THESIS

TAXONOMIC REVISION ON THE FAMILY STEMONACEAE IN THAILAND

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THESIS

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A taxonomic revision on the family Stemonaceae in Thailand was conducted by searching the literatures, comparing the herbarium specimens from several herbaria in Thailand and the data gained from Kew Herbarium. Additional field surveys and specimen collections were made thoughout the country. There are 10 species and 4 taxa of the Stemonaceae are enumerated and examined in this treatment, which belong to 2 genera, *Stemona* Lour. and *Stichoneuron* Hook.f.. Morphological characters were investigated, described, and supported by line drawing illustrations. A key to the genera and species based on the flowering and vegetative characters is presented. Thai Stemonaceae species mostly occur in seasonal climate and dry habitats. They are distributed at various altitudal levels from sea level to 1,200 meters above sea level.

Stemona comprises of 9 species and 2 taxa as follows: *Stemona aphylla* Craib, *S. burkillii* Prain, *S. cochinchinensis* Gagnep., *S. collinsiae* Craib, *S. curtisii* Hook.f., *S. kerrii* Craib, *S. phyllantha* Gagnep., *S. pierrei* Gagnep., *S. tuberosa* Lour., *Stemona* sp. 1 and *Stemona* sp. 2, while genus *Stichoneuron* comprises of one species and 2 taxa as follows: *Stichoneuron caudatum* Ridl., *Stichoneuron* sp. 1 and *Stichoneuron* sp. 2. Two species are endemic to Thailand *i.e. Stemona aphylla* Craib and *S. collinsiae* Craib. *Stichoneuron caudatum* Ridl. is endemic to Malay Peninsular. Two species *i.e. Stemona cochinchinensis* Gagnep. and *S. pierrei* Gagnep. are new record in Thailand.

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Student's signature Thesis Advisor's signature

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INTRODUCTION

Thailand is situated in a tropical region, between 5°-21° N and 97°-106° E, covering an area about 513,115 sq. km and positioned at a unique crossroad of tree main floristic regions i.e. Indo-Burmese, Indo-Chinese and Malesian. The diverse topography and climate, undoubtedly render the existence and development of various vegetation types. Therefore, Thailand is rich in plant diversity, about 10,000 species of vascular plants.

Among the plant families in Thailand, the family Stemonaceae is one of the small monocotyledon family, consisting of 3 genera (*Croomia*, *Stemona* and *Stichoneuron*) and about 25 species (Duyfjes, 1993). Their ranges of distribution are centered in Southeast Asia but extends also to tropical Australia and with one species even to Southeast United States. This family is very interesting because it is the only source of the stemona alkaloids. The extracts from used tuberous roots of Stemonaceae is popular to be used as insecticides and traditional medicines. In Thailand, there are few references on this family and a taxonomic revision of the family has not been done therefore, there are still problems when people used as insecticides or for medicinal purposes because the fleshy tuberous roots of Stemonaceae from the local markets and herb-shops are similar shape, also the same vernacular names are often used by the local people for different species and even for representatives from other families such as Asparagaceae.

This study will provide a basis for plants identification possibility and the future completion of an account of Stemonaceae for the Flora of Thailand. There will encourage researches for sustainable use of plants for economical benefits as well as conservation.

OBJECTIVES

1. To conduct taxonomic revision on the family Stemonaceae in Thailand for clarifying the species identification.

2. To enumerate the number of existing species and construct key to the genus and species of Stemonaceae in Thailand.

3. To record the geographical and ecological distributions of each species of Stemonaceae in Thailand.

LITURATURE REVIEW

1. History, Systematic position and Affinities of the family Stemonaceae

The family Stemonaceae belongs to the monocotyledon group of Angiosperms and was published by Krause (1930) in Die Naturlichen Pflanzenfamilien Vol 15a. The family name was originally developed by Wallich (1832) under the name Roxburghiaceae. Krause (1930) adopted the name Stemonaceae by Franch. et Sav. (1879) because of the description of the family generic name *Stemona* Lour. (1790) antedated *Roxburghia* Roxb. (1795), so *Stemona* and *Roxburghia* are taxonomic synonyms and the type species is *Stemona tuberosa* Lour. (Bullock, 1959)

The generic name *Stemona* derives from the Greek: *stemon*, a stamen, refer to the protruding and foliaceous stamens (Quattrocchi, 2000).

Krause (1930) and Duyfjes (1993) recognized the Stemonaceae as close relatives of Liliaceae, particularly Asparagoideae and Luzuriagoideae. Hutchinson (1959) included this family in Dioscoreales. The latter placement is on the basis of their characters such as the prolongation of the connective tissue; the distinct pith in the stem; the tendencies towards an inferior position of ovary. Burkill (1966) thought that the family originated from “proto-Liliales” which is closed to the Dioscoreaceae. The position of the Stemonaceae in the Dioscoreales was also favoured by Dahlgren *et al.* (1985), while Huber (1991), rating high the articulated flowers, the entirely different testa (absence of a defined endostesta in Stemona), and the nondioscoralean stem anatomy, included them in the Asparagales (Kubitzki, 1998).

Takhtajan (1997) classified family Stemonaceae under the Division Magnoliophyta, Class Liliopsida, Subclass Liliidae, Superorder Dioscoreanae, Order Stemonales, respectively, by the following characters: perennial rhizomatous herbs with erect stems or trailing or twining herbs with fasciculate tubers; raphides present or absent; vessels only in root or also in stems and even leaves, with scalariform perforation; leaves alternate, opposite or verticillate, petiolate or sessile, lanceolate to

ovate, with parallel, arcuate-striate or pinnate-striate venation; stomata anomocytic or tetracytic; flowers solitary (axillary or terminal) or in few-flowered cymes or racemes, bisexual or rarely unisexual, actinomorphic, 2-merous, 3-merous, 4-merous or rarely 5-merous; perianth segments free or sometime more or less connate, similar or more or less dissimilar; stamens isomerous with the perianth segments; filaments free or basally connate elongate or short; anthers tetrasporangiate, basifixed, opening longitudinally, introrse, often produced in sometimes rather long appendages; pollen grains monosulcate or inaperturate; ovary superior to inferior, 3-6-(8) or 1-locular,with various types of placentation; ovules few or numerous, anatropous or hemitropous, bitegmic; endosperm nuclear; fruits capsule or less often berries; seeds ellipsoidal to globose, usually with various kind of appendages; endosperm copious, contains aleurone, fat and starch grains; embryo small.

In the recent *rbcL* study of Chase *et al.* (1995) considered Stemonaceae in Order Pandanales. The family are distinguished on the following combination of characters: herbs, trees, or climbers; raphides mostly present, silica bodies lacking; vessels in roots and mostly also in stems and leaves, with scalariform perforations, stomata tetracytic rarely anomocytic; flowers epigynous or hypogynous; gynoecium syncarpous; microsporogenesis successive; endosperm development nuclear or helobial (Kubitzki, 1998; Caddick *et al.* 2000; Sympson, 2006), because the Stemonaceae form weakly supported clade together with Pandanaceae, Cyclanthaceae and Velloziaceae. While the relationship between Pandanaceae and Cyclanthaceae in undisputed, it is hard to see what the dimerous Stemonaceae should have in common with the apparently tetramerous Cyclanthaceae (Kubitzki, 1998).

Krause (1930) classified the family Stemonaceae into 3 genera, *i.e*. *Croomia* Torr. ex Torrey et Gray., *Stemona* Lour. and *Stichoneuron* Hook.f. (Kubitzki, 1998). The key of the family is as follows:

1. Usually scandent, some erect, or rarely creeping; roots spindle-shaped thickened; anthers with apical appendages; ovules numerous, basal; leaves only with basal nerves……..……1. *Stemona*

— Erect herbs; roots not spindle-shaped thickened; anthers without appendages; ovules few, apically inserted……2

2. Leaves with curved lateral veins; partial inflorescences racemelike, with densely set stiff pedicels; tepals valvate……...……...….2. *Stichoneuron*

— Leaves with basal veins only; partial inflorescences few-(mostly 1-2-) flowered; tepals imbricate……...……3. *Croomia*

2. Morphological Characteristics

2.1. Growth habit and roots

Long-lived plants, perennial herbs or shrublets (Dahlgren *et al.*, 1985) with subterranean rhizomes (*Croomia*), rhizome with many roots (*Stichoneuron*) and short rhizomes emitting a large number of storage spindle-shaped roots in genus *Stemona* (Steenis, 1982). The subterranean rhizomes often with scale leaves and plants with sympodial growth. Plants glabrous or with uniseriate hairs (Duyfjes, 1993; Kubitzki, 1998). Leafy stems twining, creeping, trailing or erect shoots from their rhizome, branched or unbranched, the whole shoots dying off after the fertile season, not viviparous; plants mostly of seasonal climate (Duyfjes, 1991).

2.2. Leaves

Basal part of leafy stems provided with scale-leaves (Steenis, 1982). Foliage leaves papyraceous when dry (Duyfjes, 1991, 1993), distichous, alternate, opposite or verticillate (China, Japan); petiole narrowly attached to stem, pulvinate at base (*Stemona*) or slightly sheathing (*Stichoneuron*) (Hutchinson, 1959; Dahlgren *et al*., 1985; Kubitzki, 1998); blade ovate, broadly-ovate, linear, lanceolate, triangular (Takhtajan,1997) or cordate with basal or lateral nerves, 5-15 arching (Dahlgren *et al*., 1985), nerves has shallowly depressed above and numerous secondary intervenation finely trabeculate (Duyfjes, 1991, 1993) and cordate or hastate at base (Takhtajan, 1997), leaf margin entire (Dahlgren *et al*., 1985; Duyfjes, 1991, 1993; Kubitzki, 1998).

2.3. Inflorescences

Inflorescences or the flowers are solitary, axillary, sessile, fasciculate or mostly in peduncled, short, raceme-like cincinnae, cymose clusters or several in subumbellate clusters (Kubitzki, 1998), rarely one-flowered; flowers and bracts often dotted with raphides; never branched or compound, usually withering together with the whole leafy stem (Duyfjes, 1991, 1993; Kubitzki, 1998).

2.4. Flowers

Flowers articulated from pedicel with pericladium (Kubitzki, 1998), usually hermaphroditic, rarely (*Stichoneuron*) probably functionally unisexual with some dimorphism, hypogynous (*Stemona, Croomia*), haft-epigynous (*Stichoneuron*) (Dahlgren *et al*., 1985); perianth 4-merous which similar segments, representing two whorls of two tepals, these free, or basally connate, valvate (Kubitzki, 1998); stamens 4, epitepalous; filaments short, adnate to base of tepals, at base mutually free (*Croomia, Stichoneuron*), or shortly connate (*Stemona*); anthers basifixed or dorsifixed (Hutchinson, 1959), consisting of two ovoid or elongate thecae, each opening by a longitudinal lateral slit, the anthers are introrse (Dahlgren *et al*., 1985); the thecae situated on top of the filament, either without (*Stichoneuron*) or with an apically enlarged tepal-like appendage of the connective, the connective narrow or broad, moreover the connective with a median longitudinal ridge separating the thecae, the ridge either smooth and thin, or fleshy and with a brain-like wrinkled structure, the thecae themselves in addition often protruding into a common sterile appendix, 1-8 mm long, of which the tips may be fused, thus forming a crown-like structure over the stigma (*Stemona*) (Duyfjes, 1991, 1993, Heel, 1992); ovary superior or haft-inferior, unilocular, small, one-celled; ovules few to many, basally (*Stemona*) or apically (*Stichoneuron*) attached, anatropous or semi-anatropous (Bouman and Devente, 1992); style absent; stigma inconspicuous, roundish, papillose (Hutchinson, 1959; Duyfjes, 1991, 1993).

2.5. Fruits and seeds

Fruits a 2-valved capsule, a thin-walled (Kubitzki, 1998); seeds few to many, broad-ellipsoid, faintly or conspicuously longitudinally ridged seed coat, without sarcotesta; funicle long, with a coralloid or lobed, hollow, wide-celled aril (*Stemona*) or form of uniseriate hairs (*Stichoneuron*) (Duyfjes, 1991, 1993); elaiosome or caruncle, formed from the hilum, micropyle (Kubitzki, 1998) and sometimes also from raphe. The elaiosome generally contains fat (Dahlgren *et al*., 1985). Endosperm present. It contains aleurone, fat oil and cellulose, but in *Croomia* also copious starch (Dahlgren *et al*., 1985; Kubitzki, 1998).

2.6. Pollens

The pollens grains of Stemonaceae are monosulcate (*Stemona, Croomia*) or inaperturate (*Stichoneuron*), tectate-columellate with microreticulate or finely reticulate (Croomia) ornamentation, the intine is forming a thick oncus (thin in *Stichoneuron*), the shape is spheroidal to ellipsoid, the size relatively small to medium sized (20-26 x 33-40 µm), the anther wall and in *Stemona* also the exine is sparsely covered with smooth Ubisch bodies. (Erdtman, 1952; Huang, 1972; Steenis, 1982; Dahlgren *et al*., 1985; Ham, 1991, 1992; Duyfjes, 1993; Kubitzki, 1998).

3. Vegetative Anatomy

The midrib is simple. The stomata are transversely oriented on the leaves in *Stemona* and *Stichoneuron*, and are anomocytic (Dahlgren *et al*., 1985); tannin cells and raphides are common; long prismatic crystals (styloid) are known from *Stemona* and *Stichoneuron.* The stems of *Stemona* and *Stichoneuron* have the bundles in 2 closely interlaced peripheral rings, collateral in the outer ring, and amphivasal in the inner. *Croomia* has a single ring of amphivasal bundles. Vessels with scalariform perforations are present in the roots and stems of all genera (Dahlgren *et al*., 1985; Duyfjes, 1993; Kubitzki, 1998).

4. Pollination

Heel (1992) described the flower of *Stemona tuberosa*. During development of floral, the stamens broaden considerably and tangential and median wings develop on the stamens. These wings close up and touch in each flower, and lengthwise interstaminal spaces originate, in which the pollen of two neighbouring thecae is shed. By the terminal fusion of the inward apical extensions of the stamens, the flowers become a kind of window flowers. The pollen shed in the interstaminal spaces would only be accessible through these windows. The flowers of *Stemona tuberosa* and *S. javanica* are carrion-coloured (dirty green and purplish striped outside, and dark purplish inside) and produce a strong smell of carrion (Duyfjes, 1991) or cheese; they were also observed to be visited by flies (Kubitzki, 1998)

5. Distribution and Ecology

Three genera, two of which occur in Indo-Malesia (Duyfjes, 1993); *Stemona* ranges from Japan and continental Asia through Malesia to North Australia; most of the species prefer a seasonal climate and occur in rather dry places, often rocky habitats and in seasonal forests, generally not very far from the coast, at altitudes below 500 m. *Stichoneuron* is distributed in continental South-East Asia and the Malay Peninsula, and *Croomia* is disjunct between South Japan, East China and the South-East United States (Florida, Georgia). The members of two latter genera (*Croomia* and *Stichoneuron*) are small, delicate forest dwellers at low altitudes (Heywood, 1978; Duyfjes, 1993; Kubitzki, 1998).

Figure 1 Distribution of Stemonaceae.
Source: Heywood (1978).

6. The Studies on Stemonaceae in Asia and Thailand

In the Malay Peninsula, Ridley (1967) reported 2 genera, 2 species as follows: *Stemona tuberosa* and *Stichoneuron caudatum*. A key to the genus and species and full descriptions were provided.

Duyfjes (1993) reported 2 genera, 5 species and 2 varieties of Stemonaceae in Flora Malesiana as follows: *Stemona australiana, S. curtisii, S. javanica, S. lucida, S. tuberosa* var. *tuberosa, S. tuberosa* var. *ternatensis* and *Stichoneuron caudatum*. A key to the genus and species and full descriptions were provided.

Hsieh (1978) reported only one species native to Taiwan *i.e*. *Stemona tuberosa*.

Gagnepain (1934) reported 11 species in Flore Générale L'Indo-Chine, including *Stemona aphylla, S. burkillii, S. cochinchinensis, S. collinsiae, S. griffithiana, S. kerrii, S. phyllantha, S. pierrei, S. saxorum, S. squamigera* and *S. tuberosa.* A key to the species and full descriptions were provided.

In Malaysia, Henderson (1954) reported one species *i.e. Stemona curtisii*.

Merrill (1925) recorded 2 species of family Stemonaceae in the Philippines *i.e. Stemona philippinensis* and *S. tuberosa***.**

Hooker (1894) reported 2 genera, 5 species in Flora of British India *i.e. Stemona tuberosa, S. minor, S. curtisii, S. griffithiana* and *Stichoneuron membranaceum*. A key to the genus and species and full descriptions were provided.

Wadhwa and Weerasooriya (1996) reported only one species in Flora of Ceylon *i.e*. *Stemona curtisii*.

In Japan, Ohwi (1965) reported two genera and tree species *i.e*. *Stemona japonica, Croomia heterosepala* and *C. japonica*. A key to the genus and species and full descriptions were provided.

In Java, Backer and van den Brink (1968) reported only one species of Roxburghiaceae *i.e. Stemona javanica.*

Zhanhe and Duyfjes (2000) reported 2 genera 8 species in Flora of China as follows: *Stemona sessilifolia, S. kerrii, S. parviflora, S. shandongensis, S. mairei, S. japonica, S. tuberosa* and *Croomia japonica*. A key to the genus and species and full descriptions were provided.

In Thailand, The Forest Herbarium, Royal Forest Department (2001) suggested that 6 species in Thai Plant Names book *i.e. Stemona aphylla, S. burkillii, S. collinsiae, S. hutanguriana, S. phyllantha* and *S. tuberosa*

Table 1 Stemonaceae species which have been reported in Asia

Species	Authors											
	1	2	3	4	5	6	7	8	9	10	11	12
Croomia heterosepata						X						
C. japonica											X	
Stemona aphylla				X								X
S. australiana									X			
S. burkillii				X								X
S. cochinchinensis				X								
S. collinsiae				X								X
S. curtisii	X				X				X	X		
S. griffithiana	X			X								
S. hutanguriana												X
S. japonica						X					X	
S. javanica							X		X			
S. kerrii				X							X	
S. lucida									X			
S. mairei											X	
S. minor (synonym of *S. curtisii*)	X											
S. parviflora											X	
S. philippinensis (synonym of *S. lucida*)			X									
S. phyllantha				X								X
S. pierrei				X								
S. saxorum (synonym of *S. kerrii*)				X								
S. sessilifolia											X	
S. shandongensis											X	
S. squamigera				X								
S. tuberosa	X	X	X	X				X			X	X

Table 1 (Continued)

Species	Authors											
	1	2	3	4	5	6	7	8	9	10	11	12
S. tuberosa var. *ternatensis* (synonym of *Stemona tuberosa* var. *moluccana)*									X			
S. tuberosa var. *tuberosa*									X			
Stichoneuron caudatum		X							X			
S. membranaceum	X											

Notes 1 = Hooker (1894)
2 = Ridley (1924)
3 = Merrill (1925)
4 = Gagnepain (1934)
5 = Henderson (1954)
6 = Ohwi (1965)
7 = Backer & van den Brink (1968)
8 = Hsieh (1978)
9 = Duyfjes (1993)
10 = Wadhwa & Weerasooriya (1996)
11 = Zhanhe & Duyfjes (2000)
12 = The Forest Herbarium, Royal Forest Department (2001)

7. Useds

Valkenburg and Bunyapraphatsara (2002) reported that the tuberous roots of various *Stemona* are used throughout South-East Asia, China and Japan as insecticides and therapeutical agents (especially for coughs) (Perry, 1980; Duyfjes, 1993).

Stemona burkillii Prain: in Burma (Myanmar), the tuberous roots of *S. burkillii* Prain are used as an insecticide. In Thailand, the tuberous roots of *S. burkillii* Prain,

are used in discriminately to treat skin diseases (Burkill, 1966; Perry, 1980; Chuakul *et al*., 1997; Valkenburg and Bunyapraphatsara, 2002).

S. cochinchinensis Gagnep.: in Laos the people drink an infusion to make human blood deadly to fleas and lice (Perry, 1980).

