SYSTEMATICS OF ISCHAEMINAE AND ROTTBOELLIINAE (POACEAE) IN THAILAND

Miss Paweena Traiperm

A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy Program in Biological Sciences
Faculty of Science
Chulalongkorn University
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อนุกรมวิธานของพืชวงศ์หญ้าเผ่าย่อยอิคเคมินี และรอทโบล์ลิอินี ในประเทศไทย

นางสาวปวีณา ไตรเพิ่ม

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
สาขาวิชาวิทยาศาสตร์ชีวภาพ
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Thesis Title	SYSTEMATICS OF ISCHAEMINAE AND ROTTBOELLIINAE (POACEAE) IN THAILAND
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ปวีณา ไตรเพิ่ม : อนุกรมวิธานของพืชวงศ์หญ้าเผ่าย่อยอิคเคมินี และรอทโบล์ลิอินี ในประเทศไทย (SYSTEMATICS OF ISCHAEMINAE AND ROTTBOELLIINAE (POACEAE) IN THAILAND) อ. ที่ปรึกษา : ศ.ดร.ทวีศักดิ์ บุญเกิด, อ. ที่ปรึกษาร่วม : ศ.ดร.ประนอม จันทรโณทัย, ดร. เดวิด เอ ซิมสัน, 391 หน้า.

การศึกษาอนุกรมวิธานของพืชวงศ์หญ้าเผ่าย่อย Ischaeminae และ Rottboelliinae ในประเทศไทย พบหญ้าจำนวน 13 สกุล 49 ชนิด 2 พันธุ์ สกุลที่มีขนาดใหญ่ที่สุดสองสกุล ได้แก่สกุล *Ischaemum* มีจำนวน 13 ชนิด 1 พันธุ์ และสกุล *Eremochloa* มีจำนวน 11 ชนิด ในจำนวนนี้ได้ย้าย 1 ชนิดไปอยู่ในสกุล *Andropogon* L. คือ *I. tenuifolium* (A. Camus) P. Traiperm & T. Boonkerd ได้ยุบหนึ่งพันธุ์คือ *I. barbatum* Retz. var. *glaberrimum* Bor ให้เป็นชื่อพ้องของ *I. barbatum* Retz. นอกจากนี้ยังได้เลือกตัวอย่างต้นแบบจำนวน ห้าแทกซาของสกุล *Ischaemum* คือ *I. aristatum* subsp. *imberbe* var. *imbricatum*, *I. aristatus* var. *arfakense*, *I. lacei*, *I. magnum* และ *I. macrurum* พบว่ามีหญ้าที่รายงานเป็นครั้งแรกของประเทศไทย 2 แทกซา คือ *Ischaemum hubbardii* Bor และ *Mnesithea striata* (Nees ex Steud.) Koning & Sosef. var. *pubescens* (Hack.) S.M. Phillips & S.L. Chen และคาดว่า 6 ชนิด ในสกุล *Ischaemum*, *Eremochloa* และสกุล *Mnesithea* อาจจะเป็นพืชชนิดใหม่ของโลก ได้สร้างรูปวิธานจำแนกเผ่าย่อย สกุล ชนิดและพันธุ์ และได้จัดทำคำบรรยายลักษณะ วาดภาพลายเส้น บันทึกภาพ ข้อมูลการกระจายพันธุ์ของแต่ละชนิด

การศึกษาลักษณะกายวิภาคศาสตร์ของแผ่นใบและลำต้นเหนือดินของพืชทั้งสองเผ่าย่อย โดยวิธีลอกผิวและตัดตามขวาง จากตัวอย่าง 25 ชนิด ใน12 สกุล พบว่าสามารถนำลักษณะของแผ่นใบและลำต้นเหนือดินมาใช้ระบุสกุลของพืชทั้งสองกลุ่มนี้ในประเทศไทยได้

การวิเคราะห์สายสัมพันธ์ทางวิวัฒนาการของพืชจำนวน 44 ตัวอย่าง 38 แทกซา จากลำดับนิวคลีโอไทด์ในคลอโรพลาสต์ดีเอ็นเอ (*trn*L intron และ *trn*L-F intergenic spacer) และในไรโบโซมดีเอ็นเอบริเวณ internal transcribed spacer (ITS) ด้วยวิธี Maximum Parsimony โดยโปรแกรม PAUP* 4.0b10 พบว่าการวิเคราะห์รวมกันของยีนในไรโบโซมดีเอ็นเอ และคลอโรพลาสต์ดีเอ็นเอ แสดงความน่าเชื่อถือและพบว่าพืชทั้งสองเผ่าย่อยไม่เป็นชาติพันธุ์เดียว (non-monophyletic) เมื่อพิจารณาสายสัมพันธ์ภายในสองเผ่าย่อยพบว่า สกุล *Ischaemum* และ *Mnesithea* ไม่เป็นชาติพันธุ์เดียว และสกุล *Hemarthria*, *Hackelochloa* และ *Eremochloa* เป็นชาติพันธุ์เดียว (monophyletic)

สาขาวิชา วิทยาศาสตร์ชีวภาพ ลายมือชื่อนิสิต ปวีณา ไตรเพิ่ม

ปีการศึกษา 2550 ลายมือชื่ออาจารย์ที่ปรึกษา.......

ลายมือชื่ออาจารย์ที่ปรึกษาร่วม.......

ลายมือชื่ออาจารย์ที่ปรึกษาร่วม.......

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KEY WORD: POACEAE /ISCHAEMINAE /ROTTBOELLIINAE /ANATOMY / SYSTEMATICS

PAWEENA TRAIPERM: SYSTEMATICS OF ISCHAEMINAE AND ROTTBOELLIINAE (POACEAE) IN THAILAND. THESIS ADVISOR : PROF. THAWEESAKDI BOONKERD, Ph.D., THESIS COADVISOR : PROF. PRANOM CHANTARANOTHAI, Ph.D., DAVID A. SIMPSON, Ph.D. 391 pp.

A taxonomic study of subtribes Ischaeminae and Rottboelliinae in Thailand was carried out. Thirteen genera, 49 species and two infraspecific taxa are enumerated. *Ischaemum* (13 species and one infraspecific taxon) and *Eremochloa* (11 species) are the two largest genera. One new combination in *Andropogon* L.: *I. tenuifolium* (A. Camus) P. Traiperm & T. Boonkerd is made. A variety, *I. barbatum* Retz. var. *glaberrimum* Bor is treated here as a synonym of *I. barbatum* Retz. In addition, five taxa of *Ischaemum* namely, *I. aristatum* subsp. *imberbe* var. *imbricatum*, *I. aristatus* var. *arfakense*, *I. lacei*, *I. magnum* and *I. macrurum* are lectotypified. It was found that two taxa, i.e. *Ischaemum hubbardii* Bor and *Mnesithea striata* (Nees ex Steud.) Koning & Sosef. var. *pubescens* (Hack.) S.M. Phillips & S.L. Chen are new records. Six species in *Ischaemum, Eremochloa* and *Mnesithea* are new to science. Keys to the subtribes, genera and species together with descriptions, line drawings, photographs and distributional information of each species are given.

Epidermal peels and transverse sections of leaf-blades and culms were investigated in 25 species of the 12 genera from the two subtribes. It is evident that anatomical features are taxonomically useful for generic delimitation.

Phylogenetic analyses of 44 samples from 38 taxa were carried out using non-coding chloroplast DNA *trn*L intron, and *trn*L-F intergenic spacer sequence data together with nuclear ribosomal internal transcribed spacer (ITS) sequence data. Maximum Parsimony analyses were conducted using PAUP* 4.0b10. It was found that combined ITS and *trn*L-F analyses strengthen the phylogenetic signal and reveal that both subtribes are not monophyletic. The combined data also reject the monophyly of the genera *Ischaemum* and *Mnesithea* but provide evidence to show that *Hemarthria*, *Hackelochloa* and *Eremochloa* are monophyletic.

Field of study Biological Science
Academic year 2007

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Advisor's signature....Thaweesakdi Boonkerd
Co-advisor'signature.Pranom Chantaranothai
Co-advisor'signature.......................

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LIST OF ABBREVIATIONS

c. or ca.	circa or circiter	about, approximately
comb. nov.	combinatio nova	new combination of name and ephithet
det.	determinavit	he determined
e.g.	exempli gratia	for example
et al.	et aliorum	and others
f.	filius or filial	son or son of
l.c.	loco citato	compare reference
ined.	ineditus	unpublished
nom. nov.	nomen novum	new name
nom. nud	nomen nudum	name published
p.p.	pro parte	partly, in part
s.l.	sensu lato	in a broad sense
sp.	species	species (singular)
spp.	species	species (plural)
ssp.	subspecies	subspecies
syn.	synonymon, synonymia	synonym, synonymy
var.	varietas	variety
viz.	videlicet	namely

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CHAPTER I

GENERAL INTRODUCTION

1.1 Introduction

The grass family, Poaceae are mostly herbs comprising one of the largest flowering plants families, with approximately 10,000 species, including in 660 to 700 genera (Clayton & Renvoize, 1986; Watson & Dallwitz, 1999). The figures are only after Compositae, Orchidaceae Leguminosae and Rubiaceae in terms of number of species. Grasses can thrive in various habitats and that they have wider geographic range than the other plant families, and can dominate various vegetation types which cover about 30% of the earth's land surface. They are well represented throughout the world and can be found in abundance throughout tropical regions, especially Asia.

This family is the most ecologically and economically important of all plant families. Cereal crops or grains are mostly grasses cultivated for their edible grains called a caryopsis. Cereal grains are grown in greater amount and provide more energy worldwide than any other type of crop; they are therefore staple crops. They are also a rich source of carbohydrate. As food, cereals have two important advantages over roots and most food crops other than nuts. Firstly, they are relatively concentrated foods being low in water and high in reverse carbohydrates, mainly starch, and also oils. Secondly, these characteristics make them able to be stored for relatively long periods and make them more transportable than the other bulky foods such as roots. Maize, rice, wheat, oats, sorghum are among the important cereals.

Sugar cane is the source of sugar in all tropical and subtropical countries of the world. Uses of sugar cane also include the production of alcoholic drink, molasses, and ethanol for fuel. Bamboos are a special, distinctive group of grasses because most of them are woody and often very large; their culms may grow up to 40 m high in some species. Even today, bamboo is still widely used in building and scaffolding, and for utilitarian as well as artistic objects. Up to 20th century in Japan, China, Korea and much of the rest of eastern Asia, bamboo was used for virtually everything from building to cooking ware, from musical instruments to paper-making. Many grasses are definitely elegant and graceful adding structure and form to a garden such as, *Miscanthus*, *Molina*, *Pennisetum*, *Stipa*, *Festuca* (Russelle, 2001; Grounds, 1989).

Applications of Grasses for medicinal properties are locally specific. The British Pharmacopoeia is stated that the rhizome of *Agropyrum repens* contains triticin, dextrose, mucilage, mannitol and inositol. It is a demulcent diuretic and is used internally in the treatment of catarrhal diseases of the genitor-urinary tract, in the form of the lipid extract or decoction. A number of species belong to the genus *Cymbopogon*, produce aromatic oils which accumulate in the tissue and are obtained by stream distillation. *C. schoenanthus* is used in an infusion as a stomachic and the essential oil is said to be useful in rheumatism. *C. nardus*, the citronella grass, is used in an infusion as a stomachic and carminative. *C. citratus* is said to be a good laxative and of use as an anthelmintic. The oil is to be an excellent embrocation for chronic rheumatism, sprains and neuralgia. The stem and roots of *Saccharum*, particularly *S. officinarum*, enter into ayurvedic prescriptions as diuretic, cooling and aphrodisiac. Various parts of plant have figured in cures for snake-bite. The smoke of burning *Panicum antidotale* is used for fumigating wounds and as a disinfectant in smallpox. *Hackelochloa granularis* is prescribed internally with a little sweet oil, in cases of enlarged spleen and liver (Bor, 1960).

The sedges, Cyperaceae is a plant family that used to confuse many people with the grasses. Both are similar in having small flowers borne in bracteate clusters, in the lack of or the extreme modification of perianth segments, in being wind-pollinated, and in the dry, indehiscent, single-seeded fruit. The most apparent morphological differences between the grasses and the sedges are shown in *Table 1.1*.

From Table 1.1 sedges have three rows of leaves, sheaths with united edges (in contrast to the overlapping sheaths of grasses). Most stems of sedges are triangular and solid, and most leaves are entirely basal. Sedges are commonly in wet places, whereas grasses occur in a wide range of habitats. The families Poaceae and Cyperaceae have been placed in the same order (Glumiflorae, Graminales, or Poales) by many authors. These two families have also been considered close to the Liliaceae and Juncaceae (Clark & Pohl, 1996; Gould & Shaw, 1983).

Table 1.1 Morphological differences between grasses (Poaceae) and sedges (Cyperaceae) (adapted from Duistermaat, 2005; Gould & Shaw, 1983).

Characters	Grasses (Poaceae)	Sedges (Cyperaceae)
Culm	rounded to flattened, hollow	triangular (at least just below the inflorescence) or rounded to flattened, solid
Leaves	2-rank	3-rank
Sheath margins	mostly open or overlapping	mostly closed or fused
Ligule	generally present and short to long, sometimes absent	absent or present
Flower	each generally subtended by two bracts	each always subtended by only one bract (and a number of perianth-bristles or scales can be present as well)
Florets	arranged in two ranks	spirally arranged or in two ranks
Fruit	caryopsis	usually an achene, never a caryopsis

1.2 General morphology of grass (adapted from Clark & Pohl, 1996; Duistermaat, 2005; Gould & Shaw, 1983; Kucera, 1998; Wycherley & Yosof, 1974).

Habit

Grasses are herbaceous (with the exception of woody bamboos), which means that the stems are typically green and relatively soft, although fibrous, but not woody. Grasses plants may be annual or perennial vary in their duration and growth forms. The annuäls grasses die after seed set and usually complete their life cycle in one year. The shoots are all alike and all produce inflorescences. However, some grasses are biennials, because their life cycle is usually about two years. The perennials produce flowering shoots accompanied by vegetative shoots; these persist for a few to many years and have an indefinite life span. Perennial grasses are loosely or densely tufted or form large spreading plants by their rhizomes or stolons.

The grass-plant consists of a root and shoot systems. The root system is fairly uniform throughout the grasses and in individual plants. The roots which emerge from the seeds on germination are few and short-lived, but having extensive system of fibrous. Adventitious roots develops later from nodes of the stems, especially those at or below the surface of the soil. The shoot system consisting of stem, leaves and inflorescence is much diversified (Fig. 1.1).

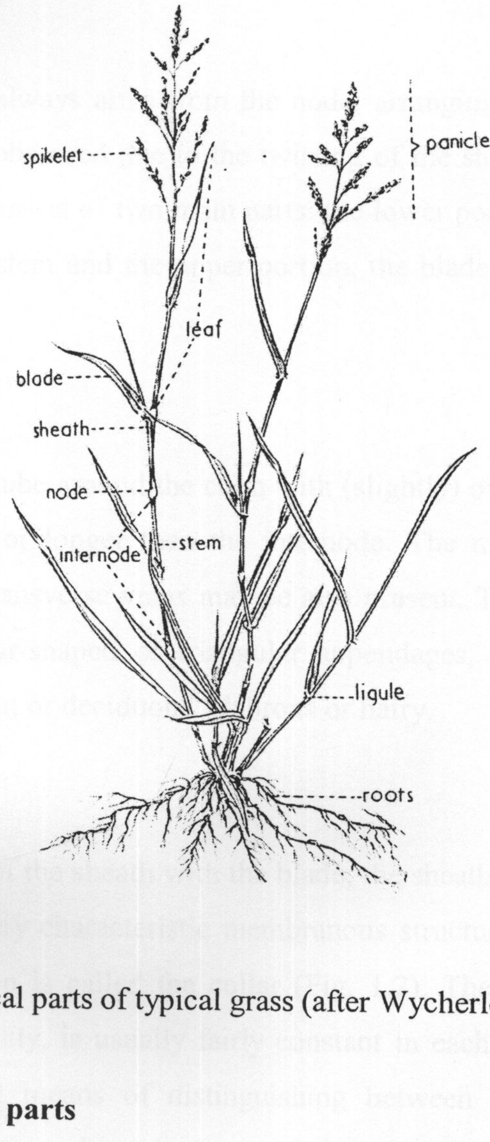


Figure 1.1 Morphological parts of typical grass (after Wycherley & Yosof, 1974).

1.2.1 Vegetative parts

Stem

The aerial stems of a grass is called a culm. It is consists of solid joints or nodes separated by short or long segments, the internodes. The nodes bear the leaves and, if present, roots and branches. The internodes are generally hollow, but are solid in a few grasses. At the base of the culm, they can be very short (about as long as the nodes) resulting in a concentration of leaves, which cover all the nodes. In the upper part of the culm the internodes are elongated. The typical culm grows vertically: erect, or ascending from a geniculate base. Some culms, however, grow horizontally.

Horizontal culms that lie on the soil surface are called stolons. They are generally green and the nodes bearing roots or not and bear well-developed leaves. Culms growing horizontally beneath the soil surface are called rhizome. Rhizomes are generally whitish with rooting nodes and reduced, scale-like leaves.

Leaves

Grasses leaves always arise from the node, arranging in two rows along the culm, but this is often obscured due to the twisting of the sheath or the culm in side the sheath. Each leaf consists of two main parts: the lower portion is the sheath which is wrapped around the stem and the upper portion, the blade, which is hinged to the top of the sheath.

Leaf-sheath

The sheath is a tube around the culm with (slightly) overlapping margins. The sheath may be shorter or longer than the internode. The midrib may be raised or winged, and (minute) transverse veins may be also present. The throat or the base of the blade may have ear-shaped or triangular appendages, referred to as auricles. Auricles can be persistent or deciduous, glabrous or hairy.

The Ligule

At the junction of the sheath with the blade, the sheath may be extended on its inner side to form a very characteristic membranous structure called the ligule; the part outside the junction is called the collar (Fig. 1.2). The ligule, a characteristic feature of the grass family, is usually fairly constant in each species and very often serves as an important means of distinguishing between specimens of different species in their vegetative phase because of they are displays various structural modifications.

Leaf-blades

The leaf-blade is similar to the other monocotyledonous plants, typically linear or lanceolate, arises on the top of the sheath. It is generally flat and elongated or inrolled with more or less prominent longitudinal veins. Transverse veins are sometimes present as well.

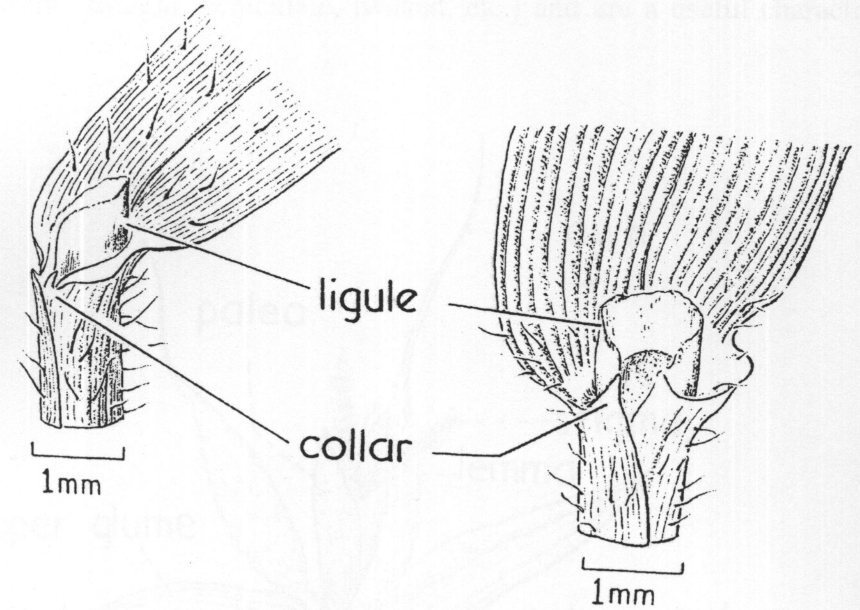


Figure 1.2 Part of leaf-blade and sheath illustrating the collar and the ligule (after Wycherley & Yosof, 1974).

1.2.2 Reproductive part

Inflorescences

The erect flowering stem or culm of a grass is terminated by an inflorescence. The inflorescence consists of distinct units called spikelets borne on the main axis or rachis. A few species have an inflorescence consisting of one spikelet only. However, the majority of grasses have inflorescences consisting of many spikelets, which display great variety in modifications of basic spikelet structure and in the different possible arrangements of the spikelets.

Spikelet

The spikelet is the basic unit of the inflorescence. It consists of one to several florets, each of which encloses the true flower, the whole subtended by two empty bracts called glumes. The lower (or first) and upper (or second) glumes. The glumes, rachilla, and the one to many florets together form a spikelet (Fig. 1.3). Above the empty glumes are one or more floral glumes. A floral glume are called "lemma" and "palea". The lemma is usually the larger and is on the side away from the rachilla. The spikelets of certain grasses or groups bear awns, which are mostly solitary projections of the mid-vein of either glumes or lemmas or both. Awns vary in length, thickness, and form (straight, geniculate, twisted, etc.) and are a useful character in identification.

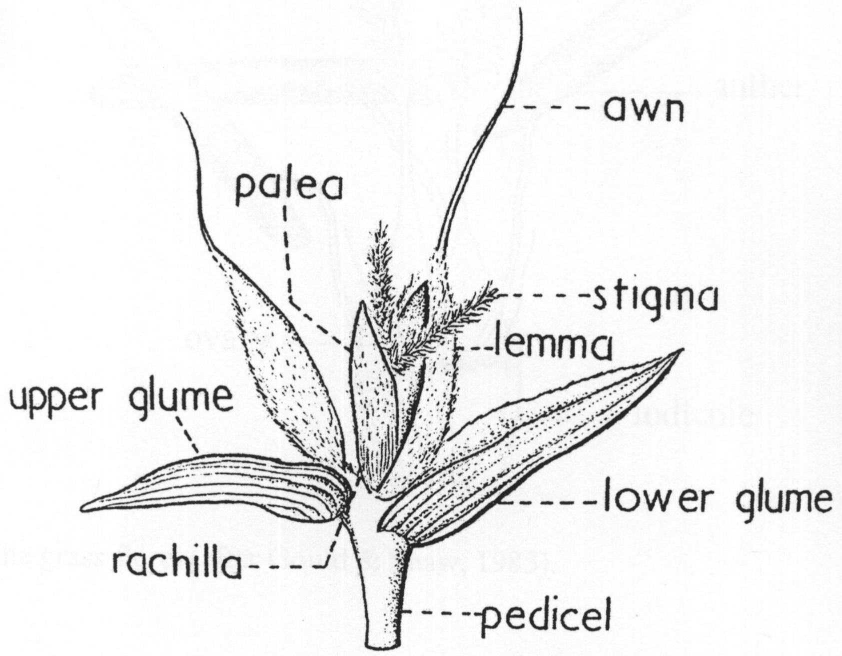


Figure 1.3 A spikelet (after Wycherley & Yosof, 1974).

Floret

The actual floret is between the lemma and palea. There is a variety of possible conditions and arrangements of the florets. The sex organs may be aborted and the floret is then sterile. If only the stamens are present or only the pistil is developed, the floret is referred to as male or female respectively. If both sexes are functional in the same floret the condition is bisexual or perfect or hermaphrodite. The perfect flower consists of stamens and pistil (Fig. 1.4). The most common number of stamen is three, but sometimes there are as many as six (e.g. *Zizania*). The filament of the grass stamen is typically delicate and flexible. The pistil consists of feathery, usually 2-parted stigmas and a 1-seeded ovary, the latter developing as the grain or caryopsis. At the base of the ovary, there are two or rarely three scales, called lodicules. The lodicules vary in sizes, but usually rather small. There are vestigial parts of an ancestral perianth. Their function is believed to push the lemma and palea apart when the sex organs are mature.

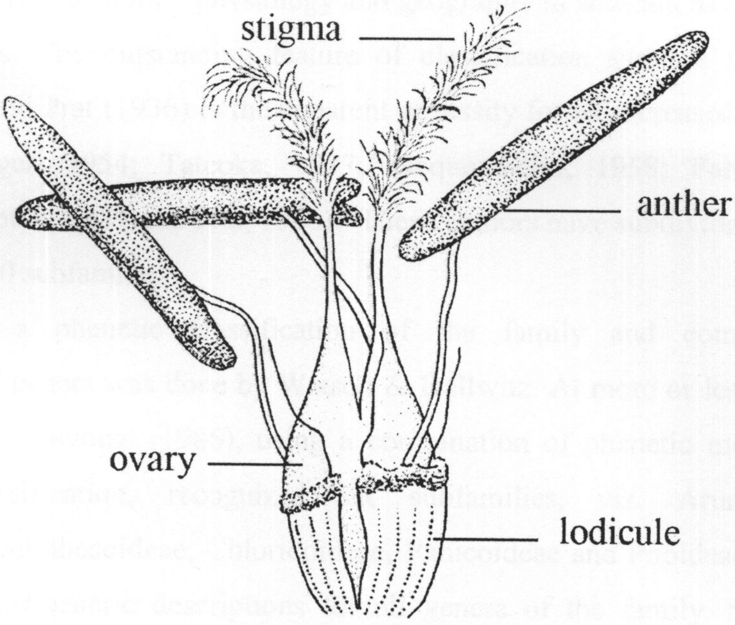


Figure 1.4 The grass floret (after Gould & Shaw, 1983).

Caryopsis

A fertilized ovule develops within the ovary, it is enclosed with ovary wall or pericarp when mature; a single seed-fruit is called a caryopsis.

1.3 Literature reviews

1.3.1 The previous classification systems of grass family

Robert Brown (1810) was the first person who subdivided the grass family into two subfamilies, the Pooideae and Panicoideae based on differences in spikelet morphology. This primary subdivision has been used as a basis by most authors later. Brown's concept was maintained and elaborated on by Bentham (1883), Hackel (1887), Hayek (1925) and Hubbard (1934). These botanists are among those who have made outstanding contributions to the classification of the Gramineae as a whole.

The modern foundation for the classification was established by Avdulov (1931), who introduced the use of cryptic characters, for example chromosome characteristics and linked them to morphological, anatomical features as well as the orientation and size of the first seedling leaf. It is really the turning point in the study of the grass family and launched new vistas in classification to which an increasing number of scientists are contributing (Bor, 1960). Synchronously, Prat (1936) also used information from anatomy, physiology and geography in addition to morphology and chromosomes. The outstanding feature of classification systems initiated by Avdulov (1931) and Prat (1936) is the apparent necessity for an increased number of sub-families (Pilger, 1954; Tateoka, 1957; Jacques-Félix, 1958; Parodi, 1959; Stebbins & Crampton, 1959 and Prat, 1960). These authors have subdivided the grass family in to 5 to 10 subfamiles.

In 1992, a phenetic classification of the family and comprehensive descriptions of all genera was done by Watson & Dallwitz. At more or less the same time Clayton and Renvoize (1986), using a combination of phenetic methods and evolutionary classification, recognized six subfamilies, viz. Arundinoideae, Bambusoideae, Centothecoideae, Chloridoideae, Panicoideae and Pooideae, and also provided diagnostic generic descriptions for all genera of the family. So far this system of grass classification is widely accepted. Recently, a new classification of the family Poaceae has been proposed by the Grass Phylogeny Working Group (GPWG, 2000, 2001) based on molecular data. This classification recognized twelve subfamilies i.e. Anomochlooideae, Aristidoideae, Arundinoideae, Bambusoideae, Centothecoideae, Chloridoideae, Danthonioideae, Ehrhartoideae, Panicoideae, Pharoideae, Pooideae and Puelioideae.

The Andropogoneae is one of the two major tribes in the subfamily Panicoideae (Clayton & Renvoize, 1986), which includes about one-third of all grass species (Mathews et al., 2002). The grass tribe Andropogoneae is a monophyletic tribe that includes both maize (*Zea may* ssp. *mays*) and sorghum (*Sorghum bicolor*), two of the world' most important crop. Clayton (1972, 1973) divided Andropogoneae into "awned" and awnless" taxa. Later, Clayton & Renvoize (1986) divided this tribe into 11 subtribes of 85 genera in the world, based largely on characters of the inflorescence. This tribe distributed throughout the tropics, particularly the savannah zone, extending into warm temperate regions. Most species of this tribe have pairs of spikelets in the inflorescence, one sessile and one on a pedicel, although in some species one or the other of these spikelets appears to be suppressed. Inflorescence form is highly variable, the members of each pair commonly dissimilar; glumes as long as the spikelet, often indurated and always firmer than the hyaline florets scales; florets two per spikelet, the lower male or barren, the upper female or bisexual; lemma of the upper floret often geniculately awned (Clayton, 1986).

In this study, two subtribes, i.e. Ischaeminae and Rottboelliinae which include about 15 genera in Thailand were studied.

The subtribes Ischaeminae and Rottboelliinae belong to the tribe Andropogoneae, which is the one of two major tribes in the subfamily Panicoideae (Clayton & Renvoize, 1986). The both subtribes in Thailand comprising of approximately 21 and 31 species, belonging to 5 genera and 10 genera, respectively. The 15 genera include *Apluda, Coelorachis, Eremochloa, Hackelochloa, Hemarthria, Ischaemum, Kerriochloa, Mnesithea, Ophiuros, Phacelurus, Rottboellia, Sehima, Thaumastochloa, Thelepogon* and *Vossia* (Nanakorn & Norsaengsri, 2001). At present taxonomic study of the family Poaceae in Thailand is slowly carried out, though it is really needed to fulfill our knowledge for the Flora of Thailand Project. This study aims to conduct taxonomic study of the subtribes Ischaeminae and Rottboelliinae in Thailand which are still scanty known. The knowledge gain from this study will be the basis for the Grass Flora of Thailand project as well as can serve as a model for further taxonomic study in Poaceae.

1.3.2 General morphological characteristics of the subtribe Ischaeminae

The first is subtribe Ischaeminae, includes over 60 species in the tropics of both hemispheres, but mainly occur in Asia and Australia. This subtribe is recognized by a single inflorescence, paired or digitate racemes or rarely solitary racemes, these usually terminal, sometimes axillary, rarely spathate; racemes with fragile rachis and linear to obovoid internodes, without homogamous pairs. Spikelets in dissimilar pair at each node of an articulated rachis or rarely becoming solitary through the reduction of the pedicelled spikelets. Sessile spikelet bisexual, dorsally or laterally compressed and composed of 1-2-flowers. The callus blunt and fitting a truncate or shallowly hollowed internode tip; lower glume chartaceous to crustaceous, convex or concave, 2-keeled or rounded on the flanks, with or without a median groove; lower florets male, with palea; upper lemma oblong, bidentate or bifid, nearly always with a glabrous awn. The pedicelled spikelet usually are staminate or neuter flowers, perfect flower are rare. The rachis-joints and the pedicels are either slender and separate or triquetrous and confluent at the base of node into U- or V-shaped structures (Keng, 1933; Clayton & Renvoize, 1986).

This subtribe composed of 8 genera in the world but occurs only 5 genera and 21 taxa in Thailand (Table 1.2) (Clayton & Renvoize, 1986; Nanakorn & Norsaengsri, 2001).

Table 1.2 List of genera in subtribe Ischaeminae of the World (Clayton & Renvoize, 1986) and Thailand (Nanakorn & Norsaengsri, 2001).

Genera	**(Clayton & Renvoize, 1986)**	**(Nanakorn & Norsaengsri, 2001)**
1. *Ischaemum* L.	✓	✓
2. *Thelepogon* Roem. & Schult.	✓	✓
3. *Apluda* L.	✓	✓
4. *Kerriochloa* C.E. Hubbard	✓	✓
5. *Triplopogon* Bor	✓	–
6. *Pogonachne* Bor	✓	–
7. *Sehima* Forssk.	✓	✓
8. *Andropterum* Stapf	✓	–
Total	**8**	**5**

1.3.3 General morphological characteristics of the subtribe Rottboelliinae

The subtribe Rottboeliinae contains 19 genera which includes 120 species or more. This subtribe is mainly found in the tropics of the Old World, with some genera extend to tropical America (Keng, 1933). This subtribe is recognized by a single inflorescence or sometimes with digitate racemes, these terminal, axillary or spathate; racemes fragile, though sometimes tardily so and rarely tough, the internodes variously thickened or swollen, without homogamous pairs. Spikelets usually in dissimilar paired, rarely ternate through the development of two sessile spikelets or solitary through the reduction of the pedicelled spikelet at each node of an articulated rachis. Sessile spikelets are dorsally compressed, bisexual and composed of 1-2-flowers. The callus sometimes obtuse with oblique scar, more often transversely truncate and then commonly reinforced by a central peg; lower glume herbaceous to crustaceous, convex, often sculptured, mostly 2-keeled; lower floret male or barren; upper lemma narrowly ovate and entire. In each floret of the spikelet, upper lemma usually has no awn. Lodicules are truncate, retuse or toothed from one corner. The pedicelled spikelet usually are staminate or neuter; the rachis-joints and the pedicels are mostly thickened and glabrous, they are often connivent or united to the internode and forming one or two cavities for the reception of the sessile spikelets (Keng, 1933; Clayton & Renvoize, 1986). This subtribe composed of 21 genera in the world but occur only 10 genera and 31 taxa in Thailand (Table 1.3) (Clayton & Renvoize, 1986; Nanakorn & Norsaengsri, 2001).

Table 1.3 List of genera in subtribe Rottboelliinae of the World (Clayton & Renvoize, 1986) and Thailand (Nanakorn & Norsaengsri, 2001).

Genera	(Clayton & Renvoize, 1986)	(Nanakorn & Norsaengsri, 2001)
1. *Urelytrum* Hack.	✓	–
2. *Loxodera* Launert	✓	–
3. *Elionurus* Kunth ex Willd	✓	–
4. *Phacelurus* Griseb.	✓	✓
5. *Vossia* Wall. & Griff.	✓	✓
6. *Hemarthria* R. Br.	✓	✓
7. *Lasiurus* Boiss.	✓	–
8. *Rhytachne* Desv.	✓	–
9. *Coelorachis* Brongn.	✓	✓
10. *Eremochloa* Büse	✓	✓
11. *Chasmopodium* Stapf	✓	–
12. *Rottboellia* L. f.	✓	✓
13. *Heteropholis* C.E. Hubbard	✓	–
14. *Hackelochloa* Kuntze	✓	✓
15. *Glyphochloa* Clayton	✓	–
16. *Manisuris* L.	✓	–
17. *Ophiuros* Gaertn.	✓	✓
18. *Oxyrhachis* Pilger	✓	–
19. *Mnesithea* Kunth	✓	✓
20. *Ratzeburgia* Kunth	✓	–
21. *Thaumastochloa* C.E. Hubbard	✓	✓
Total	**21**	**10**

1.3.4 Taxonomic historical reviews of the Poaceae

Previously, taxonomic works of the Poaceae were published in many Floras by various taxonomists (Table 1.4). The first major comprehensive study of Asian Gramineae was accomplished by Sir Joseph Hooker (1897) in his Flora of the British India. Standard works by other botanists related to the Grass flora include: Flora of tropical Africa (Stapf, 1917); the Poaceae in Laos, Cambodia and Vietnam was included in Flora Génerale de L' Indochine (Camus & Camus, 1922); Malay Peninsula (Ridley, 1925); Grasses of China was performed by Keng (1933); Burma by Rhind (1945); Flora of western Austrailia (Gardner, 1952); Notes on Malaysian Grasses (Jansen, 1953); Grasses of Ceylon (Senaratna, 1956); Grasses of Burma, Ceylon, India and Pakistan (Bor 1960); Grasses for Flora of Japan (Ohwi, 1965); Grasses of Hawai (Rotar, 1968); A manual of the Grasses of New Guinea (Henty, 1969); Flora of Malaya (Gilliland et al., 1971); Grasses in Malayan plantations (Wycherley, 1974); the Tropical Grasses of Southeast Asia (Lazarides, 1980); Flora of Pakistan (Cope, 1982); Grasses of Japan and neighbouring regions was also studied by Koyama (1987); Flora of Kerala-Grasses (Sreekumar, 1991); Flora of Ceylon (Dassanayake et al., 1994); Grasses of North-Eastern India (Shukla, 1996); the Grasses and Bamboo of India (Moulik, 1997). Recently by Duistermaat (2005) in Field Guide to the Grasses of Singapore; Flora of China (Chen et al., 2006) (Table 2.3).

1.3.5 History of Species Diversity of Poaceae in Thailand

The first taxonomic account of the family Poaceae in Thailand was prepared by Craib in 1913. He primarily reported species of Monocots in "Contribution to the Flora of Siam", which included mainly species collected by Kerr during 1907-1913. Twenty years later, Craib and Kerr published part of the Poaceae in Flora Siamensis Enumeratio. Since then all international activities were diminished due to the Second World War and the death of the authors. The Thai-Danish Botanical Projects carried over in 1957 have inspired the study on the Thai flora. Specimens collected in these expeditions were identified and species were published in Dansk Botanisk Arkiv by Bor & Larsen during 1962-1965, under the cooperation of Thai-Danish project "Studies in the Flora of Thailand" (Nanakorn, 1990).

From the last nine decades, taxonomic works on Thai grasses are rather scant. Only some accounts were reported by botanists who worked in some specific areas or in some taxa, for example Jaroenchai (2007) worked at Phu Ruea National Park, Norsaengsri (2000) at Phu Phan National Park, *Germainia* (Chai-anan, 1972), *Paspalum* (Poo-ngarm, 1982), *Setaria* (Tannukit, 1983), *Eragrostis* (Poodpong, 1984), Andropogoninae, Anthistiriinae and Saccharinae (Nanakorn, 1990), *Digitaria* (Chaiwiratnukul, 1988), *Panicum* (Prukpramool, 1992), *Aristida* (Chaisongkram, 2005) and subtribe Setariinae (Norsaengsri, 2006).

So far, the grass Flora of Thailand is rather in a slow process. It is probably due to lack of interested young botanists as well as lacking taxonomic resources such as references and type specimens. Prior to this study, little attention has been paid to the grasses of Thailand. The identification and distribution of grasses from Thailand have come from the literature of neighboring countries.

Table 1.4 List of species in subtribes Ischaeminae and Rottboelliinae in some Floras.

No.	Species \ Publications	Stapf, 1917 Africa	Rotar, 1968 Hawai	Hooker, 1897 British India	Sreekumar, 1991 Kerala (India)	Shukla, 1996 Northeastern	Moulik, 1997 India	Senaratna, 1956 Ceylon	Dassanayake et al., 1994 Ceylon	Cope, 1982 Pakistan	Rhind, 1945 Burma	Bor, 1960	Chen et al., 2006 China	Camus & Camus, 1922 Indo-China	Bor, 1962a, 1965a Thai	Nanakorn & Norsaengsri, 2001	Duistermaat, 2005 Singapore	Jansen, 1953 Malaysian	Gilliland et al., 1971 Malaya	Wycherley, 1974 Malayan	Backer & Bakhuizen , 1968	Lazarides, 1980 Southeast Asia	Henty, 1969 New Guinea	Gardner, 1952 Austrailia
1	*Apluda aristata* L.			✓				✓			✓													
2	*Apluda mutica* L.					✓	✓			✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	
3	*Apluda varia* Hack.	✓		✓																				
4	*Ischaemum angustifolium* Hack. ex Oliv	✓														✓								
5	*Ischaemum aristatum* L.			✓							✓		✓			✓								
6	*Ischaemum barbatum* Retz.				✓	✓	✓		✓		✓		✓		✓	✓		✓	✓		✓	✓	✓	
7	*Ischaemum barbatum* var. glaberrimum														✓	✓								
8	*Ischaemum barbatum* var. lodiculare (Nees) Jansen														✓	✓		✓				✓		
9	*Ischaemum ciliare* Retz.			✓									✓	✓		✓	✓							
10	*Ischaemum fieldingianum* Rendel															✓								
11	*Ischaemum hansenii* Bor															✓						✓		
12	*Ischaemum hirtum* Hack.			✓		✓	✓					✓				✓								
13	*Ischaemum hubbardii* Bor.					✓	✓					✓												
14	*Ischaemum imbricatum* Stapf ex. Ridl										✓													
15	*Ischaemum indicum* (Houtt.) Merr.		✓		✓	✓	✓		✓			✓		✓		✓			✓	✓	✓	✓		
16	*Ischaemum lacei* Stapf ex Bor					✓	✓					✓				✓								
17	*Ischaemum laxum* R. Br.			✓								✓				✓								
18	*Ischaemum magnum* Rendle			✓		✓						✓	✓			✓	✓	✓	✓	✓		✓		

Table 1.4 List of species in subtribes Ischaeminae and Rottboelliinae in some Floras (Cont.).

No.	Species / Publications	Stapf, 1917 Africa	Rotar, 1968 Hawai	Hooker, 1897 British India	Sreekumar, 1991 Kerala (India)	Shukla, 1996 Northeastern	Moulik, 1997 India	Senaratna, 1956 Ceylon	Dassanayake et al., 1994 Ceylon	Cope, 1982 Pakistan	Rhind, 1945 Burma	Bor, 1960	Chen et al., 2006 China	Camus & Camus, 1922 Indo-China	Bor, 1962a, 1965a Thai	Nanakorn & Norsaengsri, 2001	Duistermaat, 2005 Singapore	Jansen, 1953 Malaysian	Gilliland et al., 1971 Malaya	Wycherley, 1974 Malayan	Backer & Bakhuizen , 1968	Lazarides, 1980 Southeast Asia	Henty, 1969 New Guinea	Gardner, 1952 Austrailia
19	*Ischaemum mangaluricum* (Hackel) Stapf ex C.E.C.Fisch.															✓								
20	*Ischaemum muticum* L.			✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	
21	*Ischaemum rugosum* Salisb			✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓		
22	*Ischaemum tenuifolium* A. Camus															✓								
23	*Ischaemum timorense* Kunth			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓		
24	*Kerriochloa siamensis* C.E. Hubbard															✓						✓		
25	*Sehima nervosum* (Rottler) Stapf	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓		✓					✓	✓	✓	✓
26	*Sehima sulcatum* A. Camus															✓								
27	*Thelepogon elegans* Roem. & Schult.	✓		✓			✓			✓	✓	✓				✓						✓		
28	*Coelorachis cancellata* Ridl.														✓	✓			✓			✓		
29	*Coelorachis foveolata* (Holtt.) Jansen															✓		✓	✓			✓		
30	*Coelorachis glandulosa* (Trin.) Stapf. ex. Ridl.										✓	✓			✓	✓		✓	✓	✓	✓	✓		
31	*Coelorachis helferi* (Hook.f.) Henr.											✓				✓		✓	✓			✓		
32	*Coelorachis mollicoma* (Hance) Bor														✓	✓								
33	*Coelorachis pratensis* (Balansa) A. Camus													✓		✓								

Table 1.4 List of species in subtribes Ischaeminae and Rottboelliinae in some Floras (Cont.).

No.	Publications / Species	Stapf, 1917 Africa	Rotar, 1968 Hawai	Hooker, 1897 British India	Sreekumar, 1991 Kerala (India)	Shukla, 1996 Northeastern	Moulik, 1997 India	Senaratna, 1956 Ceylon	Dassanayake et al., 1994 Ceylon	Cope, 1982 Pakistan	Rhind, 1945 Burma	Bor, 1960	Chen et al., 2006 China	Camus & Camus, 1922 Indo-China	Bor, 1962a, 1965a Thai	Nanakorn & Norsaengsri, 2001	Duistermaat, 2005 Singapore	Jansen, 1953 Malaysian	Gilliland et al., 1971 Malaya	Wycherley, 1974 Malayan	Backer & Bakhuizen , 1968	Lazarides, 1980 Southeast Asia	Henty, 1969 New Guinea	Gardner, 1952 Austrailia
34	*Coelorachis striata* (Nees ex Steud.) A. Camus					✓	✓				✓	✓		✓	✓	✓						✓		
35	*Coelorachis striata* var. *pubescence* (Hack.) Bor					✓	✓				✓	✓		✓		✓						✓		
36	*Eremochloa attenuata* Stapf ex Buitenhuis																							
37	*Eremochloa bimaculata* Hack.			✓							✓	✓	✓		✓	✓						✓	✓	
38	*Eremochloa ciliaris* (L.) Merr.										✓	✓	✓	✓	✓	✓			✓			✓	✓	
39	*Eremochloa ciliatifolia* Hack.											✓				✓						✓		
40	*Eremochloa eriopoda* C.E. Hubbard															✓						✓		
41	*Eremochloa lanceolata* Buitenhuis																							
42	*Eremochloa maxwellii* Veldkamp																							
43	*Eremochloa muricata* (Retz.) Hack.			✓			✓	✓	✓			✓	✓			✓						✓		
44	*Eremochloa peltelotii* Merr.															✓						✓		
45	*Eremochloa zeylanica* Hack.															✓								
46	*Hackelochloa granularis* (L.) O. Kuntze		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			✓		✓	✓	✓	✓
47	*Hackelochloa porifera* (Hack.) D. Rhind					✓	✓				✓	✓	✓			✓								
48	*Hemarthria altissima* (Poir.) Stapf&C.E. Hubbard						✓					✓	✓			✓						✓		

Table 1.4 List of species in subtribes Ischaeminae and Rottboelliinae in some Floras (Cont.).

No.	Species \ Publications	Stapf, 1917 Africa	Rotar, 1968 Hawai	Hooker, 1897 British India	Sreekumar, 1991 Kerala (India)	Shukla, 1996 Northeastern	Moulik, 1997 India	Senaratna, 1956 Ceylon	Dassanayake et al., 1994 Ceylon	Cope, 1982 Pakistan	Rhind, 1945 Burma	Bor, 1960	Chen et al., 2006 China	Camus & Camus, 1922 Indo-China	Bor, 1962a, 1965a Thai	Nanakorn & Norsaengsri, 2001	Duistermaat, 2005 Singapore	Jansen, 1953 Malaysian	Gilliland et al., 1971 Malaya	Wycherley, 1974 Malayan	Backer & Bakhuizen , 1968	Lazarides, 1980 Southeast Asia	Henty, 1969 New Guinea	Gardner, 1952 Austrailia
49	*Hemarthria compressa* (L. f.) R. Br.					✓		✓	✓	✓	✓	✓	✓	✓		✓			✓			✓		
50	*Hemarthria debilis* Bor.														✓	✓			.			✓		
51	*Hemarthria fasciculata* Kunth													✓		✓						✓		
52	*Hemarthria longiflora* (Hook.f.) A. Camus					✓	✓				✓	✓	✓		✓	✓			✓			✓		
53	*Hemarthria longiflora* var. tonkinensis													✓		✓			✓			✓		
54	*Hemarthria pratensis* (Balansa) Clayton														✓	✓						✓		
55	*Hemarthria protensa* Steud.					✓						✓		✓	✓							✓		
56	*Hemarthria stolonifera* Bor.															✓						✓		
57	*Hemarthria subulata* Reeder														✓	✓							✓	
58	*Manisuris granularis* L.	✓		✓										✓										
59	*Mnesithea geminata* Ridl.															✓								
60	*Mnesithea glandulosa* (Trin.) Koning & Sosef.						✓									✓	✓							
61	*Mnesithea granularis* (L.) Koning & Sosef.															✓	✓							
62	*Mnesithea laevis* (Retz.) Kunth				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓			✓	✓		
63	*Mnesithea merguensis* (Hook.f.) A. Camus											✓			✓	✓						✓		
64	*Mnesithea mollicoma* (Hance) A. Camus												✓	✓		✓		✓	✓		✓	✓		
65	*Mnesithea striata* (Nees ex Steud.) Koning & Sosef.					✓							✓	✓		✓		✓	✓		✓	✓		

Table 1.4 List of species in subtribes Ischaeminae and Rottboelliinae in some Floras (Cont.).

No.	Species \ Publications	Stapf, 1917 Africa	Rotar, 1968 Hawai	Hooker, 1897 British India	Sreekumar, 1991 Kerala (India)	Shukla, 1996 Northeastern	Moulik, 1997 India	Senaratna, 1956 Ceylon	Dassanayake et al., 1994 Ceylon	Cope, 1982 Pakistan	Rhind, 1945 Burma	Bor, 1960	Chen et al., 2006 China	Camus & Camus, 1922 Indo-China	Bor, 1962a, 1965a Thai	Nanakorn & Norsaengsri, 2001	Duistermaat, 2005 Singapore	Jansen, 1953 Malaysian	Gilliland et al., 1971 Malaya	Wycherley, 1974 Malayan	Backer & Bakhuizen , 1968	Lazarides, 1980 Southeast Asia	Henty, 1969 New Guinea	Gardner, 1952 Austrailia
66	*Mnesithea striata* var. *pubescens* (Hack.) S.M. Phillips & S.L. Chen					✓							✓	✓		✓		✓	✓		✓	✓		
67	*Ophiuros bombaiensis* Bor															✓								
68	*Ophiuros exaltatus* (L.) O. Kuntze.					✓	✓		✓		✓	✓	✓	✓	✓	✓						✓	✓	✓
69	*Ophiuros megaphyllus* Stapf & Haines															✓								
70	*Phacelurus cambogiensis* (Balansa) Clayton															✓						✓		
71	*Phacelurus zea* (C.B.Clarke) Clayton					✓	✓						✓			✓						✓		
72	*Pseudovossia combogiensis* (Balansa) A. Camus	✓												✓		✓						✓		
73	*Rottboellia cochinchinensis* (Lour.) Clayton				✓	✓	✓		✓				✓				✓							
74	*Rottboellia compressa* L. f.			✓	✓				✓				✓				✓							
75	*Rottboellia exaltata* L. f.	✓		✓				✓		✓		✓		✓		✓					✓	✓		
76	*Rottboellia glandulosa* Trin.	✓		✓				✓				✓		✓		✓					✓	✓		
77	*Rottboellia helferi* Hook.f.	✓		✓				✓				✓		✓		✓					✓	✓		
78	*Rottboellia longiflora* Hook.f.	✓		✓				✓				✓		✓		✓					✓	✓		
79	*Rottboellia protensa* Hack.	✓		✓				✓				✓		✓		✓					✓	✓		
80	*Rottboellia striata* Nees ex Steud.	✓		✓				✓				✓		✓		✓					✓	✓		
81	*Vossia cuspidata* (Roxb.) Griff.	✓				✓	✓					✓		✓		✓						✓		
82	*Vossia procera* Wall. & Griff.			✓																				

1.4 Objectives

1. To accomplish a taxonomic revision of the subtribe Ischaeminae and Rottboelliinae in Thailand.
2. To examine the anatomical and molecular characters of the selected groups.
3. To develop a phylogeny of the genera and species in the subtribes Ischaeminae and Rottboelliinae in Thailand based on molecular characters.

1.5 Scopes of study

The study of the subtribes Ischaeminae and Rottboelliinae in Thailand was conducted between June 2004 and August 2007, morphological ecological and distributional data of the two subtribes were obtained from field collected specimens and herbarium specimens kept at main herbaria in Thailand and Europe. Molecular biology, leaf and culm anatomy were studied.

1.6 Anticipated benefits

This research will be the basis for the Grass Flora of Thailand project. The outcome from this research could be a model for further taxonomic study in Poaceae.

1.7 Places of study

1. Department of Botany, Faculty of Science, Chulalongkorn University, Bangkok and Applied Taxonomic Research Center, Department of Biology, Faculty of Science, Khon Kaen University.
2. Main herbaria in Thailand and Europe: Department of Systematic Botany, University of Aarhus (AAU), Kasin Suvatabandhu Herbarium, Chulalongkorn University, Bangkok (BCU); Bangkok Herbarium, Department of Agriculture, Bangkok (BK), Forest Herbarium, Bangkok (BKF), British Natural History Museum Herbarium (BM), Botanical Museum, University of Copenhagen (C), Chiangmai University Herbarium (CMU), Royal Botanic Garden, Edinburgh (E), Khon Kaen University Herbarium (KKU), Royal Botanic Gardens, Kew (K), National Herbarium Netherland University of Leiden branch (L); Linnean Society Herbarium (LINN),

Prince of Songkhla University Herbarium (PSU), Queen Sirikit Botanic Gardens Herbarium (QBG), Muséum National d' Histoire Naturelle, Paris (P), Trinity College, University of Dublin (TCD) and Department of Biology Herbarium, Chiang Mai University.

3. The molecular research was undertaken at the Jodrell laboratory, Royal Botanic Gardens, Kew, Richmond, Surrey, England.

CHAPTER II

MORPHOLOGICAL STUDY

2.1 General characters of subtribes Ischaeminae and Rottboelliinae in Thailand

2.1.1 Vegetative Morphology

2.1.1.1 Habits

It was found that grasses in subtribes Ischaeminae and Rottboelliinae are having different life cycle. The annual grasses have a rooting system which is simple and produce each ascending culm which terminates with an inflorescence. While perennials having an enduring root system which may consist of a woody root-stock or being rhizomatous or stoloniferous (e.g. *Ischaemum indicum*, *I. muticum*, *I. timorense*, *Kerriochloa siamensis*, *Thelepogon elegans*, *Eremochloa bimaculata*, *E. ciliaris*, *E. maxwellii*, *E. muricata*, *E.* sp.1, *Hemarthria altissima*, *H. compressa* and *H. stolonifera*). In addition to the flowering culm there will be other shoots in various stages of development, some of which may not flower till the following year. Plants in both subtribes are mostly perennial grass and rarely found in annual tufted as in *Ischaemum hirtum*, *I. rugosum*, *I. timorense*, *I.* sp.1, *Thelepogon elegans*, *Eremochloa ciliatifolia*, *E. lanceolata*, *Hackelochloa granularis*, *H. porifera*, *Hemarthria debilis* and *Rottboellia cochinchinensis*.

2.1.1.2 Clum

Most of culms are terete, subterete (e.g. *Kerriochloa siamensis*, *Hackelochloa granularis* and *H. porifera*) or compressed (e.g. *Hemarthria altissima*, *H. compressa* and *H. longiflora*) with a glabrous internodes, usually erect which covered with a hairs on the nodes. Only some species have a glabrous node (e.g. *Ischaemum hubbardii*, *I. magnum*, *I. tenuifolium*, *I.* sp.1, *Eremochloa bimaculata*, *E. maxwellii*, *E. petelotii*, *E.* sp.2, *Hemarthria altissima*, *H. compressa*, *H. pratensis*, *H. stolonifera* and *Vossia cuspidata*).

2.1.1.3 Leaves

Leaves are alternate arranging in two-ranks, consisting of three distinct parts: a sheath, a blade and a ligule as follow:

Leaf-sheaths

The sheath forms a hollow cylinder around the culm. It is attached to the whole circumference of the node. The margins are usually free from one another. The surface of the sheath is usually ridged and often hairy or glabrous.

The ligule

A ligule is a small structure, situates at the junction of the sheath and the blade. It is usually an appendage arising from the inner surface of the leaves. The ligules may be a membrane, a membrane tipped with hairs or a rim of hairs.

Leaf-blades

The shape, size and texture of the leaves are variable. The shape can be found from narrowly linear, linear, linear-lanceolate and oblong-lanceolate to lanceolate. Leaf size ranges from small, 3–6 cm by 2–3 mm, e.g. *Eremochloa lanceolata* to large, *ca.* 150 by 1–1.5 cm, e.g. *Phacelurus zea*. Laminas with membranous textures have been observed in most species while coriaceous lamina are rarely found, e.g. *Ischaemum* sp.1, *Phacelurus cambogiensis* and *P. zea*. Leaf base is mostly rounded or cordate, whereas apices are commonly acute or acuminate. Leaves margins are usually entire, with an exception in *Thelepogon elegans*, having undulate margins.

2.1.2 Reproductive Morphology

2.1.2.1 Inflorescence (Figs. 2.1–2.2)

Inflorescences are always terminal in both subtribes. They may, however, be found at the end of axillary shorts shoots. The peduncle is normally tereted. In general, shapes of inflorescences are having taxonomic value for identification. The determinate inflorescences can be divided in to 3 types due to differences in their lateral branches, as below:

Single spike-likes racemes (Figs. 2.1A-B & 2.2A-D): The pairs of spikelets, one spikelet sessile, the other pedicelled, are attached to a joint and fall with the joint of the axis bearing it, the pedicelled spikelet falls with its pedicel. This type is common in the all member of the genus *Sehima, Eremochloa, Hackelochloa, Hemarthria, Mnesithea, Ophiuros* and *Rottboellia*. In the genus *Kerriochloa* the racemes are embraced by a spatheole.

Paired or digitate of spike-likes racemes (Figs. 2.1C-E & 2.2E): As in the single spike-likes racemes, but the inflorescence compose of paired or sometimes digitate racemes which are separated or conjugated 1-sided and interlocked back to back in a single spike. This type is common in most members of the genus *Ischaemum*, *Thelepogon* and *Vossia*.

Panicle (Fig. 2.1F): The inflorescence with branches, each branch is raceme, borne at intervals along the rachis. This inflorescence type is found in 3 species, i.e. *Apluda mutica*, *Phacelurus zea* and *P. cambogiensis*.

Figure 2.1 Inflorescence types of Ischaeminae: A-B. single spike-likes racemes; A. *Sehima nervosum*; B. single raceme enclosed by a spatheole; C. conjugating of pairs racemes; D. separating of pairs racemes; E. digitated racemes and F. panicle inflorescence (drawn by P. Traiperm).

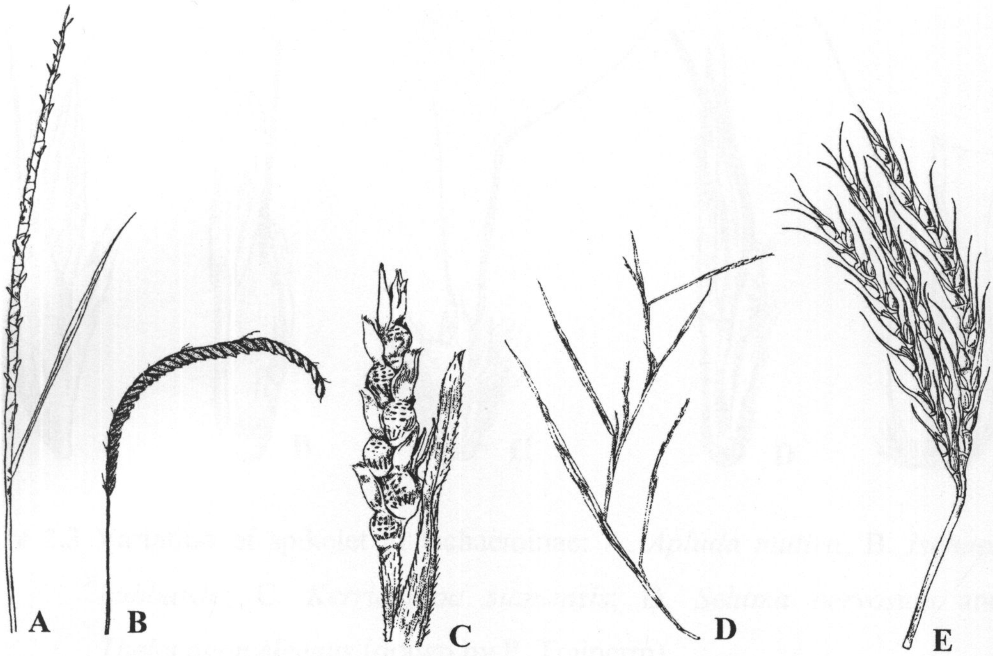


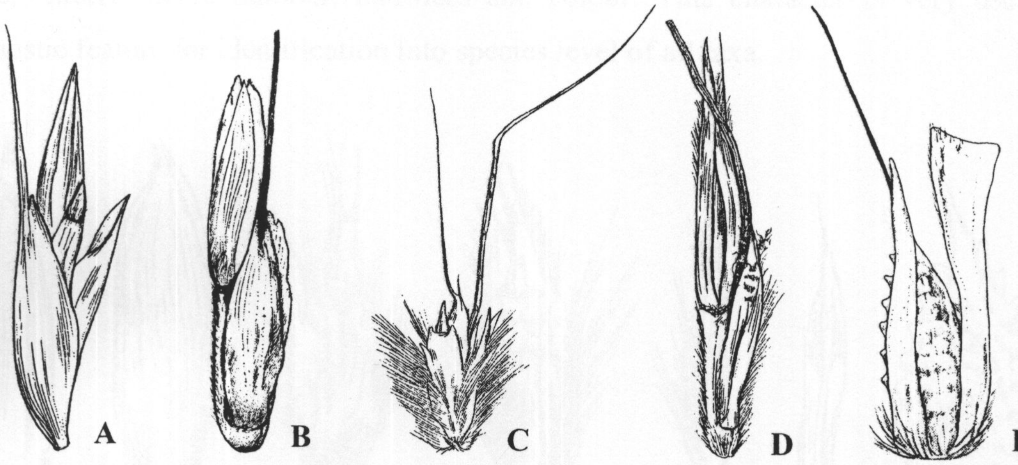
Figure 2.2 Inflorescence types of Rottboellinae: A-D. single spike-likes racemes and E. digitated racemes (drawn by P. Traiperm).

2.1.2.2 Spikelet (Figs. 2.3–2.4)

The spikelets of both subtribes are of two types, one is sessile and the other is pedicelled. Shape, size and a number of spikelet are taxonomic significant in identification. Three spikelets can be found in the genus *Apluda* or sometimes in the genus *Mnesithea*. Sessile spikelet of most genera is usually equal or larger than pedicel, except in the genus *Sehima*. The spikelets are globose in the genus *Hackelochloa*, while columnar or cylindrical forms are found in *Hemarthria*, *Mnesithea*, *Ophiuros*, *Rottboellia* and *Vossia*. The presence of pedicelled spikelet can be found in most genera, with an exception in *Thelepogon*, *Eremochloa*, *Ophiuros* and *Mnesithea laevis*.

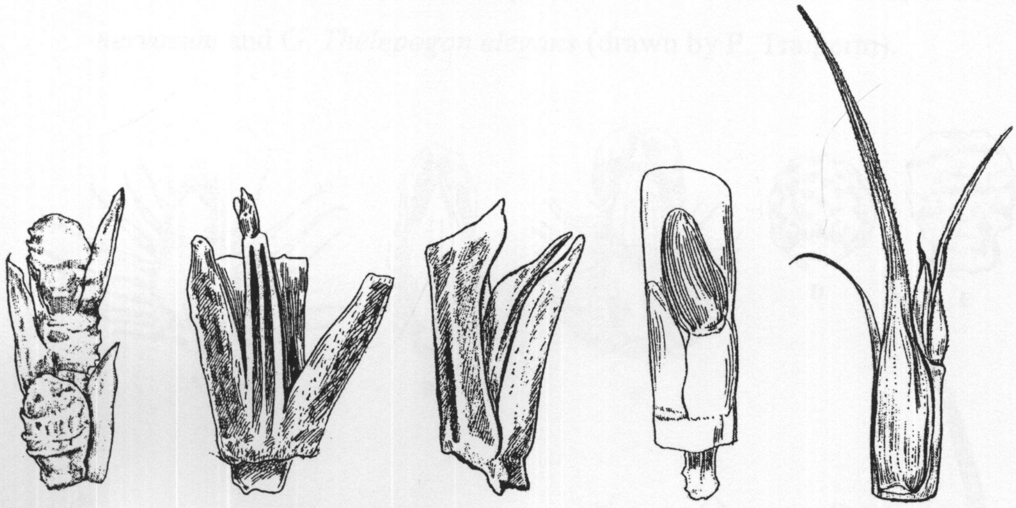
2.1.2.3 Rachis node

The grasses in the subtribe Ischaeminae are having a slender rachis node, which is linear or oblong in shape, while thickened or swollen rachis node is found in the subtribe Rottboelliinae.



A B C D E

Figure 2.3 Variation of spikelet in Ischaeminae: A. *Apluda mutica*; B. *Ischaemum hubbardii*; C. *Kerriochloa siamensis*; D. *Sehima nervosum* and E. *Thelepogon elegans* (drawn by P. Traiperm).



A B C D E

Figure 2.4 Variation of spikelet in Rottboelliinae: A. *Hackelochloa porifera*; B. *Mnesithea mollicoma*; C. *Mnesithea laevis*; D. *Rottboellia cochinchinensis* and E. *Vossia cuspidata* (drawn by P. Traiperm).

2.1.2.4 Glume (Figs. 2.5–2.6)

Glume is a scale-like bract. There are two bracts at the base of grasses in these two subtribes. The first one is inserted on the rachilla just above the other and designated the lower and the upper glume. There are variously modified in size, shape, texture, nerve number, hairiness and colour. This character is very useful diagnostic feature for identification into species level of all taxa.

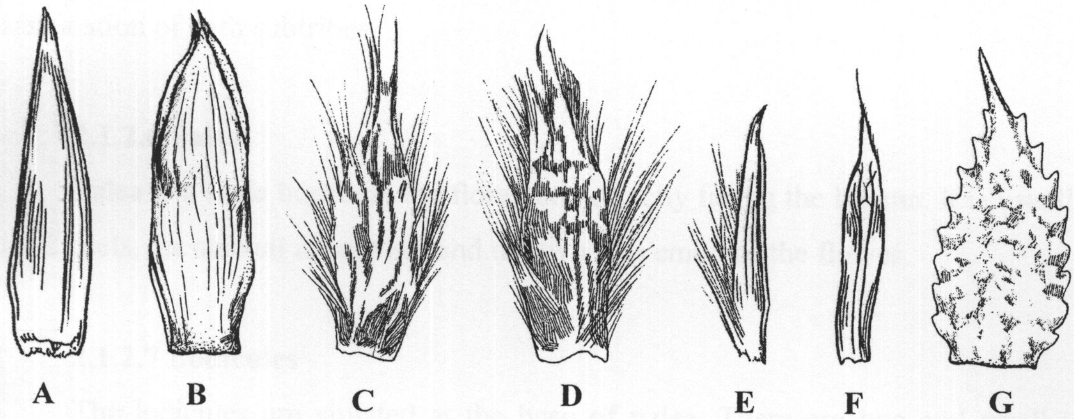


Figure 2.5 Variation of lower glume in subtribe Ischaeminae: A. *Apluda mutica*; B. *Ischaemum hubbardii*; C-D. *I.* sp.2; E. *Kerriochloa siamensis*; F. *Sehima nervosum* and G. *Thelepogon elegans* (drawn by P. Traiperm).

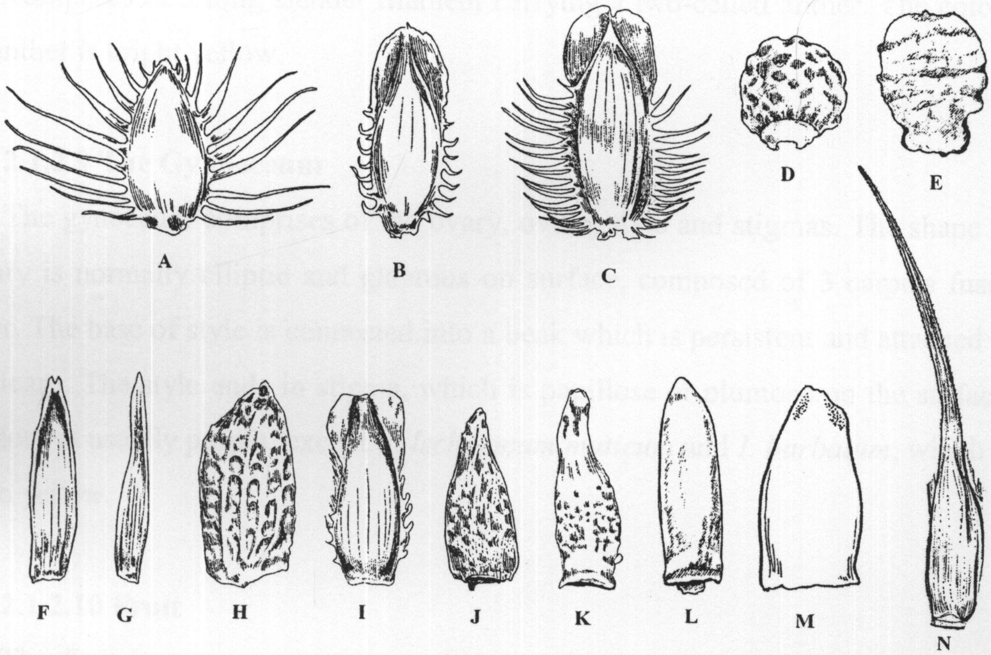


Figure 2.6 Variation of lower glume in subtribe Rottboelliinae: A. *Eremochloa eripoda*; B. *E. petelotii*; C. *E. muricata*; D. *Hackelochloa granularis*; E. *H. porifera*; F. *Hemarthria altissima*; G. *H. stolonifera*; H. *Mnesithea cancellata*; I. *M. glandulosa*; J. *M. mollicoma*; K. *M. striata* var. *pubescens*; L. *Ophiuros exaltatus*; M. *Rottboellia cochinchinensis* and N. *Vossia cuspidata* (drawn by P. Traiperm).

2.1.2.5 Lemma

Lemma is a small bract, subtending the floret. It encircles the palea and also protects the reproductive organs. The characters of the lemma are very useful in classification of both subtribes.

2.1.2.6 Palea

Palea is a scale borne on the floral axis directly facing the lemma. It is usually with 2 keels, the adaxial is concave and the two flap embrace the flower.

2.1.2.7 Lodicules

The lodicules are situated at the base of palea. There are two and small to fairly large scales. Their shapes are conical.

2.1.2.8 The Androecium

The androeceum consists of the stamens which is three in number. Each stamen composes of a long slender filament carrying a two-celled anther. The colour of the anther is bright yellow.

2.1.2.9 The Gynoeceum

The gynoceum comprises of the ovary, ovule, style and stigmas. The shape of the ovary is normally elliptic and glabrous on surface, composed of 3 carpels fused together. The base of style is connected into a beak which is persistent and attached to the pericarp. The style ends in stigma, which is papillose or plumose on the surface. The colour is usually purple, except in *Ischaemum muticum* and *I. barbatum*, which is white to yellow.

2.1.2.10 Fruit

The fruit is a caryopsis; one-seeded fruit in which the seed coat is closely fused to the fruit wall. The caryopsis is popularly called a grain and is the typical fruit of the family Poaceae.

2.2 Conclusion

The characters of inflorescence and spikelet are the most two important in identification, especially in the genera level. Some additional characters, e.g., culms, leaves and habit can be of taxonomical importance and can be useful for species identification, especially in closely related collected group.

CHAPTER III

ANATOMICAL STUDY

3.1 Introduction

The subfamilies and tribes of the family Poaceae are generally distinguished by morphological characters of the spikelet and inflorescence (Clayton & Renvoize, 1986). However, it has been known more than 75 years that anatomical investigations of the grass leaf-blade have provided valuable taxonomic information. In fact, nowadays, it is generally accepted that anatomical details, especially of the leaf-blade, are not only useful in characterizing the major taxa within the family but are also an essential ingredient of any satisfactory treatment of grass taxonomy. Furthermore, in the Poaceae, with their highly specialized and reduced flowers, very fine morphological distinctions are often necessary to define differences between taxa. Anatomical data is, therefore, regarded as being of undoubted importance in the jigsaw of complete systematic evidence in this numerically large and important family (Ellis, 1976).

3.2 Literature reviews

Grass anatomy, as revealed by transverse sections, has been emphasized as a very fundamental character by Duval-Jouve (1875), who was the first to attempt to use it for systematics. The character used was the position of the bands of bulliform cells in relation to the nerves: for example, the presence of bulliform cells over the tertiary nerves in the Paniceae and Andropogoneae and the existence of bulliform cells in both upper and lower epidermis of Paniceae.

Six major groups of anatomical features in leaf-blades of the Poaceae were recognized by Brown (1958) viz, Bambusoid, Festucoid, Arundoid, Panicoid, Aristidoid and Chloridoid types. Each type has a unique shape and arrangement of mesophyll cells, sclerified cells, chlorenchyma, parenchyma and vascular bundles. The characters considered to be of phylogenetic value are presence or absence of the inner bundle sheath (endodermis); structure and function of the outer bundle sheath (parenchyma sheath) and the arrangement of the chlorenchyma cells between the bundles. He concluded that the panicoid type is characterized by the parenchyma sheath cells developed to specialized plastids for starch storage, accompanied by a loss of starch formation by the chloroplasts of the chlorenchyma cells. Associated with this specialization in the sheath were a more regular, radial arrangement of the adjacent chlorenchyma cells and the complete elimination of the endodermis in some groups. The panicoid type is characterized in the tribe Paniceae by the retention of an endodermis on large bundles in some species of *Panicum, Tricholaena, Oplismenus, Brachiaria, Eriochloa*, and probably some other genera. Typically, however, an endodermis is lacking in this tribe. In the rosette leaves of *Panicum lindheimeri* and some species of other genera, the cells of the parenchyma sheath do not have the specialized starch plastids typical of the tribe. The chlorenchyma is, to some extent, radially arranged around the bundles, but the cells are not very long and narrow or very obviously radially arranged, as in the Chloridoideae, nor is this layer only one cell thick. There are evident air spaces among the cells of the mesophyll. In Andropogoneae there is no endodermis, the chlorenchyma is indefinitely or not at all radially arranged, and the cells are not obviously long and narrow.

Metcalfe (1955), in discussing his work on the systematic anatomy of the monocotyledons, states that in the transverse section of a grass leaf-blade both the occurrence and distribution of sclerenchyma especially in relation to the vascular bundles and the shape of the lamina are specific diagnostic characters. For the epidermal preparations, the characters that have been found to be of diagnostic value include the occurrence and distribution of large hooks or small rounded hooks, the distribution and types of epidermal papillae and the occurrence and distribution of 1-celled hairs.

Five years later, the applicable data, definitions, descriptions for the family as a whole and comparisons with any degree of assurance were greatly improved by the publication of "Anatomy of the Monocotyledons. 1. Gramineae" (Metcalfe, 1960). He arranged the descriptions of genera and species in alphabetical sequence and states that the tribe Andropogoneae has Panicoid type leaf-blades. Leaf-blades of the Panicoid type have many characters in common. From the anatomical standpoint, they are characterized by having cross to dumb-bell shaped silica-bodies over the veins; relatively long micro-hairs of which the distal cell tapers towards the apex; conspicuous to inconspicuous radiate chlorenchyma; and single or double bundle-sheaths. The double bundle-sheaths are uncommon, and when present, they are often restricted to the large vascular bundles. Grass materials for his study included *Apluda* and *Ischaemum* from the subtribe Ischaeminae and *Eremochloa, Hackelochloa, Hemarthria, Rottboellia* and *Vossia* from the subtribe Rottboelliinae.

Ellis (1976) continued to stabilize the terminology of the grass family, and at the same time presented a classification system based on description and comparison of grass leaf anatomy as viewed in transverse section (Ellis, 1976) and the epidermis as seen in surface view (Ellis, 1979).

The diagnostic anatomical characters, together with other conservative characters, enable any grass to be consistently evaluated with reference to the core subfamily concept. This has been summarized by Ellis (1986) on the basis of the leaf anatomy, and also by Renvoize (1981), Clifford & Watson (1977) and Watson et al. (1985, 1986) (Table 3.1).

Detailed descriptions of some grass genera have been compiled by Watson & Dalwitz (1992). In their study they also listed the anatomical characters of some genera, namely *Apluda, Coelorachis, Eremochloa, Hackelochloa, Hemarthria, Ischaemum, Mnesithea, Ophiuros, Phacelurus, Rottboellia, Sehima, Thelepogon* and *Vossia,* from the two subtribes Ischaeminae and Rottboelliinae. For the genus *Kerriochloa*, they commented that the anatomical data was still missing.

Leaf-blade anatomy of 86 genera in the tribe Andropogoneae was investigated by Renvoize (1982). His results show that anatomy of the leaf blade is rather uniform, and that it is therefore possible to combine most of the observations into a single generalized description with illustrations of a few selected species.

Epidermis

Long cells narrowly to broadly oblong, of constant width; usually convolute-walled (80% of the genera), occasionally wave-walled; spined, papillate or smooth; contiguous, alternating with or irregularly interspersed with short cells.

Short cells solitary, often associated with a silica-containing cell.

Stomata of the lower epidermis usually in 1-2 rows (67% of the genera) occasionally up to 10 rows; of the upper epidermis often in 1-2 rows, occasionally up to 7 but often absent; of the lower surfaces usually alternate with the interstomatal cells (74% of the genera), but occasionally scattered; equal in width or slightly narrower than the interstomatal cells (Figs. 3.1 & 3.2).

Table 3.1 Anatomical characteristic of the subfamilies of the Poaceae (Ellis, 1986).

Characters / Subfamilies	POOIDEAE	BAMBUSOIDEAE	ARUNDINOIDEAE	CHLORIDOIDEAE	PANICOIDEAE
MIDRIB	median bundle only simple vasculature no adaxial parenchyma	keeled complex vasculature adaxial parenchyma rare	keeled or not simple vasculature no adaxial parenchyma	keeled or not simple vasculature adaxial parenchyma rare	keeled simple vasculature adaxial parenchyma common
CHLORENCHYMA	non-radiate diffuse (or compact) parenchyma cells	non-radiate compact(or diffuse) arm and fusoid cells	non-radiate compact (or diffuse) rachymorphous cells	strongly radiate uniform tabular cells rachymorphous cells	strongly or weakly radiate variable cells rachymorphous cells
INTERCOSTAL LONG CELLS	fusiform or rectangular straight walled or sinuous	rectangular sinuous walled	rectangular sinuous walled	rectangular sinuous walled	rectangular sinuous walled (rarely straight walled)
STOMATA	parallel sided guard cells sunken	triangular or domed guard cells flush	domed or triangular guard cells flush	triangular (rarely domed) guard cells flush	domed or triangular guard cells flush
PAPILLAE	absent	common cuticular many/cell	absent (rarely present)	common cuticular one/cell	common or absent inflated or cuticular one or many/cell
MICROHAIRS	absent	elongated, finger-like	elongated, finger-like	inflated, spherical	elongated, finger-like
SILICA BODIES	horizontally elongated oblong nodular	vertically elongated dumbbell, saddle, cross, olyroid	horizontally elongated square, oblong, cross, saddle, dumbbell	equidimensional saddle, square, angular, round,dumbbell	horizontally elongated dumbbell, cross, nodular

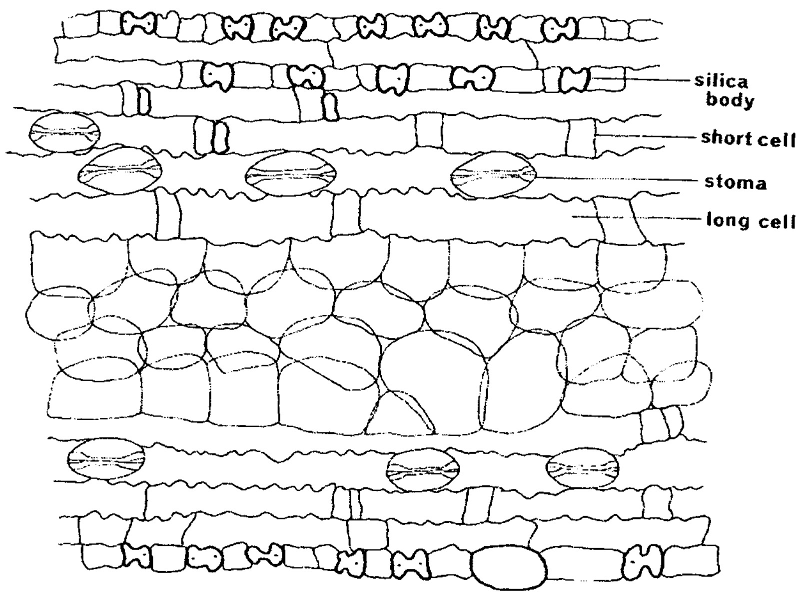


Figure 3.1 Upper epidermis of *Lasiurus scindicus* x 340 (after Renvoize, 1982).

Subsidiary cells low- to high-domed or triangular. Silica bodies longitudinal, saddle-, cross- or dumbbell-shaped (Fig. 3.3). Micro-hairs finger like, the apical cell usually of equal length to the basal cell or longer (85% of the genera), occasionally slightly shorter (Fig. 3.4).

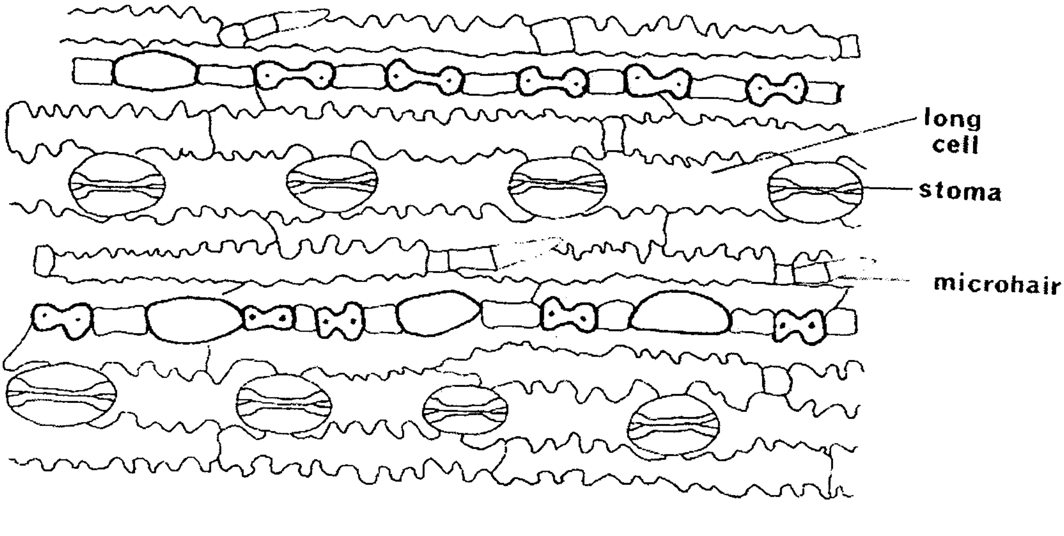


Figure 3.2 Lower epidermis of *Ischaemum afrum* x 340 (after Renvoize, 1982).

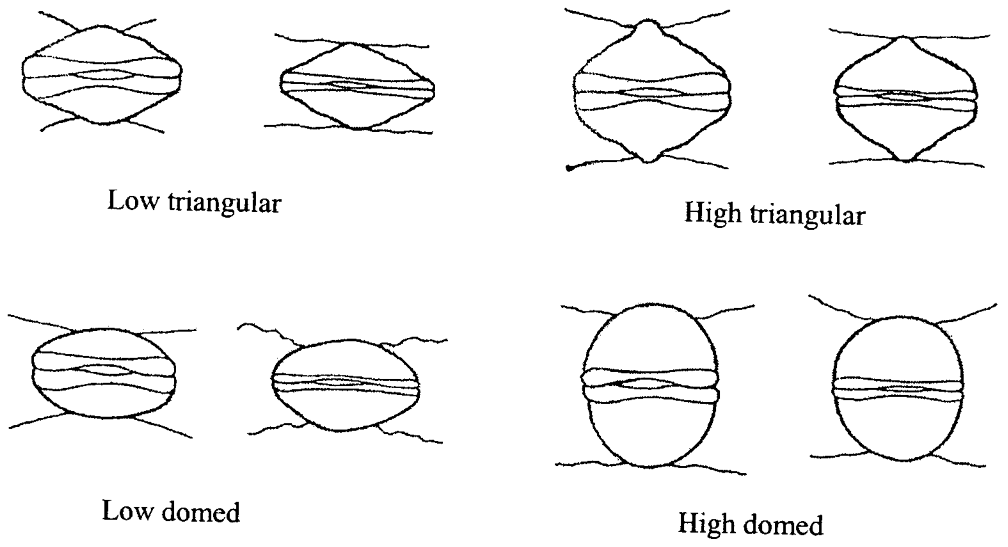


Figure 3.3 Shape of subsidiary cells in grass leaves (after Ellis, 1979).

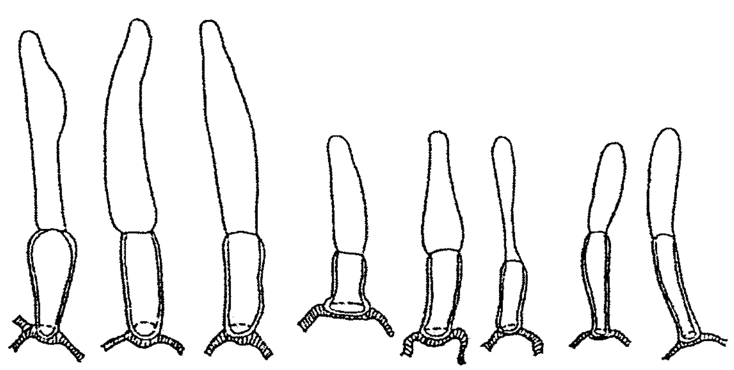


Figure 3.4 Shape of micro-hairs in grass leaves (after Metcalfe, 1960).

Transverse section

Leaves usually flat (77% of the genera), occasionally V-shaped or U-shaped.

Vascular bundles of different classes arranged in a single straight or slightly irregular lateral sequence. Primary bundle (midrib) solitary or with several smaller associated bundles and multiple layers of parenchyma cells below the upper epidermis. Secondary bundles round or rhomboidal, linked above and below the epidermis by small, square or oblong, often poorly developed, sclerenchymatous girders. Sheath single, complete or incomplete above or below or both, the cells the same size as or slightly larger than the chlorenchyma cells, thick-walled. Tertiary bundles round, sclerenchymatous girders present, poorly developed or absent, sheath complete. Quaternary bundles usually present (85% of the genera) occasionally absent, circular, sclerenchymatous girders usually absent (81% of the genera) (Fig. 3.5).

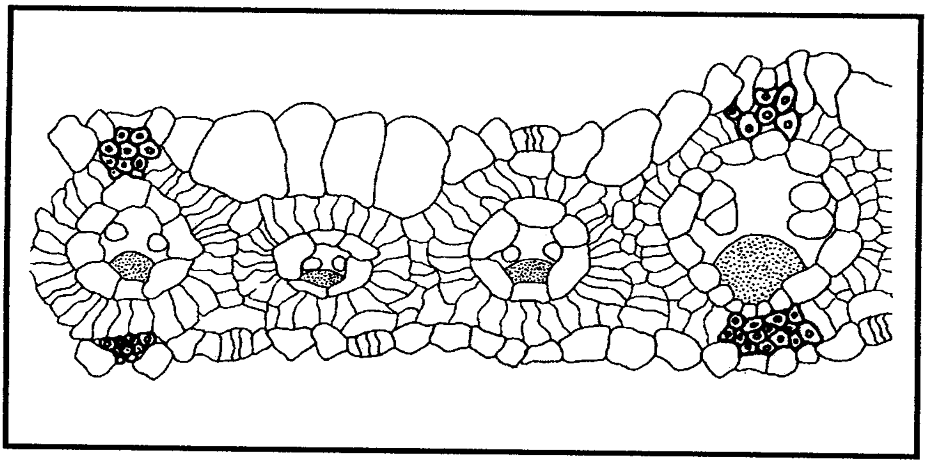


Figure 3.5 Transverse section of *Themeda triandra* x 340 (after Renvoize, 1982).

Chlorenchyma around all classes of vascular bundles, clearly radiate, obscurely radiate or non-radiate, never extensive; the number of cells between the bundles not exceeding four. Fusoid cells absent.

Upper epidermis flat or wavy. Lower epidermis of uniform small cells or of various sized cells. Bulliform cells on the upper epidermis often spanning the whole width of the intercostal zone, occasionally slightly less, often absent but then the epidermal cells often large. Motor cells usually absent (70% of the genera), occasionally present but seldom extensively developed.

However, a number of genera failed to conform completely to the general pattern. They represent extreme forms of the normal range of variation but do not appear to be associated with morphological trends within the tribe. These genera included *Andropterum, Apluda, Arthraxon, Bhidea, Diheteropogon, Dimeria, Eriochrysis, Eulalia, Eulaliopsis, Glyphochloa, Hemarthria, Heteropogon, Imperata, Miscanthus, Mnesithea, Ophiuros, Oxyrachis, Rhytachne, Saccharum, Spodiopogon, Thelepogon, Tripsacum* and *Zea* (Renvoize, 1982).

Gould & Shaw (1983) noted that the epidermis of the culm is similar to the leaf blade, consisting mainly of rows of long-cells and short-cells, with stomata developed at intervals in some of the columns of long-cells. Hair cells of various types may also be present. Beneath the epidermis is a cortex of variable width. In the early stages of culm development, the cortex is made up of both parenchyma and sclerenchyma (fiber) cells. In young, green stems the parenchyma cells contain chloroplasts and thus are referred to as chlorenchyma cells. As the culm matures, lignification of cortical cells often continues, and one to several layers of sclerenchyma will develop immediately beneath the epidermis.

They also concluded that the culm in transverse section exhibits typical monocotyledonous stem structure. Vascular bundles of the internode may be scattered in persistent pithy ground tissue, as in *Zea mays*; arranged in two to several rings around a persistent central region of ground tissue, as in *Bouteloua hirsuta* (Fig. 3.6); or arranged in two to several rings around a central ground tissue that breaks down to form a hollow stem, as in typical *Triticum aestivum* (Fig. 3.7). Solid or semisolid internodes are characteristic of grasses of the Panicoideae, especially of the tribe Andropogoneae, and hollow internodes are characteristics of the Pooideae. However, the variations do occur, even within a single species.

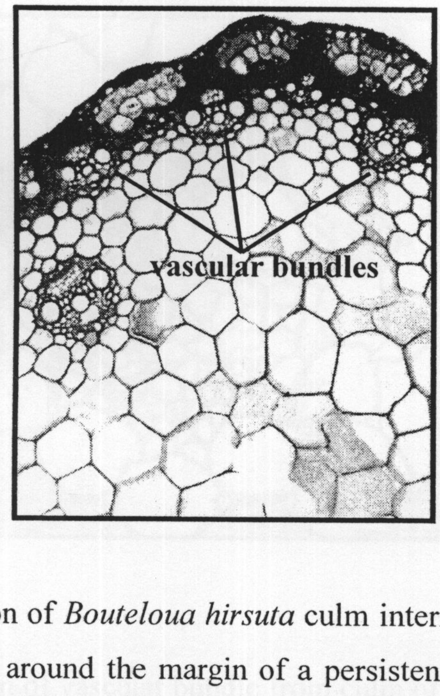


Figure 3.6 Transverse section of *Bouteloua hirsuta* culm internode showing vascular bundles arranged around the margin of a persistent central ground tissue (after Gould & Shaw, 1983).

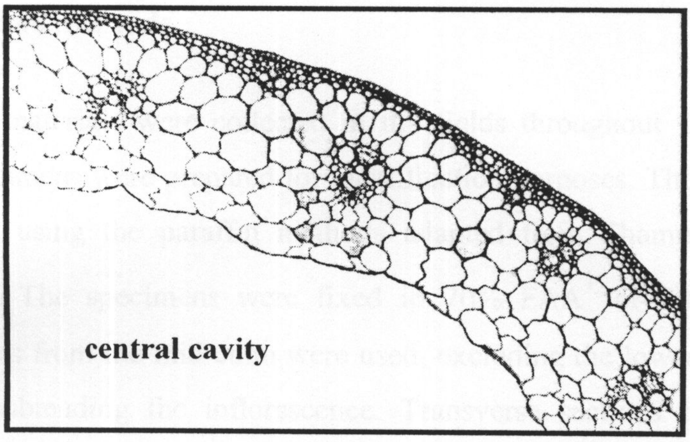


Figure 3.7 Transverse section of *Triticum aestivum* culm internode showing large central cavity (after Gould & Shaw, 1983).

The number of xylem and phloem elements and the number of the associated fiber and parenchyma cells of the vascular bundle varies with the size of the bundle (Fig. 3.8). Often there are two protoxylem and two metaxylem vessels and a number of tracheids. At maturity one or both of the protoxylem vessels usually break down, leaving irregular cavities or lacunae. Frequently, the outer vascular bundles of the stem are in the cortical region (Gould & Shaw, 1983).

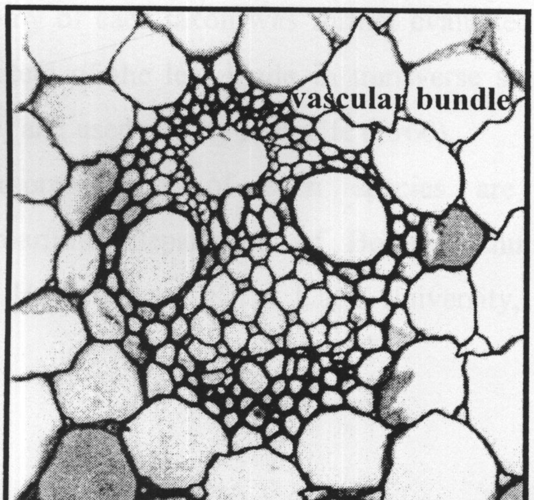


Figure 3.8 Transverse section of vascular bundle from culm of *Zea mays* (after Gould & Shaw, 1983).

3.3 Materials and methods

Living materials were collected in the fields throughout Thailand. Voucher herbarium specimens were prepared for identification purposes. The permanent slides were prepared using the paraffin methods adapted from Thammathaworn (1995) (Appendix E). The specimens were fixed in 70% FAA[1] or 70% ethanol. Fully expanded leaves from the mid-culm were used, excluding the lowermost leaf and the leaf directly subtending the inflorescence. Transverse sections of culms and the midribs at median level, as well as transverse sections of the leaf-blades in the intercostals region and in the margin were obtained. The samples were dehydrated in increasing ethanol series then embedded in paraffin, sectioned with microtome at 8–16 μm thickness, stained in safranin and fast green, cleared with xylene and mounted in DePeX.

Epidermal preparations were made by scraping pieces of softened leaves with a safety razor blade, dehydrated in increasing ethanol series, stained in safranin, cleared with xylene and mounted in DePeX.

For each species, 15 or more sections of leaf-blades and culms were examined, the anatomical characters were observed, described and recorded photographically with an Olympus BX 51 microscope and an Olympus DP11 camera, respectively.

The leaf anatomy of each taxon was further evaluated by examination of all the anatomical characters of the leaf blade in transverse section (Ellis, 1976) and epidermis (Ellis, 1979) and used also by Metcalfe (1960).

The slides representative of each species are kept at the Kasin Suvathabhandhu Herbarium, Department of Botany, Chulalongkorn University, Bangkok (BCU) and Herbarium of Khon Kaen University, Khon Kaen, Thailand (KKU).

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[1] 70% FAA (90 parts 70% EtOH; 5 parts glacial acetic acid; 5 parts 40 % formaldehyde)

3.4 Results

Leaf and culm anatomy of 25 species, representing 12 genera of subtribes Ischaeminae and Rottboelliinae in Thailand were described.

A. Subtribe Ischaeminae

Genus *Apluda*: 1 of 1 species was examined.

1. A. mutica

Leaf surface (Fig. 3.9A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elonged cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls slightly thickened, slightly cuticular flanges probably developed; moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; no short cells between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: dome-shaped subsidiary cells somewhat rounded, vertical width of the subsidiary cells smaller in relation to the horizontal length, always one row of stomata in each intercostals zone, centrally situated rows in the centre of intercostals zones; interstomatal long cells present, one cell between successive stomata, with concave ends. *Intercostal short cells*: absent. *Papillae*: absent. *Prickle hairs*: common in costal zones, overlying any vascular bundle-order, large prickles, base at least twice as long as the stomata; short barb, barb shorter than the base, point in both directions, apically and basally; one to three rows along the wholelength between all vascular bundle, rows separated by more than 5 silica bodies between successive prickles. *Micro-hairs*: bicellular, two-celled, basal and distal cells approximately equal in length; wall of distal cell thinner than wall of basal cell, apex of distal cell sharply pointed, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: absent. *Silica bodies*: dumb-bell shaped, relatively short, not elongate, present throughout the costal zones, constricted narrow central; granules present in silica bodies. *Costal short cells*: absent.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis. *Stomata* marginally present rather rare, regular in form.

Leaf in transverse section (Fig. 3.9D-F).

Outline: blade expanded, corrugated: waves rounded, or only slightly undulating with no regular pattern associated with the vascular bundles or sometimes nearly straight, the margins round to slightly acute; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, regular adaxial and abaxial group; in simple fans the central cell not much larger than bundle sheath parenchyma; thickened prickles present in epidermis; usually located opposite the vascular bundles; bulbous base; barbed; papillae and macro-hairs absent. *Midrib outline*: present, keel conspicuous, triangular-shaped, projecting strongly from the abaxial, and slightly from the adaxial surface; one vascular bundle comprising the keel, parenchyma of small round cells surrounding or immediately adaxial to the median bundle. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma strands fused forming a hypodermal band; sclerenchyma forming fairly wide abaxial girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one median bundle, 10 or more third-order bundles between one second-order bundles; all bundles situated in the center of the blade. *Primary-order vascular bundles*: circular or round to slightly square-shaped in outline; phloem completely surrounded by thick-walled fibres; enlarged protoxylem vessel present but no lysigenous cavity; very wide vessels, width of vessels very much more than that of parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: circular in outline; xylem and phloem easily distinguishable; bundles fairly large, similar size to the first-order bundles; sclerenchyma girder on both sides. *Third-order vascular bundles*: somewhat rounded in outline; usually with many small parenchyma sheath cells, vascular tissue consists of only a few vascular strands; sclerenchyma girder on both side. *Intercostal sclerenchyma*: crescent-shaped cap; sclerenchyma extends shortly along both abaxial and adaxial side of leaf margin. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.9G).

Outline: circular or somewhat oval, culm 1.5-2 mm in diameter. No well-defined sclerenchyma ring present, apart from a few layers of fibres subjacent to the epidermis. *Outer ground tissue* consisting of sclerenchyma cells, and thin-walled cells, the walls being slightly thickened at the corners where several contiguous cells meet. *Inner ground tissue* consisting of large, thin-walled cells, and without pith cavity. *Vascular bundles* scattered, but a few from the spongy tissue at the centre of the culm, the outermost vascular bundles being smaller than the remainder.

Genus *Ischaemum*: 6 out of 13 species were examined.

2.1 *I. hirtum*

Leaf surface (Fig. 3.10A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal, sometimes shape varies in single files: angled outwards, cells hexagonal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls slightly thickened, slightly cuticular flanges probably developed; moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: dome-shaped or low-dome shaped subsidiary cells somewhat rounded, one to five rows of stomata in each intercostals zone, interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: solitary short cells, tall and narrow in shape, vertical dimension greater than horizontal dimension, or sometimes square or rectangular in shape, smooth outline. *Papillae*: circular or rounded papillae as seen in surface view, small: diameter of the papillae usually less than ½ the vertical width of the long cells, more than one papillus per cell, same size and shape, unthickened, irregularly arranged present on all intercostals long cells and interstomatal longs cell. *Prickle hairs*: absent. *Hooks*: present very rare on the intercostals zone. *Micro-hairs*: bicellular, two-celled, basal cell only slightly shorter than the distal cell; wall of distal cell thinner than wall of basal cell, apex of distal cell slightly tapered, tapering to a round apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*:

unicellular, hard, long hairs usually with thickened walls, many, usually smaller, specialized epidermal cell accompanying base of hair. *Silica bodies*: intermediate between cross and dumb-bell shaped, relatively short, not elongate, present one to three rows between the costal zones, constricted narrow central; granules present in silica bodies. *Costal short cells*: square or rectangular in shape, smooth outline, present very rare.

ADAXIAL EPIDERMIS.—*Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells, or bowed outwards, inflated or rectangular cells, moderately to deeply undulating. *Stomata*: marginally present rather rare, regular in form. *Costal short cells*: tall and narrow in shape, smooth outline, present paired cells with the adjacent silica bodies.

Leaf in transverse section (Fig. 3.10D-F).

Outline: two halves of lamina curved upwards on either side of the midrib, the margins acute; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, arranged irregularly; epidermal cells rounded, inflated and much larger than bundle sheath cells, outer walls slightly thickened and covered by cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles absent; papillae present on abaxial side, papillae much less than half the width of cell, many per cell; macro-hairs present, constricted above bulbous base and sunken between the inflated epidermal cells, hairs very long and slender. *Midrib outline*: present, keel conspicuous, triangular-shaped and projection under first and second-order bundles due to sclerenchyma; many vascular bundle present in the keel, all vascular bundles abaxially arranged: three first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma absent; sclerenchyma forming abaxial girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: 2-4 third-order bundles between consecutive larger bundles; all bundles situated in abaxial of the blade. *Primary-order vascular bundles*: round or circular in outline; phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present; width of vessels much more than that of parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: elliptical in outline; xylem and phloem indistinguishable; sclerenchyma girder extension from bundle sheath on both side. *Third-order vascular bundles*: square-shape or pentagonal in outline, surrounded by a sheath of 4-6 large parenchyma, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: point-cap shaped of sclerenchyma at the margin, contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.10G).

Outline: circular or oval, culm 1-2 mm in diameter. *Epidermis* subtended by a sclerenchyma ring consisting of some 9-12 layers of fibres and assimilatory tissue bounded on the inner side, alternating with the outermost vascular bundle. *Inner ground tissue* consisting of many layers of large, thin-walled cells, extending to the hollow centre of the culm, center of the culm with a somewhat irregular pith cavity. *Vascular bundles*: the outermost vascular bundles embedded in the inner sclerenchyma ring. The other vascular bundles scattered throughout the thin-walled ground tissue.

2.2 *I. hubbardii*

Leaf surface (Fig. 3.11A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: shortened cells, length less than 3x longer than wide; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed; moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: dome-shaped subsidiary cells somewhat rounded or ovoid, one to four rows of stomata in each intercostals zone, separated by one or more than one file of intercostals long cells; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: tall and narrow in shape, smooth in outline, present very rare. *Papillae*: circular or rounded papillae as seen in surface view, large: diameter more than or equal ½ the vertical width of the long cells, more than one papillus per cell, same size and shape on individual cells but difference size in difference cells, thick-wall, inflated, arranged in one horizontal rows, present on intercostals long cells, interstomatal longs cell and sometimes on costal long cells. *Prickle hairs*: absent. *Hooks*: absent. *Micro-hairs*: not seen. *Macro-hairs*: unicellular, hard, long hairs usually with thickened walls, many smaller specialized epidermal cell accompanying base of hair. *Silica bodies*: dumb-bell shaped, constricted, narrow central portion, present one or two rows between the costal zones; granules present in silica bodies. *Costal long cells*: narrowly than intercostals long cells.

ADAXIAL EPIDERMIS.—*Intercostal long cells*: short and inflated cells. *Stomata* marginally present rather rare, regular in form.

Leaf in transverse section (Fig. 3.11D-F).

Outline: two halves of lamina curved upwards on either side of the midrib, sometimes V-shaped; the margins round or acute; no ribs or furrows present on both surface. *Epidermis*: bulliform cells present on adaxial surface, arranged irregularly; epidermal cells rounded, inflated and larger than bundle sheath cells, outer walls thickened and covered by cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles absent; papillae present on abaxial side, thin-walled wide papillae scattered throughout the epidermis; macro-hairs absent. *Midrib outline*: present, keel conspicuous, triangular-shaped to slightly round; many vascular bundle present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma absent, sclerenchyma forming abaxial girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: 10 or more third-order bundles between consecutive larger bundles; all bundles situated in abaxial of the blade. *Primary-order vascular bundles*: round or circular in outline; phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present; width of vessels much more than that of parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: round or circular in outline; xylem and phloem indistinguishable; bundles fairly large, similar size to the first-order bundles; sclerenchyma girder on both side. *Third-order vascular bundles*: square-shaped or pentagonal or hexagonal in outline, surrounded by a sheath of 4-7 large parenchyma, all vascular tissue consists of only a few vascular strands; sclerenchyma girder on both side or sometimes absent. *Intercostal* *sclerenchyma*: cap shaped of sclerenchyma at the margin, cap equal or less than the width of a third-order bundle, contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.11G).

Outline: somewhat circular or oval, culm 1.5-2.5 mm in diameter, intercellular air spaces present about 3 cells below the epidermis around the periphery of the culm, the outermost vascular bundle alternating with the spaces. Intercellular spaces followed on the inner side by a somewhat sinuous, continuous ring of fibres about 2-3 cells wide, the fibrous ring being bounded on the inner side by a zone of thin-walled ground tissue, extending to the hollow centre of the culm, with a somewhat circular pith cavity. The other vascular bundles scattered throughout the thin-walled ground tissue.

2.3 *I. muticum*

Leaf surface (Fig. 3.12A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed; moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: dome-shaped subsidiary cells somewhat rounded, vertical width of the subsidiary cells smaller in relation to the horizontal length, three to six rows of stomata in each intercostals zone, separated by more than one file of intercostals long cells; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: solitary cells, tall and narrow in shape, crenate in outline, sometimes connect to silica bodies present at only one or both end of each long cell, in 80 % of all long cells. *Papillae*: circular or rounded papillae as seen in surface view, large: diameter more than or equal ½ the vertical width of the long cells, more than one papillus per cell, different sizes or shape present on individual cells, unthickened, arranged in one horizontal rows, present on intercostals long cells and interstomatal longs cell that near the stomata. *Prickle hairs*: absent. *Hooks*: present very rare in intercostals zone. *Micro-hairs*: bicellular, two-celled, basal cell only slightly shorter than the distal cell; wall of distal cell thinner than wall of basal cell, apex of distal cell slightly tapered, tapering to a round apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: absent. *Silica bodies*: dumb-bell shaped, constricted, narrow central portion, present one or two rows between the costal zones; granules present in silica bodies. *Costal long cells*: narrowly than intercostals long cells. *Costal short cells*: square or rectangular in shape.

ADAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells, or bowed outwards, inflated or rectangular cells, moderately undulating. *Stomata* marginally present rather rare, regular in form.

Leaf in transverse section (Fig. 3.12D-F).

Outline: blade expanded, straight, the margins acute; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, fans-shaped, group of large and inflated bulliform cells, well-defined and regular on adaxial, extending over one or two vascular bundles, the central cell much larger than bundle sheath cells; outer walls thickened and covered by a distinct thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles absent; papillae present on abaxial side, papillae narrower than the epidermal cells; macro-hairs absent. *Midrib outline*: present, keel conspicuous, triangular-shaped; many vascular bundles present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma strands fused forming a hypodermal band; sclerenchyma forming abaxial girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one first-order bundle, many third-order bundles between one second-order bundles; all bundles situated in abaxial of the blade. *Primary-order vascular bundles*: round to elliptical in outline; phloem completely surrounded by thick-walled fibres; enlarged protoxylem vessel present but no lysigenous cavity; width of vessels slightly more than that of parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: elliptical in outline;

xylem and phloem easily distinguishable; bundles fairly large, similar size to the first-order bundles; sclerenchyma girder on both side. *Third-order vascular bundles*: square-shape or pentagonal or hexagonal in outline, surrounded by a sheath of 4-7 large parenchyma, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: point-cap shaped of sclerenchyma at the margin, contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.12G).

Outline: somewhat circular in outline, culm 1-2 mm in diameter. *Epidermis* subtended by a zone of 1-2 layers of fibres of small diameter and with thick walls, followed by a zone of thin-walled tissue about 4-5 cells wide, this zone being bounded internally by a sclerenchyma ring about 5-6 cells wide. *Inner ground tissue* consisting of many layers of large, thin-walled cells, extending to the hollow centre of the culm, center of the culm with a somewhat irregular pith cavity. *Vascular bundles* of the outermost circle situated at the outer or center boundary, and the next circle at the inner boundary, of the sclerenchyma ring. The other vascular bundles scattered throughout the thin-walled ground tissue.

2.4 *I. rugosum*

Leaf surface (Fig. 3.13A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed; deeply undulating, corrugated, wave-length short, amplitude relatively deep and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: dome-shaped or low-dome shape subsidiary cells somewhat rounded or ovoid, one to four rows of stomata in each intercostals zone, separated by one or more than one file of intercostals long cells; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: solitary cells, tall and narrow in shape, crenate in outline, present at only one or both end of each long cell, in 80 % of all long cells. *Papillae*: absent. *Prickle hairs*: absent. *Hooks*: absent. *Micro-hairs*: bicellular, two-celled, basal cell only slightly shorter than the distal cell; wall of distal cell thinner than wall of basal cell, apex of distal cell slightly tapered, tapering to a round apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: unicellular, hard, short, stiff hairs usually with thickened walls, two, or sometimes one specialized epidermal cell accompanying base of hair. *Silica bodies*: dumb-bell shaped, constricted, narrow central portion, present one or two rows between the costal zones; granules present in silica bodies. *Costal long cells*: narrowly than intercostals long cells. *Costal short cells*: tall and narrow in shape, crenate in outline.

ADAXIAL EPIDERMIS.— *Intercostal long cells*: Basally similar to the abaxial epidermis. *Stomata*: distribution similar to the abaxial epidermis. *Papillae*: circular or rounded papillae as seen in surface view, small: diameter of the papillae usually less than ½ the vertical width of the long cells, more than one papillus per cell, same size and shape, unthickened, irregularly arranged present on 90 % of the intercostals long cells and interstomatal longs cell. *Prickle hairs*: common in costal zones, overlying any vascular bundle-order, medium prickles, base as long as or slightly longer than the stomata; long barb, barb as long as the base, point in both directions, apically and basally; one row along the wholelength between all vascular bundle, rows separated by more than 5 silica bodies between successive prickles. *Hooks*: present very rare on the intercostals zone. *Macro-hairs*: unicellular, hard, long hairs, usually with thickened walls, many smaller specialized epidermal cell accompanying base of hair. *Silica bodies*: dumb-bell shaped, constricted, narrow central portion, or sometimes nodular silica bodies, present one or two rows between the costal zones; granules present in silica bodies.

Leaf in transverse section (Fig. 3.13D-F).

Outline: lamina rolled inwards towards the adaxial surface, inrolled from one margin only; margins wrapped around each other; the margins acute; ribs and furrows present on both surface; on adaxial surface: medium furrows, a quarter to one half the leaf thickness, furrows obtuse angle, furrows between all vascular bundles; triangular ribs, apex pointed, one vascular bundle in each rib; on abaxial surface shallow and wider than the adaxial ribs, present opposite all vascular bundles. *Epidermis*:

bulliform cells present on adaxial surface or sometimes in abaxial surface, associated with colourless cells in fan-shaped groups penetrating deeply into the mesophyll, outer walls thickened and covered by cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles absent; papillae present on adaxial side, papillae narrower than the epidermal cells, 1-many per cell or sometimes bifurcate; macro-hairs absent. *Midrib outline*: present, inconspicuous keel, no associated parenchyma developed, projection due to position or size of bundle and sclerenchyma on abaxial surface; one vascular bundle comprising the keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; sclerenchyma forming adaxial and abaxial girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: 1-4 third-order bundles between consecutive larger bundles; all bundles situated in center of the blade. *Primary-order vascular bundles*: elliptical in outline; phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present; width of vessels much more than that of parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: elliptical in outline; xylem and phloem indistinguishable; bundles fairly large, similar size to the first-order bundles; sclerenchyma girder on both side. *Third-order vascular bundles*: pentagonal or hexagonal in outline, vertically elonged, surrounded by a sheath of 4-7 large parenchyma, all vascular tissue consists of only a few vascular strands; sclerenchyma girder on both side or sometimes absent. *Intercostal sclerenchyma*: point-cap shaped of sclerenchyma at the margin, contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.13G).

Outline: circular, culm 1.5-2 mm in diameter. *Epidermis* subtended by a zone of 3-4 layers of sclerenchyma. *Inner ground tissue* consisting of 7-8 layers of large, thin-walled cells, extending to the hollow centre of the culm, center of the culm with a somewhat circular pith cavity. *Vascular bundles* of the outermost embedded in the center sclerenchyma ring. The other vascular bundles scattered throughout the thin-walled ground tissue.

2.5 *I. tenuifolium*

Leaf surface (Fig. 3.14A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls slightly thickened, slightly cuticular flanges probably developed; moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: low-dome shaped subsidiary cells ovoid, one row of stomata in each intercostals zone, rarely 2 rows, centrally situated rows in the centre of intercostals zones; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: solitary short cells, tall and narrow in shape, crenate in outline, present at only one or both end of each long cell, in 80 % of all long cells. *Papillae*: absent. *Prickle hairs*: absent. *Hooks*: absent. *Micro-hairs*: only basal cell remains. *Macro-hairs*: absent. *Silica bodies*: dumb-bell shaped, elongated with rounded ends, length of central portion equal to one third of total length of the body, present throughout the costal zones; granules present in silica bodies. *Costal long cells*: narrowly than intercostals long cells.

ADAXIAL EPIDERMIS.—*Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells, or bowed outwards, inflated or rectangular cells, slightly undulating. *Stomata* present regular in form. *Prickle hairs*: common in intercostal zones, very large prickles, base as least twice as long as the stomata; long barb, barb longer than the base, point in both directions, apically and basally.

Leaf in transverse section (Fig. 3.14D-F).

Outline: heart-shaped in outline or sometimes two halves of lamina curved upwards on either side of the midrib and inrolled in one side; the margins round or acute; ribs and furrows present on adaxial surface: slight, shallow furrows, between all vascular bundles; triangular ribs, one vascular bundle in each rib; sometimes no ribs or furrows on either side of the midrib. *Epidermis*: bulliform cells present on adaxial surface, associated with colourless cells in fan-shaped groups penetrating deeply into the mesophyll and abaxial side, outer walls very thickened and covered by cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles present, pointed broad prickle, base not bulbous; papillae absent on both side; macro-hairs absent. *Midrib outline*: present, keel conspicuous, triangular to round-shaped, three-six vascular bundle present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; sclerenchyma forming adaxial and abaxial girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: 3-8 third-order bundles between consecutive larger bundles; all bundles situated in center of the blade. *Primary-order vascular bundles*: round or slightly elliptical in outline; phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present; width of vessels much more than that of parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: round to slightly elliptical in outline; xylem and phloem indistinguishable; bundles similar size to the first-order bundles; sclerenchyma girder on both side extension from bundle sheath. *Third-order vascular bundles*: square-shaped or pentagonal or hexagonal in outline, surrounded by a sheath of 4-7 large parenchyma, all vascular tissue consists of only a few vascular strands; sclerenchyma girder on both side or sometimes absent. *Intercostal sclerenchyma*: point-cap shaped of sclerenchyma at the margin, not contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.14G).

Outline: oval, culm 1.5-2 mm in diameter. *Epidermis* subtended by a zone of 4-5 layers of sclerenchyma. *Inner ground tissue* consisting of large thin-walled cells, and without pith cavity. *Vascular bundles* of the outermost embedded in the inner sclerenchyma ring. The other vascular bundles scattered in the peripheral part of the inner thin-walled ground tissue.

2.6 *I.* sp.1

Leaf surface (Fig. 3.15A-B).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: shortened cells, length less than 3x longer than wide, or varies in shape; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed; moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; no short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: dome-shaped subsidiary cells somewhat rounded, one to four rows of stomata in each intercostals zone, separated by one or more than one file of intercostals long cells; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: absent. *Papillae*: circular or rounded papillae as seen in surface view, large: diameter more than or equal ½ the vertical width of the long cells, more than one papillus per cell, same size and shape on individual cells but diferrence size in difference cells, thick-wall, inflated, arranged in one horizontal rows, present on intercostals long cells, interstomatal longs cell and sometimes on costal long cells. *Prickle hairs*: absent. *Hooks*: absent. *Micro-hairs*: not seen. *Macro-hairs*: densely, unicellular, long and slender hairs usually with thickened walls, many smaller specialized epidermal cell accompanying base of hair. *Silica bodies*: dumb-bell shaped, constricted, narrow central portion, present one or two rows between the costal zones; granules present in silica bodies. *Costal long cells*: absent.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis. *Intercostal long cells*: short and inflated cells. *Stomata* marginally present rather rare, regular in form.

Leaf in transverse section (Fig. 3.15C-E).

