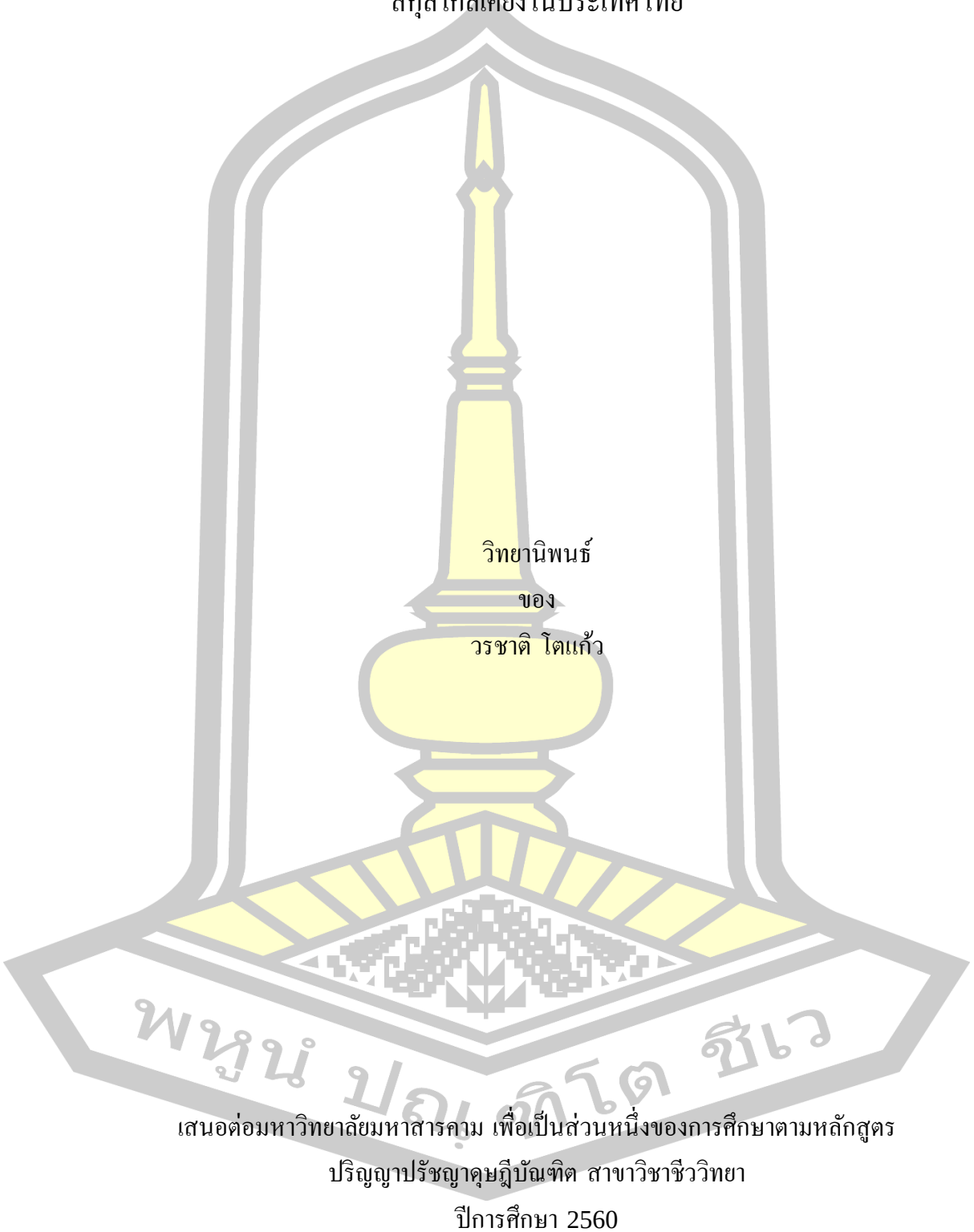
Systematics of genus *Uraria* Desv. (Leguminosae) and related genera in Thailand

Worachat Tokaew

A Thesis Submitted in Partial Fulfillment of Requirements for
degree of Doctor of Philosophy in Biology
Academic Year 2017

อนุกรมวิธานพืชสกุลหางกระรอก (*Uraria* Desv.) วงศ์ถั่ว (Leguminosae) และสกุลใกล้เคียงในประเทศไทย



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ABSTRACT

This research aim to study systematics of *Christia* Moench, *Uraria* Desv. and *Uraiopsis* Schindl. in Thailand. The plant species were survey and specimens were collected from all Thailand floristic regions. The specimens were examined, described from both collected and dried specimen in herbaria in Thailand and abroad. Leaf anatomy was studied by Paraffin method. Leaf, seed and pollen micro-morphology were examined under LM and SEM and phylogenetic tree of the three genera were constructed based on ITS sequences. The results showed that *Uraiopsis* was reduced to synonym of *Uraria*. The following three species of *Christia* and fourteen species of *Uraria* are recognized. *C. pierrei* , *U. balansae* and *U. barbaticaulis* are a new record for Thailand. and *U. pierrei* is reduced to synonymy of *Uraria rotundata*. A key to the species, ecological, distribution data, and photographs are provided. Moreover, seed and pollen morphological, leaf epidermal and anatomical characters of thirteen, eight and fourteen species respectively are presented. The phylogenetic tree shown *Urariosis* is a member of *Uraria*. Seed and pollen morphological, leaf epidermal and leaf anatomical characters don't supported for classification in generic level.

Keyword : Christia, Urariopsis, leaf anatomy, pollen morphology, seed morphology

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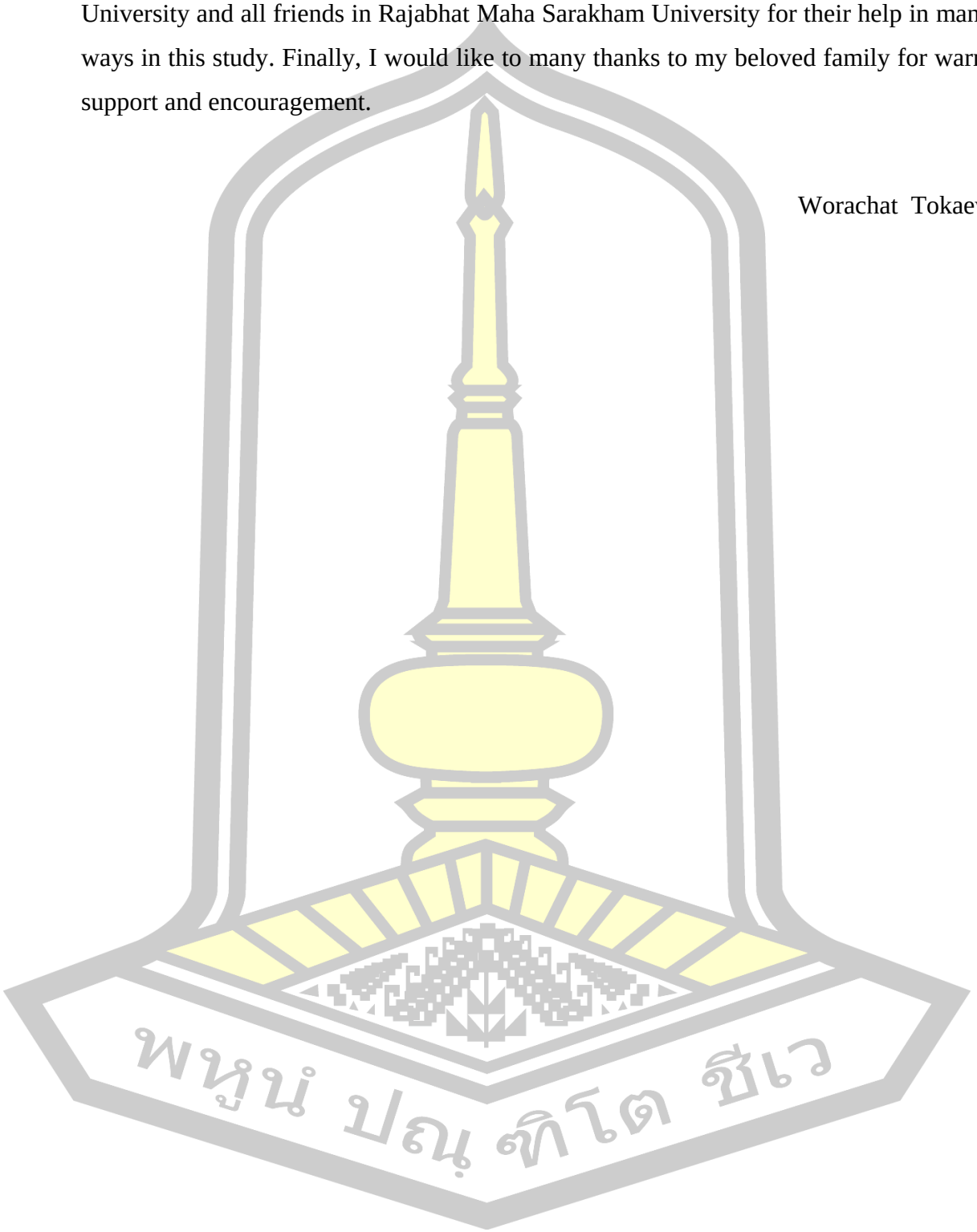

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CHAPTER 1

INTRODUCTION

1.1 Background

Leguminosae (Fabaceae) is one of largest plant family after Asteraceae and Orchidaceae (Keng, 1978). The family occurs mainly in tropical, subtropical and temperate regions and contains about 650 genera and 18,000 species worldwide (Niyomdham, 1994). The members are trees, shrubs, herbs or climbers, usually with spines. The leaves are usually compound, sometimes simple or unifoliate, usually spiral. The flowers are usually bisexual, actinomorphic or zygomorphic, hypogynous or perigynous. The calyx is aposepalous or synsepalous with (3-) 5 (-6) sepals. The corolla is aposepalous or synsepalous, with 5 (rarely 0) valvate or imbricate petals. The stamens are 5 or 10 (to many), separate or connate. Anthers are longitudinal, rarely poricidal in dehiscence. The gynoecium is unicarpellous, with a superior ovary, 1 carpel and 1 locule. Placentation is marginal and ovules are anatropous or campylotropous, bitegmic, 2-many per carpel. The fruit is generally a legume, sometimes indehiscent, samara, drupe like or individual into transverse partitions (Simson, 2006).

In Thailand, this family is about 102 genera and 614 species (Niyomdham, 1994) and traditionally classified into three subfamilies; Caesalpinioideae, Mimosoideae and Faboideae (Papilionoideae), sometimes this family is separated into three families (Simson, 2006). The subfamilies differ from each other in their flower and pod characteristics. Taxonomical study of two subfamilies were already reported, 21 genera 118 species of Caesalpinioideae (Larsen & Larsen, 1989; Larsen & S.S. Larsen, 2001; S.S. Larsen, 1999; Veesommai & Larsen, 2002) and 11 genera 51 species of Mimosoideae (Nielsen, 1985). The last subfamily contains approximately 71 genera and 450 species (Niyomdham, 1994).

Faboideae is the largest subfamily. It poorly studied, only some genera were reported keys and descriptions i.e., *Dalbergia* L.f. (Niyomdham, 2002), *Indigofera* L. (Matapha & Chantaranothai, 2012) and *Mucuna* Adans (Wilmot-Dear, 2008). The

subfamily contains mostly trees, shrubs, herbs and sometimes climbers. The leaves are mostly pinnately compound. The flowers are bisexual, irregular with 10 stamens (rarely fewer or numerous) and usually in raceme or compound raceme. The fruit is generally a legume with two-valves. This plants are important for human life such as crops, food, ornamental and herbal and about 15 species of Faboideae in Thailand are threatened species i.e., *Afgekia mahidolae* B. L. Burtt & Chermair., *Dalbergia sootepensis* Niyomdham, *Desmodium siamemsis* (Schindl.) Craib, *Indigofera kerrii* de Kort & Thijsse, *Mucuna thailandica* Niyomdham & Wilmot-Dear, etc. (Santisuk, Chayamarit, Pooma, & Suddee, 2006).

Faboid plants are divided into 24 tribes (Polhill & Raven, 1981). Sixteen tribes with 88 genera are found in Thailand (Niyomdham, 1994). Genus *Uraria* Desv. is one of small genera in tribe Desmodieae. Many species such as *U. alopecuroides* Wight, *U. crinita* Desv., *U. lagopoides* DC., *U. picta* Desv. were used as medicine (Chamratpan & Homchuen, 2005; Khare, 2007) and *U. crinita* Desv ex DC. was used for an ornamentation (Suvatti, 1978). The genus is distinct with the folding pod between seeds, which is similar to the other two genera; *Christia* Moench and *Urariopsis* Schindl. Sometimes, same species was placed in different genera by different authors. This research aims to classified the three related genera (*Christia*, *Uraria* and *Urariopsis*) in Thailand based on morphology, leaf anatomy, palynology and molecular genetic data, and constructed keys for genera and species for identification.

1.2 Objectives of Study

The objectives of this research are:

1.2.1 To report species numbers in genus *Christia*, *Uraria* and *Urariopsis*, described morphology and recorded ecological and distributions of plant studied.

1.2.2 To study seed and pollen morphology, leaf micromorphology and leaf anatomy of plant studied.

1.2.3 To study phylogenetic relationship of the members of the genus base on ITS DNA sequences.

1.2.4 To construct artificial keys to genera and species in Thailand.

1.3 Scope of the Research

Morphology is studied based on information from fieldworks in Thailand as well as types and herbarium specimens in Thailand and abroad. Specimens are examined under stereomicroscope. Distribution and ecological data are recorded. Anatomical study is carried out via permanent slides, which are prepared by Paraffin method (Johansen, 1940) and observed under light microscope (LM). For micromorphology study, pollen from plant specimens is prepared according to the acetolysis method (Erdtman, 1992), then measured and examined under both light and scanning electron microscopes (SEM). For leaves and seeds of the plants, there are examined under SEM.

Phylogenetic relationship is observed using DNA sequence data of nrDNA internal transcribed spacer (ITS) region. The heuristic parsimony analyses were obtained employing Mega 7 software. Collected specimens in this study will be deposited at Khon Kaen University Herbarium (KKU) and the Forest Herbarium, National Park, Wildlife and Plant Conservation (BKF).

1.4 Expected Outcome of the Research

1.4.1 Information of external morphology, seeds and pollen morphology, leaf micromorphology, leaf anatomy, including ecology and distribution of genus *Uraria* and their related genera in Thailand.

1.4.2 Information of molecular phylogenetic relationship of genus *Uraria* and their related genera based on ITS DNA sequences.

1.4.3 Information of species diversity of the plants and artificial key for identified genus and species in Thailand.

CHAPTER 2

LITERATUR REVIEW

Genus *Uraria* Desv. is a member of Faboideae (Leguminosae). It comprises approximately 20 species and has a center of diversity in India to Indo-China, some species are reported as common in Thailand. Two genera, *Christia* Moench and *Urariopsis* Schindl. are similar characters and taxonomic study of them are poor. Morphology, micromorphology, anatomy and molecular data of these three genera are required.

2.1 Historical Review

Subfamilies Faboideae (Leguminosae) was divided into 24 tribes by Polhill and Raven in 1981. Sixteen tribes were found in Thailand viz, *Abreae* (1 genus), *Aeschynomenae* (7 genera), *Cicereae* (1 genus), *Crotalarieae* (2 genera), *Dalbergieae* (2 genera), *Desmodieae* (13 genera), *Eushesteae* (1 genus), *Genisteae* (1 genus), *Indigoferae* (2 genera), *Lespedezeae* (3 genera), *Phaseoleae* (37 genera), *Sesbanieae* (1 genus), *Sophoreae* (2 genera), *Tephrosieae* (7 genera), *Trifolieae* (4 genera), and *Vicieae* (4 genera) (Niyomdham, 1994).

Genus *Uraria* is one of a small genus in tribe Desmodieae. This tribe is characterized by leaflets with scalariform tertiary nerves and jointed or articulate pod. Twenty-seven genera are found worldwide, mainly in tropical regions. In Thailand, 13 genera are recorded (Niyomdham, 1994) but only three genera, *Christia*, *Uraria* and *Urariopsis* are distinct pod which it is transversely folded between the seeds.

Uraria was described by Desvaux in 1813. This term came from Greek meaning “tail” refer to *U. picta* (Jacq.) DC., which has long tail-like inflorescences. The distinctive characters of genus are: herbs, sub-shrubs or shrubs, leaves with 1-11 leaflets, raceme or panicle. Flowers have campanulated calyx, monadelphous stamen and superior ovary with 2-10 ovules, and pods folded between the seeds. After that Schindler (1916) raised up *Uraria cordifolia* Wall. to be a new genus, *Urariopsis*. This similar genus is characterized by each article of pods attach in central, differ

from *Uraria* which attach in lateral. This genus is presently included in *Uraria* by many taxonomists. The other related genus, *Christia* was described by Moench in 1802. Many old publications, the members of this genus were known in *Lourea* Neck. ex Desv. (synonym of *Christia*). It differs from *Uraria* by fruits which are bearing enlarged membranous calyx. *U. campanulata* (Benth.) Gagnep. has enlarged calyx, it was accepted in the genus *Christia* by Puhua & Ohashi (2010) as *C. campanulata* (Benth.) Thoth.

2.2 Taxonomic Studies in Asia

In China, Puhua *et al*., (2010) reported five species of *Christia* viz., *C. campanulata* (Benth.) Thoth. (= *U. campanulata* (Benth.) Gagnep.), *C. constricta* (Schindler) T. C. Chen, *C. vespertilionis* (L.f.) Bakh. f., *C. obcordata* (Poir.) Bakh. f. ex Meeuwen and *C. hainanensis* Y. C. Yang & P. H. Huang (Puhua & Ohashi, 2010a) and seven species of *Uraria* viz. *U. crinita* (L.) Desv. ex DC., *U. lagopoides* (L.) DC., *U. lacei* Craib, *U. neglecta* Prain, *U. picta* (Jacq.) Desv. ex DC., *U. rufescens* (DC) Schindl. and *U. sinensis* (Hemsl.) Franch., Puhua and Ohashi reported two species of *Urariopsis* viz. *Ur. cordifolia* (Wall.) Schindl. and *Ur. brevissima* Y. C. Yang & P. H. Huang (Puhua & Ohashi, 2010b).

Ohashi & Iokawa (2007) revised four species of *Uraria* in Taiwan, namely; *U. crinita, U. lagopodioides* (L.) Desv., *U. neglecta* and *U. picta.*

Baker (1976) reported eight species of *Uraria* from India viz. *U. cordifolia* Wall. (= *Urariopsis cordifolia*), *U. crinita, U. hamosa* Wall., *U. lagopoides* DC., *U. lagopus* DC., *U. picta, U. prunellaefolia* Grah. and *U. repanda* Wall.

Ridley (1922) enumerated three species from the Malay peninsula, there were *U. crinita, U. lagopoides* and *U. picta.*

van Meeuwen *et al*., (1960) studied some genera of Faboideae in Malaysia. There are two *Uraria* viz. *U. lagopodioides, U. picta*. In 1961, they reported two *Christia* viz. *C. obcordata* and *C. vespertilionis* (van Meeuwen *et al*., 1961).

Van Thuân *et al*., (1987) revised the Faboideae in the Indo-China. There are six of *Christia* viz. *C. constricta, C. convallaria* (Schindl.) H. Ohashi, *C. lychnucha* (Schindl.) H. Ohashi, *C. obcordata, C. pierrei* (Schindl.) H. Ohashi, *C. vespertilionis*

and *C. vespertilionis* var. *grandifolia* Dy Phon, and thirteen of *Uraria* viz. *U. acaulis* Schindl., *U. acuminata* Kurze, *U. balansae* Schindl., *U. campanulata*, *U. cochinchinensis* Schindl., *U. cordifolia*, *U. crinita*, *U. lacei*, *U. lagopodioides*, *U. picta*, *U. pierrei* Schindl., *U. poilanei* and *U. rufescens.*

Kress *et al*., (2003) made a list of trees, shrubs, herbs, and climbers in Myanmar and reported sixteen of *Uraria* viz. *U. barbata* Lace, *U. clarkei*, *U. collettii* Prain, *U. cordifolia*, *U. crinita* Desv., *U. gracilis* Prain, *U. hamosa* Wall., *U. henryi* Schindl., *U. kurzii* Schindl., *U. lacei*, *U. lagopodioides* DC., *U. lagopus* DC., *U. latifolia* Prain, *U. macrostachya* Wall., *U. picta*, *U. repanda* Wall., and *U. rufescens*.

2.3 Taxonomic Studies in Thailand

Craib & Kerr (1932) made a list of Thai plants including 11 species of *Uraria* viz. *U. acaulis*, *U. acuminata*, *U. alopecuroides*, *U. clarkei*, *U. crinita*, *U. hamosa*, *U. lagopodioides*, *U. latifolia*, *U. macrostachya*, *U. picta* and *U. rotundata*. In 1978, Suvatti reported four species of *Lourea* (= *Christia*) viz. *L. campanulata* Benth., *L. obcordata* Desv., *L. paniculata* Wall. and *L. vespertilionis* Desv. and reported nine species of *Uraria* viz. *U. acuminata*, *U. alopecuroides* Wight., *U. crinita*, *U. lagopodioides*, *U. lagopoides* DC., *U. latifolia*, *U. macrostachya* Wall., *U. picta* and *U. rotundata* Craib. After that *U. cochinchinensis* and *U. pseudoacuminata* W. Tokaew & Chantar. were reported by Tokaew & Chantaranothai, (2008; 2013). Then, The Royal Forest Department (2014) enumerated and made a list of three species of *Christia* and twelve species of *Uraria* viz. *C. campanulata*, *C. obcordata*, *C. vespertilionis* var. *vespertilionis* and *C. vespertilionis* var. *grandifolia*, *U. acaulis*, *U. acuminata*, *U. cordifolia*, *U. crinita*, *U. lacei*, *U. lagopodioides*, *U. picta*, *U. pierrei*, *U. poilanei*, *U. rotundata* Craib and *U. rufescens.* (Tabs. 1-2).

Table 1 List of species in genus *Uraria* (included *Uraiopsis*) in Thailand.

No.	Scientific Name	Craib and Kerr (1932)	Suvatti (1978)	van Thuân *et al.* (1987)	Tokaew & Chantaranothai (2008; 2013)	The Royal Forest Department (2014)
1.	*U. acuminata*	√	√	√	√	√
2.	*U. alopecuroides*	√	√	–	–	–
3.	*U. campanulata*	–	–	√	√	√
4.	*U. clarkei*	√	–	–	–	–
5.	*U. cordifolia* (=*Ur. cordifolia*)	–	–	√	√	√
6.	*U. cochinchinensis* (=*Ur. cochinchinensis*)	–	–	–	√	–
7.	*U. crinita*	√	√	√	√	√
8.	*U. hamosa*	√	–	–	–	–
9.	*U. lacei*	–	–	√	–	√
10.	*U. lagopodioides*	√	√	√	√	√
11.	*U. lagopoides*	–	√	–	–	–
12.	*U. latifolia*	√	√	–	–	–
13.	*U. macrostachya*	√	√	–	–	–
14.	*U. pierrei*	–	–	√	–	√
15.	*U. picta*	√	√	√	√	√
16.	*U. poilanei*	–	–	√	–	√
17.	*U. pseudoacuminata*	–	–	–	√	–
18.	*U. rotundata*	√	√	–	√	√
19.	*U. rufescens*	–	–	√	√	√

Notation: – = not recorded, √ = recorded

Table 2 List of species in genus *Christia* in Thailand.

No.	Scientific Name	Craib and Kerr (1932)	Suvatti (1978)	van Thuân *et al*. (1987)	The Royal Forest Department (2014)
1.	*Christia campanulata* (= *Lourea campanulata*)	–	√	–	√
2	*C. obcordata* (= *L. obcordata*)	–	√	√	√
3.	*C. vespertilionis* (= *L. vespertilionis*)	–	√	√	√
4.	*C. vespertilionis* var. *grandifolia*	–	–	–	√
5.	*L. paniculata*	–	√	–	–

Notation: – = not recorded, √ = recorded

2.4 Fruits and Seeds Morphology

Kirkbride *et al*. (2003) described morphology of fruits and seeds in subfamily Faboideae (Fabaceae) (Fig. 1). The characters of fruits and seeds of 435 species from 452 genera of Faboid plants are shown. Fruits of Faboideae are legumes, many genera have legume that dehisce along just one suture or are indehiscent. Almost all fruits are unilocular, rarely bilocular. Some fruits are loments or nutlets. A few fruits are plicate, twisted and inflated. Fruit transections are categorized as compressed, flattened or terete, sometime cruciform, quadrangular or subtriangular. Some fruits have slightly constricted to constricted margins along one or both sides. The embellishments are characterized as flanges, fringe, prickles, ridges, spines, thickened sutural areas or wings are found on margins. Fruits winged are samaroid, valvular, sutural, or continuous around the fruit. The samaras are either apical or basal, the

valvular wings are on one valve or on both sides, and the sutural wings are on one suture or on both sides.

Most epicarp or outer surface of pods is monochrome. The colour varies from yellow to black, the predominant colour is brown. The surface is smooth or not. The features of non-smooth surface are categorized as blistered, concentric whorls like a fingerprint, dotted, faveolate, glandular dotted including resinous globular, knobbed, lenticular, muricate, papillose, pusticulate, raised reticulate, ribbed, rugose, scaly, scurfy, shagreen, striate, subvesicular, tessellate, tuberculate, verrucose-rugose, warty, or wrinkled. Hairs on are surface present or absent. It's categorized as glabrous (completely without hairs), glabrate (with just a few scattered hairs), pubescent and indurate (with abundant, persistent hairs), or pubescent and soon deciduous (with abundant hairs that are expected to fall off soon). The hair are simple, glandular, bristlelike (straight, coiled, curved, or hooked), plumose, setae, or T-shaped.

Faboideae have 1 to 80 seeds per fruits. The most common seed shapes are reniform, round, elliptic, oblong, and ovate. Their length ranges from 0.5 to 80 mm (averages 9.1 mm), width ranges from 0.4 to 60 mm (averages 6.1 mm), and thickness ranges from 0.1 to 60 mm (averages 3.5 mm). Some seeds have fleshy or dry aril (Figure 2.1). The seed surface is categorized as grooved (longitudinal, oblique, reticulate, or transverse), ridged, smooth or wrinkled. The faboid seeds do not have exfoliating cuticle and pieces of adhering epicarp. Raphes and lens are visibility and have the hilum concealed (fully or partially). Most seeds have endosperm, but some are much reduced or lack endosperm.

The most seed have a testa or seed coat. Therefore, when its associated structures, raphe, hilum and lens, are absent, the testa is also absent. The vast majority of testas are opaque (monochrome, mottled, streaked, or bichrome) and a few are transparent. The testas are glabrous and hairless. Their colours are variable from white to black and the most common colour is brown and many shades of brown exist. Most testas are smooth. The non-smooth testas features are categorized as bearing endocarp remnants, having a blistered cuticle, echinate, papillate, powdery, reticulate, ridged, rugose, shagreen, tessoroid, tuberculate, veined, verrucose, warty, wrinkled, concaved, cracked, large depressions, grooved, punctuate, striate or pitted and

roughened testa is added by Zorić *et al*., (2010). Most testas lack fracture lines, rim and wings and no testas have pleurograms or pseudopleurograms.

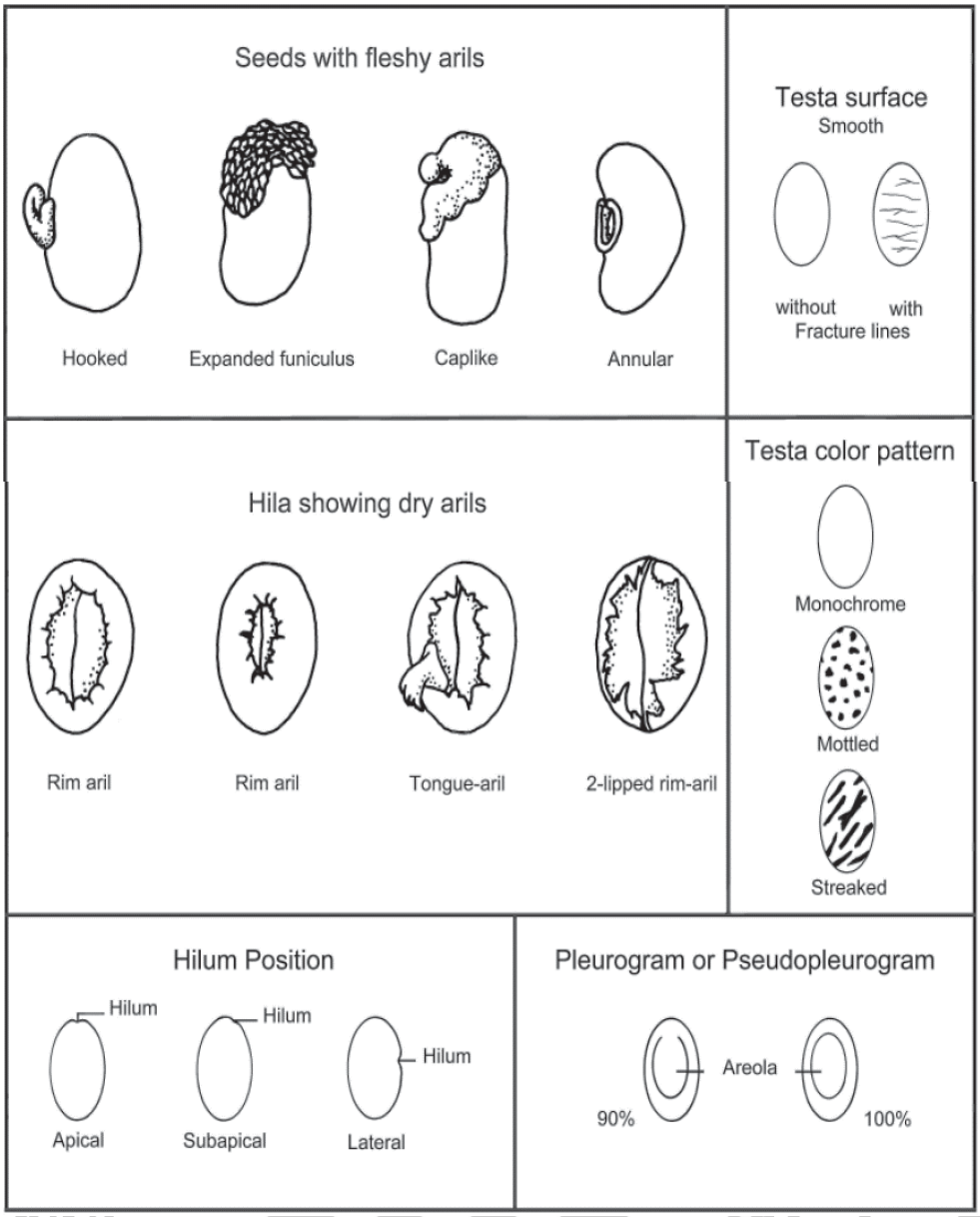

Figure 1 Some characters of Faboid seed (Kirkbride *et al.*, 2003)

2.5 Pollen Morphology

Pollen morphology for classification of subfamily Faboideae (Leguminosae) was reported by Fergiuson & Skvarla (1981) and Perveen & Qaiser (1998). The former authors summarized the essential features of the pollen in Faboideae using

light microscopy (LM), scanning electron microscopy (SEM) and transmission electron microscopy (TEM). Pollen morphological publications of the member plants were integrated and predicated. They explained the characters in subfamily and tribe levels. Pollen morphology cannot use for tribes delimitation because there are great overlap and parallels in pollen characters between groups. However, it was possible to detected tendencies for certain groups of genera and even whole tribes to have various combinations of unspecialised, specialised or relatively highly specialised associations of pollen characters. The latter studied pollen morphology of Faboideae in Pakistan using light and scanning electron microscopy. The pollen morphology of 157 species, 37 genera in 16 tribes were examined and divided into 10 groups based on characters of shape, apertural type and exine patterns.

From both reports, pollen morphology of Faboideae are generally free, radially symmemetrical, isopolar, mostly tricolporate, sometimes syncolporate, rarely colpate, porate or 6-colporate, generally triangular or trilobed in polar view. The shape is commonly prolate to sub-prolate, or prolate-spherodial, less commonly to oblate- spherodial or sub-oblate, often perprolate. There are a small number of genera with very large or very small pollen grains. The average size is not greater than 50 µm. The endoaperture is commonly la-longate or circular, rarely lolongate. Colpal membrane is psilate to sub-psilate or granulated, often scabrate. The sexine is thicker than or as thick as the nexine. The tectum shows a range of sculpturing type, the most common types are reticulate, sometime finely reticulate to coarsely reticulate, reticulate-radiate, reticulate- rugulate, rugulate, foveolate, striate, areolate, perforate, and finely punctate or smooth patterns also occur.

Ohashi (1971) study taxonomy of tribe Coronilleae (Leguminosae) and described pollen morphology of the plants under light microscopy (LM). He reported pollen morphology of three *Christia* (*C. obcordata, C. pierrei* and *C. vespertilionis*) and five *Uraria* (*U. acuminata*, *U. cordifolia*, *U. crinita*, *U. lagopodioides*, *U. rufescens* and *U. sinensis*). Pollen grains of the both genera are tricolporate, subporate or prolate spheroidal except *U. crinita* (prolate or subporate), *U. cordifolia* (subporate), and *U. sinensis* (oblate spheroidal), exine of *Christia* verrucate to very fine reticulate, exine of *Uraria* finely reticulate except *U. cordifolia* is very fine reticulate or occasionally more or less regulate.

Chen & Huang (1993) studied pollen morphology of tribe Desmodieae (Faboideae) in Taiwan using LM, SEM and TEM. Pollen morphology of 34 species in 12 genera including 2 *Uraria* species (*U. crinita* and *U. lagopodioides*) and *C. obcordata* were examined. The results show the pollen of Desmodeae is tricolporate and spheroidal, prolate to oblate in equatorial view. The pollen is small to middle in size, ranging from 17 μm to 60 μm in polar axes (P) and 17 μm to 65 μm in equatorial axes (E). The endoaperture are round or elliptic (lalongate or lolongate). The length of endoapertures are about a quarter of colpi in these pollen grain; and the length of colpi is about 3/4 to 4/5 of axes. The colpial margins are well differentiated in the majority of these genera. The colpus membrane is granulate, except some species in *Desmodium*. The endoexine is well developed and thick. The mesocolpial pouches are obvious in some genera. The most tectum are reticulate or verrucate. For *C. obcordata*, *U. crinita* and *U. lagopodioides*, the tectum are finely reticulate and weakly rugulate, psilate and microperforate, and coarsely granulate to verrucate, respectively.

2.6 Leaf Anatomy and Micromorphology

Metcalfe & Chalk (1979) summarized anatomy of dicotyledonous plants. They reported anatomy of leaf and stem of the plants, included Faboideae. Anatomy characters of leaf in Faboideae were glandular hairs and non-glandular hairs; simple (unbranched) -long, thickened (shaggy) hairs, 3–5-armed hairs, stellate hairs, (unbranched) hairs, simple (unbranched) - short hairs, simple (unbranched) -long hairs, stellate-multiangulate hairs, scale, scale-sessile, scales-peltate, and scales-porrect, mucilaginous epidermis, abaxial epidermis with papillose. Stomata were anomocytic, paracytic, or paraelocytic types, it found in both leaf surfaces. Hypodermis presented. Mesophylls were isobilateral, sclereids were fibers or branched sclereids in mesophyll cells. Veins were vertically transcurrent and Kranz structure found in some genera (*Genista* and *Spartium*).

From 1994 to 2014, leaf anatomy of Faboideae were reported in genus *Abrus* (Agbagwa & Okoli, 2016), *Apios*, *Cochlianthus* (Bo *et al*., 2007), *Cytisophyllum*, *Cytisus*, *Chamaecytisus*, *Genista* (Norverto, *et al*., 1994), *Dahlstedtia*

(Teixeira & Gabrielli, 2006), *Lathyrus* (Cildir, 2011), *Indigofera* (Marquiafável *et al*., 2009; Nwachukwu & Mbagwu, 2007; Umar *et al*., 2014). Leaf anatomy characters of the plants are summarized as followed:

Epidermis: epidermal cells are more or less isodiametrical to polyhedral in *Cytisophyllum*, *Cytisus*, *Chamaecytisus*, *Genista*, and *Lathyrus*, and irregular shape with wavy, sinous or arcuate anticlinal walls (jigsaw shape) in *Abrus*, *Cochlianthus*, except *Apios*, *Dahlstedtia* and *Indigofera*; epidermal cells varies between polygonal and irregular shape. Epidermal cells are smooth, except *Cytisophyllum*, *Cytisus*, *Chamaecytisus*, and *Genista*, are usually papillose or subpapillose.

Mature stomatal types are anomocytic, anisocytic, diacytic, laterocytic, paracytic or staurocytic. Epidermis of some genera are unique with anomocytic stomata (*Cytisophyllum*, *Cytisus*, *Chamaecytisus*, *Genista*), or with paracytic stomata (*Dahlstedtia*). The members of some genera are different; *Apios* with anomocytic, anisocytic, laterocytic or paracytic, *Cochlianthus* with anisocytic or paracytic, *Indigofera* with anomocytic or anisocytic. The members of some genera (*Abrus* and *Indigofera*) with not only one stomata types in epidermis. Stomata appear only on the abaxial epidermis of species (*Apios*, *Cochlianthus*, *Cochlianthus*, *Dahlstedtia* and most of *Abrus*) or on both surface (*Cytisophyllum*, *Cytisus*, *Chamaecytisus*, *Genista*, *Indigofera* and some of *Abrus*)

Trichomes: when present, are simple, nonglandular, unbranch, (*Abrus*, *Cytisophyllum*, *Cytisus*, *Chamaecytisus*, *Dahlstedtia* and *Genista*), unicellular unbranched trichomes (*Indigofera*), branched trichomes (*Indigofera*), and secretory trichomes (*Dahlstedtia*, *Indigofera*).

Mesophyll are isobilateral type (with palisade and spongy mesophyll). Palisade mesophyll with crystal (*Dahlstedtia*, *Indigofera*) and tannin bag (*Indigofera*). Vascular bundle with well-developed screnchyma tissue in *Lathyrus*, or with bundle parenchyma sheath in *Dahlstedtia*.

2.7 Molecular Phylogeny

Molecular techniques are being used increasingly in plants systematic. After restriction site analysis of cpDNA, the use of nucleotide sequences has been becomes

an even more powerful approach (Kass & Wink, 1995). The plastid genome has been the primary source of information for reconstructing phylogenies at the genus level and higher since the advent of plant molecular systematics, thanks to its high copy number and single-copy behavior. Five loci (*matK* gene, *rbcL* gene, *trnL* intron, *psbAtrnH* spacer, and the internal transcribed spacers ITS1 and ITS2 of nrDNA) most often used for phylogenetic studies in many plant groups, including legumes (Bruneau *et al*., 2013). The Phylogenetic studies were found both single locus and Combining loci. For the single locus phylogenies, the studies based on *matK*, *trnL* and *rbcL* sequence (Bruneau *et al*., 2013).

The chloroplast gene *rbcL*, which codes for the large subunit of ribulose-1,5-bisphosphate carboxylase/oxygenase (RuBisCO or RuBPCase). In beginning, this sequences used for analyze evolution and relationships of 500 taxon in seed plants (Chase *et al.*, 1993). It was used for phylogenetic studies with single locus (Doyle *et al*., 1997; 2000; Kajita, *et al*., 2001; Käss & Wink, 1995; 1997) and combined with other loci (Stefanović *et al*., 2009). Despite a number of insights into higher level relationships of the family derived from analysis of *rbcL* gene, many issues in legume phylogeny remain unresolved. This is particularly true for the relationships among the large clade. The need for more variable genes and non-coding sequences, alone or in combination with morphological data, to gain resolution was evident (Wojciechowski, 2003).

Wojciechowski *et al*., (2004) studied a phylogeny of legumes (Leguminosae) based on analysis of the plastid *matK* gene. The result shown the monophyly of subfamily Faboideae and at least seven major subclades were well-supported by bootstrap and Bayesian credibility values. For tribe Desmodeae (the specimens not included genus *Uraria* and related) was reported by Stefanović *et al*. (2009). They studied generic level relationship in phaseoloid legumes (included Desmodeae) using eight chloroplast DNA regions (*rbcL*, *atpB*, *trnK/matK*, *rpl2*, *clpP*, *rps16* and *ycf4*). The results provide a comprehensive picture of evolutionary divergence of one of the largest clades in the Leguminosae, Desmodeae (plus *Mucuna*) was split from Phaseoloid legume.

CHAPTER 3

METHODOLOGY

3.1 Morphology and Taxonomic Study

These studies are based on an examination of herbarium specimen from Thailand. The plant species are survey and specimens are collected and photographed from all seven Thailand floristic regions; Northern, North-Eastern, Eastern, South-Western, Central, South- Eastern and Peninsular (Fig. 2). Voucher specimens are deposited in the Khon Kaen University Herbarium (KKU) and the Forest Herbarium, National Park, Wildlife and Plant Conservation (BKF).

The morphology and taxonomic studies of Thai *Uraria* Desv. and related genera were examined, described from both collected and dried specimen in herbaria in Thailand and abroad: Aarhus University Herbarium (AAU); Bangkok Herbarium (BK); Chiang Mai University Herbarium (CMU); Herbarium of Biology Department, Chiang Mai University (CMUB); Khon Kaen University Herbarium (KKU); the Forest Herbarium, National Park, Wildlife and Plant Conservation (BKF); Mahidol University Herbarium (PBM); Muséum National d'Histoire Naturelle (P); the Natural History Museum (BM); Professor Kasin Suvatabhandhu Herbarium (BCU); Queen Sirikit Botanic Garden (QBG); Prince of Songkla University Herbarium (PSU); Trinity College Herbarium (TCD); Royal Botanic Gardens, Kew (K); University of Aberdeen Herbarium (ABD) and University of Copenhagen Herbarium (C), compared and consulted with available literature.

3.2 Seed Morphological Study

Dry, mature seeds of plants studied were took from either dried herbarium specimens or collected during field work. The seeds of 13 species (Tab. 3) from both *Christia* and *Uraria* (included *Urariopsis*) were took off from the fruits, washed with absolute alcohol and dry in air. External morphology of seeds is observed under stereo-

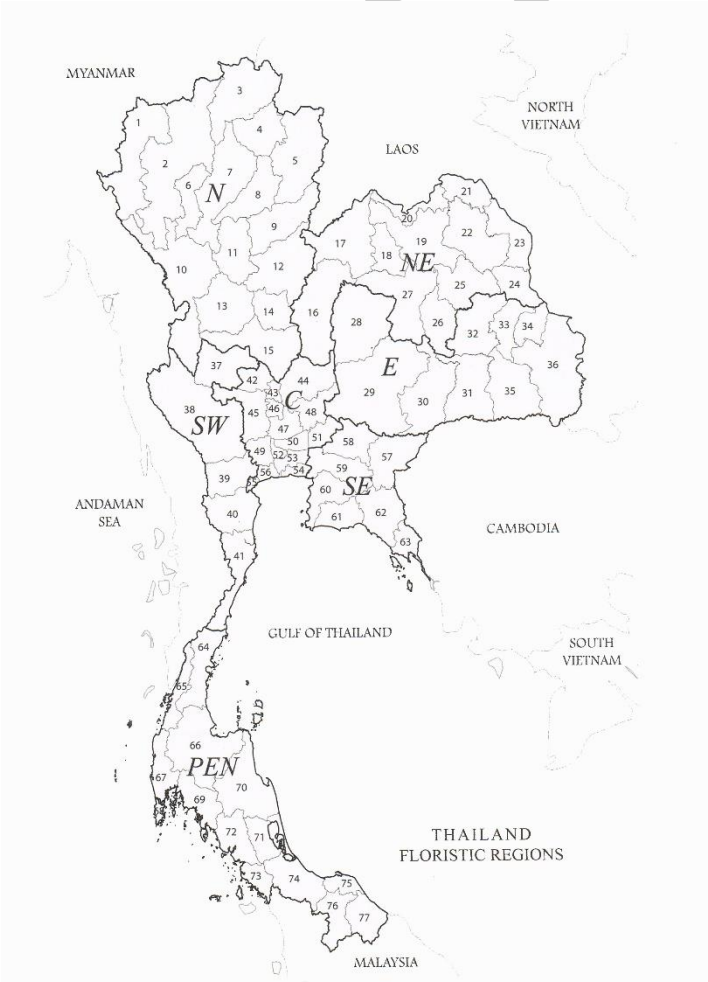

Figure 2 Thailand floristic regions

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. Bueng Kan
22. Sakon Nakhon
23. Nakhon Phanom
24. Mukdahan
25. Kalasin
26. Maha Sarakham

III. 27. Khon Kaen
E (EASTERN)
28. Chaiyaphum
29. Nakhon Ratchasima
30. Buri Ram
31. Surin
32. Roi Et
33. Yasothon
34. Amnat Charoen
35. Si Sa Ket

IV. 36. Ubon Ratchathani
SW (SOUTH-WESTERN)
37. Uthai Thani
38. Kanchanaburi
39. Ratchaburi
40. Phetchaburi

V. 41. Prachuap Khiri Khan
C (CENTRAL)
42. Chai Nat
43. Sing Buri
44. Lop Buri
45. Suphan Buri
46. Ang Thong
47. Phra Nakhon Si Ayutthaya
48. Saraburi
49. Nakhon Pathom
50. Pathum Thani
51. Nakhon Nayok
52. Nonthaburi
53. Bangkok
54. Samut Prakan
55. Samut Songkhram
56. Samut Sakhon

VI *SE* (SOUTH-EASTERN)
57. Sa Kaeo
58. Prachin Buri
59. Chachoengsao
60. Chon Buri
61. Rayong
62. Chanthaburi
63. Trat

VII. *PEN* (PENINSULAR)
64. Chumphon
65. Ranong
66. Surat Thani
67. Phangnga
68. Phuket
69. Krabi
70. Nakhon Si Thammarat
71. Phatthalung
72. Trang
73. Satun
74. Songkhla
75. Pattani
76. Yala
77. Narathiwat

Table 3 List of analyzed species, with voucher and collection site.

Taxon	Voucher Specimens	Collection site
C. obcordata	W. Tokaew 864	Kanchanaburi
C. pierrei	W. Tokaew 922	Phetchabun
C. vespertilionis	W. Tokaew 897	Nakhon Ratchasima
U. acaulis	W. Tokaew & P. Chantaranothai 396	Sakon Nakhon
U. acuminata	W. Tokaew & P. Chantaranothai 423	Chiang Rai
U. campanulata	W. Tokaew 931	Phetchabun
U. cochinchinensis (=*Ur. cochinchinensis*)	J. Leeratiwong 98-20*	Sakon Nakhon
U. cordifolia (=*Ur. cordifolia*)	W. Tanming WT809	Chiang Mai
U. crinita	W. Tokaew 908	Mukdahan
U. lagopodioides	W. Tokaew & P. Chantaranothai 421	Khon Kaen
U. picta	G. Murata *et al*. T-16574*	Nakhon Sawan
U. rotundata	W. Tokaew 909	Khon Kaen
U. rufescens	W. Tokaew 865	Kanchanaburi

Note: * = specimens from AAU herbarium

microscopy. Then the seeds are affixed on aluminum stubs with double-sided cellophane tape. Samples are sputter-coated with a gold-palladium, examined and photographed on scanning electron microscopy (SEM) JSM-6010, JEOL, Japan, at the Center for Scientific and Technological Equipment, Suranaree University of Technology, Nakhon Ratchasima province.

3.3 Pollen Morphological Study

Pollen samples were obtained from collected specimens during field work, or herbarium specimens (Table 4). The pollen grains were prepared for light and

scanning electron microscopy using acetolysis method (Erdtman, 1966). For LM, the pollen grains were mounted on unstained glycerin jelly and seal with paraffin. For SEM studies, the pollen grains were suspended in a drop of absolute alcohol and directly transferred with a fine pipette to an aluminum stub using double-side cellophane tape. Pollen samples are sputter-coated with a gold-palladium, examine and then photographed on SEM (JSM-6010, JEOL, Japan), at the Center for Scientific and Technological Equipment, Suranaree University of Technology.

Acetolysis method (Erdtman, 1966)

(1) Separate anthers from plant specimens into glass tube. Add 10 ml of 10 % KOH and place in a boiling water bath 2 minutes, stir occasionally.

(2) Remove any anthers or other debris, filtrate the liquid through fine filter and the pollen is collected in 10 ml test tubes.

(3) Wash KOH from pollen with water. Centrifuge 1 minutes at 3000 rpm and collect the sediment. Repeat its 3 time.

(4) Add about 5 ml glacial acetic acid, centrifuge 1 minutes at 3000 rpm and decant off the acetic acid.

(5) Add about 5 ml of acetolysis mixture (acetic anhydride and conc. sulphuric acid in a ratio of 9:1), place the tube of pollen in hot water (70°C to 100°C.) 1 minute.

(6) Centrifuge the tube and decant off the waste acetolysis mixture. Wash with distilled water 2 time.

(7) Dehydrate the sediment with ethyl alcohol series (70% EtOH, 95%EtOH, 100%EtOH, respectively). Centrifuge the tube 1 minute and decant off the water. Transfer one half of this to vial for SEM study.

(8) Wash the pollen with benzene, centrifuge 1 minute and decant off the water. Transfer the sediment to vial, add silicon oil followed by 2-3 drops and incubate at 50°C.

(9) Place the pollen grains in silicon oil into glass slide, mount with a thin cover slip and seal with wax and examine under LM.

Table 4 List of analyzed species, with voucher and collection site.

Taxon	Voucher Specimens	Collection site
U. acaulis	W. Tokaew 921	Phetchabun
U. acuminata	W. Tokaew 917	Tak
U. campanulata	W. Tokaew 893	Phetchabun
U. crinita	W. Tokaew 905	Nakhon Phanom
U. lagopodioides	W. Tokaew 900	Mukdahan
U. picta	W. Tokaew & P. Chantaranothai 397	Sakon Nakhon
U. pseudoacuminata.	W. Tokaew 882	Bueng Kan
U. rufescens	W. Tokaew 865	Kanchanaburi

3.4 Leaf Anatomy and Leaf Micro-Morphological Study

Leaves of three *Christia* and 11 *Uraria* species (Tab. 5) were investigated by Paraffin methods (modified from Johansen, 1940). Fresh specimens from field work were cleaned and preserved in ethanol 70% for prepare permanent slides. The slides were examined under light microscopy (LM). For outer micromorphology of leaf, dry leaves from dry specimens in same collection number of previous study were examined under SEM.

3.4.1 Paraffin methods (modified from Johansen, 1940)

3.4.1.1 Leaf specimens are cut into small pieces measuring 1×1 cm^2. Fresh specimens are preserved in Ethanol 70% bottles. The air is suctioned using suction pump at 25 in Hg Vac for about 30 minutes.

3.4.1.2 Dehydrated with 1 to 5 grades of tertiary butyl alcohol (TBA) as shown in Table 6.

3.4.1.3 Infiltrated in mixture of equal parts of TBA and paraffin oil, and then left the specimens in the mixture for about 24 hour at room temperature. Replaced three to fourths of pure melted paraffin for 24 hour in each step, left in a constant temperature oven, with the temperature at 60 ^{o}C.

Table 5 List of analyzed species, with voucher and collection site.

Taxon	**Voucher Specimens**	**Collection site**
C. obcordata	W. Tokaew 864	Kanchanaburi
C. pierrei	W. Tokaew 841	Kanchanaburi
C. vespertilionis	W. Tokaew 897	Nakhon Ratchasima
U. acaulis	W. Tokaew 921	Phetchabun
U. acuminata	W. Tokaew 917	Tak
U. barbaticaulis	W. Tokaew 916	Tak
U. campanulata	W. Tokaew 893	Phetchabun
U. cordifolia (=*Uraiopsis cordifolia*)	W. Tanming 809	Chiang Mai
U. crinita	W. Tokaew 905	Nakhon Phanom
U. lagopodioides	W. Tokaew 900	Mukdahan
U. picta	W. Tokaew & P. Chantaranothai 397	Sakon Nakhon
U. pseudoacuminata	W. Tokaew 882	Bueng Kan
U. rotundata	W. Tokaew 904	Ratchaburi
U. rufescens	W. Tokaew 865	Kanchanaburi

Table 6 TBA grades used for dehydration

TBA grades	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

3.4.1.4 The melted paraffin is poured into the paper base mound which is kept warm on the hotplate. Then a specimen is taken from the vial and put into the base mold containing melted paraffin ensuring the specimens are upright. The wax is trimmed and then fixed to a wooden block. The wax blocks were then refrigerated for at least 30 minutes.