Stemona collinsiae Craib: in Thailand, Kerr was very interesting in his remarks on *S. collinsiae*: he mentioned that so great is the faith of the Thailand in power of the plant to kill parasites, that they hold it to be enough to take a dose of an infusion of it at bed-time to find the parasites lying dead around the bed in the morning (Burkill, 1966), emulsion for insecticides (Perry, 1980), and used to insecticide and for skin diseases, and antibacterial (Ponglux *et al*., 1987; Chuakul *et al*., 1997; Valkenburg and Bunyapraphatsara, 2002). In Laos the people also drink an infusion to make human blood deadly to fleas and lice (Perry, 1980).

In Thailand, the tuberous roots of *S. curtisii* Hook.f. (a tall climber) are used in discriminately to treat skin diseases (Valkenburg and Bunyapraphatsara, 2002).

S. phyllantha Gagnep.: in Thailand the roots is applied as a shampoo to kill head lice (Chuakul *et al*., 1997; Valkenburg and Bunyapraphatsara, 2002).

Stemona japonica (Bl.) Miq., *S. sessilifolia* (Miq.) Miq and *S. tuberose* Lour. are used both internally and externally. Of these are native of East Asia (Perry, 1980). In China, the local name is Baibu or Radix Stemonae, people used the dried roots of Baibu or Radix and collected in spring and fall (Tang and Eisenbrand, 1992). The herbs and its alkaloids can suppress excitation of the respiratory center and inhibit the coughing reflex. The active principles also exert antitubuerculous, antibacterial, antifungal and anthelminthic effects. Baibu has a pesticidic effect, especially in killing *Pediculus capitus*. It was used to treat colds, coughs, ascarids, tinea and lice (Huang, 1999). An alcohol extract is used as an insecticide and a household spraying agent (National Institute for the Control of Pharmaceutical and Biological Products, 1987). In Japan, the tuberous roots of *Stemona sessilifolia* (Miq.) Miq are considered

medicinal (Burkill, 1966) and as a domestic insecticide, toxic to the silkworm and the cabbage armyworm (Harborne and Baxter, 2001).

S. javanica (Kunth) Engler (synonum *Stemona asperula* J.J. Smith) from the south coast of Java, the Moluccas and New Guinea is only occasionally used medicinally in the Moluccas. The tuberous roots are used as a fish poison and an extract from the stem is given as a drink after childbirth for purification (Valkenburg and Bunyapraphatsara, 2002).

In the Central Province (Papua New Guinea) crushed leaves of *S. australiana* (Benth.) C. H. Wright, are used to treat snakebite (Valkenburg and Bunyapraphatsara, 2002).

Stemona moluccana (Bl.) Wright (*Roxburghia moluccana* Bl.): In Indonesia, pulverized fresh roots of *Stemona moluccana* (Bl.) Wright, drive lice out of clothes and off the body (Perry, 1980).

In South-East Asia, *Stemona tuberosa* Lour., is by far the most important species. The tuberous roots are a bitter-sweet, cooling herb that lubricates the lungs. Uses of herb for internal, and external, and used fresh to make insecticidal washes (Bown, 1995; Valkenburg and Bunyapraphatsara, 2002).

Pételot (1952) and Saralamp *et al*. (1996) reported to roots of *Stemona tuberosa* Lour., it was poisonous, but although it kills lice and louse eggs, the drug is not toxic for people and is not irritant, it is calming in coughs by reducing the activity of the respiratory centers without apparent action on the heart. In Malasia, species are used in phthisis for coughs and chest complaints (Burkill, 1966). In Vietnamese folk medicine the tuberous roots are used internally as an antitussive and anthelmintic, and externally as an insecticide. As an anthelmintic it is applied as an enema or as a decoction in combination with a purgative (Valkenburg and Bunyapraphatsara, 2002). In Burma (Myanmar), the tuberous roots of *S. tuberosa* Lour., are used discriminately to treat skin diseases (Chuakul *et al*., 1997; Valkenburg and Bunyapraphatsara, 2002).

In Thailand, the tuberous roots are crushed and soaked in water and topically applied to treat scabies and kill head lice (Valkenburg and Bunyapraphatsara, 2002). In Annam it was stated that its roots were used in phthisis, for coughs and chest complaints (Burkill, 1966).

In the Moluccas, Rumpf named Moluccan species (*Stemona* spp.) as an insectifuge. The fresh tubers, drive lice from the clothes and the body. According to Rumpf, two Moluccan species have internal uses. One of them is that just mentioned as an insectifuge. In its case the tubers must undergo, before it is safe to employ them as an internal medicine, a rather complicated treatment, which removes their poison. The other, which though known to be a species of *Stemona* cannot be determined specifically with absolute certainty, does not need such precautions (Burkill, 1966; Valkenburg and Bunyapraphatsara, 2002).

The leaves of *Stichoneuron caudatum* Ridl. have been eaten with betel as a tonic in convalescence, but the Malayan name suggests an abortifacient (Burkill, 1966; Perry, 1980).

8. Phytochemistry

The family Stemonaceae is the only source of the stemona alkaloids. The stemona alkaloids are structurally characterized by the presence of the pyrrolo (1,2-a) azepine nucleus usually linked with two carbon chains mostly forming terminal lactone ring, also named perhydroazaazulene and 4-azaazulene.

Ye *et al.* (1994) separated stemona alkaloids and derivatives into eight groups according to the site of connection between the basic ring and side chain.

In 2000, Pilli and Ferreira de Oliveira separated *stemona* alkaloids into five groups as follow: stenine(1), stemoamide(2), tuberostemospironine(3), stemonamine(4) and tuberostemoamide(5) (Figure 2).

Schinnerl *et al* (2005), they found tree new pyrroloazepine type alkaloids, stichoneurines A and B and 6-hydroxycroomine were isolated from the lipophilic root extracts of *Stichoneuron caudatum* Ridl. and *Stemona tuberosa* Lour.

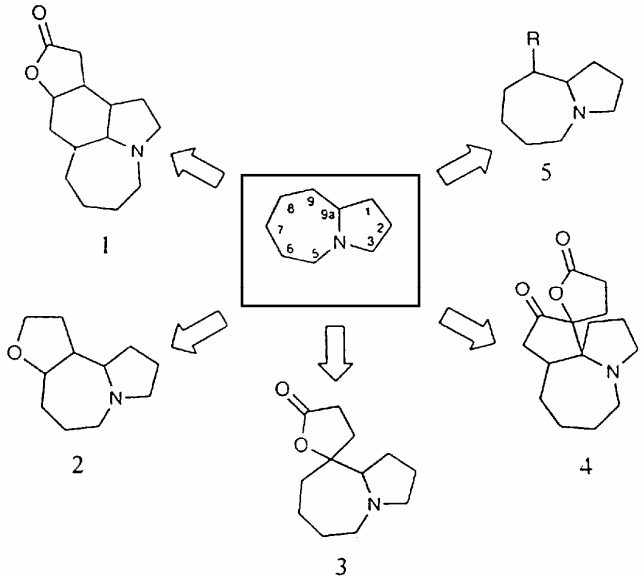

Figure 2 *Stemona* alkaloid groups.

Source: Pilli and Ferreira de Oliveira (2000).

MATERIALS AND METHODS

Materials

1. Equipment used in materials exploration are pruning shears, spade, plastic bags, plant press size 30 x 45 cm., newspapers, blotters, cardboard or aluminum corrugates, ropes, tags, field books, pencil, altimeter, camera, color film and slides.

2. Materials used in preserving and mounting specimens are ethyl alcohol 70 %, bottles, deep freezer for preserving specimens from insects and fungi, herbarium sheets of 300 gram size 26.5 x 42 cm., white paper covers of 27 x 42 cm., brown covers of 27.5 x 42 cm., needle and threads, labels size 10 x 13.5 cm. and glue.

3. Instruments used in identifying specimens comprised of stereo microscope together with scale, ruler, petri dish, dissecting needles and razor blade.

Methods

1. Data of Stemonaceae are collected from secondary sources, including floras, journals and reports on the survey of this family in various sites were collected and compiled. The herbarium specimens deposited at the Forest Herbarium (BKF), National Park Wildlife and Plants Conservation Department, Bangkok Herbarium (BK), Department of Agriculture, The herbarium of Faculty of Science, Chiang Mai University (CMU), Queen Sirikit Botanic Garden Herbarium (QBG) and Kew Herbarium (K) were also studied.

2. Collections of Stemonaceae were made in sets of three to five for living and herbarium specimens, from the natural habitats in various regions of Thailand. Photographs and notes were also taken and collected. The specimens were mounted as in herbarium sheet and some of flowers and fruits were preserved in alcohol 70 % and living specimens were cultivated at the Department of Botany, Faculty of Science, Kasetsart University for further study.

3. Morphological characteristic of plants in the family Stemonaceae were observed from the fresh materials and several herbarium specimens deposited in the Forest Herbarium (BKF), National Park Wildlife and Plants Conservation Department and Bangkok Herbarium (BK), Department of Agriculture, The herbarium of Faculty of Science, Chiang Mai University (CMU) and Queen Sirikit Botanic Garden Herbarium (QBG). The characteristics of vegetative and reproductive parts (root, stem, leaves, inflorescences, flowers and fruits) were dissected and examined under stereo microscope and also photographs as well as measurement of various parts of plants were taken.

4. Identification of plants into genus, species were done by observing morphological characteristics, checking references and comparing with herbarium specimens at the Forest Herbarium (BKF), National Park Wildlife and Plants Conservation Department and Bangkok Herbarium (BK), Department of Agriculture. Then, the names were verified to the correct botanical names by way of taxonomic study. The detailed description of each species as well as line drawing were done, followed by the construction key to species.

5. The identified specimens were kept as references at in the Forest Herbarium (BKF), National Park Wildlife and Plants Conservation Department and Bangkok Herbarium (BK), Department of Agriculture for future study and research.

RESULTS AND DISCUSSION

1. Morphology

1.1. Underground parts

The underground parts of all Stemonaceae in Thailand are mostly rhizome with scale leaves (*Stichoneuron*), short rhizome with scale leaves and tuberous root (*Stemona*). The tuberous roots of *Stemona* can be divided by shapes and forms into 3 groups, as follows: *tuberosa* group, large and thick tuber and of about 10-50 cm long and about. 3 cm thick, *curtisii* group, long and slender tuber of 10-60 cm long 1-1.5 cm thick and *kerrii* group, short and small tuber of 5-25 cm long and about 1 cm thick (Figure 3).

The large and thick tuberous roots are seen in *Stemona phyllantha* and *S. tuberosa* which are 40-50 cm and 10-30 cm long, respectively.

The long and slender tuberous roots are seen in *Stemona aphylla*, *S. burkillii*, *Stemona* sp. 2, which are 10-30 cm long and the tuberous roots up to 60 cm long are found in *S. collinsiae* and *S. curtisii*.

The short and small tuberous roots are seen in *S. cochinchinensis*, *S. pierrei* and *Stemona* sp. 1, which are 10-25 cm long and the tuberous roots 5-10 cm long are found in *S. kerrii*.

1.2. Stem and habit

The stems of many Stemonaceae in Thailand are annuals and mostly prefer a seasonal climate but *Stemona curtisii* and the genus *Stichoneuron* are perennial herbs in evergreen habitats. High moisture is the condition of evergreen forests which enable plants to become green all year round.

The stems of Stemonaceae plants are erect, twining or trailing. The erect or trailing stems are seen in plants which small shapes tuberous root or stems are very short; therefore, the stems are insufficient for twining. These plant species are as follows: *Stemona burkillii*, *S. cochinchinensis*, *S. collinsiae*, *S. pierrei*, *Stemona* sp. 1, *Stichoneuron caudatun*, *Stichoneuron* sp. 2 and *Stichoneuron* sp. 3 (plants hanging from limestone hill). While the climber stems are seen in *Stemona aphylla*, *S. curtisii*, *S. kerrii*, *S. phyllantha*, *S. tuberosa* and *Stemona* sp. 2. The prominent nodes are present in *Stichoneuron caudatum* and *Stichoneuron* sp. 1.

Field observation of the stem shows that they are glabrous or covered with hairs (*Stichoneuron* and *Stemona kerrii*). The stems surface is generally smooth but some species has shallowly longitudinal ribs, e.g. *Stemona pierrei*, *Stemona* sp. 2 *and S. cochinchinensis* . The stems are usually yellowish-green to pale green but the young shoots of several species are often reddish or pinkish.

From field observation the members of Stemonaceae which habit are trailing, the young shoots always decay when it touch to the ground. On the contrary one which twining habit, growing by the young shoot rapidly grow and are ready to circled around the trees nearby. However, this characteristic does not effect to being dense of population in the areas because of blossom and fructification occur at lower part of stem. Therefore, the member of population and distribution probably depended on vegetations and distributors. For example, from field observation, *Stemona aphylla* and *Stemona* sp. 1 in Phuphan National Park in Sakon Nakhon Province it was found that the twining habit of *Stemona aphylla* which grow in Deciduous Forest and dry habitats, is less population and scatter in wide areas. This occurrance probably due to the distributior which are insects and ants. Whereas *Stemona* sp. 1 mostly occur in blanket marsh vegetation of Dry Dipterocarp Forest which have trailing habit and the young shoots always decay after it touch to the ground more population in the areas, because of the distribution carrier are limited, which probably by only water in the swampy areas.

1.3. Leaves

The leaves are simple, mostly alternate, rarely opposite or verticillate (*Stemona phyllantha* and *S. tuberosa*). The blades are ovate to broadly ovate, deltoid, elliptic or lanceolate. Leaf base is usually shallowly deeply cordate, truncate (*Stemona* and *Stichoneuron* sp. 2), round or obtuse (genus *Stichoneuron*). The apices vary from acute to acuminate, rarely mucronate. The margins are normally entire but some species always slightly undulate. Leaves surfaces are glabrous or hairy which can be seen in genus *Stichoneuron* and *Stemona kerrii*. The texture of the leaves are chartaceous or coriaceous which turn to be chartaceous when dry. The leaves are yellowish-green to dark green, young leaves are reddish to pinkish but becoming green with aged. The nerves are basal, consist of (5)7-17(19) or lateral veins, shallowly depressed above. The secondary veins intervenation finely trabeculate (*Stemona*) or finely reticulate (*Stichoneuron*).

The petioles are often slender and usually pulvinate at base (*Stemona*) or slightly sheathing (in two taxa of *Stichoneuron*). The upper surfaces usually shallowly longitudinal channeled. The colour of petiole is same as the colour of stem but some species such as *Stemona cochinchinensis* is usually ornamented with pinkish on pulvinus base and apex at its point. The petioles are always present, 0.5-15 cm long. The genus *Stichoneuron* petioles can be very short usually not more than 1 cm long. In *Stemona* petioles can be divided into 2 groups according to the length of petioles *i.e.* 1-6.5 cm long: *Stemona aphylla*, *S. cochinchinensis*, *S. kerrii*, *S. pierrei*, *Stemona* sp. 1 and *Stemona* sp. 2, petiole 4-17 cm long: *Stemona burkillii*, *S. collinsiae*, *S. curtisii*, *S. phyllantha* and *S. tuberosa*.

1.4. Inflorescences

The inflorescences are appeared in short raceme, apically crowded raceme with stiff (Steenis, 1982), compound raceme (can be seen in *Stichoneuron* sp. 2) or cincinae (such as *Stemona burkillii*, *S. phyllantha*, *S. tuberosa*), rarely 1-3 flowered. Some species have solitary flower such as *Stemona aphylla* and

Stemona sp. 2. The inflorescences are in the axils of leaves (or leaves scale), or the peduncle fused with petioles is commonly found in *Stemona phyllantha*, rarely in *S. kerrii*. The peduncles are very vary from 0.5 to 8 cm long. *Stemona curtisii* mostly has very long peduncles, which up to 11 cm. In *Stemona* the inflorescences is erect, while *Stichoneuron* pendulous inflorescences.

1.5. Flowers

The flowers of Stemonaceae are bisexual, and unisexual reported by Dahlgren *et al*. (1982) and Kubitzki (1998). The pedicels are very short up to 2 cm in length and articulated, supported by bracts. Each flower bears 1 bract. The flowers usually glabrous or hairy (genus *Stichoneuron* and *Stemona kerrii***)**. The tepals are 4, free, represented as two whorls of two tepals. The inner whorl is often larger than the outer (*Stemona*), sometime all tepals are equal similar (*Stichoneuron*). The tepals are mostly glabrous, but the tepals with hairy outside can be seen only in *Stemona kerrii*, and hairy on both sides can be seen in *Stichoneuron* sp. 1 and *Stichoneuron* sp. 2. Sometimes the tepals are papillose which can be seen in *Stichoneuron caudatum*. The aestivation is imbricate in all species in Thailand, but Kubitzki (1998) described the tepals of *Stichoneuron* which are valvate.

The stamens are 4, with the connate base of filament (*Stemona*) or the filament adnate to base of tepals (*Stichoneuron)*. In *Stemona* the stamen is shortly connated at base with 2 elongate anther (thecae), which separated by longitudinal ridge. The thecae are situated on top of the filament with connective. There are two kinds of appendage, one is theca appendage while another is connective appendage which are found in different species. In *Stichoneuron* the stamen has short filament and 2 thecae on top of the filament.

The ovary is superior, very small and rather globose, ovoid or urceolate with few ovule. The placentation can be both apical and basal placentation in *Stichoneuron* and *Stemona* respectively.

1.6. Fruits and Seeds

The fruits are glabrous capsule, which are ovoid or spindle-shaped with 2-valved. Fruit apex is acuminate. The colour are yellowish-green, pale green and dark green.

The seeds are situated on short, or long funiculus. The length of funiculus depends on numbers of seed which the species produced; for example *Stemona phyllantha* produced many seeds up to 30 seeds, *Stemona kerrii* produced 1-3 seeded, so the funicle of *Stemona phyllantha* is longer than of *S. kerrii*. The shape of seeds are mostly ellipsoid or semi-globose with longitudinally ridged. The aril (elaiosome) surround the base of seeds are fleshy and hollow. The elaiosome can be divided by its form *i.e.* coralloid or finger-like (the apex of aril acuminate), lobed (the apex of aril obtuse) and wide-cell (Figure 9).

Figure 3 Tuberous roots: A. *tuberosa* group; B. *curtisii* group; C-D. *kerrii* group. Photographed by P. Inthachub (A-C); S. Vajrodaya (D).

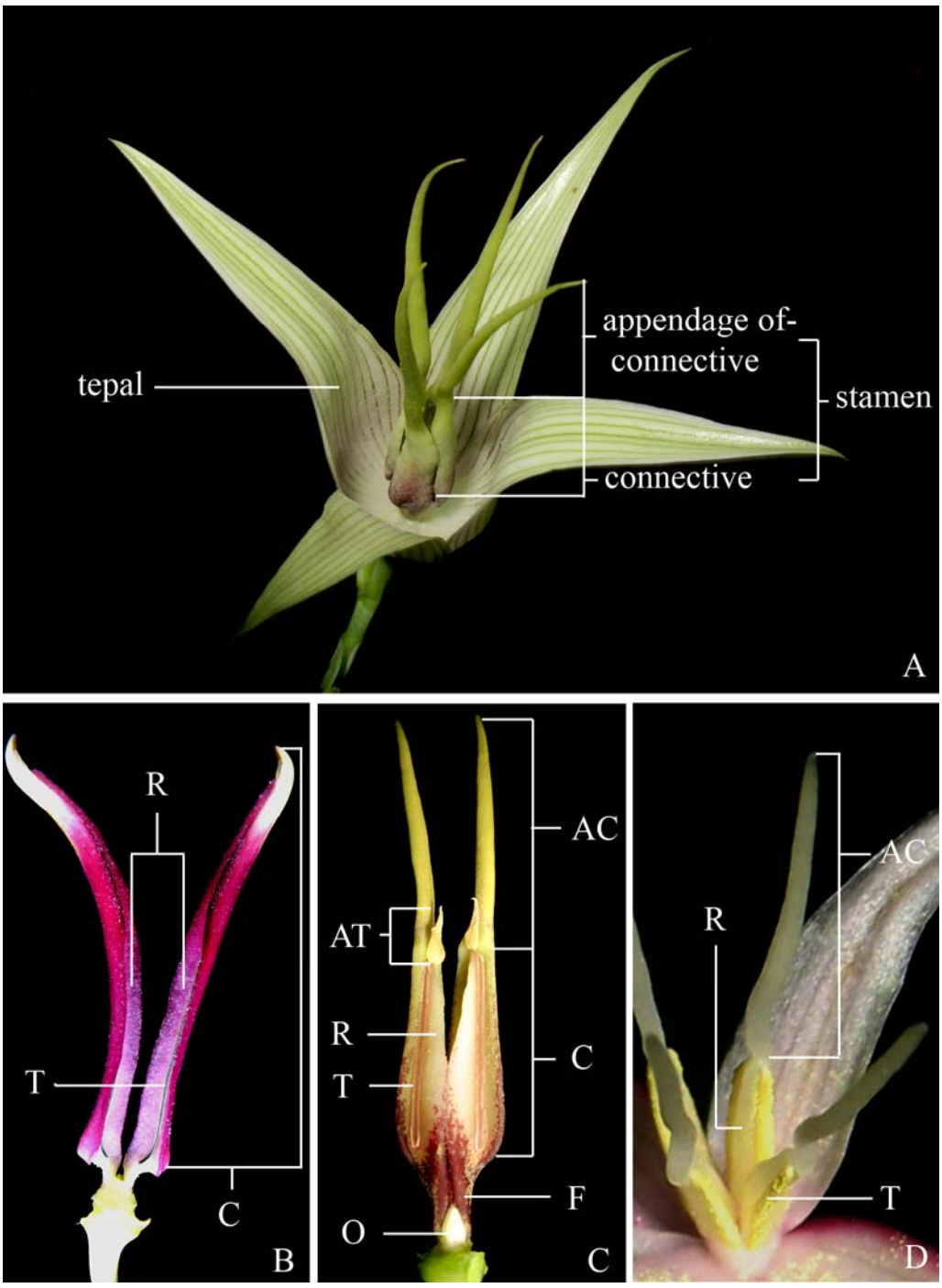

Figure 4 Flower structure of *Stemona*: A. flower of *Stemona phyllantha*; B. stamen of *S. curtisii*; C. stamen of *S. phyllantha*; D. stamen of *S. cochinchinensis* (AC= appendage of connective; AT= appendage of thecae; C= connective; F= filament; O= ovary; R= ridge; T= theca).
Photographed by P. Inthachub.