Outline: two halves of lamina curved upwards on either side of the midrib, or U-shaped; the margins round or acute; no ribs or furrows present on both surface. *Epidermis*: bulliform cells present on adaxial surface, arranged irregularly; epidermal cells rounded, inflated and much larger than bundle sheath cells, outer walls very thickened and covered by cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles absent; papillae present on abaxial side, thick-walled wide papillae scattered throughout the epidermis; macro-hairs present, constricted above bulbous base and sunken between the inflated epidermal cells, hairs long and slender. *Midrib outline*: present, keel conspicuous, triangular, sometimes inconspicuous; five vascular bundle present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma strands forming a hypodermal band; sclerenchyma forming abaxial girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: 10 or more third-order bundles between consecutive larger bundles; all bundles situated in abaxial of the blade. *Primary-order vascular bundles*: round or circular in outline; phloem completely surrounded by thick-walled fibres; enlarged protoxylem vessel present but no lysigenous cavity; width of vessels smaller than that of parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: round to slightly elliptical in outline; xylem and phloem indistinguishable; bundles similar size to the first-order bundles; sclerenchyma girder on both sides. *Third-order vascular bundles*: square-shaped or pentagonal or hexagonal in outline, surrounded by a sheath of 4-7 large parenchyma, all vascular tissue consists of only a few vascular strands; sclerenchyma girder on both side or sometimes absent. *Intercostal sclerenchyma*: cap shaped of sclerenchyma at the margin, cap more than the width of a third-order bundle, contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Genus *Kerriochloa*: 1 of 1 species was examined.

3. *K. siamensis*

Leaf surface (Fig. 3.16A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells centrally and rectangular cells laterally; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls slightly thickened, slightly cuticular flanges probably developed; moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; sometimes adjacent with single short cells. *Stomata*: low dome-shaped, ovoid or vertical width of the subsidiary cells smaller in relation to the horizontal length, one to five rows of stomata in each intercostals zone, separated by more than one file of intercostals long cells; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: solitary cells, square or rectangular in shape, smooth walls, present at only one end of each long cell, in 20% of all long cells. *Papillae*: circular or rounded papillae as seen in surface view, large: diameter more than or equal ½ the vertical width of the long cells, one papillus per cell, unthickened, present on all intercostals long cells and interstomatal longs cell, usually centrally positioned. *Prickle hairs*: absent. *Hooks*: absent. *Micro-hairs*: not seen. *Macro-hairs*: unicellular, hard, short, stiff hairs usually with thickened walls, one specialized hemispherical epidermal cell accompanying base of hair, swollen in relation to hair thickness. *Silica bodies*: equidimentional, vertical and horizontal dimensions approximately equal, acutely angled, present throughout the costal zones; granules present in silica bodies; sometimes found transverse silica bodies tall and narrow dumb-bell shape on intercostals long cells. *Costal long cells*: bowed outwards, cells inflated, thin and smooth wall, separated by silica bodies. *Costal short cells*: absent.

ADAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells, or bowed outwards, inflated or rectangular cells, slightly undulating, faintly corrugated, wave-length short, amplitude shallow and frequency high. *Stomata* marginally present rather rare, regular in form. *Intercostal short cells*: solitary or paired, tall and narrow, crenate in outline, present at near leaf margins of intercostal zones only. *Hooks*: present at near leaf margins of intercostal zones only. *Micro-hairs*: bicellular, two-celled, basal and distal cells approximately equal in length; wall of distal cell thinner than wall of basal cell, apex slightly tapered, tapering to rounded apex, base or attachment of basal cell: parallel-side, point of attachment small.

Leaf in transverse section (Fig. 3.16D-E).

Outline: blade expanded, undulating gently or nearly straight, the margins round; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, arranged irregularly; epidermal cells rounded, inflated the same size or larger than bundle sheath cells; macro-hairs constricted above bulbous base and sunken between the inflated epidermal cells, hairs long and slender; papillae present on abaxial surface, thin-walled wide papillae scattered throughout the epidermis. *Midrib outline*: present, inconspicuous keel, no associated parenchyma developed, projection due to position or size of bundle and sclerenchyma on abaxial surface; one vascular bundle comprising the keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma strands fused forming a hypodermal band; abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one median bundle, 10 or more third-order bundles between one second-order bundles; all bundles situated in the center of the blade. *Primary-order vascular bundles*: circular or round in outline; phloem completely surrounded by thick-walled fibres; enlarged protoxylem vessel present but no lysigenous cavity; very wide vessels, width of vessels very much more than that of parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: circular in outline; xylem and phloem easily distinguishable; bundles fairly large, similar size to the first-order bundles; sclerenchyma girder on both sides. *Third-order vascular bundles*: angular in outline; square-shaped or pentagonal surrounded by a sheath of 4 or 5 large parenchyma cells, vascular tissue consists of only a few vascular strands; sclerenchyma girder on both side or only one side or absent. *Intercostal sclerenchyma*: no sclerenchyma developed in association with the margin. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.16F).

Outline: somewhat circular, culm 1-1.5 mm in diameter. *Epidermis* subtended by about 4-5 layers of cells with thickened, lignified walls, with a circular of small, oval, columns of assimilatory tissue embedded in the thickened ground tissue. *Inner ground tissue* consisting of large cells, with thin walls and wide lumina, and without pith cavity. *Vascular bundles* of the outermost circle embedded in the layers of thickened cells and being smaller than the remainder. The other vascular bundles scattered in the peripheral part of the inner thin-walled ground tissue.

Genus *Sehima*: 1 of 1 species was examined.

4. *S. nervosum*

Leaf surface (Fig. 3.17A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed; deeply undulating, strongly corrugated, wave-length short, amplitude relatively deep and frequency high; no short cells between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: dome-shaped subsidiary cells somewhat rounded, vertical width of the subsidiary cells slightly smaller or nearly approximately equal in relation to the horizontal length, always one to two rows of stomata in each intercostals zone, if two: rows adjacent to one another, not separated by files of intercostals long cells; centrally situated rows in the centre furrows of intercostals zones; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: absent. *Papillae*: absent. *Prickle hairs*: common in costal zones, overlying any vascular bundle-order, medium prickles, base as long or slightly longer than the stomata; long barb, barb approximately as long or slightly shorter than the base, point in both directions, apically and basally; more than three rows along the wholelength between all vascular bundle, rows separated by one to four silica bodies between successive prickles. *Hooks*: present in margins of costal zones only. *Micro-hairs*: bicellular, two-celled, slender, basal and distal cells approximately equal in length; wall of distal cell thinner than wall of basal cell, distal cell very slender look like long caudate, angle base emerges in cells at margins of costal zones. *Macro-hairs*: absent. *Silica bodies*: dumb-bell shaped, elonged with rounded ends, length of central portion equal to one third of total length of the body, present throughout the costal zones; granules present in silica bodies. *Costal short cells*: alternating silica cells and costal short cells, short to square short or cork cells.

ADAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells centrally and rectangular cells laterally, wider cells in center of intercostals zones; sometimes adjacent with single short cells. *Stomata* marginally present rather rare, regular in form. *Intercostal short cells*: solitary, silicified silica cells containing distinct silica body or phytolith, silica body and silica cell of same or similar shape, present between 25% of successive long cells at lateral intercostals zones.

Leaf in transverse section (Fig. 3.17D-F).

Outline: blade broad wide, horizontally elongated, the margins round to slightly acute; ribs and furrows present on both surface; on adaxial surface: slight, shallow furrow less than a quarter of the leaf thickness, furrow wide and open, furrows between first-order and second-order vascular bundles, present over third-order bundles; ribs slides rounded with flat top; on abaxial surface taller than the adaxial ribs, present opposite all vascular bundles; composed of sclerenchyma in form of rounded caps on second and third-order bundles; composed of girder or strand of sclerenchyma in contact with epidermis on first-order bundles. *Epidermis*: bulliform cells present, fan-shaped present over third-order bundles, central cell much larger than bundle sheath parenchyma; thickened prickles present in both surface; usually located opposite the vascular bundles; papillae and macro-hairs absent. *Midrib outline*: present, inconspicuous keel, no associated parenchyma developed, sclerenchyma causes projection; one vascular bundle comprising the keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial and abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: 4-6 first-order bundles in half lamina, 1-3 second-order bundle between first-order bundle, 1-4 third-order bundle between second-order bundle, first and second-order bundles central and third-order bundle displaced abaxially in ribs. *Primary-order vascular bundles*: circular or round in outline; phloem completely surrounded by thick-walled fibres; enlarged protoxylem vessel present but no lysigenous cavity; very wide vessels, width of vessels not much more than that of parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: circular in outline; xylem and phloem easily distinguishable; bundles not large and not similar size to the first-order bundles; sclerenchyma girder on both sides. *Third-order vascular bundles*: rounded in outline; usually with many small parenchyma sheath cells, vascular tissue consists of only a few vascular strands; sclerenchyma cap on abaxial surface. *Intercostal sclerenchyma*: crescent-shaped cap; sclerenchyma extends shortly along both abaxial and adaxial side of leaf margin. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.17G).

Outline: circular, culm 1.2-1.5 mm in diameter. *Epidermis* subtended by about 9-12 layers of cells with thickened, lignified walls, without a circular of small assimilatory tissue. *Inner ground tissue* consisting of large, thin-walled cells, and without pith cavity. *Vascular bundles* of the outermost circle embedded in the layers of thickened cells and being smaller than the remainder. The other vascular bundles scattered in the peripheral part of the inner thin-walled ground tissue.

Genus *Thelepogon*: 1 of 1 species was examined.

5. *T. elegans*

Leaf surface (Fig. 3.18A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width, or sometimes with inflated cells separated the narrower cells; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls rounded if have short cells between the adjacent long cells or vertical if not; horizontal and vertical anticlinal walls slightly thickened, slightly cuticular flanges probably developed; moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: low-dome to dome shaped subsidiary cells somewhat ovoid to rounded, many or upto 18 rows of stomata in each intercostals zone, separated by more than two file of intercostals long cells; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: solitary of short cells situated between long cells, tall and narrow in shape, smooth in outline, usually connect to transverse silica bodies. *Papillae*: absent. *Prickle hairs*: absent. *Hooks*: present very rare in intercostals zones. *Micro-hairs*: bicellular, two-celled, basal cells shorter than distal cells, basal cells less than ½ the length of the distal cell; wall of distal cell thinner than wall of basal cell, slightly tapered, tapering to a rounded apex, base or attachment of basal cell: expanded base, constriction above bulbous base. *Macro-hairs*: unicellular, hard, short, stiff hairs usually with thickened walls, one specialized hemispherical epidermal cell accompanying base of hair. *Silica bodies*: transverse cross-shaped with four rounded apices of silica bodies in intercostal zones; costal zones with dumb-bell shaped, relatively short, not elongate, sometimes intermediate between cross and dumb-bell shaped; granules present in all silica bodies. *Costal short cells*: solitary of short cells situated between long cells, tall and narrow in shape, smooth in outline, connect to silica bodies.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis. *Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells, or bowed outwards, inflated or rectangular cells, moderately undulating. *Stomata* no stomata visible on surface of preparation examined. *Hooks*: densely with hooks around the intercostal zones.

Leaf in transverse section (Fig. 3.18D-E).

Outline: two halves of lamina curved upwards on either side of the midrib, the margins muticous or round; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, arranged irregularly; epidermal cells rounded, inflated and larger than bundle sheath cells, outer walls thickened and covered by a distinct thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; macro-hairs constricted above bulbous base and sunken between the inflated epidermal cells, hairs long and slender; thickened prickles present in epidermis; bulbous base with short barbed; papillae absent. *Midrib outline*: present, keel conspicuous, rounded or semicircular-shaped, slightly thicker than the rest of lamina; many vascular bundles present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma absent; abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one first-order bundle, 10 or more third-order bundles between one second-order bundles; all bundles situated in the center of the blade except median bundle. *Primary-order vascular bundles*: round to slightly elliptical in outline; phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels slightly larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: circular in outline; xylem and phloem easily distinguishable; bundles usually fairly large, similar size to the first-order bundles; bundle sheath extension forming sclerenchyma girder on both side. *Third-order vascular bundles*: square-shape or pentagonal or hexagonal in outline, surrounded by a sheath of 4-6 large parenchyma, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: point-cap shaped of sclerenchyma at the margin, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.18F).

Outline: circular or somewhat oval, culm 2-3 mm in diameter. *Epidermis* subtended by about 1-3 layers of thin-walled cells; this zone being bounded on its inner side by a sclerenchyma ring consisting of some 6-8 layers of fibres. *Inner ground tissue* consisting of large thin-walled cells, and without pith cavity. *Vascular bundles* of the outermost circle embedded in the sclerenchyma ring, and being smaller than the next circle. The other vascular bundles scattered in the peripheral part of the inner thin-walled ground tissue.

B. Subtribe Rottboelliinae

Genus *Eremochloa*: 3 out of 11 species were examined.

6.1 *E. attenuata*

Leaf surface (Fig. 3.19A-B).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed. Moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: triangular-shaped subsidiary cells, apex drawn out into a point; evagination but not containing the nucleus, one to three rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: paired short cells situated between long cells: tall and narrow in shaped, crenate or irregular in outline, accompanied with hook. *Papillae*: absent. *Prickle hairs*: absent. *Hook:* present. *Micro-hairs*: bicellular, two-celled, basal cell only slightly shorter than the distal cells; wall of distal cell thinner than wall of basal cell, slightly tapered; tapering to a rounded apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: present densely on intercostal zones, unicellular, long and slender, usually with thickened walls, many epidermal cells associated with base of macro-hairs, usually smaller, specialized epidermal cells accompanying base of hair. *Silica bodies*: dumb-bell shaped relatively short, not elongate, present usually one row over the costal zones, constricted narrow central; granules present in silica bodies.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis but intercostals short cells and hooks absent.

Leaf in transverse section (Fig. 3.19C-E).

Outline: two halves of lamina folded toward each other on either side of the midrib formed standard V-shaped, nearly 90° to each other, the margins acute; ribs and furrows present on both surface; medium furrow, a quarter to one half of the leaf thickness, furrow wide and open, furrows between second-order vascular bundles, present over third-order bundles; ribs slides rounded with flat top. *Epidermis*: bulliform cells present, arranged in irregularly; epidermal cells rounded, inflated and slightly larger than bundle sheath cells; prickles and papillae absent; macro-hairs present, constricted above bulbous base embedded between large epidermal, hairs long and slender. *Midrib outline*: present, conspicuous keel, round V-shaped keel, bulliform cells present in adaxial epidermis above median bundle; one vascular bundle present in the keel, abaxially arranged: first-order bundle only comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; sclerenchyma forming abaxial girder and combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one small first-order bundle in half lamina, 2-3 third-order bundles between second-order bundle, all bundles situated in center of the blade. *Primary-order vascular bundles*: circular or round in outline; sheath incomplete surrounding the bundle due to interruption of sclerenchyma, phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels slightly larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: elliptical in outline; xylem and phloem easily distinguishable; bundles larger than size to the first-order bundles; bundle sheath extension forming sclerenchyma girder on both side. *Third-order vascular bundles*: pentagonal or hexagonal in outline, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: crescent-shaped of sclerenchyma at the margin, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.19F).

Outline: oval, culm 1.2-1.5 mm in diameter. *Epidermis* with one layer of large thin-walled epidermal cells, and subtended by continuous zone of chlorenchyma layer. Chlorenchyma layers bounded on its inner side by a ring of sclerenchyma about 2-3 cells wide. *Inner ground tissue* consisting of large thin-walled cells, extending to the hollow centre of the culm, center of the culm with an oval pith cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundles scattered in the peripheral part of the inner thin-walled ground tissue, larger vascular bundles with sclerenchyma caps.

6.2 *E. bimaculata*

Leaf surface (Fig. 3.20A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed. Moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: high triangular-shaped subsidiary cells, apex drawn out into a point; evagination of ten containing the nucleus, one to three rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: paired short cells situated between long cells: tall and narrow in shaped, crenate or irregular in outline, accompanied with transverse dumb-bell shaped silica bodies. *Papillae*: absent. *Prickle hairs*: absent. *Hook:* absent. *Micro-hairs*: bicellular, two-celled, basal cell less than ½ the length of the distal cells; wall of distal cell thinner than wall of basal cell, slightly tapered; tapering to a rounded apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: absent. *Silica bodies*: dumb-bell shaped relatively short, not elongate, present one or two rows over the costal zones, constricted narrow central; granules present in silica bodies.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis. *Stomata*: one to five rows of stomata in each intercostals zone.

Leaf in transverse section (Fig. 3.20D-F).

Outline: two halves of lamina folded toward each other on either side of the midrib formed standard V-shaped, nearly 90° to each other, the margins somewhat round or slightly acute; no ribs and furrows present on both surface. *Epidermis*: bulliform cells present, arranged irregularly; epidermal cells rounded, inflated and slightly larger than bundle sheath cells; prickles and papillae absent; macro-hairs absent. *Midrib outline*: present, conspicuous keel, V-shaped or triangular keel, bulliform cells present in adaxial epidermis above median bundle; one vascular bundle present in the keel, abaxially arranged: first-order bundle only comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; sclerenchyma forming abaxial cap and not combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one first-order bundle in half lamina, 3-4 third-order bundles between second-order bundle, all bundles situated in center of the blade. *Primary-order vascular bundles*: circular or round in outline; sheath completely surrounded by parenchyma; phloem completely surrounded by thick-walled fibres; no lysigenous cavity, enlarged protoxylem vessel present, width of vessels same size of parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: round in outline; xylem and phloem easily distinguishable; bundles large and similar size to the first-order bundles; sclerenchyma girder on both side or absent on adaxial surface. *Third-order vascular bundles*: square-shape or pentagonal in outline, surrounded by a sheath of 4-5 large parenchyma, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: curved in shape with sclerenchyma extending on adaxial side, contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.20G).

Outline: oval, sometimes flattened on one side, culm 1.5-2 mm in diameter. *Epidermis* with one layer of large thin-walled epidermal cells, and subtended by incontinuous zone of chlorenchyma layer, interrupted at intervals by intercellular air spaces present about 8 cells below the epidermis around the periphery of the culm. Chlorenchyma layers bounded on its inner side by a ring of sclerenchyma about 2-3 cells wide. *Inner ground tissue* consisting of large thin-walled or thick-walled cells, extending to the hollow centre of the culm, center of the culm with an oval pith cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundles scattered in the peripheral part of the inner thin-walled ground tissue, larger vascular bundles with sclerenchyma caps.

6.3 *E. lanceolata*

Leaf surface (Fig. 3.21A-B).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed. Deeply undulating, strongly corrugated, wave-length short, amplitude relatively deep and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: low triangular-shaped subsidiary cells, apex drawn out into a point; evagination often containing the nucleus, two or three rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: paired short cells situated between long cells: tall and narrow in shaped, irregular in outline, accompanied with transverse dumb-bell shaped silica bodies. *Papillae*: absent. *Prickle hairs*: absent. *Hook:* present. *Micro-hairs*: bicellular, two-celled, basal cell only slightly shorter than the distal cells; wall of distal cell thinner than wall of basal cell, slightly tapered; tapering to a rounded apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: present at leaf margins, unicellular, slender and long, usually with thickened walls, sunken base embedded between and often below surrounding epidermal cells. *Silica bodies*: intermediate between cross and dumb-bell shaped, relatively short, not elongate, present throughout the costal zones, constricted narrow central; granules present in silica bodies.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis.

Leaf in transverse section (Fig. 3.21C-D).

Outline: two halves of lamina folded toward each other on either side of the midrib formed standard V-shaped, 45° to each other, the margins acute; no ribs and furrows present on both surface. *Epidermis*: bulliform cells present, arranged irregularly; epidermal cells rounded, inflated and much larger than bundle sheath cells; prickles and papillae absent; macro-hairs present, constricted above bulbous base embedded between large epidermal, hairs long and slender. *Midrib outline*: present, conspicuous keel, V-shaped or triangular keel, bulliform cells present in adaxial epidermis above median bundle; one vascular bundle present in the keel, abaxially arranged: first-order bundle only comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; sclerenchyma forming abaxial girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one first-order bundle in half lamina, 5-6 third-order bundle between second-order bundle, all bundles situated in center of the blade. *Primary-order vascular bundles*: circular or round in outline; sheath completely surrounded by parenchyma; phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels slightly larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: round in outline; xylem and phloem easily distinguishable; bundles large and similar size to the first-order bundles; sclerenchyma girder on both side or absent on adaxial surface. *Third-order vascular bundles*: square-shape or pentagonal in outline, surrounded by a sheath of 4-5 large parenchyma, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: curved in shape with sclerenchyma extending, sometimes fibres extend along both side of leaf margin. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.21E).

Outline: somewhat circular, flattened on one side, culm ca. 0.5 mm in diameter. *Epidermis* with one layer of large thin-walled epidermal cells, and subtended by continuous zone of chlorenchyma layers. Chlorenchyma layers bounded on its inner side by a ring of sclerenchyma about 3-4 cells wide. *Inner ground tissue* consisting of large thin-walled cells, extending to the hollow centre of the culm, center of the culm with an oval or irregular pith cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundles scattered in ground tissue.

Genus *Hackelochloa*: 2 out of 2 species were examined.

7.1 *H. granularis*

Leaf surface (Fig. 3.22A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed. Deeply undulating, strongly corrugated, wave-length short, amplitude relatively deep and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: triangular-shaped subsidiary cells, apex drawn out into a point; evagination of ten containing the nucleus, three to seven rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: paired short cells situated very rare between long cells: both are tall and narrow in shaped, crenate or irregular in outline. *Papillae*: absent. *Prickle hairs*: absent. *Hook:* absent. *Micro-hairs*: bicellular, two-celled, basal cell only slightly shorter than the distal cells; wall of distal cell thinner than wall of basal cell, slightly tapered; tapering to a rounded apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: present, unicellular, long and slender, usually with thickened walls, many epidermal cells associated with base of macro-hairs, usually smaller, specialized epidermal cells accompanying base of hair. *Silica bodies*: dumb-bell shaped relatively short, not elongate, present one or two rows over the costal zones, constricted narrow central; granules present in silica bodies. *Costal short cells*: square or rectangular in shape with smooth walls.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis. *Intercostal long cells*: variable shape; shape varies across a single intercostals zone. *Intercostal short cells*: solitary or paired of short cells situated between long cells: tall and narrow in shaped, smooth in outline, accompanied with transverse dumb-bell shaped silica bodies.

Leaf in transverse section (Fig. 3.22D-F).

Outline: two halves of lamina curved upwards on either side of the midrib, the margins round or acute; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, arranged irregularly; epidermal cells rounded, inflated and much larger than bundle sheath cells; outer walls slightly thickened and covered by a distinct thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles and papillae absent; macro-hairs present, constricted above bulbous base embedded between large epidermal, hairs long and slender. *Midrib outline*: present, keel conspicuous, triangular-shaped; many vascular bundle present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma forming a hypodermal band; sclerenchyma forming abaxial wide girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one first-order bundle, 10 or more third-order bundles between one second-order bundles; all bundles situated in center of the blade. *Primary-order vascular bundles*: elliptical in outline; sheath and phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels slightly larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: circular in outline; xylem and phloem easily distinguishable; bundles fairly large, similar size to the first-order bundles; sclerenchyma girder on both sides. *Third-order vascular bundles*: square-shape or pentagonal in outline, surrounded by a sheath of 4-5 large parenchyma, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: small point-cap shaped of sclerenchyma at the margin, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.22G).

Outline: slightly oval, flattened on one side, culm 1-1.5 mm in diameter. *Epidermis* subtended by continuous zone of chlorenchyma layers interrupted at intervals by girders of sclerenchyma connecting the vascular bundles of the outermost circle to the epidermis. Chlorenchyma layers bounded on its inner side by a not well-defined ring of sclerenchyma about 1-2 cells wide. *Ground tissue* consisting of cells with progressively thinner walls and larger diameters towards the centre of the culm, without pith cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundles scattered in the peripheral part of the inner thin-walled ground tissue, sclerenchyma girder supporting the outermost vascular bundles.

7.2 *H. porifera*

Leaf in transverse section (Fig. 3.23A-D).

Outline: two halves of lamina curved upwards on either side of the midrib, the margins acute; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, arranged irregularly; epidermal cells rounded, inflated and much larger than bundle sheath cells; outer walls slightly thickened and covered by a distinct thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles and papillae absent; macro-hairs present, constricted above bulbous base embedded between large epidermal, hairs long and slender. *Midrib outline*: present, keel conspicuous, triangular-shaped; five vascular bundles present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma forming a hypodermal band; sclerenchyma forming abaxial wide girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one first-order bundle, 10 or more third-order bundles between one second-order bundles; all bundles situated in center of the blade. *Primary-order vascular bundles*: round or circular in outline; sheath incomplete surrounding the bundle due to interruption of sclerenchyma, phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: somewhat round in outline; xylem and phloem easily distinguishable; bundles fairly large, similar size to the first-order bundles; sclerenchyma girder on both sides. *Third-order vascular bundles*: square-shape or pentagonal in outline, surrounded by a sheath of 4-5 large parenchyma, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: point-cap shaped of sclerenchyma at the margin, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.23E).

Outline: slightly oval, flattened on one side, culm 3-5 mm in diameter. *Epidermis* subtended by continuous zone of chlorenchyma layers interrupted at intervals by girders of sclerenchyma connecting the vascular bundles of the outermost circle to the epidermis. Chlorenchyma layers bounded on its inner side by a ring of sclerenchyma about 4-5 cells wide. *Ground tissue* consisting of cells with progressively thinner walls and larger diameters towards the centre of the culm, without pith cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundles scattered in the inner thin-walled ground tissue, sclerenchyma girder supporting the outermost vascular bundles.

Genus *Hemarthria*: 2 out of 6 species were examined.

8.1 *H. compressa*

Leaf surface (Fig. 3.24A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed. Moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: triangular-shaped subsidiary cells or low triangular, apex drawn out into a point, three to seven rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: paired short cells situated between long cells: both are tall and narrow in shaped, crenate or irregular in outline, sometimes accompanied with transverse dumb-bell shaped silica bodies. *Papillae*: absent. *Prickle hairs*: absent. *Hook:* absent. *Micro-hairs*: bicellular, two-celled, basal cell less than ½ the length of the distal cells; wall of distal cell thinner than wall of basal cell, slightly tapered; tapering to a rounded apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: absent. *Silica bodies*: intermediate between cross and dumb-bell shaped, relatively short, not elongate, present throughout the costal zones, constricted narrow central; granules present in silica bodies. *Costal short cells*: similar to intercostal short cells.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis. *Intercostal long cells*: variable shape; shape varies across a single intercostals zone.

Leaf in transverse section (Fig. 3.24D-F).

Outline: infolded, two halves of lamina curved upwards on either side of median bundle, two arms forming an incomplete narrow ellipse, the margins acute; ribs or furrows present on adaxial surface with no regular pattern associated with the vascular bundles. *Epidermal cells*: bulliform cells present, irregular adaxial groups; outer walls thickened and covered by a thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles, papillae and macro-hairs absent. *Midrib outline*: present, keel inconspicuous, V-shaped keel, not thicker than the rest of lamina; one vascular bundle present in the keel, abaxially arranged. *Midrib sclerenchyma*: sclerenchyma associated with the keel; forming an adaxial hypodermal band, abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one first-order bundle, 6-7 third-order bundles between consecutive larger bundles; all bundles situated in the center of the blade. *Primary-order vascular bundles*: circular in outline; sheath incomplete surrounding the bundle due to interruption of sclerenchyma, phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: somewhat circular in outline; xylem and phloem easily distinguishable; bundles larger than size to the first-order bundles; bundle sheath extension forming sclerenchyma girder on both side. *Third-order vascular bundles*: circular, tetragonal or pentagonal in outline, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: point-cap shaped of sclerenchyma at the margin, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.24G).

Outline: oval, culm 2-2.5 mm in diameter. *Epidermis* subtended by continuous zone of chlorenchyma layers interrupted at intervals by girders of sclerenchyma connecting the vascular bundles of the outermost circle to the epidermis. Chlorenchyma layers bounded on its inner side by a ring of sclerenchyma about 2-3 cells wide. *Ground tissue* consisting of cells with thick-walled cells, extending to the hollow centre of the culm, center of the culm with an oval pith cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundles scattered in the inner thick-walled ground tissue, sclerenchyma girder supporting the outermost vascular bundles.

8.2 *H. pratensis*

Leaf surface (Fig. 3.25A-B).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed; Deeply undulating, strongly corrugated, wave-length short, amplitude relatively deep and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: low triangular-shaped subsidiary cells, long and broadly angular subsidiary cells, vertical width of the subsidiary cells smaller in relation to the horizontal length, one to two rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short* *cells*: paired short cells situated between long cells: tall and narrow in shaped, crenate in outline, accompanied with transverse dumb-bell shaped silica bodies. *Papillae*: absent. *Prickle hairs*: absent. *Hook:* absent. *Micro-hairs*: bicellular, two-celled, basal cell less than ½ the length of the distal cells; wall of distal cell thinner than wall of basal cell, slightly tapered; tapering to a rounded apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: absent. *Silica bodies*: intermediate between cross and dumb-bell shaped, relatively short, not elongate, present throughout the intercostals and costal zones, constricted narrow central; granules present in silica bodies. *Costal short cells*: similar to intercostal short cells.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis. *Macro-hairs*: unicellular, hard, long, and usually with slightly thickened walls, two specialized cells accompanying base of hair.

Leaf in transverse section (Fig. 3.25C-D).

Outline: infolded, two halves of lamina curved upwards on either side of median bundle, two arms forming an incomplete narrow ellipse, the margins acute; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, regular adaxial groups; in simple fans; outer walls thickened and covered by a thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles, papillae and macro-hairs absent. *Midrib outline*: present, keel conspicuous, rounded or U-shaped keel, much thicker than the rest of lamina; many vascular bundle present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; forming a thin adaxial hypodermal band, abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: nine first-order bundle, 3-5 third-order bundles between consecutive larger bundles; all bundles situated in the center of the blade. *Primary-order vascular bundles*: elliptical in outline; sheath and phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: somewhat circular in outline; xylem and phloem easily distinguishable; bundles smaller than size to the first-order bundles; bundle sheath extension forming sclerenchyma girder on abaxial side. *Third-order vascular bundles*: circular or pentagonal in outline, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: point-cap shaped of sclerenchyma at the margin, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.25E).

Outline: oval, culm 1.5-3 mm in diameter. *Epidermis* subtended by continuous zone of chlorenchyma layers interrupted at intervals by girders of sclerenchyma connecting the vascular bundles of the outermost circle to the epidermis. Chlorenchyma layers bounded on its inner side by a ring of sclerenchyma about 3-4 cells wide. *Ground tissue* consisting of cells with thick-walled cells, extending to the hollow centre of the culm, center of the culm with a rectangular pith cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundles scattered in the inner thick-walled ground tissue, sclerenchyma girder supporting the outermost vascular bundles.

Genus *Mnesithea*: 5 out of 8 species were examined.

9.1 *M. cancellata*

Leaf surface (Fig. 3.26A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls slightly thickened, slightly cuticular flanges probably developed. Slightly undulating, faintly corrugated; wave-length short, amplitude shallow and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: triangular-shaped subsidiary cells, apex drawn out into a point; evagination often containing the nucleus, two to five rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: solitary or paired of short cells situated between long cells: tall and narrow in shaped, smooth in outline, accompanied with transverse dumb-bell shaped silica bodies or hook cells. *Papillae*: absent. *Prickle hairs*: absent. *Hooks*: present in the intercostals zones; accompanied with short cells. *Micro-hairs*:

long and slender, bicellular, two-celled, basal cell only slightly shorter than the distal cells; wall of distal cell thinner than wall of basal cell, slightly tapered; tapering to a rounded apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: absent. *Silica bodies*: dumb-bell shaped, relatively short, not elongate, present throughout the costal zones, constricted narrow central; granules present in silica bodies.

ADAXIAL EPIDERMIS.—*Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells centrally and rectangular cells laterally, wider cells in center of intercostals zones; sometimes adjacent with single short cells. Moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Intercostal short cells*: paired of short cells situated between long cells: tall and narrow in shaped, irregular in outline, accompanied with hook cells.

Leaf in transverse section (Fig. 3.26D-F).

Outline: two halves of lamina curved upwards on either side of the midrib, the margins acute; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, arranged in regular groups: in simple fans-shaped; outer walls thickened and covered by a thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles, papillae and macro-hairs absent. *Midrib outline*: present, keel conspicuous, rounded or semicircular-shape, much thicker than the rest of lamina, adaxial side of keel flat; many vascular bundle present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma forming a hypodermal band; abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one first-order bundle, 10 or more third-order bundles between one second-order bundles; all bundles situated in the central of the blade. *Primary-order vascular bundles*: somewhat circular in outline; sheath and phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels slightly larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: somewhat circular in outline; xylem and phloem easily distinguishable;

bundles usually fairly large, similar size to the first-order bundles; bundle sheath extension forming sclerenchyma girder on both side. *Third-order vascular bundles*: square-shaped, pentagonal or circular in outline, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: small point-cap shaped of sclerenchyma at the margin, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.26G).

Outline: circular or slightly oval, sometimes flattened on one side, culm 1.5-2.5 mm in diameter. *Epidermis* subtended by continuous zone of chlorenchyma layers interrupted at intervals by girders of sclerenchyma connecting the vascular bundles of the outermost circle to the epidermis. Chlorenchyma layers bounded on its inner side by a ring of sclerenchyma about 4 cells wide. *Ground tissue* consisting of cells with progressively thinner walls and larger diameters towards the centre of the culm, without its cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundle scattered throughout the culm.

9.2 *M. glandulosa*

Leaf surface (Fig. 3.27A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls slightly thickened, slightly cuticular flanges probably developed. Moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: triangular-shaped subsidiary cells, apex drawn out into a point; evagination often containing the nucleus, three to eight rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: solitary or paired of short cells situated between long cells: tall and narrow in shaped, smooth in outline, accompanied with transverse dumb-bell shaped silica bodies. *Papillae*: absent. *Prickle hairs*: absent. *Micro-hairs*:

long and slender, bicellular, two-celled, basal cell only slightly shorter than the distal cells; wall of distal cell thinner than wall of basal cell, slightly tapered; tapering to a rounded apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: absent. *Silica bodies*: dumb-bell shaped, relatively short, not elongate, present throughout the costal zones, constricted narrow central; granules present in silica bodies.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis. *Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells centrally and rectangular cells laterally, wider cells in center of intercostals zones; sometimes adjacent with single short cells.

Leaf in transverse section (Fig. 3.27D-F).

Outline: two halves of lamina curved upwards on either side of the midrib, the margins acute; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, arranged irregularly or regularly in simple fans-shaped; outer walls thickened and covered by a thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles, papillae and macro-hairs absent. *Midrib outline*: present, keel conspicuous, rounded or semicircular-shape, much thicker than the rest of lamina, adaxial side of keel flat; many vascular bundle present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma forming a hypodermal band; abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one first-order bundle, 10 or more third-order bundles between one second-order bundles; all bundles situated in the abaxial of the blade. *Primary-order vascular bundles*: somewhat circular in outline; sheath and phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: somewhat circular in outline; xylem and phloem easily distinguishable; bundles usually fairly large, similar size to the first-order bundles; bundle sheath extension forming sclerenchyma girder on both side. *Third-order vascular bundles*: square-shaped or circular in outline, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal* *sclerenchyma*: point-cap shaped of sclerenchyma at the margin, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.27G).

Outline: oval, sometimes flattened on one side, culm 2.5-3.5 mm in diameter. *Epidermis* subtended by continuous zone of chlorenchyma layers interrupted at intervals by girders of sclerenchyma connecting the vascular bundles of the outermost circle to the epidermis. Chlorenchyma layers bounded on its inner side by a ring of sclerenchyma about 4 cells wide. *Inner ground tissue* consisting of large thin-walled cells, and without pith cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundles scattered in the peripheral part of the inner thin-walled ground tissue.

9.3 *M. laevis*

Leaf surface (Fig. 3.28A-B).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: shortened cells, length slightly greater than width or length and width approximately equal or sometimes length less than width, tall and narrow; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed; Deeply undulating, strongly corrugated, wave-length short, amplitude relatively deep and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: almost parallel-sided or intermediate between parallel-sided and very low dome-shaped subsidiary cells, vertical width of the subsidiary cells smaller in relation to the horizontal length, two to four rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: paired short cells situated between long cells: tall and narrow in shaped, irregular in outline, accompanied with transverse dumb-bell shaped silica bodies. *Papillae*: absent. *Prickle hairs*: absent. *Hook:* present very rare in intercostal zones. *Micro-hairs*: bicellular, two-celled, basal cell less than ½ the length of the distal cells; wall of distal cell thinner than wall of basal cell, slightly tapered; tapering to a rounded apex, emergence of base from short cell. *Macro-hairs*: absent. *Silica bodies*: transverse dumb-bell shaped, relatively short, not elongate, present throughout the intercostals and costal zones, constricted narrow central; granules present in silica bodies. *Costal short cells*: similar to intercostal short cells.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis. *Macro-hairs*: present near leaf margins, unicellular, hard, short, stiff and usually with thickened walls, two specialized cells accompanying base of hair.

Leaf in transverse section (Fig. 3.28C-D).

Outline: two halves of lamina wided very opens V-shaped, more than 90° to each other, the margins acute; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, 1-2 rows, arranged irregularly; outer walls thickened and covered by a thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles, papillae and macro-hairs absent. *Midrib outline*: present, keel conspicuous, V-shaped keel, bulliform cells present in adaxial epidermis above median bundle; one small vascular bundle present in the keel, all vascular bundles abaxially arranged: first-order bundle only comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one first-order bundle, 4-7 third-order bundles between one second-order bundles; all bundles situated in the center of the blade. *Primary-order vascular bundles*: circular in outline; sheath incomplete surrounding the bundle due to interruption of sclerenchyma, phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: elliptical in outline; xylem and phloem easily distinguishable; bundles larger than size to the first-order bundles; bundle sheath extension forming sclerenchyma girder on both side. *Third-order vascular bundles*: circular or pentagonal in outline, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: crescent-shaped of sclerenchyma at the margin, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.28E).

Outline: oval, culm 1.5-2.5 mm in diameter. *Epidermis* subtended by continuous zone of chlorenchyma layers interrupted at intervals by girders of sclerenchyma connecting the vascular bundles of the outermost circle to the epidermis. Chlorenchyma layers bounded on its inner side by a not well-defined ring of sclerenchyma about 1-3 cells wide. *Ground tissue* consisting of cells with progressively thinner walls and larger diameters towards the centre of the culm, without pith cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundles scattered in the peripheral part of the inner thin-walled ground tissue, sclerenchyma girder supporting the outermost vascular bundles.

9.4 *M. mollicoma*

Leaf surface (Fig. 3.29A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls slightly thickened, slightly cuticular flanges probably developed. Moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: triangular-shaped subsidiary cells, apex drawn out into a point; three to eight rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: tall and narrow in shaped, smooth or irregular in outline, accompanied with hook cells. *Papillae*: absent. *Prickle hairs*: absent. *Micro-hairs*: long and slender, bicellular, two-celled, basal cell only slightly shorter than the distal cells; wall of distal cell thinner than wall of basal cell, sharply pointed apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: present densely on intercostal zones, unicellular, long and slender, usually with thickened walls, many epidermal cells associated with base of macro-hairs, usually smaller, specialized epidermal cells accompanying base of hair. *Silica bodies*: dumb-bell shaped, relatively short, not elongate, present throughout the costal zones, constricted narrow central; granules present in silica bodies. *Costal short cells*: tall and narrow in shaped, smooth in outline.

ADAXIAL EPIDERMIS.—*Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells centrally and rectangular cells laterally, wider cells in center of intercostals zones; sometimes adjacent with single short cells.

Leaf in transverse section (Fig. 3.29D-F).

Outline: two halves of lamina curved upwards on either side of the midrib, the margins acute; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, arranged irregularly; outer walls thickened and covered by a thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles, papillae absent; macro-hairs present, constricted above bulbous base embedded between large epidermal, hairs long and slender. *Midrib outline*: present, keel conspicuous, rounded or semicircular-shape, much thicker than the rest of lamina, adaxial side of keel flat; many vascular bundle present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma forming a hypodermal band; abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: three first-order bundle, 10 or more third-order bundles between one second-order bundles; all bundles situated in the abaxial of the blade. *Primary-order vascular bundles*: elliptical in outline; sheath and phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: somewhat circular in outline; xylem and phloem easily distinguishable; bundles usually fairly large, similar size to the first-order bundles; bundle sheath extension forming sclerenchyma girder on both side. *Third-order vascular bundles*: square-shaped or circular in outline, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: small point-cap shaped of sclerenchyma at the margin, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.29G).

Outline: oval, sometimes flattened on one side, culm 2-2.5 mm in diameter. *Epidermis* subtended by continuous zone of chlorenchyma layers interrupted at intervals by girders of sclerenchyma connecting the vascular bundles of the outermost circle to the epidermis. Chlorenchyma layers bounded on its inner side by a ring of sclerenchyma about 3 cells wide. *Ground tissue* consisting of cells with progressively thinner walls and larger diameters towards the centre of the culm, without pith cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundle embedded in the inner ground tissue.

9.5 *M.* sp.1

Leaf surface (Fig. 3.30A-B).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls slightly thickened, slightly cuticular flanges probably developed; slightly undulating, faintly corrugated; wave-length short, amplitude shallow and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: triangular-shaped subsidiary cells, apex drawn out into a point, up to ten rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: paired short cells situated between long cells: tall and narrow in shaped, smooth or irregular in outline, accompanied with transverse dumb-bell shaped silica bodies. *Papillae*: absent. *Prickle hairs*: absent. *Micro-hairs*: long and slender, bicellular, two-celled, basal cell only slightly shorter than the distal cells; wall of distal cell thinner than wall of basal cell, slightly tapered; tapering to a rounded apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: absent. *Silica bodies*: dumb-bell shaped, relatively short, not elongate, present throughout the costal zones, constricted narrow central; granules present in silica bodies. *Costal short cells*: similar to intercostals zones.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis. *Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells centrally and rectangular cells laterally, wider cells in center of intercostals zones; sometimes adjacent with single short cells. *Stomata* marginally present rather rare, regular in form.

Leaf in transverse section (Fig. 3.30C-E).

Outline: two halves of lamina curved upwards on either side of the midrib, the margins acute; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, arranged irregularly; outer walls thickened and covered by a thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles, papillae and macro-hairs absent. *Midrib outline*: present, keel conspicuous, rounded or triangular-shape, much thicker than the rest of lamina, adaxial side of keel flat; many vascular bundle present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma forming a hypodermal band; abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: three first-order bundle, 8 or more third-order bundles between one second-order bundles; all bundles situated in the abaxial of the blade. *Primary-order vascular bundles*: circular in outline; sheath and phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: circular in outline; xylem and phloem easily distinguishable; bundles usually fairly large, similar size to the first-order bundles; bundle sheath extension forming sclerenchyma girder on both side. *Third-order vascular bundles*: square-shaped, pentagonal or hexagonal in outline, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: point-cap shaped of sclerenchyma at the margin, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.30F).

Outline: oval, sometimes flattened on one side, culm 3.5-7 mm in diameter. *Epidermis* subtended by continuous zone of chlorenchyma layers interrupted at intervals by girders of sclerenchyma connecting the vascular bundles of the outermost circle to the epidermis. Chlorenchyma layers bounded on its inner side by a ring of sclerenchyma about 7-8 cells wide. *Inner ground tissue* consisting of large thin-walled cells, and without pith cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundles scattered in the peripheral part of the inner thin-walled ground tissue, sclerenchyma girder supporting larger vascular bundles, smaller bundles with crescentiform sclerenchyma caps.

Genus *Ophiuros*: 1 of 1 species was examined.

10. *O. exaltatus*

Leaf surface (Fig. 3.31A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls moderately thickened, cuticular flanges developed; moderately undulating, often irregular, wave-length short, amplitude variable and frequency high; short cells present between the adjacent long cells; bulliform cells present, varying in appearance with focus, inflated thin walled, rectangular in shape. *Stomata*: low dome-shaped subsidiary cells, vertical width of the subsidiary cells smaller in relation to the horizontal length, over 10 rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: pairs: tall and narrow in shaped, irregular in outline, accompanied with transverse dumb-bell shaped silica bodies. *Papillae*: absent. *Prickle hairs*: absent. *Hook:* absent. *Micro-hairs*: bicellular, two-celled, basal cell less than ½ the length of the distal cells; wall of distal cell thinner than wall of basal cell, slightly tapered; tapering to a rounded apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: present at leaf margins, unicellular, hard, long, usually with thickened walls, sunken base embedded between and often below surrounding epidermal cells. *Silica bodies*: transverse dumb-bell shaped present with short cell in the intercostals zones: or intermediate between cross and dumb-bell shaped, present throughout the costal zones, constricted narrow central; granules present in silica bodies. *Costal short cells*:

pairs: tall and narrow in shaped, irregular in outline, accompanied with transverse dumb-bell shaped silica bodies.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis. *Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells, or bowed outwards, inflated or rectangular cells, slightly undulating, faintly corrugated, wave-length short, amplitude shallow and frequency high.

Leaf in transverse section (Fig. 3.31D-E).

Outline: two halves of lamina curved upwards on either side of the midrib formed U-shaped, tall and narrow, vertically elongated, the margins round; no ribs or furrows present on either surface. *Epidermis*: bulliform cells present, arranged irregularly; outer walls thickened and covered by a slightly thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles, papillae and macro-hairs absent. *Midrib outline*: present, keel conspicuous, rounded or semicircular-shape, much thicker than the rest of lamina, adaxial side of keel flat; many vascular bundle present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma forming a hypodermal band; abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: three first-order bundle, 9 or more third-order bundles between one second-order bundles; all bundles situated in the abaxial of the blade. *Primary-order vascular bundles*: elliptical in outline; phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: elliptical in outline; xylem and phloem easily distinguishable; bundles usually fairly large, similar size to the first-order bundles; bundle sheath extension forming sclerenchyma girder on both side. *Third-order vascular bundles*: pentagonal or hexagonal in outline, surrounded by a sheath of 5-6 large parenchyma, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: point-cap shaped of sclerenchyma at the margin, sometimes relatively small, less than the width of a third order vascular bundle, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig: 3.31F).

Outline: somewhat circular, culm 2-2.5 mm in diameter. *Epidermis* subtended by continuous zone of chlorenchyma layers interrupted at intervals by girders of sclerenchyma connecting the vascular bundles of the outermost circle to the epidermis. Chlorenchyma layers bounded on its inner side by a not well-defined ring of sclerenchyma about 1-3 cells wide. *Ground tissue* consisting of cells with progressively thinner walls and larger diameters towards the centre of the culm, without pith cavity. *Vascular bundles* of the outermost circle embedded in peripheral sclerenchyma ring. The other vascular bundles scattered in the inner thin-walled ground tissue.

Genus *Phacelurus*: 1 of 2 species was examined.

11. *P. zea*

Leaf surface (Fig. 3.32A-B).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls slightly thickened, slightly cuticular flanges probably developed; Deeply undulating, strongly corrugated, wave-length short, amplitude relatively deep and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: low triangular subsidiary cells, long and broadly angular subsidiary cells or dome-shaped, subsidiary cells somewhat rounded, vertical width of the subsidiary cells smaller in relation to the horizontal length, often containing the nucleus, three to six rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: pairs: tall and narrow in shaped, irregular in outline, accompanied with transverse dumb-bell shaped silica bodies. *Papillae*: absent. *Prickle hairs*: absent. *Hook:* present in intercostal zones. *Micro-hairs*: bicellular, two-celled, basal shorter than distal cells; wall of distal cell thinner than wall of basal cell, slightly tapered;

tapering to a rounded apex, base or attachment of basal cell: parallel-side, point of attachment small. *Macro-hairs*: absent. *Silica bodies*: dumb-bell shaped or intermediate between cross and dumb-bell shaped, relatively short, not elongate, usually accompanied by short cells, present throughout the intercostals and costal zones, constricted narrow central; granules present in silica bodies. *Costal short cells*: solitary or pairs: tall and narrow in shaped, irregular in outline, if pairs accompanied with transverse dumb-bell shaped silica bodies.

ADAXIAL EPIDERMIS.—In general, similar to the abaxial epidermis. *Prickle hairs*: common in costal zones, overlying any vascular bundle-order, medium prickles base as long or slightly longer than the stomata; short barb, barb shorter than the base, point to leaf apex; one to two rows along the wholelength, one row along the wholelength over all vascular bundle, rows separated silica bodies between successive prickles.

Leaf in transverse section (Fig. 3.32C-E).

Outline: two halves of lamina wide very open V-shaped, more than 90° to each other, the margins round; no ribs or furrows present on either surface. *Epidermis*: bulliform present, 1-2 rows, irregular adaxial groups; outer walls thickened and covered by a slightly thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; prickles, papillae and macro-hairs absent. *Midrib outline*: present, keel very conspicuous, elongated U-shape, very much thicker than the rest of lamina; many vascular bundle present in the keel, all vascular bundles abaxially or marginally arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma forming a narrow hypodermal band and extend to colourless subepidermal parenchyma; abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one first-order bundle, 6-7 third-order bundles between one second-order bundles; all bundles situated in the center of the blade. *Primary-order vascular bundles*: circular or round in outline; phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels much larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: elliptical in outline; xylem and phloem easily distinguishable; bundles usually fairly large, similar size to the first-order bundles; bundle sheath extension forming sclerenchyma girder on both side. *Third-order vascular bundles*: round or slightly elliptical in outline, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: point-cap shaped of sclerenchyma at the margin, contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section (Fig. 3.32F).

Outline: oval, flattened on one side, culm ca. 1 cm in diameter. No well defined sclerenchyma ring present, intercellular air spaces present about 3-4 cells below the epidermis around the periphery of the culm, the outermost vascular bundle alternating with the spaces. *Inner ground tissue* consisting of large thin-walled cells, and without pith cavity. *Vascular bundle* usually being accompanied by fibres. The other vascular bundle numerous and scattered in the peripheral part of the inner thin-walled ground tissue.

Genus *Rottboellia*: 1 of 1 species was examined.

12. *R. cochinchinensis*

Leaf surface (Fig. 3.33A-C).

ABAXIAL EPIDERMIS.—Costal and intercostal zones well differentiated. *Intercostal long cells*: elongated cells, length 3x or more than 3x longer than the width; side walls or anticlinal horizontal long walls parallel to one another, cell rectangular, square or trapezoidal; end walls or anticlinal vertical cross-members vertical; horizontal and vertical anticlinal walls slightly thickened, slightly cuticular flanges probably developed; Deeply undulating, strongly corrugated, wave-length short, amplitude relatively deep and frequency high; short cells present between the adjacent long cells; no bulliform cells present on surface of the preparation examined. *Stomata*: high triangular-shaped subsidiary cells, apex drawn out into a point, rarely low dome-shaped, one to four rows of stomata in each intercostals zone; interstomatal long cells present, interstomatal cell between successive stomata, with concave ends. *Intercostal short cells*: solitary, rarely pairs, both cells of the pair tall and narrow in shaped, irregular in outline, sometimes short cells accompanied with transverse dumb-bell shaped silica bodies. *Papillae*: absent. *Prickle hairs*: present at the margins, large prickles, base at least twice as long as the stomata; short barb, barb shorter than the base, point to leaf apex; one to two rows along the wholelength. *Micro-hairs*: bicellular, two-celled, only basal cell remains or visible. *Macro-hairs*: absent. *Silica bodies*: cross or dumb-bell shaped present rarely in intercostals zones; dumb-bell shaped, relatively short, not elongate, present throughout the costal zones, constricted narrow central; granules present in silica bodies. *Costal short cells*: square or rectangular in shape, sinuous or undulating walls.

ADAXIAL EPIDERMIS.—*Intercostal long cells*: variable shape; shape varies across a single intercostals zone, hexagonal cells centrally and rectangular cells laterally, wider cells in center of intercostals zones; sometimes adjacent with single short cells. *Stomata* marginally present rather rare, regular in form. *Prickle hairs*: common in costal zones, overlying any vascular bundle-order, large prickles, base at least twice as long as the stomata; short barb, barb shorter than the base, point to leaf apex; one to two rows along the whole length, one row along the wholelength over all vascular bundle, rows separated silica bodies between successive prickles. *Hook:* present in intercostal zones. *Silica bodies*: intermediate between cross and dumb-bell shaped, relatively short, not elongate, present throughout the costal zones, constricted narrow central; granules present in silica bodies.

Leaf in transverse section (Fig. 3.33D-F).

Outline: two halves of lamina folded toward each other on either side of the midrib formed standard V-shaped, 90° to each other, the margins round; nodular on adaxially surface. *Epidermis*: bulliform cells present, regular adaxial groups; in simple fans, outer walls thickened and covered by a slightly thick cuticle continuous over the epidermal cells, cuticle and cell wall less than the depth of the average epidermal cells; thickened prickles present in epidermis; usually located opposite the vascular bundles; papillae and macro-hairs absent. *Midrib outline*: present, keel conspicuous, rounded or semicircular-shape, much thicker than the rest of lamina, adaxial rib slightly developed; many vascular bundle present in the keel, all vascular bundles abaxially arranged: first-order bundle and smaller bundles comprise keel. *Midrib sclerenchyma*: sclerenchyma associated with the keel; adaxial sclerenchyma forming a hypodermal band; abaxial sclerenchyma girder combined with vascular bundle. *Vascular bundle arrangement in the lamina*: one first-order bundle, 10 or more third-order bundles between one second-order bundles; all bundles situated in the abaxial of the blade. *Primary-order vascular bundles*: elliptical or slightly angular in outline;

phloem completely surrounded by thick-walled fibres; lysigenous cavity and enlarged protoxylem vessel present, width of vessels much larger than parenchyma sheath cells; metaxylem vessels circular in T/S, distinctly thickened; inner secondary wall distinct. *Secondary-order vascular bundles*: elliptical in outline; xylem and phloem easily distinguishable; bundles usually fairly large, similar size to the first-order bundles; bundle sheath extension forming sclerenchyma girder on both side. *Third-order vascular bundles*: pentagonal or hexagonal in outline, surrounded by a sheath of 5-7 large parenchyma, all vascular tissue consists of only a few vascular strands; no associate with sclerenchyma. *Intercostal sclerenchyma*: point-cap shaped of sclerenchyma at the margin, not in contact with the lateral bundle. *Mesophyll*: radiate chlorenchyma: radially arranged around the vascular bundles which are often close together; single layer isodiametric.

Culm in transverse section

Outline: circular or flattened on one side, culm 3-7 mm in diameter. No well defined sclerenchyma ring present, sclerenchyma girders present about 2-3 cells over the outermost vascular bundle subjacent to the epidermis. *Inner ground tissue* consisting of large thin-walled cells, and without pith cavity. *Vascular bundle* of the outermost being accompanied by fibres and associated with sclerenchyma strands fused forming a hypodermal band, sclerenchyma forming fairly wide girder combined with vascular bundle. The other vascular bundle numerous and scattered throughout the culm.

3.5 Discussion and conclusion

Leaf surfaces

From Table 3.4, it can be concluded that the intercostal long cells are mostly elongated cells of rectangular, square or trapezoidal shape with slightly to deeply undulating walls, except in *Mnesithea laevis* having a shortened cell with deeply sinuous walls. Renvoize (1982) noted that the genus *Mnesithea* has long cell walls exceptionally deeply convolute; very shallow stomatal subsidiary cells and transverse silica bodies. In this study only *M. laevis* agreed with the study by Renvoize. In contrast, the other species of *Mnesithea* have a slightly to moderately sinuous wall and dome or triangular-shaped subsidiary cells (Table 3.5). Gould & Shaw (1983) stated that significant differences in long cell structure exist among genera and even among species of the same genus. The basic types of long cells have proved very useful for broad surveys of the grasses (Metcalfe, 1960), but they are not adequate for all purposes since there are many intermediates and variants. For detailed studies of limited numbers of species, it may be necessary to introduce some additional types for descriptive purposes (Ellis, 1979).

In this study the transverse silica bodies can be found in all species of *Mnesithea* (Table 3.5).

The above descriptions indicate that *O. exaltatus* is the most definitely related to *Mnesithea* species, because of similarities in leaf and culm structure. These two species are also closely related morphologically, because both species have cylindrical racemes, sessile spikelets dorsally compressed and sunken in the hollow of rachis internode. Considering these morphological and leaf and culm anatomical features, *O. exaltatus* seems to be closer to the species of *Mnesithea* than *M. laevis* (Table 3.4 and 3.5).

Because of the information given above, the system proposed by Veldkamp et al. (1986) that sunk all *Coelorachis* species into the genus *Mnesithea,* is probably not acceptable.

The stomata of all genera are confined to the intercostal zones, especially in abaxial surfaces. The paracytic type cells are recognized as a grass type (Dahlgren et al., 1985), characterized by low- or tall-dome or triangular-shaped subsidiary cells; rarely (as in *M. laevis*) the subsidiary cells are almost parallel-sided or intermediate between parallel-sided and low dome-shaped. However, stomata of more than one type may occur together in a single leaf and the shape can be somewhat intermediate in certain species. Renvoize (1982) observed stomata of more than 10 rows across the intercostal zone of the lower epidermis in genera *Hemarthria*, *Ophiuros* and *Thelepogon*, while this study found one to seven rows in *Hemarthria*, more than 10 rows in *Ophiuros* and up to 18 rows in *Thelepogon*. Ellis (1979) suggested that the number of bands and rows of stomata in each intercostal zone vary not only from one species to another but also in different parts of a single leaf blade or in leaves taken from different levels of the same plant.

It is an important to note that the papillae are a good diagnostic character for dividing the genera in the subtribe Ischaeminae into 2 main groups. A papilla per cell occurs in *Kerriochloa*, while papillae occur in *Ischaemum* but they are absent in *Apluda*, *Sehima* and *Thelepogon*. However, some species in the genus *Ischaemum* fail to conform completely to the general pattern; namely absent papillae and culm without a central cavity in *Ischaemum tenuifolium* (Table 3.3). It appears to be associated with morphological trends within the genera, *I. tenuifolium* should be separated and placed in another subtribe. Papillae are absent in all genera of Rottboelliinae.

Prickles are common in the genera *Apluda* and *Sehima*. The latter genus showed the distinctness of ribs and furrows on both surfaces. This character also appears in *Ischaemum rugosum* but it is completely different from *Sehima* in degree and shape of ribs and furrows and the masses of sclerenchymatous cells below the epidermis. The ribs slightly rounded with flat top and the furrow wide and open in genus *Sehima* while triangular ribs and furrows are obtuse in *I. rugosum*. In some grass species which grow on dry places (xerophytic grass species) the prickles from adjacent costal zones overly the intervening intercostal zone. These interlocking prickles serve to protect the underlying stomatal groove. This type of situation is only found in leaves with narrow, relatively deep furrows as well as ribs especially on the adaxial surface (Ellis, 1979). Those characters are found in genus *Sehima*.

Most genera in Rottboelliinae do not have prickles on the leaf surface, except in the genus *Rottboellia*, where the prickles are present on both sides and very common in costal zones on adaxial surface, overlying any vascular bundle-order. The large prickles point to the leaf apex; their base is at least twice as long as the stomata; the barb is shorter than the base, and occurs one to two rows along the whole length separated with silica bodies.

Ribs and furrows can be found in some species of some genera in Rottboelliinae, such as *Eremochloa bimaculata*, *Hemarthria compressa* and *Rottboellia cochinchinensis*, while in the other genera these ribs and furrows are absent.

Bicellular micro-hairs have been detected in most of the studied species except, *Ischaemum hubbardii*, *I. tenuifolium* and *I.* sp.1. The micro-hairs of these species probably were damaged or destroyed during the slide preparation. Although the micro-hairs vary in the ratio of length to width or in the ratio of the length of the upper cell to that of the lower cell, they are uniformly included among the so-called panicoid micro-hairs or rod-like micro-hairs (Tateoka et al., 1959). This observation agrees with Metcalfe (1960).

The shape of silica bodies on the nerves is variable. In most species the bodies are dumb-bell shaped or intermediate between dumb-bell and cross-shaped, relatively short, not elongate. According to the investigation of Renvoize (1982), he found aberrant features in some genera in Andropogoneae that could not be combined into a single generalized description. The present study supports his conclusions. The silica bodies in all genera are cross-shaped, dumb-bell or intermediate between cross and dumb-bell shaped, except in the genus *Apluda* where the silica bodies are nodular.

Leaf in transverse section

The character which is useful for initial identification of the leaf in transverse section is the outline of the leaf-blade. An expanded lamina with a nearly straight line occured in all genera in subtribe Ischaeminae, except in genus *Thelepogon* and some species of the genus *Ischaemum*. The leaf-blade is folded or V-shaped is found in genus *Eremochloa* and *Hemarthria*, while two halves of lamina folded toward each other on either side of the midrib are found in genus *Hackelochloa*, *Mnesithea*, *Ophiuros*, *Phacelurus* and *Rottboellia*. However, the degree of infolding or inrolling varies with the environment conditions and thus is not of much value diagnostically (Metcalfe, 1960).

The arrangement of the bulliform cells can be recognized in the subtribes Ischaeminae and Rottboelliinae in two main groups; the first group has bulliform cells arranged in irregular groups and the second group has bulliform cells arranged in fan-shaped groups. The first group composed of *Kerriochloa* and *Thelepogon* in Ischaeminae and *Eremochloa*, *Hackelochloa*, *Ophiuros* and *Phacelurus* in Rottboelliinae, while the second group comprised of *Apluda*, *Ischaemum* and *Sehima* in subtribe Ischaeminae and *Hemarthria*, *Mnesithea* and *Rottboellia* in subtribe Rottboelliinae.

The midrib of *Thelepogon* is usually composed of a few vascular bundles, keel conspicuous, rounded or semicircular-shaped because of sclerenchymatous cells which make masses below the upper epidermis and above the lower epidermis, one or a few rows of colorless parenchyma below the upper epidermis and chlorenchyma surround the small vascular bundles. In contrast, the midrib of *Kerriochloa* and *Sehima* are arranged in a straight or somewhat uneven row, in which a large bundle is situated in the center and a few small bundles are placed on both sides of it. Keel is inconspicuous, not associated with developed parenchyma, the projection due to position or size of bundle and sclerenchyma on abaxial surface. The conspicuous keels occurred in all genera and species in Rottboelliinae, but they do vary in shape from V-shaped, triangular, rounded, semicircular, U-shaped to elongated U-shaped. Five to many of small and large vascular bundles are situated in the midrib, except in genus *Eremöchloa*, *Hemarthria compressa* and *Mnesithea laevis* which have only one vascular bundle at the center. Metcalfe (1955) has suggested that the anatomical midrib traits can be used for classifying grass species to some extent, and the results described above support his suggestion.

It was found that all genera of both subtribes having a radiate chlorenchyma which is radially arranged around the vascular bundles and often close together; single layer isodiametric. To be in line with Renvoize (1982), all the investigated genera have a single layer and composed of relatively thick-walled cells.

Culm in transverse section

Intercellular air spaces can be observed below the epidermis in some species and some genera of both subtribes viz, *Ischaemum hubbardii*, *Eremochloa bimaculata* and *Phacelurus zea*.

The genus *Ischaemum* from the subtribe Ischaeminae and genus *Eremochloa* and *Hemarthria* form the subtribe Rottboelliinae are the genera that have a pith cavity. All genera are found in wet habitats. Gould & Shaw (1983) noted that culms of a number of grasses, especially those adapted to aquatic or marshy habitats, also have other cavities and air chambers. McClure (1963) has used the air canals of the rhizomes of *Arundinaria tecta* as a taxonomic character in the separation of this species from *A. gigantean*.

This anatomical feature does not support the separation of the two subtribes, Ischaeminae and Rottboelliinae in this study. Neither nor the morphological classification system proposed by Clayton & Renvoize (1986).

The results from this study suggested that some anatomical characters have considerable taxonomic values in separating the related genera in the subtribes Ischaeminae and Rottboelliinae of Thai grass. The significant characters include leaf blade outline, ribs and furrows on both surfaces, bulliform cells, midrib and keel, number of vascular bundles in the keels, shape of sclerenchyma at margins, intercostal long cells, papillae, prickles, macro-hairs, silica bodies, culm outline and central cavity in ground tissue of culm. Table 3.2 and 3.4 show that certain characters have been found useful in determining species in these two subtribes. This finding is in agreement with Metcalfe (1960), Renvoize (1982) and Watson & Dallwitz (1992) who studied the leaf blades with light microscopes (LM) and concluded that anatomical characters of leaf blades were significant for grass identification. However, this study show more apparent variations between the genera and described some useful characters of culms which have not been reported in most genera previously. In addition, the genus *Kerriochloa* is studied here for the first time.

However, in some genera only one species was available and investigated, so the output features may not represent the typical characteristics of the whole genus. Though the anatomy features alone are insufficient for the delineation in some genera, in general, we consider that those features have considerable systematic value and giving additional support for the species distinction. However, like all other taxonomic evidences, anatomical characters must be interpreted with caution.

Table 3.2 Comparative anatomical features of genera in subtribe Ischaeminae.

Characters \ Genus	*Apluda*	*Ischaemum*	*Kerriochloa*	*Sehima*	*Thelepogon*
Leaf anatomy					
Leaf blade outline	blade expanded, slightly undulating or nearly straight	blade expanded or straight or two halves of lamina curved upwards on either side of the midrib or rolled	blade expanded, undulating gently or nearly straight	blade broad wide, horizontally elongated	two halves of lamina curved upwards on either side of the midrib
Adaxial ribs and furrows	absent	present or absent	absent	present	absent
Abaxial ribs and furrows	absent	present or absent	absent	present	absent
Bulliform cells	simple fans	fans-shaped or arranged in irregular groups	arranged in irregular groups	fans-shaped	arranged in irregular groups
Midrib	conspicuous, triangular-shaped	conspicuous, triangular-shaped or inconspicuous keel (rare)	inconspicuous	inconspicuous	conspicuous, rounded or semicircular-shaped
Number of vascular bundles in keel	one	one to many	one	one	many
Sclerenchyma at margins	crescent-cap shaped	point-cap or cap shaped	absent	crescent-cap shaped	point-cap shaped
Abaxial intercostal long cells	elongated cells, moderately undulating	elongated or shortened cells or variable in shape, deeply or moderately undulating	variable shape, moderately undulating	elongated cells, deeply undulating	elongated cells, moderately undulating
Abaxial intercostal short cells	absent	present (solitary)	present (solitary)	absent	present (solitary)
Papillae	absent	more than one papilla per cell on abaxial or adaxial surface, absent in *I. tenuifolium*	one papilla per cell on abaxial surface	absent	absent
Abaxial prickles	present (common)	absent	absent	present (common)	absent
Abaxial macro-hairs	absent	present or absent	present	absent	present
Abaxial silica bodies	nodular	dumb-bell or intermediate between cross and dumb-bell shaped	cross-shaped	dumb-bell shaped	cross, dumb-bell or intermediate between cross and dumb-bell shaped
Abaxial costal short cells	absent	present	absent	present	present
Culm anatomy					
Culm outline, diameter (mm)	circular, 1.2-1.5	circular or oval, 1-2	somewhat circular, 1-1.5	circular, 1.2-1.5	circular or somewhat oval, 2-3
Pith cavity	absent	present, except *I. tenuifolium*	absent	absent	absent

Table 3.3 The main anatomical differences separating the species in the genus *Ischaemum*.

Genus / Characters	*I. hirtum*	*I. hubbardii*	*I. muticum*	*I. rugosum*	*I. tenuifolium*	*I.* sp.1
Leaf anatomy						
Midrib	conspicuous, triangular-shaped	conspicuous, triangular-shaped to slightly round	conspicuous, triangular-shaped	inconspicuous	conspicuous triangular to round-shaped	conspicuous or inconspicuous, triangular-shaped
Ribs and furrows	absent	absent	absent	present on both surfaces	present on adaxial surface	absent
Number of vascular bundles in the keel	> 6	> 6	> 6	1	3-6	5
Papillae	present on abaxial surface	present on abaxial surface	present on abaxial surface	present on adaxial surface	absent	present on abaxial surface
Macro-hairs	present	present	absent	present	absent	present
Culm anatomy						
Pith cavity	present, somewhat irregular-shaped	present, somewhat circular-shaped	present, somewhat irregular-shaped	present, somewhat circular-shaped	absent	not seen

Genus / Characters	*Eremochloa*	*Hackelochloa*	*Hemarthria*	*Mnesithea*	*Ophiuros*	*Phacelurus*	*Rottboellia*
Leaf anatomy							
Leaf blade outline	standard V-shaped, 45-90°	two halves of lamina curved upwards on either side of the midrib	infolded, two halves of lamina curved upwards on either side of median bundle, two arms forming an incomplete narrow ellipse	two halves of lamina curved upwards on either side of the midrib or open V-shaped	two halves of lamina curved upwards on either side of the midrib formed U-shaped, tall and narrow	two halves of lamina wided very open V-shaped, more than 90° to each other	two halves of lamina folded toward each other on either side of the midrib formed standard V-shaped, 90° to each other
Ribs and furrows	absent, except *E. attenuata*, present on both surface, a quarter to one half of the leaf thickness	absent	absent or present on adaxial surface with no regular pattern in *He. compressa*.	absent	absent	absent	nodular on adaxial surface
Bulliform cells	arranged in irregular groups	arranged in irregular groups	simple fans or arranged in irregular groups	simple fans or arranged in irregular groups	arranged in irregular groups	arranged in irregular groups	simple fans
Midrib	conspicuous, rounded, triangular or v-shaped	conspicuous, triangular-shaped	conspicuous, rounded or U-shaped or inconspicuous	conspicuous, V-shaped, triangular, rounded or semicircular-shaped	conspicuous, rounded or semicircular-shaped	very conspicuous, elongated U-shaped	conspicuous, rounded or semicircular-shaped
Number of vascular bundles in keel	1	5	1 to > 6	1 to > 6	> 6	> 6	> 5
Sclerenchyma at margins	curved or crescent-shaped	point-cap shaped	point-cap shaped	point-cap shaped except, crescent-shaped in *M. laevis*	point-cap shaped	point-cap shaped	point-cap shaped
Abaxial intercostal long cells	elongated cells, moderately to deeply undulating	elongated cells, deeply undulating	elongated cells, moderately to deeply undulating	shortened to elongated cells, slightly to deeply undulating	elongated cells, moderately undulating	elongated cells, deeply undulating	elongated cells, deeply undulating
Abaxial intercostal short cells	paired	paired	paired	solitary or paired	paired	paired	solitary, rarely paired
Papillae	absent	absent	absent	absent	absent	absent	absent
Prickles	absent	absent	absent	absent	absent	absent	present on both surfaces, common on adaxial suface
Macro-hairs	present or absent	Present	absent	present or absent	absent	absent	Absent
Abaxial silica bodies	dumb-bell or intermediate between cross and dumb-bell shaped, relatively short, not elongate	dumb-bell shaped, relatively short, not elongate	intermediate between cross and dumb-bell shaped, relatively short, not elongate	dumb-bell or transverse dumb-bell shaped, relatively short, not elongate	intermediate between cross and dumb-bell or transverse dumb-bell shaped, constricted narrow central	dumb-bell or intermediate between cross and dumb-bell shaped, relatively short, not elongate	dumb-bell shaped, relatively short, not elongate
Culm anatomy							
Culm outline, diameter (mm)	oval or circular, 0.5-2	slightly oval, 1-5	oval, 1.5-3	circular to oval, 1.5-7	somewhat circular, 2-2.5	oval, *ca.* 10	circular, 3-7
Pith cavity	present, oval or irregular-shaped	absent	present, oval or rectangular-shaped	absent	absent	absent	absent

Table 3.5 The main anatomical differences separating the species in the genus *Mnesithea*.

Genus / Characters	*M. cancellata*	*M. glandulosa*	*M. laevis*	*M. mollicoma*	*M.* sp.1
Leaf anatomy					
Leaf blade outline	two halves of lamina curved upwards on either side of the midrib	two halves of lamina curved upwards on either side of the midrib	two halves of lamina wide very open V-shaped, more than 90°	two halves of lamina curved upwards on either side of the midrib	two halves of lamina curved upwards on either side of the midrib
Midrib	conspicuous, rounded or semicircular-shaped	conspicuous, rounded or semicircular-shaped	conspicuous, V-shaped - shaped	conspicuous, rounded or semicircular-shaped	conspicuous, rounded or triangular-shaped
Number of vascular bundles in keel	> 6	> 6	1	> 6	> 6
Sclerenchyma at margins	point-cap shaped	point-cap shaped	crescent-shaped	point-cap shaped	point-cap shaped
Abaxial intercostal long cells	elongated cells, slightly undulating	elongated cells, moderately undulating	shortened cells, deeply undulating	elongated cells, moderately undulating	elongated cells, slightly undulating
Abaxial intercostal short cells	solitary or paired	Solitary or paired	paired	solitary or paired	paired
Stomata	triangular-shaped, subsidiary cells	triangular-shaped, subsidiary cells	almost parallel-sided or intermediate between parallel-sided and low dome-shaped subsidiary cells	triangular-shaped, subsidiary cells	triangular-shaped, subsidiary cells
Abaxial silica bodies	dumb-bell shaped, relatively short, not elongate	dumb-bell shaped, relatively short, not elongate	transverse dumb-bell, relatively short, not elongate	dumb-bell shaped, relatively short, not elongate	dumb-bell shaped, relatively short, not elongate
Culm anatomy					
Culm outline and width	circular or slightly oval, 1.5-2.5	oval, 2.5-3.5	oval, 1.5-2.5	oval, 2-2.5	oval, 3.5-7

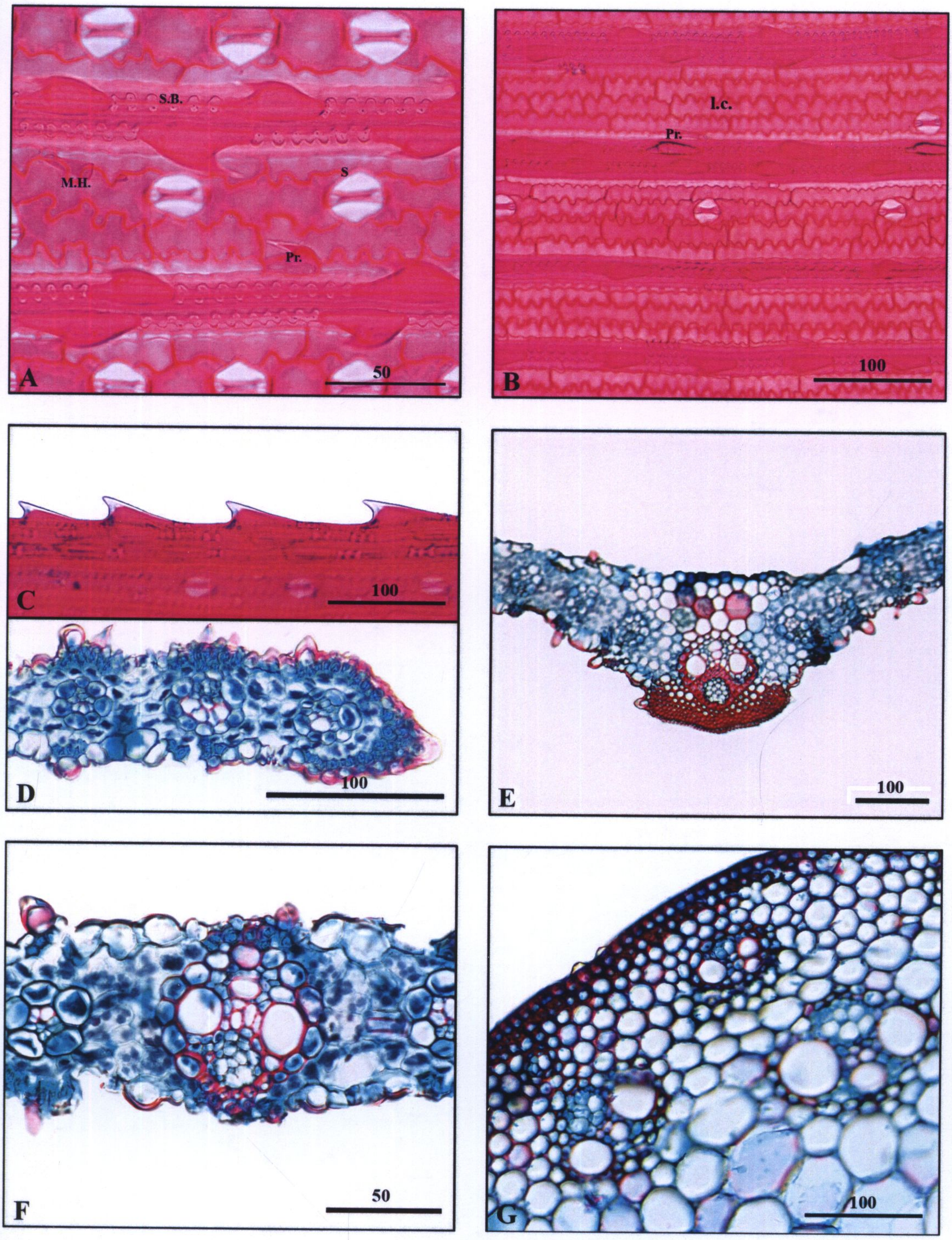

Figure 3.9 Leaf and culm anatomy of *Apluda mutica* (*P. Traiperm* 152 and 321): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. (SB= silica bodies; MH= micro-hairs; S=stomata; Pr=prickles; lc=long cells) Scale bar in μm.

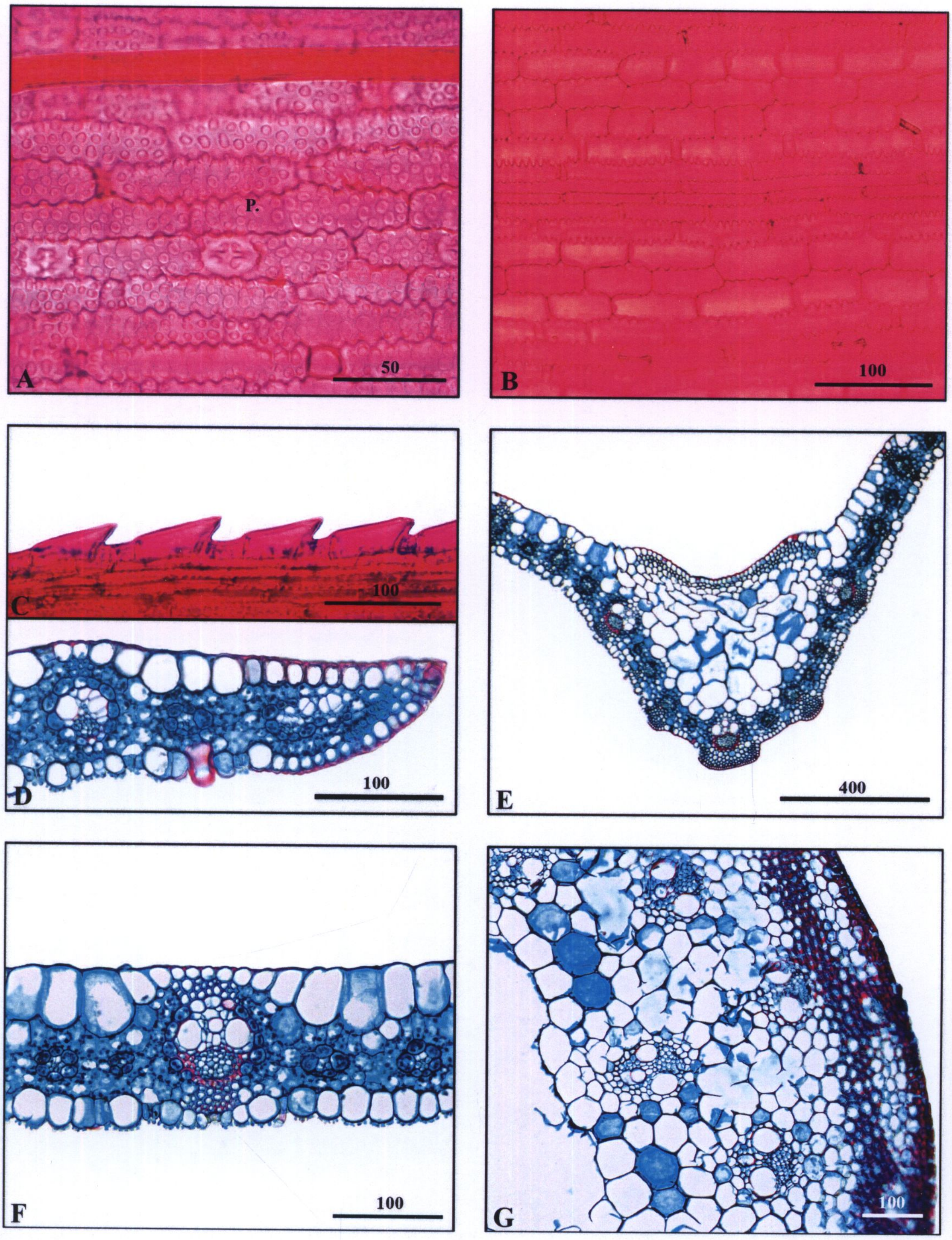

Figure 3.10 Leaf and culm anatomy of *Ischaemum hirtum* (*P. Traiperm* 171): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. (P=papillae) Scale bar in μm.

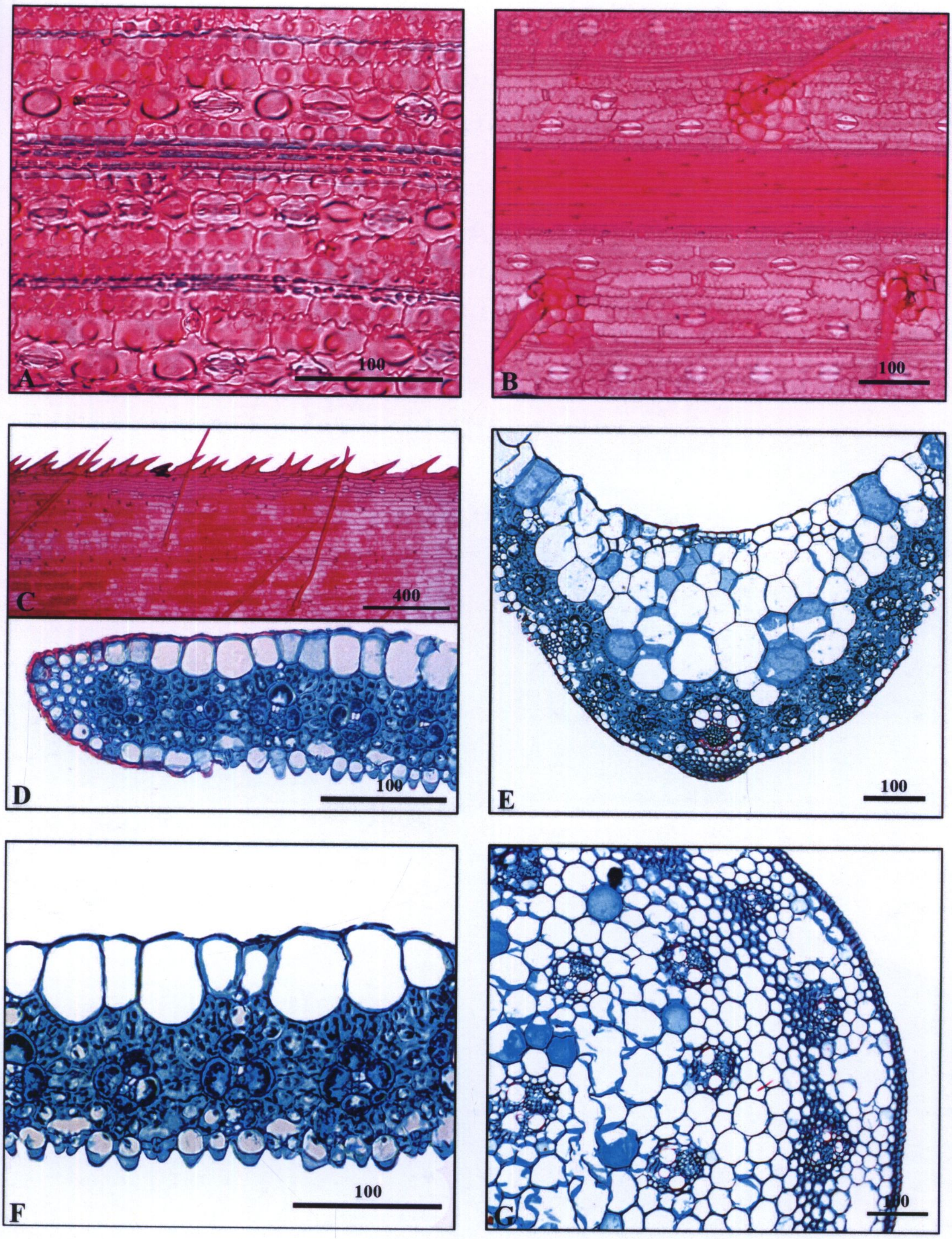

Figure 3.11 Leaf and culm anatomy of *Ischaemum hubbardii* (*P. Traiperm* 308): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. Scale bar in μm.

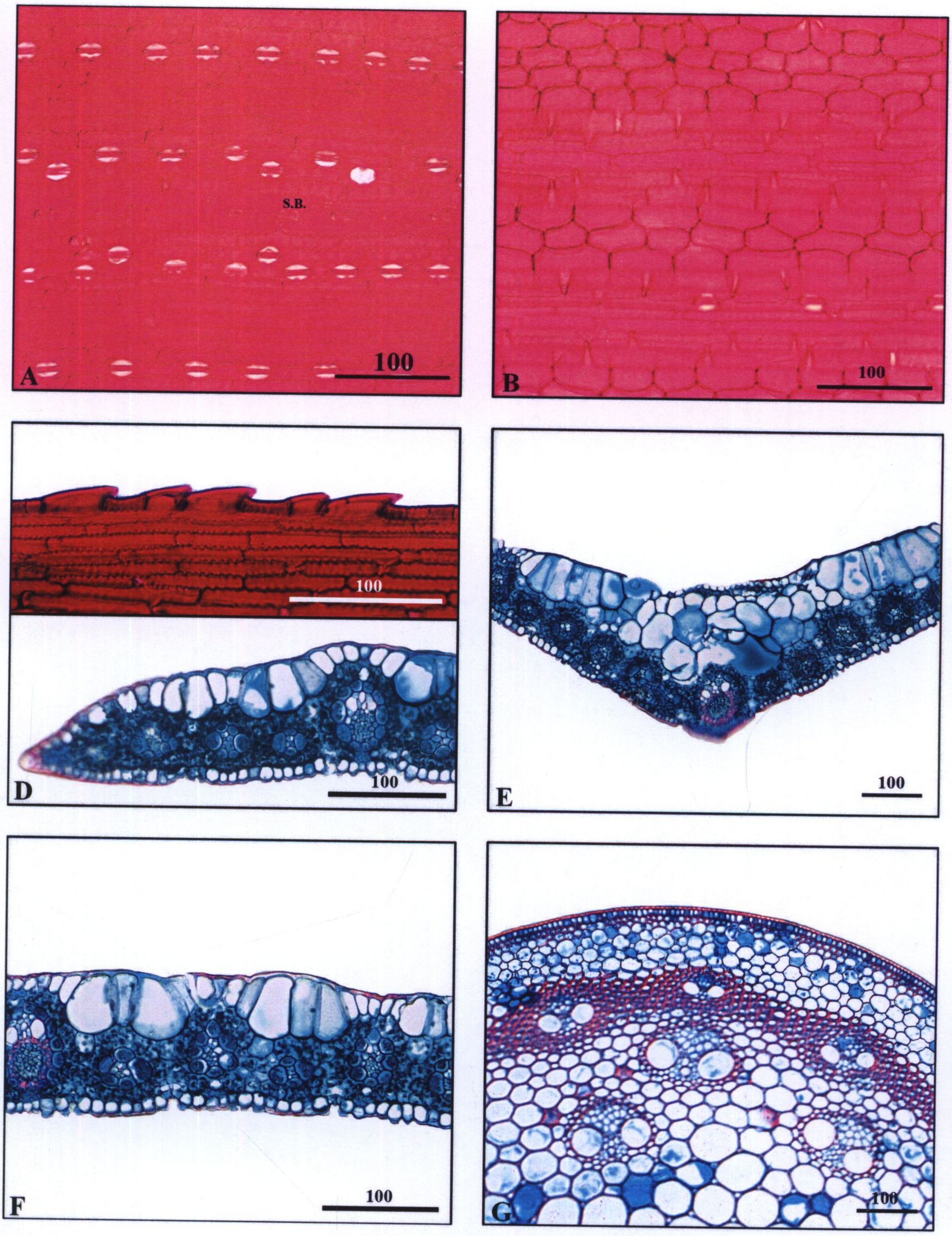

Figure 3.12 Leaf and culm anatomy of *Ischaemum muticum* (*P. Traiperm* 138 and 199): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. (SB=silica bodies) Scale bar in μm.

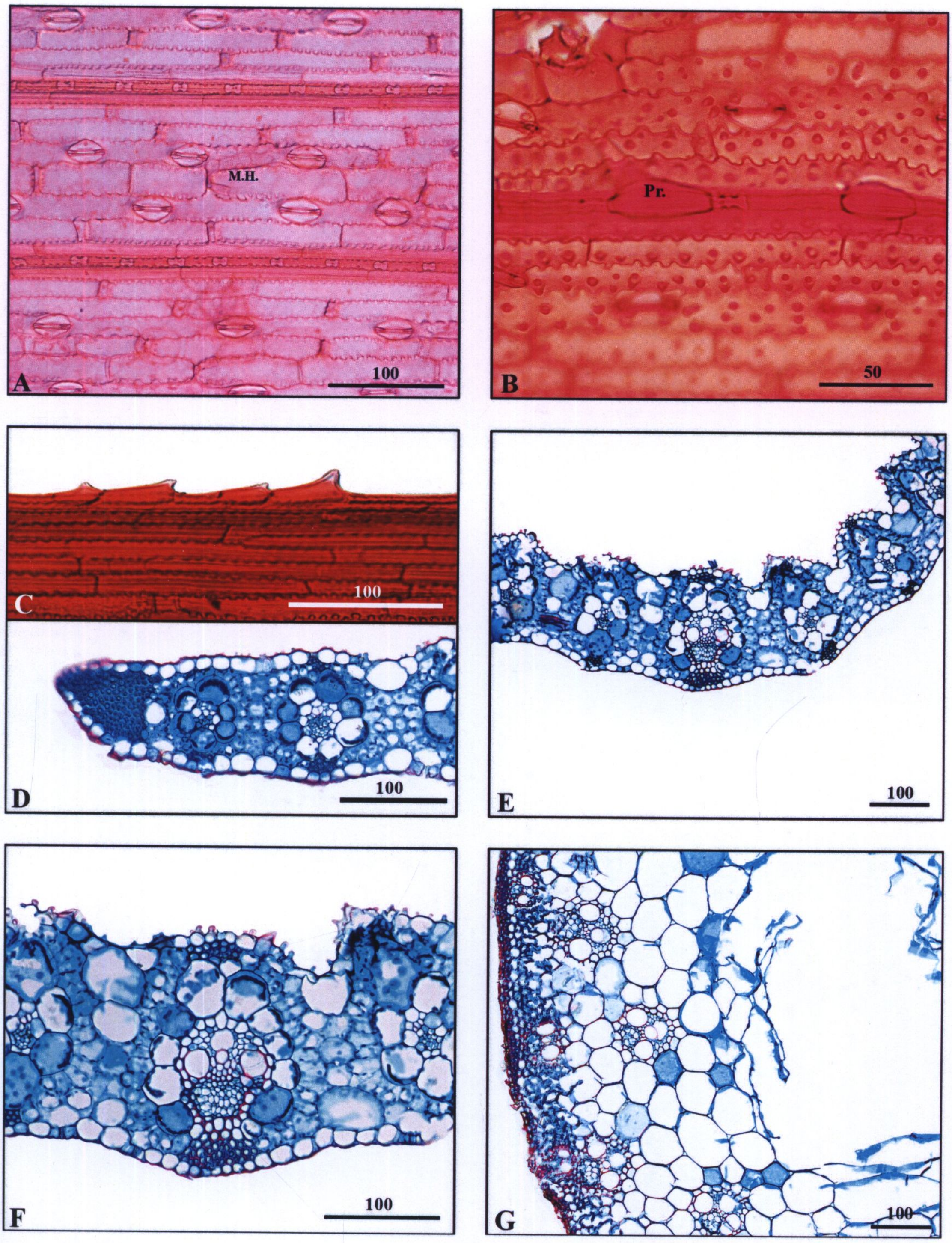

Figure 3.13 Leaf and culm anatomy of *Ischaemum rugosum* (*P. Traiperm* 127 and 293): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. (MH=micro-hairs; Pr=prickles) Scale bar in µm.

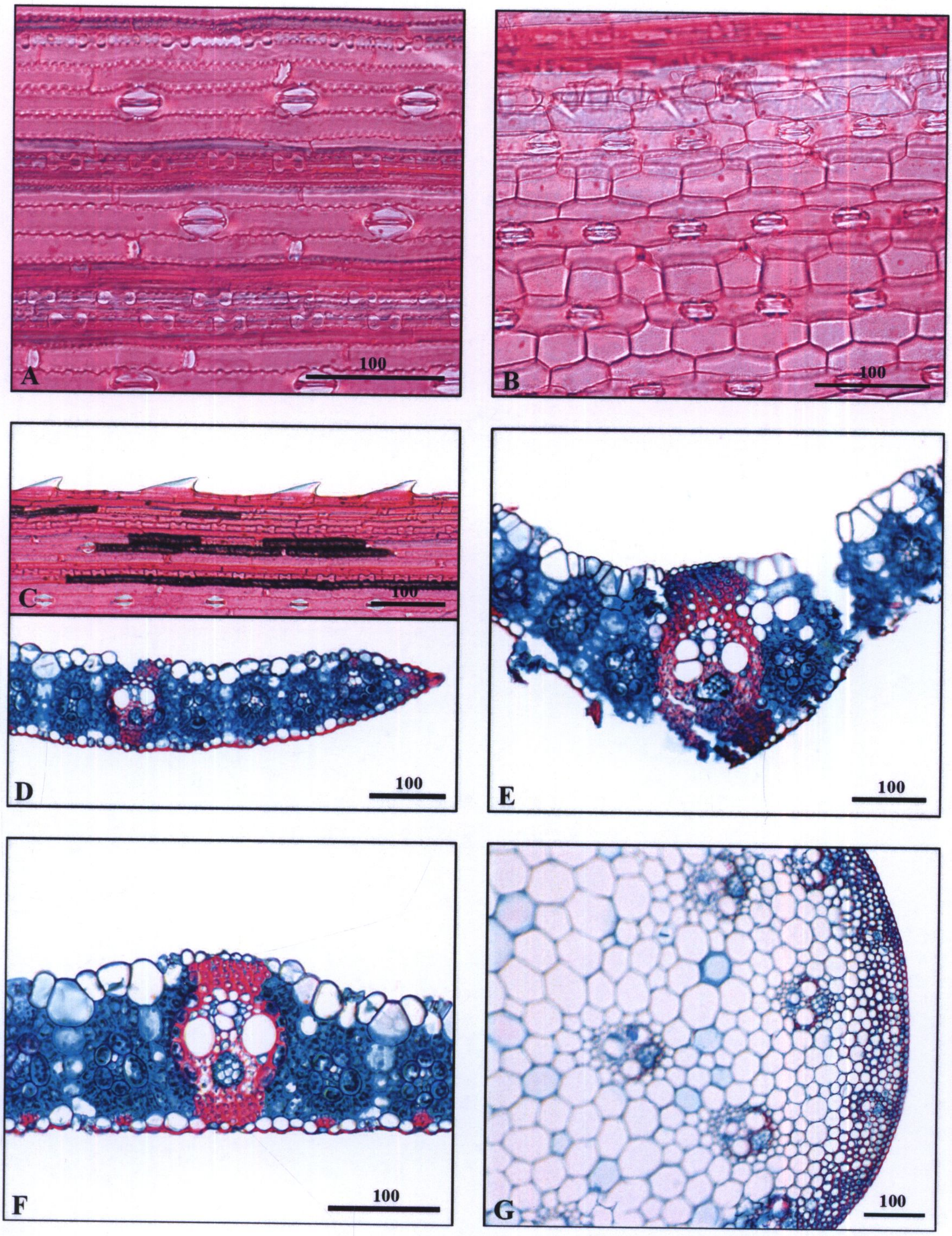

Figure 3.14 Leaf and culm anatomy of *Ischaemum tenuifolium* (*P. Traiperm* 233 and 287): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. Scale bar in μm.

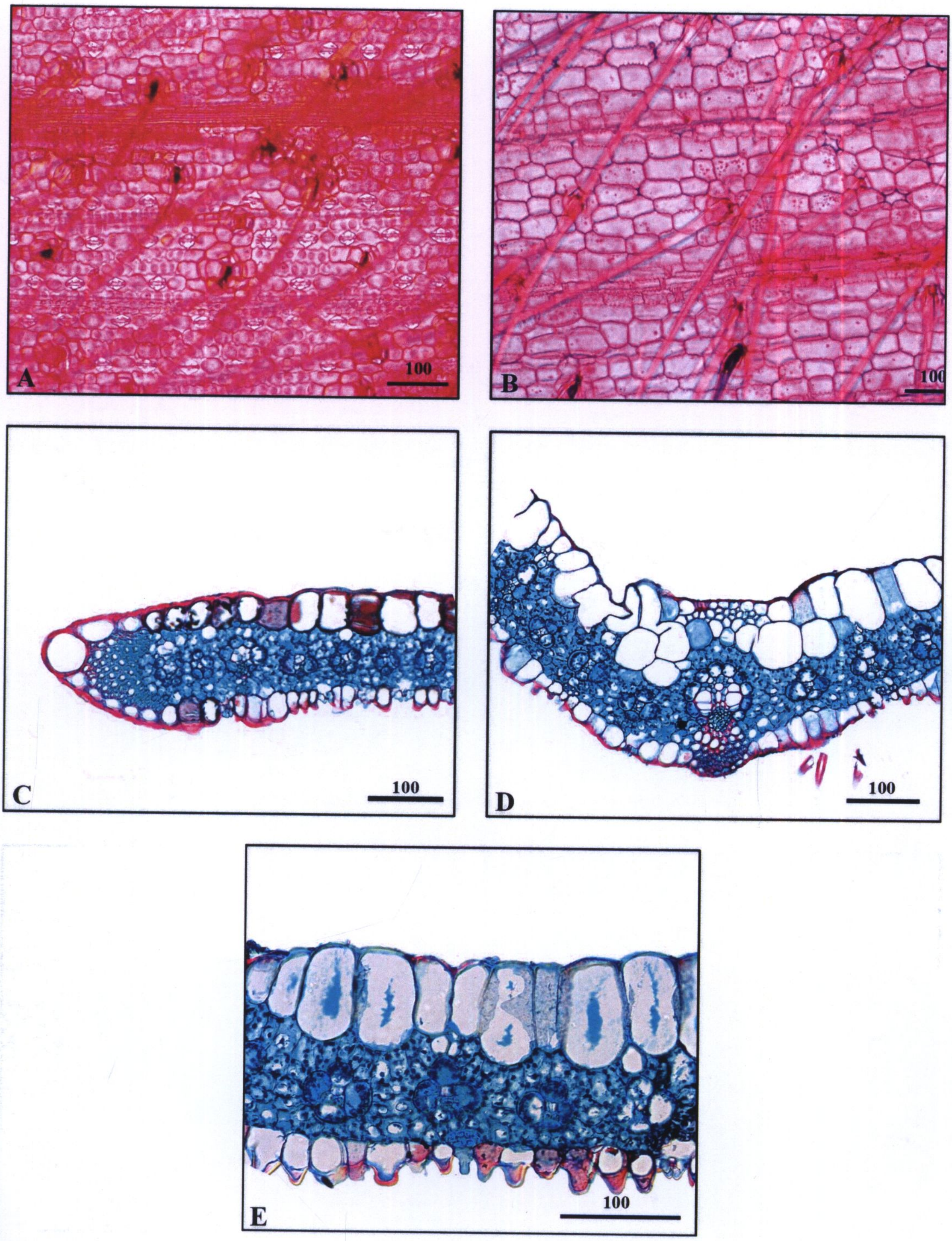

Figure 3.15 Leaf anatomy of *Ischaemum* sp.1 (*P. Traiperm* 327): A. abaxial epidermis, B. adaxial epidermis, C-E. x.s. leaf. Scale bar in μm.

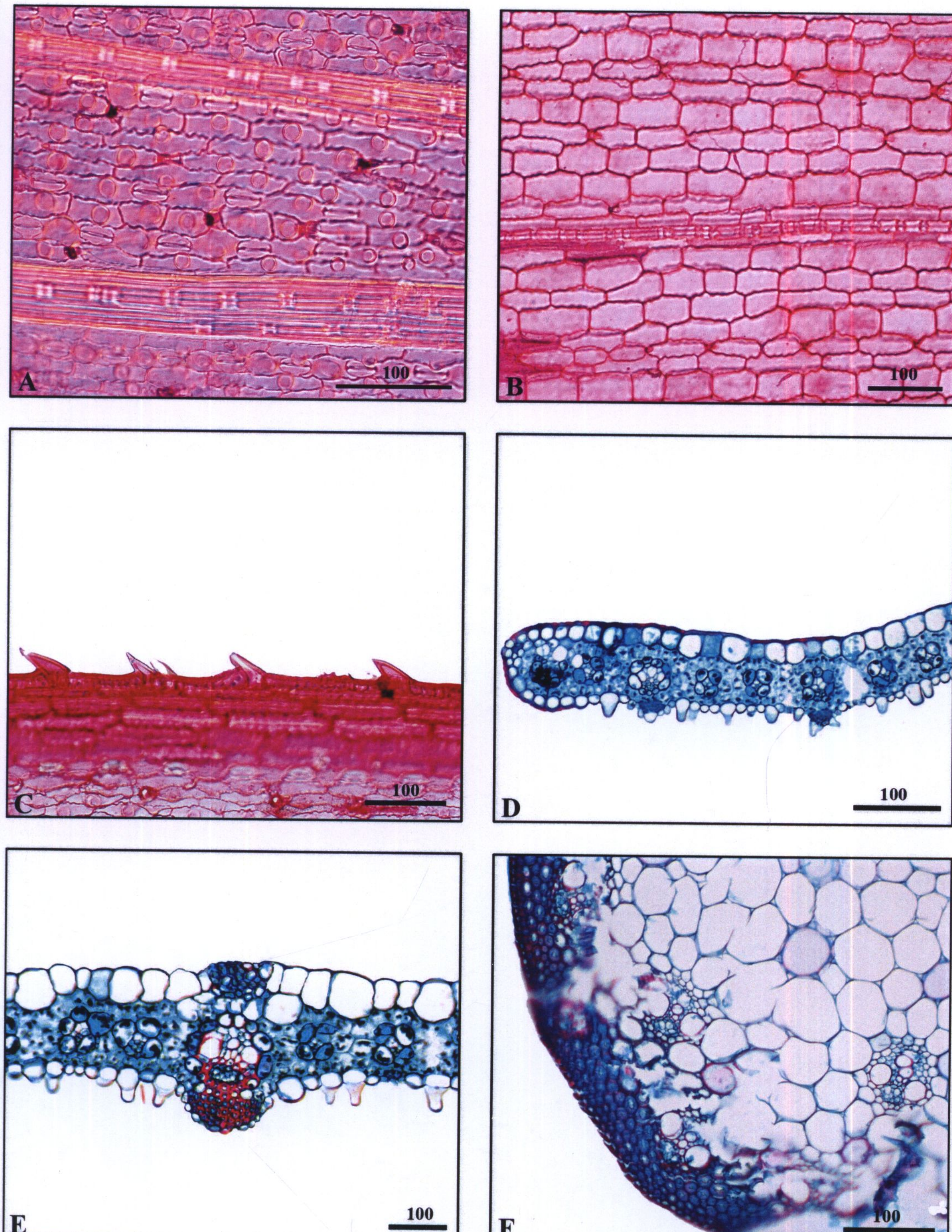

Figure 3.16 Leaf and culm anatomy of *Kerriochloa siamensis* (*P. Traiperm* 235): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-E. x.s. leaf, F. x.s. culm. Scale bar in μm.

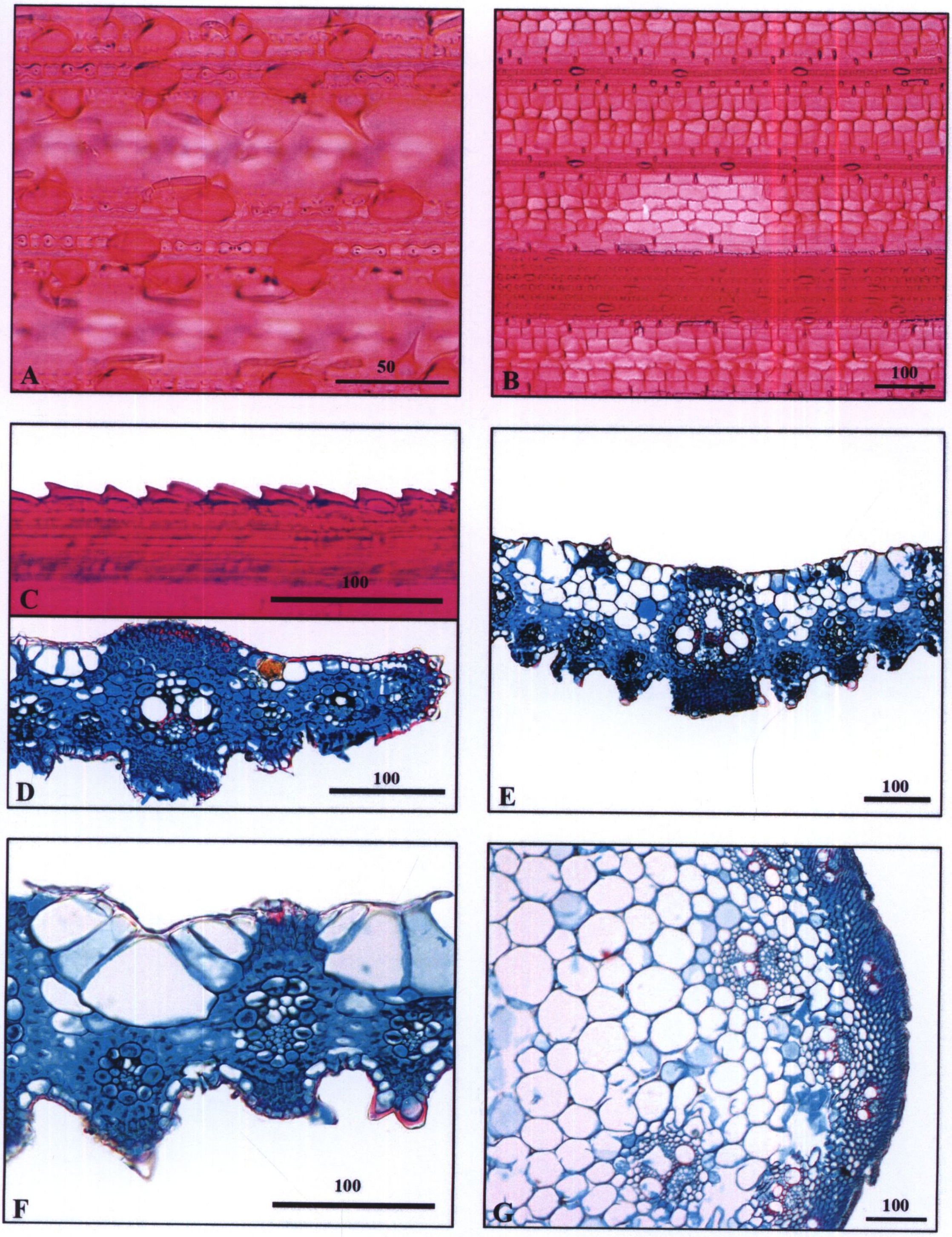

Figure 3.17 Leaf and culm anatomy of *Sehima nervosum* (*P. Traiperm* 170 and 323): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. Scale bar in μm.

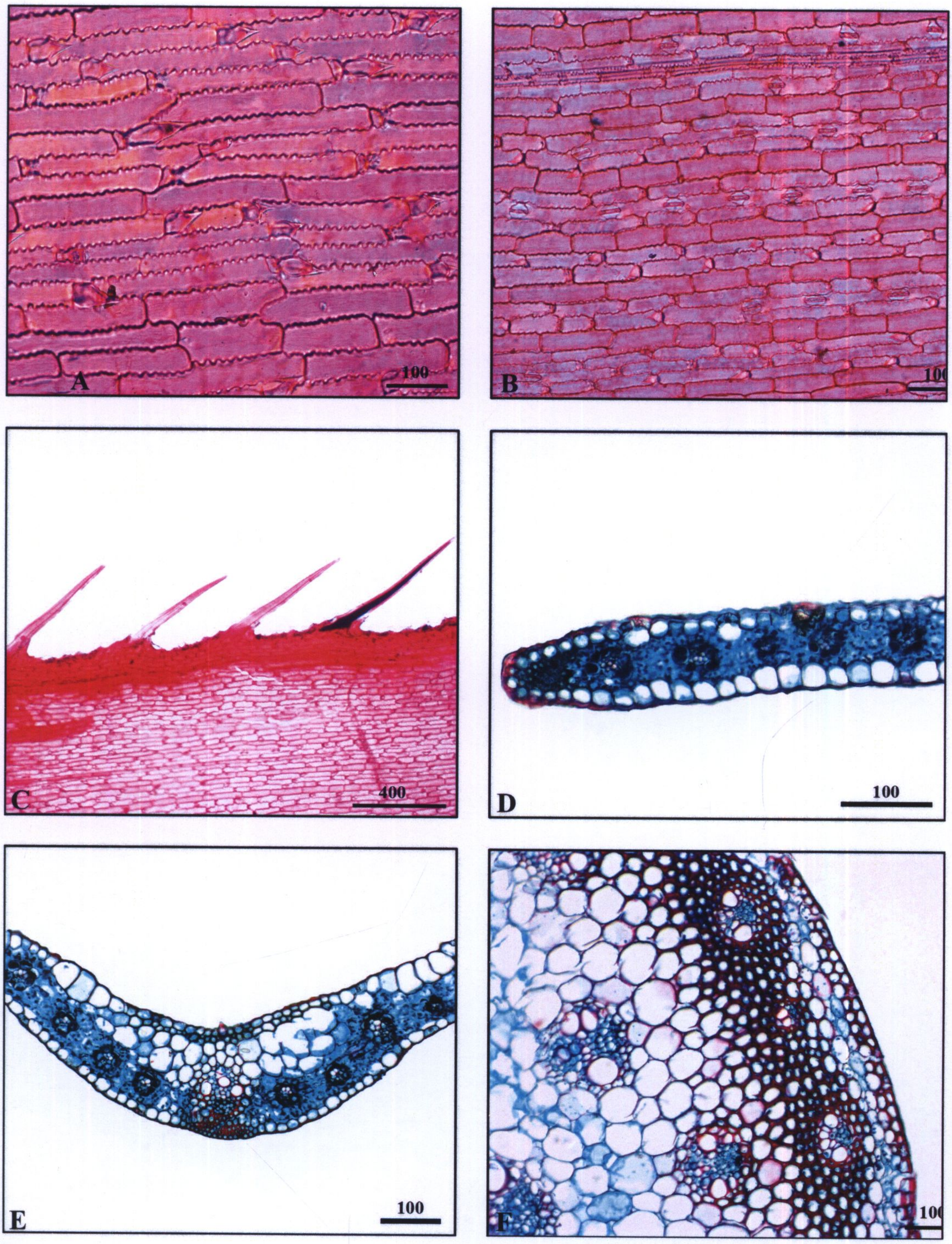

Figure 3.18 Leaf and culm anatomy of *Thelepogon elegans* (*P. Traiperm* 276): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-E. x.s. leaf, F. x.s. culm. Scale bar in μm.

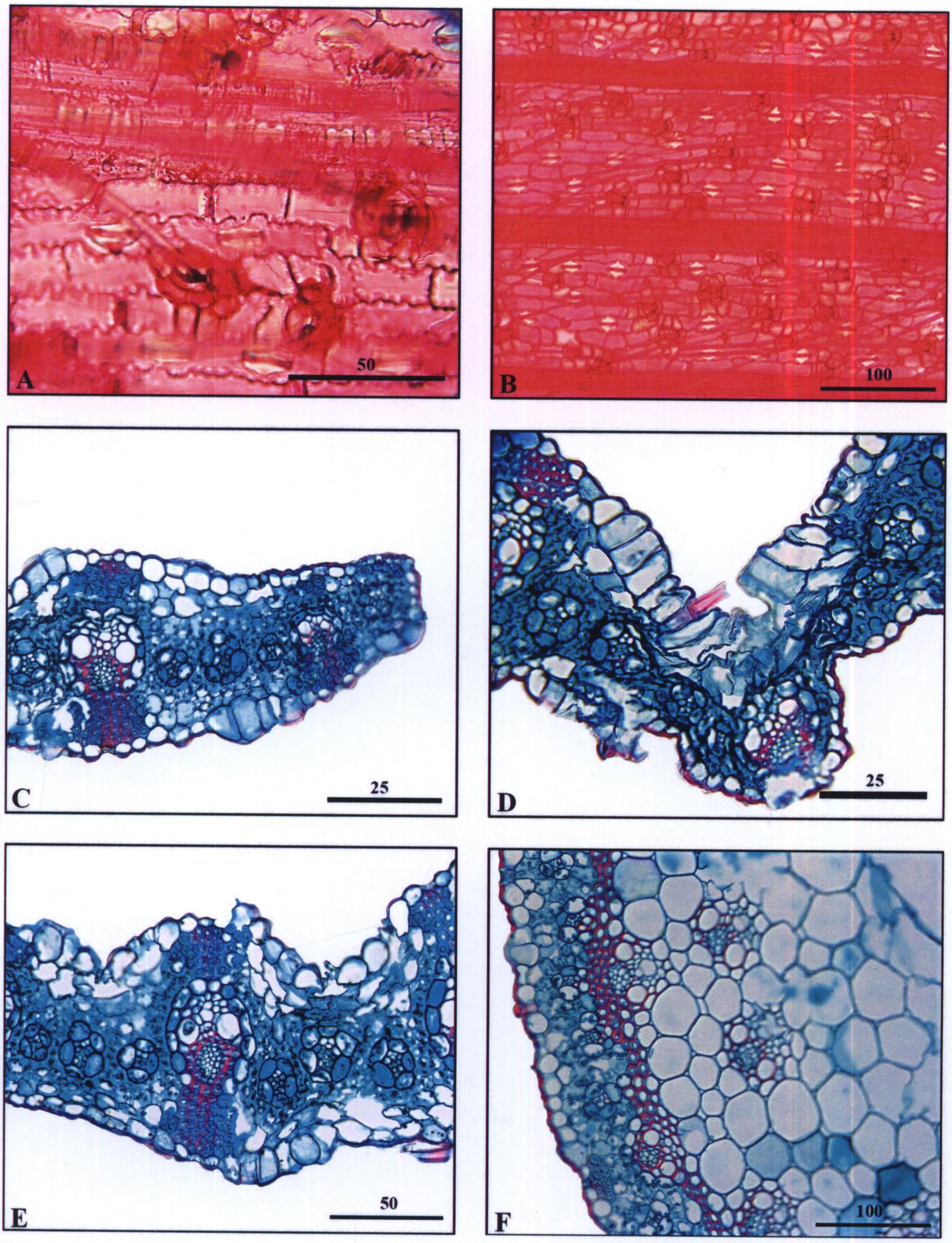

Figure 3.19 Leaf and culm anatomy of *Eremochloa attenuata* (*P. Traiperm* 162): A. abaxial epidermis, B. adaxial epidermis, C-E. x.s. leaf, F. x.s. culm. Scale bar in μm.

