without coded gaps). Length = 2,590, CI = 0.57, RI = 0.50, RC = 0.29. Values above branches are steps. Bootstrap percentages greater than 50% (1,000 replicates) are shown below the branches. Arrowed branches are not consensus resolved.

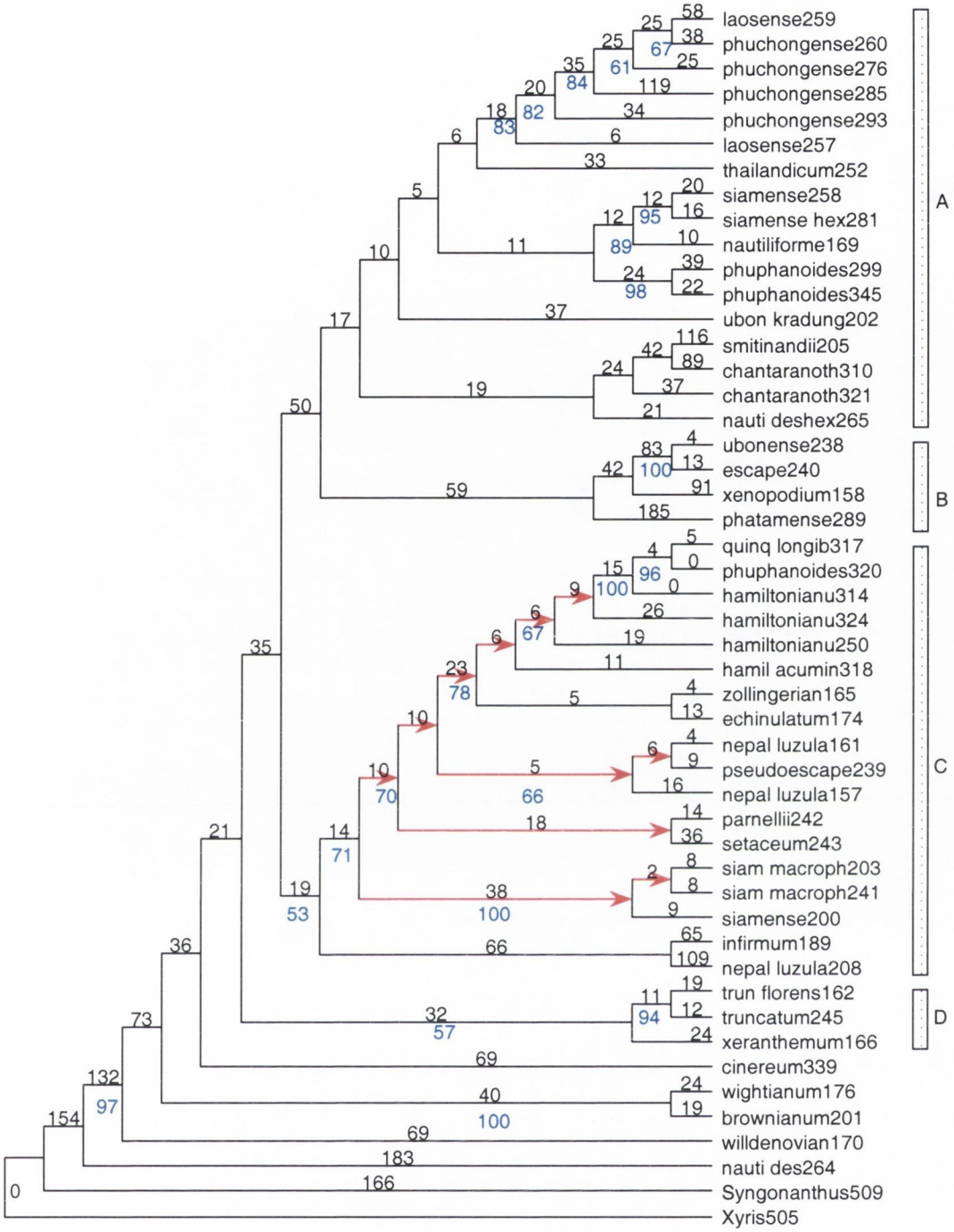

Figure 4.11 One of 16 equally most parsimonious trees for 46 samples in 34 taxa of *Eriocaulon* and two outgroup taxa, based on equally weighted parsimony analysis of the combined entire *trnL-F* sequence data, anatomical and morphological data (without coded gaps). Length = 2,770, CI = 0.55, RI = 0.50, RC = 0.27. Values above branches are steps. Bootstrap percentages greater than 50% (1,000 replicates) are shown below the branches. Arrowed branches are not consensus resolved.

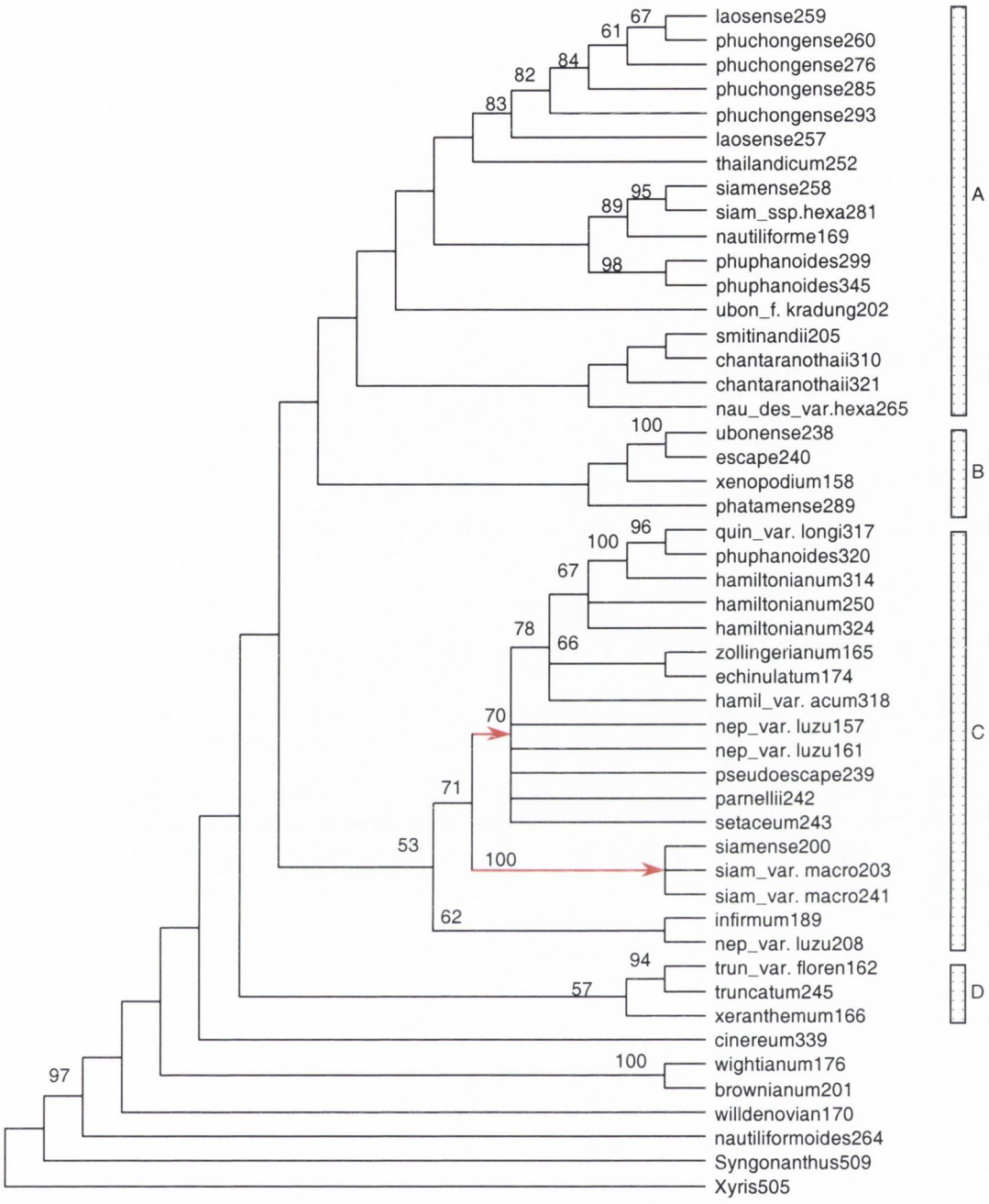

Figure 4.12 Strict consensus of 16 equally most parsimonious trees for 46 samples in 34 taxa of *Eriocaulon* and two outgroup taxa, based on equally weighted parsimony analysis of the combined entire *trnL-F* sequence data, anatomical and morphological data (without coded gaps). Length = 2,770, CI = 0.55, RI = 0.50, RC = 0.27. Bootstrap percentages greater than 50% (1,000 replicates) are shown above the branches. The different branches from the strict consensus of the entire *trnL-F* sequence data are shown by arrowed branches.

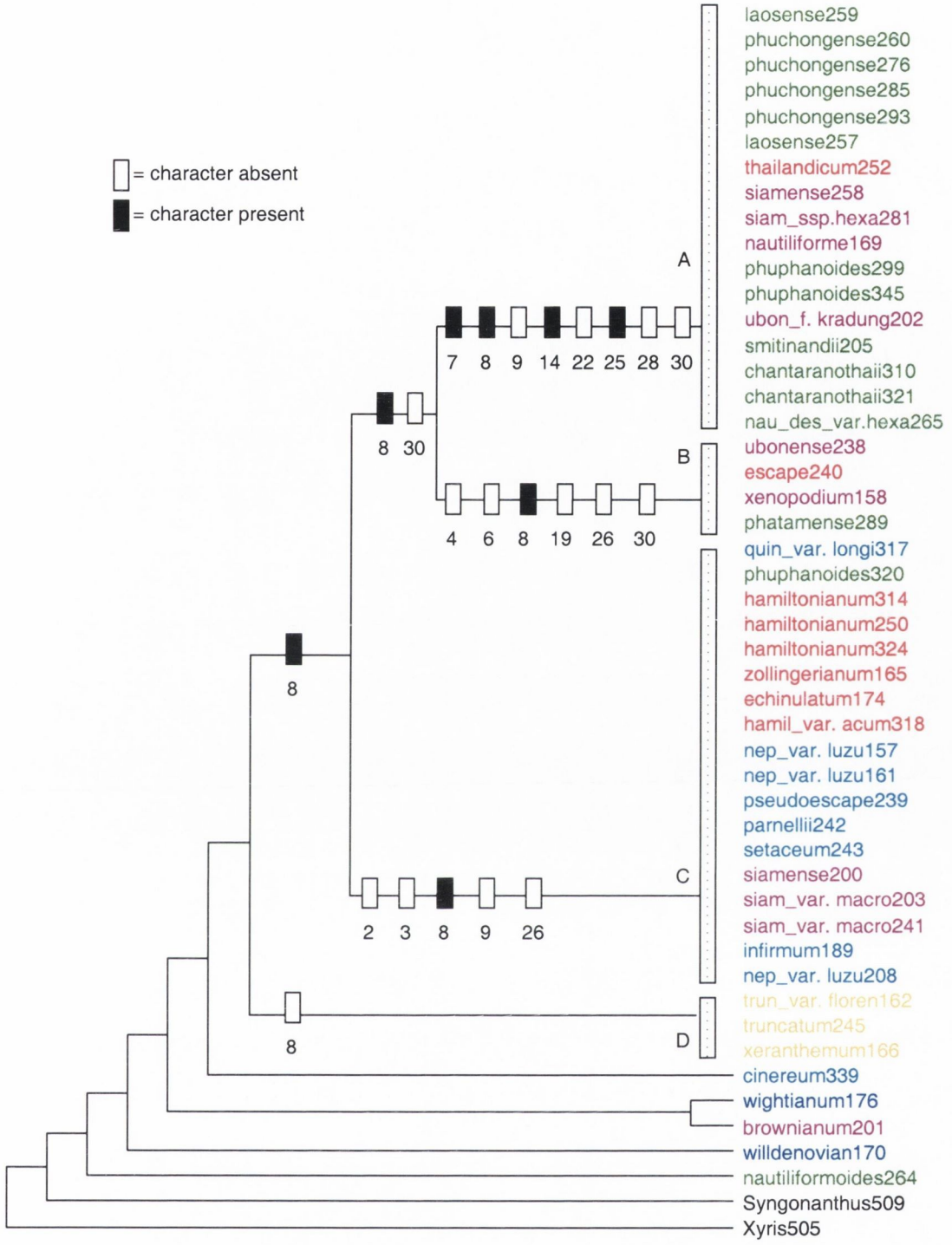

Figure 4.13 Summary of anatomical and morphological character states supporting the combined phylogeny in Figure 4.12. The colours indicate the groups as shown in Phenetic analysis (Figure 4.6, Blue = group I, Yellow = group II, Red = group III, Purple = group IV, Light blue = group V and Green = group VI in the dendrogram) for comparison the grouping. The number below branches are number of character from anatomical and morphological matrix (Appendix 4 Table A).

Table 4.2 Statistical values from tree number one of the parsimony analysis for 46 samples in 34 taxa of *Eriocaulon* and two outgroup taxa, using the anatomical and morphological data. Tree length = 97, Consistency index (CI) = 0.31, Retention index (RI) = 0.75 and Rescaled consistency index (RC) = 0.23

Characters	Statistical Values		
	CI	RI	RC
#1 stem rhizome or corm	0.200	0.500	0.100
#2 leaf length equal or longer than 10 cm	0.500	0.800	0.400
#3 leaf hairy	0.250	0.250	0.062
#4 leaf papillate	1.000	1.000	1.000
#5 leaf apex obtuse	0.333	0.714	0.238
#6 leaf reddish	0.500	0.500	0.250
#7 scape	0.500	0.000	0.000
#8 receptacle hairy	0.500	0.800	0.400
#9 involucral bracts as long as or longer than the length of capitula	0.333	0.000	0.000
#10 involucral bracts papery	0.250	0.864	0.216
#11 involucral bracts hairy	0.167	0.583	0.097
#12 involucral bracts apex long acuminate	0.500	0.500	0.250
#13 floral bracts blackish	0.333	0.889	0.296
#14 floral bracts hairy	0.250	0.667	0.167
#15 floral bracts apex long acuminate	0.200	0.429	0.086
#16 male flowers 2 sepals	0.333	0.750	0.250
#17 male flowers blackish sepals	0.500	0.950	0.475
#18 male flowers unequal petals	0.167	0.773	0.129
#19 male flowers petals exserted beyond the floral bracts	0.333	0.714	0.238
#20 male flowers petals hairy	0.250	0.842	0.211
#21 male flowers glandular petals	0.333	0.846	0.282
#22 female flowers lateral sepal winged-keeled	0.333	0.846	0.282
#23 female flowers dimorphic sepals	0.200	0.429	0.086
#24 female flowers blackish sepals	0.333	0.905	0.302
#25 female flowers petals	0.500	0.500	0.250
#26 ovary 5-6 locules	0.500	0.000	0.000
#27 seed papillate	0.200	0.765	0.153
#28 leaf, hypodermis	0.333	0.000	0.000
#29 leaf, vascular tissue equidistant	0.333	0.818	0.273
#30 leaf, mesophyll homogeneous	0.500	0.667	0.333

Table 4.3 Statistical values from tree number one of the parsimony analysis for 46 samples in 34 taxa of *Eriocaulon* and two outgroup taxa, using the combined entire *trn*L-F sequence data, anatomical and morphological data (without coded gaps). Tree length = 2,770, Consistency index (CI) = 0.55, Retention index (RI) = 0.50 and Rescaled consistency index (RC) = 0.27

Characters	Statistical Values		
	CI	RI	RC
#1 stem rhizome or corm	0.143	0.250	0.036
#2 leaf length equal or longer than 10 cm	0.200	0.200	0.040
#3 leaf hairy	0.200	0.000	0.000
#4 leaf papillate	0.500	0.750	0.375
#5 leaf apex obtuse	0.143	0.143	0.020
#6 leaf reddish	0.333	0.000	0.000
#7 scape	0.500	0.000	0.000
#8 receptacle hairy	0.250	0.400	0.100
#9 involucral bracts as long as or longer than the length of capitula	0.333	0.000	0.000
#10 involucral bracts papery	0.091	0.545	0.050
#11 involucral bracts hairy	0.143	0.500	0.071
#12 involucral bracts apex long acuminate	0.333	0.000	0.000
#13 floral bracts blackish	0.111	0.556	0.062
#14 floral bracts hairy	0.167	0.444	0.074
#15 floral bracts apex long acuminate	0.143	0.143	0.020
#16 male flowers 2 sepals	0.200	0.500	0.100
#17 male flowers blackish sepals	0.125	0.650	0.081
#18 male flowers unequal petals	0.091	0.545	0.050
#19 male flowers petals exserted beyond the floral bracts	0.250	0.571	0.143
#20 male flowers petals hairy	0.111	0.579	0.064
#21 male flowers glandular petals	0.167	0.615	0.103
#22 female flowers lateral sepal winged-keeled	0.200	0.200	0.040
#23 female flowers dimorphic sepals	0.143	0.143	0.020
#24 female flowers blackish sepals	0.111	0.619	0.069
#25 female flowers petals	0.333	0.000	0.000
#26 ovary 5-6 locules	0.500	0.000	0.000
#27 seed papillate	0.125	0.588	0.074
#28 leaf, hypodermis	0.333	0.000	0.000
#29 leaf, vascular tissue equidistant	0.100	0.182	0.018
#30 leaf, mesophyll homogeneous	0.250	0.000	0.000

Shared characters between the groups (Figure 4.13)

Groups A and B shared 2 characters, the receptacle hairy (#8) and the absence of homogeneous mesophyll (#30).

Groups A, B and C shared only 1 character, the receptacle hairy (#8).

4.4.3 Comparison grouping

The grouping produced by phylogenetic analysis (group D) supports the monophyly of group II produced by phenetic analysis (Yellow colour in Figures 4.6 and 4.13) with 100% bootstrap support when using combined molecular, anatomical and morphological data matrix, with 57% bootstrap support when using only molecular data matrix. However, there is no strong bootstrap support in any phylogenetic analysis to reject the remaining five groups produced by phenetic analysis in Figure 4.6.

4.5 Discussion and conclusion

According to Sokal and Sneath (1963), as the number of characters sampled increases, the value of the similarity coefficient becomes more stable. This means, ideally that as many characters as possible should be used so that the phenetic correlation would be strengthened. However, the maximum ideal number of characters varies significantly depending upon the types of characters used and the natural congruence among the different kind of data (Stuessy, 1990) and I noted that there was variation and that the quantitative characters of the sample within *Eriocaulon* were continuously varying (no gap). Therefore the characters used in the analysis were mostly qualitative characters. Additionally, one of the aims of this chapter was to compare the results from the phenetic analysis with 3 types of phylogenetic method. Therefore, the anatomical and morphological data used in phenetic and phylogenetic analyses must suit both analyses, *i.e.* uninformative characters cannot be used in phylogenetic analysis or characters which have missing values cannot be used in homogeneity analysis, therefore these characters were not included in the data matrices. Especially, binary state characters can be used for homogeneity analysis. Therefore, only 30 binary state characters were available for the analyses.

The results from the phenetic analysis (Figure 4.6) and homogeneity analysis (Figure 4.8) suggested that the 34 taxa of *Eriocaulon* could be divided into six groups.

The results from the phylogenetic analyses of the anatomical and morphological data set did not provide any strong suggestion for the relationships between the 34 taxa. Whereas, the phylogenetic analyses of the molecular data set showed that the number of clades resolved in the consensus tree was much greater from the combined data set than from the molecular data set. Additionally, the results from the molecular data set showed that the number of bootstrap values (greater than 50%) were fewer than from the combined data set, though most of the pattern of the cladograms is similar (Figures 4.10, 4.11 and 4.12). Because of the weak bootstrap support in both these cladograms, five of

six groups defined by phenetic analysis is neither supported or rejected. However, the monophyly of group II, as defined by phenetic analysis in Figure 4.6, was confirmed in the strict consensus trees of both phylogenetic analyses (Clade D, Figures 4.10 and 4.11). Furthermore, the three remains groups (Group A, B and C) could be isolated by the strict consensus of combined data set (Figure 4.13) in relation to the distribution of the anatomical and morphological characters. The distribution of groupings using phenetic analysis (Group I to VI, indicates by distribution of colour in Figures 4.13) showed that there is not any support for the other 5 phenetic groups.

According to the Consistency Index (CI) and Retention Index (RI) values from the two analyses (the anatomical and morphological analysis and the combined molecular and anatomical and morphological data matrix analysis) (Tables 4.2 and 4.3), it is noted that the CI and RI value of most of the 30 characters used in the anatomical and morphological analysis were lower than corresponding values in the combined data matrix analysis. This means that most of the characters showed higher homoplasy when there were more characters in the data matrix. Only the CI and RI values of character numbers 7, 9, 26 and 28 from two analyses were exactly the same, and the RI values of these characters were 0.000. All these characters do is explain the cladograms at its terminal branches. Therefore, the character numbers 7, 9, 26 and 28 do not have much effect for grouping or classification within the genus. Character numbers 4 (leaf papillate) was the highest (1.000) CI and RI values for the anatomical and morphological analysis, character numbers 2, 6, 7, 8, 12, 16, 25, 26, and 30 were the group of the high CI values (0.500) and character numbers 2, 8, 10, 13, 17, 20, 21, 22, 24 and 29 were the group of high RI values (0.800-0.950). Whereas, character number 4, 7 and 26 were the highest (0.500) CI values but only character numbers 4 was the highest (0.750) RI values for the combined molecular and anatomical and morphological data matrix analysis.

In considering the 14 shared characters between and among the groups— the character numbers 2, 3, 4, 6, 7, 8, 9, 14, 19, 22, 25, 26, 28 and 30 (Figure 4.13) and the CI and RI value, it is noted that the CI value of character numbers 7, 9, 26 and 28 from the two analyses were exactly the same and the CI and RI values of the remaining characters were lower in the combined data matrix analysis. There was only CI value found for character number 4 (presence or absence of leaf papillate) was 1.000 in the anatomical and morphological analysis. This means this character fits the cladograms perfectly (fit to a single node on the cladogram) and therefore this character has no homoplasy, however, its value was decreased in the combined data matrix analysis as mentioned above.

A comparison with these results with the historical infrageneric classification of *Eriocaulon* (Chapter 1, topic 1.5), indicates a number of points:

There were eight taxa in this study which were included in Fyson (1919-1922), these are: *E. setaceum* (section 2 of Fyson), *E. echinulatum* (section 4 of Fyson), *E. hamiltonianum* (section 5 of Fyson), *E. nepalense* var. *luzulaefolium* (section 6 of Fyson), *E. truncatum* (section 6 of Fyson), *E. xeranthemum* (section 6 of Fyson), *E. brownianum* (section 7 of Fyson) and *E. wightianum* (section 7 of Fyson).

Therefore, Clade C of this study contained sections 4, 5 and 6 of Fyson. Section 6 of Fyson also appears polyphyletic as it appears in both Clades C and D. Even though, this phylogenetic analysis does support section 7 of Fyson with 100% bootstrap support. However, my phenetic analysis did not support this section.

Only *E. cinereum* in this study was included in Satake (1940) (as *E. sieboldtianum*, section 3 of Satake). Therefore, it is not possible to use my results to commend on Satake's.

There were five taxa in this study which were included in Ma (1991); *E. brownianum* (section 1.1 of Ma), *E. setaceum* (section 1.1 of Ma), *E. zollingerianum* (section 1.2 of Ma), *E. echinulatum* (section 2 of Ma) and *E. cinereum* (section 2 of Ma). The results from my study show that section 1.1 of Ma is polyphyletic as is section 2 of Ma.

There were seven taxa in this study which were included in Ansari and Balakrishnan (1994); *E. wightianum* (section 2 of Ansari and Balakrishnan), *E. brownianum* (section 3 of Ansari and Balakrishnan), *E. xeranthemum* (section 3 of Ansari and Balakrishnan), *E. setaceum* (section 4 of Ansari and Balakrishnan), *E. truncatum* (section 7 of Ansari and Balakrishnan), *E. hamiltonianum* (section 7 of Ansari and Balakrishnan) and *E. cinereum* (section 12 of Ansari and Balakrishnan). Clade C contains sections 4 and 7 of Ansari and Balakrishnan, whereas section 3 of Ansari and Balakrishnan is polyphyletic as is section 7 of Ansari and Balakrishnan.

There were 21 taxa in this study which were included in Zhang (1999), all of them belong to Subgenus *Trimeranthus* Nakai, comprising *E. setaceum* (section 1 of Zhang), *E. brownianum* (section 2 of Zhang), *E. infirmum* (section 2 of Zhang), *E. laosense* (section 2 of Zhang), *E. nepalense* var. *luzulaefolium* (section 2 of Zhang), *E. smitinandii* (section 2 of Zhang), *E. thailandicum* (section 2 of Zhang), *E. wightianum* (section 2 of Zhang), *E. xenopodium* (section 2 of Zhang), *E. xeranthemum* (section 2 of Zhang), *E. ubonense* f. *kradungense* (section 3 of Zhang), *E. nautiliforme* (section 3 of Zhang), *E. siamense* (section 3 of Zhang), *E. willdenovianum* (section 4 of Zhang), *E. escape* (section 5 of Zhang), *E. echinulatum* (section 5 of Zhang), *E. hamiltonianum* (section 5 of Zhang), *E. truncatum* (section 5 of Zhang), *E. truncatum* var. *florensense* (section 5 of Zhang), *E. zollingerianum* (section 5 of Zhang) and *E. cinereum* (section 6 of Zhang). The results of this study show that sections 2, 3 and 5 of Zhang are polyphyletic.

My analysis shows that there is variation in the *trnL-F* within taxa follows:

E. siamense collector numbers 200 and 258: collector number 200 was collected from Phu Soi Dao National Park, Uttraradit which has narrower, reddish and non-papillate leaves whereas collector number 258 was collected from Phuchong Nayoy National Park, Ubon Ratchathani which has broader, green and papillate leaves.

E. phuphanoides collector numbers 299, 320 and 345: collector number 299 collected from Khong Cheim District, Ubon Ratchathani which having scapes just 6 cm long; whereas collector

numbers 320 and 345 were collected from Phu Phan National Park, Sakol Nakhon which having scapes 23-27 cm long. However, collector numbers 299 and 345 have 3-ribbed scapes whereas collector number 320 has 4-ribbed scapes.

E. nepalense var. *luzulaefolium* collector numbers 157, 161 and 208: collector number 157 was collected from Phu King, Thung Kamung Wildlife Sanctuary, Chaiyaphum and collector number 161 was collected from Khao Yai National Park, Nakhon Nayok, both have the short stem whereas collector number 208 was collected from Thung Non Son, Thung Salang Luang National Park, Phetchaboon, which the plant has longer stems as it was in the shallow water.

It is noted that the data from the *trnL-F* region has proven valuable for differentiating some closely allied species, for example *E. ubonense* from Phu Kradung National Park, Loei, has blackish female petals and belongs to group A whereas *E. ubonense* f. *kradungense* from Thung Non Son, Thung Salang Luang National Park, Phetchaboon has whitish female petals and belongs to group B.

The results of the phenetic analysis do not lend any support to any section described by previous workers. However, the phylogenetic analysis shows that section 7 of Fyson (1919-1922) forms a well-supported monophyletic group. Perhaps, the differences in my results from those of previous studies are due to differences in the methods of analysis, number of taxa, type of information and in the size of the data set. Previous studies were based on only morphological and anatomical characters from different datasets and different characters; for example Fyson (1919-1922) studied 51 species of *Eriocaulon* from India, Satake (1940) studied 36 species of *Eriocaulon* in Japan and Ma (1991) studied 33 taxa from China. Additionally, I found that many anatomical and morphological characters in *Eriocaulon* previously used are variable (chapters 2 and 3). Therefore there were only 30 invariable binary characters including into the matrix for analyses. The data from the *trnL-F* region has not proven valuable for studying relationships of 34 taxa within *Eriocaulon.* Therefore 5 of the 6 groups defined by phenetic analysis were neither supported or rejected. All these 6 groups may be artificial and it is not advisable to use a classification based on plants from a limited geographic region (Ansari and Balakrishnan, 1994). Therefore, more gene regions and more samples from geographic regions should be included in further studies in order to define practical sections within the genus.

CHAPTER 5

TAXONOMIC TREATMENT

5.1 Introduction

This chapter aims to provide a taxonomic revision of the Eriocaulaceae in Thailand. The area this study encompasses Thailand only. Where endemic species are refered to in this account I intend to indicate that I do not know of any report of this species occurrence from anywhere else in the world.

5.2 Materials and Methods

The study was undertaken at the Herbarium, Department of Botany, Trinity College Dublin (**TCD**). Approximately 2,400 herbarium specimens were examined from the following 15 herbaria: Herbarium Jutlandicum, Botanical Institute, University of Aarhus, Denmark (**AAU**); Herbarium, Plant and Soil Science Department, University of Aberdeen, Scotland, U.K. (**ABD**); Herbarium, Botany Section, Botany and Weed Science Divsion, Department of Agriculture, Bangkok, Thailand (**BK**); Forest Herbarium, National Park Wildlife and Plant Conservation Department, Bangkok, Thailand (**BKF**); Herbarium, Botanical Museum and Library, University of Copenhagen, Denmark (**C**); Herbarium, Royal Botanic Garden Edinburgh, Scotland, U.K. (**E**); Herbaria, Harvard University, Cambridge, U.S.A. (**GH**); Herbarium, Royal Botanic Gardens Kew, England, U.K. (**K**); Herbarium, Department of Biology, Faculty of Science, Khon Kaen University, Thailand (**KKU**); Nationaal Herbarium Nederland, Leiden University, Netherlands (**L**); Herbarium, Botanische Staatssammlung München, Germany (**M**); William and Lynda Steere Herbarium, New York Botanical Garden, U.S.A. (**NY**); Herbier, Departement de Systematique et Evolution, Museum National d'Histoire Naturelle, Paris (**P**); (**TCD**) and Museum of Evolution, Botany Section (Fytoteket), Uppsala University, Sweden (**UPS**) (Appendix 1).

Dimensions given in the descriptions are based on herbarium specimens and on living plants, including observations of plants made in the field. For dried specimens, flowers were softened in water before measurements were taken. All floral drawing was undertaken using Leica MZ12 stereomicroscope with camera lucida (Leica 10446193), Leica LS150 light source: most of the inflorescences were photographed using a digital camera (Nikon Coolpix 4500, 4.0mega pixels 4xZoom) taken directly through the ocular lens of the stereomicroscope. Magnification used for floral drawings were 10-30 times, for inflorescences 5-10 times. Herbarium specimens were photographed using a digital camera (Cannon PowerShotG2, 3.0mega pixels), daylight.

Taxa are arranged alphabetically. Most of the major Floras and publications in SE Asia are cited. Synonyms listed in the works mentioned above are included and verified. All specimens cited under each species have been seen and are arranged alphabetically by collector's name. Almost all types of correct names and synonyms have been seen and these are indicated by (!) after herbaria abbreviation.

For the correct names, when there is no holotype or previous lectotypification, a lectotype or neotype has been chosen. Geographic distribution and ecological information were taken from herbarium specimens and from field observations in Thailand.

The description was constructed by putting the data into Microsoft Excel version 10 then manually typing it into Microsoft Word version 10. The key to species was made using vegetative characters first; however, I found that the most of characters which were most useful for identification were reproductive. I found it difficult to produce a key with more than a single facter at a dichotomy due to the variability of characters. The format of the key follows the format of the Flora of Thailand.

Publications (books or periodicals) title and author citations abbreviations follow "The International Plant Names Index" (2004)— www.ipni.org/index.html. For publications which are not included in the web-site above, follow those commonly used in botanical literature. For the author citations that are not included in the web-site above, abbreviations were not used.

Field work took place in 21 Thai National Parks, 2 Wildlife Sanctuaries and 25 other Districts totalling 26 Provinces in Thailand between September and December 2002 (Table 5.1). In total, approximately 200 specimens were collected, forty six duplicate samples of which were used for anatomical and molecular study. The collections are held in **BK**, **BKF**, **K**, **KKU** and **TCD**.

Table 5.1 List of the areas visited for the collection of specimens in Thailand. D. = District, NP = National Parks, WS = Wildlife Sanctuaries.

Areas/Districts	National Parks /Wildlife Sanctuaries (approx. Long., Lat.)	Provinces
Muang D.	Doi Suthep-Doi Pui NP (18.80N, 98.99E)	Chiang Mai
Doi Kam	Ob Luang NP (18.21N, 98.60E)	Chiang Mai
Yor Song Lan Son	Doi Khuntan NP (18.45N, 99.15E)	Lamphun
Muang Bahn	Chae Sawn NP (18.80N, 99.53E)	Lampang
Lan Son	Phu Soi Dao NP (17.75N, 100.95E)	Uttaradit
Thung Non Son	Thung Saleang Luang NP (16.60N, 100.80E)	Phetchabun
	Phu Rua NP(17.27N, 101.22E)	Loei
	Phu Kradung NP (16.90N, 101.80E)	Loei
	Phu Phan NP (17.05N, 104.00E)	Sakon Nakhon
Lan Phu Wat	Phu Sa Dok Bua NP (16.19N, 104.48E)	Mukdahan
Muang D.	(16.32N, 104.43E)	Mukdahan
Phu King	Phu Khieo WS (16.20N, 101.47E)	Chaiyapum
Kab Cherng D.	(14.45N, 103.40E)	Surin

Table 5.1 Continued

Areas	National Parks /Wildlife Sanctuaries (approx. Long., Lat.)	Provinces
Prasart D.	(14.40N, 103.60E)	Surin
Phrai Bung D.	(14.65N, 104.30E)	Si Sa Ket
	Phu Chong Nayoi NP (14.50N, 105.30E)	Ubon Ratchathani
Buntharig D.	(14.78N, 105.40E)	Ubon Ratchathani
Det Udom D.	(14.98N, 105.33E)	Ubon Ratchathani
Pimoon Mungsahan D.	(15.15N, 105.30E)	Ubon Ratchathani
Khong Chiem D.	Pha Tam NP (15.40N, 105.60E)	Ubon Ratchathani
Khame Ratch D.	(16.05N, 105.15E)	Ubon Ratchathani
Khao Sahm Lahn	Phra Buddha Chai NP (14.50N, 101.00E)	Saraburi
	Khao Yai NP (14.40N, 101.10E)	Nakhon Nayok
Muang D.	Pang Sida NP (13.80N, 102.10E)	Sa Kaeo
Klaeng D.	Khao Chamao -Khao Wong NP (12.78N, 101.68E)	Rayong
Laem Sing D.	Phriew Waterfall NP (12.48N, 102.12E)	Chanthaburi
Khao Soi Dao waterfall	Khao Soi Dao WS (13.05N, 102.20E)	Chanthaburi
Makham D.	(12.70N, 102.20E)	Chanthaburi
Muang D.	(12.10N, 102.65E)	Trat
Klong Yai D.	(11.90N, 102.80E)	Trat
	Koh Chang NP (12.05N, 102.40E)	Trat
Bo Rai D.	(12.55N, 102.48E)	Trat
	Khlong Kaew waterfall NP (12.60N, 102.60E)	Trat
Khao Saming D.	(12.35N, 102.47E)	Trat
Suk Sahm Lahn D.	(09.45N, 98.45E)	Ranong
Tha Chang D.	(09.28N, 99.20E)	Surat Thani
Kapong D.	(08.41N, 98.27E)	Phangnga
Takua Pa D.	(08.52N, 98.21E)	Phangnga
Thalang D.	(08.05N, 98.35E)	Phuket
Kathu D.	(07.93N, 98.30E)	Phuket
Muang D.	(07.90N, 98.36E)	Phuket
Thung Song D.	(08.15N, 99.70E)	Nakhon Sri Thammarat
Ya Roy waterfall	Thale Ban NP (06.80N, 100.08E)	Satun

Table 5.1 Continued

Areas	National Parks /Wildlife Sanctuaries (approx. Long., Lat.)	Provinces
	Tarutao NP (06.36N, 99.37E)	Satun
Chana D.	(06.92N, 100.75E)	Songkhla
Had Yai D.	(07.00N, 100.45E)	Songkhla
Thepha D.	(06.48N, 100.57E)	Songkhla
Nong Chig D.	(06.85N, 101.20E)	Pattani

5.3 Results

ERIOCAULACEAE

Annual or perennial herbs. Stems often forming a basal disc, infrequently shortly rhizomatous or elongate. Leaves crowded into a basal rosette or dispersed along an elongate stem, sessile, linear or acicular. Scapes mostly few or numerous, slender, rarely scape absent. Sheaths loose. Capitula (inflorescence) dense hemispherical or ovoid to globose. Flowers unisexual, rarely bisexual, monoecious. Perianth scarious, usually composed of 2 distinct whorls; sepals usually free in female flowers and connate and 2-3-lobed in the male flowers; petals free in female flowers, 3 small lobed seated on an elongated clavate stipe in male flowers. Stamen (5-) 6 connected with the petal. Ovary superior, composed of (2-) 3 (-6) carpels— the same as number as the locular, style simple, tipped with 3(-6) elongate stigmas. Fruits a loculicidally dehiscent capsule, ellipsoidal or ovoidal seed in each locule.

A family of 11 genera and about 1300 species, widely distributed in tropical and subtropical regions, with most of the species found in South America and Africa. Monogeneric in Asia with 35 species in Thailand.

ERIOCAULON

Eriocaulon *L.*, Sp. Pl. 1: 87 (1753) & Gen. Pl., ed. 5: 38 (1754); Crantz, Inst. Rei. Herb. 1: 360 (1766); Lour., Fl. Cochinch. 1: 60 (1790); R.Br., Prodr. Fl. Nov. Holland: 253 (1810); Humb., Bonpl. & Kunth, Nov. Gen. Sp. 1: 251 (1815); Kunth, Enum. Pl. 3: 539 (1841); Steud., Syn. Pl. Glumac. 2: 268 (1855); Körn. in Linnaea. 27: 577 (1856); Benth., Fl. Hongk.: 381 (1861); Maxim., Diagn. Pl. Nov. Asiat. 8: 5 (1893); Hook.f., Fl. Brit. Ind. 6: 571 (1894); Hook.f. & Trimen, Handb. Fl. Ceylon 5: 1 (1900); N.E.Br. in Dyer, Fl. Trop. Afr. 8: 231 (1902); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 30 (1903); Lecomte, Fl. Indo-Chine 7(1): 1 (1912); Merr., Fl. Manila: 135 (1912); Collett, Fl. Siml.: 549 (1921); Fyson in J. Indian Bot. 2: 148 (1921a); C.E.C.Fischer, Fl. Madras 9: 1605 (1931); Moldenke, Fl. Texas in Lundell 3: 3 (1942); M.R.Hend., Malay. Wild Fls., Monocots.: 212 (1954); Gleason, Ill. Fl. NE U.S. Canada: 372 (1958); Steward, Man. Vasc. Pl. Yangtze Valley China: 502 (1958); J.M.Black, Fl. S. Austral., ed. 2 part1: 179 (1960); Griseb., Hist. Nat. Class. 30: 526 (1963);

Ridl., Fl. Malay. Penin. 5: 133 (1967); Backer & Bakh.f., Fl. Java 3: 25 (1968); C.E.Chang, Fl. Taiwan 5: 179 (1978); H.Keng, Orders Fam. Malayan Seed Pl.: 323 (1978); Gandhi in C.J.Saldanha & Nicolson, Fl. Hassan Dist.: 650 (1978); P.Royen, Alpine Fl. New Guinea 2: 823 (1979); Ghaz. in Nasir & Ali, Fl. Pakistan 142: 1 (1982); T.Koyama in Ohwi, Fl. Jap.: 265 (1984); R.Kral in J. Arnold Arbor. 70: 136 (1989); C.D.K.Cook, Aquatic Pl. Book: 89 (1990); H.Keng, D.Y.Hong & C.J.Chen, Orders Fam. Seed Pl. China: 335 (1993); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 10 (1994); C.D.K.Cook, Aquatic Wetland Pl. India: 187 (1996); S.M.Phillips in Dassan. & Clayton, Revis. Handb. Fl. Ceylon 11: 48 (1997); Stützel, Fam. Gen. Vasc. Pl. 4: 204 (1998); Z.X.Zhang in U.Kück, Diss. Bot. 313: 59 (1999); Das Das & N.P.Singh in J. Econ. Taxon. Bot. 25(2): 456 (2001). Type species: *Eriocaulon decangulare* L.

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Nasmythia Huds., Fl. Angl., ed. 2, 2: 414 (1778).
Leucocephala Roxb., Fl. Ind. 1: 612 (1820).
Randalia Beauvis. ex Desv., Ann. Sci. Nat. (Paris) 1(13): 47, pl. 5, fig.2 (1828).
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Electrosperma F.Muell, Trans. Philos. Soc. Voctoria 1: 23 (1855).
Dichrolepis Welw., Apont.: 542 (1859).
Lasiolepis Boeck, Flora 56: 90 (1873).

Annual or perennial herbs. *Stems* often forming a basal disc, infrequently shortly rhizomatous or elongate. *Leaves* simple, crowded into a basal rosette or dispersed along an elongate stem, sessile, opaque to translucent, sometime fenestrate, linear or acicular, base hairy, margin entire or papillate, apex acute, obtuse or 2-lobed, glabrous or hairy, hydrathode-like (pore at the end of apex) always present. *Scapes* mostly few or numerous, slender, glabrous or hairy, rarely scape absent. *Sheaths* loose, acute, obtuse or 2-3-lobed, often glabrous. *Capitula* hemispherical or ovoid to globose. *Receptacle* elongate or convex shaped, often villus. *Involucral bracts* in 1-3 whorls, often obovate to elliptic, hairy on the outer face or glabrous. *Floral bracts* often oblanceolate or obovate, hairy on the outer face or glabrous. *Flowers* unisexual, monoecious, mostly irregular. *Perianth* scarious, usually composed of 2 distinct whorls, sometimes reduced or absent; sepals usually free in female flowers and connate and spathaceous with 2-3-lobed in the male flowers, acute or obtuse, hairy at the edge or the upper part of the outer face or glabrous; petals free in female flowers, 3-lobed, small lobe seated on an elongated clavate stipe in male flowers, often with a conspicuous subapical black nectar-gland on the inner face, hairy at the edge or the upper part of the inner face or glabrous. *Male flowers* with (5-)6 stamens, often vestigial gynoecium reduced to black glands which are as many as the locules, anther loculicidally dehiscent, often black, infrequently white. *Female flowers* with superior (2-) 3 (-6) locular ovary, style simple, tipped with 3(-6) elongate stigmas. *Fruits* a thin walled, loculicidally dehiscent capsule, an ellipsoidal or ovoidal seed in each locule; seed coat usually with cells transversely elongate, with appendages or 1-3 tuberculae from the middle of the transverse radial

walls or absent. Common on sandy soils in open marshy places, paddy fields, on the borders of barren sandstone rocks, in or near seasonal ponds, submerged on sandy soils in pools or streams. Altitude 100-1300 m (Figure 5.1). Flowering mostly September to December.

Key to Species

1. Scape absent
 2. Heads brown, involucral bracts elliptic, long-acuminate at the tip ***8. E. escape***
 2. Heads dark-grey, involucral bracts lanceolate to oblong, acute ***26. E. pseudoescape***
1. Scape present
 3. Leaves filiform or acicular, stem elongate ***28. E. setaceum***
 3. Leaves linear or ensiform, stem corm-like or with a short rhizome
  4. Anthers white
   5. Leaves 15-20 cm long, female sepals united when flowers immature ***9. E. fluviatile***
   5. Leaves 1.5-10 cm long, female sepals free all the time
    6. Heads whitish; floral bracts obovate, hairy; female petals present ***4. E. chiangmaiense* ssp. *leucanthemum***
    6. Heads brown or blackish; floral bracts narrowly oblanceolate, more or less glabrous; female petals absent ***5. E. cinereum***
  4. Anthers black
   7. Floral bracts hairless
    8. Floral bracts long-acuminate
     9. Female petals absent ***11. E. hamiltonianum* var. *acuminatum***
     9. Female petals present
      10. Male petals showy, hairy ***20. E. oryzetorum***
      10. Male petals minute, hairless ***7. E. echinulatum***
    8. Floral bracts acute or acuminate
     11. Male petals with black glands
      12. Head brownish, involucral bracts shorter than heads, floral bracts brownish ***36. E. truncatum***
      12. Head blackish, involucral bracts as long as or longer than heads, floral bracts blackish ***37. E. truncatum* var. *florensense***
     11. Male petals without black glands
      13. Female sepals boat-shaped, dorsally winged ***45. E. zollingerianum***
      13. Female sepals linear ***10. E. hamiltonianum***
   7. Floral bracts hairy
    14. Scapes hairy
     15. Leaves hairy
      16. Leaves more than 15 cm long ***1. E. brownianum***
      16. Leaves less than 10 cm long
       17. Scapes hairy only near the heads ***22. E. phatamense***

17. Scapes hairy all over — ***2. E. chantaranothaii***

15. Leaves glabrous

18. Female sepals all similar, narrowly oblanceolate — ***35. E. smitinandii***

18. Female sepals dimorphic, 2 oblanceolate, 1 shell-like

19. Ovary with 3 locules — ***16. E. nautiliformoides***

19. Ovary with 5 or 6 locules — ***17. E. nautiliformoides* var. *hexagynum***

14. Scapes hairless

20. Female sepals connate — ***23. E. phuchongense***

20. Female sepals free

21. Ovary with 5 or 6 locules

22. Involucral bracts narrowly oblong; male petals unequal, the longest one exserted beyond the floral bracts — ***33. E. siamense* ssp. *hexagynum***

22. Involucral bracts obovate; male petals more or less equal, not exserted beyond the floral bracts — ***40. E. ubonense* var. *hexagynum***

21. Ovary with 2 or 3 locules

23. Ovary 2-locular — ***42. E. willdenovianum***

23. Ovary 3-locular

24. Longest male petals exserted beyond the floral bracts

25. Female sepals dimorphic, 2 narrowly oblanceolate, 1 shell-like — ***15. E. nautiliforme***

25. Female sepals all similar

26. Female sepals boat-shaped

27. Floral bracts acuminate; female petals elliptic, attenuate, sepals oblong-keeled — ***6. E. cristatum***

27. Floral bracts acute; female petals linear, sepals ovate-keeled — ***12. E. henryanum***

26. Female sepals oblanceolate or narrowly oblanceolate

28. Leaves obtuse, 5-10 mm wide at the base — ***32. E. siamense* var. *macrophyllum***

28. Leaves acute, 0.5-1 mm wide at the base — ***31. E. siamense***

24. Longest male petals not exserted beyond the floral bracts

29. Female sepals boat-shaped, dorsally keeled

30. Leaves up to1 mm wide at base, scapes up to 12 cm long, heads blackish-greyish — ***21. E. parnellii***

30. Leaves more than 3 mm wide at base, scapes more than 20 cm long, heads whitish

31. Involucral bracts glabrous, female petals narrowly linear

32. Stem rhizomatous, leaves and sheaths hairy — ***30. E. sexangulare* var. *australe***

32. Stem a basal disc, leaves and sheaths glabrous — ***29. E. sexangulare***

31 Involucral bracts hairy; female petals ovate, attenuate — ***41. E. wightianum***

29. Female sepals linear to narrowly elliptic or oblanceolate

33. Involucral bracts longer than heads — ***44. E. xeranthemum***

33. Involucral bracts as long as or shorter than heads

34. Floral bracts brown or pale brown

35. Floral bracts long-acuminate ***35. E. thailandicum***

35. Floral bracts acute or acuminate

36. Female sepals 3

37. Scapes more than 20 cm long, heads 4-6 mm long ***38. E. ubonense***

37. Scapes up to 10 cm long, heads 1.5-2 mm long ***14. E. laosense***

36. Female sepals 2 ***25. E. phuphanoides***

34. Floral bracts black or if brown then black at the tip

38. Male sepals 2 ***24. E. phuphanense***

38. Male sepals 3

39. Involucral bracts hairy ***13. E. infirmum***

39. Involucral bracts hairless

40. Male petals showy, equal,subapical glands present

41. Involucral bracts and floral bracts broadly obovate, female sepals broadly boat-shaped ***43. E. xenopodium***

41. Involucral bracts and floral bracts ovate or oblong, female sepals narrowly oblanceolate

42. Involucral bracts leathery ***39. E. ubonense* f. *kradungense***

42. Involucral bracts papery ***3. E. chiangmaiense***

40. Male petals minute, unequal, eglandular

43. Leaves reddish or purple; involucral bracts narrowly oblong; female sepals 2 ***27. E. quinquangulare* var. *longibracteatum***

43. Leaves green; involucral bracts broadly obovate; female sepals 3

44. Leaves obtuse, margin papillate; receptacle glabrous ***18. E. nepalense***

44. Leaves acute, margin entire; receptacle pilose ***19. E. nepalense* var. *luzulaefolium***

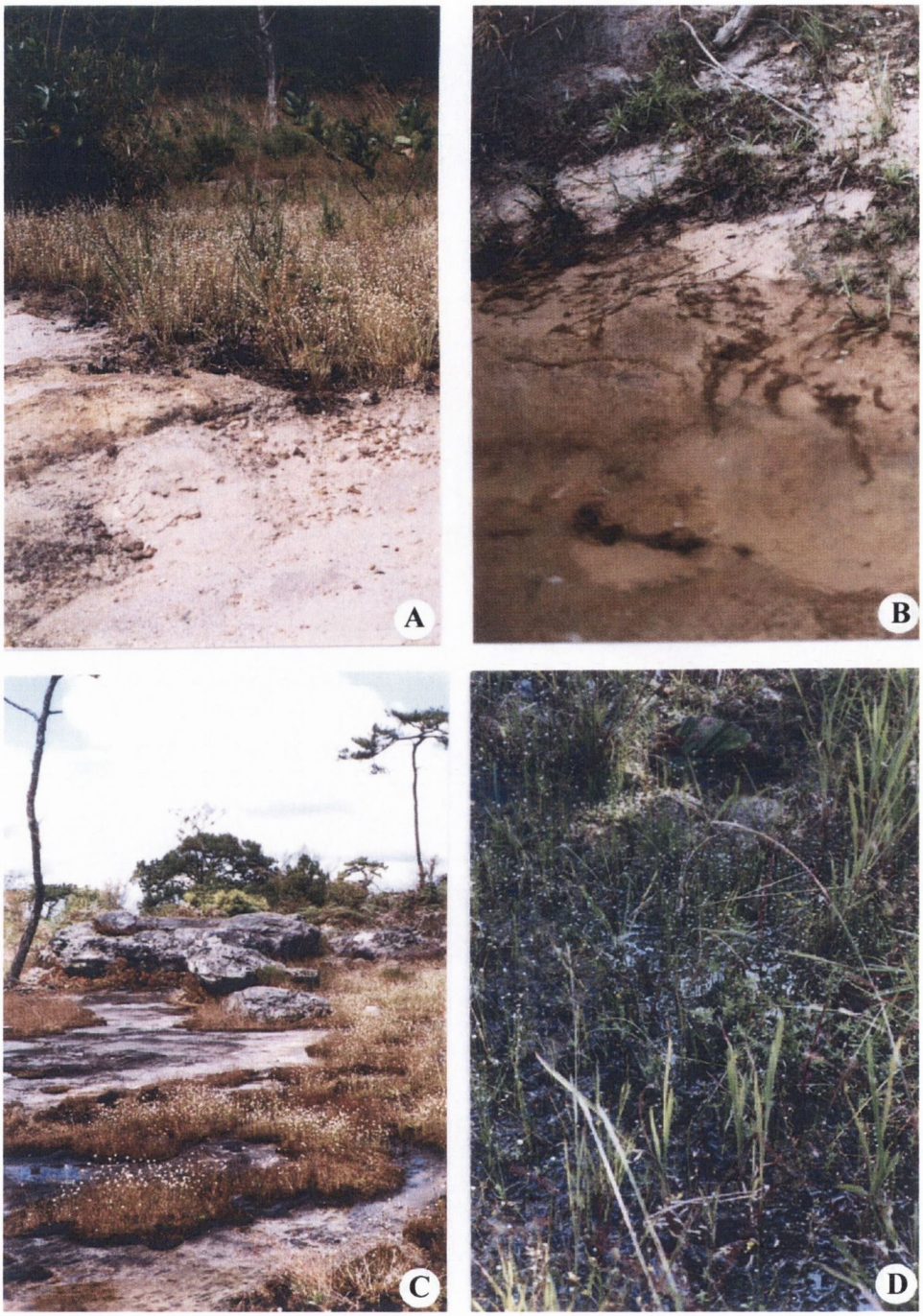

Figure 5.1 Habitats of Eriocaulaceae in Thailand. (A) Sandy soils in open places. (B) Sandy soils by the streams. (C) On the borders of barren sandstone rocks. (D) Sandy soils in marshy places. From Prajaksood (2000).

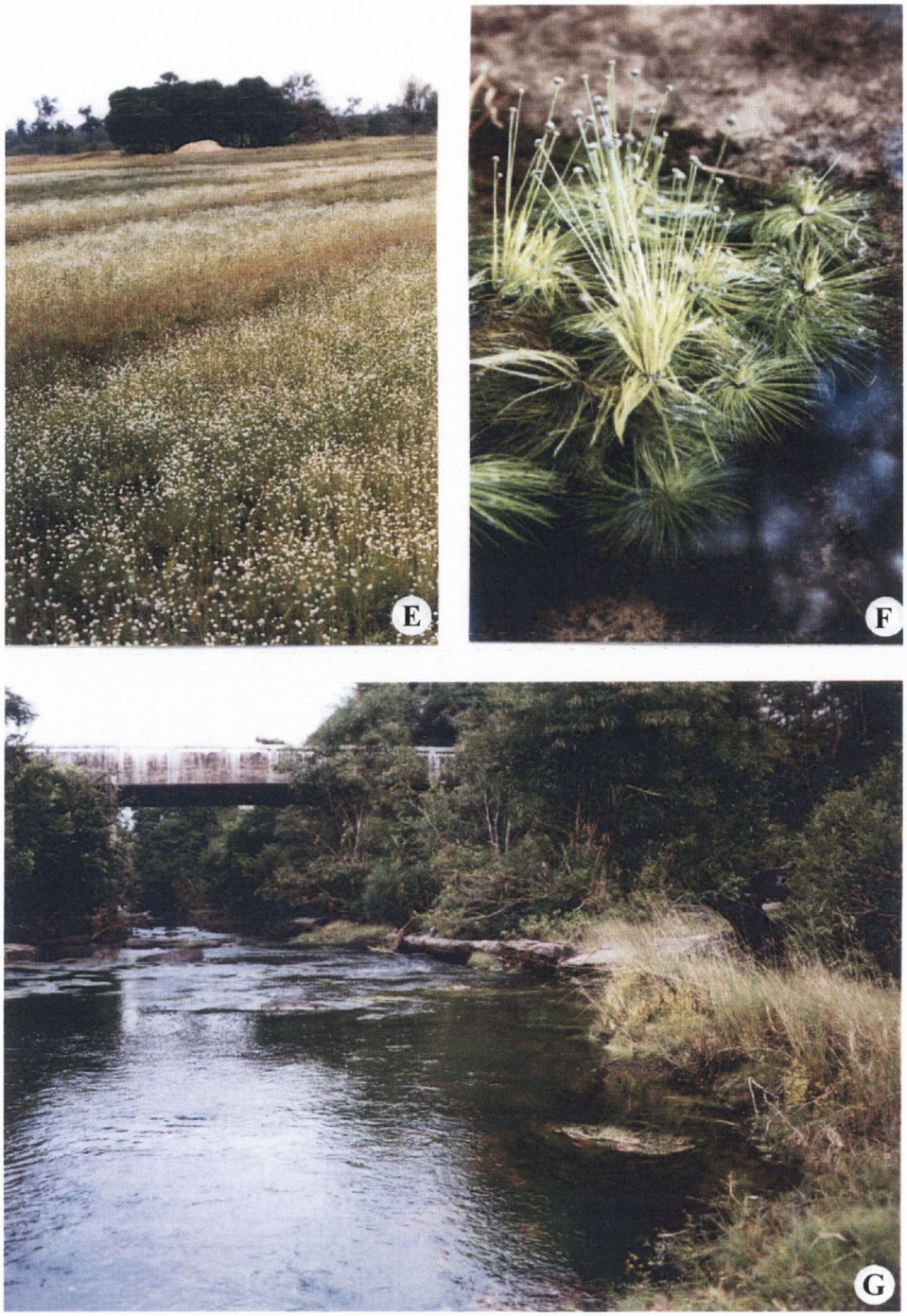

Figure 5.1 Continued. (E.) Sandy soil in paddy fields. (F) Submerged on sandy soil in seasonal ponds or pools. (G) Submerged on sandy soils in streams. From Prajaksood (2000).

1. Eriocaulon brownianum *Mart.* in Wall., Pl. Asiat. Rar. 3: 25, t. 25 (1832); Kunth, Enum. Pl. 3: 562 (1841); Steud., Syn. Pl. Glumac. 2: 271 (1855); Körn. in Linnaea. 27: 663 (1856); Thwaites, Enum. Pl. Zeyl. 5: 341 (1864); Hook.f., Fl. Brit. Ind. 6: 576 (1894); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 84 (1903); Fyson in J. Indian Bot. 2(8-9): 262 (1921c); Lecomte, Fl. Indo-Chine 7(1): 17 (1912); W.L.Ma in Acta Phytotax. Sin. 29: 289-314 (1991); P.H. Hô, Ill. Fl. Vietnam 3(1): 480 (1993); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 10 (1994); S.M.Phillips in Dassan. & Clayton, Revis. Handb. Fl. Ceylon 11: 48 (1997); Z.X.Zhang in U.Kück, Diss. Bot. 313: 79 (1999). Type: India, Silhet, Nov. 1832, *Wallich* 6066 (holotype **M!** (0064968); isotypes **B!, BR, CAL!, K!, K-WA!, L!, M!** (0064967)).

E. nilagirense Steud., Syn. Pl. Glumac. 2: 271 (1855) Type: India, Nilagiri, mountain, *R.F. Hohenacker* 953 (holotype **E** (00027127); isotypes **BM!, GH!, K!, L!**).

E. blumei Körn. in Miq., Ann. Mus. Bot. Lugduno-Batavi 3: 240-241 (1867). Type: Indonesia, Java, *Blumei* s.n. (holotype **L** (903.136-9), isotypes **L** (903.136-10), (903.136-11)).

E. macrophyllum Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 77 (1903). Type: Indonesia, Java, *Warburg* 2570 (holotype **B;** isotype **B**).

E. brownianum Mart. var. *nilagirense* (Steud.) Fyson in J. Indian Bot. 2: 262 (1921c); C.E.C.Fischer, Fl. Madras 9: 1609 (1931); W.L.Ma in Acta Phytotax. Sin. 29: 298 (1991). Type as for *E. nilagilense* Steud.

E. yunnanense Moldenke in Phytologia 2(7): 222 (1947) Type: China, Yunnan, Simao, *A. Henry* 12362 (holotype **NY!** (00102694); isotype **E** (00026973)).

E. brownianum Mart. var. *latifolium* Moldenke in Phytologia 3(8): 411 (1951). Type: Ceylon, *Thwaites* 378 (holotype **BR**; isotype **K!**).

Annual or perennial herbs. *Stem* forming a basal disc or shortly rhizomatous. *Leaves* crowded into a basal rosette, linear, 21-70 cm long, 6-16 mm wide, hairs brown, apex acute. *Scapes* few, up to 95 cm long, hairs brown. *Sheaths* 12-30 cm long, hairs brown, apex acute. *Capitula* globose, 5-10 mm long, 10-15 mm in diameter, whitish. *Receptacle* convex, pilose. *Involucral bracts* oblong to narrowly obovate, 3 mm long, brown but blackish at the apex, hairy, apex obtuse to acute. *Floral bracts* narrowly obovate, 3-3.5 mm long, blackish, hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, acute, 2-2.5 mm long, blackish, hairy in the upper part; petals equal, hairy, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, boat-shaped, two lateral ones winged and keeled, the middle one winged only, acuminate, 2.5-3 mm long, black, hairy in the upper part; petals 3, linear, acute, 3 mm long, brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.7-1 mm long, dark brown, long papillate (Figure 5.2).

Distribution: Loei- Phu Luang, Phu Kradung; Chaiyaphum- Phu Kheio, Tungkamung; Trang- Khao Bunthat, Phu Pha Mek, Uttaradit- Phu Soi Dao.

Ecology: Marshy places, common on sandy soils in open marshy places or on the borders of seasonal ponds. Altitude 800-1633 m.
Flowering: October-May.

2. Eriocaulon chantaranothai *A.Prajaksood & J.Parn.*, **sp. nov.** Differt E. smitinandii bracteae flores pilis brevi albis indutus, petalis masculi inaequalis longis florum peripheralium e capitulo exsertis; flores foeminei sepalis minuta, petalis glandulata. Type: Thailand, Sakon Nakhon, Phu Phan National Park, 7 Nov. 1997, *A. Prajaksood & P. Chantaranothai* 2 (holotype **KKU!**; isotypes **BK!, BKF!, K!, TCD!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1.5-2 cm long, 1 mm wide, hairy, apex acute. *Scapes* numerous, up to 23 cm long, hairy. *Sheaths* 2.5-3 cm long, hairy, apex acute. *Capitula* globose, 3-5 mm long, 4-6 mm in diameter, white. *Receptacle* convex, pilose. *Involucral bracts* broadly elliptic to oblanceolate, 1.5-2 mm long, brown, pilose, apex obtuse to acute. *Floral bracts* oblanceolate, 1.5 mm long, light brown, hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute, 1 mm long, brown, hairy in the upper part; petals unequal, hairy, acute, two small, the third about twice as long and exserted beyond the floral bract, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 1-3, narrowly linear, acute, 0.5-1 mm long, light brown, hairy in the upper part (deciduous); petals 3, unequal, elliptic or lanceolate, attenuate, acute, 1.5-2 mm long, brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.5 mm long, brown, glabrous (Figure 5.3).

Note: This species is similar to *E. smitinandii* as the scapes and the involucral bracts are hairy but it differs in having shorter and white hairs on the floral bracts; unequal male petals, one of which is exserted beyond the floral bracts; minute female sepal and glandular petals. The type was collected with Prof. Dr. P. Chantaranothai -in whose honour it is named- when worked together on a preliminary study in this family in Phu Phan National Park.
Distribution: Phitsanulok- Tung Salaeng Luang; Sakon Nakhon- Phu Phan Palace, Phu Phan National Park, Wat Don Thammajadee temple, Koksrisuphun. Nakhon Phanom- Ban Phaeng; Mukdahan-Phu Pha Terb, Mukdahan National Park, Lann Phu Wat, Phu Sra Dok Bua National Park.
Ecology: Common on sandy soils in open marshy places or on the borders of barren sandstone rocks. Altitude 120-500 m.
Flowering: October-Febuary.

3. Eriocaulon chiangmaiense *A.Prajaksood & J.Parn.* **sp. nov.** Differt E. nautiliformis folia brevis angustata, bracteae flores apicem acutatus, petalis masculi aequalis, sepalis foemineus uniformis. Type: Chiang Mai, west of Ob Luang, on fen area, *B. Hansen, G. Seidenfaden & T. Smitinand* 10976 (holotype **BKF!**; isotypes **AAU!, L!, C!, E!, K!**), paratype: *T. Koyama et al.* 15481 (**BKF!, NY!**).

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear or crescentic, 5-11 cm long, 3-10 mm wide, glabrous, apex acute. *Scapes* few, up to 41 cm long, glabrous. *Sheaths* 4-10 cm long, glabrous, apex acute. *Capitula* globose, 6-8 mm long, 6-10 mm in diameter, greyish. *Receptacle* convex to elongate, glabrous. *Involucral bracts* oblanceolate to oblong, 2.5 mm long, brownish, glabrous, apex acute. *Floral bracts* oblanceolate, 3 mm long, blackish, apex acute. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, acute, 1.5 mm long, blackish, hairy in the upper part; petals equal, hairy, obtuse, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, weakly keeled, acute, 2 mm long, blackish, hairy in the upper part; petals 3, unequal, elliptic, attenuate, obtuse, 2-2.5 mm long, whitish, hairy, subapical glands present; ovary 3-locular; seed 0.5 mm long, brown, tuberculate (Figure 5.4).

Note: This species is similar to *E. nautiliforme* but the leaves are shorter and narrower, the floral bracts acute, the male petals equal in size and the female sepals all of similar shape, whereas *E. nautiliforme* has longer and broader leaves, the floral bracts acuminate, one of male petals is larger than the others and the median sepal female is shell-like.

Distribution: Endemic to Chiang Mai-Om Koi, Mae Sanam, Mountain Ngat, Bo Luang, Mae Cham, Doi Inthanon.

Ecology: On stream bank, common in fen area. Dipterocarp-pine or mixed deciduous forest, alt. 900-1100 m.

Flowering: January-April.

4. Eriocaulon chiangmaiense ssp. leucanthemum *A.Prajaksood & J.Parn.* **ssp. nov.** Haec subspeciei a forma typical speciei capitula alba receptaculum pilosum flores masculi petala eglandulosa antheris eborinus flores faminei sepala alba petala eglandular ovata attenuatus semina glabratus. Type: Chiang Mai, west of Ob Luang, on fen area, *T. Smitinand* 10091 (holotype **BKF!**; isotypes **C!, K!**)

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear, 2.5-7 cm long, 3-6 mm wide, glabrous, apex acute. *Scapes* few or numerous, up to 31 cm long, glabrous. *Sheaths* 4-7 cm long, glabrous, apex acute. *Capitula* globose to ovoid, 4-7 mm long, 5-7 mm in diameter, whitish. *Receptacle* elongate, pilose. *Involucral bracts* obovate to oblong, 3 mm long, brownish, glabrous, apex acute to obtuse. *Floral bracts* obovate, 2.5 mm long, pale brown, blackish and hairy in the upper part, apex acute to acuminate. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, acute, 1.7 mm long, pale brown, blackish and hairy in the upper part; petals unequal, hairy, acute, eglandular; vestigial gynoecium present; anthers 6, whitish. *Female flowers*: sepals 3, weakly keeled, acute, 2 mm long, pale brown, hairy in the upper part; petals 3, unequal, ovate, attenuate, obtuse, 2-2.2 mm long, whitish, hairy, eglandular; ovary 3-locular; seed 0.3-0.4 mm long, brown, glabrous (Figure 5.5).

Note: This variety differs from the typical one in having its inflorescences whitish, receptacle pilose, male petals eglandular, anther whitish, female sepals whitish, female petals ovate, attenuate, eglandular and its seed glabrous.

Distribution: Endemic to Nong Khai- Bueng Karn, Huay Poo.

Ecology: Common in wet sandy soil along edge of barren sand stone rocks. Altitude 100 m.

Flowering: November.

5. Eriocaulon cinereum *R.Br.*, Prodr. Fl. Nov. Holland: 254 (1810); Merr., Fl. Manila: 136 (1912); Backer & Bakh.f., Fl. Java 3: 25 (1968); Babu, Herb. Fl. Dehra Dun: 547 (1977); Gandhi in C.J.Saldanha & Nicolson, Fl. Hassan Dist.: 650 (1978); C.E.Chang, Fl. Taiwan 5: 183 (1978); Ghaz. in Nasir & Ali, Fl. Pakistan 142: 3 (1982); W.L.Ma in Acta Phytotax. Sin. 29: 306 (1991); P.H. Hô, Ill. Fl. Vietnam 3(1): 480 (1993); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 179-180 (1994); C.D.K.Cook, Aquatic Wetland Pl. India: 191 (1996); S.M.Phillips in Dassan. & Clayton, Revis. Handb. Fl. Ceylon 11: 53 (1997); Z.X.Zhang in U.Kück, Diss. Bot. 313: 189 (1999). Type: Australia, *R. Brown* 5823 (lectotype chosen here **BM!**)

E. heteranthum Benth., Fl. Hongk.: 382 (1861). Type: China, Hong Kong, *C. Wright* 552 (holotype **K**).

E. sexangulare sensu Mart. in Wall., Pl. Asiat. Rar. 3: 28 (1832), non L.

E. tushimanii N.E.Br. in Dyer, Fl. Trop. Afr. 8: 259 (1902). Type not seen.

E. ciliflorum F.Muell., Fragm. 1: 91-96 (1859). Type not seen.

E. seiboldianum Siebold & Zucc. ex Steud., Syn. Pl. Glumac. 2: 272 (1855); Hook.f., Fl. Brit. Ind. 6: 577 (1894); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 111-112 (1903); Lecomte, Fl. Indo-Chine 7(1): 13 (1912); Collett, Fl. Siml.: 549 (1921); Fyson in J. Indian Bot. 3(1): 15 (1922); Turrill, R.Parker & Duthie, Fl. Gangetic Plain 3(3): 318 (1929); C.E.C.Fischer, Fl. Madras 9: 1605 (1931); Satake in Nakai & Honda, Nov. Fl. Jap.: (1940). Type: Japan, *Siebold & Zuccarini s.n.* Type not seen.

E. formosanum Hayata, Icon. Pl. Formosan. 10: 49(1921). Type: China, Taiwan, Tainan, *Y. Shimada* s.n., 10 April 1913 (isotypes **TAIF** 5544, 5545, 5546).

E. redactum Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 113 (1903). Type not seen.

E. cinereum var. *sieboldianum* (Siebold & Zucc.) T.Koyama in Ohwi, Fl. Jap.: 266 (1984). Type as for *E. seiboldianum* Siebold & Zucc. ex Steud.

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1.5-6.5 cm long, 1-2.5 mm wide, glabrous, apex acute. *Scapes* numerous, up to 21 cm long, glabrous. *Sheaths* 1-3 cm long, glabrous, apex acute or 2 lobed. *Capitula* ovoid, 2-4 mm long, 3-5 mm in diameter, black. *Receptacle* elongate, glabrous. *Involucral bracts* narrowly obovate, 1.5 mm long, brown, glabrous, apex obtuse. *Floral bracts* narrowly oblong to narrowly elliptic, 1.5-2 mm long, blackish, glabrous or deciduous pilose, apex acute to acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute, 1 mm long, brown, blackish in the upper part, glabrous (rarely hairy at the tip); petals unequal, acute, two small and glabrous, the third few hairs, subapical glands present; vestigial gynoecium present; anthers 6,

white. *Female flowers*: sepals 2-3, linear, acute, 1-1.3 mm long, brown, blackish in the upper part, glabrous or deciduous pilose; petals absent; ovary 3-locular; seed 0.3 mm long, brown, glabrous (Figure 5.6).

Distribution: Nong Khai- Ban Nong Song Hong; Nakhon Phanom- Ban Teng, That Phanom, Ban Nong Hoi Noi; Maha Sarakham- Nadoon; Khon Kaen- Ban Phai, Nam Phong, Ban Nawng Kung; Ubon Ratchathani- Nong Khon, Nam Yeun, Sri Muang Mai, Pha Tam National Park; Supan Buri- Rice Experiment Station, Saraburi- Sahm Lahn forest, Muang; Nakhon Nayok- Khao Yai Nation Park; Bangkok- Klong Luang, Rangsit; Chantaburi; Phangnga- Thai Muang, Thung Maprao; Songkhla- Chana.

Ecology: Common on sandy soils in open marshy places, paddy fields or on the borders of seasonal ponds. Altitude 150-200 m.

Flowering: July-February.

6. Eriocaulon cristatum *Mart.* in Wall., Pl. Asiat. Rar. 3: 28 (1832); Kunth, Enum. Pl. 3: 559 (1841); Steud., Syn. Pl. Glumac. 2: 274 (1855); Körn. in Linnaea. 27: 609 (1856); Benth., Fl. Hongk.: 382 (1861); Maxim., Diagn. Pl. Nov. Asiat. 8: 14 (1893); Hook.f., Fl. Brit. Ind. 6: 574 (1894); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 84 (1903); Fyson in J. Indian Bot. 2(10): 312 (1921d); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 10 (1994); Z.X.Zhang in U.Kück, Diss. Bot. 313: 59 (1999). Type: India, Silhet, *Wallich* 6070 (holotype **K!**; isotypes **B!, CAL, K-WA!, L**)

Perennial herbs. *Stem* shortly rhizomatous. *Leaves* crowded into a basal rosette, linear, 10-18 cm long, 1.5-3 mm wide, glabrous, apex obtuse. *Scapes* few, up to 37 cm long, glabrous. *Sheaths* 5-10 cm long, glabrous, apex acute. *Capitula* globose, 5-7 mm long, 5-8 mm in diameter, greyish. *Receptacle* convex, glabrous. *Involucral bracts* obovate to oblong, 2.5 mm long, brown, glabrous, apex obtuse. *Floral bracts* oblanceolate to obovate, 2.5 mm long, blackish, hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, acute or obtuse, 2 mm long, blackish, hairy in the upper part; petals unequal, hairy, acute, one petal exserted beyond the floral bracts, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, weakly keeled, acute, 2 mm long, blackish, hairy in the upper part; petals 3, unequal, elliptic, attenuate, acute, 2.2-2.5 mm long, light brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.7 mm long, brown, papillate (Figure 5.7).

Note: There is only one record for Thailand. It is similar to *E. xenopodium* but the leaves of this species are narrower and obtuse, the scapes few and the male petals unequal and exserted beyond the floral bract.

Distribution: Chiang Rai- Doi Langka.

Ecology: On sandy soils. Altitude 1760 m.

Flowering: October.

7. Eriocaulon echinulatum *Mart.* Mart. in Wall., Pl. Asiat. Rar. 3: 29 (1832); Kunth, Enum. Pl. 3: 568 (1841); Steud., Syn. Pl. Glumac. 2: 272 (1855); Körn. in Linnaea. 27: 619 (1856); Maxim., Diagn. Pl. Nov. Asiat. 8: 11 (1893); Hook.f., Fl. Brit. Ind. 6: 579 (1894); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 106-107 (1903); Lecomte, Fl. Indo-Chine 7(1): 14 (1912); W.L.Ma in Acta Phytotax. Sin. 29: 289-308 (1991); P.H. Hô, Ill. Fl. Vietnam 3(1): 480 (1993); C.D.K.Cook, Aquatic Wetland Pl. India: 187 (1996); Z.X.Zhang in U.Kück, Diss. Bot. 313: 167 (1999). Type: Burma, Tavoy, *Wallich* 6082 (holotype **K!**; isotypes **BM!, CAL!, G, K-WA!**)

E. echinulatum Mart. var. *tenue* Satake in Acta Phytotax. Geobot. 26(1-2): 49 (1974). Type: *M. Tagawa, K. Iwasuki & N. Fukuoka* T 546A (holotype **TYO**; isotype **BKF!**).
E. seticuspe Ohwi in Bull. Nat. Sci. Mus. 34: 3-4 (1954). Type: Japan, Kuishiu, *S. Hirata* s.n., 5 October 1952. Type not seen.

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1-6 cm long, 1-4 mm wide, glabrous, apex acute. *Scapes* few or numerous, up to 23 cm long, glabrous. *Sheaths* 1.5-4 cm long, glabrous, apex acute or 2-3 lobed. *Capitula* hemispherical, globose or ovoid, 3-7 mm long, 3.5-12 mm in diameter, brown. *Receptacle* elongate, pilose. *Involucral bracts* elliptic, 3 mm long, brown, glabrous, apex acuminate to long-acuminate. *Floral bracts* oblanceolate, 4-4.5 mm long, brown, glabrous, apex long-acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute, 1-1.3 mm long, brown, glabrous; petals equal, glabrous, acute, eglandular; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 2(-3), dissimilar, two lateral ones boat-shaped winged and keeled, acuminate, 1.5-2 mm long, the middle one (if present) linear, acute, 1-1.5 mm long, brown, deciduous pilose in the upper part; petals absent; ovary 3-locular; seed 0.5 mm long, brown, papillate (Figure 5.8).

Distribution: Phitsanulok- Tung Salaeng Luang; Phetchabun- Tung Non Son; Loei- Phu Kradung National Park, Phu Rua National Park; Udon Thani- Ban Nakha, Phu Phra Bat; Nong Khai- Bueng Karn, Tham Phun waterfall, Phu Wau National Park; Sakon Nakhon- Phu Phan National Park; Nakhon Phanom- That Phanom; Mukdahan- Phu Pha Turb, Mukdahan National Park; Chaiyaphum- Tungkamang; Ubon Ratchathani- Khong Chium, Khammarach, Phu Chong Nayoy National Park, Phimulmungsahan, Dacha Udom, Pha Tam National Park; Nakhon Nayok- Khao Yai National Park; Prachin Buri- Wattana Nakhon, Thung Phoh; Rayong; Chanthaburi- Makham, Khao Soi Dao, Khao Klua; Trat- Ban Klongsan, Bo Rai, Ban Saphanhin, Muang, Ban Toktuk, Khaosaming; Chumphon- Ban Huay Gayo, Muang, Surat Thani- Ban Tahsae, Klong Sai; Trang- Thungkai Botanic Garden; Satun.
Ecology: Paddy fields, common on sandy soils in open marshy places, on the borders of seasonal ponds or on the borders of barren sandstone rocks. Altitude 5-1365 m.
Flowering: August-March.

8. Eriocaulon escape *B.Hansen* in Dansk Bot. Ark. 27(1): 31 (1969). Type: Thailand, Loei- Phu Kradung National Park, 24 Nov. 1958, *SLH* 6178 (holotype **C**).

E. dipsacoides Satake in Acta Phytotax. Geobot. 26(1-2): 51 (1974); Z.X.Zhang in U.Kück, Diss. Bot. 313: 165 (1999). Type: *M. Tagawa, K. Iwasuki & N. Fukuoka* T 779 (or T-779) (holotype **KYO**; isotypes **BKF!, P!**), **syn. nov**.

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1-3.5 cm long, 1-2 mm wide, glabrous, apex acute. Scape absent. *Capitula* hemispherical, 1-10 mm long, 1-20 mm in diameter, brown. *Receptacle* elongate, pilose. *Involucral bracts* elliptic, 7-8 mm long, brown, glabrous, apex long-acuminate. *Floral bracts* lanceolate, 7-8 mm long, brown, glabrous, apex long-acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute, 2-2.5 mm long, brown, glabrous; petals equal, glabrous, acute, eglandular; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals (2-)3, dissimilar, two lateral ones boat-shaped keeled, acuminate, 2.3-3 mm long, brown, glabrous, the middle one (if present) narrowly elliptic or linear, acute, 2-2.5 mm long, brown, deciduous pilose in the upper part; petals (if present) 1-2, narrowly linear, acute, 1 mm long, brown, glabrous, eglandular; ovary 3-locular; seed 0.5-0.6 mm long, yellow, tuberculate (Figure 5.9).

Distribution: Endemic to Phu Kradung, Loei, Thailand.
Ecology: Common on sandy soils in open marshy places or in pine forest. Altitude 1300 m.
Flowering: November-March.

9. Eriocaulon fluviatile *Trimen* in J. Bot. 23: 270 (1885); Hook.f., Fl. Brit. Ind. 6: 585 (1894); Hook.f. & Trimen, Handb. Fl. Ceylon 5: 11 (1900); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 115 (1903); Fyson in J. Indian Bot. 3(1): 15 (1922); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 161 (1994); S.M.Phillips in Dassan. & Clayton, Revis. Handb. Fl. Ceylon 11: 52 (1997). Type: Ceylon, West province, *H. Trimen & W. Furguson* s.n., Jan 1885 (holotype **PDA**; isotype **K!**)

E. barbeyanum Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 73 (1903); Fyson in J. Indian Bot. 3(1): 15 (1922); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 162 (1994); Z.X.Zhang in U.Kück, Diss. Bot. 313: 197 (1999). Type: India, Kala Nuddi, *Dr. Ritchie* 1247 (holotype **G,** isotype **B!, CAL, E, GH!**), **syn. nov.**
E. yaoshanense Ruhland in Notizbl. Bot. Gart. Berlin-Dahlem 10 (100): 1043 (1930). Type: China, Kwangsi, Yao Shan, Dec. 1928, *S.S. Sin* 3999 (isotype **PE!**), **syn. nov.**
E. filifolium Hand.-Mazz., Pl. Nov. Chingianae Sinensia 7:619-620 (1936). Type: *R.C. Ching* 8149 (holotype **W;** isotype **PE!**), **syn. nov.**
E. mitophylum Hook.f., Fl. Brit. Ind. 6: 575 (1894); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 67 (1903); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 159 (1994). Type: India, Shampong, Jaintea, 18 Nov. 1872 *C.B. Clarke* 18270 (lectotype **CAL** selected by R.Ansari & N.P.Balakr. (1994)), **syn. nov.**

E. miserum Körn. var. *mitophylum* (Hook.f.) Fyson in J. Indian Bot. 3(1): 15 (1922). Type: as for *E. mitophylum,* **syn. nov.**

E. tonkinense Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 72-73 (1903); Z.X.Zhang in U.Kück, Diss. Bot. 313: 194 (1999). Type: Vietnam, Tonkin, 2 Nov. 1885, *B. Balansa* 247 (holotype **B!**; isotypes **BR, K!, L** (908.139-1480)), **syn. nov.**

E. cristatum Mart. var. *brevicalyx* C.H.Wright in J. Linn. Soc., Bot. 36: 199 (1903). Type: China, Hong Kong, *Hame* s.n. (holotype **K!**), **syn. nov.**

E. yaoshanense Ruhland var. *brevicalyx* (C.H.Wright) W.L.Ma in Acta Phytotax. Sin. 29: 301 (1991). Type: as for *E. cristatum* Mart. var. *brevicalyx* C.H.Wright, **syn. nov.**

Perennial herbs. *Stem* 3-5 cm rhizomatous. *Leaves* cauline, linear, 15-20 cm long, 3.5-4 mm wide, glabrous, apex acute. *Scapes* few, up to 23 cm long, glabrous. *Sheaths* 6-9 cm long, glabrous, apex acute or 2-lobed. *Capitula* globose, 4-4.5 mm long, 5-6 mm in diameter, greyish. *Receptacle* elongate, glabrous. *Involucral bracts* obovate, 2.5 mm long, brown, glabrous, apex obtuse. *Floral bracts* obovate, 2.7 mm long, blackish, hairy in the upper part, apex acute. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, acute, 1.8 mm long, blackish, hairy in the upper part; petals unequal, hairy, obtuse, subapical glands present; vestigial gynoecium present; anthers 6, white. *Female flowers*: calyx spatheate or fused at the base, 3 lobed, acute, 1 mm long (immature), blackish, hairy in the upper part; petals 3, unequal, elliptic, attenuate, acute, 0.8-1 mm long (immature), light brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed immature (Figure 5.10).

Note: No mature female flowers of *E. fluviatile* have been seen in Thailand and there is only one record of the species from Thailand. However, based on Indian material, Ansari & Balakrishnan (1994) reported that the female sepals are 1 mm long and free, the petals are 1mm long and the seeds are 0.48 mm long and glabrous. I noted that the female sepals were fused when the flower was immature. Ansari & Balakrishnan (1994) said *E. mitophylum* and *E. fluviatile* differs from *E. barbeyanum* in its female petals being glandular and *E. mitophylum* differs *E. fluviatile* by having the leaves shorter than the peduncles.

Distribution: Chiang Rai- Pah Tong; Nakhon Ratchasima- Katok; Trat- Kao Krap.

Ecology: Common on sandy soils by stream, in open marshy places, on the edge of water. Altitude 400-1000 m.

Flowering: December.

10. Eriocaulon hamiltonianum *Mart.* in Wall., Pl. Asiat. Rar. 3: 29 (1832); Kunth, Enum. Pl. 3: 552 (1841); Steud., Syn. Pl. Glumac. 2: 270 (1855); Körn. in Linnaea. 27: 679 (1856); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 107 (1903); Fyson in J. Indian Bot. 2(10): 313 (1921d); Turrill, R.Parker & Duthie, Fl. Gangetic Plain 3(3): 320 (1929); Babu, Herb. Fl. Dehra Dun: 547 (1977); Turrill, R.Parker & Duthie, Fl. Gangetic Plain 3(3): 318 (1929); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 122-125 (1994); Z.X.Zhang in U.Kück, Diss. Bot. 313: 169-172 (1999);. Type: India, *Wallich* 6075 (holotype **K!**; isotypes **CAL!, K-WA!**).

E. hamiltonianum Mart. var. *minor* Fyson in J. Indian Bot. 2(10): 313 (1921d). Type: India, Siliguri, West Bengal, Nov. 1878, *G. King* s.n. (holotype **CAL!**)

E. minimum sensu C.D.K.Cook, Aquatic Wetland Pl. India: 187 (1996), non Lam.

E. oryzetorum sensu Hook.f., Fl. Br. Ind. 6: 579. 1894, non Mart.

E. zollingerianoides Z.X.Zhang in U.Kück, Diss. Bot. 313: 181-185 (1999). Type: Thailand, Nakhon Phanom-Sakon Nakhon, 18 Dec. 1963, *T. Smitinand* 8473 (holotype **L;** isotypes **BKF!, K!**), **syn. nov.**

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear, 2-2.5 cm long, 1-2 mm wide, glabrous, apex acute. *Scapes* numerous, up to 12 cm long, glabrous. *Sheaths* 2.5-3 cm long, glabrous, apex acute. *Capitula* globose to ovoid, 2-4 mm long, 3-4 mm in diameter, brown. *Receptacle* elongate. *Involucral bracts* obovate to oblanceolate, 1.5-2 mm long, brown, glabrous, apex obtuse. *Floral bracts* elliptic to oblanceolate, 1.5 mm long, blackish-brown, glabrous, apex acute. *Male flowers*: calyx spatheate, 2 lobed, acute, 1.5 mm long, brown, glabrous; petals equal, glabrous, acute, eglandular; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals (2-)3, linear, acute, 1-1.5 mm long, brown, glabrous; petals (2-)3, linear, acute, 1-1.5 mm long, brown, hairy in the upper part, eglandular; ovary 3-locular; seed 0.3-0.5 mm long, brown, glabrous (Figure 5.11).

Note: Zhang (1999) separated *E. hamiltonianum* and *E. zollingerianoides* by the shape and size of capitula which I found these characters are variable.

Distribution: Ubon Ratchathani- Ban Hau Kon, Pho Sri, Khong Chiam, Pha Tam National Park, Ban Udomsuk, Tambon Kudprathai, Dacha Udom, Boontharik, Ban Na Pa Nieng Or, Pho Sai; Khon Kaen- Kok Phu Taka, Phu Wieng, Ban Rua, Pa Weing; Buri Ram; Sakon Nakhon- Phu Phan National Park, Lardkracheir; Nakhon Phanom- Ban Nong Hoi Noi; Nong Khai- Tha Sa-ad, Se Ka; Loei- Wangsaphung, Sithan; Si Sa Ket- Tambon Samrongplan, Pribueng; Mukdahan- Tambon Kamphalai, Muang; Surin- Ban Klongnamsub, Tambon Nangmood, Kabcherng; Nakhon Nayok- Khao Yai National Park; Prachin Buri- Thung Poh; Chon Buri- Kow Kieo, Siricha; Chanthaburi- Pong nam ron, Ban Ta Rueang; Trat- Klong Yai; Kanchanaburi- Rintin Forest, Thong Pha Phum; Pra Nakhon Si Ayutthaya; Kamphaeng Phet- Wang-Djao; Uthai Thani- Huay Kha Kaeng Wildlife Sanctuary, Larn Suk; Chiang Mai- Bo Luang Tableland, Om Koi, Doi Suthep, Mae Rim. Huay Deung Tau, Mae Tang; Lamphun- Doi Kuhn Dahn National Park.