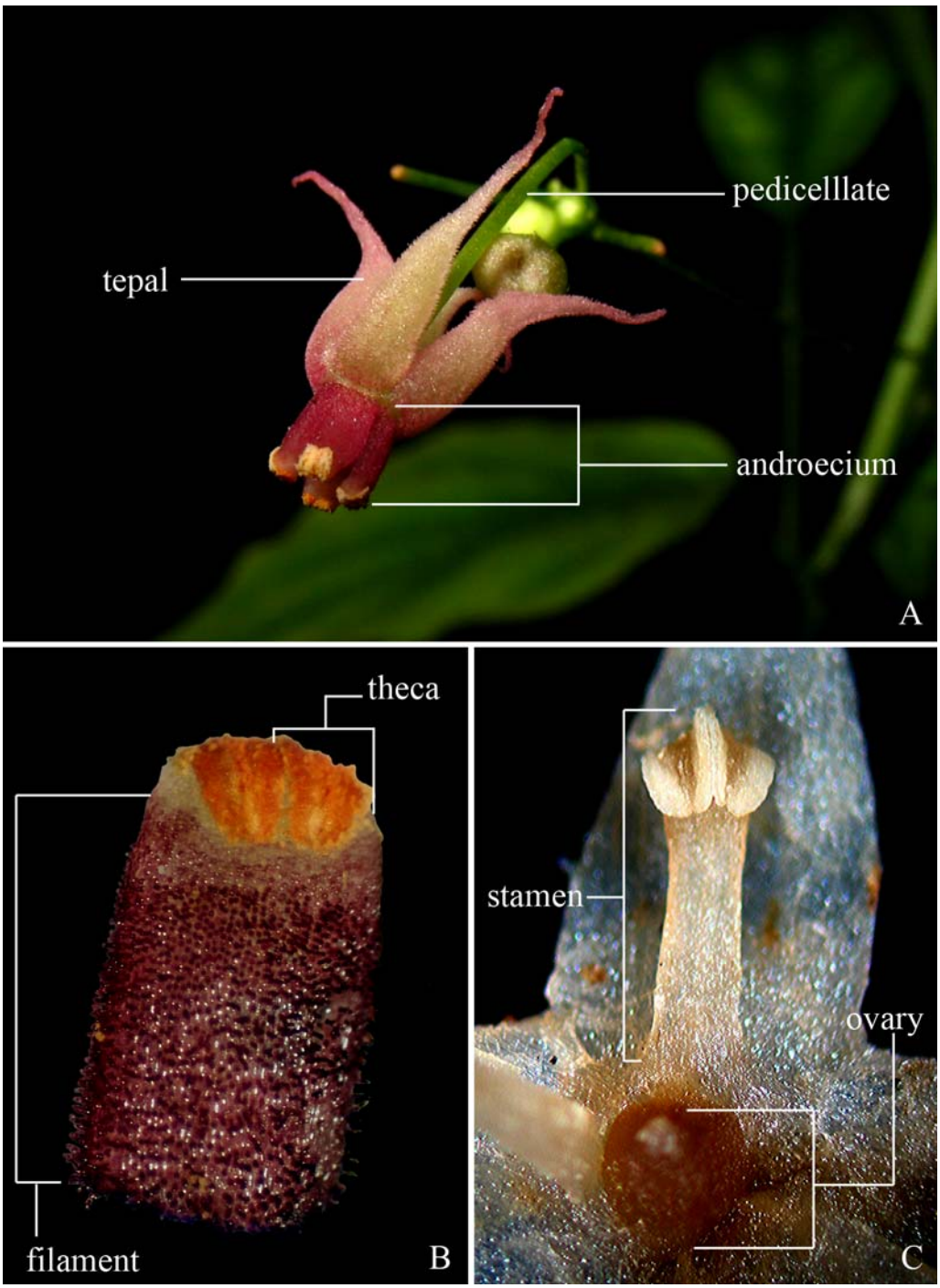

Figure 5 Flower structure of *Stichoneuron*: A. flower of *Stichoneuron caudatum*; B. showing stamen of *S. caudatum*; C. showing stamen and pistil of *Stichoneuron* sp. 1. Photographed by P. Inthachub.

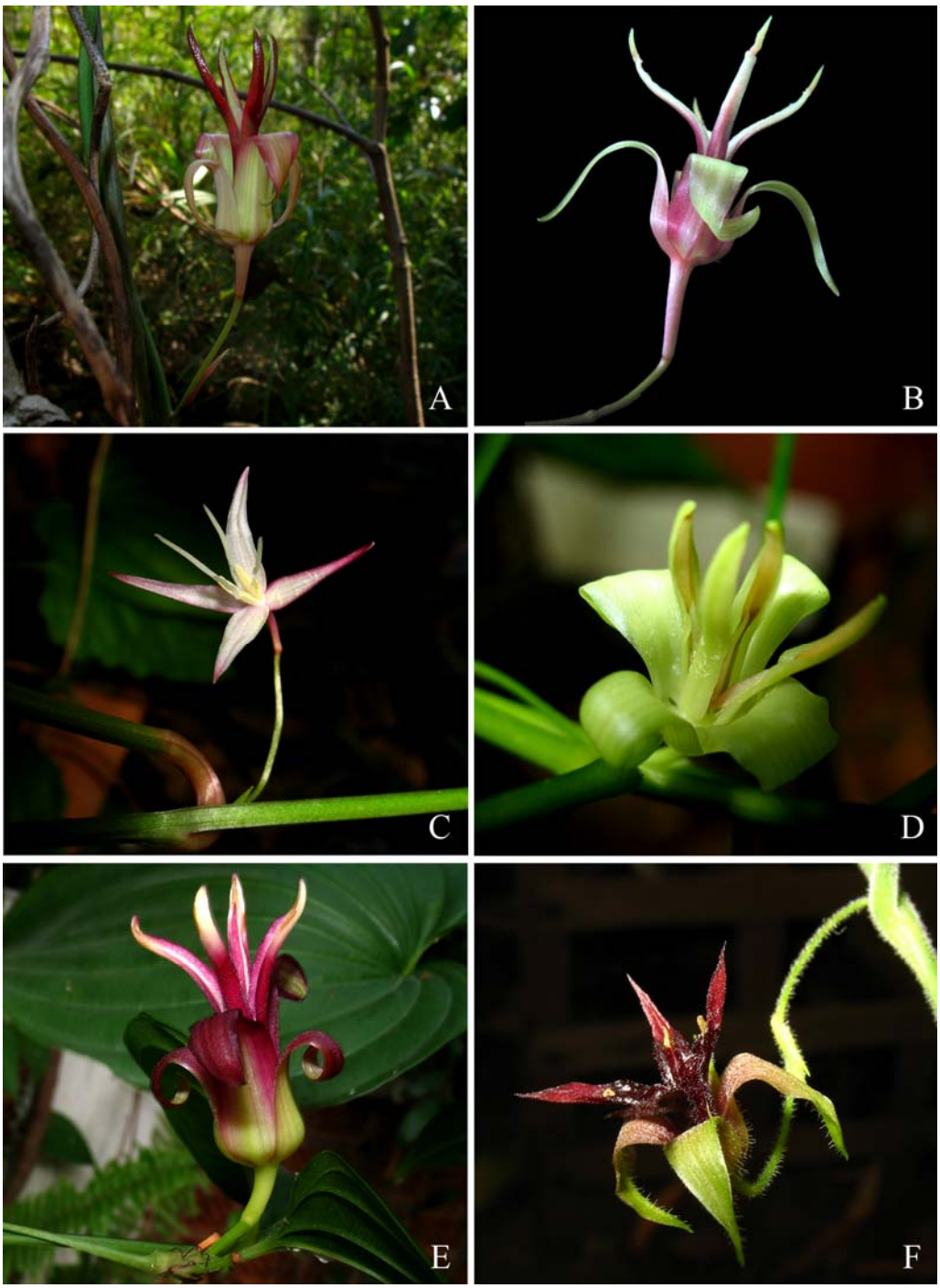

Figure 6 Inflorescence and solitary flower: A. *Stemona aphylla*; B. *S. burkillii*; C. *S. cochinchinensis*; D. *S. collinsiae*; E. *S. curtisii*; F. *S. kerrii*. Photographed by P. Inthachub.

Figure 7 Inflorescence and solitary flower: A. *Stemona pierrei*; B. *S. tuberosa*; C. *S. phyllantha*; D. *Stemona* sp. 1; E. *Stemona* sp. 2. Photographed by P. Inthachub.

Figure 8 Inflorescence: A. *Stichoneuron caudatum*; B. *Stichoneuron* sp. 1; C. *Stichoneuron* sp. 2. Photographed by P. Inthachub (A & C); M. Poopath (B).

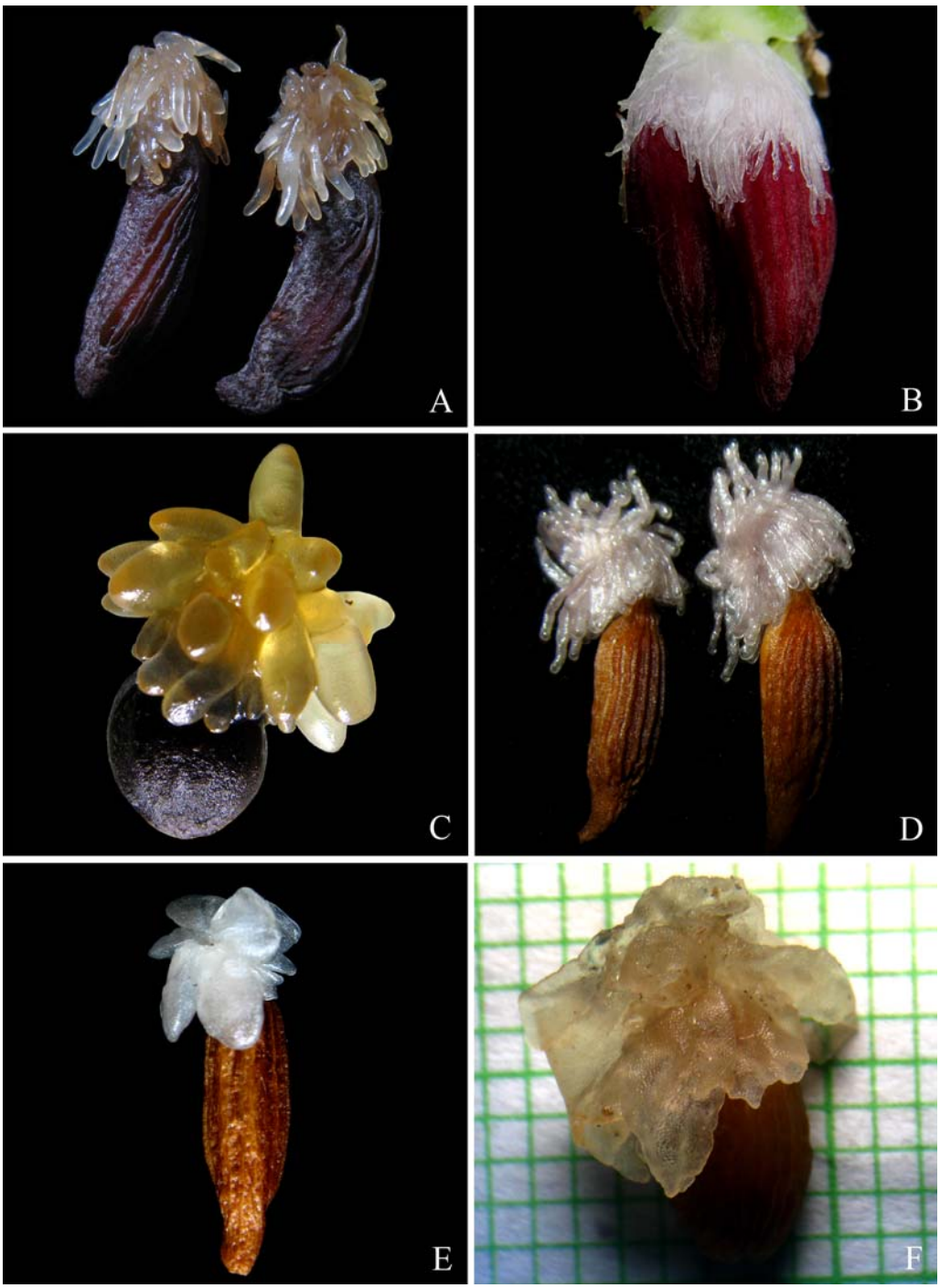

Figure 9 Aril (elaiosome): A-B. Coralloid (finger-like) form ; C-D. Lobed form; E-F. Wide-cell form (A. *Stemona burkillii*; B. *S. collinsiae*; C. *S. kerrii*; D. *S. phyllantha*; E. *S. pierrei*; F. *Stichoneuron* sp. 2).
Photographed by P. Inthachub.

2. Distribution of Stemonaceae in Thailand

Stemonaceae in Thailand comprises 2 genera, 10 species and 4 taxa. *Stemona* is rather large of 9 species and 2 taxa, occurs widespread within 7 floristic regions of Thailand, which are 6 species in the Northern region (N), 7 species in the North-Eastern (NE), 6 species in the Eastern (E), 2 species in the South-Eastern (SE), 3 species in the South-Western (SW), 2 species in the Central (C) and only one species in the Peninsular (PEN).

The Forest Herbarium, Royal Forest Department (2001) reported of 1 genus and 6 species, *i.e. Stemona aphylla* can be found in Lampang, *S. burkillii* in Chiang Mai, *S. collinsiae* in the Northern and Central, *S. hutanguriana* (becomes a synonym of *S. cochinchinensis* in this study) in the Eastern (Si Sa Ket, Ubon Ratchathani), *S. phyllantha* in the northeastern and *S. tuberosa* in Central (Chon Buri), North (Mae Hong Son) and Peninsular (Prachuap Khiri Khan).

Duyfjes (1993) reported that only one species of the genus *Stichoneuron* was found in Thailand *i.e. Stichoneuron caudatum*. However, in this study of the genus based on BKF, BK, CMU collections and additional field surveys found 3 taxa which are endermic to Thailand. The species occur only in the peninsular region. *Stichoneuron caudatum* and *Stichoneuron* sp. 1 occurs in evergreen forest near Thai-Malaysian border, while *Stichoneuron* sp. 2 is only known from Khlong Phanom National Park in Surat Thani (Table 2).

Two species are newly record in Thailand: *Stemona cochinchinensis* is known from Mukdahan, Nong Khai, Ubon Ratchathani, Si Sa Ket, along the Mae Khong River and *S. pierrei* is known from Surin and Buri Ram to Si Sa Ket province.

Two species are endemic to Thailand as follows: *Stemona aphylla* occurs in the northern, south-eastern and central region, *S. collinsiae* occurs in central, eastern and south-eastern region.

Table 2 Distribution of the Stemonaceae in Thailand

Species	Thailand Floristic Regions						
	N	NE	E	SE	SW	C	PEN
Stemona aphylla	X	X				X	
S. burkillii	X	X			X		
S.cochinchinensis (synonym—*S. hutanguriana*)		X	X				
S. collinsiae			X	X		X	
S. curtisii					X		X
S. kerrii	X						
S. phyllantha	X	X	X	X	X		
S. pierrei			X				
S. tuberosa	X	X	X				
Stemona sp. 1		X					
Stemona sp. 2	X	X	X				
Stichoneuron caudatum							X
Stichoneuron sp. 1							X
Stichoneuron sp. 2							X

Noted N= north; NE= north-east; E= east; SW= south-west; C= central; SE= south-east; Pen= peninsular.

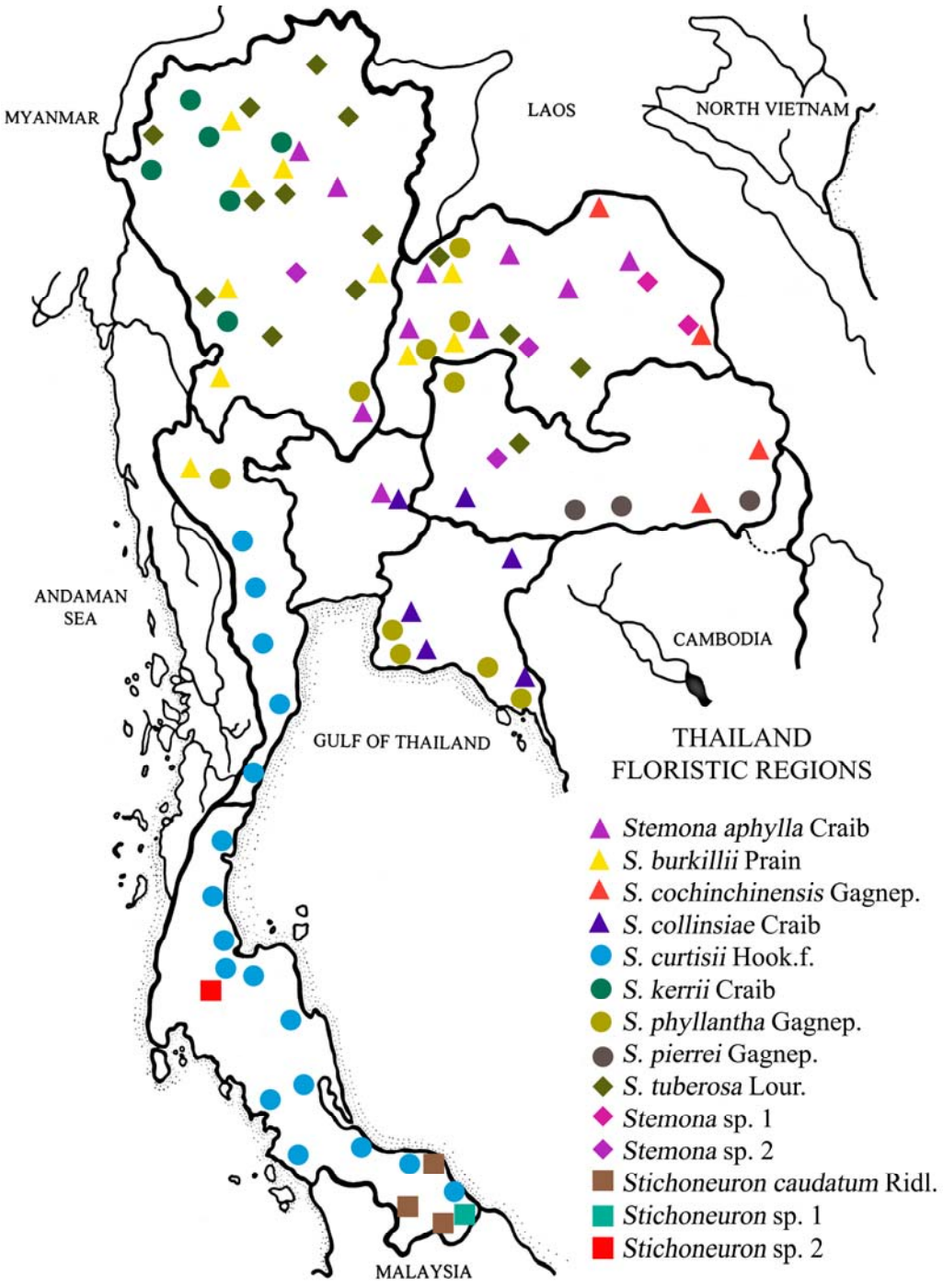

Figure 10 Distribution of Stemonaceae in Thailand.