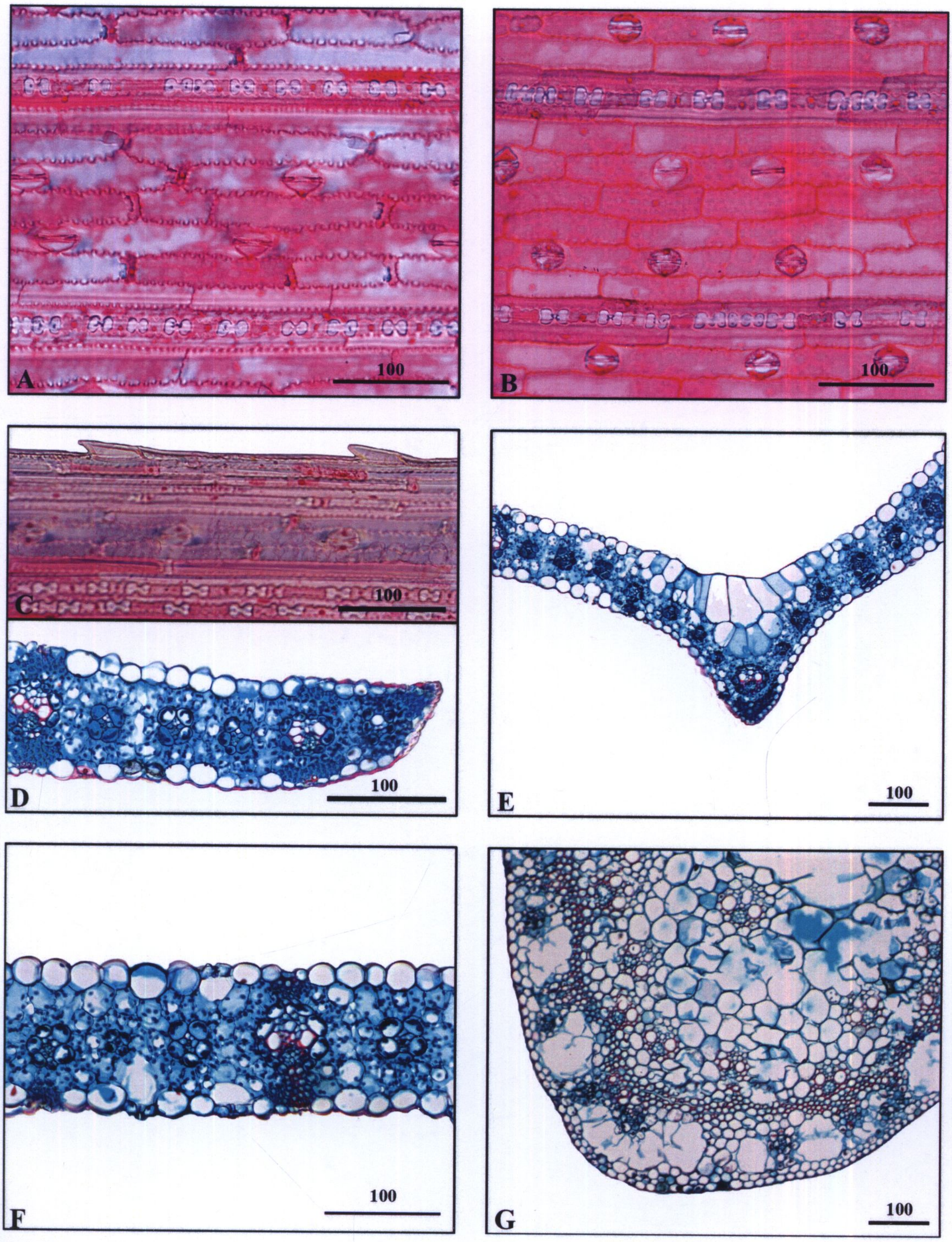

Figure 3.20 Leaf and culm anatomy of *Eremochloa bimaculata* (*P. Traiperm* 116): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. Scale bar in μm.

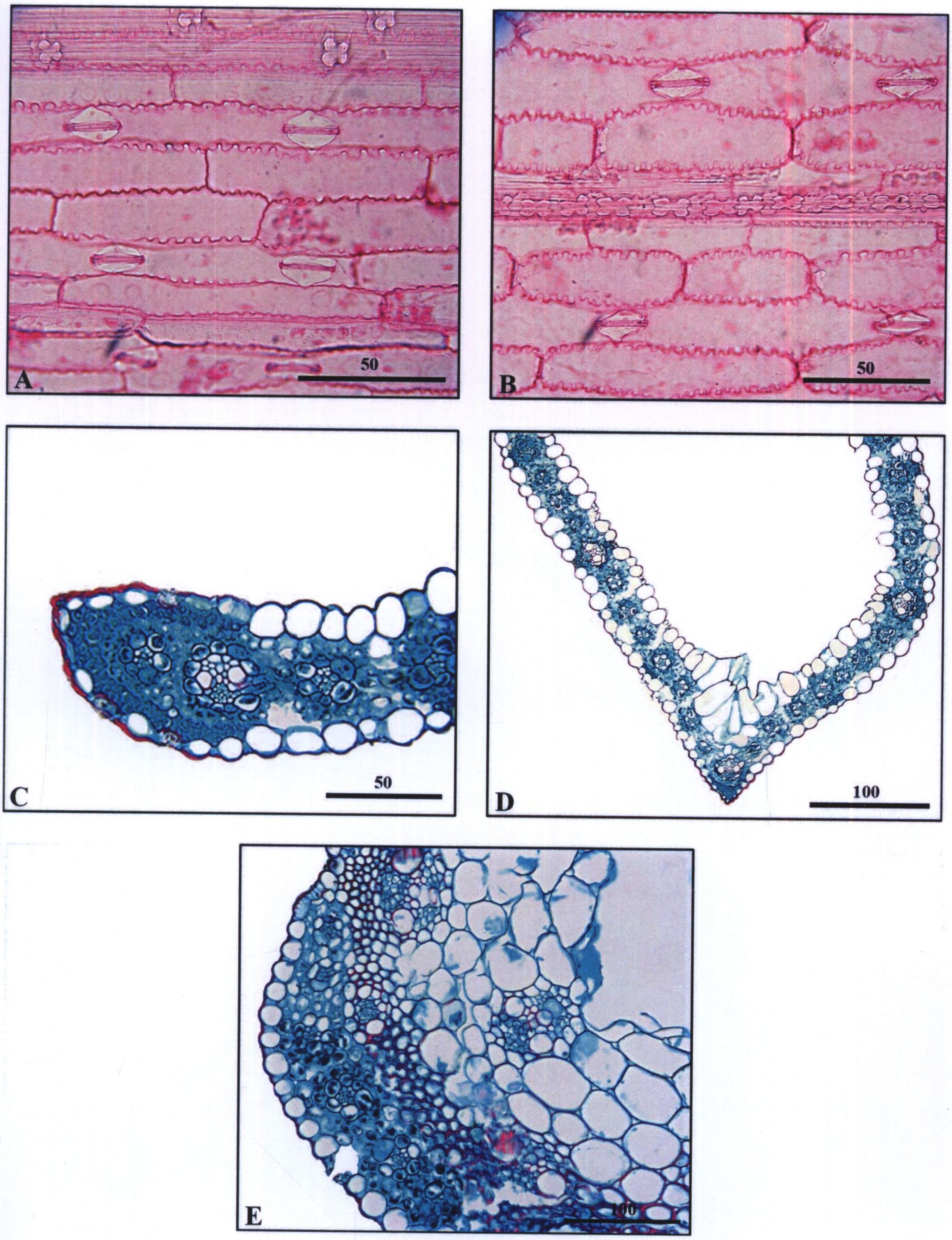

Figure 3.21 Leaf and culm anatomy of *Eremochloa lanceolata* (*P. Traiperm* 242): A. abaxial epidermis, B. adaxial epidermis, C-D. x.s. leaf, E. x.s. culm. Scale bar in μm.

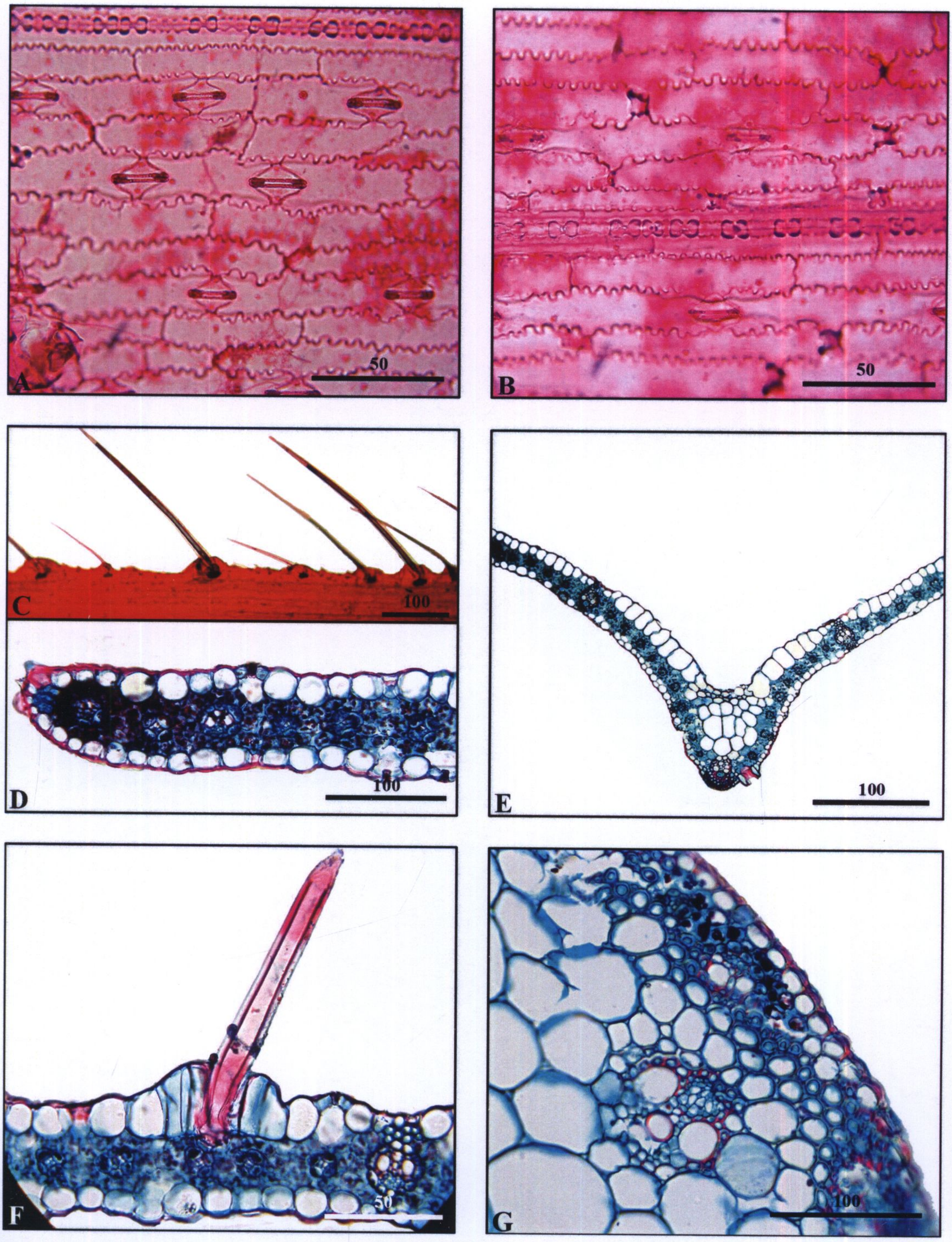

Figure 3.22 Leaf and culm anatomy of *Hackelochloa granularis* (*P. Traiperm* 303): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. Scale bar in μm.

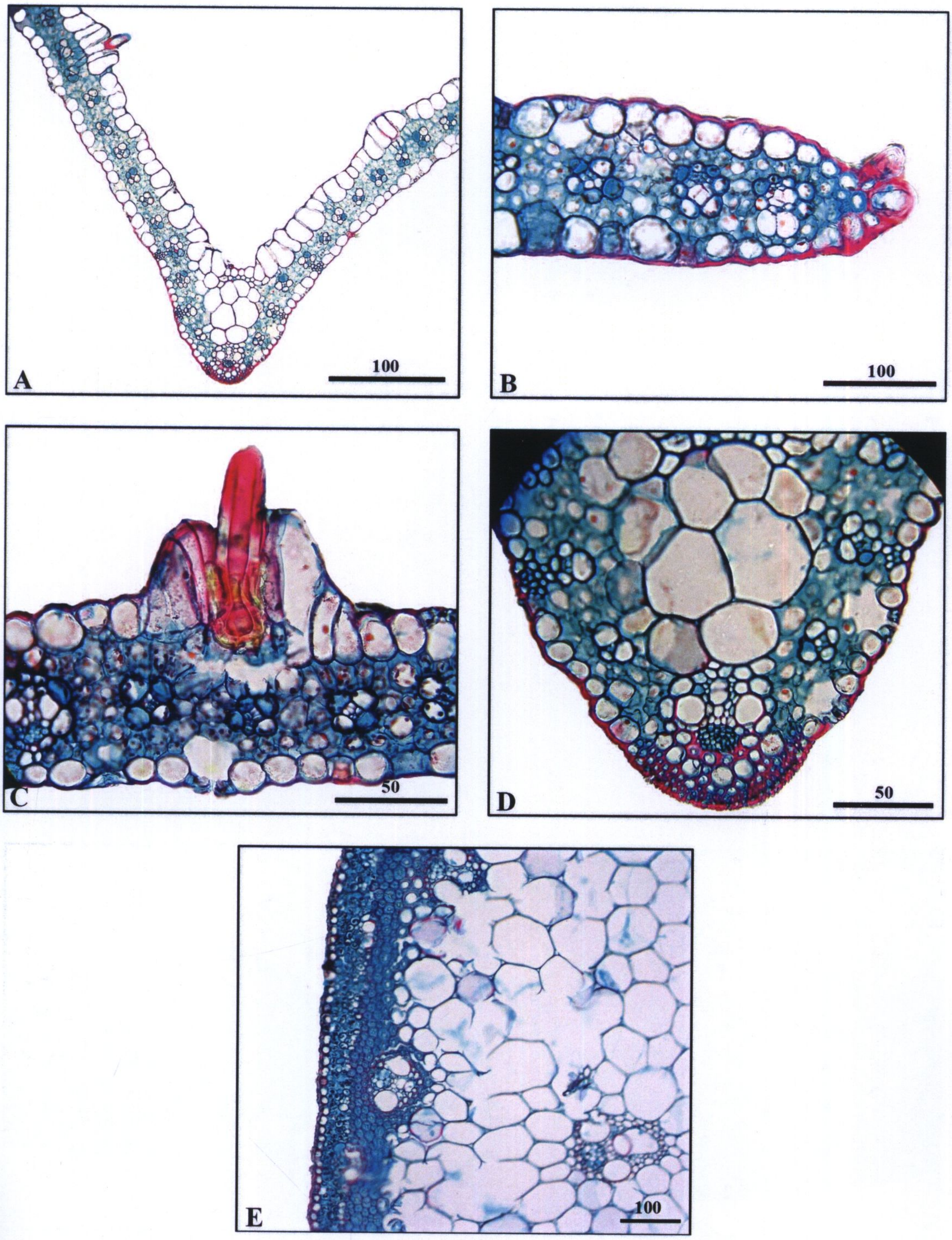

Figure 3.23 Leaf and culm anatomy of *Hackelochloa porifera* (*P. Traiperm* 311): A-D. x.s. leaf, E. x.s. culm. Scale bar in µm.

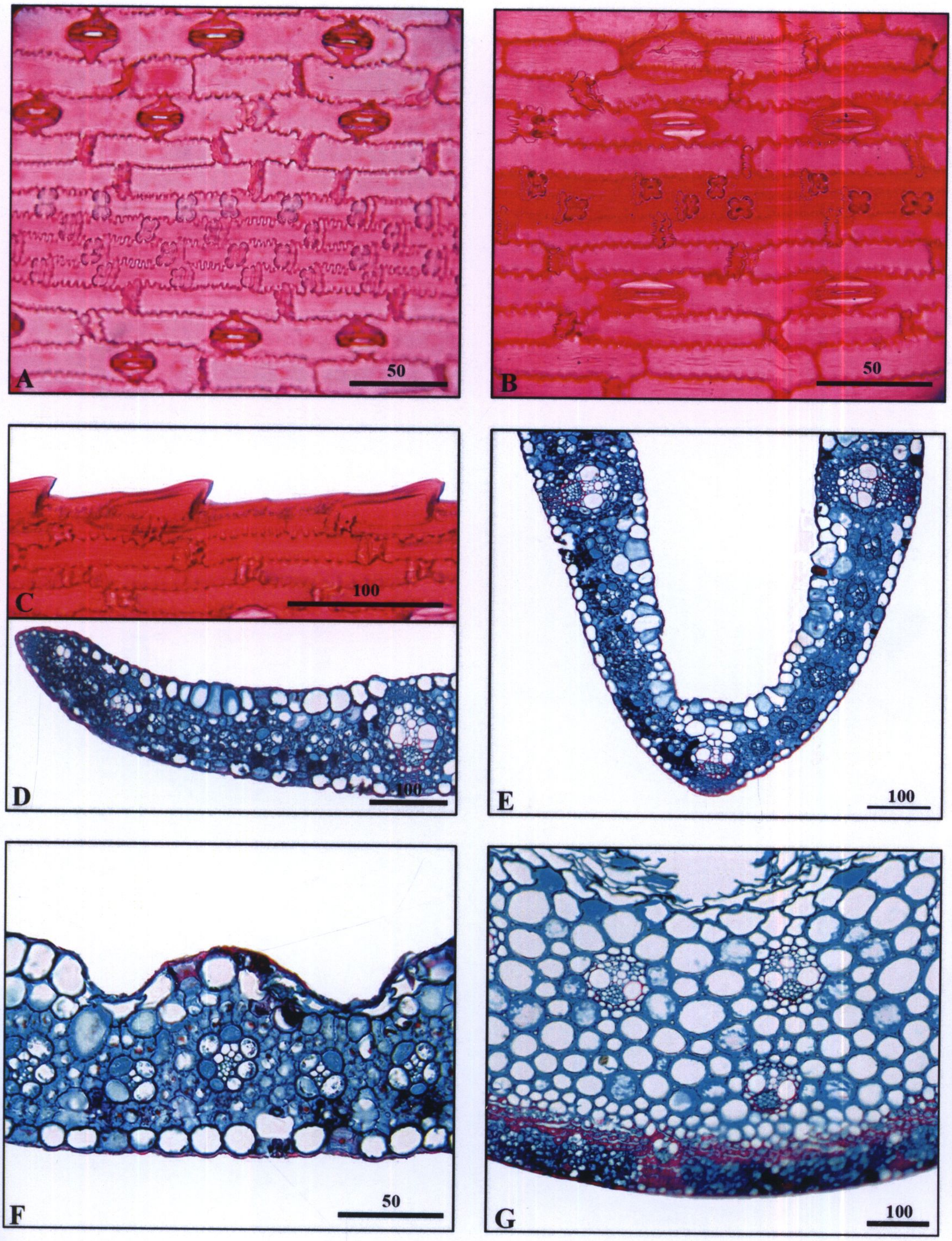

Figure 3.24 Leaf and culm anatomy of *Hemarthria compressa* (*P. Traiperm* 187): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. Scale bar in μm.

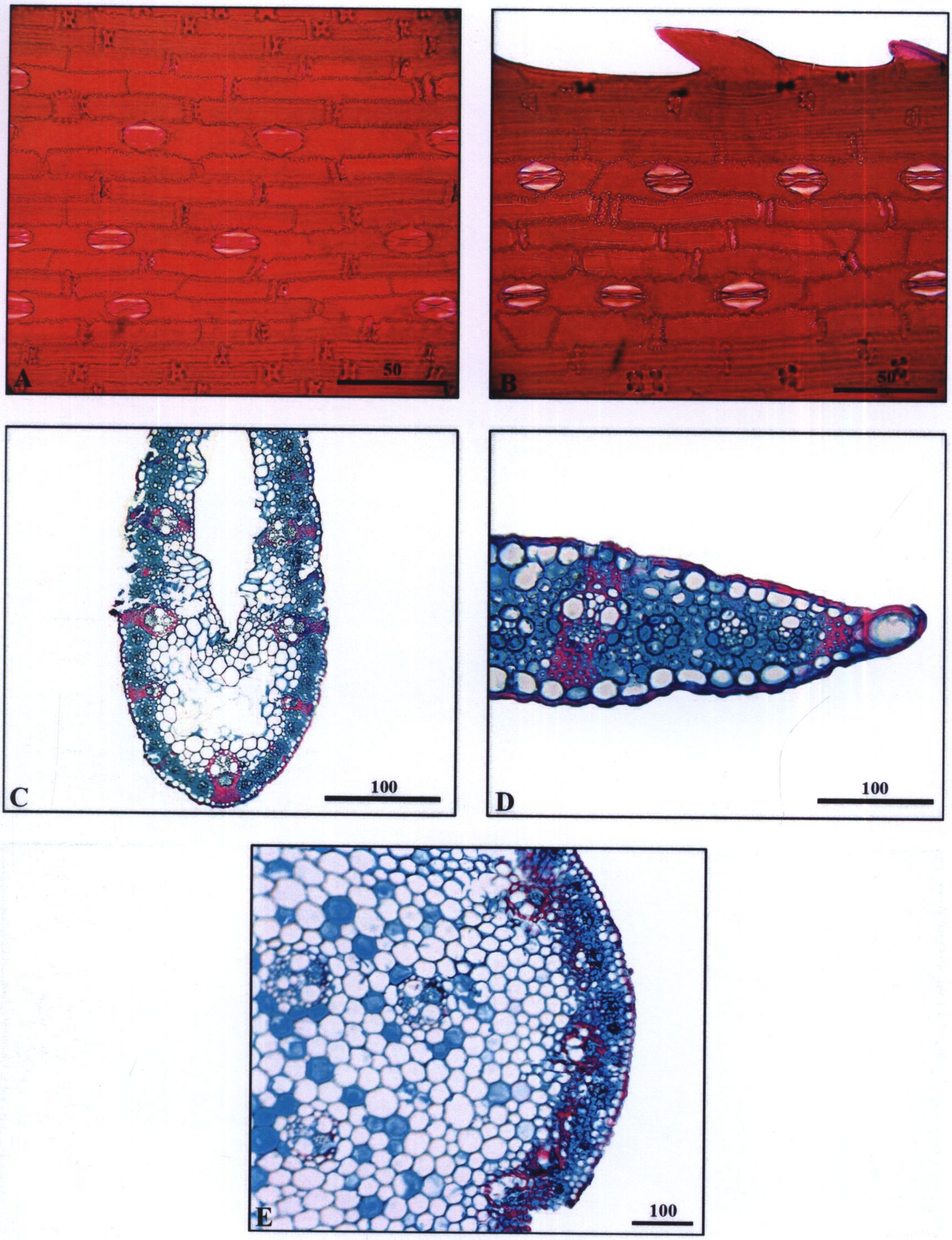

Figure 3.25 Leaf and culm anatomy of *Hemarthria pratensis* (*P. Traiperm* 158): A. abaxial epidermis, B. adaxial epidermis, C-D. x.s. leaf, E. x.s. culm. Scale bar in μm.

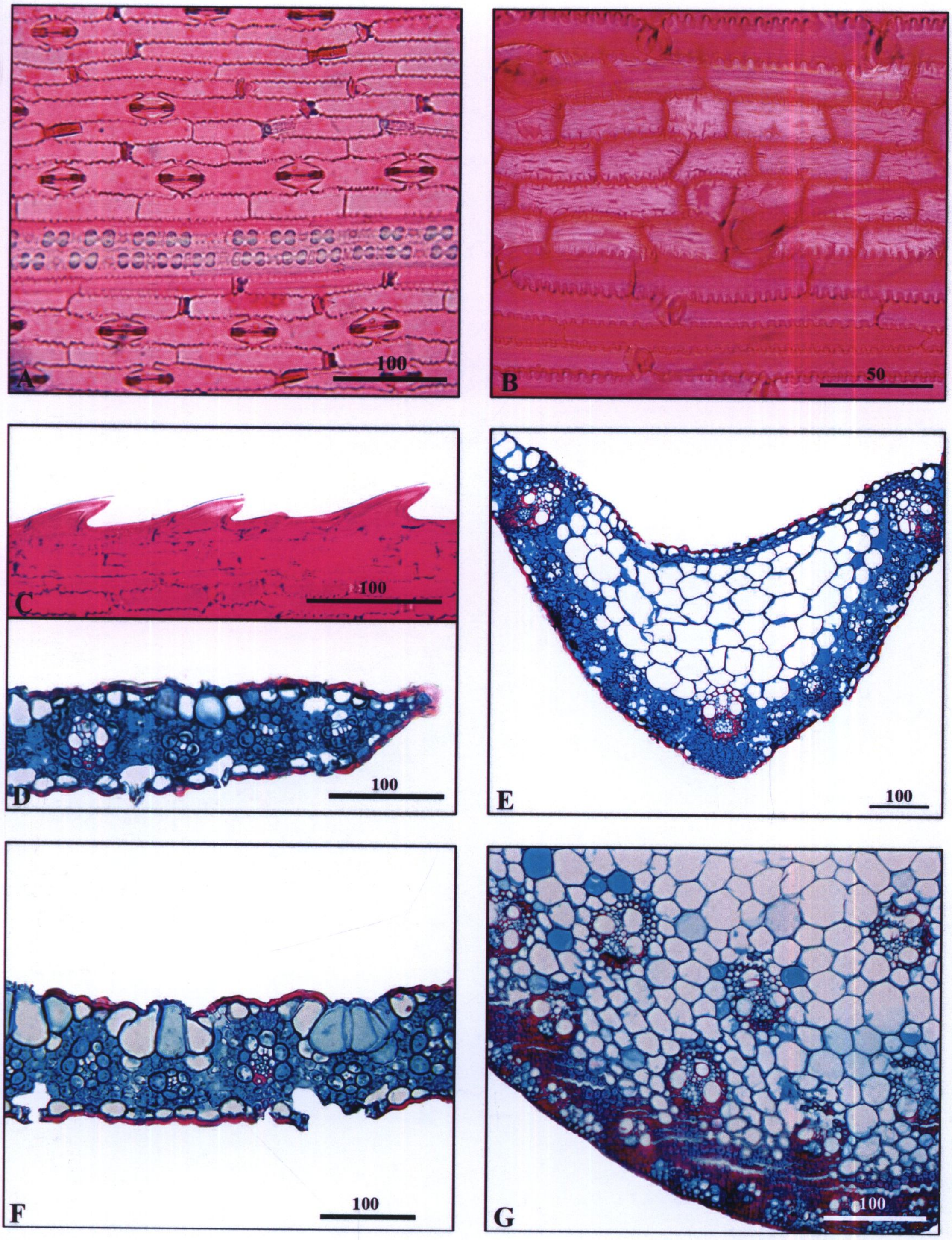

Figure 3.26 Leaf and culm anatomy of *Mnesithea cancellata* (*P. Traiperm* 161 and 183): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. Scale bar in µm.

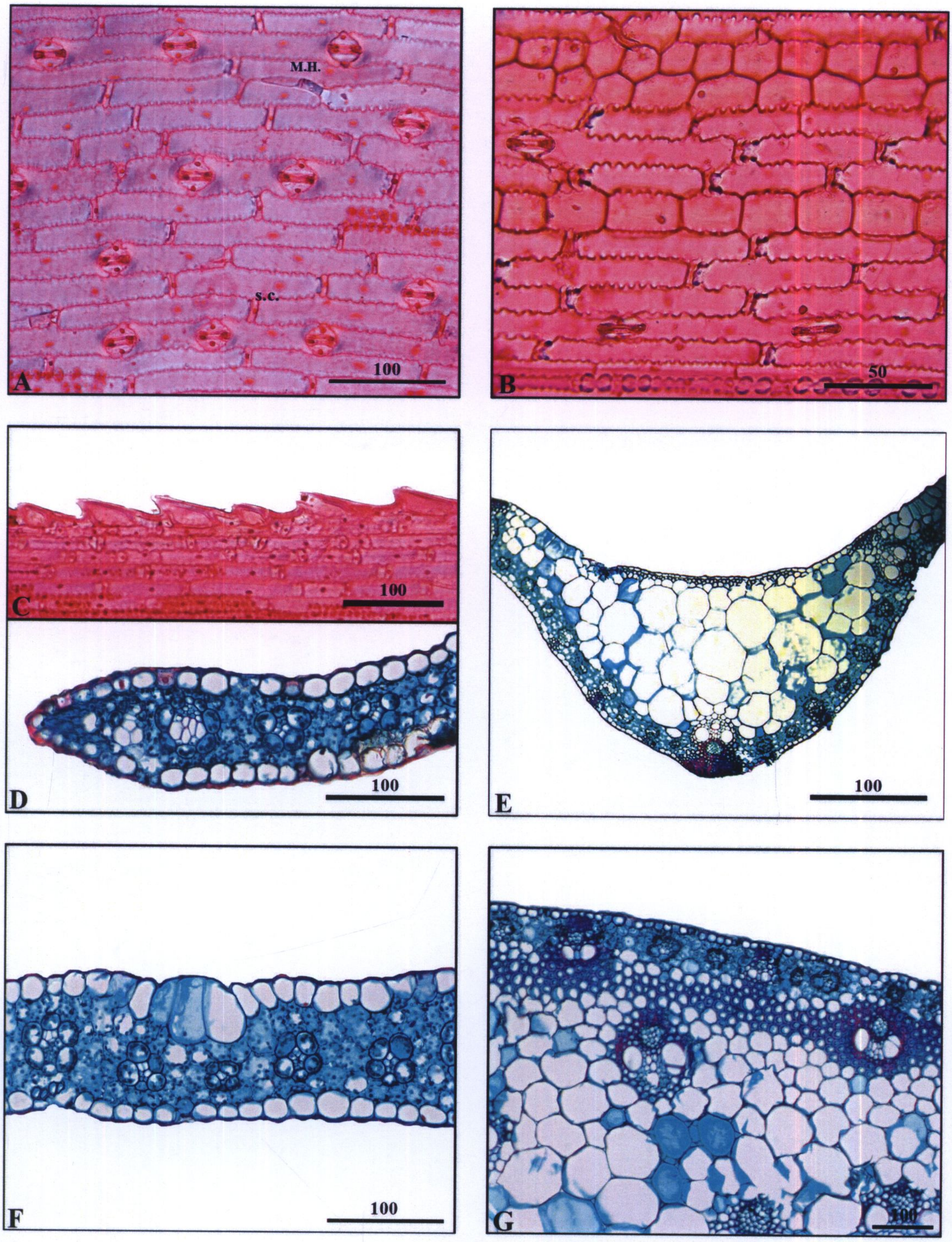

Figure 3.27 Leaf and culm anatomy of *Mnesithea glandulosa* (*P. Traiperm* 139): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. (MH=micro-hairs; sc=short cells) Scale bar in μm.

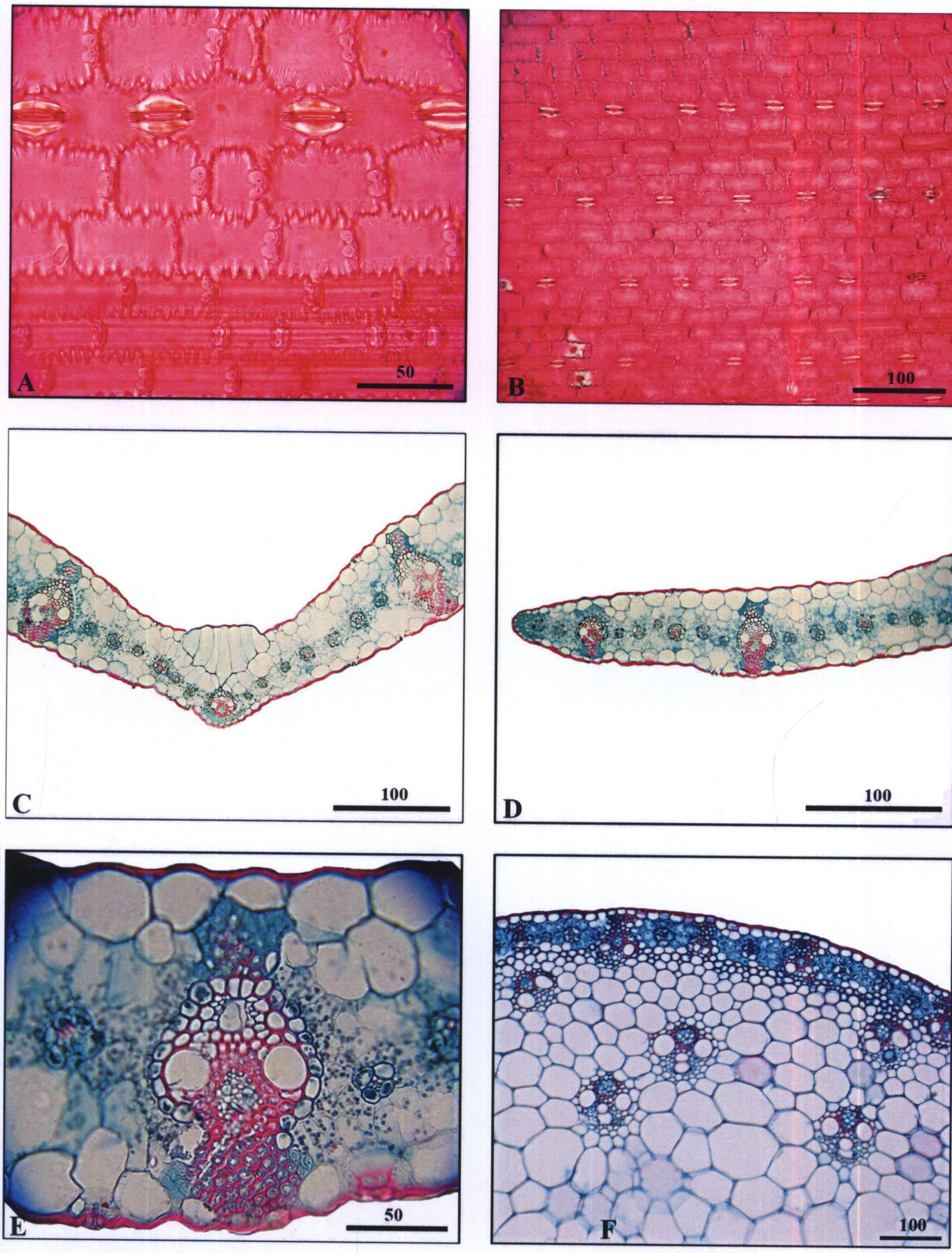

Figure 3.28 Leaf and culm anatomy of *Mnesithea laevis* (*P. Traiperm* 307): A. abaxial epidermis, B. adaxial epidermis, C-D. x.s. leaf, E. x.s. culm. Scale bar in μm.

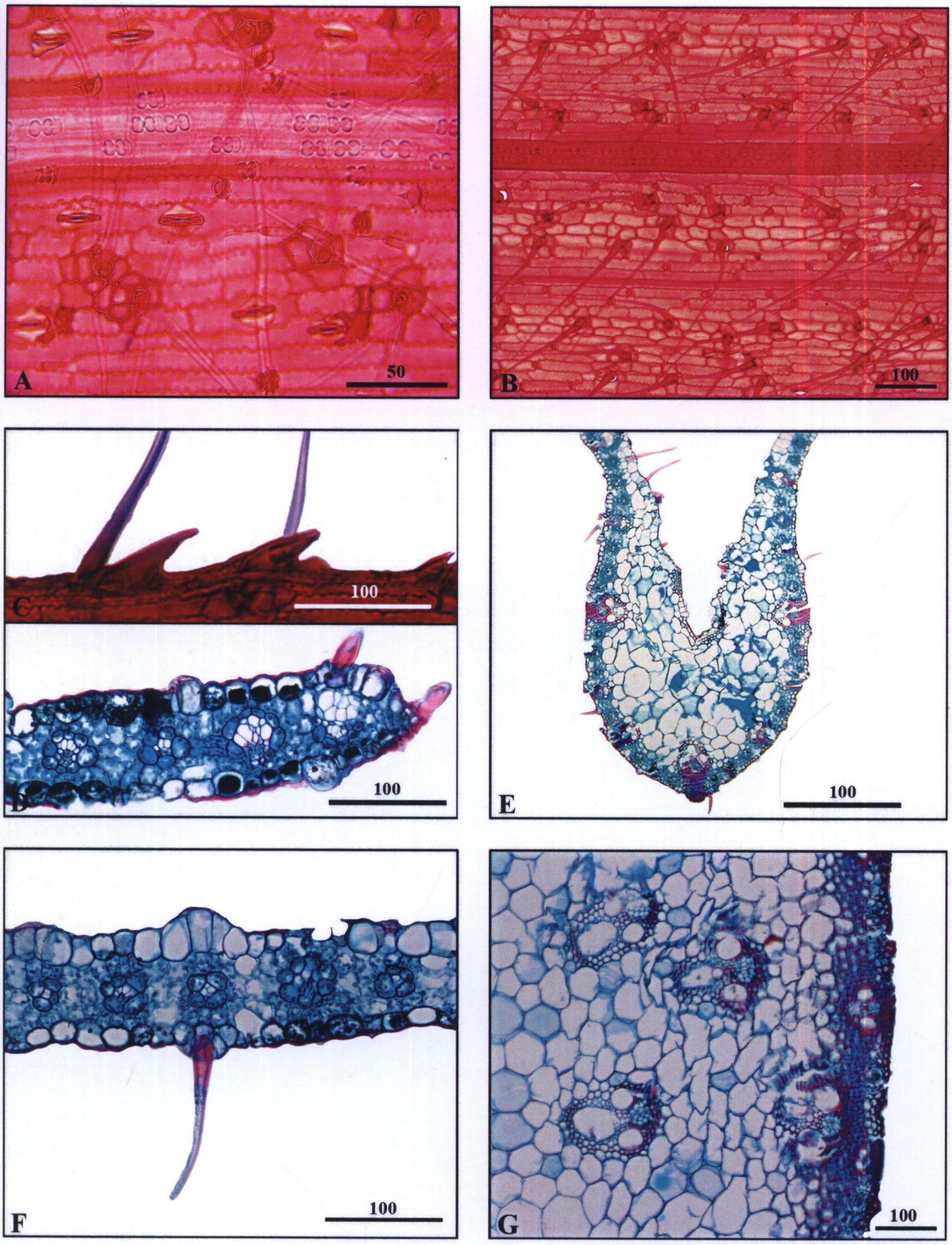

Figure 3.29 Leaf and culm anatomy of *Mnesithea mollicoma* (*P. Traiperm* 131): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf, G. x.s. culm. Scale bar in μm.

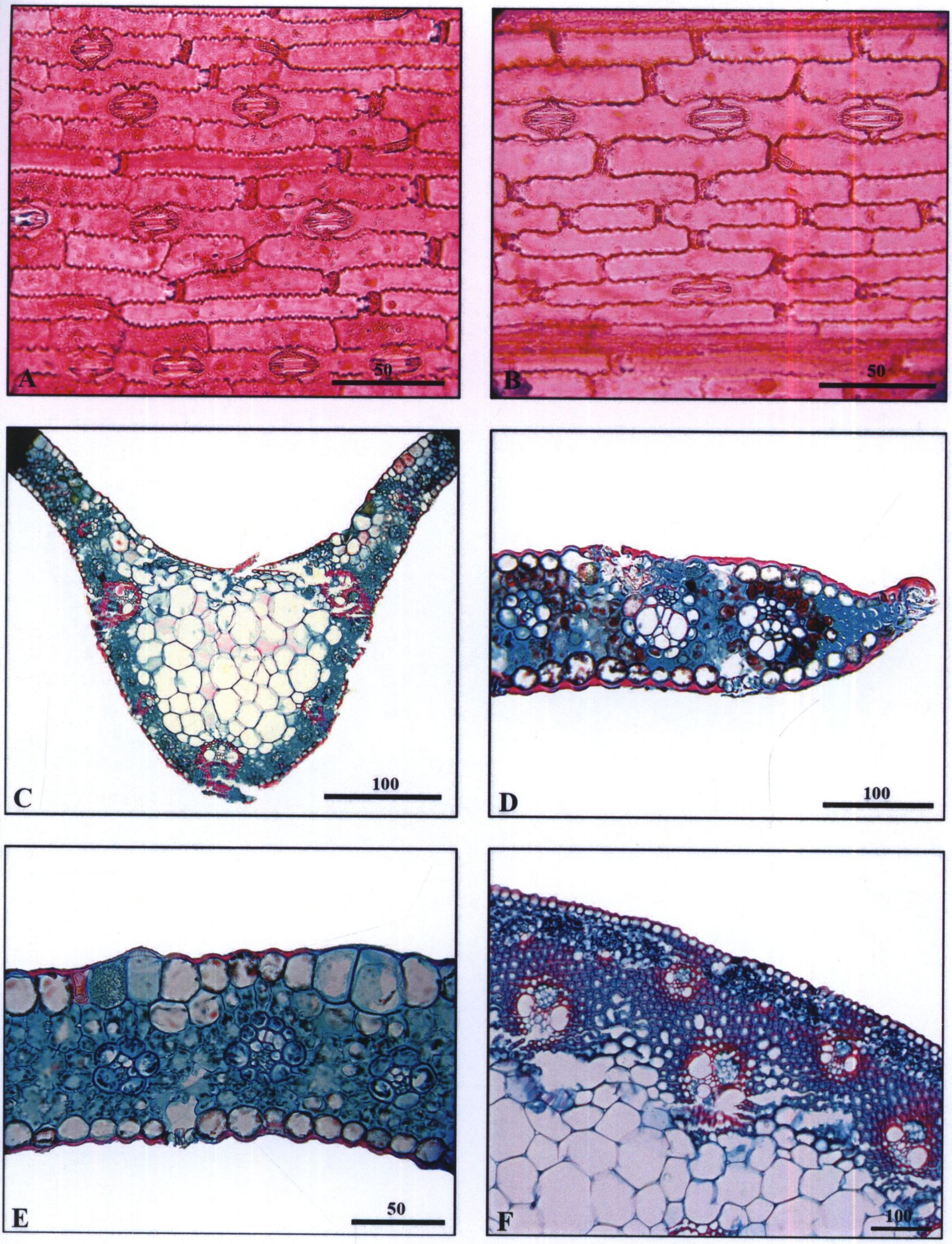

Figure 3.30 Leaf and culm anatomy of *Mnesithea* sp.1 (*P. Traiperm* 347): A. abaxial epidermis, B. adaxial epidermis, C-E. x.s. leaf, F. x.s. culm. Scale bar in μm.

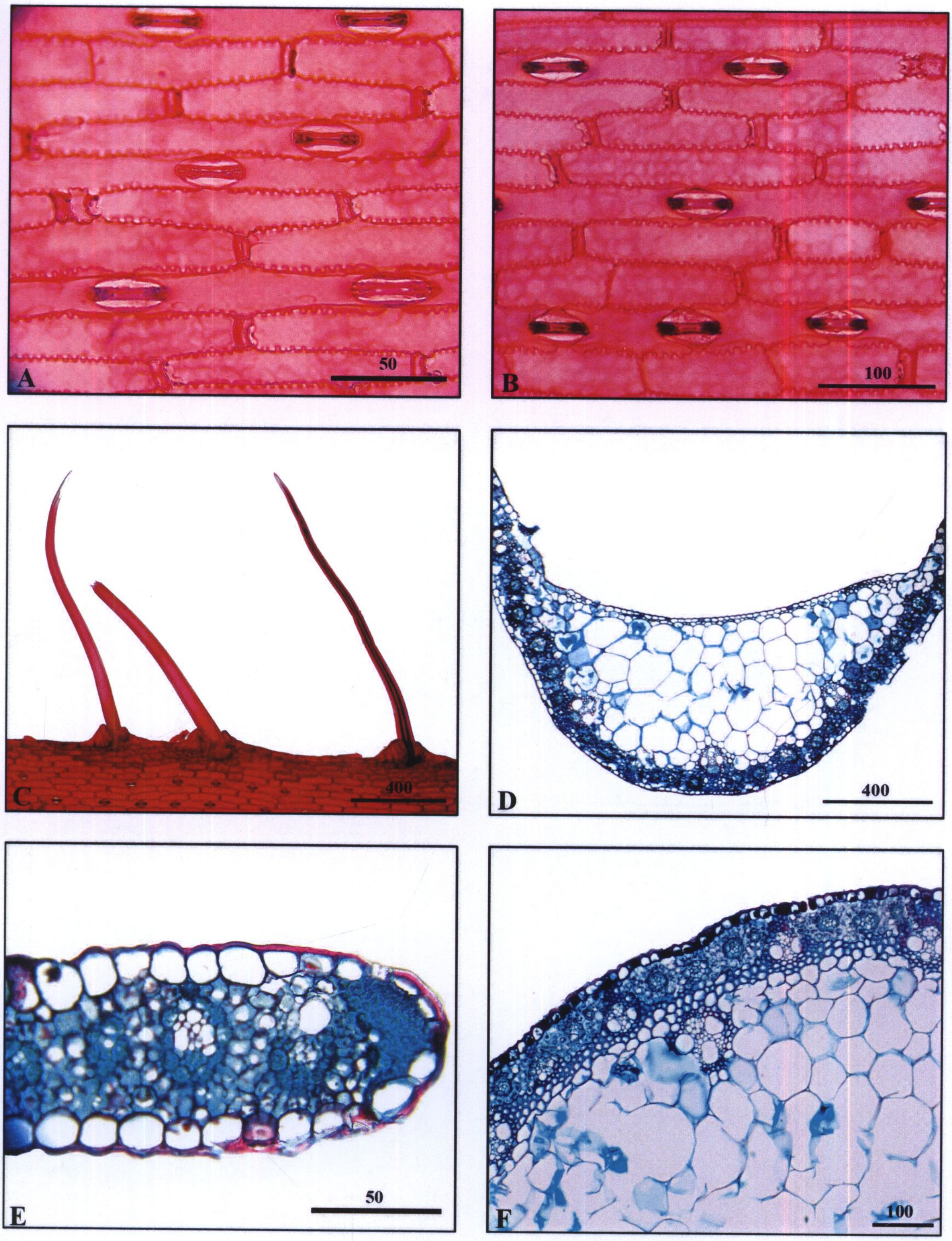

Figure 3.31 Leaf and culm anatomy of *Ophiuros exaltatus* (*P. Traiperm* 186): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-E. x.s. leaf, F. x.s. culm. Scale bar in µm.

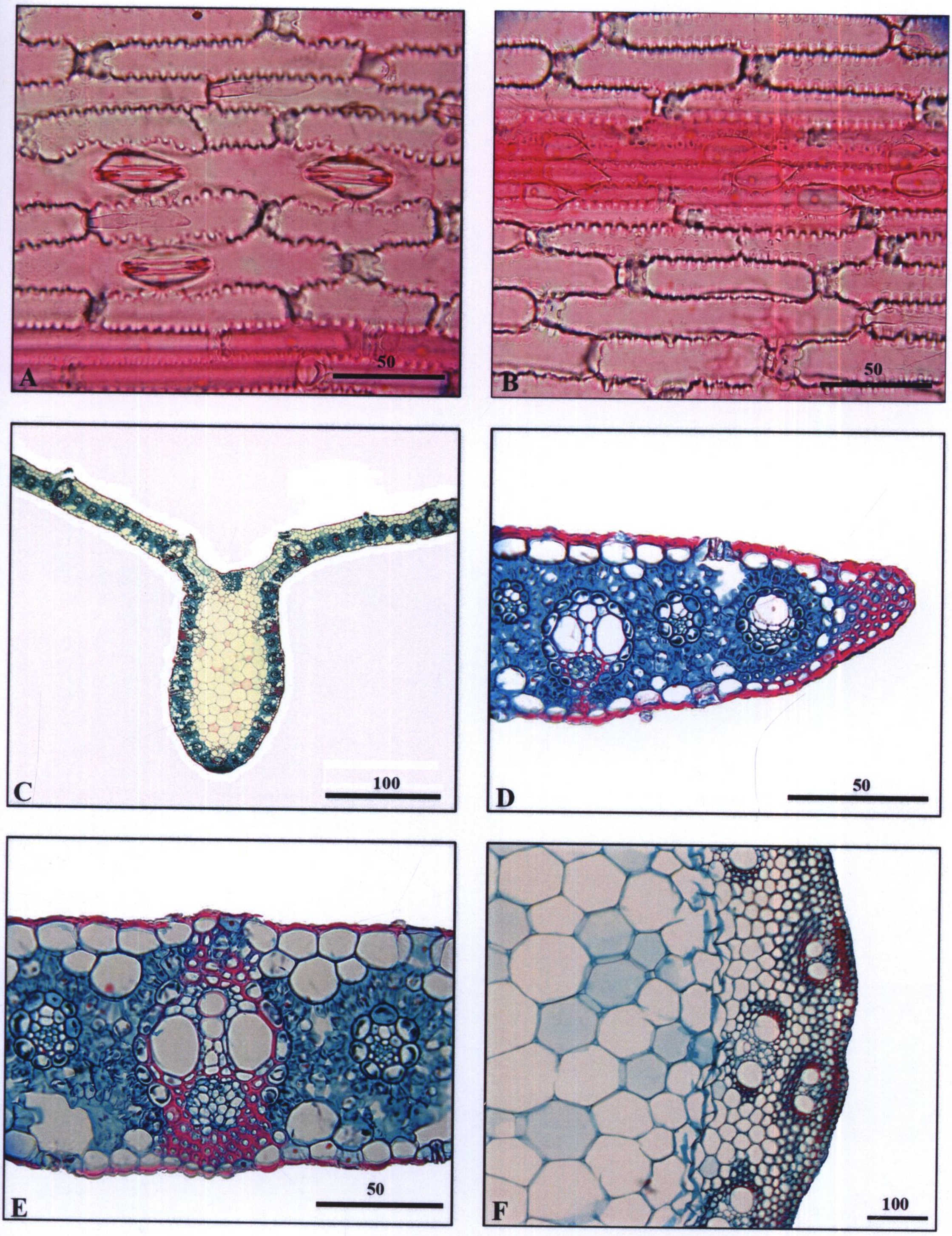

Figure 3.32 Leaf and culm anatomy of *Phacelurus zea* (*P. Traiperm* 222): A. abaxial epidermis, B. adaxial epidermis, C-E. x.s. leaf, F. x.s. culm. Scale bar in µm.

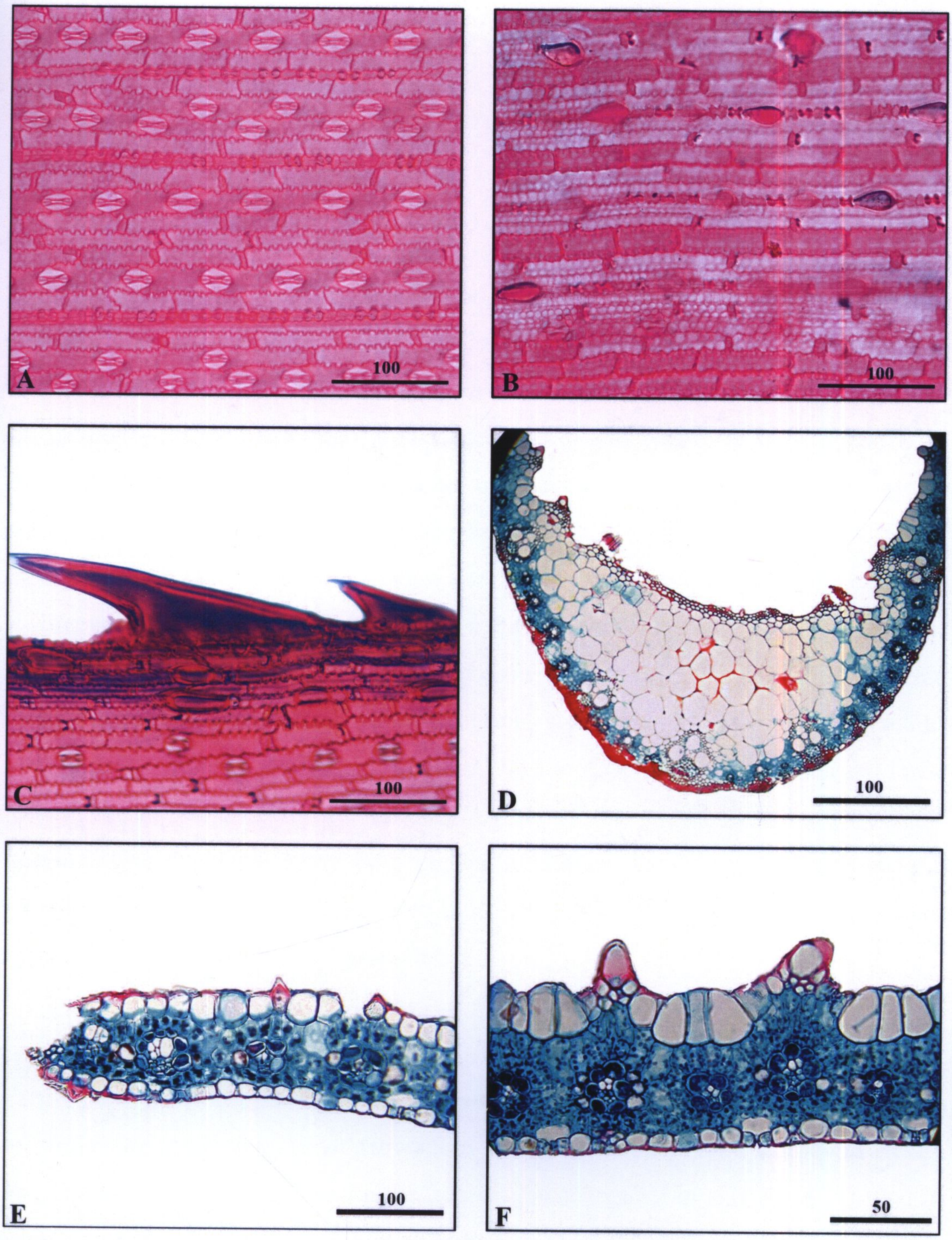

Figure 3.33 Leaf anatomy of *Rottboellia cochinchinensis* (*P. Traiperm* 133): A. abaxial epidermis, B. adaxial epidermis, C. leaf margin, D-F. x.s. leaf. Scale bar in μm.

CHAPTER IV

MOLECULAR STUDY

4.1 Introduction

Molecular data have had a profound impact on the field in plant systematics. Previously, the majority of data used in plant molecular phylogenetic studies mostly derives from chloroplast DNA and nuclear rDNA (Small et al., 2004). Phylogenetic reconstruction in the grass family, Poaceae have ongoing early in this century with proposed evolutionary hypotheses based on assessment of existing knowledge of grasses (e.g. Bew, 1929; Hubbard, 1948; Prat, 1960; Stebbins, 1956, 1982; Clayton, 1981; Tsvelev, 1983). Recently, molecular information has provided the basis for phylogenetic hypotheses in grasses at the subfamily and tribe levels. DNA sequence data are now commonly used to resolve problems which taxonomists have different opinion on relationships when using traditional characters. These molecular studies were based on information from chloroplast DNA (cpDNA) restriction sites and DNA sequencing of the *trn*L-F and the ITS region of the subtribes Ischaeminae and Rottboelliinae that have never been conducted earlier. Therefore, the analyses will provide the DNA sequence data of both subtribes in Thailand, which can be serve as a basis for further work in grass systematic.

4.1.1 Chloroplast genome

Noncoding sequences of the chloroplast genome are a primary source of data for molecular systematic, phylogeographic, and population genetic studies in plants. The chloroplast genomes from higher plants typically range in size from 120 to 170 kilobase pairs (kb), and there is a relatively high degree of conservation in size, structure, gene content, and linear order of the genes in land plants. Chloroplast (cp-) DNA genome is a circular molecule and subdivided into two single-copy regions, the large single copy (LSC) region and small single copy (SSC) region, which are separated by inverted repeats. The LSC region is slightly less conserved in sequence than the rest of the chloroplast genome (Clegg, Learn & Golenberg, 1991) (Fig. 4.1). Previous studies have suggested that the inverted repeat regions accumulate point mutations slower than the single-copy regions (Curtis & Clegg, 1984; Wolfe et al., 1987; Wolfe, 1991; Gaut, 1998). Perry and Wolfe (2002) showed that the nucleotide substitution rate is 2.3 times higher in the single-copy regions relatively to the inverted repeats. Because of the inverted repeats evolve at relatively slower rate and the first adopted chloroplast regions (e.g., *rbc*L, *atp*B, *trn*L-F) are located in the LSC, most plant researchers using molecular tools have focused on the single-copy regions. The use of non coding chloroplast DNA sequences to generate plant phylogenies began in the early 1990s with the seminal publications of Taberlet et al. (1991), Clegg et al. (1994), Morton and Clegg (1993), and Gielly and Tabelet (1994).

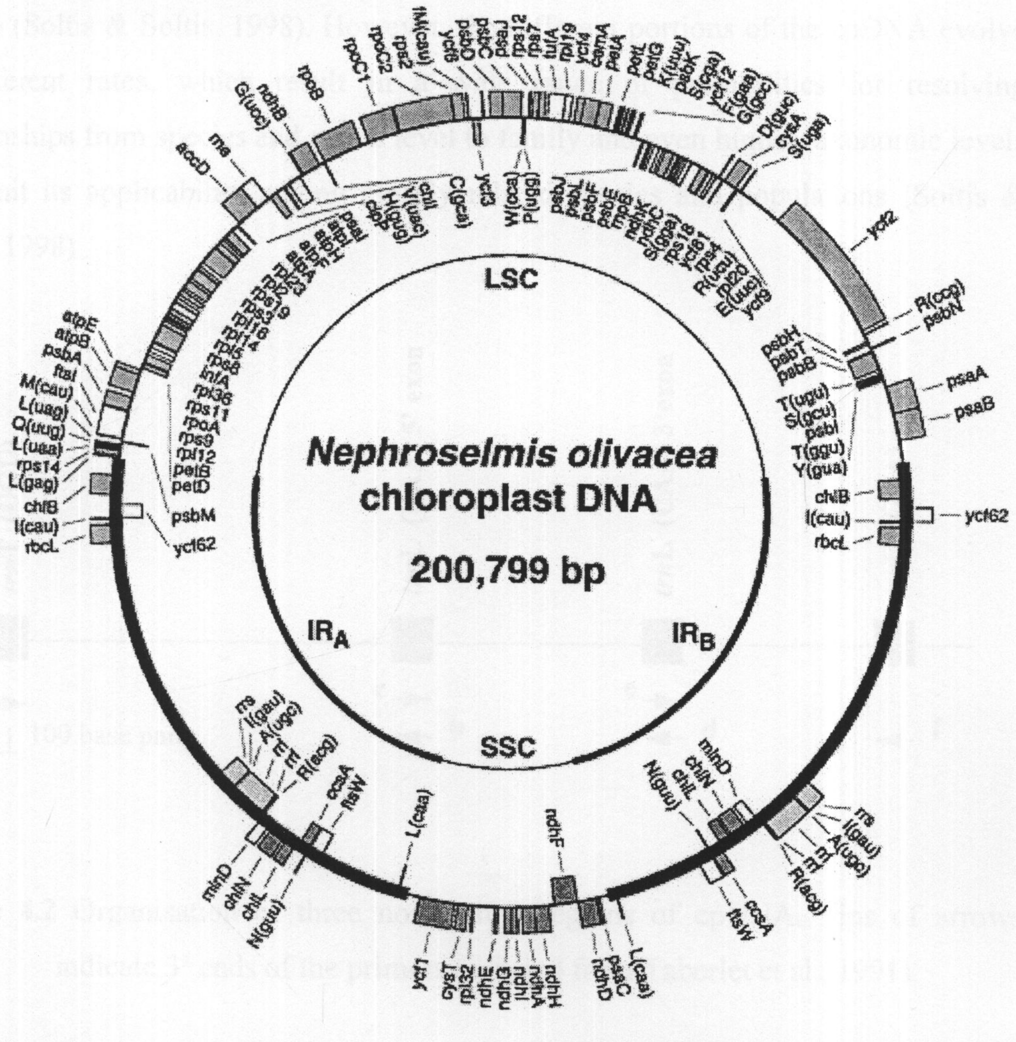

Figure 4.1 Physical and gene map of the green algae *Nephroselmis* chloroplast genome, showing the typical structural arrangement found in land plants. Genes located on the inside of the map are transcribed counter clockwise, and genes on the outside are transcribed clockwise. The inner circle shows where the Small Single-Copy region (SSC), Large Single Copy region (LSC) and Inverted Repeats (IR) are located (adapted from Turmel et al., 1999).

The cpDNA *trn*T-L-F region consists of three non-coding regions (Fig. 4.2): firstly is an intergenic spacer between *trn*T (UGU) and the *trn*L (UAA) 5' exon, second is the *trn*L (UAA) intron and the last region is another intergenic spacer between the *trn*L (UAA) 3' exon and *trn*F (GAA) (Taberlet et al., 1991). In particular the *trn*L intron and *trn*L-F spacer (collective, the *trn*L-F region) has become one of the most widely used chloroplast markers for phylogenetic analysis in plants (Quandt et al., 2004) due to their easily to amplified and their small size, with the *trn*L intron ranging from 350 to 600 bp and the *trn*L-F spacer ranging from approximately 129 to 350 bp (Soltis & Soltis, 1998). However, the different portions of the cpDNA evolve at different rates, which result in a wide range of possibilities for resolving relationships from species and genus level to family and even higher taxonomic levels but limit its applicability among closely related species and populations (Soltis & Soltis, 1998).

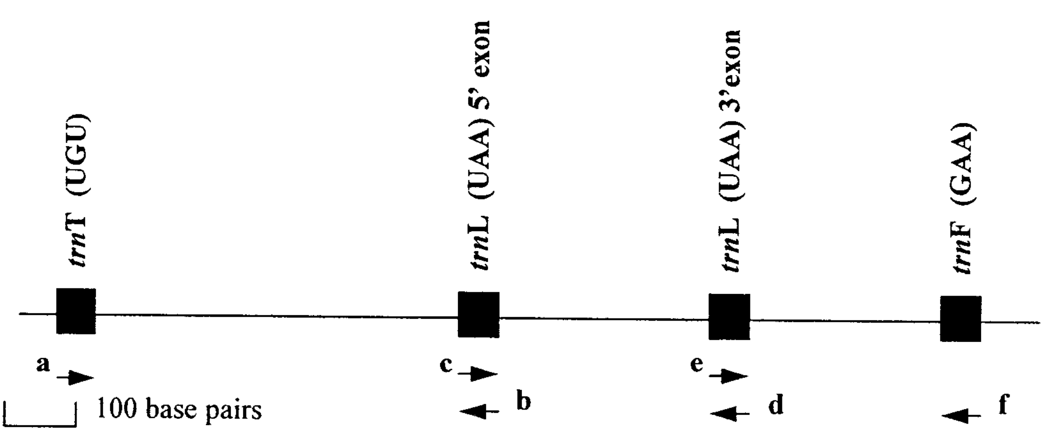

Figure 4.2 Organisation of three non-coding regions of cpDNA. Tips of arrows indicate 3' ends of the primers (adapted from Taberlet et al., 1991).

4.1.2 Nuclear sequences

Nuclear ribosomal DNA (nrDNA) is organized as individual chromosomal units that are repeated thousands of times in most of the higher plant genomes. Each repeat contains a transcribed region, which is separated from the adjacent repeat by a long non-transcribed intergenic spacer (IGS) (Hamby & Zimmer, 1992). Within the transcribed region are three conserved ribosomal RNA regions and the two non-coding spacer regions. The conserved regions, comprising the ribosomal RNA gene

(Fig. 4.3), are arranged in 5'-18S-5.8S-26S-3' order with the ITS spacers (designated as ITS1 and ITS2) flanking the 5.8S region, an evolutionary highly conserved sequence. In addition, an external transcribed spacer region (ETS) is situated at the beginning of the 5' end of the transcribed unit.

The occurrence of high nucleotide variability in combination with low length variation found in both of the internal transcribed spacer regions (ITS1 and ITS2), suggested that this part of the rDNA gene could be used in reconstructing phylogenies within plant genera. Therefore, sequences could be readily aligned across related species and yet would contain sufficient variations for resolution of phylogeny (Baldwin et al., 1995).

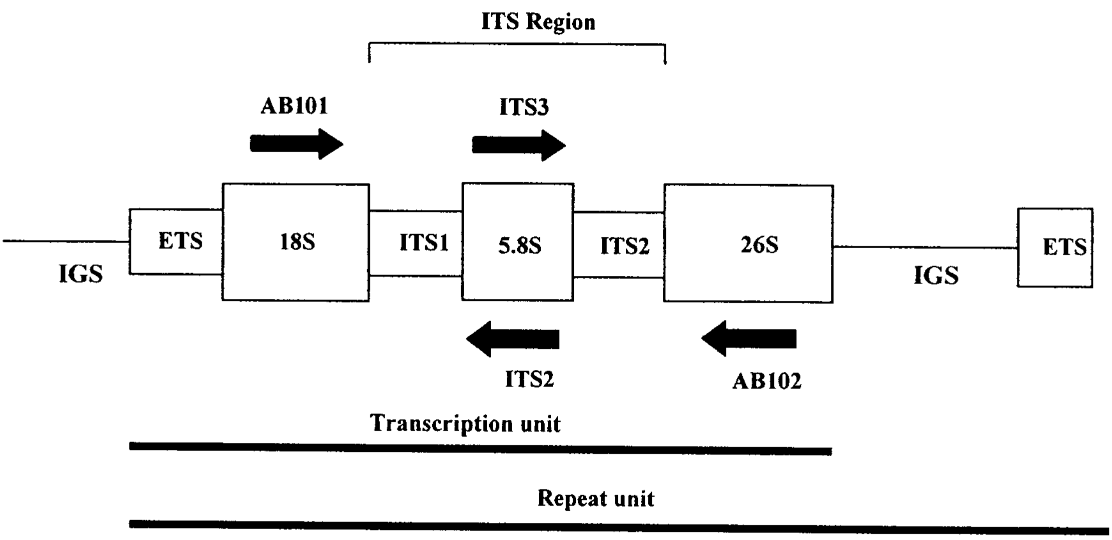

Figure 4.3 Organisation of a repeat unit of nrDNA showing the ITS, ETS, 18S, 5.8S and 26S regions. Arrows indicate the orientation and approximate position of primer sites. Primer names and sequences are from Sun et al. (1994) (adapted from Baldwin et al., 1995).

It has been relatively easy to develop primers for the amplification of the ITS region because it is flanked by the highly conserved regions 18S and 26S and the set of primers designed by White et al. (1990) has been used successfully for amplification across a wide range of plant families. Together with the rest of the nrDNA gene, ITS undergoes rapid concerted evolution, such that all members of the gene family exhibit the same sequence within an individual (Amheim, 1983) via unequal crossing over and gene conservation. Its small size (less than 800 bp) makes it particularly appropriate for direct sequencing amplified DNA obtained from PCR. The ITS sequences have proven to be a valuable source of characters to address phylogenetic relationships among closely related species in different plant families (Francisco-Ortega et al., 2001) and also have a powerful in revealing hybridization and reticulate evolution (Sang, Crawford & Stuessy, 1997).

4.2 Literature reviews

The molecular phylogenetic information available for the family has been summarized by Linder and Kellogg (1995). They concluded that the evidence gathered till now points to a monophyletic Panicoideae sister to the Centothecoideae. The monophyly of the Andropogoneae is also very well supported, but no conclusions can be reached as to the status of the rest of the tribes.

Clayton (1972, 1973) divided Andropogoneae into "awned" and "awnless" taxa. Later, Clayton & Renvoize (1986) divided the tribe into 11 subtribes, based largely on characters of the inflorescence.

Kellogg & Watson (1993) undertook a phylogenetic analysis of morphological characters for all genera of Andropogoneae. They found that the distinction between awned and awnless taxa was largely supported but most of the subtribes defined by Clayton & Renvoize (1986) were polyphyletic.

Spangler et al. (1999) using cpDNA from gene *ndhF* sequences to estimate the phylogeny of the tribe Andropogoneae. The investigations showed that subtribal designations are not informative due to the lack of resolution between clades in the strict consensus tree. However, there are well-supported clades in the tribe, including three *Sorghum* lineages and a "core" Andropogoneae clade, even though relationships among clades are poorly supported. A preliminary assessment of the generic limits of the genus *Sorghum* indicated a paraphyletic group, including the genera *Cleistachne*, *Miscanthus*, and a species of *Microstegium*. They have proposed subtribe Sorginae which included *Sorghum, Sorghastrum, Cleistachne, Bothriochloa, Capillipedium, Dichanthium* and *Chrysopogon* and does not form a monophyletic group.

Kellogg (2000) suggested that both molecular and morphological data supported the monophyly of the Andropogoneae. The characters that correlated with the origin of the traditional Andropogoneae are presence of a disarticulating rachis and differentiation of the spikelets of a pair. Within the tribe, there is variation in presence of distinctive cells in the mesophyll, formation of branch complexes on the upper part of the culm (the anthotagma), timing of inflorescence branching, sex expression of spikelets, induration of glumes, and formation of awns. However, the different states of these characters do not correlate with the molecular phylogeny. Hence, the subtribes of Andropogoneae are polyphyletic.

Mathews et al. (2002) added newly collected data from phytochrome B to the data from the other two genes (GBSSI and *ndh*F) in previous studies (Mathews et al., 1995). The phylogeny shows a single origin of a disarticulating rachis, which is a synapomorphy for the tribe. The combined data reject the monophyly of subtribes Andropogonenae and Anthistiriinae and provided evidence that subtribes Sorghinae, Saccharinae, and Rottboelliinae are paraphyletic or polyphyletic. A *Chionachne* and *Phcelurus* are shown to diverge early in the history of the tribe.

In this study, nucleotide sequences data from taxa of subtribes Ischaeminae and Rottboelliinae are cladistically analysed using outgroup comparison to produce a rooted phylogenetic hypothesis for the two subtribes. The sequence data (both substitution and insertion and deletion characters) are from regions of the taxa's chloroplast (cpDNA) and nuclear ribosomal DNA (nrDNA). In the cpDNA, the *trn*L-*trn*F region (composed of the *trnL* (UAA) intron, the *trn*L (UAA) 3' exon, and the intergenic spacer between the *trn*L (UAA) 3' exon and *trn*F (GAA)) was chosen because it has proved to be phylogenetically informative at the infra-and inter-generic levels of the other taxa (Gielly & Taberlet, 1994; Gielly et al., 1996). Similarly, the Internal Transcribed Spacer (ITS) region of nrDNA (composed of the spacers between the 18S and 5.8S genes (ITS1) and the 5.8S and 26S genes (ITS2) was chosen for its informativeness elsewhere at those levels (Baldwin et al., 1995).

The ITS regions has been investigated extensively and has been successfully used to resolve phylogenetic relationships at various levels. This includes studies of various genera such as *Brachisria* and *Urochloa* (González & Morton, 2005); *Bouteloua* (Columbus et al., 1998, 2000); *Chloris* (Alice et al., 2000); *Deschampsia* (Chiapella, 2007); *Deschampsia Antarctica* (Fernández Souto et al., 2006); *Eleusine* (Neves et al., 2005); *Elymus* (Liu et al., 2006); *Hordeum* (Blattner, 2004); *Paspalum* (Souza-Chies & Essi, 2007); *Schizostachyum* and its allies (Yang, Peng & Li, 2007); *Spartina* (Baumel et al., 2001); *Sporobolus* (Ortiz-Diaz & Culham, 2000) and *Sporobolus indicus* complex (Shrestha et al., 2003). Studies have also been conducted on a related group of grasses known as the Festucoid grass (Catalán et al., 2004); Stipoid grasses (Jacobs et al., 2000); Chloridoid grasses (Roodt-Wilding & Spies, 2006); the Chloridoid tribe Triodieae (Mant et al., 2000); the Panicoid tribe Androponeae (Hodkinson et al., 2002b); the Pooi tribes Aveneae (Grebenstein et al., 1998) and Triticeae (Hsiao et al., 1995a). The ITS regions has also been used to a lesser extent to investigate subfamily relationships in the Arundinoideae (Hsiao et al., 1998); tribe Danthonieae by Barker et al., 2000 in a combined analysis of morphology and *rpo*C2, *rbc*L and ITS sequence data and the Pooideae (Hsiao et al., 1994, 1995b). The phylogeny of the entire grass family (Hsiao et al., 1999) was also investigated using ITS.

In Poaceae the *trn*L-F regions has been also used in many levels such as *Poa jemtlandica* (Brysting et al., 2000); *Spartina anglica* (Baumel et al., 2001); *Axonopus* (Gomez-Martinez & Culham, 1997); *Bouteloua* (Columbus et al., 2000); Chloridoid grasses (Roodt-Wilding & Spies, 2006); *Deschampsia* (Chiapella, 2007); *Elymus* (Liu et al., 2006); Festucoid grass of subtribe Loliinae (Catalán et al., 2004); *Miscanthus* (Hodkinson et al., 2002a); *Paspalum* (Souza-Chies & Essi, 2007); *Spartina* (Ferris et al., 1997); the Panicoid tribes Andropogoneae (Hodkinson et al., 2002b); Paniceae (Gomez-Martinez & Culham, 2000; Doust & Kellogg, 2002); the Pooi tribe Triticeae (Mason-Gamer et al., 2002) and *trn*L-F has also demonstrated its suitability for clarifying the systematic problems in the Gramineae (Neves et al., 2005).

Separate analyses were conducted and the data sets were then combined for combined analyses. It was decided to combine the two regions in many studies in recent years have indicated that combined molecular data sets that utilize different levels of variation (as provide by ITS and *trn*L-F) provide resolution at different levels of the cladogram and, therefore, phylogenetic resolution and bootstrap values are improved by combining separate data sets (Chase & Cox, 1998; Soltis & Soltis, 1998; Whitten et al., 2000).

4.3 Material and methods

4.3.1 Taxon sampling and ingroup selection

Forty-two taxa representing 12 genera of subtribes Ischaeminae and Rottboelliinae were sampled. The species were chosen to represent variation within each genus. At least 10% of the species in each genus were included to avoid any excess heterogeneity in rates of molecular evolution that may be found. The remaining one genus in subtribe Rottboelliinae, as circumscribed by Nanakorn & Norsaengsri (2001), i.e. *Vossia* Wall. & Griff. is a monotypic genus could not be included owing to lack of material.

Field collected leaves and vouchers were collected between June 2004 and August 2007. All materials were preserved in silica gel.

4.3.2 DNA extractions

Total genomic DNA was extracted from 0.3 g of leaves from individual plants preserved in silica gel or 0.2 g of leaf material from herbarium specimens using the modified CTAB (hexadecyltrimethylammonium bromide) method of Doyle & Doyle (1987) and precipitated in isopropanol. The crude total genomic DNA was purified using the QIAquick PCR Purification kit, namely Spin column Technique and DNA levels were checked on the 1% agarose gel, and stored at -20°C or -80°C (Appendix E).

4.3.3 Amplification of target DNA regions

The nrDNA internal transcribed spacer region (ITS) and further sequencing was amplified with Polymerase Chain Reaction (PCR) using both the external primers AB101F (5'-ACG AAT TCA TGG TCC GGT GAA GTG TTC TTC G-3'), AB102R (5'-TAG AAT TCC CCG GTT CGC TCG CCG TTA C-3') and internal pair primers ITS 2 (5'-GCT GCG TTC TTC ATC GAT GC-3'), ITS 3 (5'-GCA TCG ATG AAG AAC GCA GC-3') (Sun et al., 1994). The PCR reactions were carried out in a total volume of 25 µl. Each reaction consisted of 1 µl cellular DNA, 0.5 µl dNTP (10 mM), 1.5 µl $MgCl_2$ (50 mM), 0.5 µl of each primer (100ng/µl), 2.5 µl 10X Buffer, 2.5 µl BSA, 0.5 µl DMSO, and 0.5 µl *Taq* polymerase. Strong denaturing reaction conditions were needed because of the high GC (guanine-cytosine) content of ITS region and the presence of secondary structure (Bucker & Holtsford, 1996). This was achieved by the addition of DMSO, which reduces strand reannealing (Winship, 1989; Varadaraj & Skinner, 1994). Buckler et al. (1997) also suggested that the addition of DMSO would prevent the preferential amplification of pseudogenes. These might be preferentially amplified due to low secondary structure stability. The reactions were carried out using a GeneAmp PCR System 9700 thermocycler. The thermal cycling were run on following the program comprised of 30 cycles, 2 min premelt at 94°C, 1 min denaturation at 94°C, 1 min annealing at 48°C, 1.30 min extension at 72°C and 4 min final extension at 4°C.

Table 4.1 List of primers used for amplification and sequencing.

Marker	**Name**	**Sequence**	**Reference**
ITS			
forward	AB101	5'-ACGAATTCATGGTCCGGTGAAGTGTTCTTCG-3'	Sun *et al.*, 1994
reverse	ITS2	5'-GCTGCGTTCTTCATCGATGC-3'	Sun *et al.*, 1994
forward	ITS3	5'-GCATCGATGAAGAACGCAGC-3'	Sun *et al.*, 1994
reverse	AB102	5'-TAGAATTCCCCGGTTCGCTCGCCGTTAC-3'	Sun *et al.*, 1994
***trn*L-F**			
forward	c	5'-CGAAATCGGTAGACGCTACG-3'	Taberlet *et al.*, 1991
reverse	d	5'-GGGGATAGAGGGACTTGAAC-3'	Taberlet *et al.*, 1991
forward	e	5'-GGTTCAAGTCCCTCTATCCC-3'	Taberlet *et al.*, 1991
reverse	f	5'-AATTGAACTGGTGACACGAG-3'	Taberlet *et al.*, 1991

The non-coding regions of cpDNA were PCR amplified using primers 'c' (5'-CGA AAT CGG TAG ACG CTA CG-3') and 'd' (5'-GGG GAT AGA GGG ACT TGA AC-3') for the *trn*L intron, and primers 'e' (5'-GGT TCA AGT CCC TCT ATC CC-3') and 'f' (5'-AAT TGA ACT GGT GAC ACG AG-3') for the *trn*L-F intergenic spacer (Taberlet et al., 1991). The PCR reactions were carried out in a total volume of 25 µl. Each reaction consisted of 1 µl DNA, 0.5 µl dNTP (10 mM), 2.5 µl $MgCl_2$ (50 mM), 0.5 µl of each primer (100ng/µl), 2.5 µl Buffer, 2.5 µl BSA and 0.5 µl *Taq* polymerase. The thermal cycling were run on following the program comprised 30 cycles, 2 min premelt at 94°C, 1 min denaturation at 94°C, 1 min annealing at 50°C, 1.30 min extension at 72°C and 4 min final extension at 4°C.

Three to five µl of each PCR product for both the nuclear and chloroplast regions were run on a 1% agarose gel placed in 1X TAE (Tris-Acetic acid-EDTA) buffer. Amplified products were purified using Magic mini-columns (Promega, Southampton, Hampshire, UK) or QIAquick columns (Qiagen, Crawley, West Sussex, UK), protocols were provided by manufacturers of the minicolumns (Appendix E). Cleaned PCR products were stored at -20°C after checking the DNA level on the 1% agarose gel.

4.3.4 Cycle Sequencing

The sequencing primers for both regions were the same primers used for the amplification in PCR. The cycle sequencing profile was as follows: rapid thermal ramp to 96°C followed by 96°C for 10 s, 50°C for 5 s, and 60°C for 4 min, performed for 26 cycles and held at 4°C. Sequencing of the PCR products was carried out using cycle sequencing with ABI Big Dye terminators run on an ABI 377A automatic sequencer (according to the manufacturer's protocols; Perkin-Elmer Applied Biosystems, Inc., Warrington, Cheshire, UK) at Jodrell Laboratory, the Royal Botanic Gardens, Kew, Uk.

4.3.5 Sequence assembly and alignment

Automated sequence output files were edited and assembled using Sequence Navigator and AutoAssembler (Applied Biosystems Inc.). Sequences of both regions were unambiguously aligned by visual inspection. The final aligned matrix has 818 characters of ITS region and 1,211 characters of *trn*L-F region. The alignments were directly submitted to parsimony analysis.

4.3.6 Outgroup selection

Outgroup taxa represented different degrees of relatedness to subtribe Ischaeminae and Rottboelliinae: *Eragrostis biflora* and *Centotheca lappacea* from the broader subfamily Chloridoideae and Centothecoideae, respectively.

4.3.7 Phylogenetic analyses

Heuristic parsimony analyses of the aligned sequence matrix was performed using PAUP* 4.0b10 software (Swofford, 1998) on a Macintosh G4. All characters were unordered and equally weighted (Fitch parsimony; Fitch, 1971) and individual gap positions were treated as missing data. Most-parsimonious trees were obtained using 1000 replicates of random taxon addition with equal weights and tree-bisection-reconnection (TBR) branch-swapping, with MULTREEs in effect, but holding only one tree per step and saving no more than 100 trees per replicate to minimize time swapping on suboptimal trees. Internal support was assessed using 1000 bootstrap replicates with TBR swapping and simple addition of taxa, retaining groups with frequencies above 50% in the bootstrap consensus tree. The following categories were used to describe levels of bootstrap support: weak = 50–74%; moderate = 75–84%;

and strong 85–100% (Simpson et al., 2003.). Also computed using PAUP* were the strict consensus trees, consistency index (CI) retention index (RI) and rescaled consistency index (RC). All resulting trees were rooted using both species of *Eragrostis biflora* (subfamily Chloridoideae) and *Centotheca lappacea* (subfamily Centothecoideae) as the outgroups.

4.4 Results

Sampling was designed to include 12 genera of the two subtribes in Thailand and one sequences of outgroup taxa (*Eragrostis biflora*) was taken from GenBank.

4.4.1 ITS region

The length of ITS1 ranged from 215 (*Ischaemum indicum* 1) to 403 bp (*Apluda mutica*) and ITS2 from 283 (*Hemarthria pratensis*) to 465 (*Ischaemum barbatum* 1) bp. Aligned sequences of the entire region of 44 specimens (42 ingroup and 2 outgroup specimens) consist of 818 characters. For the entire region, 113 characters (16.10%) were potentially parsimony-informative and 93 were variable. The heuristic search with ITS data produced 199 trees with the tree length of 475 steps, a consistency index (CI) = 0.6253, a retention index (RI) = 0.7367 and a rescaled consistency index (RC) = 0.4606. One of these trees with bootstrap values is shown in Fig. 4.4.

The subtribes Ischaeminae and Rottboelliinae are resolved as a polyphyletic and paraphyletic, respectively with poor bootstrap support. Within both subtribes, there are five major clades as well supported:

Clade A: Formed by all the *Ischaemum* species plus *Kerriochloa siamensis*, except *Ischaemum tenuifolium*.

Clade B: Consisted of seven genera with poor bootstrap: *Mnesithea, Hackelochloa, Hemarthria, Ophiuros, Thelepogon, Rottboellia* and *Phacelurus*.

Clade C: *Mnesithea laevis* as a sister to taxa in genus *Eremochloa* but with poor bootstrap support (<50%). Resolution is strong and fully supported (100%) monophyletic group for internal node of the genus *Eremochloa*.

Three basal lineages, the single taxon *Apluda mutica* in clade E, with poor bootstap support, a clade D (<50% bootstrap support), which include *Ischaemum tenuifolium* and *Sehima nervosum*.

4.4.2 *trn*L-F region

The length of the *trn*L intron from 498 (*Sehima nervosum*) to 531 bp (*Ischaemum hirtum*) and the *trn*L-F spacer from 381 (*Mnesithea mollicoma*) to 615 bp (*Ischaemum barbatum* 2). Aligned sequences of the entire *trn*L-F region of 44 specimens (42 ingroup and 2 outgroup specimens) consist of 1,211 characters. For the entire region 61 characters (7.15%) were potentially parsimony-informative and 53 were variable. Parsimony analysis excluding the coded gaps, resulted in 95 equally most parsimonious trees (tree length = 140 steps; CI = 0.8857; RI = 0.9797; RC = 0.8677). One of these trees with bootstrap values is shown in Fig. 4.5.

The analysis showed the polyphyly of both subtribes with weak to high support. Within both subtribes, there are two major clades.

Clade A: Formed by all taxa in genus *Ischaemum*, *Hemarthria*, *Rottboellia cochichinensis*, *Mnesithea laevis* and unresolved at its base as form a polytomy of several lineages with a weakly bootstrap support (57%).

Clade B: This clade consisted of the genera *Eremochloa*, *Ophiuros*, *Mnesithea*, *Hackelochloa* and *Apluda* with a strongly bootstrap support (100%). The analysis showed that the genus *Eremochloa* is a mophyletic as same as the analysis of ITS data.

4.4.3 Combined analysis

Because of the two regions investigated produced poorly identical results. Therefore, the sequence data of ITS and *trnL*-F were combined for additional analysis.

After alignment, the combined data matrix consisted of 2,029 characters. With indel information included the matrix consisted of 1,555 characters, of which 174 (11.19%) were parsimony-informative and 146 were variable. Analysis of this combined matrix resulted in 4 equally most parsimonious cladograms with a tree length of 632 steps, CI of 0.6661, RI of 0.8559 and RC of 0.5701. Although some polytomies are present. One of these trees with bootstrap values is shown in Fig. 4.6.

Both subtribes form a polyphyletic group with a weakly bootstrap support 53% and 52%, respectively, which composed of two main clades:

Clade A: Comprised of taxa of genus *Ischaemum*, *Mnesithea laevis*, *Sehima nervosum*, *Kerriochloa siamensis*, *Thelepogon elegans*, *Rottboellia cochinchinensis*, *Hemarthria* and *Phcelurus zea*, which was recognized as a sister taxon to the remaining of this clade.

Clade B: Consisted of the genera in subtribe Rottboelliinae: *Mnesithea, Hackelochloa, Ophiuros* and *Eremochloa* except *Apluda mutica*, which is from the subtribe Ischaeminae. Well supported internal nodes were formed in this analysis.

Table 4.2 Values and statistics from PAUP* analyses of separate and combined data sets.

Sequence characteristic	**Combined ITS & *trn*L-F**	**ITS**	***trn*L-F**
Number of characters	1,555	702	853
Invariant characters	1,235	496	739
Uninformative variable characters	146	93	53
Parsimony-informative variable characters	174	113	61
Consistency index (CI)	0.6661	0.6253	0.8857
Retention index (RI)	0.8559	0.7367	0.9797
Rescaled consistency index (RC)	0.5701	0.4606	0.8677
Maximum parsimony tree length	632	475	140
Number of trees	4	199	95

4.5 Discussion and conclusion

This study presents the first molecular phylogenetic hypothesis of the relationships among species and genera of the subtribes Ischaeminae and Rottboelliinae. The data sets of the DNA sequences of chloroplast DNA (*trn*L-F region) and the nuclear ribosomal internal transcribed spacer regions (ITS) were analyzed separately before being combined into a single data set. The analysis shows that the combined tree exhibits the best phylogenetic reconstruction of both subtribes, but the analysis of *trn*L-F resulted in phylogenies with highest retention index (RI). Two main lineages can be identified as identical to the analysis of *trn*L-F data (clades A and B; Fig. 4.6), while the analysis of ITS provides evidence for phylogenetic examination of closely related taxa. Recent studies have indicated that the use of non-coding chloroplast regions may only be useful at intergeneric but not intrageneric levels due to a lack of informative sequence variation (Roodt-Wilding & Spies, 2006). This was seen in this study with the *trn*L-F region providing resolution among, but not within, genera in both subtribes.

The results show that the subtribes Ischaeminae and Rottboelliinae are polyphyletic. Previous studies using phytochrome B, GBSSI and *ndh*F also concluded that both subtribes are polyphyletic (Mathews et al., 2002). Kellogg & Watson (1993), using morphological data, placed *Ischaemum* and its sister *Digastrium* a sister to many genera of Rottboelliinae, whereas they considered *Apluda* a sister to *Apocopis*. The *ndh*F phylogeny (Spangler et al., 1999; Spangler, 2000) also places *Ischaemum* as an early diverging branch, whereas *Apluda* is part of the "core" Andropogoneae. Hence, these two groups of subtribes do not support the subtribal designations of Clayton & Renvoize (1986).

Implications for Classification

***Ischaemum* L.**

Resolution within the *Ischaemum* clade is moderate to high (most subclades having of bootstrap support (≥78%) showing that *Ischaemum* is paraphyletic. The *Ischaemum* clade also contains three morphologically very similar genera, *Mnesithea, Sehima* and *Kerriochloa*. The species *Ischaemum tenuifolium* forms a subclade separate from the other species in the genus, but with weak support. The division of *Ischaemum* into sections, proposed by Clayton & Renvoize (1986), is supported by the present molecular study. The ITS, *trn*L-F and combined trees divide the genus into three major subclades that correspond to the morphology of the lower glume of the sessile spikelet. In the combined tree, subclade I, with a strong bootstrap support of 98%, comprises all taxa which share the character of an entirely sessile lower glume. Subclade IV is formed by the group of taxa which have nodules on the sessile lower glume, with a robust bootstrap support of 99%.

Subclades II and III are derived from species of four different genera, *Ischaemum tenuifolium*, *Mnesithea laevis*, *Sehima nervosum* and *Kerriochloa siamensis,* all of which are now placed in the genus *Ischaemum*. *K. siamensis* is a sister to the remainder of this subclade, with poor bootstrap support, indicating that this group is closely related to the genus *Ischaemum*. This result is in agreement with

Clayton & Renvoize (1986), who suggested that *Kerriochloa* is related to *Ischaemum*, particularly *I. decumnens*.

All the three analyses supported the segregation of *Ischaemum tenuifolium* from the genus *Ischaemum*. This finding is also supported by the taxonomic treatments (chapter V) that moved *I. tenuifolium* to the genus *Andropogon* and Clayton & Renvoize (1986) who noted that the genus *Ischaemum* is often quite difficult to distinguish from *Andropogon*. Unfortunately, the genus *Andropogon* is not sampled here. The two genera are circumscribed on the basis of their difference in inflorescences and lower glume of the sessile spikelet characters, with the *Ischaemum* defined by 2 rarely digitate racemes that carry a spikelet with convex or flattened lower glume, whereas the *Andropogon* species are characterized by having 3–7 racemes with a concave lower glume (Clayton & Renvoize, 1986). The leaf-blades anatomical study in chapter II concluded that papillae are present in all members of *Ischaemum*, except in *I. tenuifolium,* which shows that this species is distinct from the other species in the genus. These results confirm the conclusion of Watson & Dallwitz (1992), who stated that many of the core Andropogoneae have a single oblique papilla on each of the intercostal cells, overlying the stomata. Of the genera included in their study, *Andropogon* and *Schizachyrium* lack such papillae. Both genera include a large number of species, and *Andropogon* is likely to be polyphyletic (Mathews et al., 2002); future studies will thus have to investigate more species of each genus to test the connection demonstrated here.

However, the relationships within some of the taxa in the genus *Ischaemum,* namely, *I.* sp.1, *I.* sp.2, *I. barbatum* complex and *I. indicum* complex are unresolved; there is still a low resolution between the subclades of *Ischaemum* as they were arranged in a polytomy.

Hemarthria R. Br. & *Phazelurus* Griseb.

Most of the generic groupings including more than one species are well supported. This includes, for example, the genus *Hemarthria* which forms well supported lineages (≥98%) in all analyses, which shows that the genus *Hemarthria* is monophylic. The generic status of *Hemarthria* is clearly justified and its close relationship to *Phacelurus zea* (combined tree) is also evident with a weak bootstrap support of 53%. This is in agreement with Clayton & Renvoize (1986), who stated that the fused pedicel and basic chromosome number of 9 are evidence that *Hemarthria* is more closely related to *Phacelurus* than to *Heteropholis*.

Hemarthria compressa is a sister to *H. pratensis* with a 100% bootstrap support in combined and ITS trees and a 98% bootstrap support in *trn*L-F tree. The morphology of the two taxa is also clearly different; they are distinguished by leaf-blades and joints. In *H. compressa*, the leaf-blade is not deciduous and the joints are not long cuneate, in contrast to the deciduous leaf-blades and long cuneate joints in *H. pratensis* (Van Den Heuvel & Veldkamp, 2000).

Placement of *Phacelurus zea* (bootstrap support 53%) as sister to clade A (group of *Ischaemum*) is consistent with Clayton & Renvoize (1986), who pointed out that the two genera are clearly related. In practice, there is not much difficulty in distinguishing it from *Ischaemum*, but it is sometime quite hard to find unequivocal diagnostic characters.

***Mnesithea* Kunth**

The results presented here show that the taxa *Ischaemum tenuifolium, Mnesithea laevis, Sehima nervosum* and *Kerriochloa siamensis* are nested within *Ischaemum*, although this subclade is not strongly bootstrap supported (<50%). *Kerriochloa siamensis* appears to be a sister to the other members of both subclades. Clayton & Renvoize (1986) proposed that the genus *Mnesithea* has only one species: *M. laevis*, and retained *Coelorachis* as distinct genus. The genus *Coelorachis* differs from the other genera by a free pedicel and a pedicelled spikelet. A re-assessment of the generic limits of *Mnesithea* sensu lato by Veldkamp et al. (1986) acknowledged the addition of *Coelorachis* in to *Mnesithea,* because several species of *Coelorachis* have the lower part of pedicel completely fused to the rachis node. The pedicelled spikelet varies from well developed to minute vestige, and its absence in traditional *Mnesithea* is therefore not enough to conserve the genus (Veldkamp et al., 1986). The results of this molecular study seem to conflict with the results of the morphological study in chapter II and the investigation by Veldkamp et al. (1986), who included all members of *Coelorachis* into *Mnesithea*. A majority of the *Mnesithea* species (*Coelorachis* sensu Clayton & Renvoize, 1986) form a group in a subclade VIII which is distinctly related to *Hackelochloa* and *Ophiuros*, however with a weak bootstrap support of 61%. The arguments mentioned above clearly show that this genus is problematic and should be studied more in details.

The species *Mnesithea glandulosa* is segregated from most other species in the genus and appears to be basal-most to all others of this group with a weak bootstrap support of 61%; correlated with a distinct morphological character; a lateral hook on the lower glume of the sessile spikelet, which is a characteristic of *Eremochloa*. In 1986, Clayton & Renvoize depicted the genus *Eremochloa* as derived from *Coelorachis* (=*Mnesithea*).

Within the remaining *Mnesithea* are three subclades with a week bootstrap support less than 50%. The first topology, with a 63% bootstrap support, suggested that *M. heferi* is sister to *M. mollicoma,* sharing the pubescence leaf surface. The second topology is one of the strongest (100% bootstrap support) supported in both ITS and combined analyses: *M. striata* var. *striata* and *M. striata* var. *pubescens*. Therefore, *M. striata* var. *pubescens* might be the same species as *M. striata* var. *striata*. However, the two subspecies can be distinguished by the culm and leaf-blade, which are covered in hairs in var. *pubescens*, whereas glabrous in var. *striata* (Hackel, 1889). The last topology confirmed that *M. cancellata* is sister to *M.* sp.1 with a weak bootstrap support of 52%. In this study most materials of *M.* sp.1 were previously identified as *M. striata. M.* sp1 is different from *M. striata* by having an oblong lower glume of the sessile spikelet, indurate, 5–5.5 by 1.2–1.5 mm; an apex with unequal wings; 7–8 longitudinal rows of small pits between the nerves of the back; and margins at base puberulous. *M. striata* has an ovate lower glume of the sessile spikelet, indurate, 4.5–5 by *ca.* 1.5 mm; an apex with 2 apical wings; and a continuous ridge along the length and interrupted by tubercles or tubercle-based hairs on the back, or glabrous. Hence, the molecular as well as morphological evidences indicated that *M.* sp.1 should be proposed as a new species in the genus *Mnesithea*.

***Hackelochloa* Kuntze**

A subclade VIII grouping (Fig. 4.6) comprises of *Mnesithea*, *Hackelochloa*, *Ophiuros* with *Mnesithea glandulosa* being a sister of this group. The small genus *Hackelochloa,* represented in this study by a couple of species, is determined as monophyletic group but with a weak bootstrap support. Further sampling of these two taxa is required in order to confirm their monophyly. From the combined analysis it revealed that *Hackelochloa* is closer to *Ophiuros* than to *Mnesithea*; however with a poor bootstrap support less than 50%. The molecular results from this study are contrary to Veldkamp, et al. (1986) who treated *Hackelochloa* as a synonym of *Mnesithea*.

Hackelochloa granularis and *H. porifera* are morphologically similar and have been grouped together previously (Veldkamp, et al. 1986). In contrast, the morphological study separates the two taxa by the difference in size and sculpture on the lower glume. While the *trn*L-F tree (Fig. 4.5) shows that *H. granularis* and *H. porifera* are in the same clade, but with 79% bootstrap support, and both having a globose lower glume. Therefore, the two species are not identical. This is in agreement with Bor (1960), who stated that *H. porifera* differed from *H. granularis* by its larger spikelets and a more pronounced sculpture on the lower glume of the sessile spikelet.

***Eremochloa* Buse**

The results of all phylogenetic analyses presented here provide broadly consistent estimates of the phylogeny of *Eremochloa*. The genus *Eremochloa* comprises of a monophyletic group, with *Apluda* (represented by *A. mutica*) as sister group to the genus, with a strongest bootstrap support (100%). According to Buitenhuis & Veldkamp (2001), this genus is recognized by a single spike-like raceme and a submarginally pectinate lower glume. Clayton (1973), in a numerical analysis of awnless genera of the Andropogoneae, found *Eremochloa* in the Coelorachidastrae close to *Rhytachne* (not sampled here).

The genus *Eremochloa* can be divided into two main groups with a strongest bootstrap support (100%), however no obvious morphological character supports this division. The first group is composed of *E. bimaculata*, *E. maxwellii*, *E. ciliatifolia* and *E. attenuata* as a sister of this group with a 99% bootstrap support. The second group is formed by *E. ciliaris, E. eriopoda*, *E. lanceolata* and *E.* sp.1 as a sister of this group with 64% bootstrap support.

The morphological study shows that *Eremochloa* sp.1 is very closely related to *E. maxwellii* but differs in having an obovate and long cordate pedicel, in contrast to the obliquely-lanceolate pedicel in *E. maxwellii*. The species is found in north-eastern Thailand. The present molecular study confirmed that *E.* sp.1 should be a new species, but not a variety of *E. maxwellii*.

***Apluda* L.**

The strong support for the clade containing *Eremochloa* and *Apluda* is one of a surprised result produced by this molecular study, since there are no obvious morphological characters that unite the two genera. *Apluda* is separated from *Eremochloa*, so the closed relationship of the two genera might have been predicted.

Although not all genera and species in the subtribes Ischaeminae and Rottboelliinae were included in this analysis, the results observed here indicate the phylogenetic trends in both subtribes in Thailand. Additional taxonomic sampling in the future will result in better resolution of the relationships. Moreover, more gene regions and more samples from various geographic regions should be included in further studies in order to define the relationships among taxa in both subtribes.

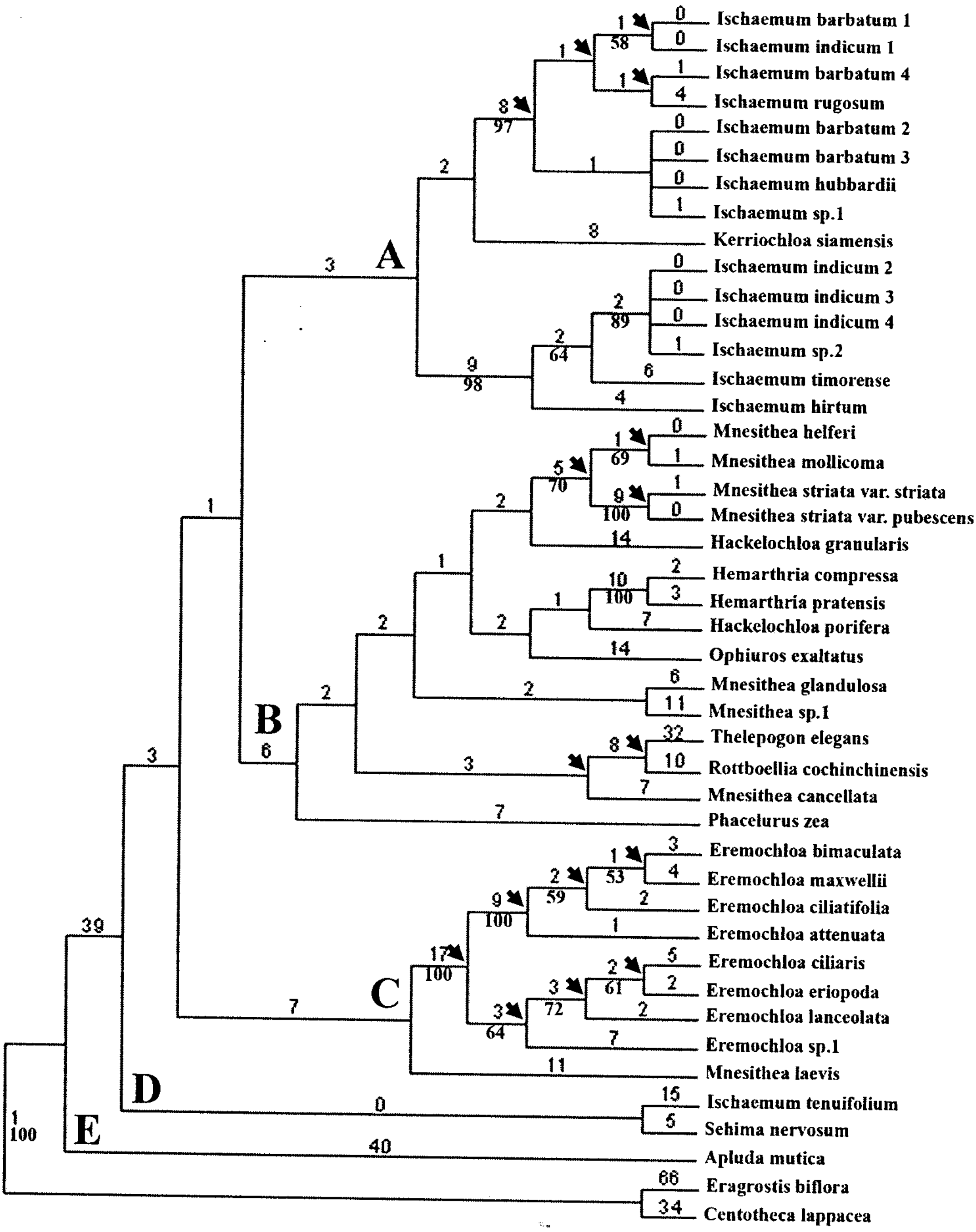

Figure 4.4 One of 199 equally most parsimonious trees of ITS region of the subtribes Ischaeminae and Rottboelliinae and outgroup taxa with a length of 475, CI of 0.63 and RI of 0.74. Branch lengths obtained using sequences are indicated above branches, bootstrap percentage values >50% are indicated below branches. Arrows show clades recovered in the strict consensus tree.

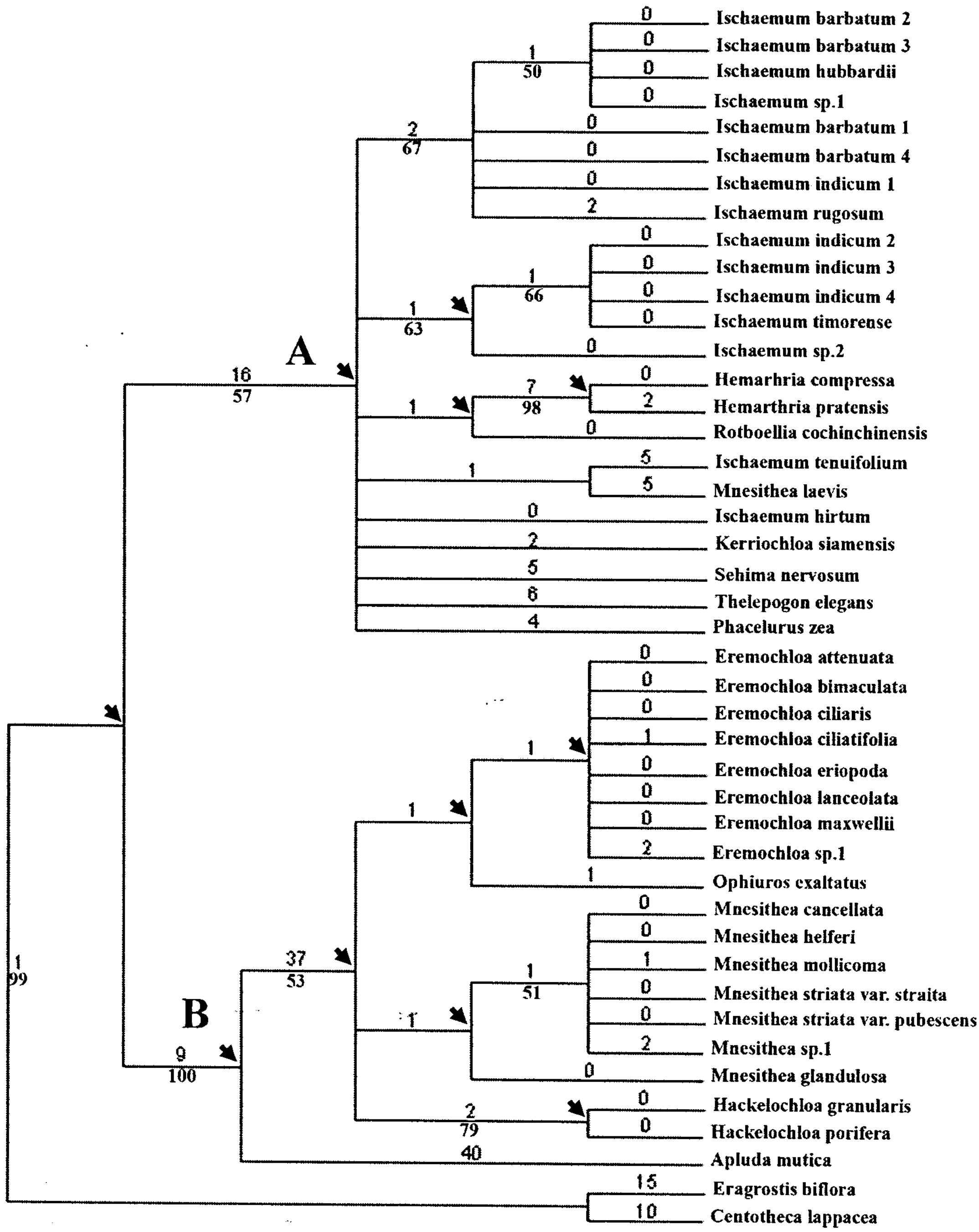

Figure 4.5 One of 95 equally most parsimonious trees of *trn*L intron and the *trn*L-F spacer of the subtribes Ischaeminae and Rottboelliinae and outgroup taxa, with a length of 140, CI of 0.89 and RI of 0.98. Branch lengths obtained using sequences are indicated above branches, bootstrap percentage values >50% are indicated below branches. Arrows show clades recovered in the strict consensus tree.

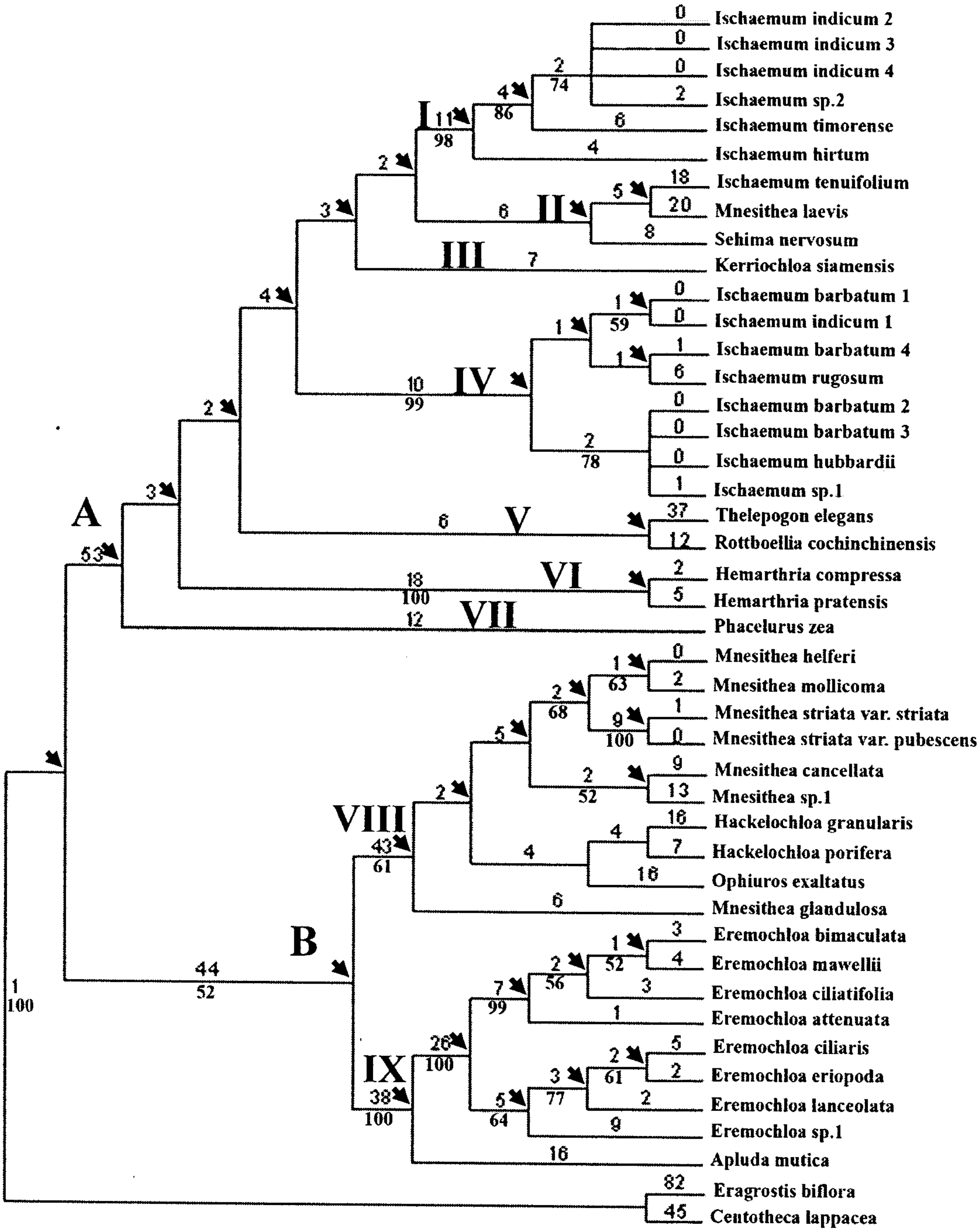

Figure 4.6 One of 4 equally most parsimonious trees of ITS region and *trn*L intron and the *trn*L-F spacer of the subtribes Ischaeminae and Rottboelliinae and outgroup taxa, with a length of 632, CI of 0.67 and RI of 0.86. Branch lengths obtained using sequences are indicated above branches, bootstrap percentage values >50% are indicated below branches. Arrows show clades recovered in the strict consensus tree.

CHAPTER V

TAXONOMIC TREATMENT

5.1 Materials and methods

5.1.1 Plant materials

Grass specimens of the subtribe Ischaeminae and the subtribe Rottboelliinae were studied from existing herbarium specimens deposited at the Department of Systematic Botany, University of Aarhus (AAU); Kasin Suvathabhandhu Herbarium, Department of Botany, Chulalongkorn University, Bangkok (BCU); Herbarium, Botanical Section, Department of Agriculture, Bangkok, Forest Herbarium (BK); National Park, Wildlife and Plant Conservation Department, Bangkok (BKF); British Natural History Museum Herbarium (BM); Botanical Museum, University of Copenhagen (C); Chiang Mai University Herbarium (CMU); Royal Botanic Garden, Edinburgh (E); Royal Botanic Gardens, Kew (K); Khon Kaen University Herbarium (KKU); National Herbarium Netherland University of Leiden branch (L); Linnean Society Herbarium (LINN); Muséum National d'Histoire Naturelle, Paris (P); Prince of Songkhla University Herbarium (PSU); Queen Sirikit Botanic Gardens, Herbarium (QBG); Department of Biology Herbarium, Chiang Mai University and Trinity College, University of Dublin (TCD).

Addition collections of grass specimens also collected from their natural habitats from various localities throughout Thailand. Specimens were collected using standard procedures for herbarium materials (Bridson & Forman, 1999).

5.1.2 Specimen determination

Determinations of the collected specimens were based on the existing keys available from Floras or manuals of neighboring countries. Then the identifications were confirmed by comparing with the type specimens.

5.1.3 Classification

In this work, genera have been arranged according to the Clayton & Renvoize classification (1986).

5.1.4 Taxonomic treatments

Taxonomic treatments of genera and species in the subtribe Ischaeminae and Rottboelliinae were based mainly on morphological data. Each genus and species were described and illustrated. Keys to subtribes, genera and species were constructed. Ecological and geographical data of each species were noted.

5.2 Results

According to the examination of plant collections from the herbarium and addition collections in the fields in Thailand during July 2004-July 2006, 18 taxa in subtribe Ischaeminae and 33 in Rottboelliinae are enumerated.

KEY TO THE SUBTRIBES

1. Rachis internodes and pedicels slender, sometimes thickening upwards, upper lemma awned **A. Ischaeminae**
1. Rachis internodes and pedicels stout, thickening upwards; upper lemma awnless **B. Rottboelliinae**

A. ISCHAEMINAE

Presl, Rel. Haenk. 1: 328. 1830.

Apludinae Hook.f., Fl. Brit. Ind. 7: 4. 1897.

Perennial or annual. *Inflorescence* of single, paired or digitate racemes, theses usually terminal, sometimes axillary, rarely spathe; racemes with slender and fragile rachis. *Spikelets* paired (except *Apluda*), dissimilar. *Sessile spikelet* bisexual, dorsally or laterally compressed; *lower glume* chartaceous to crustaceous, convex or concave, 2-keeled or rounded on the flanks, with or without a median groove; lower floret male, with palea; *upper lemma* oblong, bidentate or bifid, nearly always with a glabrous awn. *Pedicelled spikelet* variable.

About 8 genera, distributed throughout the tropics, 5 genera, 17 species and 1 infraspecific taxa in Thailand.

KEY TO THE GENERA

1. Pedicelled spikelet absent **5. Thelepogon**
1. Pedicelled spikelet present
 2. Spikelet 3; subtended by cymbiform spathes; 1 sessile and 2 pedicelled spikelet **1. Apluda**
 2. Spikelet 2; not subtended by cymbiform spathes; 1 sessile and the other one pedicelled spikelet
  3. Racemes usually 2 or more **3. Ischaemum**
  3. Racemes single
   4. Inflorescence subtended by a linear spatheole which enclosed, sessile spikelets laterally compressed, pedicelled spikelet smaller than sessile spikelet **2. Kerriochloa**
   4. Inflorescence not enclosed by spatheole, sessile spikelets dorsally compressed, pedicelled spikelet larger than sessile spikelet **4. Sehima**

1. APLUDA

L., Sp. Pl. 1: 82. 1753.— Type species: *A. mutica* L.

Calamina P. Beauv., Ess. Agrost.: 128. 1812. *nom. superfl. pro. Apluda.*

Perennial grass. *Culms* hard and tall. *Leaf-sheaths* tight. *Ligules* membranous. *Leaf*-blades linear, flat. *Inflorescence* a large panicle on terminal or axillary, consiting of numerous racemes. *Spikelets* in threes, 1 sessile and 2 pedicelled spikelets, each are subtended by cymbiform spathes, borne on a minute peduncle. *Sessile spikelet* laterally compressed. *Florets* 2; lower sterile, upper perfect. *Glumes*; lower glume coriaceous, convex, without keel and wing, awnless; upper glume boat-shaped, awnless. *Upper lemma* awn or awnless. *Pedicelled spikelet* 2, 1 neuter the other ones with 2 male, awnless. *Lodicules* 2, cuneate. *Stamens* 3. *Stigmas* laterally exerted. *Caryopsis* oblong.

This genus comprises probably only one polymorphic highly variable species, which is very common throughout Southeast Asia, India and Ceylon. Typical found in partly shaded to mostly open places in deciduous forest.

1. **Apluda mutica** L., Sp. Pl. 1: 82. 1753.— Type: India, *Herb. Linn.* 1213.1 (lectotype LINN!).