Ecology: Common on sandy soils in open marshy places, grassland, paddy fields, on the borders of seasonal ponds or on the borders of barren sandstone rocks. Dry dipterocarp forest. Altitude sea level-1000 m.

Flowering: August-January.

11. Eriocaulon hamiltonianum *Mart.* **var. *acuminatum*** *A.Prajaksood & J.Parn.*, **var. nov.** Haec varietas differt a forma typical speciei bracteae flores acuminate. Type: Thailand, Sakon Nakhon, Phu Phan National Park, *A. Prajaksood & S. Suddee* 318 (holotype **KKU!**; isotypes **BK!, BKF!, K!, TCD!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 2 cm long, 2 mm wide, glabrous, apex acuminate. *Scapes* numerous, up to 15 cm long, glabrous. *Sheaths* 2.5 cm long, glabrous, apex acute. *Capitula* ovoid to elliptic, 3-4 mm long, 2-3 mm in diameter, brown. *Receptacle* elongate. *Involucral bracts* broadly elliptic, 1.5-2 mm long, brown, glabrous, apex acuminate. *Floral bracts* oblanceolate to broadly ovoid, 2-2.5 mm long, blackish-brown, glabrous, apex long-acuminate. *Male flowers*: calyx spatheate, 2-3 lobed, acute, 1.3 mm long, brown, glabrous; petals equal, glabrous, acute, eglandular; vestigial gynoecium present; anthers (4-)5(-6), black. *Female flowers*: sepals 2-3, linear, acute, 1.3 mm long, brown, blackish in the upper part, glabrous; petals absent or 2, filiform, hairy at the tip; ovary 3-locular; seed 0.5 mm long, brown, glabrous (Figure 5.12).

Note: This variety differs from the typical form by having acuminate floral bracts.
Distribution: Chiang Mai- Doi Suthep, Bo Luang Tableland; Kamphaeng Phet- Wang Chaow forest; Sakon Nakhon- Phu Phan National Park; Chaiyaphum- Tungkamang.
Ecology: Common on sandy soils in open marshy places, by a small stream, muddy places. Dry dipterocarp forest. Altitude 210-1000 m.
Flowering: October-January.

12. Eriocaulon henryanum *Ruhland* in Engl., Pflanzenr. 4(30), 13 Heft: 86 (1903); Lecomte, Fl. Indo-Chine 7(1): 13 (1912); W.L.Ma in Acta Phytotax. Sin. 29: 297-298 (1991); P.H. Hô, Ill. Fl. Vietnam 3(1): 479-486 (1993); Z.X.Zhang in U.Kück, Diss. Bot. 313: 140-143 (1999). Type: China, Yunnan, Menzhi, *A. Henry* 9443 (holotype **B**; isotypes **E, K!, PE**).

Annual or perennial herbs. *Stem* forming a basal disc or shortly rhizomatous. *Leaves* crowded into a basal rosette, linear, 7-9 cm long, 2-6 mm wide, glabrous, apex acute, obtuse or 2 lobed. *Scapes* few, up to 43 cm long, glabrous. *Sheaths* 3.5-10 cm long, glabrous, apex acute, obtuse or 3 lobed. *Capitula* globose to elongate, 6 mm long, 5-10 mm in diameter, white. *Receptacle* elongate, pilose. *Involucral bracts* broadly oblanceolate, 2 mm long, brown, glabrous, apex acute. *Floral bracts* broadly oblanceolate, 2 mm long, blackish-brown, hairy in the upper part, apex acute to acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute, 1.5 mm long, blackish, hairy in the upper part; petals unequal, hairy, acute, two small, the third about twice as long and exserted beyond the floral bract, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, boat-shaped, acute, 1.5-2 mm long, black, hairy in the upper part; petals 3, unequal, two lateral ones linear, the middle one narrowly oblanceolate, acute, 1.5 mm long, brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.5 mm long, brown, papillate (Figure 5.13).

Distribution: Chiang Mai- Ob luand table land, Om Koi; Loei- Phu Luang.
Ecology: Common in sandy soils on open marshy places. Pine forest. Altitude 800-1400 m.
Flowering: April-July.

13. E. infirmum *Steud.*, Syn. Pl. Glumac. 2: 271 (1855); P.Royen in Nova Guinea 10(1-2): 38 (1959). Type as for *E. gracile* Mart. Type: India, Prome Mountain, Irawaddi, *Wallich* 1827. Neotype: India, Prome Mountain, *Wallich* 6079 (**K-WA!,** chosen here).

E. gracile Mart. in Wall., Pl. Asiat. Rar. 3: 29 (1832); Lecomte, Fl. Indo-Chine 7(1): 9 (1912). Type: India, Prome Mountain, Irawaddi, *Wallich* 1827. Neotype: India, Prome Mountain, *Wallich* 6079 (**K-WA!,** chosen here).

E. nakayense T.Koyama in Philipp. J. Sci. 84(3): 372 (1955). Type: Thailand, Nakay, 16 Dec. 1921, *B.* Hayata s.n. (holotype **TI**), **syn. nov.**

E. eglandulatum Z.X.Zhang in U.Kück, Diss. Bot. 313: 84-87 (1999). Type: *van C.F. Beusekom, C. Phengklai, R. Geesink. & B. Wongwan* 4288 (holotype **L** (255928)). Paratype: *C. Phengkhlai & G. Murata* T-42199a (**BKF!, L!**); *van C.F. Beusekom & T. Smitinand* 2141 (**AAU!, C!, E!, GH!, K!, L!, P!**); *van C.F. Beusekom & C. Phengklai* 2517 (**AAU!, BKF!, C!, E!, GH!, L!, P!**); *Th. Sorensen, K. Larsen & B. Hansen* 6326 (**BKF!, GH!, L!**); *Ch. Charoenphol, K. Larsen & E. Warncke* 4689 (**AAU!, BKF!, K!, L!**), **syn. nov.**

E. gracile Mart. var. *puberulentum* Moldenke in Phytologia 4(2): 128 (1952). Type: Papua New Gunea, Lake Daviumbu, Sept. 1936, *L.J. Brass* 7822 (holotype **NY;** isotypes **GH!, L!**). **syn. nov.**

E. infirmum Steud. var. *puberulentum* (Moldenke) P.Royen in Nova Guinea 10(1-2): 38 (1959). Type as for *E. gracile* Mart. var. *puberulentum* Moldenke. **syn nov.**

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1-7 cm long, 2-5 mm wide, glabrous, apex acute. *Scapes* few or numerous, up to 33 cm long, glabrous. *Sheaths* 2.5-7.5 cm long, glabrous, apex acute or 2 lobed. *Capitula* ovoid to broadly ovoid, 3-6 mm long, 4-7 mm in diameter, blackish-greyish. *Receptacle* elongate, pilose. *Involucral bracts* obovate, 1.5-2 mm long, brown, hairy, apex obtuse. *Floral bracts* oblanceolate, 2 mm long, brown but blackish and hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate or fused in the base, 3 lobed, acute, 1.5 mm long, blackish, hairy in the upper part; petals unequal, hairy, acute, eglandular; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, narrowly oblanceolate, acute, 1.5-2 mm long, black, hairy in the upper part; petals 3, unequal, elliptic, attenuate, acute, 1.5-2 mm long, brown, hairy in the upper part, eglandular; ovary 3-locular; seed 0.5 mm long, dark-brown to reddish-brown, glabrous or papillate (Figure 5.14).

Note: As the specimen of *Wallich* 1827 is not *Eriocaulon*, the neotype of *E. gracile* is chosen here based on the same specimen. Perhaps mistyping occurred in publication as *Wallich* 6079 refers to Prome 1826. Steudel (1855) published the name, *E. infirmum* for *E. gracile* Mart. (1832) without any explanation until Royen (1959) explained that the use of the specific epithet *gracile* (*-is*) is not valid since Bongard (1831) used the combination *E. gracile* for a Brazilian *Eriocaulaceae* which subsequently was reduced by Ruhland (1903) to *Syngonanthus gracilis* (Körn) Ruhland var. *olivacea* Ruhland.

Distribution: Chiang Mai- Bo Luang Tableland; Phetchabun- Thung Non Son, Thung Salangluang National Park; Loei- Phu Kradung National Park, Phu Rua National Park; Sakon Nakhon- Phu Phan National Park; Mukdahan- Lann Phu Wat, Phu Sadokbua National Park, Phu Pha Terb, Mukdahan National Park; Kalasin; Chaiyaphum- Tungkamung, Phu Khiew Wildlife Sanctuary; Ubon Ratchathani, Ban Udomsak, Dacha Udom, Khong Chium, Pham on, Pha Tam National Park, Phu Chang Nayoy National Park; Kanchanaburi- Thong Pha Phum; Chantaburi- Khao Soi Dao; Trat- Khao Saming, Bo Rai; Trang- Thung Khai Botanic Garden.

Ecology: Common on sandy soils in open marshy places, on the borders of seasonal ponds or on the borders of barren sandstone rocks. Dry dipterocarp forest. Altitude 50-1365 m.

Flowering: October-March.

14. Eriocaulon laosense *Moldenke* in Phytologia 3(6): 307-320 (1950). Type: Laos, near Saravane, 5 Sept. 1928, *E. Poilane* 15468 (holotype **NY!;** isotype **P!**).

E. laosense var. *maxwellii* Moldenke in Phytologia 35(2): 109 (1976). Type: Thailand, Trat, Klong Yai, 5 May 1974, *J.F. Maxwell* 74-376 (holotype **AAU!**), **syn. nov.**

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1-1.5 cm long, 1-4 mm wide, glabrous, apex acute. *Scapes* few or numerous, up to 10 cm long, glabrous. *Sheaths* 1.5-2 cm long, glabrous, apex acute or 2 lobed. *Capitula* hemispherical to globose, 1.5-2 mm long, 2.5-4 mm in diameter, white. *Receptacle* convex. *Involucral bracts* elliptic, 1.3 mm long, light brown, glabrous, apex acute. *Floral bracts* oblanceolate, 1 mm long, light brown, hairy in the upper part, apex acute. *Flowers* rarely perfect. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, acute, 1 mm long, light brown, hairy in the upper part; petals equal, hairy, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, narrowly oblanceolate, acute, 1 mm long, light brown, hairy in the upper part; petals 3, elliptic, attenuate, acute or 2 lobed, 1-1.3 mm long, light brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.4 mm long, yellow (Figure 5.15).

Note: The suggestion by Moldenke (1970) and Phillips (1997) that the black glandular structure in the center of the male flower is likely to represent the vestigial gynoecium is proved likely here as I found perfect flowers in this species which have never been reported before (Figure 5.15F). Moldenke (1976) reported that var. *maxwellii* differs from the typical form of the species in being of larger general aspect; however, I do not recognize this variety as distinct because the size of the plants in this species can be dependent on the moisture of ecology.

Distribution: Sakol Nakhon- Phu Phan National Park; Roi Et- Ban Pondeun, Suwanaphum; Ubon Ratchathani- Tambon Naphoglang, Khong Chium, Pha Tam National Park, Phu Chong Nayoy National Park; Nakhon Nayok- Khao Lon; Prachin Buri- Prachuntakarm; Chanthaburi- Pong nam ron, Ban Ta Rueang; Trat- Klong Yai.

Ecology: Common on sandy soils in open marshy places, on the borders of seasonal ponds or on the borders of barren sandstone rocks, in paddy fields. Dipterocarp forest. Altitude 150-210 m.
Flowering: September-June.

15. Eriocaulon nautiliforme Lecomte in J. Bot. (Morot) 1(2): 105-106 (1908), in Notul. Syst. (Paris) 2: 214-216 (1911) & Fl. Indo-Chine 7(1): 7 (1912); P.H. Hô, Ill. Fl. Vietnam 3(1): 490 (1993). Type: Cambodia, 6 Dec. 1903, *Cl. Geoffray* 215 (lectotype chosen here **P!**).

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear, 10-15 cm long, 4-6 mm wide, glabrous, apex obtuse. *Scapes* numerous, up to 30 cm long, glabrous. *Sheaths* 5-10 cm long, glabrous, apex acute. *Capitula* elongate to globose, 6-8 mm long, 9-10 mm in diameter, whitish-grey. *Receptacle* elongate, pilose. *Involucral bracts* obovate to oblanceolate, 2.5-3.5 mm long, blackish-brown, glabrous, apex acute to cuspidate. *Floral bracts* narrowly oblanceolate, 3.5 mm long, black, hairy in the upper part, apex acuminate to long-acuminate. *Male flowers*: calyx 3, narrowly oblanceolate, acute, 2-2.5 mm long, blackish-brown, hairy in the upper part; petals unequal, hairy, acute, two small, the third about twice as long and exserted beyond the floral bract, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, dissimilar, two lateral ones narrowly oblanceolate, 2 mm long, the middle one shell-like, 1 mm long, acute, black, hairy in the upper part; petals 3, unequal, elliptic, attenuate, acute, 2.5-3 mm long, light brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.4 mm long, brown, glabrous (Figure 5.16).

Note: The combination of the shell-like sepal in the female flowers and the large size of the plants are useful for recognition this species.
Distribution: Udon Thani- Ban Pheu; Surin; Si Sa Ket- Tambon Samrongplan, Pribueng; Ubon Ratchathani- Ban Hau Kon, Pho Sri, Ban Udomsuk, Tambon Kudprathai, Dacha Udom, Sirindhorn Dam, Tambon Kudchumpoo, Phimulmungsahan; Sa Kaeo- Aran Pratet; Prachin Buri- Srimahapho; Chanthaburi- Tambon Putthawee, Makham, Kao Sabab, Khao Soi Dao; Trat- Tambon Sator, Khaosaming.
Ecology: Common on sandy soils in open marshy places or paddy fields. Altitude 10-500 m.
Flowering: October-April.

16. Eriocaulon nautiliformoides *A.Prajaksood & J.Parn.* **sp. nov.** Affinis E. smitinandii sed flores foemineus sepala dimorphus unum anticum incurvatum nautiliforme; petala glandula. Type: Thailand, Nakhon Phanom, on the way to That Phanom, 16 Dec. 1963, *T. Smitinand* 8443 (holotype **BKF!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 2.5-3 cm long, 1 mm wide, glabrous, apex acute. *Scapes* numerous, up to 14 cm long, hairy. *Sheaths* 3.5 cm long, glabrous, apex acute or 2 lobed. *Capitula* globose, 5-6 mm long, 4-5 mm in diameter, brownish-white. *Receptacle* elongate, pilose. *Involucral bracts* broadly elliptic to oblanceolate, 1.5-2 mm long, brown,

pilose, apex acuminate. *Floral bracts* oblanceolate, 1.5-2 mm long, light brown, hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute, 1.5-2 mm long, brown, hairy in the upper part; petals equal, hairy, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, dissimilar, two lateral ones oblanceolate, acute, the middle one shell-like, acuminate, 1.5 mm long, brown, hairy in the upper part; petals 3, narrowly elliptic, attenuate, acute, 1.5 mm long, brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.5 mm long, brown (Figure 5.17).

Note: This species similar to *E. smitinandii* in the colour and size of capitula, the glabrous sheaths and leaves and the scapes are hairy. However, its female sepals are dimorphic, the middle one being shell-like and the female petals are all glandular.
Distribution: Endemic to Thailand, Nakhon Phanom- On the way to That Phanom; Ubon Ractchathani- Dacha Udon, Khong Chium, Warinchamrab.
Ecology: On the borders of barren sandstone rocks or paddy fields, in open marshy places, sandy soil. Dry dipterocarp forest. Altitude 150-500 m.
Flowering: October-February.

17. Eriocaulon nautiliformoides var. hexagynum *A.Prajaksood & Chantar.* **var. nov.** Haec varietas differt a forma typical speciei hexagynum. Type: Thailand, Ubon Ratchathani, Dacha Udom, 8 Nov. 2002, *A.Prajaksood and S.Suddee* 265 (holotype **KKU!;** isotypes **BK!, BKF!, K!, TCD!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1.5-2.5 cm long, 1 mm wide, glabrous, apex acute. *Scapes* numerous, up to 14 cm long, hairy. *Sheaths* 3.5 cm long, glabrous, apex acute or 2 lobed. *Capitula* globose, 5-6 mm long, 4-5 mm in diameter, brownish-white. *Receptacle* convex to elongate, pilose. *Involucral bracts* broadly ovate to broadly obovate, 2 mm long, brown, pilose, apex acuminate. *Floral bracts* obovate to oblanceolate, 1.5 mm long, light brown, hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute, 1.5-2 mm long, brown, hairy in the upper part; petals equal, hairy, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, dissimilar, two lateral ones oblanceolate, acute, the middle one shell-like, acuminate, 1.5 mm long, brown, hairy in the upper part; petals 3, elliptic, attenuate, acute, 1.5 mm long, brown, hairy in the upper part, subapical glands present; ovary 5-6-locular; seed 0.5 mm long, brown (Figure 5.18).

Note: This variety differs from the typical variety in having a 5-6-locular ovary.
Distribution: Endemic to Thailand, Ubon Ractchathani- Dacha Udon; Amnat Charoen.
Ecology: Common on sandy soils in paddy fields. Altitude 120 m.
Flowering: November-December.

18. Eriocaulon nepalense *Prescott ex Bong.* in Mém. Acad. Imp. Sci. St.-Pétersbourg Divers Savans Series 6 Sci. Math. 1: 610 (1831); Kunth, Enum. Pl. 3: 554 (1841); Steud., Syn. Pl. Glumac. 2: 270

(1855); Körn. in Linnaea. 27: 639 (1856); Hook.f., Fl. Brit. Ind. 6: 587 (1894); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 88 (1903); Fyson in J. Indian Bot. 2(6-7): 198 (1921b); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 32 (1994); Z.X.Zhang in U.Kück, Diss. Bot. 313: 101 (1999). Type: Nepal.

E. viride Körn. in Linnaea. 27: 637 (1856).Type: Nepal, 1820, *Wallich* 6072c (holotype **B!**; isotype **K!, L**).

E. schochianum Hand.-Mazz. var. *parviceps* Hand.-Mazz. in Symb. Sin. 7: 1245-1246 (1937). Type not seen.

E. nantoense Hayata var. *parviceps* (Hand.-Mazz.) W.L.Ma in Acta Phytotax. Sin. 29: 295 (1991). Type: as for *E. schochianum* var. *parviceps* Hand.-Mazz.

E. trisectum Satake in J. Jap. Bot. 15(3): 144 (1974). Types: Formosa, Taityu, Oppido Rengeti, Nov. 1932, *Y. Yamamoto & K. Mori* s.n. (holotype Herb. Imp. Univ. Taihoku).

E. nantoense Hayata var. *trisectum* (Satake) C.E.Chang, Fl. Taiwan 5: 187 (1978). Type: as for *E. trisectum*.

E. pullum Koyama T.Koyama in J. Jap. Bot. 3: 11 (1956); W.L.Ma in Acta Phytotax. Sin. 29: 300 (1991). Type not seen.

E. senile Honda in Bot. Mag., Tokyo, 42: 507 (1928); Satake in Nakai &Honda, Nov. Fl. Jap.: (1940). Type not seen.

E. staintonii Satake in J. Jap. Bot. 48(10): 316 (1973). Type: Nepal, Arun Valley, 20 Sept. 1956, *J.D.A. Stainton* 1386 (holotype **BM!**), **syn. nov.**

E. caeruleum P.Royen in Blumea 10(1): 128-129 (1960). Type: Indonesia, Celebes, 19 Jun. 1937, *van Steenis* 10320 (lectotype chosen here **L!**; isotype **BO**), **syn.nov.**

E. nepalense Prescott ex Bong. Var. *laosense* Satake in J. Jap. Bot. 49(8): 237-240 (1974b). Type: Laos, Ban Phu Phao, Phangsavanh, 2 Jan. 1958, *T. Tuyama* 57379 (holotype **TI!**) **syn.nov.**

Annual herbs. *Stem* forming a basal disc or if near water or in water then up to 2 cm long. *Leaves* crowded into a basal rosette or if stem leafy then cauline, linear, 4-10 cm long, 2-10 mm wide, glabrous, apex obtuse, margin papillate if leaves narrow (*i.e.* the leaves less than 3 mm wide). *Scapes* numerous, up to 35 cm long, glabrous. *Sheaths* 3-8.5 cm long, glabrous, apex acute or 2 lobed. *Capitula* hemispherical to ovoid, 3-6 mm long, 4-6 mm in diameter, blackish-grey. *Receptacle* convex, glabrous. *Involucral bracts* broadly obovate, 2 mm long, brown to blackish-brown, glabrous, apex obtuse. *Floral bracts* oblanceolate to oblong, 2 mm long, black, hairy in the upper part, apex acute to acuminate. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, acute, 1.5-2 mm long, blackish, hairy in the upper part or only at the tip; petals equal and glabrous if all minute but, if unequal, two small and glabrous and the third larger and hairy, acute, eglandular; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, linear to narrowly oblanceolate, acute, 2 mm long, black, hairy in the upper part; petals 3, linear, acute, 1.5 mm long, brown, hairy in the upper part, eglandular; ovary 3-locular; seed 0.5 mm long, brown, papillate (Figure 5.19).

Note: The presence of papillae at the margin of the leaves is dependent on the width of the leaves; if the leaves are broad then the papillae at the margin will be absent. The obtuse leaf apex and glabrous receptacle separate this typical variety from var. *luzulaefolium*. Satake (1974b) reported that var. *laosense* differs from the typical variety in its broader leaves, longer peduncle, male calyx dissected to the base and narrower female sepals. However, these characters are inconsistent, field experience suggests that these differences are related to habitat. This, the typical variety, is found only in Northern Thailand whereas var. *luzulaefolium* is found all over Thailand.

Distribution: Chiang Mai- Om Koi, Doi Intanon National Park, Mae Dtang, Bong Duat Nature Park, Doi Saket, Huay Gayo, Doi Suthep, Bo Luang, Mae Sanam, Chom Thong, Mae Taon Luang; Lampang- Jae Sawn National Park.

Ecology: Common in swampy area by stream, moist, muddy area along the banks of the pond, original pine-evergreen hardwood forest, mixed evergreen/deciduous forest; granite bedrock. Altitude 330-1400 m.

Flowering: All year, mostly in September-January.

19. Eriocaulon nepalense *Prescott ex Bong.* **var. luzulaefolium** (*Mart.*) *A.Prajaksood & J. Parn.* **comb. et stat. nov.** Type: as for *E. luzulaefolium*. Type: India, Silhet, Wallich 6071 (holotype **K!**; isotypes **K-WA!, B!, CAL**)

E. luzulaefolium Mart. in Wall., Pl. Asiat. Rar. 3: 28 (1832); Kunth, Enum. Pl. 3: 553 (1841); Steud., Syn. Pl. Glumac. 2: 270 (1855); Körn. in Linnaea. 27: 636 (1856); Thwaites, Enum. Pl. Zeyl. 5: 341 (1864); Hook.f., Fl. Brit. Ind. 6: 582 (1894); Hook.f. & Trimen, Handb. Fl. Ceylon 5: 7 (1900); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 88 (1903); Fyson in J. Indian Bot. 2(6-7): 200 (1921b); S.B.Malla, S.B.Rajbh., Shrestha, P.M.Adhikari & Shakya in Bull. Dept. Med. Pl. Nepal (11): 679 (1986); Z.X.Zhang in U.Kück, Diss. Bot. 313: 97-99 (1999). Type: India, Silhet, Wallich 6071 (holotype **K!**; isotypes **B!, CAL, K-WA!,**), **syn. nov.**

E. kathmanduense Satake in H.Hara, Fl. E. Himalaya: 157 (1971); S.B.Malla, S.B.Rajbh., Shrestha, P.M.Adhikari & Shakya in Bull. Dept. Med. Pl. Nepal (11): 679 (1986).Type: Nepal, Sundarijal waterfall, near Kathmandu, 20 Sept. 1963, *H. Hara, H. Kanai & S. Kurosawa* s.n. (holotype **TI**), **syn. nov.**

E. pseudonepalense Satake in Acta Phytotax. Geobot. 26(1-2): 50 (1974). Type: Thailand, Loei, Phu Kradung National Park, 29 Nov. 1965, *M. Tagawa, K. Iwasuki & N. Fukuoka* T-764 (or T 764) (holotype **KYO!**; isotype **BKF!**). Paratype: Thailand, Loei, Phu Kradung National Park, 28 Nov. 1965, *M. Tagawa, K. Iwasuki & N. Fukuoka* T 547 (**BKF!, L!**), **syn. nov.**

E. papuanum P.Royen in Nova Guinea 10: 37 (1959). Type: Papua New Guinea, near Nondugl, Western Highlands, 2 Apr. 1953, *Womersley & Hooglang* 4956 (holotype **L!**), **syn. nov.**

E. lepidum T.Koyama in Philipp. J. Sci. 84(3): 371-372 (1955). Type: Thailand, Chiang Mai, Doi Sutep, 3 Oct. 1921, *B. Hayata* s.n. (holotype **TI**), **syn. nov.**

E. pumilio Hppk.f., Fl. Brit. Ind. 6: 581 (1894). Type: India, alt. 3000-4000 m., 3 Oct. 1884, *Duthie* 3454 (**K!**), N.W. India, alt. 8000-9000 m., 19 Sept. 1885, *Duthie* 4473 (**K!** (000098634), (000098635)), **syn. nov.**

Annual herbs. *Stem* forming a basal disc or if near water or in water then up to 2 cm long. *Leaves* crowded into a basal rosette or if stem leafy then cauline, linear, 0.5-8 cm long, 1-6 mm wide, glabrous, apex acute. *Scapes* few or numerous, up to 3-22 cm long, glabrous. *Sheaths* 1-7 cm long, glabrous, apex acute. *Capitula* hemispherical to ovoid, 2.5-6 mm long, 3-6 mm in diameter, blackish-grey. *Receptacle* convex. *Involucral bracts* broadly obovate, 2 mm long, brown to blackish-brown, glabrous, apex obtuse. *Floral bracts* oblanceolate to oblong, 2 mm long, black, hairy in the upper part, apex acute to acuminate. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, acute, 1.5-2 mm long, blackish, hairy in the upper part or only at the tip; petals equal and glabrous if all minute but if unequal, two small and glabrous and the third hairy acute, eglandular; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, linear to narrowly oblanceolate, acute, 2 mm long, black, hairy in the upper part; petals 3, linear, acute, 1.5 mm long, brown, hairy in the upper part, eglandular; ovary 3-locular; seed 0.5 mm long, brown, papillate (Figure 5.20).

Note: Malla et al. (1986) recognized 3 species from the Kathmandu Valley, *E. nepalense* , *E. luzualaefolium* and *E. kathmanduense*. They recognized *E. nepalense* as it has a glabrous receptacle but the other 2 species have a pilose receptacle and the male petals of *E. kathmanduense* are unequal but are equal in *E. luzulaefolium*. Satake (1974) said that *E. pseudonepalense* differs from *E. nepalense* in its pilose receptacles, narrower female sepals and eglandular female petals. However, I noted that eglandular female petals are also found in *E. nepalense*. Additionally, the field experience suggests that this species, a plants growth conditions have a big impact on its morphology. When plants grow in water they are bigger, such material has been called *E. luzulaefolium* and *E. kathmanduense*, material growing in drier conditions, has been named *E. pseudonepalense*. I consider these all to be one species, with some characters differing depending on moisture. For example, in drier conditions, the male petals will all be minute and glabrous but in wetter conditions they will be larger. This variety (var. *luzulaefolium*) differs from the typical variety in having its leaf apex acute, margin entire and receptacle pilose; its distribution is wider than the typical variety.

Distribution: Chiang Mai- Om Koi, Doi Suthep, Doi Inthanon National Park, Doi Chiang Dao Wildlife Sanctuary; Chiang Rai- Doi Langka, Kuhn Jae National Park; Phitsanulok- Tung Sa laeng Luang; Phetchabun- Thung Non Son; Loei- Phu Kradung National Park, Phu Rua National Park; Nong Khai- Phu Wua National Park; Sakol Nakhon- Phu Phan National Park; Chaiyaphum- Tungkramung Wildlife Sanctuary, Phu King; Nakhon Ratchasima and Nakhon Nayok- Khao Yai National Park, Khao Kiew; Ubon Ratchathani- Pha Tam National Park, Kaeng Lam Duan, Yoddome Wildlife Sanctuary; Kanchanaburi- Huay Bankau; Uttaradit- Phu Soi Dao National Park.

Ecology: Paddy fields, common on sandy soils in open marshy places, on the borders of seasonal ponds, on the borders of barren sandstone rocks or on the borders of streams. Altitude 200-1633 m.

Flowering: September-February.

20. Eriocaulon oryzetorum *Mart.* in Wall., Pl. Asiat. Rar. 3: 28 (1832); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 86-87 (1903); Steud., Syn. Pl. Glumac. 2: 270 (1855); Körn. in Linnaea. 27: 639 (1856); Hook.f., Fl. Brit. Ind. 6: 579 (1894); Lecomte in Notul. Syst. (Paris) 2: 214 (1911); Lecomte, Fl. Indo-Chine 7(1): 9 (1912); Fyson in J. Indian Bot. 2(10): 312 (1921d); Collett, Fl. Siml.: 250 (1921); P.H. Hô, Ill. Fl. Vietnam 3(1): 490 (1993); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 41-43 (1994); C.D.K.Cook, Aquatic Wetland Pl. India: 198 (1996); Z.X.Zhang in U.Kück, Diss. Bot. 313: 105-107 (1999). Type: Nepal, Hawalbaqh Kumaon, 1822, *Wallich* 6069 (holotype **B!** (10 0106835); isotypes **B!** (10 0106822), **BR, BM!, CAL!, E, G, K!, K-WA!, L,M!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 2-12 cm long, 1-4 mm wide, glabrous, apex acuminate. *Scapes* few, up to 35 cm long, glabrous. *Sheaths* 4-12 cm long, glabrous, apex acute. *Capitula* globose, 4-6 mm long, 5-9 mm in diameter, greyish. *Receptacle* elongate, pilose. *Involucral bracts* broadly elliptic to obovate, 2-2.5 mm long, brown, glabrous, apex acute. *Floral bracts* obovate, 3 mm long, brown, blackish in the middle part, glabrous, apex acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute, 2-2.5 mm long, blackish, hairy in the upper part; petals unequal, hairy, acute, eglandular; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, weakly keeled, acute, 1.7-2 mm long, blackish, hairy in the upper part; petals 3, elliptic, attenuate, acute, 2-2.3 mm long, light brown, hairy in the upper part, eglandular; ovary 3-locular; seed 0.5 mm long, brown, glabrous (Figure 5.21).

Note: Only 2 records from Thailand.
Distribution: Chiang Mai- Doi Suthep; Mae Hong Son- Khun Yuam.
Ecology: Open marshy ground, small pond in bog. Altitude 600-1000 m.
Flowering: September-November.

21. Eriocaulon parnellii *A.Prajaksood & Chantar.* **sp. nov.** Differt E. odorato capitulis non niveo-villosis, sepalis foemineus 3 penitus carino-navicularibus, omnibus apice curvi-acuminatus. Type: Loei, Phu Kradung National Park, on the plain at its summit, Pra Bhuddha Matta- Arnodad pond route. *A.Prajaksood & S.Suddee* 242 (holotype **KKU!**; isotypes **BK!, BKF!, K!, TCD!**).

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear or acicular, 0.5-2.0 cm long, 0.5-1 mm wide, glabrous, apex acute. *Scapes* few or numerous, up to 12 cm long, glabrous. *Sheaths* 1.3-2.0 cm long, glabrous, apex acute or 2 lobed. *Capitula* hemispherical to globose, 2-4 mm long, 3-5 mm in diameter, blackish-greyish. *Receptacle* convex, pilose. *Involucral bracts* oblanceolate to broadly obovate, 1.5-2 mm long, brownish, glabrous, apex obtuse. *Floral bracts* oblanceolate to obovate, 1.5-2 mm long, pale brown, blackish and hairy in the upper part, apex acute to acuminate. *Male flowers*: calyx spatheate, 3 lobed, obtuse to acute, 1-1.2 mm long, blackish, hairy at the tip; petals unequal, two small petals hairy at the tip, the third hairy all over, acute,subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals

3, keeled, boat-shaped, curvi-acuminate, 1.7-2 mm long, blackish, hairy in the upper part, rarely pilose on the inner surface; petals 3, subequal, linear or narrowly elliptic, attenuate, acute, 1-1.5 mm long, whitish, hairy in the upper part,subapical glands present; ovary 3-locular; seed 0.6 mm long, brown, papillate (Figure 5.22).

Note: A very distinctive species with dark, small inflorescences. The form of each female flower is diagnostic. Superficially similar to *E. odoratum* but differing considerably in the number and shape of the female sepals (2, oblanceolate, acuminate in *E. odoratum*; 3, broadly ovate, curvi-acuminate in *E. parnellii*) and the length of the hairs (long in *E. odoratum*, short in *E. parnellii*). It is a pleasure to dedicate this species to Prof. J.A.N. Parnell, supervisor for the PhD degrees of Prof. Dr. P. Chantaranothai, Dr. S. Suddee and myself.

Distribution: Endemic to Thailand, Loei- Phu Kradung, Phu Luang.

Ecology: On the borders of seasonal ponds, common on sandy soils in open marshy places or on the borders of barren sandstone rocks. By the side of the path. Pine forest; alt. 1300 m.

Flowering: November.

22. Eriocaulon phatamense *A.Prajaksood & Chantar.* **sp. nov.** Affinis *E. thysanochephalum* sed folia vaginae et bracteae involucrantes pilis, sepala 2, flores feminei petala mediana crassus late ellipticus attenuatus. Type: Thailand, Ubon Ratchathani, Pha Mon, Pha Tam National Park, 14 Nov. 1998, *A. Prajaksood & P. Chantaranothai* 89 (holotype **KKU!**; isotypes **BK!, BKF!, K!, TCD!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1-4.5 cm long, 1-5 mm wide, hairy, apex acute. *Scapes* numerous, up to 20 cm long, hairy only near head. *Sheaths* 2-4 cm long, hairy, apex acute. *Capitula* hemispherical to globose, 3-6 mm long, 3-7 mm in diameter, white. *Receptacle* elongate, pilose. *Involucral bracts* obovate to ovate, 1.3 mm long, brown, hairy, apex acute. *Floral bracts* broadly oblanceolate, 1.5 mm long, light brown, hairy in the upper part, apex acuminate. *Male flowers*: calyx 2, free, oblanceolate, acute, 1 mm long, light brown, hairy in the upper part; petals unequal, hairy, acute, subapical glands present; vestigial gynoecium present; anthers 5-6, black. *Female flowers*: sepals 2, narrowly oblanceolate or linear, acute, 1 mm long, light brown, hairy in the upper part; petals 3, dissimilar, two lateral ones elliptic, attenuate, 1 mm long, the middle one broadly elliptic, attenuate, exserted beyond the floral bract, apex thick, 2 mm long, obtuse, light brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.5 mm long, dark-brown, glabrous (Figure 5.23).

Note: This species is similar to *E. thysanochepalum* S.M.Phillips, from Ceylon, but it differs in having hairs on the leaves, sheaths and involucral bracts. Additionally, the 2 sepals in the male and female flowers and the median female petals are thicker and broadly elliptic-attenuate.

Distribution: Endemic to Thailand, Mukdahan - Lan Phu Wat, Phu Sadokbua National Park, Phu Pha Therb National Park; Ubon Ratchathani- Pha Tam National Park.

Ecology: Common on sandy soils in open marshy places or on the borders of barren sandstone rocks. Altitude 150 m.
Flowering: October-December.

23. Eriocaulon phuchongense *A.Prajaksood & Chantar.* **sp. nov.** Affinis *E. dimorphoelytrum* sed bracteae flores longus acuminatus, flores feminei apice pilis. Type: Thailand, Ubon Ratchathani, along the road to Khong Chiam, 14 Nov. 1998, *A. Prajaksood & P. Chantaranothai* 100 (holotype **KKU!**). Paratypes: Thailand, Ubon Ratchathani, Phu Chong Nayoy National Park, 8 Nov. 2002, *A. Prajaksood & S. Suddee* 260 (**BK!, BKF!, K!, KKU!, TCD!**); Ubon Ratchathani, Khong Chium, 8 Nov. 2002, *A. Prajaksood & S. Suddee* 276 & 285 (**BK!, BKF!, K!, KKU!, TCD!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1-3.5 cm long, 1-2.5 mm wide, glabrous, apex acute. *Scapes* numerous, up to 10 cm long, glabrous. *Sheaths* 2-3.5 cm long, glabrous, apex acute. *Capitula* hemispherical to globose, 3-5 mm long, 4-6 mm in diameter, white. *Receptacle* elongate. *Involucral bracts* elliptic to lanceolate, 2.5-3 mm long, light brown, glabrous, apex acute. *Floral bracts* oblanceolate, 3 mm long, light brown, hairy in the upper part, apex long-acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute, 1.5 mm long, light brown, hairy in the upper part; petals equal, hairy, acute, subapical glands present; vestigial gynoecium present; anthers 6, black *Female flowers*: sepals united, spatheate, 3 lobed, acute, 1.5 mm long, light brown, hairy in the upper part; petals 3, unequal, elliptic, attenuate, acute, 1.3-1.5 mm long, light brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.4 mm long, brown-yellow, tuberculate (Figure 5.24).

Note: This species differs from *E. dimorphoelytrum* T.Koyama, from Japan, in having long-acuminate floral bracts and hairs in the upper part of the female petals.
Distribution: Endemic to Thailand, Ubon Ratchathani- Khong Chium, Phu Chong Nayoy National Park,
Ecology: Common on sandy soils in open marshy places or near paddy fields. Dipterocarp forest.
Flowering: November.

24. Eriocaulon phuphanense *A.Prajaksood & J.Parn.* **sp. nov.** Affinis *E. ubonense* sed bracteae involucrantes tenuis, flores masculi et feminei sepala 2. Type: Thailand, Sakon Nakhon, Phua Phan National Park, 24 Jan. 1998, *A. Prajaksood & P. Chantaranothai* 55 (holotype **KKU!**; isotypes **BK!, BKF!, K!, TCD!**).

Annual or perennial herbs. *Stem* forming a basal disc or shortly rhizomatous. *Leaves* crowded into a basal rosette, linear, 5-9 cm long, 5-10 mm wide, glabrous, apex acute. *Scapes* numerous, up to 35 cm long, glabrous. *Sheaths* 5-8 cm long, glabrous, apex acute. *Capitula* globose to ovoid, 4-8 mm long, 5-6 mm in diameter, white. *Receptacle* elongate. *Involucral bracts* elliptic to obovate, 3 mm long, brown, glabrous, apex obtuse to acute. *Floral bracts* oblanceolate, 2 mm long, brown, blackish and

hairy in the upper part, apex acuminate. *Male flowers*: calyx 2, lanceolate, acute, 2 mm long, light brown, hairy in the upper part and pilose in the lower; petals unequal, hairy, obtuse, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 2, oblanceolate, acute, 2 mm long, light brown, hairy in the upper part; petals 3, unequal, elliptic, attenuate, acute, 1.5-2 mm long, light brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.5 mm long, brown, papillate (Figure 5.25).

Note: This species differs from *E. ubonense* as the involucral bracts are thinner and there are 2 sepals in the male and female flowers.

Distribution: Endemic to Thailand, Sakon Nakhon- Phu Phan National Park.

Ecology: Common on sandy soils in open marshy places. Dipterocarp forest. Altitude 210-600 m.

Flowering: December-March.

25. Eriocaulon phuphanoides *A.Prajaksood & J.Parn.* **sp. nov.** Affinis *E. phuphanense* sed planta parvulus, bracteae involucrantes papyraceus alba, corolla fasciatus glabra, seminis testaque glabra. Type: Thailand, Ubon Ratchathani, Khong Chium, 8 Nov. 2002, *A. Prajaksood & S. Suddee* 299 (holotype **KKU!**; isotypes **BK!, BKF!, K!, TCD!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1.5-3 cm long, 1-3 mm wide, glabrous, apex acute. *Scapes* numerous, up to 6 cm long, glabrous. *Sheaths* 2-5.5 cm long, glabrous, apex acute. *Capitula* hemispherical to globose, 3 mm long, 5 mm in diameter, white. *Receptacle* elongate, pilose. *Involucral bracts* broadly elliptic, 2-3 mm long, white, glabrous, apex acute. *Floral bracts* oblanceolate, 1.5 mm long, white, hairy in the upper part, apex acuminate. *Male flowers*: calyx 2, narrowly oblanceolate, acute, 1 mm long, white, hairy in the upper part; petals unequal, hairy, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 2, narrowly oblanceolate, acute, 1 mm long, white, hairy in the upper part; petals 3, unequal, elliptic, attenuate, acute, 1.5-2 mm long, white, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.5 mm long, yellow, glabrous (Figure 5.26).

Note: This species is similar to *E. phuphanense* but is of somewhat smaller general aspect. Also the white and papery involucral bracts, the hairy cylindrical, fused, lower part of the corolla and the glabrous seeds are distinctive.

Distribution: Chiang Mai- Mae Tang; Nong Khai- ham Phun Waterfall, Phu Wau National Park; Sakon Nakhon- Phu Phan National Park; Ubon Ratchathani- Tambon Naphoglang, Khong Chium, Ban Na Pa Nieng Or, Pho Sai.

Ecology: On the borders of barren sandstone rocks or sandy soils, open marshy places. Altitude 210-1000 m.

Flowering: July-November.

26. Eriocaulon pseudoescape *A.Prajaksood & Chantar.* in Kew Bull. 57: 499-501 (2002). Type: Thailand, Loei, Phu Kradung National Park, 16 Nov. 1998, *A. Prajaksood & P. Chantaranothai* 117 (holotype **K!**; isotypes **BK!, BKF!, KKU!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1-3 cm long, 1-2 mm wide, glabrous, apex acute. Scape absent. *Capitula* hemispherical, 5 mm long, 5-10 mm in diameter, blackish-grey. *Receptacle* convex or elongate, pilose. *Involucral bracts* lanceolate to oblong, 3-4 mm long, blackish-brown, glabrous, apex acute. *Floral bracts* narrowly oblong, 2.5 mm long, blackish-brown, hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, acute, 2.5 mm long, brown but blackish and hairy in the upper part; petals unequal, acute, two small glabrous, the third hairy, eglandular; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, narrowly elliptic, acute, 2.5 mm long, blackish brown, hairy in the upper part; petals 3, linear, acute, 2.5 mm long, brown, hairy in the upper part, eglandular; ovary 3-locular; seed 0.5 mm long, brown, papillate (Figure 5.27).

Note: There are only 2 species in Thailand which have no scapes and both are endemic to Phu Kradung National Park, Loei. *E. pseudoescape* differs from *E. escape*, according to Prajaksood and Chantaranothai (2002), in its oblong involucral bracts, oblanceolate floral bracts, the presence of female petals, subequal sepals and the dark-grey or blackish capitulum. Also the cells of the seed testa are transversely elongated and papillate.
Distribution: Endemic to Thailand, Loei- Phu Kradung National Park.
Ecology: Common on sandy soils in open marshy places. Pine forest. Altitude 1300 m.
Flowering: November-December.

27. Eriocaulon quinquangulare *L.* **var. longibracteatum** *A.Prajaksood & J.Parn.* **var. nov.** Haec varietas differt a forma typical speciei longi bracteae involucrantes, flores feminei petala linear eglandulatus. Type: Thailand, Sakon Nakhon, Phu Phan National Park, 11 Nov. 2002, *A. Prajaksood & S. Suddee* 317 (holotype **K!**; isotypes **BK!, BKF!, KKU!**).

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear, 3-7 cm long, 2-4 mm wide, glabrous, apex acute. *Scapes* numerous, up to 30 cm long, glabrous. *Sheaths* 4-6 cm long, glabrous, apex acute. *Capitula* globose, 3-6 mm long, 5-7 mm in diameter, blackish-grey. *Receptacle* convex or elongate, pilose. *Involucral bracts* obovate to oblong, 2.5 mm long, light brown, glabrous, apex obtuse to acute. *Floral bracts* oblanceolate-cuneate, 2 mm long, brown but blackish and hairy in the upper part, apex acuminate to cuspidate. *Male flowers*: calyx spatheate, 3 lobed, acute, 1.5 mm long, brown but blackish in the upper part, hairy at the tip; petals unequal, hairy, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 2-3, narrowly linear, acute, 1 mm long, light brown to blackish brown, glabrous or deciduous hairy in the upper part; petals 3, linear, acute, 1.5 mm long, light brown, hairy in the upper part, eglandular; ovary 3-locular; seed 0.5 mm long, brown, glabrous (Figure 5.28).

Note: This variety differs from the typical variety in having longer involucral bracts and linear and eglandular female petals.

Distribution: Chiang Mai- Om Koi, Doi Saket; Kamphaeng Phet- Wang chow forest; Loei- Wangsaphung; Sakon Nakhon- Phu Phan National Park; Khon Kaen- Kok Phu Taka, Phu Wieng; Kanchanaburi- Rintin Forest, Thong Pha Phum.

Ecology: Common on sandy soils in open marshy places. Altitude 100-900 m.

Flowering: October-March.

28. Eriocaulon setaceum *L.* Sp. Pl. 1: 87 (1753); Crantz, Inst. Rei. Herb. 1: 360 (1766); Mart. in Wall., Pl. Asiat. Rar. 3: 28 (1832); Kunth, Enum. Pl. 3: 550 (1841); Steud., Syn. Pl. Glumac. 2: 270 (1855); Körn. in Linnaea. 27: 603 (1856); Benth., Fl. Hongk.: 383 (1861); Thwaites, Enum. Pl. Zeyl. 5: 341 (1864); Hook.f., Fl. Brit. Ind. 6: 572 (1894); Hook.f. & Trimen, Handb. Fl. Ceylon 5: 2 (1900); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 89 (1903); Lecomte, Fl. Indo-Chine 7(1): 5 (1912); Fyson in J. Indian Bot. 2(6-7): 193 (1921b); C.E.C.Fischer, Fl. Madras 9: 1605 (1931); U.C.Bhattach. in Bull. Bot. Surv. India 5(1): 62 (1963); Satake in Acta Phytotax. Geobot. 26(1-2): 49 (1974); Gandhi in C.J.Saldanha & Nicolson, Fl. Hassan Dist.: 654 (1978); W.L.Ma in Acta Phytotax. Sin. 29: 300 (1991); P.H. Hô, Ill. Fl. Vietnam 3(1): 479 (1993); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 72-75 (1994); C.D.K.Cook, Aquatic Wetland Pl. India: 187 (1996); S.M.Phillips in Dassan. & Clayton, Revis. Handb. Fl. Ceylon 11: 68-73 (1997); Z.X.Zhang in U.Kück, Diss. Bot. 313: 68-73 (1999). Type: India, *Fl. Zeyl.* 50 (lectotype **BM!**,000621372).

E. intermedium Körn. in Linnaea. 27: 601 (1856); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 90 (1903); Lecomte, Fl. Indo-Chine 7(1): 4 (1912); Fyson in J. Indian Bot. 2(6-7): 193 (1921b); Satake in Acta Phytotax. Geobot. 26(1-2): 48 (1974); P.H. Hô, Ill. Fl. Vietnam 3(1): 480 (1993). Type: Eastern India, *Wight* 2369 (lectotype chosen here **B!**; isolectotype **E, K!**), Ansari and Balakrishnan (1994) reported the specimens from **K** as the holotype which was incorrect.

E. capillus-naiadis Hook.f., Fl. Brit. Ind. 6: 572 (1894); Hook.f. & Trimen, Handb. Fl. Ceylon 5: 2 (1900); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 75 (1994). Type: Bengal, Griffith s.n. (lectotype **CAL**, isolectotype **K**).

E. setaceum L. var. *capillus-naiadis* (Hook.f.) Moldenke in Phytologia 28: 401 (1974). Type: as for *E. capillus-naiadis.*

E. intermedium var. *brevicaule* Satake in Acta Phytotax. Geobot. 26(1-2): 48 (1974). Type: Thailand, Loei, Phu Kradung, *T. Shimizu, M. Huston & D. Chaiglom* T-9035 (holotype **KYO**; isotypes **BKF!, C!, L!, K!**).

E. intermedium var. *glabrum* Satake in Acta Phytotax. Geobot. 26(1-2): 49 (1974). Type: Thailand, Pathum Thani, Rangsit, North of Bangkok, *M. Tagawa & K. Iwatsuki* T-286 (holotype **KYO**; isotype **BKF!**).

E. bifistulosum VanHeurck & Müll.Arg. in Obs. Bot.: 105 (1870). Type: Nupe, Baikie;s Niger Expedition 1857-9, *C.Barter* 1621. (isotypes **M!, S!**)

E. cauliferum Makino in Bot. Mag., Tokyo, 24(283): 165-167. (1910); T.Koyama in Ohwi, Fl. Jap.: 2670 (1984). Type: Japan, Kodzuke, 10 Aug. 1909, *T. Taka* s.n. (photograph!).
E. equisetioides P.Royen in Blumea 10(1): 128-129 (1960). Type: Java, West Java, Indramaju, Plosokerep, Mar., *van Steenis* 7542 (holotype **L**; isotypes **BO, SING**), drawing!.
E. melanocephalum Kunth, Enum. Pl. 3: 549-550 (1841). Type: South Brazil, St Paulo, Sellow. Type not seen.

Aquatic annual herbs. *Stem* elongate. *Leaves* dispersed along an elongate stem, acicular, 1.5-6 cm long, 0.3-0.5 mm wide, glabrous, apex acute. *Scapes* numerous, up to 25 cm long, glabrous. *Sheaths* 1-6 cm long, glabrous, apex acute or 3 lobed. *Capitula* hemispherical to globose, 2-4 mm long, 2.5-4 mm in diameter, black. *Receptacle* elongate. *Involucral bracts* broadly obovate, 1.5 mm long, blackish-brown, glabrous, apex obtuse. *Floral bracts* elliptic to oblanceolate, 1-1.5 mm long, black, hairy in the upper part, apex acute to acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute or obtuse, 1.5-2 mm long, blackish, hairy at the tip; petals equal, glabrous, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, boat-shaped, acute, two lateral ones keeled, 1-1.5 mm long, black, hairy in the upper part; petals 3, narrowly elliptic, acute, 1-1.5 mm long, black, hairy in the upper part, rarely with subapical glands; ovary 3-locular; seed 0.5 mm long, brown-yellow, papillate (Figure 5.29).

Note: Linnaeus (1753) first named *E. setaceum* and cited type specimens from his work in Flora Zeylanica (number 50) which contains reference to more than one specimen (Linnaeus, 1747), from in India. Later, Martius (1832) examined specimens from Ceylon and Burma (the latter Tavoy, *W.Gomez* s.n.); Kunth (1841) examined specimens from Ceylon, Tavoy and Indo-China (the latter *Wight* 2369) and also Steudel (1855) examined Reed Malab. t. 68, they all included them in *E. setaceum* and cited Linnaeus's work (1747). Then Körnicke (1856) examined *Wight* 2369 (*E. setaceum* in Kunth.), *Thwaites* 791 (as this collection is mixed I separate 791a and 791b). He found that *Wight* 2369 and *Thwaites* 791a differs from *Thwaites* 791b (which is *E. setaceum* L.) in having grey-blackish, glabrous capitula whereas *E. setaceum* L. (*Thwaites* 791b) has green-white, white-hairy capitula. Therefore, he considered them as distinct species and named the new one *E. intermedium*. However, Thwaites (1864) examined *Thwaites* 791 and did not recognize it as distinct so then he made *E. intermedium* a synonym of *E. setaceum*. Hooker (1894) agreed with Thwaites (1864), during his studies of plants in India, but he recognized a new species, *E. capillus-naiadis*, with whitish membranous floral bracts and dark black seeds (*E. setaceum* has black coriaceous floral bracts and dark brown seeds). He also included *E. setaceum* of Martius (1832) and Körnicke (1856, *Wight* 2369) and noted that the hairs on female petals vary, *i.e.* in the Burmese and Khasian specimens they are ciliate with long hairs, whereas in the Concan and Cochin-Chinese they were nearly glabrous. Perhaps Hooker (1894) might have been confused about *E. intermedium*, as Körnicke (1856) described the species as having grey-blackish capitula so the floral bracts simply cannot be white. Ruhland (1903) disagreed with Hooker (1894) and made *E. capillus-naiadis* a synonym of *E. setaceum*. Since then *E. intermedium* has been recognized by the number of authers on the basis of its glabrous floral bracts and black capitula

whereas *E. setaceum* has hairy floral bracts and grey or white capitula (Lecomte, 1912; Fyson, 1921b; Satake, 1974 and Hô, 1993). Satake (1974) not only agreed with Körnicke (1856) but also recognized 2 new varieties within *E. intermedium* from Thailand, var. *glabrum* (glabrous receptacle and puberulous floral bracts) and var. *brevicaule* (stem very short, peduncles slenderer and male sepals with acute apices). Moldenke (1974) reconsidered these species and changed the status of *E. capillus-naiadis* to that of a variety of *E. setaceum*. However, Ma (1991) did not agree with Moldenke (1974) and treated *E. capillus-naiadis* as a synonym of *E. setaceum* just as Ruhland (1903) did. Additionally, Fischer (1931) did not recognize *E. intermedium* as distinct and also Ansari and Balakrishnan (1994) not only considered *E. intermedium* as a synonym of *E. setaceum* (floral bracts, male sepals and female sepals are glabrous) but also re-recognized *E. capillus-naiadis* (floral bracts, male sepals and female sepals are hairy). Ansari and Balakrishnan (1994) appear confused because *E. setaceum* sensu Ansari and Balakrishnan (1994) is, in fact, *E. intermedium* Körn. and *E. capillus-naiadis* sensu Ansari and Balakrishnan (1994) is, in fact, *E. setaceum* L. Phillips (1997) suggestes that the differences of the colour of capitula and surface of the floral bracts and the sepals (glabrous or hairy) within the species were represent no more than extreme local variants. Finally, recent, studies in the Eriocaulaceae of Asia by Cook (1996), Phillips (1997) and Zhang (1999) recognized just *E. setaceum* and considered all of those species as synonymous.

Distribution: Kamphaeng Phet- Ban Kon; Loei- Phu Kradung National Park; Sakon Nakhon- Phu Phan National Park; Nakhon Ratchasima & Nakhon Nayok- Khao Yai National Park; Ubon Ratchathani- near Pha Tam National Park, Na Tan, Khong Chiam; Pathum Thani- Rang Sit; Sa Kaeo- Aran Pratet; Chantaburi- Plain of Makham, Khao Soi Dao-Makham route, Muang, Ban Chang Thum; Trat- Klong Kut; Ranong- Suksamlan; Phangnga- Between Takuapah and Ranong; Krabi- Ban Sai Kao, Klong Tom; Nakhon Si Thammarat- Thung Song; Songkhla- Haad Yai, Klong Hoy Kong, west of Toong Loong.

Ecology: Submerged on sandy soils in pool, in streams or common on sandy soils in open marshy places. Altitude sea level–1300 m.

Flowering: July-May (mostly October –November).

29. Eriocaulon sexangulare *L.*, Sp. Pl. 1: 87 (1753); Crantz, Inst. Rei. Herb. 1: 360 (1766); Hook.f., Fl. Brit. Ind. 6: 584 (1894); Hook.f. & Trimen, Handb. Fl. Ceylon 5: 5 (1900); Lecomte, Fl. Indo-Chine 7(1): 15 (1912); Hatus. & T.Koyama in J. Jap. Bot. 31(8): 234 (1956); Dalzell & Gribs. Bombay Fl.: 279 (1973); C.E.Chang, Fl. Taiwan 5: 187 (1978); P.H. Hô, Ill. Fl. Vietnam 3(1): 491 (1993); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 79-81 (1994); S.M.Phillips in Kew Bull. 49(2): 295 (1994); C.D.K.Cook, Aquatic Wetland Pl. India: 187 (1996); S.M.Phillips in Dassan. & Clayton, Revis. Handb. Fl. Ceylon 11: 75 (1997); Z.X.Zhang in U.Kück, Diss. Bot. 313: 157 (1999). Type: India, *Fl. Zeyl.* 49 (lectotype **BM!** (000621366)).

E. quadrangulare Lour., Fl. Cochinch. 1: 60 (1790). Cited by Z.X.Zhang in U.Kück, Diss. Bot. 313: 157 (1999). Type not seen.

E. wallichianum Mart. in Wall., Pl. Asiat. Rar. 3: 26 (1832); Dalzell & Gribs. Bombay Fl.: 280 (1973); Benth., Fl. Hongk.: 381 (1861). Type: Burma, Tavoy, *Gomez* Wallich no. 6068 (holotype **K-WA!**; isotype **K!**).

E. consanguineum Kunth, Enum. Pl. 3: 566 (1841); Steud., Syn. Pl. Glumac. 2: 272 (1855). Type: *Wight* 2364 (holotype **B**). Cited by Lecomte, Fl. Indo-Chine 7(1): 15 (1912).

E. cantoniense Hook. & Arn. Bot. Beech. Voy.: 219 (1841). Cited by Benth., Fl. Hongk.: 382 (1861). Type not seen.

E. sinicum Miq. in J. Bot. Neerl. 1: 87 (1861). Cited by Z.X.Zhang in U.Kück, Diss. Bot. 313: 157 (1999).

E. miyagianum Koidz. in Bot. Mag., Tokyo, 28: 171 (1914). Cited by Hatus. & T.Koyama in J. Jap. Bot. 31(8): 234 (1956). Type not seen.

E. pterosepalum Hayata, Icon. Pl. Formosan. 10: 55 (1921). Type: China, Taiwan, Toyencho, *Daitikuisho* s.n.

E, sinii Ruhland in Notizbl. Bot. Gart. Berlin-Dahlem 10 (100): 1041 (1930). Cited by Z.X.Zhang in U.Kück, Diss. Bot. 313: 157 (1999). Type not seen.

E. kwangtungense Ruhland in Notizbl. Bot. Gart. Berlin-Dahlem 10 (100): 1042 (1930). Cited by Z.X.Zhang in U.Kück, Diss. Bot. 313: 157 (1999). Type not seen.

E. myriophyllum Wallich. Cited C.D.K.Cook, Aquatic Wetland Pl. India: 187 (1996). Type not seen.

E. quinquangulare f. *viviparum* Moldenke. Cited by C.D.K.Cook, Aquatic Wetland Pl. India: 187 (1996). Type not seen.

E. willdenovianum Moldenke var. *fergusonii* Moldenke in Phytologia 28: 401-402 (1974). S.M.Phillips in Kew Bull. 49(2): 287-303 (1994). Type: Ceylon, Colombo, Cinnamon Gardens, March 1883, *Ferguson* s.n. (holotype **PDA**), **syn. nov.**

E. fergusonii (Moldenke) S.M.Phillips in Kew Bull. 49(2): 287-303 (1994). Type as for *E. willdenovianum* Moldenke var. *fergusonii* Moldenke, **syn. nov.**

Annual or perennial herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 10-32 cm long, 5-20 mm wide, glabrous, apex obtuse. *Scapes* numerous, up to 60 cm long, glabrous. *Sheaths* 7-28 cm long, glabrous, apex acute. *Capitula* hemispherical to globose, 5-7 mm long, 6-9 mm in diameter, whitish-grey. *Receptacle* elongate, pilose. *Involucral bracts* broadly obovate, 2.7-3 mm long, brown, glabrous, apex acute. *Floral bracts* obovate, 3-3.5 mm long, brown, blackish and hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate, crenate, 2-2.5 mm long, light brown, glabrous; petals 3, equal, hairy at the apex, acute,subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, the lateral sepals boat-shaped winged and keeled, the median sepal linear, 2.2-2.5 mm long, light brown, hairy in the upper part, acute; petals 3, equal, filiform, acute, 2 mm long, light brown, hairy (pilose) in the upper part,subapical glands present; ovary 3-locular; seed 0.6 mm long, reddish-brown, papillate (Figure 5.30).

Note: Linnaeus (1753) firstly named *E. sexangulare* based on Indian material and cited type specimens from his work in Flora of Zeylanica, *Fl. Zeyl.* 50 and *Pluk. Mant.* 48 (Linnaeus, 1747).

Phillips (1994) studied specimens from Ceylon and recognized the type material of *E. willdenovianum* var. *fergusonii* as a species, *E. fergusonii* (Moldenke) distinguished by having the female petals subulate, while those of *E. willdenovianum* are narrowly linear and these of *E. sexangulare* filiform. She also studied the seed morphology of these taxa and stated that *E. willdenovianum* and *E. fergusonii* have ellipsoid seeds, whereas these of *E. sexangulare* are subglobose. However, I consider *E. willdenovianum* var. *fergusonii* as a synonym under *E. sexangulare* because they both have 3 merous flowers and I found that the shape of seeds varied in *E. sexangulare* and, according to Phillips (1994), the seed morphology of these 3 taxa, *E. sexangulare, E. willdenovianum* and *E. fergusonii* (*E. willdenovianum* var. *fergusonii*), showed that *E. fergusonii* is similar to *E. sexangulare*.

Distribution: Chanthaburi- Makham; Trat- Kao Saming; Ranong- Tambon Naka, Suksamlan, Khlong Naka, Kapur; Trang- Thale Sawng Hawng.

Ecology: Common on sandy soils in open marshy places, paddy field, on the edge of small pond, fresh water swamp forest. Altitude sea level-50 m.

Flowering: August-December.

30. Eriocaulon sexangulare *L.* **var. australe** (R.Br.) *A.Prajaksood & J.Parn.* **comb. et stat. nov.**

E. australe R.Br., Prodr. Fl. Nov. Holland: 254 (1810); Benth., Fl. Hongk.: 382 (1861); Lecomte, Fl. Indo-Chine 7(1): 8 (1912); P.H. Hô, Ill. Fl. Vietnam 3(1): 482 (1993); Z.X.Zhang in U.Kück, Diss. Bot. 313: 154 (1999). Type: Australia, New South Wales, Port Jackson, *R. Brown*, 5821 (lectotype **BM!,** chosen here).

Perennial herbs. Stem rhizomatous. *Leaves* crowded into a basal rosette, linear, 9-37 cm long, 5-8 mm wide, hairy, apex obtuse. *Scapes* numerous, up to 70 cm long, hairy. *Sheaths* 7-17 cm long, hairy, apex acute. *Capitula* hemispherical to globose, 5-6 mm long, 7-8 mm in diameter, whitish-grey. *Receptacle* elongate, glabrous. *Involucral bracts* broadly obovate, 2.5 mm long, brown, hairy in the upper part, apex acute. *Floral bracts* obovate, 2.5 mm long, brown, blackish and hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate, crenate, 2.2 mm long, light brown, hairy at the apex; petals 3, equal, hairy at the apex, acute,subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, the lateral sepals boat-shaped winged and keeled, the median sepal linear, 2.2-2.3 mm long, light brown, hairy in the upper part, acute; petals 3, equal, linear, acute, 2 mm long, light brown, hairy at the apex,subapical glands present; ovary 3-locular; seed 0.6-0.8 mm long, reddish-brown, papillate (Figure 5.31).

Note: *E. australe* was considered as differing from *E. sexangualare* (*E. wallichianum*) in having hairy leaves (Bentham, 1861 and Zhang, 1999), sheaths, involucral bracts and receptacle (Zhang, 1999). However, I also found that this taxon is always a perennial herb with a rigid rhizome, the median female sepal is thinner than in *E. sexangulare*, the female petals are linear and there are short-white hairs at the apex rather than. In *E. sexangulare* the female petals are filiform and the hairs are long and translucent and are not confined to the apex of the female petals but occur all over the upper part of

the female petals. Additionally, because other characters are similar to *E. sexangulare*, I recognize this taxon as a variety under *E. sexangulare.*

Distribution: Chanthaburi-Khao Soi Dao, Trat- Klong Yai, Khlong Kut; Satun- Thung Kai; Songkhla- Haad Yai.

Ecology: Common on sandy soils in open marshy places. Altitude sea level to 100 m.

Flowering: September-May.

31. Eriocaulon siamense *Moldenke* in Phytologia 5(3): 83 (1954); Z.X.Zhang in U.Kück, Diss. Bot. 313: 149-152 (1999). Type: Thailand, Loei, Phu Kradung National Park, 22 Feb. 1948, *Native* 18 (holotype **S!**; isotype **P!**)

E. tagawae Satake in Acta Phytotax. Geobot. 26(1-2): 50 (1974). Type: Thailand, Loei, Phu Kradung, 28 Nov. 1965, *M. Tagawa, K. Iwasuki & N. Fukuoka*, T 553 (holotype **KYO**; isotypes **BKF!, P!**).

E. siamense Moldenke var. *leiophyllum* Z.X.Zhang in U.Kück, Diss. Bot. 313: 152 (1999). Type: Thailand, Loei, Phu Kradung National Park, 07-09 Nov. 1970, *Ch. Charoenphol, K. Laisen & E. Warncke* 4800 (holotype **L**; isotypes **AAU!, BKF!, E!, K!, P!**); paratype: Thailand, Loei, Phu Kradung National Park, 12 Ferb. 1931, *A.F.G. Kerr* 20120, **syn. nov.**

Annual or perennial herbs. *Stem* forming a basal disc or shortly rhizomatous. *Leaves* crowded into a basal rosette, linear, 1-4 cm long, 0.5-1.5 mm wide, reddish or green, mostly papillate, apex acute. *Scapes* numerous, up to 30 cm long, glabrous. *Sheaths* 2-5 cm long, reddish, mostly papillate, apex acute. *Capitula* hemispherical to globose, 5-7 mm long, 5-9 mm in diameter, white. *Receptacle* elongate, pilose. *Involucral bracts* obovate to oblong, 1.5 mm long, brown, glabrous or hairy fimbriate, apex obtuse. *Floral bracts* oblanceolate, 1.5-2 mm long, light brown, black and hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute or obtuse, 1.5 mm long, light brown, black and hairy in the upper part; petals unequal, hairy, acute or obtuse, two lateral ones small, the third about twice as long and exserted beyond the floral bract, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, narrowly oblanceolate, acute and thick, 1.5 mm long, light brown, black and hairy in the upper part; petals 3, unequal, two lateral ones 2 mm long, the middle one 3 mm long, exserted beyond the floral bract and recurved, elliptic, attenuate, acute, light brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.5 mm long, brown-yellow, papillate (Figure 5.32).

Note: Plants of this species that have papillate and reddish leaves and have been found in Phu Kradung National Park. Zhang (1999) recognized var. *leiophyllum* as differing from the typical variety in having non-papillate leaves. I found that there are only 5 records which have non-papillate leaves. They were all collected from Phu Kradung National Park. Therefore, I consider that the the papillate/ non-papillate distinction is too weak to create a new variety.

Distribution: Loei- Phu Kradung National Park; Ubon Ratchathan- Phu Chong Nayoy National Park, Khong Chiem; Uttaradit- Phu Soi Dao National Park.

Ecology: Common on sandy soils in open marshy places or on the borders of barren sandstone rocks, Pine forest, Dipterocarp forest, mixed deciduous dipterocarp forest. Altitude 100-1633 m.
Flowering: October-Febuary.

32. Eriocaulon siamense *Moldenke* **var. macrophyllum** *A.Prajaksood & J. Parn.* **var. nov.** Haec varietas differt a forma typical speciei late et obtuse foliis. Type: Thailand, Loei, Phu Kradung National Park, 14 July 1959, *T. Smitinand T. & F. Floto* 5935 (holotype: **BKF!**; isotypes **BK!, K!**). Paratypes: Phu Kradung National Park, 10 July 1959, *F. Floto* 7472 (**C!, L!**); 7-9 Nov. 1970, *Ch. Charoenphol, K. Larsen & E. Warncke* 4802 (**AAU!, L** (0444270)**!,** (0444271)**!, BKF!**); 7 March 1979, *P.J. O'Connor & C. Niyomdham* 15683 (**BKF!**); 18 Nov. 1998, *A. Prajaksood & P. Chantaranothai* 143 (**BK!, BKF!, K!, KKU!, TCD!**).

Perennial herbs. Stem shortly rhizomatous. *Leaves* crowded into a basal rosette, reddish or green, linear, 3-8 cm long, 3-10 mm wide, glabrous, if leaves narrow (less than 2 mm) and young (in the centre) then papillate, apex obtuse. *Scapes* few or numerous, up to 45 cm long, glabrous. *Sheaths* 6-8 cm long, glabrous, apex acute. *Capitula* globose to broadly elliptic, 6-9 mm long, 6-8 mm in diameter, white. *Receptacle* elongate, pilose. *Involucral bracts* obovate, 1.5 mm long, brown, hairy in the upper part, apex acuminate. *Floral bracts* oblanceolate, 1.5 mm long, brown, blackish and hairy in the upper part, apex thick and acuminate. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, thick and obtuse, 1-1.5 mm long, brown, blackish and hairy in the upper part; petals unequal, hairy, two small and acute, the third about twice as long and exserted beyond the floral bract, thick and obtuse, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, oblanceolate, thick and acute, 1 mm long, brown, blackish and hairy in the upper part; petals 3, dissimilar, two lateral ones obovate, attenuate, 1.5 mm long, the middle one broadly elliptic, attenuate, 2 mm long and exserted beyond the floral bract, thick, obtuse or acute, brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.5 mm long, brown, papillate (Figure 5.33).

Note: This variety differs from the typical variety in having broad and obtuse leaves. It is noted that mostly the leaves are glabrous. However, papillate leaves could be found in younger (near the centre) and narrower leaves on the same plant.
Distribution: Chiang Mai- Samoeng-Ban Watchan Route; Phetchabun- Thung Non Son, Thung Salangluang National Park; Loei- Phu Kradung National Park.
Ecology: Common on sandy soils in open marshy places, open boggy areas, sandy path, by the stream, pine-dipterocarp forest, pine forest, savannah, evergreen forest. Altitude 1000-1300 m.
Flowering: All year, mostly July-November.

33. Eriocaulon siamense ssp. hexagynum *A.Prajaksood & Chantar.* **var. nov.** Haec supspecie differt a forma typical speciei hexagynumlate, longus bracteae involucrantes. Type: Thailand, Ubon Ratchathani, Khong Chium, 8 Nov. 2002, *A.Prajaksood and S.Suddee* 281 (holotype **KKU!**; isotypes **BK!, BKF!, K!, TCD!**). Paratypes: Thailand, Ubon Ratchathani, Khong Chium, 8 Nov. 2002,

A.Prajaksood and S. Suddee 275 (**BK!, BKF!, K!, KKU!, TCD!**); 11 Nov. 1998, *A. Prajaksood & P. Chantaranothai* 104 (**BK!, BKF!, K!, KKU!, TCD!**) & 105 (**BK!, BKF!, K!, KKU!, TCD!**).

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1-6 cm long, 1-2 mm wide, rarely papillate, apex acute. *Scapes* few or numerous, up to 27 cm long, glabrous. *Sheaths* 3-5 cm long, glabrous, apex acute. *Capitula* ovoid to globose, 5-6 mm long, 4-8 mm in diameter, white. *Receptacle* elongate, pilose. *Involucral bracts* narrowly oblong, 3-4.5 mm long, brown, glabrous, apex acute. *Floral bracts* oblanceolate, 2 mm long, light brown, black and hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute, 1.5 mm long, light brown, black and hairy in the upper part; petals unequal, hairy, acute, two lateral ones small, the third about twice as long and exserted beyond the floral bract, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, narrowly oblanceolate, acute, 1.5 mm long, light brown, black and hairy in the upper part; petals 3, unequal, two lateral ones 1.7 mm long, the middle one 2-2.2 mm long, exserted beyond the floral bract and recurved, elliptic, attenuate, acute, light brown, hairy in the upper part, subapical glands present; ovary 6-locular; seed 0.4 mm long, brown-yellow, papillate (Figure 5.34).

Note: This variety differs from the typical variety in being hexagynoecious and processing long involucral bracts.

Distribution: Endemic to Ubon Ratchathani- Khong Chium.

Ecology: Common on sandy soils in open marshy places, near the rice fields and dry dipterocarp forest.

Flowering: November.

34. Eriocaulon smitinandii [as smitinandi] *Moldenke* in Phytologia 7(2): 87 (1959); Z.X.Zhang in U.Kück, Diss. Bot. 313: 120-122 (1999). Type: Thailand, *T. Smitinand* 3679 (holotype **NY**; isotype **K!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1-3.5 cm long, 0.5-3 mm wide, glabrous, apex acute. *Scapes* few or numerous, up to 20 cm long, hairy. *Sheaths* 2-4 cm long, glabrous, apex acute. *Capitula* globose, 3-5 mm long, 5-8 mm in diameter, brownish-white. *Receptacle* convex, pilose. *Involucral bracts* ovoid to oblanceolate, 2-2.5 mm long, brown, hairy, apex acute to acuminate. *Floral bracts* oblanceolate, 2 mm long, light brown, hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute, 1.5 mm long, brown, hairy in the upper part; petals equal, hairy at the apex, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, narrowly oblanceolate, acute, 1.3 mm long, brown, hairy in the upper part; petals 3, narrowly eilliptic, attenuate, acute or 2-lobed, 1.5 mm long, brown, hairy in the upper part, subapical glands present or eglandular; ovary 3-locular; seed 0.4 mm long, yellow (Figure 5.35).

Distribution: Phetchabun- Thung Non Son, Thung Salangluang National Park; Nong Khai- Tham Phun Waterfall, Phu Wau National Park; Sakon Nakhon- Phu Phan National Park; Mukdahan- Phu Sadokbua National Park; Ubon Rachathani- Ban Na Pa Nieng Or, Pho Sai, Pha Tam National Park, Khong Chium; Rayong; Chanthaburi- Makam, Pong Nam Rorn, Khao Soi Dao; Trang- Tungkai Botanic Garden; Satun.

Ecology: Common on sandy soils in open marshy places, paddy fields or on the borders of barren sandstone rocks. Altitude 5-400 m.

Flowering: October-March.

35. Eriocaulon thailandicum *Moldenke* in Phytologia 7(2): 88 (1959); Z.X.Zhang in U.Kück, Diss. Bot. 313: 125-126 (1999). Type: Thailand, Chantaburi, Pong Namron, Ban Tarueang, *Bunnak Sungkhachang* 571a (holotype **NY**; isotype **K!**).

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear, 1-3.5 cm long, 0.5-2.5 mm wide, glabrous, apex acute. *Scapes* few or numerous, up to 14 cm long, glabrous. *Sheaths* 1-2.5 cm long, glabrous, apex acute. *Capitula* hemispherical to globose, 3-5 mm long, 4-6 mm in diameter, brownish-white. *Receptacle* convex, pilose. *Involucral bracts* obovate to broadly obovate, 2.5 mm long, light brown, glabrous, apex acuminate to long-acuminate. *Floral bracts* oblanceolate, 2 mm long, light brown, hairy in the upper part, apex long-acuminate. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, acute, 1-1.2 mm long, light brown, hairy in the upper part; petals equal, glabrous, acute, subapical glands present or eglandular; vestigial gynoecium absent; anthers 6, black. *Female flowers*: sepals 2(-3), linear, acute, 1 mm long, light brown, hairy in the upper part; petals 3, unequal, narrowly elliptic, attenuate, acute, 1-1.5 mm long, light brown, hairy in the upper part, rarely with subapical glands; ovary 3-locular; seed 0.3 mm long, brown-yellow (Figure 5.36).

Distribution: Phitsanulok- Phu Hin Rongkla National Park, Laan Hin Taek; Loei- Dan Sai; Sakon Nakhon- Phu Phan National Park; Nakhon Ratchasima- Pak Thong Chai; Si Sa Ket- Tambon Samrongplan, Pribueng; Prachin Buri- Thung Poh; Chanthaburi- Pong Nam Ron, Ban Ta Rueang, Makham; Trang- Yan Ta Khao, Thung Khai Botanic Garden.

Ecology: Common on sandy soils in open marshy places, paddy fields. Altitude 10-300 m.

Flowering: October-January.

36. Eriocaulon truncatum *Buch.-Ham. ex Mart. in Wall.*, Pl. Asiat. Rar. 3: 29(1832); Kunth, Enum. Pl. 3: 555 (1841); Steud., Syn. Pl. Glumac. 2: 270 (1855); Körn. in Linnaea. 27: 632 (1856); Hook.f., Fl. Brit. Ind. 6: 578 (1894); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 107 (1903); Lecomte, Fl. Indo-Chine 7(1): 16 (1912); M.R.Hend., Malay. Wild Fls., Monocots.: 212 (1954); Ridl., Fl. Malay. Penin. 5: 135 (1967); Gandhi in C.J.Saldanha & Nicolson, Fl. Hassan Dist.: 654 (1978); P.H. Hô, Ill. Fl. Vietnam 3(1): 480 (1993); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 118-120 (1994); C.D.K.Cook, Aquatic Wetland Pl. India: 204 (1996); S.M.Phillips in Dassan. & Clayton, Revis.

Handb. Fl. Ceylon 11: 73 (1997); Z.X.Zhang in U.Kück, Diss. Bot. 313: 179-182 (1999). Type: India, Monghir Hills (Hamilton), 23 Jun. 1861, *Wallich* 6076 (holotype **K-WA!**; isotypes **B!, E**).

E. glabriflorum Ridl., Fl. Malay. Penin. 5: 135 (1967). Type: Lankawi, *Robinson* s.n.; Terutau, *Robinson* s.n.; Singgora, *Annandale* s.n. Type not seen.

E. merrillii Ruhland in Perkins, Fragm. Fl. Philipp. 1: 136 (1904); C.E.Chang, Fl. Taiwan 5: 183 (1978). Type: Philippine, Insel Culion, 24 Oct. 1902, *E.D. Merrill* 572 (holotype **B**; isotypes **BM!, GH!, K!, TAIF**).

E. suishaense Hayata, Icon. Pl. Formosan. 10: 55-56 (1921); Satake in Nakai & Honda, Nov. Fl. Jap.: 24 (1940). Type: China, Taiwan, Suisha, Apr. 1916, *B. Hayata* s.n. Type not seen.

E. suishaense Hayata var. *okinawense* Satake in J. Jap. Bot. 15: 141 (1939). Type not seen.

E. nigrum Lecomte var. *suishaense* (Hayata) Hatus. & T.Koyama in J. Jap. Bot. 31(8): 233 (1956). Type: as for *E. suishaense* Hayata.

E. merrillii Ruhland var. *suishaense* (Hayata) C.E.Chang, Fl. Taiwan 5: 185 (1978). Type: as for *E. suishaense* Hayata.

E.truncatum var. *malaccense* Hook.f., Fl. Brit. Ind. 6: 578 (1894). Type: Malacca, *Griffith* s.n. (**K** distribution number 5567).

E. sollyanum Royle var. s*umatranum* P.Royen in Blumea 10(1): 135 (1960). Type: Sumatra, *Bünnemeyer* 8950 (holotype **L**).

E. annuum Milne-Redh. in Hook. Icon. Pl.: 3389 (1939). Synonym cited in Zhang (1999). Type not seen.

E. ciliipetalum H.Hess in Schweiz. Bot. Ges. 65: 263 (1955). Synonym cited in Zhang (1999). Type not seen.

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 2-5.5 cm long, 1-7 mm wide, glabrous, apex acute. *Scapes* numerous, up to 15 cm long, glabrous. *Sheaths* 3.5 cm long, glabrous, apex acute or 3 lobed. *Capitula* hemispherical, 3-4 mm long, 4-5 mm in diameter, brown. *Receptacle* convex, glabrous. *Involucral bracts* obovate to oblanceolate, 2-2.5 mm long, brown, glabrous, apex obtuse to acute. *Floral bracts* obovate to oblanceolate, 1.5 mm long, brown, glabrous, apex obtuse to cuspidate. *Male flowers*: calyx spatheate or fused at the base, 2 lobed, acute, 1-1.5 mm long, brown, blackish in the upper part, hairy at the apex (deciduous); petals equal, hairy at the apex (deciduous), acute, subapical glands present; vestigial gynoecium present; anthers 5-6, black. *Female flowers*: sepals 2, linear, acute, 1.3 mm long, brown, blackish in the upper part, glabrous; petals 3, narrowly linear, acute, 1.3 mm long, light brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.4 mm long, yellow, tuberculate (Figure 5.37).

Note: Ridley (1976) recognized *E. glabriforum* on the basis of its glabrous flowers while *E. truncatum* has hairy flowers. Schmidt (1904) reported *E. quinquangualre* in Flora of Koh Chang, according to his collection number 302, even Moldenke has determined as *E.* dianae, however, I found that actually it was *E. truncatum*.

Distribution: Chiang Mai- Mah Tang, Doi Suthep; Nong Khai- Tham Phun Waterfall, Phu Wau National Park; Sakon Nakhon- Phu Phan National Park; Mukdahan- Tambon Kamphalai, Muang; Surin- Prasart, Ban Klongnamsub, Tambon Nangmood, Kabcherng; Si Sa Ket- Tambon Samrongplan, Pribueng, Kantharalak; Ubon Ratchathani- Pha Tam National Park, Tambon Naphoglang, Khong Chium, Ban Udomsuk, Tambon Kudprathai, Dacha Udom, Ban Hau Kon, Pho Sri, Khammarach; Prachuap Khiri Khan- Hat Wanakorn National Park, Thap Sa Kae; Chon Buri- Sriracha; Chanthaburi- Khao Soi Dao, Tambon Putthawee, Makham; Trat- Koh Chang, Tambon Bo Ploy, Bo Rai, Taphan Hin, Tambon Mai Rood, Klong Yai; Chumphon- Ban Huay Gayo; Ranong- Kra Buri, Leam Sohn National Park, Tambon Kamphun, Suksamlan, Ngao National Park, Muang Len; Surat Thani- Koh Samui, Chaiya, Tha Chana, Pha Phet; Phuket- Tambon Maikhao, Thalang, Ko Yao Yai; Nakhon Si Thammarat- Tasala District, Groong Ching Falls, Khao Luang National Park, Khao Lu, Karom Waterfall, Klong Jahng Falls; Phatthalung- Ban Nawng Tong, Bah Bawn; Trang- Tungkai Botanic Garden, Khao Chong; Satun- Tarutao Natioanl Park. Talo Oo Dang, Yar Roy waterfall; Songkhla- Hat Yai, Ton Nga Chang Wildlife Sanctuary, Koh Hong, Klong Hoi Khong Klong Nga, Chana; Yala- Betong; Narathiwat- Ban Khok Kraduk Mu, Khlong Nam Bang, Chalerm Phra Ket Wildlife Sanctuary.

Ecology: Common on sandy soils in open marshy places, on the borders of seasonal ponds, the border of barren sandstone rocks, by stream, paddy fileds. Altitude sea level-450 m.

Flowering: All year, mostly August-January.

37. Eriocaulon truncatum var. florensense *Z.X.Zhang* in U.Kück, Diss. Bot. 313: 183 (1999). Type: Indonesia, W. Flores-Manggarai, Pacar, 6 Jun. 1983, *F.E. Schmutz* 5744 (holotype **L**); paratype: Malasia, Sungai Layang Negeri Sembilan, 4 Feb. 1985, *S.C. Chin & Mustafa* 3316 (**L!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 3-7 cm long, 2-10 mm wide, glabrous, apex acute. *Scapes* numerous, up to 13 cm long, glabrous. *Sheaths* 2-4 cm long, glabrous, apex acute or 3 lobed. *Capitula* hemispherical, 2-3 mm long, 4-6 mm in diameter, blackish-brown. *Receptacle* convex, glabrous. *Involucral bracts* obovate to oblanceolate, 2-2.5 mm long, brown, glabrous, apex obtuse to acute. *Floral bracts* obovate to oblanceolate, 1.5 mm long, brown, glabrous, apex obtuse to cuspidate. *Male flowers*: calyx spatheate or fused at the base, 2 lobed, acute, 1 mm long, black, hairy at the apex (deciduous); petals equal, hairy at the apex (deciduous), acute, subapical glands present; vestigial gynoecium present; anthers 5-6, black. *Female flowers*: sepals 2, linear, acute, 1 mm long, black, glabrous or few hairs at the apex (deciduous); petals 3, broadly elliptic, attenuate, obtuse, 1-1.2 mm long, light brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.4 mm long, yellow, tuberculate (Figure 5.38).

Note: Zhang (1999) recognized this variety as differing from typical variety in having blackish capitula, involucral bracts long as capitula, lanceolate female sepals, ovate-lanceolate female petals while typical variety has white (brown) capitula, involucral bracts shorter than capitula and linear female sepals and petals.

Distribution: Sakon Nakhon- Phu Phan National Park; Ubon Ratchathani- Khong Chium, Boontharik, Sri Muang Mai; Saraburi- Sahm Lahn Forest; Nakhon Nayok- Khao Yai National Park; Chanthaburi; Trat- Koh Chang National Park, Ban Klong San, Tambon Dan Chumphon, Bo Rai, Ban Saphanhin Tambon Laem Glad, Muang; Ranong- Ban Naphu, Tambon Naka, Suksamlan; Phangnga- Ban Bangphang, Tambon Thana, Kaphong, Tambon Bang Naisri, Takuapha; Krabi- Klong tom; Satun- Kuan Ka Long; Songkhla- Tambon Koh Saban, Thepha, Haad Yai, Ko Hong Hill.
Ecology: Common on sandy soils in open marshy places, on the borders of seasonal ponds, the border of barren sandstone rocks, by streams, paddy fileds. Altitude 50-150 m.
Flowering: October-January.

38. Eriocaulon ubonense *Lecomte*, in J. Bot. (Morot) 1(21): 109 (1908) & Fl. Indo-Chine 7(1): 11 (1912); T.Koyama in Philipp. J. Sci. 84(3): 373-374 (1955); P.H. Hô, Ill. Fl. Vietnam 3(1): 492 (1993). Type: Cambodia, Oct. 1874, *Pierre* s.n. (lectotype **P!**, chosen here).