3.4.1.5 Specimens are cut into section on a sliding microtome at thickness of 15 µm to produce a ribbon of wax. The ribbon was cut and affixed to each slide with 0.1% gelatin in the water.

3.4.1.6 Prestained by dissolving the paraffin with xylene, transferring the slides to a mixture of equal parts absolute alcohol and xylene, absolute alcohol and ether, then remove to absolute alcohol, ethanol 95% and 70% for about 20 minutes in each.

3.4.1.7 Stained in 1% Safranin 12 hours and washed excess stain with distilled water several times.

3.4.1.8 Dehydrated with alcohol series (70%, 95% and 100%) and washed off excess stain using a mixture clove oil and absolute alcohol and xylene 2:1:1

3.4.1.9 Cleared slides in mixture of equal parts of absolute alcohol and xylene and pure xylene.

3.4.1.10 Mounted in DePeX mounting media.

3.4.2 SEM study

Leaf specimens are cut into small pieces measuring 1×1 cm. Then the leaves are affixed on aluminum stubs with double-sided cellophane tape. Samples are sputter-coated with a gold-palladium, examined and photographed on scanning electron microscopy (SEM) JSM-6010, JEOL, Japan, at the Center for Scientific and Technological Equipment, Suranaree University of Technology, Nakhon Rachasima province.

3.5 Phylogenetic Studies

3.5.1 Materials: Twenty-four samples of 14 species were examined (Tab. 7). Eighty-three sequences from seventy-two species were taken from GenBank (Tab. 8).

DNA preparation and amplification were undertaken at Walairukhavej Botanical Research Institute Mahasarakham University.

3.5.2 DNA extractions: Total DNA was extracted from 0.5 g dried samples (silica gel dry), using GF-1 plant DNA extraction kit, Vivantis and checked DNA levels on the 1% agarose gel.

3.5.3 Amplification of target DNA region and sequencing: Amplification employed gene nrDNA internal transcribed spacer (ITS) and further sequencing using external pair primers ITS1 (5'-TCC GTA GGT GAA CCTGCG G-3'), ITS4 (5'-TCC TCC GCT TAT TGA TAT GC-3') (White *et al*., 1990) Standard polymerase chain reaction (PCR) protocols were followed using 1–2 µl of total DNA. The thermal cycling was run on following the program comprised 35 cycles, 5 min predenaturation at 94ºC; 30–40 sec denaturation at 95ºC; 40 sec annealing at 63ºC; 80 sec extension at 73ºC; 5 min final extension at 72ºC and checked DNA levels on the 1% agarose gel. The PCR products were purified with using GF-AmbiClean kit, Vivantis, checked DNA levels on the 1% agarose gel and sequenced by Macrogen laboratory, Korea.

3.5.4. Sequence assembly, alignment and DNA analysis: Sequences were assembled and edited by using BioEdit version 7.2.5 and aligned by eyes and Mega 7 program.

3.5.5 Outgroup selection: Two species from tripe Phaseoleae (Leguminosae /Fabaceae); *Phaseolus vulgaris* L. and *Vigna radiata* (L.) R. Wilczek were utilized base on the analyzes of Jabbour *et al*. (2018) and *Polygala planellasi* and *Xanthophyllum hypoleucum* from family Polygalaceae (Fabales) were selected for outgroup of Leguminosae (Kajita *et al*., 2001).

3.5.6. Phylogenetic analysis: The DNA sequences were analyzed using Phylip version 3.1 software for phylogenetic analysis. The maximum likelihood dendrogram was generated, which provided more information on polymorphism. All characters were equally weight and gabs were scored as missing data. Starting trees were obtained using stepwise addition (1,000 replications). The following categories were used to describe levels of bootstrap support: weak = 50–74%; moderate = 75–84% and strong = 85–100% (Van Der Bank *et al*., 2002).

Table 7 List analyzed species, with voucher and collection site.

Taxon	Voucher Specimens	Collection site
C. obcordata	W. Tokaew 864	Kanchanaburi
	W. Tokaew 902	Khon Kaen
C. pierrei	W. Tokaew 841	Kanchanaburi
	W. Tokaew 922	Phetchabun
C. vespertilionis	W. Tokaew 897	Nakhon Ratchasima
	W. Tokaew 913	Ratchaburi
U. acaulis	W. Tokaew 921	Phetchabun
U. acuminata	W. Tokaew 917	Tak
U. barbaticaulis	W. Tokaew 916	Tak
U. campanulata	W. Tokaew 893	Phetchabun
	W. Tokaew 931	Phetchabun
U. cordifolia (=*Ur. cordifolia*)	W. Tanming 809	Chiang Mai
U. crinita	W. Tokaew 887	Sakon Nakhon
	W. Tokaew 903	Bueng Kan
	W. Tokaew 924	Ratchaburi
	W. Tokaew 906	Maha Sarakham
U. lagopodioides	W. Tokaew 884	Sukkhothai
	W. Tokaew 900	Mukdahan
U. picta	W. Tokaew & P. Chantaranothai 397	Sakon Nakhon
U. pseudoacuminata	W. Tokaew 882	Bueng Kan
U. rotundata	W. Tokaew 904	Ratchaburi
	W. Tokaew 909	Khon Kaen
U. rufescens	W. Tokaew 865	Kanchanaburi
	W. Tokaew 901	Mukdahan

Table 8 List of added taxa from GenBank, with the accession number.

Taxon	Accession Number
Akschindlium godefroyanum	KY702699.1
Alysicarpus bupleurifolius	KY702666.1
A. ovalifolius	KY702667.1
A. vaginalis	MF063693.1
Aphyllodium biarticulatum	KY702700.1
Arthroclianthus andersonii	KY702660.1
Ar. angustifolius	KY702661.1
Ar. balansae	KY702701.1
Ar. cuneatus	KY702662.1
Ar. deplanchei	KY702663.1
Ar. leratii	KY702664.1
Ar. macrobotryosus	KY702703.1
Ar. maximus	KY702665.1
Ar. obovatus	KY702704.1
Ar. sanguineus	KY702702.1
Campylotropis bonii	KY702688.1
Ca. delavayi	KY702689.1
Ca. macrocarpa	KY702690.1
Ca. polyantha	KY702691.1
Ca. sargentiana	KY702692.1
C. convallaria	KY702668.1
C. obcordata	KY702669.1
C. vespertilionis	KY702670.1
Codariocalyx gyroides	KY702671.1
Dendrolobium lanceolatum	AF467044.1, KY702705.1
D. triangulare	KY702706.1
D. adscendens	Y702672.1
D. gangeticum	GQ413941.1

Table 8 List of added taxa from GenBank, with the accession number (cont.).

Taxon	Accession Number
D. heterocarpon	GQ413942.1, KY702673.1
D. heterophyllum	KY702674.1
D. intortum	KKY702675.1
D. renifolium	GQ413946.1
D. styracifolium	FJ980290.1, JN407463.1
D. triflorum	GQ413949.1
D. velutinum	KY702676.1
Droogmansia montana	KY702707.1
Dr. pteropus	KY702708.1
Fordia cauliflora	KY702696.1
Hanslia ormocarpoides	KY702709.1
Hegnera obcordata	KY702677.1
Hylodesmum oldhamii	KY702678.1
H. podocarpum	KY702679.1
H. repandum	KY702680.1
Kummerowia striata	KY702693.1
Leptodesmia congesta	KY702681.1
Lespedeza homoloba	KY174695.1
L. juncea	KY702694.1
L. simulata	KY702695.1
Mecopus nidulans	KY702682.1
Melliniella micrantha	KY702683.1
Muellera monilis	KY702697.1
Nephrodesmus ferrugineus	KY702711.1
N. francii	KY702710.1
N. parvifolius	KY702698.1
N. sericeus	KY702712.1

Table 8 List of added taxa from GenBank, with the accession number (cont.).

Taxon	Accession Number
Ohwia caudata	KY702713.1
Ougeinia dalbergioides	KY702714.1, KY702715.1
Phaseolus vulgaris	GQ411837.1
Phyllodium elegans	KP092739.1, KY702716.1
P. longipes	KY702717.1
P. pulchellum	KY702718.1
Polygala planellasi	GQ889000.1
Pseudarthria hookeri	KY702684.1
Tadehagi triquetrum	JN407467.1, KY702719.1
U. crinita	JN189714.1, JN407473.1, JN407474.1, JN407475.1, KY702685.1
U. lagopodioides	JF970604.1, KY702686.1
U. picta	KJ950362.1, JF769488.1, KJ950361.1
U. rufescens	KY702687.1
Vigna radiata	JF430409.1
Xanthophyllum hypoleucum	GQ889054.1

CHAPTER 4

RESULTS

4.1 Morphology and Taxonomy

Fifteen species of genus *Uraria*, including two species from related genus (*Urariopsis*) and three species, four taxa of genus *Christia* are recognized. Three species of *Uraria* are firstly recorded for the country and *U. pierrei* is reduced to synonymy of *U. rotundata*. The taxonomic treatment and morphological characteristics of the genus and species are describes as follow:

Key to the genera

1. Pods with membranous hyaline calyx ……..…… 4.1.1 **Christia**

1. Pods with fleshy calyx or not developed ….. 4.1.2 **Uraria** (included **Urariopsis**)

4.1.1 Genus *Christia* in Thailand

Christia Mornch

Christia Moench, Suppl. Meth. (Moench) 2: 39. 1802.— *Lourea* Neck. ex Desv., J. Bot. 1: 122. 1813. **Type species:** *Christia lunata* Moench (=*Christia vespertilionis* (L.f.) Bakh.f. ex Meeuwen).

Herbs or subshrubs. *Leaves* alternate, odd-pinnate, 3-foliolate; leaflets opposite, stipellate; stipules free, acuminata, persistent. *Inflorescences* terminal, racemose or paniculate, with lax flowers. *Flowers* pinkish or purplish; pedicels curve upward or curve downward after anthesis; bracts ovate or lanceolate, acuminata, caducous. *Calyx* 5-lobed; lobes subulate-acuminata, spreading; two upper ones shorter; three lower ones becoming by resupination, brownish green, pinkish green or green. *Corolla* 5, papilionaceous; standard petal orbicular or obovate, clawed and

auriculate at base; wing petals falcate-oblong, adhering to keel, clawed; keel petals slightly incurved, obtuse, clawed. *Stamens* diadelphous; anthers uniform. *Ovary* sessile or shortly stipitate, with 3–5 ovules; style filiform, inflexed above; stigma terminal, capitate. *Pods* subsessile, compressed, divided transversely into rounded segments, each folded over the other, enclosed in the persistent dry-membranous calyx. *Seeds* reniform.

Key to the species

About 6 species: tropical Asia and Australia; three species (four taxa) in Thailand.

1. Pods (2–) 3–4 articles, peduncle 5–6 mm equal to calyx tube ..... **2. C. pierrei**
1. Pods 4–5 articles, peduncle about 3–3.5 mm shorter than calyx tube ..... 2.
2. Trailing or climbing, terminal leaflet more than 3 mm wide ... **3. C. vespertilionis**
3. Prostrate, terminal leaflet less than 2.5 mm wide ..... **1. C. obcordata**

1. **Christia obcordata** (Poir.) Bakh.f. ex Meeuwen, Reinwardtia 6: 91. 1961.— *Hedysarum obcordatum* Poir., Encycl. [J. Lamarck *et al.*]: 6. 425. 1804.— *Lourea obcordata* (Poir.) Desv., J. Bot. Agric. 1(2): 122. 1813. Type: Commerson *s.n.*, Java (holotype P!-JU).— *Hedysarum reniforme* (*non* L.) Lour. Fl. Cochinch.: 447. 1790. Type: *J. de Loureiro* 5451, (holotype P!). (Figs. 5 & 9A)

Prostate and branched herb, 20–80 cm long. *Leaves* (1–) 3-foliolate; petioles (0.5–) 1–1.5 (–2) cm long; stipules deltoid or lanceolate, acuminata, 2.5–5 by 1–1.5 mm. *Leaflets* thinly chartaceous, dark green; terminal leaflets obtriangular or slightly trapezoid rarely obovate or elliptic, (0.5–) 1–2 (–2.5) by (0.5–) 1–1.8 (–2.5) cm, base obtuse; apex obtuse, truncate or mucronate; margin entire; lateral leaflets elliptic, ovate or broadly ovate rarely obovate or orbicular, (0.5–) 1–1.5 (–2) by (0.4–) 1–1.5 cm; base obtuse; apex obtuse or truncate; margin entire; upper surface glabrous or grabrate; lower surface slightly scabrous; petiolules 0.6–1.2 mm long; stipels narrowly lanceolate, acuminata, (0.5–) 1–2 mm long. *Inflorescences* racemose rarely paniculate, terminal, erect, 5–15 (–20) cm long, rachis pilose. *Flowers* lax; bracts pale green, broadly ovate to ovate, acuminata, 2–2.5 mm by 1–1.5 mm; pedicels 2.5–3 mm long, up to 3–3.5 mm at maturity; pilose, curved downward, pendulous after anthesis.

Calyx pale green or pale brown, pilose; tube 1.3–1.5 mm long; lobes 1.8–2 mm long. *Corolla* purple; standard 4–5 by ca. 3.5–4 mm; wings 2.3–2.4 by 1.5 mm, claw 0.5–0.6 mm long; keel 2–2.2 by 0.7 mm, claw *ca.* 2 mm long. *Ovary* with 3, 4 or 5 ovules. *Pods* with 3–5 segments; segment orbicular, 2–2.2 by 1.6–2 mm, cream, glabrous; calyx pale brown, pale green or cream; tube 3–4 mm long; lobes 3–3.5 mm long. *Seeds* reniform, 1.5–1.7 by 1.2–1.3 mm, brown or reddish brown.

Thailand. — NORTHERN: Chiang Mai, Lamphun, Tak; NORTH-EASTERN: Loei, Khon Kaen; EASTERN: Nakhon Ratchasima; SOUTH-WESTERN: Kanchanaburi.

Distribution. — India, China, Taiwan, Laos, Vietnam, Cambodia, Malaysia, Philippines, Indonesia.

Ecology. — In mixed deciduous forest, dry dipterocarp forest, degrade dipterocarp-oak forest, open area, road side and grassy field, alt. 50-600 m. Flowering and fruiting May-January.

Vernacular. — Ya Phisuea noi (หญ้าผีเสื้อน้อย) (Khon Kaen).

Specimens examined. — *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 3995 (BKF); *C. Charoenphol, K. Larsen & E. Warncke* 4905 (AAU, BKF); *A.F.G. Kerr* 1360 (E), 10161 (AAU), 13452 (AAU, BK, E); *Y. Kittibanyangam* 90 (CMUB); *A. Marcan* 2244 (AAU, E); *J.F. Maxwell* 94-1161 (BKF, CMUB), 01-282 (BKF, CMUB), 04-305 (CMUB), 08-167 (CMUB, QBG); *I.C. Nielsen, R. Pooma, N. Koonkhunyhod & M. Poopath* 1775 (AAU); *P. Phraisurind* 2068 (AAU); 10161 (BK); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham* T-21327 (BKF), T-21341 (BKF), T-21398 (BKF); *T. Smitinand* 4524 (AAU, BKF); *Th. Sørensen, K. Larsen & B. Hansen* 2493 (E); *W. Tanming* 631 (QBG); *W. Tokaew* 841 (KKU), 864 (KKU), 912 (KKU); *W. Tokaew & P. Chantaranothai* 451 (KKU), 452 (KKU); *S. Watthana, P. Suksathan & G. Argent* 622 (QBG); *S.N.* 47 (BKF).

2. Christia pierrei (Schindl.) H.Ohashi, J. Fac. Sci. Univ. Tokyo, Bot. 11(1-2): 56. 1971.— *Lourea pierrei* Schindl. in Engl., Bot. Jahrb. 54: 62. 1916. Type: Cochinchina; *Pierre* 5815 (9.1865), (lectotype P!).— *Lourea translucida* Schindl. in

Engl., Bot. Jahrb., 54: 62. 1916 «translucica». Type: Vietnam; *C.B. Robinson* 1271 (holotype P!). (Figs. 6, 9B)

Branched herb, trailing or climbing, 20–40 cm high. *Leaves* 1–3-foliolate; petioles (1–) 1.5–2 cm long; stipules deltoid or lanceolate, acuminata, 2–5 by 0.5–1 mm. *Leaflets* thinly chartaceous, green, dark purple, reddish brown or green with dark purple band; terminal leaflets obtriangular or slightly trapezoid rarely half-orbicular or trapezoid, (1–) 2–2.6 by (1.5–) 2–3 (–4) cm, base obtuse, sometime cordate; apex truncate, obcordate or mucronate; margin entire; lateral leaflets obovate, slightly orbicular, cup-shape or trapezoid, 1–1.7 (–2) by 0.8–1.5 cm; base obtuse, truncate, sometime cordate; apex truncate or obtuse, rarely cordate; margin entire; upper surface glabrous or grabrate; lower surface slightly scabrous; petiolules 1–2 (–2.5) mm long; stipels narrowly lanceolate, acuminata, (0.5–) 1–3 mm long. *Inflorescences* paniculate, sometime racemose, terminal or lateral, erect, 10–20 cm long, rachis pubescent. *Flowers* lax; bracts pale green, broadly ovate to ovate, acuminata, 1.5–3 mm by 1–1.5 mm; pedicels 4–5 mm long, up to 5–6 mm at maturity; pubescent, straight, sometime point down after anthesis. *Calyx* pale green, pubescent; tube (1.3–) 1.5–2 mm long; lobes (1.5–) 2–2.5 mm long. *Corolla* purple; standard 2.5–3 by 2–2.5 mm; wings 3–3.5 by 1.7–2 mm, claw *ca.* 0.5 mm long; keel 2.5–3 by 1.3–1.5 mm, claw *ca.* 2 mm long. *Ovary* with 3 or 4 ovules. *Pods* with (2–) 3 or 4 segments; segment orbicular, 2.2–2.5 by 1.8–2.2 mm, cream, glabrous; calyx pale green, pale brown or cream; tube 4–5 mm long; lobes 3–4 mm long. *Seeds* reniform, 2–2.2 by 1.5–1.7 mm, reddish brown or brown.

Thailand. — NORTHERN: Chiang Mai; NORTH-EASTERN: Phetchabun, Loei; EASTERN: Nakhon Ratchasima; SOUTH-WESTERN: Kanchanaburi, Prachuap Khiri Khan; CENTRAL: Saraburi.

Distribution. — Vietnam, Cambodia, Indonesia.

Ecology. — In evergreen forest, dry evergreen forest, dry dipterocarp forest and dry deciduous forest in limestone hill, open area, alt. 50-600 m. Flowering and Fruiting July-December.

Vernacular. — Ya Kon Bueng (หญ้ากันบึ้ง) (Loei); Hang Nok Ling (หางนกลิง) (Kanchanaburi).

Specimens examined. — *Adisai* 929 (BK); *N. Aggimarangsee* 15 (CMUB); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 3877 (BKF); *D. Bunpheng* 951 (BKF); *C. Chermsiriwathana* 92 (BK); *A.F.G. Kerr* 11087 (BK); *H. Koyama, H. Terao, C. Niyomdham & T. Wongprasert* T-30345(BKF) *C. Lakoet* 219 (QBG); *K. Larsen & S.S. Larsen* 33714 (AAU); *J.F. Maxwell* 97-319 (BKF); *C. Phengklai* 578 (BKF), 12555 (BKF); *K. Piseth* 32 (CMUB); *R. Pooma, C.C. Berg, & M. Poopath* 5712 (BKF); *R. Pooma, N. Pattharahirantricin, P. Thumcharoen & R. Meeboonya* 7397 (AAU, BKF, E); *T. Santisuk 543* (BKF); *T. Shimizu, F. Konta, T. Smitinand, T. Wongprasert & B. Sangkhachand* T-28459 (BKF); *T. Smitinand & H. Sleumer* 1360 (BKF, K); *S. Sutheesorn* 2675 (BK); *W. Tanming* 617 (QBG); *W. Tokaew* 859 (KKU), 863 (KKU); 922 (KKU), 926 (KKU); *S. Vijaranayarn* s.n. (BKF); *S.N.* 1874 (BK).

3. Christia vespertilionis (L.f.) Bakh.f. ex Meeuwen, Reinwardtia 6: 90. 1961.— *Hedysarum vespertilionis* L.f., Suppl. Pl.: 331. 1781.— *Lourea vespertilionis* (L.f.) Desv., J. Bot. Agric. 1(2): 122. 1813. Type: India; Loureiro *s.n.* (holotype BM!).— *Christia lunata* Moench, Suppl. Meth. (Moench) 2: 40. 1802.

Key to the variety

1. Terminal leaflet 1–2 mm long, pods grabrate with hooked hairs, peduncle curved up after anthesis ……..….. **3.1 var. vespertilionis**
1. Terminal leaflet 2–4 mm long, pods glabrous, peduncle straight sometime point down after anthesis ……..... **3.2 var. grandifolia**

3.1 var. **vespertilionis** (Figs 3, 7 & 9C)

Branched herbs, trailing or climbing, 20–80 cm long. *Leaves* (1–) 3-foliolate; petioles (0.5–) 1–2 cm long; stipules deltoid or lanceolate, acuminate, 2–3 by 0.8–1 mm. *Leaflets* thinly chartaceous, green; terminal leaflets obtriangular, wide obtriangular or V-shape to linear-shape, (0.5–) 1–2 by (3–) 4–6 (–7.5) cm, base

obtuse, sometime truncate; apex truncate, emaginate or mucronate; margin entire; lateral leaflets obtriangular or slightly right triangular, (0.5–) 1–1.5 (–2) by (0.5–) 1–1.5 cm; base obtuse; apex truncate or emaginate; margin entire; upper surface glabrous or grabrate; lower surface grabrate or slightly scabrous; petiolules 1–1.5 mm long; stipels narrowly lanceolate, acuminate, 0.5–1 (–2) mm long. *Inflorescences* racemose or paniculate, terminal and lateral, erect, (5–) 10–20 cm long, rachis pubescent. *Flowers* lax; bracts pale green, broadly ovate to ovate, acuminate, caudate, 1.5–3 mm by 1–1.5 mm; pedicels 1.8–2 mm. long, up to 2–2.5 (–3) mm at maturity; pubescent, curved upward after anthesis. *Calyx* pale green, pilose; tube 1.8–2 mm long; lobes 2.5–3 mm long. *Corolla* purple; standard 4.5–5 by 2.5–3 mm long; wings 2.5–2.8 by 1–1.3 mm, claw 0.8–1 mm long; keel 2.5–2.8 by 1.2 mm, claw *ca.* 2.5 mm long. *Ovary* with 4–5 ovules. *Pods* with 3–5 segments; segment orbicular, 2.5–3 by 2–2.5 mm, cream, grey or black, grabrate with hooked hairs; calyx pale green or cream; tube 4–4.5 mm long; lobes 3.5–4 mm long. *Seeds* reniform, 1.2–1.5 by 0.8–1.2 mm, dark yellow, reddish brown or brown.

Thailand. — NORTHERN: Tak; NORTH-EASTERN: Phetchabun, Loei, Khon Kaen; EASTERN: Chaiyaphum, Nakhon Ratchasima, Buri Ram; SOUTH-WESTERN: Uthai Thani, Kanchanaburi, Rachaburi, Phetchaburi, Prachuap Khiri Khan; CENTRAL: Saraburi; SOUTH-EASTERN: Chachoengsao, Chon Buri; PENINSULAR: Surat Thani, Nakhon Si Thammarat.

Distribution. — India (type), China, Vietnam, Cambodia, Malaysia, Indonesia.

Ecology. — In evergreen forest, mixed deciduous forest, dry dipterocarp forest, limestone hill, open or disturbed area, alt. 0-700 m. Flowering and Fruiting August-February.

Vernacular. — Phi Suea (ผีเสื้อ) (Tak, Nakhon Ratchasima, Prachuap Khiri Khan, Chachoengsao, Chonburi, Nakhon Si Thammarat); Bik Khang Khao (ปีกค้างคาว) (Nakhon Ratchasima, Chachoengsao, Chonburi); Khiw Nang (คิ้วนาง) (Prachuap Khiri Khan); Bik Nok Nang Aen (ปีกนกนางแอ่น) (Chachoengsao).

Specimens examined. — *B.S.* 1079 (BKF); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 4019 (BKF); *C.F. van Beusekom, R. Geesink, B. Wongwan*

& C. Phengklai 3877 (K); *H.M. Burkill* 1232 (BKF, K); *K. Chayamarit, L. Phuphathanaphong, R. Pooma, S. Suddee & K. Phattarahirakanok* 3090 (BKF); *S. Chersavat* 001 (PBM); *D.J. Collins* 49 (E); *R. Geesink, P. Hiepko & C. Phengklai* 7744 (BKF, K); *W. Jarutherachon* 001 (PBM); *A.F.G. Kerr* 9319 (E), 11051 (AAU, BK), 12627 (AAU, E); *K. Larsen, T. Smitinand, & E. Warncke* 1334 (AAU); *A Marcan* 2218 (AAU, E, K), 2452 (AAU, E, K); *J.F. Maxwell* 72-592 (AAU, BK), 73-698 (AAU, BK), 03-480 (CMUB); 93-176 (BKF, CMUB), 04-621 (BKF, CMUB), *D.J. Middleton, R. Namdang, R. Pooma, S. Suddee, S. Suwanachat & K. Williams* 2518 (BKF); *S. Mitprasertporn* 001 (PBM); *G. Murata, C. Phenkhlai, S. Misuta, T. Yahara, H. Nagamasu & N. Nantasan* T-43072 (BKF); *W. Nanakorn et al.* 1680 (QBG); *C. Niyomdham* 4502 (BKF); *M. Norsaengsri* 2848 (QBG); *C. Phengklai & T. Smitinand* 6142 (BKF); *S. Phengnaren* 118 (BKF); *P. Phraisurind* 2441 (BK, E, K); *S. Phusomsaeng* 611 (BK); *R. Pooma, C.C. Berg & M. Poopath* 5712 (E); *R. Pooma, K. Phattarahirankanok, S. Sirimongkol & M. Poopath* 6112 (BKF, E); *D. Praphat* 370 (BKF); *P. Puudjaa* 772 (BKF); *R.F.D.* 746 6 (K); *J. Rachiengsaen* 001 (PBM); 9319 (BK); *T. Smitinand* 12192 (BKF), 4525 (BKF); *S. Sutheesorn* 3169 (BK); *P. Suvarnakoset* 178 (BKF); *S. Thawon* 489 (BKF), s.n. (BKF); *W. Tokaew* 896 (KKU), 913 (KKU), 925 (KKU), 932 (KKU); *TS & OP* 8817 (BKF), 8849 (BKF); *Vacharee & Santi* 80 (BK); *S.N.* 261 (BKF); *S.N.* (PBM 04277) (PBM); *S.N.* (PBM 04278) (PBM).

3.2 var. **grandifolia** Dy Phon in Thuân, Dy Phon & Niyomdham, Fl. Cambodge, Laos & Vietnam 23: 124. 1987; P.H. Hô, Ill. Fl. Vietnam 1(2): 1177, f. 3352. 1991. Type: Vietnam, Thuan Hai; *Ervard* 2454 (holotype P!). (Figs 4, 8 & 9D)

Branched herbs, trailing or climbing. *Leaves* (1–) 3-foliolate; petioles (2–) 3–4 cm long; stipules deltoid or lanceolate, acuminate, 3–6 by 0.8–1 mm. *Leaflets* thinly chartaceous, green or green with pinkish brown strip; terminal leaflets obtriangular, wide obtriangular, trapezoid or cup shape, (2–) 3–4 by 3–5 (–6) cm, base obtuse, acute or truncate, sometime cordate; apex truncate or slightly cordate; margin entire; lateral leaflets obtriangular or trapezoid, 2.5–3 by (2.5–) 3–4 cm; base acute or obtuse; apex truncate; margin entire; upper surface glabrous or grabrate; lower surface

grabrate or slightly scabrous; petiolules 1.5–2 mm long; stipels narrowly lanceolate, acuminate, 1–2 mm long. *Inflorescences* terminal, paniculate, erect, 5–10 cm long, rachis pubescent. *Flowers* lax; pedicels 2.5–3 mm. long, up to 3 (–3.5) mm at maturity; pubescent, straight, sometime point down after anthesis. *Calyx* pale green, glabrous. *Corolla* purple. *Ovary* with 4 or 5 ovules. *Pods* with (3–) 4–5 segments; segment orbicular, 2.5–3 by 2.5–3 mm, cream or pale brown, glabrous; calyx light green or cream; tube 3–4 mm long; lobes 3–4 mm long. *Seeds* reniform, 2–2.2 by 1.8–2 mm, dark yellow or brown.

Thailand. — SOUTH-WESTERN: Kanchanaburi; CENTRAL: Saraburi, Bangkok.

Distribution. — Vietnam (type).

Ecology. — In dry limestone hill or deciduous forest with bamboo in limestone hill, alt. 100-400 m. Flowering and Fruiting August-December.

Vernacular. — Phi Suea (**ผีเสื้อ**) (Bangkok).

Specimens examined. — *S. Chongko* 586 (CMUB); *Kasam* 649 (BK); *A.F.G. Kerr*16097 (BK); *J.F. Maxwell* 05-727 (CMUB); *R. Pooma, C.C. Berg, & M. Poopath* 5712 (BKF, E); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & T. Santisuk* T-17940 (BKF), T-17997 (BKF).

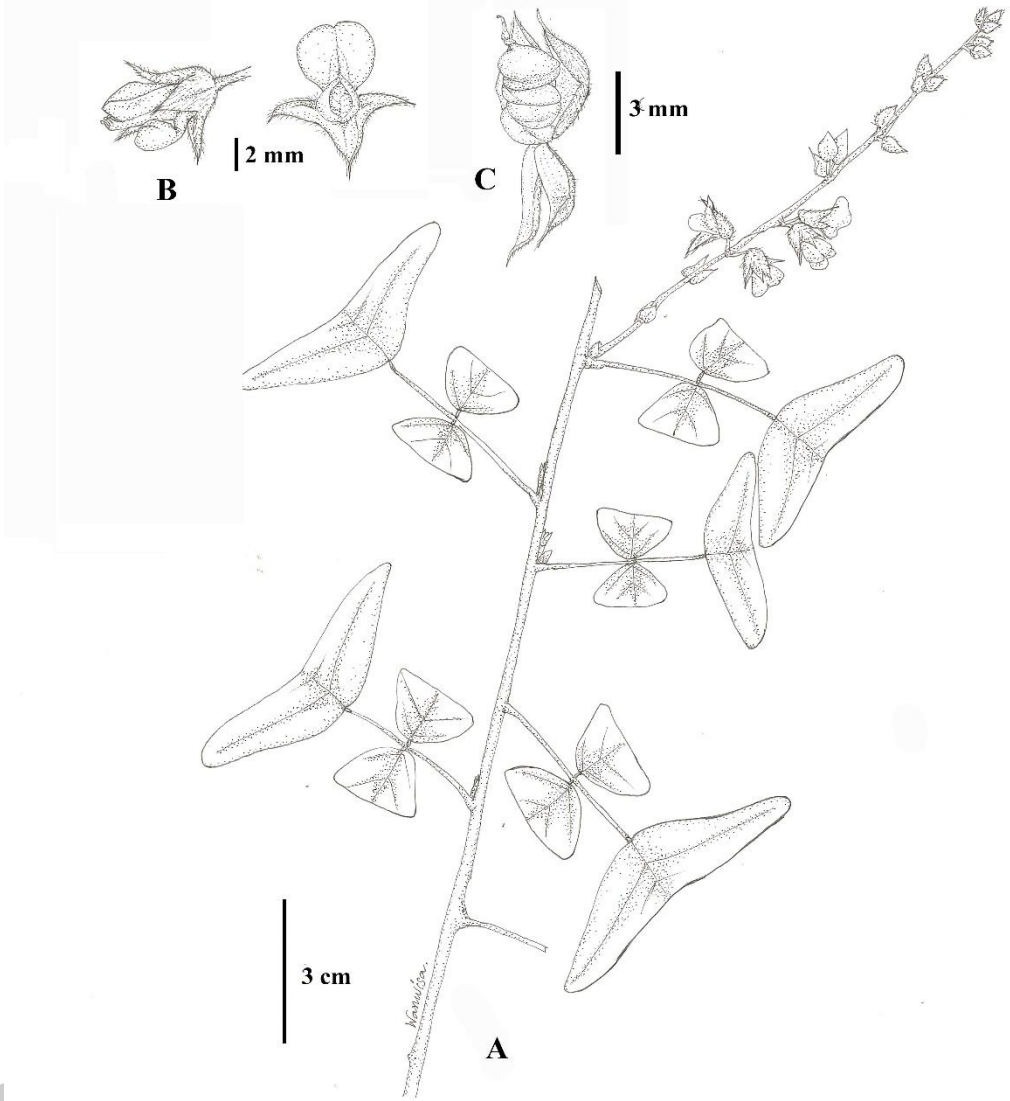

Figure 3 Drawing of *Christia vespertilionis* var. *vespertilionis:* **A**. habit; **B**. flower; **C**. fruit.

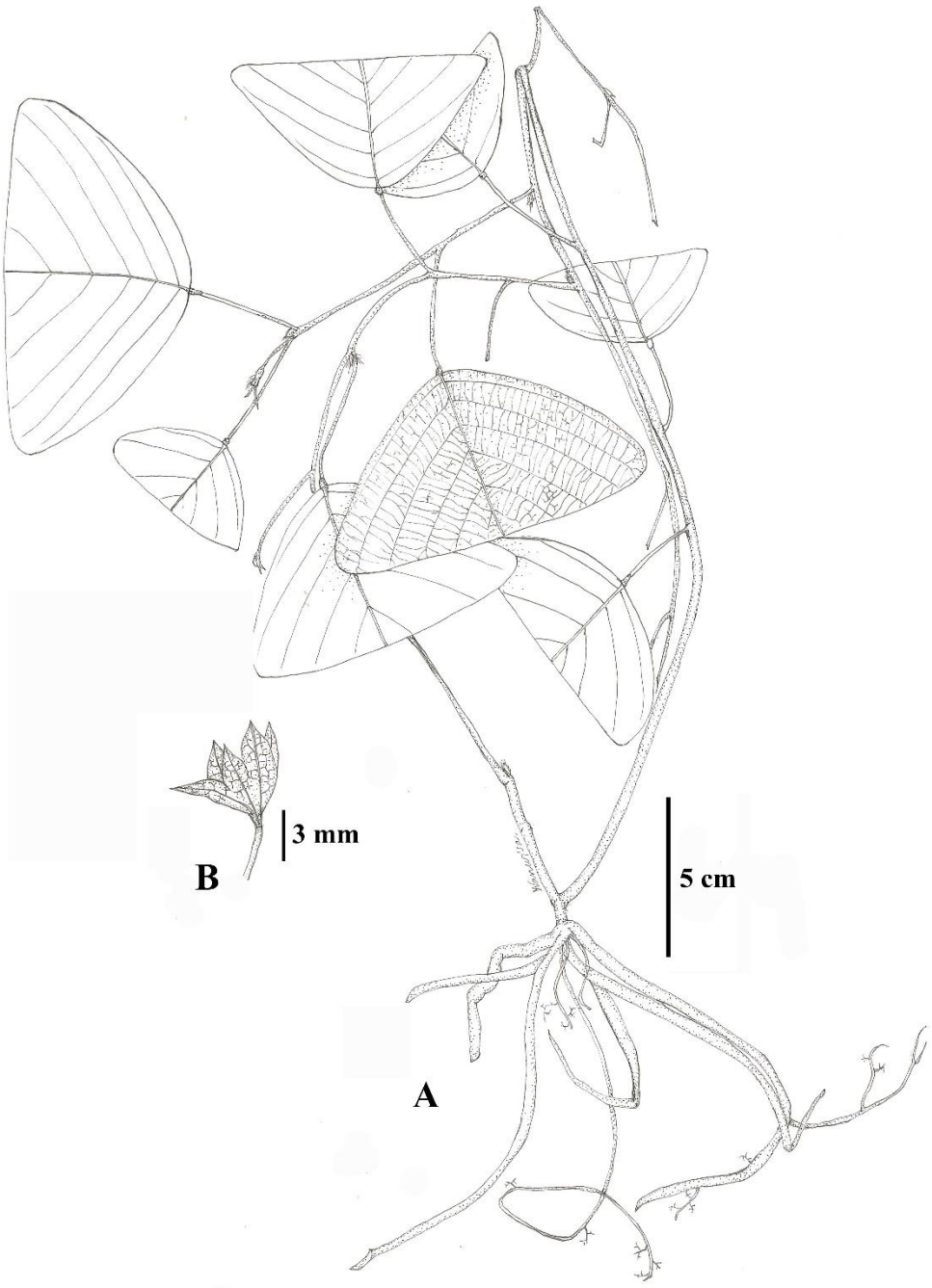

Figure 4 Drawing of *Christia vespertilionis* var. *grandifolia:*
A. habit; **B**. calyx of fruit.

Figure 5 *Christia obcordata*: **A**.-**B**. habit; **C**. flowers; **D**. fruits

Figure 6 *Christia pierrei*: **A**.-**B** habit; **C**.-**D** leave; **E**. flowers and fruits

Figure 7 *Christia vespertilionis* var. *vespertilionis*:

A. habit; **B**. leaves; **C**. inflorescence; **D**. Fruits

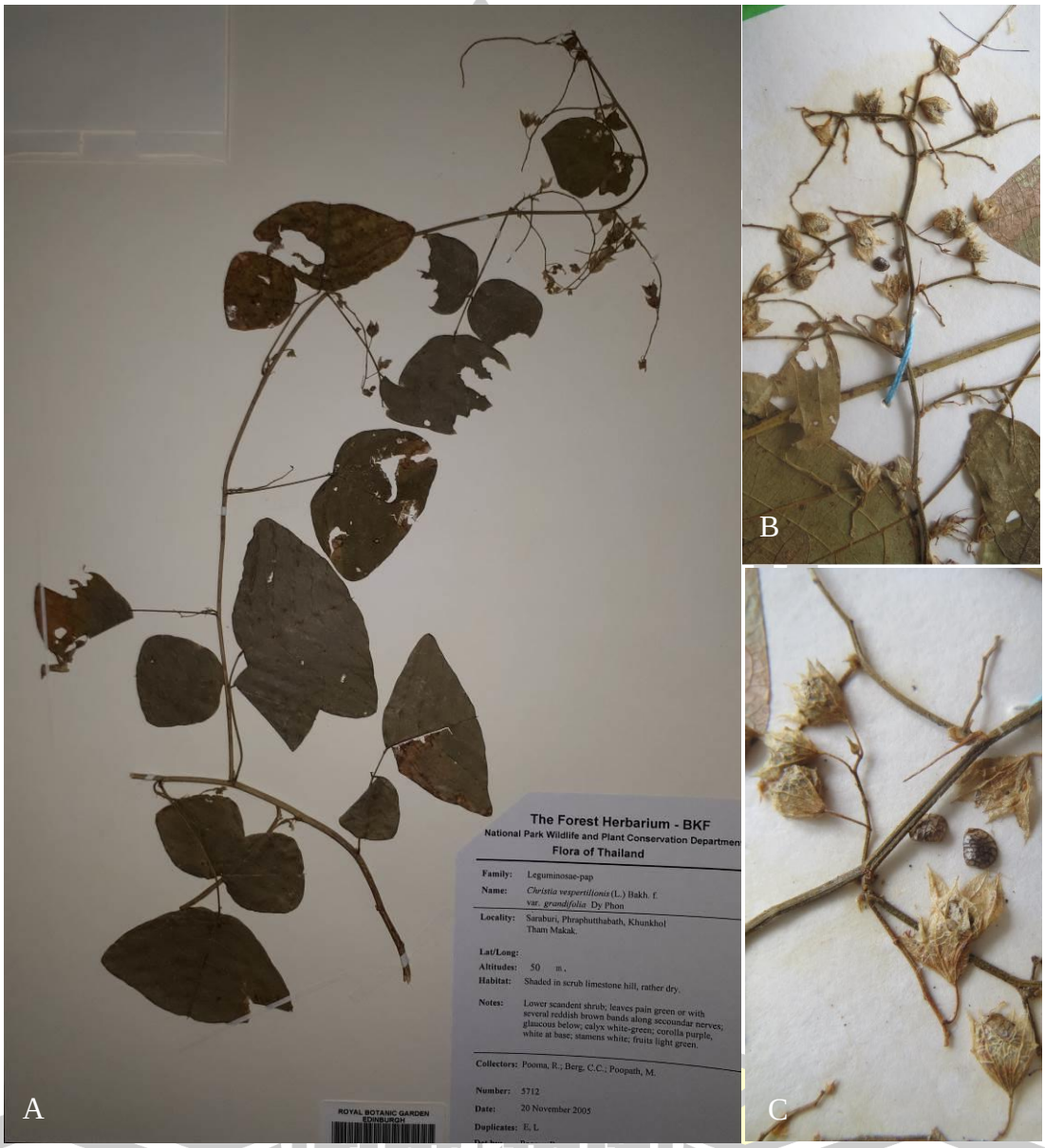

Figure 8 *Christia vespertilionis* var. *grandifolia:*

A. habit; **B**. inflorescence and fruits; **C**. fruits

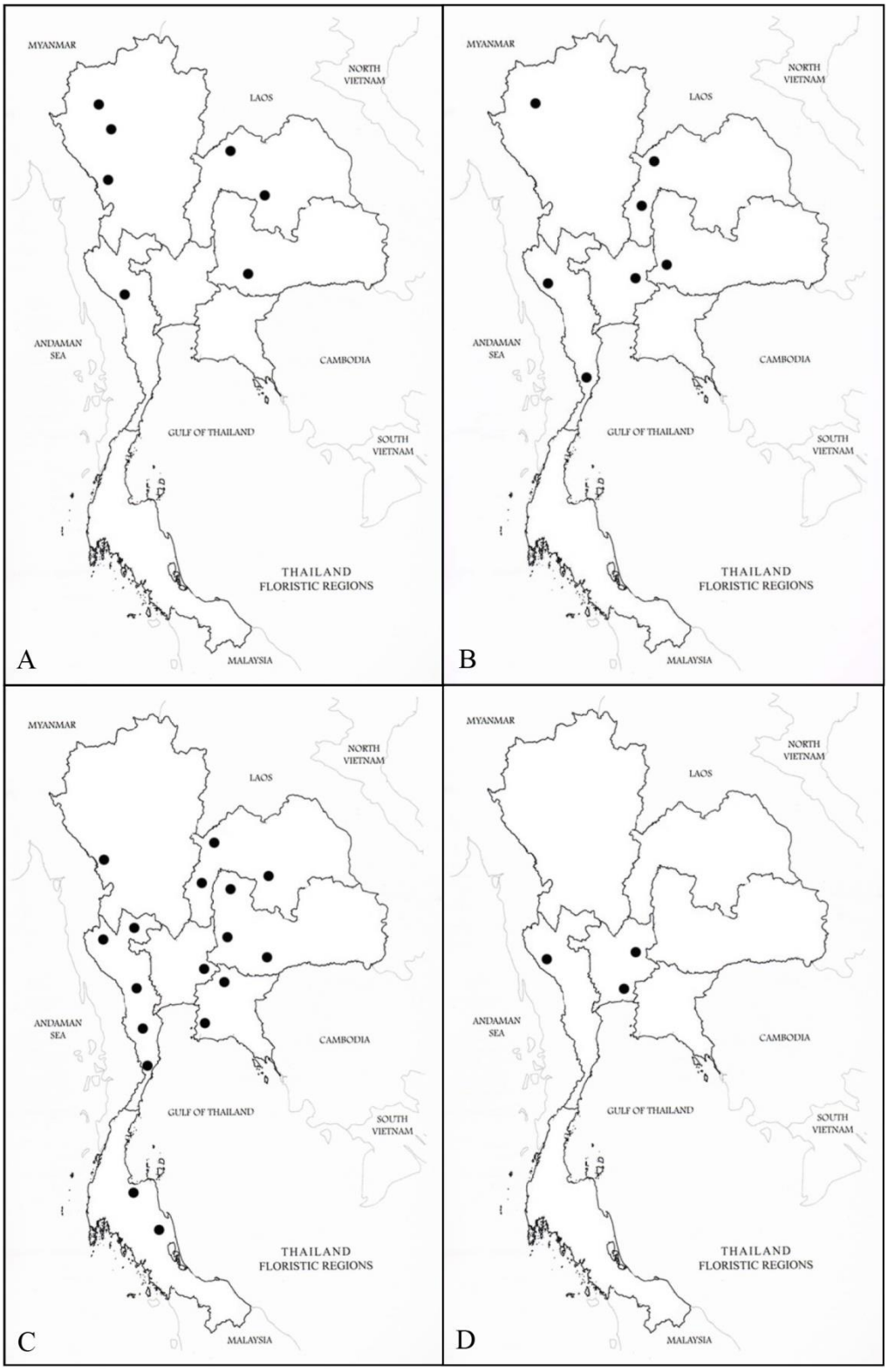

Figure 9 Distribution of *Christia* spp. in Thailand*:*

A. *C. obcordata*; **B.** *C. pierrei*; **C.** *C. vespertilionis* var. *vespertilionis*;

D. *C. vespertilionis* var. *grandifolia*

4.1.2 Genus *Uraria* in Thailand

Uraria Desvaux

Uraria Desv., J. Bot. 1: 122. 1813. — *Doodia* Roxb., [Hort. Beng.: 98. 1814, *nom. nud*.] Fl. Ind. 3: 365. 1832, *non* R. Br., 1810.— *Urariopsis* Schindl. in Engl., Bot. Jahrb. Syst. 54: 51. 1916. Type species: *Uraria picta* (Jacq.) Desv. ex DC.

Perennial herbs or shrubs. *Leaves* alternate, odd-pinnate, 3–7 (–11)-foliolate or all 1-foliolate; leaflets opposite, stipellate; stipules free, acuminata, striate at base, persistent. *Inflorescences* terminal and/or axillary, elongated or spike-like racemes or panicles, with lax or dense flowers. *Flowers* pinkish or purplish; pedicels becoming hooked distally; bracts ovate or lanceolate, acuminata, caducous. *Calyx* 5-lobed; lobes subulate-acuminata, spreading; two upper ones shorter, rarely entirely connate; three lower ones becoming by resupination, brownish green, pinkish green or green. *Corolla* 5, papilionaceous; standard petal orbicular or obovate, clawed and auriculate at base; wing petals falcate-oblong, adhering to keel, clawed; keel petals slightly incurved, obtuse, clawed. *Stamens* diadelphous; anthers uniform. *Ovary* sessile or shortly stipitate, with 1–10 ovules; style filiform, inflexed above; stigma terminal, capitate. *Pods* subsessile, articulate, compressed, divided transversely into rounded segments, each folded over the other and becoming coiled into a flat circle, sometimes enclosed in the persistent calyx or rarely deeply indented along both sutures into heart-shaped segments (in *U. cordifolia*). *Seeds* usually reniform, rarely globose or heart-shaped.

Key to the species

1. Leaves with 1-foliolate; leaflets cordate to orbiculate ……..……..…… 2
1. Leaves (1–) 3–9 (– 11)-foliolate; leaflets elliptic, ovate, obovate, lanceolate, oblong or linear, rarely cordate ……..……..…… 3
2. Inflorescence racemose; ovary with 1 (–2) ovule/s ……..…… **1. U. acaulis**
2. Inflorescence paniculate or racemose; ovary with 3–6 ovules ……..…….. 4
3. Inflorescence racemose; flowers dense ……..……..…… 5

3. Inflorescence paniculate or racemose; flowers lax …..……..…..……. 6

4. Pods with 3–6 segments, with hooked hairs ..... **4. U. barbaticaulis**

4. Pods with 3–4 segments, with straight hairs .....…….. 7

5. Stems prostrate, if erect 10–30 cm high; leaves 1–3-foliolate ……....…..……. 8

5. Stems erect, 15–200 cm high; leaves 3–9 (–11)-foliolate …….…….…..... 9

6. Leaflets obovate, sometime ovate; pods with bulbous base straight hairs 13

6. Leaflets ovate, elliptic or broadly elliptic; pods with hooked hairs ……..... 14

7. Inflorescence less than 17 cm long**;** calyx tube ca. 1 mm long ……
…….. **6. U. cochinchinensis**

7. Inflorescence more than 17 cm long; calyx tube ca. 1.5 mm long **.7. U. cordifolia**

8. Leaflets orbicular, cordate, elliptic, ovate, narrowly ovate, or rhomboid, apex caudate ……..……..…… **10. U. lagopodioides**

8. Leaflets orbicular or ovate; floral bracts lanceolate, apex acuminate
……...…… **14. U. rotundata**

9. Leaflets elliptic, ovate or oblong; ……..…..…. **8. U. crinita**

9. Leaflets lanceolate, narrowly lanceolate, narrowly oblong or linear …….
…….…… 10

10. Leaves 3-foliolate; ovary with 6–7 ovules ……..... **3. U. balansae**

10. Leaves 5–9-foliolate; ovary with 2–8 ovules ……..…..… 11

11. Leaflets linear, apex acute or acuminata; ovary with 7–8 ovules ... **11. U. picta**

11. Leaflets lanceolate or narrowly lanceolate, rarely elliptic or narrowly oblong, apex acuminata; ovary with 2 –5 ovules ……..……. 12

12. Floral bract pale pink or purple; ovary with 4 (–5) ovules ..… **2. U. acuminata**

12. Floral bract pale green or pale purple; ovary with 2 ovules
…….…….. **13. U. pseudoacuminata**

13. Inflorescence simple paniculate. ……..…..…… **9. U. lacei**

13. Inflorescence umbel-like paniculate ……. **12. U. poilanei**

14. Pods with 3–4 (–7) segments; calyx 4–7 mm long, with straight hairs
…….……..……...……..…. **5. U. campanulata**

14. Pods with (4–) 6–8 segments; calyx 2–3 mm long, with both straight hairs and bulbous base straight hairs …… **15. U. rufescens**

1. Uraria acaulis Schindl. in Engl., Bot. Jahrb. Syst. 54: 52. 1916. Type: Laos, Khammouane, Phon Thane, *Spire* 167 (lectotype P!). Lectotype was selected by Thuân, Dy Phon & Niyomdham, Fl. Cambodge, Laos & Vietnam 23: 100. 1987. (Figs. 16 & 31A)

Erect herbs, with short stem, rarely trailing, 10–30 cm high. *Leaves* 1-foliolate; petioles (3–) 8–15 (–18) cm long; stipules deltoid, acuminata, 12–15 by 4–7 mm. *Leaflets* thinly chartaceous, bright green, cordate to orbiculate, (5–) 15–20 by (5–) 16–22 cm; base cordate or emarginate; apex acute-mucronate, retuse-mucronate; margin entire; both surfaces scabrous; petiolules (2–) 3–5 mm long; stipels narrowly lanceolate, acuminata, 4–8 by 1–2 mm. *Inflorescences* racemose, terminal, erect, 8–16 cm long. *Flowers* very dense; bracts lanceolate, 9–11 by 2–4 mm, pale pink or pale yellowish; pedicels 8-9 mm long, up to 10 mm at maturity; with hooked hairs, rarely bulbous base straight hairs only towards the apex and straight hairs towards the base. *Calyx* with straight hairs and bulbous base straight hairs; tube *ca.* 1 mm long; upper lobes *ca.* 1 mm long, rarely entirely connate, lower ones thread-like, *ca.* 8 mm long. *Corolla* purple to pale violet; standard 5.5–6 by 3.5–4 mm, claw *ca.* 1.5 mm long; wings 4–4.5 by 1–1.5 mm, claw *ca.* 1 mm long; keel 4.5–5 by 1.5–2 mm, claw *ca.* 2 mm long. *Ovary* with 1 (–2) ovule/s. *Pods* with 1 (–2) segment/s; segment orbicular, 3.5–4 by 3–3.5 mm, cream or dark grey, glabrous. *Seeds* reniform 2.6–3.2 by 2–2.5 mm, reddish brown.

Thailand.— NORTHERN: Mae Hong Son, Chiang Mai, Chiang Rai, Phayao, Nan, Lamphun, Lampang, Tak, Kamphaeng Phet; NORTH-EASTERN: Phetchabun, Loei, Nong Khai, Sakon Nakhon; EASTERN: Yasothon, Ubon Ratchathani; SOUTH-WESTERN: Uthai Thani, Kanchanaburi, Ratchaburi, Phetchaburi, Prachuap Khiri Khan; CENTRAL: Saraburi, Nakhon Nayok, Bangkok; SOUTH-EASTERN: Chon Buri.