A. varia Hack. in DC., Monogr. Phan. 6: 196. 1889.— Type: Wall. Cat. no. 8760, 8761 (K).

Perennial grass. *Clums* hard, solid 50–150 m tall or more, glabrous. *Leaf-sheaths* tight, 4.5–7 cm long, grooved, glabrous. *Ligules* membranous, 1.5–2 mm long. *Leaf-blades* linear, up to 1.5 by 30 cm, strigose on both surfaces, base attenuate, apex acuminate. *Inflorescence* consiting of numerous racemes, 3 spikelets subtended by cymbiform spathes with long aristate at the apex, the lower most with an inflated joint. *Sessile spikelet* 1, perfect, laterally compressed. *Glumes*; lower glume oblong-lanceolate, 4–6 mm long, 11–13-nerved, coriaceous, adaxial surface scaberulous, margins thin, hyaline and folded, awnless; upper glume asymmetrically boat-shaped, 4–5 mm long, 6–7-nerved, margins folded, apex acute to acuminate, awnless. *Lower floret* sterile; lemma 4–5 mm long, 5-nerved, hyaline apex acuminate, awnless; palea boat-shaped, 2-nerved, hyaline. *Upper floret* perfect; lemma boat-shaped 3.5–4 mm long, expanded below the middle, hyaline, awn or awnless; palea lanceolate, 2-nerved, hyaline, acuminate. *Pedicelled spikelet* 2; one with only flattened pedicel and solitary glume, the other one with oblong pedicel, 3–3.5 mm long, flattened, glabrous. *Glumes*: lower glume oblong-ovate, 4–4.5 mm long, 11–12-nerved, papyraceous, acute; upper glume boat-shaped, *ca.* 4 mm long, 10–11-nerved, chartaceous, expanded margin, acute. *Lower floret* neutral; lemma ovate, 4–4.5 mm long, 3-nerved, hyaline, marginal winged; palea hyaline, 3.5–4 mm, 2-nerved. *Upper floret*; lemma boat-shaped, 3–3.5 mm long, 5-nerved, hyaline, acute; palea boat-shaped, 2–2.5 mm long, 2-nerved, hyaline. *Lodicules* cuneate, *ca.* 0.25 mm long. *Anthers* yellow, *ca.* 2 mm long. *Ovary* fusiform, 1–1.5 mm long. *Stigma* brown (Figs. 5.1 & 5.27A).

Thailand.— NORTHERN: Mae Hong Son [Ban Mae La Luang, 15 Jan. 1965, *S. Phengnaren* s.n. (BKF); Ban Mu Village, Mueang, 20 Feb. 1979, *T. Koyama et al.* 15,443 (AAU, BKF)], Chiang Mai [11 Oct. 1911, *A.F.G. Kerr* 2155 (BM, E, K, TCD); Doi Chiangdao, 28 Jan. 1913, *A.F.G. Kerr* 2867 (BM, K); 11 Nov. 1905, *K.B.* 1189 (BKF); 15 May 1955, *T. Smitinand* 2724 (BKF); 20 Nov. 1955, *Ploenchit* 893 (BKF, K); 16 Feb. 1958, *Th. Sørensen et al.* 1231 (C), 1244 (C); 17 Feb 1958, *Th. Sørensen et al.* 1265 (C); 7 Dec. 1959, *T. Smitinand & E.C. Abbe* 6254 (BKF, K); 3 Dec. 1961, *T. Smitinand & Anderson* 7341 (BKF, K); 28 Oct. 1979, *T. Shimizu et al.*

21028 (BKF); 15 Dec. 1990, *J.F. Maxwell* 90-1354 (CMU, L); Lao Kao Nok, 18 Sept. 1914, *A.F.G. Kerr* s.n. (BM); Doi Suthep, E side, below Doi Suthep temple, 25 Oct. 1949, *Ploenchit* 88 (BKF, K); 12 Dec. 1957, *T. Smitinand* 16803 (BKF, K); 10 Feb. 1958, *Th. Sørensen et al.* 977 (BKF, C); 4 Dec. 1958, *Th. Sørensen et al.* 2640 (C); 26 Oct. 1958, *Th. Sørensen et al.* 5920 (C, K); 18 Dec. 1958, *Th. Sørensen et al.* 6496 (C, E, K); 10 Nov. 1987, *J.F. Maxwell* 87-1396 (BKF, CMU, L); 21 Nov. 1993, *A. Phuakam* 82 (L); 22 Nov. 2005, *P. Traiperm* 297 (BCU, BKF, KKU); Wang Tao, N of Chiang Mai, 13 Feb. 1958, *Th. Sørensen et al.* 1059 (BKF, C, E); Pha Hom Pok, 25 Feb. 1958, *Th. Sørensen et al.* 1677 (C); E of Fang, 28 Feb. 1958, *Th. Sørensen et al.* 1802 (C); SW part of Doi Chang Mae Taeng, 24 Oct. 1979, *T. Shimizu et al.* T-20725 (BKF); Op Luang Gorge, off the Hot Mae-Saring highway, along Mae Jam river, Hot, 21 Dec. 1989, *J.F. Maxwell* 89-1574 (CMU, E, L); 23 Nov. 2005, *P. Traiperm* 304 (BCU, BKF, KKU); Doi Mueang Awn, W side area, San Kam Paeng, 17 Nov. 1995, *P. Palee* 348 (L); Mae Taeng, Doi Sahng Liang, S side, upper Gu Gahp Valley, Pah Dang (red Lahu) Village area; Geut Chang, 7 Nov. 1997, *J.F. Maxwell* 97-1307 (BKF, L); Den (Karen) village, Royal Project area; Ban Wat Chan: Mae Jam, 4 Dec. 1998, *J.F. Maxwell* 98-1409 (BKF); at pass *ca.* 25 km along road Mae Rim-Samoeng, 12 Oct. 2001, *S. Laegaard* 21704 (AAU); km 24-28 along road Mae Rim-Samoeng, 21 Oct. 2001, *S. Laegaard* 21769 (AAU)], Chiang Rai [km 133, 1020 road, Chiang Khong to Chiang Rai, 2 Dec. 2005, *P. Traiperm* 318 (BCU, BKF, KKU); Theng, 2 Dec. 2005, *P. Traiperm* 319 (BCU, BKF, KKU)], Lamphun [Doi Khun Tan National Park, Yaw 2, *J.F. Maxwell* 93-1334 (L)], Lampang [21 Dec. 1973, *Ch. Charoenphol* 409 (BKF); Wahng National Park, N Part, Wahng Die; Pah Ngham (Nahn Kaht) limestone mountain area; middle elevation of Maw Cave limestone hill, 19 Dec. 1996, *J.F. Maxwell* 96-1676 (BKF, L); Khun Tan National Park, 4 Dec. 2005, *P. Traiperm* 321 (BCU, BKF, KKU)], Phrae [Mae Yom National Park, W bank of the Yom river at Pah Ing station; Sahiab, 15 Nov. 1991, *J.F. Maxwell* 91-1059 (AAU, L)], Tak [Ma Bon, 5 Dec. 1957, *J. Santos* 6693 (L); Bhumipol Dam, Dec. 1959, *Sanchai* 614 (BK); Doi Pang Kluay, 22 Dec. 1965, *S. Phengnaren* s.n. (BKF); Lahn Sahng, 27 Dec. 1974, *R. Geesink et al.* 7928 (BKF, C, K, L)], Phitsanulok [Thung Salaeng Luang National Park, about 20 km E of Phitsanulok, 10 Jan. 1921, *G. Murata* T-38343 (BKF); Kang Sopa waterfalls, 13 Dec. 1966, *Prayad* 594 (BK)], Nakhon Sawan [Lahn Sahng National Park, 23 Nov. 1965, *E. Hennipman* 3108 (BKF, C, K, L, P)]; NORTH-EASTERN: Phetchabun [Chon Daen, 15 Jan. 1969, *Vacharapong* 309

(BK); Nam Nao National Park, 20 Nov. 2004, *P. Traiperm* 175 (BCU, BKF, KKU)], Loei [km 90-91, 14 Jan. 1960, *C. Chermsirivathana* s.n. (BK); Phu Kradueng, 15 Mar. 1952, *T. Smitinand* 1179 (BKF, K, L), 1858 (BKF, K), 2030 (BKF, K), 2100 (BKF, K); 27 Nov. 1965, *M. Tagawa et al.* 368 (BKF); 31 Oct. 2005, *P. Traiperm* 273 (BCU, BKF, KKU); Phu Luang, from Ban Na Luang to N ridge, 3 Dec. 1965, *M. Tagawa et al.* 1040 (BKF, E); Hw. 203, km 90-91, 14 Jan. 1982, *Y. Paisooksantivathana* y 809-82 (BK)], Nong Bua Lam Phu, [18 Nov. 1963, *M. Lazarides* 644 (BK)]; EASTERN: Chaiyaphum [Thungkamang, 15 Dec. 1971, *C.F. van Beusekom et al.* 4330 (BKF, C, K, L); 27 Nov. 2004, *P. Traiperm* 179 (BCU, BKF, KKU)], Nakhon Ratchasima [Pak Chong, 1 Jan 1924, *A. Marcan* 1574 (BM), 1593 (BM); 14 Jan. 1965, *Umpai* 177 (BK); Huai Thalaeng, 23 Dec. 1928, *Put* 2201 (BK, BM, K, TCD); Klang Dong, 9 Dec. 1962, *C. Phengklai* 405 (BKF, C, K, L)], Buri Ram [24 Nov. 1976, *C. Phengklai et al.* 3371 (BKF)]; SOUTH-WESTERN: Uthai Thani [on way to Khao Nang Rum Research Station, Huai Kha Kaeng Wildlife Sanctuary, Lahn Sak, 12 Nov. 1979, *T. Shimizu et al.* T-22435 (L)], Kanchanaburi [Tham Pha, 26 Dec. 1961, *C. Phengklai* 323 (BKF, E, K, L); Huai Bankau, 12 Nov. 1971, *C.F. van Beusekom et al.* 3719 (BKF, C, K, L, P); Sai Yok, 9 Dec. 1961, *K. Larsen* 8632 (C), 8641 (C); 19 Dec. 1961, *K. Larsen* 8821 (C)], Prachuap Khiri Khan [Cha-um, 15 Apr. 1960, *C. Chermsirivathana* s.n. (BK)]; CENTRAL: Ang Thong [24 Dec. 1928, *Put* 2545 (BK, BM, K)], Phra Nakhon Si Ayutthaya [9 Sept. 1922, *A. Marcan* 996 (BM); near Saraburi, 5 Mar. 1958, *Th. Sørensen et al.* 1937 (BKF, C, E)], Saraburi [Muak Lek, 18 Sept. 1953, *K. Suvathabhandhu* 480 (BK); Phukhae Arboretum, 25 Mar. 1950, *L. Williams* 17148 (K); 117 km N of Krung Thep Maha Nakhon, 3 Dec. 1957, *J. Santos* 6676 (L); Khao Sam Lan, 5 Nov. 2005, *P. Traiperm* 275 (BCU, BKF, KKU)], Nakhon Pathom [Pootthahmonthon, Mahidol University, Salaya Campus, 25 Jan. 1999, *J.F. Maxwell* 99-39 (L)], Krung Thep Maha Nakhon [5 Oct. 1919, *A.F.G. Kerr* 3801 (BM, K); 19 Feb. 1922, *A. Marcan 678* (BM); *E. Smith* 350 (BK, BM); 12 Feb. 1932, *Put* s.n. (BK); Bang Khen, 8 Nov. 1952, *K. Suvathabhandhu* 329 (BK)], Samut Prakan [Wat Bahng Grajow, 31 Jan. 1971, *J.F. Maxwell* 71-19 (BK)]; SOUTH-EASTERN: Chon Buri [Ban Dam, Si Racha, 5 Apr. 1920, *A.F.G. Kerr* 4163 (BM, K); 9 km N of Chon Buri, 26 Nov. 1970, *M. Lazarides* 7495 (K); Khao Khiao, Si Racha, 10 Apr. 1975, *J.F. Maxwell* 75-409 (AAU, BK, L); Sattahip, 3 Nov. 2004, *P. Traiperm* 152 (BCU, BKF, KKU)], Rayong [Klang, 29 Nov. 1964, *S. Sutheesorn* 265 (BK)], Chanthaburi [Wang Kaphae, Pong Nam Ron, 8

Oct. 1956, *T. Smitinand* 3544 (BKF); 4 Nov. 1958, *Dee* 1186 (BKF)]; PENINSULAR: Chumphon [Khao Num-Ma-Prou, Toung Kae, 1 Jan. 1974, *S. Sutheesorn* 2816 (BK)], Surat Thani [Khao Nam Ron (hot springs), Chaiya, 5 Feb. 1987, *J.F. Maxwell* 87-149 (AAU, BKF, CMU, E, L, P)].

Distribution.— Worldwide.

Ecology.— Partly shaded to mostly open places in deciduous forest, up to 2,000 m altitude. Flowering in August to May.

Vernacular.— Ya kom bang (หญ้าคมบาง) (General); Ya phai (หญ้าไผ่) (Krung Thep Maha Nakhon); Ya phrik phran (หญ้าพริกพราน) (Ang Thong).

Notes.— This species has 3 spikelets subtended by cymbiform spathes with long aristate at the apex. It is variable in the development of the awn of the upper lemma.

Uses. — The young plant is used as a fodder (Gilliland, 1971).

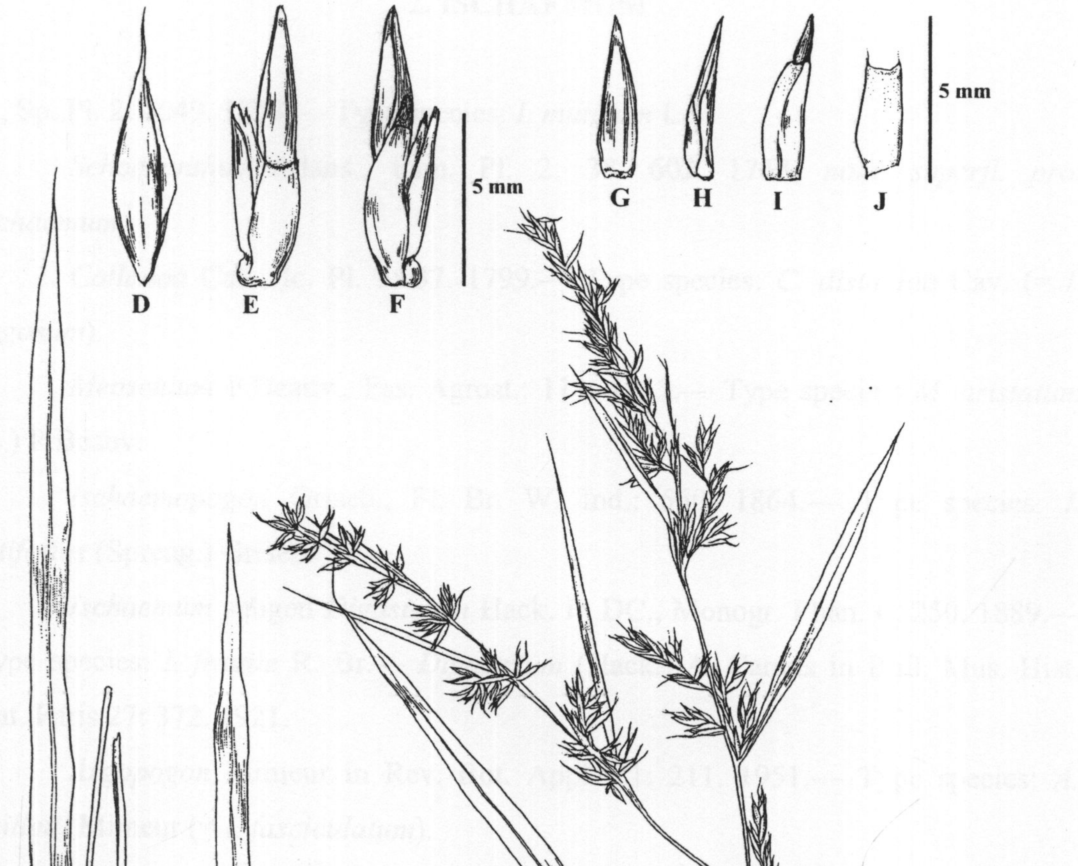

Figure 5.1 *Apluda mutica*: A. plant; B. inflorescence; C. three of spikelets subtended by cymbiform spathes; D. spatheole; E-F. two views of three spikelet; G. lower glume of sessile spikelet; H. upper glume of sessile spikelet; I. pedicelled spikelet; J. pedicel of sessile spikelet. All line drawings were drawn by P. Traiperm from *P. Traiperm* 152.

2. ISCHAEMUM

L., Sp. Pl. 2: 1049. 1753.— Type species: *I. muticum* L.

Schoenanthus Adans., Fam. Pl. 2: 38. 602. 1763, *nom. superfl. pro. Ischaemum.*

Colladoa Cav., Ic. Pl. 5: 37. 1799.— Type species: *C. distachia* Cav. (= *I. rugosum*).

Meoschium P.Beauv., Ess. Agrost.: 111. 1812.— Type species: *M. aristatum* (L.) P.Beauv.

Ischaemopogon Griseb., Fl. Br. W. Ind.: 560. 1864.— Type species: *I. latifolius* (Spreng.) Griseb.

Ischaemum subgen *Digastrium* Hack. in DC., Monogr. Phan. 6: 250. 1889.— Type species: *I. fragile* R. Br.— *Digastrium* (Hack.) A. Camus in Bull. Mus. Hist. Nat. Paris 27: 372. 1921.

Argopogon Mimeur in Rev. Bot. Appl. 31: 211. 1951.— Type species: *A. vuilletii* Mimeur (= *I. fasciculatum*).

Perennial or annual. *Inflorescence* terminal and axillary, of paired or sometimes digitate racemes, separated or conjugated 1-sided and interlocked back to back in a single spike, exserted but sometimes embraced by a spatheole; internodes and pedicels linear to obovoid, usually exposed on the back of the raceme as a U- or V-shaped segment. *Sessile spikelet* compressed; lower glume chartaceous to coriaceous, convex, 2-keeled or rounded on flanks, often rugose, sometimes winged, entire or bilobed; upper glume with or without an awn; upper lemma awnless in *I. indicum* and *I. magnum*. *Pedicelled spikelet* as large as the sessile, dorsally or laterally compressed, often asymmetrical, occasionally bisexual with the upper lemma weakly awned.

A genus of about 70 species in the Old World tropics, mainly in Asia, but a few species in tropical America; 13 species and 1 infraspecific level occur in Thailand. *Ischaemum* is a difficult genus reaching its greatest complexity in Southeast Asia and biosystematic work on the genus badly is needed.

I. angustifolium Hack., *I. fieldingianum* Rendle and *I. mangaluricum* (Hack.) Stapf ex Fisher have been reported from Thailand (see Nanakorn & Norsaengsri 2001) but no herbarium specimens are available for confirmation.

KEY TO THE SPECIES

1. Spikelets awnless, awn imperfect, not kneed, rarely 1 cm long or with a weak awn hardly exserted from the glumes
   2. Lower glume oblong on the lower part, upper part obique foliose and acute at the apex, slightly winged along the upper margins; racemes 9–15 cm long **7. I. magnum**
   2. Lower glume ovate, winged above the middle, racemes 2.5–3.5 cm long **8. I. muticum**
1. Spikelets distinctly awned
   3. Lower glume of sessile spikelet coarsely ridged across the back or with nodules along the margins
      4. Lower glume of sessile spikelet coarsely ridged across the back with 4–7 ridges **9. I. rugosum**
      4. Lower glume of sessile spikelet coarsely ridged with nodules along the margins
         5. Lower glume of sessile spikelet indurate below, without nerve
            6. Pedicelled spikelet as long as the sessile one, lower glume with 2-3 transverse ridges or nudules at each edge **1. I. barbatum**
            6. Pedicelled spikelet shorter than the sessile one, lower glume with 4-7 transverse ridges or nudules at each edge **9. I. rugosum**
         5. Lower glume of sessile spikelet subcoriaceous, with 10–14 distinct nerve
            7. Back of the lower glume of sessile spikelet glabrous **4. I. hubbardii**
            7. Back of the lower glume of sessile spikelet hairy **12. I. sp.1**
   3. Lower glume of sessile spikelet not coarsely ridged across the back or with nodules along the margins
      8. Plant often with 3 racemes **10. I. tenuifolium**
      8. Plant normally with 2 racemes
         9. Lower glume of sessile spikelet without winged **11. I. timorense**
         9. Lower glume of sessile spikelet with conspicuously winged
            10. Back of the lower glume of the sessile spikelet glabrous
               11. Inflorescences raceme, conjugated **2. I. hansenii**
               11. Inflorescences digitately raceme, separated **5. I. indicum**

10. Back of the lower glume of the sessile spikelet slightly hairy to densely hairy
  12. Leaf blade pilose without tubercle-based hair
    13. Lower glume of the sessile spikelet with distintly 2-apical wings **5. I. indicum**
    13. Lower glume of the sessile spikelet with narrowly fringed wings along the upper margins **3. I. hirtum**
  12. Leaf blade glabrous or with tubercle-based hairs at least in the lower part
    14. Leaf blade pilose with tubercle-based hairs on both surfaces **6. I. lacei**
    14. Leaf blade glabrous on both surfaces, pilose with tubercle-based hairs on the lower surface **13. I. sp.2**

1. Ischaemum barbatum Retz., Observ. Bot. 6: 35. 1791.— Type: Indonesia, Java, *D. Wennerberg* s.n. (not seen).

I. barbatum Retz. var. *glaberrimum* Bor in Dansk Bot. Arkiv (20) 2: 174. 1962. *syn. nov.*— Type: Thailand, Chiang Mai: Doi Suthep, common in a bog, alt. 1000 m, 14 April 1958, *Th. Sørensen, K. Larsen & B. Hansen* 2709 (holotype K!, isotypes BKF!, C!, E!).

Andropogon elatus (Nees) Steud., Syn. Pl. Glum. 1: 376. 1854.— Type: India, Silhet, *Wall. Cat. no.* 8861 (holotype K!).

I. aristatum L. subsp. *imberbe* Hack. var. *imbricatum* Hack. in DC., Monogr. Phan. 6: 203. 1889.— Type: India, Khasia, *J.D. Hooker & T. Thomson* s.n. (lectotype K!, selected here).

I. aristatus L. var. *arfakense* Rendle in Gibbs, Dutch N.W. New Guinea. 89. 1917.— Type: New Guinea, Arfak mountains, Angi lakes, common in open marsh by lake, *L.S. Gibbs* 5564 (lectotype K!, selected here).

I. barbatum var. *arfakense* (Rendle) Ohwi, Bot. Mag. Tokyo. 56: 11. 1942.

KEY TO THE VARIETIES

1. Raceme glabrous **a. var. barbatum**
1. Raceme hairy **b. var. lodiculare**

a. var. barbatum

Perennial. *Culms* erect somewhat prostrate, terete, up to 1 m tall, internodes glabrous, nodes glabrous or slightly pilose. *Leaf-sheaths* loose and overlapping below, glabrous or with pilose hairs or densely appressed hairs. *Ligules* prominently membranous, 1–4 mm long, glabrous or pilose outside. *Leaf-blades* narrowly linear to linear-lanceolate up to 20 by 0.5–1.5 cm, glabrous to pilose on both surfaces, rounded or subcordate or abruptly narrowed at the base, apex acute to acuminate. *Inflorescence* racemose on terminal or axillary, 5–11 cm long, conjugate with 2 racemes, rachis internodes oblong, 3–6 mm long, tough, pilose along the angles, nodes with a ring of long cilia, callus triangular, blunt *ca.* 1.5 mm long, pilose at base. *Sessile spikelet* dorsally compressed. *Glumes*; lower glume varying in size and shape, oblique-oblong, 5.5–8 by 1.5–2 mm, upper part foliose, indurate below, not nerved, with 2–3 transverse ridges or nodules at each edge and rarely extending horizontally to meet across the back of the glumes, glabrous on the back, asymmetrically with 2 small fringed marginal wings on the 1/3 of the upper, submarginally keeled towards the apex, keels unequally and narrowly winged, wing widest on side away from pedicelled spikelket; upper glume folded, 5–7.5 by *ca.* 1 mm, scabrous keeled on the back of the nerve, glabrous on the back or villous. *Lower floret*; lemma oblong-acute, 4.5–7 by *ca.* 1 mm, hyaline, margins slightly folded, upper margins ciliate; palea oblong-acute, 3–6.5 by *ca.* 1 mm, hyaline, folded. *Upper floret*; lemmas 3.5–5 mm long, hyaline, bifid, geniculately awned from sinus, awn twisted, 18-25 mm; upper palea oblong, 3–4.5 mm long, hyaline, folded. *Pedicelled spikelet*: pedicels triangular-shaped, 2.5–3 mm long, pilose along the angles. *Glumes*; lower glume oblong, 4.5–7 by 1.5–2 mm, upper foliose and many nerved, apex with a wide fringed wing its whole length on one side, indurate below; upper glume boat-shaped, 4.5–6.5 mm long, 1-keeled along the back, keel scabrous, glabrous on the back or pilose on the lower part, apex acute. *Lower floret*; lemma oblong-acute, 4–6 by *ca.* 1 mm, hyaline, folded; palea oblong-acute, 3.5–5.5 by *ca.* 0.8 mm, hyaline, folded. *Anthers ca.* 2.5

mm long. *Upper floret*; lemma boat-shaped, 4–5 by *ca.* 0.8 mm, hyaline, folded, apex acute; palea oblong-obtuse, 3–4 by *ca.* 0.8 mm, hyaline, folded (Fig. 5.27B. & C).

Thailand.— NORTHERN: Chiang Mai [Doi Suthep, 7 May 1910, *A.F.G. Kerr* 1166 (BM, E, K); 4 Oct. 1958, *Th. Sørensen et al.* 2594 (BKF, C); 14 Apr. 1958, *Th. Sørensen et al.* 2709 (BKF, C, E, K); 15 Aug. 1990, *J.F. Maxwell* 90-884 (AAU, CMU, L); 25 Oct. 1958, *Th. Sørensen et al.* 5889 (C, E, K); 10 Apr. 1958, *K. Larsen* 259 (K); Ban Watchan, Sameung, 19 Jan. 1988, *R. Pooma & W. Werner* 42 (BKF); Doi Pui, 15 Aug. 1990, *J.F. Maxwell* 90-884 (AAU, CMU, L); Mae Rim, 21 Jul. 1996, *BGO. Staff* 6926 (QBG)]; NORTH-EASTERN: Loei [Phu Kradueng, 3 Oct. 1952, *T. Smitinand* 1127 (BKF), 1137 (BKF); 23 Mar. 1954, *T. Smitinand* 1793 (BKF, F); 17 Sept. 1954, *T. Smitinand* 1936 (BKF, K); *Dee* 46 (BKF); 9 May 1967, *T. Shimizu et al.* T-9024 (BKF); 23 Nov. 1984, *G. Murata et al.* T-42970 (BKF); 9 May 1988, *H. Koyama* T-61567 (BKF), T-61568 (BKF); Phu Ruea, 24 Jul. 2004, *P. Traiperm* 118 (BCU, BKF, KKU), 120 (BCU, BKF, KKU)], Udon Thani [Mueang, 10 Oct. 2004, *P. Traiperm* 129 (BCU, BKF, KKU)], Nong Khai [Phu Woe, 16 Oct. 2005, *P. Traiperm* 215 (BCU, BKF, KKU)], Sakon Nakhon [Phu Phan, 24 Dec. 1961, *P. Suvarnakoses* 1994 (K); 16 Nov. 1963, *Ploenchit* 1902 (BKF); 6 Nov. 2004, *P. Traiperm* 154 (BCU, BKF, KKU); 3 Oct. 2005, *P. Traiperm* 206 (BCU, BKF, KKU)], Maha Sarakham [km 21 on road 208 Maha sarakham-Khon Kaen, 26 Oct. 2001, *S. Laegaard et al.* 21802B (AAU, L)]; EASTERN: Chaiyaphum [Thungkamang, 15 Dec. 1971, *C.F. van Beusekom et al.* 4291 (BKF, C, K); 27 Nov. 2004, *P. Traiperm* 181 (BCU, BKF, KKU); 19 Oct. 2005, *P. Traiperm* 221 (BCU, BKF, KKU)], Nakhon Ratchasima [Khao Yai National Park, Khao Khiao, 29 Oct. 1970, *Ch. Charoenphol et al.* 4240 (AAU)], Roi Et [Ban Ngo Pa Yang, Mueang, 10 Jun. 1982, *Y. Paisooksantivathana & S. Sutheesorn* y 1080-82 (BK)], Si Sa Ket [12 Feb. 1959, *Ploenchit* 1501 (BKF, K); en route from Si Sa Ket city to Ubon Ratchathani, 10 Oct. 1984, *G. Murata et al.* T-318117, (BKF)], Ubon Ratchathani [Pa Dong Na Tham, Khong Chiam, 16 Oct. 1998, *C. Niyomdham* 5625 (AAU, BKF); surrounding of camp Marine Resort, Khong Chiam, 28 Oct. 2001, *S. Laegaard et al.* 21850 (AAU, L); km 10, 2112 road to Khong Chiam, 23 Oct. 2005, *P. Traiperm* 250 (BCU, BKF, KKU); km 36, 217 road, 22 Oct. 2005, *P. Traiperm* 234 (BCU, BKF, KKU)]; CENTRAL: Saraburi [Sam Lan forest, Mueang, 8 Sept. 1974, *J.F. Maxwell* 74-898 (AAU, BK, L)], Nakhon Nayok [near Nong Khing in Khao Yai National Park, 13 Oct. 1984, *G. Murata et al.* T 52242 (BKF)], Krung Thep Maha Nakhon [12 Oct. 1923, *A.F.G. Kerr* 7930 (BK); Bang Khen, 15 Jan. 1975, *Umpai* 522 (BK)]; SOUTH-EASTERN: Chon Buri [Pong Nam Ron, Hindat, 10 Aug. 1956, *T. Smitinand* 3549 (BKF)], Chanthaburi [Plain of Makham, 12 Jan. 1958, *Th. Sørensen et al.* 169 (C); 19 Nov. 2005, *P. Traiperm* 288 (BCU, BKF, KKU); 25 Nov. 1970, *M. Larzarides* 7463 (C, K)], Trat [Mueang, 25 Dec. 2005, *P. Traiperm* 352 (BCU, BKF, KKU); Khlong Yai, 2 Nov. 1951, *T. Smitinand* 4980 (BKF); 25 Dec. 2005, *P. Traiperm* 353 (BCU, BKF, KKU); Huai Rang, 21 Jun. 1952, *T. Smitinand* 1405 (BKF)]; PENINSULAR: Ranong [on roadside, 26 Oct. 2004, *P. Traiperm* 150 (BCU, BKF, KKU)], Surat Thani [Kanchanadit, 1 Aug. 1927, *A.F.G. Kerr* 13070 (BK, BM, K)], Phangnga [Koh Korkao, 29 Apr. 1967, *S. Sutheesorn* 2494 (BK)], Phatthalung [Sak, 1 May 1930, *A.F.G. Kerr* 19268 (BK, K); Thale Noi, 19 Mar. 1942, *P. Sukkaewmanee* PK 72, (PSU); 21 Oct. 2004, *P. Traiperm* 140, (BCU, BKF, KKU)], Trang [Thaleng Hawng, 29 Aug. 1955, *T. Smitinand* 3022 (BKF, K); Thung Kai, 13 Oct. 1992, *A.S. Barfod & T. Burholt* 43853 (AAU); 25 Oct. 1993, *K. Larsen* 43991 (L); 15 Sept. 1996, *BGO. Staff* 134 (QBG); 22 Oct. 2004, *P. Traiperm* 142 (BCU, BKF, KKU), 143 (BCU, BKF, KKU)], Satun [Kuan Gah Long, Nikhom Sahng Eng, Soi 6, Kuan Cah Long, 10 Oct. 1986, *J.F. Maxwell* 86-774 (CMU, L, PSU); Thale Ban, 4 Nov. 1990, *K. Larsen et al.* 41125 (AAU, PSU)], Songkhla [Kampengpet, 25 Jul. 1920, *A.F.G. Kerr* 15905 (BK, BM, K), 15984 (BK, BM, K); Thepa, 23 Mar. 1928, *A.F.G. Kerr* 14705 (BK, BM); Rattaphum, 21 Dec. 1965, *Umpai* 280 (BK); Rubber Research Institutes, 5 May 1970, *S. Sutheesorn* 1712 (BK); Prince of Songkla University, Hat Yai, 4 Dec. 1975, *A. Yiamudom* 26 (PSU); Ban Thom Island Sating, Lake Songkhla, 21 Oct. 1983, *P. Sirirugsa* 671b (PSU); 1 Aug. 1976, *P. Sirirugsa* s.n. (BKF); Hat Yai, near Kwan Sahdaw village, 20 Nov. 1984, *J.F. Maxwell* 84-449 (BKF, PSU); Hat Yai, Khlong Hoi Khong, W of Thoong Loong, 6 Jun. 1985, *J.F. Maxwell* 85-578 (AAU, BKF, E, L, PSU); Ton Pliew near Ton Nga Chang, 13 Oct. 1991, *K. Larsen et al.* 42352 (AAU, PSU); km 54 on road to Pattani, 19 Oct. 2004. *P. Traiperm* 135 (BCU, BKF, KKU)], Pattani [Thung Yang Daeng, 30 Oct. 2001, *R. Pooma et al.* 3126A (BKF)], Narathiwat [Pa Wai, Su Ngai Pade, 6 Aug. 1987, *C. Niyomdham* 1468 (AAU, BKF, C); Kok Kun Bet, Tak Bai, 2 Sept. 1987, *C. Niyomdham & D. Sriboonma* 1511 (AAU, BKF, C, E, K, L, P)].

Distribution.— India and Southeast Asia.

Ecology.— Tufted grass common in paddy fields and wet places, up to 1500 m altitude. Flowering throughout the year.

Vernacular.— Ya yon hu (หญ้ายอนหู) (Peninsular); Ya wai (หญ้าหวาย) (Trat); Ya hang khang (หญ้าหางค่าง) (Loei); Ya daeng (หญ้าแดง), Ya wai dang (หญ้าหวายแดง) (Narathiwat).

Notes.— This is a widespread and polymorphic species, to which many specific and infraspecific names have been applied. Variation depends mainly on the degree of hairiness of the leaves and spikelets and the number and prominence of the nodules and ridges on the sessile spikelet. In extreme cases the ridges are particularly well-developed and approach the condition in *I. rugosum*, but such plants can be recognised as *I. barbatum* by their more robust, perennial habit and more oblong sessile spikelets.

b. var. lodiculare (Nees) Jansen, Reinwardtia 2: 294. 1953.

Meoschium lodiculare Nees in Hook. & Arn., Beech. Voy.: 246. 1838.— Type: *Meyen, Millet, G.H. Vachell* (not seen).

I. aristatum subsp. *barbatum* var. *lodiculare* (Nees) Hack. in DC., Monogr. Phan. 6: 205. 1889.— Type: China, Cap Syng-Moon (*Meyen*); Hong-Kong (*Hance* 1257); Futschan-yen (ex *Debeaux*) (not seen).

Spikelets with long, white hairs. Joints of the racemes ciliate on all the sides. Sheaths usually long-hirsute, nodes bearded (Fig. 5.27D).

Thailand.— NORTH-EASTERN: Phetchabun [Thung Salaeng Luang, 17 Nov. 2005, *P. Traiperm* 284 (BCU, BKF, KKU)]; Loei [Phu Luang, 15 Nov. 1968, *C. Chermsirivathana* 1096 (BK); Phu Kradueng, 19 Mar. 1948, *K. Suvathabhandhu* 151 (BK); 19 Mar. 1958, *Th. Sørensen et al.* 2314 (BKF, C, K); 29 Nov. 1958, *Th. Sørensen et al.* 6328 (C, E, K); 15 Dec. 1963, *Umpai* 111 (BK); 16 Mar. 1974, *C. Chermsirivathana & T. Boonkerd* 1837 (BK), 1838 (BK); 3 Nov. 1984; *G. Murata et al.* T-42970 (BKF, L); 12 Nov. 2004, *P. Traiperm* 159 (BCU, BKF, KKU); 13 Nov. 2004, *P. Traiperm* 164 (BCU, BKF, KKU), 167 (BCU, BKF, KKU); 29 Oct. 2005, *P. Traiperm* 262 (BCU, BKF, KKU), 263 (BCU, BKF, KKU)], Udon Thani [Ban Nakha, 24 Dec. 1964, *C. Chermsirivathana* 231 (BK)], Nong Khai [Phonpisai, 19

Nov. 1963, *Pradit* 704 (BK); Phu Woe, 16 Oct. 2005, *P. Traiperm* 217 (BCU, BKF, KKU), 218 (BCU, BKF, KKU)], Sakon Nakhon [Phu Phan, 6 Nov. 2004, *P. Traiperm* 155 (BCU, BKF, KKU)]; EASTERN: Chaiyaphum [Phu Khiao, 22 Feb. 1931, *A.F.G. Kerr* 20218 (BK)], Nakhon Ratchasima [Khao Yai National Park, Khao Khiao, 29 Aug. 1963, *T. Smitinand & H. Sleumer* 8321 (BKF, K, L)], Roi Et [Ban Wa Ngarm, Kaset Wisai, 9 Jun. 1982, *Y. Paisooksantivathana & S. Sutheesorn* y 978-82 (BK)], Si Sa Ket [Dongrak range, Chong Bat Lak, Kantharalak, 20 Aug. 1976, *J.F. Maxwell* 76-591 (AAU, BK, L)]; SOUTH-EASTERN: Prachin Buri [Watana, 27 Dec. 1923, *A.F.G. Kerr* 9783 (BK, BM, K)], Chanthaburi [25 Nov. 1970, *M. Larzarides* 7459 (BKF, C, K, L)], Trat [Khlong Yai, 25 Dec. 2005, *P. Traiperm* 351, (BCU, BKF, KKU)]; PENINSULAR: Satun [28 Dec. 1927, *A.F.G. Kerr* 13711 (BK, BM, K); Thung Nui, 2 Sept. 1961, *T. Smitinand* 7128 (BKF)].

Distribution.— Southeast Asia.

Ecology.— In open grassy pine forest or in open area, at 50-1,300 m altitude. Flowering in June to March.

Notes.— This is a very distinctive variety. The inflorescence is suffused with purple and covered with long white hairs.

2. Ischaemum hansenii Bor, Dansk Bot. Arkiv (23) 4: 470. 1968.— Type: Thailand, Trang, Ko Talibong, *B. Hansen & T. Smitinand* 12198 (holotype K!, isotypes BKF!, C!, L!).

Perennial. *Culms* 20–25 cm, creeping or somewhat prostrate, culm glabrous, node glabrous or ciliolate. *Leaf-sheaths* loose, 2–3 cm long, glabrous. *Ligules*, membranous with ciliate margin, 0.8–1 mm long, brownish. *Leaf-blades* lanceolate, 3-7 by 0.6–0.9 cm, acute at the apex, glabrous on both surfaces. *Inflorescences* racemes, terminal, 2.5–4.5 cm long, conjugate not separating into 2 racemes when mature, rachis internodes triangular-shaped, *ca.* 5 by 1 mm, pilose on keel, nodes with a ring of long cilia, callus *ca.* 1 mm long, glabrous. *Sessile spikelet*; lower glume elliptic, 5.5–6 by 2–2.5 mm, indurated below, 2-apical wings and along the upper margins, wings scabrous, glabrous on the back, folded, lower glume apex dentate; upper glume boat-shaped, *ca.* 7 by 1.2 mm, acuminate, keeled along the upper back, keeled scabrous, upper margins ciliate. *Lower floret*; lemma lanceolate, *ca.* 5 by 1 mm, upper margins folded, margins ciliate; lower elliptic, *ca.* 5 by 1 mm, margins folded, upper margins long ciliate; upper lemma *ca.* 4.5 by 1 mm, bifid, awned from sinus, twisted column, 12–15 mm long, upper margins ciliate; palea lanceolate, *ca.* 5 by 0.8 mm, hyaline, slightly folded, margins ciliate. *Ovary* ellipsoid, *ca.* 1.5 mm long. *Pedicelled spikelets* laterally compressed. *Pedicels* triangular shaped, *ca.* 4 by 1 mm, pilose along keel. *Glumes*; lower glume oblique-lanceolate, plicate, *ca.* 6 by 1 mm, indurate and convex below, margins scabrous, wing on keel, keel scabrous, glabrous on the back; upper glume boat-shaped, *ca.* 6 by 1 mm, acuminate, keel along the upper back, keel scabrous, margins ciliate. *Lower floret*; lemma boat-shaped or ovate, *ca.* 5 by 1 mm, hyaline, upper margins ciliate; palea lanceolate, *ca.* 5 by 0.8 mm, hyaline, slightly folded, upper margins ciliate. *Lodicules* cuneate, *ca.* 0.5 mm long. *Anthers* 3, *ca.* 2.5 mm long, yellow. *Upper floret*; lemma, *ca.* 4 by 1 mm, bifid, awned from sinus, twisted, 13–15 mm long, upper margins ciliate; palea lanceolate, *ca.* 4.5 by 0.8 mm, hyaline, slightly folded (Fig. 5.28A-C).

Thailand.— PENINSULAR: Trang [Ko Talibong, 10 Nov. 1966, *B. Hansen & T. Smitinand* 12198 (BKF, C, K, L)].

Distribution.— Endemic to Thailand.

Ecology.— Creeping on rocks by the sea, at sea level. Flowering in November.

Notes.— Known only from the type specimen. I can not be collected even in their original locality.

3. Ischaemum hirtum Hack. in DC. Monog. Phan 6.: 1889. 228.— Type: India, Khasia, *J.D. Hooker & T. Thomson* 1937 (holotype K!).

Annual, tufted. *Culms* erect, terete, 45–70 cm tall, nodes ciliate, internodes glabrous. *Leaf-sheaths* tight, 4–6 cm long, glabrous to pilose. *Ligules*, membranous, 1–2 mm long. *Leaf-blades* linear, 8–15 by 0.4–0.6 cm, pilose on both surfaces, margins scabrous, base tapering, acute at the apex. *Inflorescences* racemes, terminal and axillary, 4–6 cm long, separating into 2 racemes, rachis internodes oblong, triangular or quadrangular in transverse, 3–4 mm long, hairy along the angles, nodes with a ring of long cilia, hairs up to 3 mm long, callus 1–1.3 mm long. *Sessile spikelet*; lower glume 5–5.5 mm long, 9–10-nerved, pilose on the back, upper margins scabrous, expanded at base, marginals nerved prolonged form 2 points, narrowly fringed wings along the upper margins; upper glume boat-shaped, 6.5–7 mm long, midnerve extended to long tail, scabrous wing along tail, glabrous on the back, upper margins ciliate. *Lower floret*; lemma *ca.* 5 mm long, plicate, scabrous along marginal keel; palea *ca.* 5 mm long, hyaline, slightly folded, upper margins ciliate. *Lodicules ca.* 0.5 mm long. *Anthers* yellow, *ca.* 2 mm long. *Upper floret*; lemmas boat-shaped, *ca.* 5 mm long, hyaline, bifid, twisted awn from sinus, 8–10 mm long; palea lanceolate, *ca.* 5 mm long, hyaline, slightly folded, upper margins ciliate. *Ovary* narrowly ovate, 1.5–2 mm long. *Pedicelled spikelets*; pedicels triangular, 3–4 mm long, hairy along the angles. *Glumes*; lower glume plicate, 5–5.5 mm long, scabrous wing along keel, pilose, upper margins ciliate; upper glume folded, 5.5–6 mm long, keeled along mid-nerved and prolonged in to long tail, upper margins ciliate. *Lower floret*; lemma *ca.* 5 mm long, hyaline, folded, upper margins ciliate; palea 4.5–5 mm long, hyaline, folded, upper margins ciliate. *Anthers* yellow, *ca.* 2 mm long. *Upper floret*; lemma *ca.* 4 mm long, bifid, hyaline, folded, twisted awn from sinus, 7–10 mm long; palea narrow, *ca.* 5 mm long, apex with tail, scabrous, hyaline (Fig. 5.28D-F).

Thailand.— NORTH-EASTERN: Phetchabun [Nam Nao National Park, 20 Nov. 2004, *P. Traiperm* 171 (BCU, BKF, KKU)]; EASTERN: Chaiyaphum [Nam Phrom, 10 Dec. 1971, *C.F. van Beusekom et al.* 4069 (BKF, C, K, L, P);], Nakhon Ratchasima [Dan Chumpon, 21 Dec. 1929, *A.F.G. Kerr* 17653 (BM, K)]; PENINSULAR: Ranong [Khao Paw Ta Luang Kaew, 10 Dec. 1979, *T. Shimizu et al.* T-26890 (L)].

Distribution.— India and Thailand.

Ecology.— Along river banks or near stream, at 50-1300 m altitude. Flowering between November and December.

Notes.— The distribution has a curious disjunction between India and Thailand. This species should occur somewhere in upper Myanmar. However, there still scanty available taxonomic data of this plant group from this country.

4. Ischaemum hubbardii Bor in Indian Forest Rec., n.s. Bot. 1: 98. 1938.— Type: India: Assam, fairly common in the Khasia and Jaintia hills, alt. 4,000-5,000 m, *N.L. Bor* 2264 (holotype K!).

Perennial, densely tussocking grass. *Culms* slender, terete, 25–60 cm tall, internodes and nodes glabrous. *Leaf-sheaths* tight, 4–7 cm long, glabrous or slightly pilose, margins thin. *Ligules*, long membranous 3.5–5 mm long, glabrous. *Leaf-blades* lanceolate, 5–15 by 0.3–1 cm, tuberculate pilose on both surfaces, margins scabrous, apex acute. *Inflorescences* raceme, terminal, 3–5 cm long, conjugated with 2 racemes, rachis internodes oblong 6–6.5 by *ca.* 0.1 mm, triangular in transverse section, pilose along central keel, nodes with a ring of long cilia, callus *ca.* 1 mm long, glabrous. *Sessile spikelet*; lower glume oblong, 6.5–8 by 1.5–1.8 mm, distinctly 10–14-nerved, subcoriaceous, transverse humped along the lower 1/3, glabrous on back, unequally narrowly laterally winged above, wing scabrous; upper glume boat-shaped, 8–9 mm by 1.8-2.2 mm, keeled, scabrous, margins ciliate, apex acuminate, with a small wing at the apex. *Lower floret*; lemma lanceolate, 7–7.5 by *ca.* 1.5 mm, hyaline, slightly folded, upper margins ciliate; palea elliptic, 5.5–6 by *ca.* 1.5 mm, hyaline, folded, apex muticous. *Upper floret*; lemmas *ca.* 7 mm long, bifid, geniculately awned from sinus, awn twisted, 18–25 mm; palea ovate, *ca.* 5 by 1.3 mm, apex acute, hyaline. *Lodicules* cuneate, 1–1.2 mm long. *Pedicelled spikelets*; pedicels 5.5–6 by *ca.* 1 mm, pilose along central keel. *Glumes*; lower glume obliquely-oblong, 7–7.5 by 2.7-3 mm, 6–8-nerved, with 2 subequal wings along whole length of the margins, glabrous on back, margins folded, apex bifid; upper glume boat-shaped, 7–8 by 1.5 mm, keeled along the upper of mid-nerve, scabrous on keel. *Lower floret*; lemma lanceolate, *ca.* 6 by 1.2 mm, hyaline, folded, glabrous, apex acute; palea oblong, *ca.* 5 by 0.8 mm, apex acute, hyaline, slightly folded. *Anthers ca.* 3 mm long. *Upper floret*; lemma ovate, *ca.* 5.5-6.5 by 0.9-1.4 mm, apex acute, hyaline, folded; palea oblong, *ca.* 4.5-6 by 0.8-1.2 mm, apex rounded, hyaline, slightly folded. *Caryopsis* ellipsoid, *ca.* 3 mm long (Figs. 5.2 & 5.29A. & B).

Thailand.— NORTHERN: Chiang Mai [Kio Mae Pan nature trail, Doi Inthanon, 25 Nov. 2005, *P. Traiperm* 308 (BCU, BKF, KKU); 3 Oct. 2001, *S. Laegaard & M. Norsangsri* 21669 (AAU, K, L); Doi Inthanon National Park, along road from summit *ca.* 5 km towards entrance, 16 Oct. 2001, *S. Laegaard & M. Norsangsri* 21728 (AAU)].

Distribution.— India.

Ecology.— Common along Kio Mae Pan nature trail or in lawn near pagoda, alt. 1,950-2,350 m. Flowering between October and November.

Notes.— *I. hubbardii* is characterized by its tuberculate-pilose leaves together with a lower glume that has 10–14 distinct nerves, and transverse hump on the lower 1/3 of the glume, which is glabrous on the back. It is similar to *I. indicum* (Houtt.) Merr. in having glabrous surface on the back of the lower glume of sessile spikelets but differs in having the unequal narrowly lateral wings above and hairs on both surfaces of the leaf-blades. The lower glume of the sessile spikelet in the Thai specimens has a transverse, nearly flat hump on the lower 1/3 of the glume whereas the hump is slightly convex on the back of the type specimen from India.

5. Ischaemum indicum (Houtt.) Merr., J. Arn. Arbor. 19: 320. 1938.

Phleum indicum Houtt., Nat. Hist. 2 (13): 198. 1782.

Perennial, rhizomatous. *Culms* slender, erect, up to 1 m tall, rooting at the lower nodes, internodes glabrous, terete, nodes pilose. *Leaf-sheaths* nearly tight, 5-11 cm long, glabrous but pilose or with tubercle-based hairs at margins especially near ligule or rarely pubescent on surface. *Ligules* membranous, 1–2 mm long. *Leaf-blades* 7–25 by 0.4–1.2 cm, pilose or pubescent on both surfaces, margins scabrous, base rounded, sometimes abruptly narrow. *Inflorescences* digitate, separating into 2 racemes or v-shaped, terminal, 4–9 cm long, rachis internodes oblong, pilose along the angles, nodes hirsute; callus 1.5–2 mm long, at base. *Sessile spikelet*; lower glume oblong, 4–6 mm long, many nerved, coriaceous, indurate and expanded below, upper foliose, bifid, distintly 2-apical winged at the apex, sometimes lateral nerve prolonged form short caudate, glabrous on the back, margins folded; upper glume boat-shaped, 6–8 mm long, scabrous winged on keel, 5-nerved, midnerved prolonged form tail, glabrous on the back, sometimes pilose, margins folded, upper margins ciliate. *Lower floret*; lemma 4–5 mm long, hyaline, folded; paleas 4–5 mm long, plicate, margins ciliate. *Upper floret*; lemma folded, 4–4.5 mm long, hyaline, bifid, geniculately awned from sinus, awn twisted, 15–18 mm long, margins ciliate; palea lanceolate, 3.5–4 mm long, plicate, 2-nerved, hyaline. *Pedicelled spikelets* laterally compressed. *Pedicels* rachis internode like but shorter. *Glumes*; lower glume 4–6 mm long, folded, scabrous winged on keel, apex short caudate, glabrous on the back or pilose; upper glume boat-shaped, 4–6.5, mm long, short tail, margins long ciliate, pilose on the back, winged on keel. *Lower florets* and upper florets same as the sessile spikelet (Fig. 5.29C-E).

Thailand.— NORTHERN: Mae Hong Son [Doi Mae Yae, Pai, 11 Mar. 1999, *P. Suksathan* 2036 (QBG); Doi Pui, 20 Oct. 1999, *P. Suksathan* 1958 (QBG)], Chiang Mai [Mae Wang, 27 Feb. 1993, *J.F. Maxwell* 93-209 (L); Mae Jam, Den (Karen) Village, Ban Wat Chan, 12 Apr. 1998, *J.F. Maxwell* 98-1405 (BKF); Mae Rim, 8 Nov. 1994, *M. Norsangsri* s.n. (QBG); 10 Feb. 1995, *M. Norsangsri* 738 (QBG); 16 Nov. 1996, *M. Norsangsri* s.n. (QBG); 11 Apr. 1999, *M. Norsangsri* 910 (QBG); 21 Nov. 1996, *BGO. Staff* 7874 (QBG); Hang Dong, 25 Nov. 2005, *P. Traiperm* 309 (BCU, BKF, KKU)], Chiang Rai [Khun Korn waterfalls, 1 Dec. 2005, *P. Traiperm* 317 (BCU, BKF, KKU)], Nan [Pua: W side of Phu Kha National Park, near forest station, 21 Nov. 1993, *K. Larsen et al.* 44716 (AAU); Doi Phu Waae, 14 Nov. 2000, *P. Srisanga* 1905 (QBG)], Uttaradit [Phu Soi Dao National Park, 28 Oct. 1998, *H.J. Esser* 982-238 (L)], Tak [Mae Ra Mad, 21 Nov. 1989, *Y. Paisooksantivathana* y 2528-89 (BK)], Sukhothai [Khao Luang National Park, 16 Dec. 2005, *P. Traiperm* 330 (BCU, BKF, KKU), 331 (BCU, BKF, KKU), 332 (BCU, BKF, KKU), 333 (BCU, BKF, KKU), 334 (BCU, BKF, KKU), 335 (BCU, BKF, KKU), 336 (BCU, BKF, KKU); 17 Dec. 2005, *P. Traiperm* 337 (BCU, BKF, KKU), 338 (BCU, BKF, KKU), 340 (BCU, BKF, KKU), 341 (BCU, BKF, KKU), 342 (BCU, BKF, KKU)], Nakhon Sawan [Hua Wai, 29 Nov. 1828, *Put* 2170 (BKF, BM, K); roadside on mt. slope Wat Par Devastaporn, 4 Dec. 1957, *J. Santose* 6681 (L)]; NORTH-EASTERN: Loei [1 Oct. 1952, *Dee* 616 (BKF, K); Phu Luang, Nam Thop, 18 Nov. 1968, *C. Chermsirivathana* 1163 (BK); Phu Kradueng, 17 Sept. 1954, *T. Smitinand* 1935 (BKF); *Ch. Charoenphol et al.* 4618 (AAU, BKF, K); 18 Aug. 1958, *T. Smitinand* 1845 (BKF); 31 Oct. 1984, *S. Mitsuta et al.* T-42284 (BKF, L); 12 Nov. 2004, *P. Traiperm* 157 (BCU, BKF, KKU), 160 (BCU, BKF, KKU); 13 Nov. 2004, *P. Traiperm* 165 (BCU, BKF, KKU), 166 (BCU, BKF, KKU); 29 Oct. 2005, *P. Traiperm* 257 (BCU, BKF, KKU), 258 (BCU, BKF, KKU), 259 (BCU, BKF, KKU); 31 Oct. 2005, *P. Traiperm* 271 (BCU, BKF, KKU); Tham Yai water falls to Phen Phop water fall, Phu Kradueng, 9 Feb. 1988, *H. Koyama* T-61517 (BKF); on the way to Pha Makdook, 5 Sept. 1988, *H. Koyama* T-61569 (AAU, BKF); Na Haew, 10 Mar. 1995, *M. Norsangsri* 763 (QBG); Phu Ruea, 4 Dec. 2004, *P. Traiperm* 189 (BCU, BKF, KKU), 191(BCU, BKF, KKU), 192 (BCU, BKF, KKU), 195 (BCU, BKF, KKU); 6 Dec. 2004, *P. Traiperm* 196 (BCU, BKF, KKU), 197 (BCU, BKF, KKU)], Nong Khai [Phu Woa, 16 Oct. 2005, *P. Traiperm* 219 (BCU, BKF, KKU)], Khon Kaen [Phu Wiang National Park, 5 Nov. 1996, *BGO. Staff.* 6490 (QBG)]; EASTERN:

Chaiyaphum [Thungkamang, 15 Dec. 1971, *C.F. van Beusekom et al.* 4291 (K, L); Phu Khiao, 27 Nov. 2004, *P. Traiperm* 180; 19 Oct. 2005, 220 (BCU, BKF, KKU); Tat Tone, 1 Jan. 2006, *P. Traiperm* 369 (BCU, BKF, KKU)], Roi Et [km 25 on road 208 E of Roi Et, 26 Oct. 2001, *S. Laegaard et al.* 21806 (AAU); Suwannaphum, 22 Oct. 2005, *P. Traiperm* 230 (BCU, BKF, KKU)], Ubon Ratchathani [km 36 on road 217 E of Warin Chamrap, 27 Oct. 2001, *S. Laegaard et al.* 21810 (AAU, L); km 10 on road 2112 to Khong Chiam, 23 Oct. 2005, *P. Traiperm* 251 (BCU, BKF, KKU)]; SOUTH-WESTERN: Kanchanaburi [Kwae Noi River Basin, near Neckey, near Wangka, 18 Apr. 1946, *G. den Hoed* 590 (K)], Prachuap Khiri Khan [Khao Luang, 5 Jul. 1926, *A.F.G. Kerr* 10859 (BK); Cha-um, 15 Apr. 1960, *C. Chermsirivathana* s.n. (BKF)]; CENTRAL: Nakhon Nayok [Nang Rong, 24 Nov. 1957, *J. Santose* 6670 (L); 5 Nov. 2005, *P. Traiperm* 278 (BCU, BKF, KKU)], Krung Thep Maha Nakhon [28 Oct. 1923, *A.F.G. Kerr* 7937 (BK)]; SOUTH-EASTERN: Chanthaburi [Klung, 30 Dec. 1924, *A.F.G. Kerr* 9538 (BM, K); Makham, Khao Klua, 24 Nov. 1956, *T. Smitinand* 3622 (BKF); 19 Nov. 2005, *P. Traiperm* 289 (BCU, BKF, KKU); foot of Khao Soi Dao; 12 Nov. 1969, *C.F. van Beusekom & T. Smitinand* 2149 (AAU, C, E, L); Taluang, 21 Dec. 1994, *A.F.G. Kerr* 9731 (BK); 17 Oct. 2004, *J.F. Maxwell* 71-337 (BKF)], Trat [Dan Chumpon, 21 Dec. 1929, *A.F.G. Kerr* 17653 (BK, BM, K)]; PENINSULAR: Chumphon [27 Jan. 1927, *A.F.G. Kerr* 11647 (K)], Ranong [Kra Buri, 25 Dec. 1928, *A.F.G. Kerr* 16367 (BK, BM, K); Ngaow, 26 Oct. 2004, *P. Traiperm* 147 (BCU, BKF, KKU)], Phangnga [Nop Pring, 6 Mar. 1930, *A.F.G. Kerr* 18396 (BK); Thai Mueang, 19 Feb. 1971, *J. Sadakorn* 232, 19 Feb. 1971 (BK); 24 Oct. 2004, *P. Traiperm* 144 (BCU, BKF, KKU), 145 (BCU, BKF, KKU); Takua Pa, 24 Oct. 2004. *P. Traiperm* 146 (BCU, BKF, KKU); Takua Thung, Tongland plantation, 30 Nov. 1986, *J. Supapol* 103 (CMU, PSU)], Krabi [Phanom Bencha, 28 Mar. 1930, *A.F.G. Kerr* 18716 (BM)], Satun [28 Dec. 1927, *A.F.G. Kerr* 13711A (BK, K); Tah Pae, 14 Nov. 1986, *J.F. Maxwell* 86-918 (BKF, CMU, L, P, PSU].

Distribution.— India to Japan, S to Malaysia, Australia.

Ecology.— Lawns, roadsides, open places, paddy fields or wet places up to 1,950 m altitude. Flowering between September and April.

Notes.— The extreme variations of hairiness and apical wings in lower glume of the sessile spikelet are certainly distinct; however, they are connected by a complete series of intermediates. It seems better not to divide this species into a number of microspecies, but to wait until a monographic study of the whole genus should finally clear the difficulties.

6. Ischaemum lacei Stapf ex Bor, Kew Bull. 4: 187. 1950.— Type: Burma, Amherst, Daiona Range, Muleyit Peak, 27 Jan. 1912, *J.H. Lace* 5627 (lectotype K!, selected here).

Perennial. *Culms* slender, erect, up to 1 m tall, rooting at the lower nodes, internodes glabrous, terete, nodes ciliate. *Leaf-sheaths* nearly tight, 3.5–6 cm long, pilose with tubercle- based hairs. *Ligules* membranous, 1.5–2 mm long. *Leaf-blades* lanceolate, 5–14 by 0.7–1.2 cm, pilose with tubercle-based hairs on both surfaces, margins scabrous, base rounded. *Inflorescences* digitate, separating into 2 racemes or V-shaped, terminal, 3–7 cm long, rachis internodes oblong, pilose along the angles, nodes hirsute; callus 0.5–1 mm long, at base. *Sessile spikelet*; lower glume oblong, 4–4.5 mm long, coriaceous, indurate and expanded below, upper foliose, pilose on the upper back, margins folded, apex bifid, 2-obliquely narrowly lateral winged above, wing scabrous or sometime wingless; upper glume boat-shaped, 6–6.5 mm long, scabrous winged on keel, glabrous on the back, apex slightly caudate. *Lower floret*; lemma oblong, 5.5–6 mm long, hyaline, upper margins ciliate; palea 5–5.5 mm long, hyaline, margins folded and ciliate. *Upper floret* lemma 4.5–5 mm long, hyaline, margins ciliate, apex bifid, geniculately awned from sinus, awn twisted, 11–12 mm long; upper palea lanceolate, 4.5–5 mm long, hyaline. *Pedicelled spikelets* laterally compressed. *Pedicels* look-like rachis internode. *Glumes*; lower glume 4.5–5 mm long, margins folded, expanded at base, scabrous winged on keeled, apex acute, slightly pilose on the back; upper glume boat-shaped, 5.5–6.5 mm long, margins folded, slightly pilose on the above. *Lower florets* and upper florets same as sessile spikelet (Fig. 5.30A. & B).

Thailand.— NORTHERN: Chiang Mai [Doi Nang Ka, 4 Nov. 1930, *Put* 3356 (BK, BM, K)].

Distribution.— India to Burma.

Ecology.— Not recorded. Flowering in November.

Notes.— This species differs from *I. hubbardii* in having smooth lower glume of the sessile spikelet, while the lower glume of *I. hubbardii* coarsely ridge with nodules along the margins.

The original description cited the collection of *J.H. Lace* 5627 and *R.N. Parker* s.n.. Therefore, *J.H. Lace* 5627 kept at K is selected as the lectotype because it is the best preserved specimen.

7. Ischaemum magnum Rendle, J. Bot. 32. 102. 1894.— Type: Singapore, Blakan Mate, October 1892, *J.B. Feilding* s.n. (lectotype BM!, selected here, isolectotype K!).

I. leave Ridl., J. As. Soc. Straits 44: 207. 1905.— Type: Singapore, Galang, *Ridley* 9143 (isotype K!).

Perennial, tufted. *Culms* erect, robust, up to 2 m tall, nodes and internodes glabrous. *Leaf-sheaths* loose, 11–14 cm long, glabrous. *Ligules* membranous *ca.* 1 mm long. *Leaf-blades* lanceolate-acute, 13–40 cm by 1.3–3 mm, glabrous on both surfaces, margins scabrous, base cordate. *Inflorescences* composed of racemes, digitate racemes, 2–4 racemes, 9–15 cm long, rachis internodes clavate, *ca.* 8.5 by 2 mm, glabrous, callus cupuliform, *ca.* 1 mm long, glabrous. *Sessile spikelet*; lower glume oblong on the lower part, upper part obiquely foliose 10–11 by *ca.* 2 mm, margins folded, glabrous on the back, acute at the apex, slightly winged along the upper margins, wing scabrous; upper glume boat-shaped, 9–10 by *ca.* 1.5 mm, scabrous along margins, keeled on the back, apex acute. *Lower floret*; lemma slightly boat-shaped, 8.5–9 mm long, hyaline, margins folded, scabrous along upper margins, apex acute; palea 8–8.5 mm long, hyaline, margins folded, scabrous along margins and apex. *Upper floret*; lemma *ca.* 7 by 0.8 mm, hyaline, slightly folded; palea boat-shaped, 9–9.5 by *ca.* 1.5 mm, hyaline, margins ciliate, acuminate. *Ovary* elliptic, *ca.* 2 mm long. *Pedicelled spikelet*; pedicels glume *ca.* 10 by 2.5 mm, with 2 subequal wings, longer wing along margins, margins scabrous, the smaller wing only on the apex, glabrous on the back; upper glume boat-shaped or lanceolate, 9–9.5 by 1.8 mm, keeled along the back, scabrous along keel, apex acute. *Lower floret*; lemma lanceolate, *ca.* 9 by 2 mm, hyaline, folded, glabrous; palea elliptic, *ca.* 8 by 1.2 mm, hyaline, folded, acute. *Upper floret*; lemma linear, *ca.* 6.5 by 0.5 mm, hyaline folded; palea linear-lanceolate, *ca.* 8.5 by 1 mm, hyaline, folded, acute (Fig. 5.30C-E).

Thailand.— CENTRAL: Saraburi [Sam Lan forest, Mueang, 8 Sept. 1974, *J.F. Maxwell* 74-898 (BK, L)], Krung Thep Maha Nakhon [15 Oct. 1922, *A. Marcan* 1024 (BM); 7 Oct. 1923, *A.F.G. Kerr* 7858A (BK, BM, K); 18 Oct. 1923, *A.F.G. Kerr* 7930 (K); 30 Sept. 1923, *A.F.G. Kerr* 7858 (BK, BM, K); 28 Oct. 1928, *A.F.G. Kerr* s.n. (BK, BM); 2 Nov. 1924, *A. Marcan* 1831 (BM); 2 Nov. 1924, *A.F.G. Kerr* 9351 (BK, BM, K); Bang Khen, 10 Apr. 1958, *T. Smitinand* 5398 (BKF)]; PENINSULAR: Trang [Kuan Pring Research Station, 21 Nov. 1986, *J. Supapol* 47 (CMU)]; Satun [Tarutao, 18 Feb. 1979, *J.F. Maxwell* 280 (PSU)], Songkhla [Thepa, 30 Oct. 1986, *P. Atchariyapanya & J. Supapol* 47 (CMU, PSU)].

Distribution.— Burma to Borneo.

Ecology.— Margin of rivers, canals and lakes, 0-280 m altitude. Flowering in September to May.

Notes.— *Ischaemum magnum* is similar to *I. barbatum*, but differs in having no awn while the distinctly awns in *I. barbatum*. For the type of *I. magnum*, the original description referred to the collection *J.B. Feilding* s.n.. A duplicate deposited at BM is selected as the lectotype because it is the best preserved specimen.

8. Ischaemum muticum L., Sp. Pl.: 1049. 1753.— Type: *Herb. Linn.* 1214.1 (lectotype LINN!).

Rottboellia brevis Chauvin ex Steud. Syn., Pl. Glumac. 1: 361. 1855.— Type: *Steudel* s.n. (holotype P!).

Perennial. *Culms* stoloniferous, long-creeping, stolon internodes up to 10 cm, erect, glabrous. *Leaf-sheaths* loose, 2–3 mm long, glabrous to slightly pilose, ciliate along margins. *Ligules* membranous, *ca.* 1 mm long, pale brown. *Leaf-blades* linear to linear-lanceolate, 2.5–6 by 4–8 mm, glabrous above, strigrillose along their margins, slightly cordate to rounded at the base, acuminate at the apex. *Inflorescences* racemes, terminal, exserted with two closely appressed racemes, 2.5–3.5 cm long. *Sessile spikelet*; lower glume ovate, 7–7.5 by *ca.* 3 mm, coriaceous, yellowish, glabrous, winged above the middle; upper glume boat-shaped or ovate, 7–8 by *ca.* 2.5 mm, keeled in the upper half, glabrous, fringed on the upper margins, apex acute. *Lower floret* staminate; lemma ovate-acute, 6–6.5 mm long, 3-nerved, hyaline, hairy above margins; palea 6–6.5 mm long, subcoriaceous, enfolded, 2-fringe keeled on both margins. *Anther ca.* 3 mm long, yellow. *Stigmas* whitish. *Upper floret* hermaphrodite;

lemma ovate, *ca.* 7 mm long, subcoriaceous, enfolded, bifid at the tip, awnless, fringe on marginal winged; palea *ca.* 6 mm long, hyaline, margins narrowly inflexed in the upper part. *Anthers ca.* 3 mm long, yellow. *Stigmas* whitish. *Pedicelled spikelet*; pedicels *ca.* 5 mm long, similar in structure and pubescence to the rachis. *Glumes*; lower glume ovate-acute, *ca.* 6 mm long, subcoriaceous, enfolded, glabrous; upper glume ovate or boat-shaped, subchartaceous, asymmetrically, 1-fringe keeled on the upper part, enfolded, glabrous, apex acute. *Lower floret* staminate; lemma *ca.* 6 mm long, chartaceous, enfolded, glabrous 2-winged above; palea ovate-acute, 5.5–6 mm long, subchartaceous, enfolded. *Anthers* 2.5–3 mm long, yellow. *Stigmas* whitish. *Upper floret* hermaphrodite; lemma narrowly ovate-acute, *ca.* 6 mm long, hyaline, enfolded; palea linear, *ca.* 5 mm long, hyaline. *Lodicules* truncate. *Anthers* 2.5–3 mm long, yellow. *Stigmas* whitish (Fig. 5.31A. & B).

Thailand.— SOUTH-EASTERN: Chon Buri [Sattahip, 6 Apr. 1971, *J.F. Maxwell* 71-294 (AAU, BK, L)], Rayong [Ban Pae, 27 Nov. 1964, *S. Sutheesorn* 234 (BK); Klang, 26 Sept. 1965, *C. Chermsirivathana* 384 (BK); 22 Aug. 1977, *C. Phengklai et al.* 3802 (BKF); Koh Samet, 18 Mar. 1970, *C.F. van Beusekom & T. Santisook* 3246 (AAU, C, E, K, L, P); 12 km E of Ban Phae, 23 Sept. 1990, *P. Chantaranothai et al.* 90/348 (AAU, K); Laem Son, 20 Nov. 2005, *P. Traiperm* 294 (BCU, BKF, KKU)], Chanthaburi [Laem Sing, 8 Apr. 1923, *A. Marcan* 1345 (BM); *A.F.G. Kerr* 6941 (BK, BM, K); 10 Sept. 1964, *Adisai* 858 (BK)], Trat [19 Jan. 1927, *Put* 500 (BK, BM, K); Koh Kut, *C. Phengklai* 13020 (BKF), 13600 (BKF); Koh Chang, 1 Oct. 1924, *A.F.G. Kerr* 9274 (K); 17 Nov. 1970, *Ch. Charoenphol et al.* 4940 (AAU, C, E, K, P); road near port, 25 Mar. 2001, *K. Chayamarit et al. 2928* (BKF); 9 Jun. 1925, *Rabil* 67 (BK, BM, K); 26 Feb. 1955, *T. Smitinand* 2311 (K); 4 Apr. 1959, *Th. Sørensen et al.* 7166 (C, K); 24 Dec. 2005, *P. Traiperm* 350 (BCU, BKF, KKU)]; PENINSULAR: Chumphon [Pak Nam Chumpon, 15 Feb. 1968, *Vacharapong* 024, (BK); Lang Suan, 5 Jun. 1969, *Jaray* 129 (BK)], Ranong [Ban Keow, 5 Aug. 1973, *R. Geesink & C. Phengklai* 6343 (AAU, C, E, L)], Surat Thani [Koh Tao, 1 Jan. 1927, *A.F.G. Kerr* 11226 (BK, BM, K); 30 Dec. 1926, *A.F.G. Kerr* 11184 (BK, BM, E, K, L); Ban Wat Hmai, Samhui, 29 Aug. 1983, *C.A.* 42 (PSU); Prunseeng, Chaiya, 29 May 1960, *Chirayupin* 105 (BK); Koh Samui, Feb. 1995, *T.B. Ryves*, KS95/016 (K)], Phangnga [Koh Tachai, *C. Phengklai* 12813 (BKF); 4 Apr. 1999, *Th. Wongprasert* s.n. (BKF)], Phuket [*C. Phengklai et al.* 15,277 (AAU);

Thalang, 13 Aug. 1965, *T. Smitinand* 8910 (BKF); under Sarasin bridge, 23 Jul. 1968, *C. Chermsirivathana* 980 (BK); Mueang, 2 Jul. 1979, *T. Koyama et al.* 15,299 (BKF)], Krabi [Banklongrad, Khlong Thom, 29 Nov. 1986, *J. Supapol* 184 (CMU, PSU); Lan Ta National Park, 1 Jul. 1992, *C. Niyomdham* 2851 (BKF)], Satun [Tarutao, 20 Apr. 1969, *C. Chermsirivathana & Kasem* 1427 (BK); 18 Feb. 1979, *G. Congdon* 282 (AAU, PSU); 31 Jan. 1980, *G. Congdon* 313 (AAU, PSU), 429 (AAU, PSU); 5 Apr. 2005, *P. Traiperm* 199 (BCU, BKF, KKU); 20 May 2005, *P. Traiperm* 213 (BCU, BKF, KKU)], Songkhla [Pattani road, 55 km form Songkhla, 31 Oct. 1990, *K. Larsen et al.* 41020 (AAU, PSU); Mueang, beach, 13 Feb. 1999, *P. Buapet* 2 (PSU); 19 Oct. 2004, *P. Traiperm* 138 (BCU, BKF, KKU); Banthom, Lake Songkhla, 19 Aug. 1983, *W. Eddie* 54 (PSU)], Narathiwat [Paa Wai, Su Ngai Paa Dee, 31 Aug. 1988, *C. Niyomdham & W. Ueachirakan* 1919 (AAU, BKF, C, E, K, L, P)].

Distribution.— Worldwide.

Ecology.— Creeping grass, common along road to seashore, at sea level. Flowering throughout the year.

Vernacular.— Ya wai tham (หญ้าไหวทาม) (Trat).

Notes.— It is readily distinguished from the other species of *Ischaemum* by the short inflorescence with whitish stigmas sticking out laterally and awnless upper lemma.

9. Ischaemum rugosum Salisb., Icon. Stirp. Rar.: 1, t.1. 1791.— Type: India, Orissa, *Koenig* s.n. (holotype BM!, isotype K!).

Annual, tufted, caepitose. *Culms* usually erect somewhat prostrate, 30–120 cm tall, culm glabrous, ciliolate at node. *Leaf-sheaths* loose, 10-12 cm long, pilose hairs 1–1.5 mm long. *Ligules* membranous, 3–3.5 mm long, brownish. *Leaf-blades* lanceolate, 10–30 by 1–1.3 cm, lower blades narrowed gradually to the base, upper blades abruptly rounded, margins scabrous, surface pilose, base densely hairy, acuminate at the apex. *Inflorescences* racemes, terminal, 6–10 cm long, conjugate when young, and separating into 2 racemes when mature, rachis internodes 3.5–4.5 mm long, fragile, thickened upwards, long pilose on the central keel, nodes with a ring of long cilia, callus short, *ca.* 0.8 mm long, glabrous. *Sessile spikelet* oblong-ovate, 5 mm long. *Glumes*; lower glume oblong-ovate, 5–5.5 by 2–2.5 mm, indurated and coarsely ridged with 4–7 ridges for the lower part, many nerved above and margins narrowly inflexed, keeled towards the asymmetric apex, 2-obliquely lateral winged at the apex, ciliolate rounded at the apex; upper glume narrowly ovate, 4.5–5 mm long, keeled along the back with a hump slightly above the middle, margins ciliolated on the upper part, apex acute. *Lower floret*; lemma elliptic, *ca.* 4.5 by 1 mm, hyaline slightly folded, margins scabrous, apex muticous; palea narrowly ovate, *ca.* 4.5 by 1 mm, hyaline, folded, margins ciliate, apex acute. *Ovary* elliptic, *ca.* 2 mm long. *Upper floret*; lemmas narrow, *ca.* 4 mm long, bifid, geniculately awned from sinus, awn twisted, 15–20 mm; palea ovate-acute, *ca.* 3.5 by 0.8 mm, hyaline, upper margins scabrous. *Pedicelled spikelets*; pedicels triangular, *ca.* 1.5 mm long, pilose along keel. *Glumes*; lower glume oblique-ovate, *ca.* 2–5 by 2 mm, indurate below, upper foliose and many nerved, subequal winged along margins, wings scabrous, 2–3 transverse nodule at each edge; upper glume boat-shaped, *ca.* 5 by 1 mm, keeled along the back, keel scabrous, lower margins entire, upper margins scabrous, apex acute. *Lower floret*; lemma lanceolate, *ca.* 4.5 by 1 mm, hyaline, folded, glabrous, apex acute; palea elliptic-acute, *ca.* 3.5 by 0.8 mm, hyaline, folded. *Upper floret*; lemma linear, *ca.* 3.5 by 0.5 mm, hyaline, slightly folded, awned from the apex, awn scabrous, *ca.* 4 mm long; palea elliptic-muticous, *ca.* 2 by 0.7 mm, hyaline, slightly folded. *Caryopsis* ellipsoid, *ca.* 2 mm long (Fig. 5.31C-E).

Thailand.— NORTHERN: Mae Hong Son [Ban Na Pa Pak, 21 Oct. 1999, *P. Suksathan* 1974 (QBG)], Chiang Mai [Doi Inthanon, en route from Pha Mawn (Ban Yang) to the camp, 10 Feb. 1971, *G. Murata et al.* T-15882 (BKF), T-15888 (BKF); around Wachira water falls, 12 Jun. 1984, *G. Murata et al.* T-39945 (BKF); along road to Doi Inthanon, near visitor center 1-2 km inside park, 15 Oct. 2001, *S. Laegaard & M. Norsaengsri* 21721 (AAU, L); San Pa Tong, Mae Win, 10 Nov. 1980, *Y. Paisooksantivatthana* y 392 A-80 (BK); Mae Rim, 10 Apr. 1994, *M. Norsangsri* 803 (QBG); 11 Feb. 1995, *BGO. Staff* 5062 (QBG); 16 Nov. 1996, *M. Norsangsri* s.n. (QBG); 21 Nov. 1996, *BGO. Staff* 7866 (QBG); Wiang Hang-Ka Noi, 16 Jan. 2001, *M. Norsangsri* 1228 (QBG)], Phrae [Long, Tao Poon, 27 Nov. 1986, *Y. Paisooksantivatthana* y1934-86 (BK); Hot, 23 Nov. 2005, *P. Traiperm* 301 (BCU, BKF, KKU)], Uttaradit [Pichai, Ban Bak Klong, 20 Oct. 1992, *J.F. Maxwell* 92-635 (AAU, L, P)], Nakhon Sawan [Nong Bone, 12 Jan. 1982, *Y. Paisooksantivatthana* y779-82 (BK)]; NORTH-EASTERN: Loei [Sithan, 17 Oct. 1955, *T. Smitinand* 3047

(BKF, K); Nong Hin, 23 Nov. 1963, *Pradit* 729 (BK); Ban Nah Awe, Mueang, 11 Mar. 1993, *J.F. Maxwell* 93-243 (L)], Udon Thani [Ban Phue, 18 Nov. 1963, *Pradit* 676 (BK)], Nong Khai [Nong Song Hong, Pak Pree, 15 Nov. 1964, *S. Sutheesorn* 129 (BK)], Kalasin [near border of Sakhon Nakhon and Kalasin, along route 213, 12 Nov. 1984, *G. Murata et al.* T-51335 (BKF)], Maha Sarakham [Chiang Yuen, 6 Oct. 2004, *P. Traiperm* 127 (BCU, BKF, KKU)], Khon Kaen [Nam Phong, 7 Oct. 2005, *P. Traiperm* 212 (BCU, BKF, KKU)]; EASTERN: Roi Et [Suwannaphum, 22 Oct. 2005, *P. Traiperm* 231 (BCU, BKF, KKU)], Ubon Ratchathani [Lam Don Noi, 4 Dec. 1968, *T. Smitinand & J. Tunbang* 10496 (BKF)]; SOUTH-WESTERN: Kanchanaburi [Ban Kao, 12 Nov. 1961, *K. Larsen* 8158 (C, K); Erawan National Park, 19 Nov. 1971, *C.F. van Beusekom et al.* 3873 (BKF, C, K, P)], Prachuap Khiri Khan [Cha-um, 15 Apr. 1960, *C. Chermsirivathana* s.n. (BK)]; CENTRAL: Chai Nat [*Y. Paisooksantivatthana* s.n. (BK)], Ang Thong [29 Dec. 1929, *Put* 2588 (BK, BM, K); 11 Dec. 1971, *J.F. Maxwell* 71-782 (AAU, BK)], Saraburi [Sam Lan forest, Mueang, 14 Dec. 1974, *J.F. Maxwell* 74-1042 (AAU, BK, L)], Krung Thep Maha Nakhon [24 Dec. 1922, *A.F.G. Kerr* 6729 (BK, K); Pakret, 14 Oct. 1923, *A. Marcan 1495* (BM); 14 Oct. 1923, *A.F.G. Kerr* 7926 (BK, BM, K); Bang Khen, 26 Nov. 1953, *K. Suvathabhandhu* 350 (BK)]; SOUTH-EASTERN: Chon Buri [Nah Kate feelds near Si Racha, 23 Nov. 1927, *D.J. Collins* 1910 (BK, K); Khao Khiao, Si Racha, 22 Nov. 1975, *J.F. Maxwell* 75-1089 (AAU, BK, L)], Rayong [Laem Son, 20 Nov. 2005, *P. Traiperm* 293 (BCU, BKF, KKU)], Chanthaburi [Plain of Makham, 19 Nov. 2005, *P. Traiperm* 291 (BCU, BKF, KKU)]; PENINSULAR: Chumphon [13 Jan. 1927, *A.F.G. Kerr* 11401 (BK, K)], Satun [Nikhom Sahug Eng, Soi 6, Kuan Gah Long, Kuan Gah Long, 10 Oct. 1986, *J.F. Maxwell* 86-789 (CMU, PSU)].

Distribution.— Worldwide.

Ecology.— Very common in paddy fields, roadsides, up to 1800 m altitude. Flowering in April to January.

Vernacular.— Ka dueai nu (กระเดือยหนู), Ya kraduk kai (หญ้ากระดูกไก่) (Chai Nat); Ya daeng (หญ้าแดง), Ya nok si chomphu (หญ้านกสีชมพู)(Krung Thep Maha Nakhon); Ya phraek daeng (หญ้าแพรกแดง) (Ang Thong); Wrinkle duck-beat.

Notes.—*Ischaemum rugosum* is similar to *I. barbatum* in a number and shape of transverse ridge, but differs in having an indurate yellowish-green lower glume below, greenish on the upper, while brownish or reddish lower glume in *I. barbatum*.

10. Ischaemum tenuifolium A. Camus, Bull. Mus. Hist. Nat. Paris: 284. 1919.— Type: Laos, *M. Counillon* s.n. (holotype P!, phototype K!).

Perennial, tufted. *Culms* erect up to 1.5 m tall, terete, internodes glabrous, nodes glabrous. *Leaf-sheaths* tight, up to 15 cm long, glabrous. *Ligules* ciliate, *ca.* 1 mm long. *Leaf-blades* up to 50 cm by 0.3–0.5 mm, upper surface pruinose and slightly pilose, lower surface glabrous, margins scabrous and involute. *Inflorescences* digitate racemes, 3–7 racemes, 6–12 cm long, rachis internodes clavate, 3–3.5 by *ca.* 1 mm, pilose along the angles, nodes long ciliate, hairs up to 4 mm long. *Sessile spikelet*; lower glume lanceolate, 3.5–4.5 mm long, 2-nerved, subcoriaceous, scabrous on the upper nerve, concave along the length, margins folded and ciliate on the upper, apex bifid; upper glume lanceolate, plicate or narrowly boat-shaped, 8–9 mm long, subcoriaceous, keel along the back, prolonged from awned, pilose on upper keeled and upper margins. *Lower floret*; lemma *ca.* 3 mm long, hyaline, folded, upper margins ciliate; palea absent. *Upper floret*; lemmas *ca.* 4 mm long, bifid, twisted awn from sinus, 15–20 mm long; upper palea 2.5–3 mm long, hyaline, expanded at base, upper margins ciliate. *Pedicelled spikelet* dissimilar to the sessile spikelet. *Pedicels* clavate, 2.5–3 mm long, pilose along the angles. *Glumes*; lower glume lanceolate, 3–3.5 by *ca.* 1 mm, 2-nerved, subcoriaceous on each margin, scabrous; upper glume boat-shaped, 3–4.5 mm long, scabrous keel along the back, sometime prolonged from awn. *Lower floret*; lemma oblong, *ca.* 3 mm long, hyaline, sometime absent; palea absent. *Upper floret*; lemma hyaline, *ca.* 3 mm long, bifid, twisted awn from sinus, 10–12.5 mm long; palea *ca.* 2.5 mm long, hyaline, expanded at base.

Thailand.— NORTH-EASTERN: Loei [Phu Kradueng, 10 Nov. 1970, *Ch. Charoenphol et al.* 4879 (AAU, BKF, C, E, K, P)]; EASTERN: Nakhon Ratchasima [Pak Thong Chai, 25 Dec. 1923, *A.F.G. Kerr* 8108 (K); Khao Saming, 25 Nov. 1924, *A.F.G. Kerr* 9395 (K); Bua Yai, 31 Oct. 1931, *Put* 4232 (K)], Ubon Ratchathani [km 36 on road 217 E of Warin Chamrap, 27 Oct. 2001, *S. Laegaard et al.* 21812 (AAU, K, L); 22 Oct. 2005, *P. Traiperm* 233 (BCU, BKF, KKU)]; SOUTH-EASTERN: Chanthaburi [Makham, 19 Nov. 2005, *P. Traiperm* 287 (BCU, BKF, KKU)].

Distribution.— Indo-China.

Ecology.— Secondary grasslands or in dipterocarp forests, Dense tussock, up to 130 m altitude. Flowering in October to December.

Notes.— *I. tenuifolium* is distinct with a pruinose on the upper surface of lamina. This species proved that indeed it belongs in *Andropogon*. So, I place *I. tenuifolium* under *Andropogon*, not *Ischaemum*.

11. Ischaemum timorense Kunth, Rev. Gram. 1: 369. 1830.— Type: Timor, *Wall. Cat. no.* 8863 (holotype K!, CAL).

Andropogon timorensis Steud., Syn. Pl. Glumac. 1: 376. 1855. — Type: Timor (not seen).

I. macrurum Stapf ex Ridl., Fl. Mal. Penins. 5: 203. 1925.— Type: Peninsular Malaysia, Negri Sembilan, *H.N. Ridley* 10013 (lectotype K!, selected here).

Annual, rhizomatous, long creeping. *Culms* erect, 20–45 cm tall, rooting from the lower nodes, nodes slightly to densely long ciliate, internodes glabrous. *Leaf-sheaths* tight, 3–7 cm long, glabrous or sometimes pilose on both margins. *Ligules* ciliate or membranous with ciliate margins, 1–1.3 mm long. *Leaf-blades* lanceolate, 2–9 by 0.5–1.2 cm, pilose on both surfaces, margins scabrous, acute at the apex. *Inflorescences* racemes on terminal, 2.5–6 cm long, separating into 2 racemes, rachis internodes triangular, 2.5–3 mm long, hairy along the angles, nodes long ciliate, hairs up to 2 mm long, callus 0.3–1 mm long. *Sessile spikelet*; lower glume ovate-bifid, like boat-shaped, foliar, 3–4 mm long, 6–8-nerved folded, outer nerves prolonged form 2 points, wingless, glabrous on the back or pilose on the upper part or scabrous along nerves, margins scabrous; upper glume boat-shaped, 4.5–7 mm long, 5–6-nerved, apex with a long scabrous tail which prolonged from the mid nerved, tail 1–3 mm long, wing on the upper back, upper margins ciliate, lower glabrous. Lower floret; lemma *ca.* 3 mm long, 2-nerved and scabrous along nerve, margins plicate and ciliate; palea *ca.* 3 mm long, 1-nerved, hyaline, folded, ciliate along margins, thinner than lemmas. *Upper floret*; lemmas 2–2.5 mm long, hyaline, apex bifid, geniculately awned from sinus, awn twisted, 12–15 mm, margins ciliate, folded; palea lanceolate, 3–3.5 mm long, hyaline, slightly folded, upper margins ciliate. *Lodicules* cuneate. *Anthers ca.* 1.5 mm long. *Pedicelled spikelets*; pedicels triangular shaped, 1.5–3 mm long, hairy along the angles. *Glumes*; lower glume boat-shaped, 3–4 mm long, slightly winged on keel, midnerved prolonged into long tail, scabrous along nerved, sometime pilose on the back, upper margins ciliate; upper glume boat-shaped, 4–4.5 mm long, scabrous along mid-nerve and pilose on the upper back, upper margins ciliate, apex with long tail. Lower floret; lemma 2.5–3 mm long, 2–nerved, scabrous along nerve, margins ciliate; palea 2.5–3.5 mm long, 1-nerved, hyaline, slightly folded, upper margins ciliate. *Upper floret*; lemma boat-shaped, *ca.* 2 mm long, hyaline, bifid, geniculately awned from sinus, awn twisted, 8–10 mm long; palea *ca.* 2.5 mm long, hyaline, slightly folded, upper margins ciliate. *Anthers*, *ca.* 2 mm long, yellow. *Stigmas* purplish. *Caryopsis* ellipsoid, *ca.* 1-1.2 mm long (Fig. 5.32A-C).

Thailand.— NORTHERN: Chiang Rai [Doi Thung, 12 Jan. 1975, *R. Geesink et al.* 8265 (C, L)]; CENTRAL: Krung Thep Maha Nakhon [31 Jan. 1920, *A.F.G. Kerr* 3974 (K); 25 Nov. 1923, *A.F.G. Kerr* 7937A (BK, BM)]; SOUTH-WESTERN: Kanchanaburi [near Neckey, near Wangka, 18 May 1946, *G. den Hoed* 590 (K, P); Ban Pilog, E-Tong, 20 Feb. 1967, *C. Chermsirivathana* 647 (BKF); 29 Dec. 2005, *P. Traiperm* 354 (BCU, BKF, KKU), 355 (BCU, BKF, KKU), 357 (BCU, BKF, KKU), 358 (BCU, BKF, KKU), 359 (BCU, BKF, KKU), 360 (BCU, BKF, KKU)]; PENINSULAR: Chumphon [27 Jan. 1927, *A.F.G. Kerr* 11647 (BKF, K)], Ranong [Kraburi, 25 Dec. 1918, *A.F.G. Kerr* 16367 (BK, BM, K); 23 Nov. 1983, *Y. Paisooksantivathana* y 1370-83 (BK); Kaper, Laem Son National Park, 30 Jan. 1927, *A.F.G. Kerr* 11705 (BK, K); 30 Nov. 1996, *J.F. Maxwell* 96-1570 (L)], Surat Thani [Khao Phra Mi, 9 Jan. 1966, *B. Hansen & T. Smitinand* 11869 (BKF, C, E, K, L)], Phangnga [Langsan, 7 Feb. 1927, *A.F.G. Kerr* 11866 (BK, K); 6 Mar. 1930, *A.F.G. Kerr* 18396 (BK, BM); Takua Pa, 6 Mar. 1972, *J. Sadakorn* s.n. (BK)], Trang [Kachawng, *L. Williams* 17246 (K)], Songkhla [Suan Dtoon Falls, Mueang, 12 Feb. 1985, *J.F. Maxwell* 85-178 (BKF, P, PSU)], Yala [Padang Besar, 23 Dec. 1927, *A.F.G. Kerr* 13571 (BK, BM, K)].

Distribution.— Africa, China, India, Indo-China, Malesia, South America, Northern South America, and western South America.

Ecology.— Very common along roadsides, near stream in savannah, weed in partly shaded area or in evergreen forest up to 1,500 m altitude. Flowering in November to March.

Notes.— *Ischaemum timorense* differs from *I. indicum* in normally having the lower glume wingless whereas the distinct wing in *I. indicum*, however intermediates wing do occur in some specimens.

Two collections, *H.N. Ridley* 10013 and *Hullett* s.n. were mentioned in the original description. *H.N. Ridley* 10013 kept at K is chosen as the lectotype because it is well preserved.

12. Ischaemum sp.1

Annual, tufted, caepitose. *Culms* erect, sometime prostrate, slender, terete, 25–45 cm tall, internodes and nodes glabrous. *Leaf-sheaths* loose, 3–5 cm long; glabrous, margins thin. *Ligules* long membranous, 2–2.5 mm long, glabrous. *Leaf-blades* 4.5–8.5 by 0.5–0.8 cm, pubescent on both surfaces, recurved, margins folded, base tapering, acute at the apex. *Inflorescences* racemes, terminal, 5–6 cm long, conjugate with 2 racemes, rachis internodes triangular, 3.5–4 mm long, pilose along keel, nodes with a ring of cilia, callus *ca.* 1.5 mm long. *Sessile spikelet*; lower glume oblong, 6.5–7 by 1.5–2 mm, pilose on the back, margins nearly smooth or with one marginal nodule at each edge, apex bifid with 2 subequal apical wings, wings scabrous; upper glume boat-shaped, 7–7.5 by *ca.* 1 mm, keeled along the back, wing on the upper keel, wing scabrous, margins ciliate. *Lower floret*; lemma lanceolate, 5.5–6 by *ca.* 1 mm, hyaline, slightly folded, upper margins ciliate, apex muticous; palea elliptic, *ca.* 5 by 0.8–1 mm, hyaline, slightly folded, upper margins ciliate, apex muticous. *Lodicules* cuneate, *ca.* 0.8 mm long. *Anthers ca.* 2 mm long. *Upper floret*; lemmas 4–5 mm long, hyaline, folded, apex bifid with geniculately awned from sinus, awn twisted, 18–20 mm long, upper margins ciliate; palea oblong-muticous, *ca.* 4 by 0.8 mm, hyaline. *Lodicules* cuneate, *ca.* 1 mm long. *Anthers ca.* 2 mm long. *Pedicelled spikelets*; pedicels clavate, 4–4.5 mm long, pilose along keel. *Glumes*; lower glume oblong-ovate, *ca.* 6 by 1.5 mm, with 2 subequal wings along margins, wing scabrous, pilose on the back, margins folded, apex bifid; upper glume boat-shaped, *ca.* 6.5 by 1 mm, pilose on the back, margins ciliate. *Lower floret*; lemma lanceolate-acute, *ca.* 5 by 1 mm, hyaline, slightly folded, upper margins ciliate; palea oblong-muticous, *ca.* 3 by 0.7 mm, hyaline. *Upper floret*; lemma *ca.* 4 by 1 mm, hyaline, slightly folded; palea *ca.* 3 by 0.5 mm, hyaline. Anthers *ca.* 2 mm long (Figs. 5.3 & 5.32D. & E).

Thailand.— SOUTH-EASTERN: Chanthaburi [Khao Soi Dao, 12 Dec. 2005, *P. Traiperm* 327 (BCU, BKF, KKU) PENINSULAR: Krabi [Phanom Bencha, 28 Mar. 1930, *A.F.G. Kerr* 18716 (BM, K)].

Distribution.— Endemic to Thailand.

Ecology.— Growing on an open ground in evergreen forest on high mountain up to 1,450 m altitude. Flowering in December to March.

Notes.— *Ischaemum* sp.1 resembles to *I. barbatum* in the lower glume of the sessile spikelet. However, the latter is easily distinguished by its coarsely ridge more than one across the back or with 2 or more nodules along the margins. *I.* sp.1 has pubescent on both surfaces of the leaf, margins recurved or folded, while *I. barbatum* flattened leaf-blade, which glabrous to pilose on both surfaces.

13. Ischaemum sp.2

Perennial, tufted. *Culms* erect, terete, up to 1 m tall, nodes with long ciliate, internodes glabrous. *Leaf-sheaths* nearly tight, 5.5–10 cm long, glabrous below, upper pilose with tubercle-based hairs especially near the junction of leaf-blades and leaf-sheaths. *Ligules* prominently membranous 1.5–2 mm long. *Leaf-blades* 8–25 by 0.6–0.8 cm, glabrous on both surface, pilose with tubercle-based hairs below, margins scabrous, sometimes with tubercle- based hairs below, acute at the apex. *Inflorescences* racemes, V-shaped, terminal, 7.5–10 cm long, separating into 2–3 racemes, rachis internodes oblong, *ca.* 3 mm long, pilose along the angles, nodes hirsute, callus *ca.* 1 mm long. *Sessile spikelet*; lower glume oblong, 5–6.5 mm long, 4–6-nerved, expanded and indurate, upper foliose, hirsute on the back, apex bifid with 2-apical wing, wings scabrous, marginals nerves prolonged form 2 long tail at the apex; upper glume boat-shaped, 8–9 mm long, subcoriaceous, scabrous winged on keel, keeled prolonged from long tail, pilose on the upper back, upper margins ciliate. *Lower floret*; lemma, *ca.* 5 mm long, 1-nerved, chartaceous, upper margins ciliate; palea *ca.* 5 mm long, 2-nerved and plicate on each margins, upper margins ciliate. *Anthers* yellow, *ca.* 2.5 mm long. *Upper floret*; lemmas boat-shaped, *ca.* 5 mm long, hyaline, apex bifid with geniculately awned from sinus, awn twisted, 18–20 mm long, upper margins ciliate; palea narrow, *ca.* 5 mm long, hyaline. *Pedicelled spikelets*; pedicels clavate, *ca.* 3 mm long, pilose along the angles. *Glumes*; lower glume folded, 7–8 mm long, scabrous wing along keel, awn from mid-nerve, hirsute on the back; upper glume folded, narrower than the lower glume, 7–8 mm long, scabrous winged on keel, awn from mid-nerved, hirsute on the back, ciliate along margins. *Lower floret*; lemma folded, 3.5–4.5 mm long, 1-nerved, chartaceous, upper margins ciliate;

palea 3.5–4.5 mm long, 2-nerved and plicate on each margins, upper margins ciliate. *Anthers* yellow, 1.8–2.5 mm long. *Upper floret*; lemma boat-shaped, 4.5–5 mm long, upper margins ciliate, bifid, geniculately awned from sinus, awn twisted, 15–18 mm long; palea narrowly lanceolate, 3.5–4.2 mm long, hyaline (Fig. 5.4).

Thailand.— PENINSULAR: Ranong [Phu Khao Yah, 26 Oct. 2004, *P. Traiperm* 148, 149 (BCU, BKF, KKU)].

Distribution.— Endemic to Thailand.

Ecology.— Savannah or in wet places up to 600 m altitude. Flowering in November to March.

Notes.— This species resembles to *I. lacei*, but it is distinguished by its glabrous leaf blade, while pilose with tubercle-based hairs on both surfaces of the leaf in *I. lacei*.

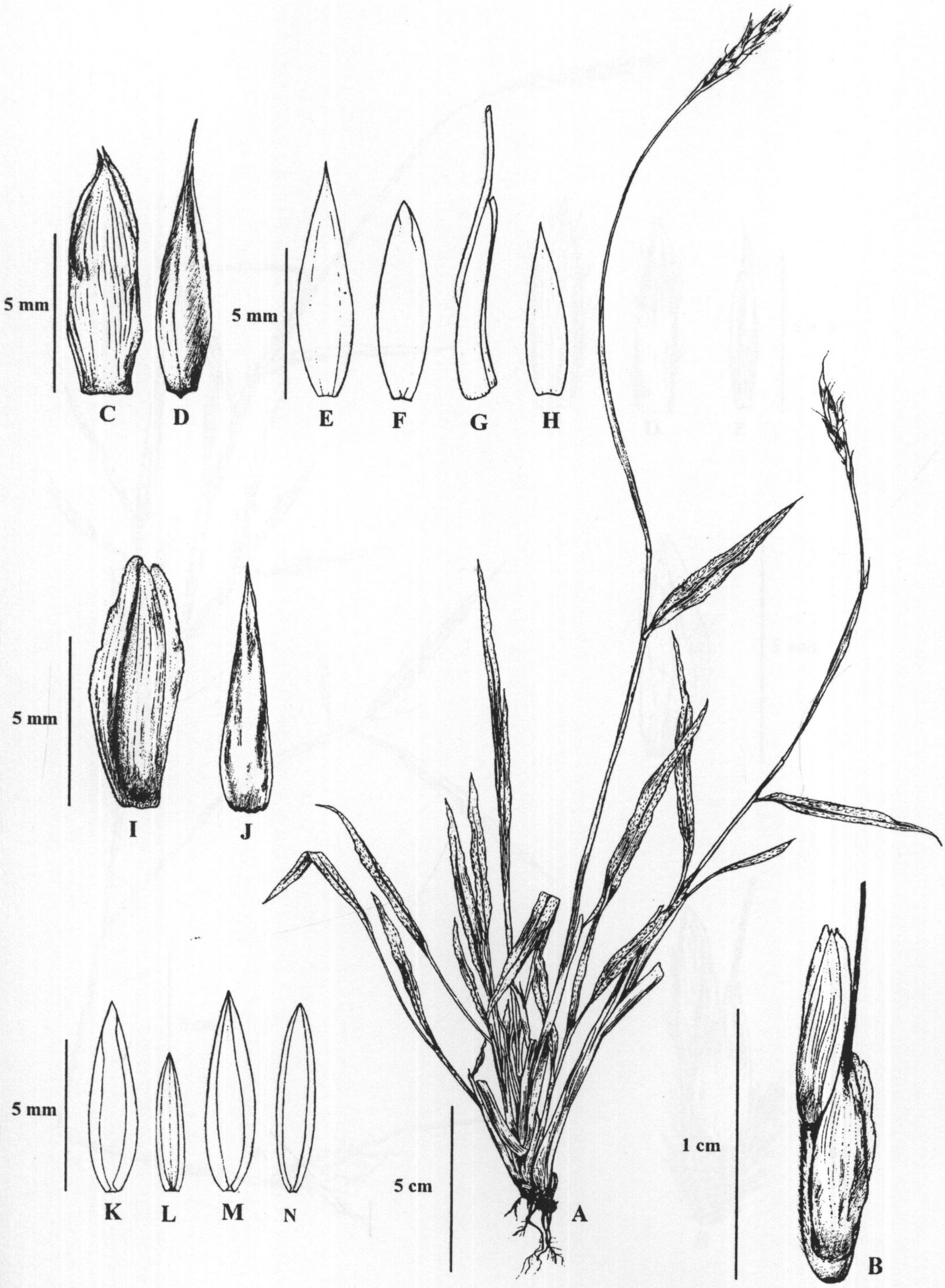

Figure 5.2 *Ischaemum hubbardii*: A. plant; B. spikelet pair; C-H. sessile spikelet: C. lower glume, D. upper glume, E. lower lemma, F. lower palea, G. upper lemma, H. upper palea; I-N pedicelled spikelet: I. lower glume, J. upper glume, K. lower lemma, L. lower palea, M. upper lemma, N. upper palea. All line drawings were drawn by P. Traiperm from *P. Traiperm* 308.

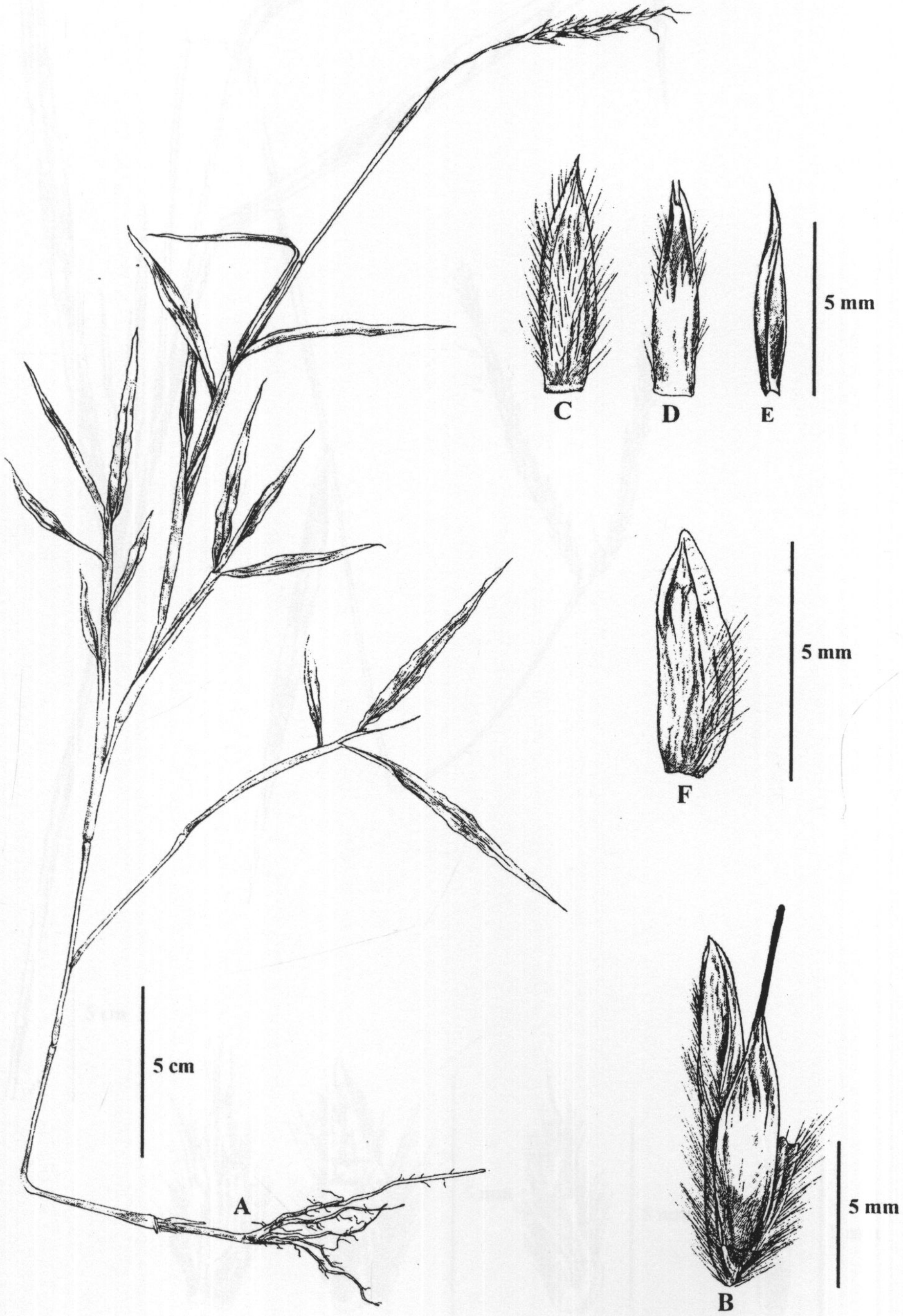

Figure 5.3 *Ischaemum* sp.1: A. plant; B. spikelet pair; C-E. sessile spikelet: C. & D. lower glume (two views), E. upper glume; F. lower glume of pedicelled spikelet. All line drawings were drawn by P. Traiperm from *P. Traiperm* 327.

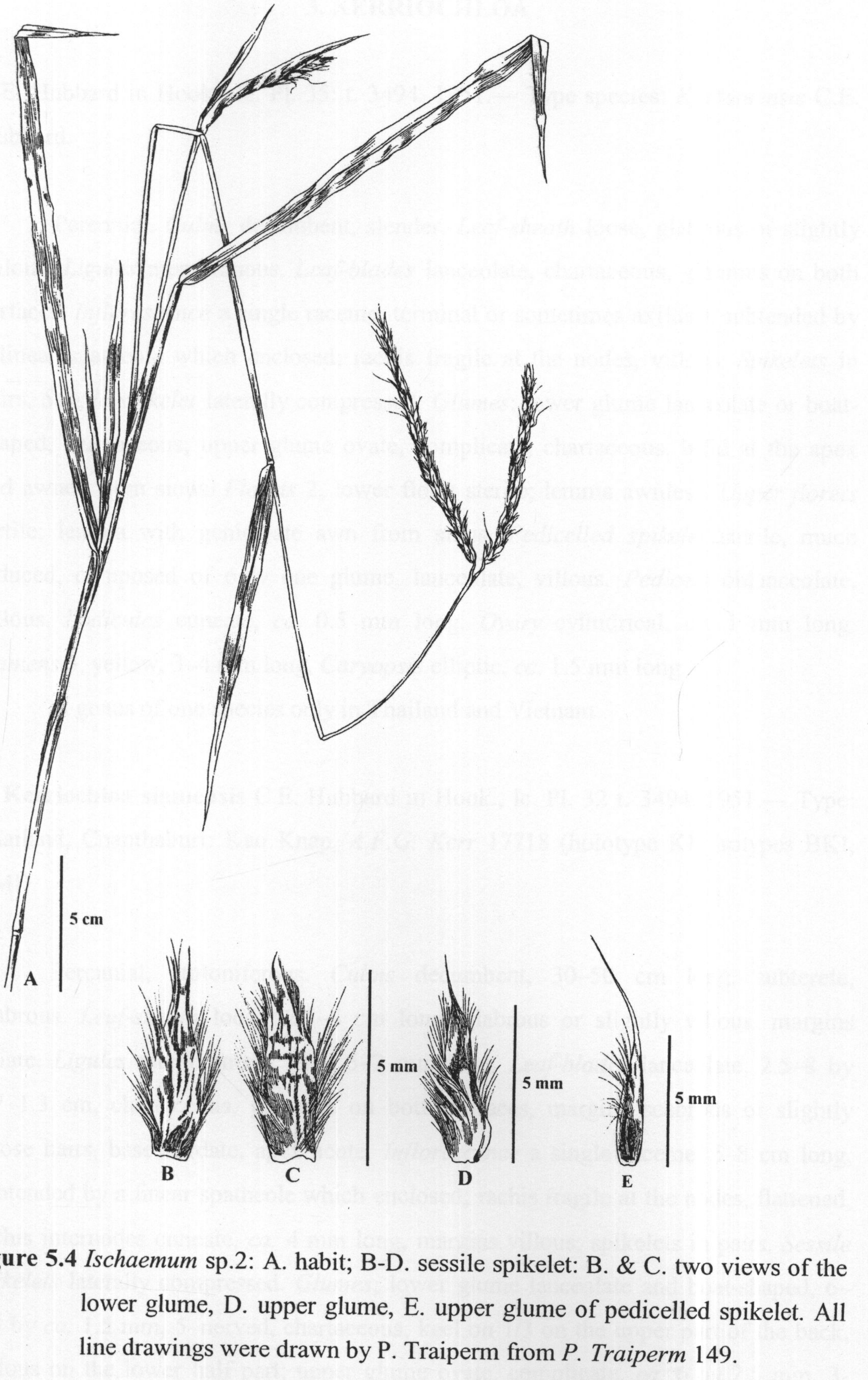

Figure 5.4 *Ischaemum* sp.2: A. habit; B-D. sessile spikelet: B. & C. two views of the lower glume, D. upper glume, E. upper glume of pedicelled spikelet. All line drawings were drawn by P. Traiperm from *P. Traiperm* 149.

3. KERRIOCHLOA

C.E. Hubbard in Hook., Ic. Pl. 35: t. 3494. 1951.— Type species: *K. siamensis* C.E. Hubbard.

Perennial. *Culms* decumbent, slender. *Leaf-sheath* loose, glabrous or slightly villous. *Ligules* membranous. *Leaf-blades* lanceolate, chartaceous, glabrous on both surfaces. *Inflorescence* a single raceme, terminal or sometimes axillary, subtended by a linear spatheole which enclosed; rachis fragile at the nodes, villous. *Spikelets* in pairs. *Sessile spikelet* laterally compressed. *Glumes*; lower glume lanceolate or boat-shaped, chartaceous; upper glume ovate, complicate, chartaceous, bifid at the apex and awned from sinus. *Florets* 2, lower floret sterile; lemma awnless. *Upper florets* fertile; lemma with geniculate awn from sinus. *Pedicelled spikelet* sterile, much reduced, composed of only one glume, lanceolate, villous. *Pedicels* oblanceolate, villous. *Lodicules* cuneate, *ca.* 0.5 mm long. *Ovary* cylindrical, *ca.* 1 mm long. *Stamens* 3, yellow, 3–4 mm long. *Caryopsis* elliptic, *ca.* 1.5 mm long.

A genus of one species only in Thailand and Vietnam.

1. Kerriochloa siamensis C.E. Hubbard in Hook., Ic. Pl. 32 t. 3494. 1951.— Type: Thailand, Chanthaburi: Kao Knap, *A.F.G. Kerr* 17718 (holotype K!, isotypes BK!, BM!).

Perennial, stoloniferous. *Culms* decumbent, 30–50 cm long, subterete, glabrous. *Leaf-sheath* loose, 2.5–4 cm long, glabrous or slightly villous, margins ciliate. *Ligules* membranous, *ca.* 1.5–2 mm long. *Leaf-blades* lanceolate, 2.5–8 by 0.7–1.3 cm, chartaceous, glabrous on both surfaces, margins scabrous or slightly pilose hairs, base cordate, apex acute. *Inflorescence* a single raceme, 5–8 cm long, subtended by a linear spatheole which enclosed; rachis fragile at the nodes, flattened, rachis internodes cuneate, *ca.* 4 mm long, margins villous; spikelets in pairs. *Sessile spikelets* laterally compressed. *Glumes*; lower glume lanceolate and boat-shaped, 6–6.5 by *ca.* 1.5 mm, 5–nerved, chartaceous, keel on 1/3 on the upper part of the back, villous on the lower half part; upper glume ovate, complicate, *ca.* 6 by 2.5 mm, 3-nerved, chartaceous, bifid at the apex and awned from sinus, awn 8–9 mm long, margins of the upper glume, ciliate 1-keeled on the back, keel scabrous. *Lower floret* sterile; lemma oblanceolate, *ca.* 6 by 0.8 mm, 3-nerved, membranous, upper margins ciliate; palea lanceolate, *ca.* 5 by 0.7 mm, membranous, 2-nerved, apex acute, upper margins ciliate. *Ovary* cylindrical, 1 mm long. *Upper florets* fertile; lemma oblong, *ca.* 3.5 mm long, 3-nerved, hyaline, margins ciliolate, hairy above, apex bifid, incised, 0.4 of lemma length, awn from sinus, geniculate, 28–35 mm long; with twisted column; palea lanceolate, *ca.* 3 mm long, 3-nerved, hyaline. *Lodicules* cuneate, *ca.* 0.5 mm long. *Anthers* 3, yellow, 3–4 mm long. *Pedicelled spikelet* sterile, smaller than sessile spikelet; composed of only one glume, lanceolate, *ca.* 2 mm long, villous. *Pedicels* oblanceolate, villous on both margins, apex curved. *Caryopsis* elliptic, *ca.* 1.5 mm long (Figs. 5.5 & 5.33A. & B).

Thailand.— EASTERN: Ubon Ratchathani [Warin Chamrap, 27 Oct. 2001, *S. Laegaard* 21830 (AAU); 22 Oct. 2005, *P. Traiperm* 235 (BCU, BKF, KKU); *ca.* 5 km of dam of Khong Chiam, 27 Oct. 2001, *S. Laegaard* 21844 (AAU); Pha Taem Nat. Park, 23 Oct. 2005, *P. Traiperm* 245 (BCU, BKF, KKU)]; SOUTH-EASTERN: Chanthaburi [Kao Knap, 23 Dec. 1929, *A.F.G. Kerr* 17718 (BK, BM, K)].

Distribution.— Vietnam.

Ecology.— Creeping over the rocks or in open sandy soil, at 140-600 m altitude. Flowering between October and December.

Notes.— *Kerriochloa siamensis* is easily recognized by a laterally compressed sessile spikelets and a linear spatheole, which are enclosed the inflorescence.