Annual or perennial herbs. *Stem* forming a basal disc or shortly rhizomatous. *Leaves* crowded into a basal rosette, linear, 3.5-11 cm long, 2-5 mm wide, glabrous, apex obtuse. *Scapes* few or numerous, up to 55 cm long, glabrous. *Sheaths* 6.5-10 cm long, glabrous, apex acute, 2 or 3 lobed. *Capitula* globose to cylindrical, 5-8 mm long, 7-11 mm in diameter, white. *Receptacle* convex, pilose. *Involucral bracts* broadly ovate to elliptic, 2.5 mm long, brown, glabrous, apex obtuse. *Floral bracts* narrowly oblanceolate, 2.5-3 mm long, brown, hairy in the upper part, apex acute to acuminate. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, acute, 2 mm long, brown, hairy in the upper part; petals unequal, hairy, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, oblanceolate, acute, 2.5 mm long, brown, hairy in the upper part; petals 3, unequal, narrowly elliptic, attenuate, acute or obtuse, 2-2.5 mm long, brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.5 mm long, brown, glabrous (Figure 5.39).

Distribution: Nongkhai- Tham Foon, Phu Wua Wildlife Sanctuary; Sakon Nakhon- Phu Phan National Park; Chanthaburi- Makham; Trat- Klong Yai; Surat Thani- Kanchanadit, Kao Thum Nang, Na Sara; Trang- Thung Khai Botanic Garden; Satun; Songkhla- Chana, Haad Yai, Klong Hoy Kong.
Ecology: Common on sandy soils in open places, the border of barren sandstone rocks. Altitude sea level-400 m.
Flowering: All year, mostly October-January.

39. Eriocaulon ubonense f. kradungense (Satake) *A.Prajaksood & J.Parn.* **comb. et stat. nov.** Affinis a forma typical sed bracteae involucrantes, bracteae flores, flores masculi sepalis eborinus superus niger. Type: as for *E. kradungense* Satake. Type: Thailand, Loei, Phu Kradung National Park, 4 Sept. 1967, *T. Shimizu, M. Hutoh & D. Chaiglom* T 8884 (holotype **KYO**; isotypes **BKF!, C!, K!, L!, P!**).

E. kradungense Satake in Acta Phytotax. Geobot. 26(1-2): 50 (1974); Z.X.Zhang in U.Kück, Diss. Bot. 313: 145 (1999). Type: Thailand, Loei, Phu Kradung National Park, 4 Sept. 1967, *T. Shimizu, M. Hutoh & D. Chaiglom* T 8884 (holotype **KYO**; isotypes **K!, L!, P!**)). **syn. nov.**

Annual or perennial herbs. *Stem* forming a basal disc or shortly rhizomatous. *Leaves* crowded into a basal rosette, linear, 2.5-8 cm long, 2-6 mm wide, glabrous, apex obtuse. *Scapes* few, up to 35 cm long, glabrous. *Sheaths* 5-7 cm long, glabrous, apex acute or 3 lobed. *Capitula* globose to cylindrical, 4-6 mm long, 8-9 mm in diameter, white. *Receptacle* convex, pilose. *Involucral bracts* broadly ovate to elliptic, 2-2.5 mm long, brown, blackish in the upper part, glabrous, apex obtuse. *Floral bracts* narrowly oblanceolate, 2-2.5 mm long, brown, blackish and hairy in the upper part, apex acute to acuminate. *Male flowers*: calyx spatheate or fused at the base, 3 lobed, acute, 1.5-2 mm long, brown, blackish and hairy in the upper part; petals unequal, hairy, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, oblanceolate, acute, 1.5-2 mm long, brown, blackish (or brown) and hairy in the upper part; petals 3, unequal, narrowly elliptic, attenuate, acute, 1.5-2.5 mm long, brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.4-0.5 mm long, brown, glabrous (Figure 5.40).

Note: This form differs from the typical form in its involucral bracts, floral bracts and male sepals which are all blackish in the upper part. Material of this species from Phu Kradung National Park is all of this form.

Distribution: Phetchabun- Thung Non Son, Thung Salangluang National Park; Loei- Phu Kradung; Si Sa Ket- Dongrak Range at Cong Bat Lak, Kantaralak.

Ecology: Common on sandy soils in open marshy places. Altitude 550-1300 m.

Flowering: June-March.

40. Eriocaulon ubonense var. hexagynum *A.Prajaksood & Chantar.* **var. nov.** Haec varietas differt a forma typical speciei hexagynum, lamina acutatus. Type: Thailand, Udonthani, Ban Phue, 18 Nov. 1963, *Pradit* 677 (holotype **BK!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 2-2.5 cm long, 4-6 mm wide, glabrous, apex acute. *Scapes* numerous, up to 25 cm long, glabrous. *Sheaths* 5-7 cm long, glabrous, apex acute. *Capitula* elongate to globose, 5-7 mm long, 8 mm in diameter, white. *Receptacle* elongate. *Involucral bracts* broadly oblanceolate, 2.5 mm long, brown, glabrous, apex acute. *Floral bracts* oblanceolate, 2.5-3 mm long, brown, hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate, 3 lobed, acute, 2 mm long, light brown, hairy in the upper part; petals unequal, hairy, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, narrowly oblanceolate, acute, 1.7mm long, light brown, hairy in the upper part; petals 3, unequal, elliptic, attenuate, acute, 2-2.5 mm long, light brown, hairy in the upper part, subapical glands present; ovary 6-locular; seed 0.4 mm long, yellow, glabrous (Figure 5.41).

Note: This variety differs from the typical variety in being hexagynoecious, with leaves acute.
Distribution: Udonthani- Ban Phue; Ubon Ratchathani.
Ecology: Common on sandy soils in open marshy places. Altitude 500 m.
Flowering: November.

41. Eriocaulon wightianum *Mart.* in Wall., Pl. Asiat. Rar. 3: 28 (1832); Kunth, Enum. Pl. 3: 563 (1841); Steud., Syn. Pl. Glumac. 2: 271 (1855); Körn. in Linnaea. 27: 658 (1856); Thwaites, Enum. Pl. Zeyl. 5: 341 (1864); Hook.f., Fl. Brit. Ind. 6: 576 (1894); Hook.f. & Trimen, Handb. Fl. Ceylon 5: 8 (1900); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 75-76 (1903); Fyson in J. Indian Bot. 2(8-9): 266 (1921c); C.D.K.Cook, Aquatic Wetland Pl. India: 204 (1996); Z.X.Zhang in U.Kück, Diss. Bot. 313: 127-129 (1999). Type: India, *Griffith* Wallich 6067a (holotype **K-WA!**; isotypes **K!, E**).

E. helferi Hook.f., Fl. Brit. Ind. 6: 583 (1894). Type: India, Tenasserim, *Helfer* s.n. (Kew distribution number 5584) (holotype **K!**; isotype **CAL!**).
E. wightianum var. *helferi* (Hook.f.) Fyson in J. Indian Bot. 2(8-9): 266 (1921c). Type: as for *E. helferi* Hook.f.
E. sericans Mart. in Wall., Pl. Asiat. Rar. 3: 29 (1832). Type: India, *Wallich* s.n. (isotype **BR**).

Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear, 6-23 cm long, 7-20 mm wide, glabrous, apex obtuse. *Scapes* few to numerous, up to 63 cm long, hairy. *Sheaths* 6-24 cm long, glabrous, apex acute. *Capitula* globose to cylindrical, 5-10 mm long, 7-10 mm in diameter, whitish. *Receptacle* convex, pilose. *Involucral bracts* broadly obovate, 3 mm long, light brown, hairy, apex obtuse. *Floral bracts* obovate to oblanceolate, 3 mm long, light brown, hairy in the upper part, apex acute to acuminate. *Male flowers*: calyx spatheate, 3 lobed, obtuse, 1.5-2 mm long, light brown, glabrous or with a few hairs in the upper part; petals equal, glabrous, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, dissimilar, boat-shaped, the two lateral ones keeled, the middle not keeled, acute, 2-2.5 mm long, light brown, hairy in the upper part; petals 3, broadly elliptic, attenuate, obtuse, the middle one 2.7 mm long, the lateral ones 2.3 mm long, light brown, hairy at the margin, subapical glands present; ovary 3-locular; seed 0.6 mm long, brown, long papillate (Figure 5.42).

Note: The combination of the large size of the plant, whitish capitula, hairy scapes but glabrous leaves and sheaths and broad leaves are distinctive characters of this species. This species has been observed being eaten by buffalo.
Distribution: Chanthaburi- Makham, foot of Khao Soi Dao; Trat- Ban Klong San, Bo Rai, the way to Klong Kaew Waterfall National Park, Koh Chang National Park, Mai Rood, Klong Yai.
Ecology: Common on sandy soil in open marshy places, grassland. Altitude 15-400 m.
Flowering: October-November.

42. Eriocaulon willdenovianum Moldenke in Phytologia 18: 44 (1968) & in Phytologia 19(7): 440-496 (1970); S.M.Phillips in Kew Bull. 49(2): 296-297 (1994); C.D.K.Cook, Aquatic Wetland Pl. India: 205 (1996); S.M.Phillips in Dassan. & Clayton, Revis. Handb. Fl. Ceylon 11: 78 (1997); Z.X.Zhang in U.Kück, Diss. Bot. 313: 160 (1999). Type as for *E. longifolium* Nees ex Kunth.

E. longifolium Nees ex Kunth, Enum. Pl. 3: 567 (1841); Steud., Syn. Pl. Glumac. 2: 503 (1855); Körn. in Linnaea. 27: 690 (1856); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 30 (1903); S.M.Phillips in Kew Bull. 49(2): 296 (1994); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 81-84 (1994). Type: Madagascar, *Chapelier* Herb. Willdenow no. 2369 (holotype **B!**). Name invalid (see below)
E. sexangulare L. var. *longifolium* (Nees ex Kunth.) Hook.f., Fl. Brit. Ind. 6: 580 (1894). Type as for *E. longifolium* Nees ex Kunth.
E. sexangulare L. f. *viviparum* Moldenke in Phytologia 8: 388 (1962). Type: Singapore, Johore Rengam, *E.J.H. Corner* 37693 (holotype **S!**), cited Z.X.Zhang in U.Kück, Diss. Bot. 313: 161 (1999).

Annual or perennial herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 10-44 cm long, 7-12 mm wide, glabrous, apex obtuse. *Scapes* numerous, up to 60 cm long, glabrous. *Sheaths* 6-20 cm long, glabrous, apex acute or 2-lobed. *Capitula* hemispherical to cylindrical, 5-7 mm long, 5-7 mm in diameter, whitish-grey. *Receptacle* elongate, glabrous. *Involucral bracts* broadly obovate, 2 mm long, brown, glabrous, apex obtuse. *Floral bracts* broadly obovate, 2.2-2.5 mm long, brown, hairy in the upper part, apex acute. *Male flowers*: calyx spatheate, crenate, 1.7 mm long, light brown, glabrous; petals 2, equal, hairy at the apex, acute,subapical glands present; vestigial gynoecium absent; anthers 4, black. *Female flowers*: sepals 2, boat-shaped winged and keeled, 2 mm long, light brown, glabrous, acute; petals 2, equal, linear, acute, 1.5 mm long, light brown, hairy at the apex,subapical glands present; ovary 2-locular; seed 0.7-0.8 mm long, brown, papillate (Figure 5.43).

Note: This species is similar to *E. sexangulare* but it differs in the combination of the cylindrical capitula, the reflexed involucral bracts and the floral bracts broadly obovate and the acute apex. There are 3 opinions on the *E. sexangulare-willdenovianum* (*longifolium*) complex as follows:
1. Considered to be two distinct species
i.e. Ruhland (1903), Moldenke (1968 & 1970), Ansari and Balakrishnan (1994), Zhang (1999)
2. Considered as two varieties under *E. sexangulare* (Hooker's reduction)
i.e. Hooker (1894), Hatusima and Koyama (1956)
3. Considered as a single species (*E. sexangulare*)
i.e. Fyson (1921d), Ma (1991)
The difference between dimerous and trimerous flowers of this genus is of high taxonomic value (according to Hatusima and Koyama, 1956 and Moldenke, 1970). However, there is much confusion and diversity of opinion about these taxa. Firstly, Thwaites (1864) placed *E. willdenovianum* (as *E. longifolium* Nees ex Kunth) as a synonym of what he called *E. wallichianum* Mart. (now known as *E. sexangulare*). Then Hooker (1894) recognized them as two varieties. Fyson (1921d) disagreed with Hooker (1894) as he thought that in every other respect the two forms were identical. He also

indicated that it would always be necessary to dissect the capitula to determine their identity and also he found no gap in their geographical distribution. Therefore he merged the two species. However, Hatusima and Koyama (1956) agreed with Hooker's reduction and recognized that their areas of distribution overlap and the characters of both vegetative and floral parts are not very different, excepted for the number of floral leaves. Moldenke (1968) recognized that the name *E. longifolium* Nees ex Kunth (1841), is invalidated by *E. longifolium* Raf. (1840). Therefore he published the name, *E. willdenovianum* for this taxon. Ansari and Balakrishnan (1994) agreed with Ruhland's work and reinstated the species and suggested that the nature of petals in female flowers (female petals shorter than the sepals in *E. sexangulare* but equal in *E. longifolium*) and the shape of the seeds (globose or ovoid in the former but oblong-ellipsoid in the latter) were constant characters of specific value when comparing these two species. I noted that Ansari and Balakrishnan (1994) misnamed *E. willdenovianum* as *E. longifolium*.

According to Phillips (1994), *E. sexangulare* and *E. willdenovianum* are similar in habit. The leaves are always glabrous and usually over 4 mm wide and the floral bracts white-hoary, but *E. willdenovianum* tends to be shorter and more slender, with narrower leaves and smaller capitula. She also reported that the separate specific status of these 2 taxa is confirmed by their different seed morphology, though they all have longitudinal ridges (thickening arising from the center of the transverse anticlinal cell walls) but *E. willdenovianum* has ellipsoid seeds and the cells are larger. Additionally, Zhang (1999) and I still consider that the difference between dimerous and trimerous flowers is important. I noted that in Thailand, populations of *E. willdenovianum* are bigger than *E. sexangulare* and that the most of the former records of *E. sexangulare* in Thailand also refer to *E. willdenovianum*.

Distribution: Nan- Doi Phu Kha; Nakhon Nayok- Khao Yai National Park; Rayong; Chanthaburi- West of Kao Sabab, Ban Ang, Ban Chang Thum, Makham, Ban Klong Sadet, Klung, Laem Sadet Khoong Kaben Bay; Trat- Huay Raeng, Charng Kluae, Klong Yai, Lan Sai Beach, Taphan Hin, Khlong Kut, Koh Chang National Park, Tambon Bo Ploy, Bo Rai, on the way to Klong Kaew Waterfall National Park, Ban Saphanhin, Muang; Chumphon- Ban Huay Keaw, Muang; Ranong- Muang Len, Klong Nakha, Ngao National Park; Surat Thani- Bandon, Bangbas, Chan Khot, Ban Tahsae, Klong Sai, Chaiya-Tha Chana route; Phangnga- Ko Kho Khao, Takuapah and Ranong route; Phuket- Koh Yao Yai; Nakhon Si Thammarat- suburb of Tong Song; Phatthalung- Bah Bawn; Trang- Yan Ta Khao, Thung Khai Botanic Garden, Off the coast of Trang, Thalac Song Hong; Satun- Tarutao National Park, Talo Oo Dang, Kuan Gah Long; Songkhla- East of Chana, Ton Plio waterfalls, Ton Nga Chang Wildlife Sanctuary, Ko Hong Hill, Hat Yai, Songkhla-Pattani route, Klong Rhang Hill, Nah Mawn, Thepha Bay; Yala; Narathiwat- Ku Chum, Tak Bai, Plaiwan, Paa Waai, Sungai Padi.

Ecology: Evergreen forest, dry deciduous forest, melaleuca forest, tropical rain forest, swamp forest, grassland, rice field, silica sand shore, sandy soil, peat, on sandstone plateau, granite bed rock, common in open marshy places, along streams, floating in ditches. Altitude sea level-1600 m.

Flowering: All year, mostly August-January.

43. Eriocaulon xenopodium [as xenopodion] *T.Koyama* in Philipp. J. Sci. 84(3): 374 (1955). Type: Thailand, Nakay, 16 Dec. 1921, *B.Hayata* s.n. (holotype **TI**).

Perennial herbs. *Stem* ovoid cormous. *Leaves* crowded into a basal rosette, linear (wider at base), 10-20 cm long, 4 mm wide, glabrous, apex acute. *Scapes* numerous, up to 30 cm long, glabrous. *Sheaths* 3-6 cm long, glabrous, apex acute. *Capitula* elongate to globose, 4-6 mm long, 5-7 mm in diameter, whitish-grey. *Receptacle* convex, pilose. *Involucral bracts* obovate, 1.5 mm long, brown, blackish in the upper part, glabrous, apex acute. *Floral bracts* oblanceolate, 1.5 mm long, brown, blackish and hairy in the upper part, apex acuminate. *Male flowers*: calyx spatheate or fuse at the base, 2-3 lobed, acute, 1.5 mm long, brown, hairy in the upper part; petals subequal, hairy, obtuse, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 2-3, oblanceolate, two lateral ones acute, the middle one obtuse, 1.5 mm long, light brown, hairy in the upper part; petals 3, unequal, elliptic, attenuate, acute, 1.8-2.0 mm long, light brown, hairy in the upper part, subapical glands present; ovary 3-locular; seed 0.5 mm long, brown-yellow, papillate (Figure 5.44).

Note: The numbers of male and female sepals of this species vary within the same capitula.
Distribution: Nong Khai- Phu Wua Wildlife Sanctuary, Sakon Nakhon- Phu Phan National Park; Nakhon Ratchasima-Nakhon Nayok- Khao Khieo, Khao Rom, Nong King, Khao Yai National Park.
Ecology: Common on open, swampy, marshy places, near streams, in bog, stagnant water, sandy soil, moist sandstone, dry deciduous forest. Altitude 200-1400 m.
Flowering: August-December.

44. Eriocaulon xeranthemum *Mart.* in Wall., Pl. Asiat. Rar. 3: 29(1832); Kunth, Enum. Pl. 3: 555 (1841); Steud., Syn. Pl. Glumac. 2: 270 (1855); Körn. in Linnaea. 27: 624 (1856); Hook.f., Fl. Brit. Ind. 6: 584 (1894); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 96 (1903); Fyson in J. Indian Bot. 2(6-7): 200 (1921b); C.E.C.Fischer, Fl. Madras 9: 1614 (1931); Ridl., Fl. Malay. Penin. 5: 135 (1967); R.Ansari & N.P.Balakr., Fam. Eriocaul. India: 58-60 (1994); C.D.K.Cook, Aquatic Wetland Pl. India: 205 (1996); Z.X.Zhang in U.Kück, Diss. Bot. 313: 131-133 (1999). Type: Nepal, 1821, *Wallich* 6081a (holotype **B!**; isotypes **BM!, CAL!, E, K!, K-WA!, M!,**). Paratypes: India, Silhet, *Wallich* 6081b (**BR, K!, K-WA!,**; Burma, Tavoy, *Wallich* 6081c (**B, BM!, K!, K-WA!**).

Annual herbs. Stem forming a basal disc. *Leaves* crowded into a basal rosette, linear, 2-3.5 cm long, 3-4 mm wide, glabrous, apex acute. *Scapes* numerous, up to 2.5-5.5 cm long, glabrous. *Sheaths* 2-3 cm long, glabrous, apex acute. *Capitula* hemispherical, 3-4 mm long, 6-8 mm in diameter, brown. *Receptacle* convex, glabrous. *Involucral bracts* oblong, 3-4 mm long, white, glabrous, apex acute-serrulate. *Floral bracts* oblanceolate, 1.5 mm long, white, hairy in the upper part, apex acute or truncate. *Male flowers*: calyx spatheate, crenate or truncate, 1 mm long, white, blackish and hairy in the upper part; petals equal, glabrous, acute, subapical glands present; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 2, narrowly oblong, acute, 1 mm long, white, blackish and hairy in the upper part; petals 3, unequal, elliptic, attenuate, acute, 1-1.2 mm long, white, hairy in the

upper part, subapical glands present; ovary 3-locular; seed 0.5 mm long, yellow-brown, papillate (Figure 5.45).

Distribution: Saraburi- Sahm Lahn Forest; Chanthaburi- Khao Soi Dao-Makham route, Putthawee, Makham, Pong Nam Ron-Pailin; Trat- Bo Rai, the way to Klong Kaew Waterfall National Park, Ban Salukkok-Koh Chang National Park; Ranong- Suksamlan; Phangnga- the local road Oil Kam-PhakPho route, Ban Bangphang, Kaphong.
Ecology: Common in wet localities, wet paddy fields, seasonal ponds, mud, sandy soil. Altitude 1-130 m.
Flowering: August-December.

45. Eriocaulon zollingerianum Körn. in Linnaea. 27: 682 (1856); Ruhland in Engl., Pflanzenr. 4(30), 13 Heft: 99 (1903); W.L.Ma in Acta Phytotax. Sin. 29: 304 (1991); Z.X.Zhang in U.Kück, Diss. Bot. 313: 185-189 (1999). Type: Java, Im Schlamm an einem Waldflusse nahe Tjikoya, 24 Jul. 1842, *H. Zollinger* 333 (holotype **B!**; isotype **BM!**).

E. alatum Lecomte in J. Bot. (Morot) 1(21): 104 (1908) & Fl. Indo-Chine 7(1): 17 (1912); Merr., Fl. Manila: 136 (1912); P.H. Hô, Ill. Fl. Vietnam 3(1): 480 (1993). Type: Indo-China, *L. Pierre* s.n. (lectotype **K!** chosen here; isolectotype **G**).
Annual herbs. *Stem* forming a basal disc. *Leaves* crowded into a basal rosette, linear, 2-5 cm long, 2.5-4 mm wide, glabrous, apex acute. *Scapes* numerous, up to 14 cm long, glabrous. *Sheaths* 2.5-3 cm long, glabrous, apex acute or 2-3 lobed. *Capitula* ovoid to globose or elongate, 3-7 mm long, 3.5-5 mm in diameter, brown. *Receptacle* elongate, pilose. *Involucral bracts* broadly obovate, 1.5 mm long, light brown, glabrous, apex obtuse. *Floral bracts* broadly obovate, 1.5 mm long, brown, glabrous or few hairs in the upper part, apex acute. *Male flowers*: calyx spatheate, crenate or acute, 1-1.5 mm long, light brown, glabrous or few hairs at the apex; petals unequal, glabrous or few hairs at the apex, acute, the large one acute or obtuse, eglandular; vestigial gynoecium present; anthers 6, black. *Female flowers*: sepals 3, the lateral ones boat-shaped winged and keeled, 1-1.3 mm long; the median one linear, 0.5 mm long; light brown, outer face glabrous, pilose on the inner face; petals 3, unequal, linear, acute or 2 lobed, 1-1.3 mm long, light brown, few hairs in the upper part, eglandular; ovary 3-locular; seed 0.3–0.5 mm long, brown, glabrous (Figure 5.46).

Note: Most of the *E. zollingerianum* specimens from Thailand are misnamed as *E. alatum.*
Distribution: Nong Khai- Tham Phun Waterfall, Phu Wau National Park; Sakon Nakhon- Phu Phan National Park; Nakhon Phanom- Ban Nong Hoi Noi; Mukdahan- Kamphalai; Khon Kaen- Ban Rua, Pa Wieng; Surin- Prasart, Kabcherng; Si Sa Ket- Pribueng; Ubon Ratchathani- Khong Chiam, Phimolmungsakan, Pha Tam National Park, Khe marat- Pha Tam route, Dacha Udom, Boontharik, Phu Chong Nayoy National Park; Kanchanaburi- Nong Daeng; Saraburi- Sahm Lahn forest; Nakhon Ratchasima-Nakhon Nayok- the way to Hel Narok Waterfall, Khao Yai National Park, Prachin Buri-Thung Phoh; Chanthaburi- Foot of Khao Soi Dao, Pong Nam Ron, Makham; Trat- Bo Rai, the way to

Klong Kaew Waterfall National Park, near Wat Saphanhin, Laem Glad junction, Khaosaming; Chumphon- Ban Huay Gayo, Muang; Surat Thani- Kanchanadit; Trang- Tungkai Botanic Garden.

Ecology: Paddy fields, common on sandy soils in open marshy places, on the borders of barren sandstone rocks or on the borders of seasonal ponds. Altitude 5-400 m.

Flowering: September-March.

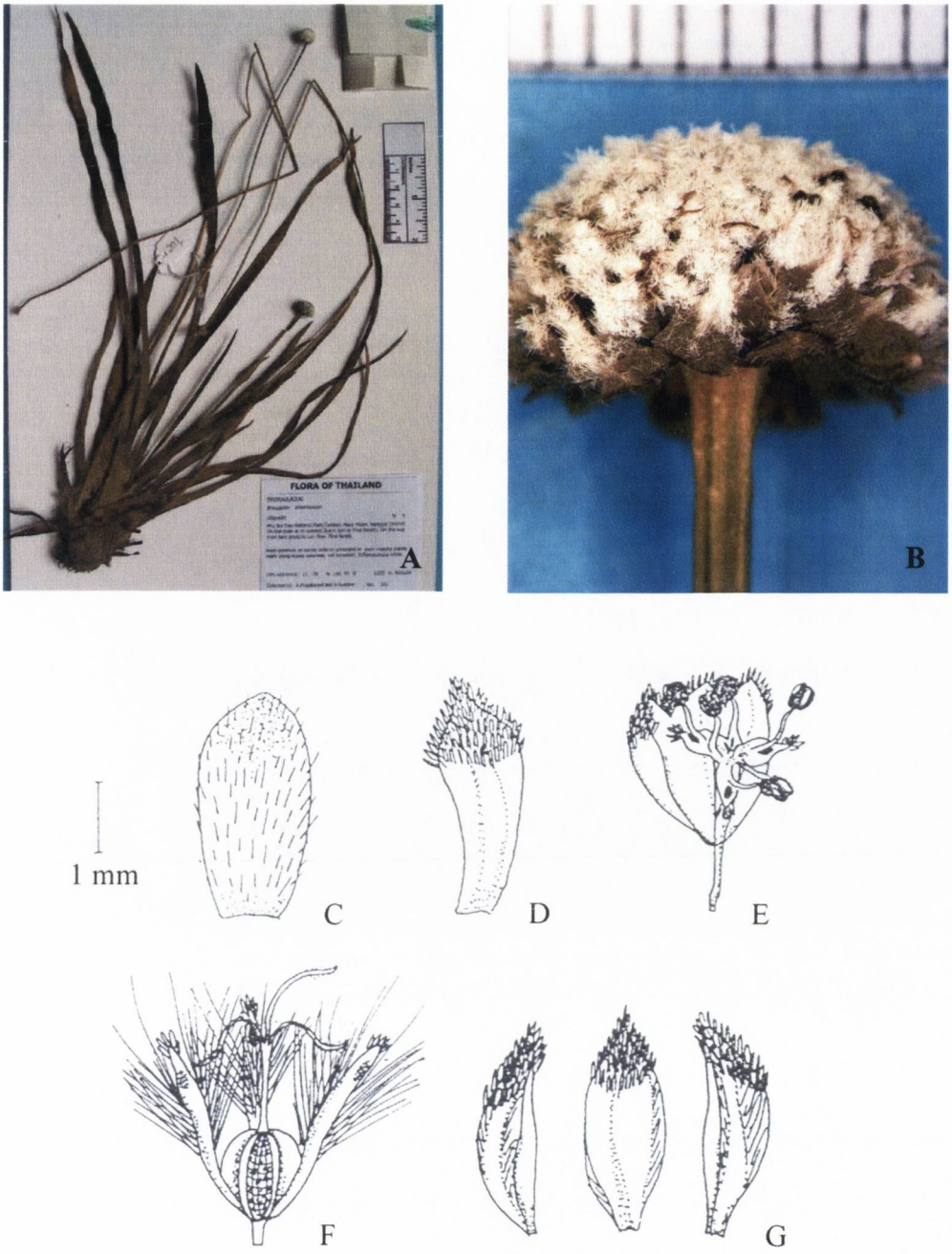

Figure 5.2 *Eriocaulon brownianum* Mart. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(G) Female flower, (F) gynoecium and petals, (G) sepals. All from *A. Prajaksood & S. Suddee* 201 (**KKU**). Drawn by A. Prajaksood.

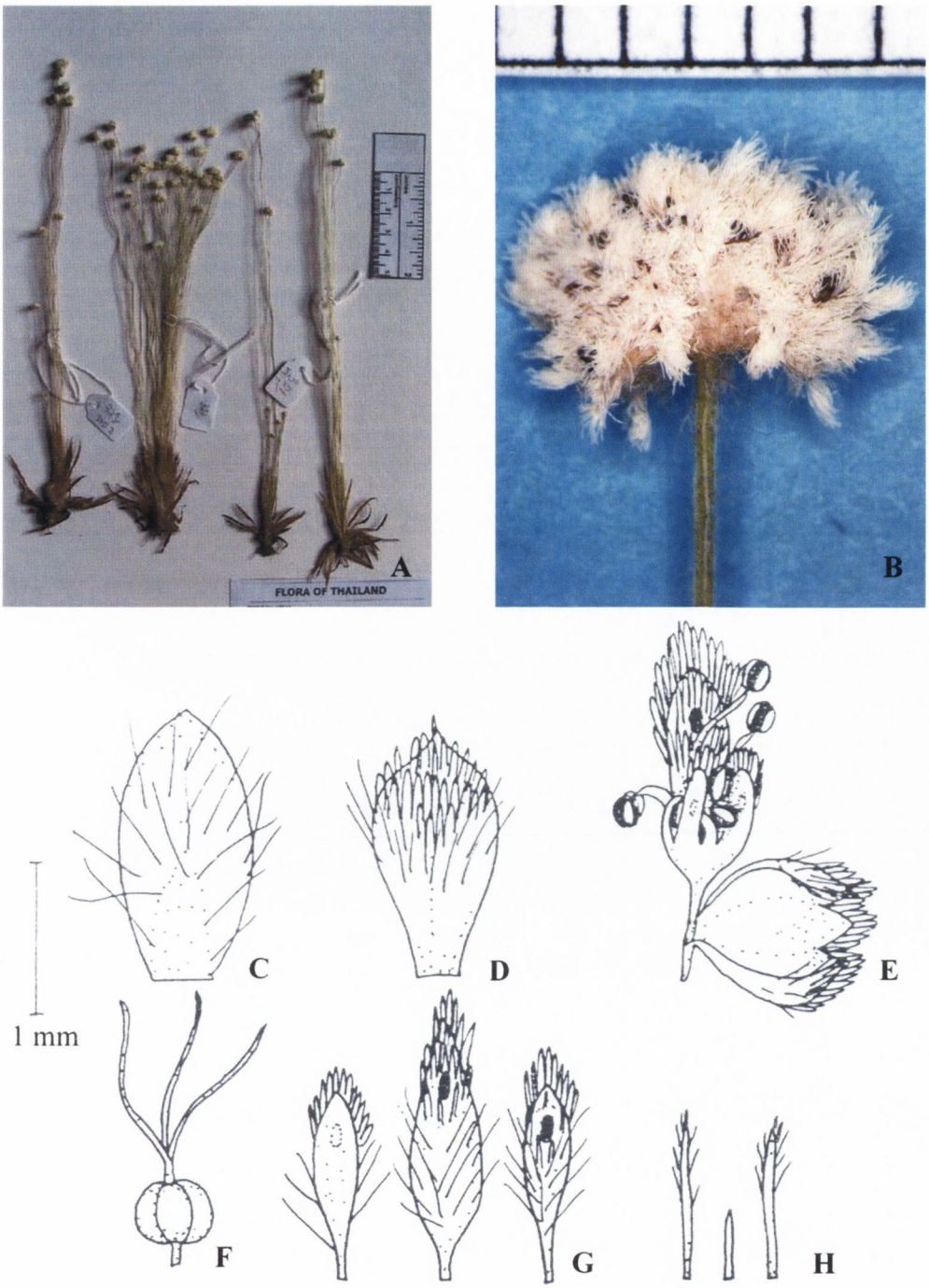

Figure 5.3 *Eriocaulon chantaranothai* A.Prajaksood & J.Parn. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. (A)-(B) from *A. Prajaksood & S. Suddee* 321 (**KKU**); (C)-(H) from *A. Prajaksood & P. Chantaranothai* 864BRT. Drawn by A. Prajaksood.

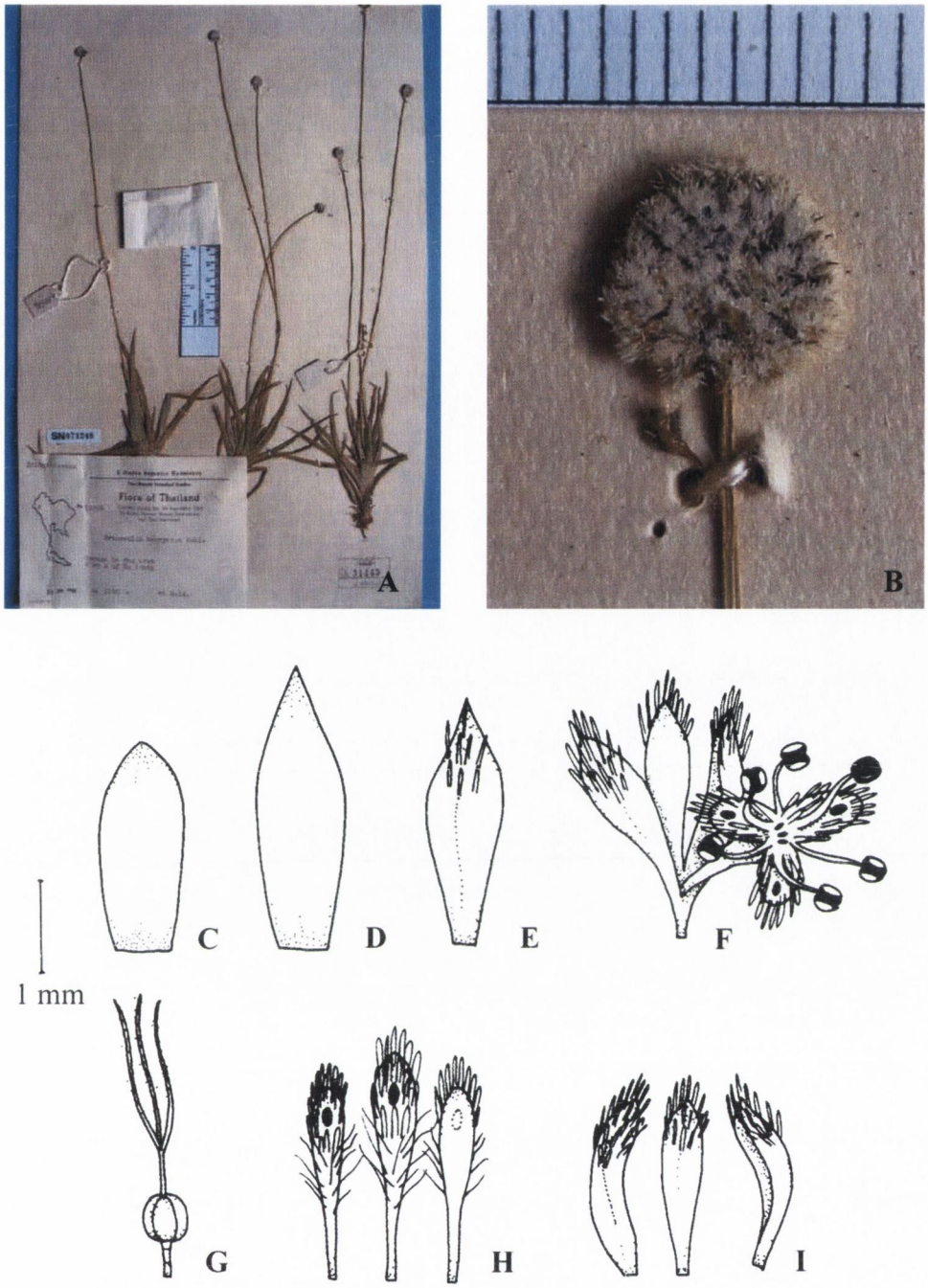

Figure 5.4 *Eriocaulon chiangmaiense* A.Prajaksood & J.Parn. (A) Habit. (B) Capitulum. (C)-(D) Involucral bract, (C) outer whorl, (D) inner whorl. (E) Floral bract. (F) Male flower. (G)-(I) Female flower, (G) gynoecium, (H) petals, (I) sepals. All from *B. Hansen, G. Seidenfaden & T. Smitinand* 10976 (**BKF**). Drawn by A. Prajaksood.

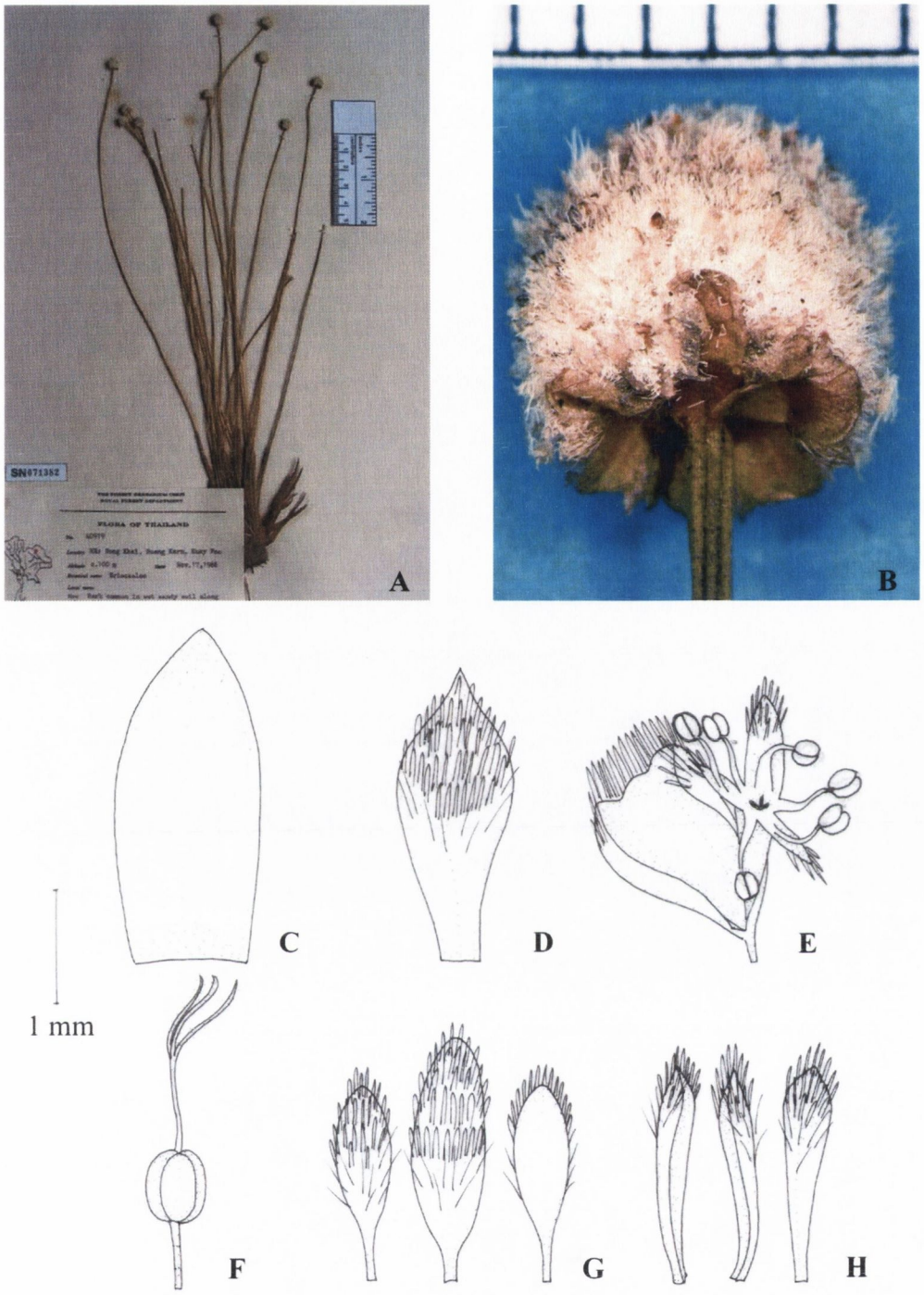

Figure 5.5 *Eriocaulon chiangmaiense* ssp. *leucanthemum* A.Prajaksood & J.Parn. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *T. Smitinand* 10091 (**BKF**). Drawn by A. Prajaksood.

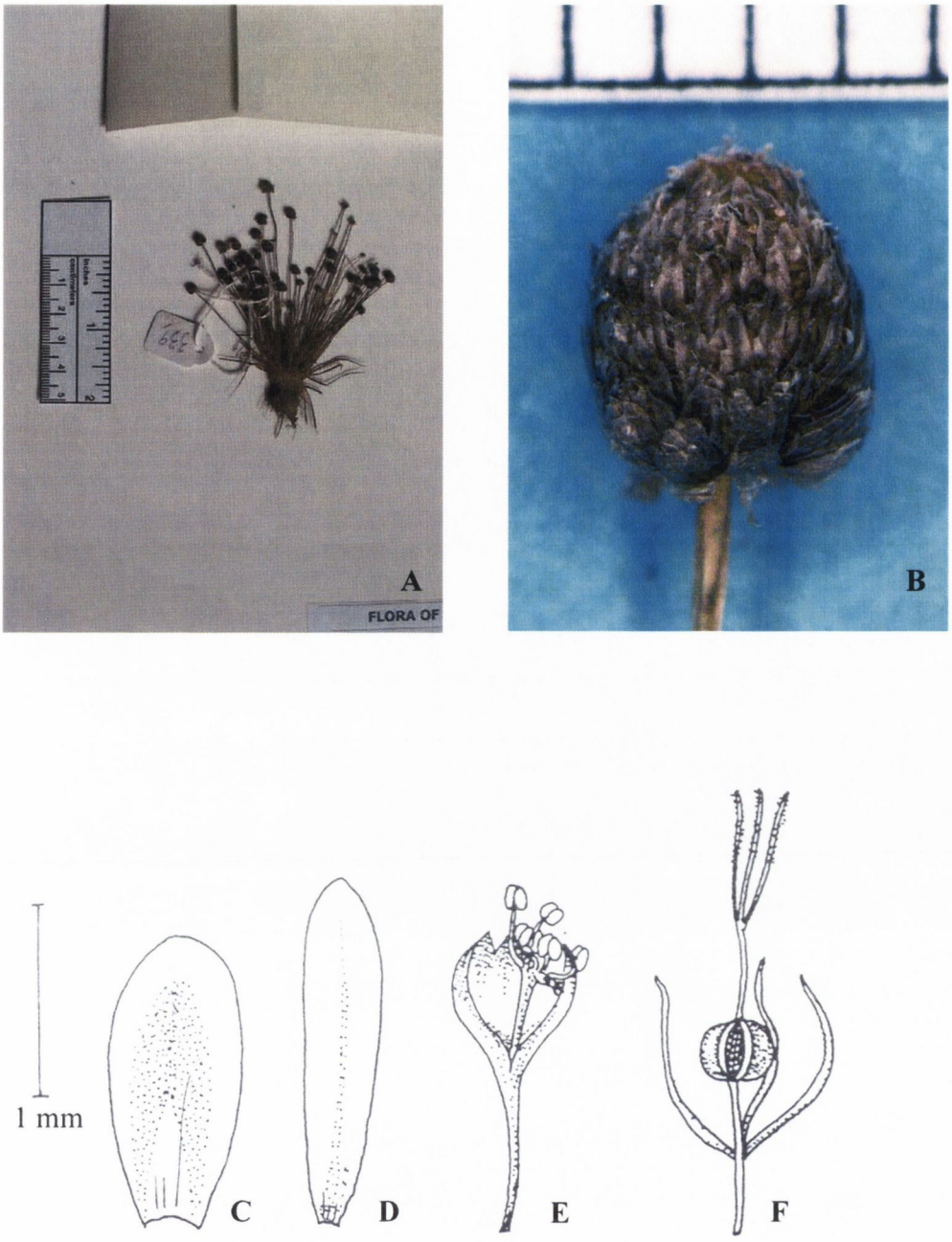

Figure 5.6 *Eriocaulon cinereum* R.Br. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F) Female flower. All from *A. Prajaksood & S. Suddee* 339 (**KKU**). Drawn by A. Prajaksood.

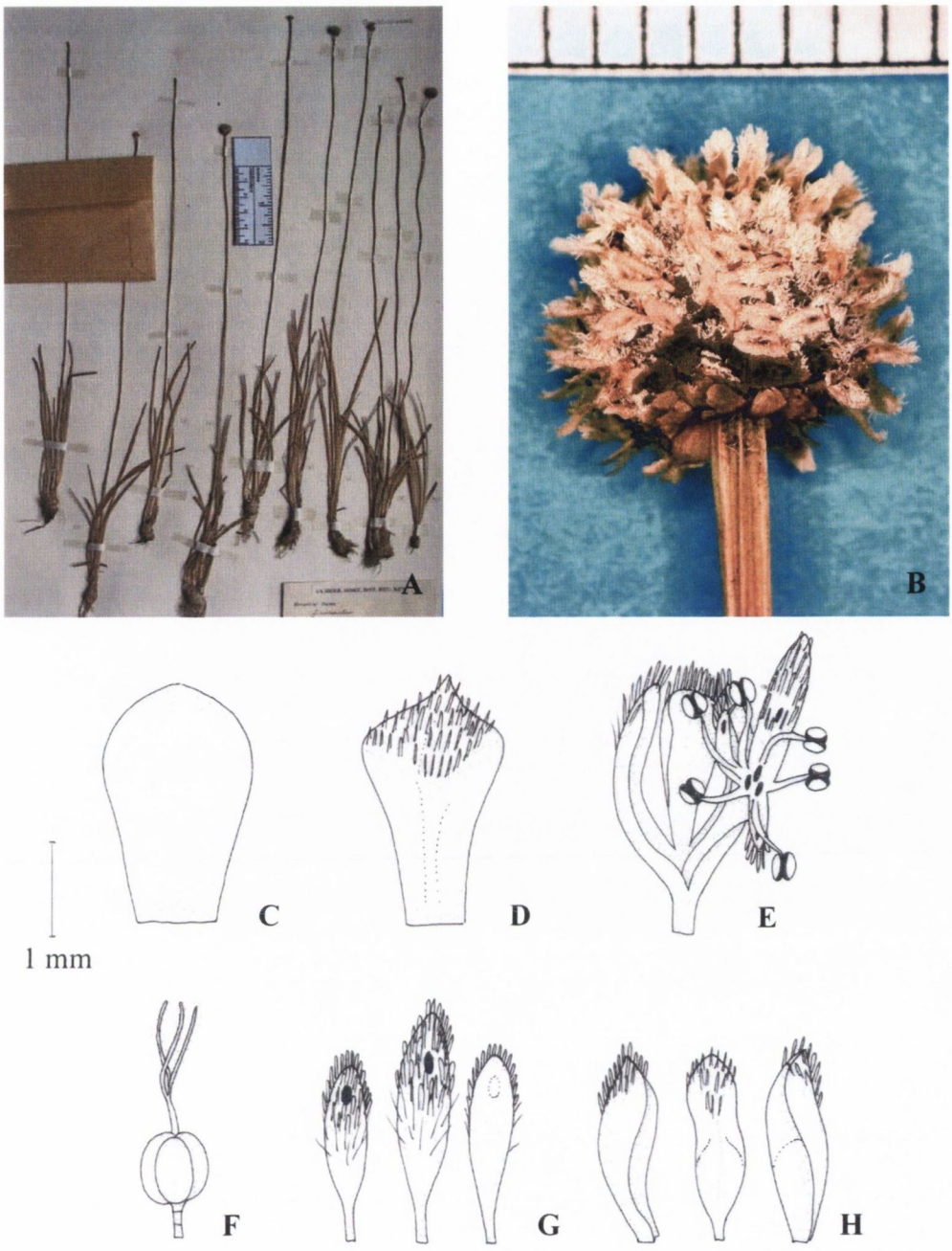

Figure 5.7 *Eriocaulon cristatum* Mart. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *H.B.G. Garrett* 1106 (**L**). Drawn by A. Prajaksood.

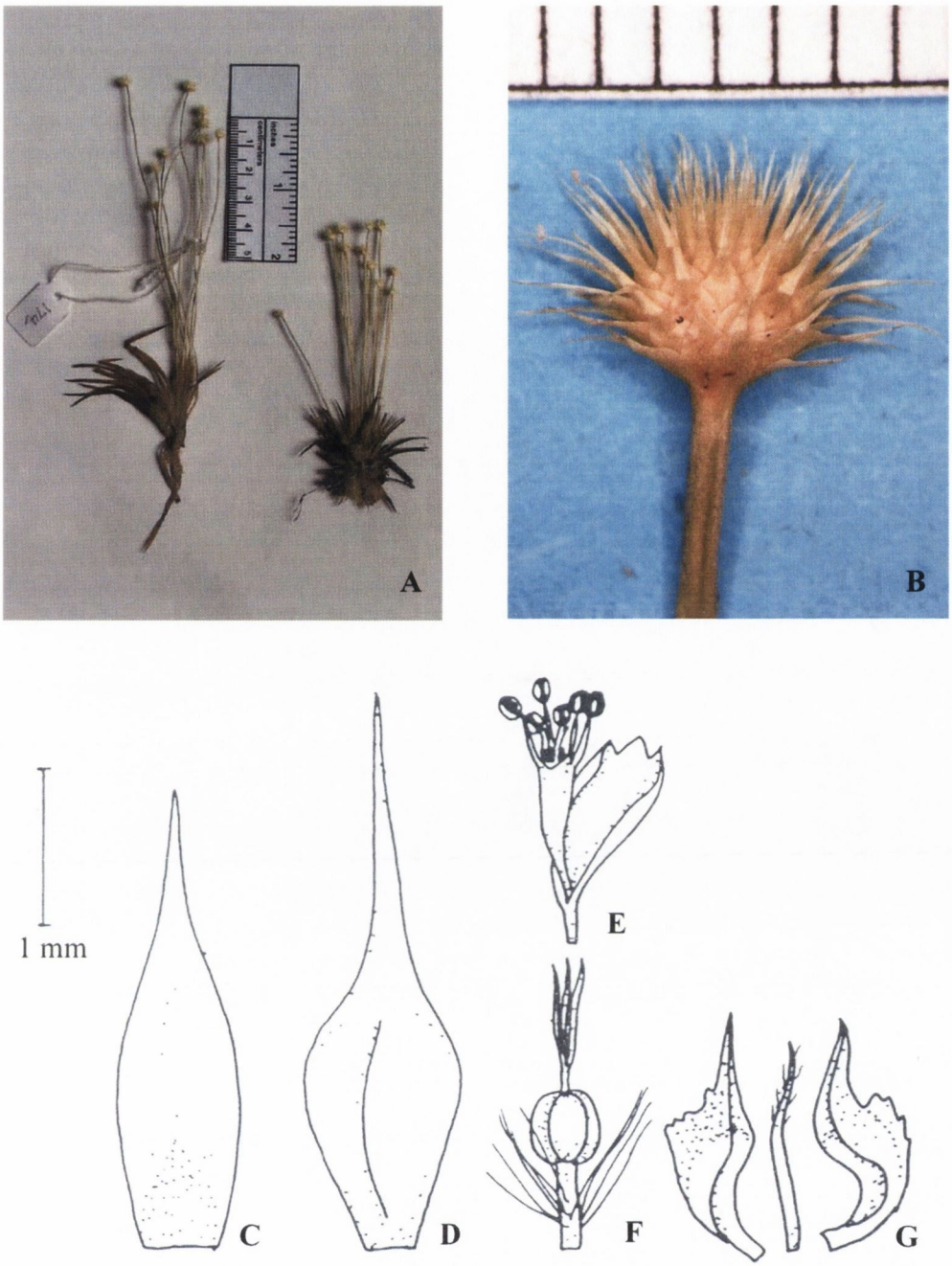

Figure 5.8 *Eriocaulon echinulatum* Mart. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(G) Female flower, (F) gynoecium, (G) sepals. (A)-(B) from *A. Prajaksood & S. Suddee* 174 (**KKU**); (C)-(G) from *M. Tagawa, K. Iwasuki & N. Fukuoka* T 546-A (**BKF**), isotype of *E. echinulatum* var. *tenue* Satake. Drawn by A. Prajaksood.

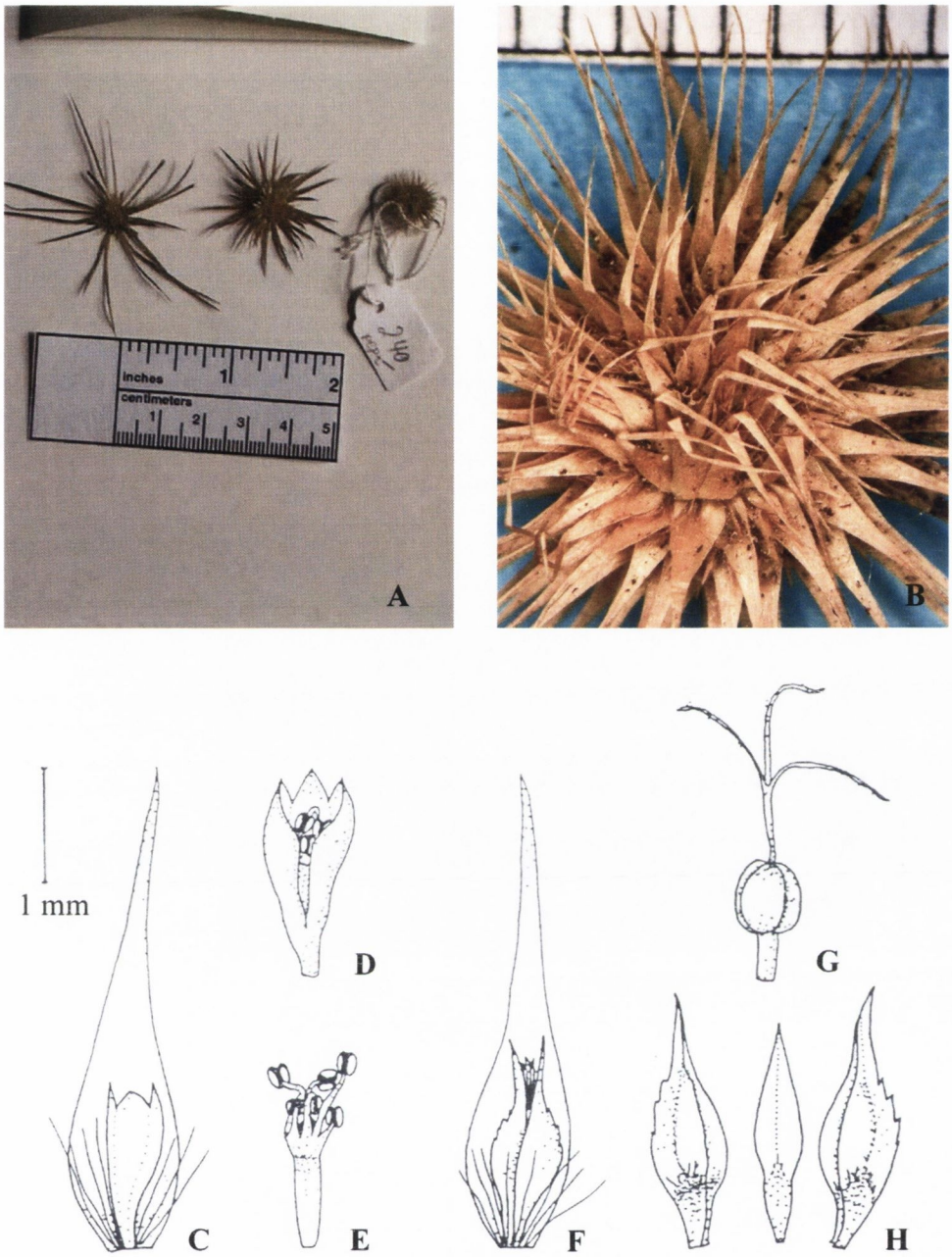

Figure 5.9 *Eriocaulon escape* B.Hansen (A) Habit. (B) Capitulum. (C) Floral bract and male flower. (D)-(E) Male flower, (D) male flower, (E) androecium and minute petals. (F) Floral bract and female flower. (G)-(H) Female flower, (G) gynoecium, (H) sepals. (A)-(B) from *A. Prajaksood & S. Suddee* 240 (**KKU**); (C)-(H) from *T. Smitinand* s.n., Dec. 1973, (**BKF**). Drawn by A. Prajaksood.

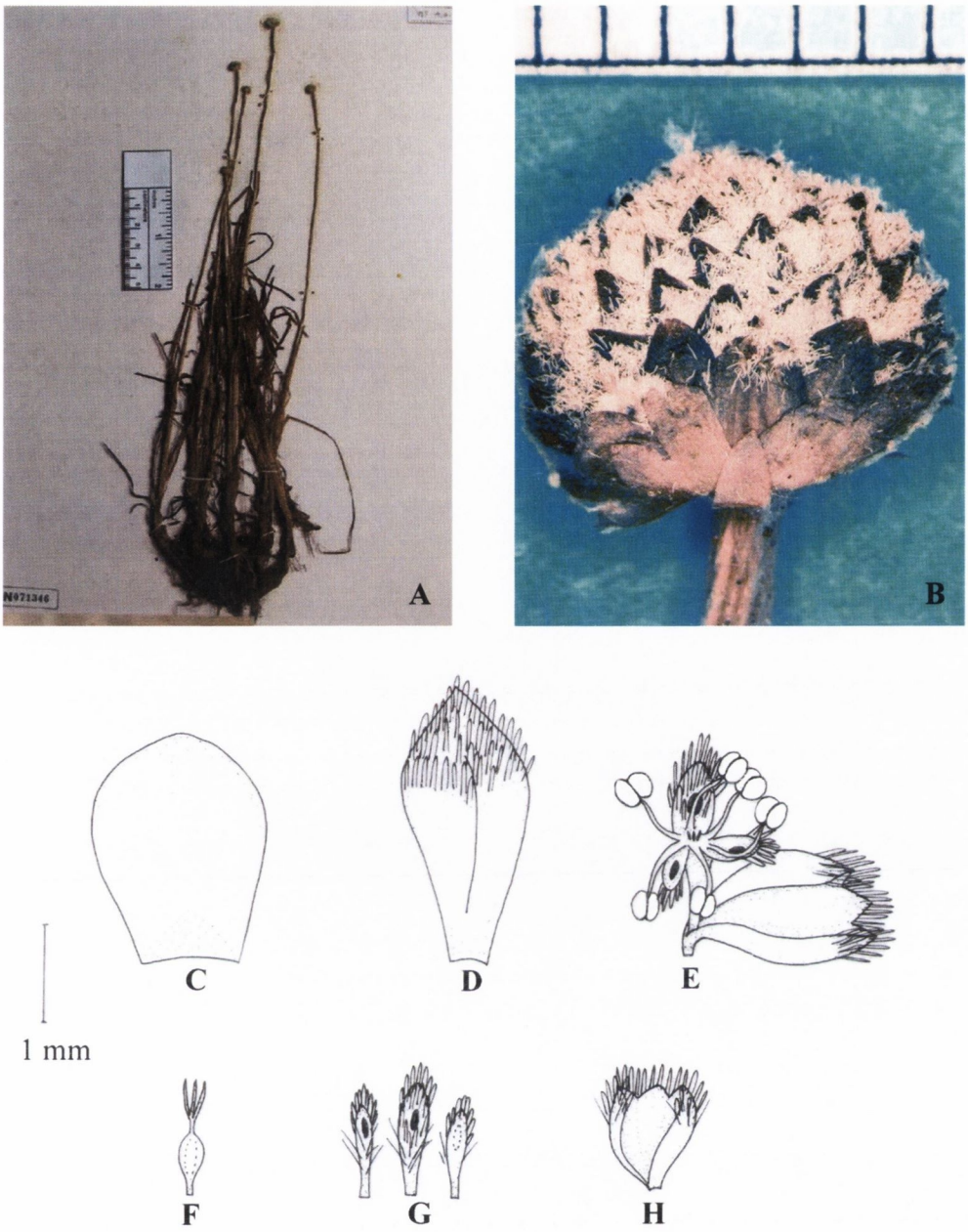

Figure 5.10 *Eriocaulon fluviatile* Trimen (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *T. Smitinand* 89-42 (**BKF**). Drawn by A. Prajaksood.

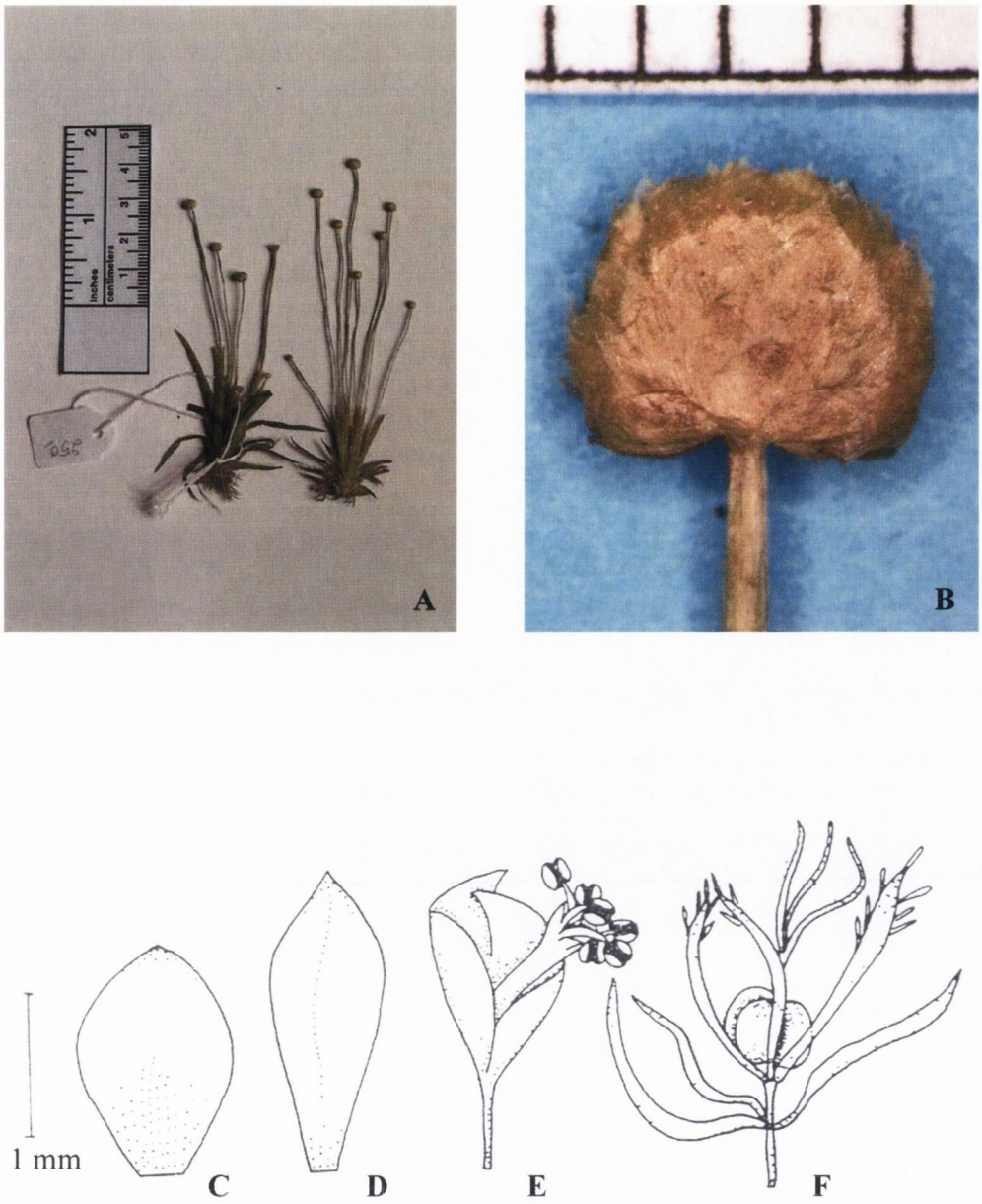

Figure 5.11 *Eriocaulon hamiltonianum* Mart. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F) Female flower. All from *A. Prajaksood & S. Suddee* 250 (**KKU**). Drawn by A. Prajaksood.

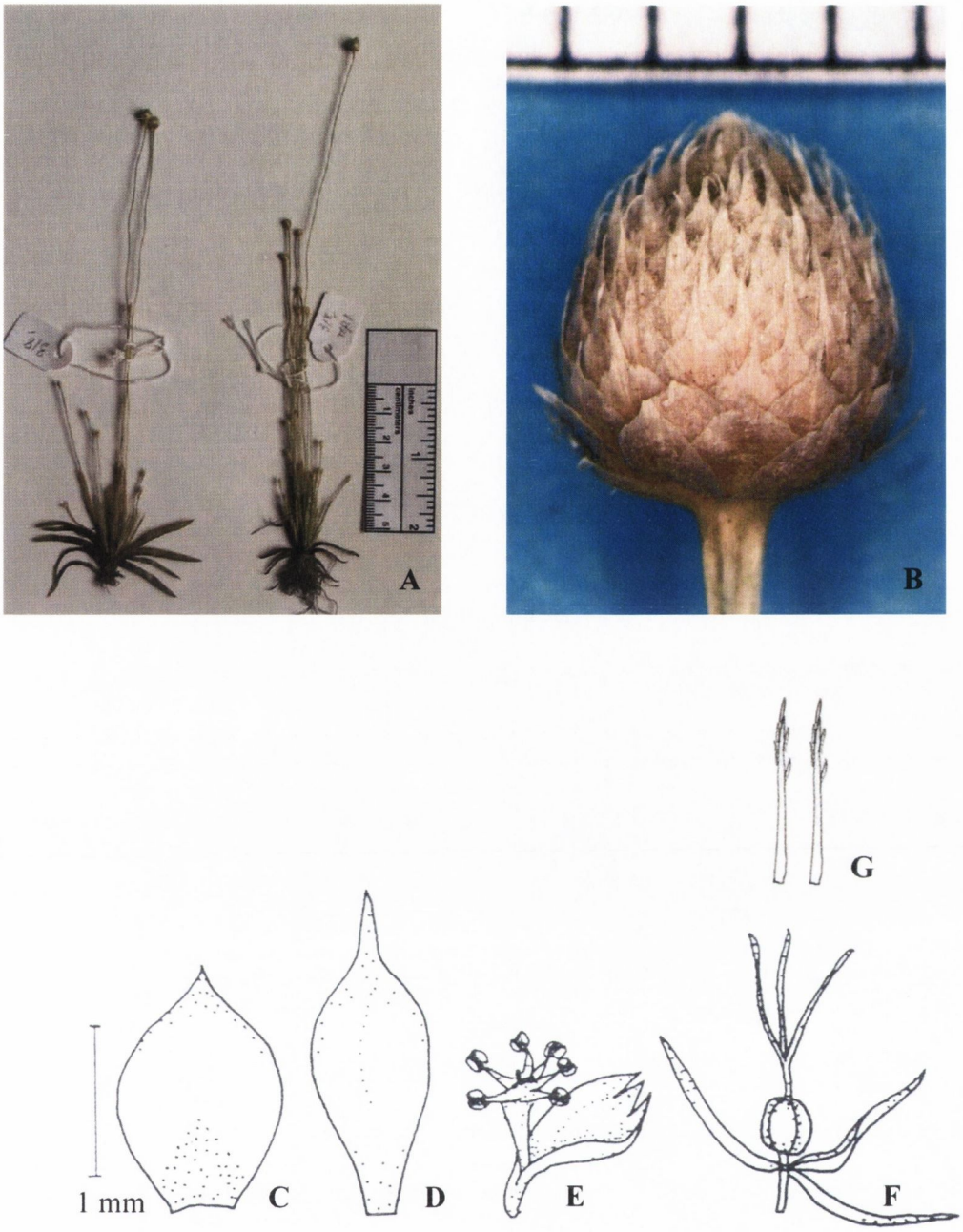

Figure 5.12 *Eriocaulon hamiltonianum* var. *acuminatum* A.Prajaksood & J.Parn. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(G) Female flower, (F) gynoecium and petals, (G) sepals. All from *A. Prajaksood & S. Suddee* 318 (**KKU**). Drawn by A. Prajaksood.

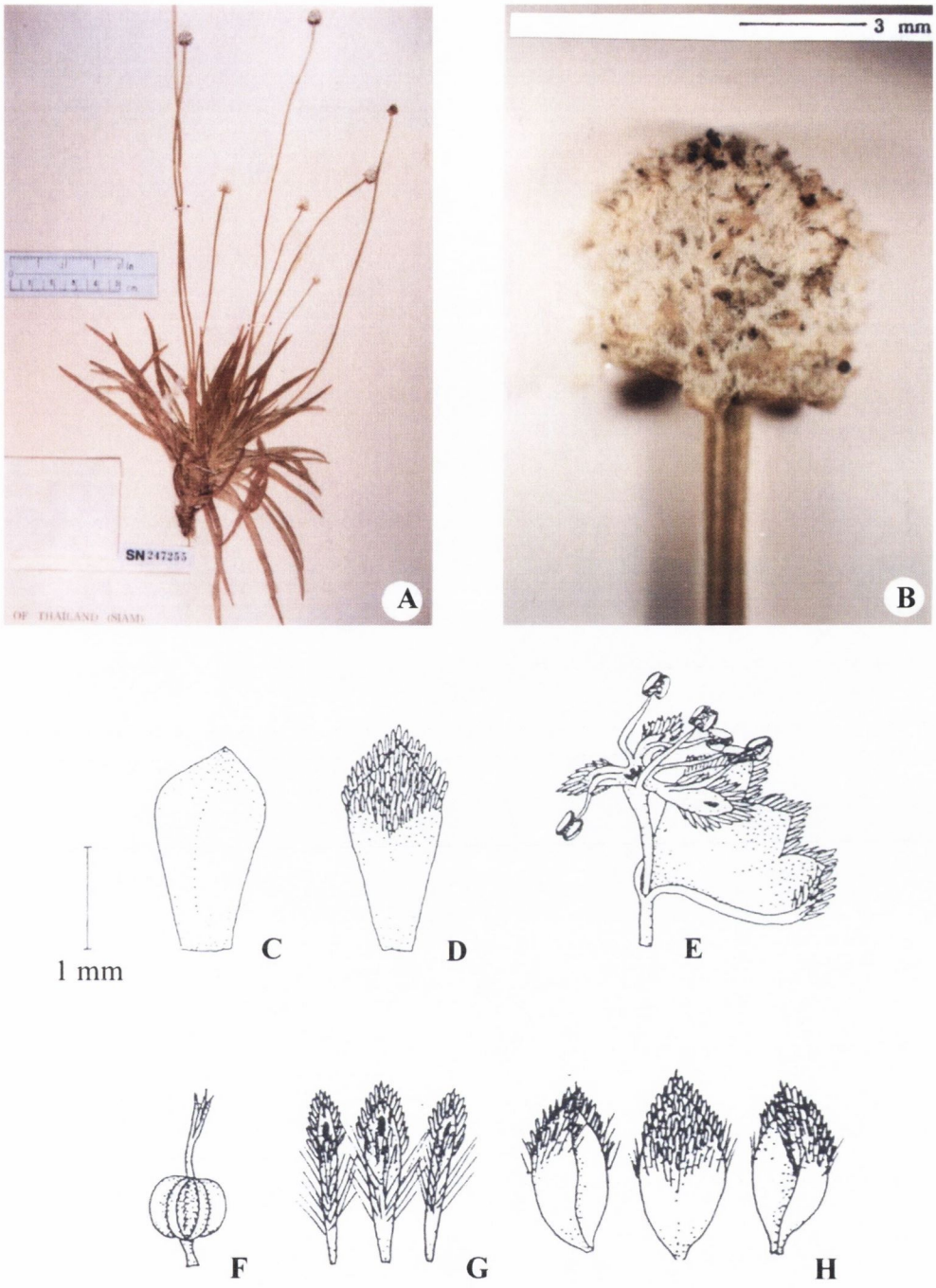

Figure 5.13 *Eriocaulon henryanum* Ruhland (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *C. Chermsirivathana* 866 (**BK**). Drawn by A. Prajaksood.

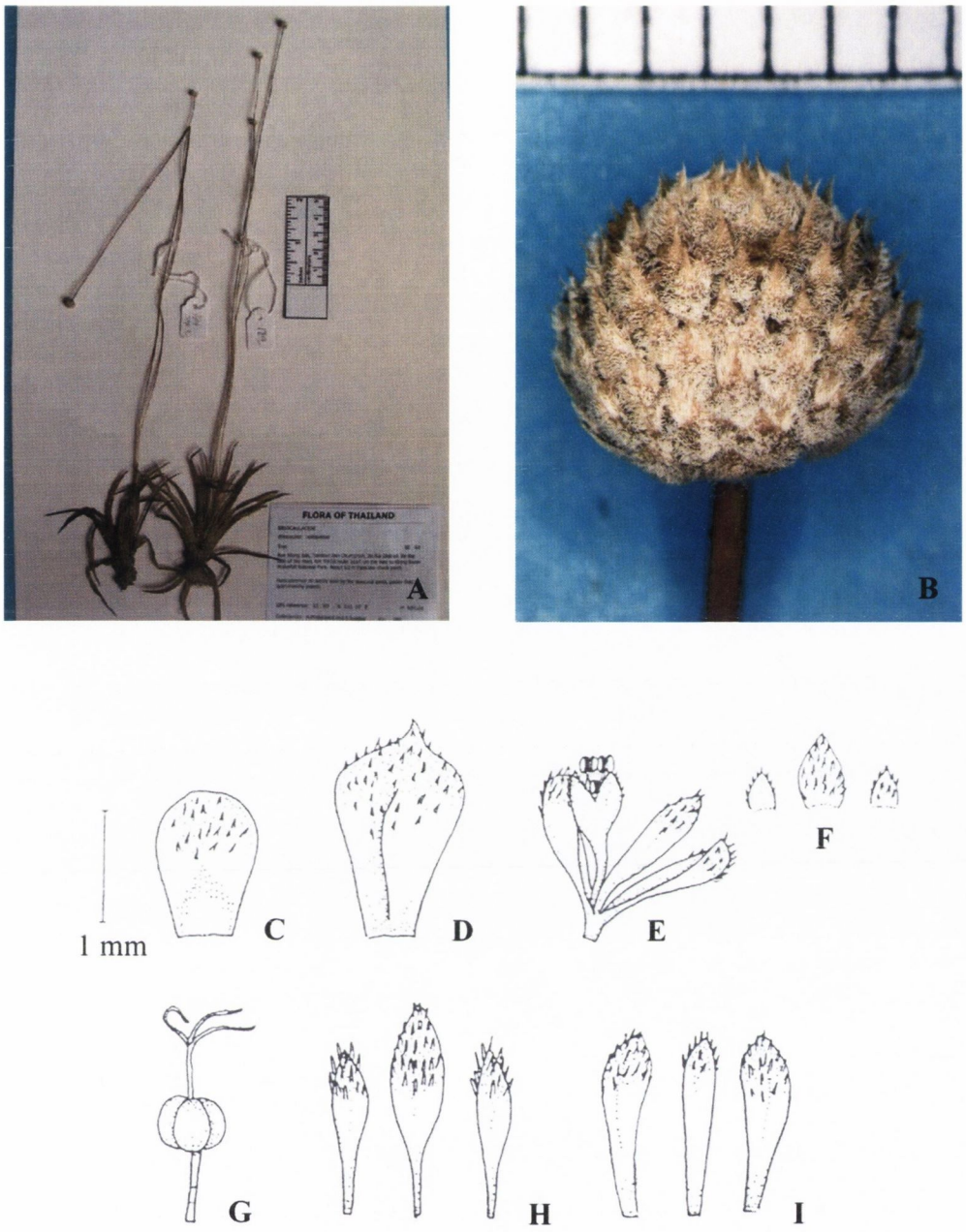

Figure 5.14 *Eriocaulon infirmum* Steud. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E)-(F) Male flower, (E) male flower, (F) petals. (G)-(I) Female flower, (G) gynoecium, (H) petals, (I) sepals. All from *A. Prajaksood & S. Suddee* 189 (**KKU**). Drawn by A. Prajaksood.

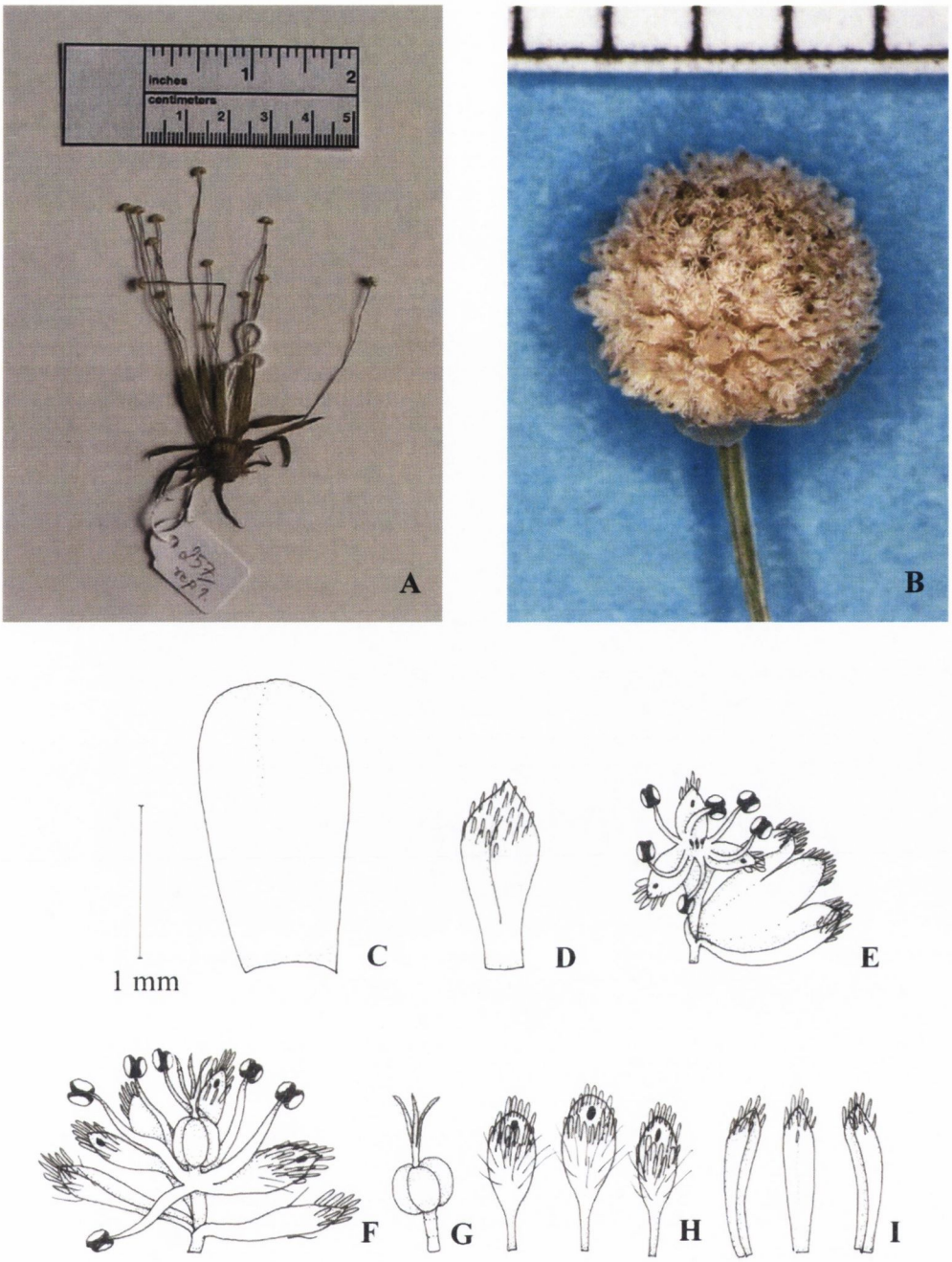

Figure 5.15 *Eriocaulon laosense* Moldenke (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F) Flower perfect. (G)-(I) Female flower, (G) gynoecium, (H) petals, (I) sepals. All from *A. Prajaksood & S. Suddee* 257 (**KKU**). Drawn by A. Prajaksood.

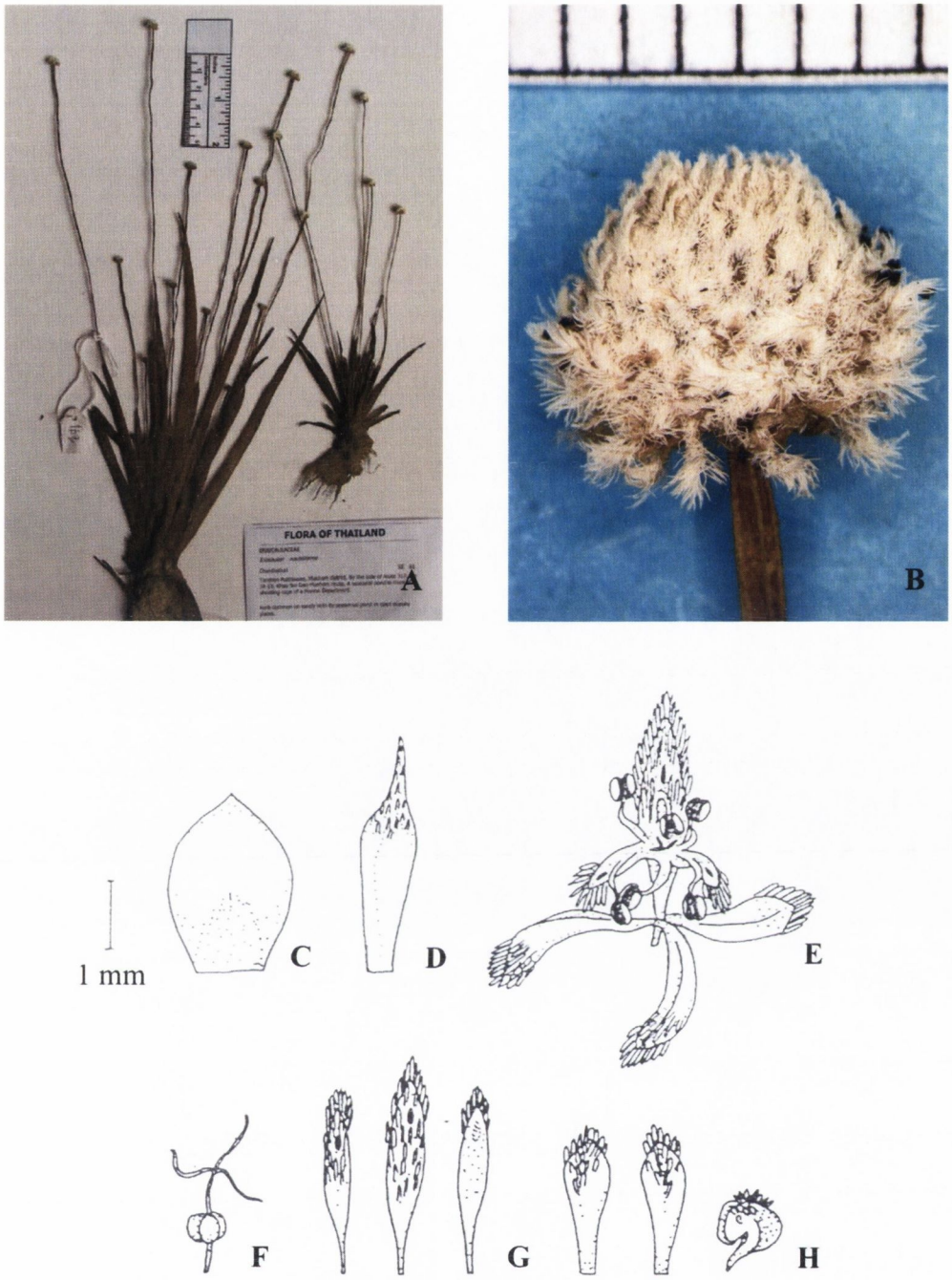

Figure 5.16 *Eriocaulon nautiliforme* Lecomte (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *A. Prajaksood & S. Suddee* 169 (**KKU**). Drawn by A. Prajaksood.

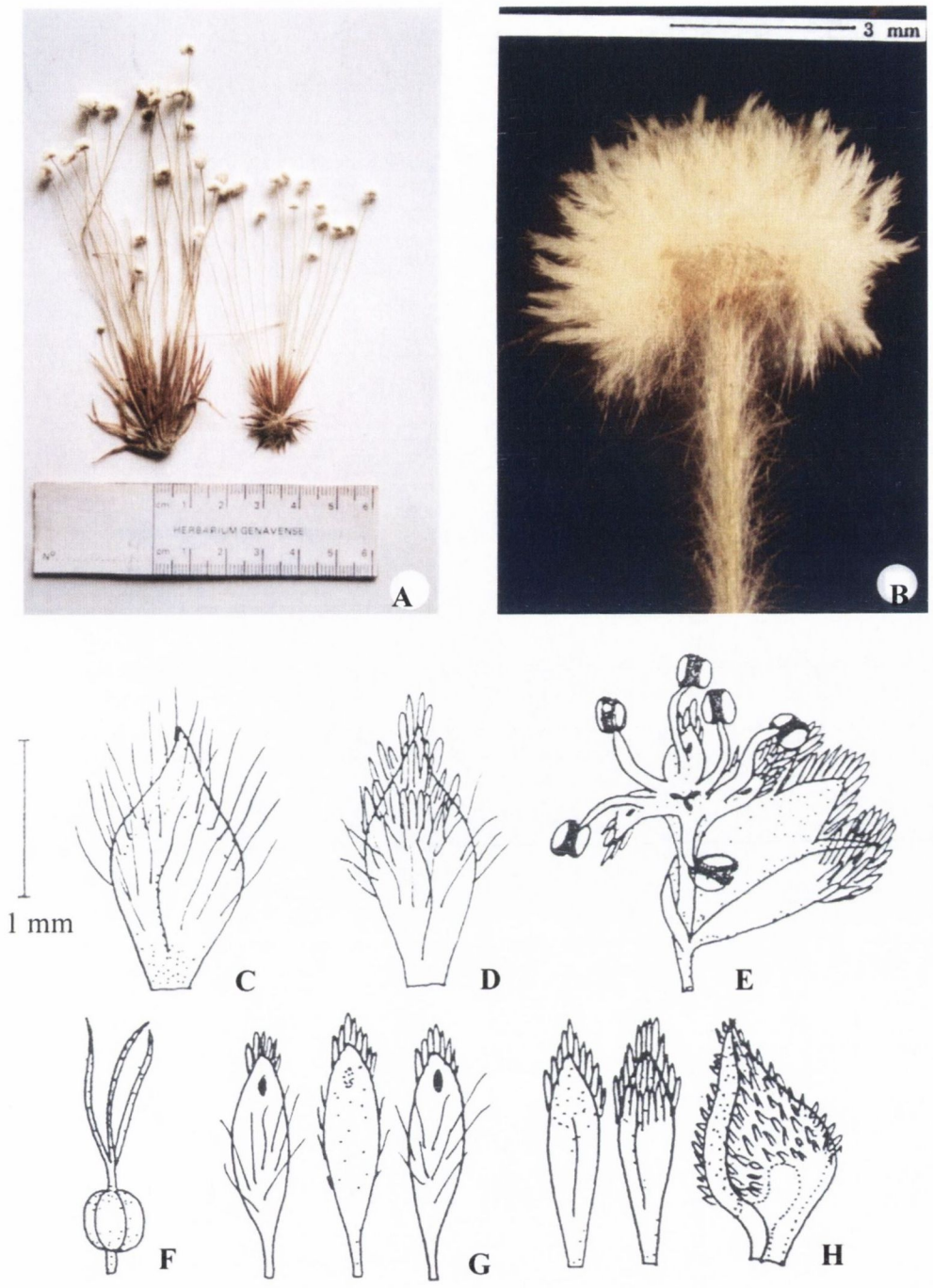

Figure 5.17 *Eriocaulon nautiliformoides* A.Prajaksood & J.Parn. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. (A)-(B) from *A. Prajaksood & P. Chantaranothai* 108 (**KKU**); (C)-(H) from *T. Smitinand* 8443 (**BKF**). Drawn by A. Prajaksood.