3. Ecology

Stemonaceae in Thailand normally occurs in seasonal climate, opened area and almost dry habitats. However, some species can be seen in shaded area and mostly grow near the streams, or rather moist climate e.g. *Stichoneuron caudatum, Stichoneuron* sp. 2.

The genus *Stemona* is very widespread in Thailand, commonly found in Deciduous Forest and dry habitats *i.e. Stemona aphylla, S. cochinchinensis* and *Stemona* sp. 2.

Stemona pierrei and *Stemona* sp. 1 grow in sandstone hill or moist sandy soil in deciduous dipterocarp forest, growing as blanket marsh vegetation.

S. burkillii and *S. kerrii* occur in fower montane pine-oak forest, mix-deciduous forest and deciduous dipterocarp forest. However, *S. bukillii* prefers moist and friable soil than other habitats. Some species such as *S. collinsiae*, *S. phyllantha* are found in dry evergreen forest and mostly near waterfall or stream, while *S. tuberosa* grows in dried habitats.

S. curtisii occurs in wide varieties of habitats in evergreen forest, secondary forest, beach forest, in scrubs or orchard.

Stichoneuron sp. 2 grows in a very specific habitats, especially on limestone hill.

Members of Stemonaceae in Thailand occur at various altitudes from sea level to 1,200 m. *Stemona curtisii* is specific to the low altitude, along the coast and 500 m far from the coast. *S. phyllantha* occurs in vary altitude from low to 1,200 m, also in beach forest, dry evergreen forest or deciduous forest. Other species are commonly found from 300 to 750 m such as: *S. burkillii, S. cochinchinensis* and *S. kerrii*.

4. Taxonomic Treatment

STEMONACEAE

Prain, J. Astat. Soc. Bengal, Pl. 2, Nat. Hist. 73: 39. 1904; K. Krause, in Nat. Pflanzenfam. 15a: 224. 1930; Gagnep., Fl. Indo-Chine 6: 745. 1934; Burkill, J. Linn. Soc. Bot. 56: 319. 1960; Steenis, Blumea 28: 151. 1982; R. Dahlgren *et. al.*, The families of the Monocotelydons. 121. 1985; Duyfjes, Blumea 36: 239. 1991; Duyfjes, Fl. Males., Ser. 1. 11(2): 399. 1993; Wadhwa & Weerasooriya, Fl. Ceylon 10: 383. 1996: Zhanhe & Duyfjes, Fl. China 24: 70. 2000. **—** *Roxburghiaceae*, Benth. & Hook.f., Gen. Pl. 3:747. 1965; Hook.f., Fl. Brit. India. 6: 297. 1894; Hutch., Fam. fl. pl. Monocot. 2 ^{ed}. 2: 656. 1959; Ridl., Fl. Malay. Penin. 4: 320. 1967; Backer & Bakh.f., Fl. Java 3: 154. 1968. Type species **—** *Stemona tuberosa* Lour.

Perennial herbs, trailing to twining non-woody climber or erect, mostly with a short rhizome with scale leaves, with or without fasciculate tuberous roots (*Stichoneuron*); stem glabrous or with uniseriate hairs; leafy stems shoots arise from rhizome, branched or unbranched, the whole shoot dying off after the fertile season. *Leaves* simple, distichous, alternate, opposite or verticillate, lower part of leafy stem leaves reduced to scale-leaves; blade ovate, broadly ovate, linear, lanceolate, triangular or cordate, base cordate or hastate, apex acute to acuminate, margin entire or slightly undulate, nerves basal or lateral nerves, 5-19 arching, shallowly depressed above, numerous secondary intervenation; petiole narrowly attached to stem, pulvinate at base (*Stemona*) or slightly sheathing (*Stichoneuron*). *Inflorescences* axillary or pedunculate sometime in fasciculate or shortly raceme (rarely 1-2 flowered), branching (*Stichoneuron*) or solitary, sessile, usually withering together with the whole leafy stem; bracteoles. *Flowers*: pedicellate, articulate; perianth 4-merous which similar segments, representing two rows of to two tepals, free, imbricated. *Stamen* 4, epitepalous, filaments short, adnate to base of tepals, free (*Stichoneuron*) or shortly connate at base (*Stemona*), anthers dorsifixed or basifixed with 2 thecae, ovoid or elongate, each opening by a longitudinal slit, introrse (*Stemona*), opening laterally (*Stemona cochinchinensis*) or antrorse (*Stichoneuron*);

theca on top of filament (*Stichoneuron*) or with an apically enlarged tepal-like appendage of the connective, connective narrow or broad, with a median longitudinal ridge separating the thecae, ridge either smooth and thin, of fleshy and with a brain-like wrinkled structure, thecae often protruding into a common sterile appendage (*Stemona collinsiae, S. kerrii, S. phyllantha, S. pierrei, S. tuberosa and Stemona* sp. 1), apex fused or free, protruding over the stigma. *Ovary* small, superior, unilocular; ovule few to many, basal (*Stemona*) or apical (Stichoneuron) placentation; style absent; stigma inconspicuous, roundish, papillose. *Fruits* a 2-valved capsule, thin-walled. *Seed* few to many, broad-ellipsoid or ellipsoid, with conspicuously or inconspicuously longitudinally ridged seed coat; funicle long, with a coralloid, lobed, hollow or wide-celled aril.

A family of 3 genera and about 25 species: *Stemona* occurs in Japan and continental Asia, extending through Malesia to northern Australia, *Stichoneuron* in continental South-East Asia and the Malay Peninsula. The genus *Croomia* occurs in eastern China, southern Japan, and South-East United States (Florida, Georgia) (Duyfjes, 1993).

Key to the genera of Thai Stemonaceae

Rhizome with tuberous roots, leaves with basal nerves. Anther dorsifixed, petal-like connective long. Seed basally attached ***Stemona***

Rhizome without tuberous roots, leaves with lateral nerves. Anther basifixed, without connective. Seed apically attached ***Stichoneuron***

STEMONA

Lour., Fl. Cochinch. 1: 404. 1790; Benth. & Hook.f., Gen. Pl. 3:747. 1880; Hook.f., Fl. Brit. Ind. 6: 298. 1892; C.H.Wright, J. Linn. Soc., Bot. 32: 490. 1896; Prain, J. Astat. Soc. Bengal, Pl. 2, Nat. Hist. 73: 39. 1904; K. Krause, in Engl. & Prantl, Nat. Pflanzenfam. 15a: 226. 1930; Gagnep., Fl. Indo-Chine 6: 745. 1908-1942; M.R.Hend., Malay. Wild. fls., Monocots. 172. 1954; Ridl. Fl. Malay. Penin. 4: 320. 1967; Backer & Bakh.f., Fl. Java 3:154. 1968; Duyfjes, Fl. Males., Ser. 1. 11(2): 402. 1993; B.M.Wadhwa & A. Weerasooriya, Revis. Handb. Fl. Ceylon. 10: 383. 1996; Zhanhe and Duyfjes, Fl. China 24: 70. 2000.

Perennial herbs, twining, non woody climber, trailing or erect. Short rhizome, with spindle shape tuberous roots. *Leaves* simple alternate, opposite or verticillate; blades with basal nerves; petioles pulvinus not sheathing. *Inflorescences* sessile or peduncled, raceme-like, rarely one to few flowered. *Flowers*: perianth small to rather large, tepals the inner two tepals slightly wider than the outer ones. *Anthers* with the thecae dorsally attached to the base of a long tepaloid outgrowth of the connective, with a median longitudinal ridge separating the thecae; the thecae apically with or without appendage, filaments short, connate at base. *Ovary* superior, unilocular; ovule few to many, basal placentation; style absent; stigma inconspicuous. *Fruits* capsule, pendulous, opening with two valves, few to many seeded. *Seeds* basally attached, hanging on long funicles, with a coralloid lobed, or wide-cell, hollow aril.

The largest genus in the family with about 20 species distributed from Japan, continental Asia, through Malesia to northern Australia (Duyfjes, 1993).

Note. — The large perianth group in Thailand (*Stemona phyllantha* and *S. tuberosa*), flower has smell.

Key to the species of Stemona in Thailand

1. Plants hairy **6. *Stemona kerrii***
1. Plants glabrous
    2. Leaves opposite or verticillate; roots 2-4 cm in diameter; flowers smell
        3. Flower 5.5-6.5 cm long, carrion smell; inflorescence on the petiole **7. *S. phyllantha***
        3. Flower 2.5-3.5 cm long, antiseptic smell; inflorescence axillary **9. *S. tuberosa***
    2. Leaves alternate; roots 1 cm in diameter; flowers not smell
        4. Herbs erect or trailing
            5. Theca appendage present
                6. Leaf blade 5-11 by 11-15 cm, base cordate; tepals 1.3-2 cm long, whitish-green, rarely whitish-pink with green stripes **4. *S. collinsiae***
                6. Leaf blade 2.5-7.5 by 4.5-12 cm, base obtuse or truncate; tepals 0.6-1.5 cm long
                    7. Flowers 1-1.5 cm long; stamen reddish-brown, connective lanceolate, green at apex **10. *Stemona* sp.1**
                    7. Flowers 0.6-0.9 cm long; stamen dark purple, connective oblong, dark purple all over **8. *S. pierrei***
            5. Theca appendage absent
                8. Leave large, 5.5-10.5 by 9.5-17 cm, base cordate. Flowers 1.8-2.2 cm long, tepal pink or yellowish-pink, small connective appendages **2. *S. burkillii***
                8. Leave smaller, 2-4.5 by 4-7 cm, base truncate or shallowly cordate. Flowers 0.8-1 cm long, tepal whitish-pink, connective appendages conical **3. *S. cochinchinensis***
        4. Herbs twining
            9. Inflorescences axillary, peduncle up to 11 cm long; flowers outside dark brownish-red with green stripes, inside brownish-pink or dark brownish-red **5. *S. curtisii***

9. Inflorescences in scales at lower part of stem, sessile or short peduncle; flowers outside greenish, inside usually pink, dark reddish-purple or yellowish-pink or greenish-purple
    10. Flowers 2-2.5 cm long, connective wide spread toward the tip **1. *S. aphylla***
    10. Flowers 1.5-1.9 cm long, connective involute **11. *Stemona* sp. 2**

1. Stemona aphylla Craib, Bull. Misc. Inform. Kew 1912: 408. 1912; Gagnep., Fl. Indo-Chine 6: 750. 1934.

Herb; twining 4 m long, glabrous; short rhizome. *Roots* tuberous, fleshy, long spindle shape, 10-30 cm long, ca 1 cm diameter. *Leaves* alternate, scales at lower part of stem narrow, deltoid, 5-20 mm long, apex acute; blade ovate or deltoid, 3-4.5 by 6-8 cm; base shallowly cordate or truncate; apex acute; margins entire; basal nerves 9-11, longitudinally parallel; petiole slender, pulvinous, 4-6.5 cm long. *Inflorescences* (or solitary flower) born in the axil of leaf scales, sessile or peduncled, 1-2 flower; peduncles 0.5-1.5 cm long; bracts narrow, 8-10 mm long. *Flowers*: pedicels 5-10 mm long; tepal inside pink or yellowish-pink or greenish-purple, outside greenish, lanceolate, 4-6 by 20-25 mm, nerves (5)7-9(11). *Stamens* 4, purple or pink, 20-27 mm long, ca 2 mm broad; filament ca 2 mm long, basally connate; anthers 8-13 mm long, ridge separating the thecae fleshy, smooth, more or less undulate, ca 1 mm high, elongate to the top of tepaloid connective, thecae appendage absent. *Ovary* urceolate, 1 by 2 mm; stigma inconspicuous. *Fruits* 13-16 by 20-30 mm. *Seeds* 5-6(10), light brown, ellipsoid, ca 4 by 10-12 mm, base surrounded by lobed and hollow aril.

Thailand. — NORTHERN: Lampang, Phrae (Mae Ta, type: KERR 2351), Nakhon Sawan; NORTH-EASTERN: Phetchabun, Loei, Khon Kaen, Sakon Nakon, Udon Thani.

Distribution. — Endemic.

Vernacular. — Khruea Pung (เครือปุง) (Lampang, Phrae), Nawn Tai Yak (หนอนตายหยาก) (Udon Thani).

Ecology. — Scattered in Mixed-Deciduous Forest, Deciduous Forest, limestone hill; altitude: 300-1,600 m.

Notes. — Flowers are mostly borned on lower part of stem and before leaves appear. The differences between *Stemona. aphylla* and *S. curtisii, S. aphylla* has smallest leaf sizes, blade ovate or deltoid, flower pink or sometimes greenish-purple, peduncles very short and occurs in northern and northeastern.

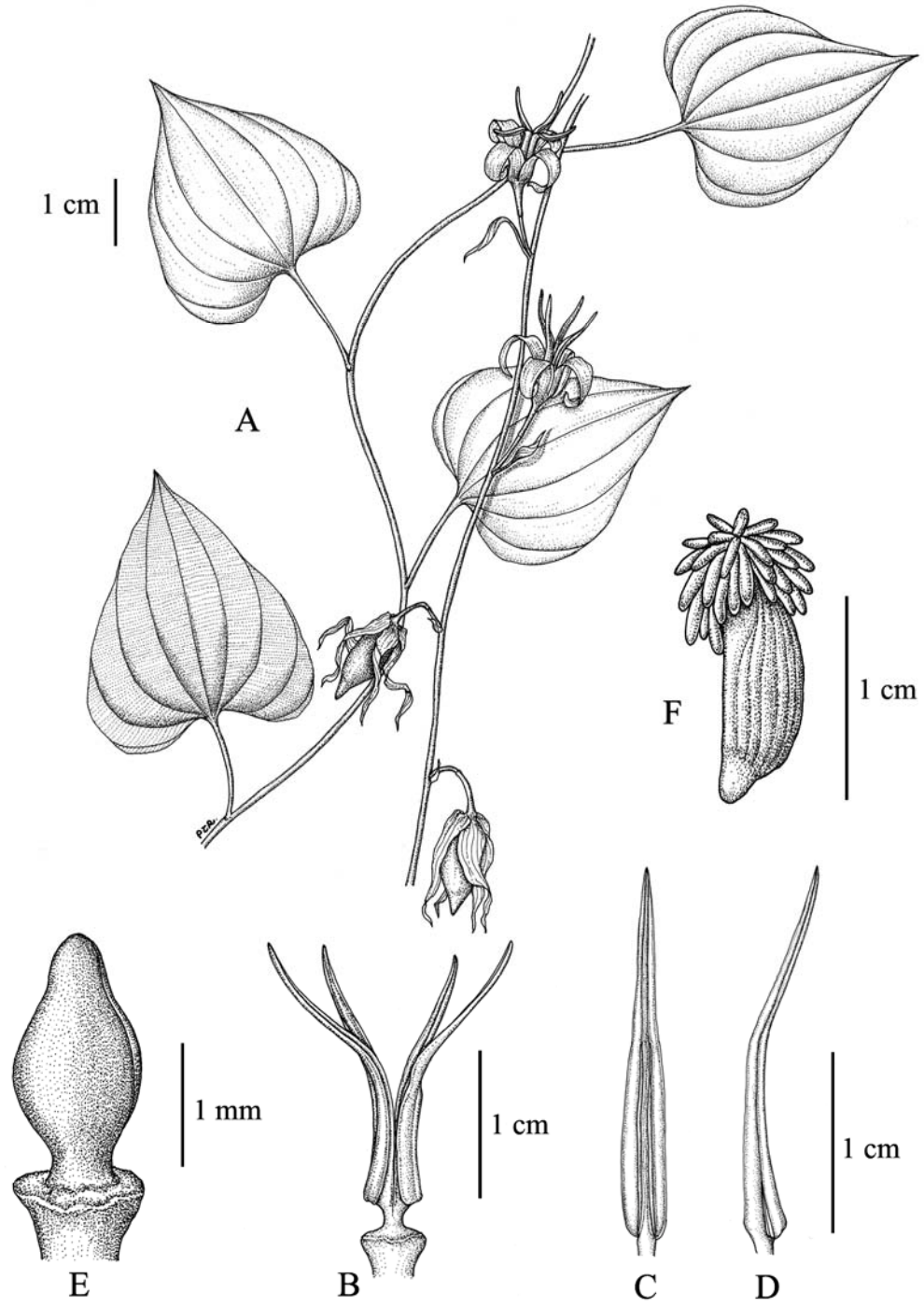

Figure 11 *Stemona aphylla* Craib: A. flowering and leaves stem; B. androecium; C. front view of stamen; D. side view of stamen; E. ovary; F. seed. Drawn by P. Inthachub.

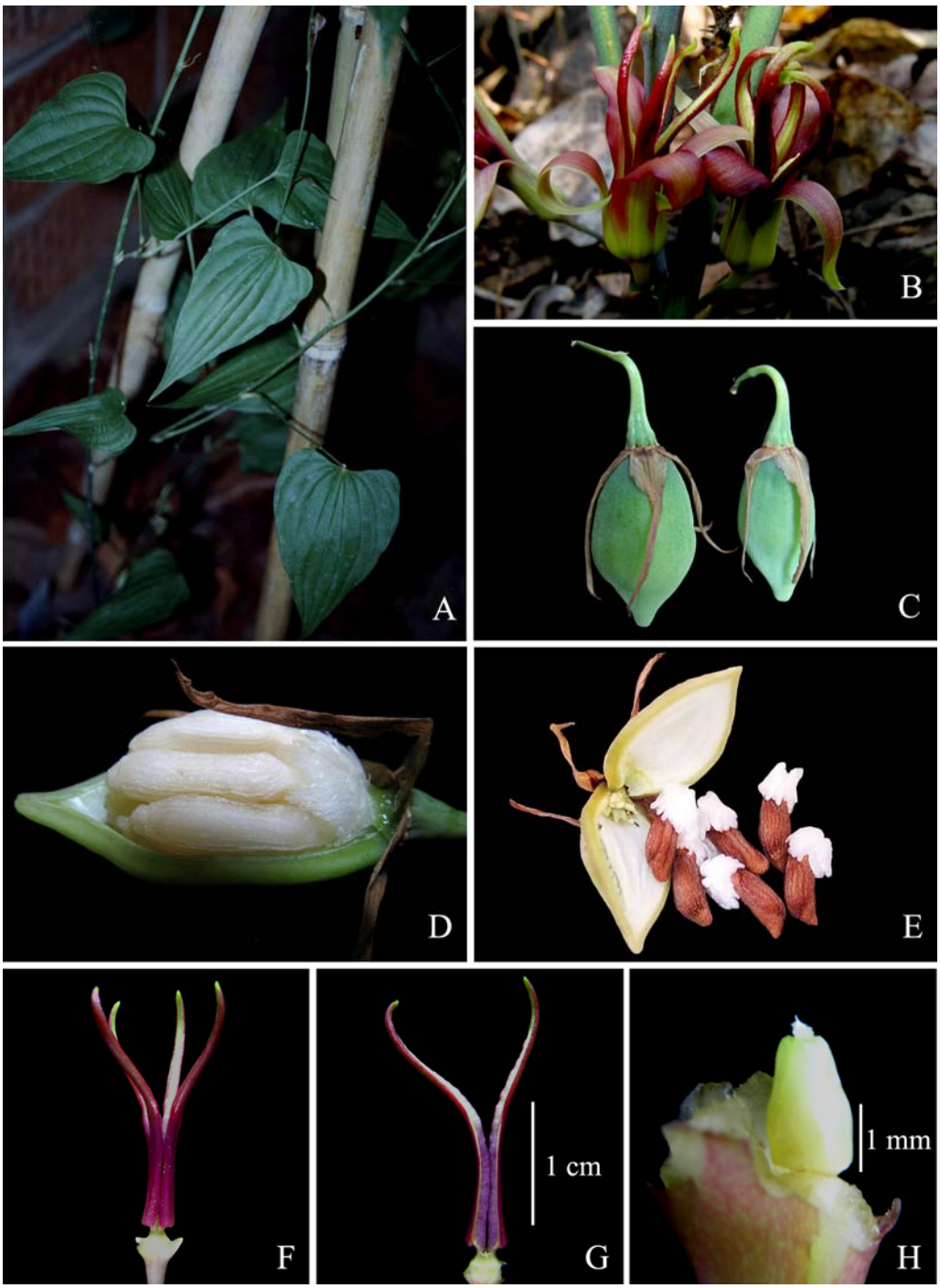

Figure 12 *Stemona aphylla* Craib: A. leaves stem; B. flowers; C. fruits; D. young seeds; E. opened fruit with mature seeds; F. androecium compound with 4 stamen; G. stamen showing ridge and thecae; H. ovary. Photographed by P. Inthachub.