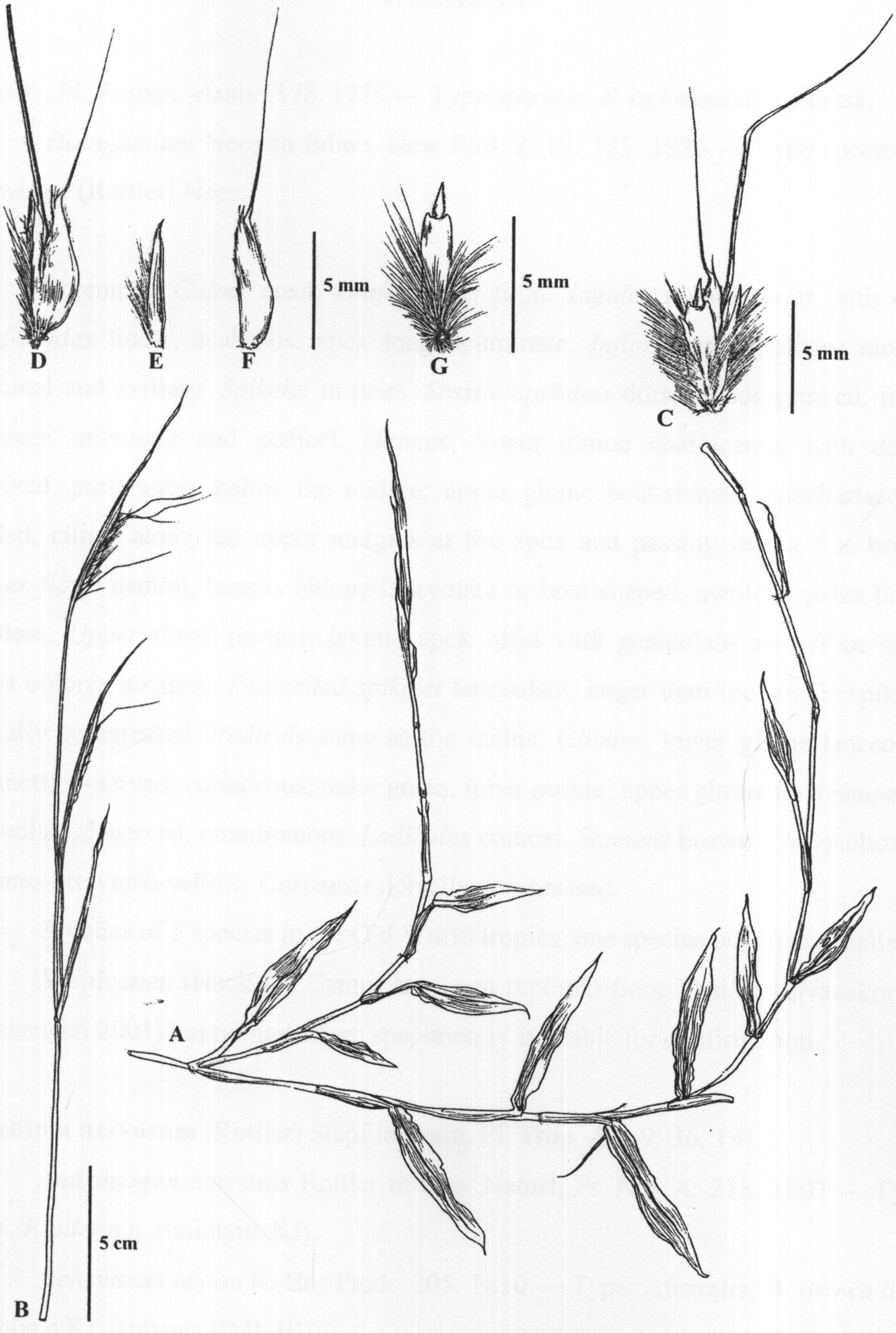

Figure 5.5 *Kerriochloa siamensis*: A. plant; B. inflorescence; C. spikelet pair; D-F. sessile spikelet: D. sessile spikelet, E. lower glume, F. upper glume; G. pedicelled spikelet. All line drawings were drawn by P. Traiperm from *P. Traiperm* 235.

4. SEHIMA

Forssk., Fl. Aegypt.-Arab.: 178. 1775.— Type species: *S. ischaemodies* Forssk.

Hologamium Nees in Edinb. New Phil. J. 18: 185. 1835.— Type species: *H. nervosum* (Rottler) Nees.

Perennial. *Culms* erect. *Leaf-sheaths* tight. *Ligules* membranous with cilia. *Leaf-blades* linear, scabrous, apex long acuminate. *Inflorescence* solitary raceme, terminal and axillary. *Spikelet* in pairs. *Sessile spikelets* dorsally compressed, fitting between internode and pedicel. *Glumes*; lower glume chartaceous with deeply grooved, particularly below the middle; upper glume boat-shaped, subchartaceous, keeled, ciliate along the upper margins at the apex and passing into a fine bristle. *Lower floret* neutral, lemma oblong-lanceolate or boat-shaped, awnless; palea linear, awnless. *Upper floret* perfect; lemma apex bifid with geniculate awn from sinus; palea oblong, awnless. *Pedicelled spikelet* lanceolate, larger than the sessile spikelet, dorsally compressed. *Pedicels* same as the rachis. *Glumes*: lower glume lanceolate, distinctly 5-nerved, coriaceous, outer green, inner purple; upper glume boat-shaped or lanceolate, 3-nerved, membranous. *Lodicules* conical. *Stamens* brown. *Ovary* obovate. *Stigmas* brownish-yellow. *Caryopsis* dorsally compressed.

A genus of 5 species in the Old World tropics: one species occurs in Thailand.

S. sulcatum (Hack.) A.Camus has been reported from Thailand (Nanakorn & Norsaengsri 2001) but no herbarium specimen is available for confirmation.

1. Sehima nervosum (Rottler) Stapf in Prain, Fl. Trop. Afr. 9: 36. 1917.

Andropogon nervosus Rottler in Ges. Naturf. Fr. N.S. 4: 218. 1803.— Type: India, *Rottler* s.n. (holotype K!).

Ischaemum laxum R. Br.: Prodr. 205. 1810.— Type: Australia, *R. Brown* 6155 (holotype K!, isotypes BM!, E!).

A. philippinensis Merr., Philipp. Journ. Sc. 14: 367. 1919.— Type: Philippines, Luzon, Burgos, *M. Ramos 32946*, July 1918, (holotype K!).

Perennial. *Culms* erect, 30–150 cm long, slender, terete, glabrous. *Leaf-sheaths* tight, 6–15 mm long, terete, glabrous or slightly hirsute. *Ligules* membranous, ciliate, *ca.* 1 mm long. *Leaf-blades* linear, 20–45 cm by 4–6 mm, scabrous, margins with short rigid hairs, apex long acuminate. *Inflorescence* solitary racemes, long erect or slightly curved, terminal and axillary, 8–12 cm long; joints and pedicels parallel, compressed, 4–5 mm long, densely ciliate with white hairs on both margins and joints. *Sessile spikelets* dorsally compressed, 8–9 mm long, pale green. *Glumes*; lower glume oblong, 8–9 by 1 mm, 4-nerved, chartaceous, deeply grooved, particularly below the middle, distally with transverse veinlets, apex bidentate; upper glume boat-shaped, 6–15 mm long, subchartaceous, keeled, ciliate along the upper margins at the apex and passing into a fine bristle. *Lower floret* neutral, lemma oblong-lanceolate or boat-shaped, 3–6.5 by 0.8 mm, 2-nerved, hyaline, margins entire; palea linear, 6–7 by 0.8 mm, hyaline. *Upper floret* perfect; lemma, 4–7 mm long; bifid, geniculately awned from sinus, awn 2.5–4 cm long, slender, spirally twisted; palea oblong, 6–6.5 by 0.8 mm, hyaline. *Lodicules* conical, 4–5 mm long. *Anthers* brown, *ca.* 2–3.5 mm long. *Ovary* obovate, 1–2 mm long. *Stigma* brownish-yellow. *Pedicelled spikelet* lanceolate, larger than the sessile spikelet, dorsally compressed; rachis triangular, 4–5 mm long, compressed, white marginal hairs along the angles. *Pedicels* same as the rachis. *Glumes*; lower glume lanceolate, 8–11 mm long, 5-nerved, coriaceous, outer green, inner purple, apex bifid, long-ciliate from the the tightly inflexed margins; upper glume boat-shaped or lanceolate, 5–9 by 1.2–1.5 mm, 3-nerved, membranous, ciliate along the margins. *Lower floret*; lemma lanceolate, 7–7.5 by 1 mm, hyaline, margins folded and ciliate; palea oblong-lanceolate, 6–7 by 0.8 mm, hyaline. *Upper floret*; lemma narrowly lanceolate, 7–8 by 1 mm, hyaline, margins folded and ciliate; upper palea narrowly lanceolate, 6.5–7 by 0.8 mm, hyaline, margins folded. *Caryopsis* dorsally compressed (Figs. 5.6 & 5.33C-E).

Thailand.— NORTHERN: Chiang Mai [Doi Suthep, 24 Nov. 1911, *A.F.G. Kerr* 2255 (E, K); Wang Saphung, Sithan, 17 Oct. 1955, *T. Smitinand* 3052 (BKF); *Khantachai* 697 (BKF); Doi Tao, Mae Doop Reservoir, dam area, 23 Oct. 1987, *J.F. Maxwell* 87-1248 (BKF, CMU, L); Hot, Op Luang, 19 Oct. 1989, 89-1256 (CMU, L); 23 Nov. 2005, *P. Traiperm* 300 (BCU, BKF, KKU); Mae Soi Valley, 10 Nov. 1990, *J.F. Maxwell* 90-1253 (AAU, CMU, L); Doi Saket, Huai Heng Khrai Royal Development Project, 8 Nov. 1993, *S. Suwannaratana* 34 (L); Along road to Doi Inthanon, *ca.* 5 km from Chom Thong, 3 Oct. 2001, *S. Laegaard & M. Norsaengsri* 21661 (AAU); 15 Oct. 2001, 21715 (AAU, L)], Lamphun [Mae Tah, Doi Khun Tan National Park, Yaw1 area, 28 Oct. 1993, *J.F. Maxwell* 93-1332 (L)], Lampang [Khun

Tan National Park, 4 Dec. 2005, *P. Traiperm* 323 (BCU, BKF, KKU)], Tak [Bhumipol Dam, *Ploenchit* 411 (BK)]; NORTH-EASTERN: Phetchabun [Tung Luang, 10 Dec. 1931, *A.F.G. Kerr* 20636 (BK, BM, K); at km 25 on road 12 Lom Sak-Khon Kaen, 25 Oct. 2001, *S. Laegaard & M. Norsaengsri* 21785 (AAU, K, L); Nam Nao National Park, 20 Nov. 2004, *P. Traiperm* 170 (BCU, BKF, KKU)], Loei [Phu Kradueng, 10 Nov. 1970, *Ch. Charoenphol et al.* 4889 (AAU, C, E, BKF, K, P); 4891 (AAU)], Nong Bua Lam Phu [12 Nov. 1963, *Pradit* 647 (BK)]; EASTERN: Chaiyaphum [Phu Lan Ka, 1 Jan. 2006, *P. Traiperm* 367 (BCU, BKF, KKU)]; SOUTH-WESTERN: Uthai Thani [Ban Rai, 28 Oct. 1971, *S. Sutheesorn* 3144 (BK)], Kanchanaburi [19 Oct. 1930, *A.F.G. Kerr* 19767 (BK, K); Ban Kao, 11 Nov. 1961, *K. Larsen* 8307 (C, K); Mueang, 15 Nov. 1967, *C. Chermsirivathana* 798 (BKF); 18 Nov. 1970, *M. Lazarides* 7417 (BKF, C, K, L); Si Sawat, 15 Nov. 1971, *C.F. van Beusekom et al.* 3808 (BKF, C, K, L, P)]; SOUTH-EASTERN: Prachin Buri [Watana Nakhon, 18 Nov. 1964, *S. Sutheesorn* 161 (BK)], Chon Buri [11 Jan. 1961, *K. Larsen* 8014 (C); Khao Khiao, Si Racha, 26 Apr. 1975, *J.F. Maxwell* 75-434 (AAU, BK, L); Sichang Island, E side, coastal area near Kow Kwang, Si Racha, 8 Nov. 1992, 92-711 (P)].

Distribution.— India to tropical Australia.

Ecology.— Open, dry dipterocarp forest, at sea level to 950 m altitude. Flowering between September and Apirl.

Notes.— *Sehima nervosum* is distinguished by its pedicelled spikelet, which is larger than the sessile spikelet.

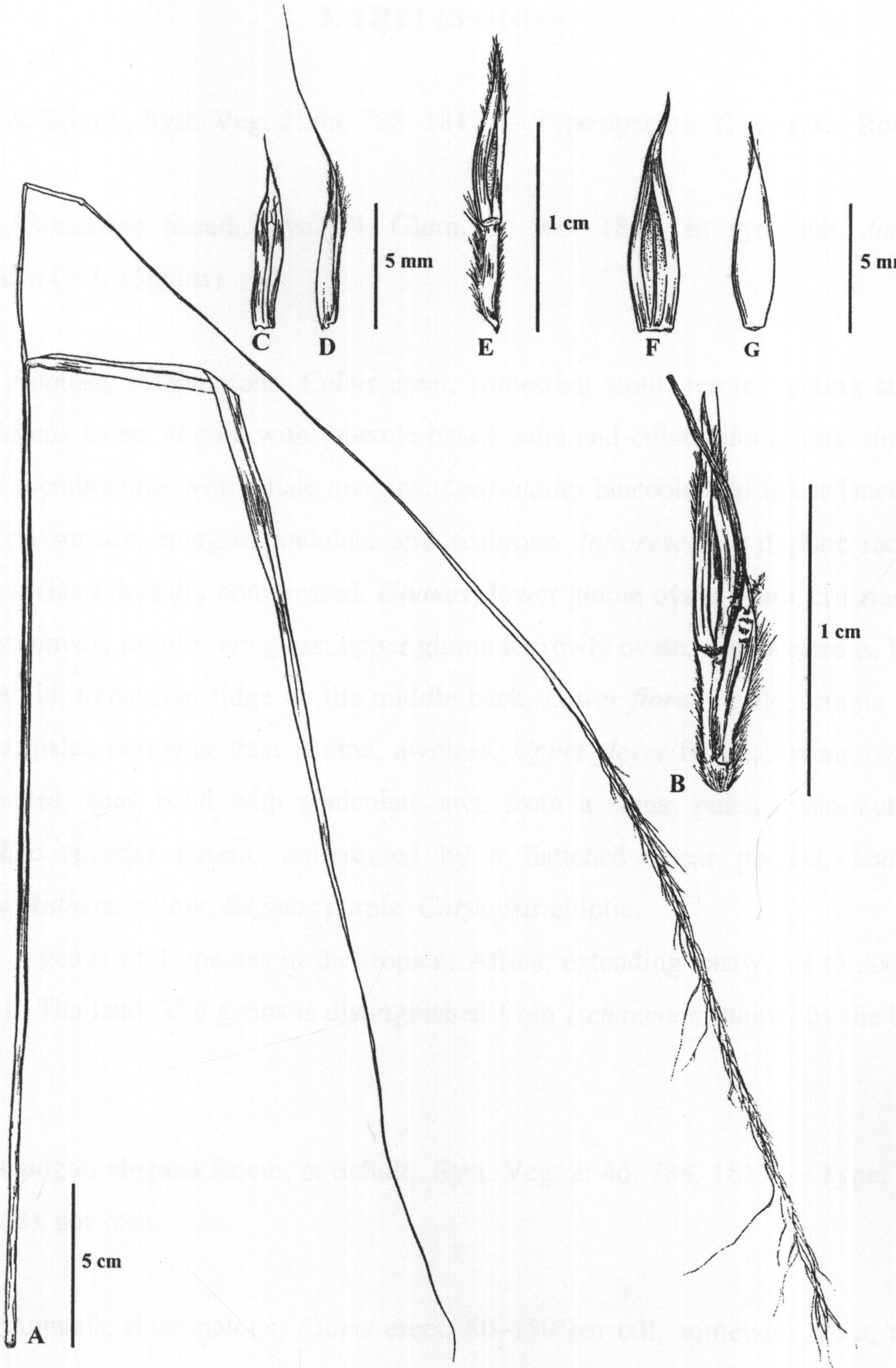

Figure 5.6 *Sehima nervosum*: A. plant; B. spikelet pair; C-D. sessile spikelet: C. lower glume, D. upper glume; E-G pedicelled spikelet: E. pedicelled spikelet with pedicel, F. lower glume, G. upper glume. All line drawings were drawn by P. Traiperm from *P. Traiperm* 300.

5. THELEPOGON

Roem. & Schult., Syst. Veg. 2: 46. 788. 1817.— Type species: *T. elegans* Roem. & Schult.

Rhiniachne Steud., Syn. Pl. Glum. 1: 360. 1854, in syn. sub. *Jardinea abyssinica* (= *T. elegans*).

Annuals, rhizomatous. *Culms* erect, somewhat stout, terete, rooting at base. *Leaf-sheaths* loose, hirsute with tubercle-based hairs and ciliate along outer margins. *Ligules* membranous with ciliate margins. *Leaf-blades* lanceolate to linear-lanceolate, hispid on surface, margins undulate and scabrous. *Inflorescence* digitate racemes. *Sessile spikelet* dorsally compressed. *Glumes*; lower glume ovate-acute, crusrtaceous, broadly convex, rugose, wingless; upper glume narrowly ovate, subcoriaceous, keeled and scabrid, transverse ridge on the middle back. *Lower floret* sterile; lemma ovate, awnless; palea narrower than lemma, awnless. *Upper floret* fertile; lemma ovate or boat-shaped, apex bifid with geniculate awn from a sinus; palea ovate-muticous. *Pedicelled* spikelet absent, represented by a flattened linear pedicel. *Lodicules* cuneate. *Anthers* yellow. *Stigmas* purple. *Caryopsis* elliptic.

A genus of 1 species in the tropical Africa, extending eastwards to Asia and occurs in Thailand. The genus is distinguished from *Ischaemum* mainly by the barren pedicel.

1. Thelepogon elegans Roem. & Schult., Syst. Veg. 2: 46. 788. 1817.— Type: India, *Heyne* (B), not seen.

Annuals, rhizomatous. *Culms* erect, 80–150 cm tall, somewhat stout, terete, glabrous, rooting at base. *Leaf-sheaths* loose, 3–7 cm long, hirsute with tubercle-based hairs and ciliate along outer margins. *Ligules* membranous with ciliate margins, 1–1.5 mm long. *Leaf-blades* lanceolate to linear-lanceolate, 10–25 by 1.5–2.5 cm, hispid on adaxial surface and glabrous or slightly hispid on abaxial surface, margins undulate and scabrous, base round, apex acute. *Inflorescence* digitate racemes, composed of 2–4 racemes, if many the lowest verticillate, simple or divided, rachis fragile at nodes, nodes with a ring of cilia, rachis internodes cuneate, slightly curved, angular and scabrid along the rib, 7.5–8.5 mm long, rachis internodes tip transverse, cupuliform; spikelet in pairs, composed of fertile sessile spikelets and sterile pedicelled spikelets. *Sessile spikelet* dorsally compressed, ovate, 6–7 mm long. *Glumes*; lower glume ovate-acute, 5–5.5 mm long, 7-nerved, coriaceous, indurate on margins, rugose on the back; upper glume narrowly ovate, *ca.* 7 mm long, 1-nerved, subcoriaceous, keeled and scabrid, 6–8 transverse ridges on the middle back, ciliate along margins long acuminate at the apex. *Lower floret* sterile; lemma ovate, *ca.* 4.2 mm long, hyaline, enfolded, ciliate along the upper part of both margins; palea narrower than lemma, *ca.* 4.2 mm long, hyaline. *Upper floret* fertile; lemma ovate or boat-shaped, *ca.* 4 mm long, 5-nerved, hyaline, ciliate along the upper part of the margins, bifid in a half length, geniculate awn from a sinus, 20–30 mm long with a twisted column, scabrous on whole length; palea ovate-muticous, *ca.* 3.8 mm long, 3-nerved, hyaline. *Lodicules* cuneate, *ca.* 0.5 mm long. *Anthers ca.* 2.5 mm long, yellow. *Stigmas* purple. *Caryopsis* elliptic, *ca.* 3 mm long. *Pedicelled spikelet* absent (Figs. 5.7 & 5.33F-I).

Thailand.— NORTHERN: Lampang [Mae Mo, 24 Oct. 1971, *T. Boonkird* 1 (BK)]; EASTERN: Nakhon Ratchasima [Klang Dong, 9 Dec. 1962, *C. Phengklai* 407 (BKF, C, K, L); Pak Chong, 31 Dec. 1923, *A. Marcan* 1568 (BK, BM)]; CENTRAL: Lop Buri [Chai Badan, Pasak river, 13 Dec. 1923, *A.F.G. Kerr* 7978 (BK, BM, K, TCD)], Saraburi [Mueang, Sam Lan forest, 20 Oct. 1974, *J.F. Maxwell* 74-953 (AAU, BK, L,); 5 Nov. 2005, *P. Traiperm* 276 (BCU, BKF, KKU); Muak Lek; railway track side, 10 Nov. 1924, *A. Marcan* 1864 (BK, BM)].

Distribution.— Tropical Africa and Asia.

Ecology.— Mostly erect grass, growing in a weedy places on roadsides, deciduous forest, or in open area, at 50-300 m altitude. Flowering between October and December.

Notes.— *Thelepogon elegans* is easily recognised by a special lower glume of the sessile spikelet, which are strongly rugose. A hispid leaf-blades on adaxial surface and glabrous or slightly hispid on abaxial surface, margins undulate and scabrous.

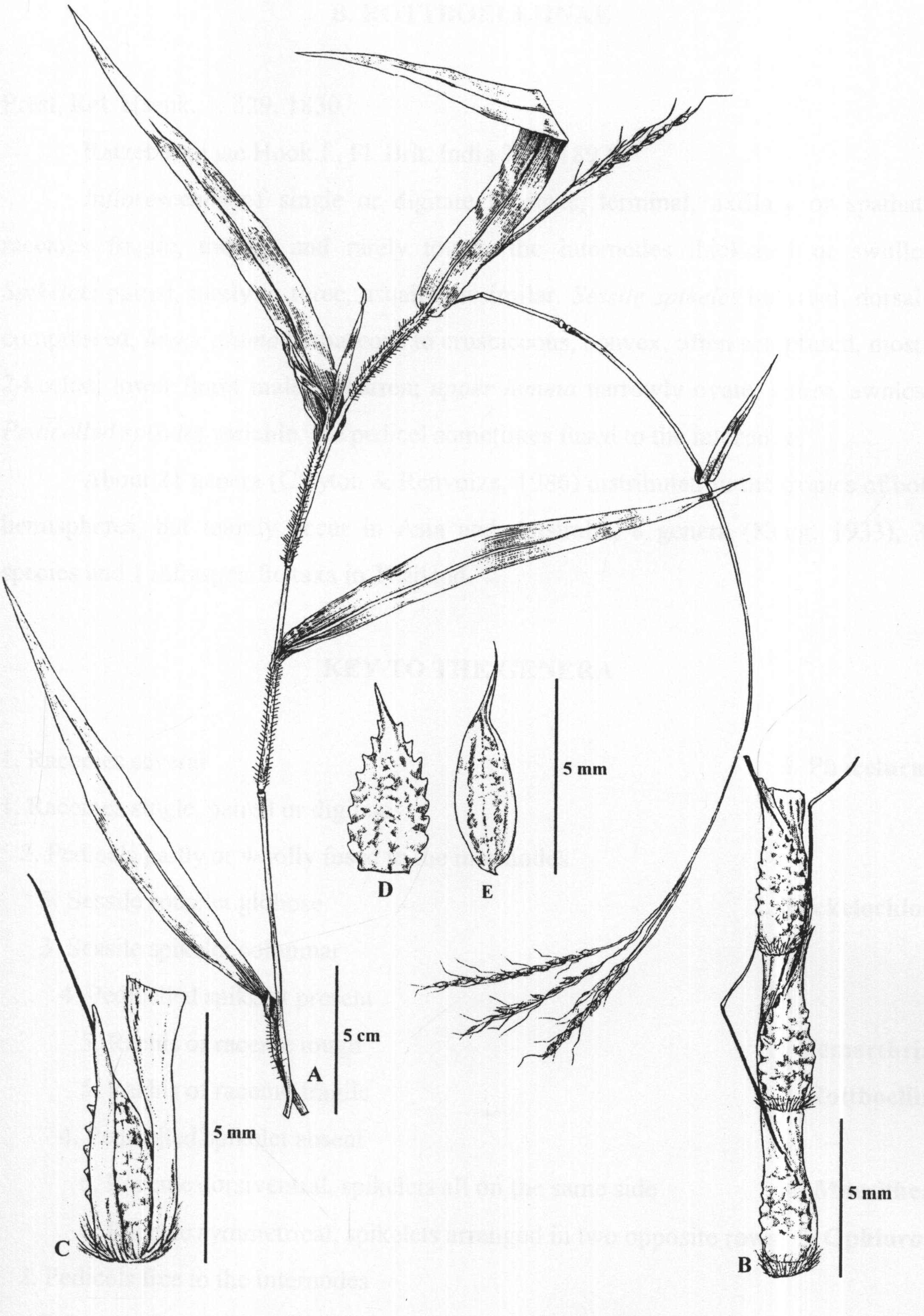

Figure 5.7 *Thelepogon elegans*: A. plant; B. partial raceme; C. spikelet pair; D. lower glume of sessile spikelet; E. upper glume of sessile spikelet. All line drawings were drawn by P. Traiperm from *P. Traiperm* 276.

B. ROTTBOELLIINAE

Presl, Rel. Haenk. 1: 329. 1830.

Ratzeburgiinae Hook.f., Fl. Brit. India 7: 4. 1897.

Inflorescence of single or digitate racemes, terminal, axillary or spathate; racemes fragile, though and rarely tough, the internodes thickened or swollen. *Spikelets* paired, rarely in three, usually dissimilar. *Sessile spikelet* bisexual, dorsally compressed; *lower glume* herbaceous to crustaceous, convex, often sculptured, mostly 2-keeled; lower floret male or barren; *upper lemma* narrowly ovate, entire, awnless. *Pedicelled spikelet* variable, the pedicel sometimes fused to the internode.

About 21 genera (Clayton & Renvoize, 1986) distributed in the tropics of both hemispheres, but mainly occur in Asia and Australia, 8 genera (Keng, 1933), 32 species and 1 infraspecific taxa in Thailand.

KEY TO THE GENERA

1. Racemes several **6. Phacelurus**
1. Racemes single, paired or digitate
  2. Pedicels partly or wholly fused to the internodes
    3. Sessile spikelet globose **2. Hackelochloa**
    3. Sessile spikelet columnar
      4. Pedicelled spikelet present
        5. Rachis of raceme tough **3. Hemarthria**
        5. Rachis of raceme fragile **7. Rottboellia**
      4. Pedicelled spikelet absent
        6. Raceme dorsiventral, spikelets all on the same side **4. Mnesithea**
        6. Raceme symmetrical, spikelets arranged in two opposite rows **5. Ophiuros**
  2. Pedicels free to the internodes
    7. Lower glume of sessile spikelet produced into a long flattened tail **8. Vossia**
    7. Lower glume of sessile spikelet without a herbaceous tail
      8. Pedicelled spikelet present **4. Mnesithea**
      8. Pedicelled spikelet absent **1. Eremochloa**

1. EREMOCHLOA

Buse in Miq., Pl. Jungh. 1: 357. 1854.— Type species: *E. horneri* Buse [= *E. ciliaris* (L.) Merr.].

Ischaemum L. sect. *Pectinaria* Benth., J. Linn. Soc., Bot. 19: 71. 1882.— Type species: *I. ophiuroides* Munro [= *Eremochloa ophiuroides* (Munro) Hack.].

Sehima auct. non Forssk.

Perennial. *Inflorescence* a single terminal, strongly flattened; internodes clavate. *Sessile spikelet*; lower glume chartaceous to coriaceous, the keels pectinately spinose, sometimes winged at tip; lower florets male, with palea. *Pedicelled spikelet* absent or represented by a bristle; *pedicel* free, narrowly foliaceous.

A genus of 11 species from India, Sri Lanka, S China, Indochina, Australia. Distinguished from *Mnesithea* mainly by pectinately spinose at the lower glume of the sessile spikelets.

KEY TO THE SPECIES

1. Lower glume apex with apical wings
  2. Pedicel less than 1.5 times as long as the sessile spikelet
    3. Lower glume setae hook-like, longest ones *ca.* 0.5 mm long, shorter than the width of the lower glume **9. E. petelotii**
    3. Lower glume setae straight, longest ones 1.5–1.6 mm long, as long as the width of the lower glume **11. E. sp.2**
  2. Pedicel more than or equal 1.5 times as long as the sessile spikelet
    4. Lower glume apex with a small apical wings, 0.1–0.3 length of the lower glume
      5. Pedicel subulate or oblique-lanceolate
        6. Pedicel subulate, lower glume setae straight, longest ones 1.5–2.0 mm long, equal or shorter than the width of the lower glume **1. E. attenuata**
        6. Pedicel oblique-lanceolate, lower glume setae straight, longest ones 2.5–3.0 mm long, much longer than the width of the lower glume **7. E. maxwellii**
      5. Pedicel oblique-obovate or obovate, usually with short or long cordate at apex

7. Pedicel oblique-obovate with short cordate at apex, foliose, 4–4.5 mm long, 0.75–0.85 times as long as the sessile spikelet **2. E. bimaculata**

7: Pedicel obovate with long cordate at apex, 4.5–6 mm long, 0.9–1.2 times as long as the sessile spikelet **10. E. sp.1**

4. Lower glume apex with a large apical wings, more than or equal 0.4 length of the lower glume **8. E. muricata**

1. Lower glume apex without apical wing

8. Pedicel more than 1 times as long as the sessile spikelet

9. Lower glume setae flattened, cataphylls woolly hairy **5. E. eriopoda**

9. Lower glume setae terete, cataphylls glabrous **6. E. lanceolata**

8. Pedicel less than 1 times as long as the sessile spikelet

10. Pedicel obovate with long cordate at apex **4. E. ciliatifolia**

10. Pedicel subulate without long cordate at apex **3. E. ciliaris**

1. Eremochloa attenuata Stapf ex Buitenhuis, Blumea 46 (2): 404. 2001.— Type: Thailand, Phu Kradueng, *A.F.G. Kerr* 8686 (holotype BM!, isotypes K! & P!).

Perennial grass, tufted, cataphylls slightly appressed hairs. *Culms* erect, 35–50 cm tall, extravaginal branching at base, internodes with densely pilose hairs, nodes slightly hairs. *Leaf-sheaths* nearly tight, 4–8 cm long, densely white hairy. *Ligules* membranous with ciliate margins,. 0.3–0.5 mm long. *Leaf-blades* flat to slightly folded, 8–20 cm by 2–2.5 mm, woolly hairs on both surfaces, acute at apex. *Inflorescence* racemes, solitary, straight, 4–6 cm long, rachis internodes clavate, 3–3.5 mm long, *ca.* 0.75–0.9 length of sessile spikelets, sparsely hairy, joints at base with ciliate hairs. *Sessile spikelets*; lower glume ovate, 4–5 by 1.8–2 mm, distinctly 9–10-nerved, glabrous to sparsely hairy on the back, setae straight, terete, longest ones 1.5–2 mm long, equal or shorter than the width of the lower glume, apex with a small apical wings, 0.2–0.3 length of the lower glume; upper glume oblong, 4–4.5 by *ca.* 1 mm, 3-nerved, keeled in the middle in the lower half and along the margins, distally with transverse veinlets, sparsely hairy on the lower part of the back, margins folded. *Lower floret*; lemma oblong, *ca.* 4 by 1 mm, hyaline, margins folded; palea oblong, *ca.* 3 by 0.8 mm, hyaline. *Upper floret*; lemma oblong, *ca.* 3.2 by 0.8 mm, hyaline, margins folded; palea oblong, *ca.* 3 by 0.5 mm, hyaline. *Lodicules* cuneate *ca.* 0.5 mm long. *Anthers* brown, *ca.* 2.5 mm long. *Ovary* elliptic, *ca.* 1 mm long. *Stigmas* purplish. *Pedicelled spikelet* absent. *Pedicels* subulate, 3–3.5 mm long, 0.6–0.7 times as long as the sessile spikelet (Figs. 5.8A-E & 5.34A-C).

Thailand.— NORTHERN: Chiang Mai [Doi Inthanon, 14 Jun. 2004, *P. Traiperm* 111 (BCU, BKF, KKU); Doi Suthep, 20 May 1912, *A.F.G. Kerr* 2607 (K); 12 May 1958, *Th. Sørensen et al.* 3379 (C, K); near Fang, 25 May 1958, *Th. Sørensen et al.* 3583 (C); Wang Bua Ban, *M. Norsangsri* 544, 17 May 1995, (QBG)], Lamphun [between Tak & Lamphun, 6 Jun. 1960, *T. Smitinand & H. St. John* 6799 (BKF, K); Khun Tan National Park, 6 Jun. 1993, *J.F. Maxwell* 93-590 (L)], Lampang [Ngao Mae Huad, *T. Kokkamhaeng* 34 (BKF, K)]; NORTH-EASTERN: Loei [Phu Kradueng, 13 Mar. 1924, *A.F.G. Kerr* 8686 (BM, K, P); 18 Mar. 1958, *Th. Sørensen et al.* 2242 (C); 17 Mar. 1974, *C. Chermsirivathana & T. Boonkerd* 1857 (BK); 13 Nov. 2004, *P. Traiperm* 162 (BCU, BKF, KKU); 27 Mar. 2006, *P. Traiperm* 377 (BCU, BKF, KKU)]; EASTERN: Si Sa Ket [Kanthararom, 6 Apr. 1954, *T. Smitinand* 591 (BKF)].

Distribution.— Endemic to Thailand.

Ecology.— Dry dipterocarp forest, at 450-1800 m altitude. Flowering in November to May.

2. Eremochloa bimaculata Hack. in DC. Monogr. Phan. 6: 265. 1889.— Type: India, East Bengal, *Griffith* 6774 (holotype B†, isotypes G, K!, frag. in L).

Perennial grass, tufted, slender rhizomatous, cataphylls glabrous. *Culms* erect, 20–60 cm tall, extravaginal branching at base, internodes glabrous, nodes glabrous. *Leaf-sheaths* loose, 3.5–7 cm long, glabrous. *Ligules* an ecilate membrane, *ca.* 0.5 mm long. *Leaf-blades* flat, 4–12 by 0.2–0.4 mm, glabrous on both surfaces, acute at apex. *Inflorescence* racemes, 1–3 together, straight, 5–8 cm long, rachis internodes clavate, 2–2.5 mm long, 0.45–0.5 length of sessile spikelets, glabrous, joints at base glabrous to slightly with a ring short ciliate hairs. *Sessile spikelets*; lower glume oblong, 4.5–5 by 2 mm, distinctly 5–7-nerved, glabrous on the back, setae straight, terete, longest ones 1.5 mm long, shorter than the width of the lower glume, apex with moderately green apical wings, 0.2–0.3 length of the lower glume; upper glume oblong, *ca.* 4.5 by 1.5 mm, 3-nerved, keeled in the middle in the lower half and along the margins, distally with transverse veinlets, glabrous on the lower part of the back, margins folded. *Lower floret*; lemma oblong, *ca.* 4 by 1 mm long, hyaline, margins folded, ciliate along the upper margins; palea oblong, *ca.* 2.5 by 1 mm, hyaline. *Upper floret*; lemma oblong, *ca.* 3 by 0.8 mm, hyaline; palea oblong, smaller than the lemma, hyaline. *Lodicules* cuneate *ca.* 0.5 mm long. *Anthers* brown, *ca.* 1.5 mm long. Ovary elliptic, *ca.* 1.5 mm long. *Stigmas* purplish. *Pedicelled spikelet* absent. *Pedicels* oblique-obovate with short cordate at the apex, foliose, 4–4.5 mm long, 0.75–0.85 times as long as the sessile spikelet (Figs. 5.8F-J & 5.34D-F).

Thailand.—NORTHERN: Chiang Mai [near Fang, 25 May 1958, *Th. Sørensen et al.* 3583 (BKF)]; EASTERN: Surin [Kap Choeng, 20 May 1965, *S. Sutheesorn* 293 (BK); Thung Kula Rong Hai, 8 Sept. 1970, *S. Sutheesorn* 2113 (BK)], Roi Et [Mueang, 1 Aug. 2004, *P. Traiperm* 116 (BCU, BKF, KKU); Suwannaphum, 22 Oct. 2005, *P. Traiperm* 229 (BCU, BKF, KKU); Kaset Wisai, Ban Wa Ngarm, 9 Jun. 1982, *Y. Paisooksantivathana & S. Sutheesorn* y 982-82 (BK)], Si Sa Ket [Dongrak Range, at Chong Bat Lak, 19 Aug. 1976, *J.F. Maxwell* 76-561 (BK, L)], Ubon Ratchathani [Sirindhorn, 23 Oct. 2005, *P. Traiperm* 254 (BCU, BKF, KKU)]; SOUTH-WESTERN: Prachuap Khiri Khan [Sam Roi Yot, 8 Jul. 1926, *A.F.G. Kerr* 10902, (BM, K)]; SOUTH-EASTERN: Sa Kaeo [Aranyaprathet, 9 Aug. 1930, *A.F.G. Kerr* 19583 (BM, K)].

Distribution.— Burma, Thailand, Cambodia, Vietnam, China, Malesia and Australia.

Ecology.— Grass common in dry dipterocarb forest, at altitude 50-650 m. Flowering in May to September.

Vernacular.— Ya hang nok yung (หญ้าหางนกยูง) (Si Sa Ket).

Notes.— *Eremochloa bimaculata* is usually misidentified as *E. mawellii*, but it is different from the latter species in having an oblique-obovate pedicels with short cordate at the apex, while oblique-lanceolate pedicels in *E. maxwellii*.

3. Eremochloa ciliaris (L.) Merr., Philipp. J. Sci. 1, Suppl.: 331. 1906.

Nardus ciliaris L., Sp. Pl.: 53. 1753. — Type: *Herb. Linn.* 73.7 (lectoype LINN!).

E. horneri Buse in Miq., Pl. Jungh. 3: 357. 1854.— Type: *Horner* 137 (holotype L!, phototype BRI, K!).

E. leersioides (Munro) Hack. in DC., Monogr. Phan. 6: 264. 1889.— Type: *C. Wright* s.n. (holotype K!, isotype P!).

E. falcata Hack. in DC., Monogr. Phan. 6: 263. 1889.— Type: *Meyen* s.n. (holotype B†).

E. malayana Ridl., Mat. Fl. Malay Penins. 3: 155. 1907.— Type: *Ridley* 5154 (holotype SING, isotypes BM!, K!).

E. leersioides (Munro) Hack. var. *gigantean* A. Camus, Notul. Syst. (Paris) 3: 87. 1914.— *E. ciliaris* (L.) Merr. var. *gigantean* A. Camus, Fl. Indo-Chine 7: 291. 1922.— Type: Vietnam, *Eberhardt* 1890 (holotype P!, syntype K!).

E. leersioides (Munro) Hack. var. *pygmaea* A. Camus, Notul. Syst. (Paris) 3: 87. 1914.— *E. ciliaris* (L.) Merr. var. *pygmaea* A. Camus, Fl. Indo-Chine 7: 291. 1922.— Type: *Bauche* 97 (holotype P!).

E. leersioides (Munro) Hack. var. *thorelii* A. Camus, Notul. Syst. (Paris) 3: 87. 1914.— *E. ciliaris* (L.) Merr. var. *thorelii* A. Camus, Fl. Indo-Chine 7: 291. 1922.— Type: *Thorel* s.n. (holotype P!).

E. ciliaris (L.) Merr. var. *elata* Reeder, J. Arnold Arbor. 29: 351. 1948.— Type: *Brass* 7808 (holotype US).

Perennial grass, tufted, rhizomatous, cataphylls glabrous to pilose. *Culms* erect, 25–45 cm tall, extravaginal branching at base, internodes glabrous to pilose, nodes glabrous to slightly pilose. *Leaf-sheaths* loose, 2–10 cm long, glabrous, margins thin. *Ligules* membranous, 0.4–1 mm long. *Leaf-blades* flat to slightly folded, 3–15 cm by 2.5–8 mm, glabrous to sparsely hairy on both surfaces, margins thick and scabrous, acute at apex. *Inflorescence* racemes, 1–3 together, falcate, 1–5 cm long, rachis internodes clavate, 1.8–2.5 mm long, 0.5–0.6 length of sessile spikelets, pilose, joints at base with short ciliate hairs. *Sessile spikelets*; lower glume ovate, 4–4.5 by 1.8–2 mm, obscurely 4–7-nerved, glabrous to densely hairy on the back, setae straight, flattened, longest ones 3–3.5 mm long, much longer than of the width of the lower glume, apex wingless; upper glume oblong to elliptic, 3.8–4.2 by *ca.* 1 mm, 3-nerved, keeled in the middle in the lower half and along the margins, distally with transverse veinlets, slightly appressed hairs on the lower part of the back, margins folded. *Lower floret*; lemma elliptic, *ca.* 3 by 0.8 mm, margins folded, hyaline; palea oblong, *ca.* 2.8 by 0.8 mm, hyaline. *Upper floret*; lemma oblong, *ca.* 2.8 by 0.8 mm, hyaline; palea oblong, *ca.* 2.5 by 0.5 mm, hyaline. *Lodicules* cuneate *ca.* 0.5 mm long.

Anthers brown, *ca.* 2–2.5 mm long. Ovary ovoid, *ca.* 1.5 mm long. *Stigma* purplish. *Pedicelled spikelet* absent. *Pedicels* subulate, *ca.* 2-3 mm long, 0.5–0.75 times as long as the sessile spikelet, glabrous to slightly pilose (Figs. 5.8K-N & 5.35A-D).

Thailand.— NORTHERN: Mae Hong Son [Lang Mee, 7 Aug. 1958, *T. Smitinand* 4583 (BKF)], Chiang Mai [Doi Suthep, 30 Jul. 1911, *A.F.G. Kerr* 1938 (BM, E, K, TCD); 4 Aug. 1912, *A.F.G. Kerr* 2651 (BM, K); 17 Sept. 1958, *Th. Sørensen et al.* 5046 (C, K); Op Luang, along road from Bo Luang to Om Koi, 12 Jun. 1968, *C.F. van Beusekom & C. Phengklai* 1183 (BKF, L); 2 stops on road to Om Koi, 23 Feb. 1979, *T. Koyama et al.* 15,523 (AAU); Mae Rim, 21 Jul. 1996, *M. Norsaengsri* 309 (QBG)], Phitsanulok [Phu Miang mountain, 28 Jul. 1966, *K. Larsen* 992 (AAU, K); Phu Hin Rong Ka, 29 Oct. 2001, *S. Watthana & P. Suksathan* 1574 (QBG); 29 Mar. 2006, *P. Traiperm* 380 (BCU, BKF, KKU), 381, 382 (BCU, BKF, KKU), 383 (BCU, BKF, KKU)], Nakhon Sawan [31 km N of Nakhon Sawan, 6 Feb. 1959 (BKF, K), *T. Smitinand* 5804 (BKF)]; NORTH-EASTERN: Loei [Phu Luang, 17 Nov. 1968, *C. Chermsirivathana* 1139 (BK); Phu Kradueng, 21 Mar. 1958, *Th. Sørensen et al.* 2399 (K), 23 Mar. 1954, *T. Smitinand* 1796 (BKF); 18 Mar. 1958, *Th. Sørensen et al.* 2242 (BKF, K), 21 Mar. 1958, 2399 (C, E, K); 7 Mar. 1909, *P.J. O' Connor & C. Niyomdham* 15,672 (AAU, BKF); Phu Ruea, 23 May 2004, *P. Traiperm* 119; 4 Dec. 2004, *P. Traiperm* 190 (BCU, BKF, KKU)], Udon Thani [Mueang, 10 Oct. 2004, *P. Traiperm* 130 (BCU, BKF, KKU)], Nong Khai [Chaiyaburi, 1 May 1932, *A.F.G. Kerr* 21328 (BK, BM, K); Phu Woe, 16 Oct. 2005, *P. Traiperm* 216 (BCU, BKF, KKU)], Sakon Nakhon [Phu Phan National Park, 21 Jul. 1999, *S. Vessabutr et al.* 845 (QBG)]; Nakhon Phanom [Tha Uthen, 16 Feb. 1924, *A.F.G. Kerr* 8465 (BK, BM, K, P, TCD); 8 Dec. 1963, *Pradit* 428 (BKF)]; EASTERN: Chaiyaphum [Phu Khiao, 14 Aug. 1972, *K. Larsen et al.* 31819 (AAU, BKF, K, L)], Surin [near Cambodian border, *ca.* 5 km N of Sangkha, 6 Oct. 1984, *G. Murata et al.* T-37709 (BKF, L)], Roi Et [Thung Kula Rong Hai, 22 Jun. 1969, *T. Smitinand* 10746 (BKF, L)], Si Sa Ket [2 km N of Chong Bat Lak, Kantharalak, 12 Apr. 1976, *J.F. Maxwell* 76-222 (AAU, BK, L)], Ubon Ratchathani [Khong Chiam, Huai Yang, *J.F. Maxwell* 01-405, 14 Sept. 2001 (BKF)]; SOUTH-WESTERN: Uthai Thani [Huai Kha Khaeng Reserve, Ban Rai, 22 Apr. 1976, *J.F. Maxwell* 76-265 (AAU, BK, L); Khao Phetawee, 28 Jun. 1999, *M. Norsaengsri* 819 (QBG)], Kanchanaburi [Ban Kao, 11 Nov. 1961, *K. Larsen* 8138 (C,K)], Ratchaburi [Huai Yang, 9 Aug. 1966, *K. Larsen* et al. 1330 (AAU, BKF, K)], Phetchaburi [Thung Luang, 9 Nov. 1931, *A.F.G. Kerr* 20609 (BK, BM, K)], Prachuap Khiri Khan [Sam Roi Yot, 8 Dec. 26, *A.F.G. Kerr* 10902 (BK, BM, K); 23 Oct. 1964, *C. Chermsirivathana* 146 (BK)]; SOUTH-EASTERN: Sa Kaeo [Aranyaprathet, 9 Aug. 1930, *A.F.G. Kerr* 19583 (BK, K); Nang Wiang, 8 Jun. 1953, *K. Suvathabhandhu* 456 (BKF)], Prachin Buri [Prachantakham, 2 Jan. 1967, *S. Sutheesorn* 2042 (BK)], Chon Buri [Khao Khiao, 23 Jun. 1975, *J.F. Maxwell* 75-617 (AAU, BK, L)], Chanthaburi [Plain of Makham, 14 Sept. 1956, *T. Smitinand* 3506, 9 Apr. 1959, 5760 (BKF, K); 6 Jun. 1963, *K. Larsen* 9787 (C); 13 Jun. 1963, 10030 (BKF, C, K, L), 10067 (C, K), 10067a (BKF, K)], Trat [Saphan Hin, 3 May 1974, *R. Geesink et al.* 6518 (BKF, C, K, L)]; PENINSULAR: Chumphon [Ban Huai Keaw, Tungka, Mueang, 15 Jan. 1987, *J. Supapol* 217 (CMU, PSU)], Surat Thani [Kanchanadit, 1 Aug. 1927, *A.F.G. Kerr* 13073 (BK, BM, K); Kanthuli, 6 Sept. 1931, *A.F.G. Kerr* 4120 (BK, BM, K); 29 May 1960, *C. Chataraprasong* 106 (BK)], Phatthalung [Sak, 1 May 1930, *A.F.G. Kerr* 19273 (BK, BM, K)], Trang [Bangsak, 20 Apr. 1930, *A.F.G. Kerr* 19044 (K), 19046 (BK, BKF, BM, K, P); Sikao, ex Hat Chao Mai National Park, *Y. Paisooksantivathana* y 2424-89, (BK)], Satun [28 Dec. 1927, *A.F.G. Kerr* 13716 (BK, BM, K); Butang, 13 Jan. 1928, *A.F.G. Kerr* 14052 (BKF, BM, K); Thung Nui, 13 Feb. 1961, *T. Smitinand* 7160 (BKF)], Songkhla [8 Apr. 1918, *A.F.G. Kerr* 15754 (K); Khao Khiao, 28 Jul. 1928, *A.F.G. Kerr* 15960 (BK, BM, K); 2 Nov. 1982, *Chorthip* 42 (PSU); Ton Nga Chang water falls, 13 Aug. 1984, *J.F. Maxwell* 84-54 (PSU); 1 Nov. 1990, *K. Larsen et al.* 41069 (AAU, BKF, PSU); 21 Aug. 1992, *C. Niyomdham & P. Pudjaa* 3142 (BKF); Ban Bak Bang, Thepa, 26 Jun. 1985, *J.F. Maxwell* 85-641 (AAU, BKF, L, PSU); Khlong Hoi Khong, 10 km W of Toong Loong, Hat Yai, 31 Oct. 1986, *J.F. Maxwell* 86-848 (BKF, CMU, L, P, PSU)], Pattani [17 Jul. 1923, *A.F.G. Kerr* 7243 (BK, BM, K)], Narathiwat [Mueang, 17 Dec. 1986, *J.F. Maxwell* 86-1082 (BKF, CMU, L, PSU), Ban Thorn, 29 Aug. 1989, *C. Niyomdham* 2019 (BK); Talingchan, Bannangsata, 6 Aug. 2000, *C. Niyomdham et al.* 6349 (AAU)].

Distribution.— Burma, Laos, Vietnam, China, Taiwan, Singapore, Malesia and Australia.

Ecology.— In deciduous, dipterocarp or pine forest, up to 2,200 m altitude. Flowering throughout the year.

Notes.— This species has a wide variability in the lower gume of the sessile spikelet.

4. Eremochloa ciliatifolia Hack. in DC., Monogr. Phan. 6: 265. 1889.— Type: India, East Bengal, *Griffith* KD 6776 (holotype B, isotypes E!, K!, L!, MO, US).

Annuals grass, tufted, cataphylls with appressed hairs but woolly at base. *Culms* erect, 30–70 cm tall, extravaginal branching at base, internodes pilose, nodes with long ciliate hairs. *Leaf-sheaths* loose, 4–12 cm long, with slightly pilose hairs to densely pilose hairs. *Ligules* membranous with ciliate margins, *ca.* 0.35–0.4 mm long. *Leaf-blades* flat to slightly folded, 5–25 cm by 2–5 mm, obtuse to acute at apex, glabrous to densely hairs on both surfaces, margins pilose. *Inflorescence* racemes, 1–3 together, straight, 3–7 cm long, rachis internodes clavate, *ca.* 2 mm long, 0.4–0.45 length of sessile spikelets, scabrous, joints at base with long ciliate hairs. *Sessile spikelets*; lower glume oblong-ovate, 4–4.7 by *ca.* 2 mm, distinctly 6–9-nerved, with appressed hairs on the back, setae straight, terete, longest ones 3.2–3.5 mm long, much longer than of the width of the lower glume, apex wingless; upper glume elliptic, 4.2–4.5 by 1.2–1.4 mm, 3-nerved, keeled in the middle in the lower half and along the margins, with distally transverse veinlets, appressed hairs on the lower part of the back, margins folded. *Lower floret*; lemma oblong-ovate, *ca.* 4 by 1 mm, hyaline, margins folded; palea elliptic, *ca.* 3.5 by 0.8 mm, hyaline. *Upper floret*; lemma elliptic, *ca.* 3 by 0.8 mm, hyaline; palea oblong, *ca.* 3 by 0.5 mm, hyaline. *Lodicules* cuneate *ca.* 0.6 mm long. *Anthers* brown, *ca.* 3 mm long. *Ovary* elliptic, 1.8–2 mm long. *Stigmas* purplish. *Pedicelled spikelet* reduced to subulate, 0.8–1.3 mm long, pilose. *Pedicels* obovate with long cordate apex, 2.2–2.4 mm long, 0.5 times as long as the sessile spikelet (Figs. 5.9A-C & 5.35E-G).

Thailand.— NORTH-EASTERN: Phetchabun [Tung Salaeng Luang, 2 Oct. 1964, *B. Hansen et al.* 11104 (BKF, C, L)], Loei, [Phu Kradueng, 31 Aug. 1988, *H. Koyama* T-61479 (AAU, L); 13 Nov. 2004, *P. Traiperm* 163 (BCU, BKF, KKU); 29 Oct. 2005, *P. Traiperm* 261 (BCU, BKF, KKU), 264 (BCU, BKF, KKU), 266 (BCU, BKF, KKU), 267 (BCU, BKF, KKU); 30 Oct. 2005, *P. Traiperm* 268 (BCU, BKF, KKU), 269 (BCU, BKF, KKU), 270 (BCU, BKF, KKU)]; EASTERN: Chaiyaphum [Phu Khiao, 24 Feb. 1931, *A.F.G. Kerr* 20256 (BK, BM, K)]; SOUTH-EASTERN: Trat [4 May 1974, *J.F. Maxwell* 74-358 (AAU, BK)].

Distribution.— Burma and Vietnam.

Ecology.— Grassland, dipterocarp woodland and pine forests at 250–1,300 m altitude. Flowering between May and November.

Notes.— This species is similar to *E. ciliaris* in having wingless, but differs in the shape of the pedicels.

5. Eremochloa eriopoda C.E. Hubbard in Hook., Icon. Pl. 34: t3376. 1939.— Type: Thailand, Ubon Ratchathani: Muang Samsip, *A.F.G. Kerr* 8354 (holotype K!, isotypes BK!, BM!, TCD!).

Perennial grass, tufted; cataphylls with woolly hairs. *Culms* erect, up to 1 m tall, extravaginal branching at base, internodes glabrous to densely hairs, nodes with long ciliate hairs. *Leaf-sheaths* loose, 5–8 cm long, glabrous to slightly pilose, margins with sparse hairs. *Ligules* ciliate, *ca.* 0.35–0.4 mm long. *Leaf-blades* flat to slightly folded, up to 45 cm by 3–4 mm, glabrous to densely hairy on both surfaces, margins glabrous to pilose, usually wooly hairy at base, acute at apex. *Inflorescence* racemes, 1 to several, falcate, 2–4.5 cm long, rachis internodes clavate, 1.5 mm long, *ca.* 0.35 length of sessile spikelets, scabrous, joints at base with long ciliate hairs. *Sessile spikelets*; lower glume oblong-ovate to ovate, 4.5–5 by 1.8–2 mm, obscurely 5–6-nerved, glabrous to densely hairy on the back, setae straight, flattened, longest ones 4–4.5 mm long, much longer than of the width of the lower glume, apex wingless; upper glume elliptic, 4.5–5 by 1–1.2 mm, 3-nerved, keeled in the middle in the lower half and along the margins, without distally with transverse veinlet, densely hairy on the lower part of the back, margins folded. *Lower floret*; lemma elliptic, *ca.* 4 by 1 mm long, hyaline, margins folded; palea elliptic, *ca.* 3.5 by 1 mm, hyaline. *Upper floret*; lemma oblong, *ca.* 3.5 by 1 mm, hyaline, margins folded; palea oblong, *ca.* 3.2 by 0.8 mm, hyaline. *Lodicules* cuneate, *ca.* 0.6 mm long. *Anthers* brown, *ca.* 3 mm long. *Ovary* elliptic, *ca.* 2 mm long. *Stigmas* purplish. *Pedicelled spikelet* absent. *Pedicels* subulate, 6–7 mm long, 1.45–1.5 times as long as the sessile spikelet (Figs. 5.9D-G & 5.36A-C).

Thailand.— NORTH-EASTERN: Nong Khai [Na Nok, Phon Phisai, *Adisai* 518, 6 Jun. 1963 (BK); Bueng Karn, Huai Poo, 17 Nov. 1966, *T. Smitinand* 10094 (BKF, L); Si Chiang Mai, 18 Aug. 1972, *T. Smitinand* 11646 (BKK), 11647A (K)], Mukdahan [Mukdahan National Park (Phu Pha Thueb), 23 Aug. 2001, *R. Pooma et al.*

2437 (BKF, L); 9 Oct. 2006, *P. Traiperm* 374 (BCU, BKF, KKU)]; EASTERN: Si Sa Ket [en route from Srisaket to Kantharalak about 10 km from Kantharalak, 8 Oct. 1984, *G. Murata et al.* T-49670 (BKF, L); Near cambodian border, 20 km s of Kantharalak, 8 Oct. 1984, *G. Murata et al.* T-49673 (BKF, L); *G. Murata et al.* T-49675 (BKF, L); Dongrak range, 31 Dec. 2005, *P. Traiperm* 362 (BCU, BKF, KKU); Khao Phra Wihan, 31 Dec. 2005, *P. Traiperm* 365 (BCU, BKF, KKU), 366 (BCU, BKF, KKU)], Ubon Ratchathani [Muang Sam Sip, 26 Jan. 1924, *A.F.G. Kerr* 8354 (BK, BM, K, TCD); Warin Chamrap, *S. Laegaard et al.* 21832 (AAU, K, L), 21847 (AAU, K, L); Pa Dong Na Tham, Khong Chiam, *C. Niyomdham* 5628 (AAU); km 81, 217 road, 22 Oct. 2005, *P. Traiperm* 237 (BCU, BKF, KKU); km 10, 2112 road to Khong Chiam, 23 Oct. 2005, *P. Traiperm* 253 (BCU, BKF, KKU); Pha Taem National Park, 23 Oct. 2005, *P. Traiperm* 243 (BCU, BKF, KKU), 246 (BCU, BKF, KKU), 247 (BCU, BKF, KKU), 248 (BCU, BKF, KKU); Phu Chong Na Yoi, 24 Oct. 2005, *P. Traiperm* 255 (BCU, BKF, KKU)].

Distribution.— Laos, Vietnam and Malesia.

Ecology.— In sandy soid on open rocky area in dry deciduous or diptercarp forest, at 0-210 m altitude. Flowering in August to January.

Notes.— This species very similar to *E. ciliatifolia* in having wingless in the lower glume of sessile spikelet, but differs in the shape of pedicels.

6. Eremochloa lanceolata Buitenhuis in Blumea 46 (2): 409. 2001.— Type: Thailand, Pha Taem National Park: Ubon Ratchathani, *Nanakorn* 1253 (holotype NY!, isotype BKF!).

Annuals grass, tufted, cataphylls glabrous. *Culms* erect, 20–40 cm tall, extravaginal branching at base, internodes glabrous, nodes glabrous or slightly long pilose. *Leaf-sheaths* loose, 3–6 cm long, glabrous. *Ligules* an eciliate membrane, 0.8–1 mm long. *Leaf-blades* slightly folded, 3–6 cm by 2–3 mm, glabrous or slightly pilose on both surfaces, margins pilose, acute at apex. *Inflorescence* racemes, 1–3, straight to slightly falcate, 2.5–3.5 cm long, rachis internodes clavate, 2–2.3 mm long, 0.4–0.5 length of sessile spikelets, scabrous, jointed at base with long ciliate hairs. *Sessile spikelets*; lower glume ovate, 4–4.5 by 1–1.5 mm, obscurely 5–7-nerved, glabrous to slightly appressed hairy on the back, setae straight, terete, longest ones 2.8–3 mm long, much longer than of the width of the lower glume, apex wingless;

upper glume oblong, 3–4 by 0.8–1 mm, 3-nerved, keeled in the middle in the lower half and along the margins, without distally with transverse veinlet, glabrous on the back, margins folded, scabrous along margins. *Lower floret*; lemma oblong-ovate, *ca.* 2.8 mm long, hyaline, margins folded; palea smaller than lemma, *ca.* 2.8 mm long, hyaline. *Upper floret*; lemma elliptic, *ca.* 2 mm long, hyaline, margins folded; palea smaller than lemma, *ca.* 2 mm long, hyaline. *Lodicules* cuneate, 0.4 mm long. *Anthers* brown, 1.8–2 mm long. *Ovary* elliptic, *ca.* 1.5 mm long. *Stigmas* purplish. *Pedicelled spikelet* absent. *Pedicels* subulate, 5.5–6.5 mm long, 1.5 times as long as the sessile spikelet (Figs. 5.9H-J & 5.36D-F).

Thailand.—EASTERN: Nakhon Ratchasima [Khao Kuap, 25 Dec. 1919, *A.F.G. Kerr* 17762 (BM, K)]; Ubon Ratchathani [Pha Taem National Park, *Nanakorn* 1253, (BKF, NY); 23 Oct. 2005, *P. Traiperm* 242 (BCU, BKF, KKU); km 81 on road 217 E of Warin Chamrap, 27 Oct. 2001, *S. Laegaard et al.* 21828 (AAU), 21831 (AAU, K, L), 21835 (AAU), 21843 (AAU); 22 Oct. 2005, *P. Traiperm* 236 (BCU, BKF, KKU)].

Distribution.— Endemic to Thailand

Ecology.— Secondary grassland, sandstone forest or edge of dry dipterocarp forest at *ca.* 125 m altitude. Flowering in October.

Notes.— This species has a tiny inflorescence and similar to *E. eriopoda* in having subulate pedicel, but differs in its shape and the length of setae. *Eremochloa lanceolata* having a straight setae, terete, and the longest ones 2.8–3 mm long, whereas setae straight, flattened, and a longest ones 4–4.5 mm long in *E. eriopoda.*

7. Eremochloa maxwellii Veldkamp in Blumea 48 (3): 496. 2003.— Type: Thailand, Ubon Ratchathani: km 36 on road 217 E of Warin Chamrap, *S. Laegaard et al.* 21811, (holotype AAU!).

Perennial grass, tufted, slender rhizomatous, cataphylls glabrous. *Culms* erect, up to 80 cm tall, extravaginal branching at base, internodes glabrous, nodes glabrous. *Leaf-sheaths* loose, 3–9 cm long, glabrous. *Ligules* an ecilate membrane, 0.35–0.4 mm long. *Leaf-blades* flat to slightly folded, 5–20 cm long, 2–4 mm, glabrous on both surfaces, acute at the apex. *Inflorescence* racemes, 1–3 together, straight, 5–11 cm long, rachis internodes clavate, 2–2.3 mm long, 0.45–0.65 length of sessile spikelets, glabrous, jointed at base with short ciliate hairs. *Sessile spikelets*; lower glume oblong-ovate, 3.5–5 by 1.2–1.5 mm, obscurely 6–8-nerved, glabrous on the back, setae straight, terete, longest ones 2.5–3 mm long, much longer than the width of the lower glume, apex with a moderately green apical wings, 0.2–0.3 length of the lower glume; upper glume oblong, *ca.* 3.5 by 1.5 mm, 3-nerved, keeled in the middle in the lower half and along the margins, distally with transverse veinlets, glabrous on the lower part of the back, margins folded. *Lower floret* lemma elliptic, *ca.* 3 by 1 mm, hyaline, margins folded; palea elliptic, *ca.* 3 by 0.8 mm, hyaline. *Upper floret*; lemma elliptic, *ca.* 3 by 1 mm, hyaline; palea elliptic, *ca.* 2.8 by 0.8 mm, hyaline. *Lodicules* cuneate, *ca.* 0.5 mm long. *Anthers* brown, *ca.* 1.6 mm long. *Ovary* elliptic, *ca.* 1.5 mm long. *Stigmas* purplish. *Pedicelled spikelet* absent. *Pedicels* oblique-lanceolate, foliose, 3.5–5.5 mm long, 0.7–1 times as long as the sessile spikelet (Figs. 5.10A-C & 5.37A-C).

Thailand.— EASTERN: Si Sa Ket [Dongrak, Kantharalak, 19 Aug. 1976, *J.F. Maxwell* 76-561 (AAU, BK)]; Ubon Ratchathani [km 36 on road 217 E of Warin Chamrap, 27 Oct. 2001, *S. Laegaard et al.* 21811 (AAU); 22 Oct. 2005, *P. Traiperm* 232 (BCU, BKF, KKU)].

Distribution.— Endemic to Thailand.

Ecology.— Secondary grassland in deciduous forest, at altitude *ca.* 125 m. Flowering in October.

Notes.— This species is very similar to *E. bimaculata* in having 2 apical wings, but differs in it shape of pedicels. Pecicels oblique-lanceolate, foliose, 3.5–5.5 mm long in *E. mawellii*, while oblique-obovate with short cordate at apex, foliose, 4–4.5 mm long in *E. bimaculata*.

8. Eremochloa muricata (Retz.) Hack. in DC., Monogr. Phan. 6: 262. 1889.

Aegilops muricata Retz., Observ. Bot. 2: 27. 1781. — Type: *König* s.n. (holotype K!, isotypes C, LD).

Rottboellia muricata Retz., Observ. Bot. 3: 12. 1783.

Aegilops ciliaris Koen. ex Roem. & Schult., Syst. 2: 772.— Type: India (isotype K!).

Perennial grass, tufted, slender rhizomatous, cataphylls woolly. *Culms* erect, 30–45 cm tall, extravaginal branching at base, internodes glabrous, nodes slightly pilose. *Leaf-sheaths* loose, 5–8 cm long, glabrous to pilose. *Ligules* membranous with ciliate margins, *ca.* 1–1.5 mm long. *Leaf-blades* flat to slightly folded, 6–15 cm long, 4–5 mm wide, glabrous on both surfaces, margins entire or pilose, acute at the apex. *Inflorescence* racemes, 1–2, straight, 4–6 cm long, rachis internodes clavate, 3–3.2 mm long, about 0.5 length of sessile spikelets, glabrous, jointed at base glabrous *Sessile spikelets*; lower glume elliptic, *ca.* 6 by 2 mm, distinctly 4–7-nerved, glabrous on the back, setae straight, terete, longest ones *ca.* 2 mm long, as long as the width of the lower glume, apex with large apical wings, 0.4 length of the lower glume; upper glume elliptic, 5–5.5 by *ca.* 1.2 mm, 3-nerved, keeled in the middle in the lower half and along the margins, without distally with transverse veinlet, with sparse short hairs on the lower part of the back, margins folded. *Lower floret*; lemma elliptic, *ca.* 4.5 by 1 mm, hyaline, margins folded; palea elliptic, *ca.* 5 by 0.8 mm, hyaline, slightly folded. *Upper floret*; lemma elliptic, *ca.* 3.5 by 0.8 mm, hyaline, folded; palea oblong, *ca.* 4 by 0.5 mm, hyaline, margins folded. *Lodicules* cuneate, *ca.* 0.5 mm long. *Anthers* brown, *ca.* 2–2.5 mm long. *Ovary* ovoid, *ca.* 1 mm long. *Stigmas* purplish. *Pedicelled spikelet* absent. *Pedicels* obliquely obovoid, 5–5.5 mm long, 0.9–0.95 times as long as the sessile spikelet (Figs. 5.10D-F & 5.37D. & E).

Thailand.— NORTH-EASTERN: Sakon Nakhon [Ban Thom, 12 Sept. 1962, *A. Chantanamuck* 250 (BKF)]; SOUTH-WESTERN: Ratchaburi [18 Jul. 1924, *A. Marcan* 1786 (BM, K); 1790 (K); 18 Jul. 1924, *A.F.G. Kerr* 9033 (BK, BM, K)], Phetchaburi [Thung Luang, 10 Nov. 1931, *A.F.G. Kerr* 20627 (BKF, BM, K)], Prachuap Khiri Khan [Hua Hin, 6 Nov. 1927, *A.F.G. Kerr* 13459 (BKF, BM)].

Distribution.— India, Indo-China, Australia.

Ecology.— Growing on an open sandy soil in deciduous forest, at 0-50 m altitude. Flowering in July to November.

Notes.— *Eremochloa muricata* differs from other *Eremochloa* in having a large apical wings on lower glume of sessile spikelet.

9. Eremochloa petelotii Merr., Univ. Calif. Publ. Bot. 10 (9): 423. 1924.— Type: Vietnam: Tonkin, *M. Pételot* 247 (holotype UC, isotype P!, phototype K!, P!, fragm. in A, US).

Perennial grass, tufted, cataphylls glabrous. *Culms* erect, up to 1 m tall, extravaginal branching at base, internodes glabrous, nodes glabrous. *Leaf-sheaths* loose, 3–8 cm long, glabrous. *Ligule* ciliate, 0.35–0.40 mm long. *Leaf-blades* flat, up to 45 cm, 0.7–1 cm, glabrous on both surfaces, margins scabrous, acute at the apex. *Inflorescence* racemes, solitary, straight, 3–10 cm long, rachis internodes clavate, 2.5–3 mm long, *ca.* 0.4 length of sessile spikelets, glabrous, jointed at base glabrous or glabrescent. *Sessile spikelets*; lower glume ovate, 5–5.5 by *ca.* 1.5 mm, distinctly 3–6-nerved, glabrous on the back, setae hook-like, terete, longest ones *ca.* 0.5 mm long, shorter than the width of the lower glume, apex with a large apical wings, 0.4–0.5 length of the lower glume; upper glume lanceolate, 4.5–5 by *ca.* 0.8 mm, 3-nerved, keeled in the middle in the lower half and along the margins, keeled scabrous, obscurely distally with transverse veinlets, glabrous on the lower part of the back, margins folded. *Lower floret*; lemma elliptic, *ca.* 3.5 by 1 mm, hyaline, margins folded; palea lanceolate, *ca.* 3.5 by 0.5 mm, hyaline. *Upper floret*; lemma oblong, *ca.* 2.8 by 0.5 mm, hyaline; upper palea oblong, *ca.* 2.5 by 0.5 mm, hyaline. *Lodicules* cuneate, *ca.* 0.5 mm long. *Anthers* brown, *ca.* 1.5 mm long. *Ovary* elliptic, *ca.* 2 mm long. *Stigmas* purplish. *Pedicelled spikelet* absent. *Pedicels* narrowly lanceolate, *ca.* 8–8.5 mm long, *ca.* 1.6 times as long as the sessile spikelet (Figs. 5.10G-I & 5.37F. & G).

Thailand.— EASTERN: Nakhon Ratchasima [Phimai, 27 Dec. 1958, *T. Smitinand* 5045 (BKF, K)], Surin [Thung Kula Rong Hai, Chumphon Buri, 17 Sept. 1972, *S. Sutheesorn* 2315 (BKF)].

Distribution.— Cambodia, Vietnam.

Ecology.— Tufted grass common in paddy field, at *ca.* 250 m altitude. Flowering in September to December.

Notes.— Only known from three collections from two different localities. As the previous data said to be very common in paddy field, however I have not seen in their localities.

10. Eremochloa sp.1

Perennial grass, tufted, slender rhizomatous, cataphylls glabrous. *Culms* erect, 40–100 cm tall, extravaginal branching at base, internodes glabrous, nodes ciliate.

Leaf-sheaths loose, 8–12 cm long, glabrous to hirsute. *Ligules* membranous, ciliate, 1.5–2 mm long. *Leaf-blades* flat, 12–47 cm by 3–5 mm, glabrous on both surfaces, margins scabrous and pilose, 1–2 mm long acute at apex. *Inflorescence* racemes, solitary, straight, 6–8 cm long, rachis internodes clavate, 2–2.3 mm long, 0.45–0.65 length of sessile spikelets, sparsely hairy, jointed at base, glabrous or sparsely hairy. *Sessile spikelets*; lower glume oblong-ovate to ovate, 4.5–5 by 1.5–2 mm, distinctly 7–9-nerved, glabrous on the back, setae straight, terete, longest ones 2–2.5 mm long, as long as the width of the lower glume or sometimes slightly longer than apex with a moderately green apical wings, 0.1–0.3 length of the lower glume; upper glume oblong, *ca.* 3.5 by 1.5 mm, 3-nerved, keeled in the middle in the lower half and along the margins, distally with transverse veinlets, with sparse hairs on the lower part of the back, margins folded. *Lower floret*; lemma oblong, *ca.* 3 by 1 mm long, hyaline, margins folded, ciliate along the upper margins; palea oblong, *ca.* 3 by 0.7 mm, hyaline. *Upper floret*; lemma oblong, *ca.* 2.5–3 by 1 mm, hyaline; palea lanceolate, *ca.* 2.8 by 0.5 mm, hyaline, margins folded. *Lodicules* cuneate, *ca.* 0.5 mm long. *Anthers* brown, *ca.* 0.8–1 mm long. *Ovary* ovoid, *ca.* 1 mm long. *Stigmas* purplish. *Pedicelled spikelet* absent. *Pedicels* obovate with a long cordate apex, 4.5–6 mm long, 0.9–1.2 times as long as the sessile spikelet (Figs. 5.11 & 5.38A-C).

Thailand.— NORTH-EASTERN: Khon Kaen [Khok Phu Taka, 9 Sept. 2004, *P. Traiperm* 125 (BCU, BKF, KKU); EASTERN: Chaiyaphum [Nong Bua Daeng, 15 Aug. 1972, *K. Larsen et al.* 31871 (AAU, BKF, L)], Nakhon Ratchasima [Huai Thalaeng, 20 Aug. 2001, *R. Pooma et al.* 2118 (BKF, L)].

Distribution.— Endemic to Thailand.

Ecology.— Growing on sandy soil in dipterocarp forest, at *ca.* 300 m altitude. Flowering between August and September.

Notes.— *Eremochloa* sp.1 is similar to *E. maxwellii* but differs considerably in having obovate with a long cordate pedicel, while oblique-lanceolate pedicel in *E. maxwellii*.

11. Eremochloa sp.2

Perennial grass, tufted, slender rhizomatous, cataphylls glabrous. *Culms* erect, 20–30 cm tall, extravaginal branching at base, internodes glabrous, nodes glabrous.

Leaf-sheaths loose, 3.5–7 cm long, glabrous to hirsute. *Ligules* ciliolate, *ca.* 1.5–2 mm long. *Leaf-blades* flat to slightly folded, 3–15 cm by 4–5 mm, glabrous on both surfaces, margins entire, acute at apex. *Inflorescence* racemes, solitary, straight, 3.5–6 cm long, rachis internodes clavate, 3–3.5 mm long, 0.65–0.7 length of sessile spikelets, sparsely hairy, jointed at base glabrous or sparse with a ring of short cilia. *Sessile spikelets*; lower glume oblong, 4–4.5 by *ca.* 1.5 mm, distinctly 4–6-nerved, glabrous on the back, setae straight, terete, longest ones 1.5–1.6 mm long, as long as the width of the lower glume apex with a large apical wings, 0.5–0.6 length of the lower glume; upper glume oblong, 4–4.2 by *ca.* 1 mm, 3-nerved, keeled in the middle in the lower half and along the margins, distally with transverse veinlets, glabrous on the lower part of the back, margins folded. *Lower floret*; lemma oblong, *ca.* 3.8 by 0.8 mm, hyaline, margins folded; palea oblong, *ca.* 3 by 0.5 mm, hyaline. *Upper floret*; lemma oblong, *ca.* 3 by 0.8 mm, hyaline; palea oblong, *ca.* 3.2 by 0.6 mm, hyaline, margins folded. *Lodicules* cuneate, *ca.* 0.5 mm long. *Anthers* brown, *ca.* 1 mm long. *Ovary* ovoid, *ca.* 1 mm long. *Stigmas* purplish. *Pedicelled spikelet* absent. *Pedicels* subulate, slightly expanded and foliose on the lower part, 7–7.5 mm long, 1.7–1.8 times as long as the sessile spikelet (Figs. 5.12A-C & 5.38D-F).

Thailand.— NORTH-EASTERN: Loei [Phu Kradueng: near Wang Kwang waterfalls, 29 Oct. 2005, *P. Traiperm* 260 (BCU, BKF, KKU)]

Distribution.— Endemic to Thailand.

Ecology.— Growing on the rock near stream, at *ca.* 1,300 m altitude. Flowering in October.

Notes.— *Eremochloa* sp.2 resembles *E. muricata*, but can be distinguished from the latter in having a subulate pedicel, while an obliquely obovoid pedicel in *E. muricata*.

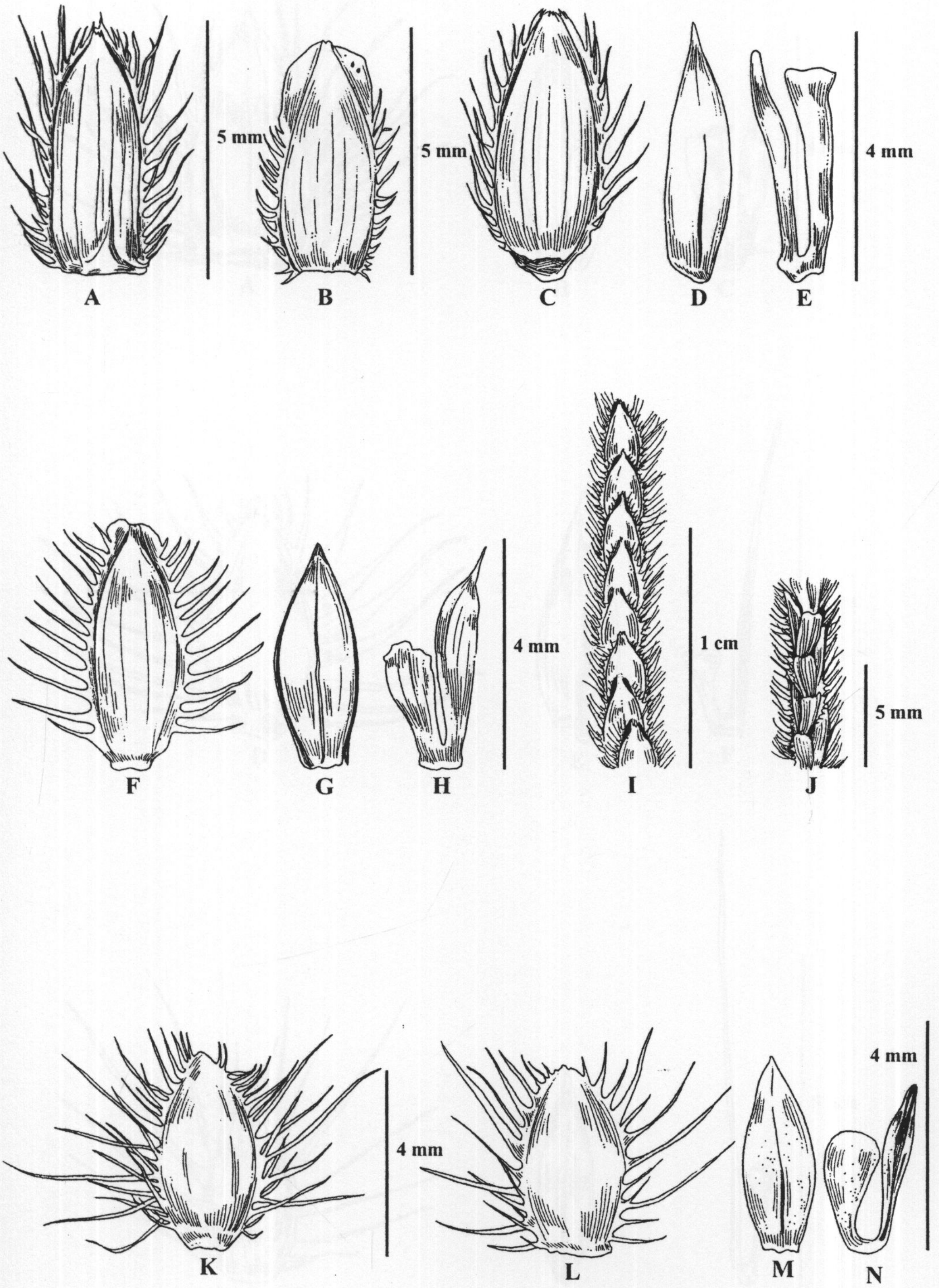

Figure 5.8 A-E. *Eremochloa attenuata*: A-C. lower glume of the sessile spikelet; D. upper glume of the sessile spikelet; E. pedicelled spikelet with rachis joint. F-J. *E. bimaculata*: F. lower glume of the sessile spikelet; G. upper glume of the sessile spikelet; H. pedicelled spikelet with rachis joint; I. & J. two views of partial raceme. K-N. *E. ciliaris*: K. & L. lower glume of the sessile spikelet; M. upper glume of the sessile spikelet; N. pedicelled spikelet with rachis joint.

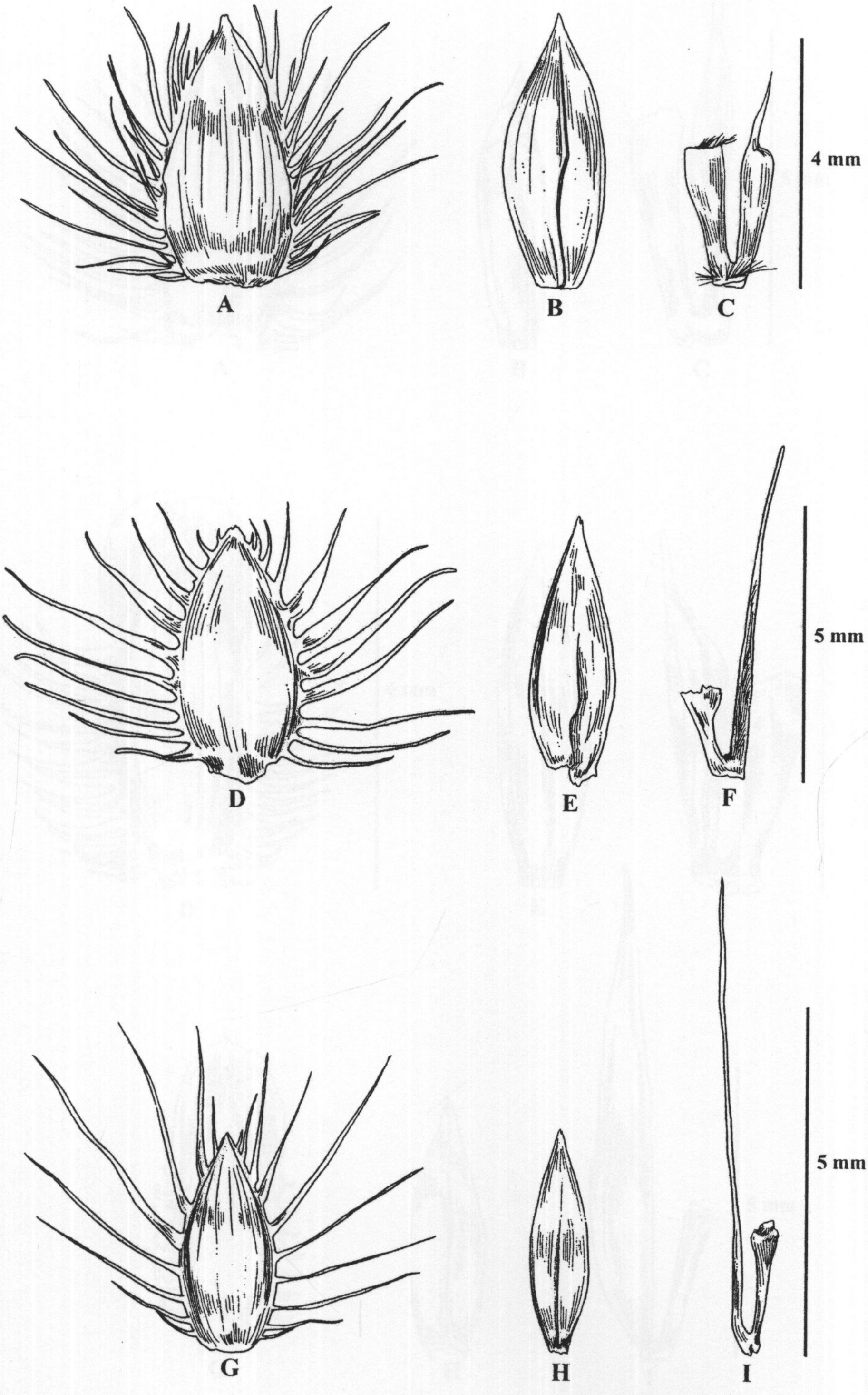

Figure 5.9 A-C. *Eremochloa ciliatifolia*: A. lower glume of the sessile spikelet; B. upper glume of the sessile spikelet; C. pedicelled spikelet with rachis joint. D-G. *E. eriopoda*: D. lower glume of the sessile spikelet; E. upper glume of the sessile spikelet; F. pedicelled spikelet with rachis joint; G. spikelet pair. H-J. *E. lanceolata*: H. lower glume of the sessile spikelet; I. upper glume of the sessile spikelet; J. pedicelled spikelet with rachis joint.

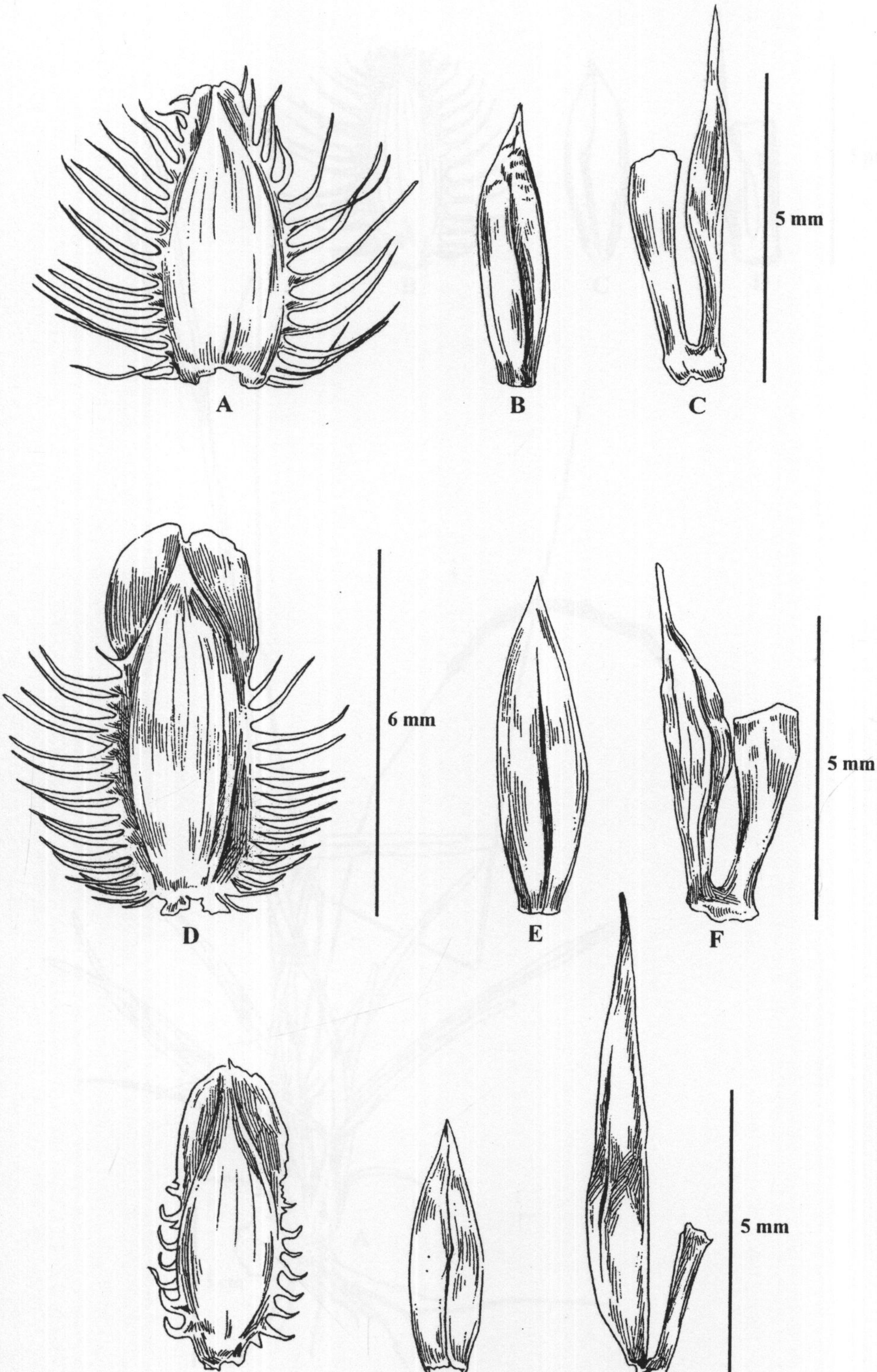

Figure 5.10 A-C. *Eremochloa maxwellii*: A. lower glume of the sessile spikelet; B. upper glume of the sessile spikelet; C. pedicelled spikelet with rachis joint. D-F. *E. muricata*: D. lower glume of the sessile spikelet; E. upper glume of the sessile spikelet; F. pedicelled spikelet with rachis joint. G-I. *E. petelotii*: G. lower glume of the sessile spikelet; H. upper glume of the sessile spikelet; I. pedicelled spikelet with rachis joint.

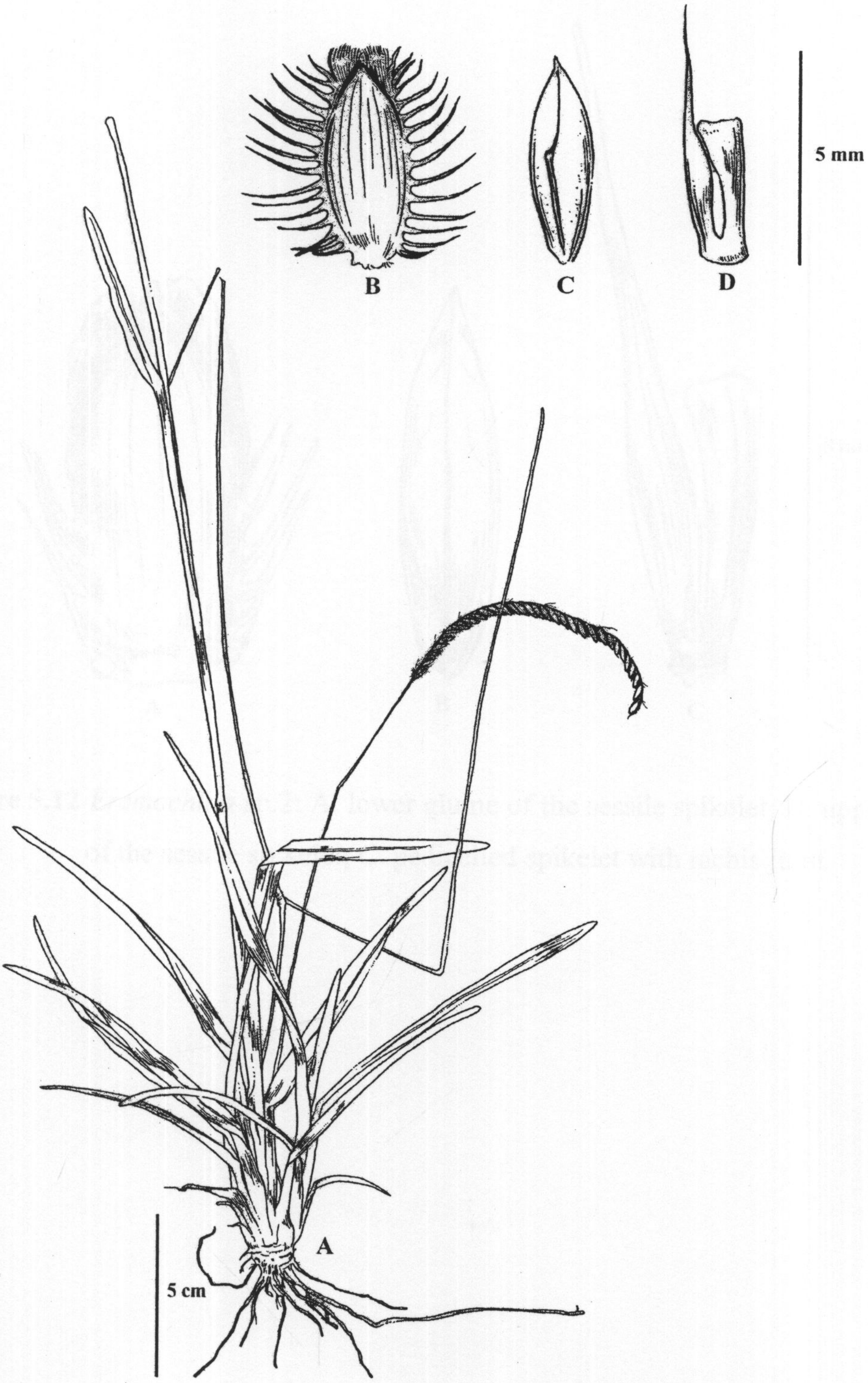

Figure 5.11 *Eremochloa* sp.1: A. plant; B. lower glume of the sessile spikelet; C. upper glume of the sessile spikelet; D. pedicelled spikelet with rachis joint. All line drawings were drawn by P. Traiperm from *P. Traiperm* 125.

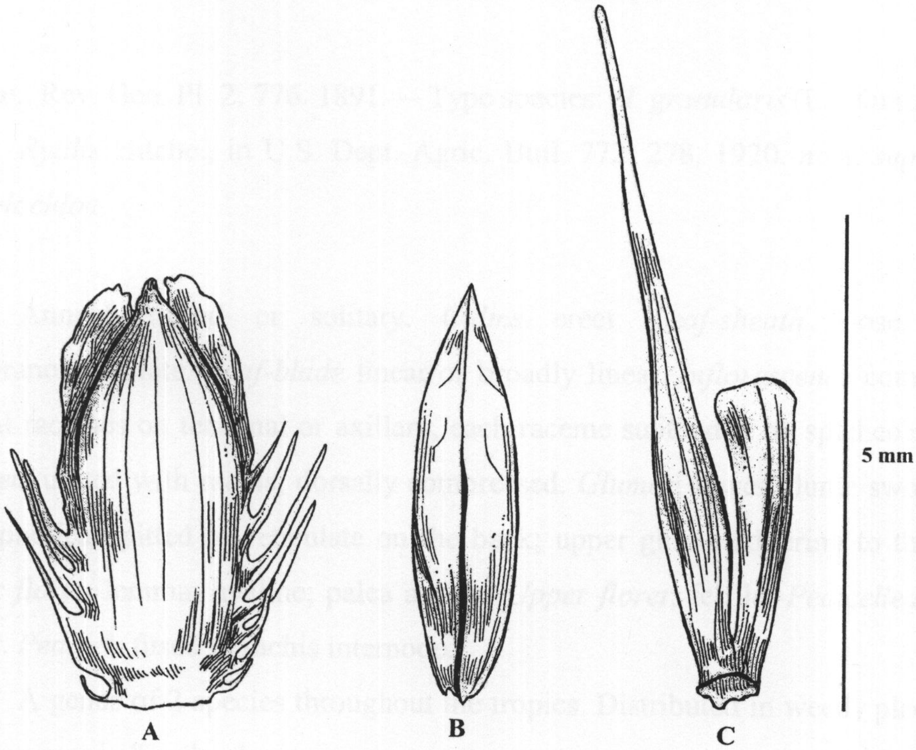

Figure 5.12 *Eremochloa* sp.2: A. lower glume of the sessile spikelet; B. upper glume of the sessile spikelet; C. pedicelled spikelet with rachis joint.

2. HACKELOCHLOA

Kuntze., Rev. Gen. Pl. 2: 776. 1891.— Type species: *H. granularis* (L.) Kuntze.

Rytilix Hitchc., in U.S. Dept. Agric. Bull. 772: 278. 1920. *nom. superfl. pro. Hackelochloa*.

Annual, tufted or solitary. *Culms* erect. *Leaf-sheath* loose. *Ligules* membranous, ciliate. *Leaf-blade* linear or broadly linear. *Inflorescence* composed of several racemes on terminal or axillary, each raceme subtended by spatheole. *Sessile spikelets* united with rachis; dorsally compressed. *Glumes*; lower glume swoolen and hemispherical, pitted or reticulate on the back; upper glume adhering to the cavity. *Lower floret*; lemma, hyaline; palea absent. *Upper floret*; fertile. *Pedicelled spikelet* neuter. *Pedicels* fused to rachis internode.

A genus of 2 species throughout the tropics. Distributed in weedy places; both species occur in Thailand.

KEY TO THE SPECIES

1. Sessile spikelets subglobose, *ca.* 1.5 mm long. Lower glume of the sessile spikelets pitted and tubercle on the back1. **H. granularis**
1. Sessile spikelets broadly oblong, *ca.* 2.5 mm long. Lower glume of the sessile spikelets ridged and reticulate on the back **2. H. porifera**

1. Hackelochloa granularis (L.) O. Kuntze., Rev. Gen. Pl. 2: 776. 1891.

Cenchrus granularis L., Mant. 2, App. 575. 1771.— Type: India orientalis, *Herb. Linn.* 1217-12 (LINN!).

Annuals grass, tufted or solitary. *Culms* erect, 15–80 cm tall, subterete on the lower part, grooved on the upper part, glabrous. *Leaf-sheath* loose, flat, pilose with tubercle-based hairs, 1–4 cm long. *Ligules ca.* 1 mm long, membranous with cilia. *Leaf-blade* linear, 2–13 by 1–1.5 cm, pilose with tubercle-based hairs on both surfaces especially on the margins, base round or subcordate, apex acute. *Inflorescence* composed of several racemes on terminal and axillary, with 1–5 racemes, each raceme subtended by spatheole, raceme 5–15 mm long; peduncle 10–30 mm long; rachis oblong, flattened, 12–15 mm long, fragile at the nodes; adherent to upper glume of sessile spikelets, rachis internode tip transverse, cup-shaped; spikelets dorsally compressed, in pairs, sessile and the other one pedicelled. *Sessile spikelets* subglobose, united with rachis. *Glumes*; lower glume turgidly swollen and hemispherical, coriaceous, *ca.* 1.5 mm diam., pitted and tubercled on the back; upper glume broadly ovate-obtuse, *ca.* 1 mm long, hyaline, enfolded, adhering to the cavity. *Lower floret*; lemma ovate, *ca.* 0.8 mm long, hyaline; palea absent. *Upper floret*; lemma ovate-obtuse, *ca.* 0.8 mm long, hyaline; palea ovate, *ca.* 0.6 mm long, hyaline. *Anthers* 3, *ca.* 0.2 mm. *Pedicelled spikelet* neuter. *Pedicels* completely fused with rachis; united whoolly; oblong. *Glumes*; lower glume elliptic, *ca.* 10 mm long, 4–5-nerved, keeled, scabrous on keel; upper glume elliptic, 6–8 mm long, 5–6-nerved, enfolded, keeled and scabrous on back. *Caryopsis* orbicular, dorsally compressed (Figs. 5.13 & 5.39A. & B).

Thailand.— NORTHERN: Mae Hong Son [Doi Pui, 23 Sept. 1995, *K. Larsen et al.* 46828 (AAU, L)], Chiang Mai [Doi Suthep, 4 Dec. 1911, *A.F.G. Kerr* 2213 (E, K); 23 Jul. 1958, *Th. Sørensen et al.* 4378 (BKF, C, K); 14 Sept. 1958, 4988 (C); 17 Sept. 1958, 5038 (C, E, K); 8 Sept. 1967, *K. Iwatsuki et al.* T-9458 (AAU, BKF, C, E, K, L); 18 Sept. 1967, *T. Shimizu et al.* T-10464 (BKF); en route from Sop Aep to Pha Mawn (Ban Yang), 1 Oct. 1971, *G. Murata et al.* T-15609 (AAU, BKF, C, K, L, P); Mueang, near the summit of Doi Come at Doi Come Temple, S tip of Doi Suthep, Mae Heeyah, 10 Sept. 1988, *J.F. Maxwell* 88-1066 (AAU, BKF, CMU, L); Ang Kang, 9 Jan. 1974, *Umpai* 517 (BKF); Doi Inthanon, Siriphum water falls, 23 Jul. 1988, *H. Koyama* T-61037 (BKF, L); 23 Jul. 1988, *M.N. Tamura* T-60223 (BKF); 23 Jul. 1988, *S. Tsugaru* T-61739 (BKF, L): S side of Mae Klang river, 8 Jan. 1988, T-61246 (BKF); 15 Sept. 1995, *BGO. Staff* 4306 (QBG); Wang Kwai waterfalls, 13 Aug. 1996, *BGO. Staff* 7113 (QBG); Hot, Op Luang National Park, Doi Op Luang, Mae Jam river, 15 km W of Hot, 23 Oct. 1987, *J.F. Maxwell* 87-1277 (BKF, CMU, L); 23 Nov. 2005, *P. Traiperm* 299 (BCU, BKF, KKU), 303 (BCU, BKF, KKU); Chiang Dao District, 2 Nov. 1999, *M. Norsangsri* 894 (QBG); Doi Chiang Dao Wildlife Sanctuary, SE side, along the road to Ban Yang Toong Bong Forest Station, 22 Sept. 1990, *J.F. Maxwell* 90-1032 (AAU, CMU, L); 24 Nov. 1989, *Y. Paisooksantivathana* y 2569-89 (BK); Doi Dao (Tau) Ban San Ba Dam, 16 Aug. 1992, *J.F. Maxwell* 92-432 (L); Sangamphaeng, Doi Mueang Awn, W side area, Sahagawn, Mae Awn Branch, 15 Sept. 1998, *P. Palee* 400 (L); NW of Mae Taeng, 9 Mar. 1958, *Th. Sørensen et al.* 4711 (C); Mae Taeng, Pah Dang (Red Lahu) Village, Geut Chang, 22 Jul. 2000, *J.F. Maxwell* 00-316 (L); 9 Aug. 1996, 96-1056 (BKF, L); 28 Aug. 1997, 97-904 (BKF, L); Mae Rim, 11 Aug. 1994, *M. Norsaengsri* s.n. (QBG); 16 Sept. 1995, *W. Nanakorn et al.* 4451 (QBG); 25 Sept. 1995, *M. Norsaengsri* s.n. (QBG); 24 Jul. 1996, *BGO. Staff* 6935 (QBG); 3 Sept. 1996, *BGO. Staff* 7379 (QBG), s.n. (QBG); Mae Rim, Mae Sa Mai (Hmong) Village, Mae Ram subdistrict, 20 Nov. 1998, *R. Wehner* 41 (L); E of nursery, Queen Sirikit Botanical Garden, 7 Oct. 2001, *S. Laegaard* 21684 (AAU, L); 11 Oct. 2001, 21690 (AAU); 26 Nov. 2005, *P. Traiperm* 310 (BCU, BKF, KKU); Proaw, Paa Mae Bon, 12 Jul. 1996, *BGO. Staff* 7 (QBG)], Chiang Rai [Mueang Payao, 13 Jul. 1931, *Put* 3989 (BK, BM, K); Doi Tung, 25 Sept. 1967, *K. Iwatsuki et al.* T-11135 (AAU, BKF, C, E, L)], Lamphun [Mae Tah, Doi Khun Tan National Park, base of the W side, at Ba Teung Station, 28 Jul. 1994, *P. Palee* 237 (BKF, L)], Lampang [Chae Son National Park, 3 Nov. 1966, *J.F. Maxwell* 96-1478 (L); Campus of Huai Tak Forest Station, 22 Sept. 1967, *T. Shimizu* T-10596 (BKF, L); Wahng Nua, Doi Luang National Park, Wahng Gayo Falls area, 6 Sept. 1997, *J.F. Maxwell* 97-952 (BKF, L)]; NORTH-EASTERN: Loei [Phu Kradueng, Samhaek, 1 Oct. 1954, *T. Smitinand* 1989 (BKF, K); 28 Aug. 1988, *H. Koyama* T-61379 (AAU, BKF, L); Wang Saphung, Sithan, 17 Oct. 1955, *T. Smitinand* 3056 (BKF); Phu Luang, 31 Aug. 1996, *S. Phusomsaeng & K. Bunchai* 23 (BKF, K, L); 14 Oct. 2000, *M. Norsangsri* 1083 (QBG); Na Haeo, 5 Nov. 1995, *NH* 5-46 (QBG)], Nong Khai [Si Chiang Mai, 18 Aug. 1972, *T. Smitinand* 11645 (BKF, L)], Sakon Nakhon [Nam Phung Dam, 17 Oct. 1990, *P. Chantaranothai & J. Parnall* 90/779 (AAU, K)]; SOUTH-EASTERN: Chon Buri [Khao Khiao, Si Racha, 4 Sept. 1975, *J.F. Maxwell* 75-983 (AAU, BK, L)].

Distribution.— Worldwide.

Ecology.— In dry dipterocarp forests, scattered on grassy slope in forest, up to 1,450 m altitude. Flowering in July to March.

Vernacular.— Ya kha naeng (หญ้าแขนง) (Chiang Rai).

Notes.— This species resembles *Hackelochloa porifera* in having lower glume turgidly swollen and hemispherical. It differs from the latter in having a small lower glume, 1.5 mm diam., pitted and tubercled on the back, raceme 5–15 mm long while lower glume *ca.* 2.5 mm long, ridged and reticulate on the back and raceme 2.5–4.5 cm long in *H. porifera*.

Used.— *H. granularis* is prescribed internally with a little sweet oil, in cases of enlarged spleen and liver (Bor, 1960).

2. Hackelochloa porifera (Hack.) D. Rhind, Grasses of Burma: 77. 1945.

Manisuris porifera Hack., Oest. Bot. Zeit. 41: 48. 1891.— Type: Sikkim, Darjeeling, *C.B. Clarke* 9752 A (holotype W, isotype K!).

Annuals grass, tufted or solitary. *Culms* erect, 50–200 cm tall, subterete, glabrous. *Leaf-sheath* loose, flat, hirsute with tubercle-based hairs, 2–6 cm long. *Ligules* membranous, 2.5–3.5 mm long, ciliate. *Leaf-blade* broadly linear, 5–30 by 1–2.5 cm, hirsute with tubercle- based hairs on both surfaces, margins scabrous, base round, apex acute. *Inflorescence* composed of several raceme on terminal and axillary, with 2–4 racemes, each raceme subtended by spatheole, raceme 2.5–4.5 cm long; peduncle 3–8 cm long; rachis oblong, flattened, 20–22 mm long, fragile at the nodes; adherent to upper glume of sessile spikelets, rachis internode tip transverse, cup-shaped; spikelets dorsally compressed, in pairs, sessile and the other one pedicelled. *Sessile spikelets* broadly oblong, united with rachis. *Glumes*; lower glume turgidly swollen, hemispherical, *ca.* 2.5 mm long, coriaceous and robust, ridged and reticulate on the back; upper glume broadly ovate, boat-shaped, 1.5–1.8 mm long, membranous, adhering to the cavity. *Lower floret* barren; lemma broadly ovate-obtuse, *ca.* 1 mm long, hyaline; palea absent. *Upper florets* fertile; lemma broadly ovate-obtuse, *ca.* 1 mm long, hyaline; palea ovate, *ca.* 0.8 mm long, hyaline. *Pedicelled spikelet* neuter. *Pedicels* completely fused with rachis; united whoolly; oblong, 18–20 mm long. *Glumes*; lower glume narrowly ovate, 3–3.5 mm long, 5–6-nerved, enfolded, scabrous on the margins; upper glume elliptic, 2.8–3 mm long, 5-nerved enfolded, keeled and scabrous on back. *Caryopsis* orbicular, dorsally compressed, 1–1.2 mm in diam. (Figs. 5.14 & 5.39C-E).

Thailand.— NORTHERN: Chiang Mai [E of nursery of Queen Sirikit Botanical Garden, 16 Sept. 1995, *M. Norsaengsri* 742 (QBG); 17 Sept. 1995, *W. Nanakorn et al.* 4453 (QBG); 25 Sept. 1995, *M. Norsaengsri* 737 (QBG); 7 Oct.

2001, *S. Laegaard* 21684 (AAU); 11 Oct. 2001, *S. Laegaard* 21689 (AAU); 26 Nov. 2005, *P. Traiperm* 311 (BCU, BKF, KKU)].

Distribution.—India, Indo-China.

Ecology.— In bamboo forest or weedy in open ground, at sea level to 1,500 m altitude. Flowering in September to November.

Notes.—*Hackelochloa porifera* has been treated as a synonym of *H. granularis* by Veldkamp *et al.* in 1986, but I still to retain *H. porifera* as a species because of the difference of the lower glume of the sessile spikelet of the two species.

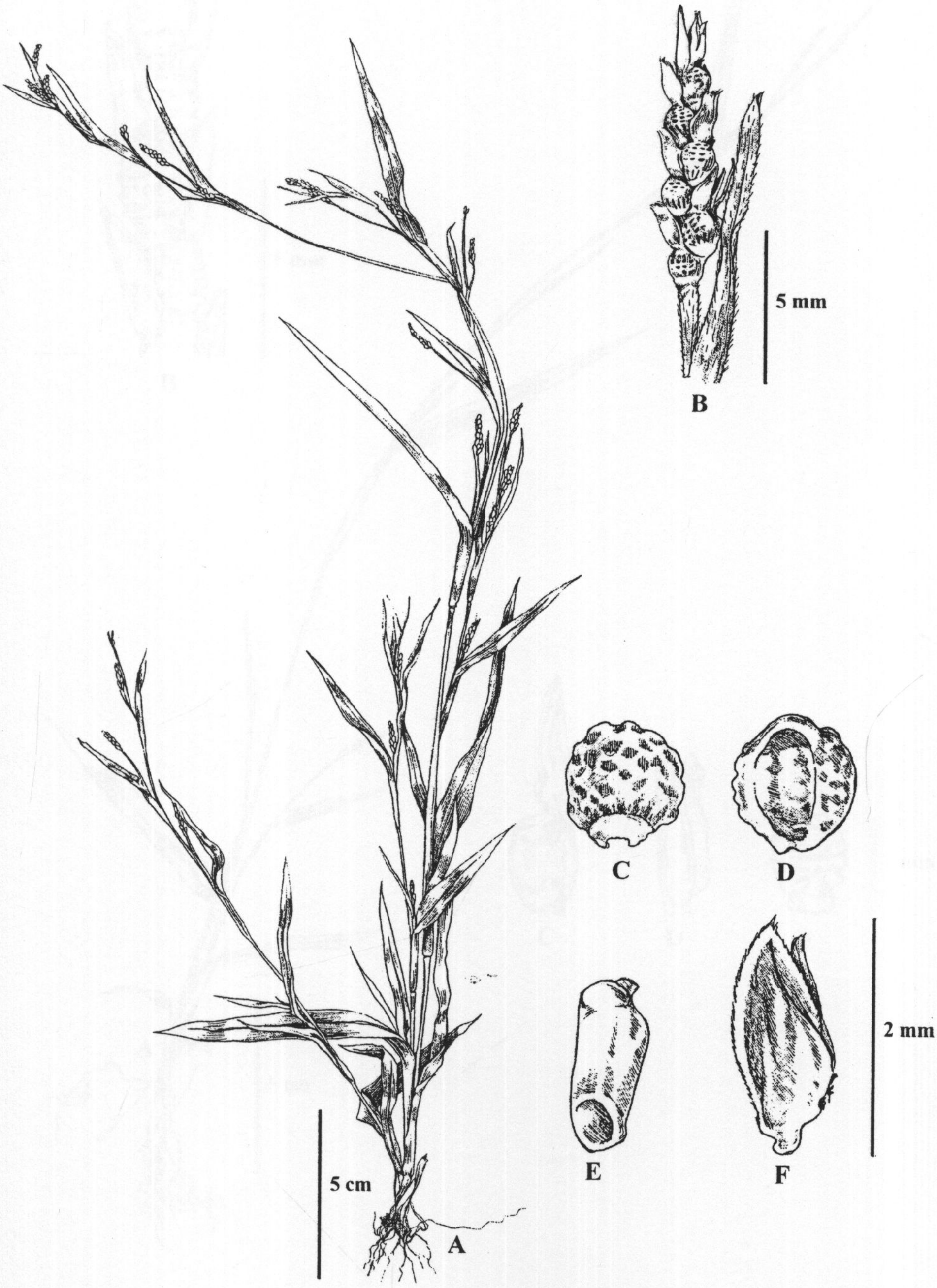

Figure 5.13 *Hackelochloa granularis*: A. plant; B. raceme; C. & D. two views of the lower glume of the sessile spikelet; E. rachis joint; F. pedicelled spikelet. All line drawings were drawn by P. Traiperm from *P. Traiperm* 299.

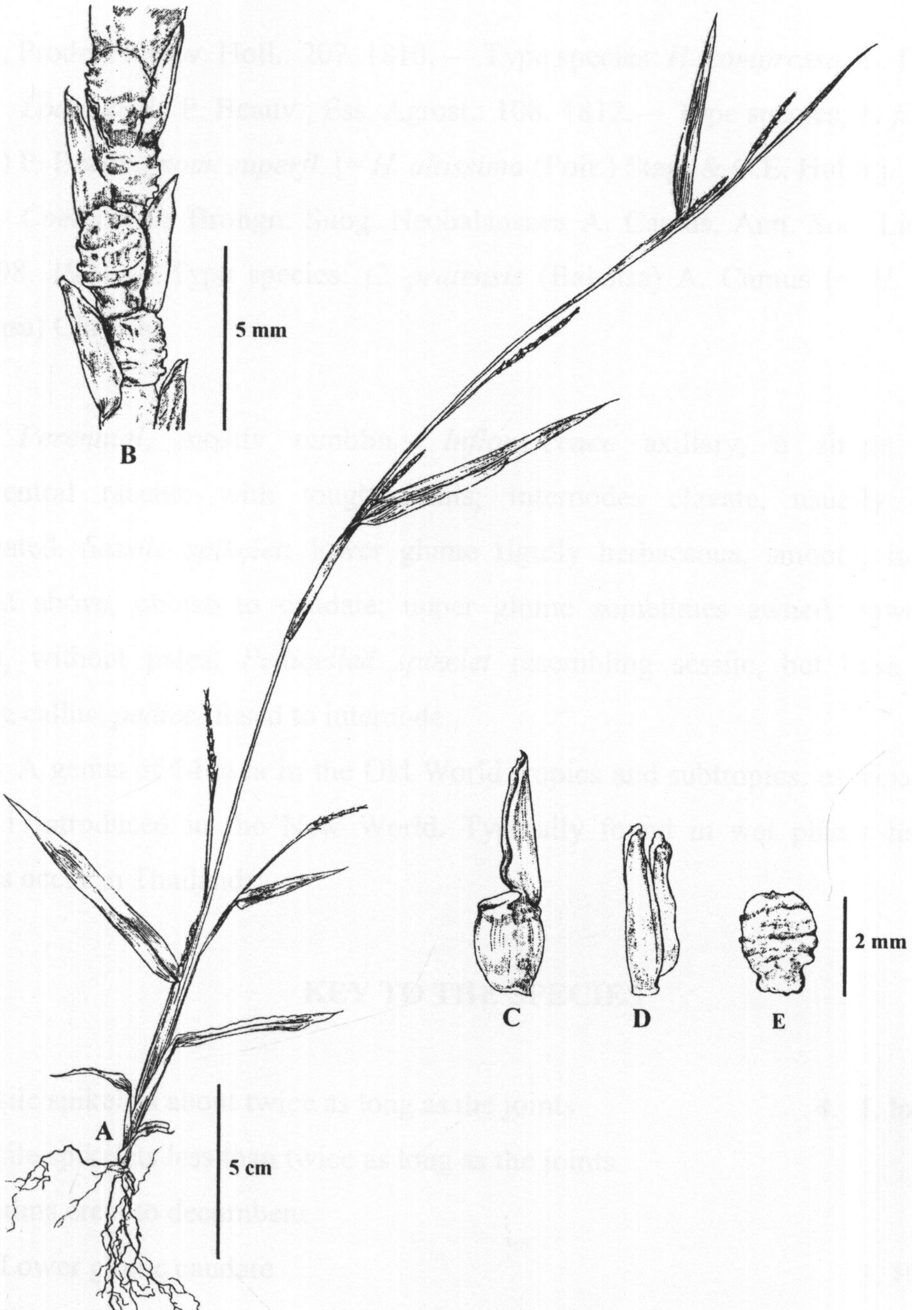

Figure 5.14 *Hackelochola porifera*: A. plant; B. partial raceme; C. rachis joint with sessile and pedicelled spikelet; D. pedicelled spikelet; E. lower glume of the sessile spikelet. All line drawings were drawn by P. Traiperm from *P. Traiperm* 311.

3. HEMARTHRIA

R. Br., Prodr. Fl. Nov. Holl.: 207. 1810. — Type species: *H. compressa* (L. f.) R. Br.

Lodicularia P. Beauv., Ess. Agrost.: 108. 1812.— Type species: *L. fasciculata* (Lam.) P. Beauv., *nom. superfl.* [= *H. altissima* (Poir.) Stapf & C.E. Hubb.].

Coelorachis Brongn. Subg. Neobalansaea A. Camus, Ann. Soc. Linn., Lyon 68: 198. 1921.— Type species: *C. pratensis* (Balansa) A. Camus [= *H. pratensis* (Balansa) Clayton].

Perennial, mostly rambling. *Inflorescence* axillary, a single flattened dorsiventral raceme with tough rachis; internodes clavate, usually obliquely articulated. *Sessile spikelet*; lower glume rigidly herbaceous, smooth, indistinctly winged above, obtuse to caudate; upper glume sometimes awned; lower florets barren, without palea. *Pedicelled spikelet* resembling sessile, but base truncate, lacking callus; *pedicel* fused to internode.

A genus of 14 taxa in the Old World tropics and subtropics, especially in SE Asia, 1 introduced in the New World. Typically found in wet places habitats; 6 species occur in Thailand.

KEY TO THE SPECIES

1. Sessile spikelets about twice as long as the joints **4. H. longiflora**
1. Sessile spikelets less than twice as long as the joints
  2. Culms erect to decumbent
    3. Lower glume caudate **3. H. debilis**
    3. Lower glume obtuse to acuminate
      4. Culms rooting at the lower nodes
        5. Margins of the lower glume scabrous **1. H. altssima**
        5. Margins of the lower glume smooth **2. H. compressa**
      4. Culms tufted, not rooting at the lower nodes **5. H. pratensis**
  2. Culms creeping **6. H. stolonifera**

1. Hemarthria altissima (Poir.) Stapf & C.E. Hubbard, Bull. Misc. Inform. Kew 1934: 109. 1934.

Rottboellia altissima Poir., Voy. Barb. 2: 105. 1789.— Type: *Poiret* s.n. (holotype P!, phototype US).

H. fasciculata (Lam.) Kunth var. *gracilis* Balansa, Bull. Soc. Bot. France 21: 11. 1874.— Type: *Balansa* 1866 (holotype P!).