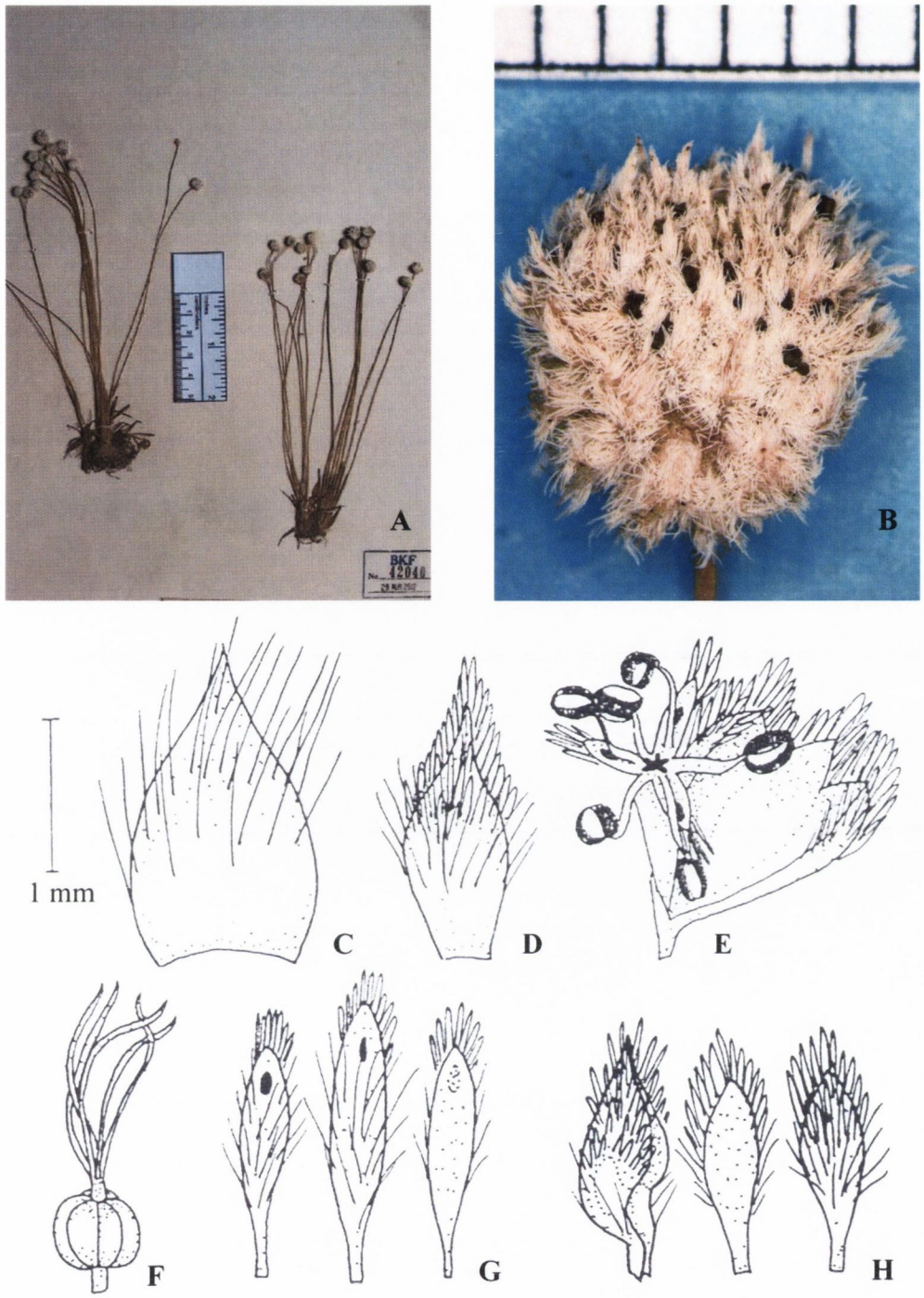

Figure 5.18 *Eriocaulon nautiliformoides* var. *hexagunum* A.Prajaksood & Chantar. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *T. Smitinand & J. Turbang 10492* (**BKF**). Drawn by A. Prajaksood.

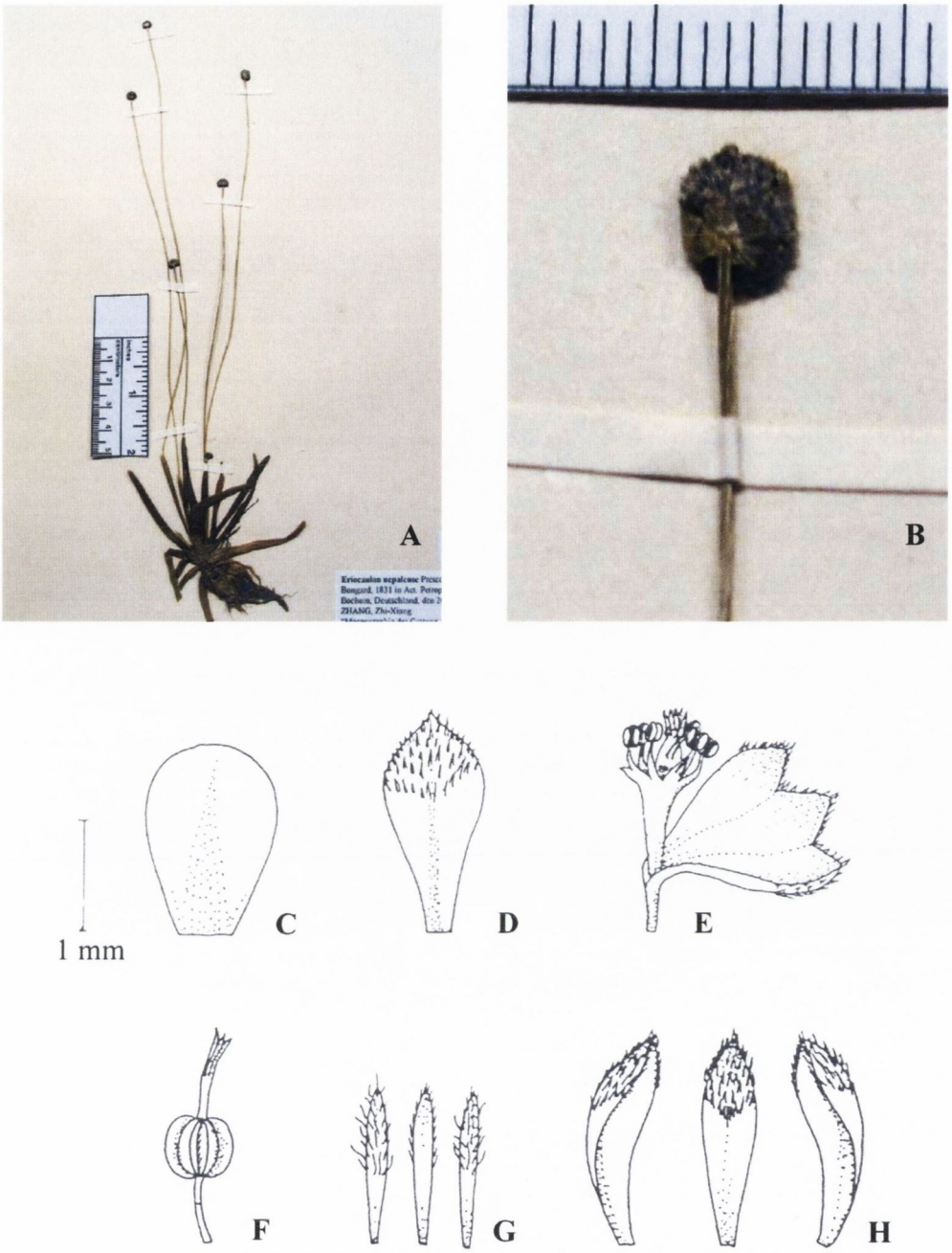

Figure 5.19 *Eriocaulon nepalense* Prescott ex Bong. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *A.F.G. Kerr* 1635 (**L**). Drawn by A. Prajaksood.

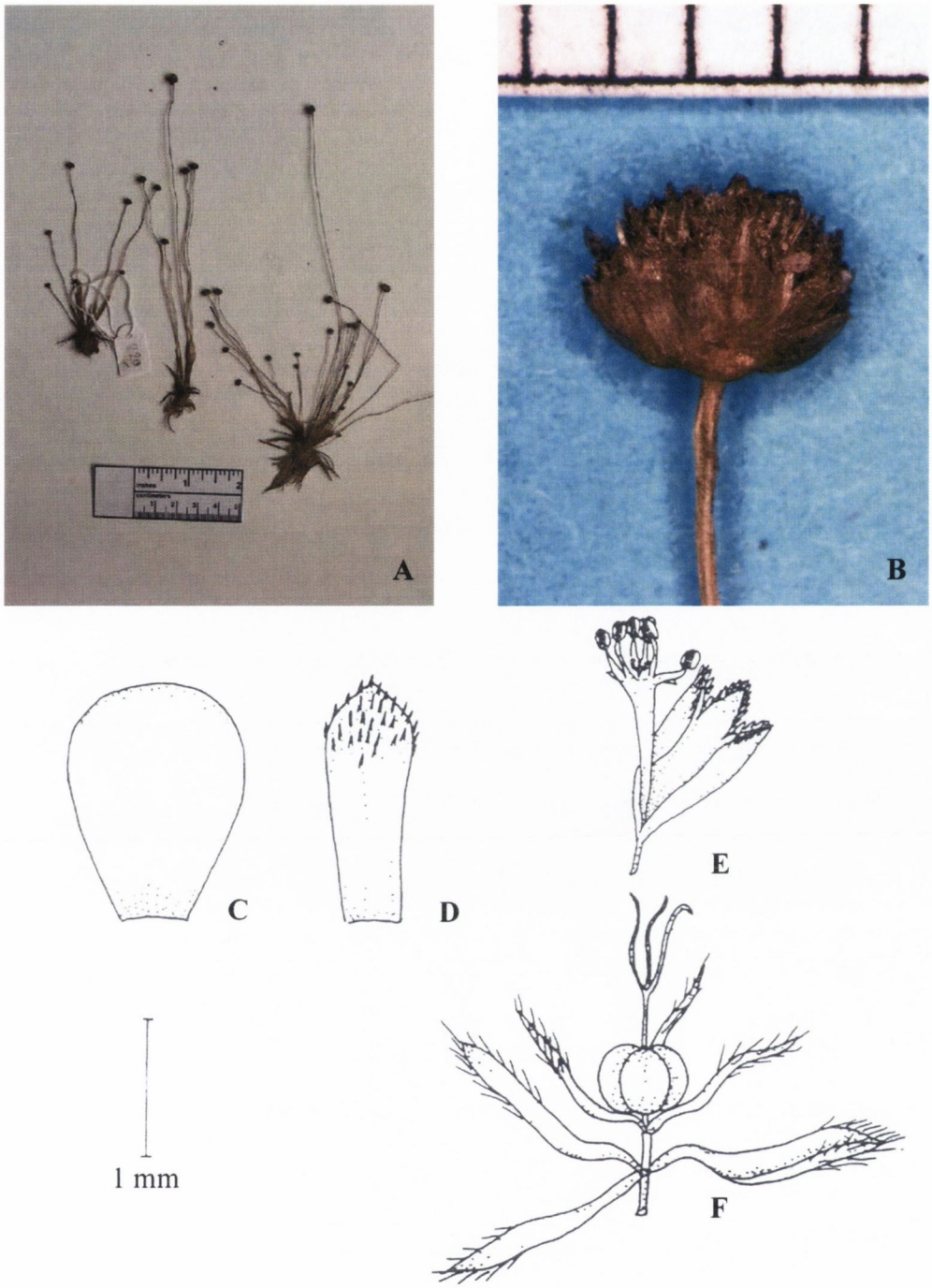

Figure 5.20 *Eriocaulon nepalense* var. *luzulaefolium* (Mart.) A.Prajaksood & J.Parn. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F) Female flower. (A)-(B) from *A. Prajaksood & S. Suddee* 220 (**KKU**); (C)-(F) from *M. Tagawa, K. Iwasuki & N. Fukuoka* T-764 (**BKF**), isotype of *E. pseudonepalense* Satake . Drawn by A. Prajaksood.

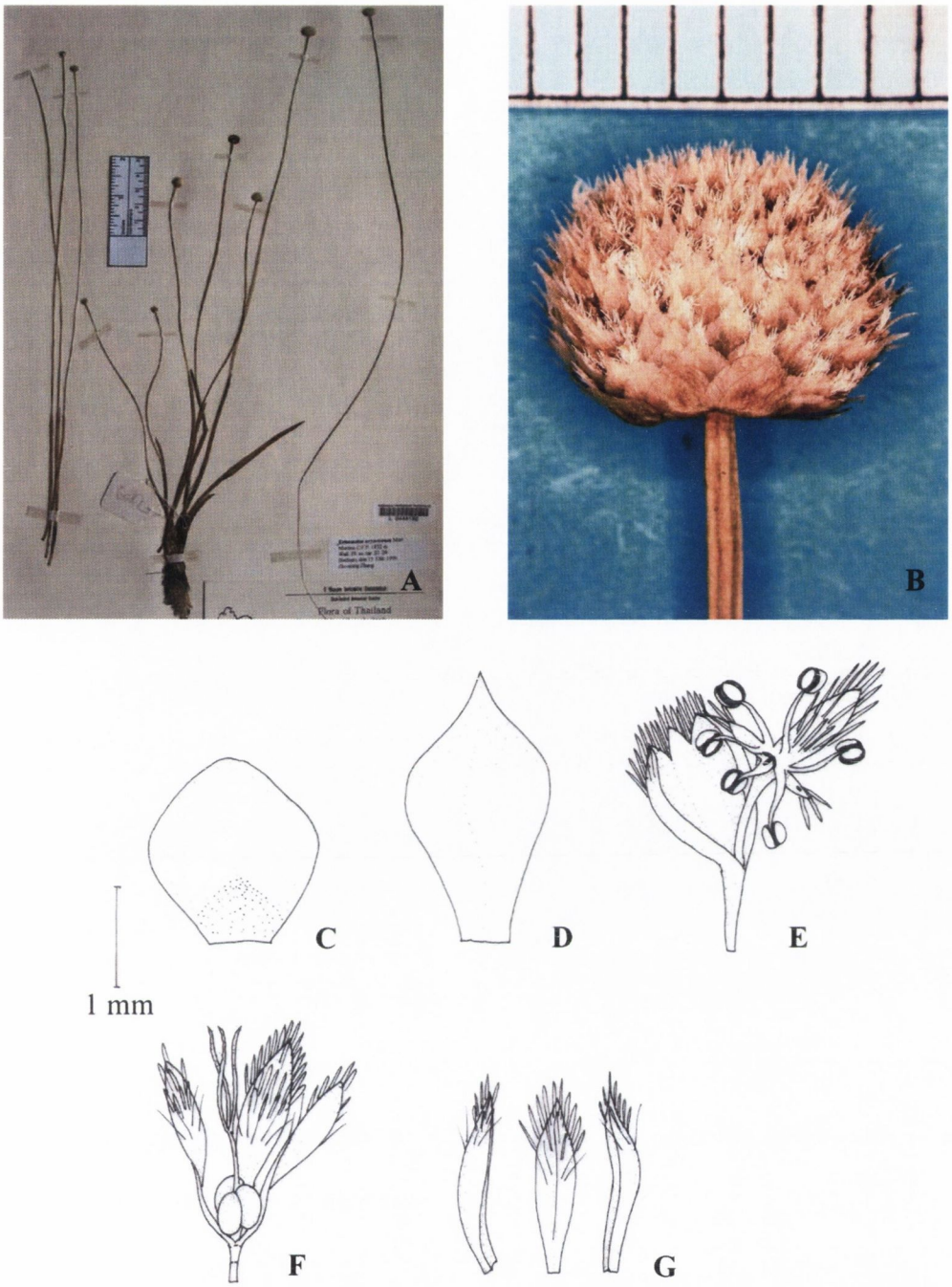

Figure 5.21 *Eriocaulon oryzetorum* Mart. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(G) Female flower, (F) gynoecium and petals, (G) sepals. All from *Th. Sorensen, K. Larsen & B. Hansen* 6082 (**L**). Drawn by A. Prajaksood.

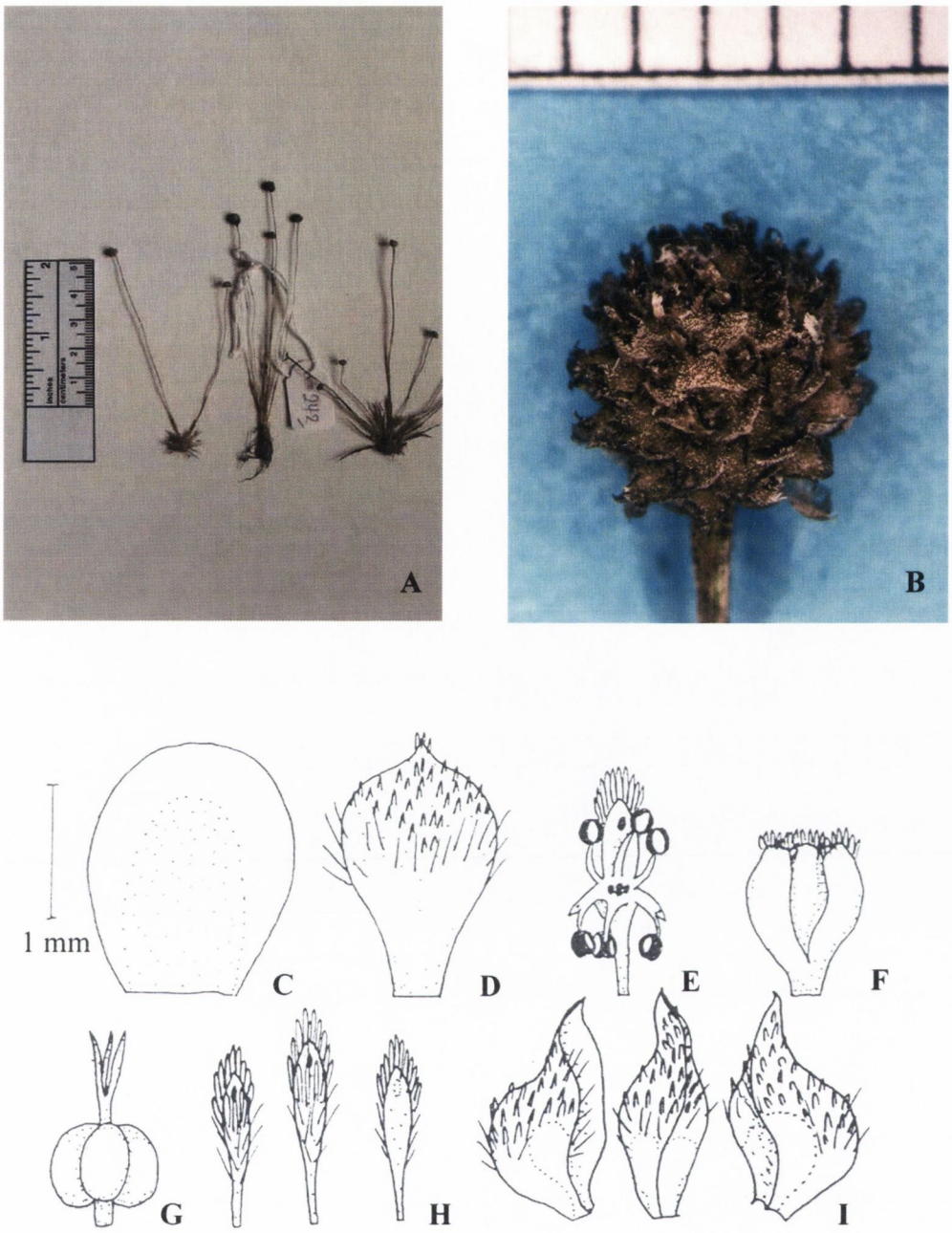

Figure 5.22 *Eriocaulon parnellii* A.Prajaksood & Chantar. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E)-(F) Male flower, (E) androecium and petals, (F) sepals. (G)-(I) Female flower, (G) gynoecium, (H) petals, (I) sepals. All from *A. Prajaksood & S. Suddee* 242 (**KKU**). Drawn by A. Prajaksood.

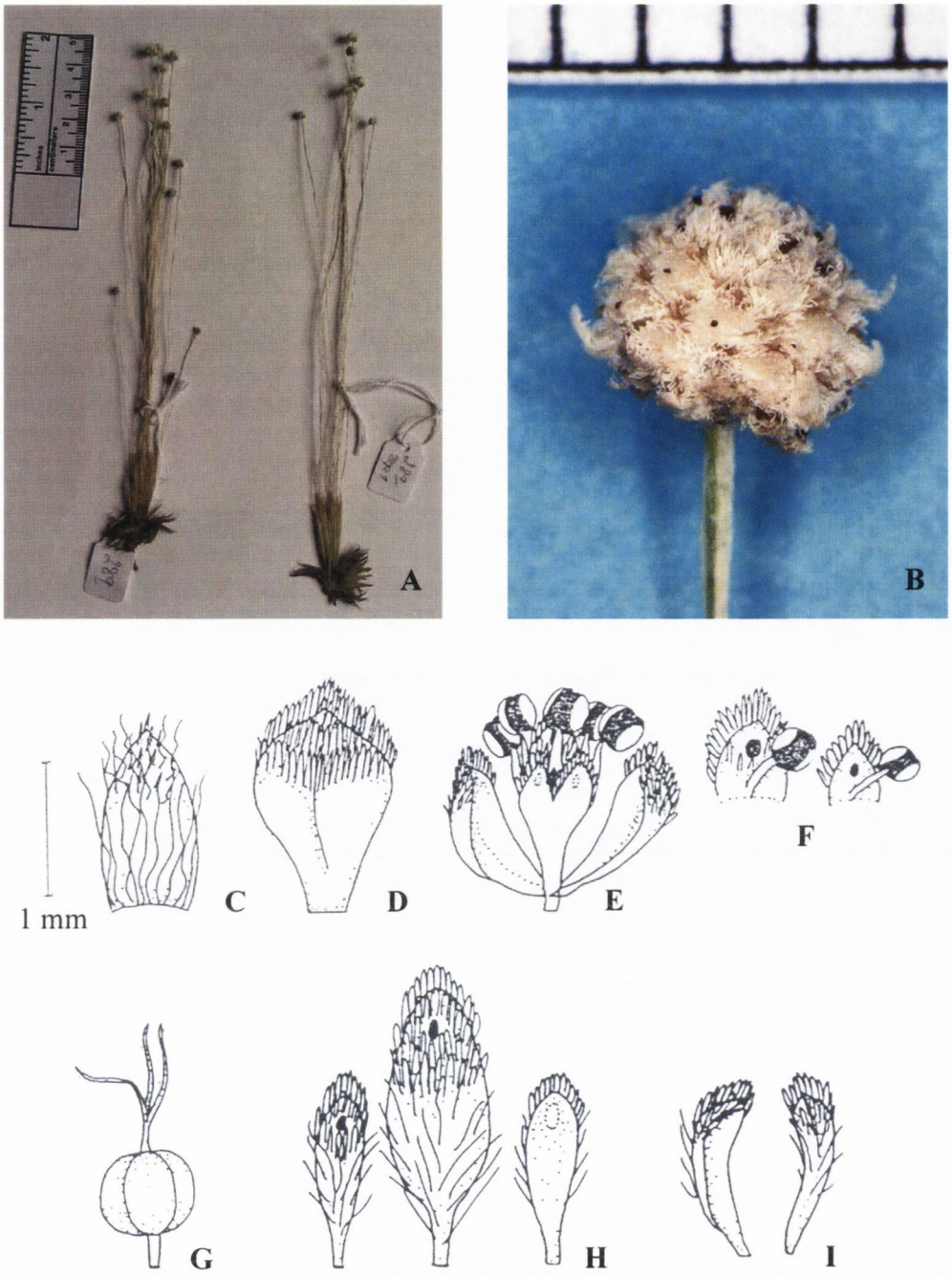

Figure 5.23 *Eriocaulon phatamense* A.Prajaksood & Chantar. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E)-(F) Male flower, (E) male flower, (F) petals. (G)-(I) Female flower, (G) gynoecium, (H) petals, (I) sepals. (A)-(B) from *A. Prajaksood & S. Suddee* 289 (**KKU**); (C)-(I) from *A. Prajaksood & P. Chantaranothai* 89 (**KKU**). Drawn by A. Prajaksood.

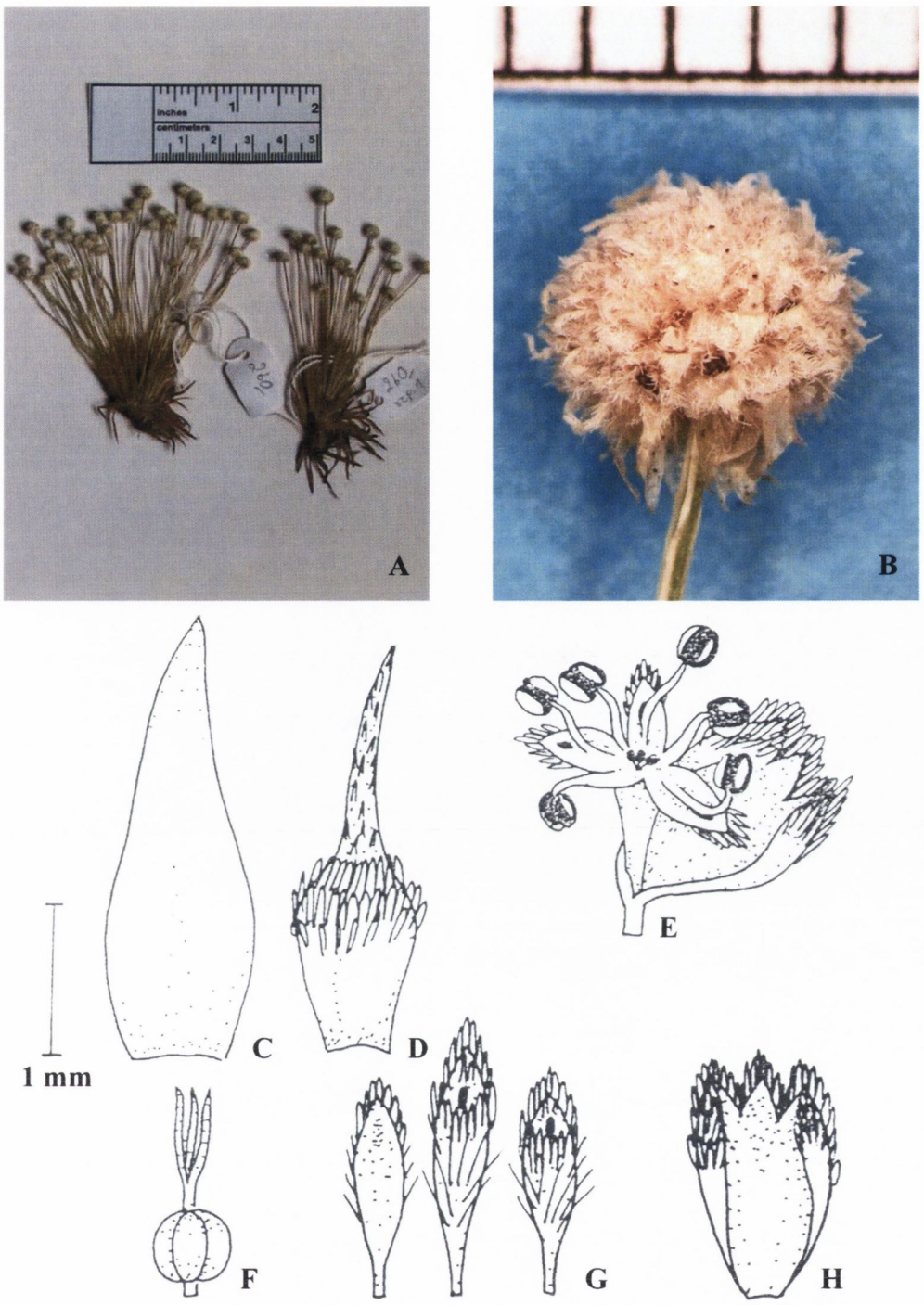

Figure 5.24 *Eriocaulon phuchongense* A.Prajaksood & Chantar. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. (A)_(B) from *A. Prajaksood & S. Suddee* 260 (**KKU**); (C)-(H) from *A. Prajaksood & P. Chantaranothai* 100 (**KKU**). Drawn by A. Prajaksood.

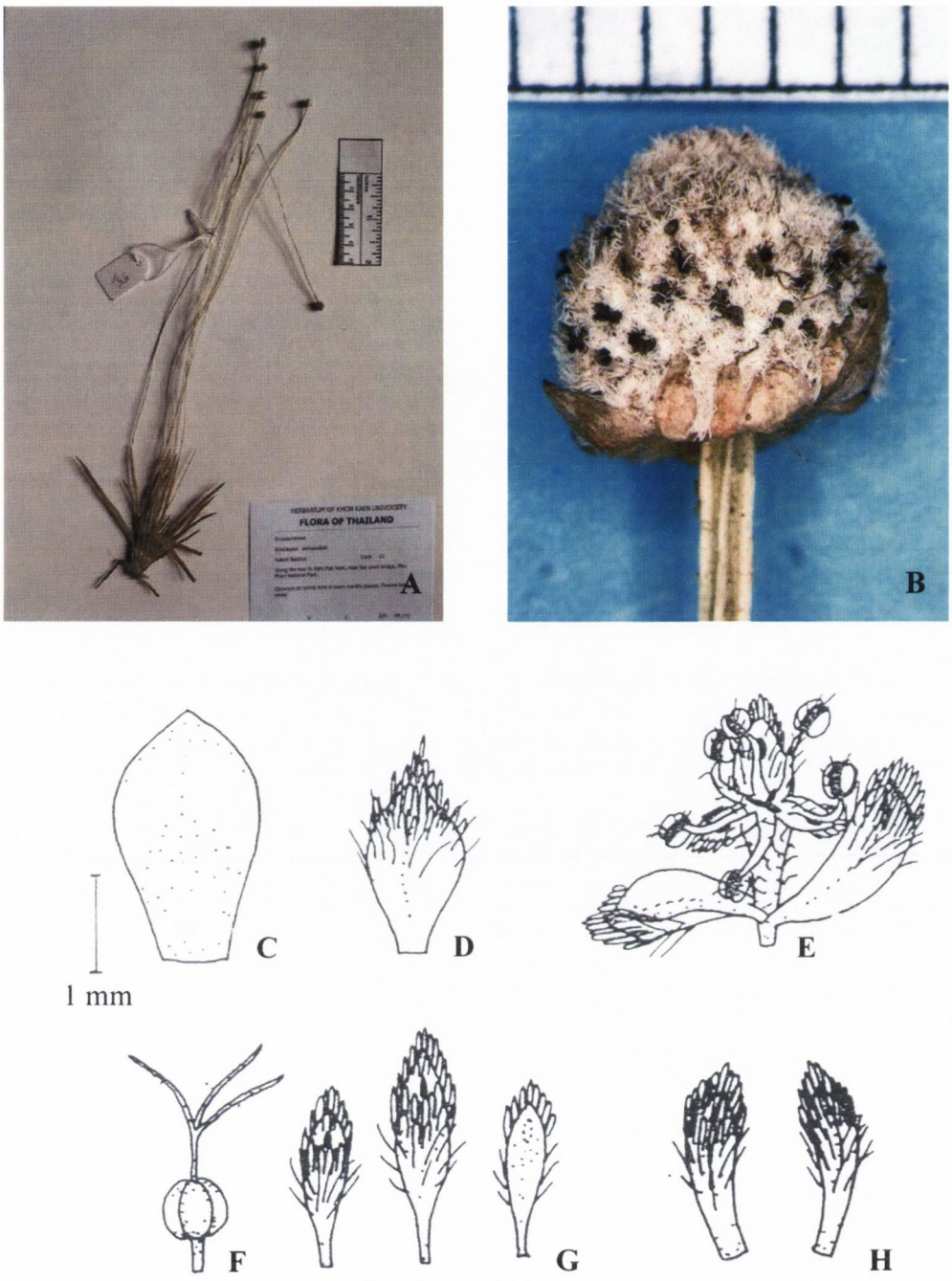

Figure 5.25 *Eriocaulon phuphanense* A.Prajaksood & J.Parn. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *A. Prajaksood & P. Chantaranothai* 55 (**KKU**). Drawn by A. Prajaksood.

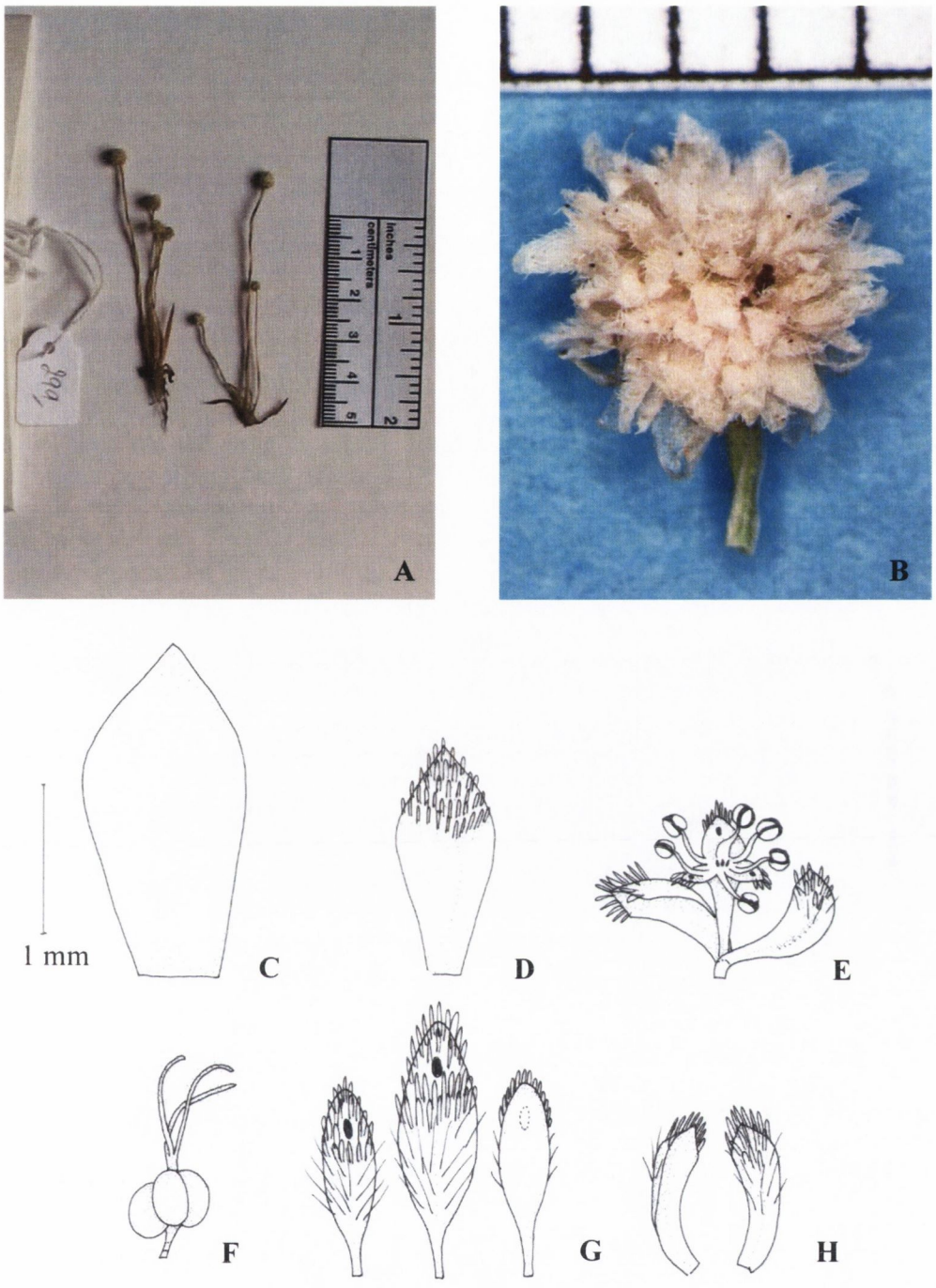

Figure 5.26 *Eriocaulon phuphanoides* A.Prajaksood & J.Parn. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *A. Prajaksood & S. Suddee* 299 (**KKU**). Drawn by A. Prajaksood.

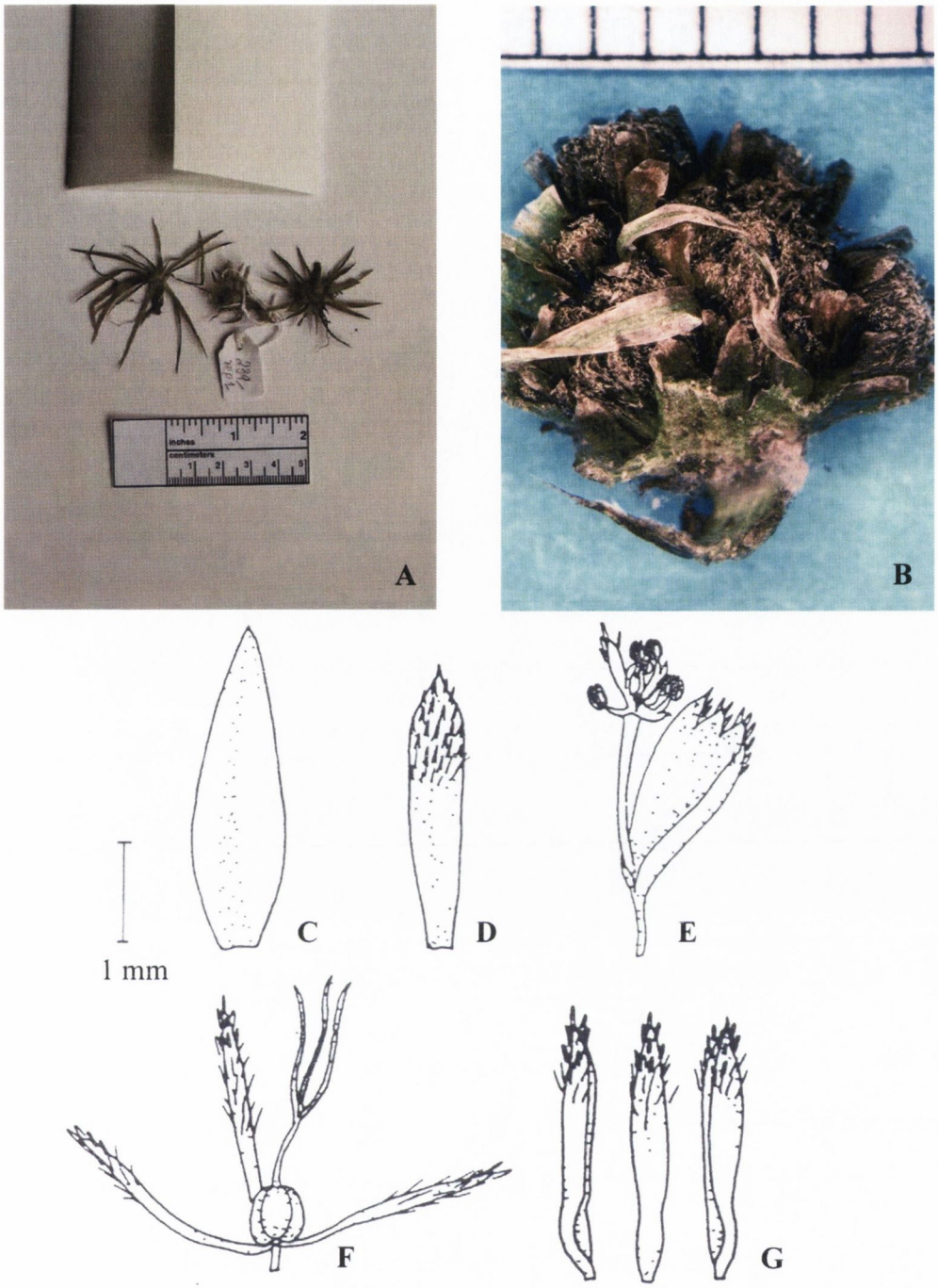

Figure 5.27 *Eriocaulon pseudoescape* A.Prajaksood & Chantar. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(G) Female flower, (F) gynoecium and petals, (G) sepals. (A)-(B) from *A. Prajaksood & S. Suddee* 239 (**KKU**); (C)-(G) from *A. Prajaksood & P. Chantaranothai* 117 (Holotype, **KKU**). Drawn by A. Prajaksood.

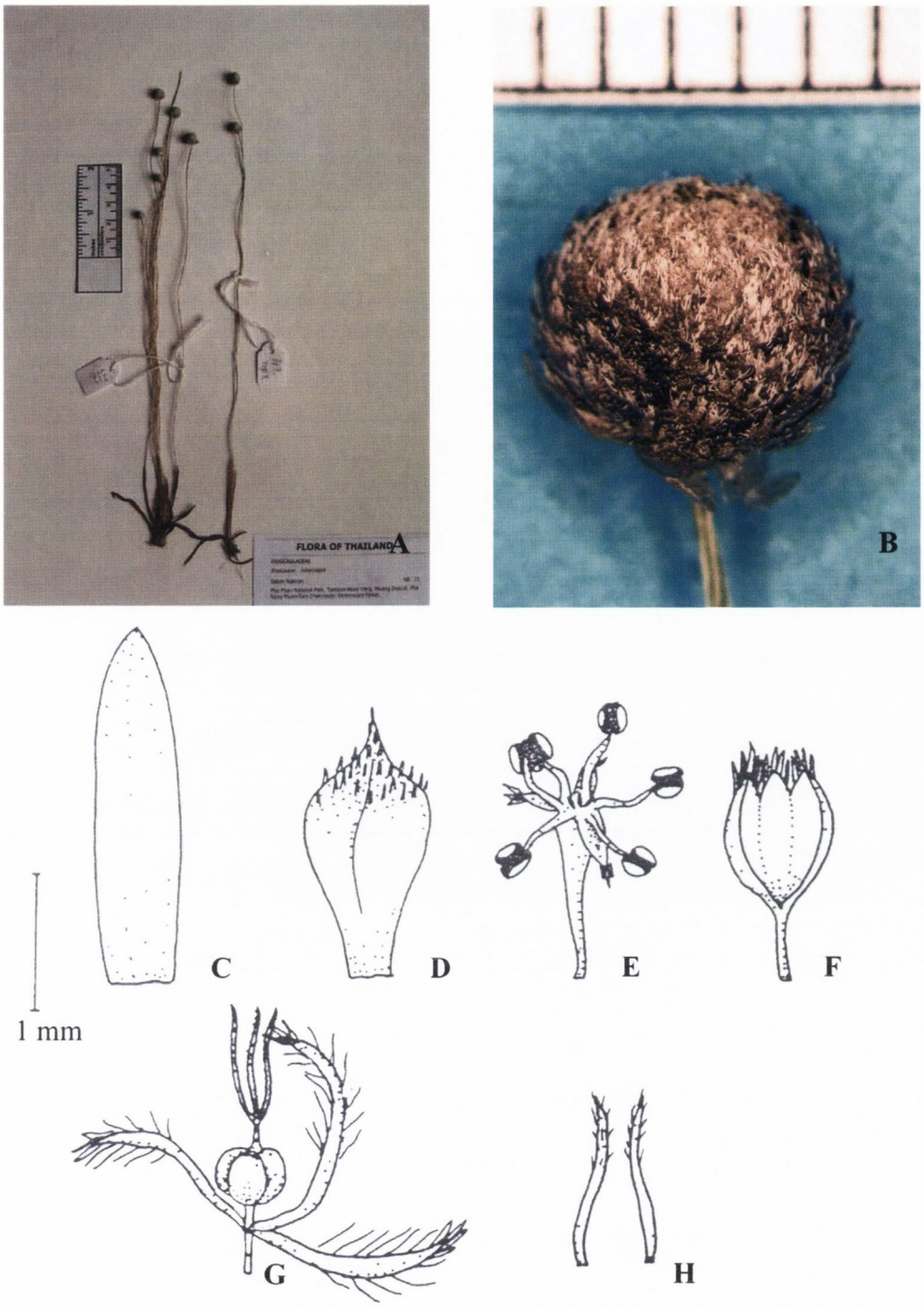

Figure 5.28 *Eriocaulon quinquangulare* var. *longibracteatum* A.Prajaksood & J.Parn. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E)-(F) Male flower, (E) androecium and petals, (F) sepals. (G)-(H) Female flower, (G) gynoecium and petals, (H) sepals. All from *A. Prajaksood & S. Suddee* 317 (**KKU**). Drawn by A. Prajaksood.

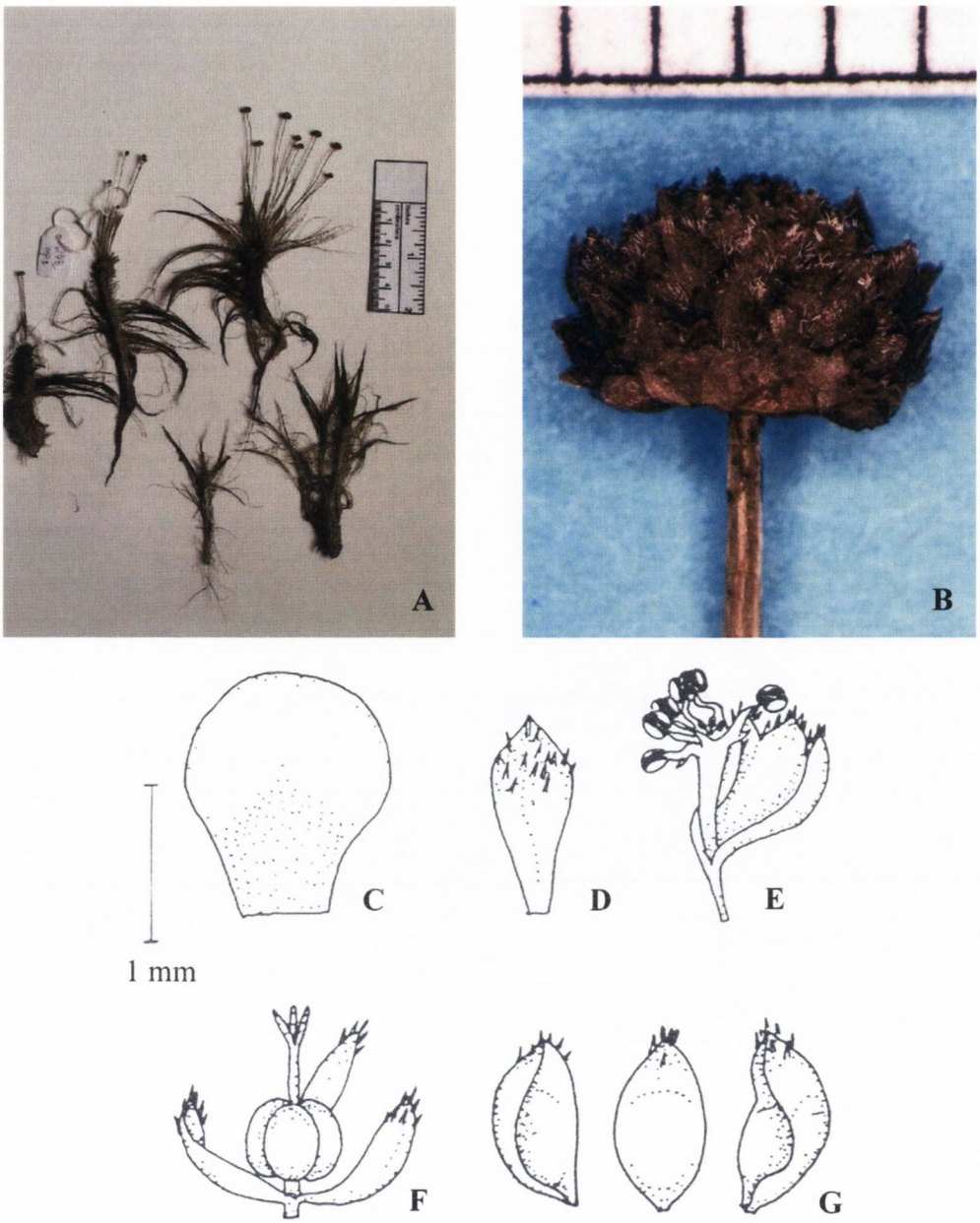

Figure 5.29 *Eriocaulon setaceum* L. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(G) Female flower, (F) gynoecium and petals, (G) sepals. (A)-(B) from *A. Prajaksood & S. Suddee* 243 (**KKU**); (C)-(G) from *T. Shimizu, M. Huton & D. Chaiglom* T-9035 (**BKF**),), isotype of *E. intermedium* var. *brevicaule* Satake. Drawn by A. Prajaksood.

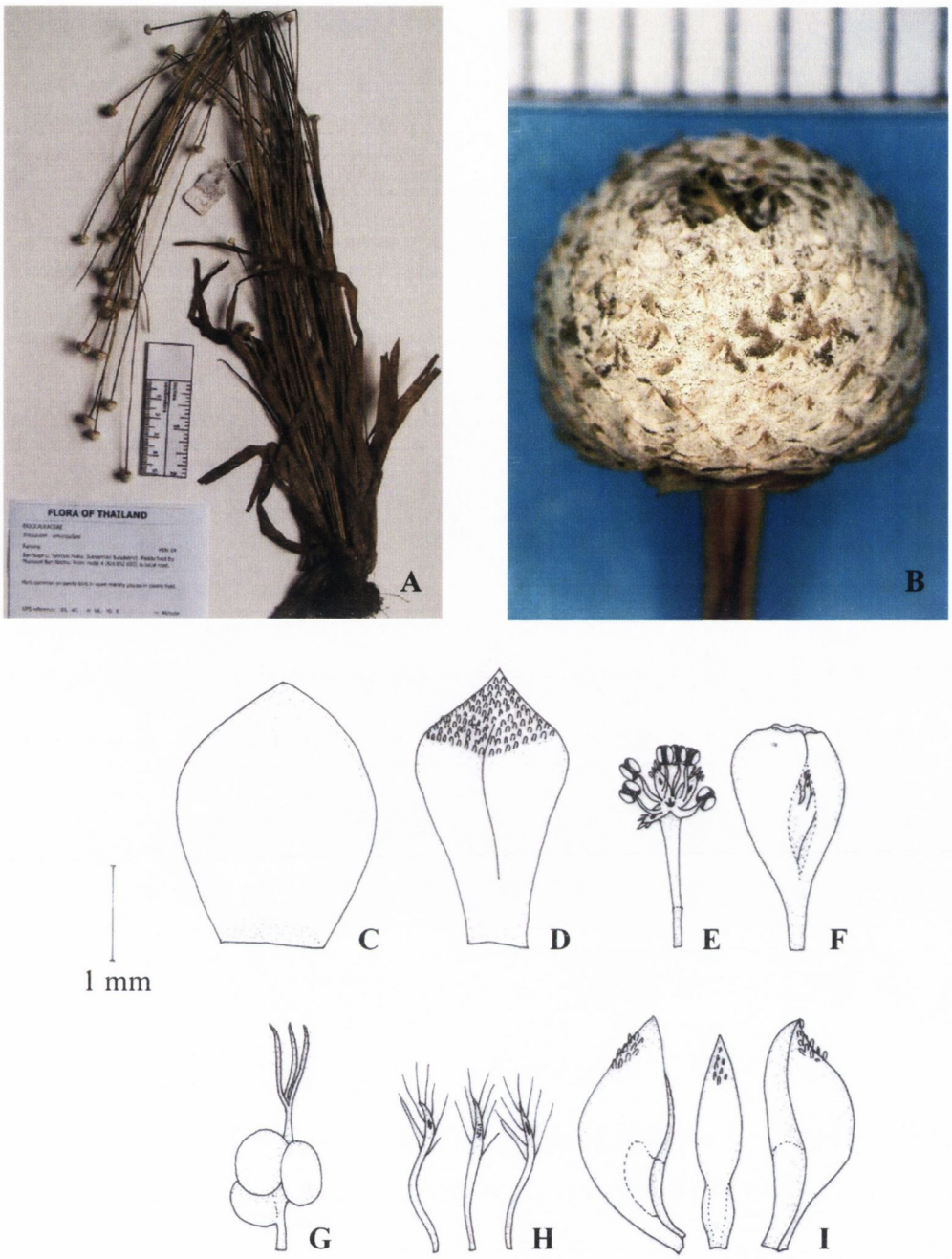

Figure 5.30 *Eriocaulon sexangulare* L. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E)-(F) Male flower, (E) androecium and petals, (F) male flower. (G)-(I) Female flower, (G) gynoecium, (H) petals, (I) sepals. All from *A. Prajaksood & S. Suddee* 337 (**KKU**). Drawn by A. Prajaksood.

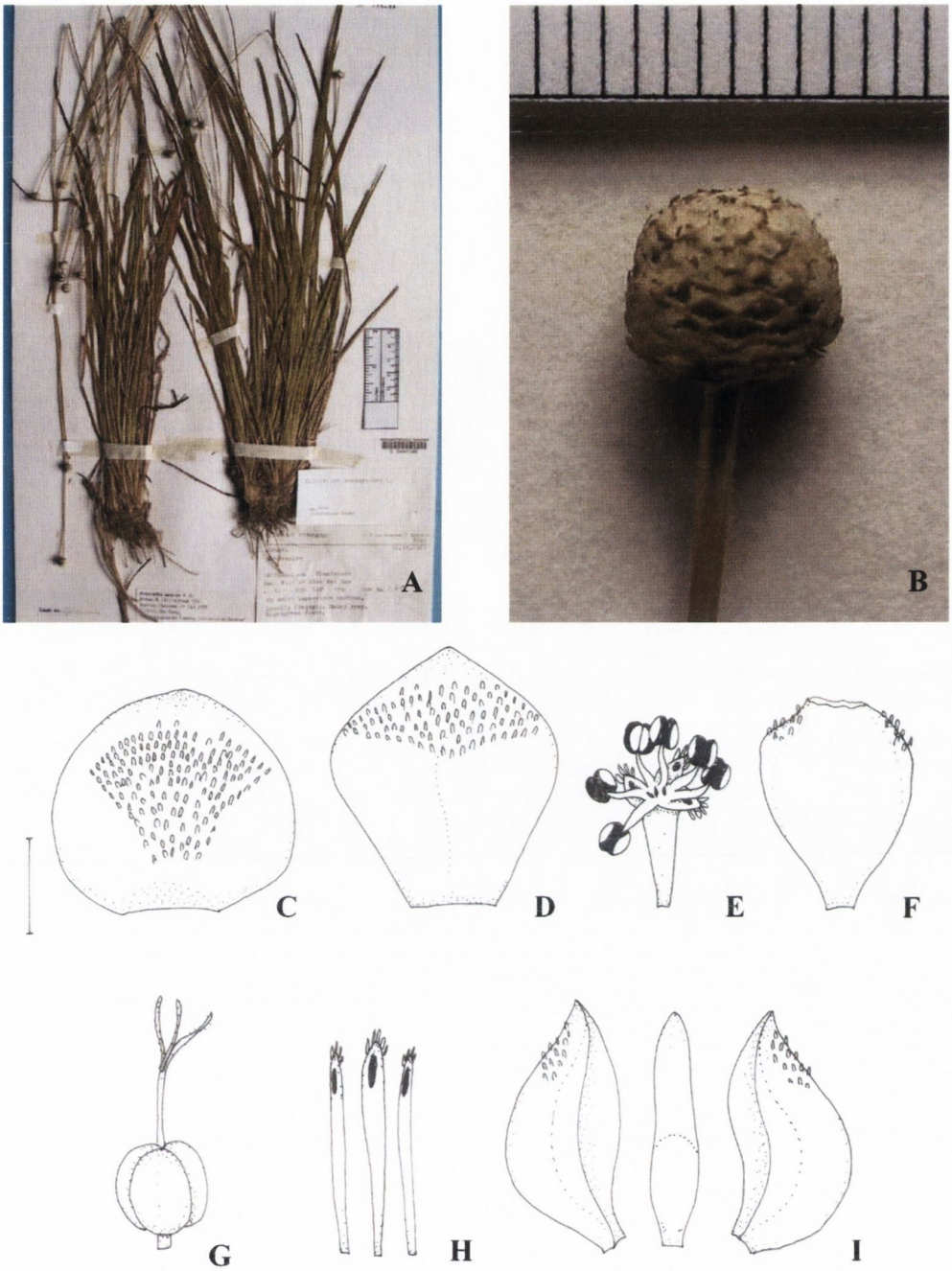

Figure 5.31 *Eriocaulon sexangulare* var. *australe* A.Prajaksood & J.Parn. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E)-(F) Male flower, (E) androecium and petals, (F) sepals. (G)-(I) Female flower, (G) gynoecium, (H) petals, (I) sepals. (A)-(B) from *C.F. van Beusekom & T. Smitinand* 2145 (**L**), (C)-(I) from *T. Smitinand* 7135 (**BKF**). Drawn by A. Prajaksood.

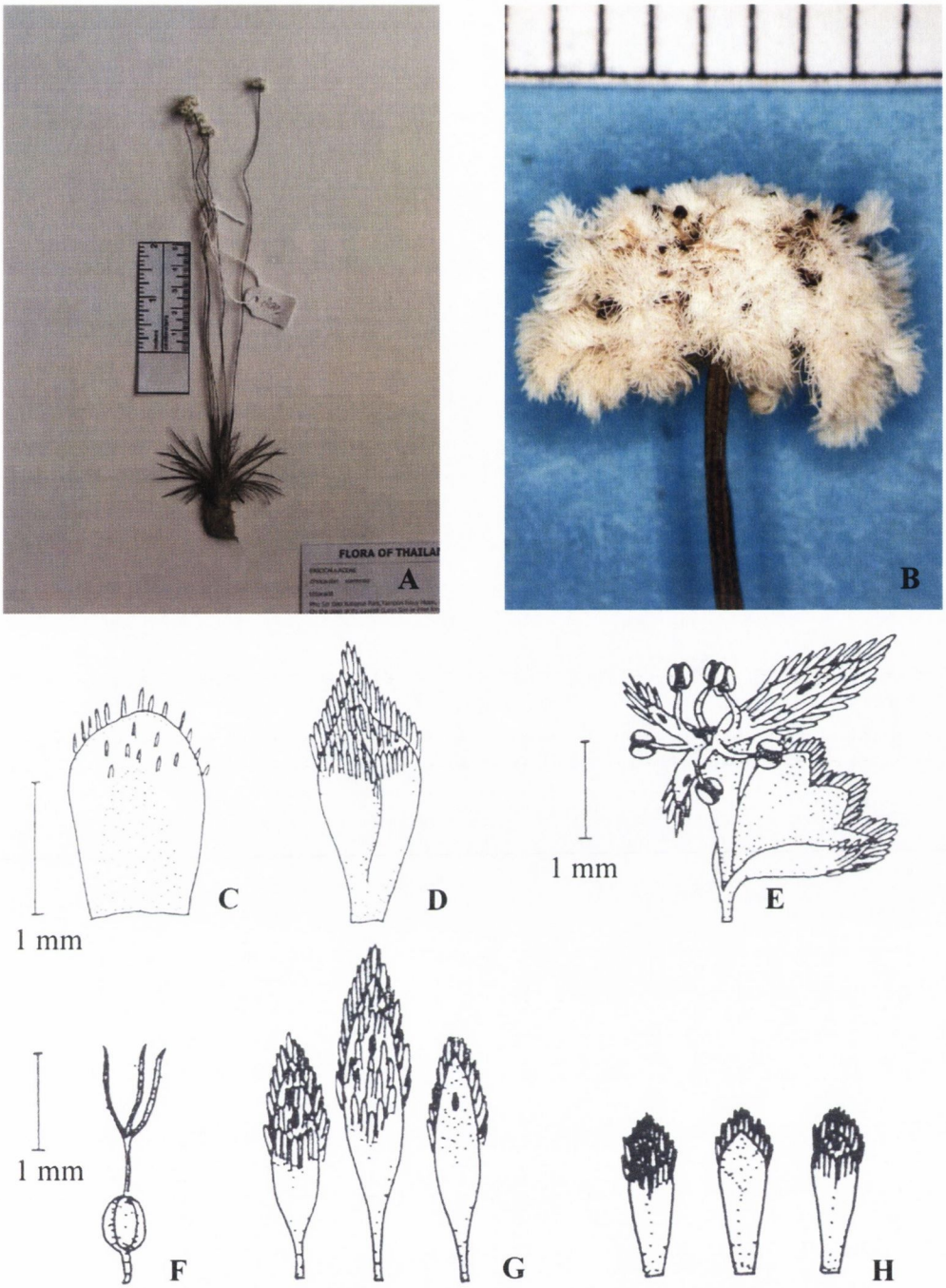

Figure 5.32 *Eriocaulon siamense* Moldenke. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. (A)-(B) from *A. Prajaksood & S. Suddee* 200 (**KKU**); (C)-(G) from *M. Tagawa, K. Iwasuki & N. Fukuoka* T 553 (**BKF**); isotype of *E. tagawae* Satake. Drawn by A. Prajaksood.

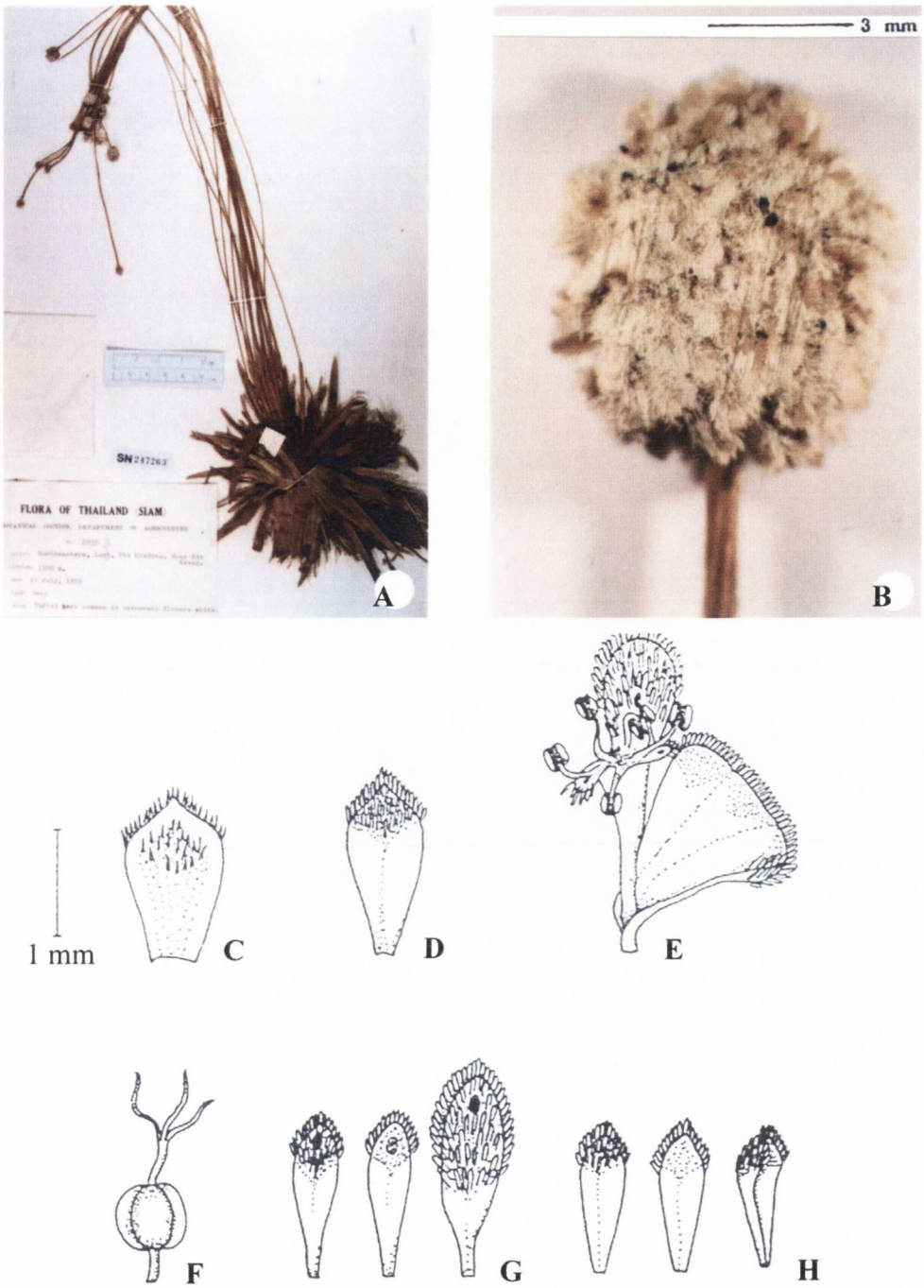

Figure 5.33 *Eriocaulon siamense* var. *macrophyllum* A.Prajaksood & J.Parn. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *T. Smitinad & F. Floto* 5935 (**BK**). Drawn by A. Prajaksood.

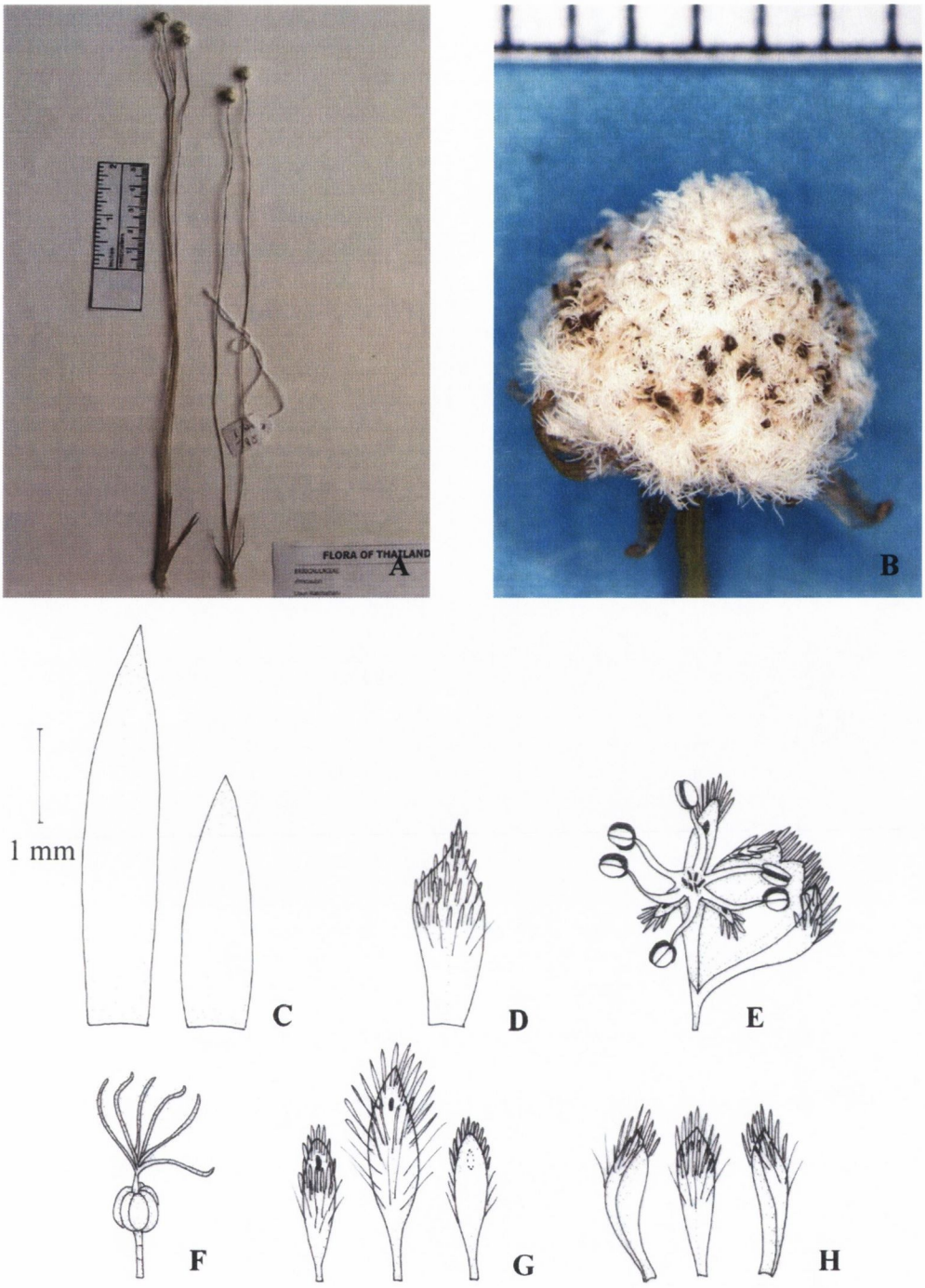

Figure 5.34 *Eriocaulon siamense* ssp. *hexagynum* A.Prajaksood & Chantar. (A) Habit. (B) Capitulum. (C) Involucral bracts. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *A. Prajaksood & S. Suddee* 281 (**KKU**). Drawn by A. Prajaksood.

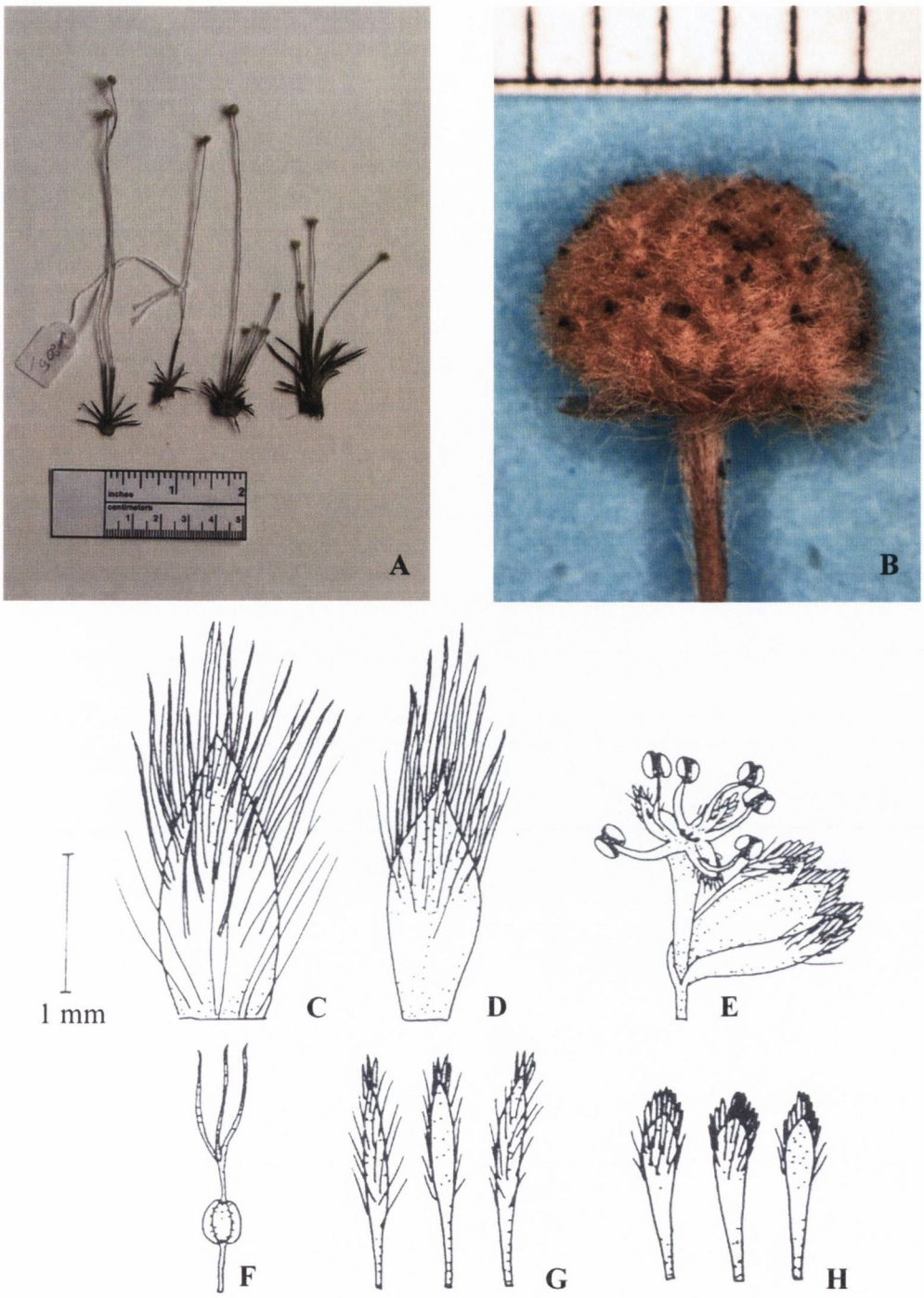

Figure 5.35 *Eriocaulon smitinandii* Moldenke (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *A. Prajaksood & S. Suddee* 205 (**KKU**). Drawn by A. Prajaksood.

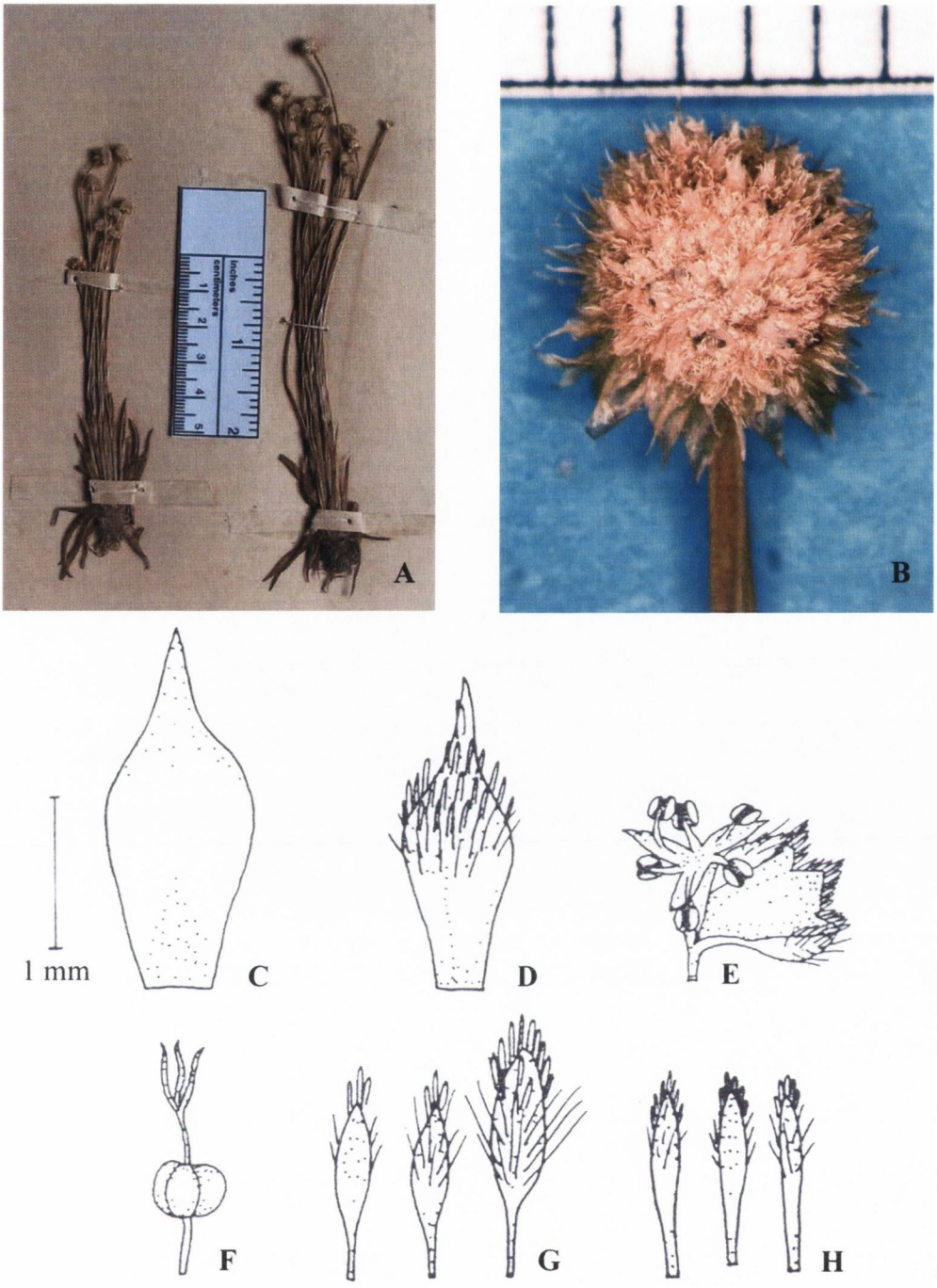

Figure 5.36 *Eriocaulon thailandicum* Moldenke (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *T. Smitinand* 3679-A (**BKF**). Drawn by A. Prajaksood.

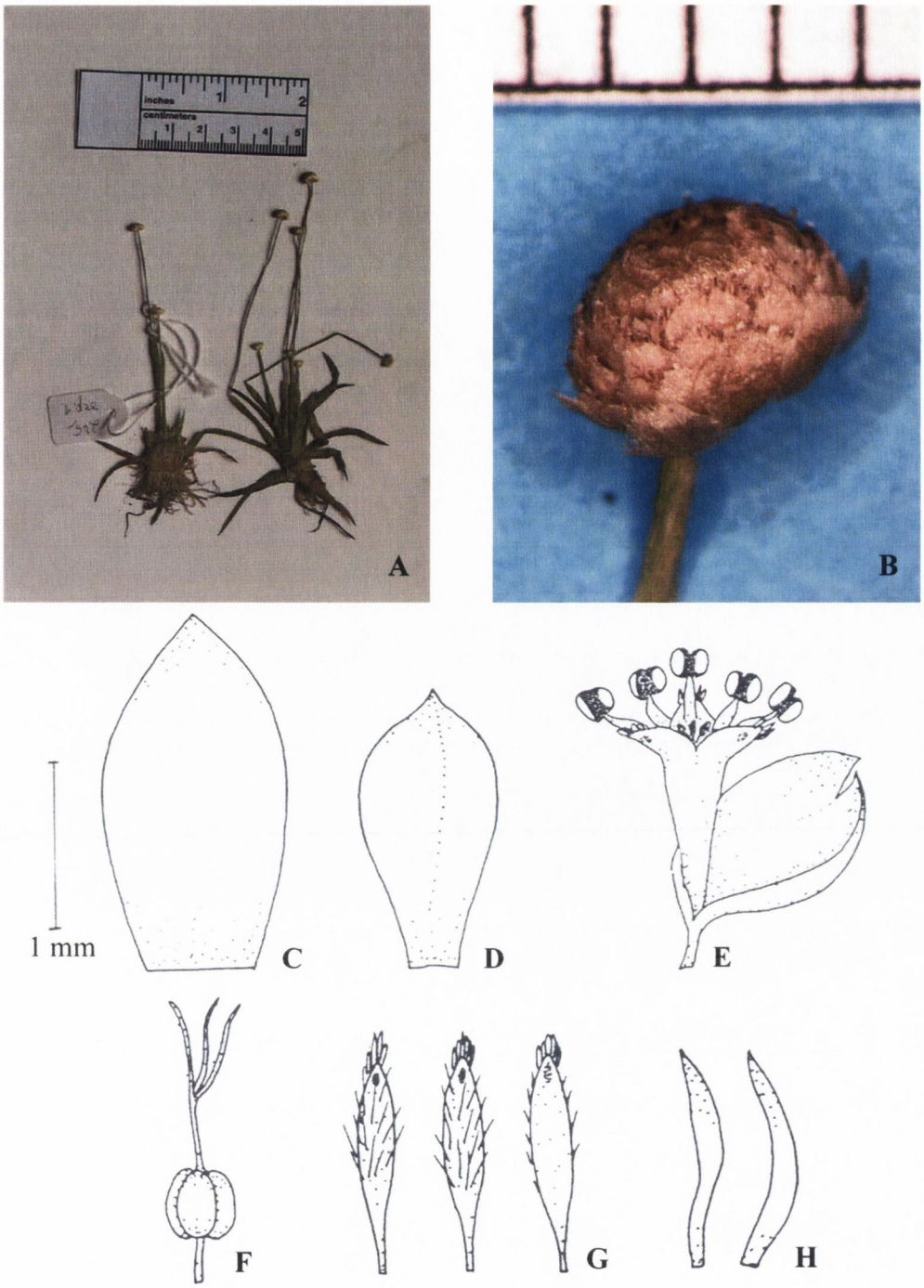

Figure 5.37 *Eriocaulon truncatum* Buch.-Ham. ex Mart. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *A. Prajaksood & S. Suddee* 245 (**KKU**). Drawn by A. Prajaksood.

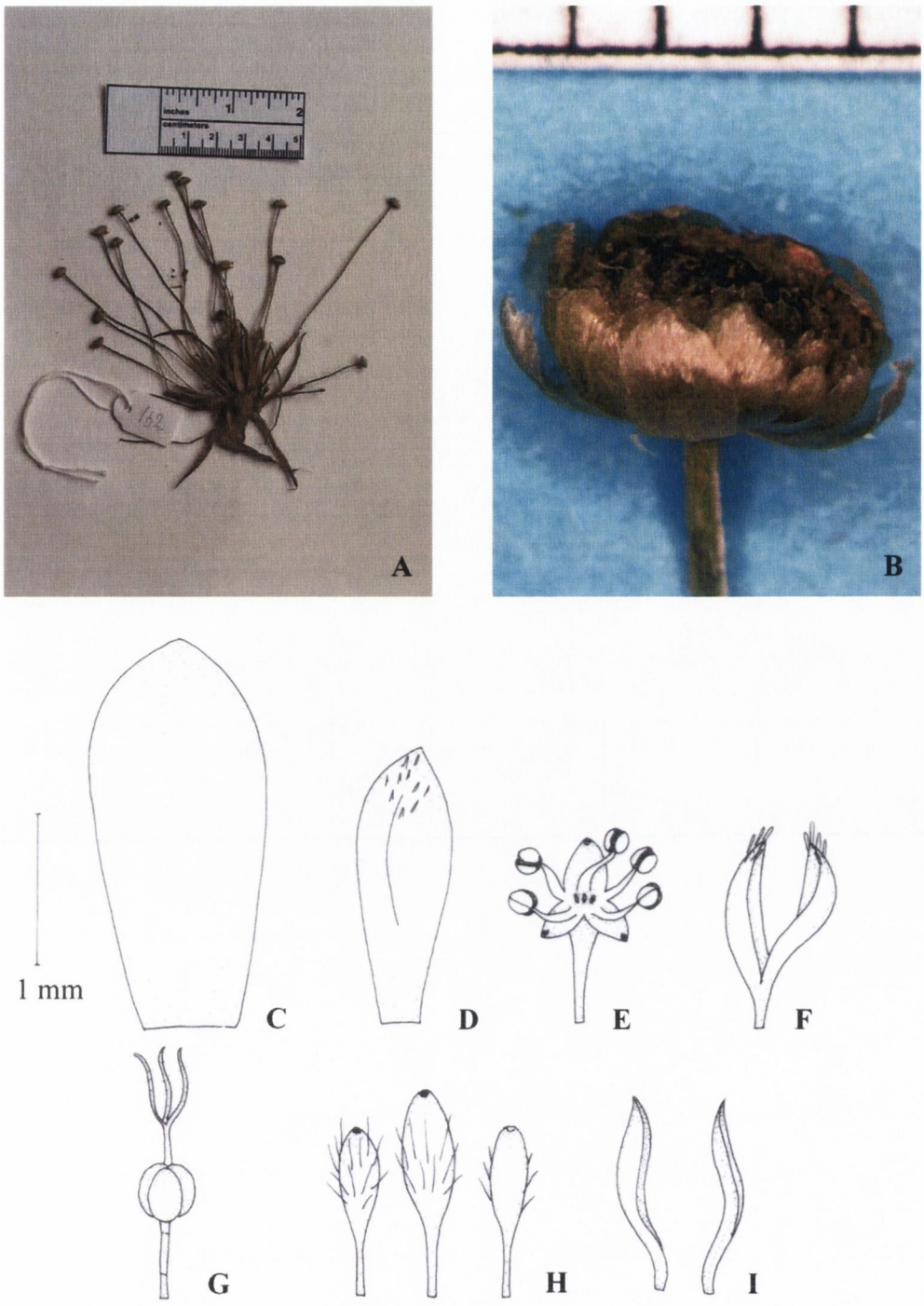

Figure 5.38 *Eriocaulon truncatum* var. *florensense* Z.X.Zhang (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E)-(F) Male flower, (E) androecium and petals, (F) sepals. (G)-(I) Female flower, (G) gynoecium, (H) petals, (I) sepals. All from *A. Prajaksood & S. Suddee* 162 (**KKU**). Drawn by A. Prajaksood.