Distribution. — Laos (type), Cambodia, Vietnam.

Vernacular. — Hang Ma (หางหมา) (Mae Hong Son), Kheu Non (ขี้หนอน) (Yasothon), Ya Non (หญ้าหนอน) (Ubon Ratchathani), Hang Karok (หางกระรอก) (Ubon Ratchathani, Chon Buri), Puang Hang Karok (พวงหางกระรอก) (Saraburi).

Ecology. — In dry evergreen, mixed deciduous and dipterocarp-oak forests, alt. 100-1,100 m. Flowering August-September. Fruiting September-December.

Specimens examined. — *P.C. Boyce* 1037 (K); *D. Bunpheng* 662 (BKF); *W. Chuakul* 41 (BK), WCK 00267 (PBM), WCK 02425 (PBM); *K. Chayamarit* 1521 (BKF); *D.J. Collins* 1284 (K); *F. Floto* 7793 (C); *A.F.G. Kerr* 20577 (BM-2 Sheets, K); *H. Koyama, H. Terao & T. Wongprasert* T-31160 (BKF); *V. Lamxay* 40-060 (KKU); *K. Larsen* 8822 (C), 8976 (C); *K. Larsen, S.S. Larsen, C. Niyomdham, P. Sirirugsa, D.D. Tirvengadum & C.T. Nørgaard* 43515 (AAU, PSU); *J. Leeratiwong* 99-86 (KKU); *S. Mattapha* 324 (KKU), 293 (BKF); *J.F. Maxwell* 74-758 (AAU, BK), 75-1053 (BK), 89-1079 (CMU), 89-1275 (CMU), 94-954 (CMUB, BKF), 95-494 (CMUB), 99-97 (CMUB), 05-705 (CMUB); *K. Mompanao* KM 147031 (BK); *G. Murata, K. Iwatsuki, C. Phengklai & C. Charoenphol* T-15518 (BKF); *I.C. Nielsen, R. Pooma, N. Koonkhunyhod & M. Poopath* 1711 (BKF); *B. Nimanong & S. Phusomsaeng* 124 (K); *C. Niyomdham & P. Phudjaa* 6990 (BKF); *M. Panatkool* 160 (CMUB); *J. Parnell, C. Pendry, M. Jebb & R. Pooma* 95-035 (K); *O. Petrmitr* 102 (CMUB); *C. Phengklai et al.* 11191 (BKF); *Prayad* 1114 (BK); *Put* 447 (BK), 461 (K, TCD1089 (BK, BM, C, K); *P. Puudjaa* 1114 (BKF), *s.n.* (BKF 116009); *Th. Sørensen, K. Larsen & B. Hansen* 1150 (C), 1134 (C); *BGO. Staff* 1341 (QBG), 4360 (QBG), 7088 (QBG); *S. Sutheesorn* 3089 (BK); *W. Tokaew* 921 (KKU); *W. Tokaew & P. Chantaranothai* 396 (KKU), 426 (KKU), 432 (KKU), 436 (KKU).

2. Uraria acuminata Kurz, J. Asiat. Soc. Bengal. 45: 235. 1876. Type: Myanmar, *Kurz* s.n. (holotype K!). (Figs. 17 & 31B)

Erect and unbranched subshrubs 50–150 cm high. *Leaves* 5–9-foliolate; petioles 10–15 cm long; stipules deltoid, acuminata, 17–20 by 5–7 mm. *Leaflets* thinly coriaceous, with bright grey bands, lanceolate, rarely elliptic or narrowly oblong, (6–) 12–22 by (2–) 2.5–5 cm, base obtuse or acute, apex acuminata, margin entire, upper surface glabrous; lower surface slightly scabrous or scabrous; petiolules 2–3 (–4) mm long; stipels narrowly lanceolate, acuminata, 5–7 by 1–2 mm. *Inflorescences* racemose, terminal, erect, 25–40 cm long. *Flowers* dense; bracts

lanceolate, 18–23 by 2–6 mm, pale pink or pale purple; pedicels 4–6 mm long, up to 13–14 mm at maturity, with rarely bulbous base straight hairs, hooked hairs only towards the apex and straight hairs towards the base. *Calyx* pale pink, with straight hairs and bulbous base straight hairs; tube *ca.* 1 mm long; upper lobes *ca*. 1.5 mm long, lower ones thread-like, 3-3.5 mm long. *Corolla* pink or purple; standard 10-12 by 9-10 mm, claw *ca.* 1 mm long; wings 4.5–5 by 1.5–2 mm, claw 0.5–0.8 mm long; keel 4.5–5 by 1.5–2 mm, claw 2–2.5 mm long. *Ovary* with 4 (–5) ovules. *Pods* with 3–4 segments; segment orbicular 3.5–4 by 3.2–3.5 mm, cream, dark grey or dark brown, with tiny straight hairs. *Seeds* reniform, 2.2–2.6 by 1.8–2 mm, brown or reddish brown.

Thailand. — NORTHERN: Mae Hong Son, Chiang Mai, Chiang Rai, Lampang, Sukhothai, Phitsanulok; NORTH-EASTERN: Phetchabun, Loei, Sakon Nakhon; EASTERN: Chaiyaphum, Nakhon Ratchasima, Ubon Ratchathani; SOUTH-WESTERN: Kanchanaburi, Ratchaburi; CENTRAL: Saraburi, Nakhon Nayok, Bangkok; SOUTH-EASTERN: Rayong, Chanthaburi; PENINSULAR: Chumphon, Narathiwat.

Distribution. — Myanmar (type), Laos, Vietnam, Cambodia.

Vernacular. — Ya Hangsuea (หญ้าหางเสือ) (Chiang Mai), Salet Pangpon (เสลดพังพอน) (Chiang Rai), Hang Karok (หางกระรอก), Hangma (หางหมา) (Sukhothai).

Ecology. — In evergreen, dry evergreen, deciduous and dipterocarp forests, alt. 0-700 m. Flowering August-September. Fruiting September-December.

Specimens examined. — *D. Bunpheng* 134 (BKF), 597 (BKF); *P. Chantaranothai & J. Parnell* 90/455 (KKU); *P. Grajay* 387 (KKU); *Herb. Trip* 7 (BCU); *Kasin* 494 (BK), 496 (BK), s.n. (BK 211483); *A.F.G. Kerr* 1367 (K); *K. Larsen & S.S. Larsen* 34313 (AAU);); *K. Larsen, S.S. Larsen, C. Niyomdham, W. Ueachirakan & P. Sirirugsa* 42310 (AAU); *K. Larsen, S.S. Larsen, C. Tange & D. Sookchaloem* 46792 (AAU); *J.F. Maxwell* 71-715 (AAU, BK), 89-1388 (CMU), 94-1177 (CMUB, BKF), 98-1185 (CMUB), s.n. (BK 211499); *C. Niyomdham & P. Phudjaa* 6957 (BKF); *M. Panatkool* 104 (CMUB), 105 (CMUB); *S. Phengnaren* 618 (BKF); *Phongsak & Prayad* 014 (BK); *M. Poopath* 185 (BKF); *Pradit* 393 (BK); *Put*

1891 (BK, K); *P. Sirirugsa* 33 (BCU); *E. Smith* 63 (BK); *T. Smitinand* 3530 (BKF); *Th. Sørensen, K. Larsen & B. Hansen* 1660 (BKF, C); *S. Srapathat* 63 (BCU); *S.P. et al*. 90 (BKF); *W. Tokaew* 917 (KKU); *W. Tokaew & P. Chantaranothai* 408 (KKU), 423 (KKU), 428 (KKU), 439 (KKU); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 3450 (BKF, C, K).

3. Uraria balansae Schindl. in Engl., Bot. Jahrb. Syst. 54: 53. 1916. Type: Vietnam, Tonkin, Mocha, *Balansa* 4448 (holotype P!). (Figs. 18 & 31C)

Erect and unbranched subshrubs 50–60 cm high. *Leaves* 3-foliolate; petioles 6–16 cm long; stipules deltoid, acuminata, *ca.* 15 by 8 mm. *Leaflets* thinly coriaceous, lanceolate, (10–) 15–23 by (2.5–) 4–6 cm; base obtuse; apex acuminata; margin entire; upper surface scabrous; lower surface pubescent; petiolules 4–5 mm long; stipels narrowly lanceolate, acuminata, *ca.* 8 by 1 mm. *Inflorescences* racemose, terminal, erect, *ca.* 30 cm long. *Flowers* dense; bracts lanceolate, 18–23 by 1.5–6 mm; pedicels *ca.* 15 mm long, up to 20 mm at maturity, with bulbous base straight hairs and sparsely straight hairs. *Calyx* with bulbous base straight hairs and sparsely straight hairs; tube 1.5–2 mm long; upper lobes *ca.* 4 mm long; lower ones 4–5 mm long. *Corolla* purple; standard *ca.*10 by 8 mm, claw *ca.* 2 mm long; wings *ca.* 6 by 2 mm, claw *ca.* 1 mm long; keel *ca.* 8 by 3 mm, claw *ca.* 2 mm long. *Ovary* with 6–7 ovules. *Pods* with 1–6 segment/s; segment ovate-orbicular, dark brown, with sparsely tiny straight hairs.

Thailand. — PENINSULAR: Narathiwat.

Distribution. — Vietnam (type).

Vernacular. — Chang Nga daew (ช้างงาเดียว).

Ecology. — Open area. alt. 50 m. Flowering August-September. Fruiting September-December.

Specimens examined. — *C. Niyomdham* 6492 (BKF); *M. Poopath, M. Thanaros, T. Weecheanchan & T. Insura* 72 (BKF).

Note. — New record for Thailand.

4. Uraria barbaticaulis Iokawa, Nemoto, J.Murata & H.Ohashi, J. Jap. Bot. 79(4): 226. 2004. Type: Myanma (Burma) Taong Dong. Wall. Cat. 5679B (lectotype K!); Cult. Hort. Bot. Calc. e Taong Dong. Wall Cat. 5679 C (K!).— *Uraria barbata* Lace, Bull. Misc. Inform. Kew 1915 (9): 397–398. *non* Desv. 1826; Haas, Bosman & Gees., Blumea 26: 439. 1980; F.Fedde. and K. Schuster, Just's Bot. Jahresber: 108. 1925. (Figs. 19 & 31D)

Erect and unbranched subshrubs 30–60 cm high. *Stem* pilose. *Leaves* 1-foliolate; petioles 1–2 cm. long, densely pilose; stipules deltoid, acuminata, puberulose, 11–13 by 3–3.5 mm. *Leaflets* ovate, broadly ovate or cordate, (4.5–) 7–12 by (2.5–) 3–6 cm, base obtuse or cordate, apex acute, margin entire, chartaceous; upper surface and lower surface pilose; petiolules 1.5–2 mm long, pilose; stipels narrowly lanceolate, acuminata, 4–6 by 0.5-1 mm. *Inflorescences* racemose, terminal and axillary at the upper part of stem, erect, 10–30 cm long. *Flowers* lax; bracts lanceolate, 3.5–4.5 by 1–1.2 mm, pale green; pedicels 4–4.5 mm long in flower and 4.5–5 mm long in fruit, pubescent with hooked hairs mixed with straight hairs. *Calyx* pale green, pilose with straight hairs; tube 1–1.5 mm long; upper lobes 1, 3–3.5 mm long; lower lobes 3, 2.5–3 mm long, well-developed in mature fruit. *Corolla*: standard 3 by 2.5–3 mm, claw 1.3–1.5 mm long, pale violet to white; wings 2.5–2.8 by 1–1.3 mm, claw 1.8–2 mm long, pale violet; keel 2.7–3 by 1–1.3 mm, claw 1–1.2 mm long, pale violet. *Ovary* with 5–6 ovules. *Pods* with (3–) 5–6 segments; segment orbicular 2–2.5 by 1.8–2.2 mm, black, with hooked hairs. *Seeds* reniform, *ca.* 2 by 1.5 mm, dark yellow.

Thailand. — NORTHERN: Tak.

Distribution. — Myanmar (type).

Vernacular. — Tong Tit (ตองติด).

Ecology. — In dry evergreen forests, alt. 900 m. Flowering October. Fruiting October-December.

Specimens examined. — *W. Tokaew* 916 (KKU)

Note. — New record for Thailand.

5. Uraria campanulata (Benth.) Gagnep. in Lecomte, Fl. Indo-Chine 2: 543. 1920.— *Lourea campanulata* Benth. in Miq., Pl. Jungh.: 215. 1852. Type: Myanmar, *Wallich* 5685 (holotype K!).— *Christia campanulata* (Benth.) Thoth., Curr. Sci.: 178. 1963.— *Desmodium formosanum* Hayata, Mat. Fl. Formos: 77. 1911. Type: Formosa (Taiwan), Banchoryo, Juchori, October 1905, *G. Nakahara* 586. Type: not located.— *Uraria formosana* (Hayata) Hayata, Ic. Pl. Formos. 9: 26. 1920. (Figs. 10, 20 & 31E)

Herbs or branched subshrubs (20–) 50–150 cm high. *Leaves* (1–) 3-foliolate; petioles 1.5–3 cm long; stipules deltoid, lanceolate, acuminata, 15–17 by 2–3 mm. *Leaflets* thinly chartaceous, elliptic, 6–13 by 2–6 cm; base obtuse to acute; apex acute or mucronate; margin entire; upper surface slightly scabrous or scabrous; lower surface pilose; petiolules 1–3.5 mm long; stipels narrowly lanceolate, acuminata, 3–4 by 1–1.5 mm. *Inflorescences* paniculate or racemose on small plants, terminal, erect, 10–30 cm long; *Flowers* lax; bracts reddish green, broadly ovate or ovate, caudate, 7–11 by 2–3.5 mm; pedicels 2–3 mm long, up to 3–4 mm at maturity, with straight hairs and hooked hairs. *Calyx* reddish green, with straight hairs; tube *ca.* 2 mm long, upper lobes *ca.* 4 mm long, lower ones 4–5 mm long. *Corolla* purple or pale violet; standard 10–12 by 8–10 mm, claw 1.5–2 mm long; wings 8–9 by 3.5–4 mm, claw *ca.* 1 mm long; keel 9–10 by 4–4.5 mm, claw 3–4 mm long. *Ovary* with 4–7 ovules. *Pods* with 3–4 (–7) segments, enclosed in the persistent calyx; segment orbicular 2.5–3 by 2–2.5 mm, dark brown, with tiny hooked hairs. *Seeds* reniform, *ca.* 2 by 1.5 mm, dark yellow.

Thailand. — NORTHERN: Mae Hong Son, Chiang Mai, Chiang Rai, Lampang; NORTH-EASTERN: Phetchabun, Sakon Nakhon; SOUTH-WESTERN: Kanchanaburi; CENTRAL: Saraburi.

Distribution. — India, Myanmar (type), Taiwan, Vietnam.

Vernacular. — Ya Non (หญ้าหนอน)

Ecology. — In dry evergreen and deciduous forests, alt. 300-1,250 m. Flowering October. Fruiting October-December.

Specimens examined. — *P. Chantaranothai et al.* 716 (KKU); *A.F.G. Kerr* 1553 (BM-2 sheets), 1553B (BM, K, TCD); *K. Larsen & S.S. Larsen* 34341 (AAU,

BKF, K); *J. Leeratiwong* 99-115 (KKU, PSU); *J.F. Maxwell* 73-553 (AAU, BK), 73-642 (AAU, BK), 73-692 (AAU), 87-1427 (AAU, BKF), 89-1396 (CMU), 90-1371 (CMU), 93-1300 (BKF), 96-1336 (BKF); *Prayad* 1124 (BK); *Th. Sørensen, K. Larsen & B. Hansen* 5675 (C); *BGO. Staff* 5283 (QBG); *W. Tokaew & P. Chantaranothai* 394 (KKU), 409 (KKU), 410 (KKU); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 3668 (BKF, C, K); *M. van de Bult* 1079 (BKF); *Winit* 1807 (BK).

6. Uraria cochinchinensis Schindl. in Fedde, Repert. Spec. Nov. Regni Veg. 21: 14. 1925. Type: Vietnam, Dong Nai, Mt. Dinh, Baria, *Pierre* s.n. (8.1866) (holotype P!).— *Uraria collettii sensu* Gagnep. in Lecomte, Fl. Indo-Chine 2: 548. 1920, *non* Prain, 1897. (Figs. 21 & 31F)

Erect and unbranched herbs or subshrubs 20–40 cm high. *Leaves* 1-foliolate; petioles 4–8 cm long; stipules deltoid, lanceolate, acuminata, 2–3 by 1–2 mm. *Leaflets* thinly chartaceous, cordate, 6–15 by 4–12 cm; base cordate; apex acute, cuspidate; margin entire; upper surface scabrous; lower surface pilose; petiolules 3–4 mm long; stipels narrowly lanceolate, acuminata, 2.5–3 by *ca.* 1 mm. *Inflorescences* paniculate, axillary or terminal, curved downward or pendulous, 6–15 cm long. *Flowers* dense; bracts ovate, 8–10 by 2.5–4 mm, pale green; pedicels *ca.* 10 mm long, up to *ca.* 15 mm at maturity, with straight hairs, hooked hairs and bulbous base straight hairs. *Calyx* with straight hairs and bulbous base straight hairs; tube *ca.* 1 mm long; upper lobes *ca.* 2 mm long, lower ones *ca.* 3 mm long. *Corolla* pink or pale violet; standard *ca.* 6 by 5 mm, claw *ca.* 1 mm long; wings *ca.* 4.5 by 1.5 mm, claw *ca.* 1 mm long; keel *ca.* 3.5 by 1 mm, claw *ca.* 2 mm long. *Ovary* with 3–5 ovules. *Pods* deeply indented along both sutures into 3–5 segments; segment orbicular 2.5–3.2 by 2.5–3.2 mm, cream or dark grey, with sparsely tiny straight hairs. *Seeds* globose, 2–2.5 by 2–2.5 mm, dark brown.

Thailand. — NORTH-EASTERN: Sakon Nakhon; EASTERN: Surin, Si Sa Ket.

Distribution. — China, Laos, Cambodia, Vietnam (type).

Vernacular. — Hangma (หางเสือ) (Surin).

Ecology. — In dry evergreen forest, alt. 100-600 m. Flowering September. Fruiting September-December.

Specimens examined. — *W. Chuakul* WCK 00176/21 (PBM); *J. Leeratiwong* 98-20 (KKU); *G. Murata, C. Phengklai, S. Mitsuta, H. Nagamasu & N. Nantasan* T-49635 (AAU, BKF); *W. Tokaew & P. Chantaranothai* 450 (KKU).

7. Uraria cordifolia Wall., Pl. Asiat. Rar. 1: 33, t. 37. 1830. Type: Myanmar, Irrawaddi, *Wallich* 5679A, (holotype K!). — *Uraria cordata* Wall., Cat. no. 5679A. 1831, *nom. nud.*— *Urariopsis cordifolia* (Wall.) Schindl. in Engl., Bot. Jahrb. Syst. 54: 51. 1916.— *Uraria latifolia* Prain, J. Asiat. Soc. Bengal. 66: 383. 1897. Type: Myanmar, Fort Stedman, *King's Collector* s.n., (holotype K). (Figs. 11, 22 & 31G)

Erect and unbranched subshrubs 20–50 cm high. *Leaves* 1-foliolate; petioles 3–6 cm long; stipules deltoid or lanceolate, acuminata, *ca.* 10 by 4 mm. *Leaflets* thinly coriaceous, cordate, 9–14 by 8–12 cm; base cordate; apex acute-mucronate; margin entire; upper surface scabrous; lower surface pilose; petiolules 5–6 mm long; stipels narrowly lanceolate, acuminata, 3–4 by *ca.* 1 mm. *Inflorescences* paniculate, rarely racemose, terminal, erect, 20–35 cm long. *Flowers* dense; bracts ovate or lanceolate, 8–9 by 2–3 mm, pale green; pedicels 9–10 mm long, up to 12–13 mm at maturity, with straight hairs and bulbous base straight hairs. *Calyx* light greenish, with straight hairs and bulbous base straight hairs; tube *ca.* 1.5 mm long; lobes 3–4.5 mm long. *Corolla* pale purple or pale violet; standard *ca.* 11 by 12 mm, claw *ca.* 2 mm long; wings *ca.* 10 by 2 mm, claw *ca.* 1.2 mm long; keel *ca.* 11 by 2 mm, claw *ca.* 4 mm long. *Ovary* with 4 ovules. *Pods* deeply indented along both sutures into 3-4 heart-shaped segments, segment *ca.* 3–3.5 by 2.8–3 mm, black, with straight tiny hairs. *Seeds* heart-shaped, 2–2.5 by 1.5–2 mm, dark yellow.

Thailand. — NORTHERN: Mae Hong Son, Chiang Mai, Chiang Rai, Phayao, Nan, Lamphun, Lampang, Phrae, Tak, Sukhothai; NORTH-EASTERN: Phetchabun, Loei, Sakon Nakhon; EASTERN: Nakhon Ratchasima; SOUTH-WESTERN: Uthai Thani, Kanchanaburi.

Distribution. — India, Myanmar (type), Laos, Vietnam, Cambodia, Indonesia.

Vernacular. — Hangma (หางหมา) (Chiang Mai, Phayao), Nontaiyak (หนอนตายอยาก) (Nakhon Ratchasima).

Ecology. — In dry evergreen, deciduous, dipterocarp and dipterocarp-oak forests, alt. 100-1,000 m. Flowering August. Fruiting August-October.

Specimens examined. — *Amnat* 60 (BKF 11274); *E.F. Anderson* 5982 (CMU); *BGO. Staff* 1443 (QBG), 1679 (QBG); *K. Chayamarit et al.* 1940 (BKF); *P. Chantaranothai et al.* 1188 (KKU); *F. Ervard* 2326 (BKF); *N. Fukuoka* T-62370 (BKF); *R. Geesink, D. Phanichapol & T. Santisuk* 5628 (AAU, BKF, K), 5847 (BKF); Kasem 336 (BK); *A.F.G. Kerr* 1275 (K), 3603 (BM, K); *K. Larsen, S.S. Larsen, C. Tange & D. Sookchaloem* 46129 (AAU); *Khanthachai* 560 (BKF); *K. Larsen, T. Santisuk & E. Warncke* 2217 (AAU, C, K); *J. Leeratiwong* 9951 (KKU); *A. Marcan* 2173 (BM, C, K); *J.F. Maxwell* 87-596 (CMU), 90-712 (CMU), 90-946 (CMU), 93-758 (CMUB, BKF), 04-292 (CMUB); *G. Murata* T-17031 (BKF); *G. Murata, N. Fukuoka & C. Phengklai* T-16815 (BKF); *P. Nangngam* 1788 (BKF); *A. Naroan* 2173 (C, K); *C. Niyomdham* 6507 (BKF); *Y. Paisooksantivatana* Y-2630-91 (BK); *Parinya & Santi* 451 (BK); *Prayad* 372 (BK); *Put* 3072 (BM, C, K), 3990 (BM, C, K); *T. Smitinand* 4593 (BKF); *T. Santisuk* 983 (BKF); *W. Tanming* 809(QBG); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 5628 (C); *Winit* 364 (BKF, K).

8. Uraria crinita (L.) Desv. ex DC., Prodr. 2: 324. 1825.— *Hedysarum crinitum* L., Mant. Pl. 1: 102. 1767. Type: Burman, Fl. Ind. 3: 169, t. 56. 1768.— *Doodia crinita* Roxb., [Hort. Beng.: 98. 1814, *nom. nud.* ex] Fl. Ind.: 3: 369. 1832.— *Uraria picta* Wight, Ic. Pl. Ind. Or. 2(1): pl. 411. 1840, *non* Desv. ex DC., 1825.— *Uraria macrostachya* Wall., Pl. Asiat. Rar. 2: 8, t. 110. 1831.— *Uraria crinita* var. *macrostachya* Wall., Pl. Asiat. Rar. 2: 8, t. 110. 1831. (Figs. 12, 23, 31H)

Erect and unbranched subshrubs (20–) 30–80 (–120) cm high. *Leaves* 5–11-foliolate, 1–3-foliolate on young plants or basal leaves on mature plants; petioles (5–) 7–13 cm long; stipules deltoid or lanceolate, acuminata, 10–18 by 5–7 mm. *Leaflets*

thinly coriaceous, with bright grey bands, oblong, rarely elliptic, 5–15 (–25) by 2–6 (–15) cm; base obtuse, acute or caudate; apex acute, obtuse or mucronate; margin entire; upper surface glabrous; lower surface slightly scabrous or scabrous; petiolules 2–2.5 mm long; stipels narrowly lanceolate, acuminata, 5–8 by 1–2 mm. *Inflorescences* racemose, terminal, erect, 15–30 (–40) cm long. *Flowers* dense; bracts ovate or lanceolate, 10–15 (–20) by 2–5 mm, pale green, pale pink or purple; pedicels *ca.* 10 mm long, up to 11–14 mm at maturity, with rarely bulbous base straight hairs, hooked hairs only towards the apex and straight hairs towards the base. *Calyx* pale pink or pale green, with straight hairs and bulbous base straight hairs; tube 1–1.5 mm long; upper lobes 2–2.5 mm long, lower ones thread-like, 3.5–4.5 mm long. *Corolla* pink, purple or pale violet; standard 9–10 by 7–8 mm, claw *ca.* 2 mm long; wings 8–9 by 2.5–3 mm, claw 1–1.5 mm long; keel 8–9 by 3–3.5 mm, claw *ca.* 2 mm long. *Ovary* with 4–7 ovules. *Pods* with 4–7 segments, segment ovate-orbicular, 3–3.5 by 2–2.5 mm, dark grey or black, with tiny straight hairs or glabrous. *Seeds* reniform, 1.5–2.2 by 1.5–2 mm, yellow, greenish yellow or brown.

Thailand. — NORTHERN: Chiang Mai, Chiang Rai, Phayao, Nan, Lamphun, Lampang, Phrae, Uttaradit, Tak, Sukhothai, Phitsanulok, Kamphaeng Phet, Nakon Sawan; NORTH-EASTERN: Phetchabun, Loei, Udon Thani, Nong Khai, Sakon Nakhon, Mukdahan, Kalasin, Maha Sarakham, Khon Kaen; EASTERN: Chaiyaphum, Nakhon Ratchasima, Surin, Ubon Ratchathani; SOUTH-WESTERN: Uthai Thani, Kanchanaburi, Ratchaburi, Phetchaburi, Prachuap Khiri Khan; CENTRAL: Lop Buri, Saraburi, Bangkok; SOUTH-EASTERN: Sa Kaeo, Chachoengsao, Chon Buri, Rayong, Chanthaburi; PENINSULAR: Chumphon, Ranong, Surat Thani, Krabi, Phatthalung, Trang, Satun, Songkhla, Yala, Narathiwat.

Distribution. — India, Myanmar (type), China, Taiwan, Laos, Vietnam, Cambodia, Malaysia.

Vernacular. — Ya Hangsuea (หญ้าหางเสือ)(Chiang Mai, Phayao, Phrae, Kanchanaburi, Ratchaburi, Chumphon), Hang Karok (หางกระรอก) (Phrae, Sakon Nakhon, Khon Kaen, Surin, Chon Buri, Chanthaburi, Chumphon, Songkhla), Hangmachok (หางหมาจอก) (Chiang Mai, Loei, Sakon Nakhon, Maha Sarakham, Kanchanaburi), Non Nai (หนอนหน่าย) (Nong Khai, Sakon Nakhon), Non Yai (หนอน

ใหญ่) (Sakon Nakhon), Khue Non (ขี้หนอน) (Chaiyaphum, Kalasin, Khon Kaen), Chang Nga daew (ช้างงาเดียว) (Nakhon Ratchasima), Tong Tit (ตองติด) (Sa Kaeo), Hang Sing (หางสิงห์) (Surat Thani, Songkhla), Hneaw Hma (เหนียวหมา) (Surat Thani), Ya Hang Maeo (หญ้าหางแมว) (Satun), Rae Ngae (แรแง่), Uekong Miachae (อิกงเมียแช) (Yala), Lukluep Ton (ลูกลีบตัน) (Chiang Mai), Hangsuea (หางเสือ) (Phrae, Loei), Nia Non (เหนียวหนอน) (Sa Kaeo).

Ecology. — In evergreen, dry evergreen, deciduous, dipterocarp-oak and dipterocarp forests, alt. 0-1,000 m. Flowering July-November. Fruiting September-December.

Specimens examined. — *Anuasat* 3 (PSU); *Anusara* 6 (KKU); *A.S. Barfod & T. Burholt* 43850 (AAU); *D. Bourcke* s.n. (K); *Brun, Bjørnland & Schumacher* 227 (C); *K. Bunchuai* 1313 (BKF); *A. Chantanamuck* 1 (BK); *P. Chantaranothai & J. Parnell* 90/762 (K, KKU, TCD); *P. Chantaranothai et al.* 347/2006 (BKF), 802 (KKU), s.n. (KKU); *C. Charoenphol, K. Larsen & E. Warncke* 3790 (AAU, BKF), 4125 (AAU); *K. Chayamarit et al.* 2095 (BKF), 2096 (BKF); *W. Chuakul* WCK 00112 (PBM); *H.H. Chung* 198 (BK); *Ch.P., S.S., R.N.* 3 (BKF); *D.J. Collins* 29 (K), 30 (TCD), 999 (BM, K), 1356 (K) 1614 (K); *P. Grajay* 371 (KKU); *M. Greijmans* 187 (CMUB, BKF); *W. Hawmchan* 808 (CMUB); *S. Homchurn* 31 (BCU, KKU); *C.C. Hosseus*, 308a (M), *T. Jonganurak* 128 (BCU); *Kasin* s.n. (BK); *A.F.G. Kerr* 1330 (K, TCD), 2184 (BM, K), 13791 (BK, BM, K, TCD), 16465 (BK, BM, K), 4500 (BK, BM, K), s.n. (BK); *K. Kertsawang* 120 (QBG); *K. Khompat* KK7 (PSU); *W. Kornson* 28 (KKU); *M.C. Lakshnakara* 449 (BK, BM, C, K), s.n. (BK 211482); *K. Larsen* 8217 (C); *K. Larsen, S.S. Larsen, A.S. Barfod, W. Nanakorn, W. Ueachirakan & P. Sirirugsa* 41140 (AAU, PSU); *K. Larsen, S.S. Larsen, C. Niyomdham, W. Ueachirakan & P. Sirirugsa* 42418 (AAU); *K. Larsen, S.S. Larsen, C.T. Nørgaad, K. Pharson, P. Puudjaa & W. Uearchirakan* 44344 (AAU); *K. Larsen, S.S. Larsen, I.C. Nielsen & T. Santisuk* 31890 (AAU, BKF); *J. Leeratiwong* 98-34 (KKU), 99-75 (KKU), 99-92 (PSU); *T. Lekugul & C. Phengklai* 70 (BKF); *S. Linasong* 11 (BCU); *A. Marcan* 441 (BM, K); *S. Mattapha* 347 (KKU), 661 (BKF); *A. Mauric* 45 (BKF); *J.F. Maxwell* 71-590 (AAU), 71-559 (AAU), 72-410 (BK), 72-710 (AAU); 73-669 (BK), 84-558 (PSU), 85-533 (PSU), 86-728 (CMU, PBM), 93-1470 (CMUB), 94-952

(CMUB, BKF), 95-923 (CMUB), 96-1140 (CMUB), 97-944 (CMUB, BKF), s.n. (AAU), s.n. (BK 48821); *D.J. Middleton, T. Boonthavikoon, S.J. Davies, C. Hemrat & M.F. Newman* 478 (BKF); *Mompanao* KM 018 (BK); *G. Murata, C. Phengklai, S. Mitsuta, H. Nagamasu & N. Nantasan* T-37188 (BKF), T-52171 (BKF), T-52199 (BKF); *G. Murata, C. Phengklai, S. Mitsuta, T. Yahara, M. Nagamasu & N. Nantasan* T-51699 (BKF), T-52200 (BKF); *G. Murata, K. Iwatsuki, C. Phengklai & C. Charoenphol* T-15506 (BKF); *N. Nantasan* s.n. (BKF 101795); *C. Napatthalung* 13 (BKF); *B. Nasongkhla* 545 (BCU); *O. Neamsuvan* 66 (BCU); *I.C. Nielsen, T. Jonganurak, N. Hemrat, J. Rilhipheth* 1519 (AAU, BKF); *C. Niyamdham* 5140 (BKF); *C. Niyomdham, P. Phudjaa & S. Chonkonjana* 5968 (BKF); *C. Niyomdham* 4481 (BKF); *P. Nitrasirirak et al.* 3 (AAU, BKF); *O.T., T.B. & C.K.* 267 (BCU); *C. Phengklai* 204 (BKF), 14419 (BKF); *C. Phengklai et al.* 7609 (BKF), 16027 (BKF); *Ploenchit* 1663 (BKF); *T. Pooltawee* TP 070 (BK); *R. Pooma* 1347 (BKF); *R. Pooma & N. Pattharahirantricin* 7752 (BKF); *R. Pooma, W.J.J.O. de Wilde, B.E.E. Duyfjes, V. Chamchumroon & K. Phattarahirankanok* 2350 (BKF); *Pradit* 315 (BK); *D. Praphat* 156 (BKF), 342 (BKF); *Prayad* 315 (BK), 357 (BK), 409 (BK), 1030 (BK); *Put* 447 (BM, K, TCD, 461 (BK, BM, K, TCD), 822 (K), 1085 (K), 1891 (BK, BM, K), 1994 (BK, BM, C, K), 3152 (BK, BM, C, K), 3703 (K), 4073 (BK, BM, K) 3976 (BK, BM, K), 4205 (K); *P. Puudjaa* 418 (BKF); *Rattana, Junratte & Wachara* 8 (KKU); *N. Sanana* 044 (BK); *B. Sangkhachand* 2042 (BK); *T. Smitinand* 547 (BKF); *Th. Sørensen, K. Larsen & B. Hansen* 712 (C), 4784 (C), 4967 (C), 5052 (BKF, C); 5511 (C); *S. Srapathat* 26 (BCU); *BGO. Staff* 1421 (QBG), 1610 (QBG); *S. Sutheesorn* 258 (BK), 601 (BK), 1703 (BK), 2853 (BK), 3018 (BK); 8018 (BK); *C. Tasahasa* 6 (BKF); *B. Teerapong* 82 (CMUB, CMU); *A. Thammathaworn* s.n. (KKU); *S. Thaworn* 501 (BKF); *A. Tongdeedum* 11 (PSU); *S. Tosuntara* 4 (BCU); *S.P. et al.* 75 (BKF); *BGO. Staff* 48 (QBG), 166 (QBG), 1531 (QBG), 1637 (QBG); *W. Tokaew & P. Chantaranothai* 383 (KKU), 384 (KKU), 385 (KKU), 406 (KKU), 407 (KKU), 411 (KKU), 416 (KKU), 420 (KKU); *P. Triboun* s.n. (BK); *C.F. van Beusekom & C. Charoenpol* 2022 (AAU, BKF); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 3450 (K), 4429 (K), 9929 (BKF, C); *W. Tokaew* 908 (KKU); *M. van de Bult* 315 (BK, CMUB); *V. Vasikul* 9 (BK); *Warosini* 36 (PSU); *Winit* 362 (BKF, K), 762 (K); *Th. Wongprasert* 012-22 (BKF), 039-19 (BKF), 049-12 (BKF),

s.n. (BKF 1247111); *W. Wuttithammawate* 01 (BKF); *S.N.* (BK 62755, 63374); *S.N.* 7066 (QBG 7066).

9. Uraria lacei Craib, Bull. Misc. Inform., Kew 1910: 276, 1910. Type: Myanmar, *Lace* 4325 (lectotype K!).— *U. clarkei* Gagnep. in Lecomte, Fl. Indo-Chine 2: 542, 1920. Type: Vietnam, *Balansa* 4430 (holotype P!).— *U. pulchra* Hains. Bull. Misc. Inform., Kew 1921: 308, 1921. Type: India, *Haines* 3962, not located. (Figs. 24 & 31I)

Erect and unbranched subshrubs 1–1.5 m high. *Leaves* 1–3-foliolate; petioles (4–) 6–10 cm long; stipels narrowly lanceolate, acuminata, 5–6 by 1–1.5 mm. *Leaflets* thinly chartaceous, obovate or ovate, (5–) 10–15 by (4–) 5–9 cm; base obtuse to acute; apex mucronate; margin entire; upper surface scabrous, lower surface pilose; petiolules 3–4 mm long; stipules lanceolate, acuminata or caudate, 7–12 by 3 mm. *Inflorescences* paniculate, terminal, erect, 15–40 cm long. *Flowers* lax; bracts ovate, acuminata, 8–10 by 2–3 mm; pedicels 5–7 mm, with hooked hairs, straight hairs and bulbous base straight hairs. *Calyx* greenish-pale purple, with hooked hairs and bulbous base straight hairs; tube 1.5–2 mm long; upper lobes *ca.* 1.5 mm long, lower ones 1.5–2 mm long. *Corolla* purple, pale violet, violet, light blue or dark blue; standard 8–10 by 6–8 mm, claw *ca.* 1 mm long; wings 6–7 by 3 mm, claw *ca.* 1 mm long. keel 5–6 by 3 mm, claw *ca.* 2 mm long. *Ovary* with 5–7 (–10) ovules. *Pods* with 6–8 segments; segment orbicular or suborbicular, 3–4 by 3 mm, brown or black, with bulbous base straight hairs. *Seeds* reniform, 2.5–2.8 by 1.3–1.6 mm, reddish brown or dark brown.

Thailand. — NORTHERN: Chiang Mai, Chiang Rai, Lamphun, Lampang; NORTH-EASTERN: Loei, Khon Kaen; EASTERN: Chaiyaphum; SOUTH-WESTERN: Kanchanaburi.

Distribution. — Myanmar (type), China, Laos, Vietnam.

Vernacular. — Ton Niaw (ต้นเหนียว).

Ecology. — In evergreen and deciduous forests, alt. 500-1,300 m. Flowering October-November. Fruiting November -December.

Specimens examined. — *A.F.G. Kerr* 2772 (BM, K, TCD); *K. Larsen, S.S. Larsen, C.T. Nørgaard, K. Pharsen, P. Puudjaa & W. Ueachirakan* 44777 (AAU); *J.F. Maxwell* 88-1405 (BKF, CMU); *G. Murata, C. Phengklai, S. Mitsuta, H. Nagamasu & N. Nantasan* T-41997 (BKF), T-50249 (BKF); *Put* 4410 (K); *T. Smitinand* 3078 (BKF).

10. Uraria lagopodioides [*lagopoïdes*] (L.) Desv. ex DC., Prodr. 2: 324. 1825.— *Hedysarum lagopodioides* L., Sp. Pl.: 1198. 1753. Type: *Herb. Linné 921.49* (LINN).— *Lespedza lagopodoides* [*lagopoïdes*] Pers., Syn. Pl. 2: 318. 1807.— *Doodia lagopodioides* Roxb., [Hort. Beng.: 98. 1814, *nom. nud*. ex] Fl. Ind. 3: 366. 1832.— *Doodia alopecuroides* Roxb., [Hort. Beng.: 98. 1814, *nom. nud*. ex] Fl. Ind. 3: 368. 1832. Type: India, not located.— *Uraria alopecuroides* (Roxb.) Wight, Ic. Pl. Ind. Or. 1(15-16): pl. 290. 1840.— *Uraria cercifolia* Desv., J. Bot. 1: 123, t. 5, fig. 19. 1813, *nom. nud*.— *Uraria cylindracea* Benth., Fl. Austr. 2: 237. 1864. Type: not located. (Figs. 13, 24, 31J)

Prostrate or ascending herbs, sometime erect, 10–30 cm high. *Leaves* (1–) 3-foliolate; petioles 1.5–2.5 cm long; stipules lanceolate, acuminata, *ca.* 8 by 2.5 mm. *Leaflets* thinly coriaceous, orbicular, cordate, elliptic, ovate, narrowly ovate, or rhomboid, 2–10 by 2–6 cm; base obtuse or cordate; apex obtuse, retuse or mucronate; margin entire; upper surface slightly scabrous or scabrous ; lower surface slightly pilose or pilose; petiolules 1–1.5 mm long; stipels narrowly lanceolate, acuminata, 2–3 by *ca.* 1 mm. *Inflorescences* racemose, terminal, erect, 3–10 cm long. *Flowers* very dense; bracts pale green, ovate, 9–10 by 2.5–6 mm; pedicels 4–6 mm long, up to 6–7 mm at maturity, with straight hairs and only hooked hairs towards the apex. *Calyx* reddish, with straight hairs, hooked hairs and bulbous base straight hairs; tube *ca.* 1 mm long; upper lobes *ca.* 1.5 mm long, lower ones thread-like, 6–7 mm long. *Corolla* purple to pale violet; standard 6–10 by 5–8 mm, claw 1–1.5 mm long; wings 5–6 by 2–2.5 mm, claw 1–1.5 mm long; keel 5.5–6 by 2–2.5 mm, claw 2–2.5 mm long. *Ovary* with 2 ovules. *Pods* with 1–2 segment/s, segment ovate-orbicular, 3–3.2 by 2.5–3 mm, dark grey or black, with tiny straight hairs. *Seeds* reniform, 2–2.3 by 1.5–1.8 mm, yellow or brown.

Thailand. — NORTHERN: Mae Hong Son, Chiang Mai, Chiang Rai, Phayao, Nan, Lampang, Phrae, Uttaradit, Tak, Phitsanulok, Kamphaeng Phet, Nakhon Sawan; NORTH-EASTERN: Phetchabun, Loei, Nong Khai, Sakon Nakhon, Maha Sarakham, Mukdahan, Khon Kaen; EASTERN: Chaiyaphum, Nakhon Ratchasima, Buri Ram, Surin, Ubon Ratchathani; SOUTH-WESTERN: Kanchanaburi, Phetchaburi, Prachuap Khiri Khan; CENTRAL: Bangkok; SOUTH-EASTERN: Chon Buri, Chanthaburi; PENINSULAR: Surat Thani, Phatthalung, Trang, Songkhla.

Distribution. — India, China, Taiwan, Laos, Vietnam, Cambodia, Malaysia, Indonesia, Australia, Polynesia.

Vernacular. — Khang Maengbong (ขางแมงโบ้ง) (Chiang Mai), Tan Kho Ma (ตาลคอม้า) (Chiang Rai), Kon Bung (กันบุ้ง) (Nakhon Sawan), Hangmeo (หางแมว), Ya Hangsuanoi (หญ้าหางเสือน้อย) (Sakon Nakhon) Hangsuanoi (หางเสือน้อย), Ya Hang On (หญ้าหางอัน) (Chaiyaphum), Khontue Din (คนทีดิน) (Surat Thani, Songkhla).

Ecology. — In hill evergreen, deciduous, dipterocarp, dipterocarp-oak and dipterocarp-pine forests, grassy places and cultivated areas, alt. 0-1,000 m. Flowering June-October. Fruiting July-January.

Specimens examined. — *Adisai* 552 (BK); *K. Bunchuai* 127 (BKF), 1010 (C, K); *D. Bunpheng* 172 (BKF); *P. Chantaranothai et al.* 356 (KKU), 552 (KKU), 1212 (KKU) s.n. (KKU 7520, KKU 8774, KKU 9286, KKU 9287); *W. Chantranon* 17 (BCU); *W. Chuakul* 56 (BK), WCK 00673 (PBM); *D.J. Collins* 1460 (K); *Din* 277 (BKF); *R. Geesink, D. Phanichpol & T. Santisuk* 5849 (AAU, BKF, C), 5972 (BKF); *R. Geesink, T. Hattink & C. Phengklai* 6964 (BKF, C, K); *C. Glamwaewwong* 243 (QBG); *P. Grajay* 344 (KKU); *S. Homchurn* 30 (BCU, KKU); *Kasin* s.n. (BK 211519); *A.F.G. Kerr* 650 (BM, K, TCD), 4065 (BM, K), 5085, (BK, BM, K), 13652 (BK, BM, C, K), s.n. (BK 211516); *V. Lamxay* 40-134 (KKU); *K. Larsen* 9965 (C); s.n. (BKF 9965); *K. Larsen, S.S. Larsen* 34223 (AAU, BKF); *K. Larsen, S.S. Larsen, C. Niyomdham, P. Sirirugsa, D.D. Tirvengadum, C.T. Nørgaard* 43657 (AAU, BKF); *K. Larsen, S.S. Larsen, I.C. Nielsen & T. Santisuk* 31669 (AAU); *K. Larsen, T. Santisuk & E. Warncke* 673 (AAU, BKF, C), 1468 (AAU), 2219 (AAU, BKF, C, K); *K. Larsen, T. Smitinand & E. Warncke* 812 (AAU, BKF); *J. Leeratiwong* 99-83 (PSU), 99-166 (KKU); *A. Marcan* 732 (BM, C), 2494 (BM, C); *S. Matthapa* 55

(KKU); *J.F. Maxwell* 75-437 (AAU, BK), 75-996 (AAU, BK), 85-819 (PSU), 87-614 (AAU, CMU), 88-722 (BKF, CMU), 90-592 (CMU), 90-626 (CMU), 91-611(CMU), 91-901 (AAU), 92-430 (CMUB), 93-838 (CMUB), 94-708 (BKF, CMU); 02-211 (CMUB), 08-711 (BKF), s.n. (AAU, BK 211528, BKF 93214); *D.J. Middleton, P. Karaket, P. Triboun, U. Kawatkul & R. Meeboonya* 4591 (BKF); *G. Murata* T-17282 (AAU, BKF, C, K); *G. Murata, C. Phengklai, S. Mitsuta, H. Nagamasu & N. Nantasan* T-37604 (BKF), T-50412 (BKF); *G. Murata, N. Fukuoka & C. Phengklai* T-16588 (AAU-2 sheets, BKF, K), T-16796 (AAU, BKF), T-16818 (BKF); *C. Nahmpisahn* 545 CMU(B); *B. Nasongkhla et al*. s.n. (BCU 3391); *C. Nathalang* s.n. (BCU A0 0 0 2 6 2); *Noy Mao* s.n. (BK 211514); *I.C. Nielsen, T. Jonganurak, N. Hemrat, J. Rilhipheth* 1509 (AAU), 1564 (AAU, BKF); *C. Niyomdham* 2956 (AAU, BKF); *Y. Paisooksantivatana* Y-2265-88 (BK); *Parinya & Santi* 467 (BK); *J. Parnell, C. Pendry, M. Jebb & R. Pooma* 95-280 (AAU, BKF, K, TCD); *C. Phengklai, M. Tamura, C. Niyomdham & B. Sangkachand* 4260 (BKF, C, K); *W. Phumphouk* 364 (CMU); *R. Pooma, N. Pattharahirantricin & S. Sirimongkol* 6644 (A, AAU, BKF, E); *R. Pooma, W.J.J.O. de Wilde, B.E.E. Duyfjes, V. Chamchumroon & K. Phattarahirankanok* 2587 (BKF); *Prayad* 306 (BK); 1014 (BK); *Put* 147 (BK, BM); 149 (TCD); 3062 (BK, BM, C, K); *Rabil* 385 (BK, BM, C, K); *N. Sana* NA 014 (BK), NA 019 (BK), NA 046 (BK); *K. Setbubpa* 29 (BKF); *Serm* 127 (QBG); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham* T-21944 (BKF) *T. Smitinand & F. Floto* 6109 (K-2 sheets); *Th. Sørensen, K. Larsen & B. Hansen* 763 (BKF), 3824 (C), 3839 (C), 3899 (C), 4783 (C); *BGO. Staff* 879 (QBG), 1044 (QBG), 1302 (QBG), 1657 (QBG), 1733 (QBG), 3662 (QBG), 7094 (QBG), 8405 (QBG), 9633 (QBG); *S. Sutheesorn* 261 (BK); *S. Suwannaratana* 12 (CMU); *M.N. Tamura* T-60439 (BKF); *O. Thaithong* s.n. (BCU 006883); *W. Tokaew & P. Chantaranothai* 381 (KKU), 382 (KKU), 386 (KKU), 387 (KKU), 388 (KKU), 390 (KKU), 391 (KKU), 392 (KKU), 417 (KKU), 421 (KKU), 431 (KKU), 434 (KKU), 435 (KKU), 442 (KKU), 437 (KKU); *S. Tsugara* T-61898 (AAU, BKF); *C.F. van Beusekom & C. Charoenpol* 2022 (AAU, BKF); *P. Vanpruk* 1023 (K); *Waraporn, Daungsamorn, Ornanong, Kanungnich* 2 (KKU); *S. Watthana, P. Suksathan & G. Argent* 624 (QBG); *Winit* 362 (BKF, K), 363 (K); *S. Wongsrithong* 611 (CMUB).

11. Uraria picta (Jacq.) Desv. ex DC., Prodr. 2: 324. 1825.— *Hedysarum pictum* Jacq., Collect. Bot. 2: 262. 1788. Type: Jacquin, Ic. Pl. Rar. 3: t. 567. 1792.— *Doodia picta* Roxb., [Hort. Beng.: 98. 1814, *nom. nud.*] Fl. Ind. 3: 368. 1832.— *Uraria linearis* Hassk., Flora 25, Beibl. 2: 48, 61. 1842. Type: not located. (Figs. 26 & 31K)

Erect and unbranched subshrubs 50–120 cm high. *Leavse* 5–9-foliolate; petioles 7–15 cm. long; stipules lanceolate, acuminata-caudate, 26–30 by 5–6 mm. *Leaflets* thinly coriaceous, with pale grey band, linear, 7–20 by 1–2.5 cm; base obtuse or acute; apex acute or acuminata; margin entire; upper surface glabrate; lower surface pubescent, both surfaces with straight hairs and hooked hairs; petiolules 2–3 mm long; stipels narrowly lanceolate, acuminata, 6–12 by 1–2 mm. *Inflorescences* racemose, terminal, erect, 20–30 cm long. *Flowers* dense; bracts lanceolate, 25–27 by 3–5 mm, purple; pedicels *ca.* 10 mm long, up to *ca.* 15 mm at maturity, with straight hairs, hooked hairs and bulbous base straight hairs. *Calyx* pale pink, with straight hairs and bulbous base straight hairs; tube *ca.* 1.5 mm long; upper lobes *ca.* 2.5 mm long, lower ones thread-like, 3–4 mm long. *Corolla* purple to pale violet; standard *ca.* 10 by 7 mm, claw *ca.* 2 mm long; wings *ca.* 10 by 3 mm, claw *ca.* 2 mm long; keel 10 by 3 mm, claw *ca.* 3 mm long. *Ovary* with 7–8 ovules. *Pods* with 5–7 segments; segment ovate-orbicular, 3–3.2 by 2.5–2.8 mm, grey or black, glabrous, rarely with tiny straight hairs. *Seeds* reniform, 2–2.2 by 1.4–1.6 mm, yellow or dark brown .

Thailand. — NORTHERN: Chiang Mai, Chiang Rai, Phayao, Nakhon Sawan; NORTH-EASTERN: Udon Thani, Sakon Nakhon; CENTRAL: Saraburi; PENINSULAR: Songkhla.

Distribution. — Africa, India, China, Taiwan, Cambodia, Vietnam, Philippines, Indonesia, Australia.

Vernacular. — Salet Pangpon (เสลดพังพอน) (Nakhon Sawan), Non Nai (หนอนหน่าย) (Sakon Nakhon).

Ecology. — In dry evergreen and deciduous forests, savanna and grassy places, alt. 0-400 m. Flowering September-October. Fruiting October-December.

Notes. — *U. picta* is a widespread species in Thailand but now the number of plants have been dramatically reduced than other species, according to many areas have been changed for agriculture, housing, touristic areas.

Specimens examined. — *P. Chantaranothai & J. Parnell* 90/761 (KKU); *H.B.G. Garrett* 174 (BKF, K-2 sheets), 174a (K); *A.F.G. Kerr* 2013 (K), 13560 (BK, BM, K); *M.C. Lakshnakara* 1042 (BK, BM, K, TCD), 10712 (BK); *A. Marcan* 1080 (BM, C); *G. Murata, N. Fukuoka & C. Phengklai* T-16574 (AAU, BKF); *Put* 1132 (BK, BM, K); *BGO. Staff* 7660 (QBG); *W. Tokaew & P. Chantaranothai* 397 (KKU), 398 (KKU); *Vanpruk* 1012 (K); *Winit* 769 (BKF, K).