R. heterochroa Gand., Bull. Soc. France 66: 302. 1920.— Type: *Schlechter 6906* (holotype LY, isotype K!).

H. guyanensis Steud., Syn. Pl. Glumac. 1: 359. 1854.— Type: *Leprieur* s.n. (holotype L!, isotype P!)

Perennial grass, rhizomatous. *Culms* erect to decumbent up to 80 cm tall, rooting at lower nodes, compressed, nodes and internodes glabrous. *Leaf-sheaths* loose, glabrous except upper margins pilose. *Ligules* ciliolate, 0.5–1 mm long. *Leaf-blade* linear-acuminate, 5–20 by 0.2–0.7 mm, folded, scabrous along the margins towards the tips and mid-nerved, glabrous, base round, pilose near mouth, slightly folded. *Inflorescence* racemes, compressed, 4–10 cm long, one to several per node on terminal and axillary, rachis internodes and nodes glabrous, callus triangular, *ca.* 1 mm long, glabrous. Spikelets oblong; pedicel of the pedicelled spikelet and the internode the rachis fused and together hollowed to accommodate the sessile spikelet. *Sessile spikelet* flat. *Glumes*; lower glume oblong, 4.5–6 by *ca.* 1 mm, 4-5 scarcely nerved, coriaceous, pale green or dark purple, scabrous along margins and on the lower nerve, glabrous on the back, bifid, with 2 apical wings; upper glume boat-shaped, 4.5–5 mm long, membranous, adhering to the hollow of the rachis, acute. *Lower floret* barren; lemma oblong-obtuse *ca.* 4 mm long, hyaline, slightly folded; palea absent. *Upper floret* fertile; lemma lanceolate-acute, 3.5–4 mm long, hyaline, folded; palea oblong-obtuse, *ca.* 1.5 mm long, hyaline, slightly folded. *Anthers* 3, *ca.* 2 mm long. *Pedicelled spikelet*; pedicels oblong, compressed, 4.5–5 mm long, slender, scabrous along keeled. *Glumes*; lower glume oblong-obtuse, 5–5.5 by *ca.* 0.1 mm, coriaceous, folded, scabrous along margins, apex slightly winged; upper glume boat-shaped, acuminate, 5–5.5 by *ca.* 0.8 mm, coriaceous, keeled and scaberulous on the back. *Lower floret*; lemma oblong-muticous, *ca.* 4 mm long, hyaline, slightly folded; palea absent. *Upper floret*; lemma lanceolate-acute or boat-shaped, *ca.* 3.5 mm long, hyaline; palea oblong, *ca.* 2 mm long, hyaline (Figs. 5.15A-D & 5.40A-D).

Thailand.— NORTH-EASTERN: Loei [Phu Kradueng, near camp, 11 Mar. 1952, *T. Smitinand* 1146 (K)].

Distribution.— Worldwide.

Ecology.— Common among the other grasses in open pine forest at 1,300 m altitude. Flowering in March.

Notes.— *Hemarthria altissima* is easily confused with *H. compressa* by shape and size of the lower glume, but it differs from the latter in having margins of the lower glume scabrous while margins smooth in *H. compressa.*

2. Hemarthria compressa (L. f.) R. Br., Prodr. 207. 1810.

Rottboellia compressa L. f., Suppl.: 114. 1781. — Type: 'in Indiis' (not extant). neotype *Wallich* 8871-E (holotype L!, isotypes K!, P!,).

H. laxa Nees ex Steud., Syn. Pl. Glumac. 1: 358. 1854.— Type: *Wall. Cat. no.* 8871 (holotype P!, isotypes K!, L, NY).

Perennial grass, rhizomatous. *Culms* erect to decumbent up to 1 m tall, rooting at the lower nodes, compressed, nodes and internodes glabrous. *Leaf-sheaths* loose, 2–4.5 cm long compressed and keeled, glabrous except the upper margins pilose, 2–4.5 cm long. *Ligules* a ciliolate, 0.3–1 mm long. *Leaf-blades* linear-acuminate, up to 10 by *ca.* 0.2 cm folded, scaberulous along the margins towards the tips and midnerve, glabrous, base round, slightly enfolded. *Inflorescence* racemes, compressed, 7–12 cm long, rachis internodes and nodes glabrous, callus triangular. Spikelets oblong; pedicel of the pedicelled spikelet and the internode of the rachis fused and together hollowed to accommodate the sessile spikelet. *Sessile spikelet* flat. *Glumes*; lower glume oblong, 4.5–6 by ca 1.5 mm, 6–7 scarcely nerved, coriaceous, pale green or dark purple, margins smooth and folded, glabrous on the back, bifid, with 2 apical wings; upper glume boat-shaped, 4.5–6 mm long, membranous, adhering to the hollow of the rachis, apex acute. *Lower floret* barren; lemma enfolded, 3–4 mm long, hyaline, muticous. *Upper floret* fertile; lemma oblong, 3.5–4 by 1 mm, hyaline, slightly enfolded, acute sometime muticous; palea oblong, *ca.* 1.5 mm long, hyaline, muticous. *Anthers* 3, *ca.* 2 mm long. *Lodicules* cuneate, *ca.* 0.5 mm long.

Ovary cylindrical, *ca.* 0.8 mm long. *Pedicelled spikelet*; pedicels compressed, 4.5–7 mm long, glabrous, slender. *Glumes*; lower glume oblong, 5–6 mm long, 7–8 scarcely nerved, coriaceous, pale green or dark purple, slightly enfolded, margins scabrous, glabrous on the back, tapering to the apex; upper glume boat-shaped, acuminate, 6–7 mm long, coriaceous, keeled and scaberulous on the back. Lower floret; lemma oblong-muticous, *ca.* 3.2 mm long, hyaline, enfolded, palea absent. *Lodicules* cuneate, *ca.* 0.5 mm long. *Anthers ca.* 2 mm long. *Ovary* cylindrical, *ca.* 0.5 mm long (Figs. 5.15E-H & 5.40E-J).

Thailand.— NORTHERN: Mae Hong Son [Khun Yuam, 7 Sept. 1974, *K. Larsen & S.S. Larsen* 34242 (AAU, BKF, K, L)], Chiang Mai [Doi Suthep, 20 Jul. 1911, *A.F.G. Kerr* 1934 (BM, E, K, TCD); Fang, 24 May 1959, *Th. Sørensen et al.* 3576 (C, E, K); Mae Rim, 15 km N of Chiang Mai, 15 Jul. 1968, *K. Larsen et al.* 2480 (AAU, BKF, E); near Chiang Mai waterlogged plain along highway, 26 Sept. 2001, *S. Laegaard & M. Norsaengsri* 21619 (AAU, K)], Chiang Rai [12 km SE of Fang along the Fang-Chiang Rai trail, 26 Jul. 1968, *K. Larsen et al.* 2743 (AAU, BKF, E, K, L)], Phrae [Long, Tao Poon, Mae Ram village, 27 Nov. 1986, *Y. Paisooksantivathana* y 1935-86 (BK)], Sukhothai [Between Sukhothai and Sawankhalok, 28 Jun. 1973, *G. Murata et al.* T-17026 (BKF)]; NORTH-EASTERN: Loei [Phu Kradueng, near camp, 11 Mar. 1952, *T. Smitinand* 6381 (K)]; EASTERN: Chaiyaphum [Phu Khiao, 27 Nov. 2004, *P. Traiperm* 187 (BCU, BKF, KKU)], Nakhon Ratchasima [Phimai, 15 Oct. 2005, *P. Traiperm* 215 (BCU, BKF, KKU)]; CENTRAL: Phra Nakhon Si Ayutthaya [Ban Hin Kong near Wang Noi, about 80 km N of Krung Thep Maha Nakhon , 8 Mar. 1971, *G. Murata et al.* T-14739 (BKF)], Krung Thep Maha Nakhon [12 Sept. 1920, *A.F.G. Kerr* 4468 (BM, K); 1 Jul. 1923, *A. Marcan* 1403 (BM); 16 Nov. 1923, *A.F.G. Kerr* 7944 (BK, BM, K); 30 Aug. 1928, *A.F.G. Kerr* 19717 (BK, BM); 10 Sept. 1919, *A.F.G. Kerr* 3764 (BM, K)]; SOUTH-EASTERN: Chanthaburi [Between Chanthaburi and Pong Nam Ron, 8 May 1973, *G. Murata et al.* T-17726 (BKF)].

Distribution.— India, China, Indo-China, Malesia.

Ecology.— Growing in paddy field near swampy place, moist places along roads, water courses, at sea level to 1,300 m altitude. Flowering in March to November.

3. Hemarthria debilis Bor, Dansk Bot. Ark. 23 (2): 162. 1965.— Type: Thailand, Chanthaburi: Makham, *K. Larsen* 10117 (holotype C!, isotypes BKF!, E!, L!).

Annuals grass, caepitose, slender. *Culms* erect, 20–60 cm tall, terete, internodes glabrous, nodes pubescent. *Leaf-sheaths* loose. *Ligules* membranous with ciliate hairs, *ca.* 1 mm long. *Leaf-blades* linear, enfolded, 1–3.5 by 0.1–0.4 cm, glabrous, apex acuminate. *Inflorescence* composed of several racemes, compressed on terminal or axillary, 10–15 cm long, rachis internodes oblong, flat, 7–10 mm long, glabrous, nodes glabrous. Spikelets dorsally compressed. *Sessile spikelet* shorter than the rachis internodes, 9–10 mm long. *Glumes*; lower glume oblong to elliptic, 8.5–10 mm long, 5–7-nerved, coriaceous, flattened, caudate, bifid, scabrous along tail; upper glume lanceolate or boat-shaped, 7–8.5 mm long, 3-nerved, thinner than lower glume, glabrous on the back, apex with long caudate, scabrous along tail. *Lower floret* sterile; lemma oblong-obtuse, 3–5 by *ca.* 0.5 mm, hyaline, slightly folded; palea absent. *Upper floret* fertile; lemma oblong-obtuse, 2.5–4.5 by *ca.* 0.5 mm, hyaline; palea absent. *Lodicules* cuneate, 0.5 mm long. *Pedicelled spikelet* 8–8.5 mm long. *Pedicels* oblong, slender, 5–6 mm long, glabrous, the pedicel and the internode of the rachis fused and together hollowed to accommodate the sessile spikelet but sometimes separated from the hollow internodes. *Glumes*; lower glume oblong-elliptic, 8–8.5 mm long, 7-nerved, flattened, caudate, bifid, scabrous along tail; upper glume boat-shaped, 8-8.5 mm long, 3–5-nerved, caudate, scabrous. *Upper floret*; lemma *ca.* 2.5 by 0.4 mm, hyaline. *Lodicules* cuneate, *ca.* 0.5 mm long. *Anthers ca.* 1 mm long. *Ovary* cylindrical. *Caryopsis* ellipsoid, *ca.* 1.5 mm long (Figs. 5.16A-E & 5.41A-E).

Thailand.— SOUTH-EASTERN: Chanthaburi [5 km N of Makham, 15 Jun. 1963, *K. Larsen* 10117 (BKF, C, E, L)].

Distribution.— Endemic to Thailand.

Ecology.— Growing in swampy area, at 50 m altitude. Flowering in July.

Notes.— Known only from the type specimen.

4. Hemarthria longiflora (Hook.f.) A. Camus in Fl. Gén. Indo-Chine 7: 380. 1922.

Rottboellia longiflora Hook.f., Fl. Brit. India. 7: 154. 1896.— Type: *Griffith KD* 1009 (holotype K!).

R. tonkinensis A. Camus in Bull. Mus. Hist. Nat. (Paris). 25: 369. 1919.— Type: Vietnam, Tonkin, *Balansa* 1783 (holotype P!, isotypes K!, L!).

H. longiflora (Hook.f.) A. Camus var. *tonkinensis* A. Camus in Fl. Gén. Indo-Chine 7: 379. 1922.

Perennial grass, tufted. *Culms* erect, 0.7–1 m tall, compressed, internodes glabrous, nodes grayish ciliate, 1–1.5 mm long. *Leaf-sheaths* loose, folded, 5–6.5 cm long, glabrous but pilose and scabrous along the margins. *Ligules* densely whitish-grey ciliate, 1–1.2 mm long. *Leaf-blades* linear, 13–20 by 5–6 mm, margins scabrous, apex acute. *Inflorescence* racemes, one to several per node, dorsally compressed on axillary or terminal. Spikelets dorsoventrally compressed. *Sessile spikelet* about twice as long as the rachis internodes. *Glumes*; lower glume lanceolate, 15–17 by 1.5–1.8 mm, 6–8-nerved, coriaceous, strigillose on the back, scabrous along the margins towards the tips, acuminate and caudate, bifid; upper glume boat-shaped, 10–12 by 1.5–1.8 mm, 1-nerved, coriaceous, thinner than the lower glume adhering to the hollow of the rachis but sometimes separated from the hollow, acuminate and caudate. *Lower floret* barren; lemma oblong-obtuse, *ca.* 5 mm long, hyaline, slightly folded; upper floret fertile; lemma oblong-ovate, 4–4.5 by *ca.* 1 mm, hyaline, enfoldeds, apex acute; palea ovate, 3.8–4 by *ca.* 1 mm, hyaline, enfolded, apex acute. *Anthers* 3, 0.5–1 mm long. *Ovary* elliptic, *ca.* 1.5 by 0.5 mm. *Pedicelled spikelet*; pedicels flattened, 5–8 mm. *Glumes*; lower glume linear to lanceolate, 11-13 by *ca.* 1 mm, 5–7-nerved, subcoriaceous, scabrous along the margins towards the tips, apex acuminate and caudate; upper glume boat-shaped, 13–18 by *ca.* 1 mm, subcoriaceous, apex acuminate and caudate, scabrous keeled on the back. *Lower florets* barren; lemma oblong-obtuse, 1–1.5 mm long. *Upper floret* fertile; lemma *ca.* 3.2 mm long, hyaline, enfolded; palea *ca.* 2.8 mm long, hyaline, enfolded (Figs. 5.16F-M & 5.41F-J).

Thailand.— NORTHERN: Chiang Mai [near Wangka, 13 May 1946, *Wichian* 491 (BKF, K, P); 6 Oct. 1960, *T. Smitinand & H.St. John* 6824 (BKF, K); near Fang, 25 May 1958, *Th. Sørensen et al.* 3594 (BKF, C); below the summit of Doi Pha Hom Pok, 13 Sept. 1967, *K. Iwatsuki et al.* T-9622 (BKF)], Chiang Rai [Mae Tun, 5 Jul. 1922, *A.F.G. Kerr* 6253 (BK, BM)]; NORTH-EASTERN: Udon Thani [Ban Paeo, 23 Apr. 2006, *P. Traiperm* 383 (BCU, BKF, KKU)], Nakhon Phanom

[Paknam Songkram, 7 May 1932, *A.F.G. Kerr* 21357 (BKF, BM, K)], Khon Kaen [Khon Kaen on the way to Chumphae, 6 Jul. 1959, *T. Smitinand* 5839 (BKF, K)]; EASTERN: Nakhon Ratchasima [N of Korat, 5 Jul. 1959, *F.Floto* 7313 (BKF, C, K); Chakkarat, *M. Norsaengsri* 2403 (KKU)]; SOUTH-WESTERN: Kanchanaburi [Si Sawat, 27 May 1962, *Kasem* 186 (BK)]; CENTRAL: Chai Nat [Chao Phya Dam, 3 Jun. 1959, *T. Smitinand* 5822 (BKF, K)], Saraburi [Pasak river, 25 May 1923, *A.F.G. Kerr* 7014 (BK, BM, K)], Krung Thep Maha Nakhon [5 Jul. 1920, *A.F.G. Kerr* 4363 (BM, TCD]; SOUTH-EASTERN: Chanthaburi [Plain of Makham, 14 Jun. 1963, *Thai-Danish* 10092 (BKF, C)].

Distribution.— China, Indo-China, Malesia.

Ecology.— Erect grass, common by path in wet place, at 5-2,350 m altitude. Flowering in April to October.

Notes.— Extremely variable in size of the lower glume of sessile spikelet. In the present species the two glumes of both spikelets are long awned, and the sessile spikelets are twice as long as the joint.

5. Hemarthria pratensis (Balansa) Clayton in Kew Bull. 24: 314. 1970.

Rottboellia pratensis Balansa, J. Bot. (Morot) 4: 110. 1890.— Type: Vietnam, Couaïnak, *Balansa* 1786 (holotype L!, isotype K!).

Coelorachis pratensis (Balansa) A. Camus, Ann. Soc. Linn., Lyon 68: 198. 1921.

H. subulata Reeder in J. Arnold. Arbor. 29: 350. 1948.— Type: New Guinea, Middle Fly River, *Brass* 7552 (holotype US, isotypes A, L!).

Perennial grass, tufted, caepitose, not rooting from the lower nodes. *Culms* erect, 50–100 cm tall, terete, nodes and internodes glabrous. *Leaf-sheaths* loose, 6–15 cm long, glabrous, pilose at the margins. *Ligules* ciliate, 5–10 mm long. *Leaf-blades* narrowly linear, enfolded, up to 50 by 2–3 mm, pilose on adaxial surface, abaxial surface glabrous, margins scabrous, apex acute, sometime muticous. *Inflorescence* racemes, compressed on terminal or axillary up to 20 cm long, rachis internodes oblong, 11–12 mm long, glabrous, nodes glabrous, callus *ca.* 3 mm long, glabrous. Spikelets oblong; the pedicel of the pedicelled spikelet and the internode of the rachis fused and together hollowed to accommodate the sessile spikelet. *Sessile spikelet* compressed. *Glumes*; lower glume linear-oblong, 7.5–8 by 1.2–1.5 mm, 6–7-nerved, coriaceous, pale green, scaberulous along the margins towards the end, apex bifid with 2-apical wings; upper glume boat-shaped, 6.5–8 mm long, membranous, adhering to the hollow of the rachis, acute to acuminate. *Lower floret* barren; lemma oblong, 5–5.5 by *ca.* 1 mm, hyaline, slightly folded, muticous. *Upper floret* fertile; lemma oblong-muticous, *ca.* 5.5 by 1 mm, hyline; palea oblong, 2–2.5 by *ca.* 0.5 mm, hyaline, muticous. *Lodicules* 2, cuneate, *ca.* 0.8 mm long. *Ovary* cylindrical, *ca.* 1 mm long. *Anthers ca.* 4.5 mm long. *Pedicelled spikelet*; pedicels terete, slender, glabrous up to 20 mm long. *Glumes*; lower glume long triangular, 9–9.5 by 1 mm, 5-nerved, coriaceous, pale green, slightly enfolded, margins scabrous, acute or muticous, tapering to the apex; upper glume boat-shaped, 9–10 mm long, coriaceous, pale green, keeled and scabrous on the back, folded, tapering to the end. *Lower floret* barren; lemma oblong, 5–5.5 by *ca.* 1 mm, hyaline, acute or muticous at the apex. *Upper floret* fertile; lemma oblong-acute, 4.5–5 by *ca.* 1 mm, hyaline, enfolded, palea linear, *ca.* 2 by 0.3 mm, hyaline, muticous. *Lodicules* 2, cuneate, *ca.* 0.8 mm long. *Anthers* 4–4.5 mm long. *Ovary* cylindrical (Figs. 5.17 & 5.42A-F).

Thailand.— NORTH-EASTERN: Loei [Phu Kradueng trail, 13 Mar. 1924, *A.F.G. Kerr* 8718 (BKF, K); Phu Kradueng, 18 Mar. 1958, *Th. Sørensen et al.* 2240 (BKF, C, E, K); 29 Nov. 1958, *Th. Sørensen et al.* 6329 (BKF, C, K); 15 Dec. 1963, *Umpai* 142 (BKF); 7 Mar. 1979, *P.J. O'Connor & C. Niyomdham* 15,669 (AAU, BKF); 12 Nov. 2004, *P. Traiperm* 158 (BCU, BKF, KKU); 29 Oct. 2005, *P. Traiperm* 265 (BCU, BKF, KKU)- 27 Mar. 2006, *P. Traiperm* 376 (BCU, BKF, KKU)].

Distribution.— Indo-China, Malesia.

Ecology.— Caespitose grass on open area in pine forest, altitude 1300 m. Flowering in October to March.

Notes.— At the base of the erect culm a tuft of leafless sheaths is found, the apices of which are sometimes blackened from burning. The species grows in savannahs, and is apparently fire-resistant, developing new shoots after the fire.

6. Hemarthria stolonifera Bor, Dansk Bot. Ark. 23: 163. 1965.— Type: Thailand: Chanthaburi, *K. Larsen* 10033 (holotype C!, isotype BKF!).

Perennial grass, stoloniferous. *Culms* creeping, slender 25–30 cm tall, prostrate, terete, internodes glabrous, nodes glabrous. *Leaf-sheaths* loose, pubescent, margins ciliate. *Ligules* membranous with ciliate hairs, *ca.* 0.8 mm long. *Leaf-blades* linear, 3–20 cm by 1.5–3 mm, glabrous on both surface sometimes with bulbous-based britles near mouth, margins scabrous, apex retuse. *Inflorescence* racemes, solitary, straight, terminal, 10–13 cm long, rachis internodes columnar, flattened, *ca.* 3 mm long, adherent to upper glume of sessile spikelet, glabrous, nodes glabrous. *Spikelets* oblong; the pedicel of the pedicelled spikelet and the internode of the rachis fused and together hollowed to accommodate the sessile spikelet. *Sessile spikelet* dorsally compressed. *Glumes*; lower glume elliptic-oblong, 5.5–6 mm long, 11-nerved, flattened, glabrous, apex obtuse; upper glume boat-shaped, *ca.* 6 mm long, 3-nerved, glabrous, apex acute. *Lower floret* barren; lemma oblong, *ca.* 4.5 mm long. Upper floret; lemma oblong *ca.* 3.9 mm long, hyaline. *Anthers* 2.5–3.5 mm long. *Pedicelled spikelet ca.* 7 mm long, callus glabrous. *Pedicels* flattened, slender, glabrous up to 20 mm long. *Glumes*; lower glume linear to lanceolate-acuminate, 6.5–7 mm long, 11–13-nerved, flattened, glabrous; upper glume boat-shaped, 7–7.5 mm long, 9-nerved, keeled scabrous, apex acuminate. *Lower floret*; lemma oblong, *ca.* 4.5 mm long. *Upper floret*; lemma *ca.* 4 mm long. *Anthers ca.* 3 mm long (Figs. 5.18 & 5.42G-I).

Thailand.— SOUTH-EASTERN: Chanthaburi [Plain of Makham, 13 Jun. 1963, *K. Larsen* 10033 (BKF, C)].

Distribution.— Endemic to Thailand.

Ecology.— Creeping on wet place, at sea level. Flowering in June.

Notes.— Known only from the type specimens and also reported that this species seems unique for its stoloniferous habit .

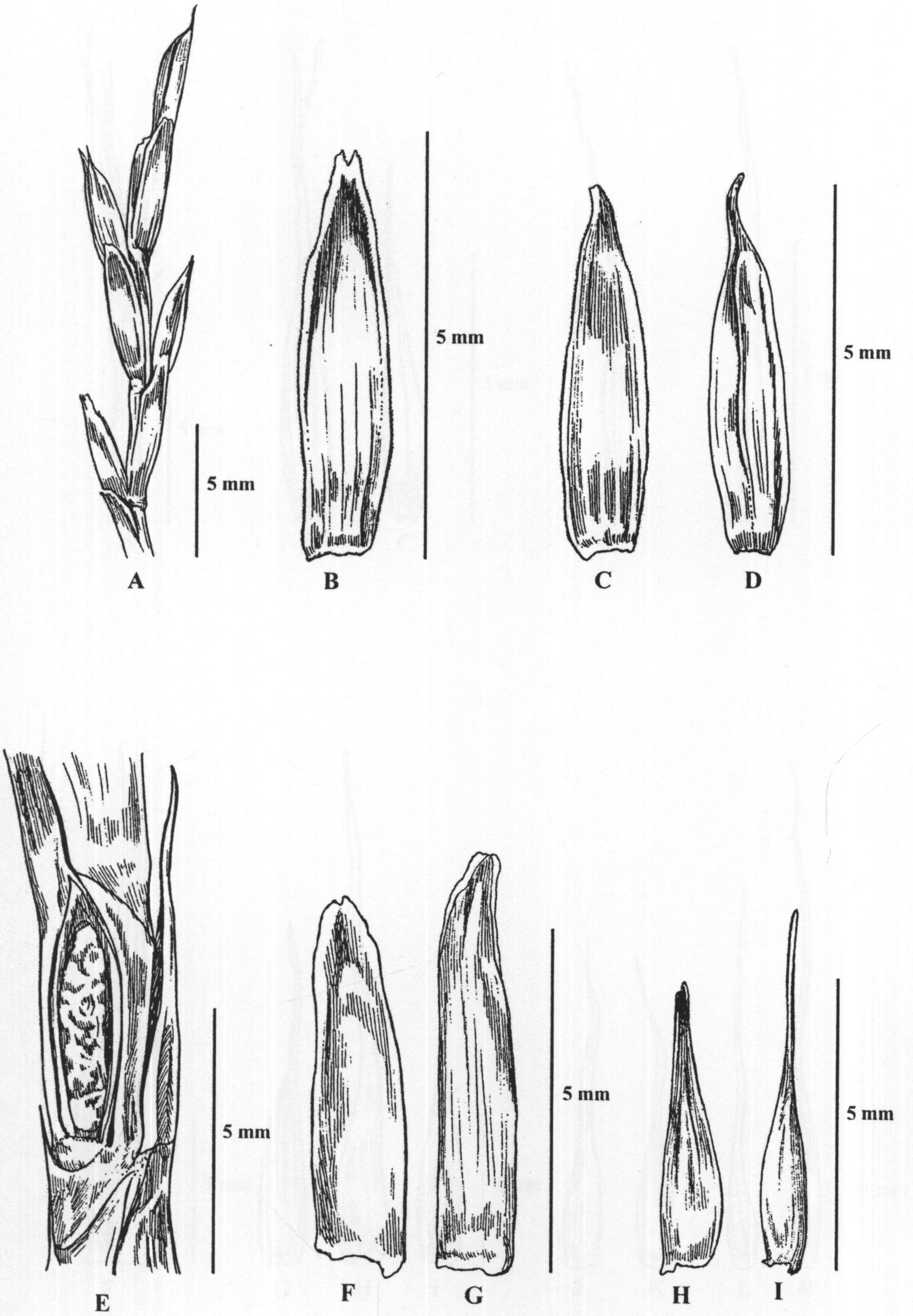

Figure 5.15 A-D. *Hemarthria altissima*: A. partial raceme; B. lower glume of the sessile spikelet; C. lower glume of the pedicelled spikelet; D. upper glume of the pedicelled spikelet. E-H. *H. compressa*: E. partial raceme; F. & G. lower glume of the sessile spikelet (two views); H. lower glume of the pedicelled spikelet; I. upper glume of the pedicelled spikelet.

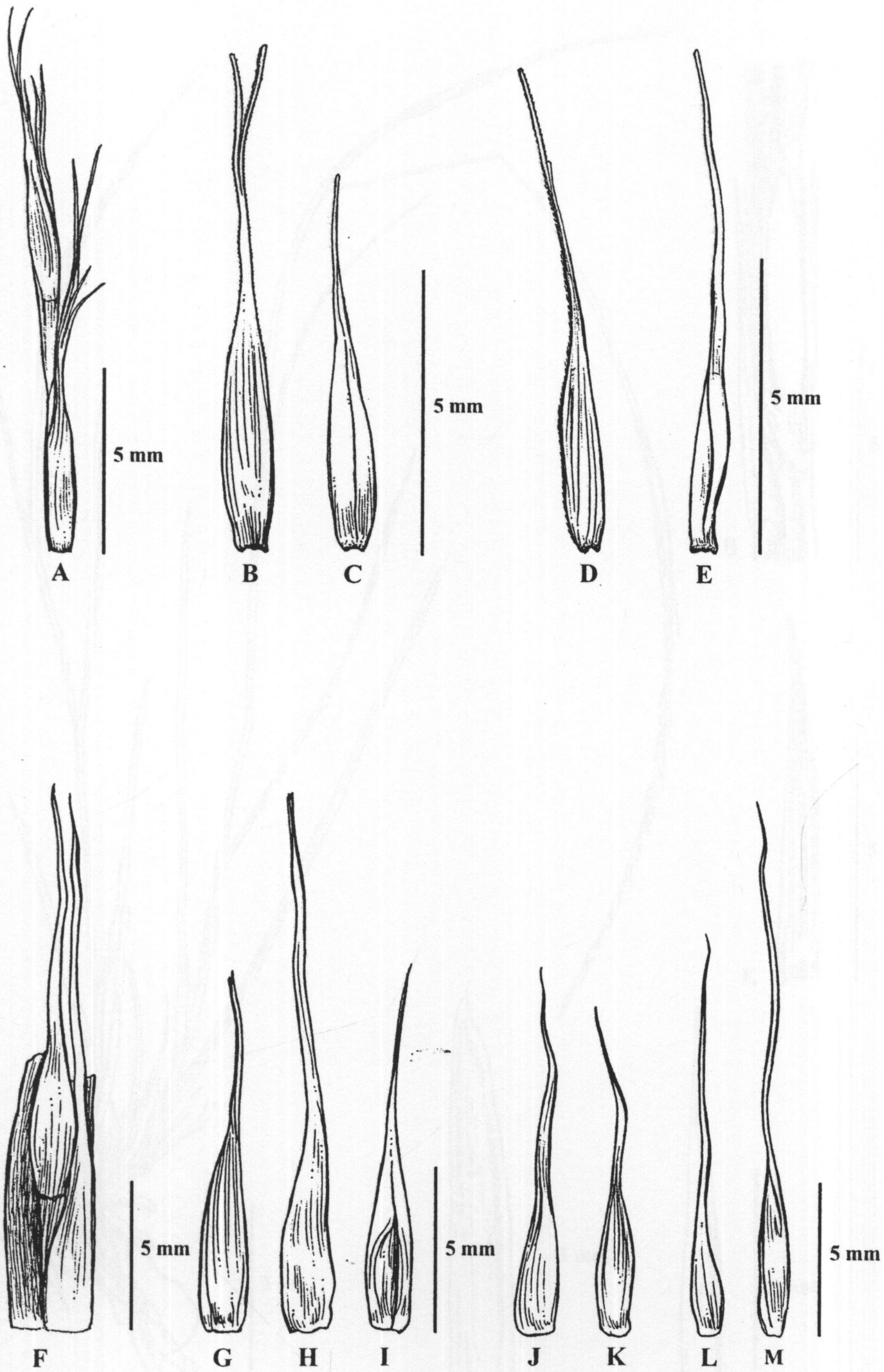

Figure 5.16 A-E. *Hemarthria debilis*: A. partial raceme; B. lower glume of the sessile spikelet; C. upper glume of the sessile spikelet; D. lower glume of the pedicelled spikelet; E. upper glume of the pedicelled spikelet. F-M. *H. longiflora*: F. partial raceme; G. & H. lower glume of the sessile spikelet (two views); I. upper glume of the sessile spikelet; J. & K. lower glume of the pedicelled spikelet; L. & M. upper glume of the pedicelled spikelet.

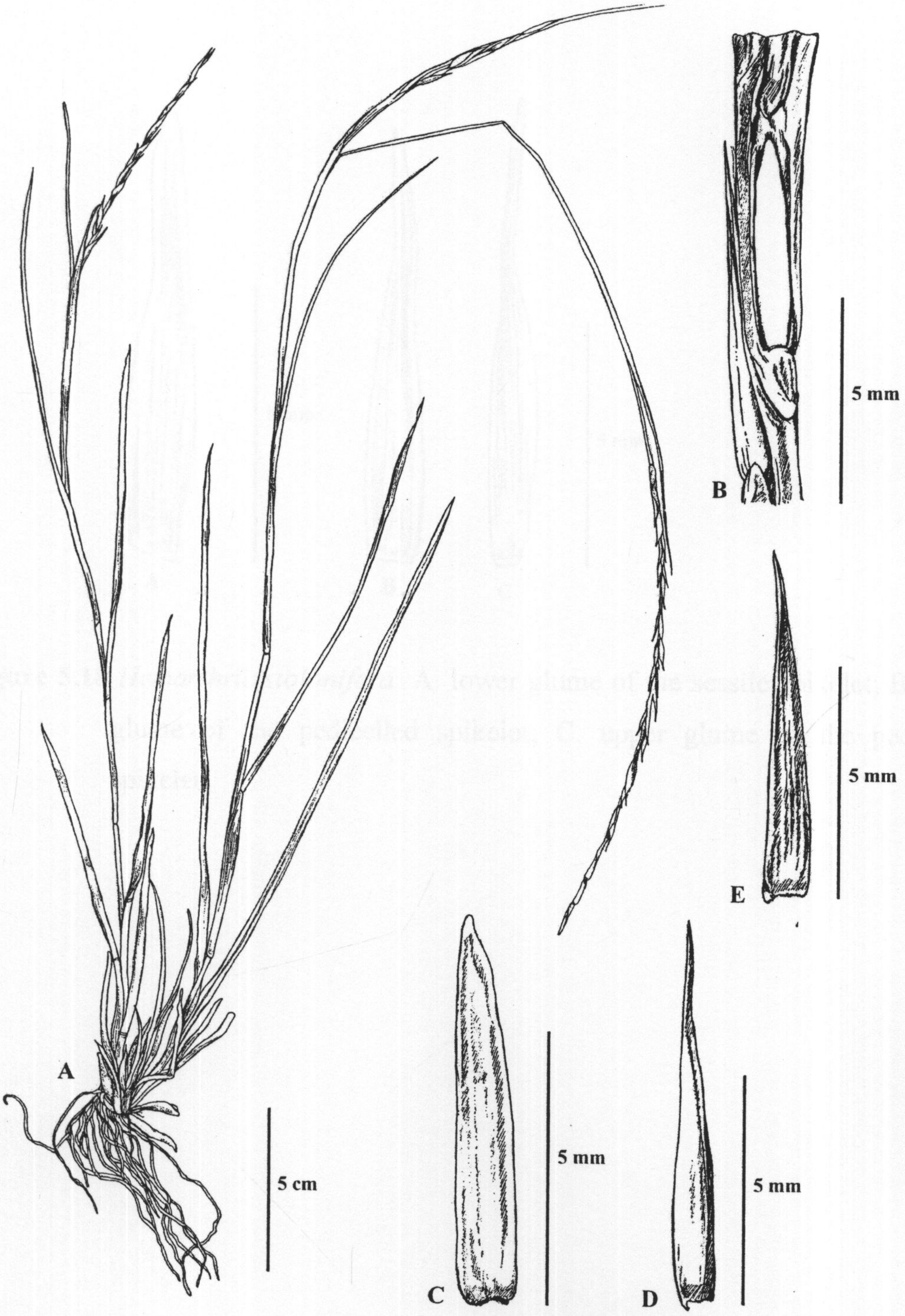

Figure 5.17 *Hemarthria pratensis*: A. plant; B. partial raceme; C. & D. sessile spikelet: C. lower glume, D. upper glume; E. lower glume of the pedicelled spikelet. All line drawings were drawn by P. Traiperm from *P. Traiperm* 158.

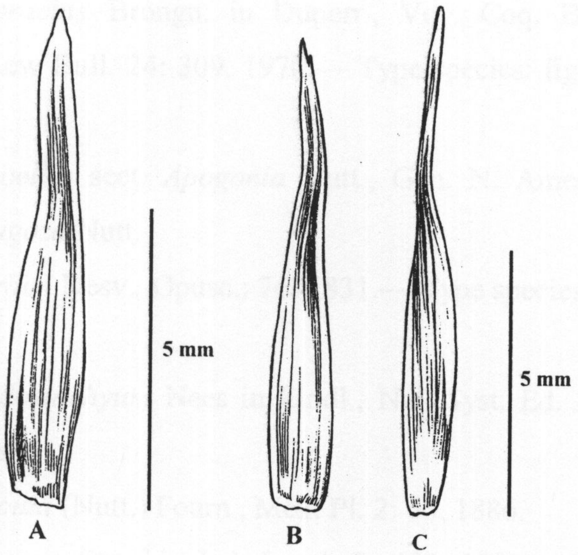

Figure 5.18 *Hemarthria stolonifera*: A. lower glume of the sessile spikelet; B. lower glume of the pedicelled spikelet; C. upper glume of the pedicelled spikelet.

4. MNESITHEA

Kunth, Rév. Gram. 1: 153. 1829.— Type species: *M. laevis* (Retz.) Kunth.

Coelorachis Brongn. in Duperr., Voy. Coq. Bot. Phan.: 64, f 14. 1831; Clayton in Kew Bull. 24: 309. 1970.— Type species: figure of *C. glandulosa* (Trin.) Ridl.

Rottboellia sect. *Apogonia* Nutt., Gen. N. Amer. Pl. 1: 83. 1818.— Type species: *R. rugosa* Nutt.

Diperium Desv., Opusc.: 76. 1831.— Type species: *D. cylindrical* Desv. (= *M. laevis*).

Thyridostachyum Nees in Lindl., Nat. Syst. Ed. 2: 379. 1836. *nom. superfl. pro. Mnesithea.*

Apogonia (Nutt.) Fourn., Mex. Pl. 2: 63. 1886.

Cycloteria Stapf in Ind. Lond. 5: 459. 1931. *nom nud.*— Type species: *C. selloana.*

Perennial, often robust with broad leaf-blades. *Leaf-sheath* tight. *Inflorescence* racemes, terminal or axillary and often spathate, a single cylindrical or flattened dorsiventral raceme, spikelets paired or occasionally in triplets of 2 sessile and 1 pedicelled, usually in three on below. *Sessile spikelet* paired or solitary, callus truncate with central peg. *Glumes*; lower glume oblong, coriaceous, winged or wingless, chartaceous to crustaceous, smooth, areolate or cancellate, 2-keeled, keels winged towards tip; upper glume awnless. *Lower floret* barren, with or without a small palea or absent. *Pedicelled spikelet* well developed or vestigial; pedicel free, clavate or foliaceous, sometimes auriculate at tip or rarely absent. *Pedicels* free from the internode, rarely fused to internode.

A genus of 8 species occurs in Thailand.

KEY TO THE SPECIES

1. Pedicelled spikelet absent **4. M. laevis**

1. Pedicelled spikelet present

  2. Lower glume of the sessile spikelet with 4–7 upwardly directed hooks on each lateral keel **2. M. glandulosa**

2. Lower glume of the sessile spikelet entirely devoid of hooks
3. Back of the lower glume of the sessile spikelet glabrous, smooth or continuous slits
4. Joint at base with a ring of cilia **3. M. helferi**
4. Joint at base glabrous
5. Lower glume of the sessile spikelet ovate, indurate, 4.5–5 by *ca.* 1.5 mm, apex with 2 apical wings, continuous ridge along the length and interrupted by tubercles or tubercle-based hairs on the back or glabrous **6. M. striata**
5. Lower glume of the sessile spikelet oblong, indurate, 5–5.5 by 1.2–1.5 mm, apex with unequal wings, 7–8 longitudinal rows of small pits between the nerves on the back, margins at base puberulous **8. M. sp.1**
3. Back of the lower glume of the sessile spikelet scaberulous or hairy
6. Lower glume of the sessile spikelet without apical or lateral wing **1. M. cancellata**
6. Lower glume of the sessile spikelet with apical wings or wings along margins
7. Back of the lower glume of the sessile spikelet with continuous ridge along the length and interrupted by hairs or tubercle-based hairs **5. M. mollicoma**
7. Back of the lower glume of the sessile spikelet smooth and densely appressed hairs **7. M. thailandica**

1. Mnesithea cancellata Ridl., Fl. Mal. Pen. 5: 206. 1925.

Rottboellia cancellata Ridl., J. As. Soc. Straits 59: 228. 1911.— Type: Malay Peninsula, *H.N. Ridley* 15231 (holotype K!).

C. clathrata Henrard, Blumea 4: 519. 1941.— Type: Vietnam, Annam: Quinhon, *Balansa* s.n. (isotype L!).

R. foveolata Holtt., Gard. Bull. Singapore 11: 297. 1947.— Type: Malay Peninsula, *H.N. Ridley* 15231 (isotype K!).

Coelorachis foveolata (Holtt.) Jansen, Reinwardtia 2: 256. 1953.

C. cancellata (Ridl.) Bor, Dansk Bot. Ark. 20. 2: 168. 1962.

Perennial grass, caespitose. *Culms* erect, slender, up to 1 m tall, internodes terete, glabrous, nodes with a ring of short ciliate hairs. *Leaf-sheaths* loose, 5–10 cm long, glabrous except for the margins and nodes densely hairy. *Ligules* short membranous with long ciliate margins. *Leaf-blades* 10–40 by 0.5–0.8 mm, adaxial surface slightly hairy, abaxial surface glabrous, margins scabrous, apex acute. *Inflorescence* racemes, 5–7 cm long, terminal and axillary, subtended by a spatheole, exserted, terete, rachis internodes oblong with cup-shaped transverse tip, 3–4 mm long, distinctly 6–7-nerved, glabrous, joint at base glabrous, spikelets oblong, dorsally compressed, 4-6 mm long, callus glabrous, base oblique with central peg. *Sessile spikelets* 3–4 mm long. *Glumes*; lower glume oblong-ovate, indurate, 3–3.5 by *ca.* 1.5 mm, cancellate on the back, apex wingless; upper glume boat-shaped, 2.5–3.5 by *ca.* 1 mm, 3-nerved, glabrous, keeled along the midnerved from base to apex on the back, keeled scabrous, apex acute. *Lower floret*; lemma oblong, 2–2.5 mm long, hyaline, folded; palea absent. *Upper floret*; lemma oblong, *ca.* 2 mm long, hyaline, folded. *Lodicules* cuneate, 0.7 mm long. *Ovary* elliptic, *ca.* 0.7 mm long. *Anthers* 1.2–1.5 mm long. *Pedicelled spikelet* reduced into 2 asymmetrical glumes, *ca.* 1.5–2.5 mm long. *Pedicels* ribbon-like 2.5–3 mm long, distinctly 2 green lines, glabrous (Figs. 5.19A-D & 5.43A. & B).

Thailand.— NORTHERN: Chiang Mai [Doi Suthep, Wang Bua Ban, 11 Aug. 1987, *J.F. Maxwell* 87-856 (CMU)]; NORTH-EASTERN: Loei [Phu Kradueng, 23 Mar. 1954, *T. Smitinand* 1792 (BKF, K); 20 Mar. 1958, *Th. Sørensen et al.* 2349 (BKF, C, E, K); 12 Nov. 2004, *P. Traiperm* 161 (BCU, BKF, KKU); Phu Ruea, 17 Apr. 1968, *C. Chermsirivathana* 943 (BK); 24 Jul. 2004, *P. Traiperm* 122 (BCU, BKF, KKU); 4 Dec. 2004, *P. Traiperm* 188 (BCU, BKF, KKU); 28 Mar. 2006, *P. Traiperm* 379 (BCU, BKF, KKU); Phu Luang, 15 Nov. 1968, *C. Chermsirivathana* 1092 (BK)], Sakon Nakhon [Phu Phan National Park, 3 Oct. 2005, *P. Traiperm* 202 (BCU, BKF, KKU), 205 (BCU, BKF, KKU)]; EASTERN: Chaiyaphum [15 km NE of Chaiyaphum, 14 Aug. 1972, *K. Larsen et al.* 31830 (AAU, BKF, K, L); Phu Khiao, 27 Nov. 2004, *P. Traiperm* 183 (BCU, BKF, KKU); Tat Tone National Park, 1 Jan. 2006, *P. Traiperm* 370 (BCU, BKF, KKU)], Nakhon Ratchasima [Huai Thalaeng, 24 Dec. 1928, *Put* 2238 (K)], Si Sa Ket [Dongrak Range at Chong Bat Lak, Kantharalak, 17 Aug. 1976, *J.F. Maxwell* 76-520 (AAU, BK, L)], Ubon Ratchathani [Km 81 on road 217 E of Warin Chamrap, 27 Oct. 2001, *S. Laegaard et al.* 21833 (AAU); Pha Taem National Park, 23 Oct. 2005, *P. Traiperm* 239 (BCU, BKF, KKU)].

Distribution.— Indo-China, Malesia.

Ecology.— Grass in rather dense tussock, in open dry deciduous forest, wet and sandy soil, at 50-1,300 m altitude. Flowering in July to April.

Notes.— *Mnesithea cancellata* is very close to *M. mollicoma*, but differing in the cancellate and wingless at the lower glume of the sessile spikelet, whereas the lower glume of *M. mollicoma* is continuous ridge along the length and interrupted by hairs or tubercle-based hairs and having unequal narrow wings along margins.

2. Mnesithea glandulosa (Trin.) Koning & Sosef., Blumea 31 (2): 290. 1986.

Rottboellia glandulosa Trin., Mem. Acad. Sci. Petersb. 6 (2): 250. 1832.— Type: Java, *Hb. Trinius* s.n. (holotype LE).

Manisuris glandulosa (Trin.) O. Ktze., Rev. Gen. Pl. 2: 780. 1891.

Coelorachis glandulosa (Trin.) Stapf ex Ridl., Fl. Mal. Penins. 5: 204. 1925.

R. muricata var. *javanica* Retz.— Type: Indonesia: Java, *Junghuhn, F.W.* s.n. (lectotype K!).

Perennial grass. *Culms* erect, a large stout tufted with prop roots below, up to 1–2 m tall, internodes glabrous or glabrescent, nodes with a ring of short ciliate hairs. *Leaf-sheaths* tight, glabrous, 8–20 cm long. *Ligules* a membranous with ciliolate hairs, 1–1.5 mm long. *Leaf-blades* lanceolate, *ca.* 100 by 1.5–3.5 cm, slightly appressed hairs on both surfaces, margins scabrous, round to a subcordate base, acuminate at the apex. *Inflorescence* racemes, 7–10 cm long, terminal and axillary, subtended by a spatheole, exserted, terete, rachis internodes cupuliform, 3–4 mm long, scabrous, joint at base scabrous, spikelets oblong, dorsally compressed, 5-6 mm long, callus scabrous, base truncate with central peg. *Sessile spikelets* 5–5.5 mm long. *Glumes*; lower glume oblong-ovate to ovate, 4-5.5 mm long, obscurely 6–7-nerved, glabrous on the back and with hooks on each lateral side in the basal part, margins enfold apex acute with 2-apical wings; upper glume boat-shaped, 4–4.5 mm long, chartaceous, glabrous, keeled along the midnerve from base to apex on the back, keeled scabrous, apex acute. *Lower floret* barren; lemma ovate-acute, 3–3.5 mm long, 3-nerved, hyaline, ciliolate on margins, enfolded; palea *ca.* 0.6 mm long. *Upper florets* fertile; lemma elliptic, 2–2.5 mm long, 3-nerved, hyaline; palea *ca.* 0.7 mm long. *Anthers* 3, *ca.* 2.5 mm long, purple. *Lodicules* cuneate, *ca.* 0.5 mm long. *Stigmas* 2. *Pedicelled spikelet* reduced to 2 glumes. *Pedicels* ribbon-shaped, 6–6.5 by *ca.* 1.5 mm, 7-nerved, comprising 2 subequal glumes. *Glumes*; lower glume ovate, *ca.* 1.5 mm long, winged along one side; upper glume more reduce (Figs. 5.19E-G & 5.43C-E).

Thailand.— NORTHERN: Chiang Mai [Doi Suthep, 22 Jul. 1911, *A.F.G. Kerr* 1912 (BM, K); 14 Sept. 1958, *Th. Sørensen et al.* 4989 (BKF, C, K); Huai Kaew, 8 Dec. 1980, *Y. Paisooksantivatthana* y 470-80 (BK)]; NORTH-EASTERN: Phetchabun [Nam Nao National Park, 17 Nov. 2005, *P. Traiperm* 279 (BCU, BKF, KKU)], Khon Kaen [Mancha Khiri, 24 Aug. 2005, *P. Traiperm* 210 (BCU, BKF, KKU)]; EASTERN: Chaiyaphum [Tat Tone waterfalls, 9 Oct. 1965, *S. Sutheesorn* 573 (BK)]; SOUTH-WESTERN: Kanchanaburi [Ban Din So, 16 Jul. 1926, *Put* 144 (BK, BM, K); Kin Sayok, 17 Jul. 1946, *A. Kostermans* 1141 (P)]; CENTRAL: Saraburi [Sam Lan waterfalls, 15 Jun. 1974, *J.F. Maxwell* 74-596 (AAU, BK, L); *C. Chermsirivathana* 622 (BK); 5 Nov. 2005, *P. Traiperm* 274 (BCU, BKF, KKU)], Nakhon Nayok [27 Jul. 1950, *K. Suvathabhandhu* 448 (BK); Nang Rong, 29 Jul. 1959, *T. Smitinand* 6086 (BKF); Wang Takrai, 27 Sept. 1969, *C. Chermsirivathana* 1562 (BK, L)], Krung Thep Maha Nakhon [25 Jul. 1920, *A.F.G. Kerr* 4360 (C, K)]; SOUTH-EASTERN: Sa Kaeo [Aranyaprathet, 9 Aug. 1930, *A.F.G. Kerr* 19603 (BK, BM, K); Klong Nam Sai, 18 Nov. 1964, *S. Sutheesorn* 173 (BK)], Prachin Buri [Ban Bung Hills, 17 Jul. 1963, *K. Larsen* 10639 (C, K); Khao Yai National Park, 10 Jul. 1966, *K. Larsen et al.* 246 (AAU, K)], Chon Buri [Bang Saen, 22 May 1919, *Nur* 4247 (K)], Chanthaburi [Ban Thale, Pong Nam Ron, 28 Nov. 1956, *T. Smitinand* 3667 (BKF)]; PENINSULAR: Chumphon [Khao Lard, Mueang, 1 Jan. 1974, *S. Sutheesorn* 2757 (BK)], Surat Thani [Ban Ta Por, Ta U Tae, 2 Feb. 1987, *P. Tepuarin* 350 (PSU)], Phangnga [Khlong Nang Yon, 28 Apr. 1973, *R. Geesink & T. Santisuk* 5004 (AAU)], Nakhon Si Thammarat [Kiriwong, Tap Chang, 28 Aug. 1951, *T. Smitinand* 765 (K)], Phatthalung [Khao Pu Khao Ya National Park, 21 Oct. 2004, *P. Traiperm* 139 (BCU, BKF, KKU)], Trang [Khao Chong, 9 Oct. 1970, *Ch. Charoenphol et al.* 3507 (AAU, BKF, K); Ton The waterfalls, 14 Nov. 1990, *K. Larsen et al.* 41374 (AAU, BKF, PSU)], Satun [Tarutao National Park, Malacca Creek to Talo Oo Dang, 13 Dec. 1979, *G. Congdon* 253 (AAU, PSU); 27 Jan. 1980, *G. Congdon* 289 (AAU, PSU); 31 Jul. 1980, *G. Congdon* 819 (AAU, PSU)], Songkhla [2 Dec. 1975, *A. Yiamudom* 18 (PSU); Suan Toon Falls, 16 Nov. 1984, *J.F. Maxwell* 84-439 (BKF, PSU); Mueang, 8 Oct. 1990, *B. Aksorn* 30 (PSU); Ton Pliew near Ton Nga Chang, 13 Oct. 1991, *K. Larsen et al.* 42369 (AAU); Khao Chum Sak at Hat Yai, 12 Aug. 1995, *K. Larsen et al.* 45494 (AAU); Khao Khor Hong, 18 Oct. 2004, *P. Traiperm* 134 (BCU, BKF, KKU)], Pattani [Sai Buri, 4 Aug. 1970, *S.*

Sutheesorn 1820 (BK)], Narathiwat [Bacho, 10 Jan. 1969, *P. Sankhachand* 1677 (BK)].

Distribution.— Indo-China, Malesia.

Ecology.— Grass common by on sandy bank by stream or edge of deciduous forest, up to 1,100 m altitude. Flowering in May to January.

Vernacular.— Ya khao pa (หญ้าข้าวป่า) (Kanchanaburi).

Notes.— This species is easily recognised by hooks on each lateral side in the basal part of the lower glume of the sessile spikelet.

3. Mnesithea helferi (Hook.f.) Koning & Sosef., Blumea 31 (2): 291. 1986.

Rottboellia helferi Hook.f., Fl. Brit. Ind. 7: 158. 1896.— Type: India, *Helfer* 913 (holotype K!).

Mnesithea rupincola Ridl., J. Roy. As. Soc. Str. Br. 57: 116. 1911.— Type: Malay Peninsula, Perak, *H.N. Ridley* 14357 (syntype K!).

Coelorachis helferi (Hook.f.) Henr., Blumea 4: 518. 1941.

Perennial grass, caespitose, with a young propagule below. *Culms* erect, 50–100 cm tall, internodes glabrous to pilose, nodes pubescent. *Leaf-sheaths* tight, 6–10 cm long, glabrous to pilose. *Ligules* membranous, 0.5–0.8 mm long. *Leaf-blades* 15–50 by 0.8–1.5 cm, glabrous to pubescent on both surfaces, margins scabrous and pilose, acuminate at apex. *Inflorescence* composed of racemes, 9–12 cm long, terminal and axillary, subtended by a spatheole, rachis internodes cupuliform on upper part, basal part cuneate, glabrous, nodes with a ring of long cilia; spikelets in pairs or tripets, 1–2 sessile spikelets and 1 pedicelled spikelet, callus long pilose, base truncate with central peg. *Sessile spikelets* dorsally compressed. *Glumes*; lower glume ovate, indurate, 3–3.5 by 1–1.2 mm, glabrous on the back, margins entire, sometimes pilose on the lower part, apex bifid with oblique, 2 apical wings, wing unequal, the biggest wing usually along the apex to the base; upper glume ovate, 2.5–3 by *ca.* 1 mm, 3–nerved, keeled along the midnerve from base to the apex, glabrous on the back, apex acute. *Lower floret*; lemma ovate, *ca.* 2 by 0.8 mm, hyaline, folded; palea absent. *Upper floret*; lemma ovate, *ca.* 2.5 by 1.5 mm, hyaline. *Lodicules* cuneate, 0.5 mm long. *Anthers ca.* 2 mm long. *Pedicelled spikelet* oblong, 0.5–0.8 mm long, reduced into 2 asymmetrical glumes. *Pedicels* ribbon-like, *ca.* 3 by 0.5 mm, distinctly 2 green lines, glabrous, apex truncate and curved (Figs. 5.19H-K and 5.44A. & B).

Thailand.— NORTH-EASTERN: Loei [Phu Ruea, 23 Apr. 2005, *P. Traiperm* 201 (BCU, BKF, KKU)], Nong Khai [Chet Si Falls, Phu Wua Wildlife Sanctuary, 26 Aug. 2001, *R. Pooma et al.* 2718 (L)], Sakon Nakhon [Phu Phan National Park, 29 Aug. 2004, *P. Traiperm* 123 (BCU, BKF, KKU); 6 Nov. 2004, *P. Traiperm* 153 (BCU, BKF, KKU); 3 Oct. 2005, *P. Traiperm* 203 (BCU, BKF, KKU)], Khon Kaen [Mancha Khiri, 24 Aug. 2005, *P. Traiperm* 209 (BCU, BKF, KKU)]; EASTERN: Chaiyaphum [Phu Khiao, 19 Oct. 2005, *P. Traiperm* 225 (BCU, BKF, KKU)], Si Sa Ket [Dongrak range, 31 Dec. 2005, *P. Traiperm* 363 (BCU, BKF, KKU); Phu La-or waterfalls, 31 Dec. 2005, *P. Traiperm* 364 (BCU, BKF, KKU)], Ubon Ratchathani [km 10, 2112 road to Khong Chiam, 23 Oct. 2005, *P. Traiperm* 252 (BCU, BKF, KKU)]; SOUTH-WESTERN: Kanchanaburi [Sai Yok, 1 Aug. 1928, *A. Marcan* 2367 (BM, K)], Prachuap Khiri Khan [Huai Yang, 2 Jul. 1924, *A.F.G. Kerr* 10745 (BK, K)]; CENTRAL: Saraburi [Sam Lan forest, Mueang, 15 Jun. 1974, *J.F. Maxwell* 74-586 (AAU, BK, L)]; SOUTH-EASTERN: Chanthaburi [Plain of Makham, 22 Aug. 1966, *K. Larsen et al.* 1682 (AAU)]; PENINSULAR: Songkhla [Hat Yai, 18 Oct. 2004, *P. Traiperm* 132 (BCU, BKF, KKU); Ton Lad waterfalls, 19 Oct. 2004, *P. Traiperm* 136 (BCU, BKF, KKU); Ton Tad Pha waterfalls, *P. Traiperm* 137 (BCU, BKF, KKU)].

Distribution.— Indo-China, Malesia.

Ecology.— Tufted grass in evergreen, deciduous forest or swampy area at 25-200 m altitude. Flowering in April to December.

Notes.—The collections of *A.F.G. Kerr* 10745 having a glabrous rachis nodes.

4. Mnesithea laevis (Retz.) Kunth in Rev. Gram. 1. 154.

Rottboellia laevis Retz., Obs. Bot. 3: 11. 1783.— Type: India, *Wight* 1722 (isotype K!).

Ophiuros undatus Nees, Hook. Kew Journ. 2. 1850.— Type: Philippines, Luzon, *Cumming, H.* 1339 (holotype K!, isotypes L!, P!).

Mnesithea laevis var. *hirta* (Retz.) Kunth in Révis. Gramin. 1: 154.— Type: Indonesia, Sulawesi, Saloe Karadjoe, *P.J. Eyma* 361 (isotype L!).

Perennial grass, tufted. *Culms* slender, erect, 30–100 cm long, terete, glabrous. *Leaf-sheath* tight, 4–7 cm long, glabrous, upper part with long ciliate hairs at margins. *Ligules* an eciliate membrane, *ca.* 0.5 mm long. *Leaf-blade* linear, incurved, 15–70 by 0.2–0.5 cm, glabrous on both sides, abruptly acute. *Inflorescence* racemes, terminal or axillary, 7-21 cm long, rachis internodes cuneate, 3.5–4 mm long, apex crateriform; spikelets sunken, arranged in two or three, usually in three on below. *Sessile spikelets* paired or solitary, oblong; dorsally compressed. *Glumes*; lower glume oblong, 3–3.5 by *ca.* 1 mm, coriaceous, glabrous, apex obtuse, wingless; upper glume oblong, *ca.* 3 by 1 mm, membranous, slightly enfolded, obtuse at apex. *Lower floret*; lemma lanceolate, 2.5–2.8 mm long, hyaline; palea absent. *Upper floret*; lemma lanceolate, *ca.* 2.8 mm long, hyaline; palea absent. *Pedicelled spikelet* absent. *Pedicels* fused to internode, united wholly (Figs. 5.20 & 5.44C-E).

Thailand.— NORTHERN: Chiang Mai [Doi Inthanon, *ca.* 5 km from Chom Thong, 3 Oct. 2001, *S. Laegaard & M. Norsaengsri* 21657 (AAU, K, L), 15 Oct. 2001, *S. Laegaard & M. Norsangsri* 21713 (AAU); 24 Nov. 2005, *P. Traiperm* 307 (BCU, BKF, KKU); along road; Op Luang table-land, 12 Jun. 1968, *C.F. van Beusekom & C. Phengklai* 1192 (C, E, K, L, P)], Sukhothai [N Sukhothai, between Tak and Ban Dan Lan Hoi, 24 Jul. 1973, *G. Murata et al.* 16988 (L)], Kamphaeng Phet [20 Jul. 1959, *T. Smitinand* 5960 (BKF, K)], Nakhon Sawan [10 km NW of Nakhon Sawan, 21 Jul. 1973, *G. Murata et al.* T-16580 (BKF, L, P)]; NORTH-EASTERN: Loei [Phu Kradueng, Ban Na Noi To Na Noi station, 26 Aug. 1988, *H. Koyama T*-61335 (BKF)], Nong Khai [Dong Si chompu, 22 Jun. 1963, *Adisai* 550 (BK)], Khon Kaen [Ban Nawng Khuean, 7 Jul. 1967, *T. Smitinand* 10406 (BKF)]; EASTERN: Chaiyaphum [Nong Bua Daeng, 15 Aug. 1972, *K. Larsen et al.* 31888 (AAU, L)], Nakhon Ratchasima [Huai Thalaeng, 24 Dec. 1828, *Put* 2239 (K); 20 Aug. 2001, *R. Pooma et al.* 2119 (L)], Buri Ram [40 km S of Buriram, along route, 4 Oct. 1984, *G. Murata et al.* T-37457 (BKF, L)], Surin [Kap Choeng, 20 May 1965, *S. Sutheesorn* 305 (BK); Thung Kula Rong Hai: Chumphon Buri, 7 Sept. 1972, *S. Sutheesorn* 2117 (BK)]; SOUTH-WESTERN: Kanchanaburi [Khao Tawng, 31 Aug. 1930, *A.F.G. Kerr* 19649 (BK, BM, K)], Prachuap Khiri Khan [Khao Yai, 8 Nov. 1927, *A.F.G. Kerr* 13508 (BK, BM, K); Klong Wan, 21 Oct. 1964, *C. Chermsirivathana* 120 (BK)]; SOUTH-EASTERN: Sa Kaeo [Aranyaprathet, 9 Aug. 1930, *A.F.G. Kerr* 19584 (BK, BM, K)]; Chon Buri [Khao Khiao, 26 Apr. 1975, *J.F.*

Maxwell 75-433 (AAU, BK, L)]; PENINSULAR: Surat Thani [Kanchanadit, 1 Aug. 1927, *A.F.G. Kerr* 13085 (BK, BM, K)], Phatthalung [Sak, 30 Apr. 1930, *A.F.G. Kerr* 19253 (BK, BM, K)], Songkhla [Thepa, 23 Mar. 1928, *A.F.G. Kerr* 14720 (BM, K); 4 Dec. 1975, *A. Yiamudom* 27 (PSU); Songkhla-Pattani road, 55 km from Songkhla, 31 Oct. 1990, *K. Larsen et al.* 41021 (AAU, PSU); highway 4, near Pru village, 8 Aug. 1994, *J.F. Maxwell* 84-8 (PSU); 23 km E of Chana, 21 Aug. 1995, *K. Larsen et al.* 45821 (AAU, L); Suan Dtoon falls, 11 Oct. 1984, *J.F. Maxwell* 84-306 (BKF, PSU); 1 Nov. 1993, *K. Larsen et al.* 44202 (AAU); Khao Chum Sak at Hat Yai, 12 Aug. 1995, *K. Larsen et al.* 45502 (AAU, L)], Narathiwat [Rueso, 10 Nov. 1970, *S. Sutheesorn* 1843 (BK)].

Distribution.— India, China, Indo-China.

Ecology.— Dry deciduous, dipterocarp, bamboo or pine forest, up to 400 m altitude. Flowering in July to May.

Notes.—*A.F.G. Kerr* 13508 has a longitudinal slit on the back of the lower glume of the sessile spikelet.

5. Mnesithea mollicoma (Hance) A. Camus, Bull. Mus. Hist. Nat. Paris 25: 57. 1919.

Rottboellia mollicoma Hance, J. Bot. 9: 134. 1871.— Type: China, *Hance* 7558 (holotype, isotype and syntype K!, isotype BM!).

Mnesithea pubescens Ridl., Journ. As. Soc. Straits, xliv. 44: 207. 1905.— Type: Malay Peninsula, *H.N. Ridley* 11017 (holotype K!).

Coelorachis mollicoma (Hance) Bor, Dansk. Bot. Ark. 20: 169. 1962.

Perennial grass, caespitose, with a young propagule. *Culms* erect, 30–100 cm tall, internodes pilose with appressed hairs, nodes pubecsent. *Leaf-sheaths* loose, 6–10 cm long, pubescent. *Ligules* membranous with long ciliate margins, *ca.* 1–1.5 mm long. *Leaf-blades* 20–60 by 0.8–1.8 cm, pubescent on both surfaces, apex acute. *Inflorescence* composed of racemes, 8–14 cm long, terminal and axillary, subtended by a spatheole, rachis internodes cupuliform on upper part, basal part cuneate, glabrous, nodes with a ring of ciliate hairs; spikelets in pairs or tripets, callus pubescent. *Sessile spikelets*; lower glume oblong-ovate, indurate, 3.5–4.5 by 1.8–2 mm, subequal narrow winged along margins, continuous ridge along the length and interrupted by hairs or tubercle-based hairs; upper glume ovate or boat-shaped, *ca.* 3.5 by 1 mm, 3-nerved, keeled along the upper back, glabrous, apex acute. *Lower floret*;

lemma ovate, *ca.* 2.5 by 1 mm, hyaline, folded; palea absent. *Upper floret*; lemma ovate, *ca.* 3 by 2 mm, 3-nerved, hyaline; palea ovate, *ca.* 2.8 by 1 mm, hyaline. *Lodicules* cuneate, 0.5 mm long. *Anthers ca.* 2 mm long. *Pedicelled spikelet* ovate, 0.5–1.5 mm long, reduced into 2 asymmetrical glumes. *Pedicels* oblong or ribbon-like, 3–4.5 by 0.5–0.8 mm with distinctly 2 green lines, glabrous, apex truncate, curved (Figs. 5.21A-D & 5.45A-C).

Thailand.— NORTHERN: Chiang Mai [Along the highway between Mae Saring and Chom Thong, 19 Sept. 1967, *K. Iwatsuki & N. Fukuoka* T-10393 (BKF, E, L); Doi Suthep, 23 Jul. 1958, *Th. Sørensen et al.* 4377 (C, E, K); 27 Jul. 1958, *Th. Sørensen et al.* 4494 (C, K); 30 Aug. 1958, *Th. Sørensen et al.* 4629 (C, K); 10 May 1958, *Th. Sørensen et al.* 5463 (C); 9 Dec. 1965, *T. Smitinand* 10006 (BKF); 18 Sept. 1967, *T. Shimizu et al.* T-10473 (BKF, L); 22 Aug. 1987, *J.F. Maxwell* 87-856 (BKF, L), 87-1020 (BKF, CMU, L), 88-1106 (BKF, CMU, L); 92-622 (L, P); 93-19 (L, P); Mae Klang river, Doi Inthanon, 3 Aug. 1988, *H. Koyama* T-61213 (BKF, L), T-61248 (BKF), T-61625 (AAU, BKF, L); 3 Aug. 1988, *S. Tsugaru* T-61849 (AAU, BKF, L); 14 Jun. 2004, *P. Traiperm* 112 (BCU, BKF, KKU), 113 (BCU, BKF, KKU); 22 Nov. 2005, *P. Traiperm* 296 (BCU, BKF, KKU); 24 Nov. 2005, *P. Traiperm* 305 (BCU, BKF, KKU); Forest above Training Center of Queen Sirikit Botanical Garden, 9 Oct. 2001, *S. Laegaard & M. Norsaengsri* 21688 (AAU, L)], Lamphun [en route from Ban Khun Tan to Doi Khun Tan, 9 Apr. 1967, *M. Tagawa et al.* T-9205 (BKF); Mae Tah, 28 Jul. 1994, *J.F. Maxwell* 94-808 (L)], Lampang [Khun Tan, 4 Dec. 2005, *P. Traiperm* 320 (BCU, BKF, KKU)]; NORTH-EASTERN: Phetchabun [Nam Nao National Park, 17 Nov. 2005, *P. Traiperm* 280 (BCU, BKF, KKU)], Loei [Phu Ruea, 24 Jul. 2004, *P. Traiperm* 117; 28 Mar. 2005, *P. Traiperm* 378 (BCU, BKF, KKU)]; EASTERN: Chaiyaphum [Phu Khiao, 27 Nov. 2004, *P. Traiperm* 182 (BCU, BKF, KKU); Phu Lanka, 1 Jan. 2006, *P. Traiperm* 368 (BCU, BKF, KKU)], Nakhon Ratchasima [Huai Thalaeng, 12 Dec. 1928, *Put* 2238 (BK, BM)]; SOUTH-EASTERN: Chanthaburi [Makham, 4 Aug. 1954, *T. Smitinand* 1827 (BKF, K); 22 Aug. 1966, *K. Larsen et al.* s.n. (BKF); 19 Nov. 2005, *P. Traiperm* 290 (BCU, BKF, KKU)]; PENINSULAR: Surat Thani [6 Jan. 1927, *A.F.G. Kerr* 11282 (BK, BM, K); Kanchanadit, 1 Aug. 1927, *A.F.G. Kerr* 13074 (BK, K)], Trang [Thung Kai, 22 Oct. 2004, *P. Traiperm* 141 (BCU, BKF, KKU)], Songkhla [Koh Hong, Hat Yai, 18 May 1960, *C. Chantaraprasong* 25 (BK); 11 Aug. 1984, *J.F. Maxwell* 84-33 (BKF, PSU);

Hat Yai, 18 Oct. 2004, *P. Traiperm* 131 (BCU, BKF, KKU); 23 km E of Chana, 21 Aug. 1995, *K. Larsen et al.* 45819 (AAU, L)].

Distribution.— China, Indo-China, Malesia.

Ecology.— Tufted grass common in mixed deciduous forest, at sea level to 1,200 m altitude. Flowering throughout the year.

6. Mnesithea striata (Nees ex Steud.) Koning & Sosef., Blumea 31 (2): 292. 1986.

Rottboellia striata Nees ex Steud., Syn. Pl. Glum. 1: 361. 1855.— Type: *Wall. Cat. no.* 8877 C (lectotype K!).

R. merguensis Hook.f., Fl. Brit. India 7: 158. 1897.— Type: Burma, Tenasserim, Mergui, *Helfer, J.W.* 457 (holotype L!), *Griffith* s.n. (syntype K!).

M. merguensis (Hook.f.) A. Camus, Bull. Mus. Hist. Nat. Paris. 25: 59. 1919.

Coelorachis striata (Nees ex Steud.) A. Camus, Ann. Soc. Linn. Lyon. 68: 197. 1921.

KEY TO THE VARIETIES

1. Leaf-blades glabrous on both surfaces; lower glume of the sessile spikelet glabrous or nearly smooth on the back **a. var. striata**
1. Leaf-blades pubescent on both surfaces; lower glume of the sessile spikelet with continuous ridges along the length and interrupted by tubercles or tubercle-based hairs, margins glabrous **b. var. pubescens**

a. var. striata

Perennial grass, caespitose, large stout tufted with propagules below. *Culms* erect, up to 2 m tall, terete, internodes glabrous, nodes slightly hairy or glabrescent. *Leaf-sheaths* nearly tight, 5–12 cm long, glabrous, margins pilose. *Ligules* membranous with ciliate margins, 1.5–2 mm long. *Leaf-blades* 30–60 by 1–2 cm, glabrous on both surfaces, margins scabrous and pilose, apex acute. *Inflorescence* composed of many racemes, 8–12 cm long, terminal and axillary, subtended by a spatheole, rachis internodes oblong, flattened at base swollen at the upper part, 4–6.5 by *ca.* 1 mm, glabrous, nodes glabrous; spikelets in pairs or tripets, callus glabrous. *Sessile spikelets* dorsally compressed. *Glumes*; lower glume oblong, indurate, 3.5–5 by 1–1.5 mm, glabrous or nearly smooth on the back, apex with 2 small apical wings; upper glume boat-shaped, acute, 3–4 by 1–1.5 mm, keeled on the back, on the upper part, glabrous. *Lower floret*; lemma ovate-acute, *ca.* 2.8 by 0.8 mm, 3-nerved, hyaline, glabrous; palea lanceolate, *ca.* 2 by 0.5 mm, hyaline, glabrous. Upper floret; lemma ovate-acute, *ca.* 2.8 by 0.8 mm, hyaline, glabrous; palea boat-shaped, *ca.* 2.5 by 0.5 mm, hyaline, glabrous, apex acute. *Lodicules* cuneate, 0.5 mm long. *Anthers* 1.8-2 mm long. *Pedicelled spikelet* oblong or ovate, 1–2.5 mm long, reduced into 2 asymmetrical glumes, glumes dissimilar, winged at the apex, slightly folded, glabrous. *Pedicels* oblong or ribbon-like 3.5–4.5 by *ca.* 1 mm, with distinct 2 green lines, glabrous, apex concave (Figs. 5.21E-J & 5.45D-F).

Thailand.— NORTHERN: Chiang Mai [Mae Sa Valley, *J.K. Jackson* 6165 (BKF); Doi Suthep, 22 Jun. 1958, *Th. Sørensen et al.* 3689 (C, K); 7 Jan. 1993, *J.F. Maxwell* 93-18 (L, P); 22 Nov. 2005, *P. Traiperm* 298 (BCU, BKF, KKU); Doi Pui, 24 Mar. 1965, *C.H. & B.S.* 305 (BKF); Pangboh, Hill E of camp, 3 Nov. 1965, *T. Smitinand* 8715 (BKF); 15 Oct. 1992, *J.F. Maxwell* 92-622 (P); Wang Tao, N of Chiang Mai, 13 Feb. 1958, *Th. Sørensen et al.* 1080 (K); Doi Inthanon, en route from Pha Mon (Ban Yang) to the camp, 10 Feb. 1971, *G. Murata et al.* T-15870 (BKF); along Mae Klang river, 3 Aug. 1988, *H. Koyama* T-61213 (L); 30 Jul. 1988, *H. Koyama* T-61625 (AAU, L); 3 Aug. 1988, *S. Tsugaru* T-61849 (AAU, L); Tham Chiang Dao, 16 Feb. 1958, *Th. Sørensen et al.* 1161 (C); Doi Chiang Dao, 1 Jun. 1966, *M. Tagawa et al.* T-4416 (BKF); Wieng Pa Pao, Doi Luang National Park, 26 Oct. 1997, *J.F. Maxwell* 97-1223 (BKF, L); above Training Center of Queen Sirikit Botanical Garden, 24 Sept. 2001, *S. Laegaard* 21613 (AAU); 5 Oct. 2001, *S. Laegaard* 21677 (AAU)], Lamphun [Mae Tah, 24 Sept. 1993, *J.F. Maxwell* 93-1081 (BKF, L)], Lampang [Chae Son National Park, 20 Oct. 1995, *J.F. Maxwell* 95-924 (BKF, L); Khun Tan, 4 Dec. 2005, *P. Traiperm* 325 (BCU, BKF, KKU)], Tak [Doi Musoe, 12 Sept. 1960, *T. Smitinand* 7081 (BKF)], Sukhothai [Khao Luang, 17 Dec. 2005, *P. Traiperm* 343 (BCU, BKF, KKU), 344 (BCU, BKF, KKU), 345 (BCU, BKF, KKU)]; NORTH-EASTERN: Phetchabun [Nam Nao, 20 Aug. 2004, *P. Traiperm* 121 (BCU, BKF, KKU); 20 Nov. 2004, *P. Traiperm* 172 (BCU, BKF, KKU), 173 (BCU, BKF, KKU); Phu Khiao, 19 Oct. 2005, *P. Traiperm* 211(BCU, BKF, KKU), 223 (BCU, BKF, KKU)], Loei [Phu Kradueng, 12 Nov. 2004, *P. Traiperm* 156 (BCU, BKF, KKU)], Khon Kaen [Phu Khiao, *ca.* 80 km E of

Phetchabun, 11 Jul. 1984, *G. Murata et al.* T-41627 (BKF)]; EASTERN: Nakhon Ratchasima [Huai Thalaeng, 12 Dec. 1928, *Put* 2238 (BK, BM)]; SOUTH-WESTERN: Kanchanaburi [Huai Bankau, 9 Nov. 1971, *C.F. van Beusekom et al.* 3597 (BKF, P)]; PENINSULAR: Phangnga [Khao Phra Mi, 9 Jan. 1966, *B. Hansen & T. T. Smitinand* 11868 (BKF, C, K); Khlong Nang Yon, 28 Apr. 1973, *R. Geeink & T. Santisuk* 5004 (BKF, P)].

Distribution.— China, India, Indo-China.

Ecology.— On sunny slope, edge of dipterocarp forest or in evergreen forest, up to 1,225 m altitude. Flowering in June to February.

Vernacular.— Ya khon (หญ้าขน) (Nakhon Ratchasima).

b. var. pubescens (Hack.) S.M. Phillips & S.L. Chen, Novon 15 (3): 470. 2005.

Rottboellia striata Nees ex Steud. var. *pubescent* Hack. in DC., Monogr. Phan. 6: 302. 1889.— Type: India, Khasia, Meghalaya, *J.D. Hooker & T. Thomson* s.n. (holotype K!, isotype L!).

Coelorachis striata var. *pubescens* (Hack.) Bor, Grasses Burma, Ceyl., India Pak.: 121. 1960.

Perennial grass, caespitose, large stout tufted with propagules below. *Culms* erect, up to 1.5 m tall, terete, internodes glabrous, nodes slightly hairy to pubescent. *Leaf-sheaths* tight, 6.5–15 cm long, glabrous to pilose, if glabrous usually pilose at margins. *Ligules* membranous with ciliate margins. *Leaf-blades* up to 70 by 1–2.5 cm, pilose or pubescent on both surfaces, margins scabrous and pilose, apex acute. *Inflorescence* composed of many racemes, 7–11 cm long, terminal and axillary, subtended by a spatheole, rachis internodes clavate, swollen at the upper part, 3.5–4.5 by 1–1.5 mm, glabrous, nodes glabrous; spikelets in pairs or tripets, callus glabrous. *Sessile spikelets* dorsally compressed. *Glumes*; lower glume ovate, indurate, 4.5–5 *ca.* 1.5 mm, continuous ridge along the length and interrupted by tubercles, or tubercle-based hairs, margins glabrous, apex with 2 apical wings; upper glume boat-shaped, *ca.* 3.5 by 1 mm, keeled on the back, on the upper part, glabrous, apex acute. *Lower floret*; lemma ovate-acuminate, *ca.* 2.8 by 0.8 mm, hyaline, glabrous, slightly folded; palea lanceolate, *ca.* 2 by 0.3 mm, hyaline, muticous. *Upper floret*; lemma lanceolate, *ca.* 2 by 0.3 mm, hyaline, glabrous; palea boat-shaped, *ca.* 2.5 by 0.8 mm, hyaline, glabrous, apex acute. *Lodicules* cuneate, *ca.* 0.5 mm long. *Anthers* 2–2.5 mm long. *Pedicelled spikelet* oblong, 0.5–2 mm long, reduced into 2 asymmetrical glumes, glumes dissimilar, winged at apex, slightly folded, glabrous. *Pedicels* oblong or ribbon-like, 3.5–4.5 by 0.8–1 mm, with distinct 2 green lines, glabrous, apex concave (Fig. 5.21K-N).

Thailand.— NORTHERN: Mae Hong Son [Huai He, Mueang, 22 Dec. 2005, *P. Traiperm* 349 (BCU, BKF, KKU)], Chiang Mai [Doi Suthep, 11 Nov. 1911, *A.F.G. Kerr* 1601B (BM, E, K); 25 Nov. 1920, *J.F. Rock* 187 (P); 8 Feb. 1958, *Th. Sørensen et al.* 878 (BKF, C); 20 Apr. 1958, *Th. Sørensen et al.* 2923 (C); 27 Sept. 1958, *Th. Sørensen et al.* 5280 (C); 21 Nov. 2005, *P. Traiperm* 295 (BCU, BKF, KKU); Doi Inthanon, 24 Nov. 2005, *P. Traiperm* 306 (BCU, BKF, KKU); Doi Chiang Dao, 22 Sept. 1990, *J.F. Maxwell* 90-1033 (AAU, CMU, L); 10 Oct. 1995, *J.F. Maxwell* 95-881 (BKF, L); Queen Sirikit Botanical Garden, 26 Nov. 2005, *P. Traiperm* 313 (BCU, BKF, KKU), 314 (BCU, BKF, KKU), 315 (BCU, BKF, KKU); Mae Sao, 18 Dec. 2005, *P. Traiperm* 346 (BCU, BKF, KKU); Hill between Thoen & Lee, 29 Nov. 1959, *T. Smitinand & E.C. Abbe* 6168 (K)], Chiang Rai [Doi Tung: en route from Ban Huai Khrai to Wat Doi Tung, 24 Sept. 1967, *K. Iwatsuki et al.* T 10929 (BKF, E)], Lampang [Khun Tan, 4 Dec. 2005, *P. Traiperm* 322 (BCU, BKF, KKU), 324 (BCU, BKF, KKU)], NORTH-EASTERN: Phetchabun [Nam Nao, 20 Nov. 2004, *P. Traiperm* 168 (BCU, BKF, KKU), 169 (BCU, BKF, KKU), 174 (BCU, BKF, KKU); 17 Nov. 2005, *P. Traiperm* 281 (BCU, BKF, KKU); 7 Jan. 2006, *P. Traiperm* 373 (BCU, BKF, KKU); Thung Salaeng Luang, 17 Nov. 2005, *P. Traiperm* 283 (BCU, BKF, KKU), 286 (BCU, BKF, KKU)], Loei [Phu Ruea, 6 Dec. 2004, *P. Traiperm* 198; 23 Apr. 2005, *P. Traiperm* 200 (BCU, BKF, KKU); 15 Nov. 2005, *P. Traiperm* 326 (BCU, BKF, KKU); Phu Kradueng, 31 Oct. 2005, *P. Traiperm* 272 (BCU, BKF, KKU)], Khon Kaen [Khok Phu Taka, 9 Sept. 2004, *P. Traiperm* 126 (BCU, BKF, KKU)]; EASTERN: Chaiyaphum [Phu Khiao, 27 Nov. 2004, *P. Traiperm* 184 (BCU, BKF, KKU), 185 (BCU, BKF, KKU); 19 Oct. 2005, *P. Traiperm* 224 (BCU, BKF, KKU), 227 (BCU, BKF, KKU), 228 (BCU, BKF, KKU)]; SOUTH-WESTERN: Kanchanaburi [Sai Yok, 07 Dec. 1961, *K. Larsen* 8581 (C, K)]; PENINSULAR: Phangnga [Khao Phra Mi, 9 Jan. 1966, *B. Hansen & T. Smitinand* 11868 (BKF, K); Khlong Nang Yon, 28 Apr. 1973, *R. Geeink & T. Santisuk* 5004 (BKF, C, E, P)].

Distribution.— China, India and Indo-China.

Ecology.— Grass common in moist localities in mixed deciduous forest, at 100-2,200 m altitude. Flowering in September to April.

Notes.— Newly recorded for the country.

7. Mnesithea thailandica P. Traiperm & T. Boonkerd *sp. nov.* (*ined.)*

Perennial with caespitose. *Culms* erect, slender, 26 cm tall, internodes pilose to pubescent, nodes dense ciliate hairs. *Leaf-sheaths* loose, 2.5–6 cm long, pilose. *Ligules* membranous with ciliate margins, *ca.* 0.5 mm long. *Leaf-blades* 5–20 by 0.4–0.8 mm, pilose on both surfaces, apex acute. *Inflorescence* racemes, *ca.* 6 cm long, terminal, subtended by a spatheole, rachis internodes cupuliform, 2–2.5 mm long, with densely appressed hairs, nodes pubescent; spikelets in pairs, callus pubescent. *Sessile spikelets* dorsally compressed. *Glumes*; lower glume triangular, *ca.* 4 by 2 mm, indurate, margins folded, smooth and densely appressed hairs on the back, apex with 2 narrow wings; upper glume ovate or boat-shaped, *ca.* 3 by 1.3 mm, keeled on the upper and pilose along keel. *Pedicelled spikelet* oblong, *ca.* 1 mm long, reduced into 2 asymmetrical glumes, keeled along the margins, with densely appressed hairs on surface. *Pedicels* oblong or ribbon-like *ca.* 3 by 0.6 mm, with densely appressed hairs (Figs. 5.22 & 5.46A-D).

Thailand.— EASTERN: Roi Et [Suwannaphum, Nayai, Ban Hang Hoei, 10 June 1982, *Y. Paisooksantivathana & S. Sutheesorn* y 1048-82 (BK)].

Distribution.— Endemic to Thailand.

Ecology.— Common in paddy field, at 100 m altitude. Flowering in June.

Note.— *Mnesithea thailandica* is distinguished by the appressed hairs on the inflorescence. It is similar to Malaysian species, *M. geminata* but differs in having a small erect and slender culm, *ca.* 26 cm tall. The species has pubescent hairs on the back of the triangular lower glume, rachis nodes, pedicels and rachis internode, while lanceolate and hirsute below and glabrous on rachis nodes, pedicels and rachis internode in *M. geminata*.

8. Mnesithea sp.1

Perennial grass, caespitose, large stout tufted with propagules below. *Culms* erect, up to 2 m tall, terete, internodes glabrous, nodes glabrous to pubescent. *Leaf-*

sheaths tight, 5–10 cm long, slightly pilose on margins. *Ligules* membranous, *ca.* 2 mm long. *Leaf-blades* 20–80 by 1.5–2.5 cm, glabrous to pilose on both surfaces, margins scabrous and pilose, apex acuminate. *Inflorescence* composed of several racemes, slightly flattened, 6–8 cm long, terminal and axillary, subtended by a spatheole, rachis internodes oblong, flattened but swollen at the tip or the upper part, 5–6.5 by 1.2–1.5 mm, 7–10-nerved, glabrous, nodes glabrous; spikelets in pairs alternating rows, callus glabrous. *Sessile spikelets* dorsally compressed. *Glumes*; lower glume oblong, indurate, 5–5.5 by 1.2–1.5 mm, 7–8-nerved, 7–8 longitudinal rows of small pits between the nerves, glabrous on the back, margins at base puberulous, folded, unequal winged at apex; upper glume boat-shaped, *ca.* 5 by 1 mm, keeled on the back, along the midnerve, margins slightly folded, glabrous, apex acute. *Lower floret*; lemma ovate-acute, *ca.* 4.8 by 1.5 mm, hyaline, glabrous, slightly folded; palea ovate-acute, *ca.* 2 by 0.8 mm, hyaline. *Upper floret*; lemma ovate, *ca.* 3.5 by 0.8 mm, hyaline; palea boat-shaped, *ca.* 4.5 by 1 mm, hyaline. *Lodicules* cuneate, 0.5 mm long. *Anthers* 2–2.5 mm long. *Pedicelled spikelet* oblong-ovate, 1.8–2.5 mm long, reduced into 2 asymmetrical glumes, glumes dissimilar, narrowly winged along margins, folded, glabrous. *Pedicels* oblong or ribbon-like, 4.5–5 by 0.8–1.2 mm, with distinct 2–6 green lines, glabrous, apex truncate, pedicels fused to the internodes at the lower part (Figs. 5.23 & 5.46E-G).

Thailand.— NORTHERN: Mae Hong Son [Pai, 20 Dec. 2005, *P. Traiperm* 372 (BCU, BKF, KKU)], Chiang Mai [Doi Suthep, 11 Dec. 1957, *T. Smitinand* 3973 (BKF, K); Doi Inthanon, Sia Leung water falls, 17 Feb. 1979, *T. Koyama et al.* T-15,423 (AAU, BKF); 28 Feb. 1979, *T. Koyama et al.* T-15,586 (AAU); along trail above park wardens house, Chiang Doi Hills, 28 Sept. 2001, *S. Laegaard & M. Norsaengsri* 21641 (AAU); Doi Chiang Dao, 3 Dec. 1984, *W.N.* 1068 (AAU); 28 Nov. 2005, *P. Traiperm* 316 (BCU, BKF, KKU); Pha Hom Pok, 18 Dec. 2005, *P. Traiperm* 347, 19 Dec. 2005, *P. Traiperm* 348 (BCU, BKF, KKU); Wang Tao, 13 Feb. 1958, *Th. Sørensen et al.* 1080 (C, E, K); Doi Suthep, 27 Sept. 1990, *J.F. Maxwell* 90-1063 (CMU, L); on trail from Khun Wang highland, Mae John Luang, 11 Jan. 1986, *Y. Paisooksantivatthana* y 1748-86 (BK)]; SOUTH-WESTERN: Kanchanaburi [Huai Bankau, 9 Nov. 1971, *C.F. van Beusekom et al.* 3597 (BKF, C, P)].

Distribution.— Endemic to Thailand.

Ecology.— Common in Oak pine forest, roadsides, small ravine extending out from hillside. Grass 1-2 m. tall, along edge of small dried-up stream, at altitude 600-1,800 m altitude. Flowering between June and March.

Note.— Most materials of *M.* sp.1 in Thailand were identified as *M. striata*. This species is different from *M. striata* by having oblong lower glume of the sessile spikelet, indurate, 5–5.5 by 1.2–1.5 mm, apex with unequal wings, 7–8 longitudinal rows of small pits between the nerves of the back, margins at base puberulous, while ovate lower glume of the sessile spikelet, indurate, 4.5–5 by *ca.* 1.5 mm, apex with 2 apical wings, continuous ridge along the length and interrupted by tubercles or tubercle-based hairs on the back or glabrous in *M. striata*. It is very clear that I found the two taxa in their same locality.

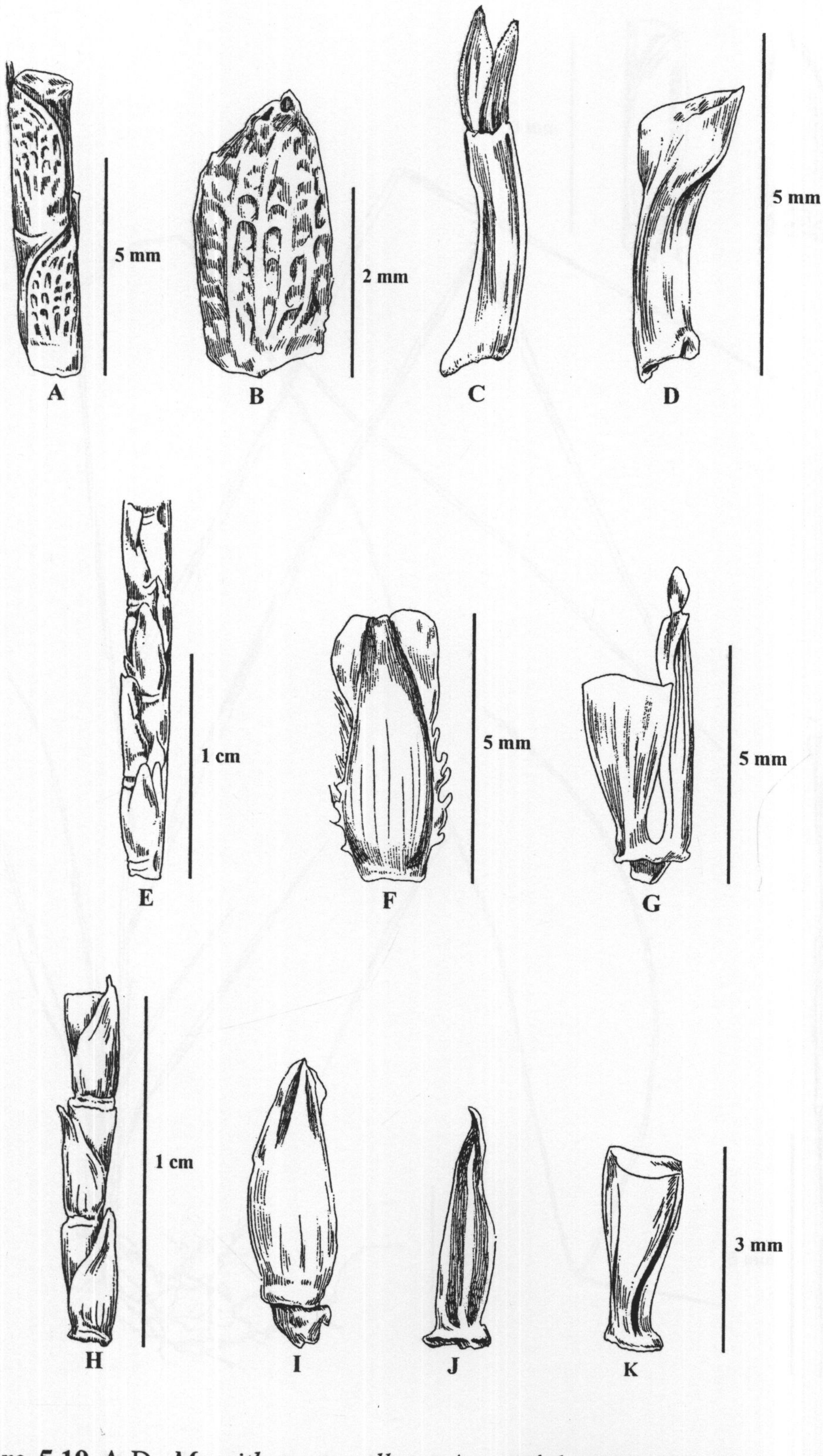

Figure 5.19 A-D. *Mnesithea cancellata*: A. partial raceme; B. lower glume of the sessile spikelet; C. pedicelled spikelet; D. rachis joint. E-G. *M. glandulosa*: E. partial raceme; F. lower glume of the sessile spikelet; G. rachis joint with pedicelled spikelet. H-K. *M. helferi*: H. partial raceme; I. lower glume of the sessile spikelet; J. pedicelled spikelet; K. rachis joint.

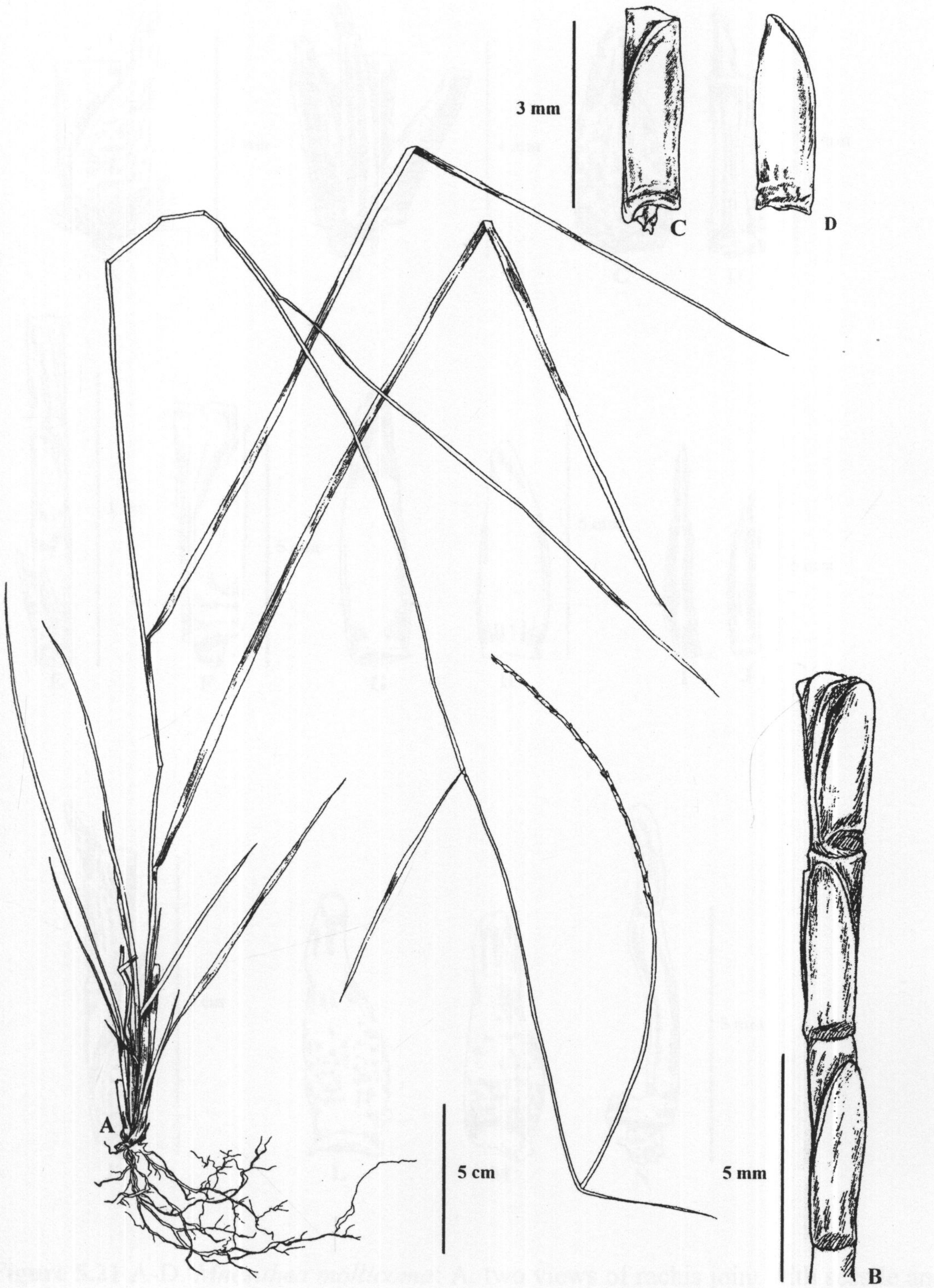

Figure 5.20 *Mnesithea laevis*: A. plant; B. partial raceme; C. spikelet pair; D. lower glume of the sessile spikelet. All line drawings were drawn by P. Traiperm from *P. Traiperm* 307.

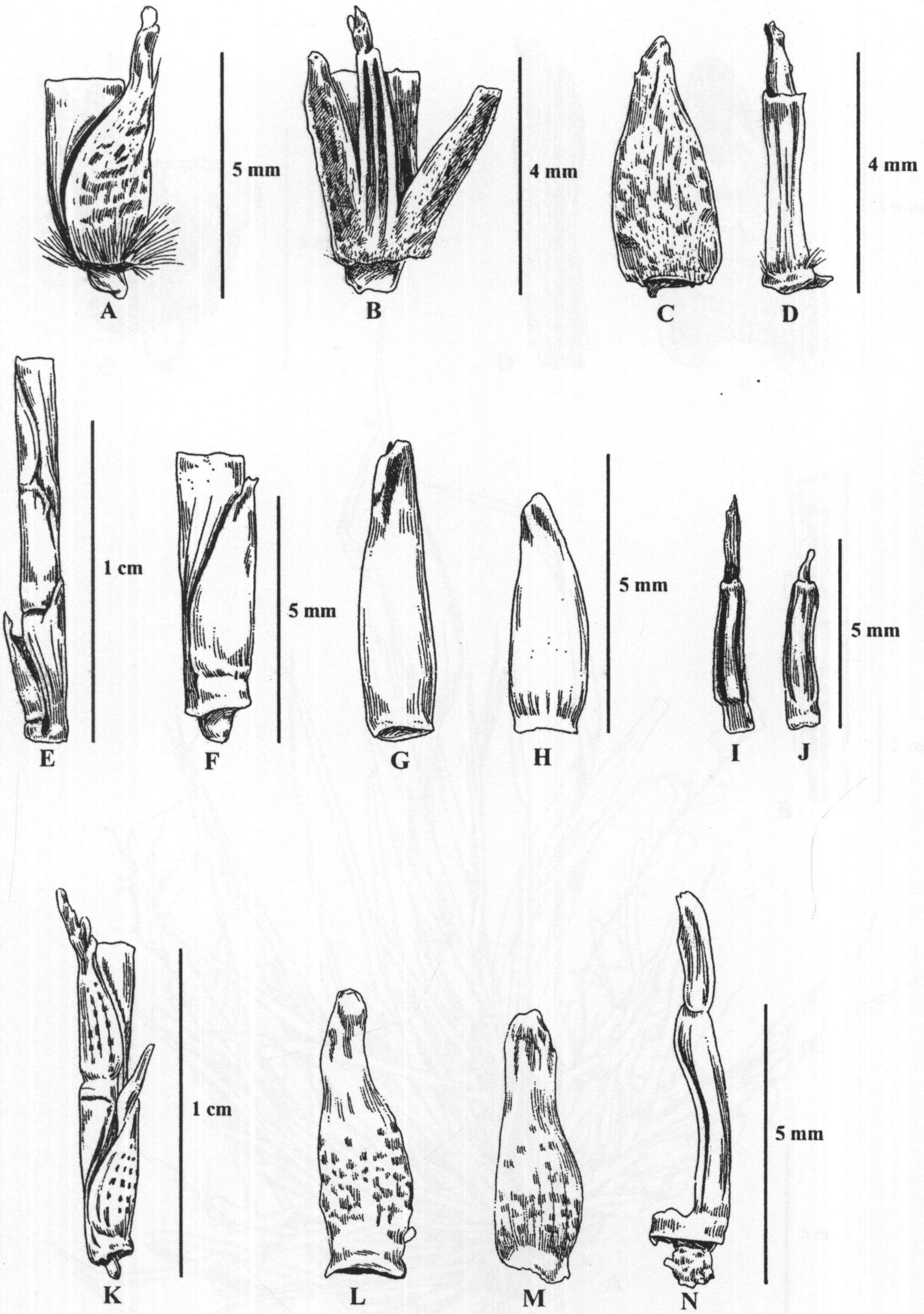

Figure 5.21 A-D. *Mnesithea mollicoma*: A. two views of rachis joint with sessile and pedicelled spikelet; B. three of spikelets; C. lower glume of the sessile spikelet; D. pedicelled spikelet. E-J. *M. striata*: E. partial raceme; F. rachis joint with sessile and pedicelled spikelet; G. & H. lower glume of the sessile spikelet; I. & J. pedicelled spikelet with rachis joint. K-N. *M. striata* var. *pubescens*: K. partial raceme; L. & M. lower glume of the sessile spikelet; N. pedicelled spikelet.

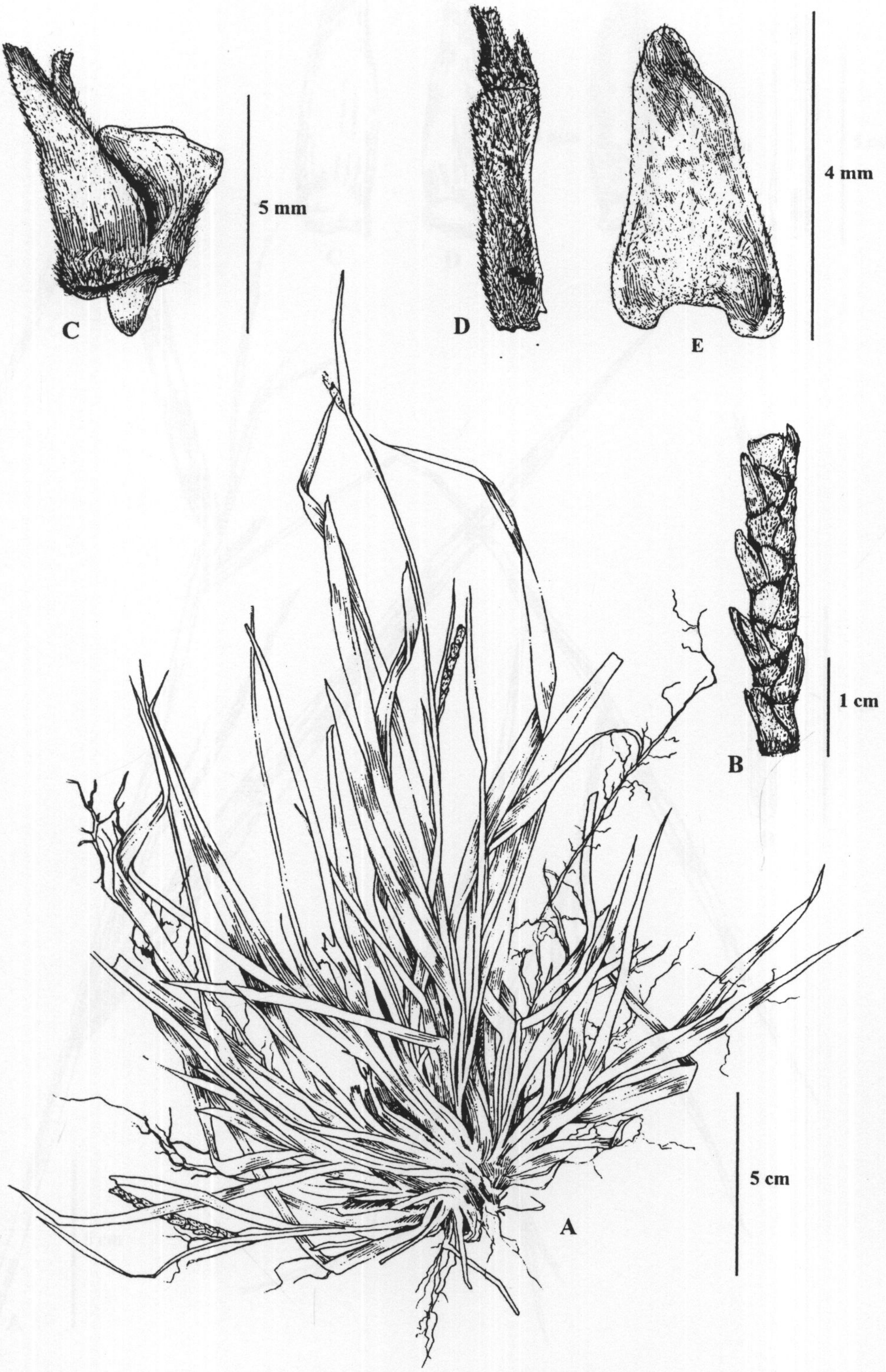

Figure 5.22 *Mnesithea thailandica*: A. plant; B. partial raceme; C. rachis joint with sessile and pedicelled spikelet; D. lower glume of the sessile spikelet; E. pedicelled spikelet with pedicel. All line drawings were drawn by P. Traiperm from the type specimen.

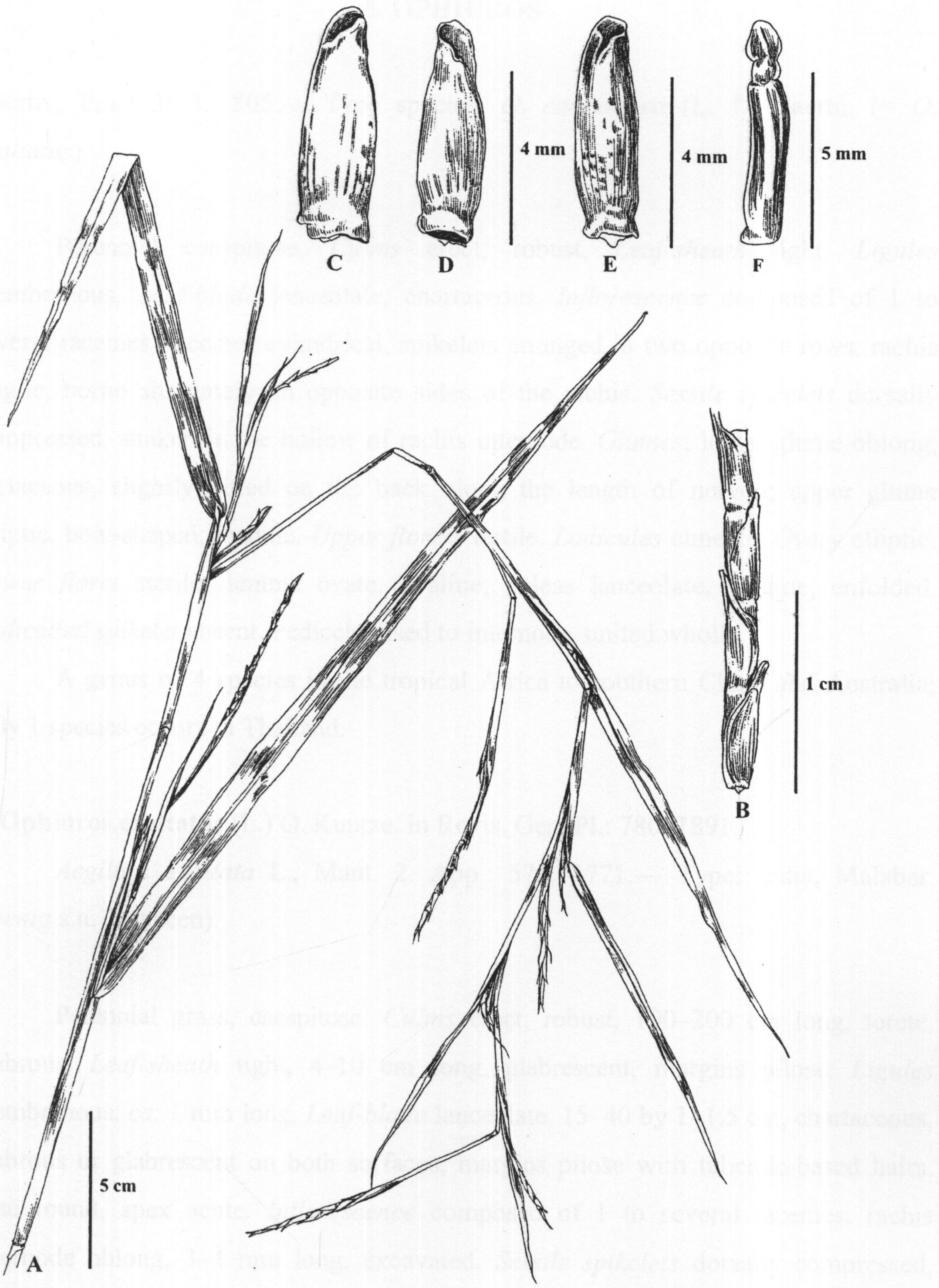

Figure 5.23 *Mnesithea* sp.1: A. plant; B. partial raceme; C-E. lower glume of the sessile spikelet; F. pedicelled spikelet. All line drawings were drawn by P. Traiperm from *P. Traiperm* 347.

5. OPHIUROS

Gaertn., Fruct. 3: 3. 1805.— Type species: *O. corymbosa* (L. f.) Gaertn. (= *O. exaltatus*).

Perennial caespitose. *Culms* erect, robust. *Leaf-sheath* tight. *Ligules* membranous. *Leaf-blade* lanceolate, chartaceous. *Inflorescence* composed of 1 to several racemes, racemes cylindrical, spikelets arranged in two opposite rows, rachis fragile, borne alternately on opposite sides of the rachis. *Sessile spikelets* dorsally compressed, sunken in the hollow of rachis internode. *Glumes*; lower glume oblong, coriaceous, slightly pitted on the back along the length of nerved; upper glume elliptic, boat-shaped, hyaline. *Upper florets* fertile. *Lodicules* cuneate. *Ovary* elliptic. *Lower floret* sterile; lemma ovate, hyaline; paleas lanceolate, hyaline, enfolded. *Pedicelled spikelet* absent. Pedicels fused to internode, united wholly.

A genus of 4 species in the tropical Africa to southern China and Australia; only 1 species occurs in Thailand.

1. Ophiuros exaltatus (L.) O. Kuntze. in Revis. Gen. Pl.: 780. 1891.

Aegilops exaltata L., Mant. 2. App.: 575. 1771.— Type: India, Malabar, *Koenig* s.n. (not seen).

Perennial grass, caespitose. *Culms* erect, robust, 100–200 cm long, terete, glabrous. *Leaf-sheath* tight, 4–10 cm long, glabrescent, margins pilose. *Ligules* membranous, *ca.* 1 mm long. *Leaf-blade* lanceolate, 15–40 by 1–1.5 cm, chartaceous, glabrous or glabrescent on both surfaces, margins pilose with tubercle-based hairs, base round, apex acute. *Inflorescence* composed of 1 to several racemes, rachis internode oblong, 3–4 mm long, excavated. *Sessile spikelets* dorsally compressed, 3.5–4 mm long, sunken in the hollow of rachis internode. *Glumes*; lower glume oblong, 3.5–4 by *ca.* 1 mm, 4–6-nerved, coriaceous, slightly pitted or distinct on the back along the length of nervea, apex acute; upper glume elliptic, boat-shaped, *ca.* 3 by 1 mm, 3–nerved, hyaline. *Upper florets* fertile; lemma elliptic, *ca.* 2.8 by 1 mm, hyaline, enfolded, apex acute; palea lanceolate, *ca.* 2.5 by 0.7 mm, hyaline. *Lodicules* cuneate, *ca.* 0.5 mm long. *Ovary* elliptic, *ca.* 0.4 mm long. *Lower floret* sterile; lemma ovate, *ca.* 2.8 by 1 mm long, hyaline, margins slightly enfolded; palea lanceolate, *ca.*

2.8 by 0.7 mm long, hyaline, enfolded. *Pedicelled spikelet* absent. Pedicels fused to internode, united wholly (Figs. 5.24 & 5.47A-C).

Thailand.— NORTH-EASTERN: Phetchabun [Nam Nao National Park, 20 Nov. 2004, *P. Traiperm* 176 (BCU, BKF, KKU)]; EASTERN: Chaiyaphum [Tungkamang, 15 Dec. 1971, *C.F. van Beusekom et al.* 4290 (C, K, L, P); 27 Nov. 2004, *P. Traiperm* 186 (BCU, BKF, KKU)]; CENTRAL: Saraburi [Ban Nang Bua, Za Kao Pat, 4 Oct. 1927, *Put* 1150 (BK, BM, K)].

Distribution.— China, India, Indo-China, Malesia, Australia.

Ecology.— Growing in moist savannah on clayey soil, at 800-2,200 m altitude. Flowering between October and December.

Vernacular.— Ya khao phot phi (หญ้าข้าวโพดผี) (Saraburi).

Notes.— *Put* 1150 and *C.F. van Beusekom et al.* 4290 with a deeply pitted or distinct on the back along the length of nerves in lower glume of sessile spikelet.

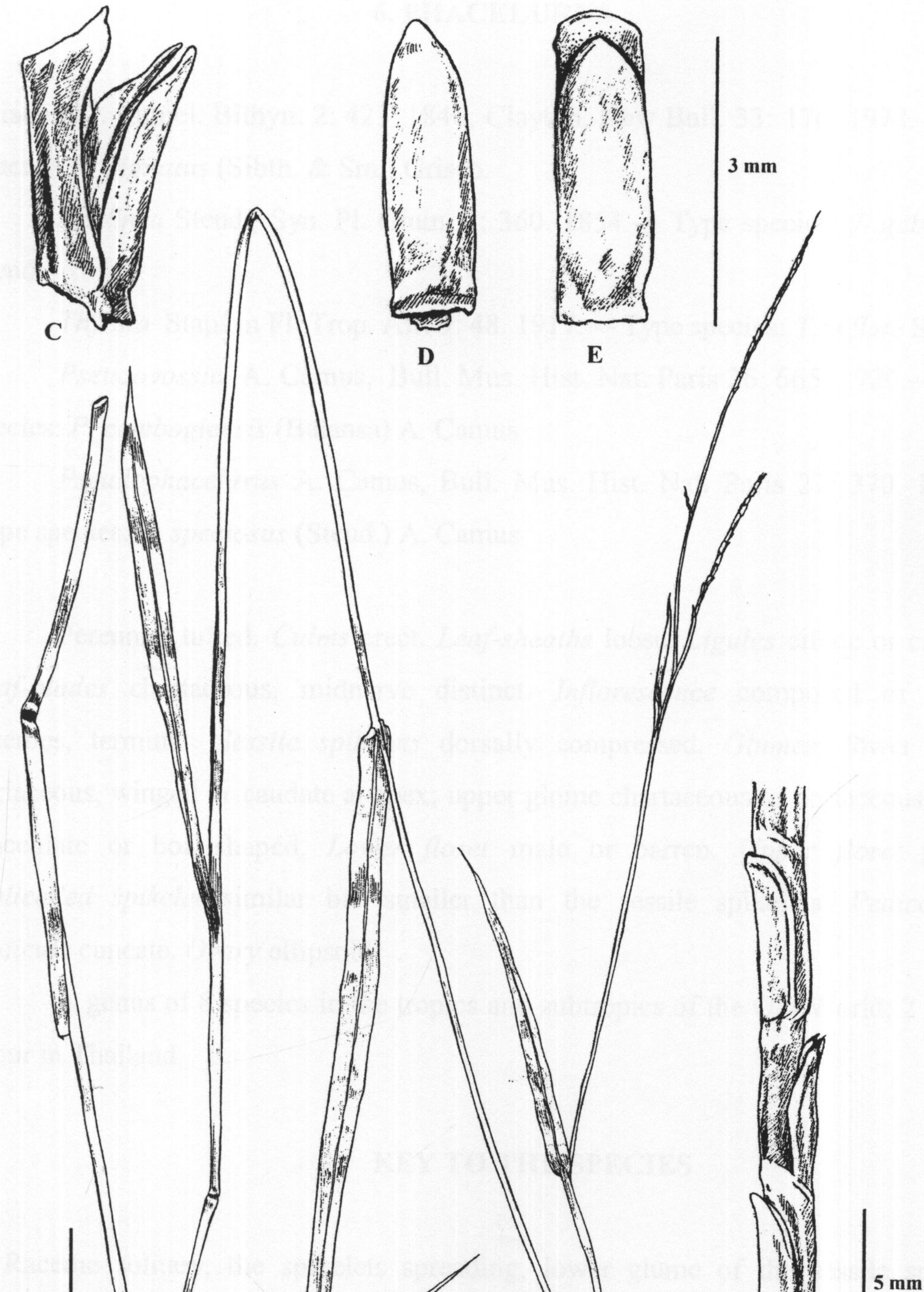

Figure 5.24 *Ophiuros exaltatus*: A. plant; B. partial raceme; C. spikelet pairs; D. lower glume of the sessile spikelet; E. joint. All line drawings were drawn by P. Traiperm from *P. Traiperm* 176.