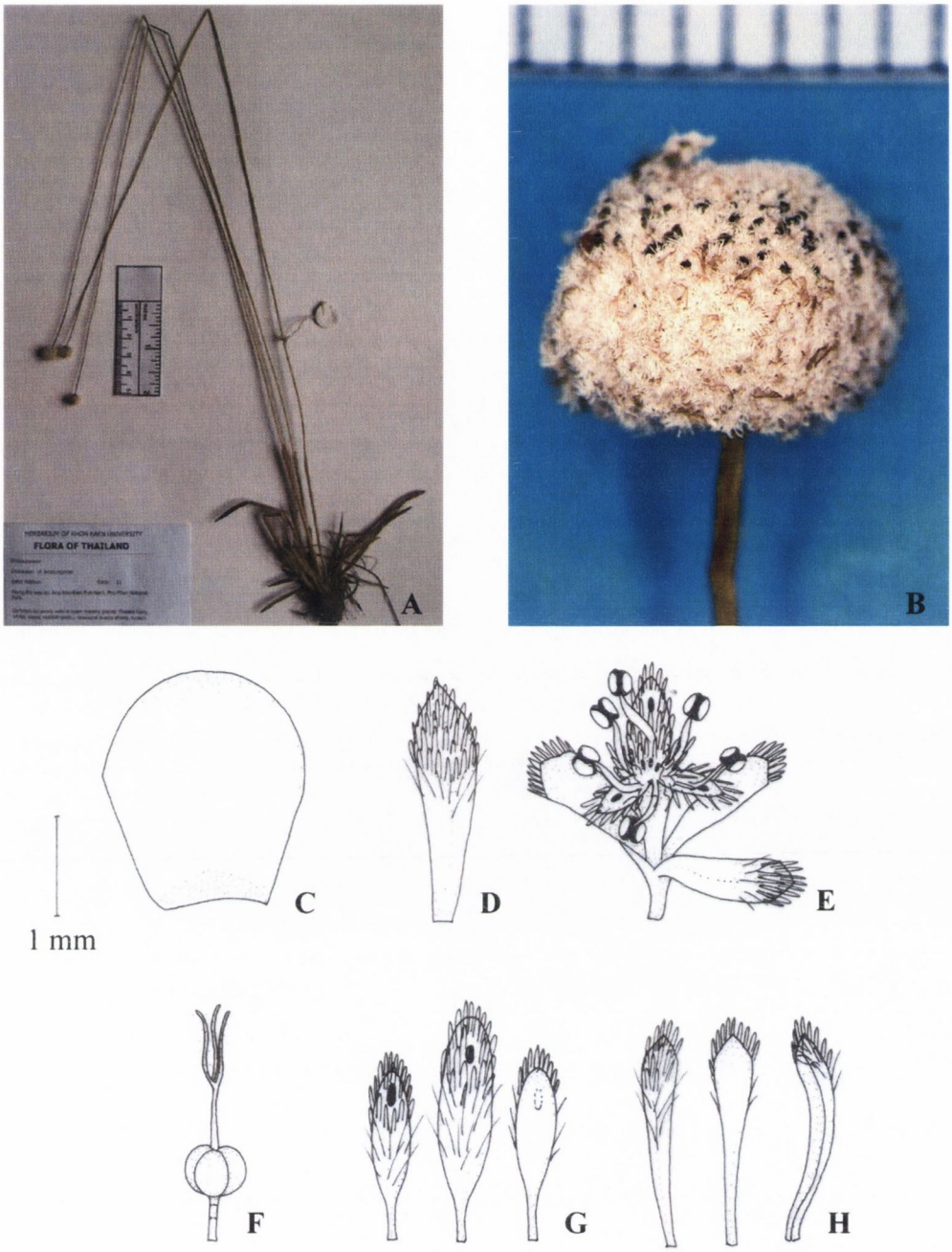

Figure 5.39 *Eriocaulon ubonense* Lecomte (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *A. Prajaksood & P. Chantaranothai* BRT 222 (**KKU**). Drawn by A. Prajaksood.

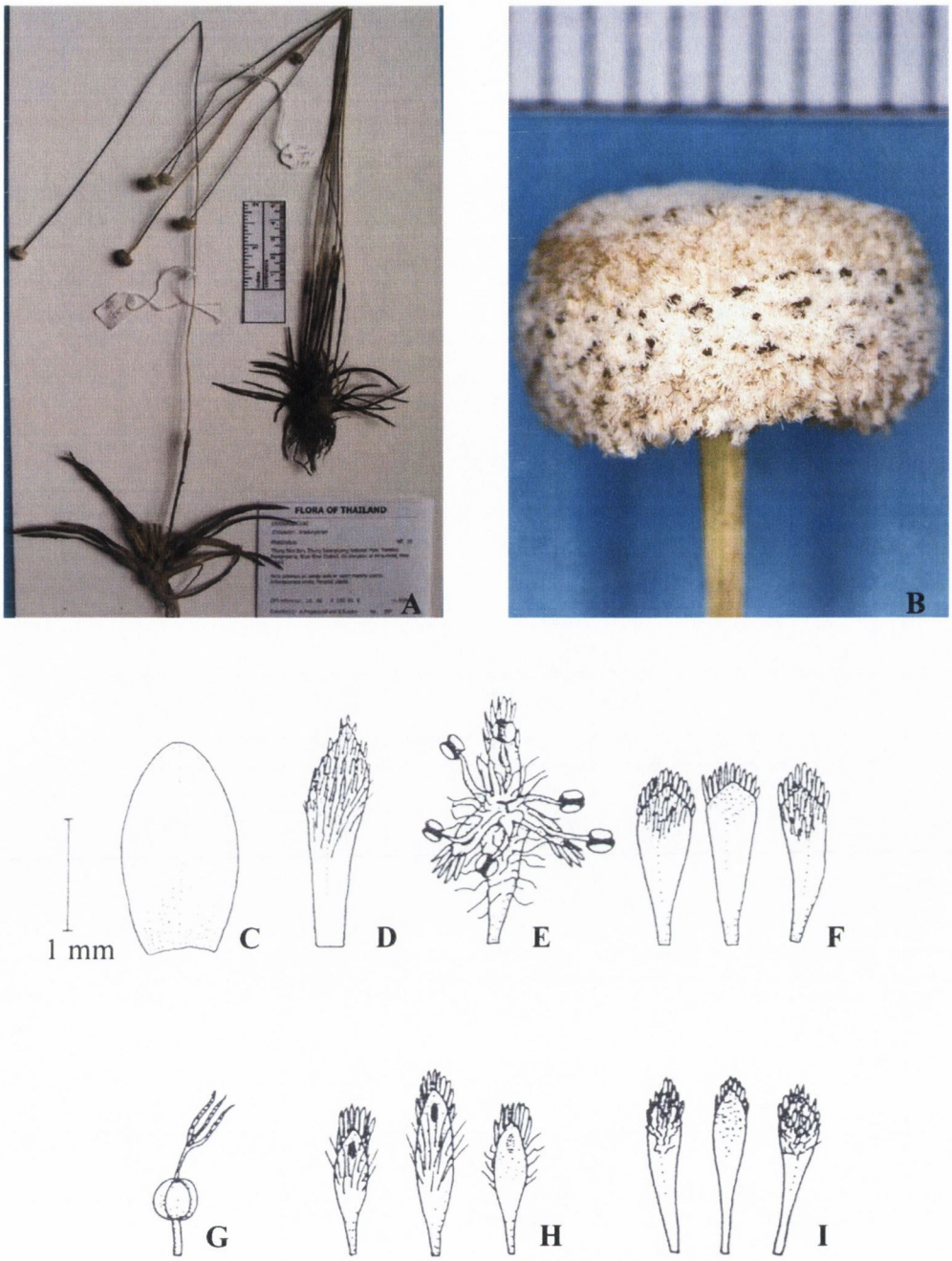

Figure 5.40 *Eriocaulon ubonense* f. *kradungense* (Satake) A.Prajaksood & J.Parn. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E)-(F) Male flower, (E) androecium and petals, (F) sepals. (G)-(I) Female flower, (G) gynoecium, (H) petals, (I) sepals. (A)-(B) from *A. Prajaksood & S. Suddee* 202 (**KKU**); (C)-(I) from *T. Shimizu, M. Huton & D. Chaiglom* T 8884 (**BKF**), isotype of *E. kradungense* Satake Drawn by A. Prajaksood.

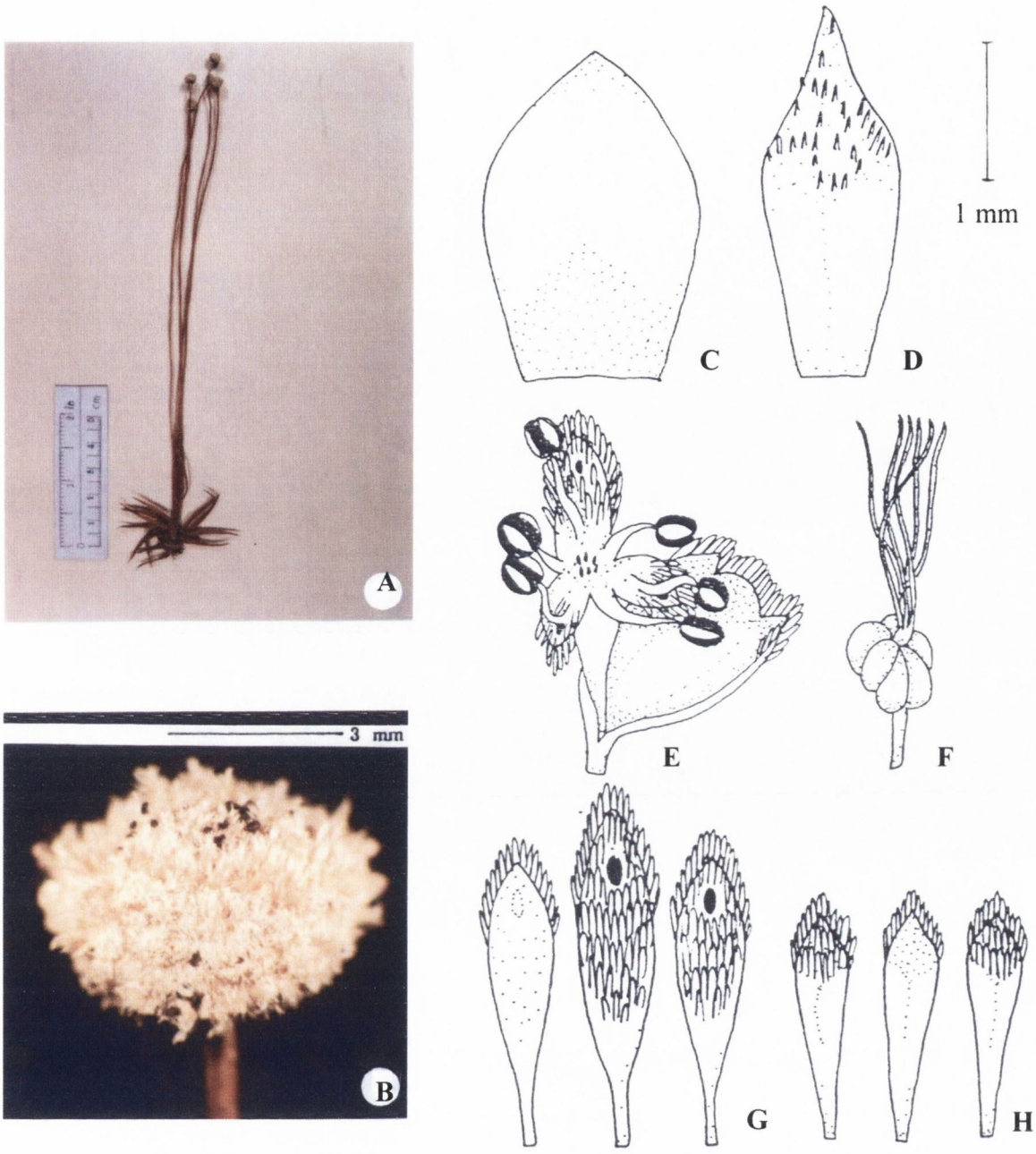

Figure 5.41 *Eriocaulon ubonense* var. *hexagynum* A.Prajaksood & Chantar. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from Pradit 677 (**BK**). Drawn by A. Prajaksood.

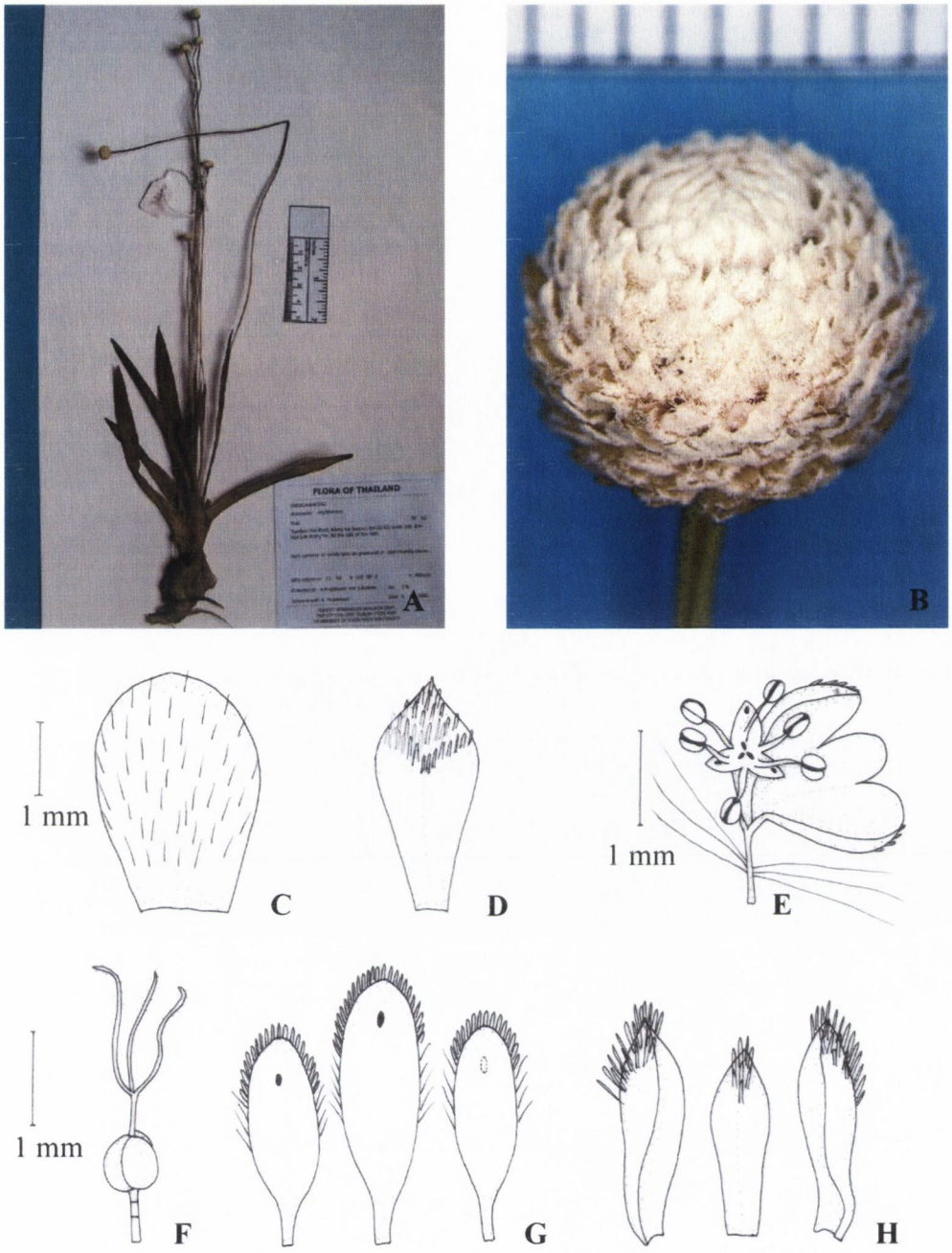

Figure 5.42 *Eriocaulon wightianum* Mart. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *A. Prajaksood & S. Suddee* 176 (**KKU**). Drawn by A. Prajaksood.

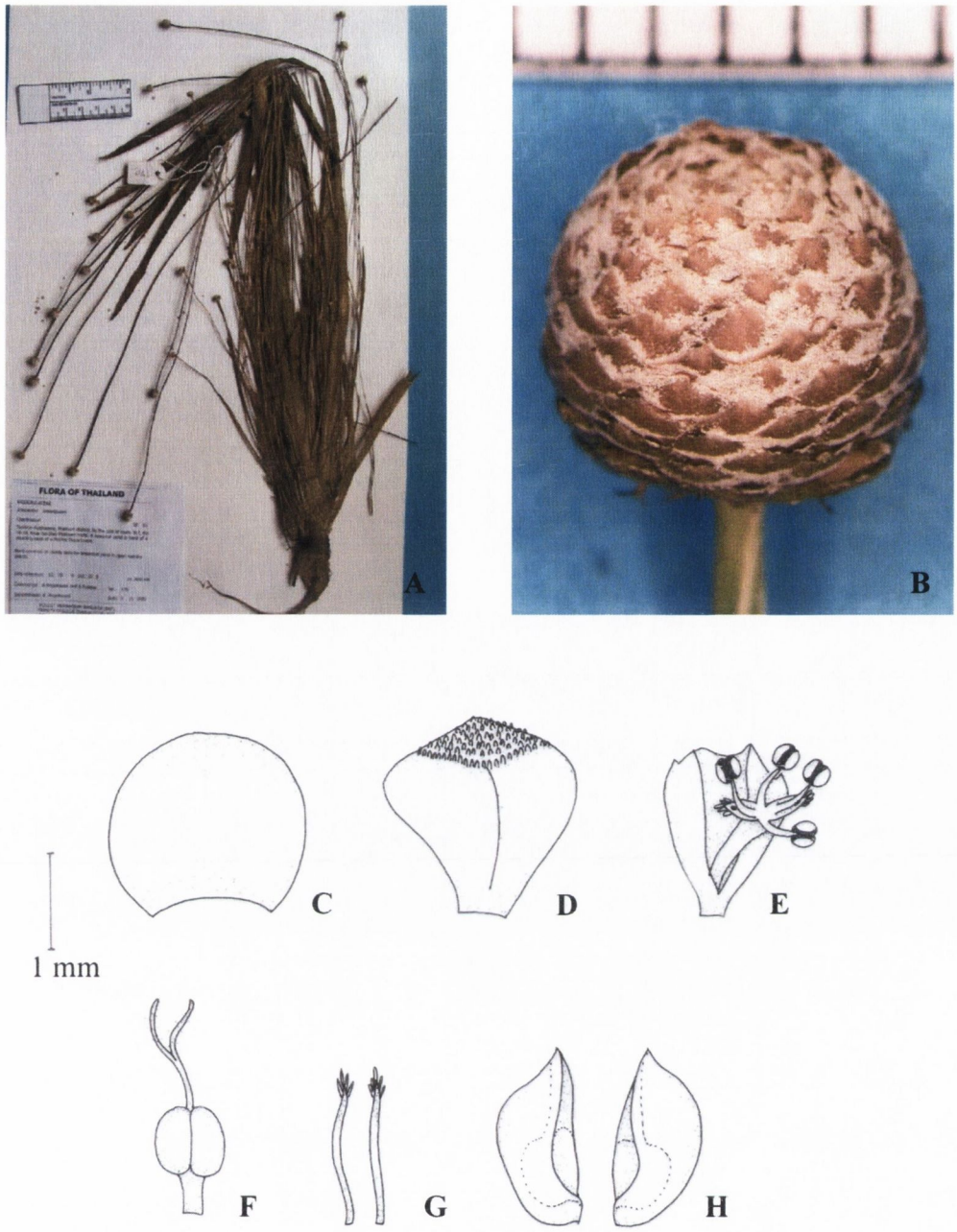

Figure 5.43 *Eriocaulon willdenovianum* Moldenke (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *A. Prajaksood & S. Suddee* 170 (**KKU**). Drawn by A. Prajaksood.

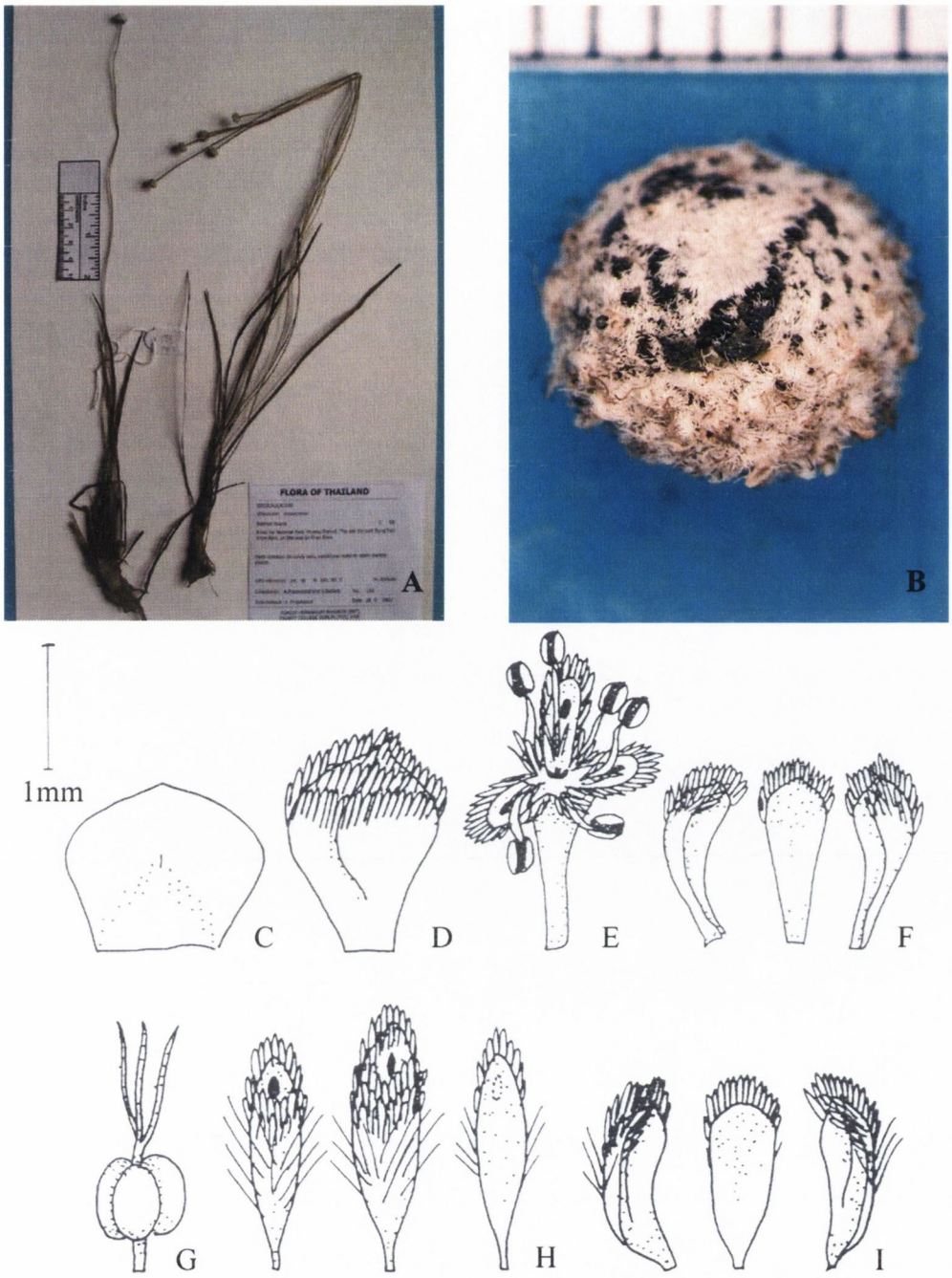

Figure 5.44 *Eriocaulon xenopodium* T.Koyama (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E)-(F) Male flower, (E) androecium and petals, (F) sepals. (G)-(I) Female flower, (G) gynoecium, (H) petals, (I) sepals. All from *A. Prajaksood & S. Suddee* 158 (**KKU**). Drawn by A. Prajaksood.

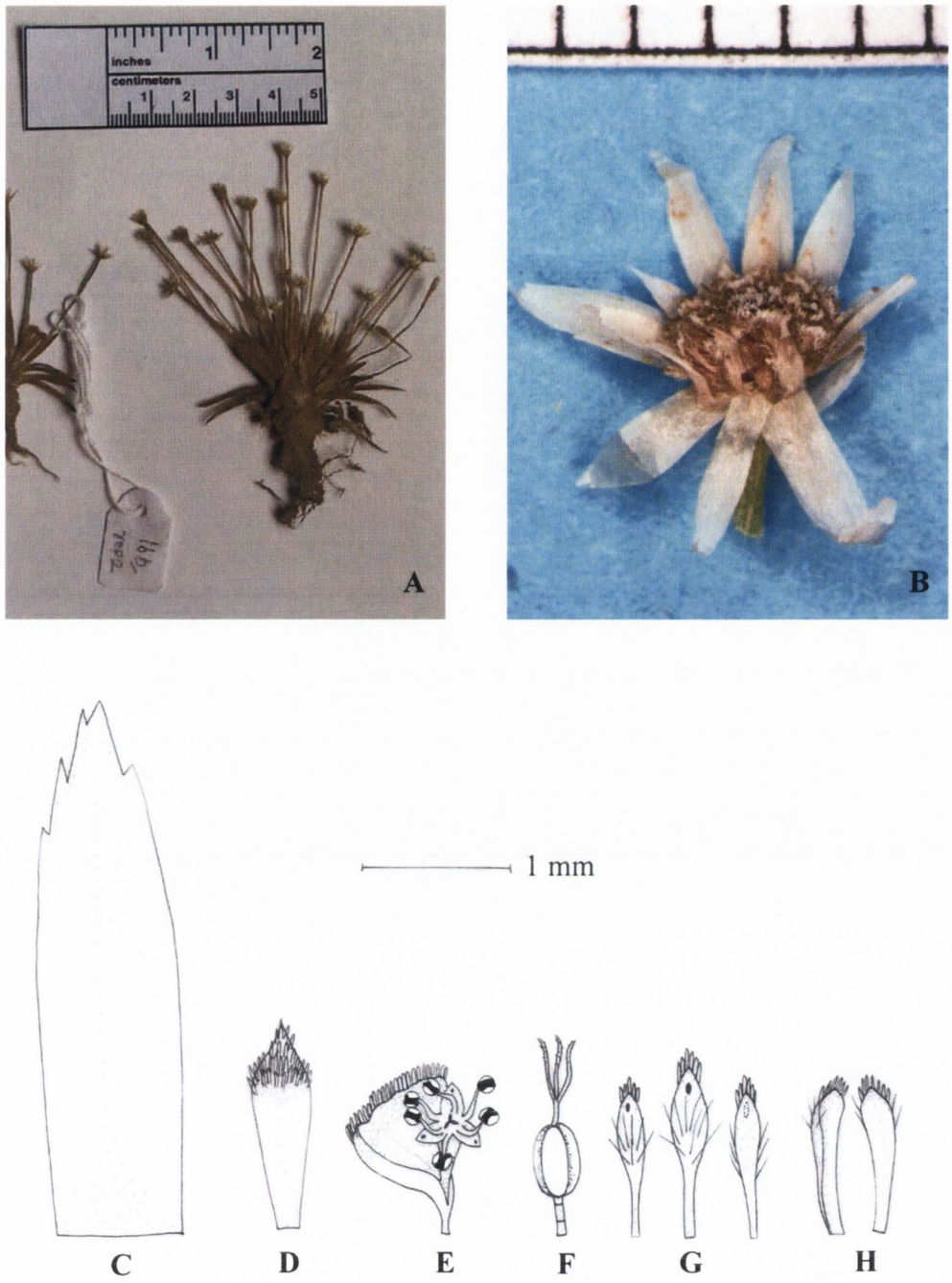

Figure 5.45 *Eriocaulon xeranthemum* Mart. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E) Male flower. (F)-(H) Female flower, (F) gynoecium, (G) petals, (H) sepals. All from *A. Prajaksood & S. Suddee* 166 (**KKU**). Drawn by A. Prajaksood.

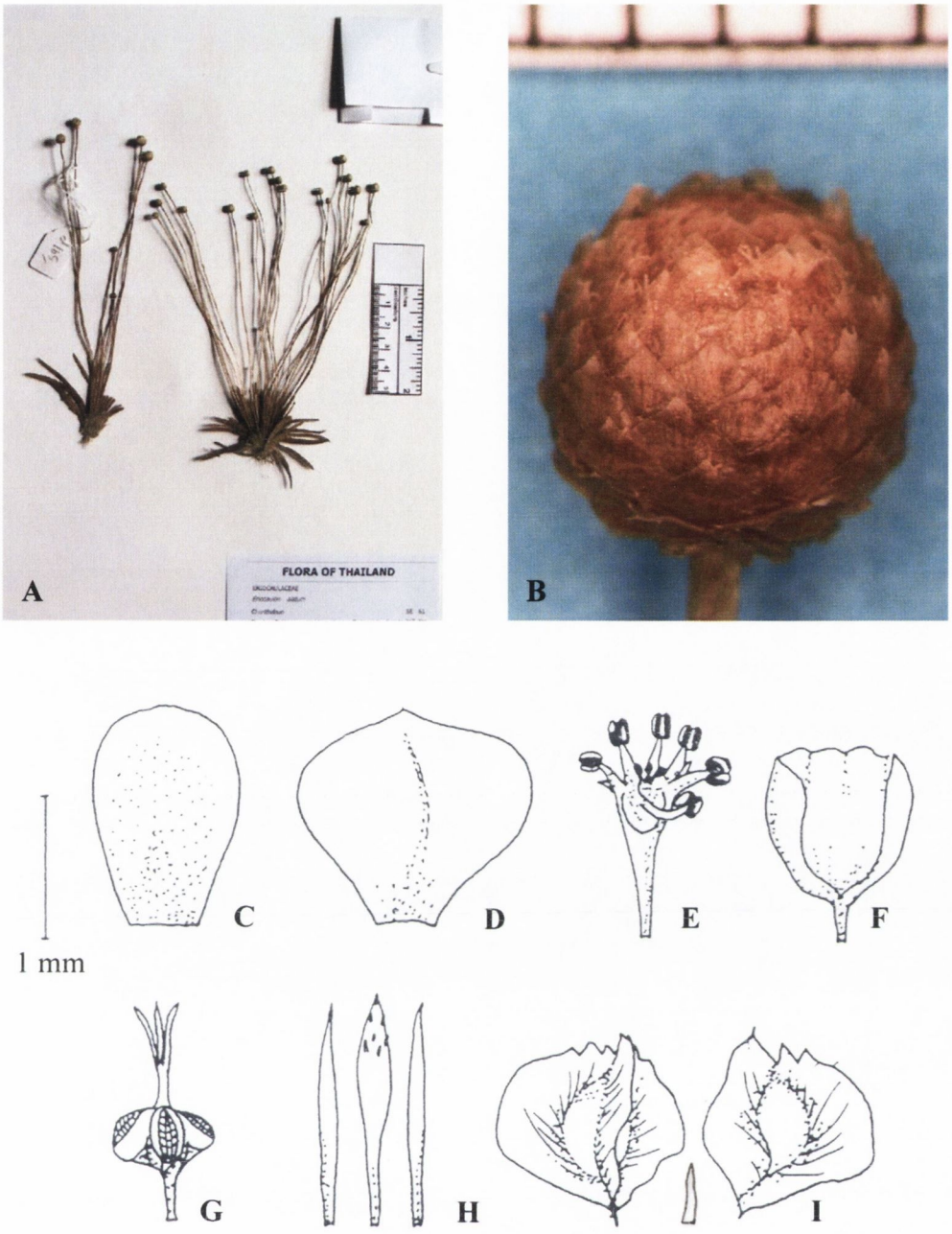

Figure 5.46 *Eriocaulon zollingerianum* Körn. (A) Habit. (B) Capitulum. (C) Involucral bract. (D) Floral bract. (E)-(F) Male flower, (E) androecium and petals, (F) sepals. (G)-(I) Female flower, (G) gynoecium, (H) petals, (I) sepals. All from *A. Prajaksood & S. Suddee* 165 (**KKU**). Drawn by A. Prajaksood.

5.4 Conclusion

The results from morphological study of Eriocaulaceae in Thailand can be summarised as follows.

5.4.1 The complete account of the family in Thailand and the identity of the unknown Thai taxa.

There is only one genus, *Eriocaulon*, of Eriocaulaceae found in Thailand which is composed of 45 taxa, belonging to 35 species (Table 5.2). The unknown Thai taxa which have been shown to be new to science comprise 15 taxa as follows: *E. chantaranothaii*, *E. chiangmaiense*, *E. chiangmaiense* ssp. *leucanthemum*, *E. hamiltonianum* var. *acuminatum*, *E. nautiliformoides*, *E. nautiliformoides* var. *hexagynum*, *E. parnellii*, *E. phatamense*, *E. phuchongense*, *E. phuphanense*, *E. phuphanoides*, *E. quinquangulare* var. *longibracteatum*, *E. siamense* var. *macrophyllum*, *E. siamense* ssp. *hexagynum* and *E. ubonense* var. *hexagynum*.

Three new combinations were made:- *E. nepalense* var. *luzulaefolium*, *E. sexangulare* var. *australe* and *E. ubonense* f. *kradungense*.

Additionally, 27 new synonyms within 10 taxa were reported:- (1) *E. dipsacoides* is a synonym of *E. escape*; (2) *E. barbayanum, E. yaoshanense, E. yaoshanense* var. *brevicalyx, E. cristatum* var. *brevicalyx, E. filifolium, E. mitophyllum, E. miserium* and *E. tokinense* are synonyms of *E. fluviatile*; (3) *E. zollingerianoides* is a synonym of *E. hamiltonianum*; (4) *E. nakayense, E. eglandulatum, E. gracile* var. *puberulentum* and *E. infirmum* var. *puberulentum* are synonyms of *E. infirmum*; (5) *E. laosense* var. *maxwellii* is a synonym of *E. laosense*; (6) *E. staintonii, E. caeruleum* and *E. nepalense* var. *laosense* are synonyms of *E. nepalense*; (7) *E. luzulaefolium, E. kathmanduense, E. pseudonepalense, E. papaunum* and *E. lepidum* are synonyms of *E. nepalense* var. *luzulafolium*; (8) *E. fergusonii* and *E. willdenovianum* var. *fergusonii* are synonyms of *E. sexangulare*; (9) *E. siamense* var. *leiophyllum* is a synonym of *E. siamense*; and (10) *E. kradungense* is a synonym of *E. ubonense* var. *kradungense*.

According to previous work on the family in Thailand, 59 taxa were reported from the country (Chapter 1, Table 1.1). However, it is noted that a number of these were misidentifications and synonyms, as follows:

E. achiton sensu Moldenke (1971) are actually *E. hamiltonianum*, *E. nepalense*, *E. nepalense* var. *luzulaefolium* and *E. truncatum*.

E. alatum is a synonym of *E. zollingerianum*.

E. alpestre sensu Moldenke (1971) is actually *E. nepaense* var. *luzualaefolium*.

E. australe is reduced to a new combination as *E. sexangulare* var. *australe*.

E. bassacense sensu Prajaksood (2000) is actually *E. xenopodium*.

E. christopheri sensu Prajaksood (2000) is actually a new species, *E. parnellii*.

E. cinereum sensu Moldenke (1971), some of the specimens are *E. hamiltonianum*.

E. dianae is a synonym of *E. heterolepis*, however, *E. dianae* sensu Moldenke (1971) are *E. quinquangulare* var. *longibracteatum* and *E. truncatum*.

E. dianae var. *longibracteatum* is a synonym of *E. heterolepis*, however, *E. dianae* var. *logibrateatum* sensu Moldenke (1971) are *E. hamiltonianum* var. *longibracteatum* and *E. quinquangulare* var. *longibracteatum*.

E. dipsacoides is a synonym of *E. escape*.

E. echinulatum var. *tenue* is a synonym of *E. echinulatum*.

E. eglandulatum is a synonym of *E. infirmum*.

E. henryanum sensu Moldenke (1971), some of the specimens are actually *E. infirmum, E. siamense* var. *macrophyllum, E. ubonense* var. *kradungense, E. nepalense* and *E. chiangmaiense*.

E. heterolepis sensu Prajaksood (2000) is actually *E. quinquangulare* var. *longibracteatum*.

E. hookerianum sensu Moldenke (1971) are *E. truncatum* var. *florensense* and *E. nepalense*, sensu Prajaksood (2000) is *E. henryanum*.

E. infirmum sensu Moldenke (1971), some of the specimens are *E. nepalense* var. *luzulaefolium*.

E. intermedium, *E. intermedium* var. *brevicaulae* and *E. intermedium* var. *glabrum* are synonyms of *E. setaceum*.

E. kathmanduense is a synonym of *E. nepalense* var. *luzulaefolium*.

E. kradungense is a synonym of *E. ubonense* f. *kradungense*.

E. lepidum is a synonym of *E. nepalense* var. *luzulaefolium*.

E. longifolium is an invalid name and the valid name is *E. willdenovianum*.

E. luzulaefolium is a synonym of *E. nepalense* var. *luzulaefolium*, however, *E. luzulaefolium* sensu Moldenke (1971), some of the specimens are *E. nepalense* and *E. quinquangulare* var. *longibracteatum*.

E. minimum sensu Prajaksood (2000) is actually *E. hamiltonianum*.

E. nakayense is a synonym of *E. infirmum*.

E. odoratum sensu Moldenke (1971) actually are *E. chiangmaiense, E. nautiliforme, E. phuphanense, E. phuphanoides* and *E. siamense* var. *macrophyllum*.

E. oryzetorum sensu Moldenke (1971), some of the specimens are *E. infirmum*.

E. pseudonepalense is a synonym of *E. nepalense* var. *luzulaefolium*.

E. quinquangulare sensu Moldenke (1971) and sensu Zhang (1999) are actaully *E. quinquangulare* var. *longibracteatum*.

E. reductum sensu Moldenke (1971) is actually *E. setaceum*.

E. robusto-brownianum sensu Moldenke (1971) is actually *E. ubonense* var. *kradungense*.

E. siamense var. *leiophyllum* is a synonym of *E. siamense*.

E. sollyanum sensu Moldenke (1971) are actually *E. nepalense* var. *luzualfolium* and *E. truncatum*.

E. soucherei sensu Moldenke (1971) is actually *E. hamiltonianum* var. *acuminatum*.

E. stellulatum sensu Moldenke (1971) are actually *E. hamiltonianum*.

E. tagawae is a synonym of *E. siamense*.

E. tokinense is a synonym of *E. fluviatile*.

E. truncatum sensu Moldenke (1971), some of the specimens are *E. hamiltonianum, E. nepalense* and *E. nepalense* var. *luzulaefolium*.

E. ubonense sensu Moldenke (1971), some of the specimens are *E. nepalense*.

E. willdenovianum sensu Moldenke (1971), some of the specimens are *E. sexangulare* var. *australe*.

E. zollingerianoides is a synonym of *E. hamiltonianum*.

Table 5.2 Distribution of *Eriocaulon* in Thailand. The seven floristic regions follow "Flora of Thailand, Volume 9 Part 1, 2005" (Appendix 6). N = northern, NE = north-eastern, E = eastern, SW = south-western, C = central, SE = south-eastern and PEN = peninsular, / = found in that region, - = not found in that region, * = endemic to Thailand.

No.	Taxa	N	NE	E	SW	C	SE	PEN
1	*E. brownianum*	/	/	/	-	-	-	/
2	*E. chantaranothaii**	/	/	-	-	-	-	-
3	*E. chiangmaiense**	/	-	-	-	-	-	-
4	*E. chiangmaiense* ssp. *leucanthemum**	-	/	-	-	-	-	-
5	*E. cinereum*	-	/	/	-	/	/	/
6	*E. cristatum*	/	-	-	-	-	-	-
7	*E. echinulatum*	/	/	/	-	/	/	/
8	*E. escape**	-	/	-	-	-	-	-
9	*E. fluviatile*	/	-	/	-	-	/	-
10	*E. hamiltonianum*	/	/	/	/	/	/	-
11	*E. hamiltonianum* var. *acuminatum**	/	/	/	-	-	-	-
12	*E. henryanum*	/	/	-	-	-	-	-
13	*E. infirmum*	/	/	/	/	-	/	/
14	*E. laosense*	-	/	/	-	/	/	-
15	*E. nautiliforme*	-	/	/	-	-	/	-
16	*E. nautiliformoides**	-	/	/	-	-	-	-
17	*E. nautiliformoides* var. *hexagynum**	-	-	/	-	-	-	-
18	*E. nepalense*	/	-	-	-	-	-	-
19	*E. nepalense* var. *luzulaefolium*	/	/	/	/	/	-	-
20	*E. oryzetorum*	/	-	-	-	-	-	-
21	*E. parnellii**	-	/	-	-	-	-	-
22	*E. phatamense**	-	/	/	-	-	-	-
23	*E. phuchongense**	-	-	/	-	-	-	-
24	*E. phuphanense**	-	/	-	-	-	-	-
25	*E. phuphanoides**	/	/	/	-	-	-	-
26	*E. pseudoescape**	-	/	-	-	-	-	-
27	*E. quinquangulare* var. *longibracteatum**	/	/	-	/	-	-	-

Table 5.2 Continued.

No.	Taxa	N	NE	E	SW	C	SE	PEN
28	*E. setaceum*	/	/	/	-	/	/	/
29	*E. sexangulare*	-	-	-	-	-	/	/
30	*E. sexangulare* var. *australe*	-	-	-	-	-	/	/
31	*E. siamense**	/	/	/	-	-	-	-
32	*E. siamense* var. *macrophyllum**	/	/	-	-	-	-	-
33	*E. siamense* ssp. *hexagynum**	-	-	/	-	-	-	-
34	*E. smitinandii**	-	/	/	-	-	/	/
35	*E. thailandicum**	/	/	/	-	-	/	/
36	*E. truncatum*	/	/	/	/	-	/	/
37	*E. truncatum* var. *florensense*	-	/	/	-	/	/	/
38	*E. ubonense*	-	/	-	-	-	/	/
39	*E. ubonense* f. *kradungense**	-	/	/	-	-	-	-
40	*E. ubonense* var. *hexagynum**	-	/	/	-	-	-	-
41	*E. wightianum*	-	-	-	-	-	/	-
42	*E. willdenovianum*	/	-	-	-	/	/	/
43	*E. xenopodium**	-	/	/	-	/	/	-
44	*E. xeranthemum*	-	-	-	-	/	/	/
45	*E. zollingerianum*	-	/	/	/	/	/	/
	Total number of taxa in each region	21	32	26	6	11	20	16

5.4.2 The distribution of *Eriocaulon* in Thailand

The distribution of forty-five taxa of *Eriocaulon* in Thailand has been elucidated as shown in Table 5.2, which contains twenty-two taxa which are endemic to Thailand. Most of the species which are endemic to Thailand have restricted distributions (found in less than 3 provinces within less than 3 floristic regions in Table 5.2) however, some do not and are found in at least 3 floristic regions in the country. The twenty taxa which have restricted distributions in Thailand are:-

(1) *E. chantaranothaii* is endemic to Thailand and restricted to Phitsanulok and Sakol Nakhon.

(2) *E. chiangmaiense* is endemic to Thailand and restricted to Chiang Mai.

(3) *E. chiangmaiense* var. *leucanthemum* is endemic to Thailand and restricted to Nong Khai.

(4) *E. cristatum* is restricted to Doi Langka, Chiang Rai.

(5) *E. escape* is endemic to Thailand and restricted to Phu Kradung, Loei.

(6) *E. henryanum* is restricted to Chiang Mai and Loei.

(7) *E. nautiliformoides* is endemic to Thailand and restricted to Nakhon Phanom and Ubon Ratchathani.

(8) *E. nautiliformoides* var. *hexagynum* is endemic to Thailand and restricted to Amant Charoen and Ubon Ratchathani.

(9) *E. nepalense* is restricted to Chiang Mai and Lampang.

(10) *E. oryzetorum* is restricted to Mae Hong Son and Chiang Mai.

(11) *E. parnellii* is endemic to Thailand and restricted to Phu Luang and Phu Kradung, Loei.

(12) *E. phatamense* is endemic to Thailand and restricted to Mukdahan and Ubon Ratchathani.

(13) *E. phuchongense* is endemic to Thailand and restricted to Ubon Ratchathani.

(14) *E. phuphanense* is endemic to Thailand and restricted to Phu Phan, Sakol Nakhon.

(15) *E. pseudoescape* is endemic to Thailand and restricted to Phu Kradung. Loei.

(16) *E. siamense* var. *macrophyllum* is endemic to Thailand and restricted to Phu Kradung, Loei; Thung Salaeng Luang, Phetchabun and Chiang Mai.

(17) *E. siamense* ssp. *hexagynum* is endemic to Thailand and restricted to Ubon Ratchathani.

(18) *E. ubonense* f. *kradungense* is endemic to Thailand and restricted to Thung Non Son, Phetchabun; Phu Kradung, Loei and Si Sa Ket.

(19) *E. ubonense* var. *hexagynum* is endemic to Thailand and restricted to Udon Thani and Ubon Ratchthani.

(20) *E. wightianum* is restricted to Chantaburi and Trat.

I note that *E. willdenovianum*, *E. sexangulare* and *E. sexangulare* var. *australe* have an overlapping distribution. All of them are found in the south-eastern and the peninsular regions. However, there is no record of *E. sexangulare* and *E. sexangulare* var. *australe* from the northern and the central regions, whereas *E. willdenovianum* is found in the northern region (Doi Phu Ka, Nan) and the central region (Khao Yai, Nakhon Nayok).

There are 10 taxa which have widespread distribution in Thailand (distributed in 5-6 floristic regions) these are: *E. cinereum, E. echinulatum, E. hamiltonianum, E. infirmum, E. nepalense* var. *luzulaefolium, E. setaceum, E. thailandicum, E. truncatum, E. truncatum* var. *florensense* and *E. zollingerianum*.

CHAPTER 6

GENERAL DISCUSSION

6.1 Introduction

The thesis focuses on providing a complete account of the Eriocaulaceae for the Flora of Thailand thereby resolving the identity of unknown Thai taxa in the family and investigating the relationships between Thai species using morphological, anatomical and molecular approaches. This section deals with general conclusions and issues that have arisen as a result of this work.

6.2 Species Diversity and Geographical Distribution of Eriocaulaceae in Thailand

To understand the diversity of Thai Eriocaulaceae, it is first important to consider its worldwide distribution. *Eriocaulon* is one of the most widespread genera in tropical and subtropical areas of the world (Stützel, 1998). Moldenke (1971) revised the family and recognized 439 species of *Eriocaulon* in the world. He also reported the number of endemic species of the genus found in various geographical regions. For example, he reported 20 species from Madagascar, 14 of which were endemic to the country; 61 species in Brazil, 51 (83%) of which were endemic species; nine species in Canada and the USA with no reported endemic species; 13 species in Mexico, six (46%) of which were endemic species; four species in Panama, three (75%) of which were endemic species; seven species in Guyana, two (29%) of which were endemic to the country.

Clearly, the rates of endemism are exceptionally high— perhaps suggesting that *Eriocaulon* is very closely adapted to its environment and ecology. Such high rates of endemism, could also alternatively, be due to the use of a rather narrow species concept, though I do not believe this to be the case. If such high rates of endemism do represent close adaptation of species to narrow niches then, necessarily, this has implications for the breeding biology of *Eriocaulon*. For speciation to occur, this has to be restriction of gene flow and therefore, given the gregarious growth of many *Eriocaulon* species, self-fertilization may be common. There are some observations by Stützel (1998) on pollinations of *Eriocaulon* but there have been no experiments done to test its breeding biology. Such experiments may, however, be very difficult or almost impossible to undertake given the very small size of the flowers and the close proximity of male and female flowers in the single inflorescence.

In Asia, *Eriocaulon* is only the genus of Eriocaulaceae present (Phillips, 1997). In India, Fyson (1919-1922) reported 51 species and Moldenke (1971) reported 65 species, 34 (52%) of which are endemic species. Recently, Ansari and Balakrishnan (1994) revised the family from India and also reported 65 species. Moldenke (1971) reported 20 species, 5 species and 7 species from Pakistan, Sikkim and Nepal, respectively, these species were also found in India. He also reported 23 species from Ceylon, 7 of which were endemic to the country. Phillips (1997) also revised the family for Ceylon and reported 21 species, 10 of which were endemic to the country and the remaining 11 species were also found in India. In Burma, Moldenke (1971) reported 18 species, 4 of which are endemic to the

country. In Japan, Satake (1940) reported 36 species. Moldenke (1971) reported 47 species, 31 of which were endemic. He also reported 32 species from China, 14 (44%) of which were endemic. Ma (1991) also revised the family in China and reported the same number of species.

Recently Zhang (1999) reported 74 species from eastern and southern Asia. Therefore, *Eriocaulon* has a great Asiatic concentration of species (Dahlgren *et al.*, 1985) and the rates of endemism appear comparable with those elsewhere.

Results obtained in Chapter 5 showed that there are 45 taxa of Eriocaulaceae (35 species) known from Thailand. 22 taxa (49%) are endemic, 15 of which have been proved to be new to Science (Table 5.2). Calculation of the ratio of the number of species found in Thailand to the total number of species in the genus (35/400), indicates that Thailand is not especially rich in *Eriocaulon* species, certainly by comparison with India with 65/400. However, Thailand does contain almost 10% of the species and is an important area of endemism and diversity.

Most of the Northeast floristic region in Thailand has a sandy soil, with many open places and lots of dry Dipterocarp forest. This conditions suit the growth of *Eriocaulon* and on the plain or plateau (Korat Plateau), it is easy for a collector to collect the plant. Therefore this region is the most species diverse in Thailand for *Eriocaulon* (32 taxa). In contrast, the North floristic region has a variety of moisture conditions and altitudes and a consequence diversity of vegetation ranging from moist evergreen forest, to gallery evergreen forest, to deciduous forest or even dry Dipterocarp forest (Gardner *et al.*, 2000). This area is characterized by mountains lying north-south. These mountains are a continuation of the western mountain ranges from the Southwest floristic region to Peninsular floristic regions (Graham, 1991); many areas are limestone rich (Gardner *et al.*, 2000). Additionally, the Southwest floristic region is characterized by evergreen forest and the Peninsular floristic region is characterized by rainforests (Graham, 1991), therefore their geography and ecology leads to a lower species diversity of the family in the North, Southwest and Peninsular floristic regions. However, the geography of the these areas also poses difficulty for the collectors in reaching or finding suitable sites; therefore, the lack of species diversity in these areas may result from a lack of collection. Certainly, Parnell *et. al.* (2003) showed that collecting density is generally low in many areas of Thailand.

6.3 Effect of Habitat on Habit of Eriocaulaceae

It is interesting that there are only two species of Eriocaulaceae in Thailand without a scape (*Eriocaulon escape* and *E. pseudoescape*); both are endemic to Phu Kradung at 1300 m altitude, Loei Province. There are also reports of very short scaped species of *Eriocaulon*, *i.e. E. distichoides* Mangen from Irian Java, Indonesia found in subalpine, Mountain Trikora, 3100 m altitude, (Mangen, 1986) and 10 species endemic to the alpine zone of New Guinea: *E. lustratum* P.Royen (scape 1-2 cm long) and *E. pioraense* P.Royen (scape 0.8 cm long) found in alpine bog, 2700-3200 m. altitude, *E.*

batholithicola P.Royen (scape 1-2 cm long) found in alpine grassland bog, 3300 m. altitude, Mountain Giluwe; *E. tubiflorum* P.Royen (scape 1-3 cm long), *E. alpinum* P.Royen (scape 1-1.5 cm long) and *E. pulvianatum* P.Royen (scape 0.8-1.4 cm long) found in alpine grassland, 3225-3560 m altitude, Mountain Wilhelmina; *E. montanum* P.Royen (scape 1-2 cm long) found in the alpine grassland in 3150-4000 m. altitude; *E. giluwense* P.Royen (scape 0.1-0.2 cm long) found in alpine bog, 3000-3800 m. altitude; *E. novoguineense* P.Royen (scape 0.7-2.5 cm long) found in montane to alpine grasslands, 2590-3680 m. altitude and *E. scorpionensis* P.Royen (scape 1-1.6 cm long) (Royen, 1979) or scape absent in *E. sessile* Meikle found in Dalaba plateau, 1225 m altitude, French Guinea, West Africa (Meikle, 1954). There are no short-scaped species of *Eriocaulon* reported from low altitude and therefore these above reports appear to indicate that the lack of a scape maybe on adaptation to high altitude.

6.4 Effect of Habitat on Anatomical characters of the Eriocaulaceae in Thailand

Eriocaulaceae comprise mostly swampy terrestrial species; *Eriocaulon setaceum* is the only submerged species found in Asia. My studies confirms that their anatomical characters (shown in chapter 3) reflect their ecology and comprise a mixture of terrestrial and hydromorphic uniforms.

The hydromorphic characters (Fassett, 1957) found in the family are:

1. Typically large epidermal cells
2. The thin fine cuticle on the epidermis
3. The presence of large networks of air spaces (lacunae)
4. The loosed cells in mesophyll in leaves and cortex in scapes
5. Mostly superficial or slightly raised stomata.

The terrestrial characters (Fassett, 1957) found in the family are:

1. Abaxial satomata
2. Adaxial xylem, abaxial phloem
3. Well developed xylem

The homogeneous mesophyll found in *E. parnellii* and *E. wightianum* is indicative of a submerged leaf anatomy (Fassett, 1957) though these are not submerged species; they grow in swampy areas. The hypodermis found in *E. siamense* var. *macrophyllum* and *E. xenopodium* indicates that the plants need a lot of water but their environment dries so quickly, that it is possible that the plants need to store the water and have evolved a hypodermis to help them do this.

The results obtained in chapter 3 showed that the anatomical characters in Eriocaulaceae are less important for identification because they dependant on their environment. However, there are only a few characters that are less influenced by environment and available for such analysis including the presence/absence of a hypodermis in leaves, the position of the vascular tissue in leaves, the presence/absence of homogenous mesophyll in leaves, the presence/absence of scapes and the presence of a chlorenchymatous band wider than the diameter of stele in scapes.

6.5 Grouping and relationships within Eriocaulaceae in Thailand and Further Studies

Dahlgren *et al.* (1985) stated that the family still needs much intensive investigation because information on it is based on a few, very incomplete studies. This thesis has gone some way to broaden our understanding of *Eriocaulon*.

Six groups from the 34 taxa of *Eriocaulon* are recognized using Phenetic analysis and five of which was neither supported or rejected, though the monophyly of group II, as defined by phenetic analysis, was also found in strict consensus trees of both phylogenetic analyses (using the *trnL-F* region and another using the *trnL-F* region combined with characters derived from morphological and anatomical dataset). However, the current study was carried out in a single geographic region (Thailand only). Therefore the grouping produced in phenetic and phylogenetic analyses in chapter 4 must be interpreted with care. Revision of *Eriocaulon* in neighbouring countries is essential to more accurately study their phylogeny. Even the results of my anatomical studies did not satisfactorily allow identification but their showed that there are lots of variation in anatomical characters within the family. Therefore, a revision of the Eriocaulaceae for the Flora of Cambodia, Laos and Vietnam is my next project.

Study of seed morphology is probably one of the most interesting avenues of research not included in this study but will be carefully observed in the future. As in recent years seed surface morphology in the family has been recognized as a useful taxonomic aid (Nair, 1987; Giulietti *et al.*, 1988, Phillips, 1994). During the morphological study, I noticed that in the same inflorescence of species in *Eriocaulon*, seed sculpturing does vary. For example, sometimes the sculpturing within a single species differs depending on whether the seed is in the water or not. Therefore, it is possible to question whether seeds are or are not good characters for identification. However, at a moment, I accept that the seed surface morphology is useful in distinguishing species as Phillips (1994) stated.

Co-operation between the few individuals' working on the Eriocaulaceae needs to be better organized. Only by such collaborative efforts can a large number of species found over a wide geographic range be tackled. The settle-up of a website for researchers on the family would be important and potentially very useful.

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APPENDIX 1

SPECIMENS EXAMINED IN MORPHOLOGICAL STUDIES

Eriocaulon brownianum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Smitinand T.	10703	BK,BKF	Loei	Phu Kradung, Huai Wang wang.	1300	?	5	1969
Chermsirivathana C.	1113	BK	Loei	Phu Luang.	1300	16	11	1968
Chayamarit K. et al	1466	BKF	Loei	Phu Luang Wildlife Sanctuary.		16	5	1998
Suvatabandhu K.	185	K, BK	Loei	Phu Kradung.	?	25	3	1948
D.J. Middleton, V. Chamchamroon, S. Lindsay, R. Pooma and S. Suwanachat	2004	TCD	Trang	Khao Banthat Mountains. Summit area of Phu Pha Mek. 7.26N, 99.51E	1240	7	4	2003
A.Prajaksood and S.Suddee	201	KKU,K, BK,BKF,TCD	Uttaradit	Phu Soi Dao National Park. On the plain at its summit. 17.75N, 100.95E	1633	17	10	2002
Kerr A.F.G.	20216	BK	Chaiyaphum	Phu Keio.	1000	22	2	1931
van Beusekom C.F. , Phengklai C., Geesink R. & Wongwan B.	4260	L,BKF	Chaiyaphum	Tungkamang. 16.20N, 101.45E	800	14	12	1971
Geesink R., Hattink T. & Phengklai C.	7048	P, AAU, K, L,BKF	Chaiyaphum	Tunkamung. 15.04N, 102.00E	850	29	5	1974
J. Parnell	98/23/JP	TCD	Loei	Phu Luang Wildlife Sanctuary. On trail around top; south of Kok Nok Krabi Ranger Station.17.16N, 101.31E	1600	26	10	1998
Wongprasert Th.	s.n.	BKF	Loei	Phu Luang Wildlife Sanctuary, Pha Somdet.	1400	13	12	1997
Wongpresert Th. et al	s.n.	BKF	Loei	Phu Luang Wildlife Sanctuary, Lone Tae.	1250	16	5	1998

Eriocaulon chanratanothaii

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Hansen B., Siedenfaden G. & Smitinand T.	11096	C,L,BKF	Phitsanulok	Tung Salaeng Luang.	500	10	2	1964
Hansen B., Siedenfaden G. & Smitinand T.	11099	K, C, AAU,L,BKF	Phitsanulok	Tung Salaeng Luang.	500	10	2	1964
A. Prajaksood & P. Chantaranothai	16	KKU,K,BK,BKF	Sakon Nakhon	Along the way to Pha Nang Mern-Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	9	11	1997
A. Prajaksood & P. Chantaranothai	2	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	7	11	1997
A. Prajaksood & P. Chantaranothai	22	KKU	Sakon Nakhon	Beside Wat Don Thammajadee temple, Koksrisuphun.	210	21	1	1998
A. Prajaksood & P. Chantaranothai	23	KKU	Sakon Nakhon	Beside Wat Don Thammajadee tempie, Koksrisuphun.	210	21	1	1998
A. Prajaksood & P. Chantaranothai	24	KKU,K,BK,BKF	Sakon Nakhon	Beside Wat Don Thammajadee temple, Koksrisuphun.	210	21	1	1998
A. Prajaksood & P. Chantaranothai	26	KKU,K,BK,BKF	Sakon Nakhon	Near the Phu Phan Palace.	300	21	1	1998
A. Prajaksood & P. Chantaranothai	27	KKU,K, BK,BKF,TCD	Sakon Nakhon	Beside Wat Don Thammajadee temple, Koksrisuphun.	210	21	1	1998
A.Prajaksood and S.Suddee	321	KKU,K, BK,BKF,TCD	Sakon Nakhon	Phu Phan National Park, Pha Nang Muen-Tam Chan route. 17.05N, 104.00E		11	11	2002
A. Prajaksood & P. Chantaranothai	42	KKU,K, BK,BKF,TCD	Sakon Nakhon	Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	31	10	1998
A. Prajaksood & P. Chantaranothai	51	KKU,K, BK,BKF,TCD	Sakon Nakhon	Hui Wian Prai, Phu Phan National Park.	210	1	11	1998
Umpai	607	BK	Sakon Nakhon	Phu Phan Rajanivach.	?	10	12	1980
A. Prajaksood & P. Chantaranothai	66	KKU,K, BK,BKF,TCD	Mukdahan	Summit of Phu Pha Terb, Mukdahan Nation nal Park.	-	12	11	1998
A. Prajaksood & P. Chantaranothai	70	KKU,K, BK,BKF,TCD	Mukdahan	Lann Phu Wat, Phu Sra Dok Bua National Park.	-	13	11	1998
Chantaranothai P. & Parnell J.	90/724	TCD,KKU	Sakon Nakhon	Phu Phan National Park, Park HQ to Lann Sao.	?	14	10	1990
Wongprasert Th.	s.n.	BKF	Mukdahan	Phu Sa Dok Bua National Park, Dontan District.	350	26	10	1998
Wongprasert Th. et al	s.n.	BKF	Nakhon Phanom	Ban Phaeng District.	120	30	10	1998
Santisuk T. & Wongprasert Th.	s.n.	BKF	Sakon Nakhon	Phu Phan Royal Palace.	250	12	12	1997
Sahas	s.n.	BKF	Sakon Nakhon	Phu Phan Palace.	200	-	11	1997
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-50825	BKF	Mukdahan	Phu Hin Turb. Roky hill, ca 18 km S of Mukdahan city. 16.29N, 104.43E	?	17	11	1984

Eriocaulon chiangmaiense

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Hansen B., Seidenfaden G. & Smitinand T.	10814	C,AAU,L,BKF	Chiang Mai	Om Koi.	900	20	1	1964
Hansen B., Seidenfaden G. & Smitinand T.	10976	K,C,E,AAU,L,BKF	Chiang Mai	5 km west of Bo Luang, Mae Cham, Doi Inthanon.	1100	29	1	1964
Koyama T., Phengklai C., Niyomdham C., Tamura M., Okada H. & O' Connor P.J.	15481	BKF,NY	Chiang Mai	Mae Sanam. Pine Improvement Center.	?	22	2	1979
Sorensen Th., Larsen K. & Hansen B.	7049	C,L	Chiang Mai	5 km west of Bo Luang, Mae Cham, Doi Inthanon.	1020	26	2	1959
Smiles J.H.	s.n.	K	?	Northern Siam. Grass on Plain of Mountain Ngat in moist places.	?	14	4	1893
Koyama H., Terao H. & Wongprasert Th.	T-32216	GH	Chiang Mai	Along route 1099, Om Koi District.	1050-1150	10	1	1983
Koyama H.	T-62201	BKF	Chiang Mai	Om Koi tableland, near Om Koi.	1100	13	1	1994

Eriocaulon chiangmaiense ssp. leucanthemum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*
Smitinand T.	10091	K,C, BKF	Nong Khai	Bueng Karn, Huay Poo.	100	17 11 1966

Eriocaulon cinereum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
P. Thubthimthong	1	KKU,TCD	Nong Khai	Prachasongkhlor Dek Chai, Ban Nong Song Hong, Muang District.	-	31	12	1997
Chantaranothai P., Klinhom U., Simpson D., Simpson R. , Pawaputanon na Mahasarakham P. & Thammathaworn A.	1612a	K	Maha Sarakham	Nadoon, vicinity of Walai Rukhavej Botanical Research Institute. 15.46N, 102.15E	200	31	10	1994
Chermsirivathana C.	209	BK	Khon Kaen	Ban Nawng Kung, Sila, growing in paddy field.		22	12	1964
A. Prajaksood & P. Chantaranothai	25	KKU	Khon Kaen	Beside the pond along the road number 209.		21	1	1998
A. Prajaksood & P. Chantaranothai	32	KKU,K, BK,BKF,TCD	Na khon Nayok	Along the way to Hel Narok Waterfall, 2.9 km from the headquarters of Khao Yai National Park.	-	21	10	1998
A.Prajaksood and S.Suddee	339	KKU,K, BK,BKF,TCD	Nakhon Nayok	Khao Yai National Park. Route 2090 from HQ to Km 40, 14.40N, 101.40E		28	9	2002
A. Prajaksood & P. Chantaranothai	36	KKU,K, BK,BKF,TCD	Na khon Nayok	Along the way to Hel Suwat Waterfall, Khao Yai National Park.	-	21	10	1998
Vesterdal A.	465	C	Chanthaburi	Siam	?	25	8	1937
Umpai	526	BK	Bangkok	Klong Luang, Rangsit, Ya Hua Ngok.		20	11	1974
A. Prajaksood & P. Chantaranothai	65	KKU,K, BK,BKF,TCD	Nakhon Phanom	Along the road number 2033 (Ray Nu Nakhon-Na gae), near Ban Nong Hoi Noi.	-	12	11	1998
Maxwell J.F.	73-457	AAU,BK	Saraburi	Sahm Lahn forest, Muang dist	?	13	10	1973
Suthisorn S.	746	BK	Khon Kaen	Nam Phong.		7	12	1965
A. Prajaksood & P. Chantaranothai	77	KKU,K, BK,BKF,TCD	Ubon Rachathani	Along the road number 2112, 35 km further to Pha Tam, Sri Muang Mai District.	-	13	11	1998
Sorensen Th., Larsen K. & Hansen B.	784	L, C	Phangnga?	Between Thai Moang ang Thungmaprao. Small lake.	150	29	1	1958
A. Prajaksood & P. Chantaranothai	80	KKU,TCD	Ubon Ratchathani	Pha Tam National Park on the road number 2112. Khong Chiam District.	-	13	11	1998
Maxwell J.F.	85-738	GH,L,BKF	Songkhla	Chana Dist, c. 2 km NE of Chana along highway 43.	s.l.	20	7	1985
Chantaranothai P., Middleton D., Parnell J. & Simpson D.	887	KKU,TCD	Nakhon Panom	On dried out river-bed, between Ban Teng and That Phanom. 16.55N, 104.40E	?	24	2	1993
Kerr A.F.G.	9443	BK	Trat	Kao Saming.	20	27	11	1924
Srisurang	s.n.	BK	Khon Kaen	Banphai. .		14	11	1971
s.n.	s.n.	BK	Supan Buri	Supanburi Rice Experiment Station.	?	16	12	1973
Kasetsart Graduate Students in Advanced Weed Control	s.n.	BK	Supan Buri	Supanburi Rice Experiment Station, weed in the rice field.	?	12	12	1973
Murata G., Phengklai C., Mitsuta S., Nagamasu H. & Nantasan N.	T-52168	BKF	Ubon Ratchathani	Nong Khon and Nam Yeun, ca. 90 km SSE of Ubon Ratchathaini city. 14.37N, 105.12E	180	11	10	1984

Eriocaulon cristatum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Garrett H.B.G.	1106	E, K, P, TCD, L	Chiang Rai	Doi Langka. Top of the Kiu Luang.	1760	31	10	1938

Eriocaulon echinulatum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Smitinand T.	10092	BKF	Nong Khai	Bueng Karn, Huay Poo.	100	17	11	1966
A. Prajaksood & P. Chantaranothai	103	KKU,TCD	Ubon Ratchathani	Along the road at 4th km of the road number 2112, 10 km further to Khong Chiam.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	107	KKU,TCD	Ubon Ratchathani	Along the road at 4th km of the road number 2112, 10 km further to Khong Chiam.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	11	KKU,TCD	Sakon Nakhon	Along the way to Pha Nang Mern-Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	9	11	1997
Hansen B., Siedenfaden G. & Smitinand T.	11097	BKF	Phitsanulok	Tung Salaeng Luang.	500	10	2	1964
Umpai	113	BK	Loei	Phu Kradung.	1300	15	12	1963
Smitinand T. & Larzarides M.	11380	BK,BKF	Rayong	Between Rayong-Chantaburi.	20	22	11	1970
A. Prajaksood & P. Chantaranothai	125	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Anodad pond.	1300	16	11	1998
A. Prajaksood & P. Chantaranothai	128	KKU,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Wang Kwang Waterfall.	1300	17	11	1998
Kerr A.F.G.	13704	BK	Satun	Open grassy ground.	5	28	12	1927
A. Prajaksood & P. Chantaranothai	141	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Than Sawan Waterfall and Tham Saw Noer.	1300	18	11	1998
A. Prajaksood	150a	KKU,K, BK,BKF,TCD	Trang	Tungkai Swamp Forest, along footpaths from accommodation to swamp forest.	-	21	3	1999
A. Prajaksood	150b	KKU,TCD	Trang	Tungkai Swamp Forest, along footpaths from accommodation to swamp forest.	-	21	3	1999
Chantaranothai P., Simpson D., Simpson R. & Thammathaworn A.	1591	K	Udon Thani	Phu Phra Bat. 17.20N, 102.30E	?	27	10	1994
Chantaranothai P., Simpson D., Simpson R. & Thammathaworn A.	1650	K	Sakon Nakhon	Phu Phan National Park, trail N of Park HQ. 17.02N, 103.57E	250	1	11	1994
A.Prajaksood and S.Suddee	168	KKU,K, BK,BKF,TCD	Chanthaburi	Tambon Putthawee, Makham district. By the side of route 317, Km 18-19, Khao Soi Dao-Makham route. A seasonal pond in front of a shooting rage of a Marine Department. 12.70N, 102.20E		5	10	2002
A.Prajaksood and S.Suddee	174	KKU,K, BK,BKF,TCD	Trat	Ban Saphanhin Tambon Laem Glad, Muang District. Near Wat Saphanhin, Laem Glad junction. Route 318, Muang-Klong Yai. 12.20N, 102.40E		5	10	2002
A.Prajaksood and S.Suddee	186	KKU,TCD,BKF,K,BK	Trat	By the side of the road, Km 49-50 route 3157, on the way to Klong Kaew Waterfall National Park. About 50 m from the check point.12.60N, 102.60E		8	10	2002
A.Prajaksood and S.Suddee	192	KKU,K, BK,BKF,TCD	Trat	Tambon Bo Ploy, Bo Rai District. By the side of the road, route 3389, on the way to Klong Kaew Waterfall National Park. 12.60N, 102.60E		8	10	2002
Smitinand T.	1934	K,BK,BKF	Loei	Phu Kradung.	1300	17	9	1954

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Put	1947	BK	?	Watana nakhon.	?	15	10	1928
J.A.N. Parnell, K. Chayamarit, R. Pooma, D.A. Simpson, S. Suddee, B. De Wilde	1956	BKF,K,TCD	Trang	Yan Ta Khao, Thung Khai Botanic Garden. 07.27N, 99.40E	10	31	1	2002
A.Prajaksood and S.Suddee	197	KKU,TCD,BKF,K	Trat	Ban Toktuk, Tambon Sator, Khaosaming District. By the side of the road, route 3157 from Klong Kaew Waterfall National Park to Pliew Waterfall National Park, Km 16-17. 12.30N, 102.35E		8	10	2002
Smitinand T.	1983	K,BK,BKF	Loei	Phu Kradung.	1300	29	9	1954
A.Prajaksood and S.Suddee	207	KKU,K, BK,BKF,TCD	Phetchabun	Thung Non Son, Thung Salangluang National Park. Tambon Nongmaena, Khao Khor District. On the plain at its summit. 16.60N, 100.80E		20	10	2002
A.Prajaksood and S.Suddee	213	KKU,K, BK,BKF,TCD	Loei	Phu Rua National Park. On the plain at its summit. 17.27N, 101.22E	1365	31	10	2002
van Beusekom C.F. & Smitinand T.	2143	C,E, AAU,K,L,GH	Chanthaburi	Foot of Khao Soi Dao. 13.00N, 102.15E	400	12	11	1969
A.Prajaksood and S.Suddee	215	KKU,K, BK,BKF,TCD	Loei	Phu Rua National Park, Tambon Nongbua, Phu Rua District. On the plain at its summit. Suan Hin Pha Lee. 17.27N, 101.22E	1365	31	10	2002
A.Prajaksood and S.Suddee	219	KKU,K, BK,BKF,TCD	Loei	Phu Rua National Park, Tambon Nongbua, Phu Rua District. On the plain at its summit. Hin San Chun waterfall-Lan Hin Tag route. 17.27N, 101.22E	1365	31	10	2002
A.Prajaksood and S.Suddee	222	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Tent area- Lan Wat Pra Kaew route. By the side of the path. 16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	230	KKU,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Tent area- Wang Kwang waterfall route. By the side of the path.16.90N, 101.80E	1300	1	11	2002
Chermsirivathana C.	233	BK	Udon Thani	Ban Nakha.		24	12	1964
A.Prajaksood and S.Suddee	236	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Phone Phoob waterfall - Pra Bhuddha Matta route. By the side of the path. Pine forest.16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	256	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Phu Chong Nayoy National Park, Tambon Nacharuey, Nacharuey District. Phalanphachad, Dipterocarp forest. 14.50N, 105.30E		8	11	2002
A.Prajaksood and S.Suddee	270	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Ban Udomsuk, Tambon Kudprathai, Dacha Udom District. By the side of the road route 2172, Km 26-27. 14.98N, 105.33E		8	11	2002
A.Prajaksood and S.Suddee	273a	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Tambon Kudchumpoo, Phimulmungsahan District. By the side of the road route 217, Km 51-52. 15.15N, 105.30E		8	11	2002
A.Prajaksood and S.Suddee	273b	KKU	Ubon Ratchathani	Tambon Kudchumpoo, Phimulmungsahan District. By the side of the road route 217, Km 51-52.		8	11	2002
A.Prajaksood and S.Suddee	283	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khong Chium District. By the side of the road route 2112, Km 4. 15.35N, 105.55E		8	11	2002
A.Prajaksood and S.Suddee	298	KKU,K, BK,BKF,TCD	Ubon Ratchathani	By the side of the road route 2112, Km 20-21, Phatam-Khammarach route. 15.58N, 105.55E		8	11	2002
A. Prajaksood & P. Chantaranothai	3	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	7	11	1997
A.Prajaksood and S.Suddee	303	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Ubon Ratchathani Forest Department, Khong Chium District. By the side of the road route 2112, Km 100-101. 16.05N, 105.15E		8	11	2002

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A.Prajaksood and S.Suddee	306	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khammarach District. By the side of the road route 2242, Km 10-11. 16.05N, 105.15E		8	11	2002
A.Prajaksood and S.Suddee	322	KKU,K, BK,BKF,TCD	Sakon Nakhon	Phu Phan National Park, Tambon Huey Yang, Muang District. Pha Nang Muen-Tam Chan route. Dipterocarp forest. 17.05N, 104.00E		11	11	2002
Bunpheng D.	324	K,BK,BKF	Loei	Phu Kradung.	1300	13	8	1950
Smitinand T.	3678	BK, BKF	Chanthaburi	On trail between Makham and Khao Klua.	100	29	11	1956
Smitinand T.	3695	K, BKF	Chanthaburi	Makham, Okphok.	50	25	10	1956
A. Prajaksood & P. Chantaranothai	37	KKU,K, BK,BKF,TCD	Na khon Nayok	Along the way to Hei Suwat Waterfall, 4.2 km from the headquarters of Khao Yai National Park.	-	21	10	1998
A. Prajaksood & P. Chantaranothai	41	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way from headquarters to Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	31	10	1998
van Beusekom C.F. , Phengklai C., Geesink R. & Wongwan B.	4373	L,BKF	Chaiyaphum	Tungkamang. Border of dry dipterocarp forest and dry evergreen forest. 16.20N, 101.45E	800	16	12	1971
van Beusekom C.F. , Phengklai C., Geesink R. & Wongwan B.	4590	C,P,K,L,BKF	Loei	Phu Kradung.	1300	25	12	1971
Charoenphol Ch., Larsen K. & Warncke E.	4693	E,AAU,K,L,BKF	Loei	Phu Kradung, South of Loei. 16.53N, 101.53E	1100	7,8,9	11	1970
A. Prajaksood & P. Chantaranothai	49	KKU,K, BK,BKF,TCD	Sakon Nakhon	The barren sandstone along the seasonal small stream at Hui Wian Prai, Phu Phan National Park.	210	1	11	1998
Vesterdal A.	5-E	C	Chanthaburi	East Siam.	?	?	?	1936
A. Prajaksood & P. Chantaranothai	60	KKU,K, BK,BKF,TCD	Nong Khai	Tham Phun Waterfall, Phu Wau National Park.	-	11	11	1998
Sorensen Th., Larsen K. & Hansen B.	6325	GH,C,L,BKF	Loei	Phu Kradung.	1200	29	11	1958
A. Prajaksood & P. Chantaranothai	67	KKU,TCD	Mukdahan	Summit of Phu Pha Terb, Mukdahan Nation nal Park.	-	12	11	1998
Smitinand T.	7153	BKF	Satun	Thung Kai.	50	13	2	1961
Maxwell J.F.	71-564	AAU,BK	Chanthaburi	Chanthaburi	?	17	10	1971
Sorensen Th., Larsen K. & Hansen B.	7257	C	Chanthaburi	Plain of Makam, near Chantaburi.	50-100	12	1	1958
Smitinand T.	8397	BKF	Prachin Buri	Thung Phoh.	20	7	11	1963
A. Prajaksood & P. Chantaranothai	84	KKU,K,BK,BKF	Ubon Ratchathani	Besides the bridge of 26 km further to Pha Tam National Park on the road number 2112. Khong Chiam District.	-	13	11	1998
Smitinand T.	8442	K, BKF	NaKhon Phanom	On the way to That Phanom. Herb, brownish flowers, common in cleary.	150	16	12	1963

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Maxwell J.F.	87-159	GH,L,BKF	Surat Thani	Tachang Dist, Ban Tahsae, Klong Sai Subdistrict.	10	5	2	1987
Maxwell J.F.	87-48	GH,L,BKF	Chumphon	Muang,Ban Huay Gayo.	5	15	1	1987
A. Prajaksood & P. Chantaranothai	90	KKU,TCD	Ubon Ratchathani	Along the way Pha Mon to Car Park, Pha Tam National Park.	-	14	11	1998
Chantaranothai P. & Parnell J.	90/723	TCD,KKU	Sakon Nakhon	Phu Phan National Park, Park HQ to Lann Sao.	?	14	10	1990
Kerr A.F.G.	9433	BK	Trat(Krat)	Kao Saming.	20	26	11	1924
A. Prajaksood & P. Chantaranothai	95	KKU,K,BK,BKF	Ubon Ratchathani	Under the bridge, 5 km from Pha Tam National Park.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	BRT 750	KKU,K,BK,BKF	Sakol Nakhon	Along the way from Evergreen forest to open area of Ang Kob, Phu Phan National Park. 07.04N, 103.60E	210	3	10	1997
Tagawa M., Iwasuki K. & Fukuoka N.	T 546A	BKF	Loei	Phu Kradung. On the plain of its summit.	1100-1200	28	11	1965
Shimizu T., Toyokuni H., Koyama H., Yahara T. & Niyomdham C.	T-22770	BKF	Loei	Phu Kradung.	1250-1280	15	11	1979
Shimizu T., Toyokuni H., Koyama H., Yahara T. & Niyomdham C.	T-22869	BKF	Loei	Phu Kradung.	1250-1280	15	11	1979
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-40183	BKF	Loei	Phu Kradung. Along trail to the headquater of National Park. 16.52N, 101.50E	900-1200	30	10	1984

Eriocaulon escape

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	118	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Anodad pond.	1300	16	11	1998
A. Prajaksood & P. Chantaranothai	130	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Wang Kwang Waterfall.	1300	17	11	1998
A. Prajaksood & P. Chantaranothai	147	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Tham Saw Noer to Pha Yeab Make.	1300	18	11	1998
Kerr A.F.G.	20417	BK	Loei	Phu Kradung, on bare patches of ground.	1200	12	3	1931
A.Prajaksood and S.Suddee	221	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Tent area- Lan Wat Pra Kaew route. By the side of the path. Pine forest. 16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	231	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Tent area- Wang Kwang waterfall route. By the side of the path. Pine forest. 16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	240	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Phone Phoob waterfall - Pra Bhuddha Matta route. Seasonal pond by the side of the path, the right hand side of Statue. Pine forest. 16.90N,	1300	1	11	2002
Charoenphol Ch., Larsen K. & Warncke E.	4607	AAU	Loei	Phu Kradung, South of Loei. 16.53N, 101.53E	1100	7,8,9	11	1970
Smitinand T.	s.n.	BKF	Loei	Phu Kradung.	1300	-	12	1973
Tagawa M., Iwasuki K. & Fukuoka N.	T 779	P, BKF	Loei	Phu Kradung, on the plain at its summit.	1200	29	11	1965

Eriocaulon fluviatile

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Kerr A.F.G.	17776	BK	Trat	Kao Krap, in wet ground at edge of stream.	700	25	12	1929
Kerr A.F.G.	8185	BK	Nakhon Ratchasima	Katok, growing on edge of water.	400	30	12	1923
Smitinand T.	89-41	BKF	Chiang Rai	Pang Tong.	1000	2	12	1989
Smitinand T.	89-42	BKF	Chiang Rai	Pang Tong.	1000	2	12	1989

Eriocaulon hamiltonianum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
K. Phoonphong & P. Phornphongroongrueng	1	KKU,TCD	Khon Kaen	Kok Phu Taka, Phu Wieng.	-	20	10	1998
A. Prajaksood & P. Chantaranothai	101	KKU,BK,BKF	Ubon Ratchathani	Along the road at 4th km of the road number 2112, 10 km further to Khong Chiam.	-	14	11	1998
Hosseus C.C.	102	M	?	Wang Djao.	100	14	10	1904
Hossens C.C.	102a	L	Kamphaeng Phet	Wang-Djao, W.S.W. Savannenwald, hanfig.	?	14	10	1904
Hansen B., Seidenfaden G. & Smitinand T.	10839	C	Chiang Mai	Om Koi.	900	20	1	1964
A. Prajaksood & P. Chantaranothai	113	KKU,K,BK,BKF	Ubon Ratchathani	Along the road, Ban Hau Kon, Pho Sri District. 10 km from crossroad of road number 2112 to Phimolmungsakan District.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	12	KKU,TCD	Sakon Nakhon	Along the way to Pha Nang Mern-Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	9	11	1997
Adisai	136	BK	Sakon Nakhon	Lardkracheir.	?	23	12	1962
Franck C.W.	1463	C	?	North Siam. Den Laya	?	?	10	1929
A. Prajaksood & P. Chantaranothai	156	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way from headquarters to Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	31	10	1998
Franck C.W.	184	C	?	North Siam. Den Laya	?	2	10	1929
Phernchit	1932	BKF	Sakon Nakhon	Lard Ka cher, Phu Pan National Park.	?	22	11	1962
A.Prajaksood and S.Suddee	246	KKU,TCD	Surin	Ban Klongnamsub, Tambon Nangmood, Kabcherng District. By the side of the road route 2121, Km 18-19. 14.45N, 103.40E		7	11	2002
Chermsirivathana C.	249	BK	Khon Kaen	Ban Rua, Pa Weing.	?	26	12	1964
A.Prajaksood and S.Suddee	250	KKU,K, BK,BKF,TCD	Si Sa Ket	Tambon Samrongplan, Pribueng District. By the side of the road route 24, Km 237. 14.65N, 104.30E		7	11	2002
van Beusekom C.F. & Phengklai C.	2517B	K	Chiang Mai	Bo Luang Tableland. 18.45N, 98.25E	1000	14	12	1969
A.Prajaksood and S.Suddee	263	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Boontharik District. By the side of the road route 2182, Km 36-37. 14.78N, 105.40E		8	11	2002
A.Prajaksood and S.Suddee	267	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Ban Udomsuk, Tambon Kudprathai, Dacha Udom District. By the side of the road route 2172, Km 26-27. 14.98N, 105.33E		8	11	2002
A.Prajaksood and S.Suddee	279	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khong Chium District. By the side of the road route 2222, Km 6-7. 15.30N, 105.50E		8	11	2002
Pooma R., de Widle W.J.J.O., Duyfjes B.E.E., Chamchunroon V. & Phattarahirankanok K.	2888	BKF	Nong Khai	Tha Sa-ad, Se Ka District. KM 77 road no. 222. 18.19N, 103.43E	160	28	8	2001

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Smitinand T.	3065	BKF	Loei	Wangsaphung, Sithan.	300	17	10	1955
A.Prajaksood and S.Suddee	311	KKU,K, BK,BKF,TCD	Mukdahan	Tambon Kamphalai, Muang District. By the side of the road route 212, Km 177-178. 16.32N, 104.43E		10	11	2002
A.Prajaksood and S.Suddee	314	KKU,K, BK,BKF,TCD	Sakon Nakhon	Phu Phan National Park, Tambon Huey Yang, Muang District. Pha Nang Muen-Tam Chan route. Dipterocarp forest. 17.05N, 104.00E		11	11	2002
A.Prajaksood and S.Suddee	316	KKU,K, BK,BKF,TCD	Sakon Nakhon	Phu Phan National Park, Tambon Huey Yang, Muang District. Pha Nang Muen-Tam Chan route. Dipterocarp forest. 17.05N, 104.00E		11	11	2002
Larsen K.,Larsen S.S., Nielsen I. & Santisuk T.	32341	AAU,BKF	Trat	18 km N of Klong Yai. 11.50N, 102.48E	s.l.	2	9	1972
A.Prajaksood and S.Suddee	324	KKU,K, BK,BKF,TCD	Sakon Nakhon	Phu Phan National Park, Tambon Huey Yang, Muang District. Lan Sao Ae-Pha Nang Muen route. Dipterocarp forest. 17.05N, 104.00E		11	11	2002
Phengklai C. et al.	3474	GH,BKF	Buri Ram	Buriram.	130	27	11	1976
A. Prajaksood & P. Chantaranothai	39	KKU	Nakhon Nayok	Along the way to Hel Suwat Waterfall, 4.2 km from the headquarters of Khao Yai National Park.	-	21	10	1998
A. Prajaksood & P. Chantaranothai	44	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way from headquarters to Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	31	10	1998
Sorensen Th., Larsen K. & Hansen B.	5345	GH,C	Chiang Mai	Doi Suthep.	450	30	9	1958
Sorensen Th., Larsen K. & Hansen B.	5626	C,L,BK,BKF	Chiang Mai	Mae Tang. Dipterocarp-tuberc. Forest.	450	12	10	1958
Sangkhachand B.	571-C	BKF	Chanthaburi	Pong nam ron, Ban Ta Rueang.	200	5	12	1956
Sorensen Th., Larsen K. & Hansen B.	5899	C	Chiang Mai	Doi Suthep.	?	25	10	1958
A. Prajaksood & P. Chantaranothai	6	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	7	11	1997
A. Prajaksood & P. Chantaranothai	63	KKU,K, BK,BKF,TCD	Nakhon Phanom	Along the road number 2033 (Ray Nu Nakhon-Na gae), near Ban Nong Hoi Noi.	-	12	11	1998
Maxwell J.F.	75-1067	AAU,L,BK	Chon Buri	Kow Kieo, Siricha Dist.	75	15	11	1975
A. Prajaksood & P. Chantaranothai	76	KKU,K, BK,BKF,TCD	Ubon Rachathani	Along the road number 2112 (Khe marat- Pha Tam), near Ban Na Pa Nieng Or, Pho Sai District.	-	13	11	1998
Larsen K.	8070	C	?	Ban Kao.	?	8	11	1961
A. Prajaksood & P. Chantaranothai	82	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Besides the bridge of 26 km further to Pha Tam National Park on the road number 2112. Khong Chiam District.	-	13	11	1998
Smitinand T.	8395	BK,BKF	Prachin Buri	Thung Poh.	20	7	11	1963
Smitinand T.	8396b	BKF	Prachin Buri	Thung Phoh.	20	7	11	1963