12. Uraria poilanei Dy Phon in Thuân, Dy Phon & Niyomdham, Fl. Cambodge, Laos & Vietnam 23: 109, pl. 19. 1987. Type: Laos, Xieng Khouang, Tam La, *Poilane* 2159 (holotype P!). (Figs. 27, 31L)

Erect and unbranched subshrubs 1–2 m high. *Leaves* 1–3-foliolate; petioles 8–12 cm long; stipels narrowly lanceolate, acuminata, 5–6.5 by 1–1.5 mm. *Leaflets* thinly chartaceous, obovate, rarely ovate, 12–16 by 7–9 cm; base obtuse to acute; apex mucronate; margin entire; upper surface scabrous, lower surface pilose; petiolules 4–5 mm long; stipules lanceolate, acuminata or caudate, 7–12 by 3 mm. *Inflorescences* umbel-like paniculate, terminal, erect, 20–30 cm long. *Flowers* lax; bracts ovate, acuminata, 8–10 by 2.5–3 mm; pedicels 6–8 mm, with hooked hairs, straight hairs and bulbous base straight hairs. *Calyx* greenish-pale purple with hooked hairs and bulbous base straight hairs; tube *ca.* 1.5 mm long; upper lobes *ca.* 1.5 mm long, lower ones 1.5–2 mm long. *Corolla* pale violet to dark blue; standard 8–10 by 6–8 mm, claw *ca.* 1 mm long; wings 6–7 by 3 mm, claw *ca.* 1 mm long. keel 5–6 by 3 mm, claw *ca.* 2 mm long. *Ovary* with 7–8 ovules. *Pods* with 6–8 segments; segment semi-orbicular or suborbicular, 3–4 by 3 mm, with bulbous base straight hairs.

Thailand. — NORTHERN: Chiang Mai.

Distribution. — Laos (type).

Vernacular. — Ton Niaw Bai Yai (**ต้นเหนียวใบใหญ่**).

Ecology. — In deciduous forests, alt. 700-1,000 m. Flowering November-December. Fruiting December-January.

Specimens examined. — *Adisai* 688 (BK); *K. Bunchuai* 1377 (BKF); *C. Chermsiriwathana* 1184 (BK); *H. Koyama, H. Terao, C. Niyomdham & T. Wongprasert* T-30495 (BKF); *J.F. Maxwell* 05-659 (CMUB), 88-1331 (CMU), 93-1436 (CMUB), 94-151 (CMUB) 95-1039 (CMUB, BKF), 96-1465 (BKF), 96-1466 (CMUB), 96-1550 (CMUB, BKF); *N. Panatkool* 44 (CMUB); *T. Smitinand* 89-44 (BKF), s.n. (BKF); *BGO. Staff* 50 (QBG), 5274 (QBG), 5394 (QBG); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 4206 (BKF).

13. Uraria pseudoacuminata W. Tokaew & Chantar., ScienceAsia 39: 327. 2013. Type: Thailand, Bueng Kan, Bungkhla, Phu Wua Wildlife Sanctuary, *W. Tokaew & P. Chantaranothai 403* (holotype KKU!). (Figs. 28, 31M)

Erect and unbranched subshrubs 40–60 cm high. *Leaves* (3–) 5–7-foliolate; petioles 6–10 cm. long, with; stipules deltoid, acuminata, 7–8 by 2–3 mm. *Leaflets* slightly coriaceous, bright green, lanceolate or narrowly lanceolate, 7–12 by (1–) 2–3.5 cm, base obtuse, apex acuminata, margin entire, upper surface glabrous; lower surface scabrous; petiolules 1.5–2 mm long; stipels narrowly lanceolate, acuminata, 1.5–2 by 1 mm. *Inflorescences* racemose, terminal, erect, 10–15 cm long. *Flowers* densely packed on the axis; bracts lanceolate, 12–14 by 1–2 mm, pale purple or pale green; pedicels 8–10 mm long, with hooked hairs and bulbous base straight hairs, rarely with straight hairs. *Calyx* pale purple, with straight hairs and bulbous base straight hairs; tube *ca.* 2 mm long; upper lobes 2, *ca.* 2.5 mm long; lower lobes 3, thread-like, *ca.* 4 mm long. *Corolla* pale violet; standard 10-12 by 9-10 mm, claw *ca.* 2 mm long; wings 8–9 by 3–3.5 mm, claw *ca.* 1 mm long; keels 8-9 by 3–3.5 mm, claw 2–2.5 mm long. *Ovary* with 2 ovules. *Pods* with 2 segments, each segment orbicular, 4–5 by 3–4 mm, connected on the transverse side of each segment, pale brown or gray, glabrous, sometime with few tiny straight hairs. *Seeds* reniform, 2–3 by 2 mm, pale brown.

Thailand. — NORTH-EASTERN: Udon Thani, Bueng Khan (type), Khon Kaen; EASTERN: Chaiyaphum, Nakhon Ratchasima; SOUTH-EASTERN: Chonburi, Chanthaburi.

Distribution — Vietnam.

Vernacular. — Hangsua Baipai (**หางเสือใบไผ่**).

Ecology. – In dry evergreen and deciduous forests, alt. 300-1,000 m. Flowering August-September. Fruiting September-December.

Specimens examined. — *C. Charoenpol, K. Larsen & E. Warncke 4491* (AAU); *K. Larsen, S.S. Larsen, I.Nielsen & T. Santisuk 31388*(AAU); *J.F. Maxwell 76-631*(AAU); *G. Murata, C. Phengklai, S. Mitsuta, H. Nagamasu & N. Namtasan* T-41860 (BKF); *I.C. Nielsen, C. Niyomdham, T. Jonganutak, N. Hemrat & J. Rithipheth* 1580 (AAU); *B. Sangkhachand* s.n. (BKF 13174); *W. Sidajium* 54 (BKF); *C.H.* 374 (BKF 46328); *W. Tokaew* 403 (KKU); *C.F. van Beusekom, Chanwid & R. Geesink* 3299 (BKF, C, K); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 9167 (BKF).

14. Uraria rotundata Craib, Bull. Misc. Inform., Kew 1912: 151. 1912 & Fl. Siam. En.: 60. 1912. Type: Thailand, Chon Buri, Sriracha, *A.F.G. Kerr* 2136 (holotype K!, isotypes BM!, K!, TCD!).— *Uraria pierrei* Schind. in Engl., Bot. Jahrb. Syst. 54: 53. 1916. Type: Cambodia, Thpong (Kompong Speu), *Pierre* 1009 (5.1870) (holotype P!), **syn.nov**. (Figs. 14, 29 & 31N)

Erect herbs, sometime ascending 10–30 cm high. *Leaves* 1 (–3)-foliolate; petioles 2.5–5 cm long; stipules lanceolate, acuminata, *ca.* 10–15 by 1–2 mm. *Leaflets* thinly chartaceous, orbicular or ovate, 2–6 by 2–6 cm; base obtuse; apex obtuse, retuse-mucronate; margin entire; upper surface and lower surface grabrate; petiolules 1–2 mm long; stipels narrowly lanceolate, acuminata, 2–3 by *ca.* 1 mm. *Inflorescences* racemose, terminal, erect, 3–10 cm long. *Flowers* very dense; bracts lanceolate, acuminata, 15–20 by 3–4 mm; pedicels 3–4 mm long; with straight hairs, glandular hairs and only hooked hairs towards the apex. *Calyx* with straight hairs, hooked hairs and bulbous base straight hairs; tube *ca.* 1 mm long; upper lobes *ca.* 2 mm long, lower ones thread-like, 4–5 mm long. *Corolla* purple to pale violet;

standard 6–8 by 5–8 mm, claw *ca.* 1 mm long; wings 5–6 by 2–2.5 mm, claw *ca.* 1 mm long; keel 5–6 by 2–2.5 mm, claw *ca.* 2 mm long. *Ovary* with 2 ovules. *Pods* with 1–2 segments; segment orbicular, 2.5–2.7 by 2–2.5 mm, dark grey or black, with tiny straight hairs. *Seeds* reniform, 1.5–2 by 1.2–1.5 mm, yellow or greenish yellow.

Thailand. — NORTHERN: Tak; EASTERN: Chaiyaphum, Buri Ram; SOUTH-WESTERN: Kanchanaburi, Phetchaburi, Prachuap Khiri Khan; SOUTH-EASTERN: Chon Buri (type).

Distribution. — Cambodia.

Vernacular. — Makkanuan Kuy (มักก่านวนกุ่ย) (Buri Ram), Ya Hang On (หญ้าหางอัน) (Chon Buri) (type).

Ecology. — In deciduous forest, alt. 0-400 m. Flowering May-October. Fruiting June-December.

Note. — *Uraria pierrei* is supposed to be distinct from *U. rotundata* in having 3-foliolate and rarely 1-foliolat leaves. However, some specimens show marked character overlap with *U. rotunda* which usually has 1-foliolate leaves. Therefore, we do not consider the two taxa to be distinct.

Specimens examined. — *Bunnak* 609 (BCU, BK); *C. Chermsiriwathana* 94 (BK); *D.J. Collins* 1612 (K); *A.F.G. Kerr* 2136 (BM, K-2 sheets, TCD), 12847 (BK, BM, K); *A. Marcan* 933 (BK, BM, C, K); *J.F. Maxwell* 71-432 (AAU, BK), 75-412 (AAU, BK); *G. Murata, C. Phengklai, S. Mitsuta, H. Nagamasu & N. Nantasan* T-37279 (BKF), T-37375 (BKF); *C. Niyomdham* 5766 (BKF); *C. Niyomdham & P. Puudjaa* 5886 (BKF); *C. Phengklai et al.* 12522 (BKF); *C. Phengklai, M. Tamura, C. Niyomdham & B. Sangkhachand* 4246 (BKF); *R. Pooma & N. Pattharahirantricin* 7744 (AAU, MBK); *R. Pooma, N. Pattharahirantricin, S. Sirimongkol & P. Supachok* 7489 (AAU, BKF); *B. Sangkhachand* 1577 (AAU, C, K); *T. Shimizu, F. Konta, T. Wongprasart & B. Sangkhachand* T-28714 (BKF); *S. Sutheesorn* 663 (BK); *O. Thaithong et al.* 217 (BCU); W. Tokaew 904 (KKU), 909 (KKU); *C.F. van Beusekom, C. Phengklai, R. Geesink & B. Wongwan* 4012 (BKF).

15. Uraria rufescens (DC.) Schindl. in Fedde, Repert. Spec. Nov. Regni Veg. 21: 14. 1925.— *Desmodium rufescens* DC., Ann. Sci. Nat. (Paris) 4: 101. 1825 & Prodr. 2:

335. 1825. Type: India, de Candolle microfiche no. 95 (G-DC).— *Meibomia rufescens* (DC.) Kuntze, Revis. Gen. 1: 198. 1891.— *Hedysarum hamosum* Roxb., Hort. Beng.: 57. 1814, *nom. nud*.— *Doodia hamosa* Roxb., [Hort. Beng.: 98. 1814, *nom. nud*.] Fl. Ind. 3: 367. 1832. Type: India, Bengal, *Wallich* 5681B (K!-W!).; *Wallich* 5681A=*Hed. Lagopodioides*.— *Uraria hamosa* (Roxb.) Wight & Arn., Prodr. Fl. Ind. Orient. 1: 222. 1834.— *Uraria paniculata* Hassk., Cat. Hort. Bog.: 273. 1844. Type: not located.— *Uraria gracilis* Prain, J. Asiat. Soc. Bengal 66: 383. 1897. Type: Myanmar, Sagaing, *King's Colector* s.n., not located. (Figs. 15, 30, 31O)

Erect and branched herbs or subshrubs, sometime ascending, rarely prostrate 20–100 cm high. *Leaves* (1–) 3-foliolate; petioles 1–2 cm long; stipules deltoid or lanceolate, acuminata, 10–15 by 2–3 mm. *Leaflets* thinly chartaceous, green, ovate, elliptic or broadly elliptic, (2.5–) 4–10 by (1.5–) 3–6 cm; base obtuse, retuse; apex obtuse, retuse or mucronate; margin entire; upper surface slightly scabrous or scabrous; lower surface pilose; petiolules 2–3 mm long; stipel*s* narrowly lanceolate, acuminata, 5–6 by 1–1.5 mm. *Inflorescences* paniculate or racemose on small plants, terminal, erect, (10–) 15–30 cm long. *Flowers* lax; bracts green, broadly ovate to ovate, caudate, 8–10 by 2.5–3 mm; pedicels 2–3 mm. long, up to 3–4 mm at maturity, with straight hairs, hooked hairs and bulbous base straight hairs. *Calyx* reddish green, pubescent with straight hairs and bulbous base straight hairs; tube *ca.* 1 mm long; upper lobes *ca.* 1 mm long; lower ones *ca.* 2 mm long. *Corolla* purple to pale violet; standard 5–6 by 4–5 mm, claw *ca.* 1 mm long; wings 4–5 by 2 mm, claw *ca.* 1 mm long; keel 4–5 by 2 mm, claw *ca.* 2 mm long. *Ovary* with (4–) 6–8 ovules. *Pods* with (4–) 6–8 segments; segment orbicular, *ca.* 2.5 by 2 mm, black, with tiny hooked hairs. *Seeds* reniform, 1.3–2 by 1.2–1.5 mm, yellow or brown.

Thailand. — NORTHERN: Mae Hong Son, Chiang Mai, Chiang Rai, Lampang, Phrae, Tak, Nakon Sawan; NORTH-EASTERN: Phetchabun, Loei; EASTERN: Nakhon Ratchasima; SOUTH-WESTERN: Uthai Thani, Kanchanaburi, Prachuap Khiri Khan; SOUTH-EASTERN: Chon Buri, Rayong; PENINSULAR: Surat Thani, Songkhla.

Distribution. — India (type), Myanmar, China, Laos, Vietnam, Cambodia, Indonesia.

Vernacular. — Ton Niaw Lek (ต้นเหนียวเล็ก) (Prachuap Khiri Khan).

Ecology. — In evergreen, dry evergreen and deciduous forests and savanna, alt. 0-1,000 m. Flowering October-November. Fruiting November-December.

Specimens examined. — *A.F.G. Kerr* 1553B (BK, BM, C, K, TCD), 3008 (BM, K), 4563 (BK, BM, C, K, TCD), 11269 (AAU, BK, BM, K), 13597 (BK, BM, K, TCD); *K. Larsen* 8653 (C), 8882 (C); *A. Marcan* 1117 (BM, C); *J.F. Maxwell* 74-985 (AAU, BK), 75-1065 (AAU, BK); 87-1307 (BKF, CMU); 90-11 (CMU), 90-1161 (CMU), 90-1196 (AAU, CMU), 91-905 (AAU), 94-48 (BKF), 94-1107 (BKF), 94-1229 (BKF), 95 -10 0 3 (BKF), 96-1340 (BKF), 97-1310 (BKF); *Y. Paisooksantivatana* Y-2291-88 (BK); *O. Petrmitr* 404 (BKF); *R. Pooma, N. Pattharahirantricin, S. Sirimongkol & P. Supachok* 7612 (AAU, BKF, K, MBK); *T. Shimizu, H. Toyokuni, H. Koyama, T. Yahara & C. Niyomdham* T-22420 (AAU, BKF, C), T-22433 (BKF, C); *T. Smitinand* 4897 (BKF); *Th. Sørensen, K. Larsen & B. Hansen* 5513 (C), 5521 (C); *BGO. Staff* 9759 (QBG); *Put* 2127 (AAU, BK, BM, C, K), 2457 (AAU, BK, BM, K), 2518 (BK, BM, C, K, TCD), 4293 (BK, BM, C, K); *W. Tokaew* 901 (KKU); *W. Tokaew & P. Chantaranothai* 414 (KKU), 415 (KKU), 419 (KKU), 424 (KKU), 425 (KKU), 427 (KKU), 430 (KKU), 433 (KKU), 444 (KKU), 446 (KKU), 448 (KKU); *Vacharapang* 383 (BK); *C.F. van Beusekom & C. Charoenpol* 1987 (AAU).

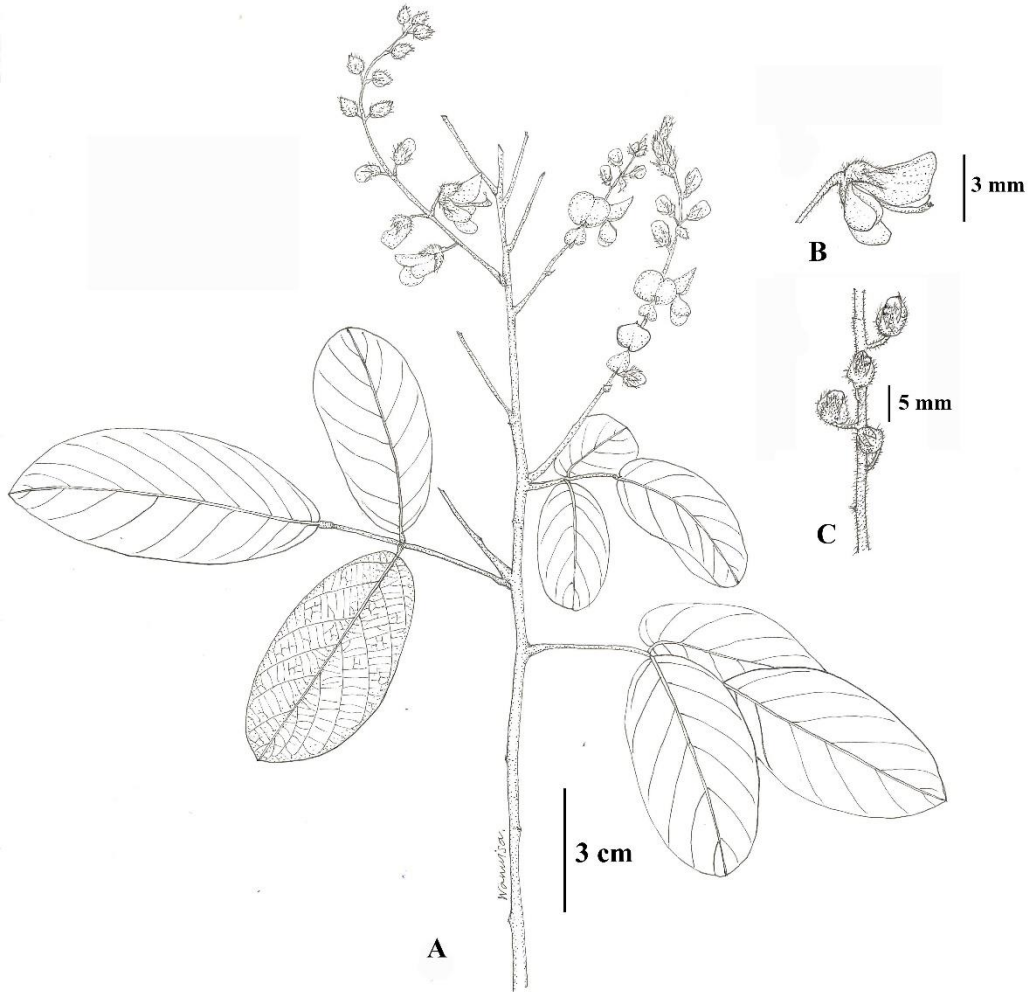

Figure 10 Drawing of *Uraria campanulata:*
A. habit; **B**. flower; **C**. fruits

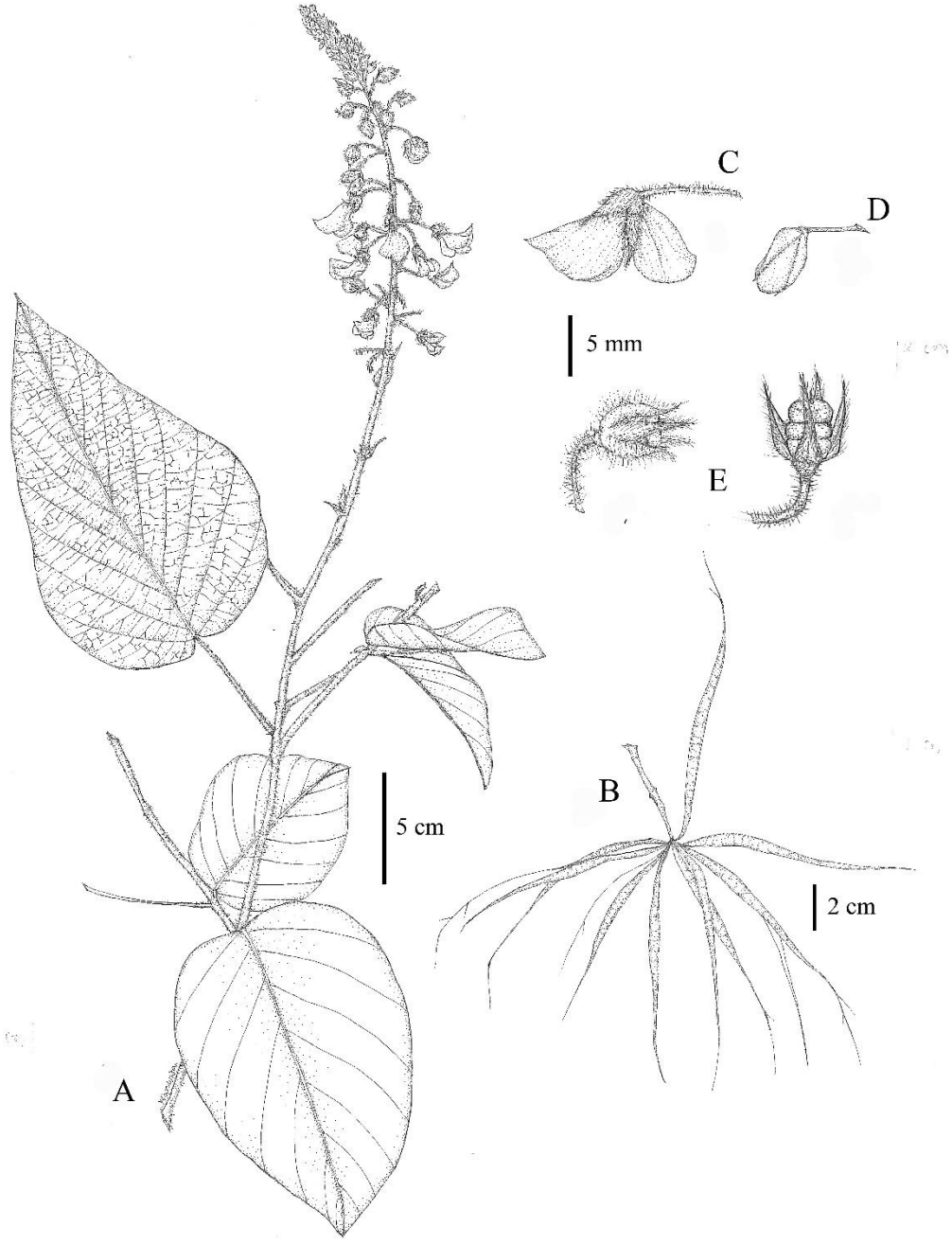

Figure 11 Drawing of *Uraria cordifolia:*

A. habit; **B**. root; **C.** flower; **D**. flower bud; **E.** fruit

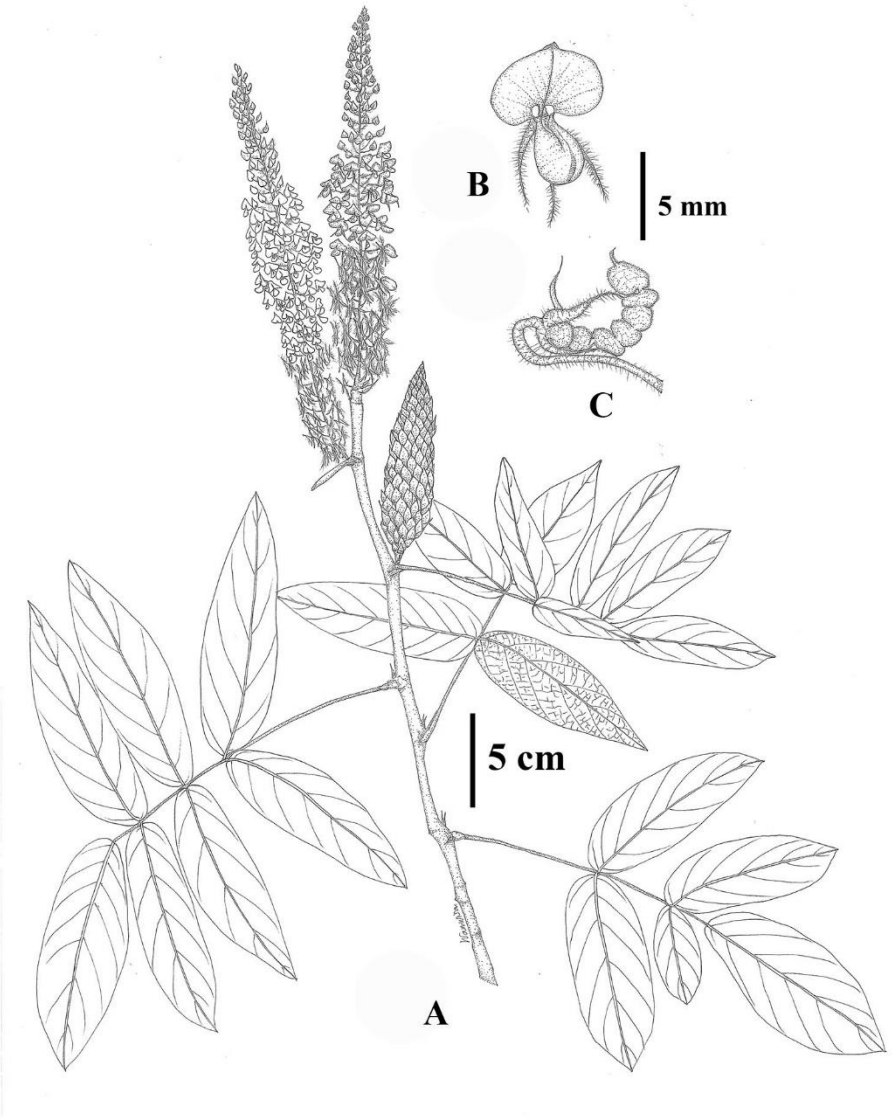

Figure 12 Drawing of *Uraria crinita*:
A. habit; **B**. flower; **C**. fruit

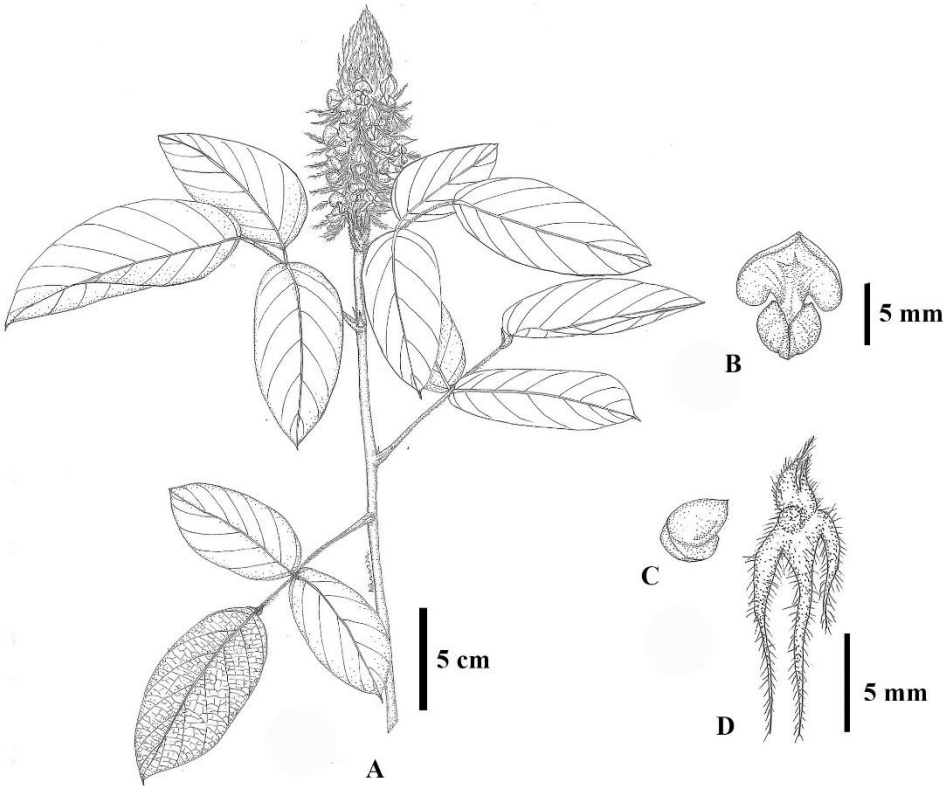

Figure 13 Drawing of *Uraria lagopodioides:*
A. habit; **B.** flower; **C**. fruit; **D**. calyx of fruit.

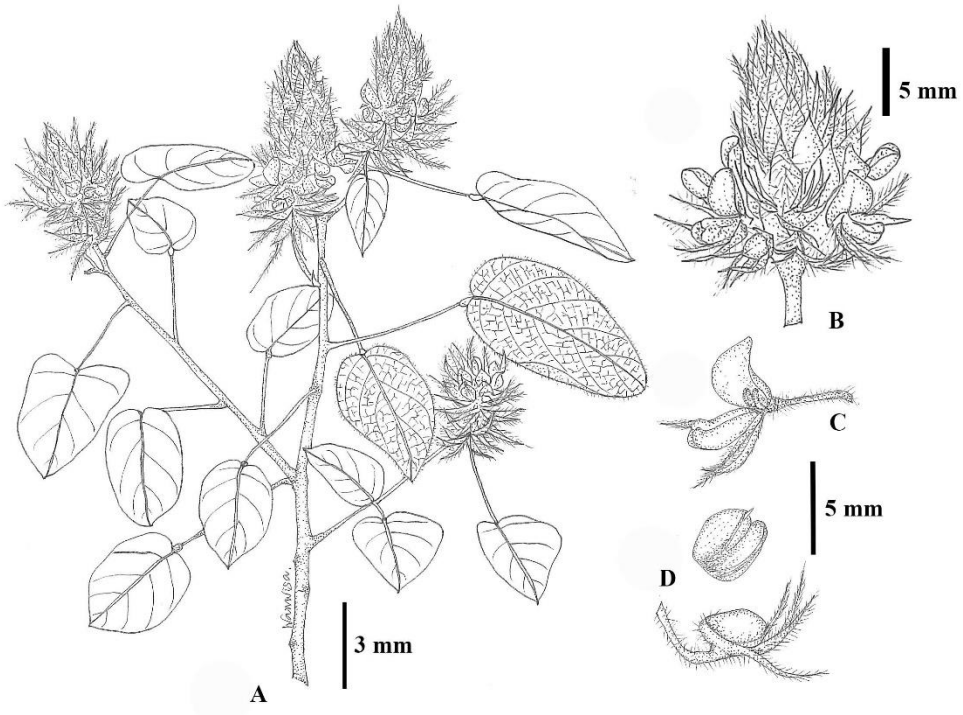

Figure 14 Drawing of *Uraria rotundata:*
A. habit; **B**. inflorescent; **C**. flower; **D**. fruit

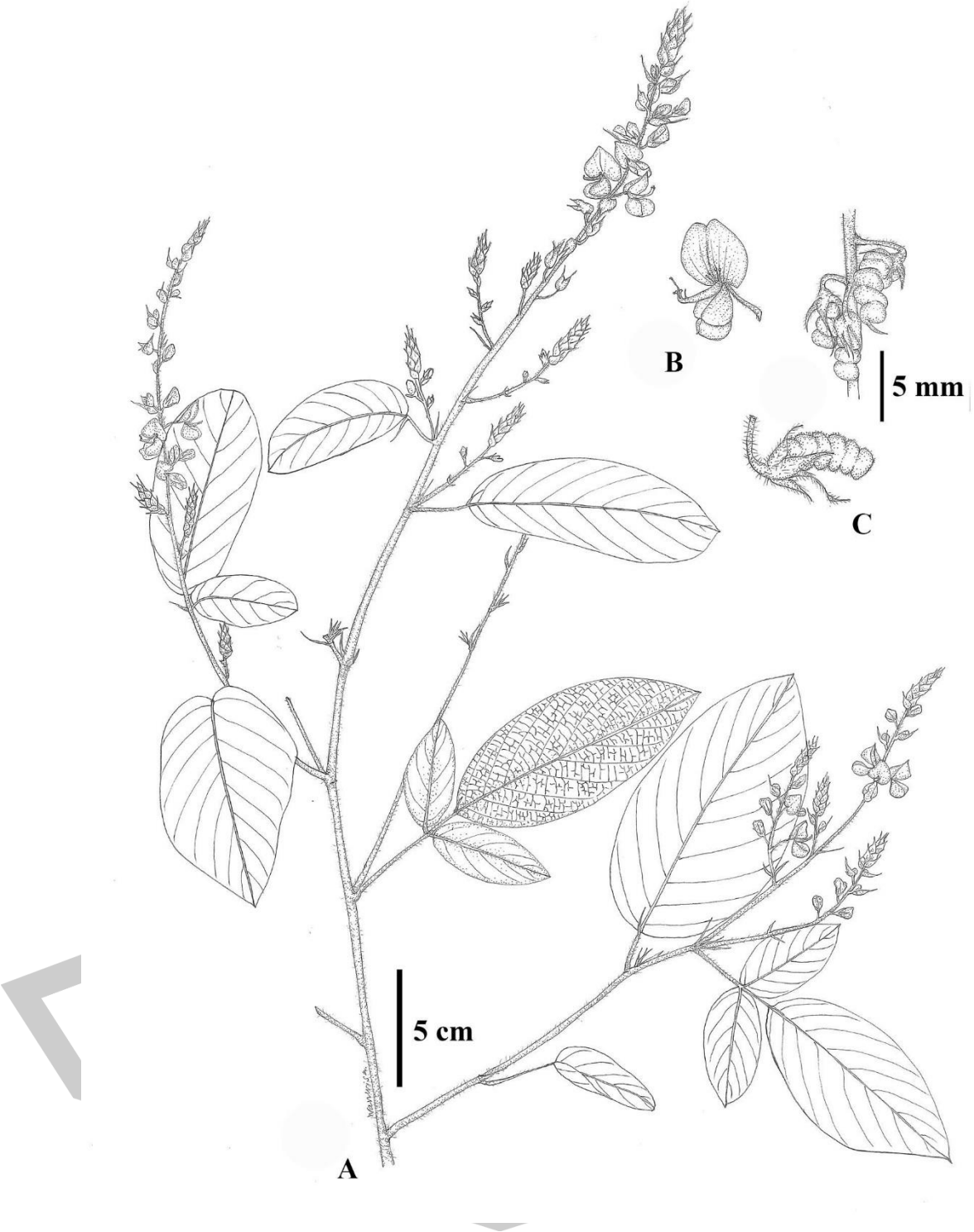

Figure 15 Drawing of *Uraria rufescens:*

A. habit; **B**. flower; **C.** fruit

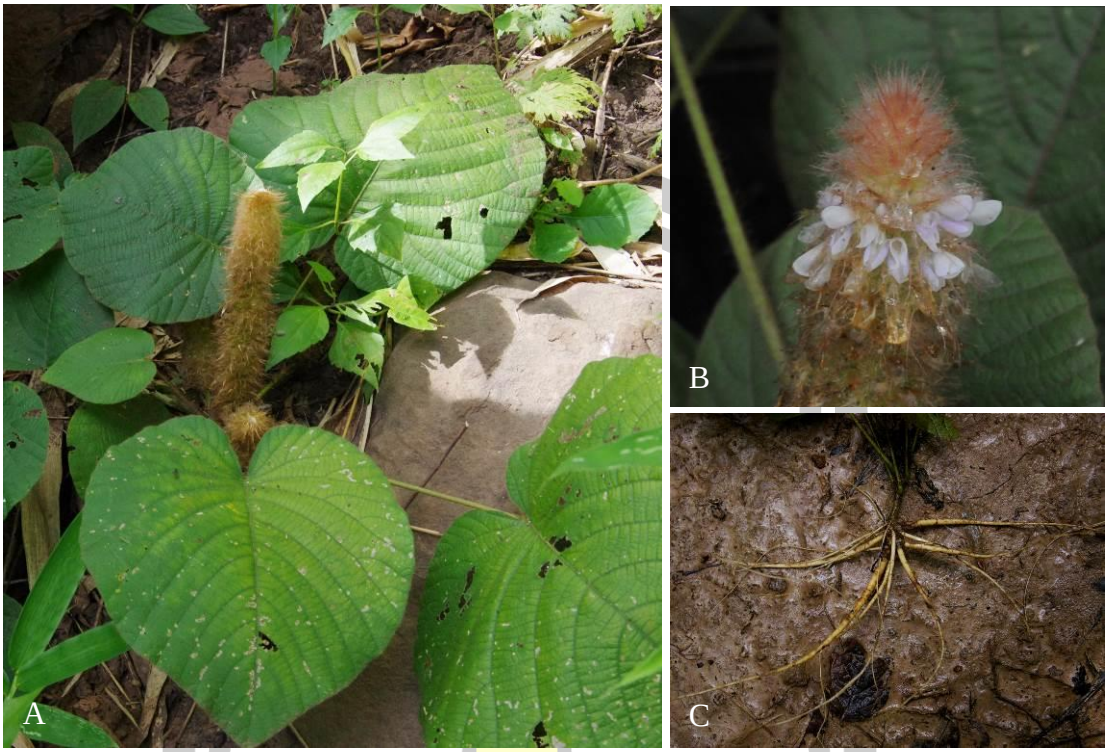

Figure 16 *Uraria acaulis:*

A. habit; **B**. inflorescence; **C**. roots

Figure 17 *Uraria acuminata:*

A. habit; **B**. leaves; **C**. inflorescence and flowers

Figure 18 *Uraria balansae:*

A. leaves and inflorescence; **B**. fruits

Figure 19 *Uraria barbaticaulis:*

A. habit; **B**. inflorescence; **C**. fruits (Photographs by Sawai Mattapha).

Figure 20 *Uraria campanulata:*

A.-**B**. habit; **C**.-**D**. inflorescence and flowers; **E**. fruits

Figure 21 *Uraria cochinchinensis:* Leaves, inflorescence and flowers (Photograph by Wongsatit Chuakul).

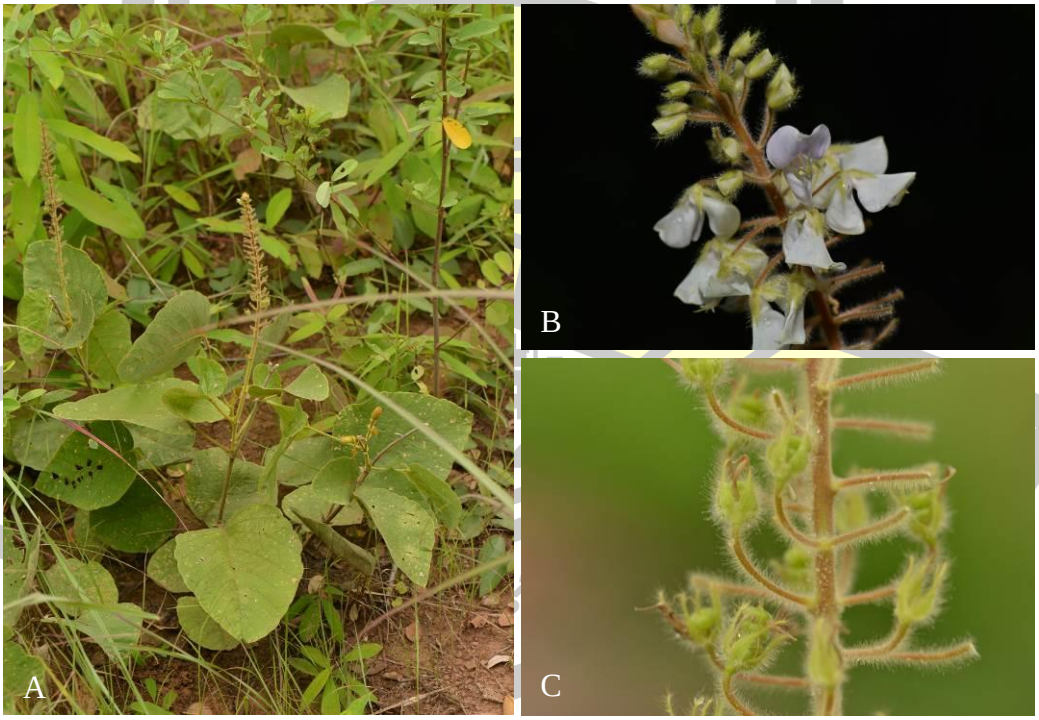

Figure 22 *Uraria cordifolia:*

A. habit**; B**. flowers; **C**. fruits (Photographs by Henrik Balslev).

Figure 23 *Uraria crinita:* **A**.**-D**. habit; **E**. inflorescence**; F**. fruits

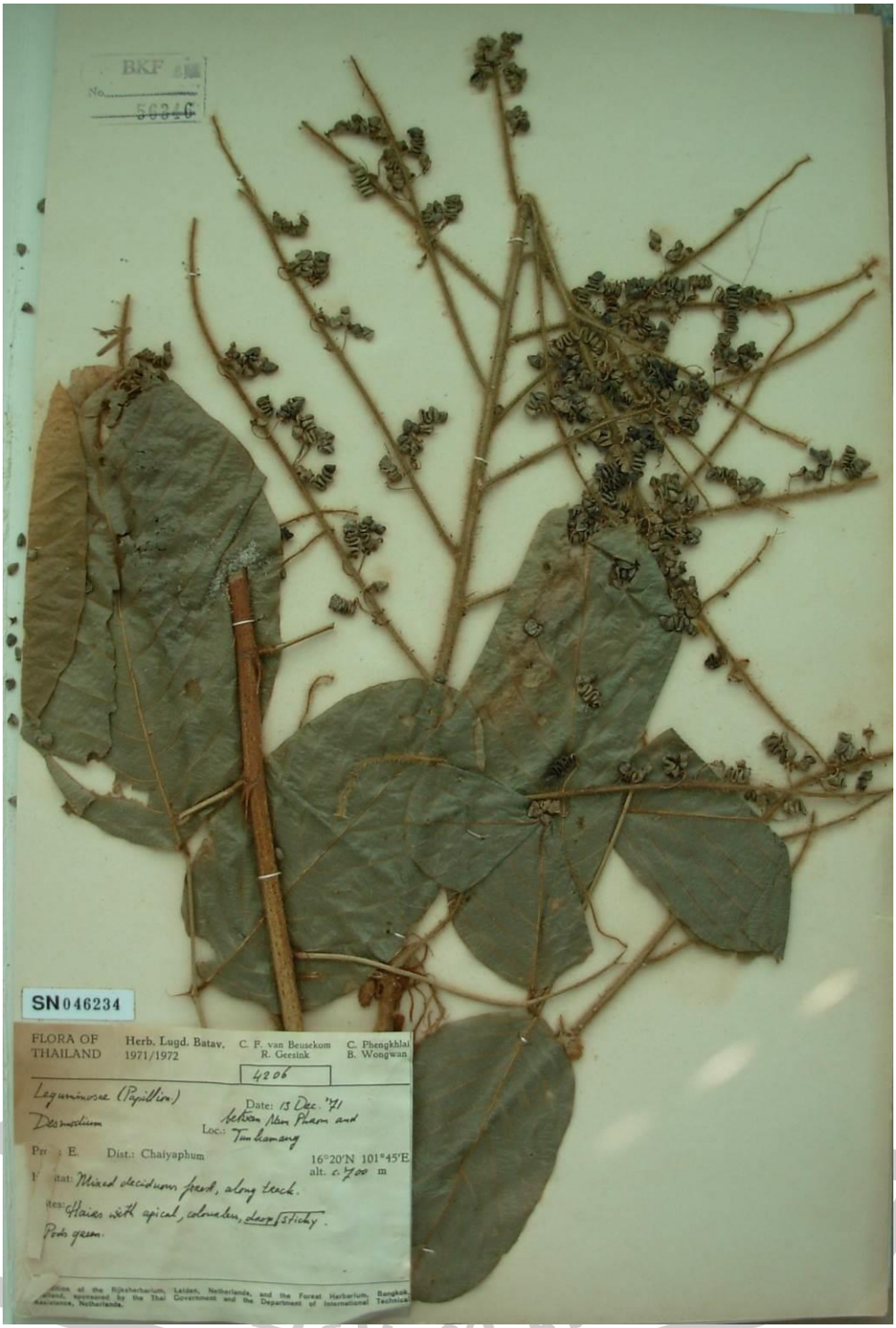

Figure 24 *Uraria lacei:* leaves, inflorescence and fruits

Figure 25 *Uraria lagopodioides*: **A**.-**B**. habit; **C**. leaves and inflorescence

Figure 26 *Uraria picta*: habit, leaves and inflorescence

Figure 27 *Uraria poilanei*: leaves, inflorescence and flowers

Figure 28 *Uraria pseudoacuminata*: **A**. habit, leaves and flowers; **B**. fruits

Figure 29 *Uraria rotundata*: **A**. habit and leaves; **B**. inflorescence

Figure 30 *Uraria rufescens*: **A**. habit; **B**. inflorescence; **C**. fruits

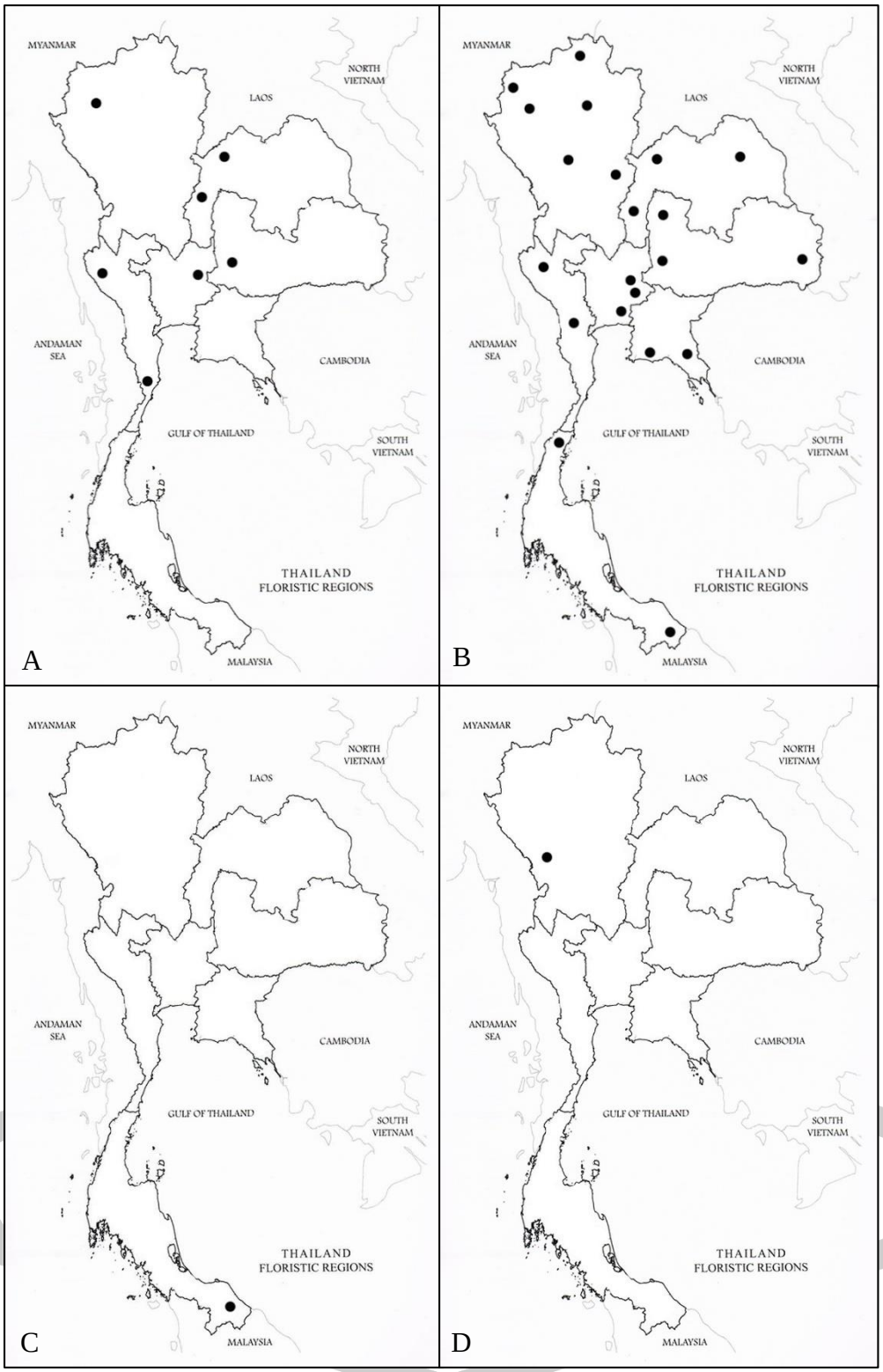

Figure 31 Distribution of *Uraria* spp. in Thailand*:*

A. *U. acaulis*; **B**. *U. acuminata*; **C**. *U. balansae*; **D**. *U. barbaticaulis*

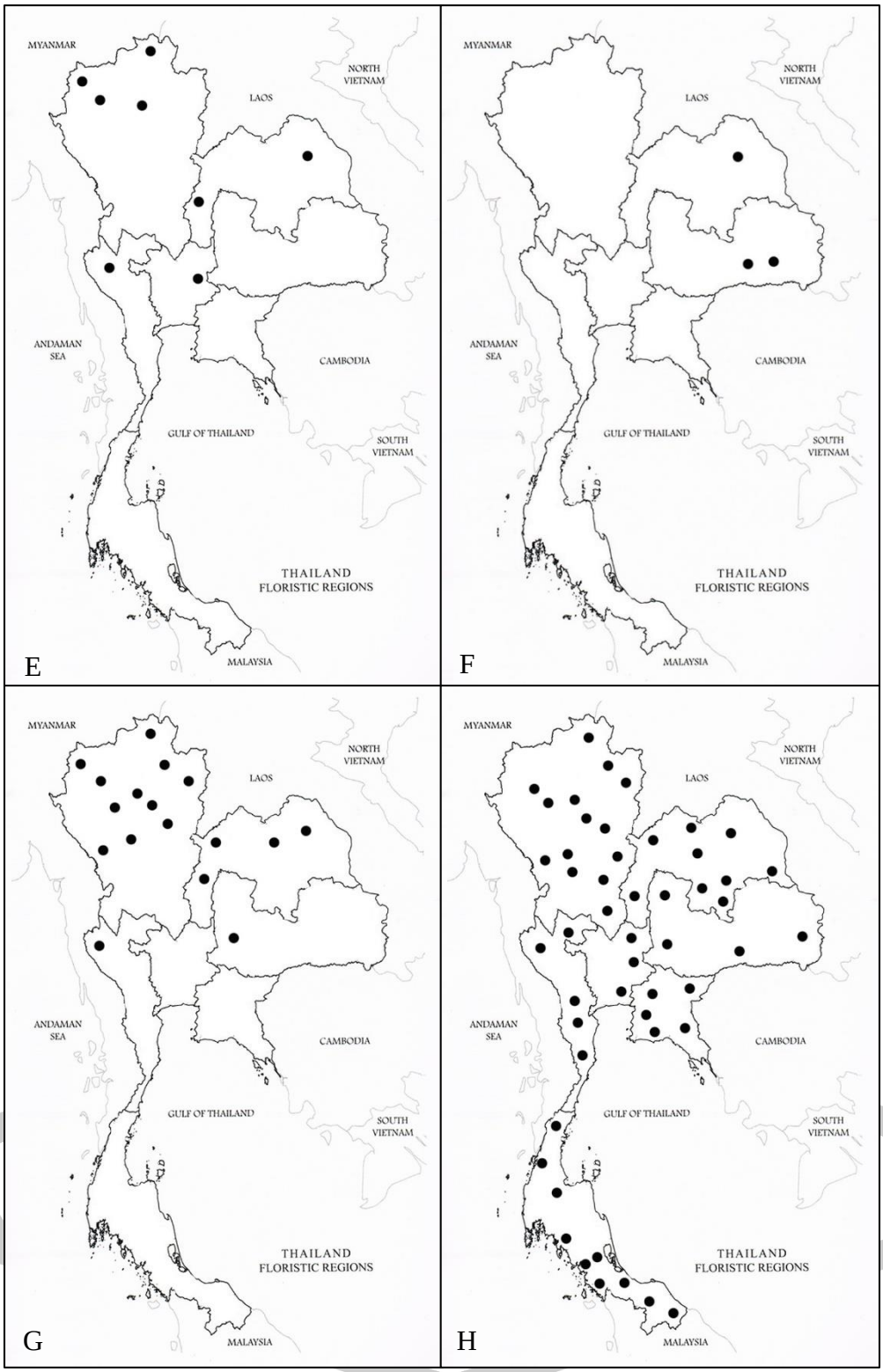

Figure 31 Distribution of *Uraria* spp. in Thailand (Cont.):