6. PHACELURUS

Griseb., Fl. Rumel. Bithyn. 2: 423. 1846; Clayton, Kew Bull. 33: 176. 1978.— Type species: *P. digitatus* (Sibth. & Sm.) Griseb.

Jardinea Steud., Syn. Pl. Glum. 1: 360. 1854.— Type species: *J. gabonensis* Steud.

Thyrsia Stapf in Fl. Trop. Afr. 9: 48. 1917.— Type species: *T. inflate* Stapf

Pseudovossia A. Camus, Bull. Mus. Hist. Nat. Paris 26: 665. 1920.— Type species: *P. cambogiensis* (Balansa) A. Camus

Pseudophacelurus A. Camus, Bull. Mus. Hist. Nat. Paris 27: 370. 1921.— Type species: *P. speciosus* (Steud.) A. Camus

Perennial tufted. *Culms* erect. *Leaf-sheaths* loose. *Ligules* ciliate or ciliolate. *Leaf-blades* chartaceous, midnerve distinct. *Inflorescence* composed of several racemes, terminal. *Sessile spikelets* dorsally compressed. *Glumes*; lower glume, coriaceous, winged or caudate at apex; upper glume chartaceous or coriaceous, ovate, lanceolate or boat-shaped. *Lower floret* male or barren. *Upper floret* perfect. *Pedicelled spikelet* similar but smaller than the sessile spikelets. *Pedicel* free. *Lodicule* cuneate. *Ovary* ellipsoid.

A genus of 8 species in the tropics and subtropics of the Old World; 2 species occur in Thailand.

KEY TO THE SPECIES

1. Raceme solitary, the spikelets spreading, lower glume of the sessile spikelets lanceolate, 16–17 by *ca.* 1.5 mm **1. P. cambogiensis**
1. Raceme borne on along central axis, lower glume of the sessile spikelets oblong or narrowly ovate, 3–3.5 by 1–1.2 mm **2. P. zea**

1. Phacelurus cambogiensis (Balansa) Clayton, Kew Bull. 33 (2): 177. 1978.

Vossia cambogiensis Balansa, Journ. Bot. (Morot) 4: 109. 1890.— Type: Cambodia, Toule-sap, *Godefroy* 129 (holotype L!, isotype K!).

Pseudovossia cambogiensis (Balansa) A. Camus, Bull. Mus. Hist. Nat. Paris 26: 665. 1920.

Perennial, tufted. *Culms* erect, *ca.* 45 cm tall, slender, terete, internodes glabrous, nodes glabrous or slightly hairy. *Leaf-sheaths* loose, glabrous. *Ligules* ciliate. *Leaf-blades* 30–50 by 0.5–0.7 cm, chartaceous, glabrous or glabrescent on both surfaces, margins scabrous, midnerve distinct. *Inflorescence* composed of racemes, raceme solitary, the spikelets spreading, up to 20 cm long, rachis internodes and nodes glabrous. *Sessile spikelets*. *Glumes*; lower glume lanceolate, 16–17 by *ca.* 1.5 mm, coriaceous, glabrous on the back, scabrous wing on keel, tapering to apex, caudate; upper glume lanceolate-acumonate, 11–12 by *ca.* 1 mm, coriaceous, glabrous on the back, scabrous wing on keel. *Lower floret* male, lemma linear, 9–10 by *ca.* 1 mm, hyaline, folded upper margins scabrous; palea lanceolate-acute, 7–7.5 by *ca.* 0.8 mm, hyaline, slightly folded. *Lodicules ca.* 1.5 mm long. *Anthers ca.* 2 mm long. *Upper floret*; lemma linear, *ca.* 8 by 0.8 mm, hyaline, folded; palea linear, *ca.* 7 by 0.8 mm, hyaline, folded. *Ovary ca.* 1.5 mm long. *Pedicelled spikelet* usually resembling the sessile spikelet. *Pedicels* oblong, flattened. *Glumes*; lower glume linear-obtuse, 22–23 by *ca.* 1.5 mm, obliquely plicate, coriaceous, scabrous wing on keel, glabrous on the back, apex caudate; upper glume lanceolate, 10–11 by *ca.* 1.3 mm, coriaceous, plicate, scabrous wing on keel on the back. *Lower floret*; lemma lanceolate, plicate, 8–9 by *ca.* 1 mm, hyaline, folded, upper margins ciliate; palea linear-obtuse, 7–8 by *ca.* 0.8 mm, hyaline, folded. *Anthers ca.* 2 mm long. *Upper floret*; lemma lanceolate-acuminate, 7–7.5 by *ca.* 1 mm, hyaline, folded upper margins scabrous; palea linear, 6.5–7 mm long, hyaline, folded (Fig. 5.47D-F).

Thailand.— NORTH-EASTERN: Nakhon Ratchasima [Phimai, Sai Ngam, 26 Aug. 1958, *T. Smitinand* 4781 (K); Phimai, 27 Dec. 1958, *T. Smitinand* 5046 (BK, K)].

Distribution.— Cambodia.

Ecology.— Tufted grass, common along edge of swampy, at 200-250 m altitude. Flowering between August and December.

Notes.— *P. cambogiensis* was recorded only two times from Thailand. I can not be collected even their original localities.

2. Phacelurus zea (C.B. Clarke) Clayton, Kew Bull. 33 (2): 177. 1978.

Rottboellia zea C.B. Clarke, J. Linn. Soc., Bot. 25: 86, t. 35. 1889.— Type: India, Muneypore, *C.B. Clarke* 41980 (holotype K!).

R. thyrsoidea Hack. in DC., Monogr. Phan. 6: 283. 1889.— Type: India, Khasia, *J.D. Hooker & T. Thomson* s.n. (isotypes K!, L!).

Thyrsia thyrsoidea (Hack.) A. Camus in Bull. Mus. Hist. Nat. Paris 27: 369. 1921.

T. zea (C.B. Clarke) Stapf in Hook., Ic. Pl. 31: t. 3078. 1922.

Perennial grass, tufted, large stout plant. *Culms* erect, up to 2.5 m tall, terete, internodes glabrous, nodes ciliate. *Leaf-sheaths* loose, 15–30 cm long, glabrous, margins with white pilose hairs. *Ligules* ciliolate. *Leaf-blades* oblong-lanceolate, 30–150 by 1–1.5 cm, chartaceous, adaxial suface scabrous and slightly long hairy sometimes short hairs, abaxial surface glabrous, midnerve distinct, margins scabrous and slightly pilose, apex acuminate. *Inflorescence* compound racemose, terminal, composed of numerous racemes (25–45), borne along a central axis, central inflorescent axis up to 50 cm long, rachis semi-terete, glabrous, rachis internodes cuneate, 3–8 mm long, glabrous. *Sessile spikelets* ovate, dorsally compressed, 3–4 mm long, callus truncate. *Glumes*; lower glume oblong or narrowly ovate, 3–3.5 by 1–1.2 mm, coriaceous, muticous keeled and narrowly winged all along the margins, scabrous; upper glume ovate, boat-shaped, 3–3.5 by *ca.* 1 mm, 3-nerved, chartaceous, keeled along the back and scabrous, apex acute. *Lower floret* male or barren; lemma narrowly ovate, 3–3.2 by *ca.* 1 mm, 3-nerved, hyaline, margins enfolded; palea absent. *Upper floret* perfect; lemma ovate, boat-shaped, *ca.* 3 by 1 mm, hyaline, keeled along the back; palea lanceolate, *ca.* 2 by 0.5 mm, hyaline, margins enfolded. *Pedicelled spikelet* usually resembling but smaller than the sessile spikelet. *Pedicels* linear, flattened, 1–2 mm long. *Glumes*; lower glume oblong-ovate, 3–3.5 by *ca.* 0.1 mm, coriaceous, with scabrous wing along the margins, apex acute; upper glume boat-shaped, *ca.* 3 by 1 mm, subcoriaceous, with scabrous wing on keeled on the back, apex acute. *Lower floret*; lemma oblong-ovate, *ca.* 3 by 0.8 mm, 3-nerved, hyaline, apex acute, folded; palea absent. *Upper floret*; lemma oblong-ovate, 2.5–3 by *ca.* 0.8 mm, hyaline, folded; palea ovate, 2–2.5 by *ca.* 0.8 mm, hyaline, folded, apex acute. *Caryopsis* ellipsoid, *ca.* 1.5 mm long (Fig. 5.48A-D).

Thailand.— NORTH-EASTERN: Phetchabun [Pine Grove, 1 Jun. 1960, *T. Smitinand* 6307 (BKF); Tung Salaeng Luang Nat. Park 17 Nov. 2005, *P. Traiperm* 282 (BCU, BKF, KKU)]; EASTERN: Chaiyaphum [Tungkamang, 14 Dec. 1971, *C.F. van Beusekom et al.* 4267 (K, L, P), 19 Oct. 2005, *P. Traiperm* 222 (BCU, BKF, KKU)].

Distribution.— India, Indo-China.

Ecology.— Tufted grass, common in oak and pine forest on clayey soil, at altitude 800-900 m. Flowering between June and December.

Notes.— *Phacelurus zea* is easily recognised from *P. cambogiensis* by a robust plant with a compound racemes inflorescence on terminal, which composed of numerous racemes (25–45) borne along a central axis.

7. ROTTBOELLIA

L. f., Nov. Gram. Gen.: 23. 1779. & Suppl. Pl.: 114. 1781. *nom. cons. non* Scop. 1777.— Type species: *R. exaltata* L. f. (= *R. cochinchinensis*).

Stegosia Lour., Fl. Cochin.: 51. 1790.— Type species: *S. cochinchinensis* Lour.

Robynsiochloa Jac.-Fél. in J. Agric. Trop. 7: 406. 1960.— Type species: *R. purpurascens* (Robyns) Jac.-Fél.

Annual tufted. *Culms* erect. *Leaf-sheaths* tight, hirsute. *Ligules* membranous with ciliolate margins. *Leaf-blades* linear-lanceolate or broadly linear. *Inflorescence* racemes, terminal and axillary. *Sessile spikelets* fertile and sunk in concavities on lateral internodes of rachis. *Glumes*; lower glume ovate, coriaceous, smooth, 2-toothed; upper glume boat-shaped, subcoriaceous. *Lower floret* staminate. *Upper floret* perfect. *Pedicelled spikelet* staminate or neutral, reduced and compressed. *Pedicel* wholly fuse to the internodes.

A genus of 4 species in the Old World tropics and introduced to the Caribbean; 1 species occurs in Thailand.

1. Rottboellia cochinchinensis (Lour.) Clayton, Kew Bull. 35 (4): 817. 1981.

Stegosia cochinchinensis Lour., Fl. Cochich. 1: 51. 1790.— Type: Cochinchina, (holotype BM!, isotypes K!; L!).

R. exaltata L. f., Suppl. Pl.: 114. 1781, non (L.) L. f., Nov. Gram. Gen.: 23: 37. 1779.— Type: In Indiis, *Thunberg* (holotype LINN!).

Ophiuros appendiculatus Steud.— Type: Javanica, *Zollingero* 7257 (holotype P!, isotype L!).

Annual grass. *Culms* erect, 0.7–2 m tall, terete, internodes solid, supported below by stilt roots, hirsute. *Leaf-sheaths* tight, terete, usually more hirsute, margins open. *Ligules* membranous with ciliolate hairs, brown. *Leaf-blades* linear-lanceolate or broadly linear, up to 45 by 1–2 cm, scabrous with minute stiff hairs above, very rough along margins, apex tapering to a long fine point. *Inflorescence* racemes, terminal and axillary, 1–4 racemes together, several inflorescences per culm, 8–15 by 0.2–0.3 cm. *Sessile spikelets* fertile and sunk in concavities on lateral internodes of rachis. *Glumes*; lower glume ovate, 4.5–5 by *ca.* 2 mm, 9–11-nerved, coriaceous, smooth or very slightly rough on the back, subacute at apex, entire or very minutely 2-toothed; upper glume boat-shaped, 9–12-nerved, subcoriaceous, apex acute. *Lower floret* staminate; lemma boat-shaped, 3-4 by 1.4–1.5 mm, 3-nerved, membranous, apex acute; palea ovate, 4–4.5 by 1.6–1.7 mm, 2-nerved, membranous acute. *Lodicules* conical, 4–5 mm long, entire marginal. *Anthers ca.* 2 mm long, brown. *Upper floret* perfect; lemma boat-shaped, obliquely ovate, 3–3.5 by 3.5–4 mm, 3-nerved, chartaceous; palea hastate, 2.5–3 mm long, 2-nerved, membranous. *Anthers* 2.3–3 mm long, purple or brown. *Ovary* elliptic, 1–1.5 mm long. *Stigmas* purple. *Pedicelled spikelet* staminate or neutral, reduced and compressed, 3.5–4 mm long. *Pedicels* wholly fused to the internodes, flattened (Figs. 5.25 & 5.48E-G).

Thailand.— NORTHERN: Mae Hong Son [Pai, Ban Tah By, near by river, Tung Yo, 12 Sept. 1992, *J.F. Maxwell* 92-535 (AAU, E, L, P)], Chiang Mai [Hahng Dong, Huai Din Dam, Nam Prae, 29 Aug. 1987, *J.F. Maxwell* 87-913 (CMU, L); Chom Thong, Mae Soi Valley, 6 Sept. 1992, *J.F. Maxwell* 92-513 (P); Doi Saket, Huai Hong Khrai Royal Development Project, 8 Nov. 1993, *S. Suwannaratana* 35 (L); Doi Suthep, 11 Aug. 1996, *BGO. Staff* 7051 (QBG); Sangampaeng, Doi Mueang Awn, W side, Sahagawn, Mae Awn, 15 Sept. 1998, *P. Palee* 399 (L); above Training Center of Queen Sirikit Botanical Garden, 5 Oct. 2001, *S. Laegaard* 21676 (AAU)], Lampang [Wahng Nua, Doi Luang National Park, near Wahng Gayo Falls, Ban Hang, 22 Apr. 1997, *J.F. Maxwell* 97-383 (BKF, L)], Tak [Bhumipol Dam, *Bunnak* 533

(BK); Tha Ki Lek, 19 Nov. 1961, *K. Larsen* 8327 (C); Hat Palom, 20 Dec. 1961, *K. Larsen* 8855 (C, K); along Huai Mae Lamao, *ca.* 60 km W of Tak, 23 Jul. 1973, *G. Murata et al.* T-16831 (BKF, L, P)]; NORTH-EASTERN: Loei [Phu Kradueng, 16 Dec. 1954, *T. Smitinand* 2114 (BKF, K); 25 Aug. 1994, *BGO. Staff* s.n. (QBG); Phu Luang National Park, 14 Oct. 2000, *M. Norsangsri* 1087 (QBG)], Sakon Nakhon [23 Oct. 1931, *A.F.G. Kerr* 20565 (BK, BM, K); Phu Phan, 12 May 1958, *Ploenchit* 2015 (BKF)], Khon Kaen [Phu Khiao, *ca.* 80 km E of Phetchabun, 11 Aug. 1984, *G. Murata et al.* T-41776 (BKF); Mueang, 31 Jul. 2004, *P. Traiperm* 115 (BCU, BKF, KKU); 6 Oct. 2004, *P. Traiperm* 128 (BCU, BKF, KKU); Mancha Khiri, 24 Aug. 2005, *P. Traiperm* 208 (BCU, BKF, KKU)]; EASTERN: Nakhon Ratchasima [Pak Chong, 9 May 1958, *T. Smitinand* 4860 (BKF)]; SOUTH-WESTERN: Uthai Thani [Thum Prayarpaishu, 7 Sept. 1975, *S. Sutheesorn* 3429 (BK)], Kanchanaburi [Sai Yok, 40 Jul. 1963, *K. Larsen* 10504 (C, K); Si Sawat, 12 Aug. 1970, *C.P. et al.* 2916 (AAU, K, L)], Prachuap Khiri Khan [Cha-um, 15 Apr. 1960, *C. Chermsirivathana* s.n. (BK); Khao Sam Roi Yot, Kui Buri, 25 Oct. 1973, *S. Sutheesorn* 2698b (BK); Bang Sapan Noi, 24 Aug. 1996, *BGO. Staff* 210 (QBG)]; CENTRAL: Chai Nat [Mae Klang, 12 Apr. 1953, *K. Suvathabhandhu* 387 (BK)], Lop Buri; [Dong Pa Ya Yen, Chai Badan, 15 Dec. 1923, *A.F.G. Kerr* s.n. (BM); along road, S of Lop Buri, 23 Sept. 1971, *G. Murata et al.* 14818 (BKF, P); along route 21, *ca.* 9 km N from the junction of route 1 and 21, 20 Oct. 1984, *G. Murata et al.* T-38219 (BKF); Bencha Khiri temple, Phathana Nikhom, 30 Aug. 2001, *R. Pooma et al.* 2998 (BKF, L)], Suphan Buri [Uthong, 15 Apr. 2004, *P. Traiperm* 193 (BCU, BKF, KKU)], Saraburi [Muak Lek, Waste-land, 10 Feb. 1963, *T. Smitinand & H. Sleumer* s.n. (BKF); Khao Talu, Na Pra Larn, 6 Oct. 1979, *T. Shimizu et al.* T-18014 (AAU, BKF, L); 29 Sept. 1991, *K. Larsen et al.* 42100 (AAU)], Krung Thep Maha Nakhon [20 Jun. 1920, *A.F.G. Kerr* 4283 (BM, K, TCD); 28 Sept. 1923, *A.F.G. Kerr* 7854 (BK, BM, K, TCD); Bang Khen, 10 Sept. 1958, *T. Smitinand* 5400 (BKF); Bang Ka Pi, 26 Jul. 2004, *P. Traiperm* 114 (BCU, BKF, KKU)], Samut Prakan [Bahng Grah Jow Temple, Phra pradaeng, 8 Aug. 1971, *J.F. Maxwell* 71-471 (AAU, L)]; SOUTH-EASTERN: Prachin Buri [Krabin Buri, 5 Sept. 2004, *P. Traiperm* 194 (BCU, BKF, KKU)], Chon Buri [Si Racha, 9 Dec. 1927, *D.J. Collins* 1911 (BK, K); Sattahip, 2 Nov. 2004, *P. Traiperm* 151 (BCU, BKF, KKU)], Chanthaburi [Pong Nam Ron, Wang Kaphae, 10 Aug. 1956, *T. Smitinand* 3545 (BKF)]; PENINSULAR: Songkhla [Mueang, 18 Oct. 2004, *P. Traiperm* 133 (BCU, BKF, KKU)].

Distribution.— Worldwide.

Ecology.— Weed on roadsides in open area, at sea level up to 1,300 m altitude. Flowering throughtout the year.

Vernacular.— Ya ko (หญ้ากอ) (Trat); Ya khayong (หญ้าโขย่ง) (Krung Thep Maha Nakhon); Ya prong khai (หญ้าโปร่งคาย) (Lampang); Itchgrass, Corngrass.

Notes.—*Rottboellia cochinchinensis* is readily distinguished from others genus in subtribe Rottboelliinae by the internodes of the inflorescence are corky. This species is variable in size and likely to spread further as it is one of the world's worst weed.

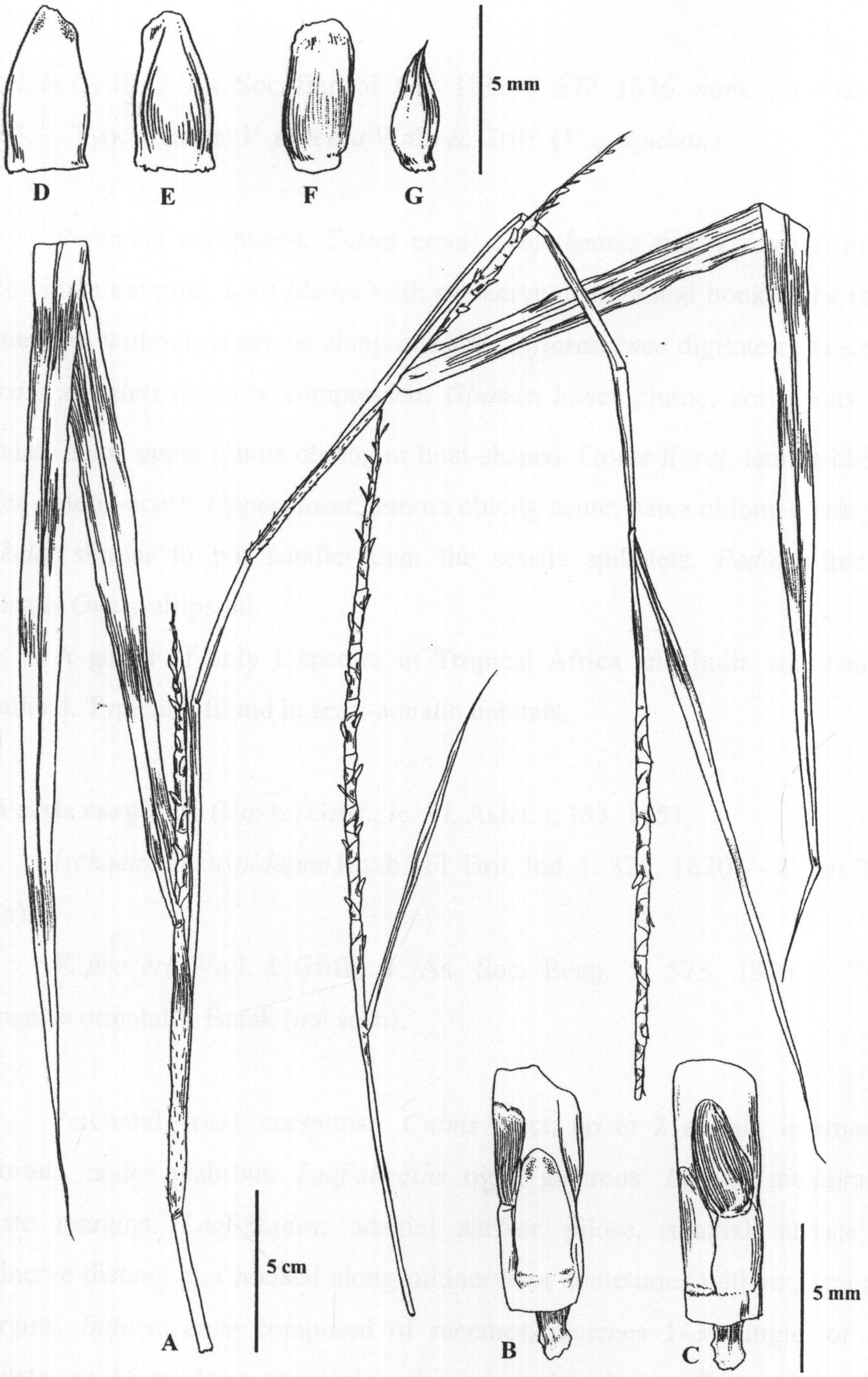

Figure 5.25 *Rottboellia cochinchinensis*: A. plant; B. & C. spikelet pairs (two views); D. & E. lower glume of the sessile spikelet; F. lower glume of the pedicelled spikelet; G. upper glume of the pedicelled spikelet. All line drawings were drawn by P. Traiperm from *P. Traiperm* 133.

8. VOSSIA

Wall. & Griff., J. As. Soc. Bengal. Nat. Hist. 5: 572. 1836. *nom. cons. non* Adanson 1763.— Type species: *V. procera* Wall. & Griff. (*V. cuspidata*).

Perennial caespitose. *Culms* erect. *Leaf-sheaths* tights. *Ligules* membranous with ciliate margins. *Leaf-blades* with midnerve distinct and hook along midnerve or sometimes without, scabrous along margins. *Inflorescence* digitate racemes, terminal. *Sessile spikelets* dorsally compressed. *Glumes*; lower glume, coriaceous, with long caudate apex; upper glume oblong or boat-shaped. *Lower floret*; lemma oblong-acute; palea oblong-acute. *Upper floret*; lemma oblong-acute; palea oblong-acute. *Pedicelled spikelet* similar to but smaller than the sessile spikelets. *Pedicel* free. *Lodicule* cuneate. *Ovary* ellipsoid.

A genus of only 1 species in Tropical Africa and India and also occurs in Thailand. Typically found in semi-aquatic habitats.

1. Vossia cuspidata (Roxb.) Griff., Ic. Pl. Asiat. t. 153. 1851.

Ischaemum cuspidatum Roxb., Fl. Brit. Ind. 1: 325. 1820.— Type: Bengal (not seen).

V. procera Wall. & Griff., J. As. Soc. Beng. 5: 573. 1836.— Type: India Bengalae orientalis, Barak (not seen).

Perennial grass, caespitose. *Culms* erect, up to 2 m tall, internodes terete, glabrous, nodes glabrous. *Leaf-sheaths* tight, glabrous. *Ligules* membranous with ciliate margins. *Leaf-blades*; adaxial surface pilose, abaxial surface glabrous, midnerve distinct and hooked along midnerve or sometimes without, scabrous along margins. *Inflorescence* composed of racemes, racemes 1–3: single, or paired, or digitate, *ca.* 15 cm long, terminal, rachis internodes clavate, flattened, *ca.* 1 cm long, scabrous along keel, nodes glabrous or slightly scabrous. *Sessile spikelets* dorsally compressed. *Glumes*; lower glume oblong-ovate, indurate, 2.3–2.5 cm by *ca.* 3.5 mm, coriaceous, glabrous on the back but scabrous along margins, with long caudate apex; upper glume oblong or boat-shaped, 10.5–11 by *ca.* 3.0 mm, 3-nerved, keeled along the upper part on the back and scabrous along keel, apex acute. *Lower floret*; lemma oblong-acute, 9–9.5 by 1.8–2 mm, hyaline, glabrous but hairy along margins, folded; palea oblong-acute, *ca.* 7.5 by 1.2 mm, hyaline, glabrous, folded. *Upper floret*; lemma oblong-acute, *ca.* 7.5 by 1.5 mm, hyaline, hairy along margins, folded; palea oblong-acute, *ca.* 8 by 1 mm, hyaline, slightly hairs along the upper margins, folded. *Lodicule* cuneate, *ca.* 0.8 mm long. *Ovary* ellipsoid, *ca.* 1 mm long. *Pedicelled spikelet* very similar to but smaller than the sessile spikelets. *Pedicels* cuneate, flattened, 7–8 mm long, scabrous along margins. *Glumes*; lower glume oblong-ovate, 2.3–2.4 by 2.5–2.8 mm, glabrous on the back, with scabrous margins, with long caudate apex; upper glume oblong-ovate or boat-shaped, *ca.* 8.5 by 2 mm, keeled on the upper back, scabrous along keeled, upper margins hairy, apex acute. *Lower floret*; lemma oblong-acute, *ca.* 7 by 1.5 mm, hyaline, glabrous, folded; paleas oblong-ovate, *ca.* 6.5 by 1 mm, hyaline, folded, apex acute, glabrous. *Upper floret*; lemma oblong-ovate, *ca.* 6.5 by 1 mm, hyaline, glabrous slightly folded; palea ovate, *ca.* 6.5 by 1.5 mm, hyaline, hairy along the upper margins, folded (Figs. 5.26 & 5.49).

Thailand.— CENTRAL: Krung Thep Maha Nakhon [Bang Khen, 1 Oct. 1960, *C. Chermsirivathana* s.n. (BK)].

Distribution.— Throughout tropical Africa and Southeast Asia.

Ecology.— Growing on the canal banks, at sea level. Flowering in October.

Notes.— Only one collection of *V. cuspidata* in BK herbarium has been recorded.

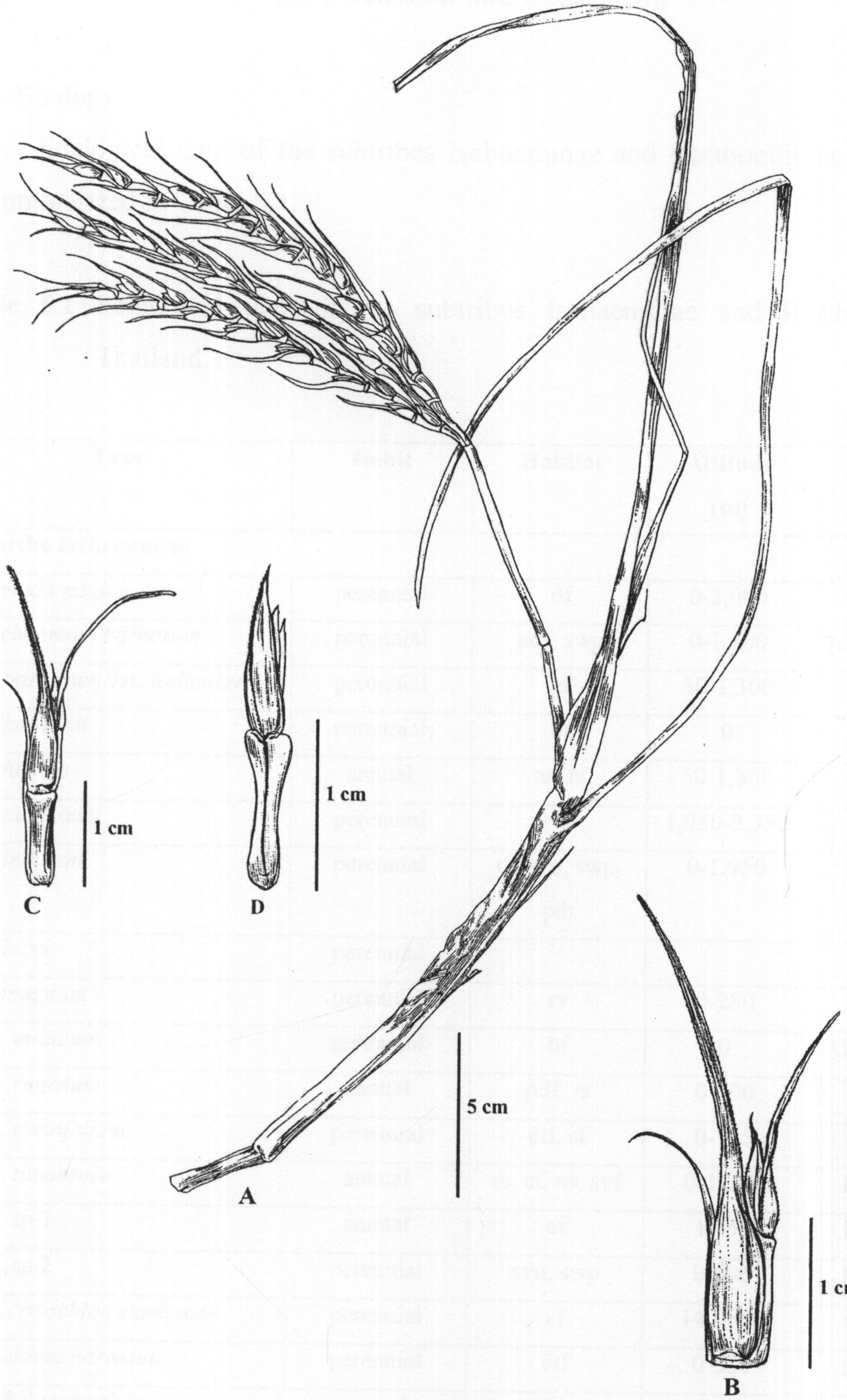

Figure 5.26 *Vossia cuspidata*: A. plant; B. & C. spikelet pairs; D. upper glume of the sessile spikelet with joint. All line drawings were drawn by P. Traiperm from *C. Chermsirivathana* s.n. (BK).

5.3 Discussion and Conclusion

5.3.1 Ecology

Ecological data of the subtribes Ischaeminae and Rottboelliinae in Thailand are summarized in Table 5.1.

Table 5.1 Ecological data of the subtribes Ischaeminae and Rottboelliinae in Thailand.

Taxa	Habit	Habitat	Altitude (m)	Flowering periods
Subtribe Ischaeminae				
1. *Apluda mutica*	perennial	df	0-2,000	Aug.-May
2. *Ischaemum barbatum*	perennial	pdf, swp	0-1,300	All year round
3. *I. barbatum* var. *lodiculare*	perennial	pf	50-1,300	Jun.-Mar.
4. *I. hansenii*	perennial	bf	0	Nov.
5. *I. hirtum*	annual	ns, rs	50-1,300	Nov.-Dec.
6. *I. hubbardii*	perennial	svn	1,950-2,350	Oct.-Nov.
7. *I. indicum*	perennial	rs, svn, swp, pdf	0-1,950	Sept.-Apr.
8. *I. lacei*	perennial	–	–	Nov.
9. *I. magnum*	perennial	rv	0-280	Sept.-Apr.
10. *I. muticum*	perennial	bf	0	All year round
11. *I. rugosum*	annual	pdf, rs	0-800	Apr.-Jan.
12. *I. tenuifolium*	perennial	dtf, sf	0-125	Oct.-Dec.
13. *I. timorense*	annual	rs, ef, ns, svf	0-1,500	Nov.-Mar.
14. *I.* sp.1	annual	ef	1,450	Dec.-Mar.
15. *I.* sp.2	perennial	svn, swp	0-600	Nov.-Mar.
16. *Kerriochloa siamensis*	perennial	sf	140-600	Oct.-Dec.
17. *Sehima nervosum*	perennial	dtf	0-950	Sept.-Apr.
18. *Thelepogon elegans*	annual	df, rs	50-300	Oct.-Dec.
Subtribe Rottboelliinae				
19. *Eremochloa attenuata*	perennial	dtf	450-1,800	Nov.-May
20. *E. bimaculata*	perennial	dtf	50-650	May-Sept.
21. *E. ciliaris*	perennial	dtf, df, pf	0-2,200	All year round
22. *E. ciliatifolia*	annual	dtf, pf	250-1,300	May-Nov.
23. *E. eriopoda*	perennial	dtf, df	0-210	Aug.-Jan.

Table 5.1 Ecological data of the subtribes Ischaeminae and Rottboelliinae in Thailand (Cont.).

Taxa	Habit	Habitat	Altitude (m)	Flowering periods
24. *E. lanceolata*	annual	sf, dtf	125	Oct.
25. *E. maxwellii*	perennial	df	125	Oct.
26. *E. muricata*	perennial	df	0-50	Jul.-Nov.
27. *E. peltelotii*	perennial	pdf	250	Sept.-Dec.
28. *E.* sp.1	perennial	dtf	300	Aug.-Sept.
29. *E.* sp.2	annual	ns	1,300	Oct.
30. *Hackelochloa granularis*	annual	dtf	1,450	Jul.-Mar.
31. *H. porifera*	annual	bb, wd	1,500	Sept.-Nov.
32. *Hemarthria altissima*	perennial	pf	1,300	Mar.
33. *H. compressa*	perennial	swp, rs	1,300	Mar.-Nov.
34. *H. debilis*	annual	swp	50	Jul.
35. *H. longiflora*	perennial	swp	5-2,350	Apr.-Oct.
36. *H. pratensis*	perennial	pf	1,300	Oct.-Mar.
37. *H. stolonifera*	perennial	swp	0	Jun.
38. *Mnesithea cancellata*	perennial	df, swp	50-1,300	Jul.-Apr.
39. *M. glandulosa*	perennial	ns, df	0-1,100	May-Jan.
40. *M. helferi*	perennial	ef, df, swp	25-200	Apr.-Dec.
41. *M. laevis*	perennial	df, dtf, pf	400	Jul.-May
42. *M. mollicoma*	perennial	df	1,200	All year round
43. *M. striata*	perennial	dtf, ef	1,225	Jun.-Feb.
44. *M. striata* var. *pubescens*	perennial	df	100-2,200	Sept.-Apr.
45. *M. thailandica*	perennial	pdf	100	Jun.
46. *M.* sp.1	perennial	pf	60-1,800	Jun.-Mar.
47. *Ophiuros exaltatus*	perennial	svn	800-2,200	Oct.-Dec.
48. *Phacelurus cambogiensis*	perennial	swp	200-250	Aug.-Dec.
49. *P. zea*	perennial	pdf	800-900	Jun.-Dec.
50. *Rottboellia cochinchinensis*	annual	wd	0-1,300	All year round
51. *Vossia cuspidata*	perennial	rs	0	Oct.
Total number of taxa: 51				

habitat: bb = bamboo forest, bf = beach forest, dtf = dipterocarp forest, ef = evergreen forest, sf = sandstone forest, ns = near stream, rv = rivers sides, df =

deciduous forest, pf = pine forest, sf = secondary forest; rs = roadsides, svn = savannah, swp = swampy area, pdf = paddy field, weedy area = wd; – = no data.

It can be seen that grass members of the subtribe Ischaeminae can grow in many types of habitat from sea level up to high altitude (2,350 m). They can be found along roadside (5 taxa), paddy field (3 taxa), swampy area (3 taxa) and savannah (3 taxa). Some species occur in deciduous forest (2 taxa), beach forest (2 taxa), near stream (2 taxa), dipterocarp forest (2 taxa), secondary forest (2 taxa) and evergreen forests (2 taxa). Two species is restricted to rivers sides (*Ischaemum magnum*) and pine forest (*I. barbatum* var. *lodiculare*). The Ischaeminae plants in commonly produce flowers in November to December but only two species, *I. barbatum* and *I. muticum* produce a flower all year round.

In the subtribe Rottboelliinae, the grass can be found from sea level up to high elevation (2,350 m). Most species are often found in dry dipterocarp forest or dry deciduous forest, each comprising of 10 taxa. However, nine and seven taxa are also observed in pine forest and swampy area, respectively. There are few taxa occasionally found near stream (2 taxa), weedy area (2 taxa), along roadsides (2 taxa) and in evergreen forest (2 taxa). Three species were reported in different habitat such as in bamboo forest (*Hackelochloa porifera*), sandstone forest (*Eremochloa lanceolata*) and savannah (*Ophiuros exaltatus*). The flowering period is between August and November. *E. ciliaris*, *Mnesithea mollicoma* and *Rottboellia cochinchinensis* produce flowers throughout the year.

5.3.2 Distribution

Most species of Ischaeminae are recorded in the penninsula (12 taxa), south-eastern (10 taxa), eastern (10 taxa) and northern (9 taxa) Thailand, while Rottboelliinae are mostly distributed in the north-eastern (22), eastern regions (21 taxa) and northern regions (14 taxa) (Table 5.2). Some taxa in both subtribes can be found throughout the country, especially *Apluda mutica*, *Ischaemum indicum*, *I. rugosum*, *Mnesithea glandulosa* and *Rottboellia cochinchinensis* which are distributed in all floristic regions (Table 5.2).

Table 5.2 The distributions of the Ischaeminae and Rottboelliinae in Thailand.

Taxa	**Floristic Regions of Thailand**						
	N	**NE**	**E**	**SW**	**C**	**SE**	**PEN**
Subtribe Ischaeminae							
1. *Apluda mutica* (C)	/	/	/	/	/	/	/
2. *Ischaemum barbatum* (C)	/	/	/	–	/	/	/
3. *I. barbatum* var. *lodiculare*	–	/	/	–	–	/	/
4. *I. hansenii* * (R)	–	–	–	–	–	–	/
5. *I. hirtum*	–	/	/	–	–	–	/
6. *I. hubbardii* (R)	/	–	–	–	–	–	–
7. *I. indicum* (C)	/	/	/	/	/	/	/
8. *I. lacei* (R)	/	–	–	–	–	–	–
9. *I. magnum*	–	–	–	–	/	–	/
10. *I. muticum*	–	–	–	–	–	/	/
11. *I. rugosum* (C)	/	/	/	/	/	/	/
12. *I. tenuifolium*	–	/	/	–	–	/	–
13. *I. timorense*	/	–	–	/	/	–	/
14. *I.* sp.1 *, ***	–	–	–	–	–	/	/
15. *I.* sp.2 *, ***	–	–	–	–	–	–	/
16. *Kerriochloa siamensis*	–	–	/	–	–	/	–
17. *Sehima nervosum*	/	/	/	/	–	/	–
18. *Thelepogon elegans*	/	–	/	–	/	–	–
Subtribe Rottboelliinae							
19. *Eremochloa attenuata* *	/	/	–	–	–	–	–
20. *E. bimaculata*	–	–	/	/	–	/	–
21. *E. ciliaris* (C)	/	/	/	/	–	/	/
22. *E. ciliatifolia*	–	/	/	–	–	/	–
23. *E. eriopoda*	–	/	/	–	–	–	–
24. *E. lanceolata* *	–	–	/	–	–	–	–
25. *E. maxwellii* *	–	–	/	–	–	–	–
26. *E. muricata* (R)	–	–	–	/	–	–	–
27. *E. peltelotii* (R)	–	–	/	–	–	–	–
28. *E.* sp.1 *, ***	–	/	/	–	–	–	–
29. *E.* sp.2 *, ***	–	/	–	–	–	–	–

Table 5.2 The distributions of the Ischaeminae and Rottboelliinae in Thailand (Cont.).

Taxa	**Floristic Regions of Thailand**						
	N	**NE**	**E**	**SW**	**C**	**SE**	**PEN**
30. *Hackelochloa granularis*	/	/	–	–	–	/	–
31. *H. porifera*	/	–	–	–	–	–	–
32. *Hemarthria altissima*	–	/	–	–	–	–	–
33. *H. compressa*	/	/	/	–	/	/	–
34. *H. debilis* * (R)	–	–	–	–	–	/	–
35. *H. longiflora*	/	/	/	/	/	/	–
36. *H. pratensis*	–	/	–	–	–	–	–
37. *H. stolonifera* * (R)	–	–	–	–	–	/	–
38. *Mnesithea cancellata*	/	/	/	–	–	–	–
39. *M. glandulosa* (C)	/	/	/	/	/	/	/
40. *M. helferi*	–	/	/	/	/	/	/
41. *M. laevis*	/	/	/	/	–	/	/
42. *M. mollicoma*	/	/	/	–	–	/	/
43. *M. striata*	/	/	/	/	–	–	/
44. *M. striata* var. *pubescence* **	/	/	/	/	–	–	/
45. *M. thailandica* *, *** (R)	–	–	/	–	–	–	–
46. *M.* sp.1*, ***	/	–	–	/	–	–	–
47. *Ophiuros exaltatus*	–	/	/	–	/	–	–
48. *Phacelurus cambogiensis* (R)	–	/	–	–	–	–	–
49. *P. zea*	–	/	/	–	–	–	–
50. *Rottboellia cochinchinensis* (C)	/	/	/	/	/	/	/
51. *Vossiacuspidata* (R)	–	–	–	–	/	–	–
Total number of taxa	**24**	**31**	**31**	**16**	**14**	**24**	**20**

* indicate endemic to Thailand, ** = new record for Thailand, and *** = probably new to science, C = common species, R = rare species, N = Northern, NE = North-Eastern, E = Eastern, SW = South-Western, C = Central, SE = South-Eastern, PEN = Peninsular, / = present, – = absent.

According to the study, twelve endemic taxa are endemic species to Thailand. Three taxa of Ischaeminae and nine taxa of Rottboelliinae are presently known from one or two floristic regions, one or several localities in each region. Those taxa are listed as follow:

1. *Ischaemum hansenii* is restricted to Trang (Ko Talibong).

2. *I.* sp. 1 is found in Chanthaburi (Khao Soi Dao) and Krabi (Phanom Bencha).

3. *I.* sp.2. This species is only found in Ranong (Phu Khao Yah).

4. *Eremochloa attenuata* is recorded in Chiang Mai [Doi Inthanon, Doi Suthep, near Fang, Wang Bua Ban), Lamphun (between Tak & Lamphun, Khun Tan National Park), Lampang (Ngao Mae Huad), Loei (Phu Kradueng).

5. *E. lanceolata* is presented in Nakhon Ratchasima (Khao Kuap), Ubon Ratchathani (Pha Taem National Park, Warin Chamrap).

6. *E. mawellii* is found in Si Sa Ket (Dongrak, Kantharalak), Ubon Ratchathani (Warin Chamrap).

7. *E.* sp.1 only occurs in Khon Kaen (Khok Phu Taka), Chaiyaphum (Nong Bua Daeng), Nakhon Ratchasima (Huai Thalaeng).

8. *E.* sp.2 is confined to Loei (Phu Kradueng).

9. *Hemarthria debilis* is limited to Chanthaburi (Makham).

10. *H. stolonifera* is restricted to Chanthaburi (Makham).

11. *Mnesithea thailandica* is confined to Roi Et (Suwanaphoom).

12. *M.* sp. 1 is only recorded in Mae Hong Son (Pai), Chiang Mai (Doi Suthep, Doi Inthanon, Chiang Doi Hills, Doi Chiang Dao, Pha Hom Pok, Wang Tao, Khun wang highland, Mae John Luang), Kanchanaburi (Huai Bankau).

Moreover, there are 12 taxa are not endemic to Thailand, but rather have a restricted distribution, either confined to one or two floristic regions or found in a single locality. Further works are needed to determine the population size and their distribution. Those taxa are listed as follow:

1. *Ischaemum hirtum* is recorded in Phetchabun (Nam Nao National Park) and Chaiyaphum (Nam Phrom).

2. *I. hubbardii* is limited to Chiang Mai (Doi Inthanon).

3. *I. lacei* is restricted to Chiang Mai (Doi Nang Ka).

4. *I. magnum* is confined to Krung Thep Maha Nakhon.

5. *Kerriochloa siamensis* occurred in Ubon Ratchathani (Warin Chamrap, Pha Taem Nat. Park) and Chanthaburi (Kao Knap).

6. *Eremochloa petelotii* is presented in Nakhon Ratchasima (Phimai) and Surin (Thung Kula Rong Hai)

7. *Hackelochloa porifera* is limited to Chiang Mai (nursery of Queen Sirikit Botanical Garden).

8. *Hemarthria altissima* is restricted to Loei (Phu Kradueng).

9. *H. pratensis* is limited to Loei (Phu Kradueung).

10. *Phacelurus cambogiensis* is confined to Nakhon Ratchasima (Phimai: Sai Ngam).

11. *P. zea* is found in Phetchabun (Tung SaLaeng Luang Nat. Park) and Chaiyaphum (Tungkamang).

12. *Vossia cuspidata* is limited to Krung Thep Maha Nakhon (Bang Khen).

Nine taxa have been recorded only once or twice in Thailand from the last two decades and no new or recent collection has been made, *e.g. E. petelotii, H. altissima, H. debilis, H. stolonifera, I. hansenii, I. lacei, M. thailandica, P. cambogiensis* and *V. cuspidata*. Those taxa are listed as follow:

1. *Eremochloa petelotii* is found only in two collections which collected in Nakhon Ratchasima (Phimai) in December 27th, 1958 by *T. Smitinand* and in Surin (Thung Kula Rong Hai, Chumphon Buri) by *S. Sutheesorn* in September 17th, 1972. This species is said to be common in paddy fields, however it could not be found from this study.

2. *Hemarthria altissima* was collected by *T. Smitinand* in Loei (Phu Kradueng, near camp) in March 11th, 1952. It is said to be common among the other grasses in open pine forest at 1,300 m altitude.

3. *H. debilis* is growing on swampy area, at 50 m altitude in Chanthaburi (5 km N of Makham). It is only known from the type specimen that collected by *K. Larsen* in June 15th, 1963.

4. *H. stolonifera* is only known from the type specimen collected by *K. Larsen* in Chanthaburi (Makham) in June 13th, 1963. This species is found creeping on wet place, at sea level.

5. *Ischaemum hansenii* is only known from the type specimen, *B. Hansen & T. Smitinand* that collected in Trang (Ko Talibong) in November 10th, 1966. The plants were creeping on rocks, at sea level.

6. *Ischaemum lacei* has been recorded only once in Thailand in Chiang Mai (Doi Nang Ka) in November 4th, 1930 by *Put.*

7. *Mnesithea thailandica* was collected in Roi Et (Suwanaphoom, Nayai, Ban Hang Hoey) in June 10th, 1982 by *Y. Paisooksantivathana & S. Sutheesorn*. This plant is common in paddy field, at 100 m altitude.

8. *Phacelurus cambogiensis* has been recorded only twice in Thailand. Both collections were collected by *T. Smitinand* from Nakhon Ratchasima (Phimai: Sai Ngam) in August 26th and December 27th, 1958. They are common along edge of swampy area, at 200-250 m altitude.

9. *Vossia cuspidata* has been recorded only once in Krung Thep Maha Nakhon (Bang Khen) in 1960 by *C. Chermsirivathana*. The plant was found growing on the canal bank.

The above mentioned species could not be found from their previously described habitats. Though, they were common in their localities in the past. There are several potential answers for their missing from my surveys such as the possibitity of domination by a new weed species which preventing the growth of the other plant species. Another answer is that the environment in which those species were found have changed, either naturally or unnaturally, probably due to human disturbance. Change in species flowering periods may also be another reason why the above species could not be found, this also includes the fact that when I went to collect the specimens it was too early or too late for the species to produce flowers, therefore the grass plant was not easily notice and could not be collected.

Three taxa in Ischaeminae and 7 taxa in Rottboelliinae are rare species, while 4 and 3 common taxa have been noted in Ischaeminae and Rottboelliinae, respectively.

5.3.3 New records and new species

Nanakorn & Norsaengsri (2001) have reported a total of 21 and 31 taxa of the subtribes Ischaeminae and Rottboelliinae in Thailand, respectively (Table 5.3). One species of Ischaeminae and one variety of Rottboelliinae are newly recorded for Thailand from this research.

I. hubbardii is found along Kio Mae Pan nature trail, Doi Inthanon National Park, Chiang Mai, characterized by its tuberculate-pilose leaves with a lower glume that has 10–14 distinct nerves and transverse hump on the lower 1/3 of the glume. It is similar to *I. indicum* (Houtt.) Merr. in having glabrous surface on the back of the lower glume of sessile spikelets but differing in the unequal narrow lateral wings above and hairs on both leaf surfaces. The lower glume of the sessile spikelet in the Thai specimens has a transverse, nearly flat hump on the lower 1/3 of the glume although the hump is slightly convex on the back in the type specimen from India. So far, this species has been found at high altitude in India and Thailand and seems to be a member of the Indo-Burmese elements, but no Burmese collection yet. Further work in this area is needed.

M. striata var. *pubescens* is found in north, north-eastern, eastern, south-western and peninsular Thailand. Hairy forms of *M. striata* are segregated at the varietal level in the treatment of the subtribe Rottboelliinae in this study, however this variety is a first record for the country.

There are two species in Ischaeminae and four species in Rottboelliinae which are expected to be new species.

1. *Ischaemum* sp.1 resembles *I. barbatum* in lower glume of the sessile spikelet. However, the latter is easily distinguished by the presence of coarsely ridge more than one across the back or with 2 or more nodules along the margins. *I.* sp. 1 has pubescent leaf-blade on both surface, margins recurved or folded while *I. barbatum* has flattened leaf-blade, both surface glabrous to pilose.

2. *I.* sp.2 is similar to *I. lacei*, but can be distinguished by its glabrous of leaf blade, while the leaf-blade of *I. lacei* is pilose with tubercle-based hairs on both surfaces.

3. *Eremochloa* sp.1 is very closely related to *E. maxwellii* but differs considerably in having obovate with a long cordate pedicel, while obliquely-lanceolate pedicel in *E. maxwellii*. This species is collected from the north-eastern Thailand.

4. *Eremochloa* sp.2 resembles *E. muricata*, but can be distinguished from the latter in having a subulate pedicel, while an obliquely obovoid pedicel in *E. muricata*. This species is only found in Phu Kradueng, Loei.

5. *M. thailandica* P. Traiperm & T. Boonkerd (*ined.*) is distinguished by the appressed hairs on the inflorescence. It is similar to *M. geminata* in Malaysian species, but differs in having a small erect and slender culm, *ca.* 26 cm tall. The species has pubescent hairs on the back of the triangular lower glume, rachis nodes, pedicels and rachis internode, while *M. geminata* has lower glume lanceolate, covered with hirsute hairs below and glabrous on rachis nodes, pedicels and rachis internode.

6. *M.* sp.1 is closely related to *M. striata* in having the lower glume of the sessile spikelet oblong, indurate, 5–5.5 by 1.2–1.5 mm, apex with unequal winges, 7–8 longitudinal rows of small pits between the nerves of the back, margins at base puberulous, while the lower glume of the sessile spikelet ovate, indurate, 4.5–5 by *ca.* 1.5 mm, apex with 2 apical wings, continuously ridged along the length and interrupted by tubercles or tubercle-based hairs on the back or glabrous in *M. striata*.

5.3.4 Comparison with other works

Comparison of the previous studies (Table 5.3), there are eight taxa which are additionally reported from this study, namely *Ischaemum hubbardii*, *I.* sp.1, *I.* sp.2, *Eremochloa* sp.1, *E.* sp.2, *Mnesithea striata* var. *pubescens*, *M. thailandica* and *M.* sp.1. Seven misidentified taxa are found in this study, e.g., *I. mangaluricum* (*I. babartum*), *Sehima sulcatum* (*Andropogon* sp.), *E. zeylanica* (*E. bimaculata*), *M. geminata* (*M. mollicoma*), *Ophiuros bombaiensis* (*M. laevis*), *O. megaphyllus* (*O. exaltatus*) and *Thaumastochloa cochinchinensis* (*M. laevis*).

Nanakorn & Norsaengsri (2001) reported the occurrence of 52 species of the two subtribes in Thailand. However, two species which they previously mentioned, *Ischaemum angustifolium* (Hack.) and *I. fieldingianum* Rendle, can not collect even from their original localities. Furthermore there is no specimen under these names, deposited in any herbaria in Thailand or overseas. It is probably due to missed identified.

Table 5.3 Comparative treatment of Ischaeminae and Rottboelliinae by some authors.

Taxa	Nanakorn & Norsaengsri 2001	Buitenhui & Veldkamp 2001	Present study
1. *Apluda mutica*	/	–	/
2. *Ischaemum angustifolium* ***	/	–	–
3. *I. aristatum*	/	–	=*I. barbatum* Retz.
4. *I. barbatum*	/	–	/
5. *I. barbatum* var. *glaberrimum*	/	–	=*I. barbatum* Retz.
6. *I. barbatum* var. *lodiculare*	/	–	/
7. *I. fieldingianum* ***	/	–	–
8. *I. hansenii*	/	–	/
9. *I. hirtum*	/	–	/
10. *I. hubbardii*	–	–	/
11. *I. indicum*	/	–	/
12. *I. lacei*	/	–	/
13. *I. magnum*	/	–	/
14. *I. mangaluricum* **	/	–	misidentified
15. *I. muticum*	/	–	/
16. *I. rugosum*	/	–	/
17. *I. tenuifolium*	/	–	/
18. *I. timorense*	/	–	/
19. *I.* sp.1 *	–	–	/
20. *I.* sp.2 *	–	–	/
21. *Kerriochloa siamensis*	/	–	/
22. *Sehima nervosum*	/	–	/
23. *S. sulcatum* **	/	–	misidentified
24. *Thelepogon elegans*	/	–	/
25. *Coelorachis cancellata*	/	–	= *M. cancellata*
26. *C. glandulosa*	/	–	= *M. glandulosa*
27. *C. helferi*	/	–	= *M. helferi*
28. *C. mollicoma*	/	–	= *M. mollicoma*
29. *C. striata*	/	–	= *M. striata*
30. *Eremochloa attenuata*	–	/	/
31. *E. bimaculata*	/	–	/
32. *E. ciliaris*	/	–	/

Table 5.3 Comparative treatment of Ischaeminae and Rottboelliinae by selected authors (Cont.).

Taxa	Nanakorn & Norsaengsri 2001	Buitenhui & Veldkamp 2001	Present study
33. *E. ciliatifolia*	/	–	/
34. *E. eriopoda*	/	–	/
35. *E. lanceolata*	–	/	/
36. *E. maxwellii*	–	/	/
37. *E. muricata*	/	–	/
38. *E. peltelotii* Merr.	/	–	/
39. *E. zeylanica* Hack. ***	/	–	misidentified
40. *E.* sp.1 *	–	–	/
41. *E.* sp.2 *	–	–	/
42. *H. granularis*	/	–	/
43. *H. porifera*	/	–	/
44. *Hemarthria altissima*	/	–	/
45. *H. compressa*	/	–	/
46. *H. debilis* Bor	/	–	/
47. *H. longiflora*	/	–	/
48. *H. pratensis*	/	–	/
49. *H. stolonifera*	/	–	/
50. *H. subulata*	/	–	= *H. pratensis*
51. *Mnesithea cancellata*	–	–	/
52. *M. geminata* **	/	–	misidentified
53. *M. glandulosa*	–	–	/
54. *M. helferi*	–	–	/
55. *M. laevis*	/	–	/
56. *M. merquensis*	/	–	= *M. striata*
57. *M. mollicoma*	–	–	/
58. *M. striata*	–	–	/
59. *M. striata* var. *pubescence* *	–	–	/
60. *M. thailandica* *	–	–	/
61. *M.* sp.1 *	–	–	/
62. *Ophiuros bombaiensis* **	/	–	misidentified
63. *O. exaltatus*	–	–	/

Table 5.3 Comparative treatment of Ischaeminae and Rottboelliinae by some authors (Cont.).

Taxa	Nanakorn & Norsaengsri 2001	Buitenhui & Veldkamp 2001	Present study
64. *O. megaphyllus*	/	–	misidentified
65. *Phacelurus cambogiensis*	/	–	/
66. *P. zea*	/	–	/
67. *Rottboellia cochinchinensis*	/	–	/
68. *Thaumastochloa cochinchinensis*	/	–	misidentified
69. *Vossia cuspidata*	/	–	/
Total taxa	52		51

* indicate newly repoted taxa, ** = misidentified taxa, *** = taxa which can not be found the specimen cited to its scientific name, / = present and – = absent.

5.3.5 A taxonomic problems in some genera and species

***Coelorachis* Brongn. & *Mnesithea* Kunth**

Mnesithea has been described previously by the presence of 2 sessile spikelets separated by a pedicel at each rachis node, but this character is now known to be variable. Furthermore, in the present study a pair of sessile spikelets also occur sporadically in the racemes of species that normally have single sessile spikelets.

The genus *Coelorachis* Brongn. differs from the other genera by a free of pedicel and a presence of the pedicelled spikelet, but these characters are unstable. It was found that the lower part are partially or completely fused to the rachis node in several species of *Coelorachis*. The pedicelled spikelet varies from well developed to minute vestige, and its absence in traditional *Mnesithea* is just the final step. Hence, Veldkamp et al. (1986) has treated the genus *Coelorachis* as a synonym of *Mnesithea* Kunth. The result from this present study also support their treatment.

***Hackelochloa* Kuntze & *Mnesithea* Kunth**

Hackelochloa Kuntze, a genus of the Old World tropics. There are two species: *H. granularis* (L.) O. Kuntze and *H. porifera* (Hack.) Rhind. Veldkamp et al. (1986) combined *Hackelochloa* with *Mnesithea* despite their morphological differences and the aberrant basic number of the chromosome count from *Mnesithea* (Pohl & Davidse, 1971). In this study I treated *Hackelochloa* as distinct genus based on its globose sessile spikelets with wingless lower glumes.

H. granularis **(L.) O. Kuntze. &** ***H. porifera*** **(Hack.) D. Rhind**

According to Veldkamp et al. (1986) the species *H. porifera* has been treated as a synonym of *H. granularis* because they failed to find any representative specimen in the Rijsherbarium and they did not except the different characters of *H. porifera* from *H. granularis* such as robust plant, large-spikelet. After collecting two living specimens and compared with the type specimens of the two species. The type material of *H. porifera* at K, collected from India by *C.B. Clarke* 9752-A (Sikkim, Darjeeling, isotype), showed apparently fairly robust plant with indeed large sessile spikelets with prominent sculpture on lower glumes (Table 5.4). Therefore, I retain *H. porifera* and *H. granularis* as distinct species as was noted by Bor (1960).

Table 5.4 Comparison of some morphological characters of *H. granularis* and *H. porifera*.

Species / Characters	*H. granularis*	*H. porifera*
Habit	culms erect, 15–80 cm tall	culms erect, 50–200 cm tall
Leaf-blade	linear, 2–13 by 1–1.5 cm	broadly linear, 5–30 by 1–2.5 cm
Inflorescence	1–5 racemes, each raceme 5–15 mm long, peduncle 10–30 mm long	2-4 racemes, each raceme 2.5–4.5 cm long, peduncle 3–8 cm long
Size of the lower glume of the sessile spikelet	*ca.* 1.5 mm diam.	*ca.* 2.5 mm long
Sculpture on the lower glume of the sessile spikelet	pitted and tubercled on the back	ridged and reticulate on the back

Ischaemum indicum **(Houtt.) Merr.**

The extreme variations of hairiness and size and form of an apical wings in lower glume of the sessile spikelet are certainly distinct (Bor, 1960). However, they are connected by a complete series of intermediates. So it seems better not to divide this species into a number of infraspecific species at present, but a monographic study is needed to clear the taxonomic status of this species.

5.3.6 Lectotypification

The Lectotypification of five taxa in the subtribe Ischaeminae are made. They are *Ischaemum aristatum* subsp. *imberbe* var. *imbricatum* (synonym of *I. barbatum*), *I. aristatus* var. *arfakense* (synonym of *I. barbatum*), *I. lacei*, *I. magnum* and *I. macrurum* (synonym of *I. timorense*).

5.3.7 New combination

Careful examination of recent collections of *I. tenuifolium* proved that this species does indeed belong to the genus *Andropogon*. The plants have digitate racemes, 3–7 racemes, 6–12 cm long, borne upon subequal flattened raceme-bases and the lower glume of sessile spikelet concave. These are all diagnostic features of *Andropogon* (Clayton & Renvoize, 1986). This study also presented a detailed anatomical description of the genus but these species fail to comform completely to the general pattern in the genus *Ischaemum*. So, *I. tenuifolium* is transfered to be a member of the genus *Andropogon*.

5.3.8 New Synonymy

Bor (1962a) described a new variety of *I. barbatum* from Chiang Mai: Doi Suthep, northern Thailand as *I. barbatum* var. *glaberrimum*. After carefully studied the types of the species and variety I found that they are conspecific. Therefore, the latter variety is reduced to a synonym of the former.

Figure 5.27 *Apluda mutica*: A. habit. *Ischaemum barbatum* var. *barbatum*: B. & C. inflorescence. *I. barbatum* var. *lodiculare*: D. inflorescence.

Figure 5.28 A-C. *Ischaemum hansenii*: A. plant; B. inflorescence; C. spikelet in pairs. D-F. *I. hirtum*: D. plant; E. partial inflorescence; F. spikelet in pairs.

Figure 5.29 A. & B. *Ischaemum hubbardii*: A. habit; B. inflorescence. C-E. *I. indicum*: C. habit; D. inflorescence; E. partial inflorescence.

Figure 5.30 A. & B. *Ischaemum lacei*: A. plant; B. inflorescence. C-E. *I. magnum*: C. plant; D. inflorescence; E. spikelet in pairs.

Figure 5.31 A. & B. *Ischaemum muticum*: A. habit; B. inflorescence. C-E. *I. rugosum*: C. habit; D. inflorescence; E. partial inflorescence.

Figure 5.32 A-C. *Ischaemum timorense*: A. plant; B. inflorescence; C. partial inflorescence. D. & E. *I.* sp.1: D. habit; E. inflorescence.

Figure 5.33 A-B. *Kerriochloa siamensis*: A. habit; B. partial inflorescence. C-E. *Sehima nervosum*: C. habit; D. & E. partial inflorescence. F-I. *Thelepogon elegans*: F. habit; G. leaf-sheath and leaf blade; H. partial inflorescence; I. inflorescences.

Figure 5.34 A-C. *Eremochloa attenuata*: A. plant; B. partial inflorescence; C. lower glume, upper glume and joint with pedicelled spikelet. D-F. *E. bimaculata*: D. habit; E. partial inflorescence; F. reversed of partial inflorescence.

Figure 5.35 A-D. *Eremochloa ciliaris*: A. habit; B-D. inflorescence. E-G. *E. ciliatifolia*: E. habit; F. partial inflorescence; G. lower glume, upper glume and joint with pedicelled spikelet.

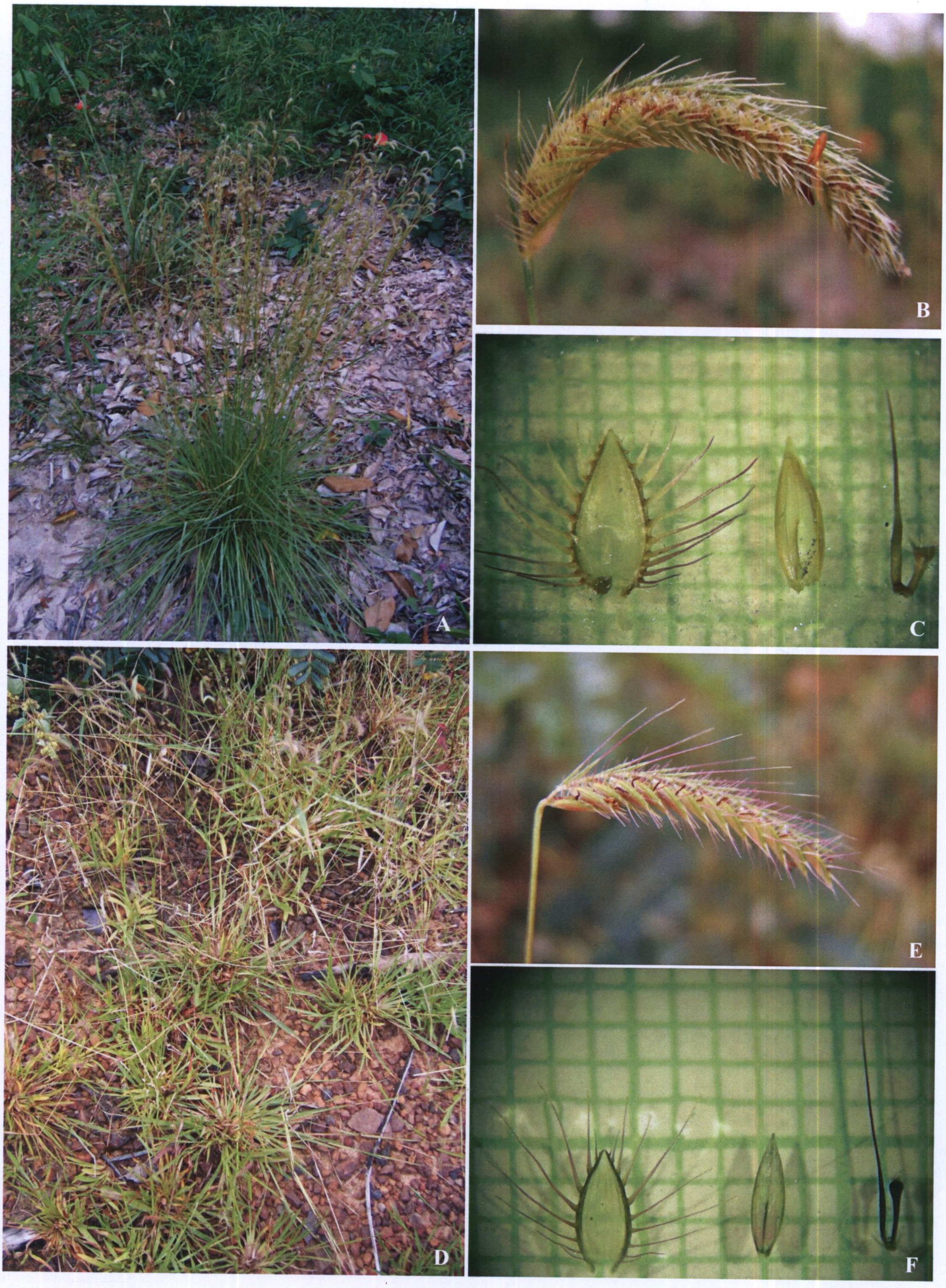

Figure 5.36 A-C. *Eremochloa eriopoda*: A. habit; B. inflorescence; C. lower glume, upper glume and joint with pedicelled spikelet. D-F. *E. lanceolata*: D. habit; E. inflorescence; F. lower glume, upper glume and joint with pedicelled spikelet.

Figure 5.37 A-C. *Eremochloa maxwellii*: A. habit; B. partial inflorescence; C. lower glume, upper glume and joint with pedicelled spikelet. D. & E. *E. muricata*: D. plant; E. lower glume, upper glume and joint with pedicelled spikelet. F. & G. *E. peltelotii* F. partial inflorescence; G. lower glume, upper glume and joint with pedicelled spikelet.

Figure 5.38 A-C. *Eremochloa* sp.1: A. habit; B. partial inflorescence; C. lower glume, upper glume and joint with pedicelled spikelet. D-F. *Eremochloa* sp.2: D. habit; E. inflorescence; F. lower glume, upper glume and joint with pedicelled spikelet.

Figure 5.39 A. & B. *Hackelochloa granularis*: A. habit; B. inflorescence. C-E. *H. porifera*: C. habit; D. & E. inflorescence.

Figure 5.40 A-D. *Hemarthria altissima*: A. plant; B. partial inflorescence; C. lower glume of sessile spikelet; D. lower glume and upper glume of pedicelled spikelet. E-J. *H. compressa*: E. habit; F. inflorescence; G. & H. partial inflorescence; I. lower glume of sessile spikelet; J. lower glume and upper glume of pedicelled spikelet.

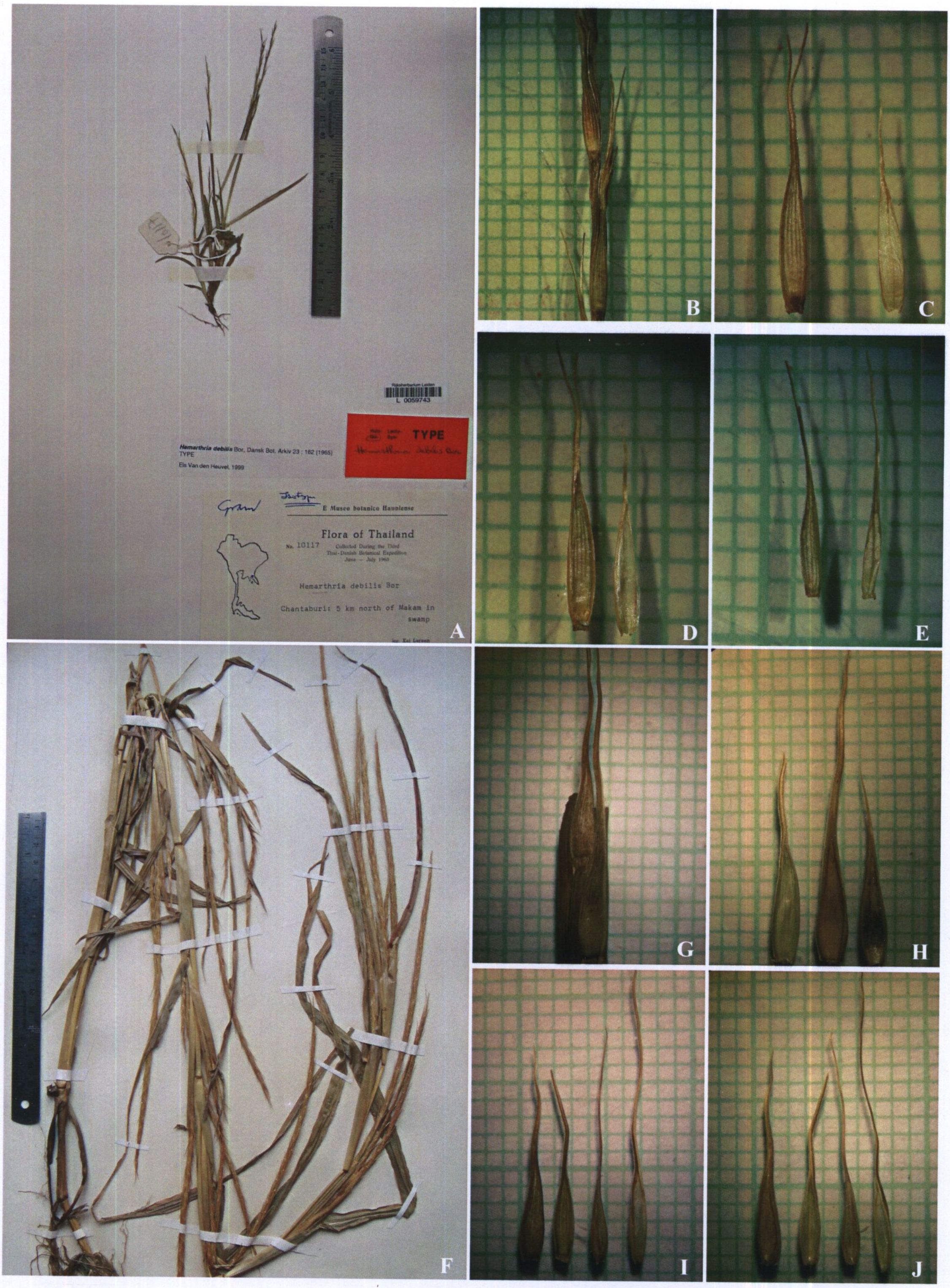

Figure 5.41 A-E. *Hemarthria debilis*: A. plant; B. partial inflorescence; C. lower glume and upper glume of sessile spikelet; D. reverse of lower glume and upper glume of sessile spikelet; E. lower glume and upper glume of pedicelled spikelet. F-J. *H. longiflora*: F. plant; G. partial inflorescence; H. varies of lower glume of sessile spikelet; I. variations of lower glume of pedicelled spikelet; J. reversed of lower glume of pedicelled spikelet.

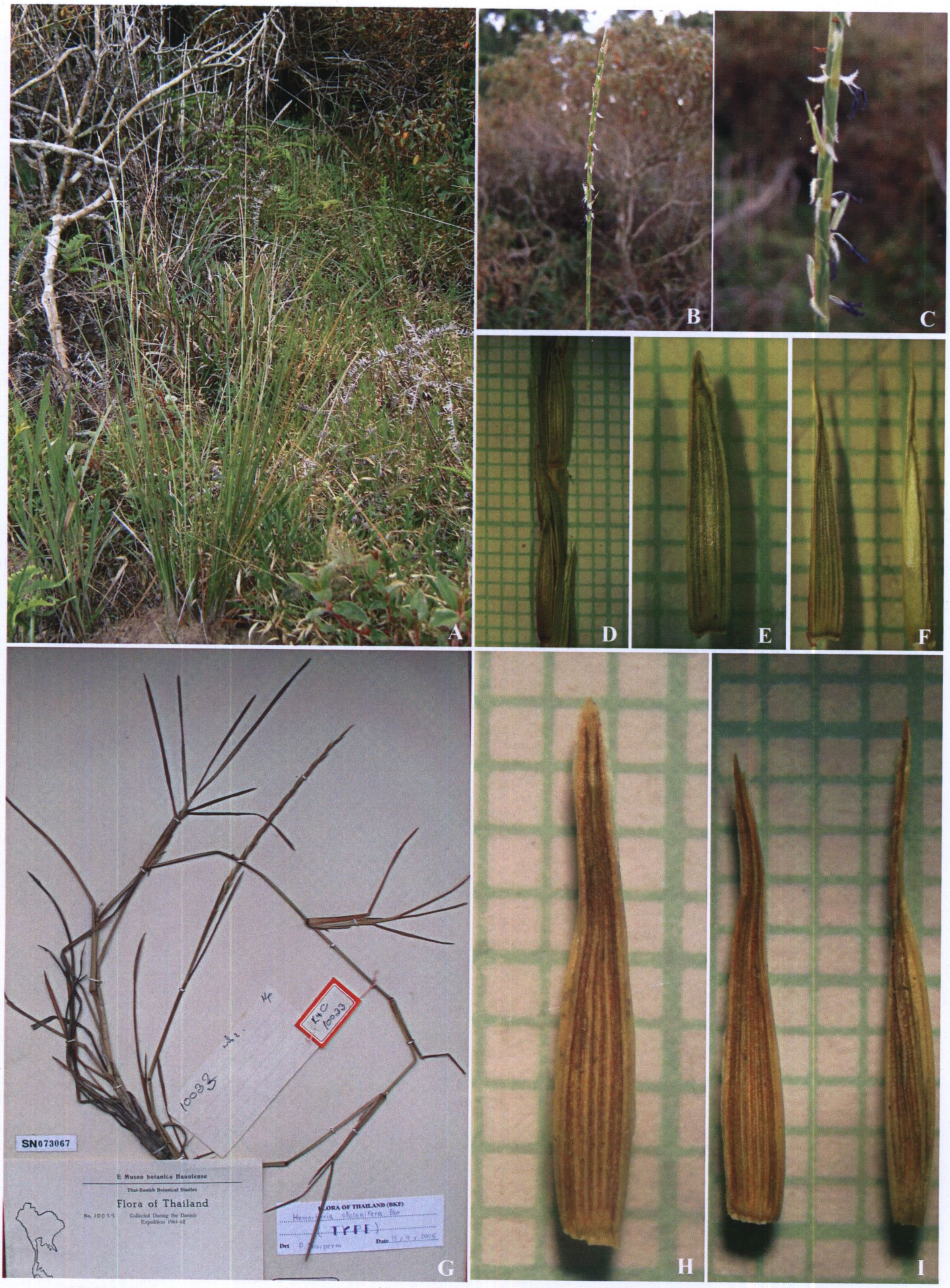

Figure 5.42 A-F. *Hemarthria pratensis*: A. habit; B. partial inflorescence; C. & D. partial inflorescence; E. lower glume of sessile spikelet; F. lower glume and upper glume of pedicelled spikelet. G-I. *H. stolonifera*: G. plant; H. lower glume of sessile spikelet; I. lower glume and upper glume of pedicelled spikelet.

Figure 5.43 A. & B. *Mnesithea cancellata*: A. habit; B. partial inflorescence. C-E. *M. glandulosa*: C. habit; D. inflorescence; E. partial inflorescence.

Figure 5.44 A. & B. *Mnesithea helferi*: A. habit; B. partial inflorescence. C-E. *M. laevis*: C. habit; D. & E. partial inflorescence.

Figure 5.45 A-C. *Mnesithea mollicoma*: A. plant; B. young inflorescence; C. partial inflorescence. D-F. *M. striata*: D. habit; E. & F. partial inflorescence.

Figure 5.46 A-D. *Mnesithea thailandica*: A. plant; B. inflorescence; C. spikelets with a joint; D. pedicel with pedicelled spikelet and lower glume of the sessile spikelet. E-G. *M.* sp.1: E. habit; F. inflorescence; G. partial inflorescence.

Figure 5.47 A-C. *Ophiuros exaltatus*: A. plant; B. partial raceme; C. lower glume of sessile spikelet and joint. D-F. *Phacelurus cambogiensis*: D. plant; F. partial inflorescence; G. spikelet in pairs.

Figure 5.48 A-D. *Phacelurus zea*: A. habit; B. partial raceme; C. panicle inflorescence; D. partial raceme. E-G. *Rottboellia cochinchinensis*: E. habit; F. inflorescence; G. partial inflorescence.

Figure 5.49 *Vossia cuspidata*: A. whole plant; B. partial inflorescence.

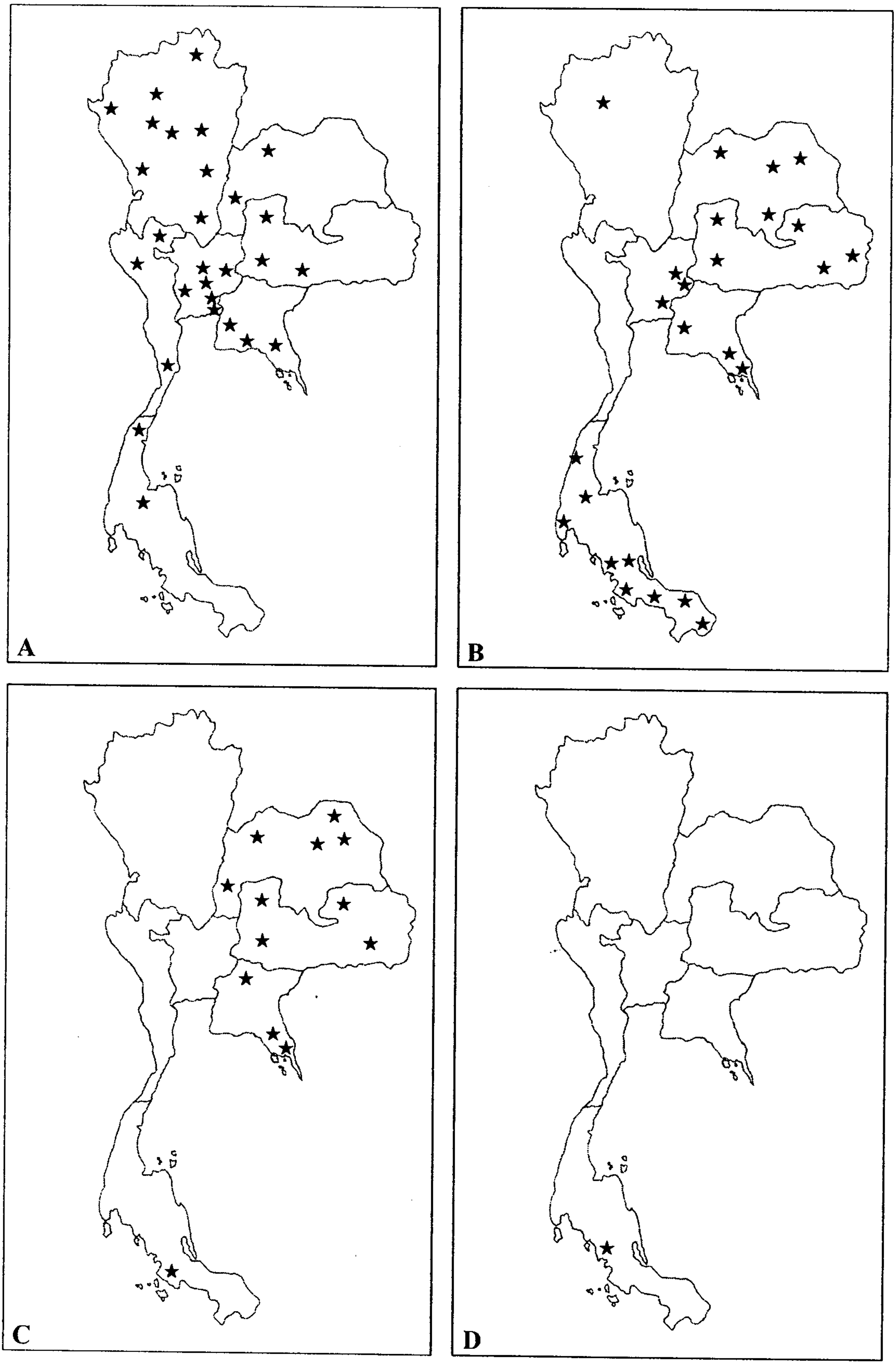

Figure 5.50 Distribution of *Apluda mutica* (A), *Ischaemum barbatum* (B), *I. barbatum* var. *lodiculare* (C) and *I. hansenii* (D).

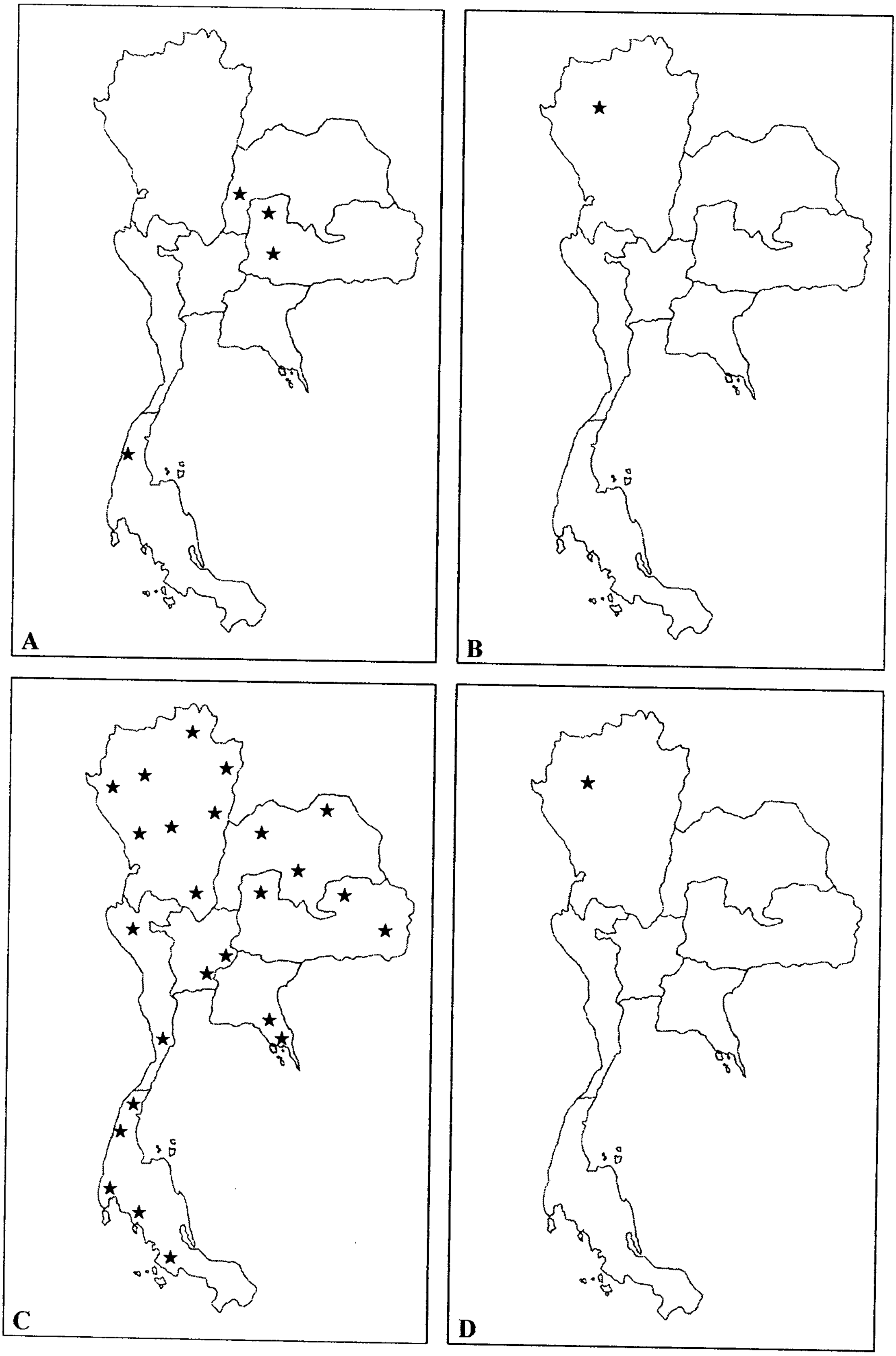

Figure 5.51 Distribution of *Ischaemum hirtum* (A), *I. hubbardii* (B), *I. indicum* (C) and *I. lacei* (D).

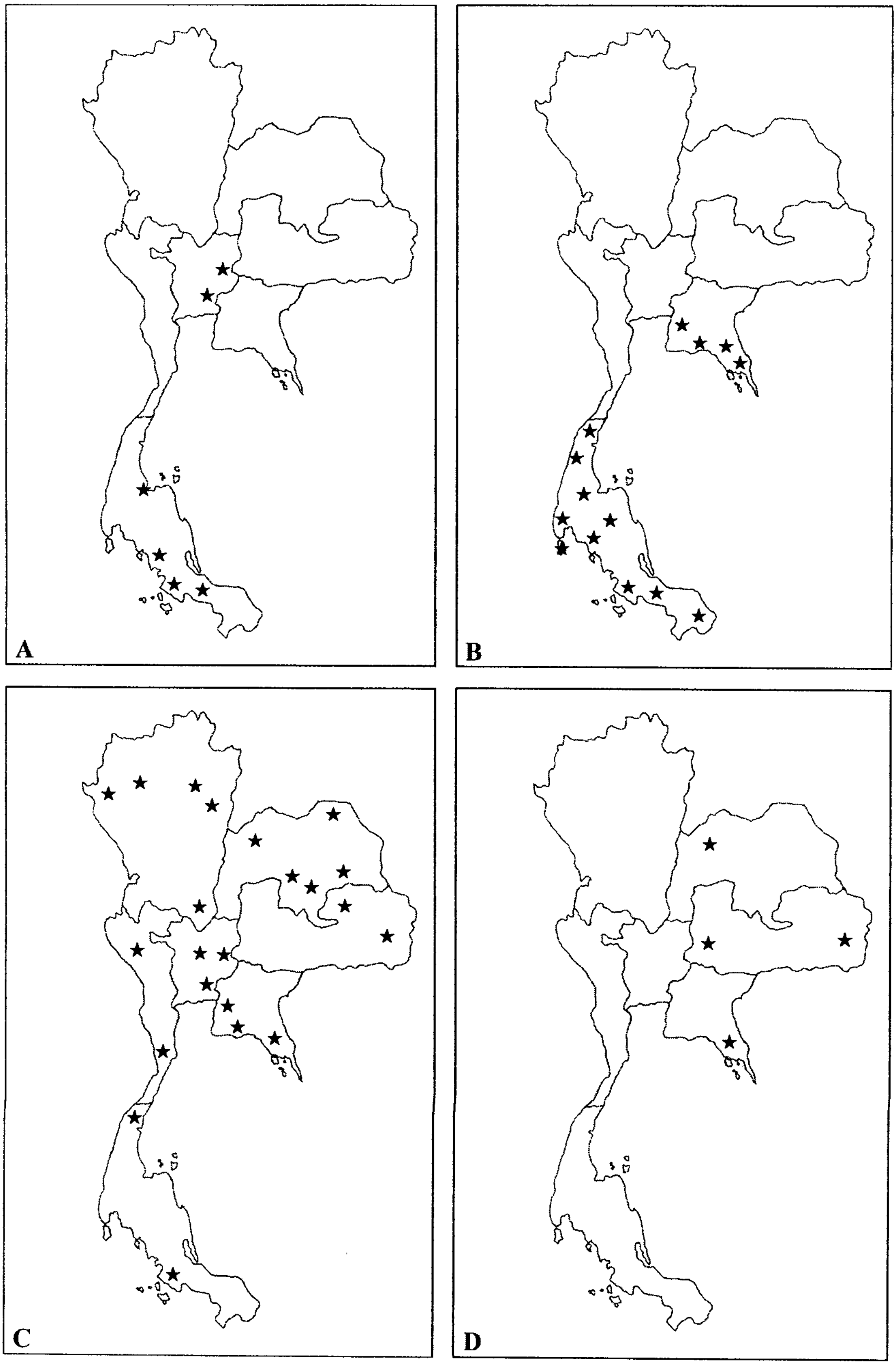

Figure 5.52 Distribution of *Ischaemum magnum* (A), *I. muticum* (B), *I. rugosum* (C) and *I. tenuifolium* (D).

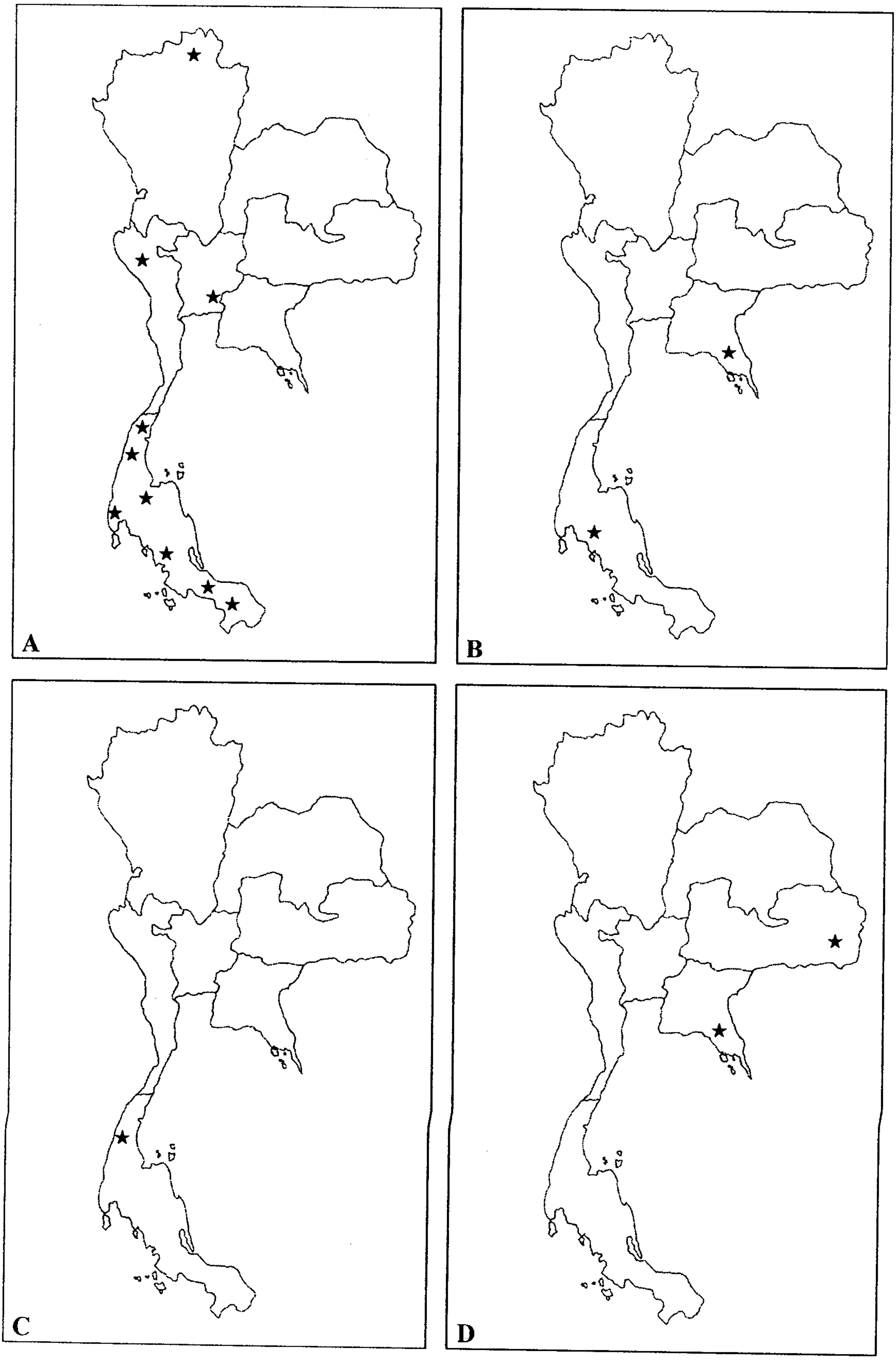

Figure 5.53 Distribution of *Ischaemum timorense* (A), *I.* sp. 1 (B), *I.* sp. 2 (C) and *Kerriochloa siamensis* (D).

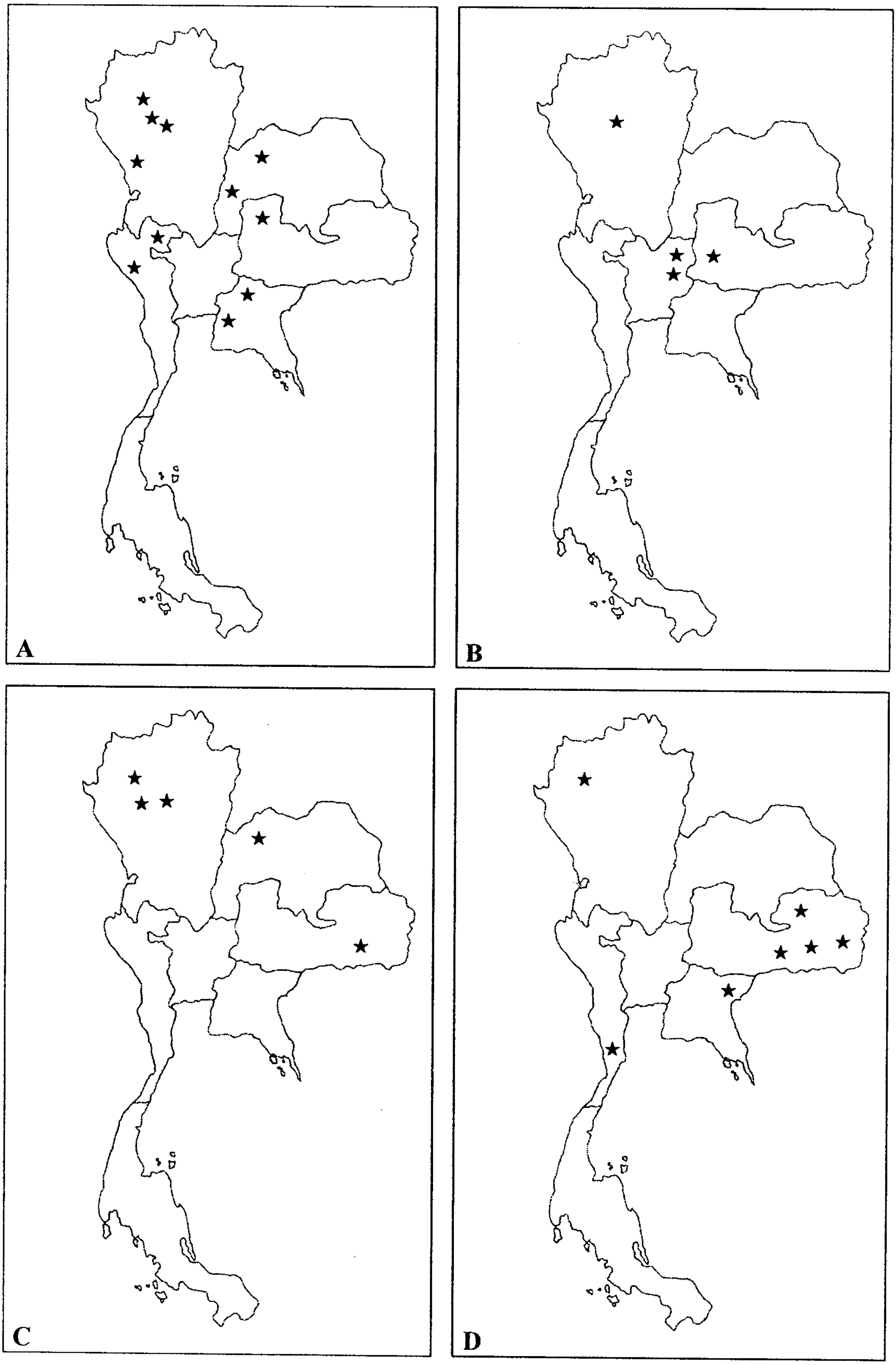

Figure 5.54 Distribution of *Sehima nervosum* (A), *Thelepogon elegans* (B), *Eremochloa attenuata* (C) and *E. bimaculata* (D).

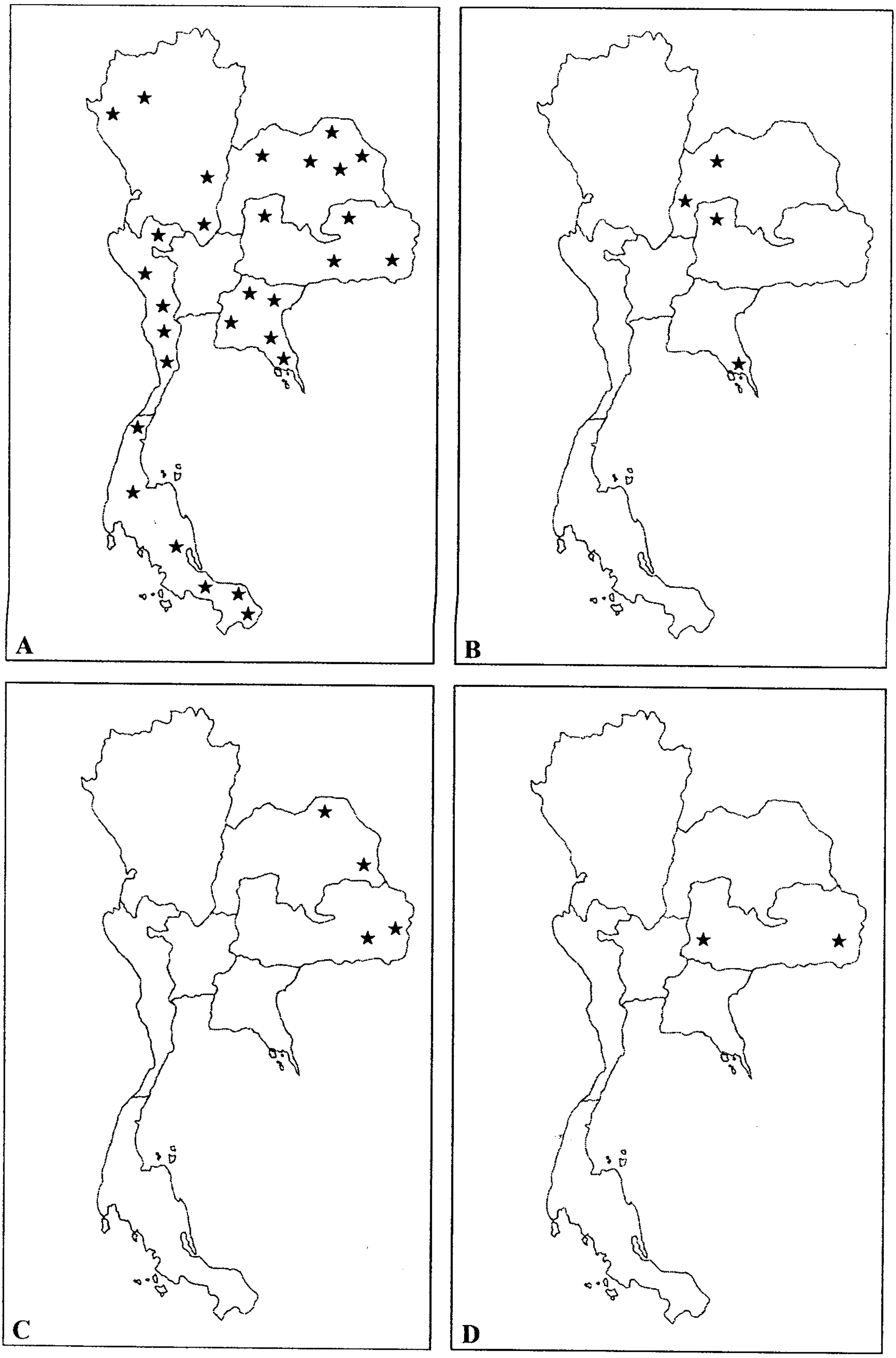

Figure 5.55 Distribution of *Eremochloa ciliaris* (A), *E. ciliatifolia* (B), *E. eriopoda* (C) and *E. lanceolata* (D).

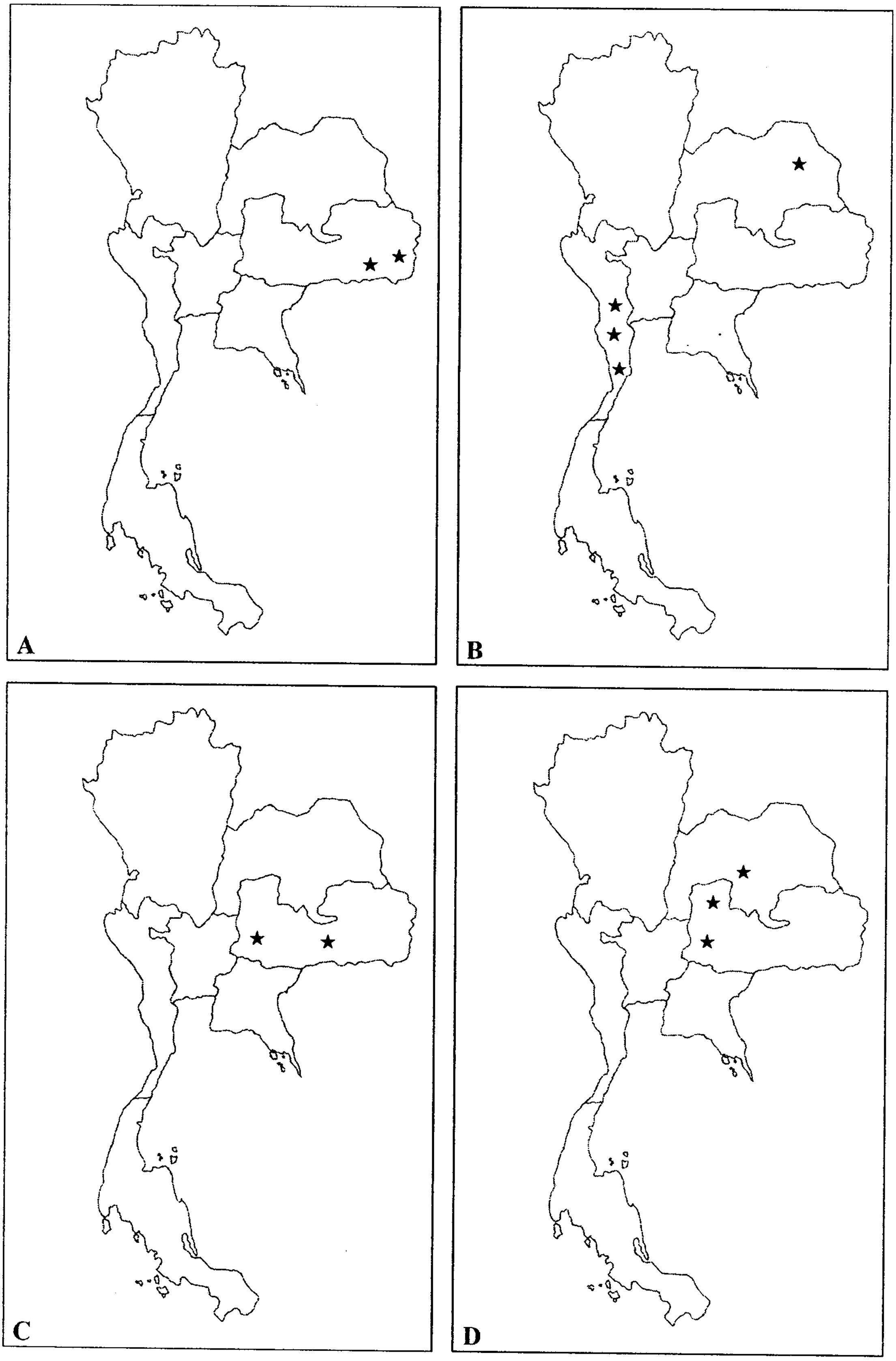

Figure 5.56 Distribution of *Eremochloa maxwellii* (A), *E. muricata* (B), *E. peltelotii* (C) and *E.* sp.1 (D).

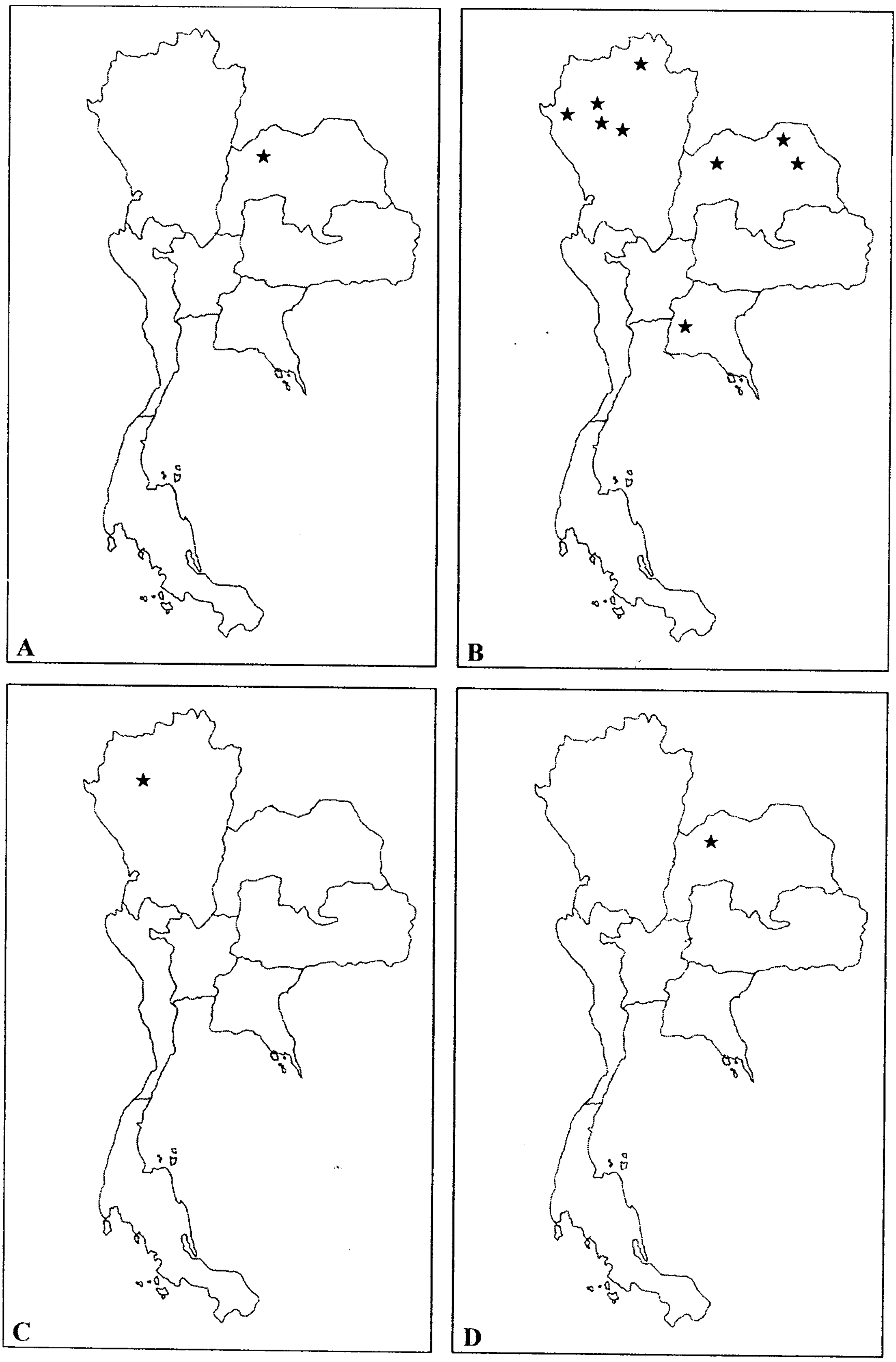

Figure 5.57 Distribution of *Eremochloa* sp. 2 (A), *Hackelochloa granularis* (B), *H. porifera* (C) and *Hemarthria altissima* (D).

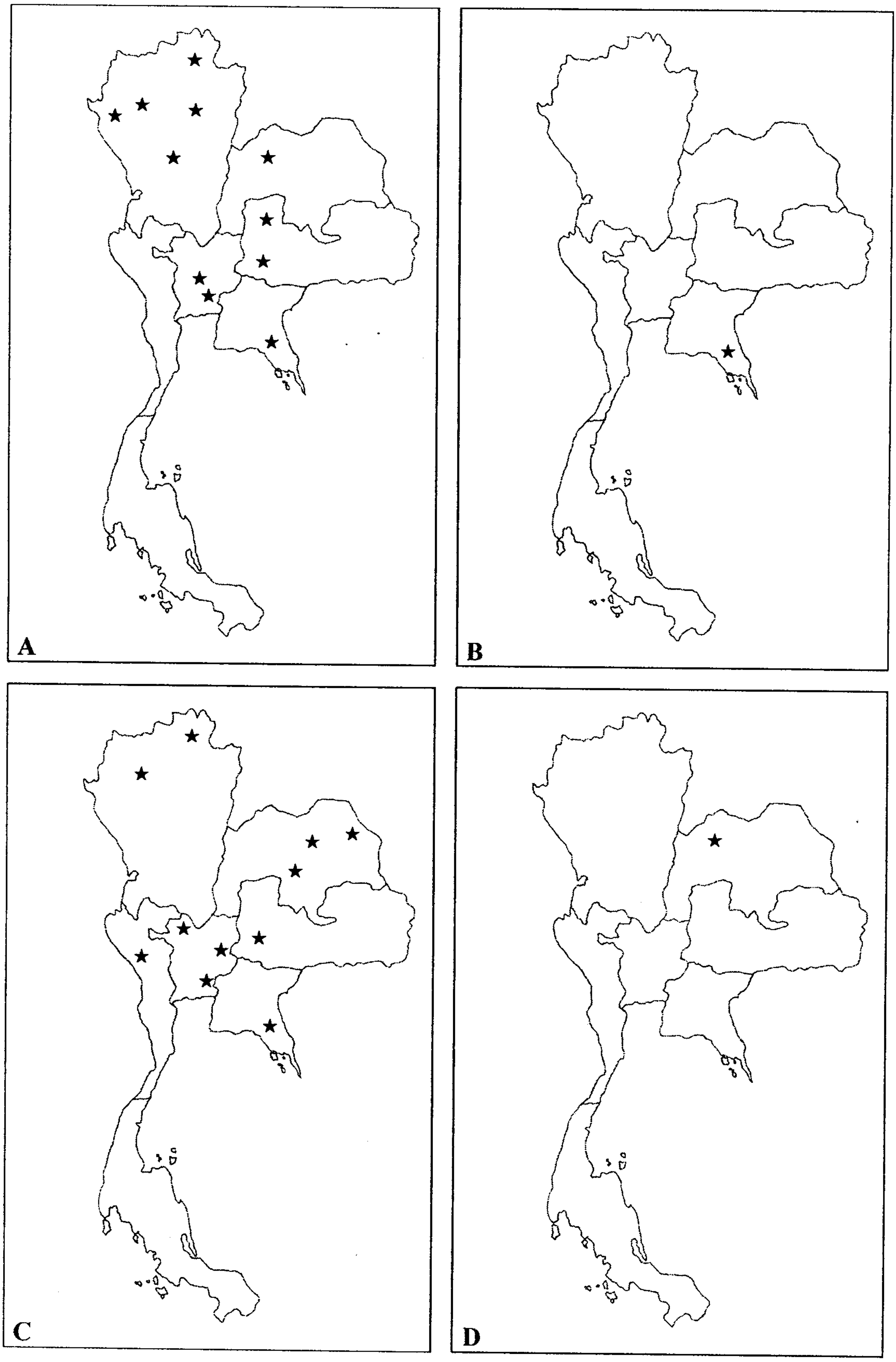

Figure 5.58 Distribution of *Hemarthria compressa* (A), *H. debilis* (B), *H. longiflora* (C) and *H. pratensis* (D).