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Larsen K.	8397	C		Ban Kao-Ban Ta Kien.	70	27	11	1961
Larsen K.	8402	C		Between Ban Kao & Ban Ta Kien	70	27	11	1961
Larsen K.	8425	C	?	Ban Kao.	70	28	11	1961
Smitinand T.	8473	K,BKF	Nakhon Phanom & Sakon Nakhon	Nakhon Pranom-Sakon Nakhon.	150	18	12	1963
Maxwell J.F.	87-1416	L,BKF	Chiang Mai	Doi Suthep, East side, above Pah Ngeub.	500	14	11	1987
Maxwell J.F.	88-1136	AAU,BKF	Chiang Mai	Mae Rim. Huay Deung Tau, NE side of Doi Suthep.	400	28	9	1988
Maxwell J.F.	94-1153	GH,BKF	Lamphun	Mae Tah Dist. Doi Kuhn Dahn National Park, Bah Dteung Station- Khun Dahn Village trail, along the railroad tracks.	575	30	10	1994
A. Prajaksood & P. Chantaranothai	96	KKU	Ubon Ratchathani	Under the bridge, 5 km from Pha Tam National Park.	-	14	11	1998
Shimizu T., Toyokuni H., Koyama H., Yahara T. & Niyomdham C.	T-19528	BKF	Nakhon Nayok	Khao Yai National Park. Tropical rain forest near the Orchid water fall. At humid locality by the stream.	650	8	10	1979
Shimizu T., Toyokuni H., Koyama H.,Yahara T. & Niyomdham C.	T-21888c	L,BKF	Kanchanaburi	Rintin Forest, Thong Pha Phum District.	210	6	11	1979
Shimizu T., Toyokuni H., Koyama H., Yahara T. & Niyomdham C.	T-22203	BKF	Uthai Thani	Near the entrance of Huay Kha Kaeng Wildlife Sanctuary, Larn Suk District.	280	11	11	1979
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-49783a	BKF	Sakon Nakhon	Phu Phan National Park, ca. 30 km. Sw. of Sakol Nakhon city. Along road in dipterocarp forest to small water fall.	380	13	11	1984
Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-50440	BKF	Sakon Nakhon	Phu Pan National Park, 30 km southwest of Sakol Nakhon city. 17.00N, 104.00E	380	15	11	1984
Murata G., Phengklai C., Mitsuta S., Nagamasu H. & Nantasan N.	T-52543	BKF	Pra Nakhon Si Ayutthaya	Near Pra Nakhon Si Ayutthaya. 14.19N, 100.36E	30	16	10	1984

Eriocaulon hamiltonianum var. acuminatum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Pernchit	1928a	BKF	Sakon Nakhon	Lardgacher, Phu Phan National Park. Deciduous forest.	-	21	11	1962
Lindhard E.	20	C	Kamphaeng Phet	Raheng District. Near Tapofsah, Wang Chaow forest.	?	8	1	1904
van Beusekom C.F. & Phengklai C.	2517A	K	Chiang Mai	Bo Luang Tableland. Dry dipterocarp forest. 18.45N, 98.25E	1000	14	12	1969
A.Prajaksood and S.Suddee	318	KKU,K, BK,BKF,TCD	Sakon Nakhon	Phu Phan National Park, Tambon Huey Yang, Muang District. Pha Nang Muen-Tam Chan route. Dipterocarp forest. 17.05N, 104.00E		11	11	2002
van Beusekom C.F. , Phengklai C., Geesink R. & Wongwan B.	4261a	BKF, P	Chaiyaphum	Tungkamang. 16.20N, 101.45E	800	14	12	1971
A. Prajaksood & P. Chantaranothai	48	KKU	Sakon Nakhon	Along the way from headquarters to Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	31	10	1998
Sorensen Th., Larsen K. & Hansen B.	5295	C,L	Chiang Mai	Doi Suthep.	?	28	9	1958
Sorensen Th., Larsen K. & Hansen B.	6473	C,L	Chiang Mai	Doi Suthep. Foot hill in dec. forest.	?	17	12	1958

Eriocaulon henryanum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
van Beusekom C.F. & Phengkhlai C.	1153	K, C, E, AAU, P, L,BKF	Chiang Mai	Ob Luang table land, along road from Bo luang to Om Koi. Open forest of Pinus khasya and Dipterocarpus tuberculatus.	?	11	6	1968
Phengklai C., Tamura M., Niyomdham C. & Sangkachand B.	4163	BKF, NY	Chiang Mai	Omkoi.	800	28	6	1978
Phengklai C. et al.	6274	BKF	Chiang Mai	Omkoi.	950-1050	20	7	1987
Chermsirivathana C.	866	BK	Loei	Phu Luang.	1400	14	4	1968

Eriocaulon infirmum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	124	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Anodad pond.	1300	16	11	1998
A. Prajaksood & P. Chantaranothai	132	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Wang Kwang Waterfall.	1300	17	11	1998
A. Prajaksood & P. Chantaranothai	140	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Than Sawan Waterfall and Tham Saw Noer.	1300	18	11	1998
A. Prajaksood	153	KKU	Trang	Tungkai Swamp Forest, along footpaths from accommodation to swamp forest.	-	21	3	1999
Chantaranothai P., Simpson D., Simpson R. & Thammathawom A.	1657	K	Sakon Nakhon	Phu Phan National Park, trail N of Park HQ. 17.02N, 103.57E	250	1	11	1994
A.Prajaksood and S.Suddee	189	KKU,TCD,BKF,K,BK	Trat	Ban Klong San, Tambon Dan Chumphon, Bo Rai District. By the side of the road, Km 49-50 route 3157, on the way to Klong Kaew Waterfall National Park. About 50 m from the check point.12.60N, 102.60E		8	10	2002
A.Prajaksood and S.Suddee	196	KKU,K, BK,BKF,TCD	Trat	Ban Toktuk, Tambon Sator, Khaosaming District. By the side of the road, route 3157 from Klong Kaew Waterfall National Park to Pliew Waterfall National Park, Km 16-17.12.30N, 102.35E		8	10	2002
A.Prajaksood and S.Suddee	204	KKU,K, BK,BKF,TCD	Phetchabun	Thung Non Son, Thung Salangluang National Park. Tambon Nongmaena, Khao Khor District. On the plain at its summit, Pine forest. 16.60N, 100.80E		20	10	2002
A. Prajaksood & P. Chantaranothai	21	KKU	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	13	12	1997
van Beusekom C.F. & Smitinand T.	2141	K,GH,E,P,AAU,C, L	Chanthaburi	Foot of Khao Soi Dao. 13.00N, 102.15E	400	12	11	1969
A.Prajaksood and S.Suddee	216	KKU,K, BK,BKF,TCD	Loei	Phu Rua National Park, Tambon Nongbua, Phu Rua District. On the plain at its summit. Suan Hin Pha Lee. 17.27N, 101.22E	1365	31	10	2002
A.Prajaksood and S.Suddee	218	KKU,K, BK,BKF,TCD	Loei	Phu Rua National Park, Tambon Nongbua, Phu Rua District. On the plain at its summit. Hin San Chun waterfall-Lan Hin Tag route. 17.27N. 101.22E	1365	31	10	2002
A.Prajaksood and S.Suddee	224	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Tent area- Lan Wat Pra Kaew route. By the side of the path. Pine forest.16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	232	KKU,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Tent area- Wang Kwang waterfall route. By the side of the path. Pine forest. 16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	235	KKU,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Phone Phoob waterfall - Pra Bhuddha Matta route. By the side of the path.16.90N, 101.80E	1300	1	11	2002
van Beusekom C.F. & Phengklai C.	2517	GH,E,P,AAU,C, L,BKF	Chiang Mai	Bo Luang Tableland. 18.45N, 98.25E	1000	14	12	1969
van Beusekom C.F. & Phengklai C.	2517c	K	Chiang Mai	Bo Luang Tableland. 18.45N, 98.25E	1000	14	12	1969
A.Prajaksood and S.Suddee	255	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Phu Chong Nayoy National Park, Tambon Nacharuey, Nacharuey District. Phalanphachad, Dipterocarp forest. 14.50N, 105.30E		8	11	2002
A.Prajaksood and S.Suddee	271	KKU	Ubon Ratchathani	Ban Udomsuk, Tambon Kudprathai, Dacha Udom District. By the side of the road route 2172, Km 26-27. 14.98N, 105.33E		8	11	2002
A.Prajaksood and S.Suddee	277	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khong Chium District. By the side of the road route 2222, Km 6-7. 15.30N, 105.50E		8	11	2002

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A.Prajaksood and S.Suddee	284	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khong Chium District. By the side of the road route 2112, Km 4. 15.35N, 105.55E		8	11	2002
A.Prajaksood and S.Suddee	288	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Pha Tam National Park, Khong Chium District. Thung Dok Yah. 15.40N, 105.60E		9	11	2002
A.Prajaksood and S.Suddee	290	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Pha Tam National Park, Khong Chium District. Pha Mon-Car park route. 15.42N, 105.33E		9	11	2002
A.Prajaksood and S.Suddee	294	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Tambon Naphoglang, Khong Chium District. By the side of the road route 2112, Km 20-21, Phatam-Khammarach route. 15.58N, 105.55E		8	11	2002
A.Prajaksood and S.Suddee	309	KKU,K, BK,BKF,TCD	Mukdahan	Phu Sadokbua National Park, Tambon Pha Rai, Don Tal District. Lan Phu Wat, on the plain at its summit. 16.19N, 104.48E		10	11	2002
van Beusekom C.F. , Phengklai C., Geesink R. & Wongwan B.	4288	BKF	Chaiyaphum	Tungkamang.16.20N, 101.45E	800	15	12	1971
Larsen ., Larsen S.S., Norgaard Chr. T., Pharsen K., Puudjaa P. & Uerchirakan W.	43983	AAU	Trang	Thung Khai.07.27N, 99.40E	50	25	10	1993
Charoenphol Ch. , Larsen K. & Warncke E.	4689	AAU,BKF,K;L	Loei	Phu Kradung, south of Loei. 16.53N, 101.53E	1100	7,8,9	11	1970
A. Prajaksood & P. Chantaranothai	50	KKU,K, BK,BKF,TCD	Sakon Nakhon	The barren sandstone along the seasonal small stream at Hui Wian Prai, Phu Phan National Park.	210	1	11	1998
Smitinand T.	5014a	K,BK,BKF	Loei	Phu Kradung.	1300	29	11	1958
Sorensen Th., Larsen K. & Hansen B.	6326	L, GH, BKF	Loei	Phu Kradung.	1200	29	11	1958
A. Prajaksood & P. Chantaranothai	68	KKU,K, BK,BKF,TCD	Mukdahan	Summit of Phu Pha Terb, Mukdahan National Park.	-	12	11	1998
A. Prajaksood & P. Chantaranothai	7	KKU,TCD	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	7	11	1997
A. Prajaksood & P. Chantaranothai	71	KKU,TCD	Mukdahan	Lann Phu Wat, Phu Sra Dok Bua National Park.	-	13	11	1998
A. Prajaksood & P. Chantaranothai	85	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Besides the bridge of 26 km further to Pha Tam National Park on the road number 2112. Khong Chiam District.	-	13	11	1998
A. Prajaksood & P. Chantaranothai	88	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Along the way Pha Mon to Car Park, Pha Tam National Park.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	94	KKU,K,BK,BKF	Ubon Ratchathani	Under the bridge, 5 km from Pha Tam National Park.	-	14	11	1998
Shimizu T., Toyokuni H., Koyama H.,Yahara T. & Niyomdham C.	T-21888a	AAU,L ,BKF	Kanchanaburi	Rintin Forest, Thong Pha Phum District.	210	6	11	1979
Phengkhlai C. & Murata G.	T-42199a	L	Loei	Phu Kradung. 16.54N, 101.48E	?	31	10	1984
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-51336	BKF	Kalasin	Near border of Sakol Nakhon & Kalasin Province, along route 213. Along gallery forest by stream/road side.	250	12	11	1984
Nanakorn W.	W.N.858	NY	Chaiyaphum	Thung Kamung, Phu Khiew Wildlife Sanctuary.	800	11	11	1984

Eriocaulon laosense

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Chermsirivathana C.	1553	BK	Nakhon Nayok	Khao Lon.	?	27	9	1969
S and J	2044	BK	Prachin Buri	Prachuntakarm.	?	29	12	1966
A.Prajaksood and S.Suddee	257	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Phu Chong Nayoy National Park, Tambon Nacharuey, Nacharuey District. Phalanphachad, Dipterocarp forest. 14.50N, 105.30E		8	11	2002
A.Prajaksood and S.Suddee	259	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Phu Chong Nayoy National Park, Tambon Nacharuey, Nacharuey District. Phalanphachad, Dipterocarp forest. 14.50N, 105.30E		8	11	2002
A.Prajaksood and S.Suddee	291	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Pha Tam National Park, Khong Chium District. Pha Mon-Car park route. 15.42N, 105.33E		9	11	2002
A.Prajaksood and S.Suddee	293	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Tambon Naphoglang, Khong Chium District. By the side of the road route 2112, Km 20-21, Phatam-Khammarach route.15.58N, 105.55E		8	11	2002
Sangkhachand B.	571	K,BK,BKF	Chanthaburi	Pong nam ron, Ban Ta Rueang.	200	5	12	1955
Maxwell J.F.	74-376	AAU,BK	Trat	Klong Yai.	150	5	5	1974
A. Prajaksood & P. Chantaranothai	87	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Besides the bridge of 26 km further to Pha Tam National Park on the road number 2112. Khong Chiam District.	-	13	11	1998
A. Prajaksood & P. Chantaranothai	97	KKU, BK,BKF,TCD	Ubon Ratchathani	Under the bridge, 5 km from Pha Tam National Park.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	BRT 755	KKU,K,BK,BKF	Sakol Nakhon	Along the way in open area, Kam Hom waterfall to Lan Sao A, Phu Phan National Park. Dipterocarp forest.	210	4	10	1997
Chermsirivathana C.	s.n.	BK	Prachin Buri	Plant on sale in the market for ornamemtal in Bangkok, said come from Prachin buri, head white.		14	12	1974
Suvatabandhu K.	s.n.	BK	Nakhon Nayok	Khao Lon.	?	?	?	?
Paisooksantivatana Y. & Sitheesorn S.	y 1105-82	BK	Roi Et	Ban Pondeun, Suwanaphum District, T. Srisawang, .	?	11	6	1982

Eriocaulon nautiliforme

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	111	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Along the road, Ban Hau Kon, Pho Sri District. 10 km from crossroad of road number 2112 to Phimolmungsakan District.	-	14	11	1998
A.Prajaksood and S.Suddee	169	KKU,K, BK,BKF,TCD	Chanthaburi	Tambon Putthawee, Makham district. By the side of route 317, Km 18-19, Khao Soi Dao-Makham route. A seasonal pond in front of a shooting rage of a Marine Department. 12.70N, 102.20E		5	10	2002
A.Prajaksood and S.Suddee	195	KKU,K, BK,BKF,TCD	Trat	Ban Toktuk, Tambon Sator, Khaosaming District. By the side of the road, route 3157 from Klong Kaew Waterfall National Park to Pliew Waterfall National Park, Km 16-17. 12.30N, 102.35E		8	10	2002
Put	2024	BK	Sa Kaeo	Aran Pratet.		18	10	1928
van Beusekom C.F. & Smitinand T.	2144	K,GH,C, E, AAU,P, L	Chanthaburi	Foot of Khao Soi Dao. 13.00N, 102.15E	400	12	11	1969
Gillett R.	21b	K	Ubon Ratchathani	Korat Plateau. 15.00N, 104.00E	500	?	10,11	1956
Chermsirivathana C.	226	BK	Udon Thani	Ban Pheu.	?	24	12	1964
A.Prajaksood and S.Suddee	253	KKU,K, BK,BKF,TCD	Si Sa Ket	Tambon Samrongplan, Pribueng District. By the side of the road route 24, Km 237. 14.65N, 104.30E		7	11	2002
A.Prajaksood and S.Suddee	269	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Ban Udomsuk, Tambon Kudprathai, Dacha Udom District. By the side of the road route 2172, Km 26-27. 14.98N, 105.33E		8	11	2002
Seidenfaden G.	2699	C	Chanthaburi	West of Kao Sabab. Rice fields.	10	25	2	1935
A.Prajaksood and S.Suddee	272	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Tambon Kudchumpoo, Phimulmungsahan District. By the side of the road route 217, Km 51-52. 15.15N, 105.30E		8	11	2002
Smitinand T.	3607	K,AAU,BK,BKF	Chanthaburi	Makham, Okphok.	50	25	10	1956
Vesterdal A. et al	464	C	Chanthaburi	Siam.	?	11	12	1935
Smitinand T.	5049	BKF	?	?	?	?	?	?
Sakol	64	BK	Prachin Buri	Srimahapho.	?	12	11	1964
Kerr A.F.G.	8243	BK	Surin	Surin.	100	9	1	1924
s.n.	s.n.	L	Ubon Ratchathani	In rice fields.	?	?	4	1957
Wongprasert Th. et al	s.n.	BKF	Ubon Ratchathani	Sirindhorn Dam.	150	15	1	1999

Eriocaulon nautiliformoides

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	108	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Along the road at 4th km of the road number 2112, 10 km further to Khong Chiam.	-	14	11	1998
Chirayupin	173	BK	Ubon Ratchathani	Warinchamrab.	?	24	2	1961
Gillett R.	21a	K	Ubon Ratchathani	Korat Plateau. 15.00N, 104.00E	500	?	10,11	1956
A.Prajaksood and S.Suddee	264	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Ban Udomsuk, Tambon Kudprathai, Dacha Udom District. By the side of the road route 2172, Km 26-27. 14.98N, 105.33E		8	11	2002
Smitinand T.	8443	BKF	Nakhon Phanom	On the way to That Phanom	150	16	12	1963

Eriocaulon nautiliformoides var, hexagynum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Smitinand T. & Turbang J.	10492	BK,BKF	Amnat Charoen		120	3	12	1968
A.Prajaksood and S.Suddee	265	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Ban Udomsuk, Tambon Kudprathai, Dacha Udom District. By the side of the road route 2172, Km 26-27. 14.98N, 105.33E		8	11	2002

Eriocaulon nepalense

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Niyomdham C., Suangtho M. & Sangkhachand B.	107	K,C, AAU,L,BKF	Chiang Mai	Om Koi.	1200	23	12	1978
Hansen B., Seidenfaden G. & Smitinand T.	10966	K, C, L,BKF	Chiang Mai	Fen area 5 km W of Bo Luang.	1100	29	1	1964
Smitinand T. (& Phernchit)	119	P,BKF	Chiang Mai	Doi Sutep.	1100	18	3	1951
Niyomdham C., Suangtho M. & Sangkhachand B.	150	K,BKF	Chiang Mai	Mae Sanam.	?	26	12	1978
Kerr A.F.G.	1635	C,E,TCD,K,L	Chiang Mai	Doi Suthep.	330-420	4	1	1911
Kerr A.F.G.	1932	K,E,TCD	Chiang Mai	Doi Suthep.	1100	28	7	1911
Hosseus C.C.	306a	M	Chiang Mai	Doi Sutep.	900	2	1	1905
Sorensen Th., Larsen K. & Hansen B.	3122	C,L	Chiang Mai	Doi Suthep.	700	28	4	1958
Larsen K. & Larsen S.S. in collaboration with The Forest Department, Bangkok.	34463	AAU,BKF,L,NY	Chiang Mai	Doi Intanond. 18.30N, 98.30E	1400-1700	13	9	1974
Larsen K., Larsen S.S., Norgaard Chr. T., Pharsen K., Puudjaa P. & Uerchirakan W.	44832	AAU	Chiang Mai	West of Mae Taon Luang, km 16.5 along road 1252, a side-road to 118 (formerly 1019). 18.58N, 98.20E	900	25	11	1993
Hosseus C.C.	492	M	Chiang Mai	Doi Sutep.	1050	14	04	1905
Sorensen Th., Larsen K. & Hansen B.	5235	C,L	Chiang Mai	Bo Luang Plateau, small lakes.	1120	24	9	1958
Geesink R., Phanichapol & Santisuk T.	5915	L,BKF	Chiang Mai	Bo Luang. 18.45N, 98.25E	1100	13	6	1973
Sorensen Th., Larsen K. & Hansen B.	6083	C	Chiang Mai	Doi Suthep.	1000	9	11	1958
Vidal J.E., Vidal Y. & Niyomdham C.	6253	P	Chiang Mai	Ban Pha Mon (Chom Thong).	900	31	5	1979
Smitinand T. & Alsterlund I.	6740	BKF	Chiang Mai	Tat Noi.	1000	18	04	1960
Maxwell J.F.	87-1445	L, BKF	Chiang Mai	Doi Suthep, East side, Chiang Mai Univeristy Observatory area.	850	18	11	1987
Maxwell J.F.	89-1485	GH,L	Chiang Mai	Sangampang District. Ban Mae Kum Bawng, Huay Gayo Subdistrict.	1075	3	12	1989
Maxwell J.F.	90-1231	GH	Chiang Mai	Mae Dtang District. Ban Bah Bae, Bah Bae Subdistrict.	850	6	11	1990
Maxwell J.F.	92-750	GH	Chiang Mai	Mae Dtang District. Bong Duat Nature Park, Hot springs. Bak Bae Subdistrict.	825	19	11	1992

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Maxwell J.F.	93-100	GH,L	Chiang Mai	Jawm Tong District. Doi Intanon National Park, east side, below Siripum Falls, Headquarters area.	1300	29	1	1993
Maxwell J.F.	95-602	BKF	Chiang Mai	Doi Sutep-Pui National Park, east side, near Nahiden Falls, north slope below the falls.	-	2	9	1995
Maxwell J.F.	96-1266	GH,BKF	Chiang Mai	Doi Saket District. Mawk Village, Tep Sadet Subdistrict, bordering Jae Sawn National Park, Lampang.	1225	23	9	1996
Maxwell J.F.	96-1614	GH,BKF	Lampang	Muang Bahn District. Jae Sawn National Park, Mae Jam Yao Village area.	1200	14	12	1996
Tsugaru S.	T-61733	BKF	Chiang Mai	Near geast house (RS-15). Doi Intanon.	1280	23	7	1988

Eriocaulon nepalense var. luzulaefolium

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Wongprasert Th.	0012-39	BKF	Ubon Ratchathani	Kaeng Lam Duan, Yoddome Wildlife Sanctuary.	200	26	12	2000
Hansen B., Seidenfaden G. & Smitinand T.	10839	BKF	Chiang Mai	Om Koi.	900	20	1	1964
Chermsirivathana C.	1085	BK	Loei	Phu Luang.	1300	15	11	1968
Garrett H.B.G.	1107	K,P,L	Chiang Rai	Doi Langka, top of Kiu Luang.	1760	31	10	1938
Hansen B., Seidenfaden G. & Smitinand T.	11098	C	Phitsanulok	Tung Sa laeng Luang.	500	10	2	1964
A. Prajaksood & P. Chantaranothai	115	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Anodad pond.	1300	15	11	1998
A. Prajaksood & P. Chantaranothai	123	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Anodad pond.	1300	16	11	1998
A. Prajaksood & P. Chantaranothai	127	KKU,K,BK,BKF	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Wang Kwang Waterfall.	1300	17	11	1998
A. Prajaksood & P. Chantaranothai	135	KKU	Loei	Top of Phu Kradung National Park, along footpaths from Wang Kwang Water fall to Phem Phob Mai Waterfall.	1300	17	11	1998
A. Prajaksood & P. Chantaranothai	136	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Wang Kwang Water fall to Phem Phob Mai Waterfall.	1300	17	11	1998
A. Prajaksood & P. Chantaranothai	138	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Than Sawan Waterfall and Tham Saw Noer.	1300	18	11	1998
A. Prajaksood & P. Chantaranothai	142	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Than Sawan Waterfall and Tham Saw Noer.	1300	18	11	1998
A.Prajaksood and S.Suddee	157	KKU,K, BK,BKF,TCD	Chaiyaphum	Tungkramung Wildlife Sanctuary. Phu King, Kasetsomboon District. Lae Klang. En route Head quarter to Lae Hin Tung. 16.20N, 101.47E	1110	19	9	2002
A.Prajaksood and S.Suddee	159	KKU,K, BK,BKF,TCD	Nakhon Nayok	Khao Yai National Park,Muang District. The site for visit Tung Yah Khao Kam, on the way to Khao Kiew. 14.40N, 101.40E		28	9	2002
A.Prajaksood and S.Suddee	160	KKU,TCD,BKF	Nakhon Nayok	Khao Yai National Park,Muang District. The site for visit Tung Yah Khao Kam, on the way to Khao Kiew. 14.40N, 101.40E		28	9	2002
A.Prajaksood and S.Suddee	161	KKU,K, BK,BKF,TCD	Nakhon Nayok	Khao Yai National Park,Muang District. Route 2090 from HQ to Km 40 (about 2.8 km from HQ), before the junction to Khao Kiew, the pond on the right hand side. 14.40N, 101.40E		28	9	2002
A.Prajaksood and S.Suddee	164	KKU,TCD	Nakhon Nayok	Khao Yai National Park,Muang District. Route 2090 from HQ to Km 40 (about 2.8 km from HQ), before the junction to Khao Kiew, the pond on the right hand side. 14.40N, 101.40E		28	9	2002
van Beusekom C.F. & Charoenpol C.	1682	K, GH,C,E,P,AAU,BKF	Nakhon Nayok	Khao Yai National Park, Khao Kieo. Evergreen forest. Along roadside in moist open places. 14.45N, 102.00E	1200	17	10	1969
Smitinand T.	1934a	K,BKF	Loei	Phu Kradung.	1300	29	9	1954
A.Prajaksood and S.Suddee	199	KKU,TCD,BKF,K,BK	Uttaradit	Phu Soi Dao National Park,Tambon Houy Moon, Nampad District. On the plain at its summit (Lann Son or Pine forest). On the way from tent areas to Lan How. Pine forest. 17.75N, 100.95E	1633	17	10	2002

Collector	Number	Herbarium	Province	Place	Altitude	Date		
A.Prajaksood and S.Suddee	206	KKU,K, BK,BKF,TCD	Phetchabun	Thung Non Son, Thung Salangluang National Park. Tambon Nongmaena, Khao Khor District. On the plain at its summit, Pine forest. 16.60N, 100.80E		20	10	2002
A.Prajaksood and S.Suddee	208	KKU,K, BK,BKF,TCD	Phetchabun	Thung Non Son, Thung Salangluang National Park. Tambon Nongmaena, Khao Khor District. On the plain at its summit, Pine forest. 16.60N, 100.80E		20	10	2002
A.Prajaksood and S.Suddee	209	KKU,K, BK,BKF,TCD	Loei	Phu Rua National Park, Tambon Nongbua, Phu Rua District. Sandstone rock areas near Lan Hin Tao. 17.27N, 101.22E	1300	30	10	2002
A.Prajaksood and S.Suddee	210	KKU,K, BK,BKF,TCD	Loei	Phu Rua National Park, Tambon Nongbua, Phu Rua District. On the way to Lan Hin Kularb Khao. 17.27N, 101.22E	1300	30	10	2002
A.Prajaksood and S.Suddee	211	KKU,K, BK,BKF,TCD	Loei	Phu Rua National Park, Tambon Nongbua, Phu Rua District. On the plain at its summit. Sa Sawan. 17.27N, 101.22E	1365	31	10	2002
A.Prajaksood and S.Suddee	212	KKU,K, BK,BKF,TCD	Loei	Phu Rua National Park, Tambon Nongbua, Phu Rua District. On the plain at its summit. Checkpoint 2-Tent area route. 17.27N, 101.22E	1365	31	10	2002
A.Prajaksood and S.Suddee	214	KKU	Loei	Phu Rua National Park, Tambon Nongbua, Phu Rua District. On the plain at its summit. Suan Hin Pha Lee. 17.27N, 101.22E	1365	31	10	2002
A.Prajaksood and S.Suddee	217	KKU,K, BK,BKF,TCD	Loei	Phu Rua National Park, Tambon Nongbua, Phu Rua District. On the plain at its summit. Hin San Chun waterfall-Lan Hin Tag route. 17.27N, 101.22E	1365	31	10	2002
A.Prajaksood and S.Suddee	220	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Tent area- Lan Wat Pra Kaew route. By the side of the path. Pine forest. 16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	228	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Tent area- Wang Kwang waterfall route. By the side of the path. Pine forest. 16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	233	KKU,K, BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Phone Phoob waterfall - Pra Bhuddha Matta route. By the side of the path. Pine forest. 16.90N, 101.80E	1300	1	11	2002
Umpai	321	BK	Loei	Phu Rua. .		12	12	1966
A. Prajaksood & P. Chantaranothai	33	KKU,K, BK,BKF,TCD	Na khon Nayok	Along the way to Hel Narok Waterfall, 2.9 km from the headquarters of Khao Yai National Park.	-	21	10	1998
Put	3341	BK	Chiang Mai	Doi Nang Ka.	?	3	11	1930
A. Prajaksood & P. Chantaranothai	34	KKU,K, BK,BKF,TCD	Na khon Nayok	3 km from the crossroad of the road number 3182 to Khao Khaew, Khao Yai National Park.	-	21	10	1998
A.Prajaksood and S.Suddee	342	KKU,TCD,BKF,K	Nakhon Nayok	Khao Yai National Park,Muang District. Route 2090 from HQ to Km 40 (about 2.8 km from HQ), before the junction to Khao Kiew, the pond on the right hand side. 14.40N, 101.40E		28	9	2002
A.Prajaksood and S.Suddee	343	KKU,K, BK,BKF,TCD	Nakhon Nayok	Khao Yai National Park, Muang District. The site for visit Tung Yah Khao Kam, on the way to Khao Kiew. 14.40N, 101.40E		20	12	2002
A. Prajaksood & P. Chantaranothai	35	KKU,TCD	Na khon Nayok	Near the summit of Khao Khaew, Khao Yai National Park.	-	21	10	1998
van Beusekom C.F. , Phengklai C., Geesink R. & Wongwan B.	3602	K,C,P, L,BKF	Kanchanaburi	Huay Bankau. 14.55N, 90.45E	?	9	11	1971
Hennipman E.	3651a	K,AAU,C,L,BKF	Loei	Phu Kradung. Forest along streamlet near Forest Station. 16.50N, 101.45E	1200	14	1	1966
A. Prajaksood & P. Chantaranothai	38	KKU	Na khon Nayok	Along the way to Hel Suwat Waterfall, 4.2 km from the headquarters of Khao Yai National Park.	-	21	10	1998

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Charoenphol Ch. , Larsen K. & Warncke E.	4232	E, AAU,L, BKF, K,P	Nakhon Nayok	Khao Yai National Park, Khao Khieo. Evergreen forest. 14.21N, 101.22E	1200-1300	29	10	1970
van Beusekom C.F. , Phengklai C., Geesink R. & Wongwan B.	4261b	C,K,L, P	Chaiyaphum	Tungkamang.	800	14	12	1971
Charoenphol Ch. , Larsen K. & Warncke E.	4684	C,E,P,AAU,K,L,BK, M	Loei	Phu Kradung, south of Loei. 16.53N, 101.53E	1100	7,8,9	11	1970
Charoenphol Ch. , Larsen K. & Warncke E.	4806	K,E,AAU,L,BKF	Loei	Phu Kradung, south of Loei. 16.53N, 101.53E	1100	7,8,9	11	1970
Charoenphol Ch., Larsen K. & Warncke E.	4810	K, AAU,L,BKF	Loei	Phu Kradung, South of Loei. 16.53N, 101.53E	1100	7,8,9	11	1970
Smitinand T.	5014a	K	Loei	Phu Kradung.	1300	29	11	1958
Smitinand T.	5014b	K	Loei	Phu Kradung.	1300	29	11	1958
Smitinand T.	5018	K,BK,BKF	Loei	Phu Kradung.	1300	29	11	1958
Smitinand T.	5020	K,BKF	Loei	Phu Kradung.	1300	29	11	1958
Sorensen Th., Larsen K. & Hansen B.	5294	C,L	Chiang Mai	Doi Suthep.	450	28	9	1958
A. Prajaksood & P. Chantaranothai	53	KKU,K, BK,BKF,TCD	Sakon Nakhon	The barren sandstone along the seasonal small stream at Hui Wian Prai, Phu Phan National Park.	210	1	11	1998
A. Prajaksood & P. Chantaranothai	61	KKU,K, BK,BKF,TCD	Nong Khai	The seasonal pond near Tham Phun Waterfall, Phu Wau National Park.	-	11	11	1998
Sorensen Th., Larsen K. & Hansen B.	6326	C, E	Loei	Phu Kradung.	1200	29	11	1958
Smitinand T.	7537	BKF	Nakhon Nayok	Khao Yai National Park.	800	7	10	1962
A. Prajaksood & P. Chantaranothai	81	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Besides the bridge of 26 km further to Pha Tam National Park on the road number 2112. Khong Chiam District.	-	13	11	1998
Smitinand T. & Williams	8410	AAU	Nakhon Nayok	Khao Khieo, Khao Yai	1400	11	11	1963
Chantaranothai P., Parnell J. & Simpson D.	90/490	TCD	Loei	Phu Rua National Park, summit road c. 3 km from Park HQ.	?	30	9	1990
A. Prajaksood & P. Chantaranothai	93	KKU,TCD	Ubon Ratchathani	Under the bridge, 5 km from Pha Tam National Park.	-	14	11	1998
Maxwell J.F.	95-659	BKF	Chiang Mai	Chiang Dao, Doi Chiang Dao Animal Sanctuary, east of Huay Nae Cawk Station.	1475	11	9	1995
Maxwell J.F.	97-1365	GH,BKF	Chiang Rai	Wiengbahbao District. Kuhn Jae National Park, HQ, Mae Jedi Mai Subdist.	925	18	11	1997
J. Parnell	98/21/JP	TCD	Loei	Phu Luang National Park. On trail around top; south of Kok Nok Krabi Ranger Station. 17.16N, 101.31E	1600	26	10	1998

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
J. Parnell	98/22/JP	TCD	Loei	Phu Luang National Park. On trail around top; south of Kok Nok Krabi Ranger Station. 17.16N, 101.31E	1600	26	10	1998
J. Parnell	98/35/JP	TCD	Uttaradit	Phu Soi Doi National Park. Pine Forest. 17.44N, 100.59E	500	28	10	1998
A. Prajaksood & P. Chantaranothai	BRT 753	KKU	Sakol Nakhon	Along the way in open area, NE of ICS to Kam Hom waterfall, Phu Phan National Park. Dipterocarp forest. 17.08N, 103.59E	210	4	10	1997
Tagawa M., Iwasuki K. & Fukuoka N.	T 546B	C,BKF	Loei	Phu Kradung. On the plain of its summit.	1100-1200	28	11	1965
Tagawa M., Iwasuki K. & Fukuoka N.	T 547	L,BKF	Loei	Phu Kradung, on the plain of its summit.	1100-1200	28	11	1965
Tagawa M., Iwasuki K. & Fukuoka N.	T 764	BKF	Loei	Phu Kradung, on the plain at its summit.	1200	29	11	1965
Shimizu T., Toyokuni H., Koyama H.,Yahara T. & Santisuk T.	T-18049	K,C,P,AAU,L,BKF	Nakhon Nayok	Top area of Khao Yai National Park Hill, everygreen forest zone. Dump glade.	1170	9	10	1979
Shimizu T., Toyokuni H., Koyama H., Yahara T. & Niyomdham C.	T-22996	BKF	Loei	Phu Kradung, Um Khao.	1300	16	11	1979
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-40184	BKF	Loei	Phu Kradung. Along trail to the headquater of National Park. 16.52N, 101.49E	900-1200	30	10	1984
Phengkhlai C. & Murata G.	T-42199b	L,BKF	Loei	Phu Kradung.16.54N, 101.48E	?	31	10	1984
Murata G. & Phengklai C.	T-42206	GH,L,BKF	Loei	Phu Kradung. 16.53N, 101.48E	?	31	10	1984
Phengkhlai C. & Murata G.	T-42353	L,BKF	Loei	Phu Kradung. 16.54N, 101.48E	?	31	10	1984
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-42798	GH,L,BKF	Loei	Phu Kradung.	1250	2,3	11	1984
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-42866	GH,AAU,L,BKF	Loei	Phu Kradung. 16.54N, 101.48E	1250	2,3	11	1984
Mitsuta S., Yahara T. & Nagamasu H.	T-46473	BKF	Chiang Mai	Doi Inthanon National Park, near Ban Sop Hat. In dry open forest mixed with Lithocarpus and Castanopsis.	850	6	12	1984
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-50510	GH,BKF	Sakon Nakhon	Phu Phan National Park, ca. 30 km SW of Sakhon Nakhon city. 17.00N, 104.00E	380	14	11	1984
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-51896	BKF	Sakon Nakhon	Phu Phan National Park, ca. 30 km. Sw of Sakol Nakhon city. 17.00N, 104.00E	350	13	11	1984

Eriocaulon oryzetorum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Larsen K. & Larsen S.S.	34135	AAU,BKF	Mae Hong Son	Khun Yuam. 18.15N, 98.00E	600-700	5	9	1974
Sorensen Th., Larsen K. & Hansen B.	6082	GH, C,L,BKF	Chiang Mai	Doi Suthep.	1000	9	11	1958

Eriocaulon parnellii

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Chermsirivathana C.	1079	BK	Loei	Phu Luang.	1300	15	11	1968
Chermsirivathana C.	1114	BK	Loei	Phu Luang.	1300	16	11	1968
A. Prajaksood & P. Chantaranothai	126	KKU,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Anodad pond.	1300	16	11	1998
A. Prajaksood & P. Chantaranothai	145	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths in front of Tham Saw Noer.	1300	18	11	1998
A.Prajaksood and S.Suddee	242	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Pra Bhuddha Matta-Arnodad pond route. By the side of the path. Pine forest. 16.90N, 101.80E	1300	1	11	2002

Eriocaulon phatamense

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A.Prajaksood and S.Suddee	289	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Pha Tam National Park, Khong Chium District. Thung Dok Yah.15.40N, 105.60E		9	11	2002
A.Prajaksood and S.Suddee	292	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Pha Tam National Park, Khong Chium District. Pha Mon-Car park route. 15.42N, 105.33E		9	11	2002
A.Prajaksood and S.Suddee	308	KKU,K, BK,BKF,TCD	Mukdahan	Phu Sadokbua National Park, Tambon Pha Rai, Don Tal District. Lan Phu Wat, on the plain at its summit. 16.19N, 104.48E		10	11	2002
A. Prajaksood & P. Chantaranothai	69	KKU,K, BK,BKF,TCD	Mukdahan	Lann Phu Wat, Phu Sra Dok Bua National Park.	-	13	11	1998
A. Prajaksood & P. Chantaranothai	89	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Along the way Pha Mon to Car Park, Pha Tam National Park.	-	14	11	1998
Wongprasert Th.	s.n.	BKF	Mukdahan	Phu Pha Therb National Park.	150	27	10	1998
Santisuk T.	s.n.	BKF	Ubon Ratchathani	Pha Tam National Park, Soi Sawan Fall.	150	4	12	1999

Eriocaulon phuchongense

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	100	KKU	Ubon Ratchathani	Along the road at 4th km of the road number 2112, 10 km further to Khong Chiam.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	106	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Along the road at 4th km of the road number 2112, 10 km further to Khong Chiam.	-	14	11	1998
A.Prajaksood and S.Suddee	260	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Phu Chong Nayoy National Park, Tambon Nacharuey, Nacharuey District. Phalanphachad, Dipterocarp forest. 14.50N, 105.30E		8	11	2002
A.Prajaksood and S.Suddee	276	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khong Chium District. By the side of the road route 2222, Km 6-7. 15.30N, 105.50E		8	11	2002
A.Prajaksood and S.Suddee	285	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khong Chium District. By the side of the road route 2112, Km 4. 15.35N, 105.55E		8	11	2002
A.Prajaksood and S.Suddee	300	KKU,K, BK,BKF,TCD	Ubon Ratchathani	By Ubon Ratchathani Forest Department, Tambon Naphoglang, Khong Chium District. By the side of the road route 2112, Km 100-101. 15.65N, 105.50E		8	11	2002

Eriocaulon phuphanense

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Hansen B., Seidenfaden G. & Smitinand T.	11279	BKF,L,C,AAU	Sakon Nakhon	Phu Phan National Park.	300	1	3	1964
A. Prajaksood & P. Chantaranothai	18	KKU,K,BK,BKF	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	13	12	1997
Kerr A.F.G.	2540	ABD	?	North Siam. Muang Prao	?	23	1	1913
A. Prajaksood & P. Chantaranothai	55	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way to Kam Pak Nam, near the small bridge, Phu Phan National Park.	210	24	1	1998
Chantaranothai P., Middleton D., Parnell J. & Simpson D.	868	K, KKU,TCD	Sakon Nakhon	Phu Phan National Park. 17.02N, 104.02E	400-600	23	2	1993
P. Chantaranothai, J. Parnell, D. Middleton and D. Simpson	871	TCD	Sakon Nakhon	Phu Phan National Park. Boggy area in clearing in dry Dipterocarp forest. 17.02N, 104.02E	400-600	23	2	1993
P. Chantaranothai, J. Parnell, D. Middleton and D. Simpson	880	TCD	Sakon Nakhon	Phu Phan National Park. Drying-out boggy area in clearing in dry Dipterocarp forest. 17.02N, 104.02E	400-600	23	2	1993

Eriocaulon phuphanoides

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	15	KKU	Sakon Nakhon	Along the way to Pha Nang Mern-Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	9	11	1997
Chantaranothai P., Simpson D., Simpson R. & Thammathaworn A.	1651	K	Sakon Nakhon	Phu Phan National Park, trail N of Park HQ.	250	1	11	1994
A. Prajaksood & P. Chantaranothai	17	KKU,K,BK,BKF	Sakon Nakhon	Along the way to Pha Nang Mern-Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	9	11	1997
Pernchit	1928b	BKF	Sakon Nakhon	Lardgacher, Phu Phan National Park.	-	21	11	1962
A.Prajaksood and S.Suddee	299	KKU,K, BK,BKF,TCD	Ubon Ratchathani	By Ubon Ratchathani Forest Department, Tambon Naphoglang, Khong Chium District. By the side of the road route 2112, Km 100-101. 15.65N, 105.50E		8	11	2002
A.Prajaksood and S.Suddee	320	KKU,K, BK,BKF,TCD	Sakon Nakhon	Phu Phan National Park, Tambon Huey Yang, Muang District. Pha Nang Muen-Tam Chan route. Dipterocarp forest. 17.05N, 104.00E		11	11	2002
A.Prajaksood and S.Suddee	345	KKU	Sakon Nakhon	Phu Phan National Park, Tambon Huey Yang, Muang District. Tam Chan-Lan Sao Ae route. Dipterocarp forest. 17.05N, 104.00E		11	11	2002
A. Prajaksood & P. Chantaranothai	40	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way from headquarters to Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	31	10	1998
A. Prajaksood & P. Chantaranothai	62	KKU,K,BK,BKF	Nong Khai	Near Tham Phun Waterfall, Phu Wau National Park.	-	11	11	1998
Kerr A.F.G.	6230	K,BK	Chiang Mai	Mae Tang.	1000	4	7	1922
A. Prajaksood & P. Chantaranothai	72	KKU,K, BK,BKF,TCD	Ubon Rachathani	Along the road number 2112 (Khe marat- Pha Tam), near Ban Na Pa Nieng Or, Pho Sai District.	-	13	11	1998
A. Prajaksood & P. Chantaranothai	8	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	7	11	1997
A. Prajaksood & P. Chantaranothai	9	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	7	11	1997
Chantaranothai P. & Parnell J.	90/725	TCD,KKU	Sakon Nakhon	Phu Phan National Park, S of Park HQ.	?	14	10	1990
A. Prajaksood & P. Chantaranothai	BRT 752	KKU,K,BK,BKF	Sakol Nakhon	Along the way from Evergreen forest to open area of Ang Kob, Phu Phan National Park. 7.03N, 103.58E	210	3	10	1997
A. Prajaksood & P. Chantaranothai	BRT 754	KKU,K,BK,BKF	Sakol Nakhon	Along the way in open area, Kam Hom waterfall to Lan Sao A, Phu Phan National Park. Dipterocarp forest.	210	4	10	1997

Eriocaulon pseudoescape

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	117	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park, along footpaths to Anodad pond.	1300	16	11	1998
Smitinand T.	12115	BKF	Loei	Phu Kradung, around Pha Daeng.	1250	6	12	1975
A. Prajaksood & P. Chantaranothai	129	KKU,K,BK,BKF	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Wang Kwang Waterfall.	1300	17	11	1998
A. Prajaksood & P. Chantaranothai	146	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Tham Saw Noer to Pha Yeab Make.	1300	18	11	1998
A.Prajaksood and S.Suddee	223	KKU	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Tent area- Lan Wat Pra Kaew route. By the side of the path. Pine forest. 16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	239	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District.On the plain at its summit. Phone Phoob waterfall - Pra Bhuddha Matta route. Seasonal pond by the side of the path, the right hand side of Statue. Pine forest. 16.90N,	1300	1	11	2002

Eriocaulon quinquangulare var. longibracteatum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	1	KKU,K, BK ,BKF,TCD	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	7	11	1997
Hossens C.C.	102	C, E, L	Kamphaeng Phet	Wang-Djao, W.S.W. Savannenwald, hanfig.	?	14	10	1904
Hansen B., Seidenfaden G. & Smitinand T.	10817	L,C,BKF	Chiang Mai	Om Koi.	900	20	1	1964
Hansen B., Seidenfaden G. & Smitinand T.	10818	C,AAU,L,BKF	Chiang Mai	Om Koi.	900	20	1	1964
Hosseus C.C.	117	M	?	Wang Djao	100	14	10	1904
A. Prajaksood & P. Chantaranothai	14	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way to Pha Nang Mern-Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	9	11	1997
Chantaranothai P., Simpson D., Simpson R. & Thammathaworn A.	1656	K	Sakon Nakhon	Phu Phan National Park, trail N of Park HQ. 17.02N, 103.57E	250	1	11	1994
A. Prajaksood & P. Chantaranothai	19	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	13	12	1997
K. Phoonphong & P. Phornphongroongrueng	2	KKU	Khon Kaen	Kok Phu Taka, Phu Wieng.	-	20	10	1998
Smitinand T.	3065 A	BKF	Loei	Wangsaphung Sithan.	300	17	10	1955
A.Prajaksood and S.Suddee	317	KKU,K, BK,BKF,TCD	Sakon Nakhon	Phu Phan National Park, Tambon Huey Yang, Muang District. Pha Nang Muen-Tam Chan route. Dipterocarp forest. 17.05N, 104.00E		11	11	2002
A. Prajaksood & P. Chantaranothai	46	KKU,K,BK,BKF	Sakon Nakhon	Along the way from headquarters to Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	31	10	1998
Smitinand T. & Seidenfaden G.	5531	K,BK,BKF	Chiang Mai	Doi Saket, Huay Ka.	400	2	3	1959
Chantaranothai P. & Parnell J.	90/726	TCD, KKU	Sakon Nakhon	Phu Phan National Park, S of Park HQ.	?	14	10	1990
A. Prajaksood & P. Chantaranothai	BRT 748	KKU	Sakol Nakhon	Along the way from Evergreen forest to open area of Ang Kob, Phu Phan National Park. 07.03N, 103.58E	210	3	10	1997
Lindhard E.	s.n.	K, C, M	Kamphaeng Phet	District Raheng, Wang chow forest, near Tapofsah.	?	8	1	1904
Shimizu T., Toyokuni H., Koyama H.,Yahara T. & Niyomdham C.	T-21888b	BKF	Kanchanaburi	Rintin Forest, Thong Pha Phum District.	210	6	11	1979
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-49783b	BKF	Sakon Nakhon	Phu Phan National Park, ca. 30 km. Sw. of Sakol Nakhon city. Along road in dipterocarp forest to small water fall. 17.00N, 104.00E	380	13	11	1984

Eriocaulon setaceum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Smitinand T.	10447	K,L,BKF	Nakhon Nayok	Khao Yai National Park.	600	21	8	1968
A. Prajaksood & P. Chantaranothai	122	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along footpaths from Mon Thien Thong House to Anodad pond.	1300	16	11	1998
C.P.(Phengklai C.?)	1247	BKF	Krabi	Ban Sai Kao, Klong Tom.	3	-	10	1965
A. Prajaksood & P. Chantaranothai	137	KKU	Loei	Top of Phu Kradung National Park, Sra Kaew Pond.	1300	17	11	1998
A. Prajaksood	155	KKU,K, BK,BKF,TCD	Sakon Nakhon	Phu Phan National Park, seasonal pond near Tang Phe Phan.	-	4	7	1999
Niyomdham C. & O'Connor P.J.	15721	AAU, NY	Loei	Phu Kradung. Pine savannah.	1300	9	3	1979
A.Prajaksood and S.Suddee	163	KKU,K, BK,BKF,TCD	Nakhon Nayok	Khao Yai National Park,Muang District. Route 2090 from HQ to Km 40 (about 2.8 km from HQ), before the junction to Khao Kiew, the pond on the right hand side. 14.40N, 101.40E		28	9	2002
Suwatabandhu K.	166	K,BK	Loei	Phu Kradung.	-	20	3(4)	1948
Larsen K., Smitinand T. & Warncke E.	1666	AAU,BKF	Chantaburi	Plain of Makham.	?	22	8	1966
A.Prajaksood and S.Suddee	171	KKU,K, BK,BKF,TCD	Chanthaburi	Tambon Putthawee, Makham district. By the side of route 317, Km 18-19, Khao Soi Dao-Makham route. A seasonal pond in front of a shooting rage of a Marine Department. 12.70N, 102.20E		5	10	2002
van Beusekom C.F. & Charoenpol C.	1770	E,AAU,L, BKF	Nakhon Nayok	Khao Yai National Park, Khao Laem. Evergreen forest. Submerged in shallow water in pond on top Khao Laem. 14.45N, 102.00E	1200	19	10	1969
van Beusekom C.F. & Charoenpol C.	1783	E,P,AAU,L,BKF	Nakhon Nayok	Khao Yai National Park, Wang Ta Kong. Margin evergreen forest. Near edge of pond in touristcamp. 14.45N, 102.00E	650	21	10	1969
Smitinand T.	1908	K,BKF	Loei	Phu Kradung, Sra Kaew.	1300	6	9	1954
Kerr A.F.G.	19600	BK	Sa Kaeo	Aran Pratet, in shallow water.	50	9	8	1930
Smitinand T.	1982	K, BK, BKF	Loei	Phu Kradung.	1300	29	9	1954
Sorensen Th., Larsen K. & Hansen B.	2253	C,L,BKF	Loei	Phu Kradung.	1300	18	3	1959
A.Prajaksood and S.Suddee	226	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Tent area- Lan Wat Pra Kaew route. By the side of the path. Pine forest. 16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	227	KKU,TCD,BKF,K	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Tent area- Lan Wat Pra Kaew route. By the side of the path. Pine forest. 16.90N, 101.80E	1300	1	11	2002
Pooma R., de Wilde W.J.J.O., Duyfjes B.E.E., Chamchumroon V. & Phattarahirankanok K.	2410	BKF	Ubon Ratchathani	Kra Chin bridge, Na Tan Subdistrict. 15.51N, 105.20E	140	23	8	2001
A.Prajaksood and S.Suddee	243	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. Tambon Srithan, Phu Kradung District. On the plain at its summit. Arnodad pond. Pine forest. 16.90N, 101.80E	1300	1	11	2002

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	29	KKU,K, BK,BKF,TCD	Nakhon Nayok	Along the way to Hel Narok Waterfall, 2.9 km from the headquarters of Khao Yai National Park.	-	21	10	1998
Larsen K., Larsen S.S., Nielsen I. & Santisuk T.	32281	AAU,BKF	Chanthaburi	Ban Chang Thum, E of Makam. 12.36N, 102.29E	50	31	8	1972
A.Prajaksood and S.Suddee	336	KKU	Ranong	Tambon Kamphun, Suksamlan Subdistrict. By the side of the road route 4, Km 697-698. 06.45N, 98.45E		18	12	2002
A.Prajaksood and S.Suddee	341	KKU,TCD	Nakhon Nayok	Khao Yai National Park,Muang District. Route 2090 from HQ to Km 40 (about 2.8 km from HQ), before the junction to Khao Kiew, the pond on the right hand side. 14.40N, 104.40E		28	9	2002
Kerr A.F.G.	4555	BK	Kamphaeng Phet	Ban Kon.	100	10	11	1920
van Beusekom C.F. , Phengklai C., Geesink R. & Wongwan B.	4601	K,C,L,BKF	Loei	Phu Kradung. 16.52N, 101.52E	1300	25	12	1971
Charoenphol Ch. , Larsen K. & Warncke E.	4796	E,AAU,L,K,BKF	Loei	Phu Kradung, south of Loei. On 20 cm water. 16.53N, 101.53E	1100	7,8,9	11	1970
Smitinand T.	5852	BKF	Loei	Phu Kradung, near resthouse.	1300	8	7	1959
Smitinand T. & Abbe E.C.	6155	K, BKF	Phangnga	Between Takuapah and Ranong.	100	18	11	1959
Sorensen Th., Larsen K. & Hansen B.	6211	C,L	Loei	Phu Kradung.	?	25	11	1958
Sorensen Th., Larsen K. & Hansen B.	6236	C	Loei	Phu Kradung.	1300	28	11	1958
Geesink R. & Phengklai C.	6334	C,L,BKF	Chanthaburi	Makham. 13.00N, 101.50E	0	5	8	1973
Smitinand T. & Abbe E.C.	6342	K,GH,P,L,BKF	Loei	Phu Kradung.	1300	11	1	1960
Geesink R., Hattink T., Phengklai C.	6571	K,AAU,P,L,BKF	Trat	Klong Kut. 12.01N, 102.40E	150	5	5	1974
Maxwell J.F.	73-387	AAU,BK	Chanthaburi	Muang Dist, off highway 3, at km 10.	25	5	8	1973
A. Prajaksood & P. Chantaranothai	79	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Besides the bridge of 26 km further to Pha Tam National Park on the road number 2112. Khong Chiam District.	-	13	11	1998
Maxwell J.F.	85-552	GH,L,BKF	Songkhla	Haad Yai, Klong Hoy Kong, west of Toong Loong.	s.l.	30	5	1985
Kerr A.F.G.	8725	BK	Loei	Phu Kradung.	1200	13	3	1924
A. Prajaksood & P. Chantaranothai	92	KKU,TCD	Ubon Ratchathani	Under the bridge, 5 km from Pha Tam National Park.	-	14	11	1998
Tagawa M. & Iwatsuki K.	T 286	BKF	Pathum Thani	Rangsit, North of Bangkok. In rice field.	?	14	11	1965
Tagawa M., Iwasuki K. & Fukuoka N.	T 766	C,BKF	Loei	Phu Kradung, on the plain at its summit.	1200	29	11	1965

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Tagawa M., Iwasuki K. & Fukuoka N.	T 767	BKF	Loei	Phu Kradung.	1200	29	11	1965
Shimizu T., Fukuoka N. & Nalampoon A.	T 8138	C,L,BKF	Nakhon Si Thammarat	In the subrub of Thung Song.	?	27	8	1967
Shimizu T., Huton M. & Chaiglom D.	T 9034	C,L,BKF	Loei	Phu Kradung.	1200	5	9	1967
Shimizu T., Hutoh M & Chaiglom D.	T 9035	K,L, C,BKF	Loei	Phu Kradung.	1200	5	9	1967
Shimizu T., Toyokuni H., Koyama H., Yahara T. & Niyomdham C.	T-22853	BKF	Loei	Phu Kradung.	1250-1280	15	11	1979
Phengkhlai C. & Murata G.	T-42354	L,BKF	Loei	Phu Kradung. 16.54N, 101.48E	1250	31	10	1984

Eriocaulon sexangulare

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Bunpheng D.	162	BKF	Trat	Bo Lim forest, Kao Saming District.	?	10	10	1989
Smitinand T.	3034	K,BKF	Trang	Thale Sawng Hawng.	<100	30	8	1955
A.Prajaksood and S.Suddee	333	KKU,TCD,BKF,K,BK	Ranong	Tambon Kamphun, Suksamlan Subdistrict. By the side of the road route 4, Km 697-698. 09.45N, 98.45E		18	12	2002
A.Prajaksood and S.Suddee	337	KKU,TCD,BKF,K,BK	Ranong	Ban Naphu, Tambon Naka, Suksamlan Subdistrict. Paddy field by Mudsayit Ban Naphu. From route 4 (Km 692-693) to local road. 09.45N, 98.45E		18	12	2002
s.n.	348	BKF	Ranong	Bang Khan, Kapur.	?	5	12	1982
Hauiff & Hur	3821	K	?	Khaw Pok.	?	1	12	1918
Santisuk T.	582	BKF	Ranong	Kapur, Klong Naka.	50	16	11	1973
Geesink R., Hipko P. & Charoenphol C.	7543	AAU, K, C,P,L,BKF	Ranong	Khlong Naka. 09.45N, 98.40E	0	24	11	1974
Shimizu T., Toyokuni H., Koyama H., Yahara T. & Niyomdham C.	T-26264	AAU,L,BKF	Ranong	Ban Kam Phuran, Kaper District.	30	7	12	1979

Eriocaulon sexangulare var. australe

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
van Beusekom C.F. & Smitinand T.	2145	AAU, K,GH,C,E,P,L	Chanthaburi	Foot of Khao Soi Dao. 13.00N, 102.40E	400	12	11	1969
Larsen K.,Larsen S.S., Nielsen I. & Santisuk T.	32318	L,BKF,AAU,C,NY	Trat	18 km N of Klong Yai. 11.50N, 102.48E	s.l.	2	9	1972
Larsen K. & Larsen S.S.	40292	AAU	Songkhla	S of Songkhla.	<100	8	10	1988
Geesink R., Hattink T. & Phengklai C.	6554	AAU,K,C,P,L,BKF	Trat	Khlong Kut. 12.00N, 102.40E	150	5	5	1974
Smitinand T.	7135	BKF	Satun	Thung Kai.	50	9	2	1961
Maxwell J.F.	85-440a	L	Songkhla	Haad Yai district, Klong Hoy Kong, west of Toong Loong.	s.l.	6	5	1985

Eriocaulon siamense

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	116	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, Lahn Buddha image.	1300	16	11	1998
A. Prajaksood & P. Chantaranothai	131	KKU,TCD	Loei	Top of Phu Kradung National Park. The way to Wang Kwang Waterfall.	1300	17	11	1998
A. Prajaksood & P. Chantaranothai	139	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, the way to Tham Saw Noer.	1300	18	11	1998
Native	18	P, S	Loei	Phu Kradung.	1045	22	2	1948
A.Prajaksood and S.Suddee	200	KKU,TCD,BKF,K,BK	Uttaradit	Phu Soi Dao National Park. On the plain at its summit. 17.75N, 100.95E	1633	17	10	2002
Kerr A.F.G.	20080	BK	Loei	Phu Kradung.	1200	11	2	1931
Kerr A.F.G.	20120	BK	Loei	Phu Kradung.	1200	12	2	1931
Smitinand T.	2050	K,BKF	Loei	Phu Kradung.	1300	29	11	1954
A.Prajaksood and S.Suddee	225	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. The way to Lan Wat Pra Kaew. 16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	237	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. The way to Pra Bhuddha Matta. 16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	258	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Phu Chong Nayoy National Park, Phalanphachad. 14.50N, 105.30E		8	11	2002
van Beusekom C.F. , Phengklai C., Geesink R. & Wongwan B.	4567	K,GH,C,P,AAU,L,BKF	Loei	Phu Kradung. 16.52N, 101.52E	1300	24	12	1971
van Beusekom C.F. , Phengklai C., Geesink R. & Wongwan B.	4571	K,C,P,AAU,L,BKF	Loei	Phu Kradung. 16.52N, 101.52E	1300	24	12	1971
van Beusekom C.F. , Phengklai C., Geesink R. & Wongwan B. (Charoenphol Ch. , Larsen K. & Warncke E.)	4691	K,E,P,AAU,L,BKF	Loei	Phu Kradung, south of Loei. 16.53N, 101.53E	1100	7,8,9	11	1970
Ch. Charoenphol, K. Laisen & E. Warncke	4800	E, K,C,P,AAU, ,BKF	Loei	Phu Kradung, south of Loei. 16.53N, 101.53E	1100	7,8,9	11	1970
Santisuk T.	520	BKF	Loei	Phu Kradung.	1300	17	10	1973
Sorensen Th., Larsen K. & Hansen B.	6162	C,L	Loei	Phu Kradung.	?	24	11	1958
Chantaranothai P., Parnell J., Simpson D. & Sridit K.	90/162	TCD,KKU	Loei	Phu Kradung, summit plateau, trail from Yhamsomue to Than Sawn via Anodat pond.	?	12	9	1990
Umpai	93	BK	Loei	Phu Kradung.	?	15	12	1963
Wongprasert Th.	s.n.	BKF	Ubon Ratchathani	En route from Phiboonmungsahan to Khong Chiem District.	100	24	10	1998

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Tagawa M., Iwasuki K. & Fukuoka N.	T 553	P, BKF	Loei	Phu Kradung, on the plain at its summit.	1100-1200	28	11	1965
Phengkhlai C. & Murata G.	T-42174	GH,P,L,BKF,AAU	Loei	Phu Kradung. 16.53N, 101.48E	?	31	10	1984
Murata G. & Phengkhlai C.	T-42197	BKF	Loei	Phu Kradung. 16.53N, 101.48E	1300	31	10	1984
Murata G. & Phengklai C.	T-42355	L,BKF	Loei	Phu Kradung. 16.54N, 101.48E	?	31	10	1984

Eriocaulon siamense var. macrophyllum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Suvatabandhu K.	118	BK	Loei	Phu Kradung.	?	16	3	1948
A. Prajaksood & P. Chantaranothai	120	KKU	Loei	Top of Phu Kradung National Park, along the way to Anodad pond.	1300	16	11	1998
A. Prajaksood & P. Chantaranothai	143	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, along the way to Pha Loam Sak.	1300	18	11	1998
O'Connor P.J. & Niyomdham C.	15683	BKF	Loei	Phu Kradung.	?	7	3	1979
Din	167	BKF	Loei	Summit of Phu Kradung.	1300	16	4	1948
A.Prajaksood and S.Suddee	203	KKU,K, BK,BKF,TCD	Phetchabun	Thung Non Son, Thung Salangluang National Park. 16.60N, 100.80E		20	10	2002
Sorensen Th., Larsen K. & Hansen B.	2257	C	Loei	Phu Kradung. Sandy path.	?	19	3	1958
A.Prajaksood and S.Suddee	241	KKU,TCD,BKF	Loei	Phu Kradung National Park. The way to Arnodad pond. 16.90N, 101.80E	1300	1	11	2002
Smitinand T. & Phernchit	416	K	Loei	Phu Kradung.	1300	14	5	1951
Smitinand T.	416a	P,BKF	Loei	Phu Kradung.	1040	14	5	1951
Charoenphol Ch. , Larsen K. & Warncke E.	4694	AAU	Loei	Phu Kradung. South of Loei. 16.53N, 101.53E	1100	7,8,9	11	1970
Charoenphol Ch., Larsen K. & Warncke E.	4802	AAU,L,BKF	Loei	Phu Kradung, South of Loei. 16.53N, 101.53E	1100 or 1200	7,8,9	11	1970
Smitinand T. & Floto F.	5935	K,BK,BKF	Loei	Phu Kradung, Huay Hin Kawng.	1300	14	7	1959
s.n. (P. Bunma)	60	L,BKF	Loei	Phu Kradung.	1300	16	9	1968
Santisuk T.	6682	BKF	Chiang Mai	Samoeng-Ban Watchan Route (c. 80 km).	1000	17	1	1988
Floto F.	7472	C,L	Loei	Phu Kradung.	1300	10	7	1959
Floto F.	7473	BKF	Loei	Phu kradung.	1300	10	7	1959
Amphorn	8	BKF	Loei	Top of Phu Kradung.	1300	11	2	1989
Kerr A.F.G.	8713	BK	Loei	Phu Kradung.	1200	13	3	1924
Chantaranothai P., Parnell J., Simpson D. & Sridit K.	90/120	TCD	Loei	Phu Kradung, summit plateau, trail from Park HQ to the Buddha image.	1100-1200	12	9	1990

Eriocaulon siamense ssp. heaxagynum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	104	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Along the road at 4th km of the road number 2112, 10 km further to Khong Chiam.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	105	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Along the road at 4th km of the road number 2112, 10 km further to Khong Chiam.	-	14	11	1998
A.Prajaksood and S.Suddee	275	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khong Chium District. By the side of the road route 2222, Km 6-7. 15.30N, 105.50E		8	11	2002
A.Prajaksood and S.Suddee	281	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khong Chium District. By the side of the road route 2112, Km 4. 15.35N, 105.55E		8	11	2002

Eriocaulon smitinandii

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	10	KKU	Sakon Nakhon	Along the way to Pha Nang Mern-Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	9	11	1997
Smitinand T.	11381	C,E,P,BKF	Rayong		?	22	11	1970
Smitinand T. & Lazarides M.	11388	AAU,BK,BKF	Chanthaburi	Makham.	?	23	11	1970
Smitinand T.	12214	BKF	Chanthaburi	Makam.	20	4	11	1976
Kerr A.F.G.	13684	BK	Satun		5	28	12	1977
A. Prajaksood	152	KKU	Trang	Tungkai Botanic Garden. Swamp Forest, along footpaths from accommodation to swamp forest.	-	21	3	1999
A.Prajaksood and S.Suddee	205	KKU,K, BK,BKF,TCD	Phetchabun	Thung Non Son, Thung Salangluang National Park. Tambon Nongmaena, Khao Khor District. On the plain at its summit, Pine forest. 16.60N, 100.80E		20	10	2002
van Beusekom C.F. & Smitinand T.	2142	K,GH,C,E,P,AAU,L	Chantaburi	Foot of Khao Soi Dao. 13.00N, 102.15E	400	12	11	1969
Sakol	286	BK	Chanthaburi	Pong Nam Rorn, Na Sloer.	?	1	12	1964
A.Prajaksood and S.Suddee	287	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Pha Tam National Park, Khong Chium District. Sao Chaleing, by the side of the path. Dipterocarp forest. 15.45N, 105.48E		9	11	2002
A.Prajaksood and S.Suddee	297	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Tambon Naphoglang, Khong Chium District. By the side of the road route 2112, Km 20-21, Phatam-Khammarach route. 15.58N, 105.55E		8	11	2002
A.Prajaksood and S.Suddee	304	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khammarach District. By the side of the road route 2242, Km 10-11. 16.05N, 105.15E		8	11	2002
A.Prajaksood and S.Suddee	310	KKU,K, BK,BKF,TCD	Mukdahan	Phu Sadokbua National Park, Tambon Pha Rai, Don Tal District. Lan Phu Wat, on the plain at its summit. 16.19N, 104.48E		10	11	2002
A.Prajaksood and S.Suddee	319	KKU,K, BK,BKF,TCD	Sakon Nakhon	Phu Phan National Park, Tambon Huey Yang, Muang District. Pha Nang Muen-Tam Chan route. Dipterocarp forest. 17.05N, 104.00E		11	11	2002
Smitinand T.	3603	BK, BKF	Chanthaburi	Makham, Okphok.	50	25	10	1956
Smitinand T.	3679	K	Chanthaburi	On trail between Makham and Khao Kheio.	100	29	11	1956
A. Prajaksood & P. Chantaranothai	4	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	7	11	1997
A. Prajaksood & P. Chantaranothai	45	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way from headquarters to Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	31	10	1998
A. Prajaksood & P. Chantaranothai	52	KKU	Sakon Nakhon	The barren sandstone along the seasonal small stream at Hui Wian Prai, Phu Phan National Park.	210	1	11	1998
A. Prajaksood & P. Chantaranothai	57	KKU,K, BK,BKF,TCD	Nong Khai	The barren stream near Tham Phun Waterfall, Phu Wau National Park.	-	11	11	1998

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Maxwell J.F.	71-563A	AAU,BK	Chanthaburi	14 km east of Chantaburi.	?	17	10	1971
A. Prajaksood & P. Chantaranothai	75	KKU,TCD	Ubon Rachathani	Along the road number 2112 (Khe marat- Pha Tam), near Ban Na Pa Nieng Or, Pho Sai District.	-	13	11	1998
Smitinand T.	8478	AAU,BK,BKF	Sakon Nakhon	Phu Phan National Park.	150	18	12	1963
Chantaranothai P. & Parnell J.	90/721	TCD,KKU	Sakon Nakhon	Phu Phan National Park, Park HQ to Lann Sao.	?	14	10	1990
Chantaranothai P. & Parnell J.	90/722	TCD	Sakon Nakhon	Phu Phan National Park, Park HQ to Lann Sao.	?	14	10	1990
A. Prajaksood & P. Chantaranothai	BRT 749	KKU,K,BK,BKF	Sakol Nakhon	Along the way from Evergreen forest to open area of Ang Kob, Phu Phan National Park. 07.03N, 103.58E	210	3	10	1997
A. Prajaksood & P. Chantaranothai	BRT 751	KKU	Sakol Nakhon	Along the way from Evergreen forest to open area of Ang Kob, Phu Phan National Park. 07.03N, 103.58E	210	3	10	1997

Eriocaulon thailandicum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
J.A.N. Parnell, K. Chayamarit, R. Pooma, D.A. Simpson, S. Suddee, B. De Wilde	1955	BKF,K,TCD	Trang	Yan Ta Khao, Thung Khai Botanic Garden. Drying out rice paddy. 07.27N, 99.40E	10	31	1	2002
A.Prajaksood and S.Suddee	252	KKU,K, BK,BKF,TCD	Si Sa Ket	Tambon Samrongplan, Pribueng District. By the side of the road route 24, Km 237. 14.65N, 104.30E		7	11	2002
Smitinand T.	3605-A	BKF	Chanthaburi	Makham, Okphok.	50	25	10	1956
Smitinand T.	3679-A	BKF	Chanthaburi	On trail between Makham and Khao Klua.	100	29	11	1956
Sangkhachand B.	571a	K	Chanthaburi	Pong Nam Ron, Ban Ta Rueang.	200	5	12	1956
Smititnad T. & Abbe E.C.	6332	BKF	Loei	Dan Sai District.	300	6	1	1960
Kerr A.F.G.	8113	BK	Nakhon Ratchasima	Pak Thong Chai.	200	25	10	1923
Smitinand T.	8394	AAU,BKF	Prachin Buri	Thung Poh.	20	7	11	1963
Smitinand T.	8478-A	AAU,BKF	Sakon Nakhon	Phu Phan National Park.	150	18	12	1963
Chantaranothai P., Parnell J. & Simpson D.	90/519	TCD	Phitsanulok	Phu Hin Rongkla National Park, Laan Hin Taek.	?	1	10	1990

Eriocaulon truncatum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	110	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Along the road at 4th km of the road number 2112, 10 km further to Khong Chiam.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	114	KKU,K,BK,BKF	Ubon Ratchathani	Along the road, Ban Hau Kon, Pho Sri District. 10 km from crossroad of road number 2112 to Phimolmungsakan District.	-	14	11	1998
Hansen B. & Smitinand T.	11897	K,P,E,C,L,BKF	Ranong	Muang Len.	160	2	1	1966
Smitinand T.	12185	BKF	Surat Thani	Chaiya-Tha Chana.	5	10	3	1976
Hansen B. & Smitinand T.	12388a	C,K	Phuket	Koh Yao Yai.	5	20	2	1966
Hansen B. & Smitinand T.	12389	K,P,C,L,BKF	Phuket	Ko Yao Yai.	5	20	2	1966
Kerr A.F.G.	12640	BK	Surat Thani	Koh Samui.	near s.l.	11	4	1927
Chanratanothai P., Middleton D., Parnell J., Simpson R. & Simpson D.	1421	K,TCD	Nakhon Si Thammarat	Khao Luang National Park, Khao Lu, Karom Waterfall, Lansaka District. 08.28N, 99.41E	100-260	26	3	1993
A. Prajaksood	154	KKU,K, BK,BKF,TCD	Trang	Tungkai Botanic Garden. Swamp Forest, along footpaths from accommodation to swamp forest.	-	21	3	1999
Kerr A.F.G.	15717	K,BK	Surat Thani	Ban Bua Put, Koh Samui.	<5	14	5	1928
A.Prajaksood and S.Suddee	167	KKU,K, BK,BKF,TCD	Chanthaburi	Tambon Putthawee, Makham district. By the side of route 317, Km 18-19, Khao Soi Dao-Makham route. A seasonal pond in front of a shooting rage of a Marine Department. 12.70N, 102.20E		5	10	2002
A.Prajaksood and S.Suddee	178	KKU,K, BK,BKF,TCD	Trat	Tambon Mai Rood, Klong Yai District. Km 62-63, route 318, Ban Kad Lek-Klong Yai. By the side of the road. 11.90N, 102.80E		5	10	2002
D.A. Simpson, K. Chayamarit, J.A.N. Parnell, R. Pooma, S. Suddee, B. De Wilde	1831	BKF,K,TCD	Ranong	Kra Buri, By main Chumphon to Ranong road. 10.31N, 99.17E	50	27	1	2002
J.A.N. Parnell, K. Chayamarit, R. Pooma, S. Suddee, D.A. Simpson, B. De Wilde	1840	BKF,K,TCD	Ranong	Ngao, Ngao National Park. 09.51N, 98.37E	50	28	1	2002
Collins D.J.	1887	BK	Chon Buri	Near Sriracha.	20 feet	30	11	1927
Pooma R., Chamchumroon V. & Phattarahirankanok K.	1919	BKF	Songkhla	Hat Yai, Ton Nga Chang Wildlife Sanctuary, Ton Plio falls, Ban Ton Plio, Thung Tam Sao Subdistrict. 06.59N, 100.14E	100	2	6	2001
A.Prajaksood and S.Suddee	193	KKU,K, BK,BKF,TCD	Trat	Tambon Bo Ploy, Bo Rai District. By the side of the road, route 3389, on the way to Klong Kaew Waterfall National Park. 12.60N, 102.60E		8	10	2002
J.A.N. Parnell, K. Chayamarit, R. Pooma, D.A. Simpson, S. Suddee, B. De Wilde	1951	BKF,K,TCD	Trang	Yan Ta Khao, Thung Khai Botanic Garden. Drying out rice paddy. 07.27N, 99.40E	10	31	1	2002
J.A.N. Parnell, K. Chayamarit, R. Pooma, D.A. Simpson, S. Suddee, B. De Wilde	1977	BKF,K,TCD	Songkhla	Route 43 Hat Yai-Chana. 06.56N, 100.48E	10	31	1	2002
J.A.N. Parnell, K. Chayamarit, R. Pooma, D.A. Simpson, S. Suddee, B. De Wilde	2001	TCD	Narathiwat	Ban Khok Kraduk Mu, Khlong Nam Bang, Chalerm Phra Ket Wildlife Sanctuary. Margin of canal. At water's edge. 06.10N, 101.55E	5	1	2	2002

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
van Beusekom C.F. & Smitinand T.	2129	GH,K,P,E,C,AAU,L,BKF	Chanthaburi	Foot of Khao Soi Dao. Disturbed evergreen forest. 13.00N, 102.15E	400	12	11	1969
Smitinand T.	2267	BKF	Trat	Koh Chang.	30	22	2	1955
A.Prajaksood and S.Suddee	245	KKU,K, BK,BKF,TCD	Surin	Ban Klongnamsub, Tambon Nangmood, Kabcherng District. By the side of the road route 2121, Km 18-19. 14.45N, 103.40E		7	11	2002
A.Prajaksood and S.Suddee	248	KKU,K, BK,BKF,TCD	Surin	Prasart District. By the side of the road route 24, Km 139-140. 14.40N, 103.60E		7	11	2002
Schmidt J.	250	C	Trat	Koh Chang.	?	13	1	1900
A.Prajaksood and S.Suddee	251	KKU,K, BK,BKF,TCD	Si Sa Ket	Tambon Samrongplan, Pribueng District. By the side of the road route 24, Km 237. 14.65N, 104.30E		7	11	2002
A.Prajaksood and S.Suddee	268	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Ban Udomsuk, Tambon Kudprathai, Dacha Udom District. By the side of the road route 2172, Km 26-27. 14.98N, 105.33E		8	11	2002
A. Prajaksood & P. Chantaranothai	28	KKU,TCD	Ubon Ratchathani	The stream under the bridge, 20 km further to Pha Tam National Park.	-	15	8	1998
A.Prajaksood and S.Suddee	280	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khong Chium District. By the side of the road route 2222, Km 6-7. 15.30N, 105.50E		8	11	2002
A.Prajaksood and S.Suddee	286	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khong Chium District. By the side of the road route 2112, Km 4. 15.35N, 105.55E		8	11	2002
A.Prajaksood and S.Suddee	296	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Tambon Naphoglang, Khong Chium District. By the side of the road route 2112, Km 20-21, Phatam-Khammarach route. 15.58N, 105.55E		8	11	2002
Schmidt J.	302	C	Trat	Koh Chang.	?	?	1	1900
A.Prajaksood and S.Suddee	307	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khammarach District. By the side of the road route 2242, Km 10-11. 16.05N, 105.15E		8	11	2002
Chayamarit K., Phuphathanaphong L., Pooma R., Suddee S. & Phattarahirankanok K.	3074	BKF	Prachuap Khiri Khan	Hat Wanakorn National Park, Thap Sa Kae. 11.38N, 99.42E	?	9	1	2002
A.Prajaksood and S.Suddee	313	KKU,K, BK,BKF,TCD	Mukdahan	Tambon Kamphalai, Muang District. By the side of the road route 212, Km 177-178. 16.32N, 104.43E		10	11	2002
A.Prajaksood and S.Suddee	325	KKU,TCD,BKF,K,BK	Satun	Tarutao National Park, Koh Tarutao. By HQ Talo Udung. 06.36N, 99.37E		13	12	2002
A.Prajaksood and S.Suddee	330	KKU,TCD,BKF,K,BK	Phuket	Tambon Maikhao, Thalang District. By the side of the road. From route 402 to the local road Maikhao-Bo Som about 200 m. 08.05N, 98.35E		17	12	2002
A.Prajaksood and S.Suddee	331	KKU,TCD,BKF,K,BK	Phuket	Thalang District. By the side of the road. From route 4031 about 4-5 km. 08.05N, 98.35E		17	12	2002
A.Prajaksood and S.Suddee	334	KKU,TCD,BKF,K,BK	Ranong	Tambon Kamphun, Suksamlan Subdistrict. By the side of the road route 4, Km 697-698. 09.45N, 98.45E		18	12	2002
Sorensen Th., Larsen K. & Hansen B.	3830	E,C,L	Chiang Mai	Doi Suthep.	450	2	7	1958
Larsen K., Larsen S.S., Barford A.S., Nanakorn W., Ueachirakan W. & Sirirugsa P.	41195	P,AAU	Satun	Yar Roy waterfall, c. 25 km NE of Satun. Along stream and waterfall. 06.45N, 100.07E	100-200	6	11	1990

Collector	Number	Herbarium	Province	Place	Altitude	Date		
Larsen K., Larsen S.S., Renner S.S., Niyomdham C., Uerchirakan W. & Sirirugsa P.	42588	P,AAU	Songkhla	Haad Yai, Ko Hong, Water reservoir. 07.00N, 100.20E	50	26	10	1991
A. Prajaksood & P. Chantaranothai	47	KKU	Sakon Nakhon	Along the way from headquarters to Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	31	10	1998
Charoenphol Ch., Larsen K. & Warncke E.	5009	AAU	Trat	Koh Chang. West side. 12.03N, 102.35E	0-50	18	11	1970
Smitinand T.	5602	K,BK,BKF	Surat Thani	Pha Phet.	50	16	3	1959
A. Prajaksood & P. Chantaranothai	59	KKU,K, BK,BKF,TCD	Nong Khai	The barren stream near Tham Phun Waterfall, Phu Wau National Park.	-	11	11	1998
Geesink R. & Phengklai C.	6311b	C	Trat	Taphan Hin, open melaleuca forest on sandy podsolic soil. 12.20N, 102.30E	0	3	8	1973
Kerr A.F.G.	6476	BK	Chiang Mai	Mah Tang.	400	29	10	1922
Umpai	649	BK	Songkhla	Klong Hoi Khong Klong Nga.	?	12	2	1987
Kerr A.F.G.	6823	BK	Trat	Koh Chang, Klong Mayom.	100	2	4	1923
Maxwell J.F.	72-506	AAU,BK	Trat	Koh Chang Island.	?	22	10	1972
A. Prajaksood & P. Chantaranothai	74	KKU,K, BK,BKF,TCD	Ubon Rachathani	Along the road number 2112 (Khe marat- Pha Tam), near Ban Na Pa Nieng Or, Pho Sai District.	-	13	11	1998
Maxwell J.F.	75-869	AAU,L,BK	Trang	Khao Chong.	150	15	8	1975
Ryding O.	833	UPS	Trat	Koh Chang, Ban Tan Majom at the NE coast of the island. 12.05N, 102.19E	?	24	12	1984
Maxwell J.F.	84-42	GH,BKF	Songkhla	Rattapoom District, Dton Nga Chang.	300	13	8	1984
A. Prajaksood & P. Chantaranothai	86	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Besides the bridge of 26 km further to Pha Tam National Park on the road number 2112. Khong Chiam District.	-	13	11	1998
Maxwell J.F.	86-1063	L	Yala	Betong District.	50	15	12	1986
Maxwell J.F.	86-131	GH,L,BKF	Nakhon Si Thammarat	Tasala District, Groong Ching Falls, Khao Luang National Park.	450	2	3	1986
Chanratanothai P. , Middleton D., Parnell J. & Simpson D.	867	K, KKU,TCD	Sakon Nakhon	Phu Phan National Park. 17.02N, 104.02E	400-600	23	2	1993
Congdon G.	869	GH,AAU	Satun	Tarutao Natioanl Park. Talo Oo Dang, near HQ.	?	8	10	1980
Maxwell J.F.	87-243	GH,L,BKF	Nakhon Si Thammarat	Nabawn Dist, Klong Jahng Falls.	100	26	2	1987
Maxwell J.F.	87-31	GH,L,BKF	Phatthalung	Ban Nawng Tong, Bah Bawn District, .	25	12	1	1987

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Maxwell J.F.	87-47	GH,AAU,L,BKF	Chumphon	Muang District, Ban Huay Gayo.	5	15	1	1987
Maxwell J.F.	96-1574	BKF	Ranong	Kapur. Leam Sohn National Park, headquater/ Bahng Village area, Muang Sluang Subdistrict.	s.l.	30	11	1996
A. Prajaksood & P. Chantaranothai	98	KKU,TCD	Ubon Ratchathani	Under the bridge, 5 km from Pha Tam National Park.	-	14	11	1998
Umpai	s.n.	BK	Songkhla	Hadd Yai, Koh Hong,	?	13	1	1971
Murata G., Phengklai C., Mitsuta S., Nagamasu H. & Nantasan N.	T-37985	BKF	Si Sa ket	En route from Si Saket city to Kantharalak about 10 km from Kantharalak. 14.54N, 104.26E	130	8	10	1984
Murata G., Phengklai C., Mitsuta S., Nagamasu H. & Nantasan N.	T-49710	BKF	Si Sa Ket	En route from Si Sa Ket city to Kantharalak about 10 km. 14.53N, 104.16E	130	8	10	1984

Eriocaulon truncatum var. florensense

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A.Prajaksood and S.Suddee	162	KKU,K, BK,BKF,TCD	Nakhon Nayok	Khao Yai National Park, Route 2090 from HQ to Km 40. 14.40N, 101.40E		28	9	2002
A.Prajaksood and S.Suddee	175	KKU,K, BK,BKF,TCD	Trat	Ban Saphanhin Tambon Laem Glad, Muang District. Near Wat Saphanhin, Laem Glad junction. Route 318, Muang-Klong Yai. 12.20N, 102.40E		5	10	2002
A.Prajaksood and S.Suddee	180	KKU,K, BK,BKF,TCD	Trat	Koh Chang National Park, Koh Chang Subdistrict, Ban Thanmayom. By the side of the road in a ditch, Km 14-15. 12.05N, 102.25E		7	10	2002
A.Prajaksood and S.Suddee	182	KKU,K, BK,BKF,TCD	Trat	Koh Chang National Park, Koh Chang Subdistrict, Ban Salukkok Moo 4. By the side of the road, Km 19-20. Coconut forest. 12.05N, 102.25E		7	10	2002
A.Prajaksood and S.Suddee	185	KKU,K, BK,BKF,TCD	Trat	Ban Klong San, Tambon Dan Chumphon, Bo Rai District. The way to Klong Kaew Waterfall National Park. 12.60N, 102.60E		8	10	2002
A.Prajaksood and S.Suddee	261	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Boontharik District. By the side of the road route 2182, Km 36-37. 14.78N, 105.40E		8	11	2002
A. Prajaksood & P. Chantaranothai	30	KKU,K, BK,BKF,TCD	Na khon Nayok	Along the way to Hel Narok Waterfall, 2.9 km from the headquarters of Khao Yai National Park.	-	21	10	1998
A.Prajaksood and S.Suddee	301	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Ubon Ratchathani Forest Department, Khong Chium District, the road route 2112, Km 100-101. 15.65N, 105.50E		8	11	2002
A.Prajaksood and S.Suddee	323	KKU,K, BK,BKF,TCD	Sakon Nakhon	Phu Phan National Park, Tam Chan-Lan Sao Ae route. 17.05.N, 104.00E		11	11	2002
A.Prajaksood and S.Suddee	326	KKU	Songkhla	Tambon Koh Saban, Thepha District. By the side of the road route 43, Km 86-87. Had Yai-Puttani route. 06.48N, 100.57E		15	12	2002
A.Prajaksood and S.Suddee	327	KKU,TCD,BKF,K,BK	Phangnga	Ban Bangphang, Tambon Thana, Kaphong District. By the side of the local road Oil Kam-PhakPho route (8 km from route 401 to route 4032). 08.41N, 98.27E		17	12	2002
A.Prajaksood and S.Suddee	332	KKU,TCD,BKF,K,BK	Phangnga	Tambon Bang Naisri, Takuapha District. By the side of the road route 4, Km 776-777. 08.52N, 98.21E		18	12	2002
A.Prajaksood and S.Suddee	338	KKU,TCD,BKF,K,BK	Ranong	Ban Naphu, Tambon Naka, Suksamlan Subdistrict. Mudsayit Ban Naphu. 09.45N, 98.45E		18	12	2002
Charoenphol Ch., Larsen K. & Warncke E.	3861	AAU	Satun	Kuan Ka Long, 40 km NW of Satun. Evergreen forest. 06.51N, 101.01E	?	15	10	1970
Maxwell J.F.	71-563	AAU,BK	Chanthaburi		?	17	10	1971
Maxwell J.F.	73-446	AAU,BK	Saraburi	Sahm Lahn Forest.	?	9	10	1973
Maxwell J.F.	74-893	AAU,L,BK	Saraburi	Muang District. Sahm Lahn Forest.	125-150	7	9	1974
A. Prajaksood & P. Chantaranothai	78	KKU,K, BK,BKF,TCD	Ubon Rachathani	Along the road number 2112, 95th km of road, 35 km further to Pha Tam, Sri Muang Mai District.	-	13	11	1998
Maxwell J.F.	86-985	GH,L,BKF	Krabi	Klong tom District, Ban Klong Rat, Group 7.	75	29	11	1986
Maxwell J.F.	87-1	GH,L,BKF	Songkhla	Haad Yai district. Ko Hong Hill, west side near Klong Ko Hong.	50	4	1	1987