2. Stemona burkillii Prain, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 73: 43. 1904; Craib, Bull. Misc. Inform. Kew 1912: 408. 1912; Gagnep., Fl. Indo-Chine 6: 752. 1934; Maxw., Nat. Hist. Siam Soc. 39: 81. 1991.

Erect or trailing herb, up to 1 m long. *Roots* tuberous, brown, spindle shape, fascicle, 10-30 cm long, ca 1 cm diameter. *Leaves* alternate, scales at lower part of stem 4-5 by 5-15 mm; blade ovate or broadly-ovate, 5.5-10.5 by 9.5-17 cm; base broadly-cordate; apex acute or acuminate; margin entire or slightly undulate; basal nerves (11)13-17(19); petiole slender, pulvinous, 4-17 cm long. *Inflorescences* axillary, 1-4 flowered; peduncles 1.5-4.5 cm; bracts narrow, 2-5 by 2-6 mm. *Flowers*: pedicels 10-25 mm long, tepal 4, pink or yellowish-pink, lanceolate, 3-5 by 18-22 mm, nerves 9-11. *Stamens* 4, pink and apex yellowish-green, 18-20 mm long; filaments 1.5-2 mm long, basally connate; anther 6-8 mm long, ridge fleshy and smooth, ca 1 mm high, 13-15 mm long, small appendage of connective. *Ovary* urceolate, 1 by 2 mm; style absent; stigma inconspicuous. *Fruits* 12-15 by 25-35 mm, beak ca 5 mm long. *Seeds* 3-5, reddish-pink, ellipsoid, 3-4 by 10-12 mm, base surrounded by aril consisting of hollow, finger-like appendages.

Thailand. — NORTHERN: Chiang Mai, Lampang, Lamphun, Phitsanulok, Tak; NORTH-EASTERN: Loei, Khon Khaen, Phetchabun; SOUTH-WESTERN: Kanchanaburi.

Distribution. — Upper Myanmar, Western Indo-China.

Ecology. — Deciduous Dipterocarp Forest, Lower Montane pine-oak Forest, mostly shaded places, near stream or open area, granite bedrock; altitude: 325-725 (-1,200) m.

Vernacular. — Pong mot ngam (โป่งมดง่าม) (Chiang Mai).

Notes. — *Stemona burkillii* has same the stem habit and tuberous root as *S. collinsiae,* but flower colour and stamen difference. *S. burkillii* has pink or yellowish-pink perianth and not appendage of thecae. Whereas *S. collinsiae* has mostly whitish-green or creamy perianth with yellow appendage of thecae.

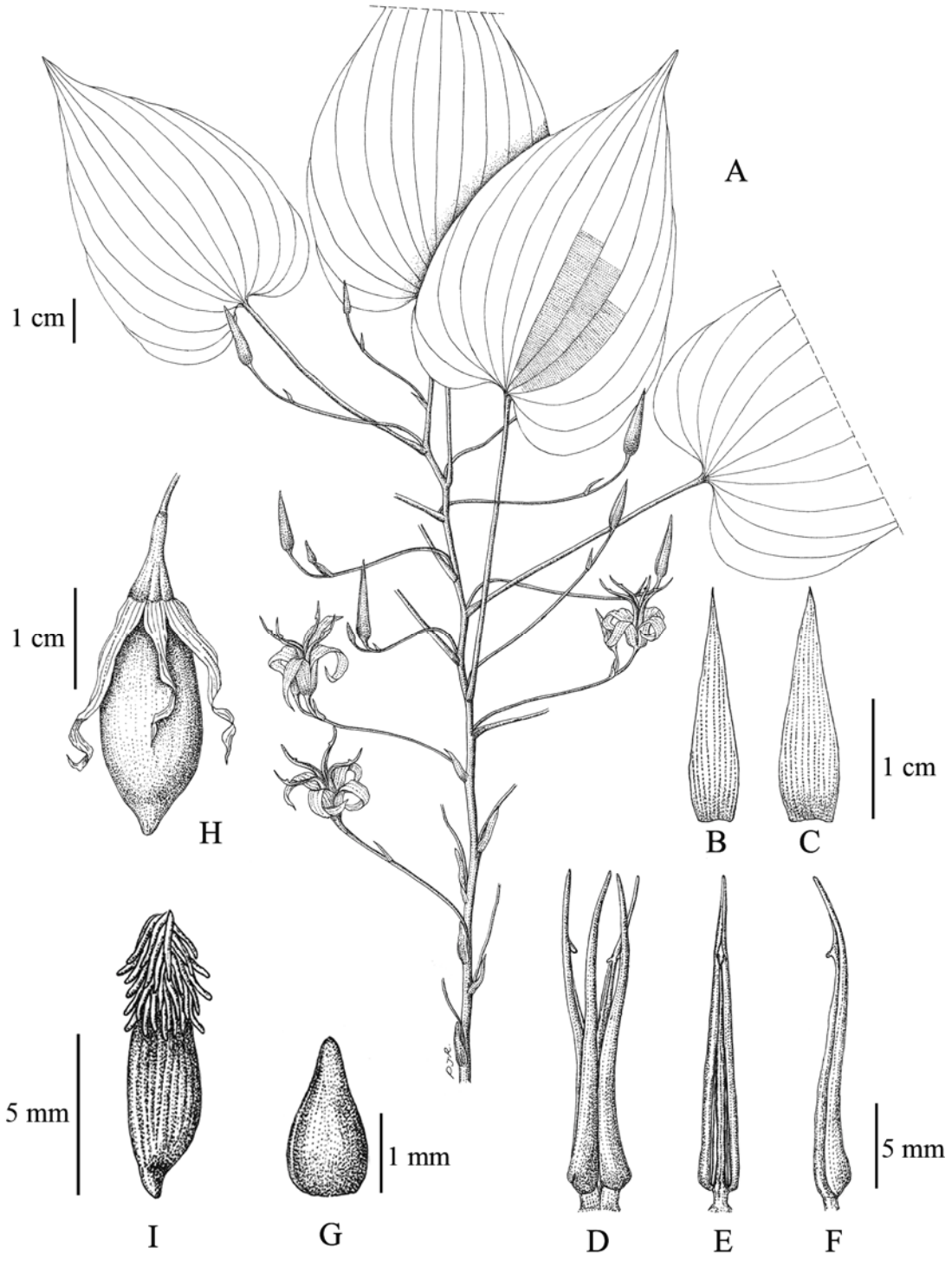

Figure 13 *Stemona burkillii* Prain: A. flowering stem; B. outer tepal; C. inner tepal; D. androecium with 4 stamen; E-F. stamen showing with ridge and small appendage of terminal ridge; G. ovary; H. fruit; I. seed. Drawn by P. Inthachub.

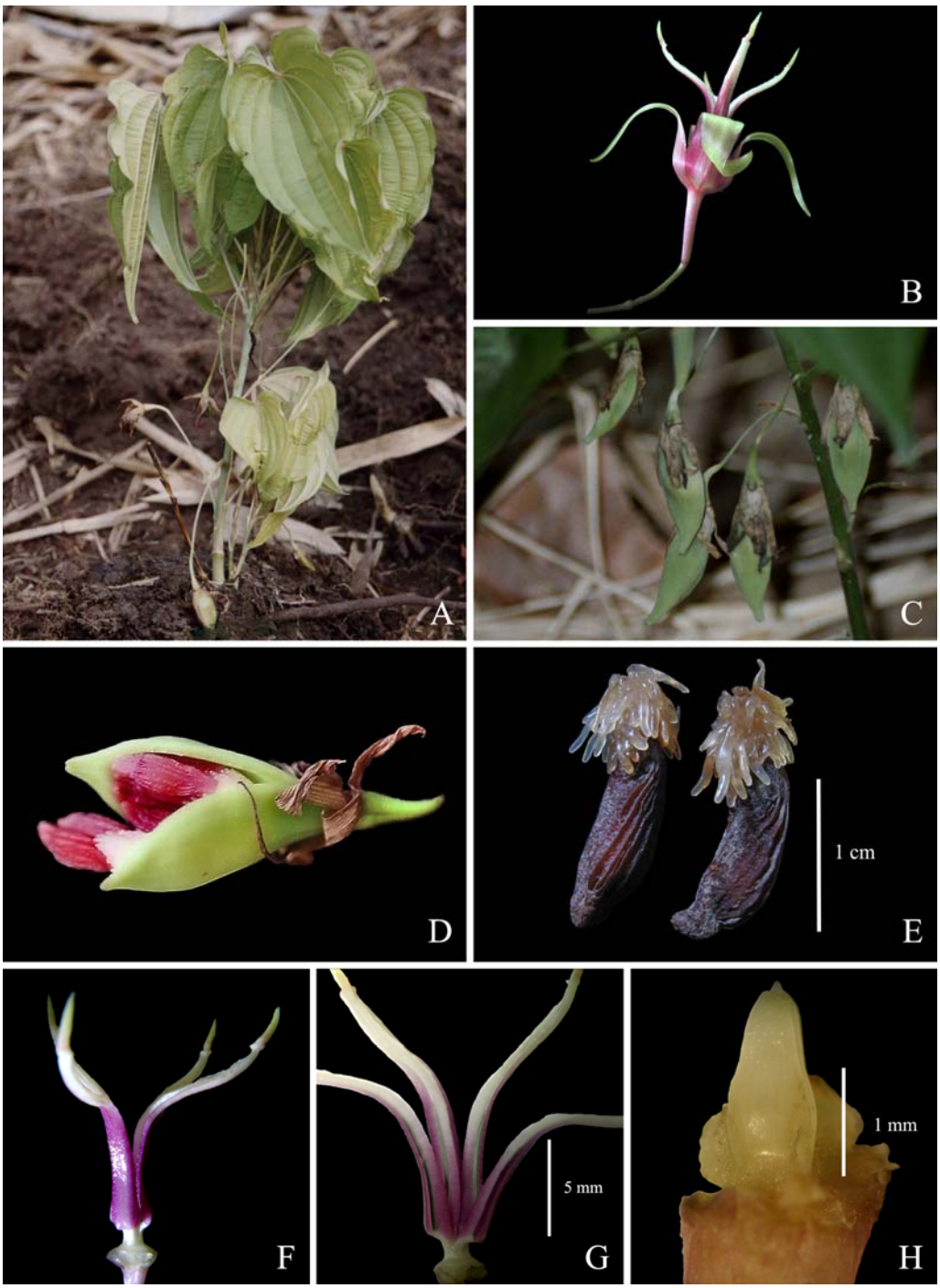

Figure 14 *Stemona burkillii* Prain: A. habit; B. flower; C. fruiting stem; D. opened fruit with young seeds; E. seed with finger-like aril; F. androecium; G. showing the thecae and ridge; H. ovary. Photographed by P. Inthachub.

3. **Stemona cochinchinensis** Gagnep., Bull. Soc. Bot. Fr. 81: 146. 1934; Fl. Indo-Chine 6: 748. 1934. — *Stemona hutanguriana* W. Chuakul, Kew Bull. 55: 977-980. 2000.

Herb; erect or trailing, up to 30(60) cm, 2-3 mm diameter, slender, glabrous, ribbed, sometime branched; short rhizome. *Roots* tuberous, brown, spindle shape and forming a bundle, 10-16 cm long, ca. 1 cm diameter. *Leaves* alternate, scales at lower part of stem 0.4 cm. long; blade ovate, ovate-oblong, or deltoid, 2-4.5 by 4-7 cm.; base truncate or shallowly cordate; apex acute or acuminate; margin entire or slightly undulate; basal nerves 7-9; petiole slender, 1-5 cm. long. *Inflorescences* axillary, sessile or peduncled, 1-3 flowered; peduncles 1-3 cm long; bracts narrow, 2-17 mm. long. *Flowers*: pedicels 3-5 mm long; tepals 4, whitish-pink, lanceolate, 2-2.5 by 8-10 mm, nerves 5-7. *Stamen*s 4, white, 0.5 by 6.5-9 mm; filaments ca. 1 mm long, basally connate; anthers 2.25-3 mm long, thecae dorsifixed, connective long, ridge smooth, connective appendages conical, theca appendage absent. *Ovary* superior, ovoid, 1 by 1.5-2 mm; style absent; stigma inconspicuous, papillose. *Fruits* green, 7 by 16-20 mm, beak 3 mm long. *Seeds* 1-3, dark-brown, ellipsoid, 3 by 7 mm, conspicuously longitudinally ridge, base surrounded by finger-like and hollow aril.

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

Distribution. — Laos, Vietnam.

Ecology. — Scattered in open areas of Deciduous Forest (Dry Dipterocarp Forest) and sandy soil.

Vernacular. — Samsip Kueb (สามสิบกีบ) (Nong Khai).

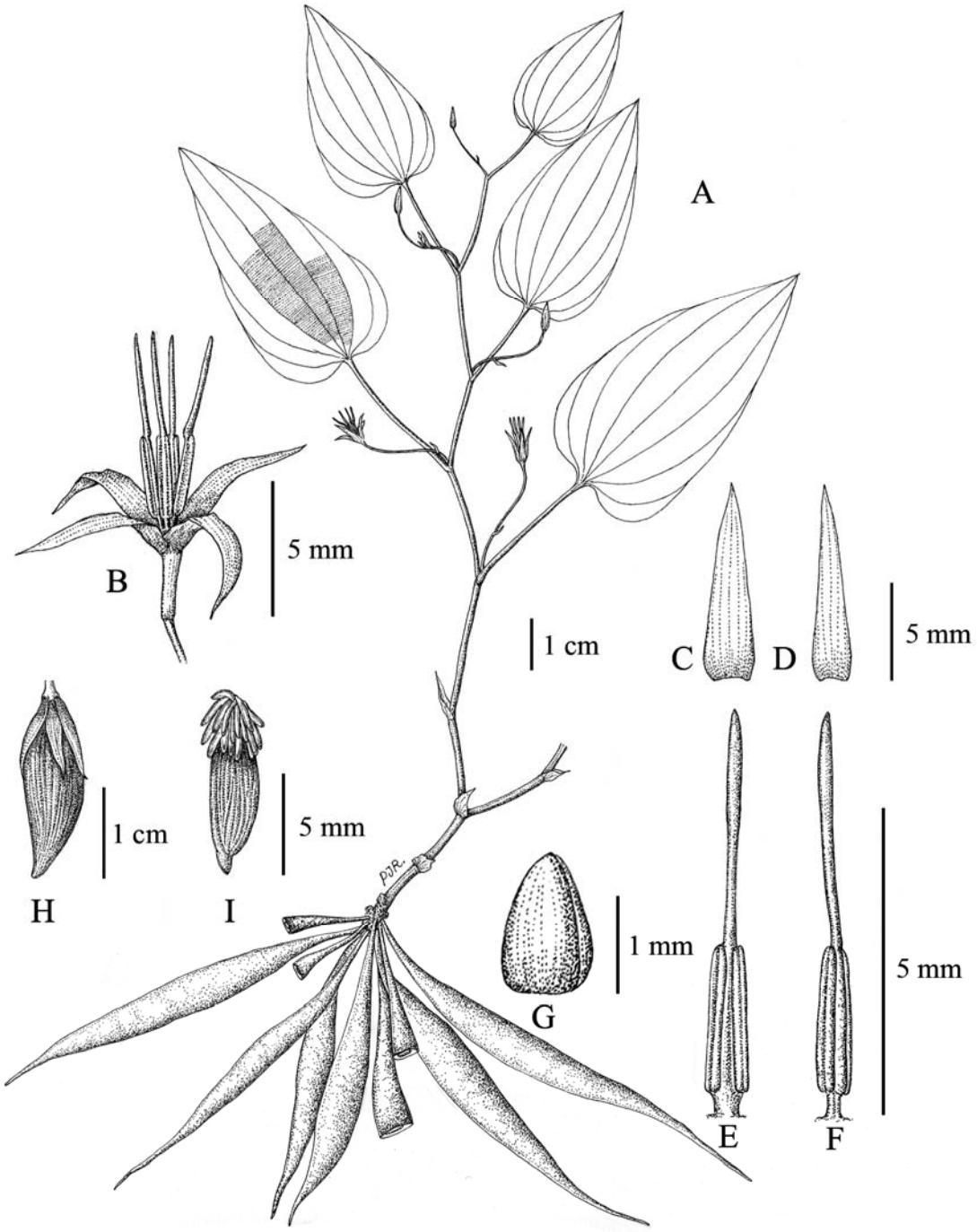

Figure 15 *Stemona cochinchinensis* Gagnep.: A. habit; B. flower; C. inner tepal; D. outer tepal; E-F. stamen; G. ovary; H. fruit; I. seed.
Drawn by P. Inthachub.

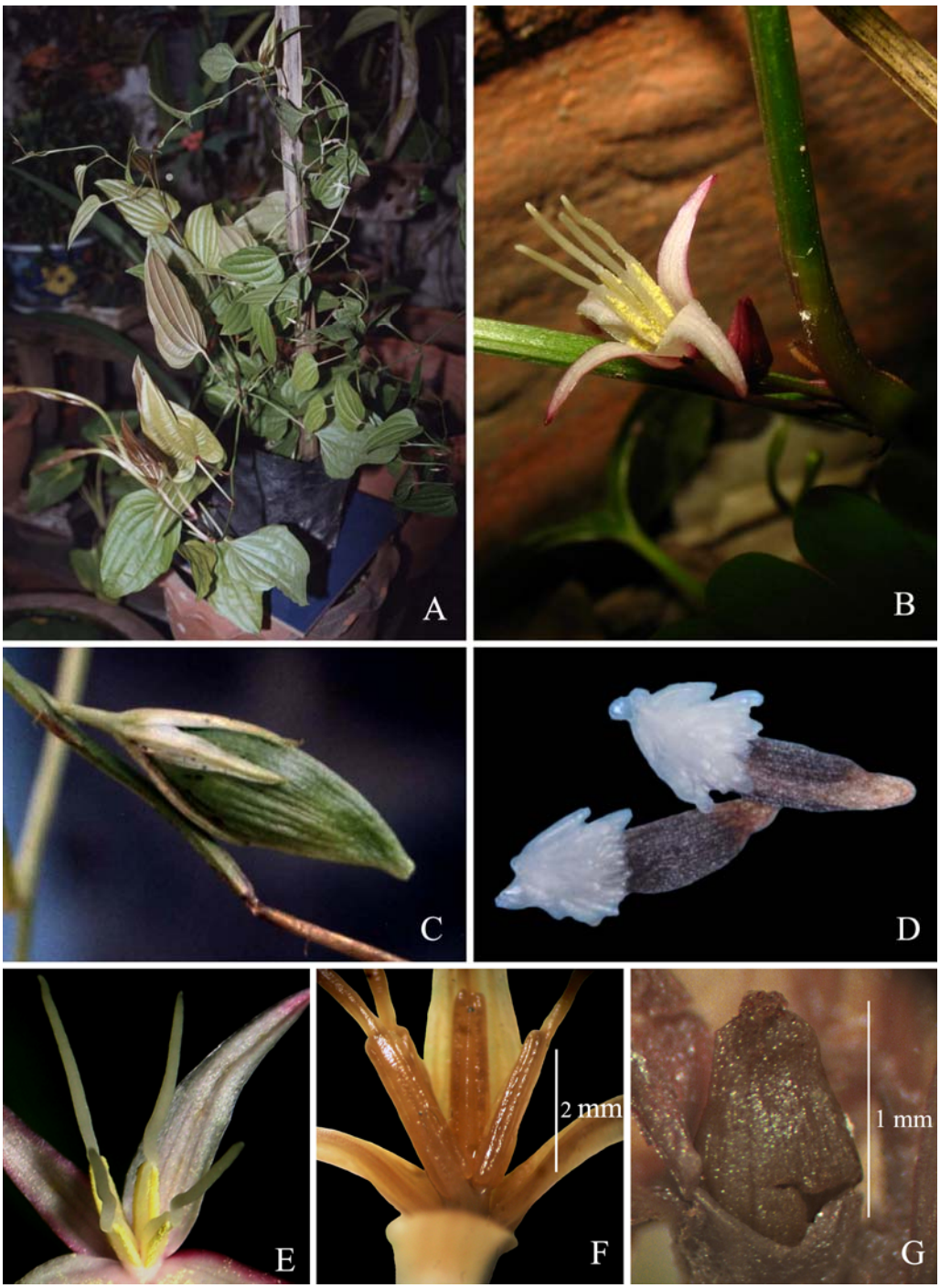

Figure 16 *Stemona cochinchinensis* Gagnep.: A. habit; B. flower; C. fruit; D. mature seed with aril; E. androecium; F. showing thecae (pollen sac); G. ovary. Photographed by P. Inthachub.