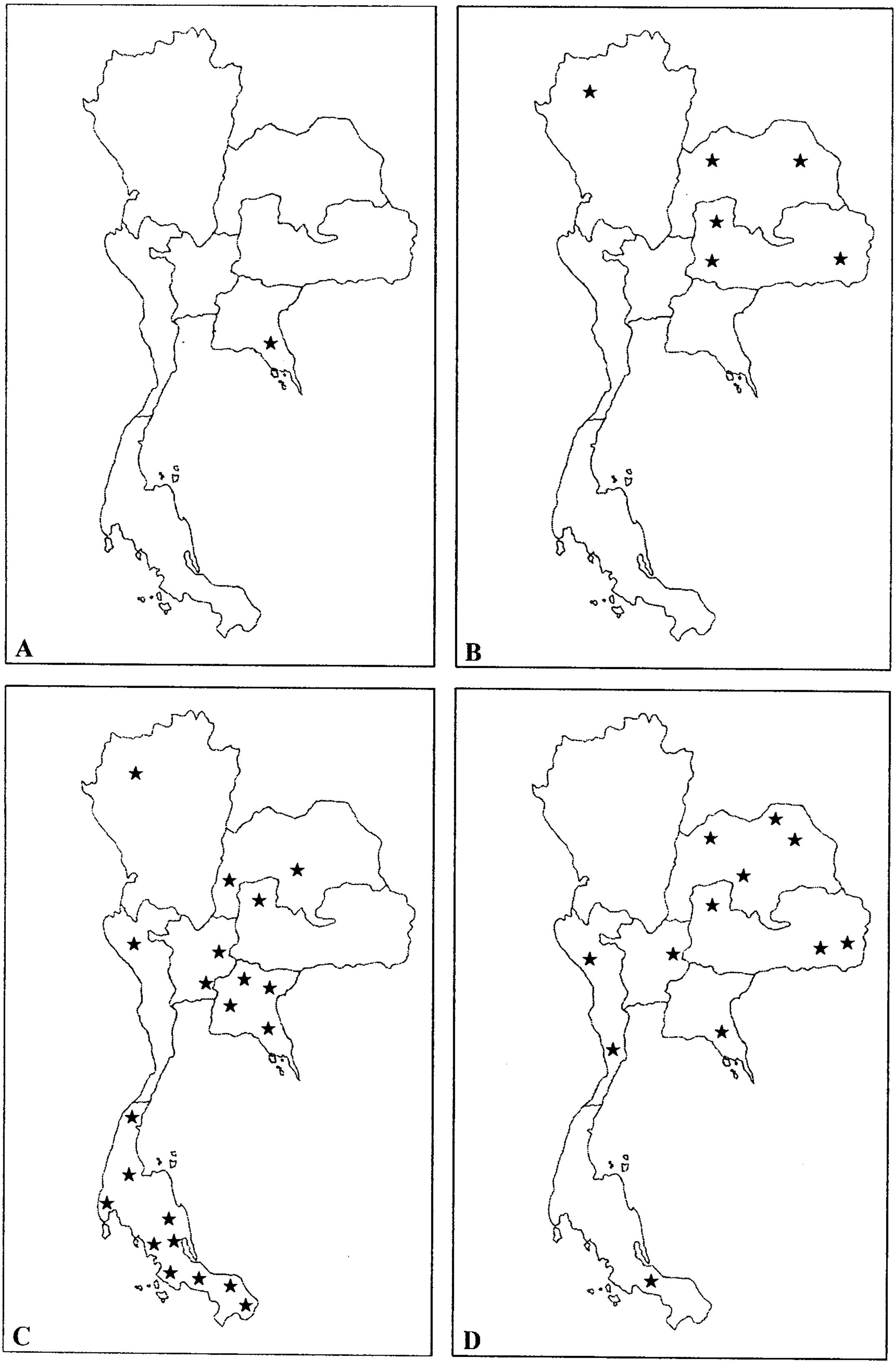

Figure 5.59 Distribution of *Hemarthria stolonifera* (A), *Mnesithea cancellata* (B), *M. glandulosa* (C) and *M. helferi* (D).

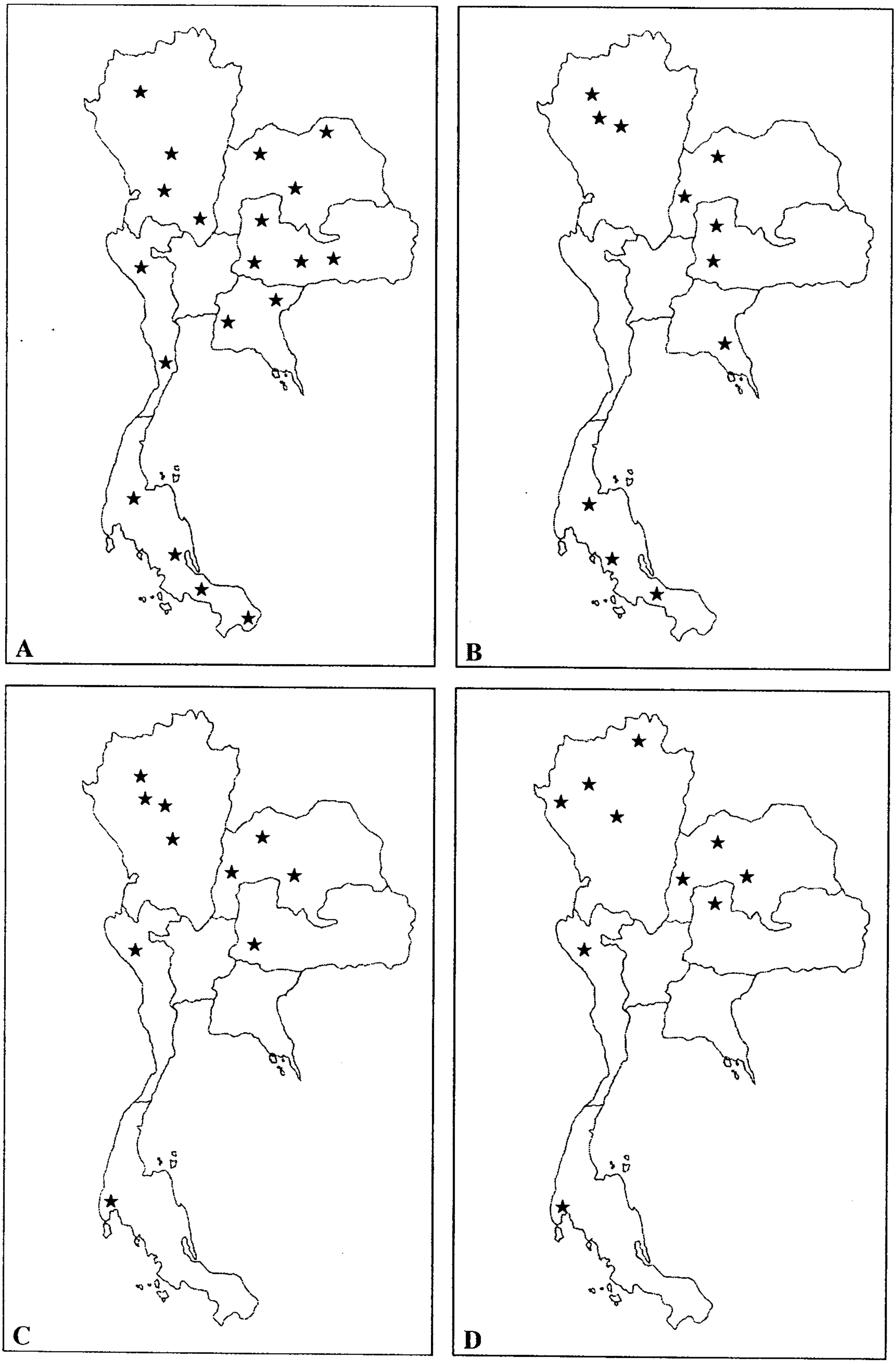

Figure 5.60 Distribution of *Mnesithea laevis* (A), *M. mollicoma* (B), *M. striata* (C) and *M. striata* var. *pubescens* (D).

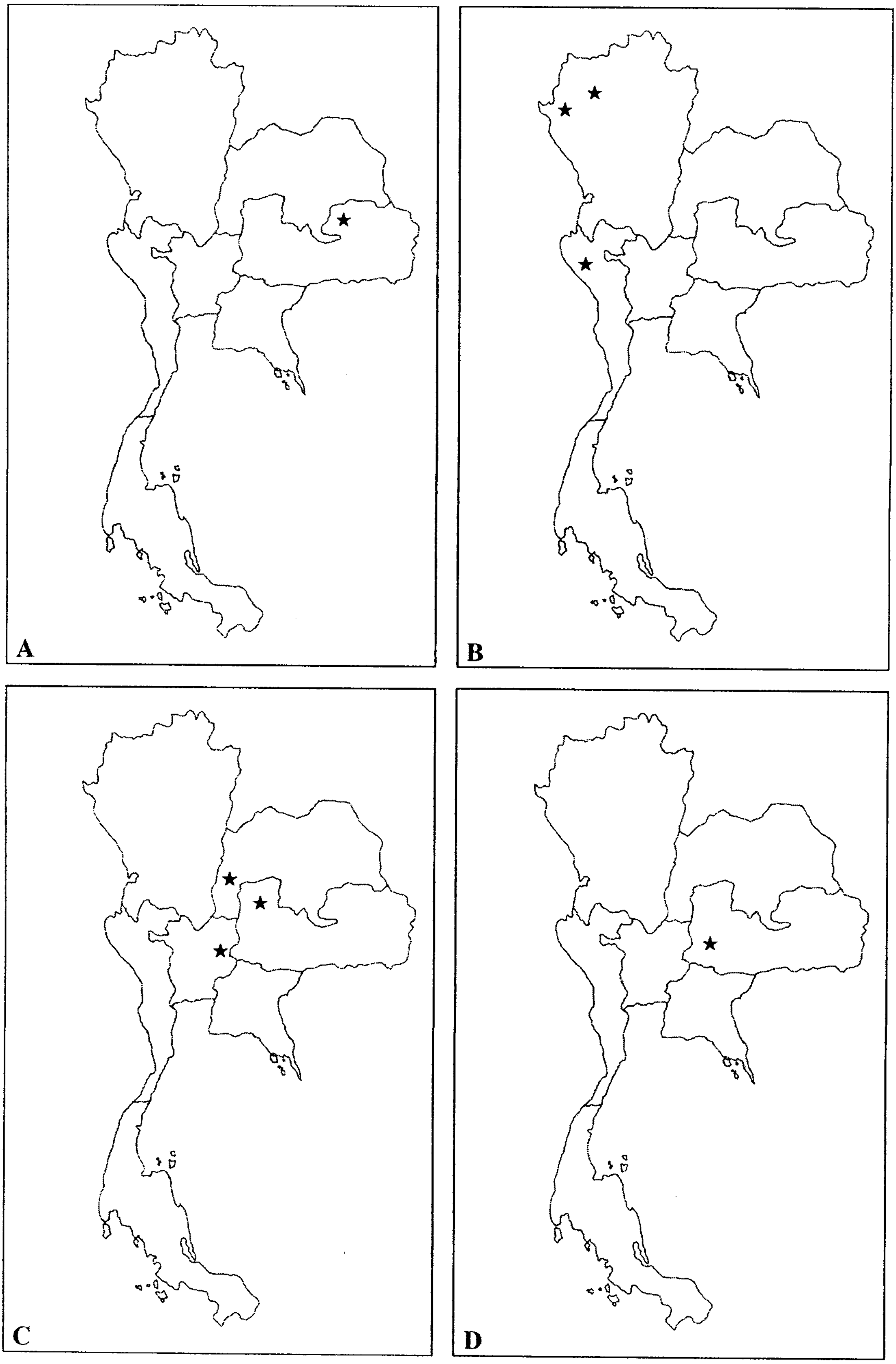

Figure 5.61 Distribution of *Mnesithea thailandica* (A), *M.* sp. 1 (B), *Ophiuros exaltatus* (C) and *Phacelurus cambogiensis* (D).

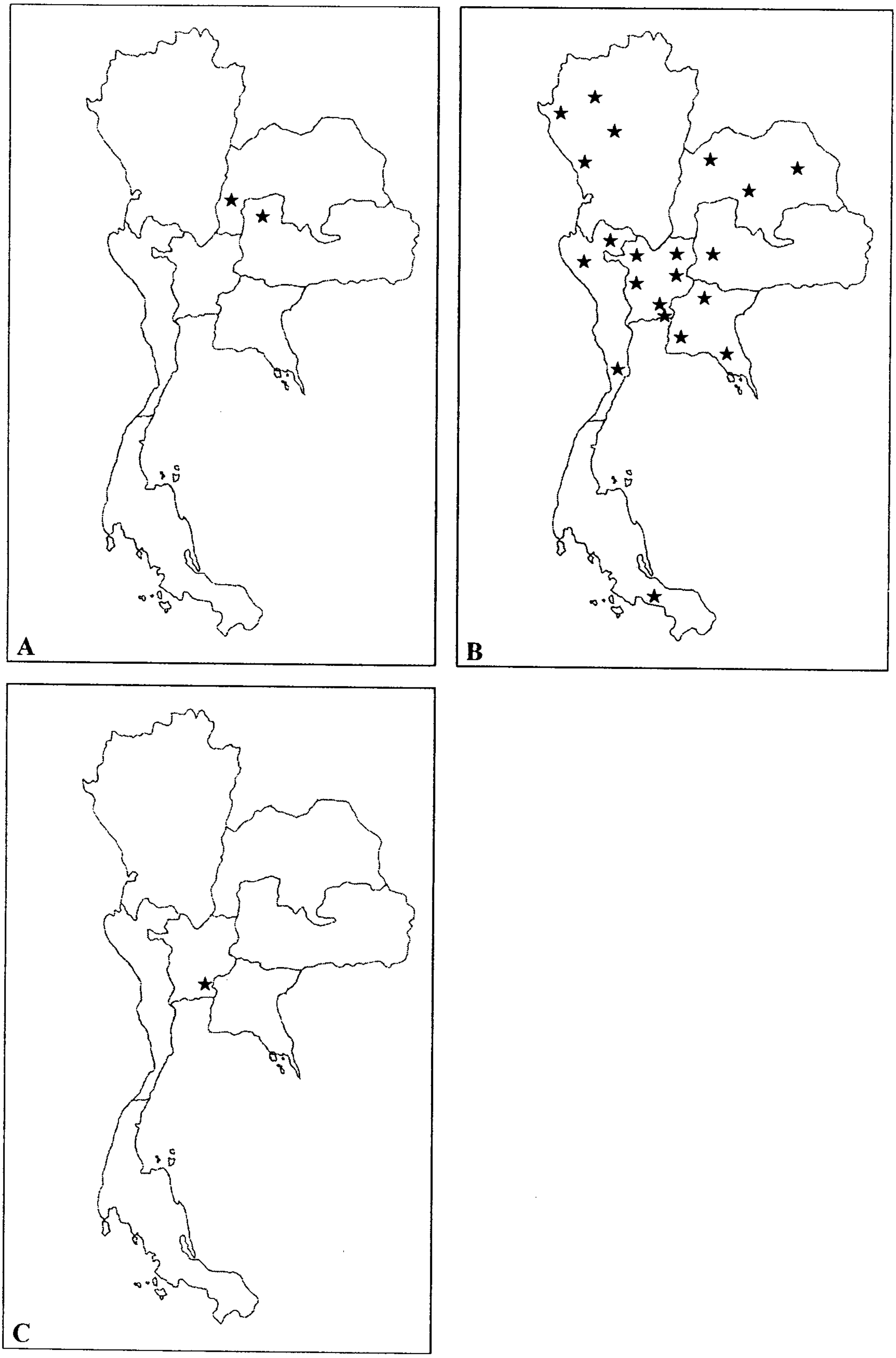

Figure 5.62 Distribution of *Phacelurus zea* (A), *Rotboellia cochinchinensis* (B) and *Vossia cuspidata* (C).

CHAPTER VI

GENERAL CONCLUSION

A preliminary taxonomic account of both subtribes is presented. Thirteen genera, 49 species and 2 infraspecific taxa are enumerated and described. Among these, *Ischaemum* (13 species and 1 infraspecific taxa) and *Eremochloa* (11 species) are the two largest genera. The members of both subtribes generally are found along roadsides, in paddy fields, swampy areas, near streams, savannas, deciduous forest, beach forest, dipterocarp forest, secondary forest, evergreen forest and pine forest from sea level to 2,350 m. Of these, *Apluda mutica*, *Ischaemum indicum*, *I. rugosum*, *Mnesithea glandulosa* and *Rottboellia cochinchinensis* are common as they are found in all floristic regions in Thailand. However, 12 species are endemic and rather have a restricted distribution.

One new combination of the genus *Andropogon* L.: *I. tenuifolium* (A. Camus) P. Traiperm & T. Boonkerd (*ined.*) is made. Two taxa, *Ischaemum hubbardii* and *Mnesithea striata* var. *pubescens* are newly recorded for the country. A variety i.e. *Ischaemum barbatum* var. *glaberrimum* was treated as synonym of *I. barbatum*. Five taxa of *Ischaemum*, i.e. *I. aristatum* subsp. *imberbe* var. *imbricatum*, *I. aristatus* var. *arfakense*, *I. lacei*, *I. magnum* and *I. macrurum* are lectotypified.

It is expected that six species in the genera *Ischaemum*, *Eremochloa* and *Mnesithea* are new species. (1) *Ischaemum* sp.1 resembles *I. barbatum* in the lower glume of the sessile spikelet. However, the latter is easily distinguished by having more than one coarse-ridge across the back of the lower glume of the sessile spikelet and by the two or more nodules along the margins. *Ischaemum* sp. 1 has a leaf-blade pubescent on both surfaces, and margin recurved or folded; while *I. barbatum* has a flat leaf-blade, which is glabrous to pilose on both surfaces. It was found at Khao Soi Dao, Chanthaburi and Khao Panom Bencha, Krabi. The molecular study showed that these two species are in the same clade with a moderate bootstrap support of 78%, therefore *Ischaemum* sp.1 can be proposed as a new species or a new variety of *I. barbatum*. (2) *Ischaemum* sp.2 is similar to *I. lacei*, but can be distinguished by its glabrous leaf blade, whereas the leaf-blade of *I. lacei* is pilose with tubercle-based hairs on both surfaces. It was only found at Phu Khao Yah National Park, Ranong. In the molecular results, *I.* sp.2 is also in the same clade with *I. indicum* with weakly bootstrap support of 74%. Hence, *Ischaemum* sp.2 can be proposed as a new species or a new variety of *I. indicum*. (3) *Eremochloa* sp.1 is very closely related to *E. maxwellii* but differs considerably in having an obovate and long cordate pedicel as compare with the obliquely-lanceolate pedicel in *E. maxwellii*. This species is found in north-eastern Thailand. The results of the molecular study confirmed that *Eremochloa* sp.1 can be purposed as a new species, not a variety of *E. maxwellii*. (4) *Eremochloa* sp.2 resembles *E. muricata*, but can be distinguished from the latter by its subulate pedicel, in contrast to the obliquely obovoid pedicel in *E. muricata*. This species is only found at Phu Kradueng, Loei. (5) *Mnesithea thailandica* is distinguished by having appressed hairs on the inflorescence. It is similar to *M. geminata*, but differs in having a small, erect and slender culm, *ca.* 26 cm tall. The species has pubescent hairs on the back of the triangular lower glume, rachis nodes, pedicels and rachis internode, while *M. geminata* is lanceolate and hirsute on the lower glume below and glabrous on rachis nodes, pedicels and rachis internode. (6) *Mnesithea* sp.1 is closely related to *M. striata*. *Mnesithea* sp.1 is characterized by the lower glume of the sessile spikelet oblong, indurate, 5–5.5 by 1.2–1.5 mm, an apex with unequal wings, 7–8 longitudinal rows of small pits between the nerves of the back of the leaf blade, and margins at base puberulous. In contrast, *M. striata* has indurate ovate lower glume at the sessile spikelet, 4.5–5 by *ca.* 1.5 mm, the apex has 2 apical wings, and having continuous ridge along the length and interrupted by tubercles or tubercle-based hairs on the back or glabrous. The molecular analysis supported that *Mnesithea* sp.1 should be proposed as a new species in the genus *Mnesithea*.

In comparison with a previous study of grass group in Thailand (Nanakorn & Norsaengsri, 2001), there are eight additional taxa reported from this study, namely *Ischäemum hubbardii*, *I.* sp.1, *I.* sp.2, *E.* sp.1, *E.* sp.2, *M. striata* var. *pubescens*, *M. thailandica* and *M.* sp.1. Seven misidentified taxa are re-determined and listed in this study, viz. *Ischaemum mangaluricum* (*I. barbatum*), *Sehima sulcatum* (*Andropogon* sp.), *Eremochloa zeylanica* (*E. bimaculata*), *Mnesithea geminata* (*M. mollicoma*), *Ophiuros bombaiensis* (*M. laevis*), *O. megaphyllus* (*O. exaltatus*) and *Thaumastochloa cochinchinensis* (*M. laevis*).

The epidermal peels and transverse sections of leaf-blades and culms have also been investigated in 25 species of the 12 genera from the two subtribes. It was shown that a number of anatomical characters are taxonomically useful for separating the related genera in the subtribes Ischaeminae and Rottboelliinae of Thai grass: leaf blade outline, ribs and furrows on both surfaces, bulliform cells, midrib and keel, number of vascular bundles in the keel, shape of sclerenchyma at margins, intercostal long cells, papillae, prickles, macro-hairs, silica bodies, culm outline and central cavity in ground tissue of culm. However, this anatomical study does not support the previous segregation of the two subtribes Ischaeminae and Rottboelliinae. It also does not support the morphological classification system proposed by Clayton & Renvoize (1986).

The phylogenetic analysis of 44 samples from 38 taxa was conducted on non-coding chloroplast DNA *trn*L intron and *trn*L-F spacer and nuclear ribosomal internal transcribed spacer (ITS) sequence data. The Maximum Parsimony analysis was conducted using PAUP* 4.0b10. Both data sets were analyzed separately before being combined into a single data set. The analysis indicated that a combined ITS and *trn*L-F analysis strengthens the signal and also points to a non-monophyletic origin of both subtribes which correspond with previous studies (Kellogg & Watson, 1993). However, these two groups of subtribes do not support the subtribal designations by Clayton & Renvoize (1986). Two main lineages can be identified as identical to the analysis of *trn*L-F data, while the analysis of ITS provides evidence for phylogenetic examination of closely related taxa or among the species. The *trn*L-F and combined analyses suggest that *Hemarthria*, *Hackelochloa* and *Eremochloa* are monophyletic. Resolution within the *Ischaemum* and *Mnesithea* clades is rather weak to high bootstrap support showing that both genera are not monophyletic.

The taxonomic study suggested that *I. tenuifolium* belongs to the genus *Andropogon* instead of *Ischaemum*. The species has 3–7 digitate racemes, 6–12 cm long, borne upon sub-equal flattened raceme-bases, and the lower glume of sessile spikelet is concave, which are all diagnostic features of *Andropogon* (Clayton & Renvoize, 1986). This new combination is in agreement with the anatomical description of the genus, while the species fails to conform completely to the general pattern in the genus *Ischaemum*. In addition to this, the molecular analysis exhibits a poor bootstrap supported (<50%) topology of *I. tenuifolium* excluded from the genus *Ischaemum*.

The genus *Coelorachis* has been reduced as a synonym of *Mnesithea* by Veldkamp et al., (1986); this was confirmed by the present taxonomic study. In several species of *Coelorachis* the lower part of pedicel is completely fused to the rachis node. The pedicelled spikelet varies from well developed to minute vestige, and its absence in traditional *Mnesithea* is just the final step. On the other hand, the analysis of the combined molecular data set demonstrates a weakly bootstrap supported clade to separate *M. laevis* from other *Mnesithea* species, and also the anatomical study emphasizes that there are some heterogeneity of these species within the genus. The analysis of the combined data set suggests the segregation of the genus *Mnesithea*, which corresponds to the classification system proposed by Clayton & Renvoize (1986).

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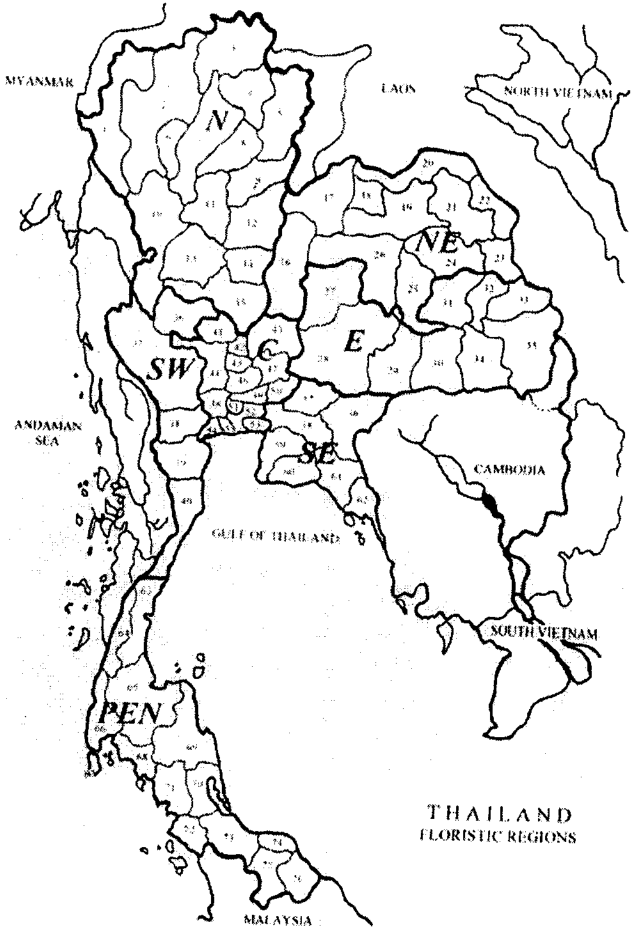
APPENDICES

APPENDIX A

The floristic regions and provincial map of Thailand

The floristic regions and provincial map of Thailand



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

APPENDIX B

Specimens examined in anatomical study

Specimens examined in anatomical study

Species	Localities	Voucher
Subtribe Ischaeminae		
1. *Apluda mutica*	Sattahip, Chon Buri	*P. Traiperm* 152
	Khun Tan, Lampang	*P. Traiperm* 321
2. *Ischaemum hirtum*	Nam Nao, Phetchabun	*P. Traiperm* 171
3. *I. hubbardii*	Doi Inthanon, Chiang Mai	*P. Traiperm* 308
4. *I. muticum*	Muang, Songkhla	*P. Traiperm* 138
	Tarutao, Satun	*P. Traiperm* 199
5. *I. rugosum*	Muang, Khon Kaen	*P. Traiperm* 127
	Klang, Rayong	*P. Traiperm* 293
6. *I. tenuifolium*	Warin Chamrap, Ubon Ratchathani	*P. Traiperm* 233
	Makham, Chanthaburi	*P. Traiperm* 287
7. *I.* sp.1	Khao Soi Dao, Chanthaburi	*P. Traiperm* 327
8. *Kerriochloa siamensis*	Warin Chamrap, Ubon Ratchathani	*P. Traiperm* 235
9. *Sehima nervosum*	Nam Nao, Phetchabun	*P. Traiperm* 170
	Khun Tan, Lampang	*P. Traiperm* 323
10. *Thelepogon elegans*	Muang, Saraburi	*P. Traiperm* 276
Subtribe Rottboelliinae		
11. *Eremochloa attenuata*	Phu Kradueng, Loei	*P. Traiperm* 162
12. *E. bimaculata*	Muang, Roi-Et	*P. Traiperm* 116
13. *E. lanceolata*	Pha Taem, Ubon Ratchathani	*P. Traiperm* 242
14. *Hackelochloa granularis*	Hot, Chiang Mai	*P. Traiperm* 303
15. *H. porifera*	Mae Rim, Chiang Mai	*P. Traiperm* 311
16. *Hemarthria compressa*	Phu Khiao, Chaiyaphum	*P. Traiperm* 187
17. *H. pratensis*	Phu Kradueng, Loei	*P. Traiperm* 158
18. *Mnesithea cancellata*	Phu Kradueng, Loei	*P. Traiperm* 161
	Phu Khiao, Chaiyaphum	*P. Traiperm* 183
19. *M. glandulosa*	Muang Phatthalung	*P. Traiperm* 139
20. *M. laevis*	Chom Thong, Chiang Mai	*P. Traiperm* 307
21. *M. mollicoma*	Muang, Song Khla	*P. Traiperm* 131
22. *M.* sp.1	Mae Soaw, Chiang Mai	*P. Traiperm* 347
23. *Ophiuros exaltatus*	Phu Khiao, Chaiyaphum	*P. Traiperm* 186
24. *Phacelurus zea*	Phu Khiao, Chaiyaphum	*P. Traiperm* 222
25. *Rottboellia cochinchinensis*	Muang, Song Khla	*P. Traiperm* 133

APPENDIX C

Specimens examined in molecular study

Taxa sampled	Voucher	Locality	GenBank accession no.	
			*trn*L-F	ITS
1. *Apluda mutica*	*P. Traiperm* 152	Satthahip, Chon Buri		
2. *Ischaemum barbatum* 1	*P. Traiperm* 140	Thale Noi, Phatthalung		
3. *Ischaemum barbatum* 2	*P. Traiperm* 206	Phu Phan, Sakon Nakhon		
4. *Ischaemum barbatum* 3	*P. Traiperm* 215	Bung Khla, Nong Khai		
5. *Ischaemum barbatum* 4	*P. Traiperm* 351	Muang, Trat		
6. *I. hirtum*	*P. Traiperm* 171	Nam Nao, Phetchabun		
7. *I. hubbardii*	*P. Traiperm* 308	Chom Thong, Chiang Mai		
8. *I. indicum* 1	*P. Traiperm* 159	Phu Kradueng, Loei		
9. *I. indicum* 2	*P. Traiperm* 195	Phu Ruea, Loei		
10. *I. indicum* 3	*P. Traiperm* 277	Sarika waterfalls, Nakhon Nayok		
11. *I. indicum* 4	*P. Traiperm* 330	Khao Luang National Park, Sukhothai		
12. *I. rugosum*	*P. Traiperm* 212	Nam Phong, Khon Kaen		
13. *I. tenuifolium*	*P. Traiperm* 233	Warin Chamrap, Ubon Ratchathani		
14. *I. timorense*	*P. Traiperm* 254	Sirindhorn, Ubon Ratchathani		
15. *I.* sp.1	*P. Traiperm* 327	Pong Nam Ron, Chanthaburi		
16. *I.* sp.2	*P. Traiperm* 149	Ngao, Ranong		
17. *Kerriochloa siamensis*	*P. Traiperm* 235	Warin Chamrap, Ubon Ratchathani		
18. *Sehima nervosum*	*P. Traiperm* 300	Hot, Chiang Mai		
19. *Thelepogon elegans*	*P. Traiperm* 276	Muang, Saraburi		
20. *Eremochloa attenuata*	*P. Traiperm* 162	Phu Kradueng, Loei		
21. *E. bimaculata*	*P. Traiperm* 116	Muang, Roi Et		
22. *E. ciliaris*	*P. Traiperm* 204	Phu Phan, Sakon Nakhon		
23. *E. ciliatifolia*	*P. Traiperm* 163	Phu Kradueng, Loei		
24. *E. eriopoda*	*P. Traiperm* 237	Warin Chamrap, Ubon Ratchathani		
25. *E. lanceolata*	*P.Traiperm* 242	Khong Chiam, Ubon Ratchathani		
26. *E. maxwellii*	*P. Traiperm* 232	Warin Chamrap, Ubon Ratchathani		
27. *E.* sp.1	*P. Traiperm* 125	Phu Ta Ka, Khon Kaen		
28. *Hackelochloa granularis*	*P. Traiperm* 299	Hot, Chiang Mai		
29. *H. porifera*	*P. Traiperm* 311	Mae Rim, Chiang Mai		
30. *Hemarthria compressa*	*P. Traiperm* 214	Phimai, Nakhon Ratchasima		
31. *H. pratensis*	*P. Traiperm* 158	Phu Kradueng, Loei		
32. *M. cancellata*	*P. Traiperm* 205	Phu Phan, Sakon Nakhon		
33. *Mnesithea glandulosa*	*P. Traiperm* 274	Muang, Saraburi		
34. *M. helferi*	*P. Traiperm* 132	Hat Yai, Songkhla		
35. *M. laevis*	*P. Traiperm* 307	Chom Thong, Chiang Mai		
36. *M. mollicoma*	*P. Traiperm* 280	Nam Nao, Phetchabun		
37. *M. striata*	*P. Traiperm* 325	Khun Tan, Lampang		
38. *M. striata* var. *pubescence*	*P. Traiperm* 314	Mae Rim, Chiang Mai		
39. *M.* sp.1	*P. Traiperm* 347	Mae Saow, Chiang Mai		
40. *Ophiuros exaltata*	*P. Traiperm* 176	Nam Nao, Phetchabun		
41. *Phacelurus zea*	*P. Traiperm* 222	Khon San, Chaiyaphum		
42. *Rottboellia cochinchinensis*	*P. Traiperm* 133	Hat Yai, Songkhla		
43. *Centotheca lappacea*	*C. Jaroenchai* 77	Phu Ruea, Loei		
44. *Ereagrostis biflora*			DQ655879	DQ655824

APPENDIX D

Paraffin Method adapted from Thammathaworn (1995)

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

1. 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).

2. 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.

3. 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.

4. Dehydration (Tertiary Butyl Alcohol (TBA) series)

2.1 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

2.2 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.

5. Infiltration

5.1 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.

5.2 Prepare a mixture of absolute TBA: paraffin oil (TBA: Oil) = 1:1 v/v.

5.3 Rinse the specimens with the TBA: Oil mixture and then leave the specimens in the mixture for about 1 hour at room temperature.

5.4 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.

5.5 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.

5.6 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.

5.7 Repeat step 6, 2 times.

6. Embedding

6.1 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.

6.2 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.

6.3 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 are 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.

6.4 Trim the blocks into a trapezium shape.

6.5 Keep the blocks in refrigerator at least 15 minutes.

7. 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".

8. Affixing section to slide

8.1 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).

8.2 Put the section in the warm gelatin solution, keep the shiny surface up and then leave for a minute to extend the section.

8.3 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.

8.4 Keep the dry slides into the microscope slide case for 20 days (up to 5 months).

9. Prestaining and Staining

As the stain (toluidine blue) is water based, it is necessary to remove the embedding wax from the sections before staining.

9.1 Prepare toluidine blue stain using toluidine blue 0.5 g in tap water 100 ml, stir well, filter, paper then keep in bottle.

9.2 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
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

10. 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 E

Molecular protocols and data matrix

MOLECULAR PROTOCOLS

Nina Rønsted 29.4.03

Isolation of total cellular DNA for long term storage

References: Saghai-Maroof et al. (1984). PNAS 81: 8014-8018; Doyle & Doyle (1987).

Phytochemical Bulletin 19: 11-15; Palmer et al. (1989). Annals of the Missouri Botanical Garden 75: 1180-1206.

1. Preheat 10 ml of isolation buffer containing 40 μl of beta-mercaptoethanol in a 50 ml plastic centrifuge tube in a 65 °C water bath. Preheat mortar and pestle as well.

2. Grind 0.3 g of silica or freeze dried or 0.2 g of herbarium leaf material in a mortar. Add the buffer and grind until a uniform slurry is obtained. Return the slurry to the centrifuge tube and leave at 65 °C for 10 minutes as above.

3. Add 10 ml SEVAG to each tube. Mix gently and open cap slightly to release gas. Leave the tubes on their side on s shaker for 1 hour (½-1½).

4. Spin at 8000 rpm at 25°C for 10 minute (Beckman J2-MC centrifuge). Ideally the aqueous (top) phase will be clear and colourless.

5. Transfer aqueous phase containing DNA with a pipette to a 50 ml centrifuge tube. An aliquot of 300 μl can be taken off for QIA quick column cleaning at this stage. Dispose SEVAG and plant debris in waist container.

If long term storage is not needed. Amounts may be reduced or the centrifuge tube with DNA may be stored in s freeze for an unknown time.

Further cleaning for inclusion in the Kew DNA bank:

6. Add 2/3 volume of -20 °C isopropanol (herbarium sample) or 2 volume of -20 °C EtOH (Fresh, freeze, silica dried sample). Put in -20 °C freeze, for at least 24 hours to precipitate DNA.

7. Spin at 3000 rpm for 5 minutes, pour off liquid and add 3 ml of 70% ethanol, dislodge pellet to facilitate washing (Harrier 15/80 MSE centrifuge, Sanyo).

8. Spin down DNA at 3000 rpm for 3 minutes, pour off liquid and leave tube on its side overnight to allow alcohol to evaporate.

9. Resuspend DNA in 3 ml 1.5 mg/ml CsCl – EtBr solution. Cover samples in foil to keep dark (EtBr degrades in sunlight). Shake until pellet dissolves (min 24 hours).

10. Pour DNA into ultra centrifuge rotor tube. Add CsCl – EtBr until total weight is 8.04-8.06 g (this weight ensures a minimum of air between sample and lids in the ultra centrifuge used at Jodrell, Which is important to avoid damage to tubes and rotor at the high speed used).

11. Spin at 45000 rpm (at least 14 hours) or 58000 for 5 hours (Beckman Ultracentrifuge XL-80).

12. Please tubes with sample on ultra violet light box. Remove 600 µl of solution above band. Take of 1200 µl of the band and transfer to transparent tubes. (If it is not possible to see the band, the 1200 µl is taken off at the same level as the band in the other sample. The rest of the sample is saved until the final gel check of DNA has shown that the level taken off did contain the DNA). At this stage sample can be left in a dark place until further clean up.

13. Add an equal volume of CsCl satisfied butanol, shake and leave tubes on the side for 15 minutes to remove EtBr. Shake tubes gently occasionally.

14. Rinse a 5 litre beaker and fill to 2 litres with milli-Q water (4 litre for 20 or more sample s). Rinse 800 ml beaker and fill to 200 ml with milli-Q water.

15. Cut dialysis tubing into 10 cm strips and rinse in 800 ml beaker.

16. Clamp lower end of each piece of tubing and pipette samples (lower layer) into tubings. Clamp top end of tubings, avoiding air bubbles in the sample.

17. Place samples in the 5 ml beaker making sure the samples are kept under stirred water. The samples are left 2-4 houes.

18. The samples are then concentrated by transferring to a tray and adding sugar (purity unimportant). Leave samples for 20-40 min depending on how much samples need to be concentrated (to obtain about 1 ml).

19. Rinse out 5 litre breaker and add 25 ml dialysis buffer and 2 litre milli-Q water (or 50 ml and 4 litre water for 20 samples or more). Put samples into water and leave for 4 hours to overnight ensuring that they are kept under stirred water.

20. Repeat step 19 again.

21. Transfer samples into 1.5 ml eppendorf tubes. Check DNA levels on gel and store at -20 °C or 80 °C for long term storage (at least up to 10 year).

Isolation buffer:	(2 x CTAB): 100 mM Tris-HCL, pH 8, 1.4 M NaCL, 20 mM EDTA, 2% CTAB (hexadecyltrimethylammonium bromide), 2% PVP.
Silica:	Sigma S4883, 28-200 M
SEVAG:	24:1 chloroform:isoamylalcohol
SSC satisfied BuOH:	1:1. BuOH:sodium citrate (0.15 molar NaCL & 0.015 molar sodium citrate)
Dialysis buffer 80X:	10mM Trizma® base, 1mM EDTA, pH adjusted to 8 by HCL.
Dialysis tuning:	Cellulose membrane. Sigma cat.no. D-9277

CsCl (cesium chloride) and EtBr (ethidium bromide) are considered possible carcinogens and should be handled with gloves, disposable pipettes and tubes.

QIAquick purification of total DNA

Reference: QIAGEN QIAquick Spin Handbook 01/99 page 20-21. QIAquick PCR purification kit (250) QIAGEN Cat. No. 28106

1. Insert QIAquick columns into a vacuum manifoder.
2. Add 750 µl Buffer PB and 150 µl of the total DNA and apply vacuum.
3. Repeat loading until all of the total DNA is passed through the column, always making sure to use
4. 5:1 volumes of Buffer PB to DNA extract.
5. Wash with 750 µl Buffer PE.
6. Switch vacuum off and transfer columns to the provided 2 ml collection tubes. Spin at 13.000 rpm for about 1 min to remove residual EtOH (PE Buffer).
7. Cut lids of sterilized 1.5 ml eppendorf tubes and place the QIAquick column into the tubes. Add 50 µl (or less depending on concentration of DNA) Buffer NE directly on the membrane of the columns and leave for 30 min to dissolve DNA in the elution buffer.
8. Spin 1 min at 13.000 rpm, cap tubes and store at -20 °C after checking DNA levels on gel.

Making an agarose gel

1. Tape sides of gel tray to hold the gel while setting, and place well forming combs.
2. Dissolve 1.g agarose in 100 ml TBE buffer in microwave for 1.5 min with loose lid. Shake gently after one min.
3. Let cool until not smoking. Add 4 µl EtBr and shake gently.
4. Pour into gel tray and leave for 20 min to set.
5. Place gel in eletrophoresis tray and cover with TBE buffer.

TBE buffer: 216 g Trizma® base, 110 g Boric acid, 16.6 g EDTA in 2 L Milli-Q water.

EtBr solution: 1 g EtBr in 100 ml water. Wrap in foil and stir for hours. Carcinogenic!

Gel check of DNA levels

1. Spot 5 µl of blue loading dye for each DNA sample on s strip of parafilm.
2. Mix 5 µl of DNA with the spot of dye and load the mix into a well on the gel. A standard can be loaded for reference.
3. Run for 10-20 min at 80 A.
4. View gel under UV light and photograph for later reference.

Loading dye: 40 g sucrose in 100 ml Milli-Q water, add 0.025 g bromophenol blue and stir to obtain a deep dark blue colour.

QUICK COLUMN CLEAN PROTOCOL

Materials needed:

3 Types of Buffer:
1. PB Buffer (alters pH)
2. PE Buffer (washing buffer) (NT3)
3. EB Buffer (eludes DNA through filter) (NE)

- 300 µl of extracted sample in Eppendorf tubes
- column tubes: pink in white(by blue "pig")

1. PB Buffer: For this buffer there has to be a ratio 5 : 1 (5 parts of PB buffer to 1 part of DNA) = 750 µl PB : 150 µl DNA sample)

Number pink and white column tubes (each separately) with the sample numbers (1 to ...)

Line up **pink** tubes onto pig; open levers underneath them (from horizontal to vertical position);

Transfer 750 µl PB buffer and 150 µl (using P1000 and P200 pipette accordingly) **of the sample** into pink column tube (=total of 900 µl). Mix well (by absorbing and releasing solution in tube with pipette).

(For transfer of buffer into all tubes, the same pipette tip can be used, but for transfer of sample a new pipette tip has to be used for each sample).

Turn on switch on wall and let solution run through column (approx. 1-2 min.).

Repeat above with second lot of sample (another 150 µl). Keep Eppendorf tubes, as they are needed again later.

2. PE Buffer

After second lot of sample with PB buffer has run through column. **Add 750 µl of PE buffer** to column (again, one pipette tip to used for all samples) and let run through column.

Then remove pink tubes from pig, close them and attach white lower tube part to it and put into small centrifuge (balancing sample equally in centrifuge). Let it spin approx. 1 min. (looking at your watch, as time switch on centrifuge has to be switch on to run, but does not stop at appropriate time; after a minute, press stop buttom and wait until green light comes on before opening centrifuge.)

Take out tubes from centrifuge and discard white lower tube with percipient into waste glass on desk.

3. EB Buffer

Put pink, column tubes into respective Eppendorf tubes. Cut off lid of Eppendorf tubes, but **keep! Add 50 µl of EB buffer right into centre of white filter** at bottom of each pink column tube.

Change pipette tip after each sample.

Then close lids and let it sit for 1 minute for buffer to elude through filter. Then out both, pink column tubes inside Eppendorfs, into small centrifuge and spin for 1 min.

Stop centrifuge, and now you should have sample (approx. 48 μl) in Eppendorf tubes.

Discard of pink column tubes into waste glass, or waste bin. Finished!

4. Run gel to check DNA content of samples.

Data matrix of aligned *trn*L-F and ITS sequences of 42 taxa of subtribes Ischaeminae and Rottboelliinae and two taxa from an outgroup.

	1 10 20 30 40 50 60 70 80 90
Api.mut.26233	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.bar.26363	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.bar.26364	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.bar.26365	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.bar.26366	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.hir.26249	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.hub.26250	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.ind.26367	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.ind.26368	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.ind.26369	????CGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.ind.26370	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.rug.26372	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.ten.26373	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.tim.26374	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.sp1.26251	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Isc.sp2.26375	??GACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Ker.sia.26252	??GACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Seh.ner.26239	??GACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
The.ele.26240	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Mne.can.26346	??GACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Mne.gla.26347	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Mne.hel.26348	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Mne.mol.26349	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Mne.str.26350	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Mne.stp.26351	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Mne.sp1.26244	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Ere.att.26352	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Ere.bim.26353	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Ere.cil.26354	??GACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Ere.cit.26355	?????GCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Ere.eri.26356	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Ere.lan.26357	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Ere.max.26358	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Ere.sp1.26245	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Hac.gra.26234	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA
Hac.por.26235	TAGACGCTACGGACTTGATTGTATTGAGCCTTGGTATGGAAACCTGCTAAGTGGTAACTTCCAAATTCAGAGAAACCCTGGAATGAAAAA

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                91       100       110       120       130       140       150       160       170      180
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Isc.bar.26363   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--CTGGTTCTCAAACTAGAACCCAAAGGAAAAGGAAGGATAGGTGCAGAG
Isc.bar.26364   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--CTGGTTCTCAAACTAGAACCCAAAGGAAAAGGAAGGATAGGTGCAGAG
Isc.bar.26365   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--CTGGTTCTCAAACTAGAACCCAAAGGAAAAGGAAGGATAGGTGCAGAG
Isc.bar.26366   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--CTGGTTCTCAAACTAGAACCCAAAGGAAAAGGAAGGATAGGTGCAGAG
Isc.hir.26249   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Isc.hub.26250   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--CTGGTTCTCAAACTAGAACCCAAAGGAAAAGGAAGGATAGGTGCAGAG
Isc.ind.26367   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--CTGGTTCTCAAACTAGAACCCAAAGGAAAAGGAAGGATAGGTGCAGAG
Isc.ind.26368   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Isc.ind.26369   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Isc.ind.26370   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Isc.rug.26372   TGGGCAATCCTGAGCCAAATCCTTTTTTT-GAAAAAACAA--CTGGTTCTCAAACTAGAACCCAAAGGAAAAGGAAGGATAGGTGCAGAG
Isc.ten.26373   TGGGCAATCCTGAGCCAAATCCCTTTTTT--TAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Isc.tim.26374   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Isc.sp1.26251   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--CTGGTTCTCAAACTAGAACCCAAAGGAAAAGGAAGGATAGGTGCAGAG
Isc.sp2.26375   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Ker.sia.26252   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAAGAAAAGGA----TAGGTGCAGAG
Seh.ner.26239   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTG-----CAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
The.ele.26240   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Mne.can.26346   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GCGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Mne.gla.26347   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GCGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Mne.hel.26348   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GCGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Mne.mol.26349   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GCGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Mne.str.26350   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GCGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Mne.stp.26351   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GCGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Mne.sp1.26244   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GCGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Ere.att.26352   TGGGCAATCCTGAGCCAAATCCCTTTTTTTGAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Ere.bim.26353   TGGGCAATCCTGAGCCAAATCCCTTTTTTTGAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Ere.cil.26354   TGGGCAATCCTGAGCCAAATCCCTTTTTTTGAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Ere.cit.26355   TGGGCAATCCTGAGCCAAATCCCTTTTTTTGAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Ere.eri.26356   TGGGCAATCCTGAGCCAAATCCCTTTTTTTGAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Ere.lan.26357   TGGGCAATCCTGAGCCAAATCCCTTTTTTTGAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Ere.max.26358   TGGGCAATCCTGAGCCAAATCCCTTTTTTTGAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Ere.sp1.26245   TGGGCAATCCTGAGCCAAATCCCTTTTTTTGAAAAAACAA--GCGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Hac.gra.26234   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Hac.por.26235   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Hem.com.26247   TGGGCAATCCTGAGCCAAATCCCTGTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Hem.pra.26248   TGGGCAATCCTGAGCCAAATCCCTGTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Mne.lae.26236   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GCGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Oph.exa.26237   TGGGTAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Pha.zea.26238   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Rot.coc.26253   TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAAGGAAAAGGA----TAGGTGCAGAG
Era.bif.        TGGGCAATCCTGAGCCAAATCCCTTTTTT-GAAAAAACAA--GTGGTTCTCAAACTAGAACCCAAATGAAAAGGA----TAGGTGCAGAG
Cen.lap.26376   TGGGCAATCCTGAGCCAAATCCCTTTTTT-G-AAAAACAA--GTGGTTCTCAAACAAGAACCCAAAAGAAATGGA----TAGGTGCAGAG
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                181       190       200       210       220       230       240       250       260       270
Apl.mut.26233   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.bar.26363   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.bar.26364   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.bar.26365   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.bar.26366   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.hir.26249   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.hub.26250   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.ind.26367   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.ind.26368   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.ind.26369   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.ind.26370   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.rug.26372   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.ten.26373   ACTCAATGGAAGCTGTTCTAACGAATTGAAGTAATAACG---------------------------------------------------
Isc.tim.26374   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.sp1.26251   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Isc.sp2.26375   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Ker.sia.26252   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Seh.ner.26239   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
The.ele.26240   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Mne.can.26346   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Mne.gla.26347   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Mne.hel.26348   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Mne.mol.26349   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Mne.str.26350   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Mne.stp.26351   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Mne.sp1.26244   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Ere.att.26352   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Ere.bim.26353   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Ere.cil.26354   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Ere.cit.26355   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Ere.eri.26356   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Ere.lan.26357   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Ere.max.26358   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Ere.sp1.26245   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Hac.gra.26234   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Hac.por.26235   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Hem.com.26247   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Hem.pra.26248   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Mne.lae.26236   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Oph.exa.26237   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Pha.zea.26238   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Rot.coc.26253   ACTCAATGGAAGCTGTTCTAACGAATCGAAGTAATAACG---------------------------------------------------
Era.bif.        ACTCAATGGAAGCTATTCTAACGAATCGAGGTG-TAATTACGTTGTGTTGGTAATGAAACTCCCTCTAAATTTGAGAAAGAGGGGCTTTA
Cen.lap.26376   ACTCAATGGAAGCTGTTCTAACGAATCAAGGT---AATTACGTTCTGTTGGTAGTGGAACTCCCTCAAAATTAGAGAAAGAGGGGCTTTC
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               271      280       290       300       310       320       330       340       350       360
Api.mut.26233  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTTTTTTT
Isc.bar.26363  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Isc.bar.26364  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Isc.bar.26365  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Isc.bar.26366  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Isc.hir.26249  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Isc.hub.26250  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Isc.ind.26367  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Isc.ind.26368  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Isc.ind.26369  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Isc.ind.26370  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
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Isc.ten.26373  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Isc.tim.26374  ----------------------------------------ATTAATCACA--GAACCCTTATTATAATATAGGTTCTTTATTTTATTTTT
Isc.sp1.26251  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Isc.sp2.26375  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Ker.sia.26252  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Seh.ner.26239  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
The.ele.26240  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Mne.can.26346  ----------------------------------------ATTAATCACA--GAACCTATATTATAATATAGGTTCTTTATTTTATTTTT
Mne.gia.26347  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Mne.hel.26348  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Mne.mol.26349  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Mne.str.26350  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Mne.stp.26351  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Mne.sp1.26244  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Ere.att.26352  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Ere.bim.26353  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Ere.cil.26354  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Ere.cit.26355  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Ere.eri.26356  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Ere.lan.26357  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Ere.max.26358  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Ere.sp1.26245  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Hac.gra.26234  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Hac.por.26235  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Hem.com.26247  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Hem.pra.26248  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Mne.lae.26236  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Oph.exa.26237  ----------------------------------------ATTAATCACA--GAACACATATTATAATATAGGTTCTTTATTTTATTTTT
Pha.zea.26238  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTT-----ATTTTT
Rot.coc.26253  ----------------------------------------ATTAATCACA--GAACCCATATTATAATATAGGTTCTTTATTTTATTTTT
Era.bif.       TACATCTAATACACACGTATAGATACTGACATAGCAAACGATTAATCACA--GAACCCATATCATAATATAGGTTCTTTATTT-ATTTTT
Cen.jap.26376  TACATCTAATACACACGTATAGATACTGACATAGCAAATGATTAATCACA--GAACCCATATCATAATTTAGGTTCTTTATTT-ATTTTA
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               361       370       380       390       400       410       420       430       440       450
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Isc.bar.26364  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.bar.26365  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.bar.26366  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.hir.26249  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.hub.26250  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.ind.26367  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.ind.26368  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.ind.26369  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.ind.26370  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.rug.26372  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.ten.26373  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.tim.26374  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.sp1.26251  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Isc.sp2.26375  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Ker.sia.26252  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Seh.ner.26239  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
The.ele.26240  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCAAAATTATTTTAGAATT------ATTGTGAATCTATTCCAATC
Mne.can.26346  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Mne.gla.26347  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Mne.hel.26348  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Mne.mol.26349  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
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Mne.stp.26351  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Mne.sp1.26244  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Ere.att.26352  ----------AGAATGAAATTTGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Ere.bim.26353  ----------AGAATGAAATTTGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Ere.cil.26354  ----------AGAATGAAATTTGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Ere.cit.26355  ----------AGAATGAAATTTGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
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Ere.lan.26357  ----------AGAATGAAATTTGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Ere.max.26358  ----------AGAATGAAATTTGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Ere.sp1.26245  ----------AGAATGAAATTTGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Hac.gra.26234  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
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Hem.com.26247  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Hem.pra.26248  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCAGAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Mne.lae.26236  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCAGAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Oph.exa.26237  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Pha.zea.26238  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATG
Rot.coc.26253  ----------AGAATGAAATTAGGAATGATTATGAAATAGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCTATTCCAATC
Era.bif.       TT---------GAATGAAATTAGGAATGATTATGAAATAGAAAATTC-TGAATTTTT----ATTAGAATTATTGTGAATCCATTCCACTC
Cen.lap.26376  TTGATTTTTTAGAATGAAATTAGGAATGATTATGAAATTGAAAATTCATAATTTTTTTAGAATT------ATTGTGAATCCATTCCAATC
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	451 460 470 480 490 500 510 520 530 540
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Isc.bar.26364	----GAATATTGAGTAATCAAATCCTTCAATTCATTCTTTTCGAGATCTTTTTAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Isc.bar.26365	----GAATATTGAGTAATCAAATCCTTCAATTCATTCTTTTCGAGATCTTTTTAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Isc.bar.26366	----GAATATTGAGTAATCAAATCCTTCAATTCATTCTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Isc.hir.26249	GATCGAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Isc.hub.26250	----GAATATTGAGTAATCAAATCCTTCAATTCATTCTTTTCGAGATCTTTTTAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Isc.ind.26367	----GAATATTGAGTAATCAAATCCTTCAATTCATTCTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Isc.ind.26368	GATCGAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGAACGAGGATAAAGAGA
Isc.ind.26369	GATCGAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGAACGAGGATAAAGAGA
Isc.ind.26370	GATCGAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGAACGAGGATAAAGAGA
Isc.rug.26372	----GAATATTGAGTAATCAAATCCTTCAATTCATTCTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Isc.ten.26373	-----AATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Isc.tim.26374	GATCGAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGAACGAGGATAAAGAGA
Isc.sp1.26251	----GAATATTGAGTAATCAAATCCTTCAATTCATTCTTTTCGAGATCTTTTTAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Isc.sp2.26375	GATCGAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGAACGAGGATAAAGAGA
Ker.sia.26252	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTTAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Seh.ner.26239	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGGGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
The.ele.26240	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTGGAGATCTT--------------GGATTAATCGGACGAGGATAAAGAGA
Mne.can.26346	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Mne.gla.26347	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Mne.hel.26348	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGACGATAAAGAGA
Mne.mol.26349	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGACGATAAAGAGA
Mne.str.26350	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Mne.stp.26351	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Mne.sp1.26244	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTTAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Ere.att.26352	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Ere.bim.26353	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Ere.cil.26354	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Ere.cit.26355	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTAAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Ere.eri.26356	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Ere.lan.26357	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Ere.max.26358	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Ere.sp1.26245	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Hac.gra.26234	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTTCAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Hac.por.26235	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTTCAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Hem.com.26247	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Hem.pra.26248	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTTAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Mne.lae.26236	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTTGAGATCTTTTAAAAAGTGGATTGGATTAATCGGACGAGGATAAAGAGA
Oph.exa.26237	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Pha.zea.26238	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTATTTTTAAAAGTGGATTAATCGGACGAGGATAAAGAGA
Rot.coc.26253	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTCGAGATCTTTTAAAAA-----GTGGATTAATCGGACGAGGATAAAGAGA
Era.bif.	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTTGAGATCTTTTAAAAA-----GAGGATTAATCGTACGAGGATAAAGAGA
Cen.lap.26378	----GAATATTGAGTAATCAAATCCTTCAATTCATTGTTTTTGAGATTTTTTAAAAA-----GTGGATTAATCAGACGAGGATAAAGAGA

	541 550 560 570 580 590 600 610 620 630
Apl.mut.26233	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Isc.bar.26363	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Isc.bar.26364	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Isc.bar.26365	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAG??
Isc.bar.26366	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Isc.hir.26249	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Isc.hub.26250	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Isc.ind.26367	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Isc.ind.26368	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAG??
Isc.ind.26369	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Isc.ind.26370	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Isc.rug.26372	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAG??
Isc.ten.26373	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Isc.tim.26374	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Isc.sp1.26251	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Isc.sp2.26375	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Ker.sia.26252	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAG??
Seh.ner.26239	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
The.ele.26240	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Mne.can.26346	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Mne.gla.26347	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Mne.hel.26348	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Mne.mol.26349	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Mne.str.26350	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Mne.stp.26351	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Mne.sp1.26244	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Ere.att.26352	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Ere.bim.26353	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Ere.cil.26354	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Ere.cit.26355	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Ere.eri.26356	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Ere.lan.26357	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Ere.max.26358	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Ere.sp1.26245	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Hac.gra.26234	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Hac.por.26235	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Hem.com.26247	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTTGTGAGGGTTCAAGTC
Hem.pra.26248	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTTGTGAGGGTTCAAGTC
Mne.lae.26236	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Oph.exa.26237	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Pha.zea.26238	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAGTC
Rot.coc.26253	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTTGTGAGGGTTCAAGTC
Era.bif.	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTCGTGAGGGTTCAAG??
Cen.lap.26376	GAGTCCCATTCTACATGTCAATACTGACAACAATGAAATTTCTAGTAAAAGGAAAATCCGTCGACTTTATAAGTTGTGAGGGTTCAAGTC

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                 631       640       650       660       670       680       690       700       710      720
Apl.mut.26233    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Isc.bar.26363    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.bar.26364    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.bar.26365    ????????????????????????????????????????????????????????????GTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.bar.26366    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.hir.26249    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.hub.26250    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.ind.26367    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.ind.26368    ??????????????????????????????????????????????????????????TTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.ind.26369    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.ind.26370    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.rug.26372    ????????????????????????????????????????????TTTCCTA-CC-TAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.ten.26373    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.tim.26374    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCC-TTTTTTCTCTTATCAATGGGT
Isc.sp1.26251    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Isc.sp2.26375    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Ker.sia.26252    ??????????????????????????????????????????????????????????????????????????????????????????
Seh.ner.26239    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCGTAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
The.ele.26240    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Mne.can.26346    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Mne.gla.26347    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Mne.hel.26348    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Mne.mol.26349    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Mne.str.26350    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Mne.stp.26351    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Mne.sp1.26244    CCTCTATCCCC---------------AATAAAAAGCCCATTTGACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Ere.att.26352    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Ere.bim.26353    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Ere.cil.26354    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Ere.cit.26355    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Ere.eri.26356    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Ere.lan.26357    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Ere.max.26358    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Ere.sp1.26245    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Hac.gra.26234    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Hac.por.26235    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Hem.com.26247    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCC-TTTTT-CTTTTATCAATGGGT
Hem.pra.26248    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCC-TTTTT-CTTTTATCAATGGGT
Mne.lae.26236    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTT-CTTTTATCAATGGGT
Oph.exa.26237    CCTCTATCCCC---------------AATAAAAAGCCCATTTTACTTCCTAACTATTG----TACCAACCTCTATTTTTCATTAATGG-T
Pha.zea.26238    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAATGGGT
Rot.coc.26253    CCTCTATCCCC---AAACCCTCTTTT-----------------ATTCCCTAACCATAGTTGTTATCCT-TTTTTTCTTTTATCAAT----
Era.bif.         ???????????????AACCCTCCTTT-----------------ATTCCCTAACCATACTATTTATCCTATTTTTTCTTTTATCAATGGGT
Cen.Jap.26376    CCTCTATCCCCAACAAACCTTCTTTT????????????????????????????????????????????????????????????????
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                721      730       740       750       760       770       780       790       800       810
Apl.mut.26233   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Isc.bar.26363   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.bar.26364   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.bar.26365   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.bar.26366   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.hir.26249   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.hub.26250   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.ind.26367   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.ind.26368   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.ind.26369   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.ind.26370   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.rug.26372   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.ten.26373   TT---CA-GATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.tim.26374   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.sp1.26251   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Isc.sp2.26375   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Ker.sia.26252   ??????????????????????????????????????????????????????????????????????????????????????????
Seh.ner.26239   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
The.ele.26240   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCTACAAGAACTCAATTAATTTTATGCTATTCA--------
Mne.can.26346   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Mne.gla.26347   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Mne.hel.26348   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Mne.mol.26349   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Mne.str.26350   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Mne.stp.26351   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Mne.sp1.26244   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Ere.att.26352   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Ere.bim.26353   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Ere.cil.26354   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Ere.cit.26355   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Ere.eri.26356   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Ere.lan.26357   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Ere.max.26358   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Ere.sp1.26245   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Hac.gra.26234   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Hac.por.26235   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Hem.com.26247   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAAATCAATGAATCTTATGCTATTCA--------
Hem.pra.26248   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCAACAAGAAATCAATGAATCTTATGCTATTCA--------
Mne.lae.26236   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Oph.exa.26237   TCAAACAAGATTCACTATCTTTCTTATTCTACTCTTTCACAAACGGA-------------------------------TCCGAACTTACT
Pha.zea.26238   TT----AAGATTCACTAGCTTTCTCATTCTACTCTTTCACAAA----------------------GAATCTTATGCTATTCA--------
Rot.coc.26253   --------GATTCACTAGCTTTCTCATTCTACTCTTTCACAAA-GGAGTGCGACAAGAACTCAATGAATCTTATGCTATTCA--------
Era.bif.        TT---CAAGATTCATTAGCTTTCTCATTCTACTCTTTCATAAA-GGAGTGCGAAGAGAACTCAATAGATCTTATGCTATTCA--------
Cen.lap.26376   ??????????????????????????????????????????????????????????????????????????????????????????
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               811      820       830       840       850       860       870       880       890       900
Apl.mut.26233  TCTTTGGATCTTATCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Isc.bar.26363  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTTTTAT
Isc.bar.26364  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTTT-AT
Isc.bar.26365  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTTT-AT
Isc.bar.26366  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTTTTAT
Isc.hir.26249  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTT--AT
Isc.hub.26250  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTTT-AT
Isc.ind.26367  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTTTTAT
Isc.ind.26368  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTT--AT
Isc.ind.26369  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTT--AT
Isc.ind.26370  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTT--AT
Isc.rug.26372  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTTTTAT
Isc.ten.26373  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTT---AT
Isc.tim.26374  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTT--AT
Isc.sp1.26251  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTTT-AT
Isc.sp2.26375  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTT--AT
Ker.sia.26252  ???????????????????????????????????????????????????????????????????????????????????????????
Seh.ner.26239  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTTT--AT
The.ele.26240  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTT-G--AT
Mne.can.26346  TCTTTGGATCTT-TCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Mne.gla.26347  TCTTTGGATCTT-TCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Mne.hel.26348  TCTTTGGATCTT-TCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Mne.mol.26349  TCTTTGGATCTT-TCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Mne.str.26350  TCTTTGGATCTT-TCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Mne.stp.26351  TCTTTGGATCTT-TCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Mne.sp1.26244  TCTTTGGATCTT-TCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Ere.att.26352  TCTTTGGATCTTATCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Ere.bim.26353  TCTTTGGATCTTATCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Ere.cil.26354  TCTTTGGATCTTATCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Ere.cit.26355  TCTTTGGATCTTATCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Ere.eri.26356  TCTTTGGATCTTATCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Ere.lan.26357  TCTTTGGATCTTATCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Ere.max.26358  TCTTTGGATCTTATCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Ere.sp1.26245  TCTTTGGATCTTATCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Hac.gra.26234  TCTTTGGATCTTATCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Hac.por.26235  TCTTTGGATCTTATCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Hem.com.26247  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTT---AT
Hem.pra.26248  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTT---AT
Mne.lae.26236  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTT---AT
Oph.exa.26237  TCTTTGGATCTTATCCCATTCATACAAATGAACATATTATAGTATAGGCAAGTAATCCC-------------------------------
Pha.zea.26238  -----------------------------------------------------------TTAAATAGAT----GATTTATTTTTT---AT
Rot.coc.26253  -----------------------------------------------------------TTAAATAGAT----GATTTCTTTTTT---AT
Era.blf.       -----------------------------------------------------------TTAAATA-------GATTTCTTTTTT-----
Cen.lap.26376  ???????????????????????????????????????????????????????????????????????????????????????????
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                  901      910       920       930       940       950       960       970       980       990
Apl.mut.26233     ------------------------------------------------------------------------------------------
Isc.bar.26363     TTATTTT--------------------------------ATTAGAGTA-----TCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Isc.bar.26364     TTATTTT--------------------------------ATTAGAGTA-----TCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Isc.bar.26365     TTATTTT--------------------------------ATTAGAGTA-----TCGGCA------CTCGATTATTAATTCGATTTTTTTA
Isc.bar.26366     TTATTTT--------------------------------ATTAGAGTA-----TCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Isc.hir.26249     TTATTTT--------------------------------ATTAGAGTAGAGTATCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Isc.hub.26250     TTATTTT--------------------------------ATTAGAGTA-----TCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Isc.ind.26367     TTATTTT--------------------------------ATTAGAGTA-----TCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Isc.ind.26368     TTATTTT--------------------------------ATTAGAGTAGAGTATCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Isc.ind.26369     TTATTTT--------------------------------ATTAGAGTAGAGTATCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Isc.ind.26370     TTATTTT--------------------------------ATTAGAGTAGAGTATCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Isc.rug.26372     TTATTTT--------------------------------ATTAGAGTA-----TCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Isc.ten.26373     TTCTTTTTTATTTTTTTAATTTTTTTTCTTTTTTTATTTATTAGAGTAGAGTATCGGCAAGGAATCTCGATTATTAATTCAATTTTTTT-A
Isc.tim.26374     TTATTTT--------------------------------ATTAGAGTAGAGTATCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Isc.sp1.26251     TTATTTT--------------------------------ATTAGAGTA-----TCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Isc.sp2.26375     TTATTTT--------------------------------ATTAGAGTAGAGTATCGGCAAGGAATCTCGATTATTAATTGGATTTTTTTA
Ker.sia.26252     ????????????TATTTATTTT-----------------ATTAGAGTAGAGTATCGGCAAGGAATCTCGATTATTAATTCGATTTACTTA
Seh.ner.26239     TTCTTTTT---------------------------ATTTATTAGAGTAGAGTATCGGCAAGGAATCTCGATTATTAATTCGATTTACTTA
The.ele.26240     TTCTTTTTTTTTT----------------------ATTT---AGAGTA-----TCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Mne.can.26346     ------------------------------------------------------------------------------------------
Mne.gla.26347     ------------------------------------------------------------------------------------------
Mne.hel.26348     ------------------------------------------------------------------------------------------
Mne.mol.26349     ------------------------------------------------------------------------------------------
Mne.str.26350     ------------------------------------------------------------------------------------------
Mne.stp.26351     ------------------------------------------------------------------------------------------
Mne.sp1.26244     ------------------------------------------------------------------------------------------
Ere.att.26352     ------------------------------------------------------------------------------------------
Ere.bim.26353     ------------------------------------------------------------------------------------------
Ere.cil.26354     ------------------------------------------------------------------------------------------
Ere.cit.26355     ------------------------------------------------------------------------------------------
Ere.eri.26356     ------------------------------------------------------------------------------------------
Ere.lan.26357     ------------------------------------------------------------------------------------------
Ere.max.26358     ------------------------------------------------------------------------------------------
Ere.sp1.26245     ------------------------------------------------------------------------------------------
Hac.gra.26234     ------------------------------------------------------------------------------------------
Hac.por.26235     ------------------------------------------------------------------------------------------
Hem.com.26247     TTCTTTTTTTTTTATTTATC---------------ATTTATTAGAGTA-----TCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Hem.pra.26248     TTCTTTTTTTTTTATTTATC---------------ATTTATTAGAGTA-----TCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Mne.lae.26236     TTCTTTATTTTTTATTTATTTATTT----ATT---ATTTATTAGAGTA-----TCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Oph.exa.26237     ------------------------------------------------------------------------------------------
Pha.zea.26238     TTCTTTTTTTTT-ATTT--CTTTTTTTTTATT---ATTTATTAGAGTAGAGTATCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Rot.coc.26253     TTCTTTTTTT-------------------------ATTTATTAGAGTAGAGTATCGGCAAGGAATCTCGATTATTAATTCGATTTTTTTA
Era.bif.          ---------------------------------------ATTAGAGTA-----TCGGCAAGGAATCTCAATTATTAATTAAATTATT--A
Cen.lap.26376     ??????????????????????????????????????????????????????????????????????????????????????????
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Isc.bar.26364	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.bar.26365	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.bar.26366	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.hir.26249	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.hub.26250	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.ind.26367	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.ind.26368	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.ind.26369	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCGTTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.ind.26370	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCGTTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.rug.26372	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCGTTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.ten.26373	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.tim.26374	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCTCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.sp1.26251	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCGTTTCCT------AATTTT-G-AATGGAATACTTTAT
Isc.sp2.26375	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Ker.sia.26252	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Seh.ner.26239	AGTATTATT------AAGTAAGCCATCCACAATACATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
The.ele.26240	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Mne.can.26346	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAG------AAGACTTTTG
Mne.gla.26347	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAG------AAGACTTTTT
Mne.hel.26348	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAG------AAGACTTTTG
Mne.mol.26349	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAG------AAGACTTTTG
Mne.str.26350	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAG------AAGACTTTTG
Mne.stp.26351	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAG------AAGACTTTTG
Mne.sp1.26244	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAG------AAGACTTTTG
Ere.att.26352	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAT------AAGACTTTTT
Ere.bim.26353	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAT------AAGACTTTTT
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Ere.cit.26355	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAT------AAGACTTTTT
Ere.eri.26356	--TATTATTATTATTAAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAT------AAGACTTTTT
Ere.lan.26357	--TATTATTATTATTAAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAT------AAGACTTTTT
Ere.max.26358	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAT------AAGACTTTTT
Ere.sp1.26245	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAT------AAGACTTTTT
Hac.gra.26234	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAT------AAGACTTTTT
Hac.por.26235	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAG------AAGACTTTTT
Hem.com.26247	AGTATTATT------AAGTAAGTAATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTT--GGAATGGAATACTTTAT
Hem.pra.26248	AGTATTATT------AAGTAAGTAATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTT--GGAATGGAATACTTTAT
Mne.lae.26236	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCTCATTTCCT------AATTTT-G-AATGCAATACTTTAT
Oph.exa.26237	--TATTATT------AAGTAAGTCATTCACAATCCATATCATTATCCT--GACATTTACTAAGTCCAATTTTAT------AAGACTTTTT
Pha.zea.26238	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Rot.coc.26253	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTACCCCTCCCCATTTCCT------AATTTT-G-AATGGAATACTTTAT
Era.bif.	AGTATTATT------AAGTAAGCCATCCACAATGCATAGGACTATCCCCCC--ATTTCCA------AATT--AGGAATGGAATACTTTAT
Cen.lap.26376	??TTAT

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Isc.bar.26363   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Isc.bar.26364   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Isc.bar.26365   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Isc.bar.26366   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Isc.hir.26249   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Isc.hub.26250   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Isc.ind.26367   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Isc.ind.26368   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Isc.ind.26369   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Isc.ind.26370   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Isc.rug.26372   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Isc.ten.26373   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGT????
Isc.tim.26374   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGA-AGCTCAGT---G
Isc.sp1.26251   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Isc.sp2.26375   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Ker.sia.26252   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAG??????????
Seh.ner.26239   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAG??????????
The.ele.26240   TGATTTTTT-AGGCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Mne.can.26346   TCTTTTTT--AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
Mne.gla.26347   TCTTTTTT--AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
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Mne.mol.26349   TCTTTTTT--AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
Mne.str.26350   TCTTTTTT--AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
Mne.stp.26351   TCTTTTTT--AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
Mne.sp1.26244   TCTTTTTT--AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
Ere.att.26352   TCTTTTTT--AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
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Ere.cil.26354   TCTTTTTT--AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
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Ere.eri.26356   TCTTTTTT--AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
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Ere.max.26358   TCTTTTTT--AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
Ere.sp1.26245   TCTTTTTT--AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAAGGGTCAGGATAGC?????????
Hac.gra.26234   TCTTTTTT--AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
Hac.por.26235   TGATTTTT-GAGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
Hem.com.26247   TGATTTTT-GAGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Hem.pra.26248   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Mne.lae.26236   TCTTTTTT--AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Oph.exa.26237   TGATTTTTT-AGTCCCTTTAATTGACATAGATACAAGTACGTACTCTACTAGGATGATGCACAAGAAATGGTCAGGATAGCTCAGTTGGT
Pha.zea.26238   TGATTTTTTGAGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Rot.coc.26253   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTTTACTAAGATGATGCACAAGAAAGGGTCAGGATAGCTCAGTTGGT
Era.bif.        TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTCTACTAGGATGATGCACAAGAAAG?????????????????????
Cen.lap.26376   TGATTTTTT-AGTCCCTTTAATTGACATAGATGCAAATA----CTCTACTAGGATGATGCACAAGAAAGGGTCAGGATAGCTCAGT????
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Isc.bar.26364	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Isc.bar.26365	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Isc.bar.26366	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Isc.hir.26249	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Isc.hub.26250	AGAGCAGAGGACTGAAAATCCTCGTGTCAC???????????GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Isc.ind.26367	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
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Isc.rug.26372	???GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Isc.ten.26373	AG-GC---GG???????????????????????????????GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Isc.tim.26374	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Isc.sp1.26251	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Isc.sp2.26375	???GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Ker.sia.26252	???GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Seh.ner.26239	AGAGCAGAGGACTGAAAATCCTCGTGTCAC???????????GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
The.ele.26240	AGAGCAGAGGACTGAAAATCCTCGTGTC?????????????GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Mne.can.26346	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTA???GTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Mne.gla.26347	AGAGCAGAGGACTGAAAATCCTCGTGTCAC???????????GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Mne.hel.26348	AGAGCAGAGGACTGAAAATCCTCGTGTCAC????????????ACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Mne.mol.26349	AGAGCAGAGGACTGAAAATCCTCGTGTCAC????????????ACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
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Ere.bim.26353	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCA????GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
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Ere.eri.26356	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCA????GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Ere.lan.26357	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Ere.max.26358	AGAGCAGAGGACTGAAAATCCTCGTGTCAC???????????GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Ere.sp1.26245	???GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Hac.gra.26234	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Hac.por.26235	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Hem.com.26247	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Hem.pra.26248	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Mne.lae.26236	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Oph.exa.26237	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Pha.zea.26238	AGAGCAGAGGACTGAAAATCCTCGTGTCACCAGTTCAATTAGACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Rot.coc.26253	AGAGCAGAGGACTGAAAATCCTCGTGTCA????????????GACGTCGCGAGAAGTCCATTGAACCTTATCATTTAGAGGAAGGAGAAGT
Era.bif.	??
Cen.lap.26376	???GACGTCGCGAGAAGTCCGTTGAACCTTATCATTTAGAGGAAGGAGAAGT

	1261 · 1270 · 1280 · 1290 · 1300 · 1310 · 1320 · 1330 · 1340 · 1350
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Isc.bar.26363	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACCGACCGCGAACGCGTCCCCCGTGCCGCC
Isc.bar.26364	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACCGACCGCGAACGCGTCCCCCGTGCCGCC
Isc.bar.26365	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACCGACCGCGAACGCGTCCCCCGTGCCGCC
Isc.bar.26366	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACCGACCGCGAACGCGTCCCCCGTGCCGCC
Isc.hir.26249	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCCCGTGCCGCC
Isc.hub.26250	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACCGACCGCGAACGCGTCCCCCGTGCCGCC
Isc.ind.26367	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACCGACCGCGAACGCGTCCCCCGTGCCGCC
Isc.ind.26368	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCCCGTGCCGTC
Isc.ind.26369	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCCCGTGCCGTC
Isc.ind.26370	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCCCGTGCCGTC
Isc.rug.26372	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACCGACCGCGAACGCGTCCCCCGTGCCGCC
Isc.ten.26373	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCCCGTGCCGCC
Isc.tim.26374	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCCCGTGCCGCC
Isc.sp1.26251	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACCGACCGCGAACGCGTCCCCCGTGCCGCC
Isc.sp2.26375	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCCCGTGCCGTC
Ker.sia.26252	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCCCGTGCCGCC
Seh.ner.26239	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCCCGTGCCGCC
The.ele.26240	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGTGTCCCTCATGCCATC
Mne.can.26346	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCCCGTGCCGCC
Mne.gla.26347	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCTCGTGCCGCC
Mne.hel.26348	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCTCGTGCCGCC
Mne.mol.26349	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCTCGTGCCGCC
Mne.str.26350	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCTAACACGTCTCTCGTGTCGTC
Mne.stp.26351	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACACGTCTCTCGTGTCGTC
Mne.sp1.26244	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGTGAACGCGTCTCTCGTGCCGCC
Ere.att.26352	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTCAAACAAGGTAGACCGCGAACGCGTCCCCCGTGCCGCC
Ere.bim.26353	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGCCGTGACCCTCAAACAAGGTAGACCGCGAACGCGTCCCCCGTGCCGCC
Ere.cil.26354	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAGGCAGACCGCGAACGTGTCCCCCGTGCCGCC
Ere.cit.26355	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTCAAACAAGGTAGACCGCGAACGCGTCCCCCGTGCCGCC
Ere.ert.26356	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAGGCAGACCGCGAACGCGTCCCCCGTGCCGCC
Ere.lan.26357	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAGGCAGACCGCGAACGCGTCCCCCGTGCCGCC
Ere.max.26358	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTCAAACAAGGCAGACCGCGAACGCGTCCCCCGTGCCGCC
Ere.sp1.26245	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGCCGTGACCCTTAAACAAGGCAGACCGCGAACACGTCCCTTGTGCCGCC
Hac.gra.26234	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGTGAACGCGTCTCTCGTGCCGCC
Hac.por.26235	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTTCCATGCCGCC
Hem.com.26247	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAATGTGTCTCTCATGCCGCC
Hem.pra.26248	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAATGTGTCTCTCATGCCGCC
Mne.lae.26236	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCCCGTGCCCCC
Oph.exa.26237	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCTCATGCCCCC
Pha.zea.26238	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGCCGTGACCCTTAAACAAAACAGACCGCGAACGCGTCTCTCGTGCCGCC
Rot.coc.26253	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGTGAACACGTTTCTCGTGCC---
Era.bif.	??TCGTGACCCTTAA-CAAAACAGACCGCGAACATGTCATCCATGCTGCC
Cen.lap.26376	CGTAACAAGGTTTCCGTAGGTGAACCTGCGGAAGGATCATTGTCGTGACCCTTAAACAAAACAGACCGCGCACGCGTCCCCCATGCCGCC

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                  1351     1360      1370      1380      1390      1400      1410      1420      1430      1440
Apl.mut.26233     GGGCCTCGGCCCGGCACCAGGCCCCCGAGCCCCCCC--------------------GCGGGGCGGAGGGG-CCGCAACAGAACCT-ACGG
Isc.bar.26363     GGGCCCCGGCCCGGCACAA--------------------------------------------------------A-CAGAACCC-ACGG
Isc.bar.26364     GGGCCTCGGCCCGGCACAA--------------------------------------------------------A-CAGAACCC-ACGG
Isc.bar.26365     GGGCCTCGGCCCGGCACAA--------------------------------------------------------A-CAGAACCC-ACGG
Isc.bar.26366     GGGCCCCGGCCCGGCACAA--------------------------------------------------------A-CAGAACCC-ACGG
Isc.hir.26249     GGGCCTCGGCCCGGCACAA--------------------------------------------------------AACAGAACCA-ACGG
Isc.hub.26250     GGGCCTCGGCCCGGCACAA--------------------------------------------------------A-CAGAACCC-ACGG
Isc.ind.26367     GGGCCCCGGCCCGGCACAA--------------------------------------------------------A-CAGAACCC-ACGG
Isc.ind.26368     GGGCCTCGGCCCGGCACAA--------------------------------------------------------AACAGAACCA-ACGG
Isc.ind.26369     GGGCCTCGGCCCGGCACAA--------------------------------------------------------AACAGAACCA-ACGG
Isc.ind.26370     GGGCCTCGGCCCGGCACAA--------------------------------------------------------AACAGAACCA-ACGG
Isc.rug.26372     GGGCCCCGGCCCGGCACAA--------------------------------------------------------A-CAGAACCC-ACGG
Isc.ten.26373     GGGCCTCGGCCCGGCACGAGGCCCCCGAG--CTCCGT--CC-----------------GGGGCGGAGGGG-CCGCAACAGAACCC-ACGG
Isc.tim.26374     GGGCCTCGGCCCGGCACAA--------------------------------------------------------AACAGAACCA-ACGG
Isc.sp1.26251     GGGCCTCGGCCCGGCACAA--------------------------------------------------------A-CAGAACCC-ACGG
Isc.sp2.26375     GGGCCTCGGCCCGGCACAA--------------------------------------------------------AACAGAACCA-ACGG
Ker.sia.26252     GGGCCTCGGCCCGGCACGAGGCCCCCGAG--CTCC-TTCCC-----------------GGGGCGGAGGGG-CCGCAACAGAACCC-ACGG
Seh.ner.26239     GGGCCCCGGCCCGGC-CAAGGCCCCCGAG--CCCCGTCTCCGAC--------------GGGGCGGAGGGG-CCGCCACAGAACCC-ACGG
The.ele.26240     GGGCTTCGGTCCGGC-CAAGGCCCCCTAG--CTTCGG--------------------------CGAAGGG-CCGCAAAAGAACCC-ACGG
Mne.can.26346     GGGCTTCGGCCCGGC-CAAGGCCCCCGAG--CTTCGG--------------------------CGGAGGG-CCGCAACAGAACCC-ACGG
Mne.gla.26347     GGGCTTCGGCCCGGC-CAAGGCCCCCGAG--CTTCGG--------------------------CGAAGGG-CCGCAACAGAACCC-ACGG
Mne.hel.26348     GGGCTTCGGCCTGGC-CAAGGCCCCCGAG--CTTCGG--------------------------CGGAGGG-CCGCAACAGAACCC-ACGG
Mne.mol.26349     GGGCTTCGGCCTGGC-CAAGGCCCCCGAG--CTTCGG--------------------------CGGAGGG-CCGCAACAGAACCC-ACGG
Mne.str.26350     GGGCTTCGGCCTGGC-CAAGGCCCCCGAG--CTTCGG--------------------------CGGAGGG-CCGCAACAGAACCC-ACGG
Mne.stp.26351     GGGCTTCGGCCTGGC-CAAGGCCCCCGAG--CTTCGG--------------------------CGGAGGG-CCGCAACAGAACCC-ACGG
Mne.sp1.26244     GGGCTTCGGCCTGGC-CAAGGCCCCCGAG--CTTCGG--------------------------CTTTGGG-CCGCAACAGAACCC-ACGG
Ere.att.26352     GGGCCACGGCCCGGC-CACGGCCCCCTAG--CCTCGG--------------------------CGAAGGG-CCGCAACAGAACCC-ACGG
Ere.blm.26353     GGGCCACGGCCCGGC-CACGGCCCCCTAG--CCTCGG--------------------------CGAAGGG-CCGCAACAGAACCC-ACGG
Ere.cil.26354     GGGCCTCGGCCTGGC-CACGGCCCCCTAG--CCTCGG--------------------------CGAAGGGGCCGACAACAGAACCC-ACGG
Ere.cit.26355     GGGCCACGGCCCGGC-CACGGCCCCCTAG--CCTCGG--------------------------CGAAGGG-CCGCAACAGAACCC-ACGG
Ere.eri.26356     GGGCCTCGGCCCGGC-CACGGCCCCCCAG--CCTCGG--------------------------GGAAGGGGCCGGCAACAGAACCC-ACGG
Ere.lan.26357     GGGCCTCGGCCCGGC-CACGGCCCCCCAG--CCTCGG--------------------------CGAAGGGGCCGGCAACAGAACCC-ACGG
Ere.max.26358     GGGCCACGGCCCGGC-CACGGCCCCCTAG--CCTCGG--------------------------CGAAGGG-CCGCAACAGAACCC-ACGG
Ere.sp1.26245     GGGCCTCGGCCCGGC-CACGGCCCCCCAG--CCTTGG--------------------------CGAAGGG-CCGCAACAGAACCC-ACGG
Hac.gra.26234     GGGCTTCGGCCTGGC-CAAGGCCCCCGAG--CTTCGG--------------------------CGGAGGG-CCGCAAAAGAACCC-ACGG
Hac.por.26235     GGGCCTCGGCCCGGC-CAAGGCCCCCGAG--CTTCGG--------------------------CGGAGGG-CCGCAAAAGAACCC-ACGG
Hem.com.26247     GGGCTTCGGCCCGGC-AAAGGCCCCCGAG--CTTCGG--------------------------CGGAGGG-CCGCAAAAGAACCC-ACGG
Hem.pra.26248     GGGCTTCGGCTCGGC-AAAGGCCCCCGAG--CTTCGG--------------------------CGGAGGG-CCGCAAAAGAACCC-ACGG
Mne.lae.26236     GGGCCTCGGCCCGGCAAAAGGCCCCCGAG--CTTCGG--------------------------CGGAGGGGCCGCAACAGAACCC-ACGG
Oph.exa.26237     GGGCTTTGGCCCGGA-CAAGGCCCCCGAG--CTCTGG--------------------------CAGAGGG-CCCCAAAAGAACCC-ACGG
Pha.zea.26238     GGGCTTCGGCCCGGC-CAAGGCCCCCGAG--CTCCGG--------------------------CGGAGGG-CCGCAACAGAACCC-ACGG
Rot.coc.26253     -----------------AAGGCCCCCGAGCACCTT--------------------ATCGGGGCGGAGGGG-CCACAACAGAACCC-ACGG
Era.bif.          GGGTGACGGGGCTTGCCTCG-CCTCCC--GGCTT---AGGTCCCAGACTTCTGTATGG-AGGTTT-GGGG-CCGCAAAAGAACCC-ACGG
Cen.lap.26376     GGACGGCGGGGCATCAT-AG-CCTCCGCCGGCCGGCCAGGCCCCCGACCCCCGAGAGG-AGG-AGAGGGG-CCGCAACAGAACCC-AGGG
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                  1441     1450      1460      1470      1480      1490      1500      1510      1520      1530
Apl.mut.26233     CGCCTTAGGCGTCAAGGAACACTT----ATATTGCCTTGCCCGGTGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCAGC----GATG-A
Isc.bar.26363     CGCCTTAGGCGTCAAGGAACACTC----ATATTGCCTCGCGCGGCGGGGCGGTCGGCCTGCCTTCCGCCCCCCGCGCAGC----GATG-A
Isc.bar.26364     CGCCTTAGGCGTCAAGGAACACTC----ATATTGCCTCGCGCGGCGGGGCGGTCGGCCTGCCCTCCGCCCCCCGCGCAGC----GATG-A
Isc.bar.26365     CGCCTTAGGCGTCAAGGAACACTC----ATATTGCCTCGCGCGGCGGGGCGGTCGGCCTGCCCTCCGCCCCCCGCGCAGC----GATG-A
Isc.bar.26366     CGCCTTAGGCGTCAAGGAACACTC----ATATTGCCTCGCGCGGCGGGGCGGTCGGCCTGCCTTCCGCCCCCCG????????????????
Isc.hir.26249     CGCCTTAGGCGTCAAGGAACACTT----GTATTGCCTTGCCCGGCGGAGCGGTCGGCCCGCCTTCCGCTCCCCGCGCGGC----GATG-A
Isc.hub.26250     CGCCTTAGGCGTCAAGGAACACTC----ATATTGCCTCGCGCGGCGGGGCGGTCGGCCTGCCCTCCGCCCCCCGCGCAGC----GATG-A
Isc.ind.26367     CGCCTTAGGCGTCAAGGAACACTC----ATATTGCCTCGCGCGGCGGG??????????????????????????????????????????
Isc.ind.26368     CGCCTTAGGCGTCAAGGAACACTT----GTGTTGCCTTGCTCGGCGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCGGC----GATC-A
Isc.ind.26369     CGCCTTAGGCGTCAAGGAACACTT----GTGTTGCCTTGCTCGGCGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCGGC----GATC-A
Isc.ind.26370     CGCCTTAGGCGTCAAGGAACACTT----GTGTTGCCTTGCTCGGCGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCGGC----GATC-A
Isc.rug.26372     CGCCTCAGGCGTCAAGGAACACTC----ATATTGCCTCGCGCGGCGGGGCGGTCGGCCTGCCCTCCGCCCCCCGCGCAGC----GATG-A
Isc.ten.26373     CGCCTTAGGCGTCAAGGAACACTCACTCATACTGCCTTGCTCGGCGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCAGCCAGCGATG-G
Isc.tim.26374     CGCCTTAGGCGTCAAGGAACACCT----GTGTTGCCTCGCACGGCGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCGGC----GATG-A
Isc.sp1.26251     CGCCTTAGGCGTCAAGGAACACTC----ATATTGCCTCGCGCGGCGGGGCGGTCGGCCTGCCCTCCGCCCCCCACGCAGC----GATG-A
Isc.sp2.26375     CGCCTTAGGCGTCAAGGAACACTT----GTGTTGCCTTGCTCGGTGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCGGC----GATC-A
Ker.sia.26252     CGCCTCAGGCGTCAAGGAACACCT----ATATTGCCTCGCTCGGCGGGGCGGTCGGCCTGCCTTCCGCTCCCCGCGCGGC----GATG-A
Seh.ner.26239     CGCCTTAGGCGTCAAGGAACACTC----ATATTGCCTTGCTCGGCGGAGCGGTCGGCCTGCCTTCCGCTCCCCGAGCAGC----GATG-A
The.ele.26240     CGCCTTAGGCGTCAAGGAACACTC----GTGTTGCCTCGCTCGGCGGGGCGGTCGGCTTGCCTTCTGCCCCCAGAGCAGC----AATG-T
Mne.can.26346     CGCCTTAGGCGTCAAGGAACACTT----CTATTGCCTTGCTCGGCGGGGCGGTCGGCTCGCCTTCCGCTCCCCGCGCGGC----GACG-A
Mne.gla.26347     CGCCTTAGGCGTCAAGGAACACTT----ATACTGCCTTGCCCGGTGGAGCGGTCGGCCCGCCTTCCGCTCCCCGCGCAGC----GATG-A
Mne.hel.26348     CGCCTTAGGCGTCAAGGAACACCT----GTGTTGCCTTGCTCGGCGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCAGC----GATG-A
Mne.mol.26349     CGCCTTAGGCGTCAAGGAACACCC----GTGTTGCCTTGCTCGGCGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCGGC----GATG-A
Mne.str.26350     CGCCTTAGGCGTCAAGGAACACCT----GTGTTGCCTTGCTCGGTGGAGCGGTTGGCTTGCCTTTCGCTCCCCGCGCGGC----GATG-A
Mne.stp.26351     CGCCTTAGGCGTCAAGGAACACCT----GTGTTGCCTTGCTCGGTGGAGCGGTTGGCTTGCCTTTCGCTCCCCGCGCGGC----GATG-A
Mne.sp1.26244     CGCCTTAGGCGTCAAGGAACACTT----GTATTGCCTTGCTCGGTGGAGCGGTCGGCCCGCCTTCTGCTCCCCGCGCGGC----TATG-A
Ere.att.26352     CGCCTTAGGCGTCAAGGAACACAT----ACGCTGCCTGGCGCGGTGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCGGC----GACT-A
Ere.bim.26353     CGCCTTAGGCGTCAAGGAACACAT----ACGCTGCCTGGTGCGGTGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCGGC----GACG-A
Ere.cil.26354     CGCCTCAGGCGTCAAGGAACACCT----ACGCTGCCTTGCGCGGCGGAGCGGTCGGCCCGCCTTCCGCTCCCCGCGCGGC----GACG-A
Ere.cit.26355     CGCCTTAGGCGTCAAGGAACACAT----ACGCTGCCTGGTGCGGTGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGTGGC----GACG-A
Ere.eri.26356     CGCCTCAGGCGTCAAGGAACACTT----ACGCTGCCTGGCGCGGCGGAGCGGTCGGCCCGCCTTCCGCTCCC??????????????????
Ere.lan.26357     CGCCTCAGGCGTCAAGGAACACCT----ACGCTGCCTTGCGCGGCGGAGCGGTCGGCCCGCCTTCCGCTCCCCGCGCGGC----GACT-A
Ere.max.26358     CGCCTTAGGCGTCAAGGAACACAT----ACGCTGCCTGGTGCGGTGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCGGC----GACG-A
Ere.sp1.26245     CGCCTCAGGCGTCAAGGAACACCT----ATGCTGCCTTGCGCGGCGGAGCGGTCGGCCCGCCTTCCGCTCCCCGTGCGGC----GACT-A
Hac.gra.26234     CGCCTTAGGCGTCAAGGAACACTT----ATATTGCCTTGCACGGCGGAGCGGTCGGCCTGCCTTCCGCTCCTCGCGCAGC----GATG-A
Hac.por.26235     CGCCTTAGGCGTCAAGGAACACTT----ATATTGCCTTGCGCGGCGGAGCGGTCGGCCTGCCTTCCGCCCCCCGCGCAGC----GATG-A
Hem.com.26247     CGCCTTAGGCGTCAAGGAACACTT----ATATTGCCTCGCGCGGCGGAGCGGTCGGCCTGCCTTCCGCTCTCCGCGC?????????????
Hem.pra.26248     CGCCTTAGGCGTCAAGGAACACTT----ATATTGCCTCGCGCGGCGGAGCGGTCGGCCTGCCTTCCGCTCTCCGCGCAGC----GATG-A
Mne.lae.26236     CGCCTTAGGCGTCAAGGAACACCC----ATGTTGCCT-GCCCGGCGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCGGC----GATC-G
Oph.exa.26237     CGCCTTAGGCGTCAAGGAACACTT----TGATTGCCTTGCTCGGCGGAGCGGTCGGCCTGCCTTCCGCTCCCCGCGCAGC----GATG-A
Pha.zea.26238     CGCCTTAGGCGTCAAGGAACACTT----ATATTGCCTTGCCCGGTGGAGCGGTCGGCTCGCCTTCCGCTCCCCGCGCAGC----GATG-A
Rot.coc.26253     CGCCTTAGGCGTCAAGGAACACTT----ATATTGCTCAGCGGAGCGG-----TCGGCTTGCCTTCCGCTCCCCGCGCAGC----GATG-A
Era.bif.          CGCCATCGGCGTCAAGGAACACTA----ATATTGCCTTGCCCAAGTTCACGACCGGCTTGCCGGACGCGACTTGAGCGGC----GATACC
Cen.lap.26376     CGCCGAAGCCGCCAAGGAACACTG----ATATTGCCATGCGCGAGGCCGTGGCCGGCCTGCCGGGCACGCCGCGCGCAGC----GATG-C
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                 1531     1540      1550      1560      1570      1580      1590      1600      1610      1620
Apl.mut.26233    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.bar.26363    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.bar.26364    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGA?GAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.bar.26365    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.bar.26366    ??????????????????????????????????????????????????????AGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.hir.26249    TATCTTAATCCAAACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGA?GA-CGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.hub.26250    TATCTTAATCCACACGACTGTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.ind.26367    ??????????????????????????????????????????????????????AGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.ind.26368    TATCTTAATCCAAACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.ind.26369    TATCTTAATCCAAACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.ind.26370    TATCTTAATCCAAACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.rug.26372    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.ten.26373    TATCCTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.tim.26374    TATCTTAATCCAAACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.sp1.26251    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGA-CGCAGCAAAATGCGATACCTGGTGTGAATTGC
Isc.sp2.26375    TATCTTAATCCAAACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Ker.sla.26252    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGA-CGCAGCAAAATGCGATACCTGGTGTGAATTGC
Seh.ner.26239    TATCTTAATCC???????????????????????????????????????????AGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
The.ele.26240    TATGTTAATCAACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Mne.can.26346    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Mne.gla.26347    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Mne.hel.26348    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Mne.mol.26349    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Mne.str.26350    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Mne.stp.26351    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Mne.sp1.26244    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Ere.att.26352    TATCTCGATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Ere.bim.26353    TATCTCGATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Ere.cil.26354    TATCTCGATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Ere.cit.26355    TATCTCGATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Ere.eri.26356    ??????????????????????????????????????????????????????AGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Ere.lan.26357    TATCTCGATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Ere.max.26358    TATCTCGATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Ere.sp1.26245    TATCTCGATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Hac.gra.26234    TACCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Hac.por.26235    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Hem.com.26247    ???????????????????????????????????????????????????????GAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Hem.pra.26248    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Mne.lae.26236    TACCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Oph.exa.26237    CATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Pha.zea.26238    TATCGTA???????????????????????????????????????????????AGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Rot.coc.26253    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
Era.blf.         TATCTTAATCCACATGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGTAGCAAAATGCGATACCTGGTGTGAATTGC
Cen.lap.26376    TATCTTAATCCACACGACTCTCGGCAACGGATATCTCGGCTCTCGCATCGATGAAGAACGCAGCAAAATGCGATACCTGGTGTGAATTGC
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	1621 1630 1640 1650 1660 1670 1680 1690 1700 1710
Api.mut.26233	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.bar.26363	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.bar.26364	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.bar.26365	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.bar.26366	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.hir.26249	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.hub.26250	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.ind.26367	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.ind.26368	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.ind.26369	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.ind.26370	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.rug.26372	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.ten.26373	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.tim.26374	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.sp1.26251	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Isc.sp2.26375	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Ker.sia.26252	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Seh.ner.26239	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
The.ele.26240	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCAGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Mne.can.26346	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Mne.gla.26347	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Mne.hel.26348	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Mne.mol.26349	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Mne.str.26350	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Mne.stp.26351	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Mne.sp1.26244	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Ere.att.26352	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Ere.bim.26353	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Ere.cil.26354	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCAAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Ere.cit.26355	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Ere.eri.26356	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Ere.lan.26357	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Ere.max.26358	AGAATCCCGTGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Ere.sp1.26245	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGACCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Hac.gra.26234	AGAATCCCGTGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Hac.por.26235	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTTTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCAAAAAG
Hem.com.26247	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGTTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Hem.pra.26248	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTTTGGTTGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Mne.lae.26236	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Oph.exa.26237	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTTTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Pha.zea.26238	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Rot.coc.26253	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Era.bif.	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGTCGAGGGCACGTCTGCCTGGGCGTCACGCCAAAAG
Can.lap.26376	AGAATCCCGCGAACCATCGAGTTTTTGAACGCAAGTTGCGCCCGAGGCCTTCTGGCCGAGGGCACACCTGCCTGGGCGTCACGCCAAAAG

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Isc.bar.26364    ACACTCCCAA-CCC--AACCCC-------GGGGAGGGACGTGGCGTCTGGCCCTCCGCGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
Isc.bar.26365    ACACTCCCAA-CCC--AACCCC-------GGGGAGGGACGTGGCGTCTGGCCCTCCGCGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
Isc.bar.26366    ACACTCCCAA-CCC--A-CCCC----GGTGGGGAGGGACGTGGCGTCTGGCCCTCCGCGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
Isc.hir.26249    ACACTCCCAA-CCC--ACCCTC-------GGGGAGGGACGTGGTGTCTGGCCCTCCGTGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
Isc.hub.26250    ACACTCCCAA-CCC--AACCCC-------GGGGAGGGACGTGGCGTCTGGCCCTCCGCGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
Isc.ind.26367    ACACTCCCAA-CCC--A-CCCC----GGTGGGGAGGGACGTGGCGTCTGGCCCTCCGCGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
Isc.ind.26368    ACACTCCCAA-CCC--ACCCCC-------GGGGAGGGACGTGGCGTCTGGCCCTCCGTGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
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Isc.ind.26370    ACACTCCCAA-CCC--ACCCCC-------GGGGAGGGACGTGGCGTCTGGCCCTCCGTGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
Isc.rug.26372    ACACTCCCAA-CCC--A-CCCC----GGTGGGGAGGGACGTGGCGTCTGGCCCTCCGCGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
Isc.ten.26373    ACACTCCCAA-CCCC-ACCCTC-------GGGGCGGGACGTGGCGTCTGGCCCCCCGCGCCGCGAGGCGCGGTGGGCCGAAGTTGGGGCT
Isc.tim.26374    ACACTCCCAA-CCC--ACCCTA-------GGGGAGGGACGTGGCGTCTGGCCCTCCGTGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
Isc.sp1.26251    ACACTCCCAA-CCC--AACCCC-------GGGGAGGGACGTGGCGTCTGGCCCTCCGCGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
Isc.sp2.26375    ACACTCCCAA-CCC--ACCCCC-------GGGGAGGGACGTGGCGTCTGGCCCTCCGCGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
Ker.sia.26252    ACACTCCCAA-CCC--AACCCC-------GGGGAGGGACGTGGCGTCTGGCCCTCCGTGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
Seh.ner.26239    ACACTCCCAA-CCC--ACCCCCCGGGTGTGGGGAGGGACGTGGCGTCTGGCCCCCCGCGCCGCAGGGCGCGGCGGGCCGAAGTTGGGGCT
The.ele.26240    TCACTCCCAA-CCC--AACCCA-------GGGGAGGGACGTGGCGTCTGGCCCCCCGCGCCACAGGGCGCGGTGGGCCGAAGTTGGGGCT
Mne.can.26346    ACACTCCCAG-CCC--ACCCTC-------GGGGAGGGACGTGGTGTCTGGCCTCCCATGCTGAATGGCGTGGTGGGCCGAAGTTGGGGCT
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Ere.att.26352    ACACTCCCAA-CCC--GCCCCTGC-----GGGGAGGGACGTGGTGTTTGGCCCCTCGCGCCGCAGGGCGCGGTGGGCCGAAGTTGGGGCT
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Ere.cil.26354    ACACTCCCAA-CCC--ACCCCC-------GGGGAGGGACGTGGCATCTGGCCCCTCGTGCCGCAGGGCGCGGTGGGCCTAAGTCAGGGCT
Ere.cit.26355    ACACTCCCAA-CCC--GCCCCCGC-----GGGGAGGGACGTGGCGTCTGGCCCCCCGCGCCACAGGGCGCGGTGGGCCGAAGTGGGGGCT
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Ere.sp1.26245    ACACTCCCAA-CCC--GCCCCCCTC----GTGGAGGGACGTGGCATCTGGCCCCTCGTGCCGCAGGGCGCGGTGGGCCGAAGTCAGGGCT
Hac.gra.26234    ACACTCCCAA-CCC--CACCTA-------GGGGAGGGACGTGGCGTCTGGCCCCCCGCGCCGCAGGGCGCGGTGGGCCGAAGTCGGGGCT
Hac.por.26235    ACACTCCCAA-CCCC-ACCC-AG------GGGGAGGGACGTGGTGTTTGGCCCCTCGCGCGCGCAGGCGCGGTGGGCCGAAGTTGGGGCT
Hem.com.26247    ACACTCCCAA-CCCC-ACC-TAG------GGGAAGGGACGTGGTGTTTGGCCCCTCGCGCCGCAGGGCGCGGTGGGCCGAAGTTGGGGCT
Hem.pra.26248    ACACTCCCAA-CCCC-ACC-TAG------GGGGAGGGACCTGGTGTTTGGCCCCCCGCGCCGCAGGGCACGGTGGGCCGAAGTTGGGGCT
Mne.lae.26236    ACACTCCCAAACCC---CCCTCGGGG---GGGGACGGACGTGGTGTTTGGCCCCCCGCGCCGCAGGGCACGGTGGGCCGAAGTTGGGGCT
Oph.exa.26237    ACACTCCCAA-CCC--ACCCTC-------AGCAAGGGACGTGGTGTCTGGCCCCTCGCGCCGCAGGGCGCGGTGGGCCGAAGTTGGGGCT
Pha.zea.26238    ACACTCCCAA-CCC--ACCCTC-------GGGTAGGGACGTGGTGTTTGGCCCCTCGCGCCGCAGGGCGCGGTGGGCCGAAGTTGGGGCT
Rot.coc.26253    ACACTCCCAA-CCC--AACCTC-------GGGGAGGGACGTGGTGTTTGGCCCCCCGCGCCGCACGGCGCGGTGGGCCGAAGTTGGGGCT
Era.bif.         ACACTCCCCA-CCC--A-TCA--------GGGGAGGGACGTGGTGTCTGGCCCCCCGTGCCGCAGGGCGTGGTGGGCCGAAGTTGGGGCT
Cen.lap.26376    ACGCTCCCAA-CCCCCA-CCCC-------TGGTGTGGATGTGGCATTTGGCTCCCCGTGCCTCACGGTGCGGTGGGCCGAAGTTGGGGCT
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Apl.mut.26233   GCCGGCGTATCGTGTCGGGCACAGCACGTGGTGGG-CGCC-A--TAG-CGCA-TCTG---TGCAGTGCCCCGGCGCGCCGGCGCATC
Isc.bar.26363   GCCGGCGAATCGCGTCGGGCACAGCACGTGGTGGG-CGAC-ACCTAGTTGTT-CTCGAGGTGCAGCGCCCCGGCGCGCGGCCGGC--ACC
Isc.bar.26364   GCCGGCGAATCGCGTCGGGCACAGCACGTGGTGGG-CGAC-ACCTAGTTGTT-CTCGAGGTGCAGCGCCCCGGCGCGCGGCCGGCGCA--
Isc.bar.26365   GCCGGCGAATCGCGTCGGGCACAGCACGTGGTGGG-CGAC-ACCTAGTTGTT-CTCGAGGTGCAGCGCCCCGGCGCGCGGCCGGCGCA--
Isc.bar.26366   GCCGGCGAATCGTGTCGGGCACAGCACGTGGTGGG-CGAC-ACCTAGTTGTT-CTCGAGGTGCAGCGCCCCGGCGCGCGGCCGGCG--TT
Isc.hir.26249   GCCGGCGAATCGCGTCGGGCACAGCACGTGGTGGG-CGAC-ACCTAGT-GTTTCTC--GGTGCAGCGCACCGGCACGCTGACGGC--ATC
Isc.hub.26250   GCCGGCGAATCGCGTCGGGCACAGCACGTGGTGGG-CGAC-ACCTAGTTGTT-CTCGAGGTGCAGCGCCCCGGCGCGCGGCCGGCGCA--
Isc.ind.26367   GCCGGCGAATCGTGTCGGGCACAGCACGTGGTGGG-CGAC-ACCTAGTTGTT-CTCGAGGTGCAGCGCCCCGGCGCGCGGCCGGC--ACC
Isc.ind.26368   GCCGGCGAATCGTGTCGGGCACAGCACGTGGTGGG-CGAC-ACTCAGT-GTTTCTC--GGTGCAGCGCCCCGGCACGCTGACGGC--ATC
Isc.ind.26369   GCCGGCGAATCGTGTCGGGCACAGCACGTGGTGGG-CGAC-ACTCAGT-GTTTCTC--GGTGCAGCGCCCCGGCACGCTGACGGC--ATC
Isc.ind.26370   GCCGGCGAATCGCGCCGGGCACAGCACGTGGTGGG-CGAC-ACCTAGTTGTT-CTCGAGGTGCAGCGCCCCGGCACGCTGACGGC--ATC
Isc.rug.26372   GCCGGCGAATCGCGCCGGGCGCAGCACGTGGTGGG-CGAC-A-TCAGTTGTT-CTC--GGTGCAGCGCCCCGGCGCGCGGCCGGCG--TC
Isc.ten.26373   GCCGGCGATTCGCGTCGGGCACAGCACGTGGTGGG-CGAC-ACTTAGT-GTTTCTC--GGTGCAGCGCCCCGGCGCGCGGTCGGCGCATC
Isc.tim.26374   GCCGGCGAATCGCGTCGGGCACAGCACGTGGTGGG-CGAC-ACCTAGTTGTT-CTCGAGGTGCAGCGCCCCGGCACGCTGACGGC--ATC
Isc.sp1.26251   GCCGGCGAATCGTGTCGGGCACAGCACGTGGTGGG-CGAC-ACTCAGT-GTTTCTC--GGTGCAGCGCCCCGGCGCGCGGCCGGCGCA--
Isc.sp2.26375   GCCGGCGAATCGTGTCGGGCACAGCACGTGGTGGG-CGAC-A-TCAGTTGTT-CTC--GGTGCAGCGCCCCGGCACGCTGACGGC--ATC
Ker.sia.26252   GCCGGCGAACCGTGTCGGGCACAGCACGTGGTGGG-CGAC--TCTAGTTGTT-CTC--GGTGCAGCGCCCCGGCACGCGGCCGGCGCATC
Seh.ner.26239   GCCGGCGAATCGTGTCGGGCACAGCACGTGGTGGG-CGACAA-CTAGTTGTT-CTC--GGTGCAGCGCCCCGGCGCGCAGCCGGCGCATC
The.ele.26240   GCCGGCGAACCGTGTCGGGCACAGCACGTGGTGGG-CGAC-ATCCAGTTGTT-CTC--GGTGCAGCGCCTCGACACGTTGCAGGCGTATT
Mne.can.26346   GCCGGCGAATCGTGTCGGGCACAGCACGTGGTGGG-CGAC-ACCTAGTTGTT-CTC--GGTGCAGCGCCCCGGCACGCGGCCGGCGCATC
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Hem.com.26247   GCCGGCGAATCGTGTCGGGCACAGCACGTGGTGGG-CGAC-ATCAAGTTGTT-CTC--GGTGCAGCGCCCCGGCACGCGGCCGGCGCATC
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Oph.exa.26237   GCCGGCGAATCGTGTCGGGCACAGCACGTGGTGGG-CGAC-ATCCAGTTGTT-CTC--GGTGCAGCGCCCCGGCACGCGGCCGGCGCATC
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Rot.coc.26253   GCCGGCTTACGGTGTCGGTCACAGCACAAGGTGGG-CGAC-ACCTAGTTGTT-CTC--GGTGCAGCGCCCCGGCACGCGGCCGGCGCATC
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Cen.lap.26376   GCCGGCGTACGGCGCCGGGCACAGCACAAGGTGGGACGAC-A-CGAGTTGTT-CAC--GGTGCAGTGCCTCGGCGCCCAGCCGGCGACGT
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Isc.bar.26363	GGCCCTACGGACCCATCGAGCACCGCAGCGCATCGCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.bar.26364	GGCCCTACGGACCCATCGAGCACCGCAGCGCATCGCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.bar.26365	GGCCCTACGGACCCATCGAGCACCGCAGCGCATCGCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.bar.26366	GGCCCTATGGACCCATCGAGCACCGCAGCGCATCGCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.hir.26249	GGCCCTACGGACCCATCTAGCACCGCAGCGCTCCGTCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.hub.26250	GGCCCTACGGACCCATCGAGCACCGCAGCGCATCGCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.ind.26367	GGCCCTACGGACCCATCGAGCACCGCAGCGCATCGCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.ind.26368	GGCCCTATGGACCCATCTAGCACCGCAGCGCTCCGTCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.ind.26369	GGCCCTATGGACCCATCTAGCACCGCAGCGCTCCGTCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.ind.26370	GGCCCTATGGACCCATCTAGCACCGCAGCGCTCCGTCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.rug.26372	GGCCCTATGGACCCAACGAGCACCGCAGCGCATCGCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.ten.26373	GGCCCTCGGGACCCATCGAGCACCGCAGCGCGCAGCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.tim.26374	GGCCCTGTGGACCCATCTAGCACCGCAGCGCTCCGTCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.sp1.26251	GGCCCTACGGACCCATCGAGCACCGCAGCGCATCGCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Isc.sp2.26375	GGCCCTATGGACCCATCTAGCACCGCAGCGCTCCGTCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Ker.sia.26252	GGCCCTGAGGACCCATCCAGCACCGCAGCGCACCGCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Seh.ner.26239	GGCCCTCAGGACCCAACCAGCACCGCAGCGCACCGCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
The.ele.26240	GGCCCTATGGACCCATAGAGCACCGCAGCGCAT-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Mne.can.26346	GGCCCTAAGGACCCACAGAGCACCGCAGCGCGC-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Mne.gla.26347	GGCCCTAAGGACCCATAGAGCACCGCAGCGCAC-GCCGCTCGGACCACGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Mne.hel.26348	GGCCCTAAGGACCCATAGAGCACCGCAGCGCAC-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Mne.mol.26349	GGCCCTAAGGACCCATAGAGCACCGCAGCGCAC-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Mne.str.26350	GGCCCTAAGGACCCATAGAGCACCGCAGCGCAC-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Mne.stp.26351	GGCCCTAAGGACCCATAGAGCACCGCAGCGCAC-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Mne.sp1.26244	GGCCCTAAGGACCCACACAACACCGCAGCGCAC-GCCGCTCGGACCACGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Ere.att.26352	GGCCCTAAGGACCCAGCGAGCACCGCGGCGCAT-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Ere.bim.26353	GGCCCTAAGGACCCAGCGAGCACCGCGGCGCAT-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Ere.cil.26354	GGCCCTAAGGACCCAGCCAGCACCGCGGCGAGC-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGCACTACCCGCTGAGTTTAAGCATAT
Ere.cit.26355	GGCCCTAAGGACCCAGCGAGCACCGCGGCGCAT-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Ere.eri.26356	GGCCCTAAGGACCCAGCGAGCACCGCGGCGAGC-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Ere.lan.26357	GGCCCTAAGGACCCAGCAAGCACCGCGGCGAGC-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Ere.max.26358	GGCCCTAAGGACCCAGCGAGCACCGCGGCGCAT-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Ere.sp1.26245	GGCCCTAAGGACCCAGCGAGCACCGCGGCGCAC-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Hac.gra.26234	GGCCCTGAGGACCCATAGAGCACCGCAGCGCAC-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Hac.por.26235	GGCCCTGAGGACCCATAGAGCACCGCAGCGCAC-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Hem.com.26247	GGCCCTAAGGACCCAAAGAGCACCGCAGCGCAA-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Hem.pra.26248	GGCCCTAAGGACCCAACGAGCACCGCAGCGCAA-GCCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Mne.lae.26236	GGCCCTGAGGACCCAA-GAGCACCGCAGCGCGC-GCCGCTCGGACCGCGACCCCAGGTCAGACGGGACTACCCGCTGAGTTTAAGCATAT
Oph.axa.26237	GGCCCTAAGGACCCATACGTCACCGCAGCGCGC-ATCGCTCGGACCGGGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Pha.zea.26238	GGCCCTAAGGACCCATCGAGCACCGAAGCGCAC-GACGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Rot.coc.26253	GGCCCTAAGGACCCATCGAGCACCGCAGCGCGTCGTCGCTCGGACCGCGACCCCAGGTCAGTCGGGACTACCCGCTGAGTTTAAGCATAT
Era.bif.	GGCCCTCACGACCCATCAATCGAAGC-GTACGTCG---CTCGGAC??
Cen.jap.26376	GGCCCTAAGGACCCATGCTCGACCGCAGCGCATGG-CGCTCGGACCGCGACCCCAGGTCAGGTGGGACTACCCGCTGAGTTTAAGCATAT

	1981 1990 2000 2010 2020 2029
Apl.mut.26233	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Isc.bar.26363	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Isc.bar.26364	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Isc.bar.26365	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Isc.bar.26366	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Isc.hir.26249	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Isc.hub.26250	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
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Isc.ind.26368	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
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Isc.ind.26370	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Isc.rug.26372	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Isc.ten.26373	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Isc.tim.26374	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Isc.sp1.26251	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Isc.sp2.26375	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Ker.sla.26252	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Seh.ner.26239	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
The.ele.26240	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Mne.can.26346	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Mne.gla.26347	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Mne.hel.26348	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Mne.mol.26349	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Mne.str.26350	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Mne.stp.26351	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Mne.sp1.26244	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Ere.att.26352	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Ere.bim.26353	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Ere.cil.26354	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Ere.cit.26355	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Ere.eri.26356	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Ere.lan.26357	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Ere.max.26358	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Ere.sp1.26245	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Hac.gra.26234	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Hac.por.26235	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Hem.com.26247	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Hem.pra.26248	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Mne.lae.26236	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Oph.exa.26237	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Pha.zea.26238	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Rot.coc.26253	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA
Era.bif.	???
Cen.lap.26376	AAATAAGCGGAGGAGAAGAAACTTACAAGGATTCCCCTAGTAACGGCGA

BIOGRAPHY

Miss Paweena Traiperm was born on November 24th, 1978 in Ayutthaya Province. She earned her Bachelor Degree in Science in Biology from the Department of Biology, Faculty of Science, Khon Kaen University, Khon Kaen, in 2000. In 2003, she received her Master of Science in Botany from the Department of Botany, Faculty of Science, Chulalongkorn University, then continued her study in Biological Science Ph.D. Program, Faculty of Science, Chulalongkorn University from 2004-2007.