Eriocaulon ubonense

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Sakol	1061	BK	Surat Thani	Kao Thum Nang, Na Sara.	?	17	6	1966
Hansen B., Seidenfaden G. & Smitinand T.	11239	C,L,AAU, BKF	?	Huey Khek.	700	23	2	1964
Kerr A.F.G.	13149	BK	Surat Thani	Kanchanadit.	5	3	8	1927
Kerr A.F.G.	13705	BK	Satun	Satun.	5	28	12	1927
A. Prajaksood	149	KKU	Trang	Tungkai Swamp Forest, along footpaths from accommodation to swamp forest.	-	21	3	1999
Chantaranothai P., Simpson D., Simpson R. & Thammathaworn A.	1639	K	Sakon Nakhon	Phu Phan National Park, trail N of Park HQ. 17.02N, 103.57E	250	1	11	1994
A. Prajaksood & P. Chantaranothai	20	KKU	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	13	12	1997
A.Prajaksood and S.Suddee	238	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. The way to Pra Bhuddha Matta. 16.90N, 101.80E	1300	1	11	2002
Larsen K.,Larsen S.S., Nielsen I. & Santisuk T.	32318	P,M	Trat	18 km N of Klong Yai. 11.50N, 102.48E	s.l.	2	9	1972
K. Larsen, Larsen S.S., Renner S.S., Niyomdham C., Uerchirakan W. & Sirirugsa P.	42910	AAU	Songkhla	23 km E of Chana. 06.53N, 100.56E	0	14	6	1992
Larsen K., Larsen S.S., Norgaard Chr. T., Pharsen K., Puudjaa P. & Uerchirakan W.	43993	AAU	Trang	Thung Khai Botanic Garden.	50	25	10	1993
A. Prajaksood & P. Chantaranothai	54	KKU	Sakon Nakhon	Along the way to Kam Pak Nam, near the small bridge, Phu Phan National Park.	210	24	1	1998
A. Prajaksood & P. Chantaranothai	56	KKU,K, BK,BKF,TCD	Nong Khai	The barren stream near Tham Phun Waterfall, Phu Wau National Park.	-	11	11	1998
Maxwell J.F.	74-374	AAU,BK	Trat	Klong Yai.	150	5	5	1974
Maxwell J.F.	85-440	GH,BKF,L	Songkhla	Haad Yai district, Klong Hoy Kong, west of Toong Loong.	s.l.	6	5	1985
Chantaranothai P., Middleton D., Parnell J. & Simpson D.	869	K, KKU,TCD	Sakon Nakhon	Phu Phan National Park. 17.02N, 104.02E	400-600	23	2	1993
Larsen K.	9791	C	Chanthaburi	Plain of Makham.	20	6	6	1963
Chantaranothai P., Middleton D., Parnell J. & Simpson D.	980	K, KKU,TCD	Sakon Nakhon	Phu Phan National Park, An Gop. 17.00N, 104.02E	280	26	2	1993
A. Prajaksood & P. Chantaranothai	BRT 222	KKU,K,BK,BKF	Sakol Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	6	5	1997
A. Prajaksood & P. Chantaranothai	BRT 489	KKU	Sakol Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	12	7	1997

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Wongprasert Th. et al	s.n.	BKF	Nongkhai	Tham Foon, Phu Wua Wildlife Sanctuary.	150	30	10	1998
Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-50316	GH,AAU,BKF	Sakon Nakhon	Phu Phan National Park, ca. 30 km SW of Sakhon Nakhon city. 17.00N, 104.00E	380	15	11	1984

Eriocaulon ubonense f. kradungense

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Umpai	100	BK	Loei	Phu Kradung.	?	14	12	1963
A. Prajaksood & P. Chantaranothai	119	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, the way to Anodad pond.	1300	16	11	1998
A. Prajaksood & P. Chantaranothai	121	KKU	Loei	Top of Phu Kradung National Park, the way to Anodad pond.	1300	16	11	1998
A. Prajaksood & P. Chantaranothai	133	KKU,TCD	Loei	Top of Phu Kradung National Park, the way to Phem Phob Mai Waterfall.	1300	17	11	1998
A. Prajaksood & P. Chantaranothai	134	KKU,K, BK,BKF,TCD	Loei	Top of Phu Kradung National Park, they way to Phem Phob Mai Waterfall.	1300	17	11	1998
A. Prajaksood & P. Chantaranothai	144	KKU,K,BK,BKF	Loei	Top of Phu Kradung National Park, the way to Pha Loam Sak.	1300	18	11	1998
A.Prajaksood and S.Suddee	202	KKU,K, BK,BKF,TCD	Phetchabun	Thung Non Son, Thung Salangluang National Park. 16.60N, 100.80E		20	10	2002
Smitinand T.	2051	BKF	Loei	Phu Kradung.	1300	29	10	1954
Sorensen Th., Larsen K. & Hansen B.	2255	C	Loei	Phu Kradung.	1300	19	3	1958
A.Prajaksood and S.Suddee	229	KKU,TCD	Loei	Phu Kradung National Park. The way to Wang Kwang waterfall. 16.90N, 101.80E	1300	1	11	2002
A.Prajaksood and S.Suddee	234	KKU,K, BK,BKF,TCD	Loei	Phu Kradung National Park. The way to Pra Bhuddha Matta. 16.90N, 101.80E	1300	1	11	2002
Bunpheng D.	40	K,BKF	Loei	Phu Kradung.	1300	28	6	1948
van Beusekon C.F., Phengklai C., Geesink R. & Wongwan B.	4539	C,P,L	Loei	Phu Kradung. 16.52N, 101.52E	1300	25	12	1971
van Beusekom C.F. , Phengklai C., Geesink R. & Wongwan B.	4589	K,BKF	Loei	Phu Kradung. 16.52N, 101.52E	1300	25	12	1971
Charoenphol Ch. , Larsen K. & Warncke E.	4645	AAU, P, BKF, K, E,L	Loei	Phu Kradung, south of Loei. 16.53N, 101.53E	1100	7,8,9	11	1970
Santisuk T.	521	BKF	Loei	Phu Kradung.	1300	17	10	1973
Smitinand T. & Floto F.	5936	K,BK,BKF	Loei	Phu Kradung, Huay Hin Kawng.	1300	14(13)	7	1959
Sorensen Th., Larsen K. & Hansen B.	6161	C,L	Loei	Phu Kradung.	?	24	11	1958
Sorensen Th., Larsen K. & Hansen B.	6341	C	Loei	Phu Kradung.	?	29	11	1958
Pinnin S. et al	72	K,BKF	Loei	Phu Kradung.	1300	16	9	1969

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Floto F.	7347	C,E,L	Loei	Phu Kradung.	1000	8	7	1959
Floto F.	7473	GH,C,L	Loei	Phu kradung.	1300	10	7	1959
Maxwell J.F.	76-544	AAU,L,BK	Si Sa Ket	Dongrak Range at Cong Bat Lak, Kantaralak District. 14.30N, 104.00E	550	18	8	1976
Adisai	837	BK	Loei	Phu Kradung.	?	4	7	1964
Chantaranothai P., Parnell J., Simpson D. & Sridit K.	90/112	TCD,KKU	Loei	Phu Kradung. Summit plateau, trail from Park HQ to the Buddha image. Pine savananh.	1100-1200	12	9	1990
Wongprasert Th.	s.n.	BKF	Loei	Phu Kradung.Tharnsawan Fall.	1200	30	8	1988
Smitinand T. & Sleumer H.	Sleumer 4779	L	Loei	Phu Kradung.	1250-1300	11	9	1963
Shimizu T., Hutoh M. & Chaiglom D.	T 8884	P,L,C,K,BKF	Loei	Phu Kradung. On the path at its summit.	1200	4	9	1967

Eriocaulon ubonense var. hexagynum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*
Gillett R.	21c	K	Ubon Ratchathani	Korat Plateau. 15.00N, 104.00E	500	? 10,11 1956
Pradit	677	BK	Udon Thani	Banphue.	?	18 11 1963

Eriocaulon wightianum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Smitinand T.(& Lasarides M.)	11389	K,C,E,P,L,BKF	Chanthaburi	Makham.	?	23	11	1970
A.Prajaksood and S.Suddee	176	KKU,K, BK,BKF,TCD	Trat	Tambon Mai Rood, Klong Yai District. Km 62-63, route 318, Ban Kad Lek-Klong Yai. By the side of the road. 11.90N, 102.80E	15	5	10	2002
A.Prajaksood and S.Suddee	181	KKU,K, BK,BKF,TCD	Trat	Koh Chang National Park, Koh Chang Subdistrict, Ban Salukkok Moo 4. By the side of the road, Km 19-20. Coconut forest. 12.05N, 102.25E	15	7	10	2002
A.Prajaksood and S.Suddee	188	KKU,TCD,BKF,K,BK	Trat	Ban Klong San, Tambon Dan Chumphon, Bo Rai District. By the side of the road, Km 49-50 route 3157, on the way to Klong Kaew Waterfall National Park. About 50 m from the check point. 12.60N, 102.60E	15	8	10	2002
van Beusekom C.F. & Smitinand T.	2158	K,GH,C,E,P,AAU,L,BKF	Chanthaburi	Foot of Khao Soi Dao. 13.00N, 102.15E	400	12	11	1969

Eriocaulon willdenovianum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Vacharapong	026	BK	Chumphon	Paknam Chumphon.	?	15	2	1968
Larsen K.	10035	AAU,C,BKF	Chanthaburi	Makham plain.	50	13	6	1963
Smitinand T. (& Lazarides M.)	11387	C,P,BKF	Rayong		?	22	11	1970
Smitinand T. (& Lazarides M.)	11390	K,C,E,L,BKF	Rayong		?	23	11	1970
Chanratanothai P., Chayamarit K., Middleton D., Parnell J. & Simpson D.	1169	K,KKU,TCD	Narathiwat	Ban Khok Ait, Plaiwan. Peat. 06.08N, 101.57E	<50	15	3	1993
Kerr A.F.G.	11708	K,C,BK	Ranong	Nam Chut.	s.l.	30	1	1927
Hansen B. & Smitinand T.	11895	K,C,E,P,L,BKF	Ranong	Muang Len.	160	2	1	1966
Sangkhachand B.	1197	K,L,BKF	Phangnga	Ko Kho Khao.	?	11	12	1965
Smitinand T.	12184	BKF	Surat Thani	Chaiya-Tha Chana.	5	10	3	1976
Hansen B. & Smitinand T.	12388	BKF	Phuket	Koh Yao Yai.	5	20	2	1966
Hansen B. & Smitinand T.	12388b	C	Phuket	Koh Yao Yai.	5	20	2	1966
Hansen B. & Smitinand T.	12418	K,C,E,P,L,BKF	Phuket	Koh Yao Yai.	5	21	2	1966
Chanratanothai P., Chayamarit K., Middleton D., Parnell J. & Simpson D.	1242	K,TCD	Narathiwat	Paa Waai, Sungai Padi District. Peat. Floating raft on the canal, south and west along the canal. 06.08N, 101.55E	<50	17	3	1993
Chermsirivathana C. & Kasem	1309	BK	Phuket	Tha Chat Chai.	?	12	4	1969
Sorensen Th., Larsen K. & Hansen B.	135	C,L	Chantaburi	Plain of Makham.	50-100	12	1	1958
Sangkhachand B.	136	K,BKF	Chanthaburi	Ban Ang.	120	3	8	1954
Kerr A.F.G.	13717	BK	Satun		5	28	12	1927
Smitinand T.	1428	K,BKF	Trat	Huay Raeng, Charng Kluae.	<50	22	6	1952
A. Prajaksood	148	KKU,K, BK,BKF,TCD	Trang	Tungkai Swamp Forest, along footpaths from accommodation to swamp forest.	-	21	3	1999
Koyama T., Phengklai C., O'Connor P.J. & Niyomdham C.	15229	AAU,BKF,NY	Ranong	Klong Nakha, between Kapoe and Kraburi, along route 4, hilly country.	?	4	2	1979

Collector	Number	Herbarium	Province	Place	Altitude	Date		
Niyomdham C. & Sriboonma D.	1555	AAU,K,C,E,P,L,BKF,NY	Narathiwat	Ku Chum, Tak Bai.	s.l.	7	9	1987
Put	1582	BK	?	Bang Son.	?	14	3	1928
Larsen K., Smitinand T. & Warncke E.	1661	AAU,L,BKF	Chantaburi	Plain of Makham.	?	22	8	1966
A.Prajaksood and S.Suddee	170	KKU,K, BK,BKF,TCD	Chanthaburi	Tambon Putthawee, Makham district. Route 317, Km 18-19, Khao Soi Dao-Makham route. 12.70N, 102.20E		5	10	2002
Chermsirivathana C. & Kasem	1706	BK	Chumphon	Sawee.	?	10	3	1970
A.Prajaksood and S.Suddee	172	KKU,K, BK,BKF,TCD	Trat	Near Wat Saphanhin, Laem Glad junction. Route 318, Muang-Klong Yai. 12.20N, 102.40E		5	10	2002
Kerr A.F.G.	17592	BK	Trat	Hui Keng.	5	18	12	1929
A.Prajaksood and S.Suddee	177	KKU,K, BK,BKF,TCD	Trat	Km 62-63, route 318, Ban Kad Lek-Klong Yai. 11.90N, 102.80E		5	10	2002
A.Prajaksood and S.Suddee	179	KKU,K, BK,BKF,TCD	Trat	Koh Chang National Park, Ban Thanmayom. Km 14-15. 12.05N, 102.25E		7	10	2002
J.A.N. Parnell, K. Chayamarit, R. Pooma, S. Suddee, D.A. Simpson, B. De Wilde	1841	BKF,K,TCD	Ranong	Ngao, Ngao National Park. By small stream. 09.51N, 98.37E	50	28	1	2002
A.Prajaksood and S.Suddee	187	KKU,TCD,BKF,K,BK	Trat	By the side of the road, Km 49-50 route 3157, on the way to Klong Kaew Waterfall National Park. 12.60N, 102.60E		8	10	2002
Chayamarit K., Pooma R. & Cheek M.	1885	BKF	Trat	Klong Yai, km 40, turn right to Lan Sai Beach, Taphan Hin Disctrict.	s.l.	18	03	2000
Pooma R., Chamchunroon V. & Phattarahirankanok K.	1915	BKF	Songkhla	Ton Plio falls, Ban Ton plio, Thung Tam Sao Subdistrict, Ton Nga Chang Wildlife Sanctuary, Hat Yai. 06.59N, 100.14E	100	2	6	2001
Pradit	192	BK	Songkhla	Hadd Yai.	?	16	4	1963
J.A.N. Parnell, K. Chayamarit, R. Pooma, D.A. Simpson, S. Suddee, B. De Wilde	1925	BKF,K,TCD	Surat Thani	Road 415 between Road 401 and Road 4. Roadside waste-land and pond. In run-off from cesspit. 08.32N, 98.43E	100	30	1	2002
A.Prajaksood and S.Suddee	194	KKU,TCD,BKF,K,BK	Trat	Bo Rai District. Route 3389, on the way to Klong Kaew Waterfall National Park. 12.60N, 102.60E		8	10	2002
J.A.N. Parnell, K. Chayamarit, R. Pooma, D.A. Simpson, S. Suddee, B. De Wilde	1947	BKF,K,TCD	Trang	Yan Ta Khao, Thung Khai Botanic Garden. 07.27N, 99.40E	10	30	1	2002
J.A.N. Parnell, K. Chayamarit, R. Pooma, D.A. Simpson, S. Suddee, B. De Wilde	1950	BKF,K,TCD	Trang	Yan Ta Khao, Thung Khai Botanic Garden. 07.27N, 99.40E	10	31	1	2002
Sakol	233	BK	Rayong	Ban Pae.	?	27	11	1964
Seidenfaden G.	2458	C	Surat Thani	W. of Kau Pet, Bandon. Rain forest.	?	28	1	1935
Sutheesorn S.	2488	BK	Phangnga	Kok Korkao.		29	4	1967

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Smitinand T.	266	P,BKF	Trat	Klong Yai.	10	11	4	1951
Seidenfaden G.	2704	C	Chanthaburi	West of Kao Sabab.	10	25	2	1935
Sutheesorn S.	2761	BK	Chumphon	Muang District.		28	12	1973
Supapol J.	285	GH	Chumphon	Muang District, Ban Huay Keaw, Moo 6, T. Tung Ka. One year oil palm plantation.	?	15	1	1986
Smitinand T.	2917	K,BKF	Surat Thani	Bangbas, Chan Khot.	<100	9	8	1955
Larsen K., Larsen S.S., Nielsen I. & Santisuk T.	31091	AAU,C,P,L,BKF,M,NY	Phangnga	Kapong 20 km S of Takuapah. 08.45N, 98.30E	50-75	17	7	1972
D.J. Middleton, M. Phuphat, R. Pooma, K. Williums	3179	TCD	Trang	Yan Ta Khao, Thung Khai. 07.28N, 99.38E	40	17	2	2004
Larsen K., Larsen S.S.,Nielsen I. & Santisuk T.	32284	AAU,BKF	Chanthaburi	Ban Chang Thum E of Makham. 12.36N, 102.29E	50	31	8	1972
A.Prajaksood and S.Suddee	328	KKU,TCD,BKF,K,BK	Phangnga	Ban Bangphang, Tambon Thana, Kaphong District. Local road Oil Kam-PhakPho route. 08.41N, 98.27E		17	12	2002
Larsen K., Larsen S.S., Barfod A.S., Nanakorn W., Ueachirakan W. & Sirirugsa P.	41010	AAU	Songkhla	Songkhla-Pattani road, c 50 km from Songkhla. 06.53N, 100.55E	0	31	10	1990
Larsen K., Larsen S. S., Nanakorn W., Ueachirakan W. & Sirirugsa P.	41011	AAU	Nan	Doi Phu Kha, ca. 70 km NE of Nan. 19.25N, 101.10E	1500-1600	13	12	1990
Charoenphol Ch., Larsen K. & Warncke E.	4146	AAU,K,L	Yala	06.34N, 101.18E	?	22	10	1970
Bogner	416	M	Chumphon		?	22	3	1971
Sutheesorn S.	4181	BK	Narathiwat	Tak Bai, fresh water swamp forest.	?	14	8	1977
Larsen K., Larsen S.S., Renner S.S., Ueachirakan W. & Sirirugsa P.	42905	AAU,P	Songkhla	23 km E of Chana. 06.53N, 100.56E	0	14	6	1992
Charoenphol Ch., Larsen K. & Warncke E.	4365	K,E,P,AAU,L,BKF	Nakhon Nayok	Khao Yai National Park."Orchid water fall" Evergreen forest along stream. 14.32N, 101.22E	700	31	10	1970
Larsen K., Larsen S.S., Norgaard Chr. T., Pharsen K., Puudjaa P. & Uerchirakan W.	43928	AAU	Songkhla	Thepha Bay. 06.55N, 100.50E	20	23	10	1993
Smitinand T.	5432	K,BKF	Chanthaburi	Makham.	20	27	1	1959
Smitinand T. & Abbe E.C.	6158	AAU,K,BK,BKF	Phangnga	Between Takuapah and Ranong.	100	18	11	1959
Geesink R. & Phengklai C.	6311	AAU,P,E,L,BKF,C	Trat	Taphan Hin, open melaleuca forest on sandy podsolic soil. 12.20N, 102.30E	0	3	8	1973
Robinson H.C.	6447	K	Trang	Is. Off the coast of Trang.	?	?	12	1916

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Geesink R., Hattink T. & Phengklai C.	6553	AAU,K,C,P,L,BKF	Trat	Khlong Kut. 12.00N, 102.40E	150	5	5	1974
Umpai	656	BK	Chanthaburi	Makam.	?	21	10	1984
Smitinand T. & John H. ST.	6853	K,BKF	Chanthaburi	Makham.	50	18	6	1960
Maxwell J.F.	71-565	AAU,L	Chanthaburi	Chanthaburi.	?	17	10	1971
Sorensen Th., Larsen K. & Hansen B.	723	C,L	Trang	Thalac Song Hong.	200	27	1	1958
Santisuk T.	763	GH,BKF	Ranong	Ban Kam Phuan.	?	4	12	1976
Sorensen Th., Larsen K. & Hansen B.	783	C,L	Trang?	Between Thai Moang and Thungmaprao. Small lake.	150	27	1	1958
Sorensen Th., Larsen K. & Hansen B.	7929	C	Chantaburi	Plain of Makham, near Chanthaburi.	50-100	12	1	1958
Chirayupin	82	BK	Krabi	Aow Luk.	?	24	5	1960
Ryding O.	836	UPS	Trat	Koh Chang, Ban Tan Majom at the NE coast of the island. 12.05N, 102.19E	?	24	12	1984
Maxwell J.F.	85-597	L	Songkhla	Haad Yai, SW watershed of Ko Hong Hill.	s.l.	16	1	1985
Maxwell J.F.	86-231	GH,L,BKF	Songkhla	Nah Mawn District, Klong Rhang Hill, along the stream.	50	9	4	1986
Maxwell J.F.	86-772	GH,L,BKF	Satun	Kuan Gah Long District, Nikom Sahng Eng Soi 6.	50	10	10	1986
Maxwell J.F.	87-166	GH,L,BKF,NY	Surat Thani	Tachang District, Ban Tahsae, Klong Sai Subdistrict.	10	5	2	1987
Maxwell J.F.	87-32	GH,AAU,L,BKF	Phatthalung	Bah Bawn District, Ban Nawng Tong.	25	12	1	1987
Smitinand T., Abbe E.C. & Abbe L.B.	9360	K,GH,L,BKF	Chanthaburi	Along access road to Mr Khid's plantation from point 3 mile SE of Chanthaburi. 12.37N, 102.10E	s.l.	21	12	1959
Congdon G.	989	AAU,GH	Satun	Tarutao National Park. Talo Oo Dang.	?	29	10	1980
Shimitsu T., Fukuoka N. & Nalampoon A.	T 8147	BKF	Nakhon Si Thammarat	In suburb of Tong Song.	?	27	08	1967
Fukuaka N. & Ito M.	T-35092	BKF	Chanthaburi	Ban Klong Sadet, Klung District.	?	10	12	1983
Fukuaka N. & Ito M.	T-35149	BKF	Chanthaburi	About 5 km west from Laem Sadet Khoong Kaben Bay.	?	11	12	1983

Eriocaulon xenopodium

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Smitinand T. & Turbang	10481	BKF	Nakhon Nayok	Khao Yai National Park.	1300	14	9	1968
A.Prajaksood and S.Suddee	158	KKU,K, BK,BKF,TCD	Nakhon Nayok	Khao Yai National Park, Muang District. The site for visit Tung Yah Khao Kam, on the way to Khao Kiew. 14.04N, 101.04E		28	9	2002
van Beusekom C.F. & Charoenpol C.	1711	C,E,AAU,P,L,BKF	Nakhon Nayok	Khao Yai National Park, Khao Kieo. 14.45N, 102.00E	1200	18	10	1969
Larsen K., Smitinand T. & Warncke E.	2	AAU,P,L,BKF	Prachin Buri	Khao Yai National Park, Khao Khieo.	1350	7	7	1966
Pooma R., de Widle W.J.J.O., Duyfjes B.E.E., Chamchunroon V. & Phattarahirankanok K.	2713	BKF	Nong Khai	Chet Si Falls, Phu Wua Wildlife Sanctuary, Se Ka District. 18.09N, 103.57E	200	26	8	2001
A.Prajaksood and S.Suddee	344	KKU,K, BK,BKF,TCD	Nakhon Nayok	Khao Yai National Park, Muang District. The site for visit Tung Yah Khao Kam, on the way to Khao Kiew. 14.40N, 101.40E		20	12	2002
Charoenphol Ch., Larsen K. & Warncke E.	4237	AAU, L,BKF	Nakhon Nayok	Eastern: Khao Yai National Park. Khao Kieo. Evergreen forest. 14.21N, 101.22E	1200-1300	29	10	1970
Maxwell J.F.	74-806	AAU,L,BK	Nakhon Nayok	Khao Yai National Park, Khao Kieo.	1000	12	8	1974
Smitinand T. & Sleumer H.	8323	K,L,BKF	Nakhon Nayok	Khao Yai National Park, Khao Khieo.	1300	29	8	1963
Smitinand T. & Williams	8410	BKF	Nakhon Nayok	Khao Khieo, Khao Yai	1400	11	11	1963
Koyama H., Terao H., Niyomdham Ch. & Wongprasert Th.	T-30023	GH	Nakhon Nayok	Khao Khieo, Khao Yai National Park, Pakchong District.	1160	19	11	1982
Fukuoka N. & Ito M.	T-34574	BKF	Nakhon Nayok	Khao Rom, Khao Yai National Park.	700-1200	2	12	1983
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-51894	BKF	Sakon Nakhon	Phu Phan National Park, ca. 30 km. Sw of Sakol Nakhon city. 17.00N, 104.00E	350	13	11	1984
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-51956	BKF	Sakon Nakhon	Phu Phan National Park, ca. 30 km. Sw of Sakol Nakhon city. 17.00N, 104.00E	350	13	11	1984
Murata G., Phengklai C., Mitsuta S., Nagamasu H. & Nantasan N.	T-52243	BKF	Nakhon Nayok	Near Nong King in Khao Yai National Park. 14.22N, 101.22E	1000-1100	13	10	1984

Eriocaulon xeranthenum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A.Prajaksood and S.Suddee	166	KKU,K, BK,BKF,TCD	Chanthaburi	Tambon Putthawee, Makham district. By the side of route 317, Km 18-19, Khao Soi Dao-Makham route. A seasonal pond in front of a shooting range of a Marine Department. 12.70N, 102.20E		5	10	2002
A.Prajaksood and S.Suddee	183	KKU,K, BK,BKF,TCD	Trat	Koh Chang National Park, Koh Chang Subdistrict, Ban Salukkok Moo 4. By the side of the road, Km 19-20. Coconut forest. 12.05N, 102.25E	1	7	10	2002
A.Prajaksood and S.Suddee	184	KKU,K, BK,BKF,TCD	Trat	Ban Klong San, Tambon Dan Chumphon, Bo Rai District. By the side of the road, Km 49-50 route 3157, on the way to Klong Kaew Waterfall National Park. About 50 m from the check point. 12.60N, 102.60E	15	8	10	2002
Sangkhachand B.	219	K, BKF, BK	Chanthaburi	Makham.	130	13	9	1954
Larsen K., Larsen S.S., Nielsen I. & Santisuk T.	32183	AAU,L,BKF,M	Chanthaburi	Pong Nam Ron-Pailin. 3.00N, 102.20E	?	28	8	1972
A.Prajaksood and S.Suddee	329	KKU,TCD,BKF,K,BK	Phangnga	Ban Bangphang, Tambon Thana, Kaphong District. By the side of the local road Oil Kam-PhakPho route (8 km from route 401 to route 4032). 08.41N, 98.27E		17	12	2002
A.Prajaksood and S.Suddee	335	KKU,TCD,BKF,K,BK	Ranong	Tambon Kamphun, Suksamlan Subdistrict. By the side of the road route 4, Km 697-698. 09.45N, 98.45E	39	18	12	2002
Hauiff & Hur	3640	K	?	Khaw Pok, Khsum.	?	30	11	1918
Maxwell J.F.	73-439	AAU,BK	Saraburi	Sahm Lahn Forest.	?	9	10	1973

Eriocaulon zollingerianum

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
A. Prajaksood & P. Chantaranothai	102	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Along the road at 4th km of the road number 2112, 10 km further to Khong Chiam.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	109	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Along the road at 4th km of the road number 2112, 10 km further to Khong Chiam.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	112	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Along the road, Ban Hau Kon, Pho Sri District. 10 km from crossroad of road number 2112 to Phimolmungsakan District.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	13	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way to Pha Nang Mern-Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	9	11	1997
A. Prajaksood	151	KKU,K, BK,BKF,TCD	Trang	Tungkai Botanic Garden. Swamp Forest, along footpaths from accommodation to swamp forest.	-	21	3	1999
A.Prajaksood and S.Suddee	165	KKU,K, BK,BKF,TCD	Chanthaburi	Tambon Putthawee, Makham district. By the side of route 317, Km 18-19, Khao Soi Dao-Makham route. A seasonal pond in front of a shooting range of a Marine Department. 12.70N, 102.20E		5	10	2002
A.Prajaksood and S.Suddee	173	KKU,K, BK,BKF,TCD	Trat	Ban Saphanhin Tambon Laem Glad, Muang District. Near Wat Saphanhin, Laem Glad junction. Route 318, Muang-Klong Yai. 12.20N, 102.40E		5	10	2002
A.Prajaksood and S.Suddee	190	KKU,TCD,BKF,K,BK	Trat	Ban Klong San, Tambon Dan Chumphon, Bo Rai District. By the side of the road, Km 49-50 route 3157, on the way to Klong Kaew Waterfall National Park. About 50 m from the check point. 12.60N, 102.60E		8	10	2002
A.Prajaksood and S.Suddee	191	KKU,TCD,BKF,K,BK	Trat	Tambon Bo Ploy, Bo Rai District. By the side of the road, route 3389, on the way to Klong Kaew Waterfall National Park. 12.60N, 102.60E		8	10	2002
Put	1943	BK	?	Watana Nakhon.		15	10	1928
J.A.N. Parnell, K. Chayamarit, R. Pooma, D.A. Simpson, S. Suddee, B. De Wilde	1954	BKF,K,TCD	Trang	Yan Ta Khao, Thung Khai Botanic Garden. 07.27N. 99.40E	10	31	1	2002
J.A.N. Parnell, K. Chayamarit, R. Pooma, D.A. Simpson, S. Suddee, B. De Wilde	1957	BKF,K,TCD	Trang	Yan Ta Khao, Thung Khai Botanic Garden. 07.27N, 99.40E	10	31	1	2002
A.Prajaksood and S.Suddee	198	KKU	Trat	Ban Toktuk, Tambon Sator, Khaosaming District. By the side of the road, route 3157 from Klong Kaew Waterfall National Park to Pliew Waterfall National Park, Km 16-17. 12.30N, 102.35E		8	10	2002
van Beusekom C.F. & Smitinand T.	2130	K, C, P, AAU,E,BKF	Chanthaburi	Foot of Khao Soi Dao, Disturbed evergreen forest. 13.00N, 102.15E	400	21	11	1969
A.Prajaksood and S.Suddee	244	KKU,TCD,BKF,K	Surin	Ban Klongnamsub, Tambon Nangmood, Kabcherng District. By the side of the road route 2121, Km 18-19. 14.45N, 103.40E		7	11	2002
A.Prajaksood and S.Suddee	247	KKU,K, BK,BKF,TCD	Surin	Prasart District. By the side of the road route 24, Km 139-140. 14.40N, 103.60E		7	11	2002
A.Prajaksood and S.Suddee	249	KKU,K, BK,BKF,TCD	Si Sa Ket	Tambon Samrongplan, Pribueng District. By the side of the road route 24, Km 237. 14.65N, 104.30E		7	11	2002
Chermsirivathana C.	249A	BK	Khon Kaen	Ban Rua, Pa Wieng.		26	12	1964
A.Prajaksood and S.Suddee	254	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Phu Chong Nayoy National Park, Tambon Nacharuey, Nacharuey District. Phalanphachad, Dipterocarp forest. 14.50N, 105.30E		8	11	2002
A.Prajaksood and S.Suddee	262	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Boontharik District. By the side of the road route 2182, Km 36-37. 14.78N, 105.40E		8	11	2002

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Phengklai C.	264	BKF	Kanchanaburi	Nong Daeng.	?	20	12	1961
A.Prajaksood and S.Suddee	266	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Ban Udomsuk, Tambon Kudprathai, Dacha Udom District. By the side of the road route 2172, Km 26-27. 14.98N, 105.33E		8	11	2002
A.Prajaksood and S.Suddee	274	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Tambon Kudchumpoo, Phimulmungsahan District. By the side of the road route 217, Km 51-52. 15.15N, 105.30E		8	11	2002
A.Prajaksood and S.Suddee	278	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khong Chium District. By the side of the road route 2222, Km 6-7. 15.30N, 105.50E		8	11	2002
A.Prajaksood and S.Suddee	282	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khong Chium District. By the side of the road route 2112, Km 4. 15.35N, 105.55E		8	11	2002
A.Prajaksood and S.Suddee	295	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Tambon Naphoglang, Khong Chium District. By the side of the road route 2112, Km 20-21, Phatam-Khammarach route. 15.58N, 105.55E		8	11	2002
A.Prajaksood and S.Suddee	302	KKU,K, BK,BKF,TCD	Ubon Ratchathani	By Ubon Ratchathani Forest Department, Tambon Naphoglang, Khong Chium District. By the side of the road route 2112, Km 100-101. 15.65N, 105.50E		8	11	2002
A.Prajaksood and S.Suddee	305	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Khammarach District. By the side of the road route 2242, Km 10-11. 16.05N, 105.15E		8	11	2002
A. Prajaksood & P. Chantaranothai	31	KKU,K, BK,BKF,TCD	Na khon Nayok	Along the way to Hel Narok Waterfall, 2.9 km from the headquarters of Khao Yai National Park.	-	21	10	1998
A.Prajaksood and S.Suddee	312	KKU,K, BK,BKF,TCD	Mukdahan	Tambon Kamphalai, Muang District. By the side of the road route 212, Km 177-178. 16.32N, 104.43E		10	11	2002
A.Prajaksood and S.Suddee	315	KKU,K, BK,BKF,TCD	Sakon Nakhon	Phu Phan National Park, Tambon Huey Yang, Muang District. Pha Nang Muen-Tam Chan route. Dipterocarp forest. 17.05N, 104.00E		11	11	2002
A.Prajaksood and S.Suddee	340	KKU,TCD,BKF	Nakhon Nayok	Khao Yai National Park,Muang District. Route 2090 from HQ to Km 40 (about 2.8 km from HQ), before the junction to Khao Kiew, the pond on the right hand side. 14.40N, 101.40E		28	9	2002
A. Prajaksood & P. Chantaranothai	43	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way from headquarters to Tham Chan-Lan Sao Ae, Phu Phan National Park.	210	31	10	1998
A. Prajaksood & P. Chantaranothai	5	KKU,K, BK,BKF,TCD	Sakon Nakhon	Along the way to Ang Kob-Kam Pak Nam, Phu Phan National Park.	210	7	11	1997
Sangkhachand B.	571-B	BKF	Chanthaburi	Pong Nam Ron, Ban Ta Rueang.	200	5	12	1956
A. Prajaksood & P. Chantaranothai	58	KKU	Nong Khai	The barren stream near Tham Phun Waterfall, Phu Wau National Park.	-	11	11	1998
A. Prajaksood & P. Chantaranothai	64	KKU,K, BK,BKF,TCD	Nakhon Phanom	Along the road number 2033 (Ray Nu Nakhon-Na gae), near Ban Nong Hoi Noi.	-	12	11	1998
Maxwell J.F.	71-563B	AAU,BK	Chanthaburi		?	17	10	1971
A. Prajaksood & P. Chantaranothai	73	KKU,K, BK,BKF,TCD	Ubon Rachathani	Along the road number 2112 (Khe marat- Pha Tam), near Ban Na Pa Nieng Or, Pho Sai District.	-	13	11	1998
Maxwell J.F.	73-597	AAU	Saraburi	Sahm Lahn forest.	200	4	11	1973
A. Prajaksood & P. Chantaranothai	83	KKU,K, BK,BKF,TCD	Ubon Ratchathani	Besides the bridge of 26 km further to Pha Tam National Park on the road number 2112. Khong Chiam District.	-	13	11	1998

Collector	*Number*	*Herbarium*	*Province*	*Place*	*Altitude*	*Date*		
Smitinand T.	8396a	BKF	Prachin Buri	Thung Phoh.	20	7	11	1963
Maxwell J.F.	87-117	GH,AAU,BKF	Surat Thani	District Kanchanadit Ban Tapaw, Surattani Horticultureal Research Station.	10	2	2	1987
Maxwell J.F.	87-49	GH,BKF	Chumphon	Muang,Ban Huay Gayo.	5	15	1	1987
A. Prajaksood & P. Chantaranothai	91	KKU	Ubon Ratchathani	Along the way Pha Mon to Car Park, Pha Tam National Park.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	99	KKU	Ubon Ratchathani	Under the bridge, 5 km from Pha Tam National Park.	-	14	11	1998
A. Prajaksood & P. Chantaranothai	BRT 747	KKU,K, BK,BKF	Sakol Nakhon	Along the way from Evergreen forest to open area of Ang Kob, Phu Phan National Park. 07.03N, 103.58E	210	3	10	1997
Murata G., Phengklai C., Mitsuta S., Yahara T., Nagamasu H. & Nantasan N.	T-50631	BKF	Sakon Nakhon	Phu Phan National Park, ca. 30 km. Sw of Sakon Nakhon city. 17.00N, 104.00E	380	12	11	1984

APPENDIX 2

SPECIMENS EXAMINED IN ANATOMY AND MOLECULAR STUDIES

Taxa	Collecting number of A.Prajaksood &S.Suddee	Dry material (g.)
Xyris indica L.	505	0.097
Syngonanthus sp.	509	0.065
Eriocaulon brownianum	201	0.071
Eriocaulon chantaranothaii	310	0.123
Eriocaulon chantaranothaii	321	0.162
Eriocaulon cinereum	339	0.210
Eriocaulon echinulatum	174	0.103
Eriocaulon escape	240	0.062
Eriocaulon hamiltonianum	250	0.066
Eriocaulon hamiltonianum	314	0.127
Eriocaulon hamiltonianum	324	0.092
Eriocaulon hamiltonianum var. *acuminatum*	318	0.100
Eriocaulon infirmum	189	0.112
Eriocaulon laosense	257	0.157
Eriocaulon laosense	259	0.074
Eriocaulon laosense	293	0.146
Eriocaulon nautiliforme	169	0.085
Eriocaulon nautiliformoides	264	0.083
Eriocaulon nautiliformoides var. *hexagynum*	265	0.129
Eriocaulon nepalense var. *luzulaefolium*	161	0.124
Eriocaulon nepalense var. *luzulaefolium*	208	0.082
Eriocaulon parnellii	242	0.092
Eriocaulon phatamense	289	0.193
Eriocaulon phuchongense	260	0.112
Eriocaulon phuchongense	276	0.145
Eriocaulon phuchongense	285	0.153
Eriocaulon phuphanoides	299	0.033
Eriocaulon phuphanoides	320	0.098
Eriocaulon phuphanoides	345	0.106
Eriocaulon pseudoescape	239	0.067
Eriocaulon quinquangulare var. *longibracteatum*	317	0.119
Eriocaulon setaceum	243	0.047
Eriocaulon siamense	200	0.123
Eriocaulon siamense	258	0.112
Eriocaulon siamense var. *macrophyllum*	203	0.123
Eriocaulon siamense var. *macrophyllum*	241	0.180
Eriocaulon siamense ssp. *hexagynum*	281	0.104
Eriocaulon smitinandii	205	0.082
Eriocaulon thailandicum	252	0.057
Eriocaulon truncatum	245	0.088
Eriocaulon truncatum var. *florensense*	162	0.071
Eriocaulon ubonense	238	0.137
Eriocaulon ubonense f. *kradungense*	202	0.108
Eriocaulon wightianum	176	0.068
Eriocaulon willdenovianum	170	0.062
Eriocaulon xenopodium	158	0.118
Eriocaulon xeranthemum	166	0.035
Eriocaulon zollingerianum	165	0.116

APPENDIX 3

PARAFFIN METHOD ADAPTED FROM THAMMATHAWORN (1995)

Outline Paraffin Method

1. Fixation (FAA 70%) and Cutting specimens
2. Suctioning (24 hours)
3. Washing (alcohol 50% 3 times)
4. Dehydration (TBA series)
5. Infiltration
6. Embedding
7. Microtoming
8. Affixing section to slide
9. Prestaining and Staining
10. Mounting and Label

Fixation (FAA70%) and Cutting specimens

Prepare FAA70% using formalin 5% v/v, glacial acetic acid 5% v/v and 70%ethyl alcohol 90% v/v, mix well. Pour FAA 70% in up to the ¾ make in a vial (small glass bottle) with a secure lid (called fixative vial). Then wash fresh specimens with tap water and then cut them into pieces, 1 cm. high, with a razor blade then immediately put the specimens into a fixative vial (now called specimen vial).

Suctioning

This step ensures that the fixative and chemical substances in the next steps get into every cell of the specimen (especially a problem for plant cells which have a lot of air space and a lumen, *e.g.* aquatic plants). Place the specimen vial into the dessicator, which is connected to a vacuum pump. Suction at 25 in Hg Vac for about 30-60 minutes, until there are no more the air bubbles moving from the specimens, then keep the specimen vial at room temperature for at least 24 hours before moving to the next step.

Washing

Rinse the specimens down with ethyl alcohol 50% for 3 times. Pouring fixative out into the "Used FAA" container then fill the vial with 50% alcohol, close the lid and gently move the vial around and pour the alcohol out, then fill the vial with 50% alcohol and leave the specimens in the alcohol for about 10 minutes. Repeat the washing 3 times.

Dehydration (Tertiary Butyl Alcohol (TBA) series)

1. Prepare the TBA grade I, II, III, IV and V as follows:

	TBA Grade (ml)				
	I	II	III	IV	V
Distilled water	50	30	15	0	0
Ethyl alcohol 95%	40	50	50	45	0
Tertiary Butyl Alcohol	10	20	35	55	75
Ethyl alcohol 100%	0	0	0	0	25
Total percentage of alcohol	50	70	85	95	100

2. Rinse the specimens with the TBA series using the same method as used for washing. Leave the specimens in each TBA grade for 24 hours. Then rinse the specimens with absolute TBA and leave in absolute TBA for 24 hours then repeat the rinse with absolute TBA 3 times to ensure all water is removed and that the wax will be able to infiltrate the specimens.

Infiltration

1. Prepare the hot air oven at 56°C then leave the paraffin wax (Paramat, pastillated, melting point 56°C) in a beaker in the hot air oven to melt the wax.
2. Prepare a mixture of absolute TBA: paraffin oil (TBA:Oil) = 1:1 v/v.
3. Rinse the specimens with the TBA:Oil mixture and then leave the specimens in the mixture for about 1 hour at room temperature.
4. Pour the melted wax (from the hot air oven) into a cleaned vial (wax vial) and fill to about ¾ make in a vial and leave the wax to set at room temperature.
5. Take the specimens from the TBA:Oil mixture and place on top of the wax vial and cover it with some the same mixture then leave the wax vial in the hot air oven for 24 hours.
6. Repeat this step for each vial each time, pour the melted wax and mixture off into the "Used paraffin" paper container then quickly replace with pure fresh melted wax and then leave the vial in the oven for 24 hours.
7. Repeat step 6, 2 times.

Embedding

1. Prepare embedding paper base moulds (for specimens whose depth is more than 5 mm) or stainless steel base molds (for specimens whose depth is less than or equal to 5 mm). Place these and the plastic holder molds into the hot air oven.
2. Pour the melted wax into the base mould which is kept warm on the hotplate then take a specimen from the vial and put into the base mold containing melted wax.
3. Move the base mould from the hotplate to the table and then set the specimens upright (for transverse section cutting) using warm needles to manipulate them then put the plastic warm holder mould on top of the base mould to form a set and pour the melted wax on top until the set is full then leave at room temperature without moving the mold to let the wax set. After the wax in the paper base mold is set, take the paper off and trim the wax into a "cubic block", which the specimens is in the center. For specimen whose depth is more than 5 mm,

as unable to put the holder mold on top of the paper base mold, prepare the "block without specimens" (make the block using the set of stainless steel base mold and plastic holder without specimen in the wax) then stick the "block without specimen" together with the "cubic block" using a hot spatula touching each surface of the blocks to melt the wax and then press them to form one piece.

4. Trim the blocks into a trapezium shape.
5. Keep the blocks in refrigerator at least 15 minutes.

Microtoming

Cut the blocks on a sliding microtome with disposable blades, 10-15 μm thickness, set the clearance angle to 5°-10°. The thin pieces with specimens produced by cutting the block are called "sections or ribbons".

Affixing section to slide

1. Melt 0.25 g of gelatin powder with 200 ml hot water in a beaker, then add 300 ml tap water and then put the beaker on the drying plate (50°C).
2. Put the section in the warm gelatin solution, keep the shiny surface up and then leave for a minute to extend the section.
3. Lift the section using a cleaned, twin frosted microscope slide and using needles arrange the position of the section on the slide as desired. Then leave the slide to stand beside the drying plate, to drain the solution, for a few minutes.
4. Keep the dry slides into the microscope slide case for 20 days (up to 5 months).

Prestaining and Staining

As the stain (toluidine blue) is water based, it is necessary to remove the embedding wax from the sections before staining.

1. Prepare toluidine blue stain using toluidine blue 0.5 g in tap water 100 ml, stir well, filter, paper then keep in bottle.
2. Prepare a Coplin's staining jar with solution of each step as follows: (Transferring the slides to other solutions in each step in the fume hood)

Step	Solutions	Time in solution
1	Absolute Xylene	10 mins
2	Absolute Xylene:Absolute alcohol = 1:1	3-5 mins
3	Absolute ether:Absolute alcohol = 1:1	3-5 mins
4	Absolute alcohol	3-5 mins
5	Alcohol 95%	3 mins-4 hrs
6	Alcohol 70%	up-down 3 times
7	Alcohol 50%	up-down 3 times
8	Alcohol 30%	up-down 3 times
9	Toluidine blue	2 hours
10	Wash with tap water in beaker	up-down 3 times

Step	Solutions	Time in solution
11	Alcohol 30%	up-down 3 times
12	Alcohol 50%	up-down 3 times
13	Alcohol 70%	up-down 3 times
14	Alcohol 95%	up-down 3 times
15	Absolute alcohol	up-down 3 times
16	Absolute Xylene:Absolute alcohol = 1:1	3-5 mins
17	Absolute Xylene	3-15 mins

Mounting and Label

The slides can then be mounted permanently in DPX mountant for microscopy. Label slides with plant name, plant organ (leaf, scape), collector and collector number, transverse section, toluidine blue.

APPENDIX 4

CHARACTERS AND CHARACTER STATES

1. Stem: rhizome or corm: (0) absent (1) present

"Absent" means stems are very short or elongate but not rhizome or corm.

2. Leaf: length: (0) < 10 cm (1) > or = 10 cm

3. Leaf: surface hairy: (0) absent (1) present

4. Leaf: papillate: (0) absent (1) present

5. Leaf: apex: (0) acute (1) obtuse

6. Leaf: reddish color: (0) absent (1) present

"Absent" means leave green.

7. Scape: (0) absent (1) present

8. Receptacle hairy: (0) absent (1) present

9. Involucral bracts as long as or longer than the length of capitula:

(0) absent (1) present

"Absent" means involucral bracts are much shorter than the length of capitula.

10. Involucral bracts texture: (0) leathery (1) papery

11. Involucral bracts hairy: (0) absent (1) present

12. Involucral bracts apex long acuminate: (0) absent (1) present

13. Floral bracts blackish: (0) absent (1) present

"Absent" means floral bracts whitish or pale brown or brown, "present" means floral bracts blackish all over, or pale brown with blackish in the upper part, or brown with blackish in the upper part.

14. Floral bracts hairy: (0) absent (1) present

"Absent" means glabrous or with few hairs.

15. Floral bracts apex long acuminate: (0) absent (1) present

16. Male flowers 2 sepals: (0) absent (1) present

"Absent" means 3 sepals.

17. Male flowers sepals blackish: (0) absent (1) present

"Absent" means sepals whitish or pale brown or brown, "present" means sepals blackish all over, or pale brown with blackish in the upper part, or brown with blackish in the upper part.

18. Male flowers unequal petals: (0) absent (1) present

"Absent" means petals equal.

19. Male flowers petals exserted beyond the floral bracts:

(0) absent (1) present

"Absent" means petals not exserted beyond the floral bracts, "present" means at least one petal exserted beyond the floral bracts.

20. Male flowers petals hairy: (0) absent (1) present

"Absent" means petals glabrous or have few hairs.

21. Male flowers glandular petals: (0) absent (1) present

"Absent" means no black gland on the petals.

22. Female flowers, lateral sepals winged-keeled: (0) absent (1) present

23. Female flowers dimorphic sepals: (0) absent (1) present

"Absent" means median female sepals absent or similar to lateral or united sepals, "present" means median sepals different from lateral sepal.

24. Female flowers blackish sepals: (0) absent (1) present

"Absent" means sepals whitish or pale brown or brown, "present" means sepals blackish all over, or pale brown with blackish in the upper part, or brown with blackish in the upper part.

25. Female flowers petals: (0) absent (1) present

26. Ovary, 5-6 locules: (0) absent (1) present

"Absent" means ovary 2 or 3 locular

27. Seed surface papillate: (0) absent (1) present

28. Leaf, hypodermis: (0) absent (1) present

"Absent" means epidermis one layer; "present" means epidermis more than one layer.

29. Leaf, vascular tissue equidistant: (0) absent (1) present

"Absent" means vascular tissue closest to adaxial epidermis.

30. Leaf, mesophyll homogenous: (0) absent (1) present

"Absent" means mesophyll differentiate to palisade and spongy, outermost mesophyll isodiametric or elongated cells, innermost stellate or irregularly shaped cells; "present" means only stellate or irregularly shaped cells in mesophyll.

Table A Characters and character states of each species for analysis. "No." means number of A.Prajaksood and S.Suddee collections.

No.	Characters and character states																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
158	1	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	1	1	0
161	0	0	0	0	0	0	1	1	0	1	0	0	1	1	0	0	1	1	0	0	0	0
162	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	1	0	0	0	1	0
165	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1
166	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	1	0	0	0	1	0
169	0	1	0	0	1	0	1	1	0	0	0	0	1	1	1	0	1	1	1	1	1	0
170	1	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1
174	0	0	0	0	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	1
176	0	1	0	0	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0
189	0	0	0	0	0	0	1	1	0	0	1	0	1	1	0	0	1	1	0	1	0	0
200	1	0	0	1	0	1	1	1	0	0	1	0	1	1	0	0	1	1	1	1	1	0
201	1	1	1	0	0	0	1	1	0	0	1	0	1	1	0	0	1	0	0	1	1	1
202	1	0	0	0	1	0	1	1	0	0	0	0	1	1	0	0	1	1	0	1	1	0
203	1	0	0	1	1	0	1	1	0	0	1	0	1	1	0	0	1	1	1	1	1	0
205	0	0	0	0	0	0	1	1	0	1	1	0	0	1	0	0	0	0	0	1	1	0
208	0	0	0	0	0	0	1	1	0	1	0	0	1	1	0	0	1	1	0	0	0	0
238	1	0	0	0	1	0	1	1	0	0	0	0	1	1	0	0	1	1	0	1	1	0
239	0	0	0	0	0	0	0	1	0	1	0	0	1	1	0	0	1	1	0	0	0	0
240	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	1
241	1	0	0	1	1	0	1	1	0	0	1	0	1	1	0	0	1	1	1	1	1	0
242	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	1	1	0	1	1	0
243	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	1	0	0	0	1	0
245	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	1	0	0	0	1	0
250	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0
252	0	0	0	0	0	0	1	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0
257	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	1	1	0
258	1	0	0	1	0	1	1	1	0	0	1	0	1	1	0	0	1	1	1	1	1	0
259	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	1	1	0
260	0	0	0	0	0	0	1	1	0	1	0	0	0	1	1	0	0	0	0	1	1	0
264	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	1	1	0
265	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	1	1	0
276	0	0	0	0	0	0	1	1	0	1	0	0	0	1	1	0	0	0	0	1	1	0
281	0	0	0	1	0	0	1	1	0	1	0	0	1	1	0	0	1	1	1	1	1	0
285	0	0	0	0	0	0	1	1	0	1	0	0	0	1	1	0	0	0	0	1	1	0
289	0	0	1	0	0	0	1	1	0	1	1	0	0	1	0	1	0	1	0	1	1	0
293	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	1	1	0
299	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	1	0	1	0	1	1	0
310	0	0	1	0	0	0	1	1	0	0	1	0	0	1	0	0	0	1	1	1	1	0
314	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0
317	0	0	0	0	0	1	1	1	0	1	0	0	1	1	0	0	1	1	0	1	1	0
318	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
320	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	1	0	1	0	1	1	0
321	0	0	1	0	0	0	1	1	0	0	1	0	0	1	0	0	0	1	1	1	1	0
324	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0
339	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	1	0	0	1	0
345	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	1	0	1	0	1	1	0
505	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	?	?	?	?	?	?	1
509	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0

Table A Continued.

No.	Characters and character states							
	23	24	25	26	27	28	29	30
158	0	0	1	0	1	1	1	0
161	0	1	1	0	1	0	0	0
162	0	1	1	0	0	0	1	0
165	1	0	1	0	0	0	0	0
166	0	1	1	0	1	0	0	0
169	1	1	1	0	0	0	1	0
170	0	0	1	0	1	0	1	1
174	1	0	0	0	1	0	0	0
176	1	0	1	0	1	0	1	1
189	0	1	1	0	1	0	0	0
200	0	1	1	0	1	0	0	0
201	0	1	1	0	1	0	1	0
202	0	1	1	0	0	0	1	0
203	0	1	1	0	1	1	1	0
205	0	0	1	0	0	0	0	0
208	0	1	1	0	1	0	0	0
238	0	1	1	0	0	0	1	0
239	0	1	1	0	1	0	0	0
240	1	0	0	0	0	0	0	0
241	0	1	1	0	1	0	1	0
242	0	1	1	0	1	0	0	1
243	0	1	1	0	1	0	0	0
245	0	1	1	0	0	0	0	0
250	0	0	1	0	0	0	0	0
252	0	0	1	0	0	0	0	0
257	0	0	1	0	0	0	0	0
258	0	1	1	0	1	0	0	0
259	0	0	1	0	0	0	0	0
260	0	0	1	0	0	0	0	0
264	1	0	1	0	0	0	0	0
265	1	0	1	1	0	0	0	0
276	0	0	1	0	0	0	0	0
281	0	1	1	1	1	0	1	0
285	0	0	1	0	0	0	0	0
289	0	0	1	0	0	0	0	0
293	0	0	1	0	0	0	0	0
299	0	0	1	0	0	0	0	0
310	0	0	1	0	0	0	0	0
314	0	0	1	0	0	0	0	0
317	0	1	1	0	0	0	0	0
318	0	1	1	0	0	0	0	0
320	0	0	1	0	0	0	0	0
321	0	0	1	0	0	0	0	0
324	0	0	1	0	0	0	0	0
339	0	1	0	0	0	0	0	0
345	0	0	1	0	0	0	0	0
505	1	0	1	0	0	0	1	1
509	0	0	1	0	0	1	0	0

Table B The three dimension values for object scores of 34 taxa of *Eriocaulon* using homogeneity analysis of dataset in Table A.

Number	Specific epithet(collection number)	Dimension		
		1	2	3
1	xenopodium158	0.981	1.405	-0.332
2	nepalense var. luzulaefolium161	0.129	-0.880	1.032
3	truncatum var. florensense162	-0.618	-0.987	0.864
4	zollingerianum165	-1.091	0.576	-0.075
5	xeranthemum166	-0.308	-0.866	0.977
6	nautiliforme169	0.872	1.116	0.388
7	willdenovianum170	0.317	2.327	-0.039
8	echinulatum174	-1.970	1.630	0.920
9	wightianum176	0.266	2.102	-0.990
10	infirmum189	0.530	-0.450	0.385
11	siamense200	1.799	-0.376	0.775
12	brownianum201	1.090	1.276	-0.184
13	ubonense f. kradungense202	1.093	0.314	0.448
14	siamense var. macrophyllum203	2.252	0.928	0.780
15	smitinandii205	-0.201	-0.497	-1.454
16	pseudoescape239	-0.105	-0.773	1.563
17	escape240	-2.565	1.540	1.588
18	parnellii242	0.687	-0.156	0.422
19	setaceum243	0.254	-0.371	0.654
20	truncatum245	-0.339	-1.319	0.114
21	hamiltonianum250	-1.099	-0.775	-0.494
22	thailandicum252	-1.318	0.006	-0.163
23	laosense257	-0.333	-0.581	-1.107
24	phochongense260	-0.552	-0.373	-0.978
25	nautiliformoides264	-0.279	0.241	-1.534
26	nautiliformoides var. hexagynum265	-0.167	0.170	-1.698
27	siamense ssp. hexagynum281	1.439	-0.674	0.745
28	phatamense289	-0.050	-0.959	-1.959
29	chantaranothaii310	0.373	-0.209	-1.689
30	quinquangulare var. longibracteatum317	0.601	-1.364	0.423
31	hamiltonianum var. acuminatum318	-0.998	-0.043	0.264
32	phuphanoides320	-0.268	-1.053	-1.165
33	cinereum339	-0.422	-0.926	1.519
34	ubonense238	1.093	0.314	0.448

APPENDIX 5

MOLECULAR PROTOCOLS AND DATA MATRIX

5.1 Isolation of total genomic DNA using CTAB

Materials	Equipment
2xCTAB Buffer (100mM Tris-HCl pH 8., 01.4M NaCl, 20mM EDTA, 2%CTAB)	Balances: Mettler Toledo College B303
Dried leaf material	Water bath: Grant SUB14 / Memmert W200
2-mercaptoethanol	10ml capped centrifuge tubes (labelled)
CI (24:1 chloroform: isoamyl alcohol)	Pestles
Isopropanol (2-propanol)	Mortars
Wash buffer (70% ethanol)	Weighing boats
TE buffer (10mM Tris-HCl pH 8, 1mM EDTA)	Fume hood
	Pipettes (P200, P5000)
	Pipette tips
EDTA= Ethylene diamine tetra acetate	Edmund BÜhler KL-2 horizontal shaker
CTAB= Hexadecyltrimethyl-Ammonium Bromide	Transfer pipettes
	50 ml centrifuge tubes
	Harrier 15/ 80 centrifuge
	1.5ml micro centrifuge tubes

Procedure

1. 10ml of 2xCTAB extraction buffer and 40ul of 2-mercaptoethanol were placed in labeled 12ml capped centrifuge tubes (fume hood).
2. The tubes and pestles and mortars were then preheated at 65°C in a water bath.
3. Each extraction required 0.05-0.1g of leaf material, cut up into small pieces. Extractions were carried out in a fume hood. Using initially a small amount of extraction buffer the leaf material was ground up using a pre-heated pestle and mortar. When the leaf material was almost ground to a pulp the remainder of the extraction buffer was added.
4. The slurry was then placed back into the 12ml centrifuge tube, sealed and incubated at 65°C for approximately 10 minutes with occasional mixing.
5. 10 ml of CI was then added to each tube and mixed gently. The lid was released briefly to release any gas that had accumulated and then tightened once more.
6. The tubes were placed on a shaker in a horizontal position for approximately 30 minutes.
7. All samples were then centrifuged at 4500 rpm for 10 minutes.
8. The samples were then carefully removed so as not to disturb the layers. The aqueous (upper) phase containing the DNA was removed using a transfer pipette and placed in 12ml capped tubes.
9. Equal volumes of isopropanol were added to each DNA sample.
10. The tubes were sealed and inverted to precipitate the DNA.
11. All samples were stored at -20°C for at least a week to further precipitate the DNA.
12. Following precipitation the samples were centrifuged at 2,500rpm for 10 minutes to pellet the DNA.

13. The supernatant was then poured off and 3ml of wash buffer was added to each tube, and mixed gently.

14. The samples were centrifuged once more at 2,500rpm for 5 minutes to pellet the DNA.

15. The supernatant was decanted off and the tubes were placed upside down for 5 minutes on a paper towel to let any excess wash buffer drain away.

16. The tubes were then turned right way up and allowed to air dry in a fume hood for approximately 25-30 minutes to remove all traces of ethanol.

17. The DNA pellets were suspended in 0.5 ml of TE buffer.

18. The eluted DNA samples (the crude total DNA) were then transferred to 1.5ml micro centrifuge tubes and stored in -20°C until used or in -80°C freezer for long periods.

5.2 Estimation of DNA fragment size, quantity and quality using agarose gel electrophoresis

Materials	Equipment
80ml of 1.2% w/v agarose gel (1.2g of agarose, 100 ml 1xTBE buffer, 2ul of Ethidium Bromide) Loading Dye (Bromophenol blue and Sucrose) 10xTBE buffer (55g of boric acid, 108g of Trizma base, 8.3g of Na_2EDTA, 1liter of water) The crude total DNA sample or amplified PCR products	Parafilm Pipette (P20) Pipette tips Gel rig (Horizon 11.14 Life Technologies, GIBCO BRL Horizontal Electrophoresis Apparatus) Power pack (EC105, E-C Apparatus Corporation) UV light box (UVP Dual-intensity transilluminator)

Procedure

1. 8 µl of the crude total DNA or 4 µl of amplified PCR products were mixed with 2 µl of loading dye on parafilm.

2. The mixture was then pipetted into a well on an agarose gel based in TBE buffer in a gel rig.

3. Once all samples were loaded onto the gel, each sample was then subjected to 118V for 30- 45 minutes.

4. The agarose gel was then placed above a UV light box and the DNA samples were visualized. and quantified.

5.3 Purification of total genomic DNA using Spin Column Technique

Materials	Equipment
the crude total DNA (or amplified PCR products for PCR purification) TE Buffer (10mM Tris/HCl ,pH 8.0) **JETQUICK PCR Purification Spin Kit/250:** 1. solution H1(Binding) contains concentrated guanidine hydrochloride, EDTA, Tris/HCl and isopropanol) 2. solution H2 (Wash, reconstituted) contains ethanol, NaCl, EDTA and Tris/HCl (add 140 ml 95-100% ethanol before use, namely reconstituted H2) 3. JETQUICK spin columns (filter tubes) 4. the receiver tubes (wash tubes)	1.5ml micro centrifuge tubes Pipettes (P20, P200 and P1000) Pipette tips Heating block: Grant QBT2 Microcentrifuge (Microlite Thermo IEC)

Protocol

1. An aliquot of TE Buffer (50 µl per sample cleaned) was preheated to 65° to 70°C.
2. Four times the volume of solution H1 was added to each crude total DNA sample (add 400 µl solution H1 to 100 µl DNA sample or 50-100 µl amplified PCR products) in 1.5 ml micro centrifuge tubes and mixed thoroughly.
3. Place filter tubes into wash tubes (the prepared spin column) then transfer the mixture (DNA sample/H1) to the prepared spin column and then centrifuge at 13,000rpm for one minute.
4. The through flow was discarded and the filter tubes placed once more into the wash tubes then 500µl of reconstituted solution H2 added and then the tubes were centrifuged at 13,000rpm for one minute.
5. The through flow was once more discarded and the filter tubes replaced. Each sample was then centrifuged for a third time at 13,000rpm for one minute.
6. The through flow was discarded and the filter tubes placed into the new 1.5 ml micro centrifuge tubes and 50µl of TE buffer was added directly to the center of the filter tubes.
7. Each was then incubated at room temperature for one minute and then centrifuged at 13,000rpm for two minutes. The filter tubes were discarded.
8. The purified total DNA solution in the micro centrifuge tubes was then stored at –20 or -80°C.

5.4 Polymerase Chain Reaction

Materials	Equipment
Total Reaction Volume 50 µl : **1. Template Volume 3 µl:** Purified total DNA 0.5-3 µl (add ultra purified water to make template volume) **2. Amplification reagents (1x) 47 µl:** Ultra pure water 34.75 µl 10xBufferPrimers (conc. 100ng/µl) 5.00 µl dNTPs (conc.100ng/µl) 1.00 µl Primer c (conc.100ng/µl) 0.50 µl Primer f (conc.100ng/µl) 0.50 µl Promega 25mM Magnesium Chloride 5.00 µl Sigma *Taq* polymerase 0.25 µl (or Magnesium Chloride 4 µl, pure water 35.75 µl)	0.2 ml micro centrifuge tubes with cap (labelled) 1.5 ml micro centrifuge tubes Pipettes (P2, P10, P20, P200, P1000) Pipette tips Micro centrifuge: Micro Centaur MSE Scotsman AF 10 Ice Maker Whirlmixer (Fison Scientific Equipment) Thermocycler: GeneAmp PCR System 9700: Premeit 95°C for 1 minute Denature 95°C for 45 seconds Anneal 48 (or 50) °C for 60 (or 45) seconds Extension 72°C for 2 minutes Final extension 72°C for 7 minutes 30-32 cycles Incubation at 4°C indefinitely

Procedure

1. All purified total DNA samples and reagents were thawed and placed on ice.
2. Each DNA sample was placed in a separate 0.2 ml tube, purified water was added if needed to make up template volume to 3 µl.
3. A master mix of purification reagent was then made in a 1.5ml tube, adding all reagents according to the table stated above.
4. The master mix was then vortexed and a 47 µl aliquoted placed into each 0.2ml tube.
5. Each sample was then centrifuged briefly.
6. The samples were then placed into a thermocycler and subjected to the temperature treatments stated above.
7. The amplified PCR products were then quantified using gel electrophoresis and subsequently purified (Appendix 5.2 and 5.3). The purified PCR products were then refrigerated at –20°C.

5.5 Big Dye Terminator: Cycle Sequencing Reactions

Materials	Equipment
Total Reaction Volume 10 µl **1. Purified PCR Products 3 µl** **2. Sequencing reagents (1x) 6 µl:** Ultra purified water 1.8 µl Sequencing buffer 3.5 µl Primer c (conc. 5ng/µl) 0.7 µl (or Primer f (conc. 5ng/µl) 0.7 µl) **3. Big Dye™ Sequencing Mix 1.0 µl**	0.2 ml micro centrifuge tubes with cap (labelled) 0.5 ml micro centrifuge tubes Pipettes (P2, P10, P20, P200, P1000) Pipette tips Micro centrifuge: Micro Centaur MSE Scotsman AF 10 Ice Maker Whirlmixer (Fison Scientific Equipment) Thermocycler: GeneAmp PCR System 9700: Denature 96°C for 10 seconds Anneal 50°C for 5 seconds Extension 60°C for 4 minutes 25 cycles Incubation at 4°C indefinitely

Procedure

1. Both the PCR products and sequencing reagents were thawed and kept on ice.
2. Big Dye™ Sequencing Mix 1.0 µl were added into each 0.2 tube.
3. A master mix of sequencing reagent was then made in a 0.5ml tube, adding all reagents according to the table stated above.
4. The master mix was then vortexed and a 6 µl aliquoted placed into each 0.2ml tube.
5. Each PCR product was placed in a mixture 0.2ml tube.
6. Each sample was then centrifuged briefly.
7. The samples were then placed into a thermocycler and subjected to the temperature treatments stated above.
8. The Cycle sequenced DNA samples were purified (Appendix 5.6) and were then stored at –20°C.

5.6 Purification of Cycle Sequenced DNA Samples

Materials	Equipment
Cycle sequenced DNA 10 µl	0.5ml micro centrifuge tubes (labelled)
Precipitate reaents (1x) 52 µl:	1.5ml micro centrifuge tubes
100% Ethanol (EtOH) 50 µl	Pipettes (P2, P20, P200. P1000)
3M Sodium Acetate (NaOAc) 2 µl	Pipette tips
Wash reagent:	Paper towels
70% Ethanol (EtOH) 300 µl	Heating block: DNA Thermal Cycler 480
	Microcentrifuge (Microlite Thermo IEC)

Procedure

1. The master mix of precipitate reagent was made in a 1.5ml tube, adding all reagents according to the table stated above.
2. The master mix was then vortexed and a 52 µl aliquoted placed into each 0.5ml tube.
3. Cycle sequenced DNA was added to the mixture and then incubated at room temperature for ten minutes and then placed on ice or in a -20°C freezer for a further ten minutes.
4. Each sample was then centrifuged at 13000rpm for 25minutes.
5. The supernatant was carefully discarded and 300µl of 70% EtOH was then added to each tube and was then centrifuged at 13000rpm for 15 minutes.
6. The supernatant was carefully discarded and a step 5 was repeated.
7. The pelleted DNA was air-dried overnight under paper towels and then stored at -20°C.

5.7 Denaturing of Samples prior to Sequencing using the ABI Prism™ 310 Genetic Analyser

Materials	Equipment
Purified cycle sequenced DNA samples	0.5ml micro centrifuge tubes tubes (labelled)
Template suppression reagent (TSR,ABI Prism)	Pipette (P200)
	Pipette tips
	Whirlmixer (Fison Scientific Equipment)
	Micro centrifuge: Micro Centaur MSE
	Heating block: DNA Thermal Cycler 480
	Septa for 0.5ml micro centrifuge tubes tubes
	Scotsman AF 10 Ice maker

Procedure

1. 25µl of TSR was added to each sample DNA pellet.
2. The samples were then vortexed slightly and heated for 5-10 minutes at 95°C.
3. The DNA samples were then chilled on ice 3-4 minutes, vortexed once more and then centrifuged briefly.
4. The samples were then run on an ABI PRISM® 310 Genetic Analyser.

5.8 Data matrix of aligned *trnL-F* sequences and 30 binary characters for 48 taxa (46 taxa of *Eriocaulon* and 2 taxa of outgroups).

Input data matrix:

```
                 1111111122222222233333333344444444445555555556666666666777777777888888888
Taxon/Node       2345678901234567123456789012345678901234567890123456789012345678901234567
-------------------------------------------------------------------------------------------
nepal luzula157  GTGGTAACTTCCAA-TCAGA-GTAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TA
xenopodium158    GTGGCAACT-CCAAATCAAA-ATAACCCCTGG-AAT-TAAAAA--GGGTAA-TCCTGAGCC-AAATCCTA-TG
nepal luzula161  GTGGTAACTTCCAAATCAGA-GTAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TA
trun florens162  GTGGTAACTTCCAAATCAGA-GTAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TT
zollingerian165  GTGGTAACTTCCAA-TCAGA-GTAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TA
xeranthemum166   GTGGTAACTTCCAAATCAGA-GTAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TG
nautiliforme169  GTGGTAACTTCCAA-TCAGA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTA-TG
willdenovian170  GTGGTAACTTCCAAAACAGA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TG
echinulatum174   GTGGTAACTTCCAAATCAGA-GTAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TA
wightianum176    GTGGTAACTTCCAAATCAGA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TG
infirmum189      GTGGTAACTTCCAAATCAGA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTCATG
siamense200      GTGGTAACTTCCAAATCAGA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TT
brownianum201    GTGGTAACTTCCAAATCAGA-GTAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TG
ubon kradung202  GTGGTAACTTCCAAATCAGA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTA-TG
siam macroph203  GTGGTAACTTCCAAATCAGA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TG
smitinandii205   GTGGTAACTTCCAAATCAGA-AGAAACCCTGG-AAGTTAAAAAA-GGGTAAGTCCTGAGCC-AAATCCTA-TG
nepal luzula208  GTGGTAACTTCCAAATCAAA--GAACCCCTGG-AATATAAAAAA-GGGTAATTCCTGAGCC-AAATCCTC-TA
ubon kradung238  GTGGTAACTTCCAAATCATA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTCATG
pseudoescape239  -TGGTAACTTCCAAATCAGAAGAAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TA
escape240        GTGGTAACTTCCAAATCATA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTCATG
siam macroph241  GTGGTAACTTCCAAATCAGA-GTAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TT
parnellii242     GTGGTAACTTCCAAATCAGATGTAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TA
setaceum243      --GGTAACTTCCAAATAACA----ACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TA
truncatum245     GTGGTAACTTCCAAATCAGATGTAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TT
hamiltonianu250  GTGGTAACTTCCAAATCAGA-G-AACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TA
thailandicum252  -TGGTAACTTCCAAATCAGA-GTAACCCCTGGCAAT-TAAAAATAGGGTAA-TCCTGAGCC-AAATCCTA-TG
laosense257      GTGGTAACTTCCAAATCAGA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTA-TG
siamense258      GTGGTAACTTCCAAATCAAA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTA-TG
laosense259      GTGGTAACTTCCAAATAAAG--TAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTA-TG
phuchongense260  GTGGTAACTTCCAAATCAGAAGAAGCCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTA-TG
nauti des264     GTGGTAACTTCCAAAACAGA----ACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TG
nauti deshex265  GTGGTAACTTCCAAATCAAT-AGAAACCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTA-TG
phuchongense276  GTGGTAACTTCCAAATCAGTAGTAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTA-TG
siamense hex281  GTGGTAACTTCCAAAT-ACA--GAACCCCTGG-AATATAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTA-TG
phuchongense285  GTGGTAACTTCCAAATCAGA-AGAACCCCTGG-AATATAAAAATAGGGTAA-TCCTGAGCC-AAATCCTA-TG
phatamense289    GTGGTAACTTCCAAAT-AAATAGAACCCCTGG-AAT--AAAAAA-GGGTAA-TCCTGAGCC-AAATCCGCATA
phuchongense293  GTGGTAACTTCCAAATCACG-AGAACCCCTGG-AATATAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTA-TG
phuphanoides299  GTGGTAACTTCCAAATAAGA----ACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTA-TG
chantaranoth310  GTGGTAACTTCCAAAT-AGA--GAAACCCTGG-AATATAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTCATG
hamiltonianu314  GTGGTAACTTCCAAATCAGA----ACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TA
quinq longib317  GTGGTAACTTCCAAATCAGA----ACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TA
hamil acumin318  GTGGTAACTTCCAAATCACA-G-AACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TA
phuphanoides320  GTGGTAACTTCCAAATCAGA----ACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTC-TA
chantaranoth321  -------------------------------------------------------------------------
hamiltonianu324  GTGGTAACTTCCAAATCAGA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCCTAAATCCTC-TA
cinereum339      GTGGTAACTTCCAAATCAGA--GAACCCCTGG-AAT--GAAAAAGGGGTAA-TCCTGAGCC-AAATCCTC-TG
phuphanoides345  GTGGTAACTTCCAAATCAGA--GAACCCCTGG-AAT-TAAAAAA-GGGTAA-TCCTGAGCC-AAATCCTA-TG
Xyris505         GTGGTAACTTCCAAATCAGA-GAAACCC-TGG-AAA-AAAAAAT-GGGCCA-TCCTGAGCC-AAATCCTTCTT
Syngonanthus509  GTGATCACTTCCAAATCAGA-GAAACCC-TGG-AATG-AAAAAT-GGGTAA-TCCTGAGCC-AAATCCTA-AG
```

Input data matrix (continued):

```
                 11111111111111111111111111111111111111111111111111111111111111111
                 88999999999911111111123333333334444445555555566666666677777778888889999
Taxon/Node       89012345678912345678900123456789012345234567890123456782345678123456723 45
-------------------------------------------------------------------------------------------
nepal luzula157  TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTAA
xenopodium158    TTGTAACGAAAACTAAAAGCAAGGATACGGTGC-AAGATCCAATGGAAGCATCATCTAACGTAT--AGAGTGA
nepal luzula161  TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTAA
trun florens162  TTT-AACAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
zollingerian165  TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
xeranthemum166   TTT-AACAAAAACTAAAATAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
nautiliforme169  TTT-AACAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
willdenovian170  TTT-AACATTAAATAAAACAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
echinulatum174   TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
wightianum176    TTT-AACAAAAA------CAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
infirmum189      TATTAACAAAAATAAAAGTAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
siamense200      TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
brownianum201    TTT-AACAAAAA--AAAACAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
ubon kradung202  TTT-AACAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
siam macroph203  TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
smitinandii205   TTT-AACAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
nepal luzula208  TTT-AATAAAAATAAAACGAAAGGATA-GGTGCAGACGCTCAATGGAAGC-TATTCTAACGTAT--AGAGTAA
ubon kradung238  TTT-AACAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
pseudoescape239  TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTAA
escape240        TTT-AACAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
siam macroph241  TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
parnellii242     TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTAAATGGAAGC-TATTCTAACGTAT--AGAGTAA
setaceum243      TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
truncatum245     TTT-AACAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
hamiltonianu250  TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
thailandicum252  TTT-AACAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
laosense257      TTT-AACAAAAACGAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
siamense258      TTT-AACAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
laosense259      TTT-AACAAAAA-GAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGCATATTCTAACGTATC-AGAGTGA
phuchongense260  TTT-AACAAAAACGAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
nauti des264     TTT-AACATTAA-TAAAACAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
nauti deshex265  TTT-AACAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
phuchongense276  TT-AAAAAAAAATGAAAAGAAGGGATA-GGTGTCCAGATCTAATGGAAGCTTATTCTAACGTATA-GGAGTGA
siamense hex281  TTT-AACAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
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Input data matrix (continued):

```
                    1111111111111111111111111111111111111111111111111111111111111111111
                    8899999999991111111112333333333344444455555555666666666777777788888889999
Taxon/Node          8901234567891234567890012345678901234523456789012345678234567812345672345
-------------------------------------------------------------------------------------------------
phuchongense285     TT-AAAAAAAAACCAAAAGAGAGGTAT-GGTGTGCGCCCCCATGGGAACCTTTTTCTAACCGATATAGAGTGT
phatamense289       TTT-AACAAAAA-TAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
phuchongense293     TT-AAAAAAAAAAAGAGAAGA-GTATA-GGTGCAGAGACTCAATGGAAGCTATTTCTAACGTATATAAGGTGG
phuphanoides299     TTT-AACAAAAACTCAAAGAAAGGATA-GGTGCTAGAGCTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
chantaranoth310     TTT-AACAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
hamiltonianu314     TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
quinq longib317     TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
hamil acumin318     TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
phuphanoides320     TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
chantaranoth321     ---------------------------------------------------------------------------
hamiltonianu324     TTT-AATAAAAACTAAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
cinereum339         TTT-AACAAAA-CAAAAACAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTTA
phuphanoides345     TTT-AACAAAAA-TCAAAGAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACGTAT--AGAGTGA
Xyris505            TCTTAACGAAATGTAAGACAAA-GATA-GGTGCAGAGACTCGATGGAAGT-TATTCTAAC--AT--AGAGTTA
Syngonanthus509     TCCTAAGTATAAGTTTATCAAAGGATA-GGTGCAGAGACTCAATGGAAGC-TATTCTAACG-AT--AGAATGA
```

Input data matrix (continued):

```
                    1111222222222222222222222222222222222222222222222222222222222222222222222
                    9999000000000011111111112222222222333333333344444444466666666667777777777
Taxon/Node          6789012345678901234567890123456789012345678901234567801234567890123456789
-------------------------------------------------------------------------------------------------
nepal luzula157     A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAAGAAC---TCTTATTCCATAAGATAAAA---GACAGC
xenopodium158       A-TTATGTTCGATCGCGAGCGCACAAC-CGGAATAAATAAAATAACACCCC--ACAAGAG------TGACACG
nepal luzula161     A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAAGAAC---ACTATTTCCATAAGATAAAAA--GACAGC
trun florens162     A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAATAAC-AACAATATTCCATAAGAGAAAA--TTACAGC
zollingerian165     A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAAGAAC---CCTATTTCCATAAGATAAAA--GGACAGC
xeranthemum166      A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAATAAC--AACATATTCCATAAGAGAAAA---GACAGC
nautiliforme169     A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAATAAC--AACAATTT--ATAATAGAAAA---GACAGC
willdenovian170     A-TTATGTTGTGTTGTGGTT--ATAAC---TAATAA-CAAC-----AATTTC-ATGAGAGAAAA---GACAGC
echinulatum174      A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAAGAAC--AACTATTTCCATAAGATAAAA---GACAGC
wightianum176       A-TTATTTCGTGTTGTGG----ATGAC-TGGAATAAATAAC---TCTAT----ATAAGAAGAAAAA--ACAGC
infirmum189         A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAATAATA---CAAACATCTAGAGAGTAAAA--GACAGC
siamense200         AATTATGTTGTGTTGCGT----ATAAC-TGGAATAAATAAC---ACTATTTCCATAAGAGTAAAA--TACAGC
brownianum201       A-TTATTTCGTGTTGTGG----ATAAC-TGGAATAAATAAC--AACATATTC-ATAAGAGAAAA---GACAGC
ubon kradung202     A-TTATTTTGTGTTGTGG----ATAAC-TGGAATAAATAAC--AACTATTT--ATAAGAGAAAA---TACAGC
siam macroph203     AATTATGTTGTGTTGCGT----ATAAC-TGGAATAAA-AAC---ACTATTTCCATAAGATAAAA--TTACAGC
smitinandii205      A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAATAAC--AACATTT---ATAAGAGAAAA---TACAGC
nepal luzula208     A-TTATACGTTGTGTTGTGGAG-TAAC-TGGAATAAATAAAC-AACACATCTCAAGCGAGTAAA---TACAGC
ubon kradung238     A-TTATTTTGTGTTCGTCGGC-ATAACCTGGAATAAATAAAAC-ACTATCCC-AAACGAGAAAAT--ATCA-C
pseudoescape239     A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAAGAAC---ACAATTTCCATAAGAGTAAAA--GACAAC
escape240           A-TTATTTTGTGTTCGTCGGC-ATAACCTGGAATAAATAAAAC-ACTATCCC-AAACGAGAAAAT--ATCA-C
siam macroph241     AATTATGTTGTGTTGCGT----ATAAC-TGGAATAAATAAC--ATCTATTTCCATAAGAGTAAAA--GACAGC
parnellii242        A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAAGAAC-ACTCTATTTCCATAAGAGTAAAA--GACAGC
setaceum243         GATTATGTTGTGTTGTGG------AACACGGAAAAAAACAAAAAACCC-----ATAAGAGTAAAA--GACAGC
truncatum245        A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAATAAC---ACGATTTCCATAAGAGAAAA---GACAGC
hamiltonianu250     A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAATAAC---ACTATTTCCATGAAGGATAAAA-GACAGC
thailandicum252     A-TTATGTTGTATTGTG--T--ATAAC-TGGAATAAACAACTCTTCTATTTATATAAGAGAAAA---GACAAC
laosense257         A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAATAAC---TCTATTT--ATAAGAGAAAA---GACAGC
siamense258         A-TTATGTTGTGTTGTGG----ATAAC-TGGAAAAACAAA----CTCATTTAAATAATAGAAAA---GACAGC
laosense259         A-TTATGTTGCCGTCGCGG----AAAC-TGGAAACAAAAACCCCCCACCC---ATAAA-------CACACATC
phuchongense260     A-TTATGTTGTGGTTGTGG---ATAAC-TGGAAATAACAAACCC--TATTT--ATAAAGAAAA----GACAGC
nauti des264        A-NNANGNNGNGNNGNGGTT--ATAAC--------AACACCCC----ACTTC-ATGATATAAAAA----CA-C
nauti deshex265     A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAACAAC---TCTATTT--ATAAGAGAAAA---GACAGC
phuchongense276     A-TTATGTTGGGTTGTGGG--AATAATATGGAATAAATAA----CCTCTTTTTATAAAAGAAAA---GACAGC
siamense hex281     A-TTATGTTGTGTTGGG------AAAC-TGGAAAAAACCAC---TTAATTT--ATAAGAGAAAA---GACAGC
phuchongense285     GAAATTAGTGTGGGGTGGGGGGAAAAA--GGACACAAAACACCCCTTTTTTTAAAAAACC------------C
phatamense289       A-TTATGTTGTGTGCGG------AAAC-TGGAACAAACACCCCC---------ATAAAAAAAA----GACA-C
phuchongense293     AA-TATAAGGTGGGGTATGGT-------GGGAATAAGCGAAAAAAACTTTTATATAAAAAAAA--GAACCGC
phuphanoides299     A-TTATGTTCGCGCCGCGG----AAAC-TGGAAACAAACCCACCGT-------ATAAAA------GAC-AGC
chantaranoth310     A-TTATGTTGTGTTGCGG----ATAAC-TGGAACAAAAACCCC---ACTTAAAATAAAAA------GAC-AGC
hamiltonianu314     A-TTATGTTGCGCGCGG-------AAC-TGGAAACAAACC-------ATTTCCATAAGATAAAA--GAC-AGC
quinq longib317     A-TTATGTTGCGCGCGG-------AAC-TGGAAACAAACC-------ATTTCCATAAGATAAAA--GAC-AGC
hamil acumin318     A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAAAAAC---TCCATTTCCATAAGGATAAAA--GACAGC
phuphanoides320     A-TTATGTTGCGCGCGG-------AAC-TGGAAACAAACC-------ATTTCCATAAGATAAAA--GAC-AGC
chantaranoth321     ---------------------------------------------------------------------------
hamiltonianu324     GATTATGTTGTCGTTGTGG---ATAAC-TGGAATAAAGAACCTCCTCCACTTTATGAAAGAAAA--CAC-AGC
cinereum339         A-TTAGGTTGTGTTGTGG----ATAAC-TGGAATAACAAGC---TCTATTTC-ATAAGAGAAAA---GACAGC
phuphanoides345     A-TTATGTTGTGTTGTGG----ATAAC-TGGAATAAACAACTCTATTT-----ATAATATAAAA--GACTAGC
Xyris505            A-TTACGTTGCATTGATAGG--------TGCAAAAT----CCGAATTGAT-------GAGAAATTACTACATA
Syngonanthus509     GCGAAGTTTACGTTATTTTG--ATAAC-TGGAATAAATGAGTCTATTGAAATT---AGAGAAA----------
```

Input data matrix (continued):