E. *U. campanulata*; **F**. *U. cochinchinensis*; **G**. *U. cordifolia*; **H**. *U. crinita*

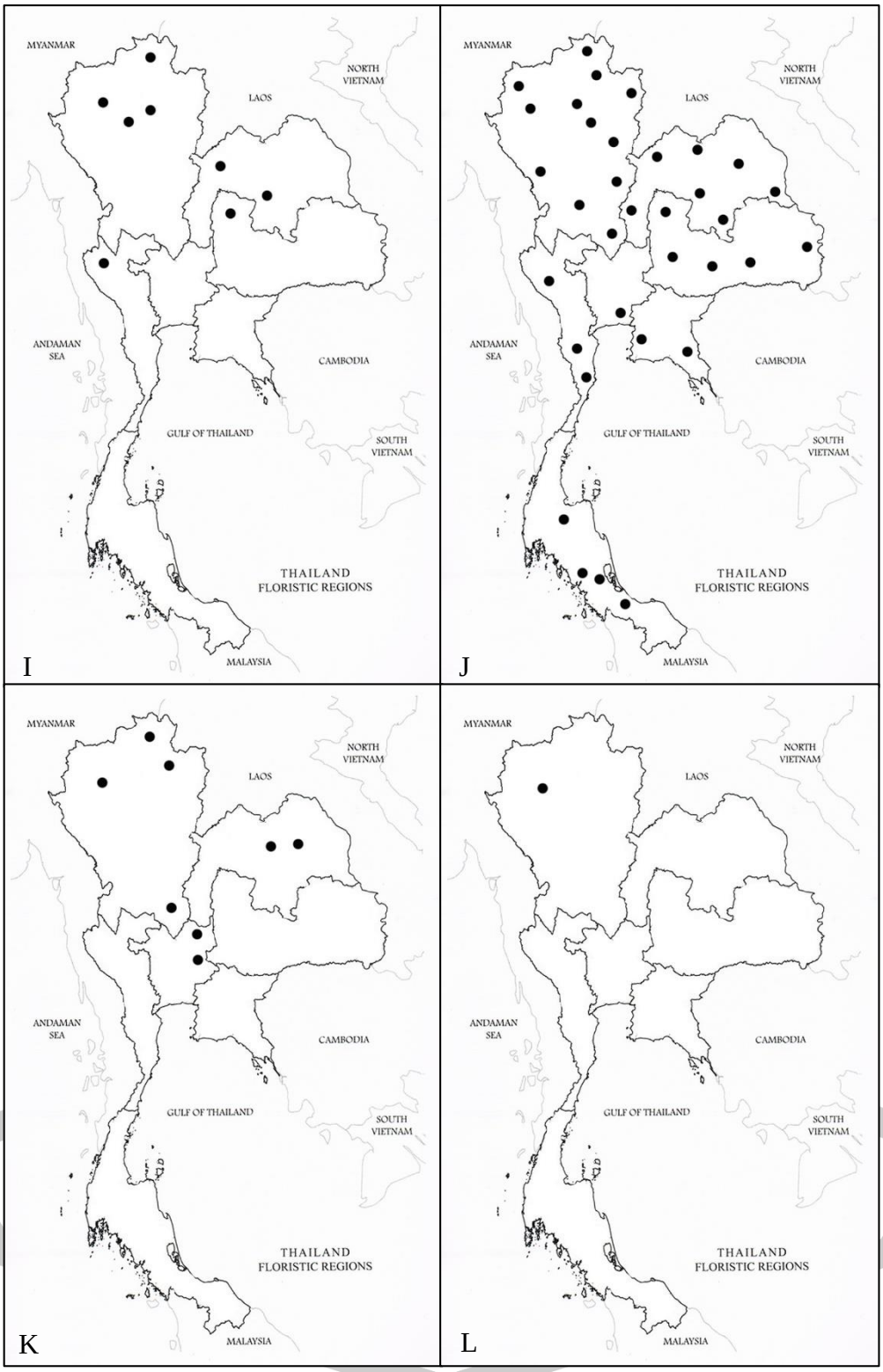

Figure 31 Distribution of *Uraria* spp. in Thailand (Cont.):

I. *U. lacei*, **J**. *U. lagopodioides*, **K**. *U. picta*, **L**. *U. poilanei*

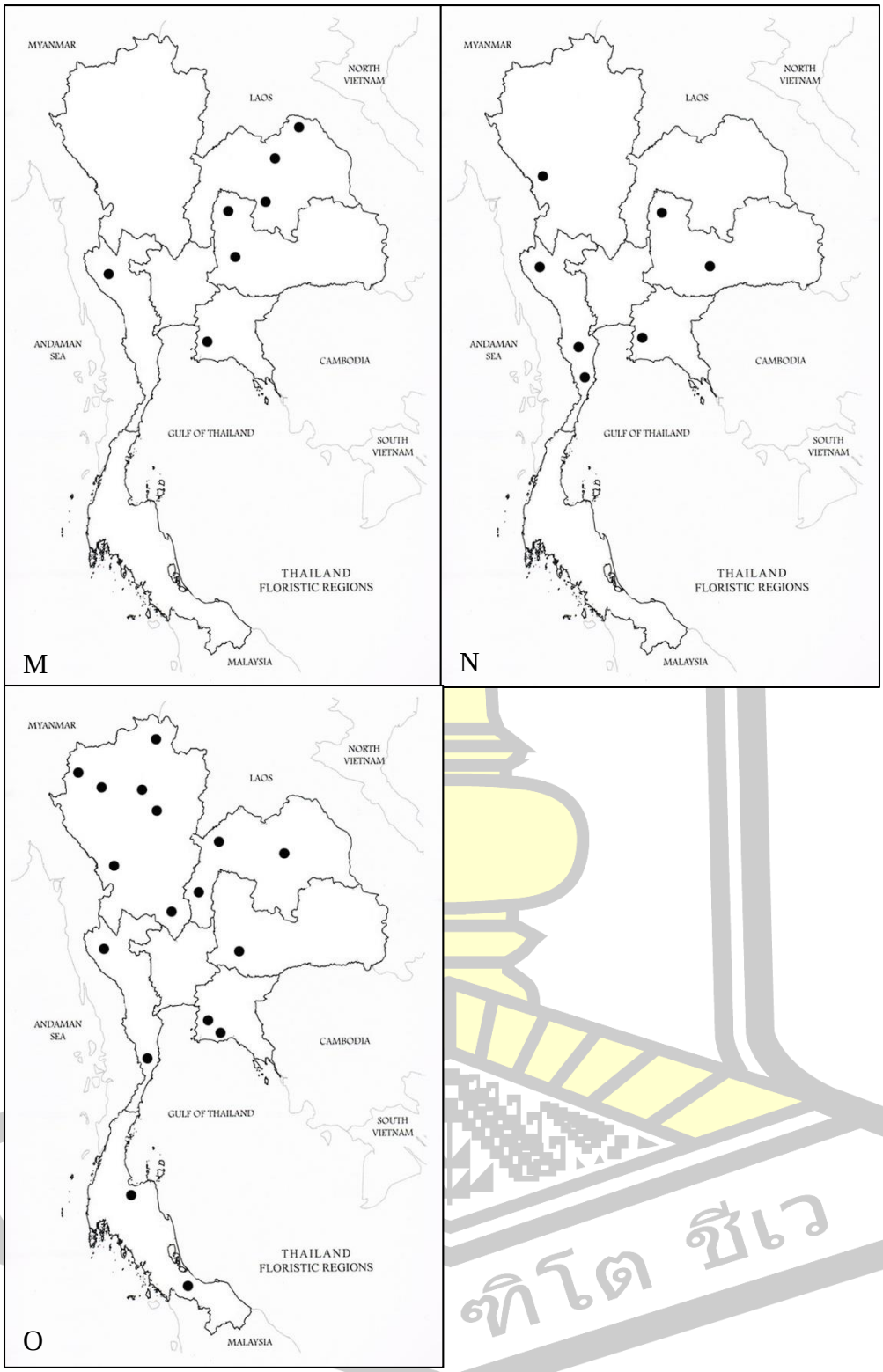

Figure 31 Distribution of *Uraria* spp. in Thailand (Cont.):

M. *U. pseudoacuminata*, **N**. *U. rotundata*, **O.** *U. rufescens*

4.2 Seeds Morphology

4.2.1 General seed character of genus *Christia*

Seed shape reniform and ovate; 1.5-2.5 mm long, 1.2-2 mm wide. Aril present, fleshy, annular. Seed surface smooth, monochrome with dark yellow, brown to dark brown or reddish brown; testa with foveolate-rugulate or reticulate-rugulate ornamentation. (Tab. 9)

4.2.1.1 *Christia obcordata*

Seed shape reniform and ovate; 1.5-1.7 mm long, 1.2-1.3 mm wide. Seed surface brown and reddish brown; testa foveolate-rugulate (Fig. 32 A-C).

4.2.1.2 *Christia pierrei*

Seed shape reniform and ovate; 2-2.2 mm long, 1.5-1.7 mm wide. Seed surface brown; testa reticulate-rugulate (Fig. 32 D-F).

4.2.1.3 *Christia vespertilionis*

Seed shape reniform and ovate; 2-2.2 mm long, 1.8-2 mm wide. Seed surface dark yellow, brown and dark brown; testa foveolate-rugulate (Fig. 32 G-I).

4.2.2 General seed character of genus *Uraria*

Seed shape reniform, cordate, round, and ovate; 1.5-3.2 mm long, 1.2-2.5 mm wide. Aril present, fleshy, annular. Seed surface smooth, monochrome with yellow to dark yellow, greenish yellow, brown to dark brown or reddish brown; testa with foveolate-rugulate or reticulate-rugulate ornamentation.

4.2.2.1 Uraria *acaulis*

Seed shape reniform and ovate; 2.6-3.2 mm long, 2.1-2.5 mm wide. Seed surface reddish brown; testa reticulate-rugulate (Fig. 33 A-C).

4.2.2.2 *Uraria acuminata*

Seed shape reniform and ovate; 2.2-2.6 mm long, 1.8-2 mm wide. Seed surface brown and reddish brown; testa reticulate-rugulate (Fig. 33 D-F).

4.2.2.3 *Uraria cochinchinensis*

Seed shape reniform and round; 2-2.5 mm long, 2-2.5 mm wide. Seed surface dark brown and reddish brown; testa foveolate-rugulate (Fig. 33 G-I).

4.2.2.4 *Uraria cordifolia*

Seed shape reniform and cordate; 2.1-2.5 mm long, 1.5-2 mm wide. Seed surface dark brown and reddish brown; testa foveolate-rugulate (Fig.33 J-L).

4.2.2.5 *Uraria crinita*

Seed shape reniform and ovate; 1.5-2.2 mm long, 1.5-2 mm wide. Seed surface yellow, greenish yellow and brown; testa foveolate-rugulate (Fig. 33 M-O).

4.2.2.6 *Uraria lagopodioides*

Seed shape reniform, elliptic and ovate; 2-2.3 mm long, 1.5-1.8 mm wide. Seed surface yellow, and brown; testa foveolate-rugulate (Fig. 33 P-R).

4.2.2.7 *Uraria picta*

Seed shape reniform and ovate; 2-2.2 mm long, 1.4-1.6 mm wide. Seed surface dark yellow and dark brown; testa foveolate-rugulate (Fig. 33 S-U).

4.2.2.8 *Uraria rotundata*

Seed shape reniform, elliptic and ovate; 1.8-2 mm long, 1.2-1.5 mm wide. Seed surface yellow and greenish yellow; testa foveolate-rugulate (Fig. 33 V-X).

4.2.2.9 *Uraria rufescens*

Seed shape reniform, ovate and round; 1.3-2 mm long, 1.2-1.5 mm wide. *Seed surface* yellow and greenish yellow; testa reticulate-rugulate (Fig. 33 Y-AA).

4.3 Pollen Morphology

The pollen morphological characters of genus *Uraria* are monads, isopolar, radial symmetry, tricolporate, middle in size, prolate spheroidal, subprolate and prolate, ranging from 25 µm to 37.5 µm in polar axis and 28.75 to 47.5 µm in equatorial axis, Sculpture smooth, weakly rugulate and regulate. List of pollen morphological characters are additionally summarized in Table 10.

4.3.1 *Uraria acaulis*

The pollen grain prolate spheroidal, rarely subprolate, 30-37.5 (33.75±2.43) µm in polar axis and 32.5-40 (34.75±2.49) µm in equatorial axis, Sculpture weakly regulate. (Figs. 34 A-B & 35 A-B).

Table 9 List of seed morphological characters of some *Christia* and *Uraria*

Species	Shape	Colour	Testa ornamentation
C. obcordata	reniform, ovate	brown, reddish brown	foveolate-rugulate
C. pierrei	reniform, ovate	brown	reticulate-rugulate
C. vespertilionis	reniform, ovate	dark yellow, brown, dark brown	foveolate-rugulate
U. acaulis	reniform, ovate	reddish brown	reticulate-rugulate
U. acuminata	reniform, ovate	brown, reddish brown	reticulate-rugulate
U. cochinchinensis (Urariopsis)	reniform, round	dark brown, reddish brown	foveolate-rugulate
U. cordifolia (Urariopsis)	reniform, cordate	dark brown, reddish brown	foveolate-rugulate
U. crinita	reniform, ovate	yellow, greenish yellow, brown	foveolate-rugulate
U. lagopodioides	reniform, elliptic, ovate	yellow, brown	foveolate-rugulate
U. picta	reniform, ovate	dark yellow, dark brown	foveolate-rugulate
U. rotundata	reniform, elliptic, ovate	yellow, greenish yellow	foveolate-rugulate
U. rufescens	reniform, ovate, round	yellow, greenish yellow	reticulate-rugulate

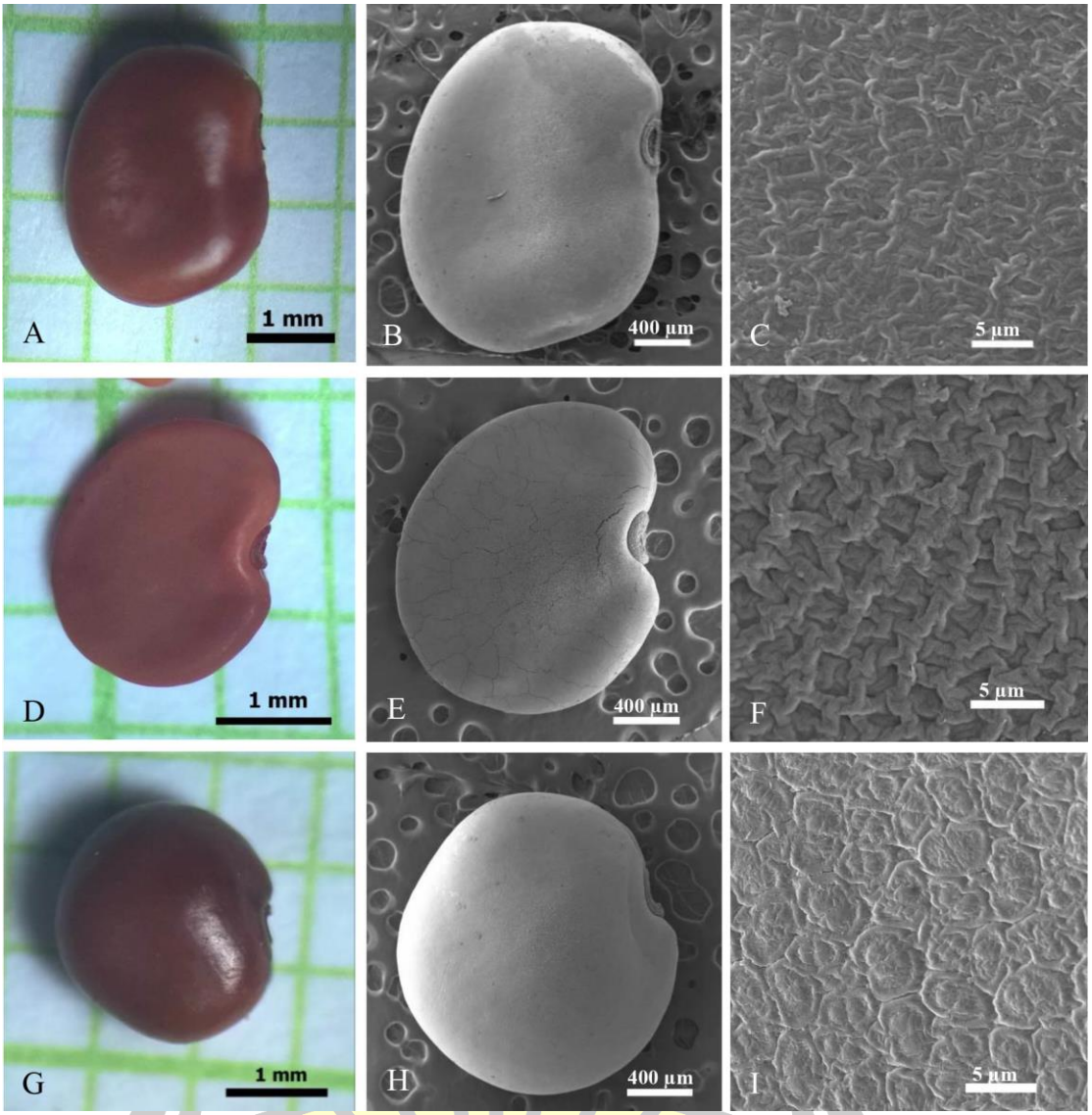

Figure 32 Seed morphology of genus *Christia:*

A.-**C**. *C. obcordata*; **A**. seed under stereo microscope, **B**. seed under SEM, **C**. Foveolate-rugulate testa of seed surface. **D**.-**F**. *C. pierrei*; **D**. seed under stereo microscope, **E**. seed under SEM, F. Reticulate-rugulate testa of seed surface, **G**.-**I**. *C. vespertilionis*; **G**. seed under stereo microscope, **H**. Seed under SEM, I. Foveolate-rugulate testa of seed surface.

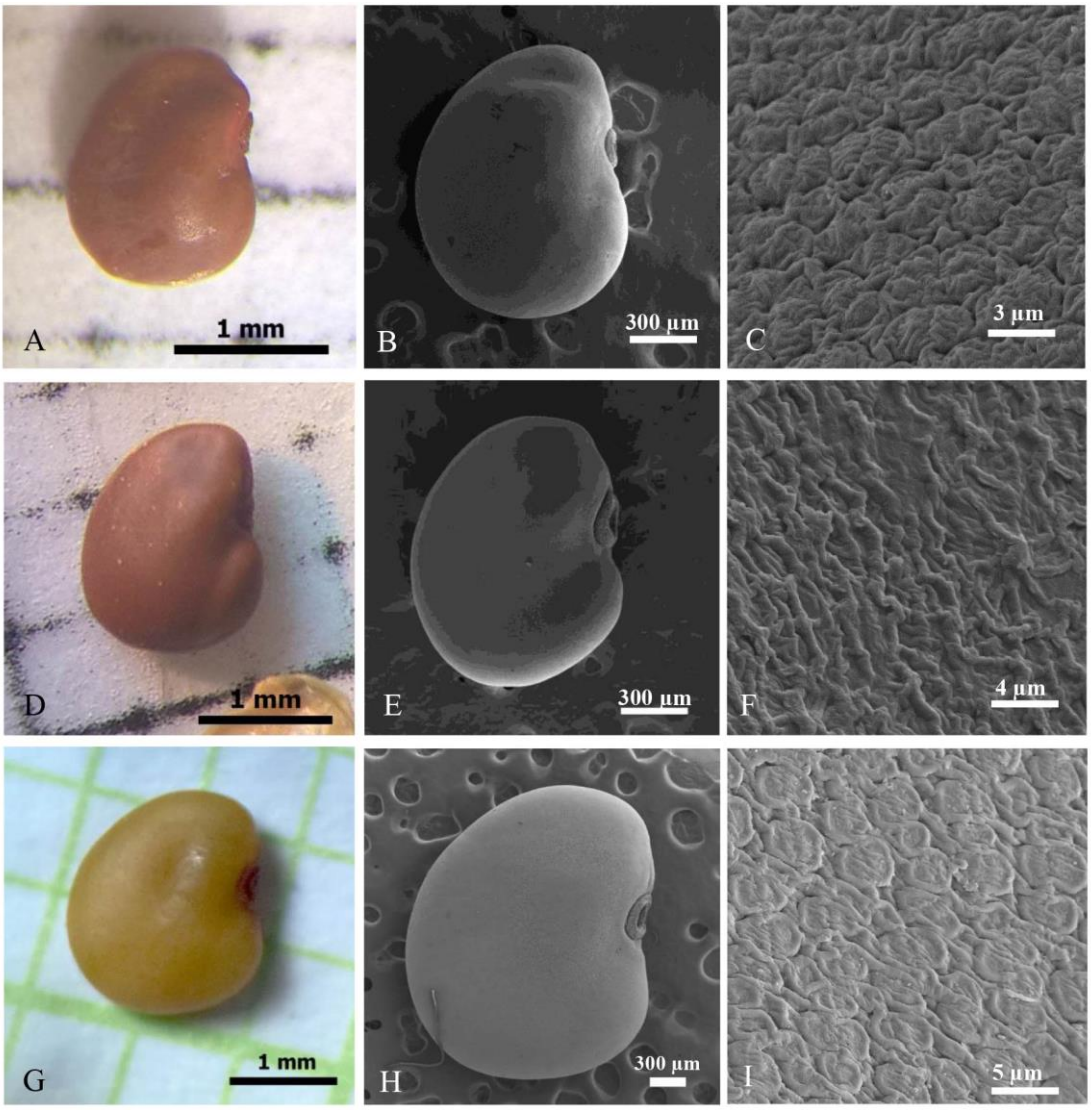

Figure 33 Seed morphology of genus *Uraria*:

A.-**C**. *U. acualis*; **A**. seed under stereo microscope, **B**. seed under SEM, **C**. Reticulate-rugulate testa of seed surface. **D**.-**F**. *U. acuminata*; **D**. seed under stereo microscope, **E**. seed under SEM, **F**. Reticulate-rugulate testa of seed surface. **G**.-**I**. *U. cochinchinensis*; **G**. seed under stereo microscope, **H**. Seed under SEM, **I**. Foveolate-rugulate testa of seed surface.

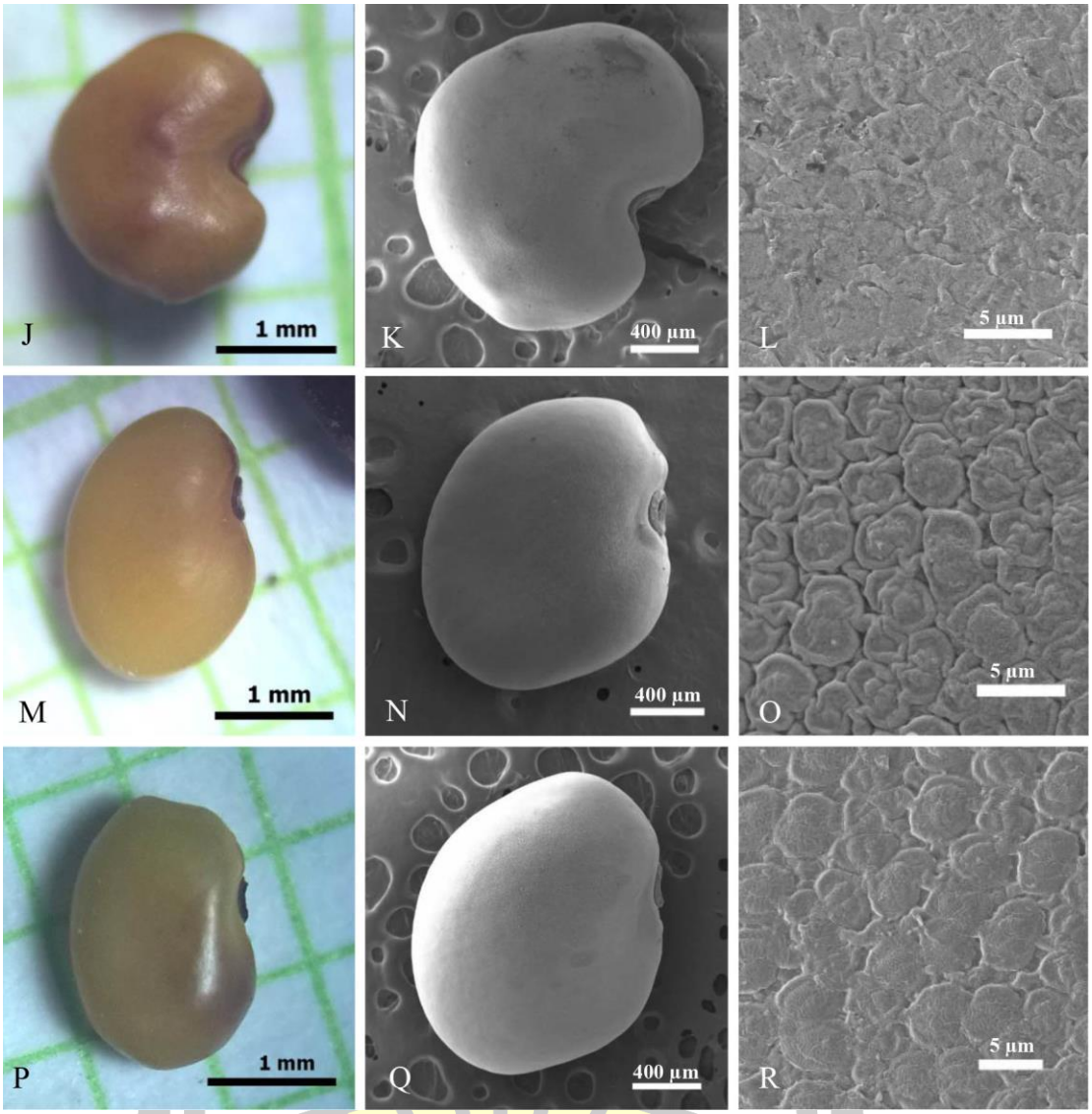

Figure 33 Seed morphology of genus *Uraria* (Cont.):

J.-**L**. *U. cordifolia*; **J**. seed under stereo microscope, **K**. seed under SEM, **L**. Foveolate-rugulate testa of seed surface. **M**.-**O**. *U. crinita*; **M**. seed under stereo microscope, **N**. seed under SEM, **O**. Foveolate-rugulate testa of seed surface. **P**.-**R**. *U. lagopodioides*; **P**. seed under stereo microscope, **Q**. Seed under SEM, **R**. Foveolate-rugulate testa of seed surface.

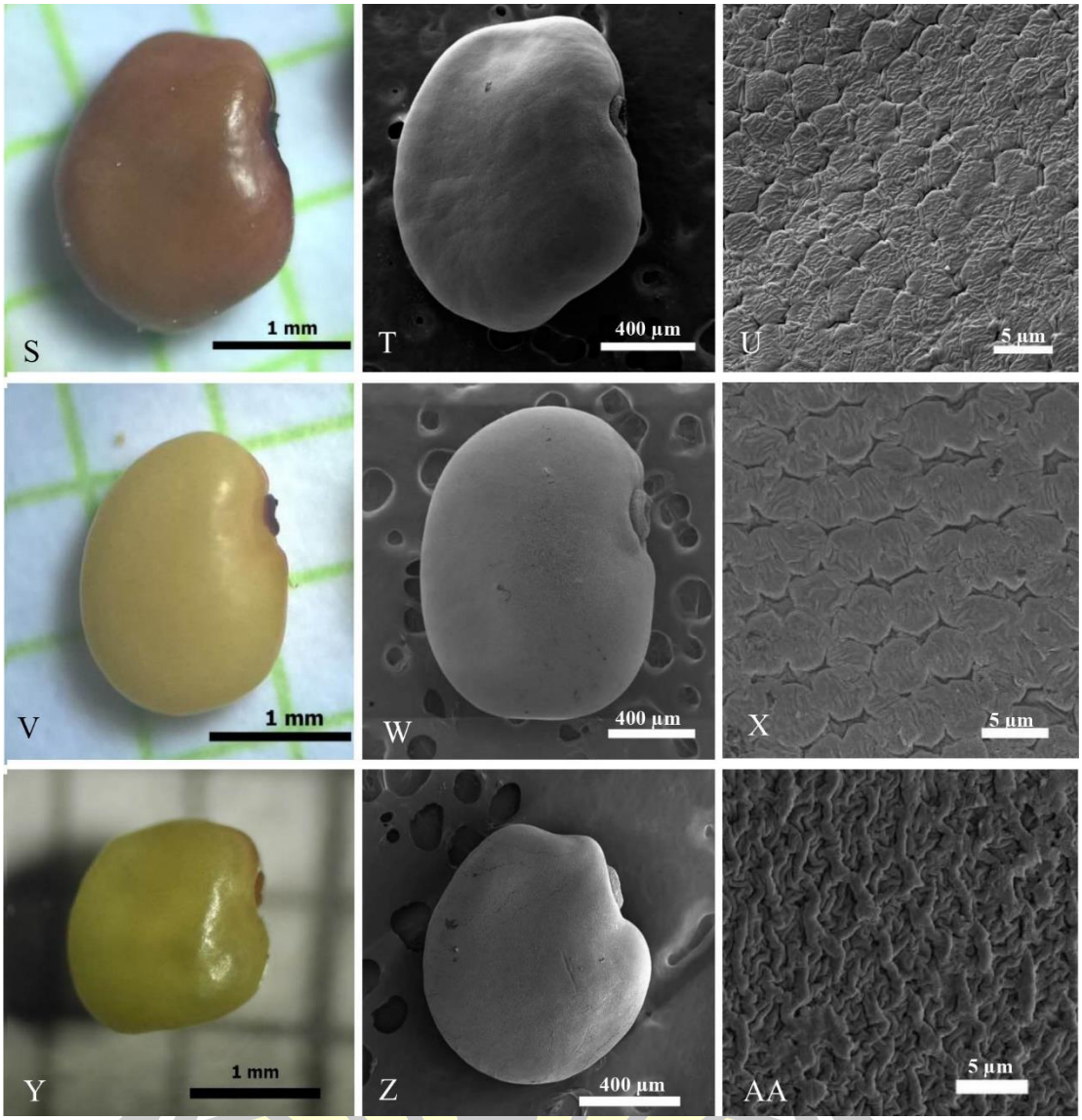

Figure 33 Seed morphology of genus *Uraria* (Cont.):

S.-**U**. *U. picta*, **S**. seed under stereo microscope, **T**. seed under SEM, **U**. Foveolate-rugulate testa of seed surface; **V**.-**X**; *U. rotundata*, **V**. seed under stereo microscope, **W**. seed under SEM, **X**. Foveolate-rugulate testa of seed surface; **Y**.-**AA**; *U. rufescens*, **Y**. seed under stereo microscope, **Z.** seed under SEM, **AA**. Reticulate-rugulate testa of seed surface.

4.2.3.2 *Uraria acuminata*

The pollen grain prolate spheroidal, rarely subprolate, 27.25-33.75 (30.63±2.14) µm in polar axis and 31.25-37.5 (34.25±1.97) µm in equatorial axis, Sculpture regulate. (Figs. 34 C-D & 35 C-D).

4.2.3.3 *Uraria campanulata*

The pollen grain subprolate, rarely prolate spheroidal, 25-30 (27.25±1.42) µm in polar axis and 30-33.75 (30.05±6.19) µm in equatorial axis, Sculpture psilate. (Figs. 34 E-F & 35 E-F).

4.2.3.4 *Uraria crinita*

The pollen grain prolate spheroidal, 32.5-35 (33.33±1.29) µm in polar axis and 32.5-37.5 (34.79±2) µm in equatorial axis, Sculpture psilate. (Figs. 34 G-H and 35 G-H).

4.2.3.5 *Uraria lagopodioides*

The pollen grain prolate spheroidal, rarely subprolate, 25-30 (27.5±1.86) µm in polar axis and 28.75-33.75 (31±1.54) µm in equatorial axis, Sculpture psilate. (Figs. 34 I-J & 35 I-J).

4.2.3.6 *Uraria picta*

The pollen grain prolate spheroidal, rarely subprolate, 30-35 (33.13±1.59) µm in polar axis and 33.75-37-5 (35.88±1.45) µm in equatorial axis, Sculpture rugulate. (Figs. 34 K-L & 35 K-L).

4.2.3.7 *Uraria pseudoacuminata*

The pollen grain subprolate or prolate, 21.5-35 (32.92±3.32) µm in polar axis and 42.5-47.5 (43.75±2.62) µm in equatorial axis, Sculpture rugulate. (Figs. 34 M-N & 35 M-N).

4.2.3.8 *Uraria rufescens*

The pollen grain prolate spheroidal, rarely subprolate, ranging from 25-31.25 (29.13±2.21) µm in polar axis and 35-40 (36.75±1.69) µm in equatorial axis, Sculpture psilate. (Figs. 34 O-P & 35 O-P)

Table 10 List of pollen morphological characters of some species in genus *Uraria* (E = equatorial axis, P = polar axis, * = uncommon)

Species	**Shape (P/E)**	**P (µm) (Range and mean ± SD)**	**E (µm) (Range and mean ± SD)**	**Ornamentation**	**Apertures**
U. acaulis	prolate spheroidal – subprolate*	32.5-40 (34.75±2.49)	30-37.5 (33.75±2.43)	weakly rugulate	tricolporate
U. acuminata	prolate spheroidal – subprolate*	31.25-37.5 (34.25±1.97)	27.5-33.75 (30.63±2.14)	rugulate	tricolporate
U. campanulata	subprolate – prolate spheroidal*	30-33.75 (30.05±6.19)	25-30 (27.25±1.42)	psilate	tricolporate
U. crinita	prolate spheroidal	32.5-37.5 (34.79±2)	32.5-35 (33.33±1.29)	psilate	tricolporate
U. lagopodioides	prolate spheroidal – subprolate*	28.75-33.75 (31±1.54)	25-30 (27.5±1.86)	psilate	tricolporate
U. picta	prolate spheroidal – subprolate*	33.75-37.5 (35.88±1.45)	30-35 (33.13±1.59)	rugulate	tricolporate
U. pseudoacuminata	subprolate – prolate	42.5-47.5 (43.75±2.62)	21.5-35 (32.92±3.32)	rugulate	tricolporate
U. rufescens	subprolate – prolate*	35-40 (36.75±1.69)	25-31.25 (29.13±2.21)	psilate	tricolporate

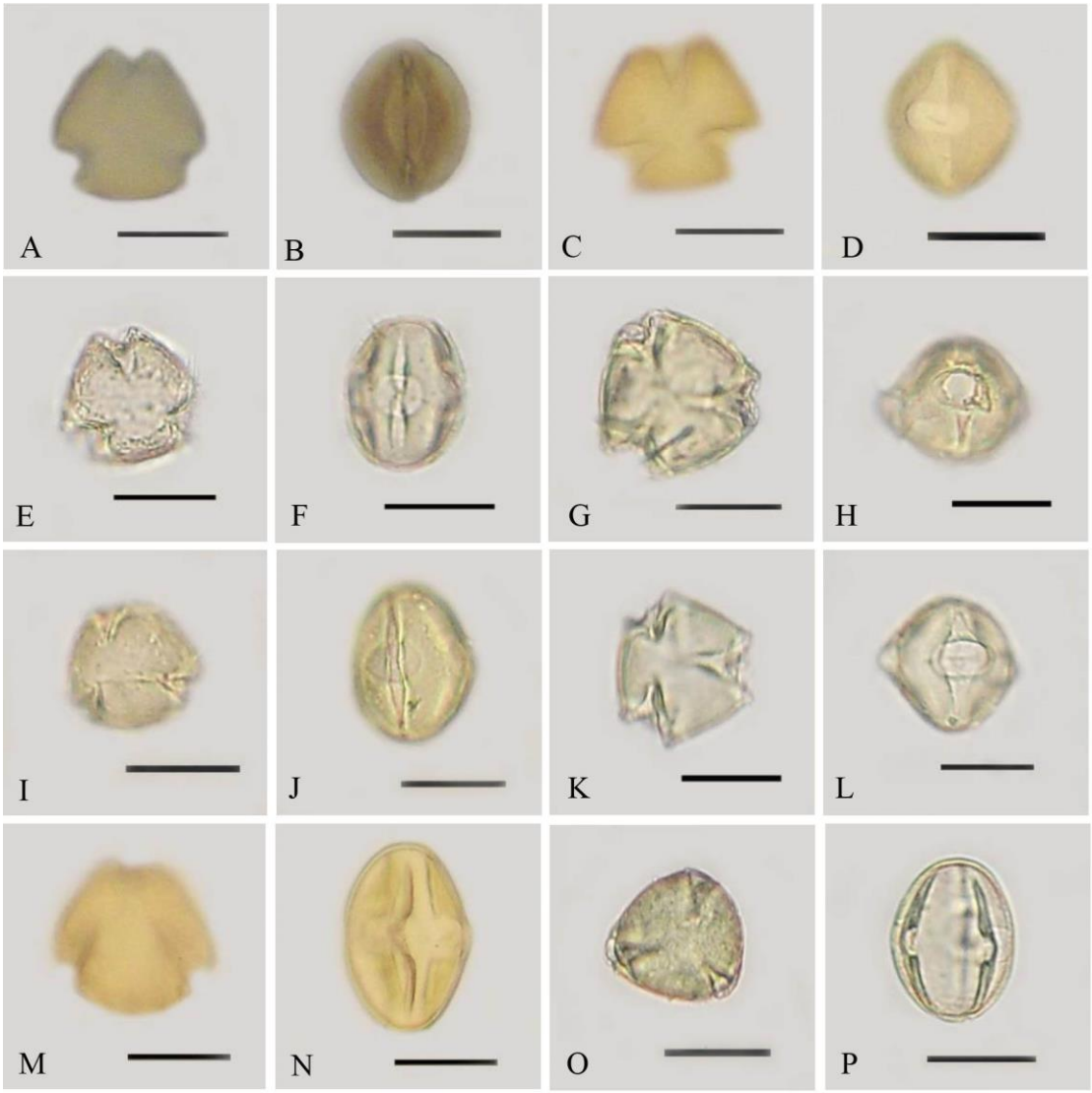

Figure 34 LM micrographs of pollen grains in genus *Uraria*:

A.-**B**. *U. acaulis*, **A**. Polar view, **B**. Equatorial view; **C**.-**D**. *U. acuminata*; **C**. Polar view, **D**. Equatorial view; **E**.-**F**. *U. campanulata*, **E**. Polar view, **F**. Equatorial view; **G**.-**H**. *U. crinita*, **G**. Polar view, **H**. Equatorial view; **I**.-**J**. *U. lagopodioides*, **I**. Polar view, **J**. Equatorial view; **K**.-**L**. *U. picta*; **K**. Polar view, **L**. Equatorial view; **M**.-**N**. *U. pseudoacuminata*, **M**. Polar view, **N**. Equatorial view; **O**.-**P**. *U. rufescens*, **O.** Polar view, **P**. Equatorial view (Scale bar = 25 µm).

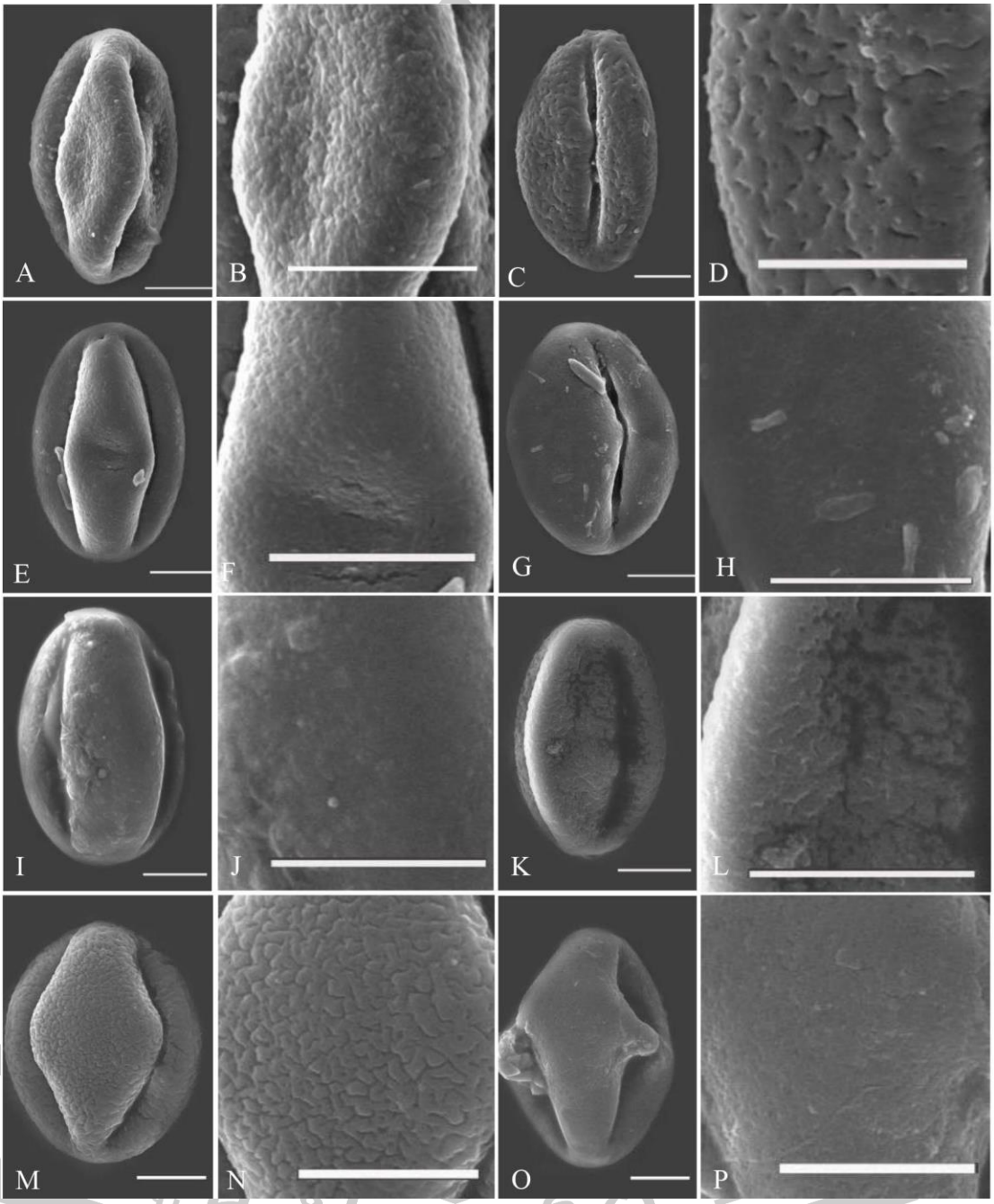

Figure 35 SEM micrographs of pollen grains in genus *Uraria:*

A.-**B**. *U. acaulis*, **C**.-**D**. *U. acuminata*, **E**.-**F**. *U. campanulata*, **G**.-**H**. *U. crinita*, **I.-J**. *U. lagopodioides*, **K**.-**L**. *U. picta*, **M**.-**N**. *U. pseudoacuminata*, **O**.-**P**. *U. rufescens*. **A**., **C**., **E**., **G**., **I**., **K**., **M**., **O**. pollen shape in equatorial view. **B., D**., **F**., **H**., **J**., **L**., **N**., **P**. exine ornamentation (Scale bar = 10 µm).

4.4 Leaf Anatomy and Leaf Micromorphology

4.4.1 The characters of genus *Christia*

Laminar surface (Tab. 11)

Upper epidermis: cuticle smooth (non-upright scale), with loosely upright scale or densely upright scale. Papillae present or absent. Stoma rarely present. Trichomes; subulate trichomes, uncinate trichomes, uniseriate trichomes, multicellular globular base trichomes and/or globose multicellular trichomes present. **Lower epidermis:** cuticle densely upright scale. Papillae present in all species. Stoma present. Trichomes; subulate trichomes, uncinate trichomes, uniseriate trichomes, multicellular globular base trichomes and/or globose multicellular trichomes present.

Laminar in transverse sections (Tab. 12)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal to rounded. Periclinal wall straight, dome-shaped and/or high curved with papillae. **Lower epidermis:** one-layer with conical, rectangular and/or polygonal. Periclinal wall high curved with papillae, straight and/or dome-shaped. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1-3 cell layers and spongy cells in 2-3 layers. **Vascular bundles** collateral. **Prismatic crystals** present only in the spongy cells or absent. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface slightly curved and lower surface a prominent U-shaped. Epidermal cells rectangular, elliptic and/or rounded. Periclinal wall straight to curved. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 1-3, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present in the bundle cap and/or phloem. **Starch grains** absent.

Margin: the margin outline in transverse section slightly inflated to non-inflated with obtuse end. Parenchyma cells and one vascular bundle occur in the margins.

4.4.1.1 *Christia obcordata*

Laminar surface (Fig. 36)

Upper epidermis: cuticle smooth. Papillae absent. Stoma rarely present. Trichomes; subulate trichomes (rarely) present. **Lower epidermis:** cuticle densely upright scale. Papillae present. Stoma present. Trichomes; subulate trichomes (rarely), uncinate trichomes and globose multicellular trichomes (rarely) present.

Laminar in transverse sections (Fig. 37)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal to rounded. Periclinal wall straight or dome-shaped. **Lower epidermis:** one-layer with conical. Periclinal wall high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1-2 cell layers and spongy cells in 2-3 layers. **Vascular bundles** collateral. **Prismatic crystals** present only in the spongy cells. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface slightly curved and lower surface a prominent U-shaped. Epidermal cells rectangular or rounded. Periclinal wall straight to curved. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 1, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present in the bundle cap. **Starch grains** absent.

Margin: the margin outline in transverse section slightly inflated with obtuse end. Parenchyma cells and one vascular bundle occur in the margins.

4.4.1.2 *Christia pierrei*

Laminar surface (Fig. 38)

Upper epidermis: cuticle with densely upright scale. Papillae present. Stoma rarely present. Trichomes; uncinate trichomes and uniseriate trichomes (rarely) present. **Lower epidermis:** cuticle with densely upright scale. Papillae present. Stoma

present. Trichomes; globose multicellular trichomes, subulate trichomes (rarely), uncinate trichomes and uniseriate trichomes (rarely) present.

Laminar in transverse sections (Fig. 39)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal to rounded. Periclinal wall high curved with papillae. **Lower epidermis:** one-layer with rectangular, polygonal. Periclinal wall dome-shaped to high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1-3 cell layers and spongy cells in 2-3 layers. **Vascular bundles** collateral. **Crystals** absent. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface slightly curved and lower surface a prominent U-shaped. Epidermal cells elliptic or rounded. Periclinal wall straight to curved. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 1-3, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present in the bundle cap and phloem. **Starch grains** absent.

Margin: the margin outline in transverse section slightly inflated to non-inflated with obtuse end. Parenchyma cells and one vascular bundle occur in the margins.

4.4.1.3 *Christia vespertilionis* var. *vespertilionis*

Laminar surface (Fig. 40)

Upper epidermis: cuticle with densely upright scale. Papillae present. Stoma rarely present. Trichomes; globose multicellular trichomes, subulate trichomes (rarely), uncinate trichomes, uniseriate trichomes (rarely) and multicellular globular base trichomes present. **Lower epidermis:** cuticle with densely upright scale. Papillae present. Stoma present. Trichomes; globose multicellular trichomes (rarely), subulate trichomes (rarely), uncinate trichomes, uniseriate trichomes (rarely) and multicellular globular base trichomes present.

Laminar in transverse sections (Fig. 41)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis** one-layer with rectangular, polygonal to rounded. Periclinal wall straight, dome-shaped, high curved with papillae. **Lower epidermis** one-layer with rectangular, polygonal, rounded. Periclinal wall straight, dome-shaped, high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1 cell layer and spongy cells in 3 layers. **Vascular bundles** collateral. **Crystals** absent. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface slightly curved and lower surface a prominent U-shaped. Epidermal cells rectangular or rounded. Periclinal wall straight to curved. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 1-3, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present in the bundle cap and phloem. **Starch grains** absent.

Margin: the margin outline in transverse section slightly inflated to non-inflated with obtuse end. Parenchyma cells and one vascular bundle occur in the margins.

4.4.2 The characters of genus *Uraria*

Laminar surface (Tab. 11)

Upper epidermis: cuticle smooth, with loosely upright scale or densely upright scale. Papillae present or absent. Stoma rarely present. Trichomes; subulate trichomes, uncinate trichomes, uniseriate trichomes, multicellular globular base trichomes and/or globose multicellular trichomes present. **Lower epidermis:** cuticle densely upright scale. Papillae present in all species. Stoma present. Trichomes; subulate trichomes, uncinate trichomes, uniseriate trichomes, multicellular globular base trichomes and/or globose multicellular trichomes present.

Laminar in transverse sections (Tab. 12)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal to rounded. Periclinal wall straight, dome-shaped and/or high curved with papillae. Trichomes absent or rarely uncinate trichomes, subulate trichome, uniseriate trichomes and/or globose multicellular trichomes. **Lower epidermis:** one-layer with conical, dome-shaped or small papillae. Periclinal wall high curved with papillae and/or dome-shaped. Trichomes 5-types, subulate trichomes, uncinate trichomes, uniseriate trichomes, globose multicellular trichomes and/or unicellular trichomes, with thin wall in some species. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1-2 cell layers and spongy cells in 2-4 layers. **Vascular bundles** collateral. **Prismatic crystals** present only in the spongy cells or absent. **Starch grains** absent or occurs near midrib.

Midrib: the midrib outline in transverse section at the upper surface slightly curved, dome-shaped to high curved and lower surface a prominent U-shaped. Epidermal cells rectangular, elliptic and/or rounded. Periclinal wall straight, curved to dome-shaped. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 2-10, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** absent or present. **Starch grains** absent or present in the parenchyma tissue or xylem of the midrib.

Margin: the margin outline in transverse section inflated to non-inflated with obtuse end. Parenchyma cells and one vascular bundle and/or fibre bundle occur in the margins.

4.4.2.1 *Uraria acaulis*

Laminar surface (Fig. 42)

Upper epidermis: cuticle with loosely upright scale. Papillae absent. Stoma rarely present. Trichomes; globose multicellular trichomes (rarely), subulate trichomes, uncinate trichomes, uniseriate trichomes (rarely) and multicellular globular base trichomes (rarely) present. **Lower epidermis:** cuticle with densely upright scale.

Papillae present. Stoma present. Trichomes; globose multicellular trichomes, subulate trichomes, uncinate trichomes, uniseriate trichomes (rarely) and multicellular globular base trichomes present.

Laminar in transverse sections (Fig. 43)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal to rounded. Periclinal wall straight or curved like dome-shaped. **Lower epidermis:** one-layer with conical. Periclinal wall high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1(-2) cell layers and spongy cells in 3(-4) layers. **Vascular bundles** collateral. **Prismatic crystals** present only in the spongy cells. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface slightly curved and lower surface a prominent U-shaped. Epidermal cells rectangular or elliptic. Periclinal wall curved to dome-shaped. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 3-5, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of two small undifferentiated vascular bundles and a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present only in the bundle cap. **Starch grains** present in the parenchyma tissue of the midrib.

Margin: the margin outline in transverse section inflated with obtuse end. Parenchyma cells and one vascular bundle occur in the margins.

4.4.2.2 *Uraria acuminata*

Laminar surface (Fig. 44)

Upper epidermis: cuticle with loosely upright scale. Papillae absent. Stoma rarely present. Trichomes; globose multicellular trichomes, subulate trichomes (rarely), uncinate trichomes (rarely), uniseriate trichomes and multicellular globular base trichomes present. **Lower epidermis:** cuticle with densely upright scale. Papillae present. Stoma present. Trichomes; globose multicellular trichomes, subulate trichomes, uncinate trichomes, uniseriate trichomes (rarely) and multicellular globular base trichomes present.

Laminar in transverse sections (Fig. 45)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal. Periclinal wall straight. **Lower epidermis:** one-layer with conical to dome-shaped. Periclinal wall papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1 cell layer and spongy cells in 3-4 layers. **Vascular bundles** collateral. **Prismatic crystals** present only in the spongy cells. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface high curved and lower surface a prominent U-shaped. Epidermal cells rounded or elliptic. Periclinal wall curved to dome-shaped. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 4-6, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of two small undifferentiated vascular bundles and a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present in the bundle cap, below the xylem, in the phloem. **Starch grains** absent.