4. Stemona collinsiae Craib, Bull. Misc. Inform. Kew 1920: 305. 1920; Gagnep., Fl. Indo-Chine 6: 750. 1934.

Erect or trailing herb, up to 60 cm long, glabrous, rarely branched; short rhizome. *Roots* tuberous, freshly, spindle shape, 10-40 cm long, ca 1-1.5 cm diameter. *Leaves* alternate; scales at lower part of stem 4-5 by 10-12 mm; blade broadly-ovate or ovate-oblong, 5-11 by 11-15 cm; base shallowly cordate or deeply cordate; apex acute; margins entire or slightly undulate; basal nerves 11-15(17); petiole 5-15 cm long. *Inflorescences* axillaly, sessile or peduncled, 1-8 flowered; peduncles 1-4.5 cm long; bracts narrow, ca 1 mm long. *Flowers*: pedicels 5-30 mm long; tepals whitish-green or creamy, rarely whitish-pink, with green stripes, lanceolate-oblong, 5-8 by 13-20 mm, nerves 7-9. *Stamens* 4, yellowish-green, 2 by 11-17 mm; filaments ca 1 mm long, basally connate and adnate the perianth; anthers 5-7mm long,ridge separating the thecae smooth, ca 1 mm high; thecae appendage 2, ovate-oblong, yellow, fused at apical connective, 8-9 mm long. *Ovary* ovoid, 1 by 1.5 mm; style absent; stigma papillose. *Fruits* 10-12 by 20-25 mm, beak ca 8 mm long. *Seeds* 3-6, pinkish-red, ellipsoid, 3-4 by 10-12 mm, apex acute, base surrounded by vesicular aril.

Thailand. — EASTERN: Nakhon Ratchasima; CENTRAL: Saraburi; SOUTH-EASTERN: Chon Buri (type), Rayong, Sa Kaeo.

Distribution. — Endemic.

Ecology. — Scattered in shaded of Dry Evergreen Forest, Deciduous Forest or opened areas of rocky hill near the coast; altitude: 5-300 m.

Vernacular. — Non Tai Yak (หนอนตายหยาก) (Central).

Notes. — *S. collinsiae* is different from *S. burkillii*, by the white or creamy flowers and present of theca appendages.

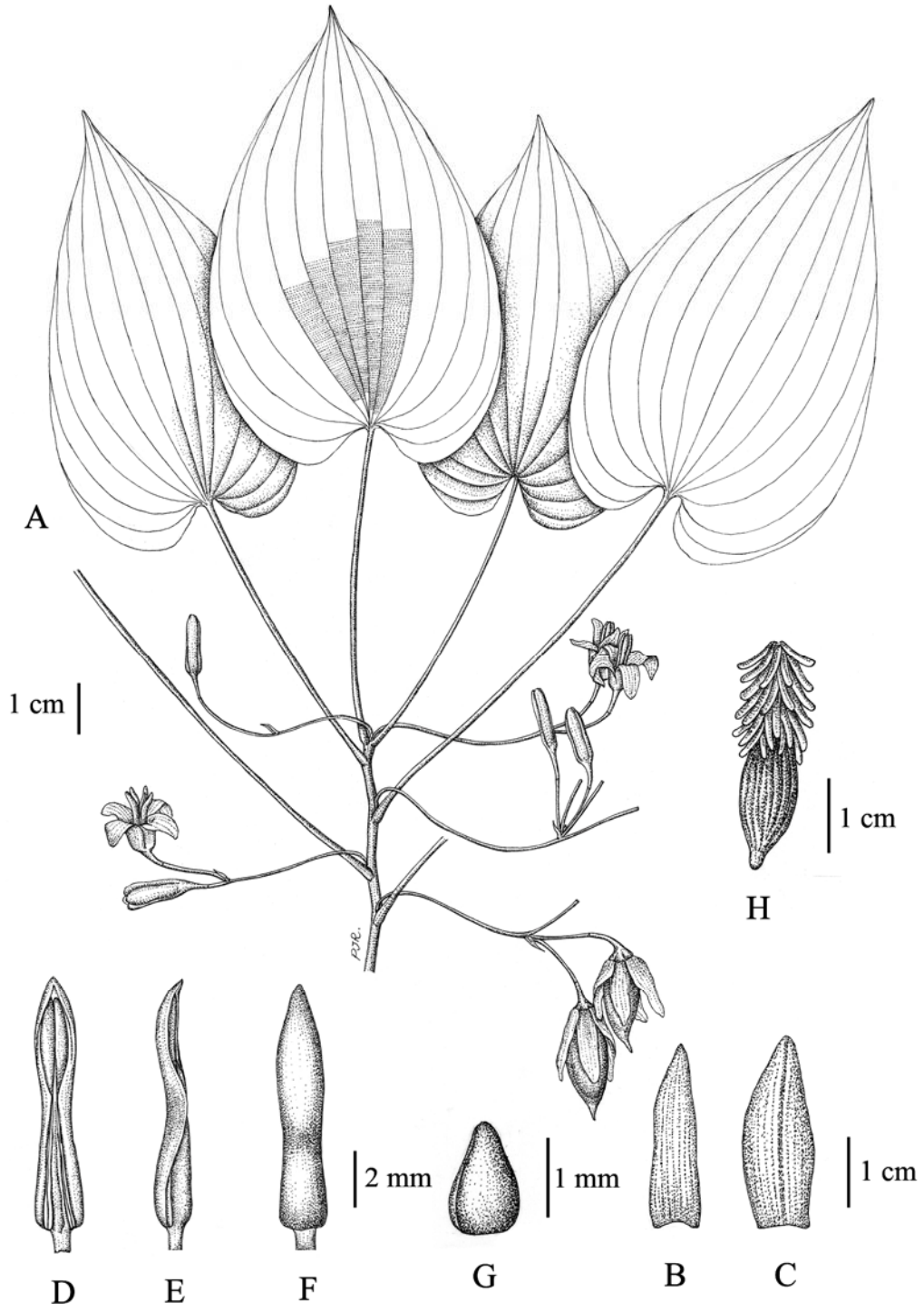

Figure 17 *Stemona collinsiae* Craib: A. flowering and fruiting stem; B. outer tepal; C. inner tepal; D-F. stamen; G. ovary; H. seed. Drawn by P. Inthachub.

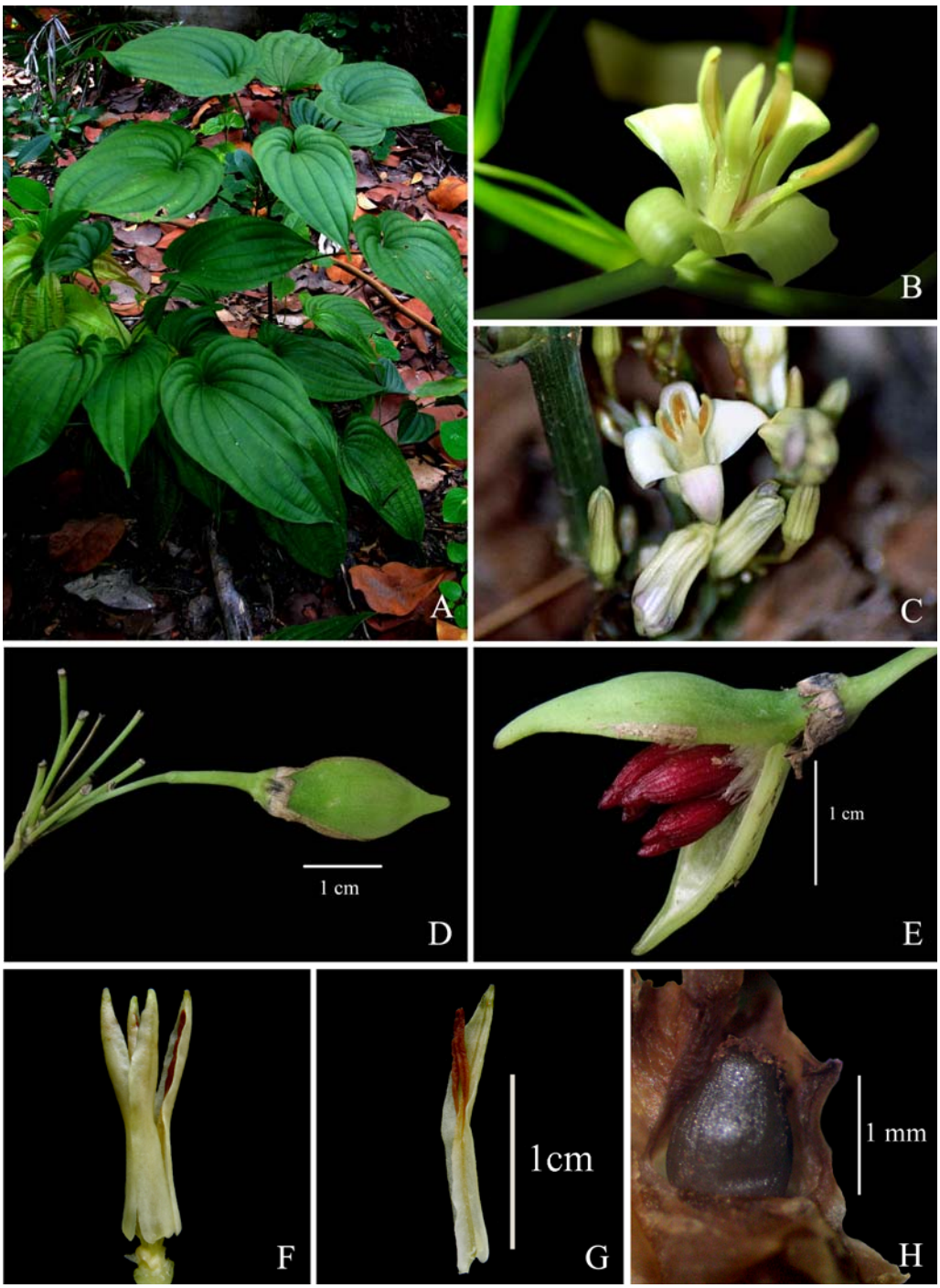

Figure 18 *Stemona collinsiae* Craib: A. habit; B-C. flower; D. fruit; E. opened fruit with young seeds; F. androecium; G. stamen with appendage of theca; H. ovary. Photographed by P. Inthachub.

5. Stemona curtisii Hook.f., Fl. Brit. Ind 6: 298. 1892; C.H.Wright, J. Linn. Soc., Bot. 32: 490-496. 1896; Prain, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 73: 39-44. 1904; M.R.Hend., Malay. Wild. fls., Monocots. 172. 1954; Duyfjes, Fl. Males., Ser. 1. 11(2): 403. 1993; Wadhwa & Weerasooriya, Fl. Ceylon 10: 384. 1996. — *Stemona minor* Hook.f., Fl. Brit. Ind. 6: 298. 1892. — *Stemona tuberosa* Lour., in Fl. Malay. Penin. 4: 320. 1924.

Herb; twining, 5 m long, glabrous, branched. *Roots* tuberous, fascicled, 10-60(-80) cm long, 1-1.5 cm diameter. *Leaves* alternate; blade ovate-oblong or broad-ovate, 4.5-12.5 by 9-18 cm; base broadly cordate; apex acuminate; margins entire; basal nerves 13-17(19); petiole 4-12 cm long. *Inflorescences* axillary, sessile or peduncled, 1-many flowers; peduncles 1-11 cm long; bracts narrow, 2 by 10-20 mm. *Flowers*: pedicals 10-20 mm long; tepals 4, outside dark brownish-red with green stripes towards the tip, inside brownish-pink or dark brownish-red, lanceolate, 5-6 by 20-27 cm, nerves 9-15. *Stamens* 4, dark brownish-red, rarely apex yellow, 3 by 18-25mm; filaments ca 2 mm long, basally connate; anthers 12-15 mm long, ridge separating the thecae smooth , 1 mm high, 15-22 mm long, thecae appendage absent. *Ovary* superior, urceolate, 3 by 4 mm; style absent; stigma inconspicuous. *Fruits* 10 by 25 mm, beak ca 2 mm long. *Seeds* 5-11, dark-red, ellipsoid, 3-5 by 10-14 mm, base surrounded by hollow and coralloid aril.

Thailand. — SOUTH-WESTERN: Kanchanaburi, Phetchaburi, Prachuap Khiri Khan, Ratchaburi; PENINSULAR: Chumphon, Nakhon Si Thammarat, Narathiwat, Pattani, Phatthalung, Satun, Songkhla, Surat Thani, Trang.

Distribution. — Sri Lanka, Thailand to Peninsular, Malaysia.

Ecology. — Wide occured in peninsular region of Thailand, common in scrubs, opened Evergreen Forest, near stream, opened area in secondary forest, limestone mountain, scattered in beach forest, herb in sandy soil; altitude: from sea level - 500 m.

Vernacular. — Non Tai Yak (หนอนตายหยาก) (Central); Ka Phiat (กะเพียด) (Prachuap Khiri Khan); Yan Ling (ย่านลิง), Rak To (รากตอ) (Surat Thani).

Notes. — Length of peduncle and color of stamen are vary variation. The peduncle mostly very long at low altitude (not far from coast) or moisture habitat more than plants grow in high altitude and dry habitat.

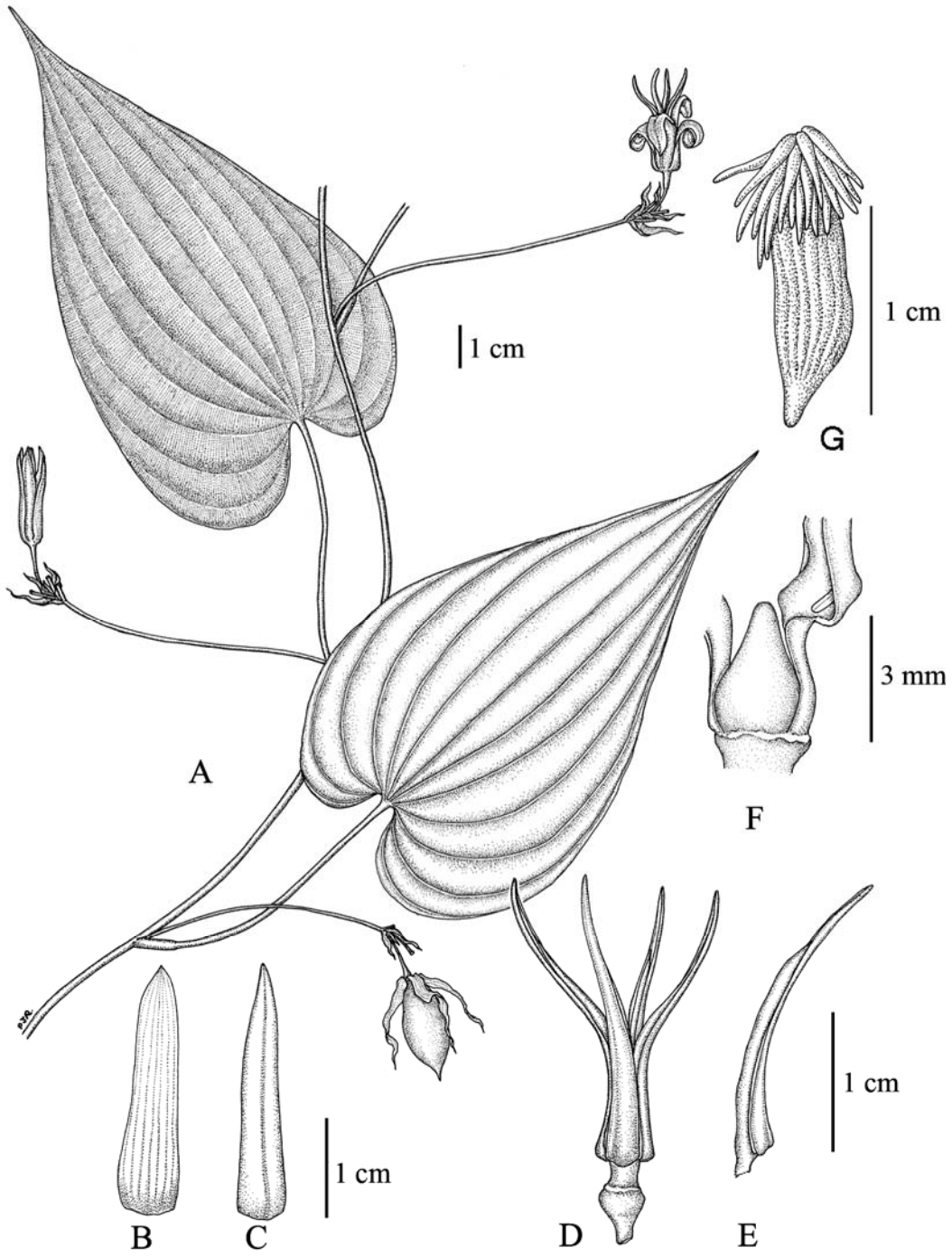

Figure 19 *Stemona curtisii* Hook.f.: A. flowering and fruiting stem; B. inner tepal; C. outer tepal; D. androecium; E. stamen; F. ovary; G. seed. Drawn by P. Inthachub.

Figure 20 *Stemona curtisii* Hook.f.: A-C. inflorescence and solitary flower; D. fruit; E. showing young seeds; F. mature seeds; G. androecium; H. stamen; I. ovary. Photographed by P. Inthachub.

6. Stemona kerrii Craib, Bull. Misc. Inform. Kew 1912: 408. 1912; Gagnep., Fl. Indo-Chine 6: 752. 1934; Maxw., Nat. Hist. Siam Soc. 39: 82. 1991; Zhanhe and Duyfjes, Fl. China 24: 71. 2000. — *Stemona saxorum* Gagnep., in Bull. Soc. Bot. Fr. 81: 148. 1934; Fl. Indo-Chine 6: 749. 1934.

Herb; twining or trailing, up to 4 m long, hairy, branched; short rhizome. *Roots* tuberous, spindle shape, fascicled, 5-10 cm long, ca 1 cm diameter. *Leaves* alternate, scales at lower part of stem 3-5 by 10-13 mm; blade ovate or broadly-ovate, membraneous, 3-5 by 4-7 cm; base cordate; apex acuminate; margin entire; basal nerves (9)13-17 ; petiole 1.5-4 cm. *Inflorescences* axillary or rarely fused with petiole, 1-3 flowered; peduncles 1-2.5 cm long; bracts narrow, ca 5 mm long. *Flowers*: pedicels 15-45 mm long; tepal 4, segment, yellowish-purple, ovate, apex acute, margin surround by shortly hair, 3-4 by 10-12 mm. *Stamens* 4, dark purple, 2 by 12 mm, longer than perianth; filament ca 1 mm long, basally connate; anthers 3-4 mm long,ridge separating the thecae smooth and undulate, ca 7 mm long; thecae appendage ovoid, fleshy, yellowish-green, 1 by 2 mm. *Ovary* ovoid, 1 by 1.5 mm; style absent; stigma inconspicuous. *Fruits* globose-ovoid, glabrous, 8-10 by 12-14 mm. *Seeds* 1-3, light brown, nearly globose, 4 by 5 mm, base surrounded by lobed and hollow aril.