```
                    2222222222222233333333333333333333333333333333333333333333333333333333333
                    8888888888999900000000011122222222223333333333444444444455555566666666677
Taxon/Node          0123456789018901234567890123456789012345678901234567890127890123456789 01
-------------------------------------------------------------------------------------------------
nepal luzula157     TT--GATTCATAACCGACCAAAGACATAAATAC-TTATGGA-TCC-AACCCGATGATT-AATCATGAT-CC-C
xenopodium158       C---GATTCATAACCGACCAGCCAAAAAAACCTCTCATGGATCGACCACCCGAGTGA-----------CCCAA
nepal luzula161     TT--GATTCATAACCGACCAAAGACATAAATAC-TTATGGA-TCC-AACCCGATGATT-AATCATGAT-CCAC
trun florens162     TT--GATTCATAACCGATCGAAGACATAAATAC-TTATGGA-TTC-AATCCGATGACC-C-TCATGAT-CCAC
zollingerian165     TT--GATTCATAACCGACCAAAGACATAAATAC-TTATGGA-TCC-AACCCGATGATT-AATCATGAT-CCAC
xeranthemum166      TT--GATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCC-AATCCGATGATT-AATCATGAT-CCAC
nautiliforme169     TT--GATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCC-AATCCGATGATT-AATCATGAT-ACAT
willdenovian170     TT--GATTCATAACCGACCGAAGATATAAATAT-TTATGGA-TCT-AATCTAATGATT-AATCATGAT-CCAC
echinulatum174      TT--GATTCATAACCGACCAAAGACATAAATAC-TTATGGA-TCC-AACCCGATGATT-AATCATGAT-CCAC
wightianum176       TT--GATTCATAAACGACCGAAGACATAAATAC-TTATGGA-TCT-AATCCAATGATT-CATCATGAT-CCAC
infirmum189         TT--TATTCATAACCGACCGAAGACATAAAGAC-TTATGGA-TCC-AATCCGATGATT-AATCATGAT-CCAC
siamense200         TT--GATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCC-AACCCGATGATT-CATCATGAT-CCAC
brownianum201       TT--GATTCATAAACGACCGAAGACATAAATAC-TTATGGA-TCT-AATCCAATGATT-AATCATGAT-CCAC
ubon kradung202     TT--GATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCC-AATCCGATGATT-AATCATGAT-CCAC
siam macroph203     TT--GATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCC-AACCCGATGATT-CATCATGAT-CCAC
```

Input data matrix (continued):

```
                2222222222222233333333333333333333333333333333333333333333333333333333333333333333
                8888888888999900000000011122222222223333333334444444444555555566666666667
Taxon/Node      0123456789018901234567789012345678901234567890123456789012789012345678901
-------------------------------------------------------------------------------------------
smitinandii205  TT--TATTCATAACCGAGCCGATCCATAAATAC-TTATGGA-TTC-AATCCGATGATT-AATCATGAT-CCAC
nepal luzula208 TT--GATTCATGACCGACCAAT---AAAAATACTGTATGGA-TCCAAGCCCGACTGACACATCATGATCCCAC
ubon kradung238 TTACGATTCATAACCGACCGAAACGATAAAGACCTTATGGA-TCC-AATCCGATGATT-AACCATGATGCCAC
pseudoescape239 TT--GATTCATAACCGACCAAAGACATAAATAC-TTATGGA-TCC-AACCCGATGATT-AATCATGAT-CCAC
escape240       TTACGATTCATAACCGACCGAAACGATAAAGACCTTATGGA-TCC-AATCCGATGATT-AACCATGATGCCAC
siam macroph241 TT--GATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCC-AACCCGATGATT-CATCATGAT-CCAC
parnellii242    TT--GATTCATAACCGACCAAAGACATAAATAC-TTATGGA-TCC-AACCCGATGATT-AATCATGAT-CCAC
setaceum243     TT--GATT-ATAACCGACCAAAGACCT-AATCT--TATGGA-TCC-AACCCGATGATT-AATCATGAT-CCAC
truncatum245    TT--GATTCATAACCGATCGAAGACATAAATAC-TTATGGA-TTC-AATCCGATGATT-AATCATGAT-CCAC
hamiltonianu250 TT--GATTCATAACCGACCAAAGACATAAATAC-TTATGGA-TCC-AACCCGATGATT-AATCATGAT-CCAC
thailandicum252 TT--GATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCC-AATTCGATGATT-AATCATGAT-CCAC
laosense257     TT--AATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCC-AATCCGATGATT-AATCATGAT-----
siamense258     TT--GATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCC--ATCCGATGATT-AATCATGAT-ACAT
laosense259     TT--GATTCATAACCGACCGAAGAC----ATAC-TTATGGAGTCCAATCCCGATGATT-AATCATCGA-TCAT
phuchongense260 TT--GATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCC-AATCCGATGATT-AATCATGATCTTAG
nauti des264    TT--GATTCATAACCGACCGAAGATATGAATAT-TTATGGA-CTC-AATCTAATGATT-AATCATGAT-CCAC
nauti deshex265 TT--GATTCATAACCGACCGAATCCATAAATAC-TTATGGA-TTC-AATCCGATGATT-AATCATGAT-CCAC
phuchongense276 TT--GATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCCTAATCCGATGATT-AATCATGATCTTAG
siamense hex281 TT--GATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCC-AATCCGATGATT-AATCATGAT-ACAC
phuchongense285 TT-GGTTTCAAACCCACCCGAA-CCAAAAATCC-TTTGGGCCCACAATCCCAAGGATA-AATCCTTGG---AC
phatamense289   TT--GATTCATAACCGACCGAAGACAGAAATAC-TTATGGA-TCC-AATTCGATGATT-AATCATGAT-CCAC
phuchongense293 TT--GATTCATAACCGACCGAAAACATAAATAC-TTATGGA-TCC-AATCCGATGATT-AATCATGAT----C
phuphanoides299 TT-GAGTTCATAATCGACCGAGGACATAAATAC-TTATGGA-TCC-AATCCGATGATT-AATCATGAT-ACAC
chantaranoth310 TT-GAGTTCATAACCGACCGAATCCATAAATAC-TTATGGATCTCAATCCCGATGATT-AATCATGAT-CCAC
hamiltonianu314 TT--GATTCATAACCGACCAAAGACATAAATAC-TTATGGA-TCCTAACCCGATGATT-AATCATGAT-CCAC
quinq longib317 TT--GATTCATAACCGACCAAAGACATAAATAC-TTATGGA-TCCTAACCCGATGATT-AATCATGAT-CCAC
hamil acumin318 TT--GATTCATAACCGACCAAAGACATAAATAC-TTATGGA-TCC-AACCCGATGATT-AATCATGAT-CCAC
phuphanoides320 TT--GATTCATAACCGACCAAAGACATAAATAC-TTATGGA-TCCTAACCCGATGATT-AATCATGAT-CCAC
chantaranoth321 -------------------------------------------------------------------------
hamiltonianu324 TT--GATTCATAACCGACCAAAGACATAAATAC-TTATGGA-TACCAACCCGATGATT-AATCATGAT-CCAC
cinereum339     TT--GATTCATAACCGACCGAAGACATAAATAC-TTATGGA-TCC-AATCCGATGATT-AATCATGAT-CCAC
phuphanoides345 TTC-GATTCATAATCGACCGAAGACATAAATAC-TTATGGA-TCC-AATCCGATGATT-AATCATGAT-ACAC
Xyris505        A--GGAT-CATACAATTCCAAAAATTCTTGT-C-ATATGAA--TTGATTTC---GATT----------------
Syngonanthus509 T----ATTCAT-------------------------------------------------------------
```

Input data matrix (continued):

```
                3333333333333333333334444444444444444444444444444444444444444444444444444444444
                7777778888899999999901111222222222233333334444444555555566667777777788
Taxon/Node      2345675678901234567890678901234567890123456345678901234566789012345678901
-------------------------------------------------------------------------------------------
nepal luzula157 CTTTTTAGATAT---GCATAATTAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
xenopodium158   CCATC-AGATGCC--ACCCTTTTAAG-----------ACTCCG-TATTTG------------------------
nepal luzula161 CTTTTTAGATAT---GCATAATTAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
trun florens162 CTTTTTGGATAT---GCATAACTAAA--GACTATAC-ACTGTGATA-TTGATATATGCAT-ATATAG----AT
zollingerian165 CTTTTTAGATAT---GCATAATTAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
xeranthemum166  CTTTTTAGATAT---GCATAATTAAA-----GATAC-ACTGTGATA-TGGATATATGCATTATATATTG--AT
nautiliforme169 CTTTTTAGATAT---GCATAATTAAA--GACTATAC-ACTGTGATA-TTGATATATGCATTATATATAG--AT
willdenovian170 ATTTATTTATATAT-TCATAATTAGAAAGACTATAC-ACTGTGACA-TTGATATATG----------------
echinulatum174  CTTTTTAGATAT---GCATAATTAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
wightianum176   CTTTATTTATATAT-TCATTTCTATAAAGACTATACG-CTGTGACA-TTGATATATGCAT-----------AT
infirmum189     CTTTTTAGATAT---GCATAAT-AAAAAGACTATAC-ATTTTGATA-TTTATATATGTATTATATAT----AT
siamense200     CTTTTTAGATAT---GCATAAATAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
brownianum201   ATTTATTTATATAG-TCATAATTAAA--GACTATAC-ACTGTGACA-TTGATATATGCAT-----------AT
ubon kradung202 CTTTTTAGATAT---GCATAATTAAA--GACTATAC-ACTGTGATA-TTGATATATGCATTATATACAG--AT
siam macroph203 CTTTTTAGATAT---GCATAAATAAAA-GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
smitinandii205  ACCTTTAGATATG--CAGTAATTAAAGAGCGTATACAGCTGTGATA-TTGATATAATCAT-CTATATACAGAT
nepal luzula208 ACTTTTAGATATGC-ATACAGTTAAA--GACTATACTACTCTCATATTGATCATATGCATCAAATAT------
ubon kradung238 CCTCTTAGATTTTATAGACTATTAAAGACATAATAC-ACTGTGATAATTGGAATATACAT----CACAGAAAT
pseudoescape239 CTTTTTATATAT---GCATAATTAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
escape240       CCTCTTAGATTTTATAGACTATTAAAGACATAATAC-ACTGTGATAATTGGAATATACAT----CACAGAAAT
siam macroph241 CTTTTTAGATAT---GCATAAATAAA--GACTATAT-ACTCTGATA-TTGATATATGCAT-ATATACAG---T
parnellii242    CTTTTTAGATAT---GCATAATTAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
setaceum243     CTTTTTAGATAT---GCATAATTAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
truncatum245    CTTTTTAGATAT---GCATAATTAAA--GACTATAC--CTGTGATA-TTGATATATGCAT-ATATAG----AT
hamiltonianu250 CTTTTTAGATAT---GCATAATTAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
thailandicum252 CTTTTTAGATAT---ACATAATTAAA--GACTAT-C-ACTGTAATA-TTGATATATGCATTATATACAG--AT
laosense257     CTT---C-ATAT---GCATAATAGAAAAGACTATAC-ACTGTGATA-TTGATATATGCATTATATACAG--AT
siamense258     CTTTTTAGATAT---GCATAATTAAA--GACTATAC-ACTGTGATA-TTGATATATGCATTATATATAG--AT
laosense259     ATATGCATATGCA--ATATAAATAAGA-AAAGACCT-ATCCTGAGA-TCGACATAATCAAAACACCCCGCAA-
phuchongense260 ATATGCATATGCTA-ATATAAA--AAAAGACTAT-C--CTGTGATA-TTGATATATGCATTATATACG---AT
nauti des264    ATTTATTTATATAT-TCATAAT-GGAAAGACTATAC-ACTGTGACA-TTGATATATG----------------
nauti deshex265 CTTTTTAGATAT---GCATAATTAAA--GACTATAC-ACTGTGATA-TTGATATATG-AT-ATACAGGAGTAT
phuchongense276 ATATGCATATGCTA-ATATAAA-GAAAAGACTATCCC-CTGTGATA-TTGATATATGCATTATAATACAGATA
siamense hex281 CTTTTTAGATAT---GCATAATTAAA--GACTATAC-ACTGTGATA-TTGATATATGCATTATATATAG--AT
phuchongense285 CTTAAACCATATTGCCTATAATAAAGAACACTTTCCC-CTGTGATATTGGATATATATATATATATACGAATA
phatamense289   CTTTTTGGATAT---GCATAATTGTGAAATTGATAT--ATGCATTA--TGAAATTCAAATAAAATATAATCAT
phuchongense293 CTTAAATGCTATT--GC-TAATAGAAAAGACTATCCC-CTGTGATA-TTGATATATGCATTATATACAGAGTA
phuphanoides299 CCTTTTAGATAT---GCATAATTAAA--GACTATAC-ACTGTGATA-TTGATATATGCATTATATATATAGAT
chantaranoth310 CTTTTTAGATAT---GCATAATTATAAAGACTATAC-ACTGTGATA-TTGATATATGCATTATATACAG--AT
hamiltonianu314 CTTTTTAGATAT---GCATAATTAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
quinq longib317 CTTTTTAGATAT---GCATAATTAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
hamil acumin318 CTTTTTAGATAT---GCATAATTAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
phuphanoides320 CTTTTTAGATAT---GCATAATTAAA--GACTATAT-ACTCTGATA-TTGATATATGCATTATA-------AT
chantaranoth321 -------------------------------------------------------------------------
hamiltonianu324 CTTTTTAGATAGC--ATAAAATTAAAAAGACTATAT-ACTCTGATA-TTGATATATGCAT-ATA-------AT
cinereum339     ATTTATTTATATT--ATATATGTATATAGACTATAC-ACTGTGATA-TTGATATATG-AT-ATATAGATATAT
phuphanoides345 CCTTTTAGATAT---GCATAATTAAA--GACTATAC-ACTGTGATA-TTGATATATGCATTATATATATAGAT
Xyris505        -------------------------------------------------------------------------
Syngonanthus509 -------------------------------------------------------------------------
```

Input data matrix (continued):

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                4444444444444444444555555555555555555555555555555555555555555555555555555555555555555
                8888888899999999990000000000122222222233333344444444445555555555666666777
Taxon/Node      2345678901234567890123456789012345678901678901234567890123456789012345345
-------------------------------------------------------------------------------------------
nepal luzula157 ATTCATTT-ATTT---CTATTTG-TATACTTCAATTCAAATACTG--GATGGAC-TTAATCTCCTATTGTATA
xenopodium158   -----CCT-ATT-AGACTTCTTC-TGTAC--CAATTCAAATAC-G--AATGGAC-TTATCTCCACT------G
nepal luzula161 ATTCATTT-ATTT---CTATTTG-TATACTTCAATTCAAATACTG--A-TGGAC-TTAATCTCCTATTGTATA
trun florens162 ATTCATCT-ATTT-ACCTATTTG-TATAC-TCAATTCACATACTG--AATGGCACTTAATCTCCAATACGATA
zollingerian165 ATTCATTT-ATT----CTATTTG-TATACTTCAATTCAAATACTG--AATGGAC-TTAATCTCCTATTGTATA
xeranthemum166  ATTCATCT-ATTT---CTATTTG-TATACTTCAATTCAAATACTG--AATGGAC-TTAATATACAATAGGATA
nautiliforme169 ATTCATCT-ATTT---CTATTTG-TATACTTCAATTCAAATACTG--AATGGAC-TGAATATACAATAGGATA
willdenovian170 --------------------------------ATTCAAATAATG--AATGGAA-TTAATATACAATAGGATA
echinulatum174  ATTCATTT-ATT----CTATTTG-TATACTTCAATTCAAATACTG--AATGGACCTTAATCTCCTATTGTATA
wightianum176   ATTCATCT-ATTT---CTATTTG-TATACTTCAATTCAAAGAATAGGAATGGAA-TTAATATACCATAGGGGA
infirmum189     ATTCATCT-ATTT---CTATTTA-TATGCTTCAATTCAAATACTG--AATGGAT-TTAATATGC------ATA
siamense200     ATTCATTT-ATTT---CTATTTG-TATACTTCAATCCAAATACTG--AATGGAC-TTAATCTCCTATTGTATA
brownianum201   ATTCATCT-ATTT---CTATTTG-TAGACTTCAATTCCA-GAATAGGAATGGAA-TTCATATACAATAGGAGA
ubon kradung202 ATTCATCT-ATTT---CTATTTG-TATACTTCAATTCAAATACTTG-AATGGAC-TTAATATGCAATAGGATA
siam macroph203 ATTCATCTTATTT---CTATTTG-TATACTTCAATCCAAAT-CTG--AATGGAC-TTAATCTCCTATTGTATA
smitinandii205  ATTCATCTGATTT---CTATTT-GTATACTTCAATTCACATACTGAATGGGAACTTTAATATACCACGTAATA
nepal luzula208 -TTCATCTTATTTCACCTAATTTGTACATTTCAATTCAAATACTG--AATGGAC-TCATAACTCTCTCATAAT
ubon kradung238 CGTCACCCCATTT-CCTCATTTCGGTAGATCAAATTCACGTACTGGAAATGGGCCCTAATACAGTGG----TT
pseudoescape239 ATTCATTT-ATTT---CTATTTG-TATACTTCAATTCAAAT-CTG--AATGG-C-TTAATCTCCTATTGTATA
escape240       CGTCACCCCATTT-CCTCATTTCGGTAGATCAAATTCACGTACTGGAAATGGGCCCTAATACAGTGG----TT
siam macroph241 ATTCATTT-ATTT---CTATTTG-TATACTTCAATCCAAATACTG--GATGGAC-TTAATCTCCTATTGTATA
parnellii242    ATTCATTT-ATTT---ATATTTG-TATACTTCAATTAAAATACTG--AATGGAC-TTAATCTCCTATTGTATA
setaceum243     ATTCATTT-ATTT---CCATTT-GTATACTTCAATTCAA-TACTG--AATGGAC-TTAATCTCCTATGT-ATA
truncatum245    ATTCATCT-ATTT---CTATTTG-TATACTTCAATTCACATACTG--AATGGAC-TTAATATAC-ATAGGATA
hamiltonianu250 ATTCATTT-ATT----CTATTTG-TATACTTCAATTCAAATCCTG--AATGGAC-TTAATCTCCTATTGTATA
thailandicum252 ATTCATCT-ATTT---CTATTTG-TATACTTCAATTCAAATACTG--AATGGAC-TTAAT-TACAATAGGATA
laosense257     ATTCATCT-ATTT---CTATTTG-TATACTTCAATTCAA-TACTG--AATCGAC-TTAATATACGGA----TA
siamense258     ATTCATCT-ATTT---CTATTT-GTATACTTCAATTCAAATACTG--AATGGACTTGAATATACAATAGGATA
laosense259     --TCGTCCAATCTMT----WKT-RTAYWYYWMWWYWMAWAYWSWR--WATGGACTTTAATTCCGGG-----TA
phuchongense260 ATTCATCT-ATTTC---TATTT-GTATACTTCAATTCACATACTG--AATGGAC-TTAATATACGG----ATA
nauti des264    --------------------------------ATTCAAATAAGTGAGATGGAAATTAATATAGCAAATAATA
nauti deshex265 GTTCATCT-ATTT---CTATTTG-TATACTTCAATTCAAATACTG--AATGGAC-TTAATATACAATAGGATA
phuchongense276 TT-CATCT-ATTT---CTATTT-GTATACTTCAATTCAAATACTG--AATGGAC-TTAATATACGG----ATA
siamense hex281 ATTCATCT-ATTT---CTATTTG-TATACTTCAATTCAAATACTG--AATGGAC-TGAATATACAATAGGATA
phuchongense285 TTTCAC---ACGCCA-TTATT--CTATATTTC-ATTCAAATACTGG-AATGGCACTTAATATACCGG---ATA
phatamense289   CATCATTCTCTAAT--CCATTT-GTATACTCCAATTCGAATAACTG-AATGG---CTGGTATACAGAAGCAGG
phuchongense293 TTTCATCCTATATT--CTATTT-GTATACTTCAATTCAAATACTGG-AATGGAC-TTAATATACGG----ATA
phuphanoides299 AGTTCATCTATTT---CTATTT-GTATACTTCAATTCAAATACTCG-AATGGAC-TGAATATACAATAGGATA
chantaranoth310 ATTCATCT-ATTT---CTATTTGGTATACTCCAATTCAAATACTG--AATGGGACTTAATAATACATAGGATA
hamiltonianu314 ATTCATTT-ATT----CTATTT-GTATACTTCAATTCAAATACTG--AATGGAC-TTAATCTCCTATTGTATA
quing longib317 ATTCATTT-ATT----CTATTT-GTATACTTCAATTCAAATACTG--AATGGAC-TTAATCTCCTATTGTATA
hamil acumin318 ATTCATTT-ATT----CTATTTG-TATACTTCAATTCATATACTG--AATGGAC-TTAATCTCCTATTGTATA
phuphanoides320 ATTCATTT-ATT----CTATTT-GTATACTTCAATTCAAATACTG--AATGGAC-TTAATCTCCTATTGTATA
chantaranoth321 --------------------------ACTTCAATTCAAATACGG---ATGGAC-TTAATCCAAGCC----TA
hamiltonianu324 ATTCATTT-ATT----C-ATT--G-ATACTTCAATTCAAATACG---AATGGAC-TTAATCTCCTATTGTATA
cinereum339     AGATATTCTATTC-ATCTGTTTC-TATTTTTCAATTCAAATAATG--AATGGA--TTCATATACATAAG-ATA
phuphanoides345 ATTCATCT-ATTT---CTATTT-GTATACTTCAATTCAAATACTG--AATGGAC-TGAATATACAATAGGATA
Xyris505        ---------------------------------------------GGAGTTCTGGG-----------------ATA
Syngonanthus509 -------------------------------------------------------------------------------
```

Input data matrix (continued):

```
                5555555555555555555555566666666666666666666666666666666666666666666666666666666666
                7777888888888899999999990000000000111111111122222222223333333333444444555
Taxon/Node      6789012345678901234567890123456789012345678901234567890123456789056789012
-------------------------------------------------------------------------------------------
nepal luzula157 TTATGAC---AAAATAATAA---GTGAATAC---ATT-CCGAGAAAAAGATT--AATG-AATCCCATTATTT-
xenopodium158   TCTTGACC--AAAATAATAA----TGAATCGC--ATT--CGTAATAAAGATT--AATG-AATCCC-TTTATT-
nepal luzula161 TTATGAC--AAAAATA-TAA---GTGAATAC---ATT-CCGAGAAAAAGAT---AATG-AATCCCATTTATT-
trun florens162 TTATGAC---AAAATCATAA--GGTGAATACC--ATTCCCGAGAAAAAGATT-AAATG-AATCCCATTTATT-
zollingerian165 TTATGAC--AAAAATAATAA---GTGAATACC--ATTCCCGAGAAAAAGATTT-AATG-AATCCCATTTATT-
xeranthemum166  TTATGACCAAAGATAAAATATAAGTGAATAC---ATT-CCGAGAAAAAGATTC----AGAATCCCATTTATT-
nautiliforme169 TTATGAG-AAGGAATAATAA---GTGAACGC---ATTCCCGATAAAAAGATTT-AATGGAATCTCTTTTATT-
willdenovian170 TTATGAC--AAAAATAATAA---GTGAATAC---ATT-CTGAGAAAAAGATTC--ATG-AATCCCATTTATT-
echinulatum174  TTATGAC--AAAAATAATAA---GTGAATAC---ATTCCCGAGAAAAAGATT-AAATG-AATCCCATTTATT-
wightianum176   TTATGAC--AAAAATAATAA--GGTGAATACC--ATT-CCGAGAAAAAGATTC--ATG-AATCCCATTTATT-
infirmum189     GGATGACC---AAATA-TAA----TGAATACC--ATT-CCGAGAAAA-GATT--AATG--ATCC-ATTTATT-
siamense200     TTATGAC---AAAATAAATAAA-GTGAATACC---TT-CCGAGAAAAAGATTCGAATG-ATTCCCATTTATT-
brownianum201   TTATGAC--AAAAATAATAA---GTGAATCC---TTT--CGAGAAAA-GATTC--ATG-AATCCCATTTATT-
ubon kradung202 TTATGAGAAAAAAATAATAA--GGTGAATGCC--ATTCCCGATAAAAAGATT--AATG-AATCCTATTTATT-
siam macroph203 TTATGAC--AAAAATAATAA---GTGAATAC---ATT-CCGAGAAAAAGAT--GAATG-AATTCCATTTATT-
smitinandii205  TTATGAATAAACAAAATAATAAGGTGAACTTGCCTATTCCGATAAAA-GATT-AAGTG-AATCCCATTTATT-
nepal luzula208 TTATGAACCACAAATAATGC-GGGTGAGAGATACATTTCCGAGAAAAGGTTTT-AATG-AATCCCTTTTATTC
ubon kradung238 TTTGGT----AAAATACATA---GTGGATGGC--CTCCCGCTTAAAAGGATT--AATG-AATTCTTTTTATT-
pseudoescape239 TTATGACC---AAATAATAA---GTGAATAC---ATT-CCGAGAAAAAGATT--AATG-AATCCCATTTATT-
escape240       TTTGGT----AAAATACATA---GTGGATGGC--CTCCCGCTTAAAAGGATT--AATG-AATTCTTTTTATT-
siam macroph241 TTATGAC---AAAATA-TAA---GTGAATAC---ATT-CCGAGAAAA-GAT---GATG-AATCCCATTTATT-
parnellii242    TTATGAC---AAAATA-TAA---GTGAATAC---ATT-CCGAGAAAA-GATT--AATG-AATCCC-ATTATT-
setaceum243     TTATGAC---AAAATAATAA---GTGAATACC--ATTCCCGAGAAAA-GATT--AATG-AATCCC-ATTATTT
truncatum245    TT-TGAC----AAATAAATATA-GTGAATAC---AT--CCGAGAAAA-GATT---ATG-AATCCC-ATTAT--
hamiltonianu250 TTATGACC--AAAATA-TAA---GTGAATACC---TT-CCGAGAAAAAGATT--AATG--ATCCCATTTATT-
thailandicum252 TTATGAA--AAAAAGAATAA---GTGAATGC---ATT-CCGATAAAA-GATT--AATGGAATCCC-ATTATT-
laosense257     TTATGA--AAAAAATAATACA---TGAATGC---ATT-CCGATAAAAAGATT--AATGGAATCCC-ATTATT-
siamense258     TTATGA--AAGGAATAATAA---GTGAACGT---ATT-CCGATAAAA-GATT--AATG-AATCTCATTTATT-
laosense259     TTATGA---AAAAATAATAA----TGAATGC---ACT-CCGATAAAAAGATT--AATG-AATCCCATTTATT-
phuchongense260 TTATGA--AAAAAATAATACCA-TGGAATGC---AT--CTGATAAAAAGGATT-AATG-AATCCCATTTATTT
nauti des264    TTATGAC-ACAACATAATAA---GTGAAGTAC--ATT-CTGAGAAAAAGATTCC-ATG-AATCCCATTTATT-
nauti deshex265 TTATGA-AAAAAAATAATAA---GTGAATGC---ATT-CCGATAAAAAGATT--AATG-AATCCCATTTATT-
phuchongense276 TTATGAC-AAAAAATAATCC----TGAATGC---ATT-CTGATAAAAAGATT--AATG-AATCCC-ATTATT-
siamense hex281 TTATGA--AAGGAATAATAA---GTGAACGT---ATT-CCGATAAAAAGATT--AATG-AATCTCATTTATT-
phuchongense285 TTATGA--AAAAAATAATCC----TGGATGGCC-ATT-CCGATAAAA-GAT---AATGAAATCCC-ATTATT-
phatamense289   TGGTGGCCGCCAAATAATCC--GGTGAATGGCC-ACTCCCCATGACGAAAGAGAAAAGGAATCCCAATTCCT-
phuchongense293 TTATGA---AAAAATAATAC----TGAATGC---ATT-CTGATAAAAAGATT--AATG-AATCCCATTTATT-
phuphanoides299 TTATGA--AAAGGATAATAA---GTGAACGC---ATTCCCGATAAAAAGAT---AATGGAATCCCATTTATTT
chantaranoth310 TTATGAAACAAATCAGATCAA--GTGAATGCC-ATTCCCCGATAAAAAGATTAAGTG-AATCCC-ATTATT-
hamiltonianu314 TTATGACC---AAATAATAA---GTGAATAC---ATT-CCGAGAAAA-GATT--AATG-AATCCC-ATTATT-
```

Input data matrix (continued):

```
                5555555555555555555555556666666666666666666666666666666666666666666666666666
                7777888888888899999999990000000000111111111122222222223333333333444444555
Taxon/Node      6789012345678901234567890123456789012345678901234567890123456789056789012
-------------------------------------------------------------------------------------------
quinq longib317 TTATGACC---AAATAATAA---GTGAATAC---ATT-CCGAGAAAA-GATT--AATG-AATCCC-ATTATT-
hamil acumin318 TTATGACC--AAAATA-TA----GTGAATAC---AT--CCGAGAAAAAGATT--AATG-AATCCCATTTATT-
phuphanoides320 TTATGACC---AAATAATAA---GTGAATAC---ATT-CCGAGAAAA-GATT--AATG-AATCCC-ATTATT-
chantaranoth321 TTTTGA-----AAATAATAA-----GGAAGC---CT-CCGGAAAAAA-GATT--AATG-AATCCC-ATTAT--
hamiltonianu324 TTATGAC--AAAAATAATAA---GTGAATAC---ATT-CCGAGAAAA-GATT--AATG-AATCCCATTTATT-
cinereum339     TTATGAC--AAAAAGAATAA---GTGAATAC---ATT-CCGAGAAAAAGATTC--ATG-AATCTCATTTATT-
phuphanoides345 TTATGACAAAGGAATAATAA---GTGAACGC---ATT-CCGATAAAAAGAT---AATGGAATCCCATTTATT-
Xyris505        T--------CTA-GTAA------GTAAGTC-----ATTC-----------------------------------
Syngonanthus509 -------------------------GAATCAC-------------------------AATCAG--TTATT-
```

Input data matrix (continued):

```
                6666666666666666666666666666666666666666677777777777777777777777777777777
                5555556666666666777777778888888888999999000000000011111111112222222222333
Taxon/Node      3456789012345678904567890123456789012349012345678901234567890123456789012
-------------------------------------------------------------------------------------------
nepal luzula157 -CCAGAGT-TTG-CTAGATCTTT--GAAAAA--CCAATTAATGGAACC-GAG-AATAAA---GAGAG---AGT
xenopodium158   CCCAGAG--TTG-CTAGATCTTTT-GAAAA---CCAATTAACTG-ACC-GAG-AATAA----GAGAG---AGT
nepal luzula161 -CCAGAGT-TTG-CTAGATCTTTT-GAAAA---CCAATTAATGGAAC--GAG-AATAA----GAGAG---AGT
trun florens162 CCCAGAGT-TGG-CTAGATCTTT--GAAAAAA-CCAATTAATGGAACC-GAG-AATAAA---GAGAG---AGT
zollingerian165 -CCAGAGT-TTG-CTAGATCTTTTTGAAAAA--CCATTTAATGGAAC--GAG-AATAAA---GAGAG---AGT
xeranthemum166  CCCAGAGT-TTG-CTAGATTTTTT-GAAAA---CCAATTAATGGAAC--GAG-AATAAA---GAGAG---AGT
nautiliforme169 CCCAGAGT-TTGGCTAGATCTTTTTGAAAAA--CCAATTAACTGAAC--GAG-AATAAA---GAGAG---AGG
willdenovian170 -CCAGAGT-TTGCCTAGATCTTTT-GAAAA--CCCAATTAATGGAAC--GAGGAATAAA---GAGAG---AGT
echinulatum174  -CCAGAGT-TTG-CTAGATCTTTTGGAAAAA--CCAATTAATGGAACC-GAGGAATAAAA--GAGAG---AGT
wightianum176   -CCAGAGT-TTGGCTAGATCTTTAAAAAAAAACCCCATTATGGGAAC--GAG-AATAAA---GAGAG---AGG
infirmum189     -CCAGAG--TTG-CTAGATCTTTT-GAAAA---CCAATT-ATGGAAC--GAG-AATAA----GAGAG---AGT
siamense200     CCCAGAGT-TTG-CTAGATCCTTT-GAAAAA-CCCATTTAATGGGAC--GAGGAATAA----GACAGG--AGT
brownianum201   -CCAGAGT-TTG-CTAGATCCTTTTGAAAA--CCC-ATTAATGGAAC--GAGGAATAAA---GAGAG---AGT
ubon kradung202 CCAGAAGT-TTGCGTAGATCCTTTTGAACGGA-CCAATTACTGGAAC--GAG-AATAA----GAGAGG--AGG
siam macroph203 CCCAGAGT-TTG-CTAGATCTTTT-GAAAAA-CCCAATTAATGGAACC-GAG-AATAAAA--GAGAGG--AGT
smitinandii205  -CCAGAGT-TTGCCTATATCCTTTTGAAAAA-CCCAATTCCTGGAACCCGAG-AATAAAGAGAGCGGAGAAGG
nepal luzula208 CCCAGAGTTTTGGCTAGATCTTTTGGAAAAAACCCAATTAATGGAATCGGAGATATTAAAAGGAGGAGG-AGT
ubon kradung238 CCCAGGAG-TTG-CTGAGTTTT-GGGAAGAA-CCCAATTAGCTTGAGCCGAGTAATATAA--GAGGAGGTAGT
pseudoescape239 -CCAGAGT-TTG-CTAGATCTTTT-GAAAA---CCAATTAATGG-ACC-GAG-AATAAA-----GAG---AGT
escape240       CCCAGGAG-TTG-CTGAGTTTT-GGGAAGAA-CCCAATTAGCTTGAGCCGAGTAATATAA--GAGGAGGTAGT
siam macroph241 -CCAGAGT-TTG-CTAGATCTTT--GAAAA---CCAAT-AATGGAAC--GAG-AATAAA---GAGAG---AGT
parnellii242    -CCAGAGT-TTG-CTAGATCTTT--GAAAA---CCATT-AATGG-ACC-GAG--ATAAA---GAGAG---AGT
setaceum243     --CAGAGT-TTTGCTGAGTCTTT--GAAA----CCAATTAATG--ACGAGG--AATAAA---GAGAG---AGT
truncatum245    -CCAGAG--TTG-CTAGATCTTT--GAAAA---CCAATT-ATGGAAC--GAG--ATAA----GAGAG---AGT
hamiltonianu250 -CCAGAGT-TTG-CTAGACTCTTT-GAAAA---CCAACTAATGGAACA-GAG-AATA-----GAGAG---AGG
thailandicum252 --CCAAGT-TTG-CTAGATCTTTT-GAAAA---CCAATTAACTGAACC-GAG-AATAAA---GAGAG---AGT
laosense257     -CCAGAGT-TTG-CTAGATCTTTT-GAAAA---CCAATTACTG--AC--GAG--ATAA----GAGAG---AGT
siamense258     -CCAGAGT-TTG-CTAGATCTTT--GAAAA---CCAAT-AACCTGAC--GAG--ATAA----GAGAG---AGT
laosense259     -CCAGAGT-TTGGCTAGATCTTT--GAAAA---CCAATTAACTGAAC--GAG-AATAAA---GAGAG---AGT
phuchongense260 -CCAGAGT-TTGGCTAGATCTTTT-GAAAA---CCAATT-ACTGGAC--GAG-AATAA----GAGAG---AGT
nauti des264    CCCAGAGT-TTG-CTAGATCTTTT-GAAAAA--CCAATTAATGGAACC-GAG-AATAA--GAGAGAGG--AGT
nauti deshex265 CCCAGAGT-TTG-CTAGATCTTTT-GAAAAA--CCAATTAACTG-ACGAGG--AATAAA---GAGAG---AGT
phuchongense276 -CCAGAGT-TTG-CTAGATCTTTT-GAAAA---CCAATT-ACTG-AC--GAG-AATAAA---GAGAG---AGT
siamense hex281 -CCAGAGT-TTG-CTAGATCTTTT-GAAAAA--CCAATTAACTG-AC--GAG-AATAA----GAGAG---AGT
phuchongense285 -CCAGAGT-TGG-CTAGATCTTT--GAAA----CCATT-AA-TGAAC--GAG-AATAAA---GAGAG---AGT
phatamense289   CCCCAGGTCTCG---AGATCCCTT-GAGAA---CCAATTCCTGGAACGC-AG-AATGCA-GGAGCAGG-CGGT
phuchongense293 -CCAGAGT-TTG-CTAGATCTTT--GAAAA---CCAATTAACTGAAC--GAG-AATAAA---GAGAG---AGT
phuphanoides299 -CCAGAG--TTG-CTAGATCTTTT-GAAAA---CCAATTAACTG-AC--GAG-AATAA----GAGAG---AGT
chantaranoth310 CCCAGAGT-TTCGCTAGATCCTTTTGAAAAA--CCAATTACCTG-ACGAGG--AATAAA-GAGAGAG---AGG
hamiltonianu314 -CCAGAGT-TTG-CTAGATCTTTT-GAAAA---CCAATTAATGGAAC--GAG-AATAA----GAGAG---AGT
quinq longib317 -CCAGAGT-TTG-CTAGATCTTTT-GAAAA---CCAATTAATGGAAC--GAG-AATAA----GAGAG---AGT
hamil acumin318 -CCAGAGT-TTG-CTAGATCTTTT-GAAAAA--CCAATTAATGGAAC--GAG-AATAAAAA-GAGAG---AGT
phuphanoides320 -CCAGAGT-TTG-CTAGATCTTTT-GAAAA---CCAATTAATGGAAC--GAG-AATAA----GAGAG---AGT
chantaranoth321 -CCAGAGT-TTG--GAGATTTTTT-GAAAA---CCAATTAACGGAAC--GAG-AATAAA---GAGAG---AGT
hamiltonianu324 -CCAGAGT-TTG-CTAGATCTTTT-GAAAAA--CCAATTAATGGAAC--GAG-AATAAA---GAGAG---AGT
cinereum339     -CCAGAGT-TTG-CTAGATCTTTT-GAAAA---CC-ATTAATGGAAC--GAG-AATAAA---GAGAG---AGT
phuphanoides345 -CCAGAGT-TTG-CTAGATCTTTTGGAAAA---CCAATTAACTGAC---GAG-AATAA----GAGAG---AGT
Xyris505        ------GT-TTG-ATAAATCTTTT-GATTGCAAAACGAAACTGGAT---GAG-AATAAA---GAGAG---AGT
Syngonanthus509 CCCATAGT-TTG-ATAGATCTTTT-GAAAAA--CGGAT-ATCGGACT--GAG-AATAAA---GAGAG---AG-
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Input data matrix (continued):

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                7777777777777777777777777777777777777777777777777777777777778888888888
                3333333444444444455555556666666667777777777888888888899999999990000011111
Taxon/Node      3456789012345678901234561234567890123456789012345678901234567890123401234
-------------------------------------------------------------------------------------------
nepal luzula157 ---CCATT-CTACAT--GTCA-TACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
xenopodium158   --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TTT-GAGAGTAAGAGG-AAAATCCGTCGACTA
nepal luzula161 --CCCATT-CTACAT-GGTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
trun florens162 --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
zollingerian165 -CCCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT-GGAGAGTAAGAGG-AAAATCCGTCGACTT
xeranthemum166  --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAATAGG-AAAATCCGTCGACTT
nautiliforme169 T-CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCACCTT
willdenovian170 --CCCATT-CTACAT--GTCAATACCGACATCATT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
echinulatum174  --CCCATTCTACCATGGTCCAATACCGACATCAATTGAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
wightianum176   T-CCCATTTCTACAT--GTCAATACCGACATCAATC-AAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
infirmum189     --CCCATT-CTACAT--GTCAATA-CGACATCAAT-GAAA-TTT--AGAGTAAGAGGGAAAATCCGTCGACTT
siamense200     --CCCATTCCTACAT--GTCAAT-CCGACATCAAT-AAAA-TT--GAGAGTAAAAGG-AAAATCCGTCGACTT
brownianum201   --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
ubon kradung202 T-CCCATTTGTACCAT-GTCAATTCCGACATCATTGGA---TTTGGAGAGTAAGAGGGAAAATCCGTCGACTT
siam macroph203 --CCCATT-CTACAT-GGTCAATACGGACATCAAT-AAAA-T---GAGAGTAAAAGG-AAAATCCGTCGACTT
smitinandii205  TCCCCATT-CTACAT-GGTCAATAACCACTTCAAT-GAAA-TT-GAGAGGTAATAGGAAAATCCCGTCACCTT
nepal luzula208 TCCCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGGACAGTAAGAATGACTT
ubon kradung238 CGCCCATTTGCTACCATGTCAAATCCGGACTCAAT-GAAATTTTGATGAGTAAGAGG-AAAATCCGTCGACTT
pseudoescape239 ---CCAT--CTACAT--GTCAATA-CGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
escape240       CGCCCATTTGCTACCATGTCAAATCCGGACTCAAT-GAAATTTTGATGAGTAAGAGG-AAAATCCGTCGACTT
siam macroph241 --CCCATT-CTACAT--GTCAATA-CGACATCA-T--AAA-T---GAGAGTAAAAGG-AAA-TCCGTCGACTT
parnellii242    ---CCATT-CTACAT--GTCAATACCGACATCAAT-GAA--T---GAGAGTAAGAGG-AAAATCCGTCGACTT
setaceum243     --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAA-TCCGTCGACTT
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Input data matrix (continued):

```
                 7777777777777777777777777777777777777777777777777777777777777778888888888
                 3333333444444444455555556666666667777777778888888888999999999900000011111
Taxon/Node       3456789012345678901234561234567890123456789012345678901234567890123401234
-------------------------------------------------------------------------------------------
truncatum245     --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-T---GAGAG-AAAGGG-AAAATCCGTCGACTT
hamiltonianu250  T-CCCATT-CGACT---GTCAATACCGACATCATT-GAA--TT--GGGAGTAAGAGG-AAA-TCCGTCGACTT
thailandicum252  ---CCATT-CTACAT--GTCAATACCGACATCAAT-GAA--TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
laosense257      --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAA-TCCGTCGACTT
siamense258      --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAA--TT--GAGAGTA-GAGG--AAATCCGTCGACTT
laosense259      --CCCATT-CTACAT--GTCAATA-CGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
phuchongense260  --CCCATT-CTACAT--GTCAATACCGACATCAAT-GGAAATTGAGAGAGTAAGAGG-AAAATCCGTCACCTT
nauti des264     --CCCATTCTAGCACATGTCAATACGGACATCAAT-GAAA-TT--GAGAGTAAGAGGGAAAATCCGTCTACTT
nauti deshex265  --CCCATT-CTACAT--GTCAATACTGACATCAATT-AAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
phuchongense276  --CCCATT-CTACAT--GTCAATACCGAC-TCA-T-GAAA-TT--GAGAGTAAGAGG--AAATCCGTCGACTT
siamense hex281  --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
phuchongense285  --CCCATT--CACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG--AAATCCGTCGACTT
phatamense289    -CCCCATT---CCAT--GTCAATACAATCCTCACTGACCGTCCGTTCGACTTGTATG--AGATTTGCT--CTC
phuchongense293  --CCCATT-CTACAT--GTCAATA-CGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
phuphanoides299  -CCCCATTTCTACAT--GTCAATTCCGACATCAAT-GAA--TT--GAGAGTAAGAGG--AAATCCGTCGACTT
chantaranoth310  T--CCATT-CTACCAT-GTCAATACCGACATCCAT-GAAA-TCGGAGAGGTAAGAGG-AAAATCCGTCGACTT
hamiltonianu314  --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
quinq longib317  --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
hamil acumin318  --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
phuphanoides320  --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATCCGTCGACTT
chantaranoth321  --CCCATT-TGACA--GGTCAATACCGACATCAAT-GAA--TT-GGAGAGTAAGAGG-AAAATCCGTCGACTT
hamiltonianu324  --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAGG-AAAATC-GTCGACTT
cinereum339      --CCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TT--GAGAGTAAGAAG-AAAATCCGTCGACTT
phuphanoides345  --CCCATTTCTACAT--GTCATTACCGACATCA-C-GAA--TT-GGGGAGTAAGAGG--AAATCCGTCGACTT
Xyris505         --CCCATT-CTACAT--GTCAATACCGGCAACAAT-GAAA-TTT--GGAGTAAGAGG-AAAATCCGTTGATTT
Syngonanthus509  -CCCCATT-CTACAT--GTCAATACCGACATCAAT-GAAA-TTT--AAAGTAAGAAG-AAAATCCGTCGACTT
```

Input data matrix (continued):

```
                 8888888888888888888888888888888888888888888888888888888888888889999999999
                 1111122222333333333344444444455555555566667777777777888888888890000000000
Taxon/Node       5678901289012345678901234567890123456767890123456789012345678900123456789
-------------------------------------------------------------------------------------------
nepal luzula157  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
xenopodium158    TA-AAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTGC-TAC-TTATTTATTTGTTAGC
nepal luzula161  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
trun florens162  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-AAACTTCC-TAC-TTATTTATTTGTTAGC
zollingerian165  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
xeranthemum166   TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
nautiliforme169  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTGC-TAC-TTATTTATTTGTTAGC
willdenovian170  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCAACTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
echinulatum174   TAGAAATTCGGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
wightianum176    TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCAACTATT-GAACTTCC-TAC-TTATTGATTTGTTAGC
infirmum189      TAGAATATGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-AAACTTCC-TACGTTATTTATTTGTTAGC
siamense200      TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTAGTTGTTAGC
brownianum201    TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCAACTATT-GAACTTCC-TAC-TTATTGATTTGTTAGC
ubon kradung202  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAATTTGC-GAC-TTATTTATTTGTTAGC
siam macroph203  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTAGTTGTTAGC
smitinandii205   TGAGAAATGCGAGGGGTTCAAGTCCCTCTTATCCACCCCTATTTGGACCTTCCGTCGGAAATTATTTCTT-TC
nepal luzula208  TAGAAAATGTGAGGGTTCAA-GTCCCTCT-ATCCCCCA-TATTGAACGCTTCCTACGTTATTTATTTGTTAGC
ubon kradung238  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCCACTATT-GAACTTGC-TAC-TTATTTATTTGTTAGC
pseudoescape239  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
escape240        TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCCACTATT-GAACTTGC-TAC-TTATTTATTTGTTAGC
siam macroph241  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTAGTTGTTAGC
parnellii242     TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
setaceum243      TAGAAATCGTGAGGGTTCAA-GTCCCTCTTATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
truncatum245     TAGAAATC-TGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-AAACTTCC-TAC-TTATTTATTTGTTAGC
hamiltonianu250  TAGAAATCTGGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
thailandicum252  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTGC-TAC-TTATTTATTTGTTAGC
laosense257      TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTGC-TAC-TTATTTAGTTGTTAGC
siamense258      TAGAAATCGTGAGGGTTCAATGTCCCTCT-ATCCCCACCTATT-GAACTTGC-TAC-TTATTTATTTGTTAGC
laosense259      TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTGC-TAC-TTATTTATTTGTTAGC
phuchongense260  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTGC-TAC-TTATTTAGTTGTTCGC
nauti des264     TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCAACTATT-GAACTTCC-TAC-TTATTTTATTGTTAGC
nauti deshex265  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCATCTATT-GAACTTGC-TAC-TGATTTATTTGTTAGC
phuchongense276  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTGC-TAC-TTATTTAGTTGTTAGC
siamense hex281  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTGC-TAC-TTATTTATTTGTTAGC
phuchongense285  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTGC-TAC-TTATTTAGTTGTTAGC
phatamense289    TAGGGGTT-GGTGGGTCCCC--TCCTTGC-CACCCGAC---TT-GG-CGTT---ACCTTATTGGTTTGCCAGC
phuchongense293  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTGC-TAC-TTATTTAGTTGTTAGC
phuphanoides299  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTGC-TAC-TTATTTATTTGTTAAC
chantaranoth310  TAGAAAATGTGAGGGTTCAA-GTCCCTCT-CCCTTC--------GAACTTTTTCCCTTTTCTTGTATGTTAAA
hamiltonianu314  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
quinq longib317  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
hamil acumin318  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
phuphanoides320  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
chantaranoth321  TAGAATTC-GGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTGGC-AAC-TTAATTATTTGGTAGC
hamiltonianu324  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-TAC-TTATTTATTTGTTAGC
cinereum339      TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTTCC-CAC-TTATTTATTTTTTAGC
phuphanoides345  TAGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCACCTATT-GAACTGGCCTAC-TTATTTATTTGTTAGC
Xyris505         TCGAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCC--CTATTTT--CTG--------TATTT---------C
Syngonanthus509  TAAAAATCGTGAGGGTTCAA-GTCCCTCT-ATCCCCATCAAGTATATTTGACTTCC--TATCTATTTATTTTG
```

Input data matrix (continued):

```
                 9999999999999999999999999999999999999999999999999999999999999999999999999
                 1111111111222222222233333334444444445555555555666666677778888888888999999
Taxon/Node       0123456789012345678901234890123456789012345678901234566789012345678901234
-------------------------------------------------------------------------------------------
nepal luzula157  AA-TC--ATTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATGGATTCTTTTT--CAAGAATGA
xenopodium158    AA-TC--ATTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATAGATTTTTTT--CCAAAATGA
nepal luzula161  AA-TC--ATTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATGGATTCTTTTT--CAAGAATGA
trun florens162  AA-TC--ATTGAAATT-AATTCATTAAATA------TACTTTTTC-AGAATAGATTCTTTTT--CCAAAATGA
zollingerian165  AA-TC--GTTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATGGATTCTTTTT--CAAGAATGA
xeranthemum166   AA-TC--ATTGAAATT-TATTTATTAAAGAA-TATTTACTTTTTC-AGAAGAAATTCTTTTT--CAAAAATGA
```

Input data matrix (continued):

```
                  9999999999999999999999999999999999999999999999999999999999999999999999999999999999999999
                  1111111111222222222233333334444444445555555555666666677778888888888899999
Taxon/Node        0123456789012345678901234890123456789012345678901234566789012345678901234
-------------------------------------------------------------------------------------------------
nautiliforme169   AA-TC--ATTGAAATT-AATTCATTAAATA----------TTTTC-AGAATAGATTTTTTTT--CCAAAATGA
willdenovian170   AA-TC--ATTGAAATT-AATTCATTAAATAA-TATTTCATTTTTC-AGAATAGATTCTTTTAT-AAAAAAAGA
echinulatum174    AA-TC--GTTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATGGATTCTTTTT--CAAGAATGA
wightianum176     AA-TC--ATTGAAATT-AATTCAT--AATAA-TATGGACTTTTTC-AGAATAGATTCTTTTT--TAAAAAAGA
infirmum189       AA-TC--ATTGAATT-----------AATA------TACTTTTTC-AGAATAGATTCTTTTTCAAAATGATGA
siamense200       AA-TC--ATTGAAATG-AATTCATTAAATAA-TATTTACTTTTTC-AGAATAGATTATTTTT--CAAGAATGA
brownianum201     AA-TC--ATTGAAATT-AATTCAT--AATAA-TATGGACTTTTTC-AGAATAGATTCTTTTT--TAAAAAAGA
ubon kradung202   AA-TC--ATTGAAATT-AATTCATTAAATAA-GGTTTACTTTTTCGAGAATAGATTTTTTTTTCCAAAAATGA
siam macroph203   AA-TC--ATTGAAATG-AATTCATTAAATAA-TATTTACTTTTTC-AGAATAGATTATTTTT--CAAGAATGA
smitinandii205    AAATGAAGGTTTACTT--TTTCCCGGAGAGA-AACTAAAAACAGAAGATGTGTTTTTTCTTTTCAAGAAATGA
nepal luzula208   AA-TC--ATTGAATATTAATTCATTAAATAAGTATTTACTTTTTC-AGAATGGATTCTTTTT--CAAGAATGA
ubon kradung238   AA-TC--ATTGAAATTTAATTCATTAAATAA-GGTTTACTTTTTC-AGAATAGATTTTTTTTTCCAAAAATGA
pseudoescape239   AA-TC--ATTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATGGATTNTTTTT--CAAGAATGA
escape240         AA-TC--ATTGAAATTTAATTCATTAAATAA-GGTTTACTTTTTC-AGAATAGATTTTTTTTTCCAAAAATGA
siam macroph241   AA-TC--ATTGAAATG-AATTCATTAAATAA-TATTTACTTTTTC-AGAATAGATTATTTTT--CAAGAATGA
parnellii242      AA-TC--ATTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATGGATTCTTTTT--CAAGAATAA
setaceum243       AA-TC--ATTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATGGATTCTTTTT--CAAGAATGA
truncatum245      AA-TC--ATTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATAGATTCTTTTT--CCAAAATGA
hamiltonianu250   AA-TC--GNTGAAATT-AATTCATTAAATAA-TATTGACTTTTTC-AGAATGGATTCTTTTT--AAAGAATGA
thailandicum252   AA-TC--ATTGAAATT-AATTAATTAAATAA-TGTTTACTTTTTC-AGAATAGATTTTTTTTT-CCAAAATGA
laosense257       AA-TC--ATTGAAATT-AATTCATTAAATAA-TGTTTACTTTTTC-AGAATAGATTTTTTTT--CCAAAATGA
siamense258       AA-TC--ATTGGAAATTAATTCATTAAATA----------CTTTTC-AGAATAGATTTTCTTTT-CCAAAATGA
laosense259       AA-TC--ATTGAAATT-AATTCATTAAATAA-TGTTTACTTTTTC-AGAATCGATTTTTTTT--CCAAAATTA
phuchongense260   AACTC--ATTGAAATT-AATTCATTAAATAA-TGTTTACTTTTTCGAGAATAGATTTTTTTTTCCAAAGATGA
nauti des264      AA-TC--ATTGAAATTTAATTCATTAAATAA-TATTTCATTTTTC-AGAATAGATTCTTTT-----ACTGGGA
nauti deshex265   AA-TC--ATTGAAATT-AATTCATTAAATAA-TGTTTACTTTTTC-AGAATATATTCTTTTTTTCAAAAATGA
phuchongense276   AA-TC--ATTGAAATT-AATTCATTAAATAA-TGTTTACTTTTTC-GGAATAGATTTTTTTTTTCCAAAATGA
siamense hex281   AA-TC--ATTGAAATT-AATTCATTAAATA----------TTTTC-AGAATAGATTTTTTTT--CCAAAATGA
phuchongense285   AA-TC--ATTGAAATT-AATTCATTAAATAA-TGTTTACTTTTTC-GGAATAGA-TTTTTTTTTCCAAAATGA
phatamense289     TCTCTTGGATCCTGTTGAATTCACTAACTAAGTGTTTACTTTTTTCAGGAATG-TCTTTTTTGCCATCAATGA
phuchongense293   AA-TC--ATTGAAATT-AATTCATTAAATAA-TGTTTACTTTTTC-GGAATAGATTTTTTTTT-CCAAAATGA
phuphanoides299   AA-TC--ATTGAAATG-AATTCATTAAATA----------TTTTC-AGAATAGATTTTTTTTT-CCAAAATGA
chantaranoth310   TGCTTTTTTTTCCTTT---TTTTCGGAAGGA-GGATGGATTTTTC-----TTTTTTTTTTCTTCAAATATTG
hamiltonianu314   AA-TC--GTTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATGGATTCTTTTT--AAAGAATGA
quing longib317   AA-TC--GTTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATGGATTCTTTTT--AAAGAATGA
hamil acumin318   AA-TC--GTTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATGGATTCTTTTT--AAAGAATGA
phuphanoides320   AA-TC--GTTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATGGATTCTTTTT--AAAGAATGA
chantaranoth321   CAATCCAATGGAAAGGAATTCCATTAATTAA-AGGTTAACTTTTCCAGGAAAAATTTTTTTTTTCAAAAATGA
hamiltonianu324   AA-TC--GTTGAAATT-AATTCATTAAATAA-TATTTACTTTTTC-AGAATGGATTCTTTTT--AAAGAATGA
cinereum339       AA-TC--ATTGAAATT-CATTCAGTAAATAA-TATTTACTTTTTC-AGAATAGACTCTTTTT--CAAAAAGGA
phuphanoides345   AA-TC--ATTGAAATG-AATTCATTTAAT------------TTTTC-AGAATAGACTTTTTTTTCCAAAACTGA
Xyris505          AAAGTAC-------------TTCT---AATTCTTCCCTCTTTTTCCAAAGTACAAACTTTATTTTTTCCCTTTA
Syngonanthus509   AA-TGAATAG-------TTTTCAT-AAGATTCACTATATCTTT---AGAA---------------AGAGATG-
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Input data matrix (continued):

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                    1111111111111111111111111111111111111111111111111111111111111111111111111
                  9900000000000000000000000000000000000000000000000000000000000000000000000000
                  9900000000011111111112222222233333334444444455555556666666777777777788888
Taxon/Node        5612345678901234567890123456734567892345678901234563456789012345678901234
-------------------------------------------------------------------------------------------------
nepal luzula157   ATCGAAATCAAAAGAATA--TCTCCTCCCATGTATACTAAAAGT-ACACAGTCAGATAA-------------G
xenopodium158     ATCGAAATCAAAAGAAGTA-TCTCATCCCATGTATACTAAAAGT-ACACGGCATCATATAGTACTTTATATAA
nepal luzula161   ATCGAAATCAAAAGAATA--TCTCCTCC-ATGTATACTAAAAGT-ACACAGTCAGATAT-------------G
trun florens162   ATCGAAATCAAAAGAATA--TCTCATCCCATGTATACTAAAAAT-ACACAGTCAGATATA--GTACTTTA--G
zollingerian165   ATCGAAATCAAAAGAATA--TCTCCTCCCATGTATACTAAAAGT-ATACAGTCAGATAT-------------G
xeranthemum166    ATCAAAATCCAAAGAATA--TCTCATCCCAGGTATACTAAAAGT-ACACAGTCAGATATA--GTACTTTA--G
nautiliforme169   ATCGAAATCAAAAGAATA--TCTCATCCCATGTATACTAAAAGT-ACACAGTCACATATA--GTGCTTTATAG
willdenovian170   ATCGGAATCAAAAGAATA--TCTCATCCCATGTATACTAAAAGA-ACACAGTCAGATATA--GTACTTTATA-
echinulatum174    ATCGAAATCAAAAGAATA--TCTCCTCCCATGTATACTAAAAGT-ACACAGTCAGATAT-------------G
wightianum176     ATCGAAATCAAAATAATA--TCTCATCCCATGTATACTAAAAGA-ACACAGTCAGATATA--GTACTTTA--G
infirmum189       ATCGAAATCAAAAGAATATGGTGCATCCGATGTATACTAAAAGT-ACACGATAGGATATA--GTACTTTA-GA
siamense200       ATCGAAATCAAAAGAATA--TCGCCTCCCATGTATACTAAAAGT-ACACAGTCAGATAT---GT---------
brownianum201     ATCGAAATCCAAATAATA--TCTCATCCCATGTATACTAAAAGA-ACACAGTCAGATATA--GTACTTTA--G
ubon kradung202   ATCGAAATCAAAAGAATA--TCTCATCCCATGTATACTAAAAGT-ACACAGTCACATATA--GTGCTTTATTG
siam macroph203   ATCGAAATCAAAAGAATA--TCGCCTCCCATGTATACTAAAAGT-ACACAGTCAGATAT---GT---------
smitinandii205    GTCGAAATCAAATG-ATATACCTCATCCCATGTATACTAAAAGTACGATACTCACATATAGTGCTTTATATGT
nepal luzula208   ATCGAAATCAATAAGAATA-TCTCCTCCCATGTATACTAAAAGT-ACACAGTCAGAT-----------GAT-G
ubon kradung238   ATCGAAATCAAAAGAATA--TCTCATCCCATGTATACTAAAAGT-ACACAGCACCATATA--GTGCTTTATGA
pseudoescape239   ATCGAAATCAAAAGAATA--TCTCCTCCCATGTATACTAAAAGT-ACACAGTCAGATAT-------------G
escape240         ATCGAAATCAAAAGAATA--TCTCATCCCATGTATACTAAAAGT-ACACAGCACCATATA--GTGCTTTATGA
siam macroph241   ATCGAAATCAAAAGAATA--TCGCCTCCCATGTATACTAAAAGT-ACACAGTCAGATATA-----------GA
parnellii242      ATCGAAATCAAAAGAATA--TCTCCTCCCATGTATACTAAAAGT-ACACAGTCAGATA----GTGGT------
setaceum243       ATCGAAATCAAAAGAATA--TCTCTTCCCAGGTATACTAAAAGTCACATGATCA------GCTTGCTTTTC--
truncatum245      ATCGAAATCAAAAGAATA--TCTCATCCCATGTATACTAAAAAT-ACACAGTCAGATATA--GTACTTTATGA
hamiltonianu250   ATCGAAATCAAAAGAATA--TCTCCTACCATGTATACTAAAAGT-ATA-AGTCAGATA-------------AA
thailandicum252   ATCGAAATCAAAAGAATA--TCTCATCCCATGTATACTAAAAGT-ACACAGTCACATATA--GTGCTTTATAA
laosense257       ATCGAAATCAAAAGAATA--TCTCATCCCATGTATACTAAAAGT-ACACAGTCACATATA--GTGCTTTATAG
siamense258       ATCGAAATCAAAAGAATA--TCTCATCGCATGTATACTAAAAGT-ACACAGTCACATTA---GTGCTTTAT-A
laosense259       ATCGAAATCAAAAGAATA--TCTCATCCCATGTATACTAAAAGT-ACACAGTCACAT-ATAGTGCTTTTGACT
phuchongense260   ATCGAACTCAAAAGAATA-CTCTCACTCC-TGTATACTAAAAGT-ACACAGTCA-ATAATATGTCTTCTTGGG
nauti des264      ATCGGAATCGGGG----CTCTCTCTCTCCATGTATACTTTAATGGGGGGTTGG--ATGGTGGGTGCAATCTAA
nauti deshex265   GTCGAAATCAAATGAATA--CCTCATCCCATGTATACTAAAAGT-ACACAGTCACATATA--GTGCTTTATAG
phuchongense276   ATCGAAATCAAAAGAATA--TCTCATCCCATGTATACTAAAAGT-ACACAGTCACATATAGTGCTTTATGACA
siamense hex281   ATCGAAATCAAAAGAATA--TCTCATCGCATGTATACTAAAAGT-ACACAGTCACATATA--GTGCTTTATAG
phuchongense285   ATCGAATTCAAAGGAATA--TCTCATCCCATGTATACTAAAGGT-ACACAGTCACATATATAATGTGCCTT
phatamense289     ATCATGCTCCAAAAGATATAGTTTCATGTATGTCTACTAAGAGT-ACACGGTCTGTATGTGCTCTTCATGGGG
phuchongense293   ATCGAAATCAAAAGAATA--TCTCATCCCATGTATACTAAAAGT-ACACAGTCACATATA--GTGCTTTATAG
phuphanoides299   ATCGAAATCAAAAGAATA--TCCCATCCCATGTATACTAAAAGT-ACACAGTCACATATA--GTGCTTTATGA
chantaranoth310   ATCGAACTCAACTGCGTCTACCTCATCCCATGTATACTAAAGGT-ACACAGTCAGATATA--GTGCTTTGTGG
hamiltonianu314   ATCGAAATCAAAAGAATA--TCTCCTACCATGTATATTAAA-GT-ACACAGTCA--------GTGGAACTGC-
quing longib317   ATCGAAATCAAAAGAATA--TCTCCTACCATGTATATTAAA-GT-ACACAGTCA--------GTGGAACTGC-
hamil acumin318   ATCGAAATCAAAAGAATA--TCTCCTCCCATGTATACTAAAAGT-ACACAGTCAGATAT-------------G
phuphanoides320   ATCGAAATCAAAAGAATA--TCTCCTACCATGTATATTAAA-GT-ACACAGTCA--------GTGGAACTGC-
chantaranoth321   ATCGAAATCAAAAGAATA--CCTCATCCCATGTATACTAAAAGT-ACACAG-CACATATA--GTGCTTTATAC
hamiltonianu324   ATCGAAATCAAAAGAATA--TCTCCTACCATGTATACTAAAAGT-ACACAGTCAGATATGACAGTGTCGTT--
```

Input data matrix (continued):

```
                  1111111111111111111111111111111111111111111111111111111111111111111111111111
                  9900000000000000000000000000000000000000000000000000000000000000000000000000
                  9900000000011111111112222222233333334444444455555556666666777777777888888
Taxon/Node        5612345678901234567890123456734567892345678901234563456789012345678901234
-------------------------------------------------------------------------------------------------
cinereum339       ATCCAAATCAAAAGAATA--TCTCATTTCATGTATACTAAAAGA-AGACAGTCAGATATA--GTACTTTA--A
phuphanoides345   ATCGAAATCAAAAGAATA--TCCCATCCCATGTATACTAAAAGT-ACACAGTCACATATAGTGCTTTATAGAC
Xyris505          CAAAG--------------------ATCCC-TTT---CTGAAA--------CGGA--------TCTTAACAGAA
Syngonanthus509   ---AAAATAAAAAAAGG-------ATCCCATCCATACGAAATGAATACCCT-----------CATTTATGTAT
```

Input data matrix (continued):

```
                  1111111111111111111111111111111111111111111111111111111111111111111111111111
                  0000001111111111111111111111111111111111111111111111111111111111111111111111
                  8888890000000011111111122222222233333334444455555566666677777777888888888
Taxon/Node        5678903456789012345678901236789014567890123445678901278923456789012345678
-------------------------------------------------------------------------------------------------
nepal luzula157   ACAAGT-AAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATGATTTTGACATTTA--CTA
xenopodium158     ACAAGT------TTAAGGTTAAGTAAGTGTATCTACGG-TATAACTCATAAAATGATTTTGACATTTA--CTA
nepal luzula161   ACAAGT-AAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATGATTTTGACATTTA--CTA
trun florens162   ACAAGTAAAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAA-GATTTTGACATTTA--CTA
zollingerian165   ACAAGT-AAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATGATTTTGACATTTA--CTA
xeranthemum166    ACAAGTAAAGTATTAAGTTTAAGTAA--------ACG-ATATAACTCAGAAGATGATTTTGACATTTA--CTA
nautiliforme169   ACAAGTAAAGTATTAAGTTTAAGTAAGTGTATCTACGGATATAACTCATAA------TTTGACATTTA--CTA
willdenovian170   CCAAGT--AGTATTCAGTTTAAGTAAGTGTATCCACG-ATATAACTCATAAAATGATTTTTACATTTA-----
echinulatum174    ACAAGT-AAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATGATTTTGACATTTA--CTA
wightianum176     ACAAGT--AGTATTCAGTTTAAGTAAGTGTATCTACG-ATACAACTCATAAAATGATTTTGACATTTA--CTA
infirmum189       GCGAGG---GTATTAAGTTTAGGTAAGTGTATGTGACGATATAAATGATTTTGTGATTTTGACATTTAC-GTA
siamense200       -CAAGTAAAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCCTAAAATGATTTTAAAATTTA--CTA
brownianum201     ACAAGTTTAGTATTCAGTTTAAGTAAGTGTATCTACG-ATACAACTCATAAAATGATTTTGACATTTA--CTA
ubon kradung202   TCTATGAAAGTATTAAGTTTAAGTAAGTGTACCTACG-ATATAACTCATAAGATGATTTTGACATTTA--CTA
siam macroph203   -CAAGTAAAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCCTAAAATGATTTTAAAATTTA--CTA
smitinandii205    ATCTATAAAGTATTAAGTTTAAGTAAGTGTACCTATG-ATATAACTCATAAAATGATTTTGACGATTGA-CTA
nepal luzula208   ACAAGT-AAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATGATTTTGACATTTA--CTA
ubon kradung238   ACAAGTAAAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAGATGATTTTGACATTTA--CTA
pseudoescape239   ACAAGT-AAGTATTCAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATGATTTTGACATTTA--CTA
escape240         ACAAGTAAAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAGATGATTTTGACATTTA--CTA
siam macroph241   TCATAGAAAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCCTAAAATGATTTTAAAATTTA--CTA
parnellii242      -CATAT-AAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATGATTTTGACATTTA--CTA
setaceum243       -------AAGTATTAATTTTAAGTAAGTGTATCTACG-ATACGACTCATAAAATGATTTTGACATTGAT-CTA
truncatum245      TCATATAAAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAA-GATTTTGACATTTA--CTA
hamiltonianu250   ACAAGT-AAGTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATGATTTTGACATTTA--CTA
thailandicum252   ACAATG----TATTAAGTTTAAGTAAGTGTACCTACG-ATATAACTCATAAGATGATTTTGACATTTA--CTA
laosense257       ACAATGAAAGTATTAAGTGTAAGTAAGTGTACCTACG-ATATAACTCATAAGATGATCTTAACATTTA--CTA
siamense258       CGACGT--AGT-TTAAGTTTAAGTA-GTGT-TCTAC-AATATATCTCATAAAATGATTTTTACATTTA--CTA
laosense259       TTGTGT---GTATTAAGTTTAAGTAAGTGTGCCTACG-ATATAACTCATAAGATGATCTTAACATTTA--CTA
phuchongense260   GCTTGT-AAGTATT-AGTGT-AGTAAGTGTCACTACG-ATATAACTCATAAGATGATCTTAACATTTA--CTA
nauti des264      TTCAGT---GTTCTCAGTTTAAGTAAGTGTATC-ACG-ATATAACTCATAAATTGATTTTGACGATTT-----
nauti deshex265   ACAAGT---GTATTAAGTTTAAGTAAGTGTACCTACGGATATAACTCATAAAATGATTTTGACATTGA--CTA
phuchongense276   ATGTGT---GTATTAAGTGTAAGTAAGTGTACCTACG-ATATAACTCATAAGATGATCTTAACATTTAT-CTA
siamense hex281   ACAGGTAAAGTAAAAAGTTTAAGTAAGTGTATCTAC-AATATATCTCATAAAATGATTTTTACATTTA--CTA
phuchongense285   GTGTGG-ACTTATGGGGTGT--GTAAGGGTACCTACGGTATTATCTCTATAAGGTATTACACTATTTAATCTG
phatamense289     CGG---AAATTATTAAGTTT--GTAAGTGTATCTACG-ATATAACTCATAAAATGACTTTGACATTTA--CTA
phuchongense293   ACAATGAAAGTATTAAGTGTAAGTAAGTGTACCTACG-ATATAACTCATAAGATGATCTTAACATTTA--CTA
phuphanoides299   CTTTT----ATATTAAGTTTAAGTAAGTGTATCTACG-ATATAGCTCATAAAATGATTTTGACATTTAT-CTA
chantaranoth310   GGCTTT----TATTATGCTT-GGTAAGTGTGACTCCG-ATATAACTCATAAAATGATTTTGACATTGAT-CTA
hamiltonianu314   --------AATATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATGATTTTGACATTTA--CTA
quinq longib317   --------AATATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATGATTTTGACATTTA--CTA
hamil acumin318   ACAATA-AAATATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATTATTTTGACATTTA--CTA
phuphanoides320   --------AATATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATGATTTTGACATTTA--CTA
chantaranoth321   GACAAG---GTATTAAGTTT-AGTA-GTGTACCTACG-ATATAACTCATAAAATGATTTTGACATTGA--CTA
hamiltonianu324   ---------GTATTAAGTTTAAGTAAGTGTATCTACG-ATATAACTCATAAAATGATTTTGACATTTA--CTA
cinereum339       ACAAGT--AGTATTAAGCTTAAGTAAGTGTATCGATG-ATATAACTCATCCAATGATTTTGACATTTA--CTA
phuphanoides345   TTTATGATTATATTAAGTTTAAGTAAGTGTA--TACG-ATATAGCTCATAAAATGATTTTGACATTTAC-GTA
Xyris505          ACC--------TTTGGATTTT----GCTTATCC---------------ATAAAA--------------------
Syngonanthus509   -----------GTTTAGAA-AAGTAAA-GTACTTATTCAATTCAGTT-TAAG-TGATTTATTTACAACTCATA
```

Input data matrix (continued):

```
                  1111111111111111111111111111111111111111111111111111111111111111111111111111
                  1111111111222222222222222222222222222222222222222222222222222222222222222222
                  8999999999900000001111122222222223333333334444444444555555555566666667777
Taxon/Node        9012345678934567890178901234567890123456789012345678901234567890123456123
-------------------------------------------------------------------------------------------------
nepal luzula157   GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTTTC-A-TTTATTGAC-ATAGAGAA-AAC
xenopodium158     GGTT-ATTCTCTTGGAATAATTTTTTTGATTTTCTACTCTCAATTTGA-A-TTTATTAAC-ATAGAAAAAAAC
nepal luzula161   GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTGTC-A-TTTATTGAC-ATAGATGAAAAC
trun florens162   GGTT-AT-TCTTTGGAATAATTTTTTTTATTTTCT--CTTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
zollingerian165   GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTTTA-A-TTTATTGAC-ATAGAGAAAAAC
xeranthemum166    GGTT-AT-TCTTTGGAATAATTTTTTTTATTTTCT--CTTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAA
nautiliforme169   GGTT-AT-TCTTTGGAATAATTTTTTTGATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
willdenovian170   CTTT-AT-TCTTTGGAATAA-TTTTTTTATTTTCT--------TTTGA-A-TTTATTGAC-ATAGAGAAA-AA
echinulatum174    GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTTTA-A-TTTATTGAC-ATAGAGAAAAAC
wightianum176     GGTT-AT-TCTTTGGAATAA-TTTGTTTATTTTCT--CTTTAATTTGC-A-TTTATTGAC-ATAGAGAAAAAC
infirmum189       GGTT-ATTCGTTTGGAATAATGTTTTTTATTTTCTG-CTTCCATGTTGAA-TTGATTGACTATAGAGAAAAGC
siamense200       GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTTTA-A-TTTATTGAC-ATAGAGAAAAAC
brownianum201     GGTT-AT-TCTTTGGAATAA-TTTTTTTATTTTCT--CTTTAATTTGC-A-TTTATTGAC-ATAGAGAAAAAC
ubon kradung202   GGTT-AT-TCTTTGGAATAATTTTTTTGATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
siam macroph203   GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCTG-CTTCCATTTTA-A-TTTATTGAC-ATAGAGAAAAAC
smitinandii205    GGTT-AT-TCTTTGGAATAATTTTTTTGATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
nepal luzula208   GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTTCTCTTCCATTTTCA---TTTATTGCACATAGATAA-AGC
ubon kradung238   GGTT-AT-TCTTTGGAATAATTTTTTTGATTTTCT--ATTCAATTTGATA-TTTATTGAC-ATAGAGAAAAAC
pseudoescape239   GGTT-AT-TCTTTGGAAGAATTTTTTGTATTTTCT--CTTCCATTTTC-A-TTTATTGGC-ATAGATGGAAAC
escape240         GGTT-AT-TCTTTGGAATAATTTTTTTGATTTTCT--ATTCAATTTGATA-TTTATTGAC-ATAGAGAAAAAC
siam macroph241   GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTTTA-A-TTTATTGAC-ATAGAGAAAAAC
parnellii242      GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTGTC-A-TTTATTGAC-ATAGATAAAAAC
setaceum243       GGTT-AT-TCTTTGGAATAATTTTTTGGTATTTTCT--TTTCCATTTTA-A-TTTATTGAC-ATAGATAAAATC
truncatum245      GGTT-AT-TCTTTGGAATAATTTTTTTTATTTTCT--CTTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
hamiltonianu250   GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTTTA-A-TTTATTGAC-ATAGAGAAAAAC
```

Input data matrix (continued):

```
                  1111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                  1111111111122222222222222222222222222222222222222222222222222222222222222222222222222
                  8999999999900000001111122222222233333333334444444444555555555566666667777
Taxon/Node        9012345678934567890178901234567890123456789012345678901234567890123456789012345678901234567
-------------------------------------------------------------------------------------------------------------
thailandicum252   GGTT-AT-TCTTTGGAATAATTTTTTTTATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGCAGAAAGC
laosense257       GGTT-AT-TCTTTGGAATAATTTTTTTGATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
siamense258       GGTT-AT-TCTTTGGAATAATTTTTTTGATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
laosense259       GGTT-AT-TCTTTGGAATAATTTTTTTGATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
phuchongense260   GGTT-ATCTCTTTGGAATAATTTTTTCTATTTTGT--ATTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
nauti des264      ACTTTAT-TCTTTGGAATAA-TTTTTTTATTTTCT--------TTTGATA-TTTATTGCACGTGGAGA---AT
nauti deshex265   GGTT-AT-TCTTTGGAATAATTTTTTTGATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
phuchongense276   GGTT-AT-TCTCTGGAATAATTTTTTTGATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGATAAAAAC
siamense hex281   GGTT-AT-TCTTTGGAATAATTTTTTTGATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
phuchongense285   GGTTTATCTCTTTGGAATATTTTTTTTGATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGAGAAAATC
phatamense289     GGTT-ATTCTT-TGGAATAATTTTTTGCATTTTCTA-TTGCCATTGGATA-TTTACTCGATATAGAGAAAAAC
phuchongense293   GGTT-AT-TCTTTGGAATAATTTTTTTGATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
phuphanoides299   GGTT-AT-TCTTTGGAATAATTTTTTTTATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGAGAAAAAC
chantaranoth310   GGTT-AT-TCTTTGGAATATTTTTTTTGATTTTCT--ATTCAATTGGATATTTTATTGAC-ATAGAGAAAAAC
hamiltonianu314   GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTTTA-A-TTTATTGAC-ATAGAGAAAAAC
quinq longib317   GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTTTA-A-TTTATTGAC-ATAGAGAAAAAC
hamil acumin318   GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTTTA-A-TTTATTGAC-ATAGAGAAAAAC
phuphanoides320   GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTTTA-A-TTTATTGAC-ATAGAGAAAAAC
chantaranoth321   GGTT-AT-TCTTTGAAATAATTTTTTTGATTTTCT--ATTGAATTTGA-A-TTTAGTGAC-ATAGAGAAAAAC
hamiltonianu324   GGTT-AT-TCTTTGGAATAATTTTTTGTATTTTCT--CTTCCATTTTA-A-TTTATTGAC-ATAGAGAAAAAC
cinereum339       GGTT-CT-TCTTTGGAATAA-TTTTTTTATTTTCT--CTTAAATTGGA-A-TTTATTGAC-ATAAAGAAAAAC
phuphanoides345   GGTT-AT-TCTTTGGAATAATTTTTTTTATTTTCT--ATTCAATTTGA-A-TTTATTGAC-ATAGATAAA-AC
Xyris505          -------------GGAACATTATTACTTGCTTTTTTTT-ATAA---TAAG-TCAAATTCC-ATAAAAAA--TC
Syngonanthus509   TCCTTATTTTGTTGACGAAA----TGCACTTTTT---ACCTACTTTTTTG--TAAGTA---ATAAAGTA-AGT
```

Input data matrix (continued):

```
                  1111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                  2222222222222222222222333333333333333333333333333333333333333333333333333333333333333
                  7777788888889999999999000000000011111111112233333333334444444444555555555
Taxon/Node        4567834567890123456789012345678901234567898901234567890123456789012345678901234567
-------------------------------------------------------------------------------------------------------
nepal luzula157   ACTTTATCTACGA---CGATAA-TGC-ACCGG-AAATGTCGG22222211212211221122222211212222
xenopodium158     ACTTTATCTAATT--CTGATAA-TGC-ACCGGAAACTCGGCG11222211222211222221122212111112
nepal luzula161   ACTTTATCTAAGA---CGATAA-TGC-ACCGG-AAATCGTCG22222211212211221122222211212222
trun florens162   ACCTTATCTACTA---CGATAA-TGC-ACCGT-AAATCGTCG22222212112222211222212211222212
zollingerian165   ACTTTATCTACGA---CGATAA-TGC-ACCGG-AAATCGTCG22222211222222222212222112122222
xeranthemum166    ACTTTATCTATTA---TGATAA-TGC-ACCGG-AAATCGTCG22222212112222122122222112122222
nautiliforme169   ACTTTATCTACTA---CGATAA-TGC-ACCGG-AAATCGTCG21222112122221112111112111222212
willdenovian170   ACTTTATCTACTT---CGATGA-TGC-ACCGG-AAATCGTCG11221212222222122222211221212111
echinulatum174    ACTTTATCTACG---TCGATAA-TGC-ACCGG-AAATCGTCG22222211222122122222211222212222
wightianum176     ACTTTATCTACTA---TGATGA-TGC-ATCGG-AAATCGTCG21222112122122122222212121212111
infirmum189       ACGTTATGGTGTTTGATGAGA--TGCTACCGGAATATCGTCG22222211221211221121222211212222
siamense200       ACTTTATCTACA---TCTATAA-TGC-ACCGG-AAATCGTCG12212111221211221111122112122222
brownianum201     ACTTTATCTACTA---CGATGA-TGC-ACCGG-AAATCGTCG11122211222112112122211121121212
ubon kradung202   ACTTTATCTACTT---CGATAA-TGC-ACCGG-AAATTGTCG12221211222221122112112211222212
siam macroph203   ACTTTATCTACG---TCGATAA-TGC-ACCGG-AAATCGTCG12211211221211221111122112111112
smitinandii205    ACTTTATCTACTA---TAATAA-TGC-ACCGG-AAATCGTCG22222211211221222221122212222222
nepal luzula208   AGCTTATGTTATGAACTGATATATGC-ACCAGAGTATAATCG22222211212211221122222211212222
ubon kradung238   ACTTTATCTACATAATAGATAA-TGC-ACCGGCAAATCGTCG12221211222211221121122112122212
pseudoescape239   ACTTTATCTACG---TCGATAA-TGC-ACCGG-AAATCG-CG22222221212211221122222211212222
escape240         ACTTTATCTACATAATAGATAA-TGC-ACCGGCAAATCGTCG22222221122121222222211222222222
siam macroph241   ACTTTATCTACAA---CGATAA-TGC-ACCGG-AAATCGTCG12211211221211221111122112121212
parnellii242      ACTTTATCTACG---TCGATAA-TGC-ACCGG-AAATCGTGC22222211222211221112112211212221
setaceum243       ACTTTATCTACT---TCGATAA-TGC-ACCGG-AAATCGTGC22222211222211221222212211212222
truncatum245      AC--CATCTACTA---CGATAA-TGC-ACCGT-AAATCGTCG22222212212221121122212211222222
hamiltonianu250   ACTTTATCTAAAA---TGATAA-TGC-ACCGG-AAATCGTCG22222211212222212222222222122222
thailandicum252   GATCTATCTACT---NAGATACATGCGACCGGAACATGGTCG22222211212121122222222221222222
laosense257       ACTTTATCTACTA---CGATAA-TGC-ACCGG--AATCGTCG22222211212221222221122212222222
siamense258       ACTTTATCTACTA---TCATAA-TGC-ACCGGAACATCGTCG12212111221211221111122112121222
laosense259       ACTTTATCTACTA---CGATAA-TGC-ACCGG-AAATCGTCG22222211212221222221122212222222
phuchongense260   ACTTTATCTACTA--GTGATAA-TGC-ACCGGAACATCGTGC22222211212221122221122212222222
nauti des264      TCTTTATCTACT------ATTTATGC--CCGG--CCTCGTCG22222211221221222221121212222222
nauti deshex265   ACTTTATCTACTA---CGATAA-TGC-ACCGG--AATCGTCG22222211221221222221121212112222
phuchongense276   ACTTTATCTACTA--GCGATAA-TGC-ACCGT-AAATCGTCG22222211212221122221122212222222
siamense hex281   ACT-CATCTACTA---CGATATATGC-ACCGG-AAATCGTGC22212211212211221111121111212212
phuchongense285   ACTTTATCTACTA--TCGATAA-TGC-ACCGT-AAATCGTCG22222211212221122221122212222222
phatamense289     ACTTTATCTACT------ATAA-TGC-ACCGG-AAATCGTCG22122211211221212121122212222222
phuchongense293   ACTTTATCTACTA---CGATAA-TGC-ACCGT-AAATCGTGC22222211212221222221122212222222
phuphanoides299   ACTTTATCTACT-----TATAA-TGC-ACCGG-AAATCGTCG22222211212221212121122212222222
chantaranoth310   ATCTTATCTATT---TTTATAA-TGC-ACCGG-AAATCGTCG22122211221212221121122212222222
hamiltonianu314   ACTTTATCTACGA--TTGATAA-TGC-ACCGG-AAATCGTCG22222211212222212222222222122222
quinq longib317   ACTTTATCTACGA--TTGATAA-TGC-ACCGG-AAATCGTCG22222211212211221121122112222222
hamil acumin318   ACTTTATCTACGAA---GATA--TGC-ACCGG-AA-TC-TCG22222211222221122222212222222222
phuphanoides320   ACTTTATCTACGA--TTGATAA-TGC-ACCGG-AAATCGTCG22222211212221212121122212222222
chantaranoth321   ACTTTATCTAC----TTGATAA-TGC-ACCGG-AAATCGTGC22122211221212212221112212222222
hamiltonianu324   ACTTTATCTACGA--CGAATAA-TGC-A--------------22222211212222212222222212222222
cinereum339       ACTTTATCTACTA---CGATAA-TGC-ACCGG-AAATCGTCG22222211212221221121221212222222
phuphanoides345   ACTTTATCTACTA---TGATAA-TGC-ACCGG-AAATCGTCG22222211212221212121122212222222
Xyris505          CCTA-ATCT-CATA-GCATTGCAAGA-ACGAG-AAATCGTCG21221212222222??????1121222211
Syngonanthus509   ACTTTATCTAAGA---TGA----TGC-ACCAG-AAAAAGTCG22122211212221222222222222122122
```

APPENDIX 6

FLORISTIC REGIONS AND PROVINCE OF THAILAND

(From Santisuk, T. and Larsen K. (eds), Flora of Thailand, Volume 9 Part 1, 2005)

FLORISTIC REGIONS AND PROVINCES OF THAILAND

I. *N* (NORTHERN)
1 Mae Hong Son
2 Chiang Mai
3 Chiang Rai
4 Phayao
5 Nan
6 Lamphun
7 Lampang
8 Phrae
9 Uttaradit
10 Tak
11 Sukhothai
12 Phitsanulok
13 Kamphaeng Phet
14 Phichit
15 Nakhon Sawan

II. *NE* (NORTH-EASTERN)
16 Phetchabun
17 Loei
18 Nong Bua Lam Phu
19 Udon Thani
20 Nong Khai
21 Sakon Nakhon
22 Nakhon Phanom
23 Mukdahan
24 Kalasin
25 Maha Sarakham
26 Khon Kaen

III. *E* (EASTERN)
27 Chaiyaphum
28 Nakhon Ratchasima
29 Buri Ram
30 Surin
31 Roi Et
32 Yasothon
33 Amnat Charoen
34 Si Sa Ket
35 Ubon Ratchathani

IV. *SW* (SOUTH-WESTERN)
36 Uthai Thani
37 Kanchanaburi
38 Ratchaburi
39 Phetchaburi
40 Prachuap Khiri Khan

V. *C* (CENTRAL)
41 Chai Nat
42 Sing Buri
43 Lop Buri
44 Suphan Buri
45 Ang Thong
46 Phra Nakhon Si Ayutthaya
47 Saraburi
48 Nakhon Pathom
49 Pathum Thani
50 Nakhon Nayok
51 Nonthaburi
52 Krung Thep Maha Nakhon (Bangkok)
53 Samut Prakan
54 Samut Songkhram
55 Samut Sakhon

VI. *SE* (SOUTH-EASTERN)
56 Sa Kaeo
57 Prachin Buri
58 Chachoengsao
59 Chon Buri
60 Rayong
61 Chanthaburi
62 Trat

VII. *PEN* (PENINSULAR)
63 Chumphon
64 Ranong
65 Surat Thani
66 Phangnga
67 Phuket
68 Krabi
69 Nakhon Si Thammarat
70 Phatthalung
71 Trang
72 Satun
73 Songkhla
74 Pattani
75 Yala
76 Narathiwat