Margin: the margin outline in transverse section inflated, non-inflated with obtuse end. Parenchyma cells and one vascular bundle or fibre bundle occur in the margins.

4.4.2.3 *Uraria barbaticaulis*

Laminar surface (Fig. 46)

Upper epidermis: cuticle smooth. Papillae absent. Stoma rarely present. Trichomes; subulate trichomes, uncinate trichomes present. **Lower epidermis:** cuticle with densely upright scale. Papillae present. Stoma present. Trichomes; globose multicellular trichomes (rarely), subulate trichomes and uncinate trichomes present.

Laminar in transverse sections (Fig. 47)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal. Periclinal wall straight to dome-shaped. **Lower epidermis:** one-layer, small papillae. Periclinal wall

high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1 cell layer and spongy cells in 3-4 layers. **Vascular bundles** collateral. **Prismatic crystals** present in the spongy cells and bundle caps. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface dome-curved and lower surface a prominent U-shaped. Epidermal cells rounded or elliptic. Periclinal wall curved to dome-shaped. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 6-9, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of a small undifferentiated vascular bundle and a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present in the bundle cap, in the ground tissue. **Starch grains** rarely present in the parenchyma tissue near xylem of the midrib.

Margin: the margin outline in transverse section inflated with obtuse end. Parenchyma cells and one vascular bundle occur in the margins.

4.4.2.4 *Uraria campanulata* (Benth.) Gagnep.

Laminar surface (Fig. 48)

Upper epidermis: cuticle with densely upright scale. Papillae present. Stoma rarely present. Trichomes; uncinate trichomes, uniseriate trichomes (rarely) and subulate trichomes (rarely) present. **Lower epidermis:** cuticle with densely upright scale. Papillae present. Stoma present. Trichomes; subulate trichomes and uncinate trichomes (rarely) present.

Laminar in transverse sections (Fig. 49)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal to rounded, elliptic. Periclinal wall straight to dome-shaped, high curved with papillae. **Lower epidermis:** one-layer, small papillae. Periclinal wall high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1 cell layer and spongy cells in (2-)3

layers. **Vascular bundles** collateral. **Prismatic crystals** present in the spongy cells and bundle caps. **Starch grains** occur near midrib.

Midrib: the midrib outline in transverse section at the upper surface dome-curved and lower surface a prominent U-shaped. Epidermal cells rounded or elliptic. Periclinal wall curved to dome-shaped and curved to straight. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 5-6, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of a small undifferentiated vascular bundle and a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present. **Starch grains** present in xylem of the midrib.

Margin: the margin outline in transverse section inflated with obtuse end. Parenchyma cells and one vascular bundle or fibre bundle occur in the margins.

4.4.2.5 *Uraria cordifolia*

Laminar surface (Fig. 50)

Upper epidermis: cuticle smooth. Papillae absent. Stoma rarely present. Trichomes; globose multicellular trichomes (rarely), subulate trichomes, uncinate trichomes and uniseriate trichomes (rarely) present. **Lower epidermis:** cuticle with densely upright scale. Papillae present. Stoma present. Trichomes; globose multicellular trichomes, subulate trichomes, uncinate trichomes (rarely) and uniseriate trichomes (rarely) present.

Laminar in transverse sections (Fig. 51)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal, elliptic. Periclinal wall straight to dome-shaped. **Lower epidermis:** one-layer, small papillae. Periclinal wall dome-shaped to high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1(-2) cell layers and spongy cells in 3(-4) layers. **Vascular bundles** collateral. **Prismatic crystals** present in the spongy cells. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface dome-curved and lower surface a prominent U-shaped. Epidermal cells rounded or

elliptic. Periclinal wall curved to dome-shaped. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 3-7, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of 1-2 small undifferentiated vascular bundles and a fibre bundle or only a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present in the bundle cap, below the xylem. **Starch grains** present in xylem of the midrib.

Margin: the margin outline in transverse section inflated with obtuse end. Parenchyma cells and one vascular bundle occur in the margins.

4.4.2.6 *Uraria crinita*

Laminar surface (Fig. 52)

Upper epidermis: cuticle with loosely upright scale. Papillae absent. Stoma rarely present. Trichomes; subulate trichomes (rarely), uncinate trichomes (rarely) present. **Lower epidermis:** cuticle with densely upright scale. Papillae present. Stoma present. Trichomes; globose multicellular trichomes, subulate trichomes, uncinate trichomes and uniseriate trichomes (rarely) present.

Laminar in transverse sections (Fig. 53)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal to rounded. Periclinal wall straight to dome-shaped. **Lower epidermis:** one-layer with conical to dome-shaped. Periclinal wall high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1-2 cell layers and spongy cells in 2(-4) layers. **Vascular bundles** collateral. **Prismatic crystals** present in the spongy cells. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface dome-curved and lower surface a prominent U-shaped. Epidermal cells rounded or elliptic. Periclinal wall curved to dome-shaped. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 3-10, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of two small undifferentiated vascular bundles and a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present in the bundle cap,

below the xylem, in the phloem. **Starch grains** rarely present in the parenchyma tissue near xylem of the midrib.

Margin: the margin outline in transverse section inflated with obtuse end. Parenchyma cells and one fibre bundle occur in the margins.

4.4.2.7 *Uraria lagopodioides*

Laminar surface (Fig. 54)

Upper epidermis: cuticle smooth. Papillae absent. Stoma rarely present. Trichomes; subulate trichomes (rarely) and uncinate trichomes (rarely) present. **Lower epidermis:** cuticle with densely upright scale. Papillae present. Stoma present. Trichomes; globose multicellular trichomes (rarely), subulate trichomes and uncinate trichomes (rarely) present.

Laminar in transverse sections (Fig. 55)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal to rounded. Periclinal wall straight to dome-shaped. **Lower epidermis:** one-layer with conical shaped. Periclinal wall high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 2 cell layers and spongy cells in 2-3 layers. **Vascular bundles** collateral. **Prismatic crystals** present in the spongy cells. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface dome-curved and lower surface a prominent U-shaped. Epidermal cells rectangular, polygonal to rounded. Periclinal wall curved to dome-shaped. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 3-4, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of a small undifferentiated vascular bundle and a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present above of the bundle cap, below the xylem, rarely in the phloem and cortex. **Starch grains** rarely present in the parenchyma tissue near xylem of the midrib.

Margin: the margin outline in transverse section inflated with obtuse end. Parenchyma cells and one vascular bundle occur in the margins.

4.4.2.8 *Uraria picta*

Laminar surface (Fig. 56)

Upper epidermis: cuticle with loosely upright scale. Papillae absent. Stoma rarely present. Trichomes; subulate trichomes (rarely) and uncinate trichomes (rarely) present. **Lower epidermis:** cuticle with densely upright scale. Papillae present. Stoma present. Trichomes; subulate trichomes (rarely) and uncinate trichomes (rarely) present.

Laminar in transverse sections (Fig. 57)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal to rounded. Periclinal wall straight. **Lower epidermis:** one-layer with rectangular, polygonal to rounded. Periclinal wall dome-shaped to high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1 cell layer and spongy cells in 2-3 layers. **Vascular bundles** collateral. **Prismatic crystals** present in the spongy cells. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface dome-curved and lower surface a prominent U-shaped. Epidermal cells elliptic to rounded. Periclinal wall straight, curved to dome-shaped. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 3, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of two small undifferentiated vascular bundles and a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present above of the bundle cap, in the phloem. **Starch grains** absent.

Margin: the margin outline in transverse section slightly inflated with obtuse end. Parenchyma cells and one vascular bundle occur in the margins.

4.4.2.9 *Uraria pseudoacuminata*

Laminar surface (Fig. 58)

Upper epidermis: cuticle smooth. Papillae absent. Stoma rarely present. Trichomes; subulate trichomes (rarely) and uncinate trichomes (rarely) present. **Lower epidermis:** cuticle with densely upright scale. Papillae present. Stoma present. Trichomes; globose multicellular trichomes (rarely), subulate trichomes, uncinate trichomes and uniseriate trichomes (rarely) present.

Laminar in transverse sections (Fig. 59)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal to rounded. Periclinal wall straight. **Lower epidermis:** one-layer with conical shaped. Periclinal wall high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1 cell layer and spongy cells in 3 layers. **Vascular bundles** collateral. **Prismatic crystals** present in the spongy cells. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface dome-curved and lower surface a prominent U-shaped. Epidermal cells rectangular, polygonal to rounded. Periclinal wall curved to dome-shaped. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 2-4, exhibit a very complex structure with usually in u-shaped, some vascular bundles connecting the strip, surrounding a central medullary region, on the top of u-shaped composed of two small undifferentiated vascular bundles and a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present in the bundle cap. **Starch grains** absent.

Margin: the margin outline in transverse section inflated to non-inflated with obtuse end. Parenchyma cells and one fibre bundle occur in the margins.

4.4.2.10 *Uraria rotundata*

Laminar surface (Fig. 60)

Upper epidermis: cuticle with densely upright scale. Papillae present. Stoma rarely present. Trichomes; subulate trichomes, uncinate trichomes and uniseriate trichomes (rarely) present. **Lower epidermis:** cuticle with densely upright scale. Papillae present. Stoma present. Trichomes; globose multicellular trichomes

(rarely), subulate trichomes, uncinate trichomes (rarely) and uniseriate trichomes (rarely) present.

Laminar in transverse sections (Fig. 61)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal to rounded, conical shaped. Periclinal wall straight to dome-shaped, high curved with papillae. **Lower epidermis:** one-layer with rounded, elliptic, conical shaped. Periclinal wall dome-shaped, high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1 cell layers and spongy cells in 3 layers. **Vascular bundles** collateral. **Prismatic crystals** present in the spongy cells. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface dome-curved and lower surface a prominent U-shaped. Epidermal cells rectangular, elliptic to rounded. Periclinal wall curved to dome-shaped. Parenchyma cells in ground tissue. **The vascular bundles** in the midrib 3-5, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Prismatic crystals** present in the bundle cap, in the phloem. **Starch grains** absent.

Margin: the margin outline in transverse section inflated to non-inflated with obtuse end. Parenchyma cells and one vascular bundle and fibre bundle occur in the margins.

4.4.2.11 *Uraria rufescens*

Laminar surface (Fig. 62)

Upper epidermis: cuticle with densely upright scale. Papillae present. Stoma rarely present. Trichomes; subulate trichomes (rarely), uncinate trichomes and uniseriate trichomes (rarely) present. **Lower epidermis:** cuticle with densely upright scale. Papillae present. Stoma present. Trichomes; globose multicellular trichomes (rarely), subulate trichomes and uncinate trichomes (rarely) present.

Laminar in transverse sections (Fig. 63)

The cuticle thickness smooth, with equal on both the upper and lower surfaces. **Upper epidermis:** one-layer with rectangular, polygonal. Periclinal wall straight to dome-shaped. **Lower epidermis:** one-layer with conical shaped to dome-shaped. Periclinal wall to dome-shaped, high curved with papillae. **Mesophyll** differentiated palisade and spongy regions. The mesophyll composed of palisade cell layers only on the upper side with 1-2 cell layers and spongy cells in 2-3 layers. **Vascular bundles** collateral. **Prismatic crystals** present in the spongy cells. **Starch grains** absent.

Midrib: the midrib outline in transverse section at the upper surface high curved and lower surface a prominent U-shaped. Epidermal cells rectangular, polygonal to rounded. Periclinal wall curved. Parenchyma cells in ground tissue.

The vascular bundles in the midrib 6-7, exhibit a very complex structure with usually in u-shaped, surrounding a central medullary region, on the top of u-shaped composed of 5 small undifferentiated vascular bundles and a fibre bundle. **Bundle caps** present, sclerenchymatous tissues. **Crystals** absent. **Starch grains** absent.

Margin: the margin outline in transverse section inflated to non-inflated with obtuse end. Parenchyma cells and one vascular bundle and fibre bundle occur in the margins.

Table 11 Anatomical characters of laminar surface of three *Chistia* and 11 *Uraria* species in Thailand

No	Scientific name	Cuticle		Papillae		Trichome	
		Ad	Ab	Ad	Ab	Ad	Ab
1	*C. obcordata*	Sm	Up	-	✓	S*	Uc, S*, G*
2	*C. pierrei*	Up	Up	✓	✓	Uc, Us*	Uc, S*, Us*, G
3	*C. vespertilionis*	Up	Up	✓	✓	Uc, S*, Us*,G, Mg	Uc, S*, Us*, G*, Mg
4	*U. acaulis*	Up*	Up	-	✓	Uc, S, Us*, G*, Mg*	Uc, S, Us*, G, Mg
5	*U. acuminata*	Up*	Up	-	✓	Uc*, S*, Us, G, Mg	Uc, S, Us*, G, Mg
6	*U. barbaticaulis*	Sm	Up	-	✓	Uc, S	Uc, S, G*
7	*U. campanulata*	Up	Up	✓	✓	Uc, S*, Us*	Uc*, S
8	*U. cordifolia*	Sm	Up	-	✓	Uc, S, Us*, G*	Uc*, S, Us*, G
9	*U. crinita*	Up*	Up*	-	✓	Uc*, S*	Uc, S, Us*, G
10	*U. lagopodioides*	Sm	Up	-	✓	Uc*, S*	Uc*, S, G*
11	*U. picta*	Up*	Up	-	✓	Uc*, S*	Uc*, S*
12	*U. psudoacuminata*	Sm	Up	-	✓	Uc*, S*	Uc, S, Us*, G*
13	*U. rotundata*	Up	Up	✓	✓	Uc, S, Us*	Uc*, S, Us* G*
14	*U. rufescens*	Up	Up	✓	✓	Uc, S*, Us*	Uc*, S, G*

Note: Ab=Abaxial epidermis, Ad=Adaxial epidermis, Up=Upright scales cuticle, Sm=Smooth, Su = Smooth with upright, G = Globose multicellular trichomes, Mg = Multicellular globular base trichome, S = Subulate trichomes, Uc = Uncinate trichomes, Us = Uniseriate trichomes * = rarely, - = absent, ✓ = present

Table 12 Anatomical characters of laminar in transverse sections of three *Christia* and 11 *Uraria* species in Thailand

No.	Scientific name	Mesophyll				Vascular bundles (No.)	Margin outline
		Palisade layer (s)	Spongy layer (s)	Crystals	Starch grains		
1	*C. obcordata*	1-2	2-3	Pr	-	1	In*
2	*C. pierrei*	1-3	2-3	-	-	1-3	In*, N*
3	*C. vespertilionis*	1	3	-	-	1-3	In*, N*
4	*U. acaulis*	1 (-2)	3 (-4)	Pr	-	3-5	In
5	*U. acuminata*	1	3-4	Pr	-	4-6	In, N
6	*U. barbaticaulis*	1	3-4	Pr	-	6-9	In
7	*U. campanulata*	1	(2-) 3	Pr	✓	5-6	In
8	*U. cordifolia*	1 (-2)	3 (-4)	Pr	-	3-7	In
9	*U. crinita*	1	2 (-4)	Pr	-	3-10	In
10	*U. lagopodioides*	2	2-3	Pr	-	3-4	In
11	*U. picta*	1	2-3	Pr	-	3	In*
12	*U. pseudoacuminata*	1	3	Pr	-	2-4	In, N
13	*U. rotundata*	1	3	Pr	-	3-5	In, N
14	*U. rufescens*	1-2	2-3	Pr	-	6-7	In, N

Note: In = Inflated, N = non-inflated, Pr = Prismatic crystals, * = slightly, - = absent, ✓ = present)

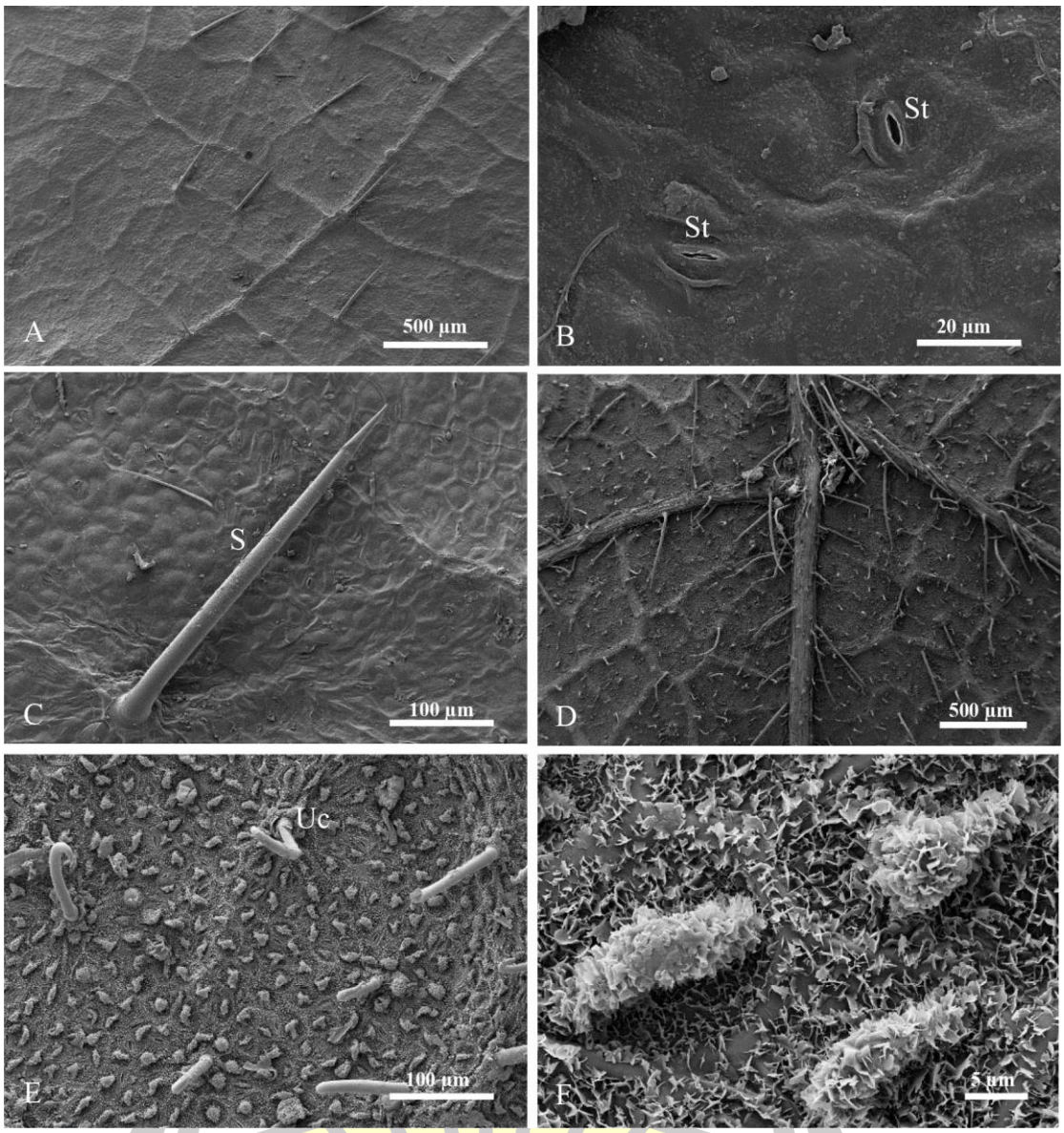

Figure 36 Leaf micromorphology of *Christia obcordata*:
A.-C. upper epidermis; **A.** superficial view, **B**. stomata, **C**. subulate trichome, **D-F** lower epidermis; **D.** superficial view, **E**. uncinate trichome, **F**. papillae and upright scale cuticle (S = Subulate trichome, St = Stomata, Uc = Uncinate trichome).

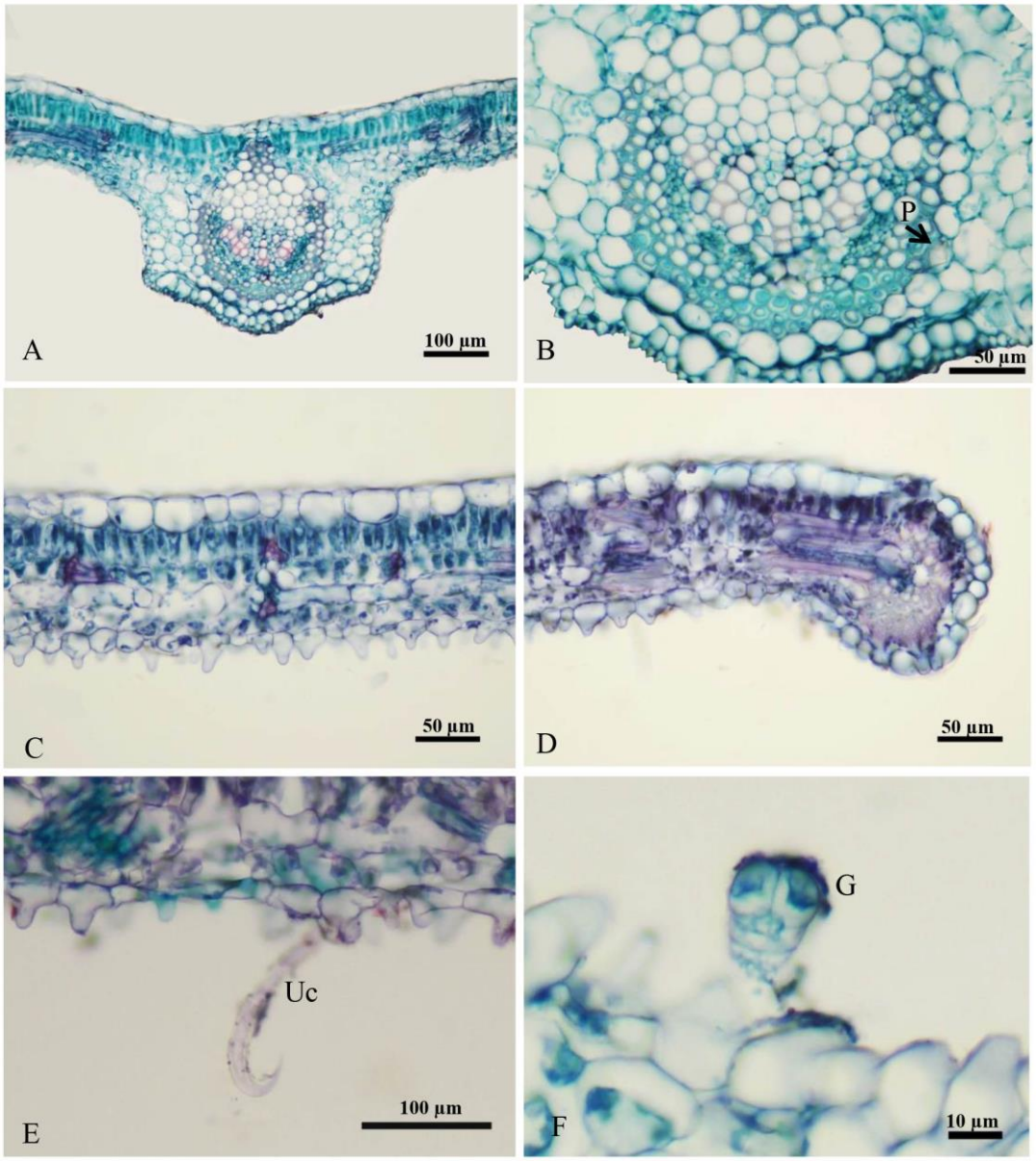

Figure 37 Transverse sections of *Christia obcordata*:

A. the outline of midrib; **B**. vascular tissue showing prismatic crystal in the bundle cap; **C**. laminar showing palisade mesophyll layers only on the upper side with 1-3 cell layers and spongy cells in 2-3 layers; **D**. leaf margin outline showing slightly inflated with obtuse end; **E**. uncinate trichome in lower epidermis; **F**. globose multicellular trichome (G = Globose multicellular trichome, P = Prismatic crystal, Uc = Uncinate trichome).

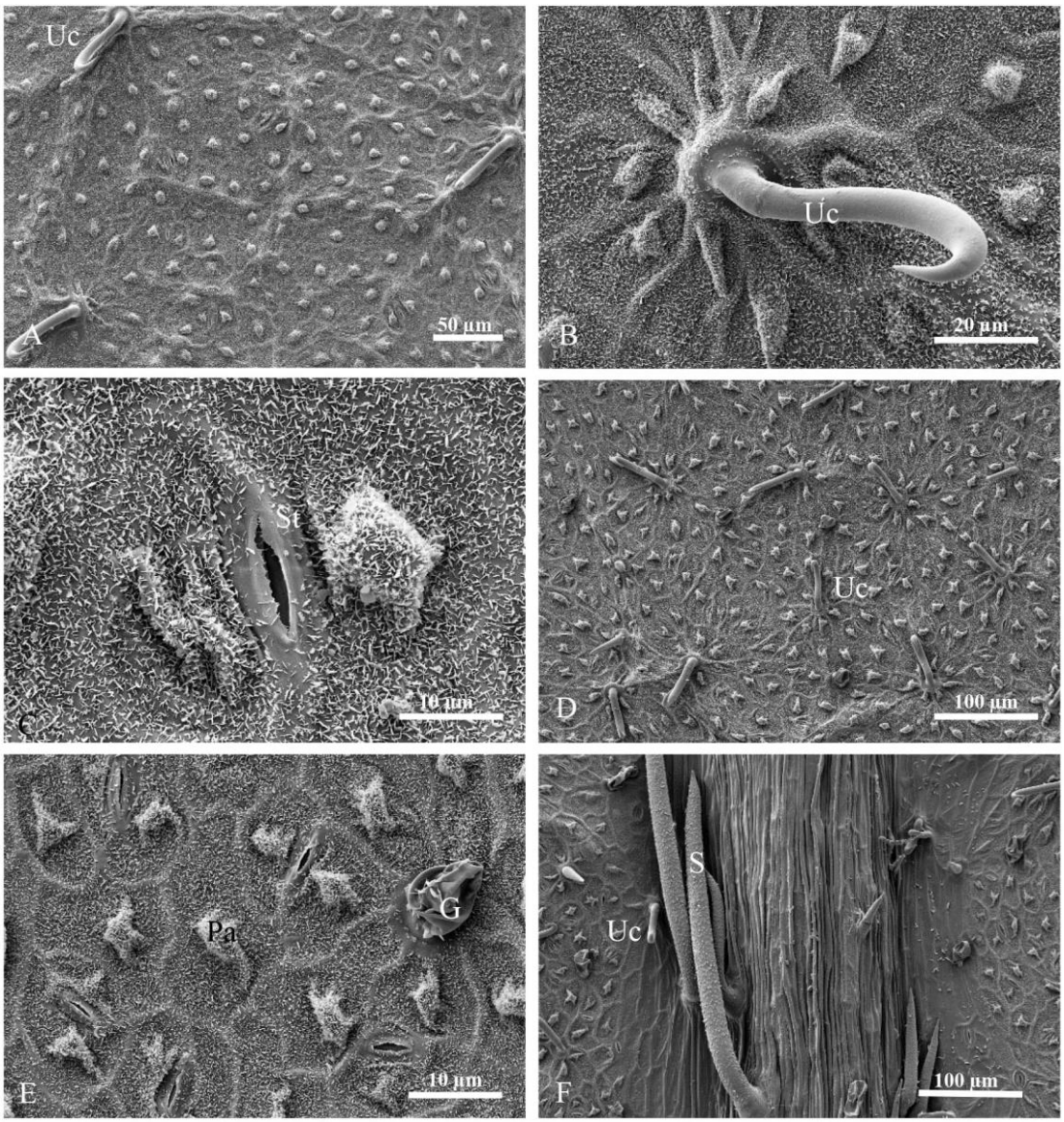

Figure 38 Leaf micromorphology of *Christia pierrei*:

A.-C. upper epidermis; **A**. superficial view, **B**. uncinate trichome, **C**. stomata and upright scale cuticle, **D.-F.** lower epidermis; **D**. Superficial view, **E**. papillae and globose multicellular trichome, **F**. subulate trichome and uncinated trichome (G = Globose multicellular trichome, Pa = Papillae, S = Subulate trichome, St = Stomata, Uc = Uncinate trichome).

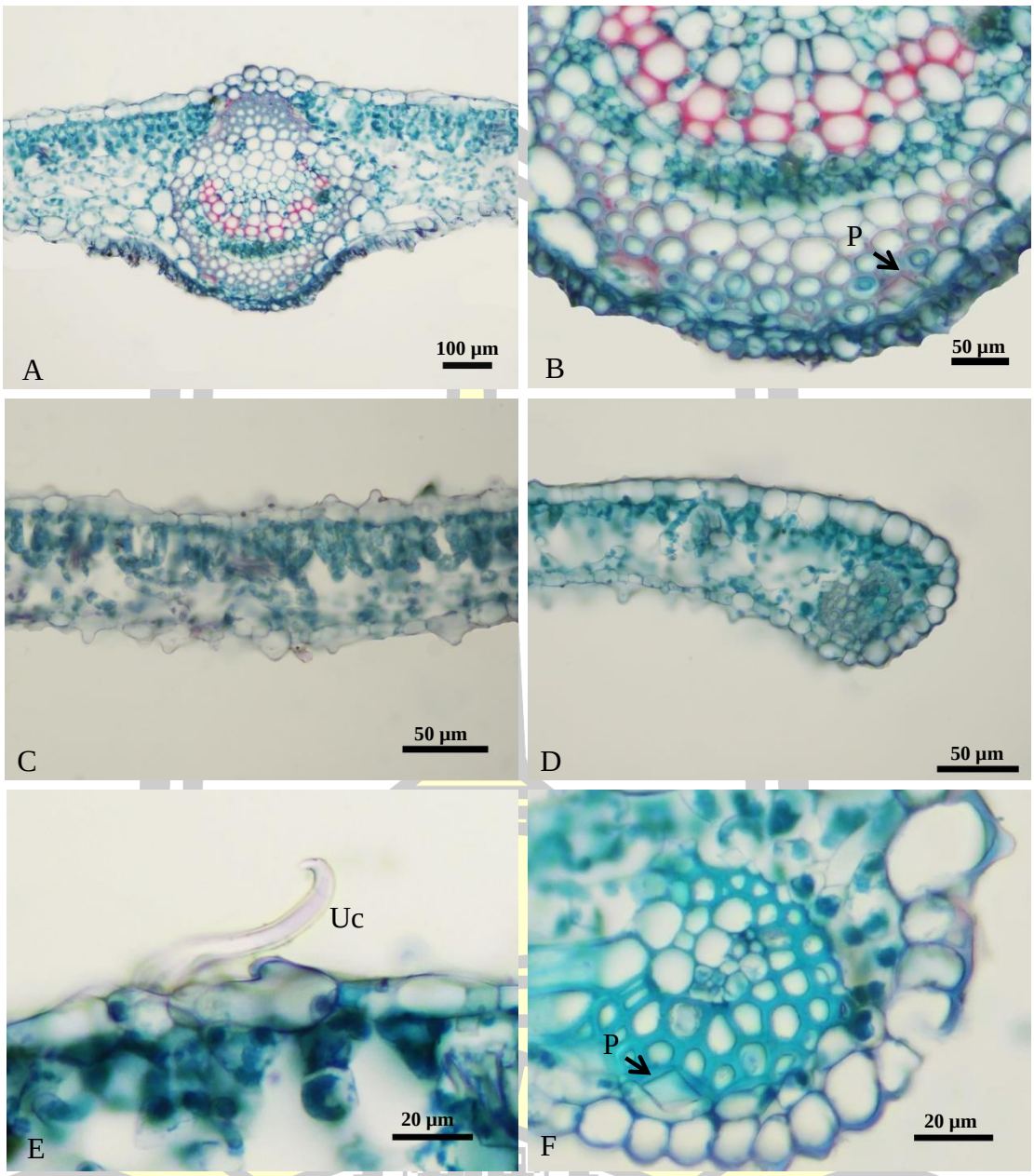

Figure 39 Transverse sections of *Christia pierrei:*

A. the outline of midrib; **B**. vascular tissue showing prismatic crystal in the bundle cap; **C**. laminar showing palisade mesophyll layers only on the upper side with 1-3 cell layers and spongy cells in 2-3 layers; **D**. leaf margin outline showing slightly inflated with obtuse end; **E**. uncinate trichome in lower epidermis; **F**. prismatic crystal in the margin (P = Prismatic crystal, Uc = Uncinate trichome).

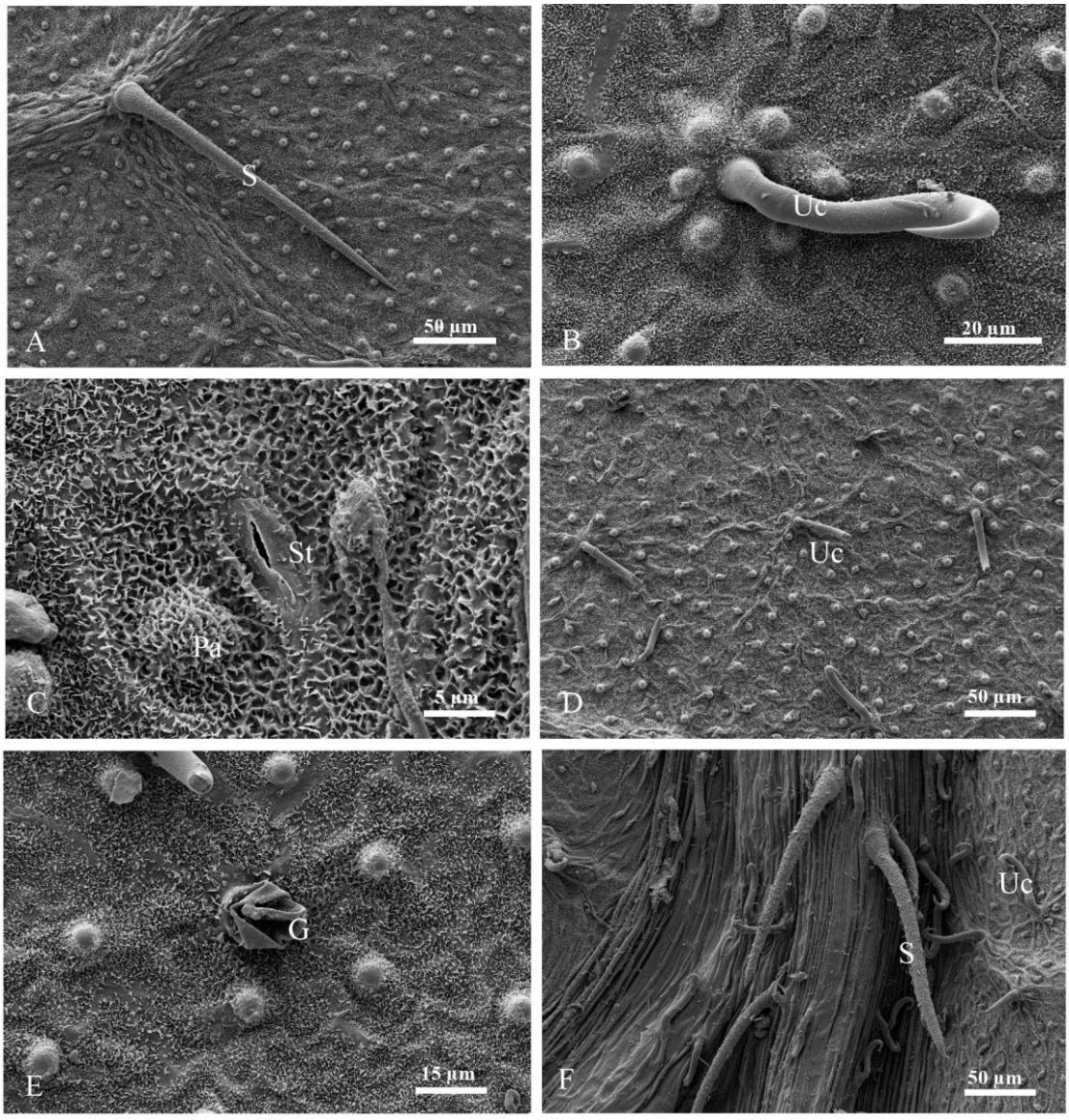

Figure 40 Leaf micromorphology of *Christia vespertilionis:*
A.-C. upper epidermis; **A**. superficial view and subulate trichome, **B.** uncinate trichome, **C.** stomata, papillae and upright scale cuticle, **D.-F**. lower epidermis; **D.** superficial view, **E.** globose multicellular trichome, **F.** subulate trichome and uncinated trichome (G = Globose multicellular trichome, Pa = Papillae, S = Subulate trichome, St = Stomata, Uc = Uncinate trichome).

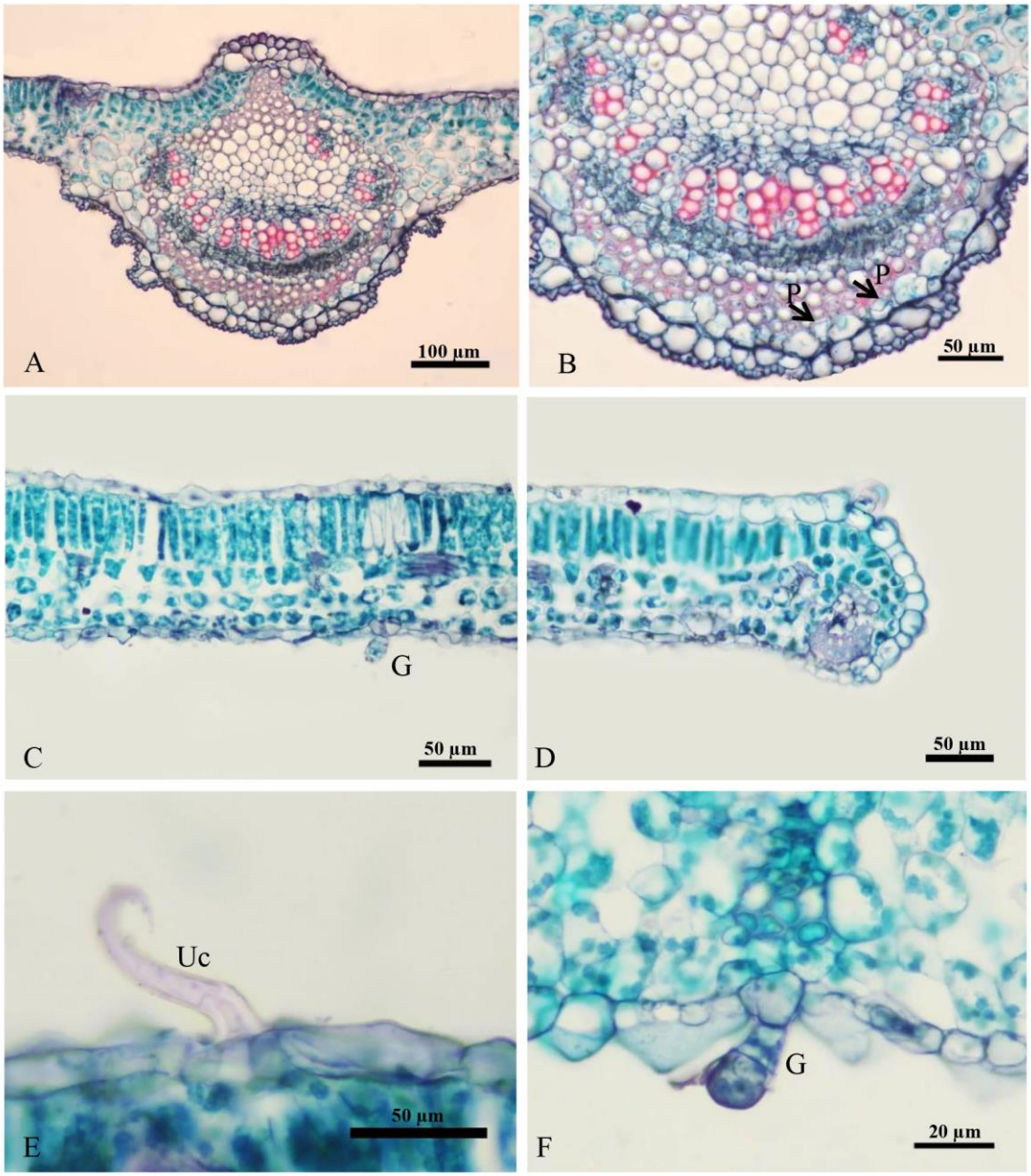

Figure 41 Transverse sections of *Christia vespertilionis:*

A. the outline of midrib; **B**. vascular tissue showing prismatic crystals in the bundle cap; **C**. laminar showing palisade mesophyll layers only on the upper side with 1 cell layer and spongy cells in 3 layers; **D**. leaf margin outline showing slightly inflated to non-inflated with obtuse end; **E**. uncinate trichome in upper epidermis of laminar; **F**. globose multicellular trichome in lower epidermis of laminar (G = Globose multicellular trichome, P = Prismatic crystal, Uc = Uncinate trichome).

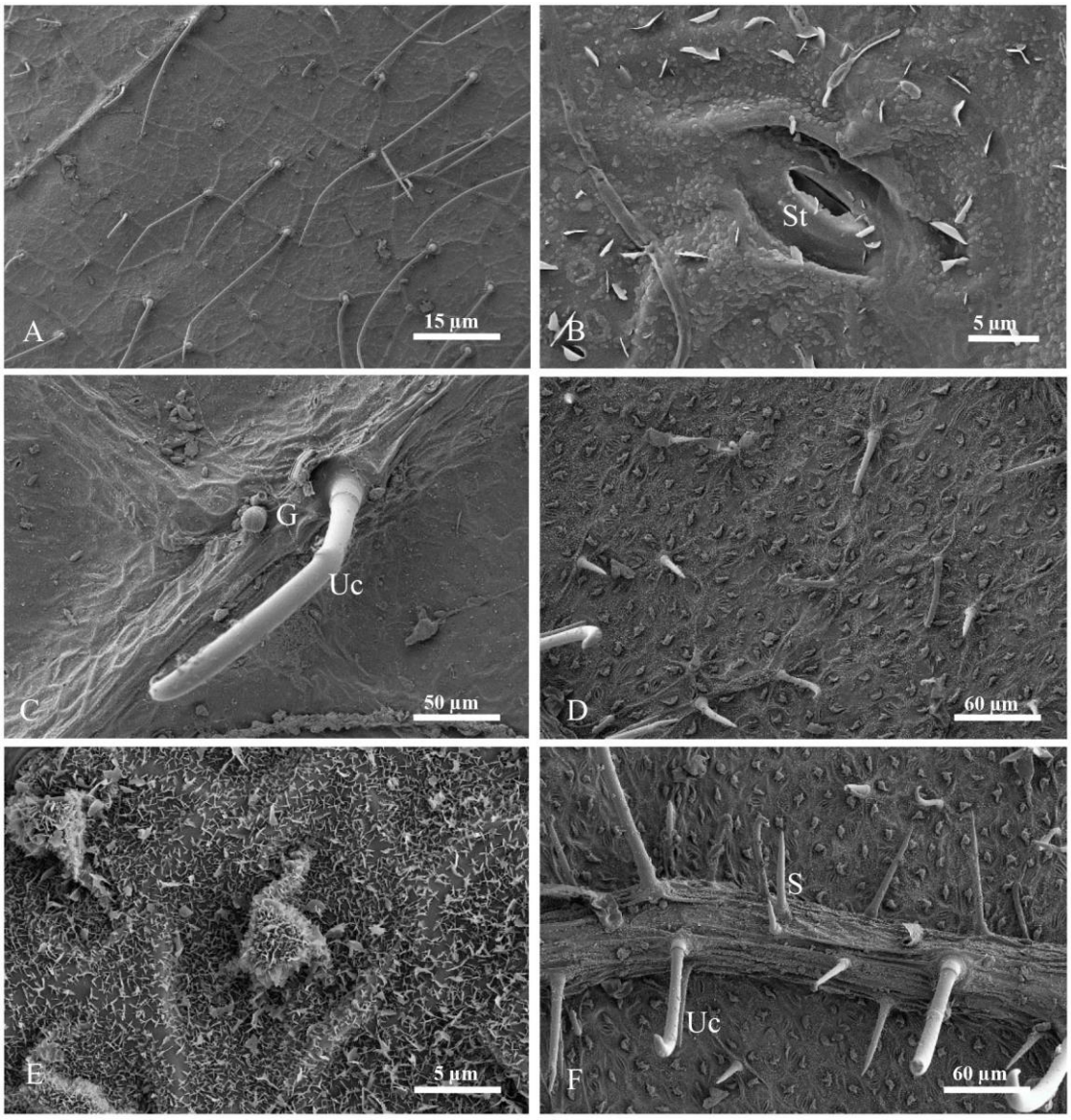

Figure 42 Leaf micromorphology of *Uraria acaulis:*

A.-C. upper epidermis; **A.** superficial view, **B.** stomata and upright scale cuticle, **C.** Globose multicellular trichome and uncinated trichome, **D.-F.** lower epidermis; **D.** superficial view, **E.** papillae and upright scale cuticle, **F.** uncinate trichome and subulate trichome (G = Globose multicellular trichome, S = Subulate trichome, St = Stomata, Uc = Uncinate trichome).

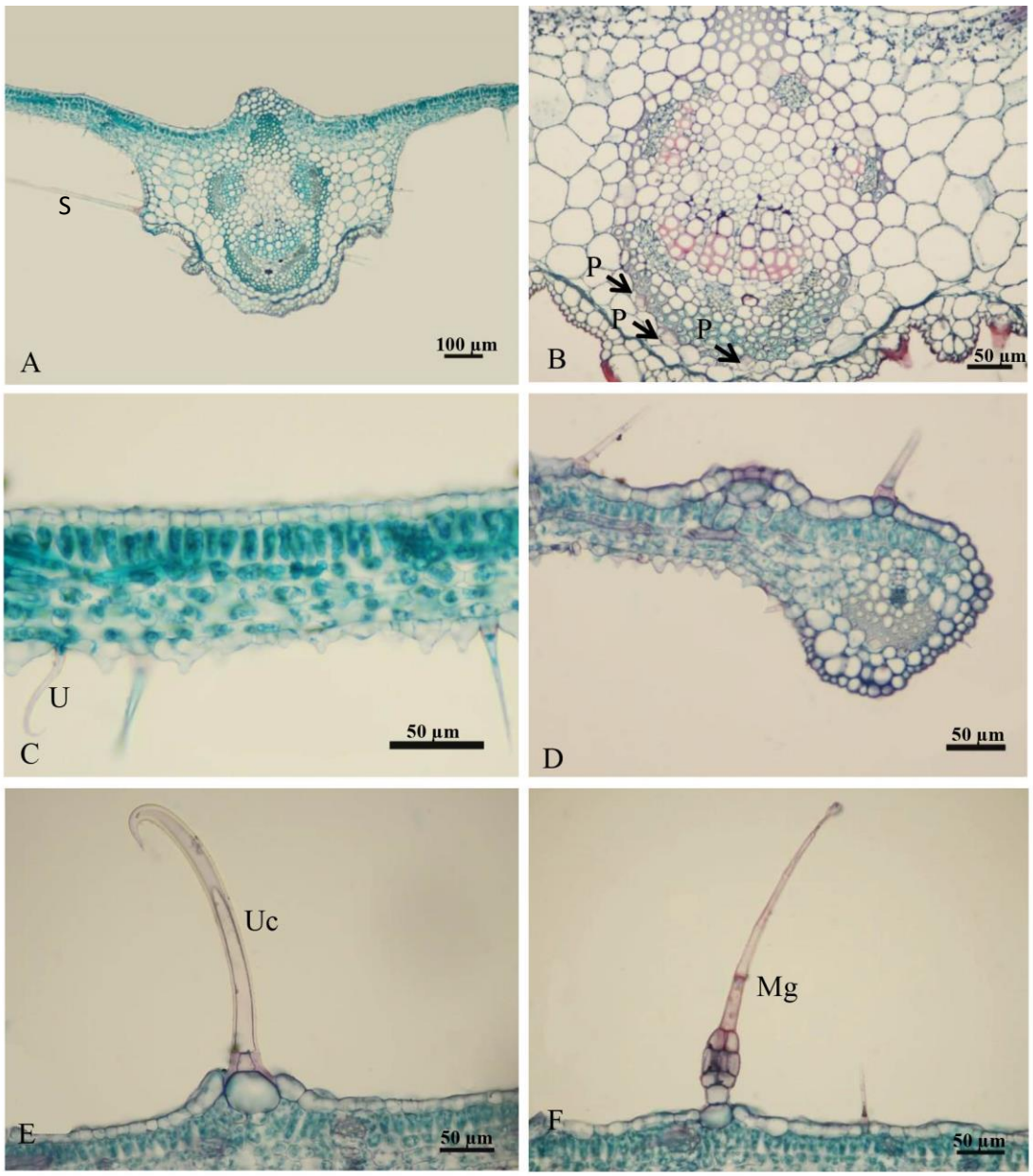

Figure 43 Transverse sections of *Uraria acaulis:*

A. the outline of midrib; **B.** vascular tissue showing prismatic crystals in the bundle cap; **C.** laminar showing palisade mesophyll layers only on the upper side with 1-2 cell layers and spongy cells in 3-4 layers, uncinate trichome in lower epidermis; **D**. leaf margin outline showing inflated with obtuse end; **E**. uncinate trichome in upper epidermis of laminar; **F.** multicellular globular base trichome in upper epidermis of laminar (Mg = Multicellular globular base trichome, P = Prismatic crystal, Uc = Uncinate trichome).

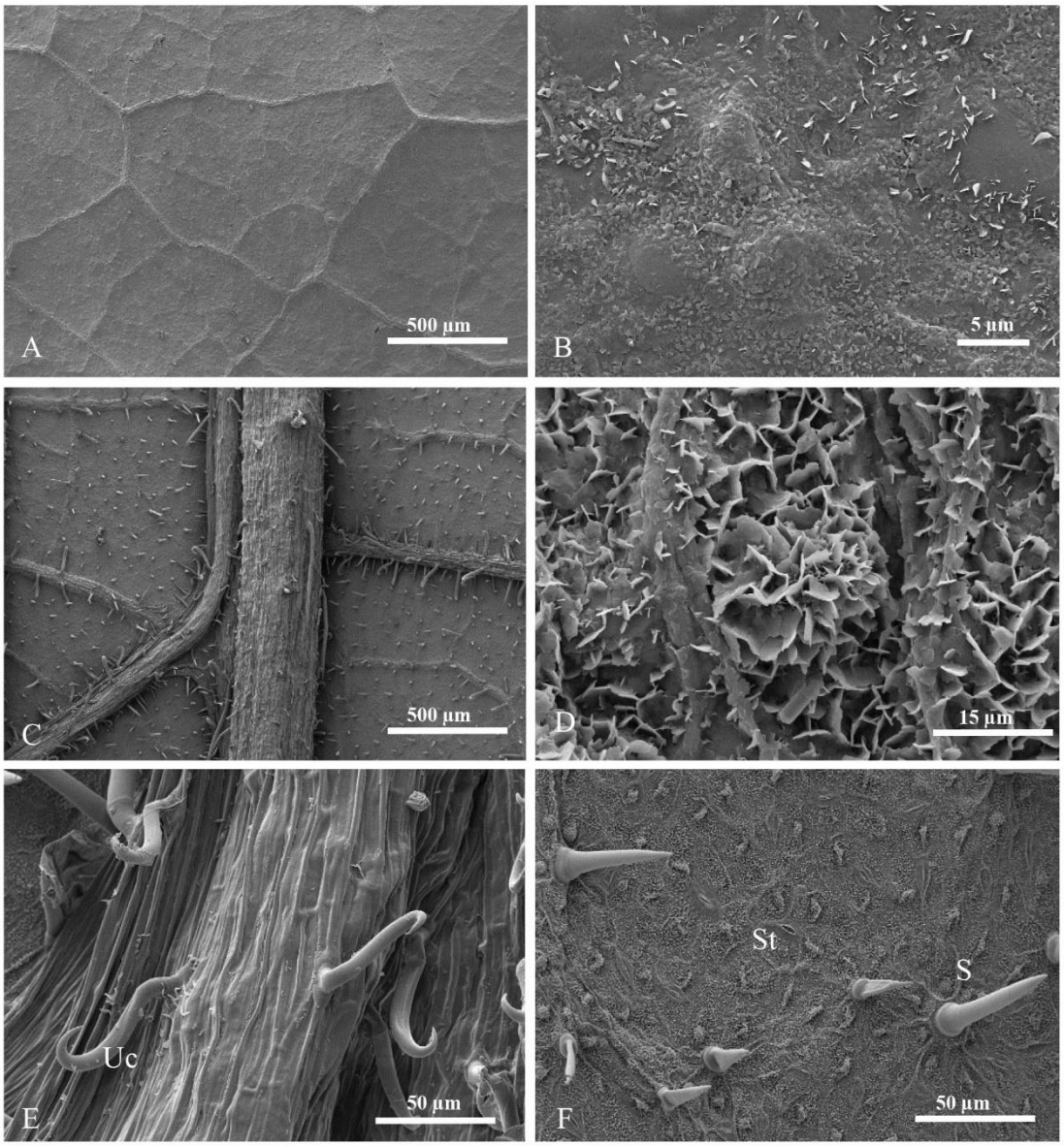

Figure 44 Leaf micromorphology of *Uraria acuminata:*

A.-B. upper epidermis; **A**. superficial view, **B**. upright scale cuticle, **C.-F.** Lower epidermis; **C**. superficial view, **D**. papillae and upright scale cuticle, **E**. uncinated trichome, **F**. stomata and subulate trichome (S = Subulate trichome, St = Stomata, Uc = Uncinate trichome).