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

Distribution. — China, Vietnam, Thailand (type).

Ecology. — Dry Deciduous Forest, Mixed Deciduous Forest,Lower Montane pine-oak Forest; altitude: 350-700 m.

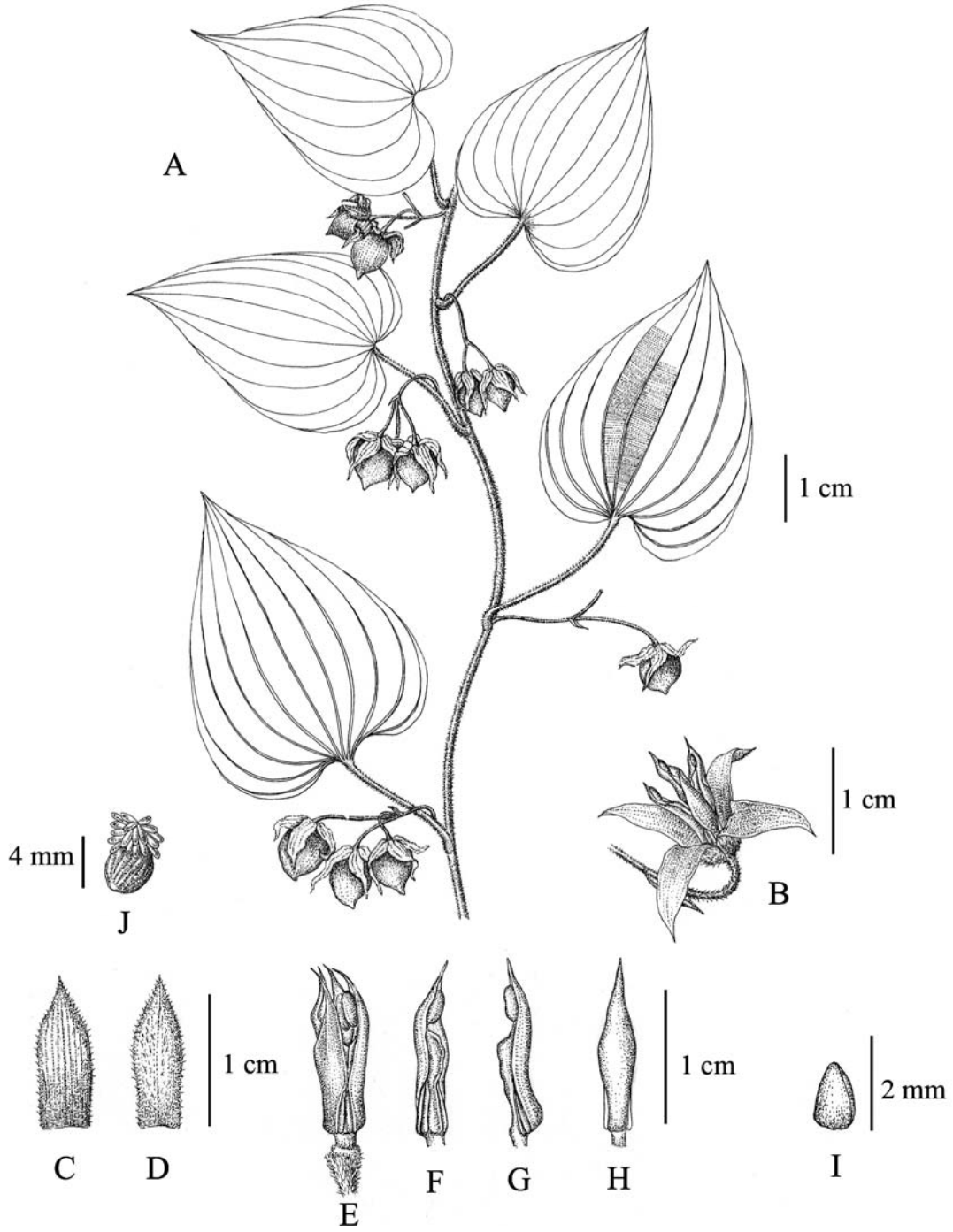

Figure 21 *Stemona kerrii* Craib: A. fruiting stem; B. flower; C. inner tepal; D. outer tepal; E. androecium; F-H. stamen; I. ovary. Drawn by P. Inthachub.

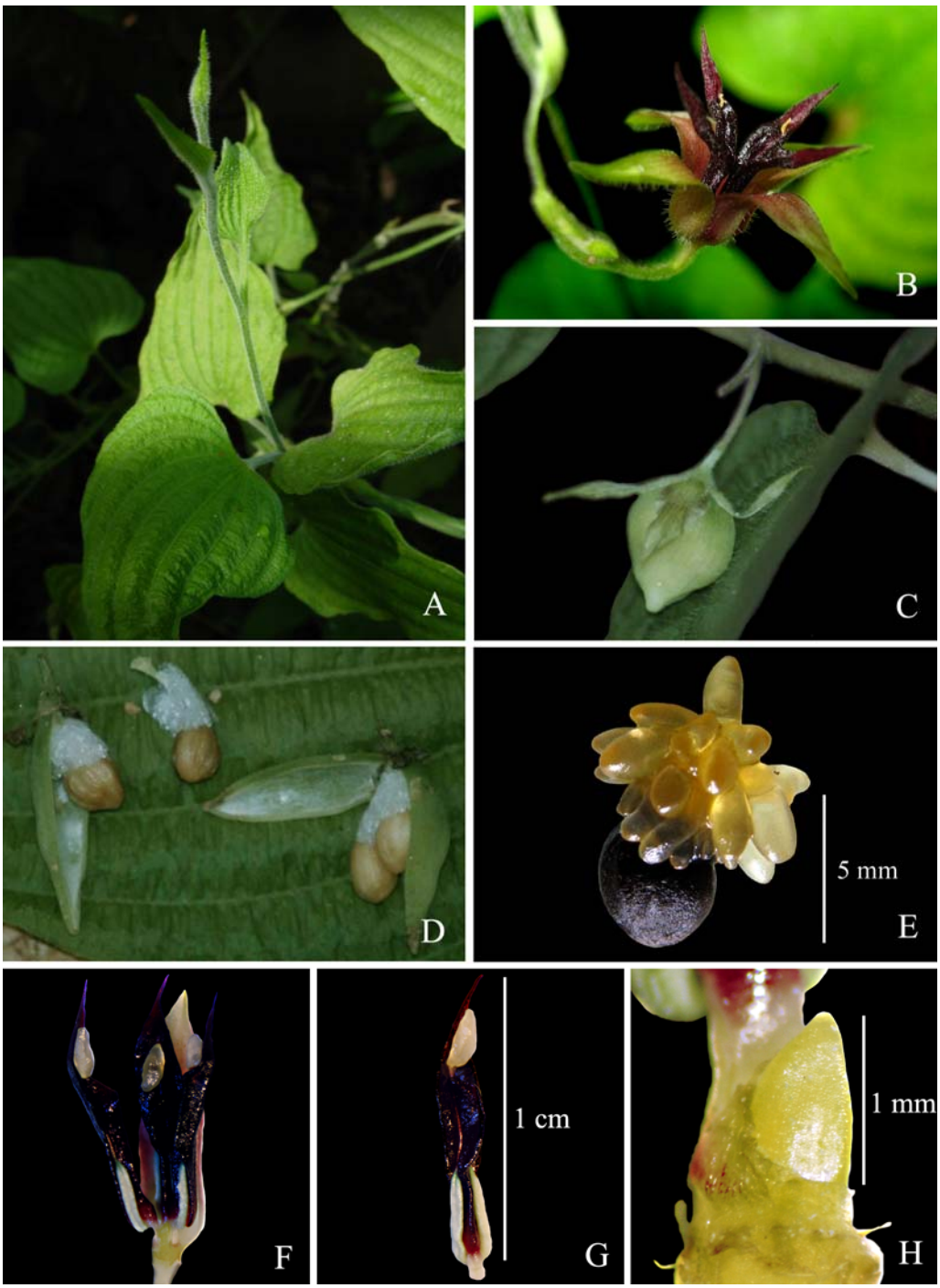

Figure 22 *Stemona kerrii* Craib: A. shoot covered with hair; B. inflorescence; C. fruit; D. opened fruit with seeds; E. seed with aril; F. androecium; G. stamen; H. ovary. Photographed by P. Inthachub.

7. Stemona phyllantha Gagnep., Bull. Soc. Bot. Fr. 81: 147. 1934; Fl. Indo-Chine 6: 747. 1934.

Trailing or twining, up to 6 m, glabrous, branched. *Roots* tuberous, thick, spindle shape, fascicled, 40-50 cm long, 2-4 cm diameter. *Leaves* alternate, opposite or whorled; blade ovate or broadly-ovate, 8-10 by 12-17 cm; base cordate or shallowly cordate; apex acuminate; margins entire; basal nerves 9-13; petiole: base pulvinous, 5-9 cm. *Inflorescences* axillary or fused with the petiole for 0.5-1.5 cm long; peduncles 3-8 cm long; bracts 0.5-1 cm long. *Flowers*: pedicels 0.5-1.5 cm long; tepals outside green or yellowish green with dark green and purple-red stripes towards the tips, inside with purple-red stripes, lanceolate, 1.2-2 by 5.5-6.5 cm, nerves 11-15. *Stamens* 4, basal purple and yellowish-green at tip, 5-6 cm long; filaments ca 5 mm long, basally connate; anthers redish-brown, 0.5 by1.7-1.9 cm, ridge separating the thecae smooth, 2 mm high; thecae appendage ovoid, apex acuminate, 5-7 mm long, tip fused; connective appendage conical, 2.7-3 cm long. *Ovary* ovoid, flat, 2 by 3 mm; style absent; stigma in conspicuous. *Fruits* green, ovoid-oblong, 2-2.8 by 3-4 cm. *Seeds* 20-25, brown, young seeds white, ellipsoid, 3 by 10 mm long, base surrounded by lobed and vesicular aril.

Thailand. — NORTHERN: Nakhon Sawan; NORTH-EASTERN: Loei, Khon Kaen, Phetchabun; EASTERN: Chaiyaphum; SOUTH-WESTERN: Kanchanaburi; SOUTH-EASTERN: Chanthaburi, Chon buri, Rayong, Trat.

Distribution. — Cambodia.

Ecology. — In open Deciduous Ferest, bamboo forest, scattered in Dry Evergreen Forest near waterfall, on rocky granite hill along the coast; altitude: from sea level-1200 m.

Vernacular.- Non Tai Yak (หนอนตายหยาก) (Loei, Central); Khruea Sam Sip (เครือสามสิบ) (Chon buri).

Notes. — Flowers of *Stemona phyllantha* are very strong smell and the vegetative stem are more robust than *S. tuberosa*.

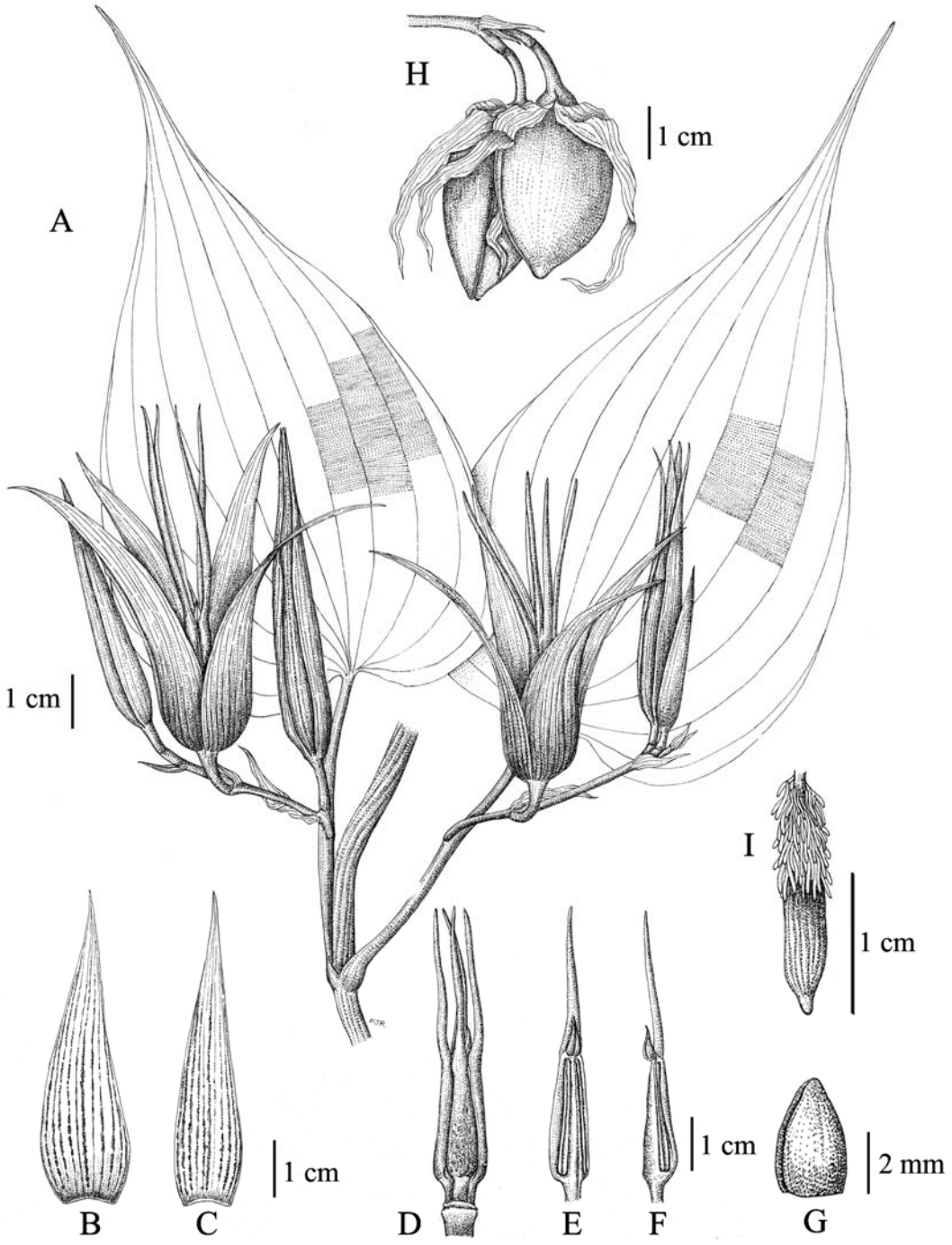

Figure 23 *Stemona phyllantha* Gagnep.: A. flowering stem; B. inner tepal; C. outer tepal; D. androecium; E-F. stamen; G. ovary; H. fruit; I. seed. Drawn by P. Inthachub.

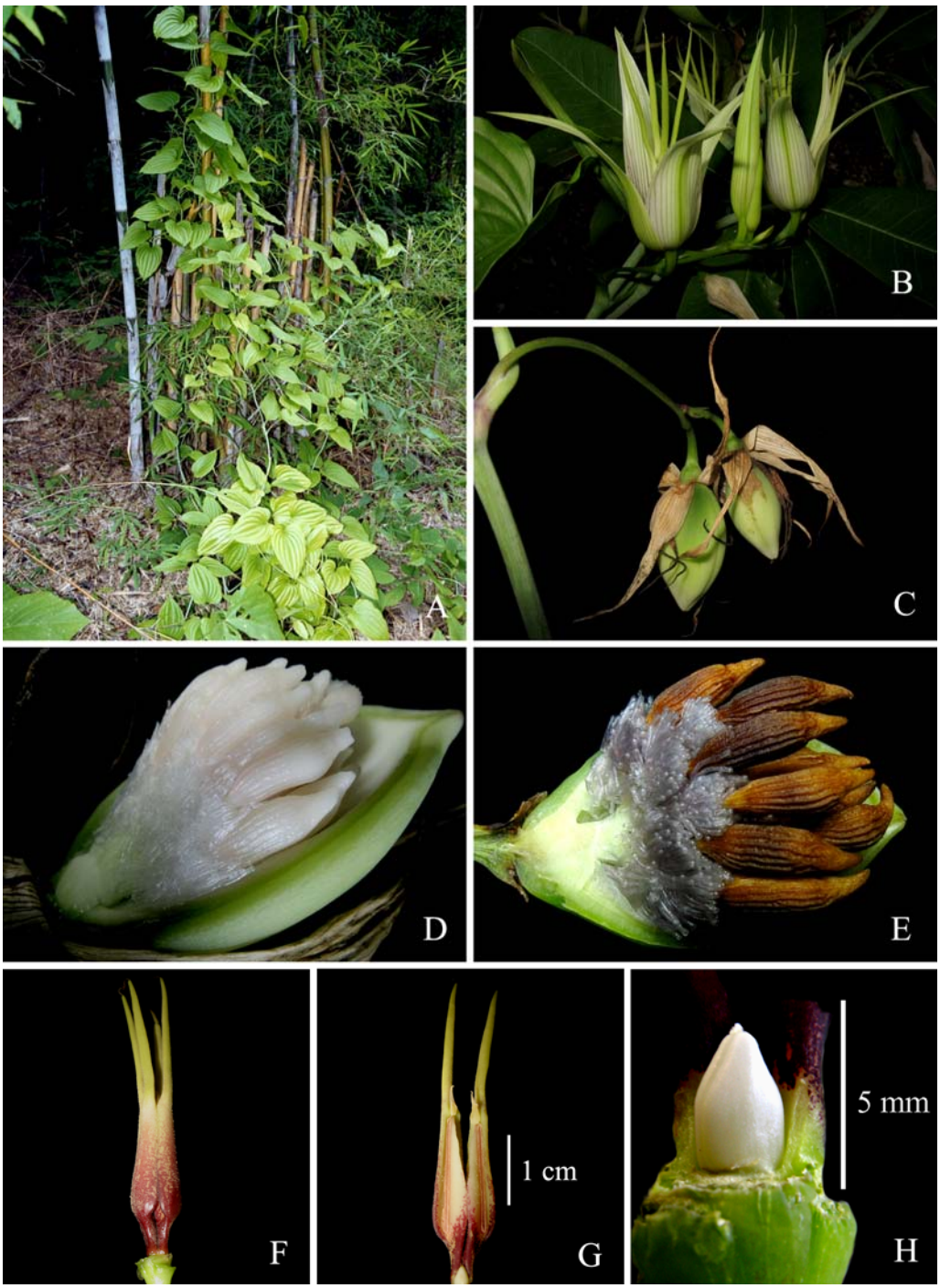

Figure 24 *Stemona phyllantha* Gagnep.: A. habit; B. inflorescence; C. fruits; D. young seeds; E. mature seeds; F. androecium; G. stamen; H. ovary. Photographed by P. Inthachub.

8. Stemona pierrei Gagnep., in Bull. Soc. Bot. Fr. 81: 147. 1934; Fl. Indo-Chine 6: 749. 1934.

Herb; erect or trailing up to 30 cm long, slender, glabrous, ribbed, few-branched; short rhizome. *Roots* tuberous, spindle shape, 10-20 cm. long, 1 cm diameter. *Leaves* alternate, scales at lower part of stem 4-10 mm long; blade ovate or ovate-oblong, 2.5-6.5 by 4.5-10 cm; base truncate; apex mucronulate; margins entire; basal nerves (5)7-9; petiole slender, upper groove, 1-4.5 cm long. *Inflorescence*s axillary, sessile, 3-5 flowerd; bracts scale-like, ca. 5 mm long. *Flowers*: pedicels 2 mm. long; tepals 4, inside dark purple, outside dark purple with greenish veins, lanceolate, ca. 2-2.5 by 6-9 mm. *Stamens* 4, dark purple, 7-9 mm long; filaments ca. 1 mm long, basally connate; anthers 2-2.5 mm long, ridge smooth, wing-like, ca 0.5 mm high; thecae appendage filiform, 1.5 mm long, apex connate when anthesis. *Ovary* superior, urceolat; style absent; stigma inconspicuous. *Fruits* green, 10 by 20 mm, beak ca. 5 mm. *Seeds* 1-2, ellipsoid, apex acuminate, 3 by 10 mm, base surrounded by a wild-vesicular aril.

Thailand. — EASTERN: Si Sa Ket, Surin, Ubon Ratchathani.

Distribution. — Laos, Vietnam.

Ecology. — Scattered in open rather wet area of Dry Dipterocarp Forest.

Notse. — Herbarium specimens often lack of flowers, but the flower description in this study is based on living material, which collected from Ubon Ratchathani.