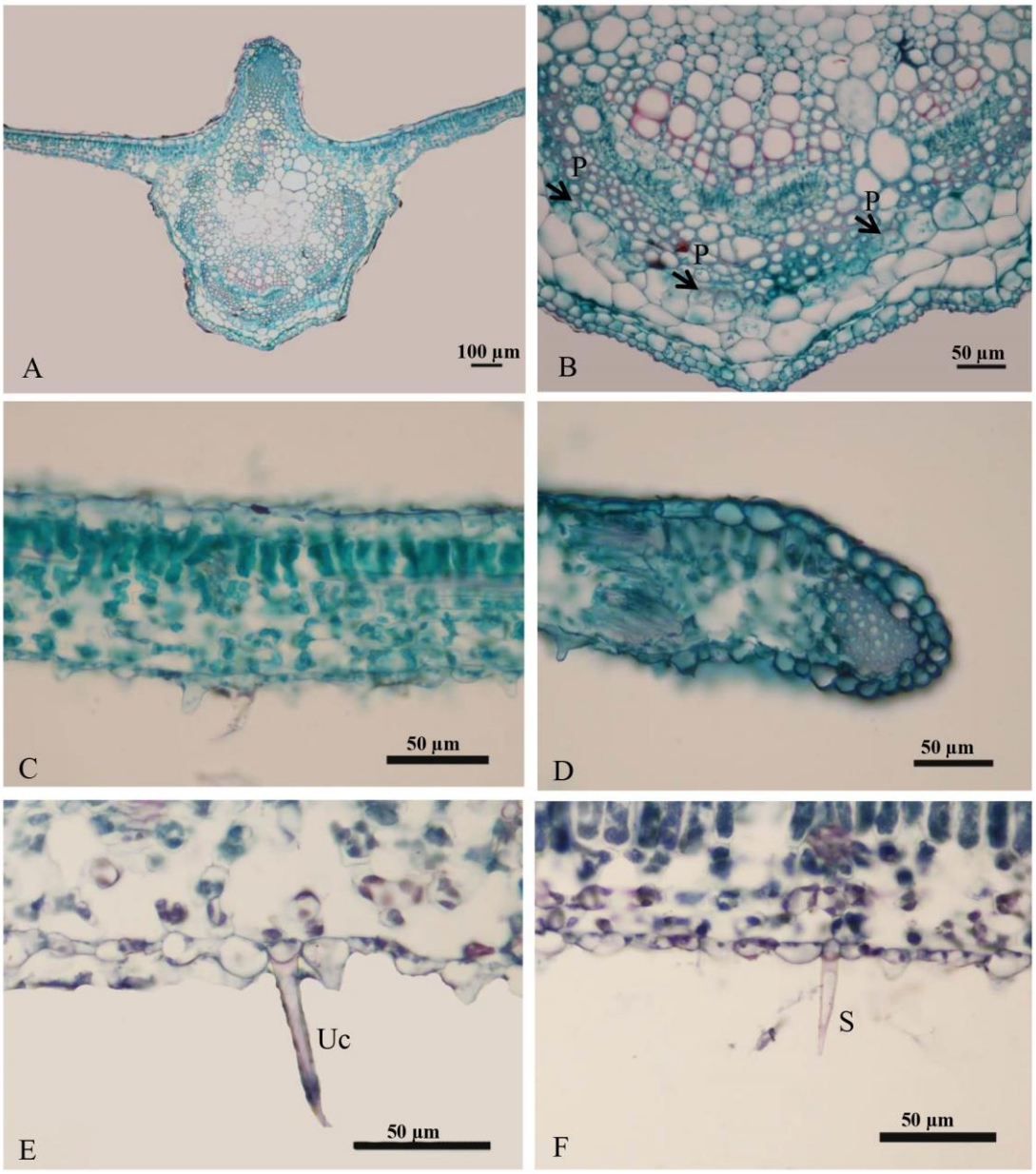

Figure 45 Transverse sections of *Uraria acuminata:*

A. the outline of midrib; **B.** vascular tissue showing prismatic crystals in the bundle cap; **C.** laminar showing palisade mesophyll layers only on the upper side with 1 cell layer and spongy cells in 3-4 layers; **D.** leaf margin outline showing inflated, non-inflated with obtuse end; **E.** uncinate trichome in lower epidermis of laminar; **F.** subulate trichome in lower epidermis of laminar. (P = Prismatic crystal, S = Subulate trichome, Uc = Uncinate trichome).

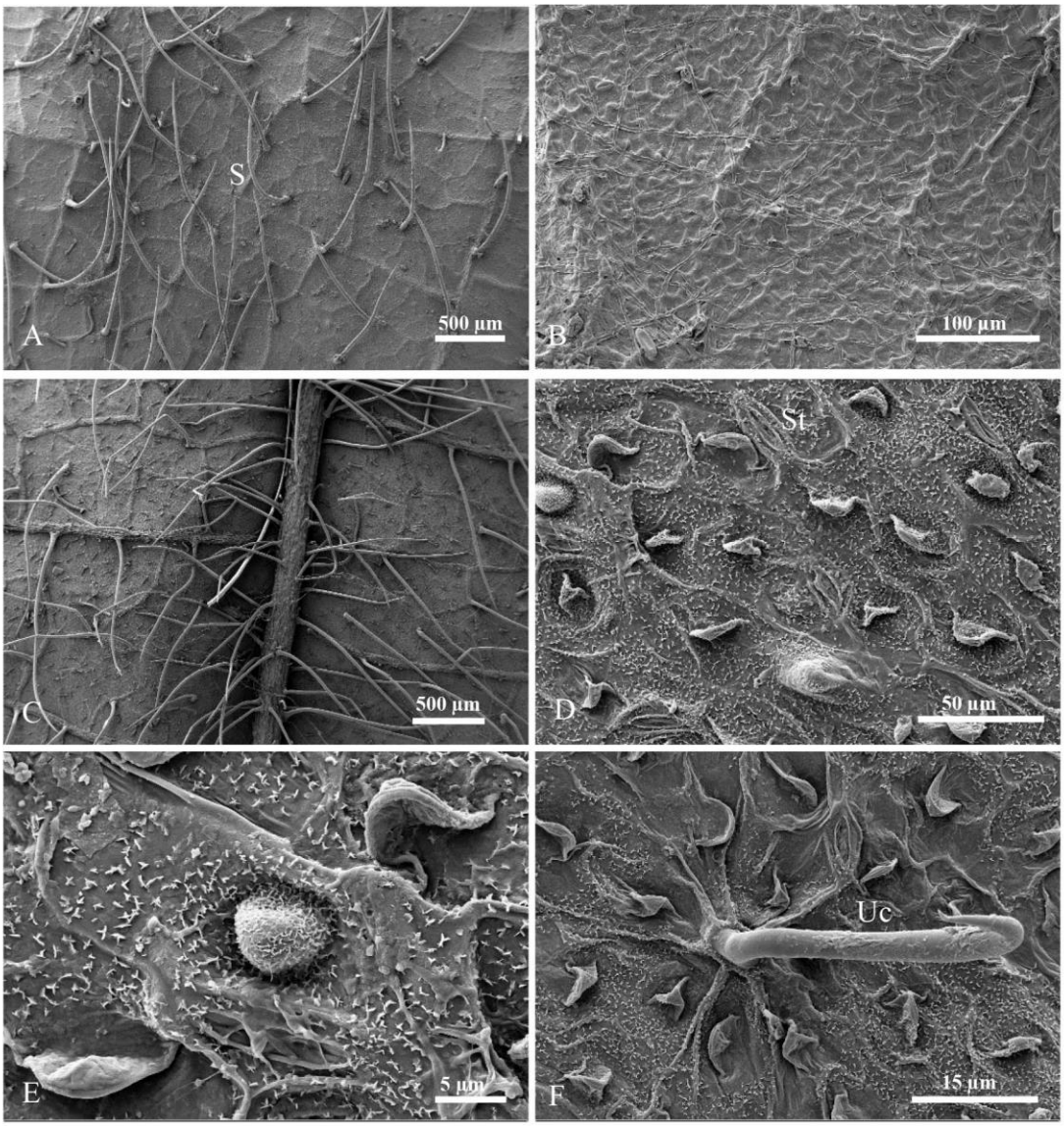

Figure 46 Leaf micromorphology of *Uraria barbaticaulis:*

A.-B. upper epidermis; **A**. superficial view and subulate trichome, **B**. smooth cuticle, **C.-F.** lower epidermis; **C**. superficial view and subulate trichome, **D**. stomata and papillae, **E**. papillae and upright scale cuticle, **F**. uncinated trichome (S = Subulate trichome, St = Stomata, Uc = Uncinate trichome).

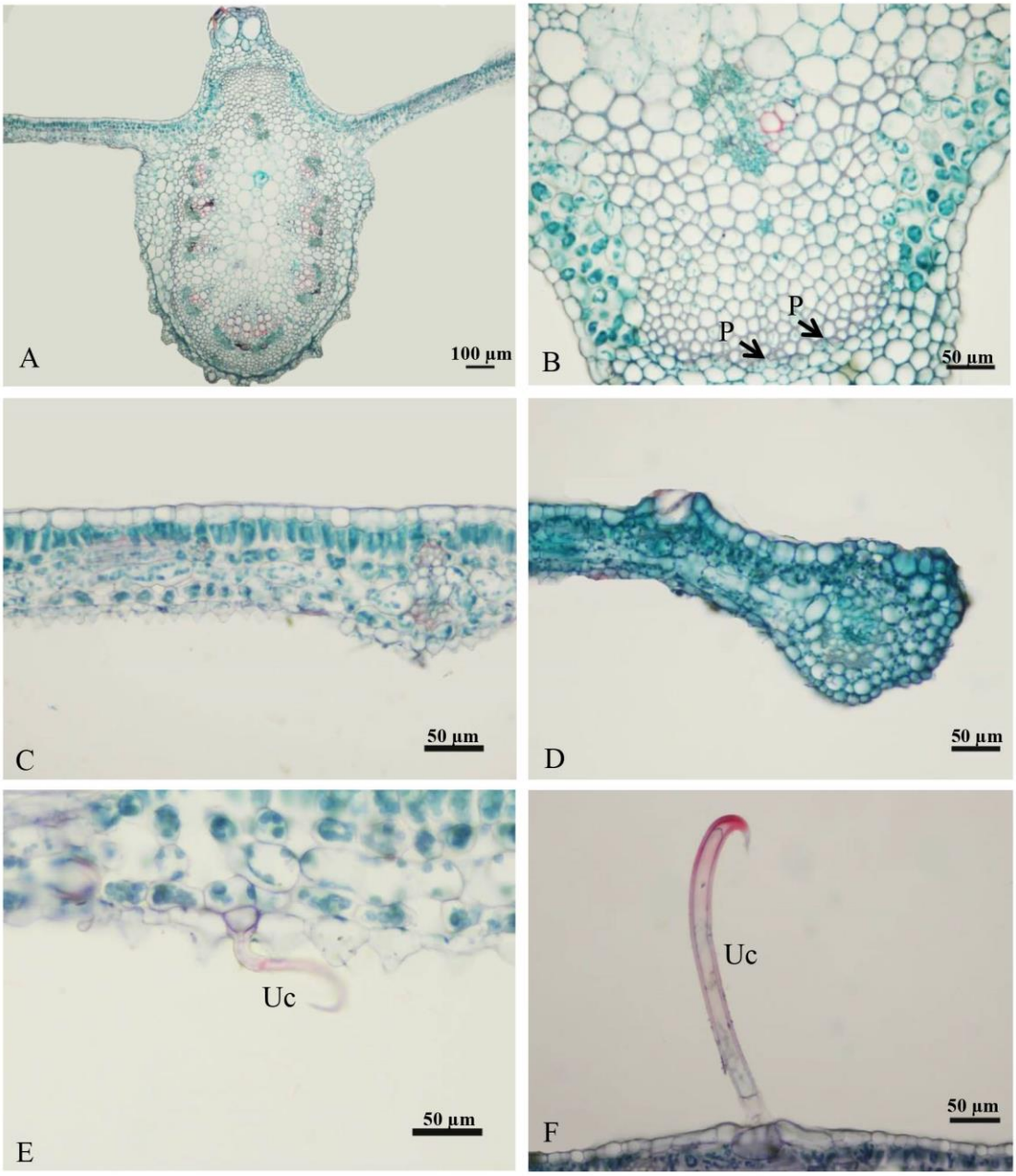

Figure 47 Transverse sections of *Uraria barbaticaulis:*

A. the outline of midrib; **B**. vascular tissue showing prismatic crystals in the bundle cap; **C**. laminar showing palisade mesophyll layers only on the upper side with 1 cell layer and spongy cells in 3-4 layers; **D**. leaf margin outline showing inflated with obtuse end; **E**. uncinate trichome in lower epidermis of laminar; **F**. uncinate trichome in upper epidermis of laminar. (P = Prismatic crystal, Uc = Uncinate trichome).

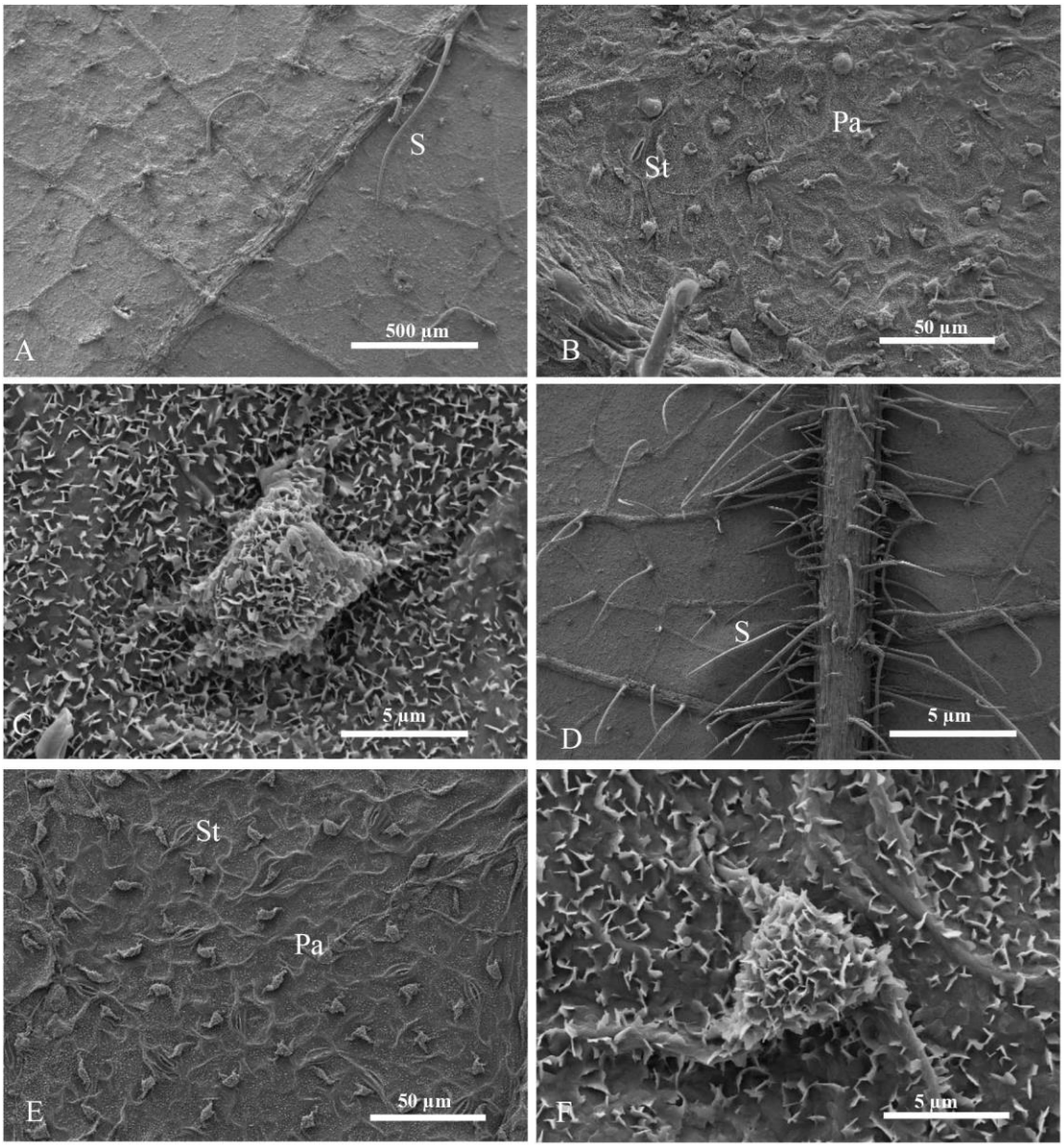

Figure 48 Leaf micromorphology of *Uraria campanulata:*
A.-C. upper epidermis; **A**. superficial view and subulate trichomes, **B**. papillae and stomata, **C**. papillae and upright scale cuticle, **D.-F**. Lower epidermis; **D**. superficial view and subulate trichome, **E**. papillae and stomata, **F**. papillae and upright scale cuticle (Pa = Papillae, S = Subulate trichome, St = Stomata).

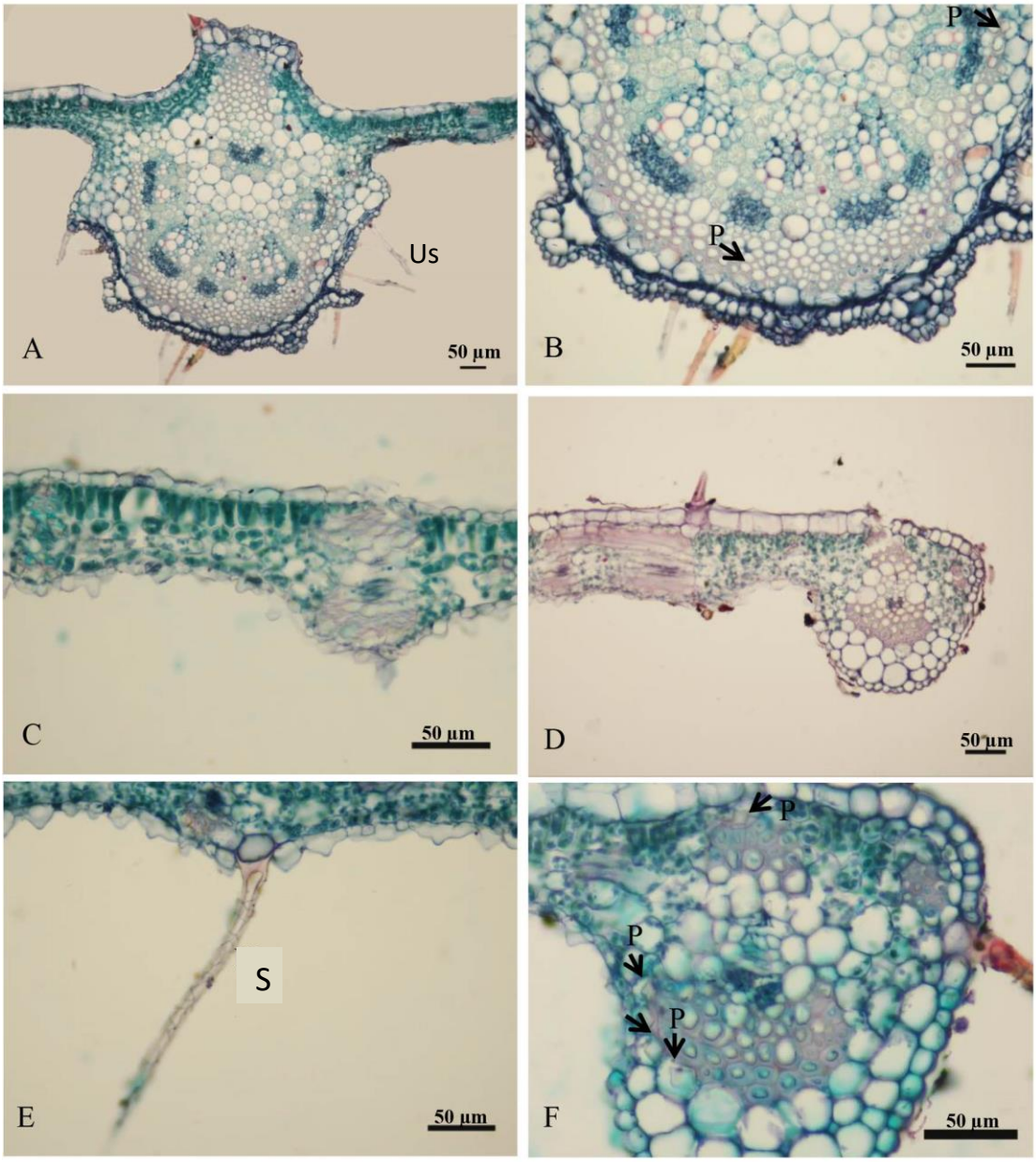

Figure 49 Transverse sections of *Uraria campanulata:*

A. the outline of midrib; **B**. vascular tissue showing prismatic crystals in the bundle cap; **C**. laminar showing palisade mesophyll layers only on the upper side with 1 cell layer and spongy cells in 3-4 layers; **D**. leaf margin outline showing slightly inflated with obtuse end; **E**. uniseriate trichomes in lower epidermis; **F**. prismatic crystal in the margin. (P = Prismatic crystal, S = Subulate trichome, Us = Uniseriate trichome).

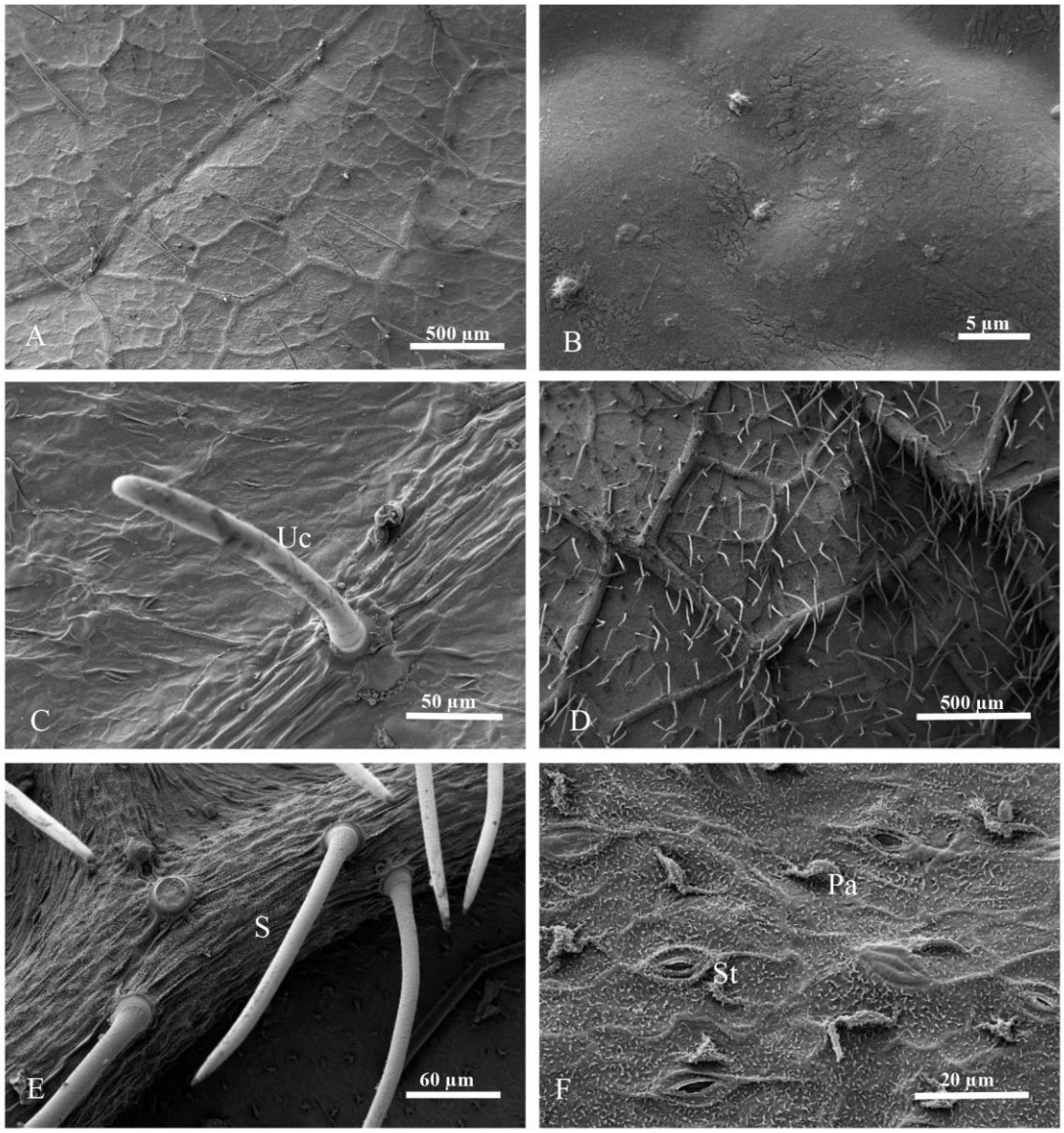

Figure 50 Leaf micromorphology of *Uraria cordifolia:*

A.-C. upper epidermis; **A**. superficial view, **B**. smooth cuticle, **C**. uncinate trichome, **D.-F.** lower epidermis; **D**. superficial view, **E**. subulate trichome, **F**. papillae, upright scale cuticle and stomata (Pa = Papillae, S = Subulate trichome, St = Stomata, Uc = Uncinate trichome).

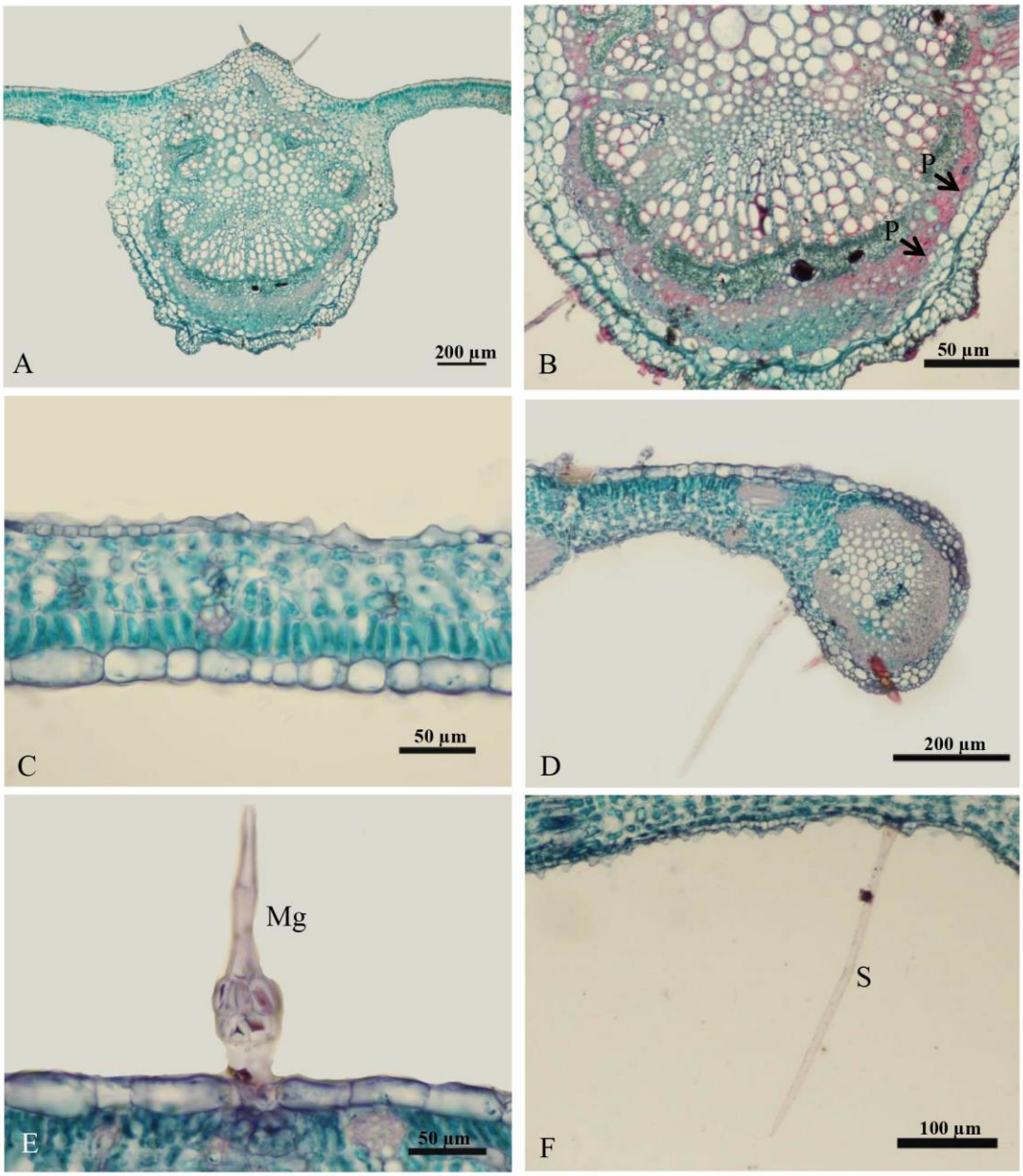

Figure 51 Transverse sections of *Uraria cordifolia:*

A. the outline of midrib; **B**. vascular tissue showing prismatic crystals in the bundle cap; **C**. laminar showing palisade mesophyll layers only on the upper side with 1-2 cell layers and spongy cells in 3-4 layers; **D**. leaf margin outline showing inflated to non-inflated with obtuse end; **E**. Multicellular globular base trichome in upper epidermis of laminar; **F**. subulate trichome in lower epidermis of laminar. (Mg = Multicellular globular base trichome, Uc = Uncinate trichome).

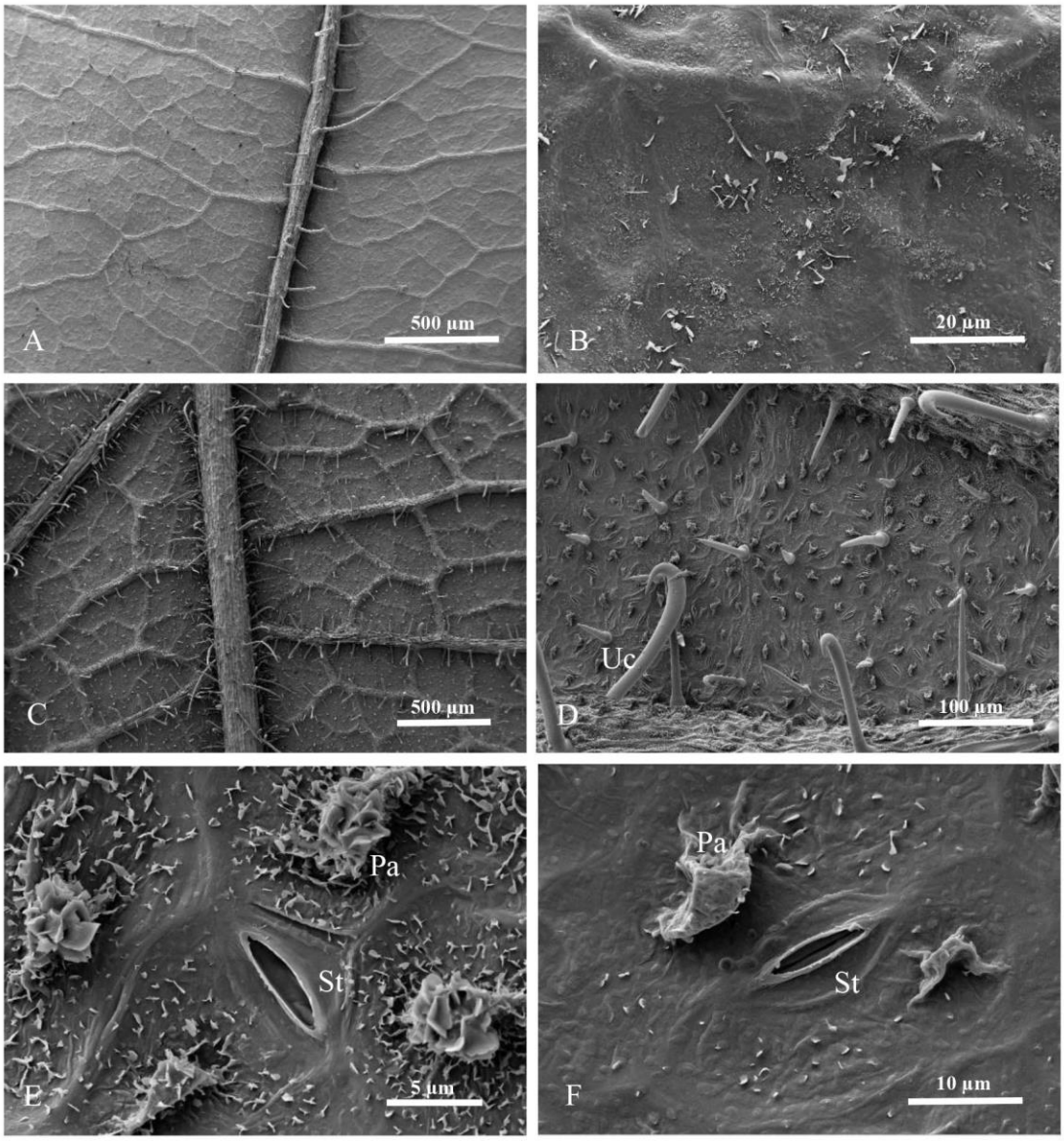

Figure 52 Leaf micromorphology of *Uraria crinita:*

A.-B. upper epidermis; **A**. superficial view, **B**. smooth cuticle, **C.-F.** lower epidermis; **C**. superficial view, **D**. uncinate trichome, **E.-F.** papillae, upright scale cuticle and stomata (Pa = Papillae, St = Stomata, Uc = Uncinate trichome).

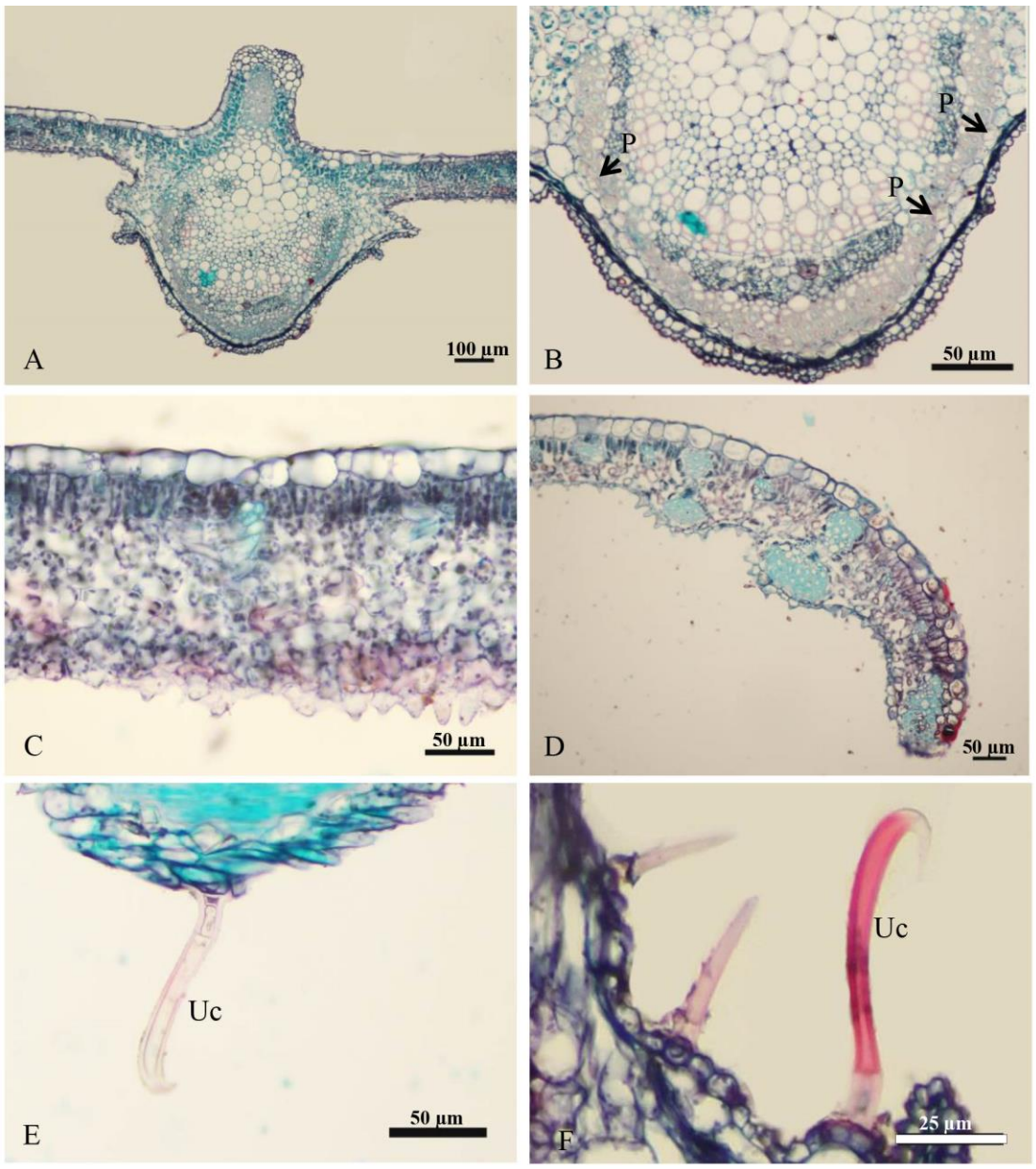

Figure 53 Transverse sections of *Uraria crinita*:

A. the outline of midrib; **B**. vascular tissue showing prismatic crystals in the bundle cap; **C**. laminar showing palisade mesophyll layers only on the upper side with 1-2 cell layers and spongy cells in 2-4 layers; **D.** leaf margin outline showing inflated with obtuse end; **E**. uncinate trichome in lower epidermis of laminar; **F**. uncinate trichome in lower epidermis of midrib. (P = Prismatic crystal, Uc = Uncinate trichome).

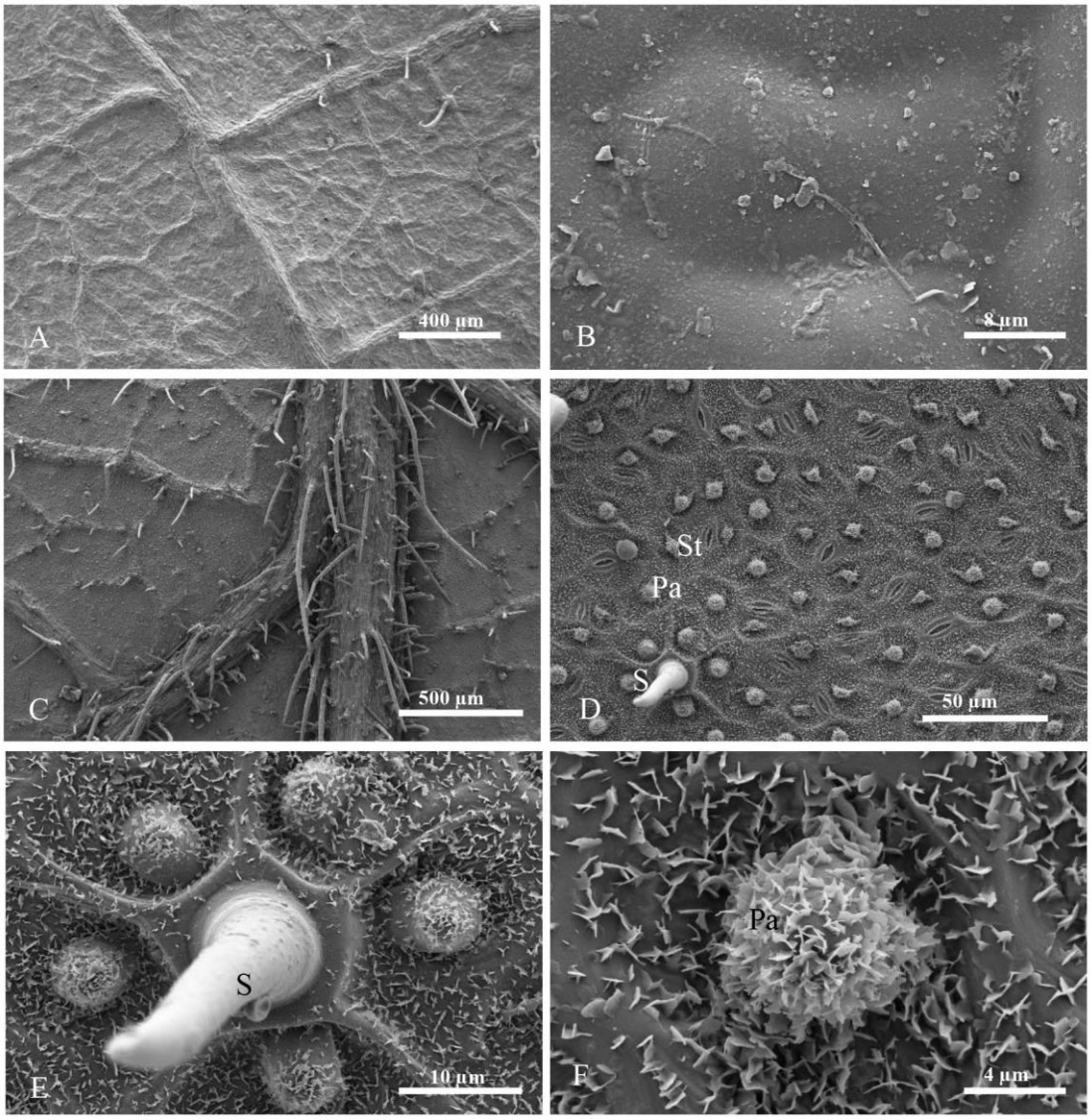

Figure 54 Leaf micromorphology of *Uraria lagopodioides:*

A.-B. upper epidermis; **A**. superficial view, **B**. smooth cuticle, **C.-F.** lower epidermis; **C**. superficial view, **D**. subulate trichome, papillae and stomata, **E**. Subulate trichome, **F**. papillae and upright scale cuticle (Pa = Papillae, S = Subulate trichome, St = Stomata).

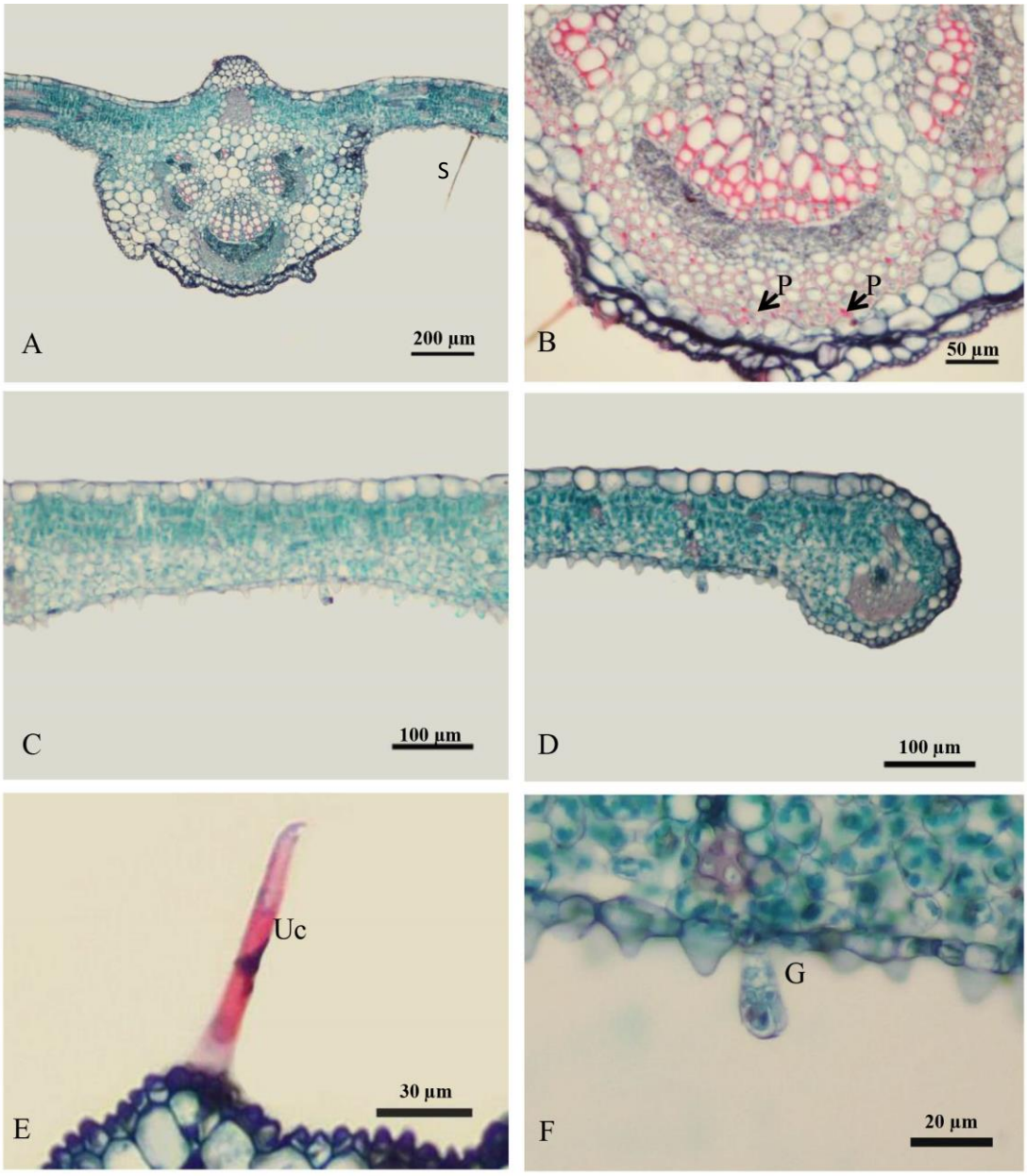

Figure 55 Transverse sections of *Uraria lagopodioides:*

A. the outline of midrib; **B**. vascular tissue showing prismatic crystals in the bundle cap; **C**. laminar showing palisade mesophyll layers only on the upper side with 2 cell layers and spongy cells in 2-3 layers; **D**. leaf margin outline showing inflated with obtuse end; **E**. uncinate trichome in upper epidermis of midrib; **F**. globose multicellular trichome in lower epidermis of laminar. (G = Globose multicellular trichome, P = Prismatic crystal, S = Subulate trichome, Uc = Uncinate trichome).

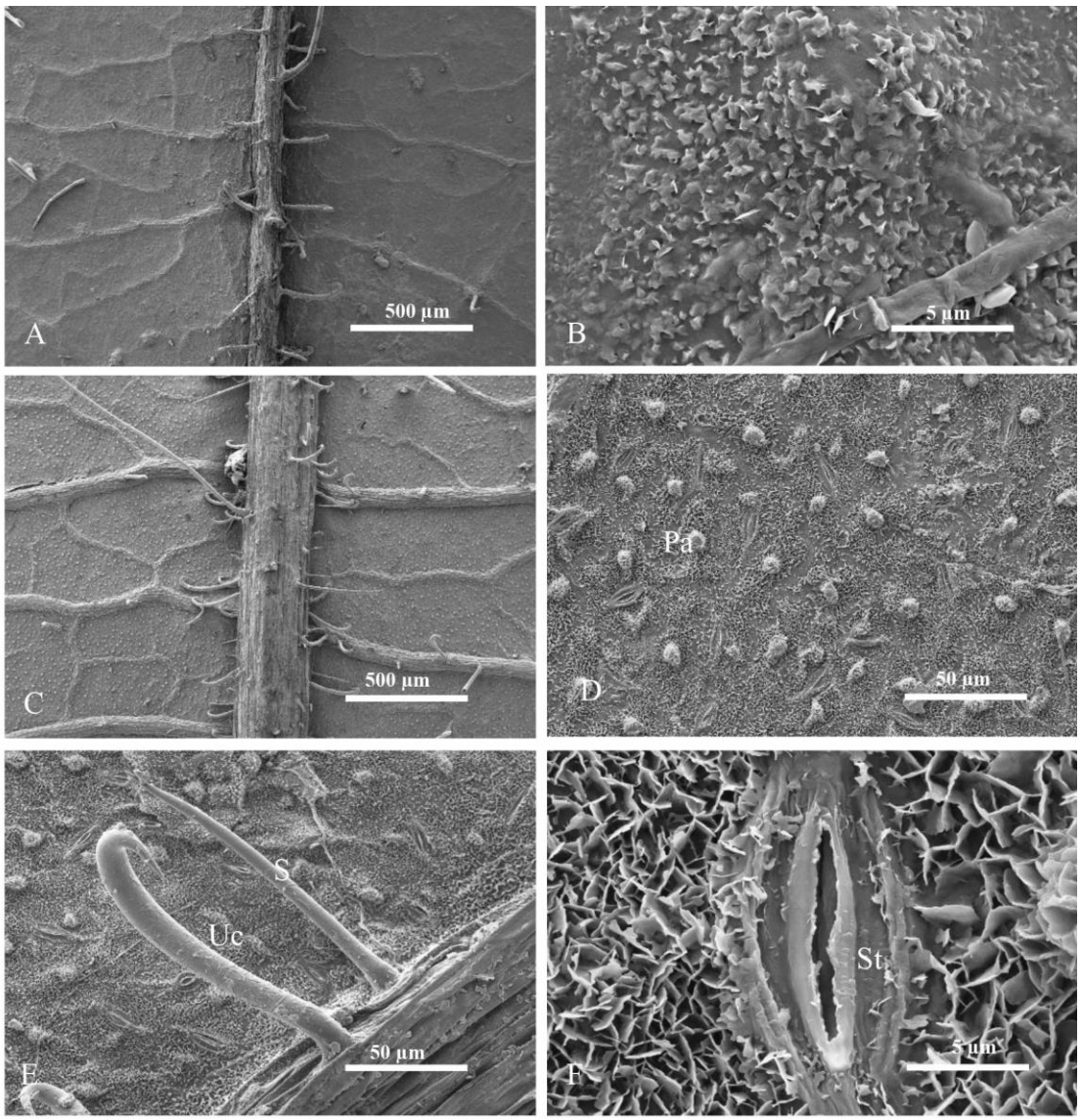

Figure 56 Leaf micromorphology of *Uraria picta:*

A.-B. upper epidermis; **A**. superficial view, B. upright scale cuticle, **C.-F.** lower epidermis; **C**. superficial view, **D**. papillae, **E**. subulate trichome and uncinate trichome, **F**. stomata and upright scale cuticle (Pa = Papillae, S = subulate trichome, St = Stomata, Uc = Uncinate trichome).

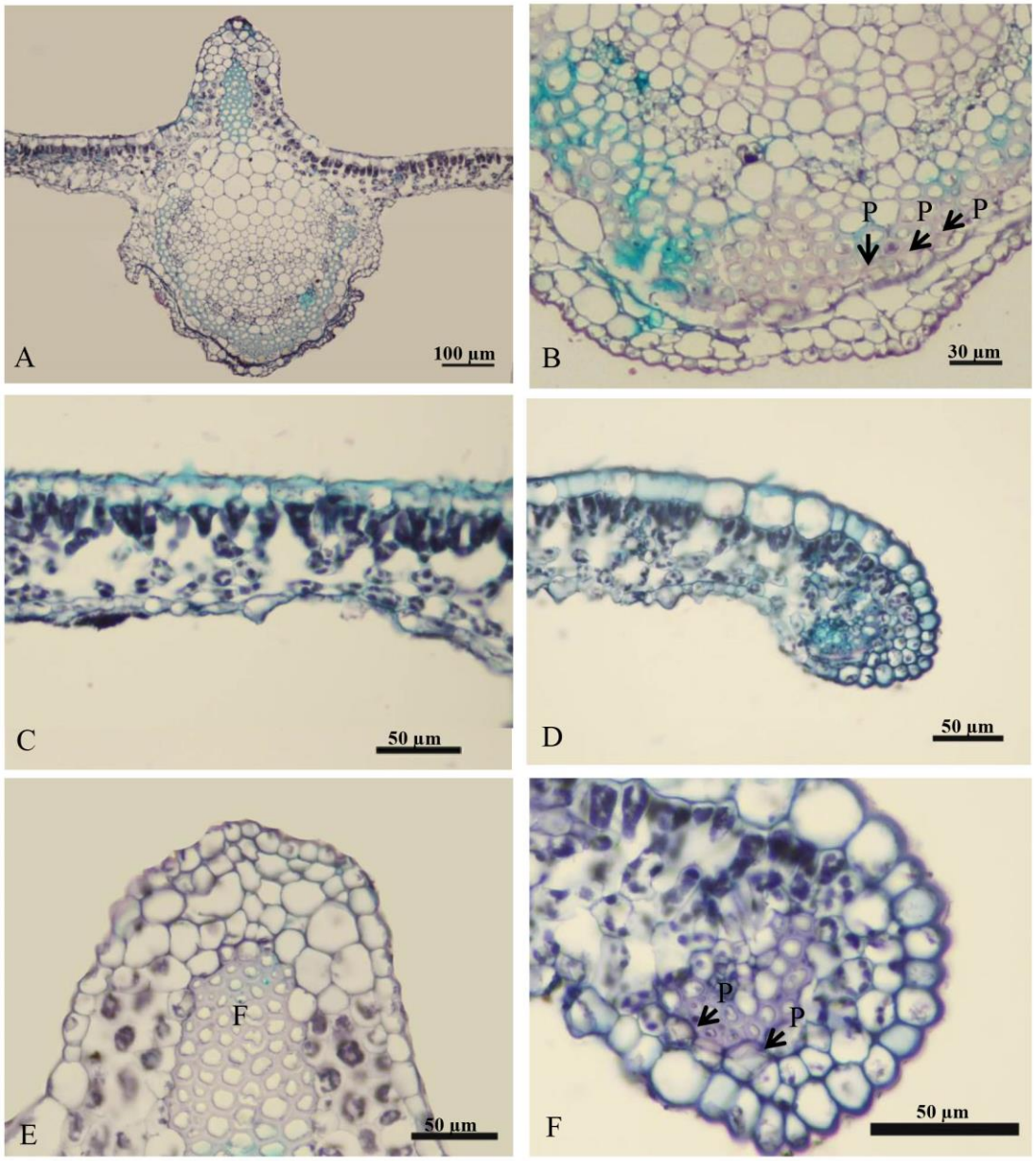

Figure 57 Transverse sections of *Uraria picta:*

A. the outline of midrib; **B**. vascular tissue showing prismatic crystals in the bundle cap; **C**. laminar showing palisade mesophyll layers only on the upper side with 1 cell layer and spongy cells in 2-3 layers; **D**. leaf margin outline showing slightly inflated with obtuse end; **E**. fibre cap in the margin; **F**. prismatic crystal in the margin. (F = Fibre, P = Prismatic crystal, Us = Uniseriate trichome).

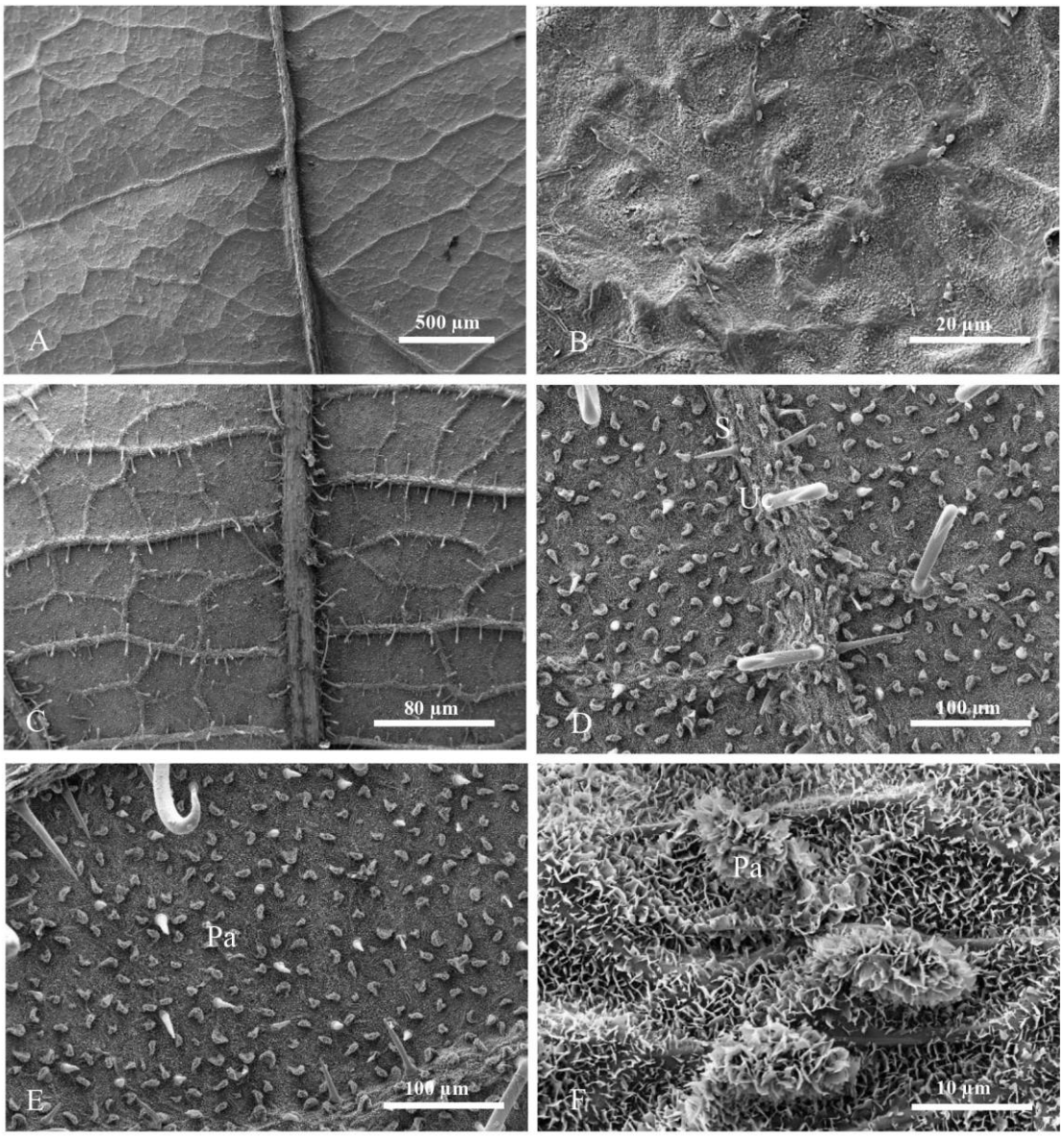

Figure 58 Leaf micromorphology of *Uraria pseudoacuminata:*
A.-B. upper epidermis; **A**. superficial view, **B**. smooth cuticle, **C.-F.** lower epidermis; **C**. superficial view, **D**. uncinate trichome and subulate trichome, **E**. papillae, **F**. papillae and upright scale cuticle (Pa = Papillae, S = Subulate trichome, Uc = Uncinate trichome).

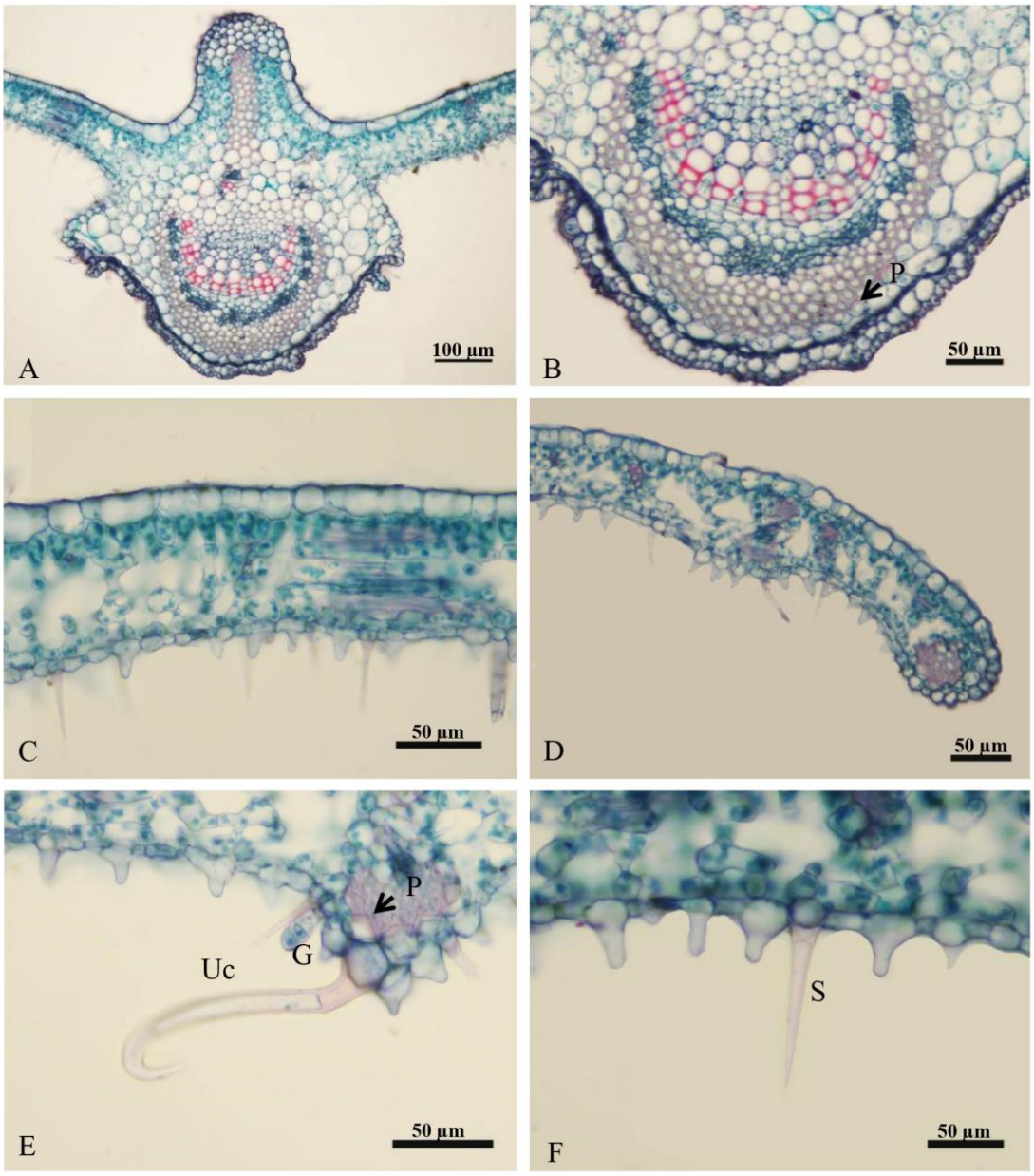

Figure 59 Transverse sections of *Uraria pseudoacuminata:*

A. the outline of midrib; **B**. vascular tissue showing prismatic crystal in the bundle cap; **C**. laminar showing palisade mesophyll layers only on the upper side with 1 cell layer and spongy cells in 3-4 layers; **D**. leaf margin outline showing inflated, non-inflated with obtuse end; **E**. uncinate trichome and globose multicellular trichome in lower epidermis of laminar; **F**. subulate trichome in lower epidermis of laminar. (G = Globose multicellular trichome, P = Prismatic crystal, S = Subulate trichome, Uc = Uncinate trichome).

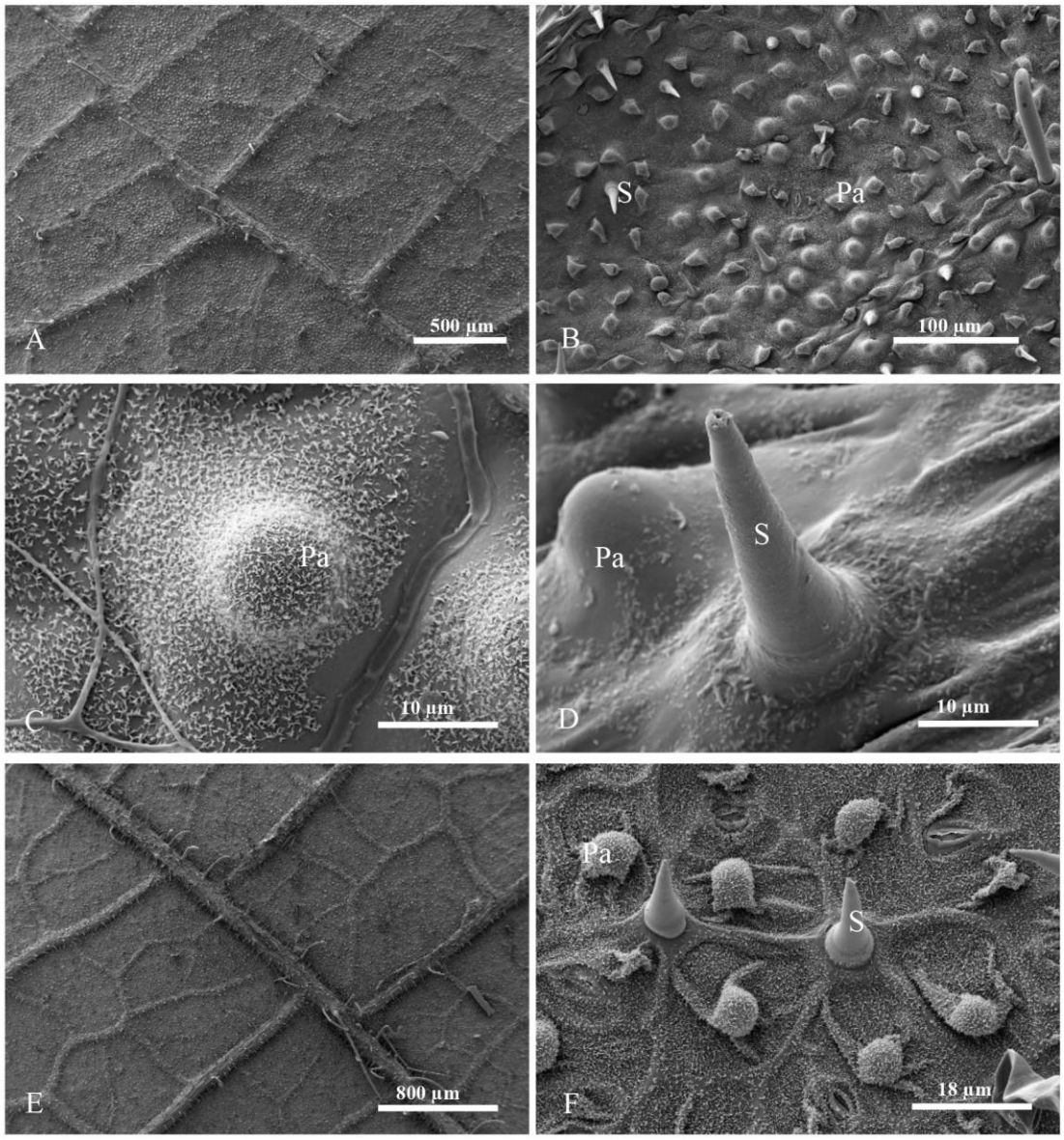

Figure 60 Leaf micromorphology of *Uraria rotundata:*

A.-D. upper epidermis; **A**. superficial view, **B**. subulate trichome and papillae, **C**. papillae and upright scale cuticle, **D**. subulate trichome and papillae, **E.-F.** lower epidermis; **E**. superficial view, **F**. subulate trichome and papillae (Pa = Papillae, S = Subulate trichome).

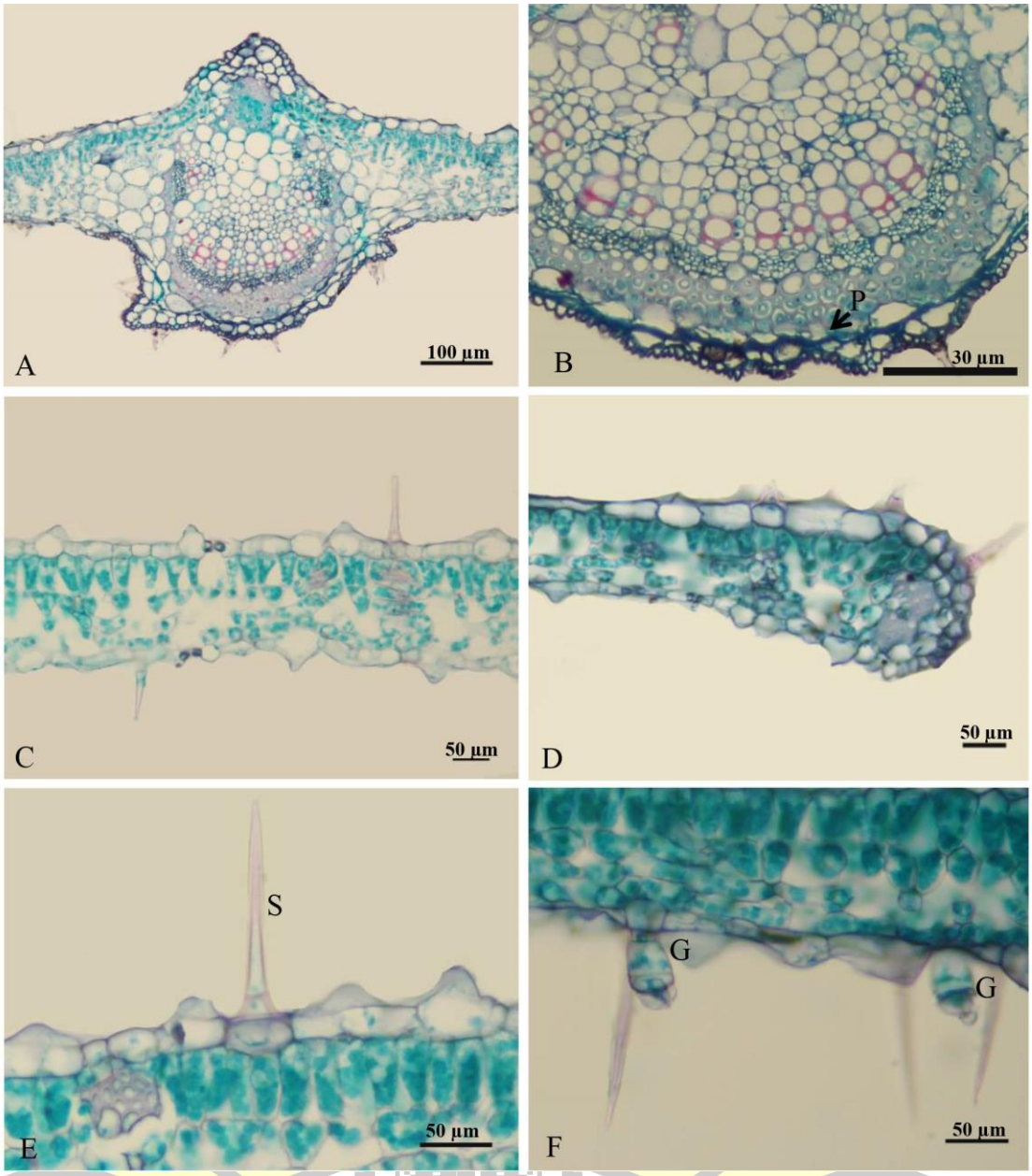

Figure 61 Transverse sections of *Uraria rotundata:*

A. the outline of midrib; **B**. vascular tissue showing prismatic crystal in the bundle cap; **C**. laminar showing palisade mesophyll layers only on the upper side with 1 cell layer and spongy cells in 2-3 layers; **D**. leaf margin outline showing Inflated to non-inflated with obtuse en; **E**. subulate trichome in upper epidermis of laminar; **F**. globose multicellular trichome in lower epidermis of laminar. (G = Globose multicellular trichome, P = Prismatic crystal, S = Subulate trichome).

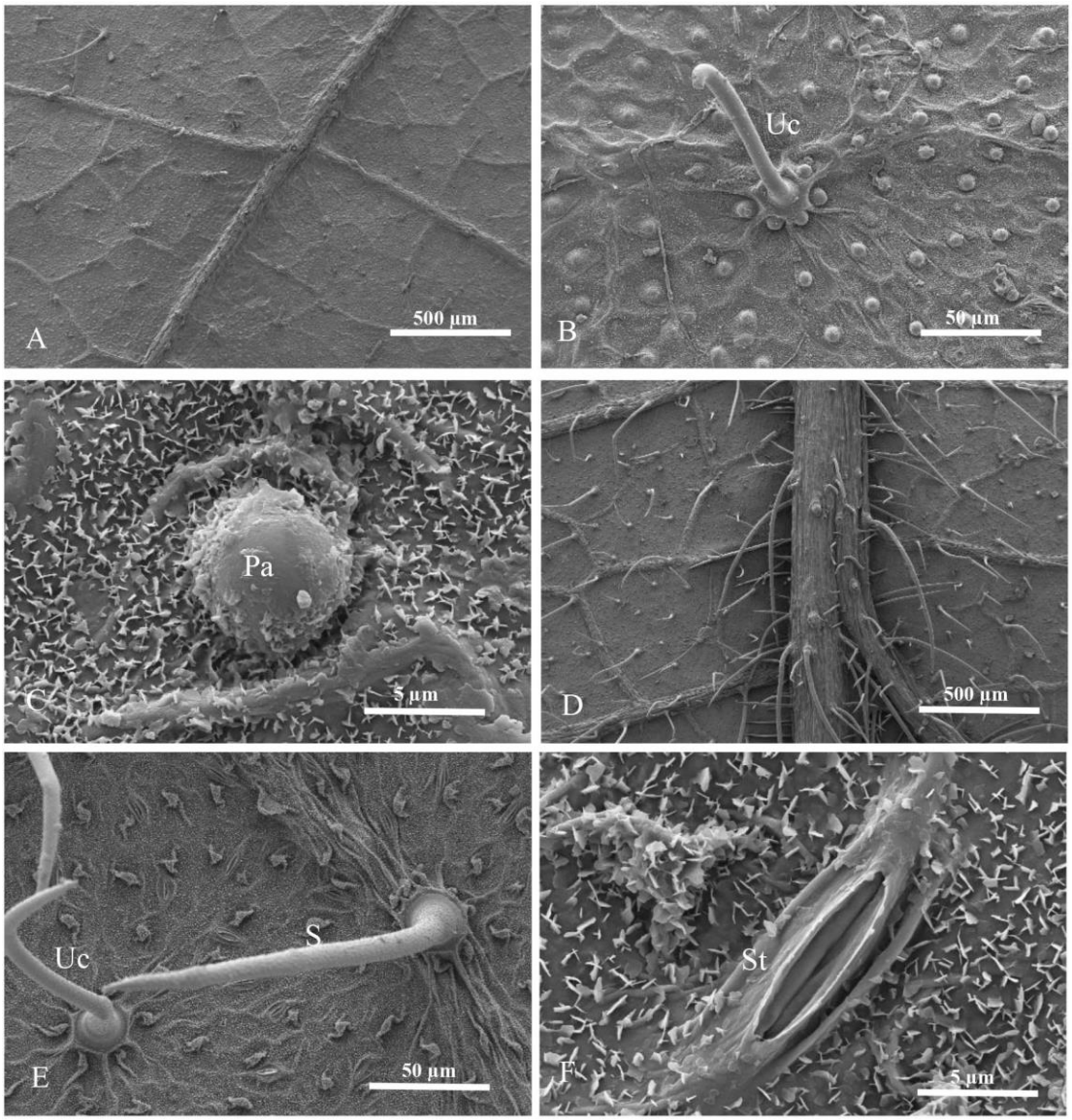

Figure 62 Leaf micromorphology of *Uraria rufescens:*

A.-C. upper epidermis; **A**. superficial view, **B**. uncinate trichome, **C**. papillae and upright scale cuticle, **D.-F.** Lower epidermis; **D**. Superficial view; **E**. subulate trichome and uncinate trichome; **F**. stomata (Pa = Papillae, S = Subulate trichome, St = Stomata, Uc = Uncinate trichome).

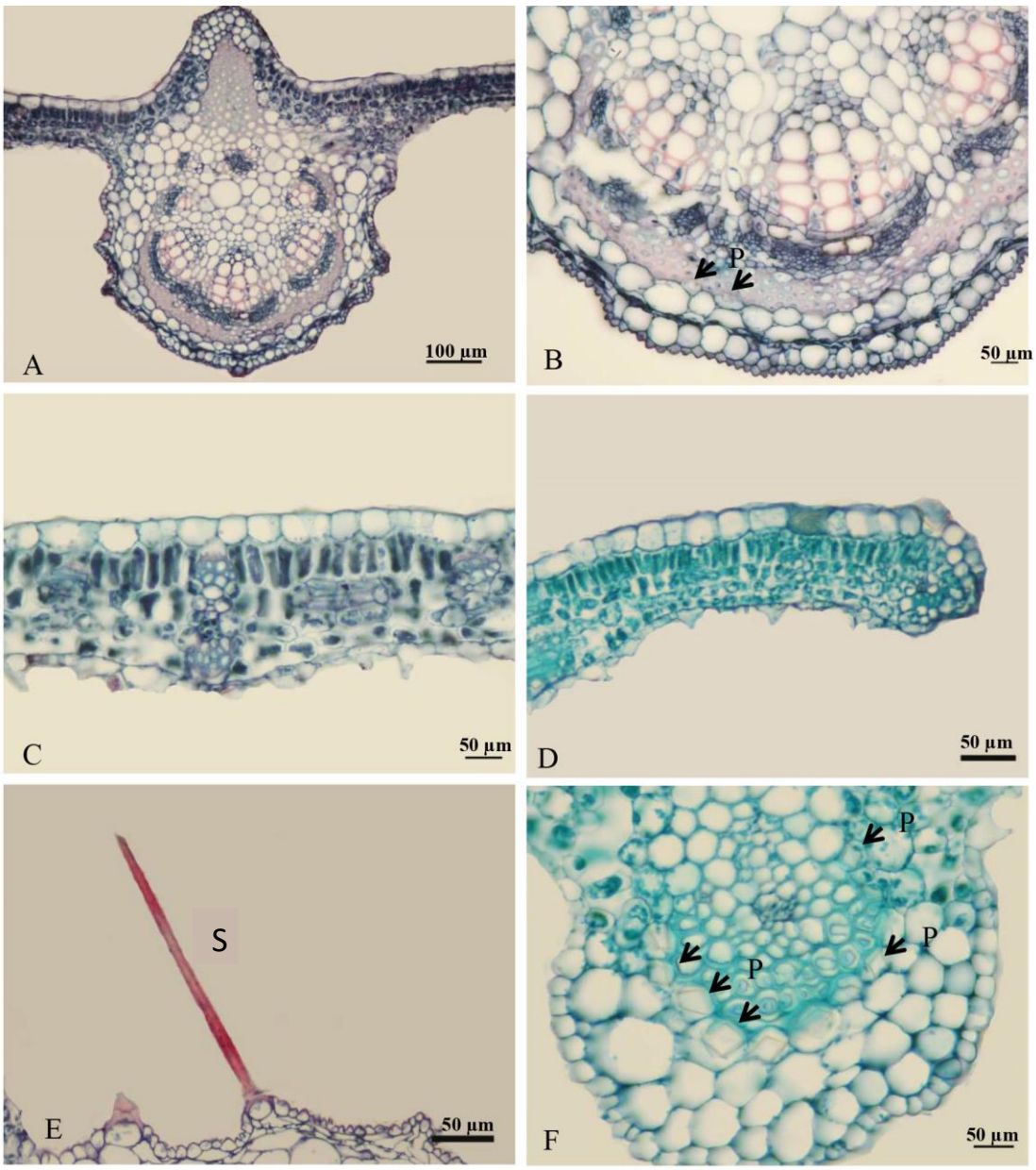

Figure 63 Transverse sections of *Uraria rufescens:*

A. the outline of midrib; **B**. vascular tissue showing prismatic crystals in the bundle cap. **C**. laminar showing palisade mesophyll layers only on the upper side with 1-2 cell layer and spongy cells in 2-3 layers; **D**. leaf margin outline showing inflated to non-inflated with obtuse end; **E**. subulate trichome in upper epidermis; **F**. prismatic crystals in parenchyma cells above bundle cap. (P = Prismatic crystal, Us = Uniseriate trichome).

4.5 Phylogenetic Studies

The DNA sequencing of nrDNA internal transcribed spacer (ITS) were analyzed in 24 samples, 14 species of three *Christi*a, ten *Uraria* and one *Urariopsis* in Thailand. The analysis included 72 sequences of Desmodeae from GenBank as well as the three sequences of *Christia*, four sequences of *Uraria*, 61 sequences of difference genera in Desmodeae and two Phaseoleae (Paphilionoideae; Leguminosae) (*Phaseolus vulgaris* and *Vigna radiata*) and two Polygalaceae (Fabales) (*Polygala planellasi* and *Xanthophyllum hypoleucum*) were used as outgroup.

The results showed that the PCR products of ITS regiont were sequenced successfully. We were able to generate about 600 bp of ITS for each species. Tree of genus *Uraria* is polyphyletic, *U. acuminata* is separated from *Uraria* core group and placed between other genera in tribe Desmodeae with strong bootstrap support (88.2%). The tree strong supports monophyly of *Christia* (99.9% bootstrap), which is sister to *Uraria* core group with strong bootstrap support (98.4%). For genus *Urariopsis* (*Ur. codifolia*), the phylogenetic analysis indicated that *Ur. codifolia* is within *Uraria*, it is placed in members of *Uraria* core group with moderate bootstrap support (77.5%) (Fig. 64).

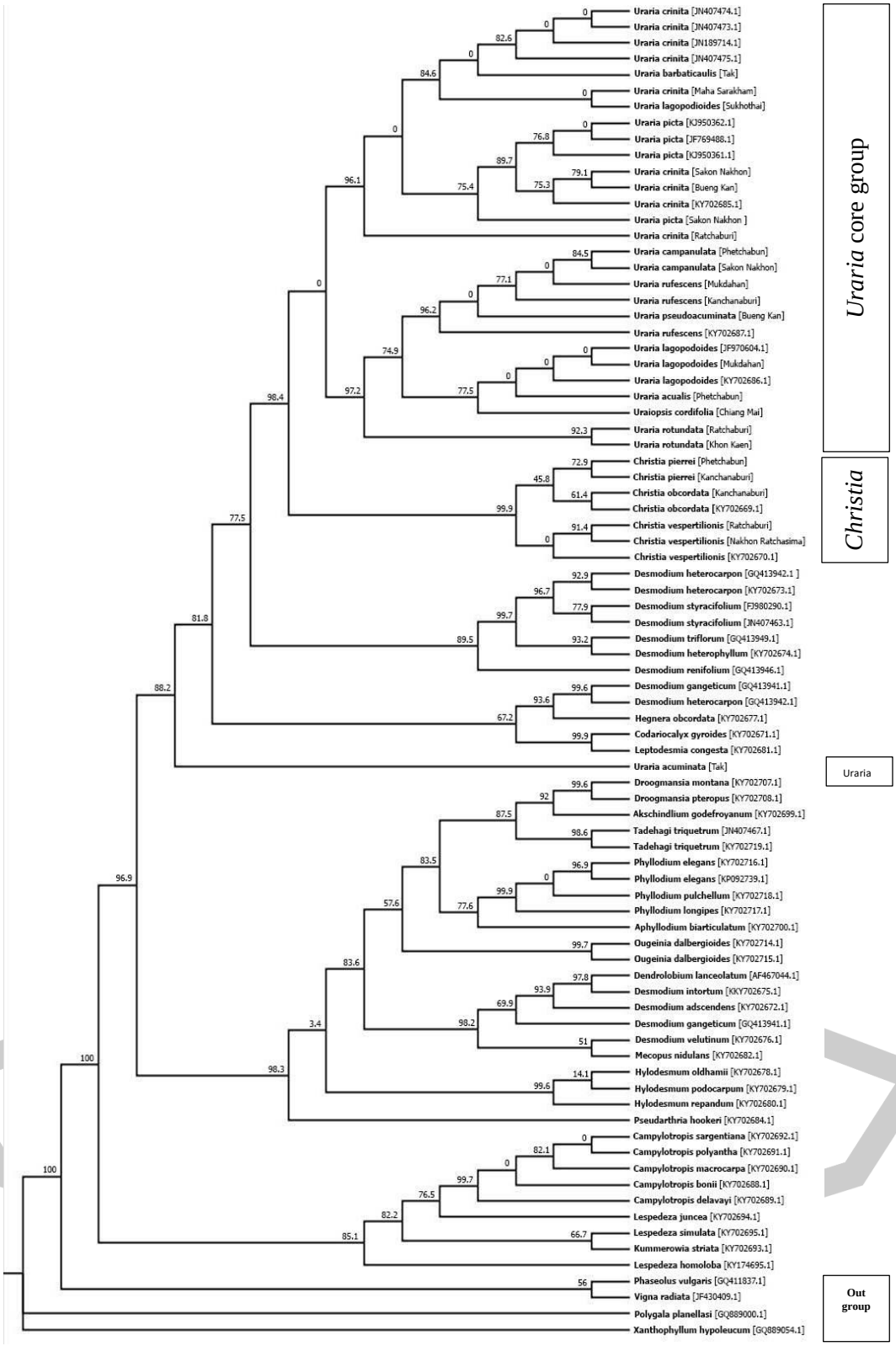

Figure 64 Phylogenetic trees of members of the genus *Uraria* and some member in related genera based on ITS 1 and ITS 4 sequences.

CHAPTER 5

DISCUSSINNS AND CONCLUSION

5.1 Discussions

A taxonomic revision of the genus *Christia*, *Uraria* and *Urariopsis* are presented. Key to species, descriptions, the list of examined specimens, ecology and distribution in Thailand are provided. Three species, four taxa of *Christia*, 13 species of *Uraria* and two of *Urariopsis* were found in Thailand. From this study, morphological character of genus *Urariopsis* differs from genus *Uraria* by its shape of fruits. Therefore, *Urariopsis* is placed as a member of *Uraria* as previous studies (van Thuân *et al.*, 1987; The Royal Forest Department, 2014). Fifteen species namely; *Uraria acaulis, U. acuminata, U. balansae, U. barbaticaulis, U. campanulata, U. cochinchinensis* (*Urariopsis*), *U. cordifolia* (*Urariopsis*), *U. crinita, U. lagopodioides, U. lacei, U. picta, U. poilanei, U. pseudoacuminata, U. rotundata* and *U. rufescens*, are recognized.

Uraria balansae and *U. barbaticaulis* are newly report from Thailand. The former was published from Vietnam and reported again in Thailand. This species may be found in the neighbouring countries such as Cambodia and Malaysia. Taxonomic revision of the mainland South-east Asian countries are needed. *U. barbaticaulis* was published from Myanmar as *U. barbata*. This is the first recorded from Tak province, Thailand.

In previous worked, *Uraria pierrei* and *U. rotundata* were listed from Thailand by the Royal Forest Department (2014). On examination of the type specimens, both species are similar by having rounded leaf shape but their habit are different, the former is an erect herb and the latter is a prostrate herb and. I have concluded that *U. pierrei* should be regarded as conspecific with *U. rotundata*. The Royal Forest Department (2014) accepted both *C. campanulata* (Benth.) Thoth. and *U. campanulata* (Benth.) Gagnep. but in this study *C. campanulata* is reduced to synonymy of *U. campanulata*.

Genus *Christia* distinctly differs from genera *Uraria* and *Urariopsis* by having membranous hyaline calyx on fruits. The calyx is well-developed and enclosed the fruit after anthesis. Three species and one variety of *Christia* are recognized; *C. obcordata*, *C. pierrei*, *C. vespertilionis* and *C. vespertilionis* var. *grandifolia*. *C. pierrei* is a newly report from Thailand. *C. vespertilionis* var. *grandifolia* differs from the type variety by its larger leaves. This variety is widespread from Bangkok to limestone forest in Saraburi and Kanchanaburi provinces. The collected specimen from Bangkok presents only one leaf with dark bands along veins as an ornamental plant, Butterfly Leaf (*Christia* sp.). This specimen may be a cultivated plant. However, both specimens from Saraburi and Kanchanaburi are different from the type by fruit characteristics. Pedicel of fruits of the both varieties are more or less equal to the calyx tube and curve up whereas the specimens from Thailand are longer than the calyx tube and not curve up as the type.

Christia vespertilionis var. *vespertilionis*, *U. acuminata*, *U. crinita,* and *U. lagopodioides* are distributed in all of seven Thailand floristic regions. *U. barbaticaulis and U. balansae* are rare species and new record for Thailand. *U. barbaticaulis* is found only Umphang, Tak province and *U. balansae* is found from Sirindhon waterfall and Hala-Bala Wildlife Sanctuary, Narathiwat province. *U. poilanei* is distributed in Chiang Mai province whereas the similar species, *U. lacei* is more widespread are in northern, northeastern, eastern and central Thailand floristic regions (Tab. 13). *U. picta* is a common species and widely distributed throughout tropical Africa, Pakistan, India, South-east Asia through Japan, and Australia (Puhua & Ohashi, 2010b). In Thailand, the specimens of *U. picta* were collected from many locolities especially in Chiang Rai province, but after plant surveyed, the species is also found in Sakon Nakhon province. The plant is found in open area and a number of plants are decreased by human acivities.Seed characters of genera *Christia* and *Uraria* are similar. Seed shapes are reniform, cordate, round, elliptic, oblong or ovate. Their length ranges from 1.5-3.2 mm and thewidth ranges from 0.8-2.5 mm, seeds have fleshy annular aril. According to Al-Ghamdi (2011), Gandhi *et al.* (2011), Gholami & Pandey (2016) and Mirzaei, *et al*. (2015), seed shapes of Leguminosae-Papilionoideae varies from circular (in *Indigofera articulata*, *I. hochstetteri*, *I. intricata*, *I. sessiliflora* and *I. spinosa*), irregular (in *I. amorphoides*, *I. arabica*, *I.*

arrecta, *I. oblongifolia*, *I. spiniflora* and *I. trita* var. *subulata*), rectangular (in *I. argentea*, *I. coerulea* var. *occidentalis*, *I. spinosa*, *I. tinctoria* and *I. volkensii*), cordate (in *Colutea persica*, *C. buhsei*, *C. porphyrogramma* and *C. gracilis*), oblong (in *Alysicarpus monilifer*), ovoid (in *A. procumbens*) and kidney (some species in *Crotolaria*). The seed surface is smooth which is similar to Gandhi *et al.* (2011) concluded that seed of some species in *Alysicarpus*, *Crotolaria* and *Indigofera* are smooth except *I. cordifolia*, *I. echinata*, *I. linifolia*, *I. tinctoria* and *Cr. orixensis* are rough.

Table 13 Distribution of *Christia* and *Uraria* species in Thailand

No.	Scientific name	Distribution						
		N	NE	E	SW	C	SE	PEN
1	*C. obcordata*	√	√	√	√	√	√	-
2	*C. pierrei*	√	√	-	√	√	√	-
3	*C. vespertilionis* var. *vespertilionis*	√	√	√	√	√	√	√
4	*C. vespertilionis* var. *grandifolia*	-	-	-	√	√	-	-
5	*U. acaulis*	√	√	√	√	√	√	-
6	*U. acuminata*	√	√	√	√	√	√	√
7	*U. barbaticaulis*	√	-	-	-	-	-	-
8	*U. balansae*	-	-	-	-	-	-	√
9	*U. campanulata*	√	√	√	√	√	-	-
10	*U. crinita*	√	√	√	√	√	√	√
11	*U. lacei*	√	√	√	-	√	-	-
12	*U. lagopodioides*	√	√	√	√	√	√	√
13	*U. picta*	√	√	-	-	√	-	√
14	*U. poilanei*	√	-	-	-	-	-	-
15	*U. pseudoacuminata*	-	√	√	√	-	-	-
16	*U. rotundata*	√	√	√	√	-	-	-
17	*U. rufescens*	√	√	√	√	-	√	√
18	*U. cochinchinensis* (= *Ur. cochinchinensis*)	-	√	√	-	-	-	-
19	*U. cordifolia* (= *Ur. cordifolia*)	√	√	√	√	-	-	-

Note: **-** = absent, √ = present

Colour pattern of seed are monochrome. Their colours are variable from yellow to dark brown. These characters are common in Leguminosae (Kirkbride *et al*., 2003). The seed colours vary from brown (in *Indigofera amorphoides*, *I. arabica*, *I. hochstetteri*, *I. linifolia*, *I. oblongifolia*, *I. spiniflora* and *I. volkensii*), dark brown (in *I. argentea*, *I. trita* var. *subulata*, *Colutea persica*, *Co. buhsei*, *Co. uniflora*, *Co. porphyrogramma* and *Co. gifana*), black colour (in *I. arrecta*), light brown/orange (in *I. intricata*), creamy (in *I. spinose*), greyish (in *I. tinctoria*) and green (in *Alysicarpus procumbens*) (Al-Ghamdi, 2011; Gandhi *et al*., 2011; Mirzaei *et al*., 2015).

For the testa ornamentation of the both genera in this study are only 2 types, foveolate-rugulate (*C. obcordata*, *C. vespertilionis, U. cochinchinensis, U. cordifolia*, *U. crinita*, *U. lagopodioides*, *U. picta* and *U. rotundata*) and reticulate-rugulate (*C. pierrei, U. acaulis*, *U. acuminate* and *U. rufescens*). This ornamentation pattern of seed testa found in *Alysicarpus* (Gholami & Pandey, 2016) and *Genista* (Din & Erbakan, 2013). Seeds of *Hedysarum pannosum* have rugolo-reticulate ornamentation (Dural & Citak, 2015).

The pollen morphological characters of genus *Uraria* are monad, isopolar, radial symmetry, tricolporate, medium-sized, prolate spheroidal, subprolate and prolate, ranging from 25 μm to 37 . 5 μm in polar axis and 28.75 to 47.5 μm in equatorial axis. Sculpturing ornamentation is psilate (*U. campanulata*, *U. crinita*, *U. lagopodioides* and *U. rufescens*), weakly rugulate (*U. acaulis*) and rugulate (*U. acuminata*, *U. picta* and *U. pseudoacuminata*). The pollen of *Uraria* species is similar to Fergiuson & Skvarla (1981), Chen & Huang (1993) and Perveen & Qaiser (1998) who reported the pollen has monads, isopolar, radial symmetry and tricolporate. In this study, there are slightly variation in shape and size. The pollen sculpture is not supported the taxonomic classification of these genera or the genus *Uraria*. However, pollen sculpturing is valuable for identification of closely related species, *U. acuminata* and *U. crinita*. Both species are differed by having only leaf shape and number of pod articles but pollen sculpturing are strongly different, *U. acuminata* is rugulate and *U. crinita* is psilate.

The exine ornamentation differs strikingly with Chen & Huang (1993) who indicated that *U. crinita* and *U. lagopodioides* are psilate, microperforate and coarsely granulate to verrucate. However, the result of this study shows that exine

ornamentation of them are psilate only. Ohashi (1971) described pollen morphology of *Christia* (*C. obcordata, C. pierrei* and *C. vespertilionis*) and *Uraria* (*U. acuminata, U. cordifolia, U. crinita, U. lagopodioides, U. rufescens* and *U. sinensis*) under light microscopy (LM). Pollen grains are tricolporate, finely reticulate exine. Except exine of *U. cordifolia* is very fine reticulate or occasionally more or less rugulate. This is in contrast with this study, which the exine is rugulate and psilate.

The general anatomical characters of *Christia*, *Uraria* and *Urariopsis* are similar in terms of the ornamentation of cuticle, presence of papillae and stomata, shape of epidermal cells and trichomes, occurrence of prismatic crystals and starch grains. The characters cannot use for classification in generic level of these genera. Anatomical characters of laminar surface and in transverse sections of three *Chistia* and 11 *Uraria* (included *Urariopsis*) species in Thailand are follow:

Cuticle: the cuticle of laminar surface on adaxial epidermis is densely upright scale or loosely upright scale (*U. acaulis, U. acuminate, U. crinita* and *U. picta*) and smooth or non-upright scale (*C. obcordata, U. barbaticaulis, U. cordifolia* and *U. pseudoacuminata*), while on abaxial epidermis is upright scale. There are densely upright scales except *U. crinita* which is loosely upright scale. Upright scale cuticle of *U. acuminata* and smooth cuticle of *U. pseudoacuminata* on adaxial epidermis shown difference character between the similar species. From the laminar transverse surface, the cuticle thickness is smooth, with equal on both upper and lower surfaces. According to Shaheen (2008) reported that both epidermal layers of *Desmodium tortuosum* are covered with thick cuticle.

Epidermal cells: The laminar in transverse surface, the adaxial and abaxial epidermis only consist of one-layer of cell as *D. tortuosum* (Shaheen, 2008). The adaxial epidermis is rectangular, polygonal to rounded shape. The abaxial epidermis is conical, rectangular and/or polygonal shape. The adaxial epidermis is thicker than abaxial epidermis. Periclinal wall of both epidermis are straight, dome-shaped and/or high curved with papillae.

Papillae: papillaes are present on epidermal cells of abaxial surface in all species. However, papillaes absent on adaxial epidermis of *C. obcordata, U. acaulis, U. acuminata, U. cordifolia, U. barbaticaulis, U. crinita, U. lagopodioides, U. picta*

and *U. pseudoacuminata.* Papillae are an additional useful for separating species in genus *Dalbergia* (Farooqui *et al.*, 1989).

Stomata: The stomata occur on the both surfaces. They are rarely distributed on the adaxial epidermis with density on abaxial surface. Similar to Shaheen (2008) who reported the distribution of stomata on both leaf surfaces of *D. tortuosum.*

Trichomes: the trichomes are present on both surfaces of all species. There are 5 types including; subulate trichomes, uncinate trichomes (hooked trichomes), uniseriate trichomes, multicellular globular base trichomes and globose multicellular trichomes. This characters are similar according to Shaheen (2008) found that *D. tortuosum* has unicellular, multicellular hooked trichomes and glandular trichomes. Secretory and non-glandular trichomes are distributed on the laminar of seven species in genus *Rhynchosia* (*R. balansae* var. *balansae, R. balansae* var. *psilantha, R. minima, R. melanocarpa, R. corylifolia* and *R. leucophylla*). Non-glandular trichomes are single, unicellular to multicellular and non-branched (Vargas *et al.* 2015. Devecchi *et al*. (2014) presented the trichomes of some Brazilian species in *Crotalaria* which are non-glandular, uniseriate and filiform trichomes, while in this study found 2 types of glandular trichomes are multicellular globular base trichomes and globose multicellular trichomes.

Two of non-glandular trichomes; subulate trichomes and uncinate trichomes are common in *Christia, Uraria* and *Urariopsis* species. Both trichomes are present in abaxial and adaxial epidermis of all species except adaxial epidermis of *C. obcordata* (uncinate trichomes absent) and *C. pierrei* (subulate trichomes absent). For uniseriate trichomes, multicellular globular base trichomes and/or globose multicellular trichomes are present in some species and used for species identification. *U. acuminata* and *U. pseudoacuminata* are similar species by morphology but anatomy and micro-morphology of their leaf are different. Subulate trichomes, uncinate trichomes, uniseriate trichomes, multicellular globular base trichomes and globose multicellular trichomes presence on the both sides of epidermis in *U. acuminata* whereas multicellular globular base trichomes absent in abaxial epidermis and adaxial epidermis presence only subulate trichomes and uncinate trichomes in *U. pseudoacuminata*.

Mesophyll: the mesophyll is composed of palisade and spongy regions. There are 1–3 layers of palisade parenchyma cell and 2–4 layers of spongy parenchyma cell, whereas in the palisade parenchyma of *H. pannosum* is 1–3-layered above and 1–2-layered below the mesophyll. The spongy parenchyma cells which are 1–3-layered are present among the palisade parenchymatous cells with large intercellular spaces (Dural & Citak, 2015).

Vascular bundles: the vascular bundles are collateral types in all the studied species. There are 1-10, exhibit a very complex structure with usually in U-shaped, surrounding a central medullary region, on the top of u-shaped composed of a fibre bundle. Bundle caps are present with sclerenchymatous tissues.

Crystals: prismatic crystals present in the mesophyll layers (spongy cells) in all species except *C. pierrei* and *C. vespertilionis*. There are in the vascular bundle (bundle cap and phloem) except *U. rufescens*. Similar to Teixeira & Gabrielli (2006) revealed that the crystals of some species in genus *Dahlstedtia* are prismatic. This character is taxonomic value of *Dahlstedtia*.

Starch grains: starch grains are present in the parenchyma tissue or xylem in the midrib of *U. acaulis*, *U. barbaticaulis*, *U. campanulata*, *U. cordifolia*, *U. crinita*, and *U. lagopodioides*. In mesophyll cell, starch grains are absent except *U. campanulata*, starch grains present in the spongy cells near the midrib.

For phylogenetic tree of the DNA sequencing of nrDNA internal transcribed spacer (ITS) of 24 samples from three *Christi*a, 10 *Uraria* and one *Urariopsis*) in Thailand included 72 sequences of Desmodeae from GenBank showed that The tree strong supports monophyly of *Christia* (99.9% bootstrap), which is sister to *Uraria* core group with strong bootstrap support (98.4%). The phylogenetic tree indicated *Uraria* is polyphyletic and *Urariopsis* (*Ur. cordifolia*) within the *Uraria* core group with moderate bootstrap support (77.5%). This supported to separate the plants to two genus; *Christia* and *Uraria* whereas *Urariopsis* species is a member of *Uraria*.

5.2 Conclusions

Christia, *Uraria* and *Urariopsis* are similar genera in tribe Desmodeae. These genera are characterized by their habits are herb or subshrub, pinnately

compound leaf with 1–11-foliolate, alternate vernation, racemose or paniculate inflorescence, campanulated calyx with (4–) 5-lobed, papilionaceous corolla, diadelphous stamens, one superior ovary with 1–10 ovules and articulated pods with folded segments. Pods of *Christia* and *Uraria* are divided transversely into rounded segments and each folded over the other. The pod of *Christia* has membranous hyaline calyx whereas calyx on pod in *Uraria* with or without developed to fleshly calyx. The pod of *Urariopsis* is deeply indented along both sutures into heart-shaped or rounded segments.

These plants are divided into two groups based on testa ornamentation; foveolate-rugulate and reticulate-rugulate. Based on the pollen morphology, the plants are divided into three groups by exine ornamentation; psilate, weakly rugulate and rugulate. For leaf anatomy, the separation of the plants is into two groups by present or absent of crystals and starch grains and the last, micro-morphology of leaf can be divided the plants into four groups based on cuticle pattern on adaxial epidermis (densely upright scale cuticle, loosely upright scale cuticle and smooth cuticle) and present or absent of papillae on adaxial epidermis. All these characters cannot use for generic classification. Characters of seed and pollen can be used for the separation of some related species and micro-morphology of leaf can also be valuable for species identification. For DNA analysis of nrDNA internal transcribed spacer (ITS), phylogenetic tree show monophyletic of genus *Christia* and polyphyletic of genus *Uraria* whereas *Urariopsis* is placed into members of *Uraria* core group. This tree support to accept genus *Christia* and place *Urariopsis* species to be a member of *Uraria*.

Three species, four taxa of *Christia*, *C. obcordata*, *C. pierrei*, *C. vespertilionis* and *C. vespertilionis* var. *grandifolia* are recognized and *C. pierrei* is newly report from Thailand. Fifteen species of genus *Uraria* (included two *Urariopsis*) namely; *U. acaulis*, *U. acuminata*, *U. balansae*, *U. barbaticaulis*, *U. campanulata*, *U. cochinchinensis*, *U. cordifolia*, *U. crinita*, *U. lagopodioides*, *U. lacei*, *U. picta*, *U. poilanei*, *U. pseudoacuminata*, *U. rotundata* and *U. rufescens*, are recognized. *U. balansae* and *U. barbaticaulis* are newly report from Thailand and *U. pierrei* is reduced to synonymy of *U. rotundata*.

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