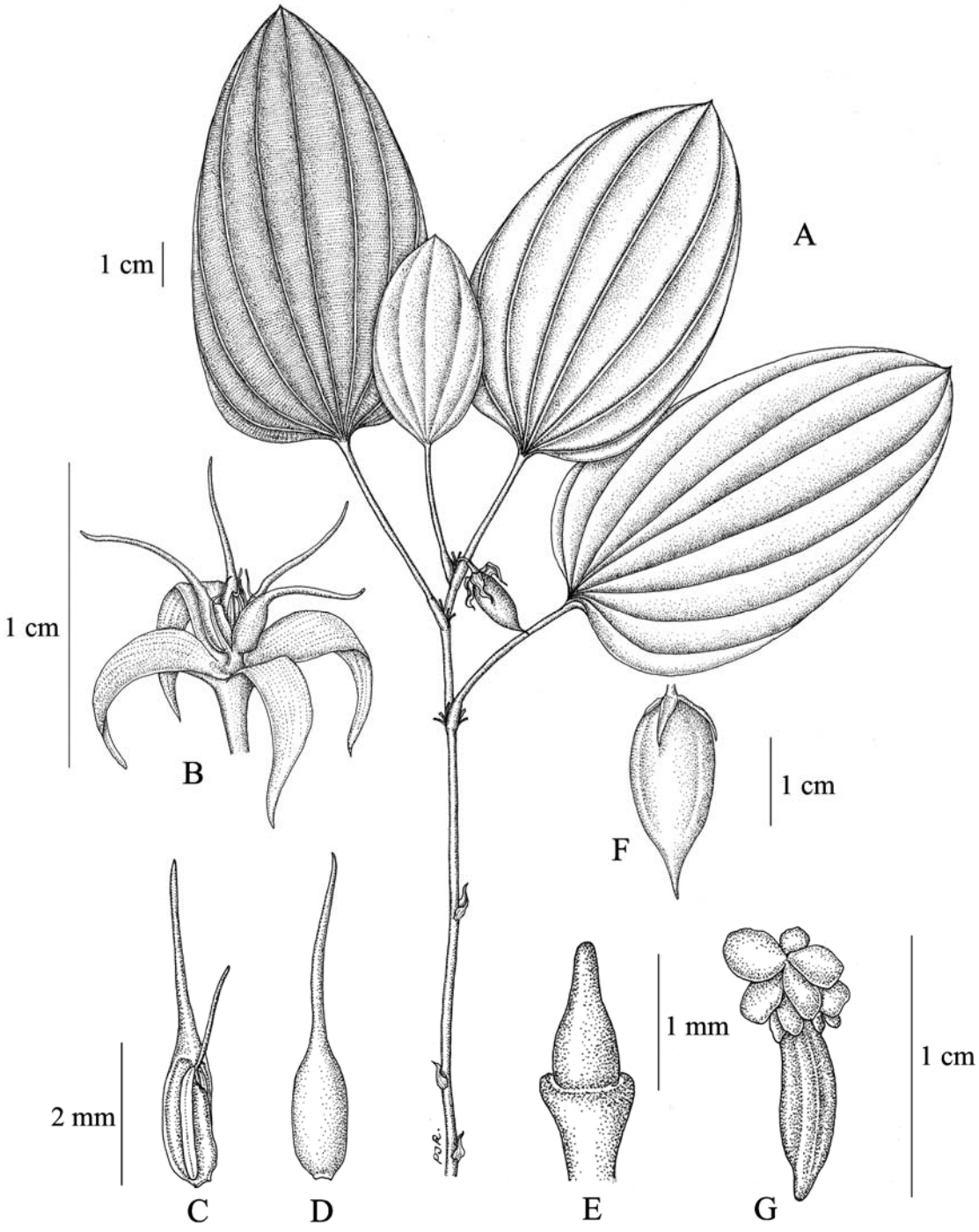

Figure 25 *Stemona pierrei* Gagnep.: A. fruiting stem; B. flower; C-D. stamen; E. ovary; F. fruit; G. seed. Drawn by P. Inthachub.

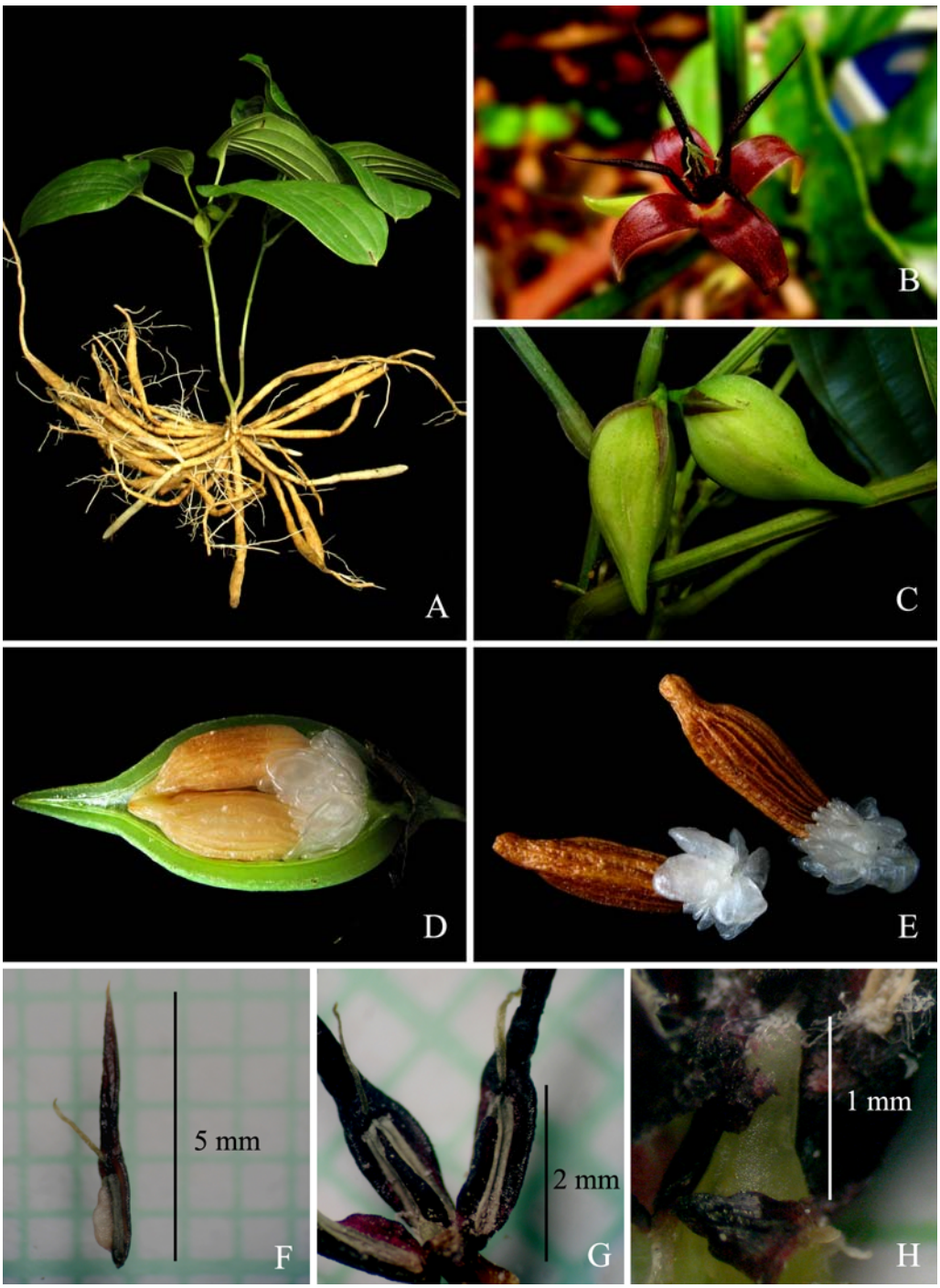

Figure 26 *Stemona pierrei* Gagnep.: A. habit; B. inflorescence; C. fruits; D. young seeds; E. mature seeds; F-G. stamen; H. ovary. Phorographed by P. Inthachub.

9. Stemona tuberosa Lour., Fl. Cochinch.: 404 (1790); Hook.f., Fl. Brit. Ind. 6: 298. 1892; C.H.Wright, J. Linn. Soc., Bot. 32: 490-496. 1896; Prain, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 73: 39-44. 1904; Ridl., Fl. Malay. Penin. 4: 320. 1967; Gagnep., Fl. Indo-Chine 6: 746. 1934; Duyfjes, Fl. Males., Ser. 1. 11(2): 405. 1993; Zhanhe and Duyfjes, Fl. China 24: 71. 2000.

Twining, up to 5 m long, smooth, glabrous; short rhizome. *Roots* tuberous, fleshy, fascicled, spindle shape, 10-30 cm long, ca. 2-3 cm diameter. *Leaves* opposite or whorled, lower part of stem often alternate; blade ovate, ovate-lanceolate, or broadly-ovate, 5-12 by 10-21 cm; base cordate or shallowly cordate; apex acuminate; margins entire; basal nerves 13-15; petiole 6-10 cm long, pulvinate. *Inflorescences* axillary, 1-many flowers; peduncles 0.8-3.5 cm, free with the petioles; bracts 0.5-2.5 cm long. *Flowers*: pedicels 0.5-1.8 cm long; tepals 4, each segment similar, inside yellowish-green with brownish-red, outside yellowish-green with green stripes towards the tip, lanceolate, 0.5-0.6 by 2.5-3.5 cm, nerves 7-9. *Stamens* 4, brownish-red and apex yellowish-green, shorter than perianth, ca 3 cm long; filaments ca 1-2 mm, basally connate; anthers 9 mm long, ridge smooth, 1-1.5 mm high; thecae appendage filiform, apex fused, 5-6 mm lomg; connective appendage conical, 2 cm long. *Ovary* ovoid, 1 by 2 mm; style absent; stigma inconspicuous. *Fruits* green, ovoid-oblong, 0.8-2.5 by 2-4 cm. *Seeds* 10-20, ellipsoid, brown, 1-1.2 cm long, beak ca 3 mm long, base surrounded by vesicular lobed aril; funicle 1-1.5 cm long.

Thailand. — NORTHERN: Chiang Mai, Kamphaeng Phet, Lampang, Lamphun, Mae Hong Son, Phayao, Phitsanulok, Tak, Uttaradit; NORTH-EASTERN: Khon Kaen, Loei, Maha Sarakham, Nakhon Ratchasima

Distribution. — Widely distributed from tropical and subtropic Asia, throughout China, Taiwan, India, Cambudia, Laos, Malasia, Vietnam and Philippines.

Ecology. — Climber in open area of Evergreen Forest, Mixed Deciduous Forest, Dry Deciduous Forest, bamboo forest; altitude: 150-1200 m.

Vernacular. — Poong Chang (ปุงช้าง) (Lampang); Non Tai Yak (หนอนตายหยาก) (Central).

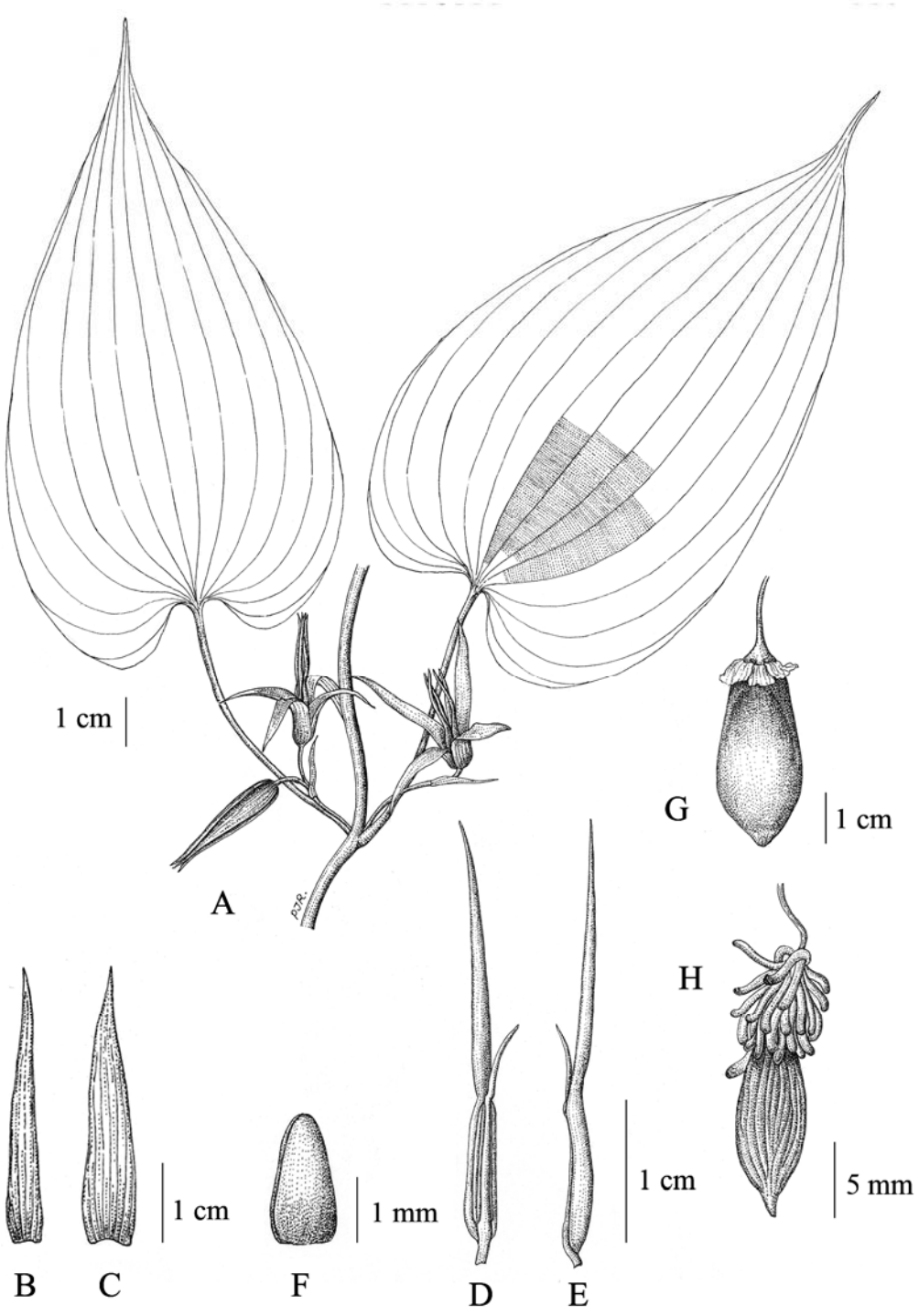

Figure 27 *Stemona tuberosa* Lour.: A. flowering stem; B. outer tepal; C. inner tepal; D-E. stamen; F. ovary; G. fruit; H. seed. Drawn by P. Inthachub.

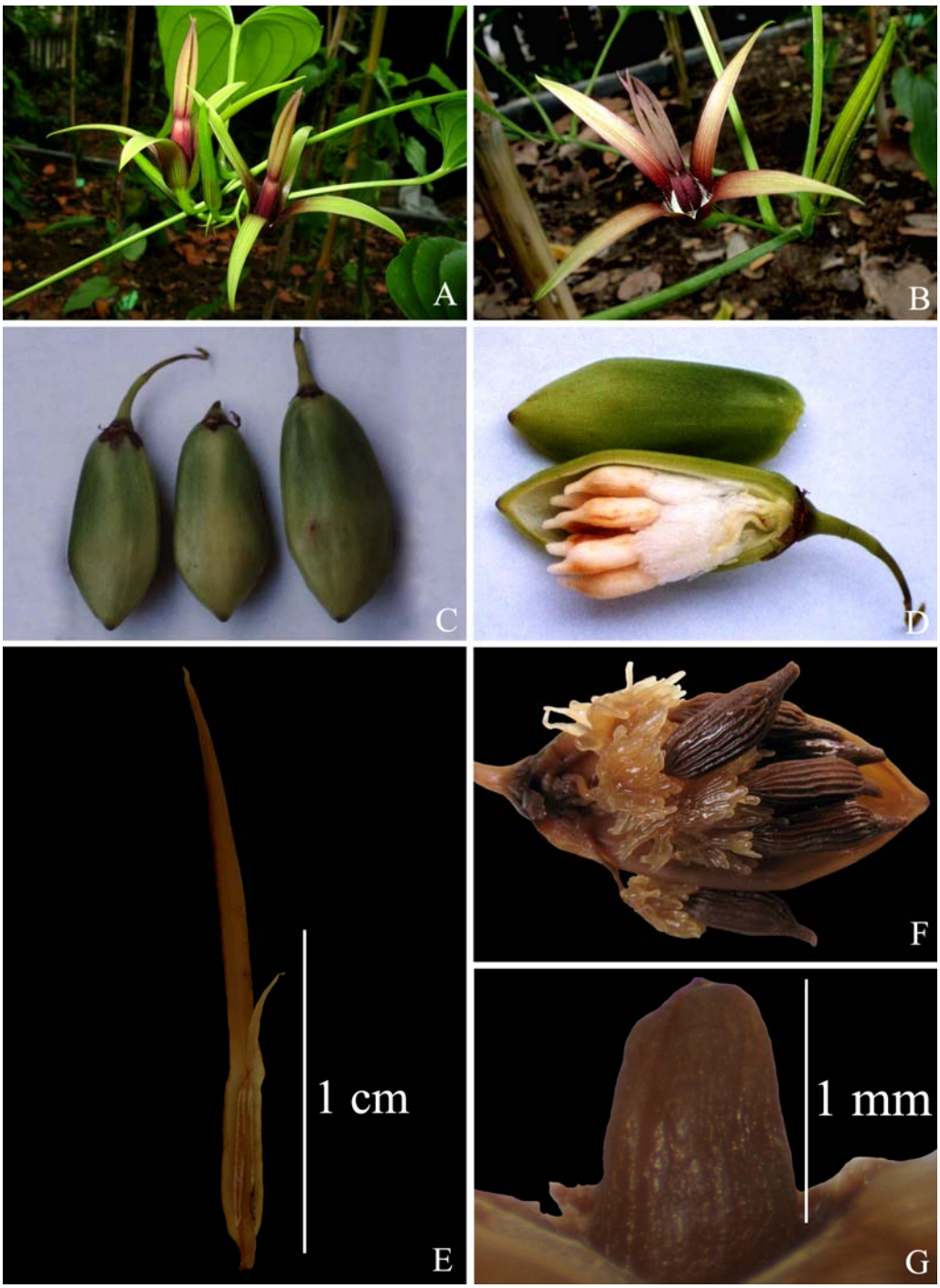

Figure 28 *Stemona tuberosa* Lour.: A-B. inflorescence; C. fruits; D. young seeds; E. stamen; F. seed with aril; G. ovary. Photographed by P. Inthachub.

10. Stemona sp. 1

Herb; erect or trailing (procumbent), up to 30 cm, slender, glabrous, ribbed, sometime branched; short rhizome. *Roots* tuberous, forming a fascicle, 10-25 cm long, 1 cm diameter. *Leaves* alternate, scales at lower part of stem 2-5 by 4-8 mm; blade ovate or ovate-oblong, 2.6-7.5 by 5.5-12 cm; base obtuse or truncate; apex acuminate or mucronate; margins entire; basal nerves 5-7; petioles 2-5 cm long. *Inflorescences* axillary, sessile, 1-5 flowered, usually one flowered in full bloom; bracts 2 by 3.5 mm. *Flowers*: pedicels 4-10 mm long; tepals 4, blackish-red or dark purple with greenish veins, lanceolate, 2-3.5 by 10-15 mm. *Stamens* 4, slender, reddish-brown, apex green, 9-10 mm long; filaments very short, basally connate; anthers 5-6 mm long, ridge fleshy, smooth, 7 mm long; thecae appendage filiform, 1-1.5 mm long. *Ovary* superior, ovoid; style absent; stigma inconspicuous. *Fruits* green, 6 by 15 mm (young fruit), beak 3 mm long, *Seeds* 2-4, ellipsoid, 2 by 11 mm, apex acuminate, base surrounded by hollow and finger-like aril.

Thailand. — NORTH-EASTERN: Mukdahan, Sakon Nakhon.

Ecology. — Scattered in blanket marsh vegetation on sandstone hill, open or rarely wet area in Deciduous Dipterocarp Forest.

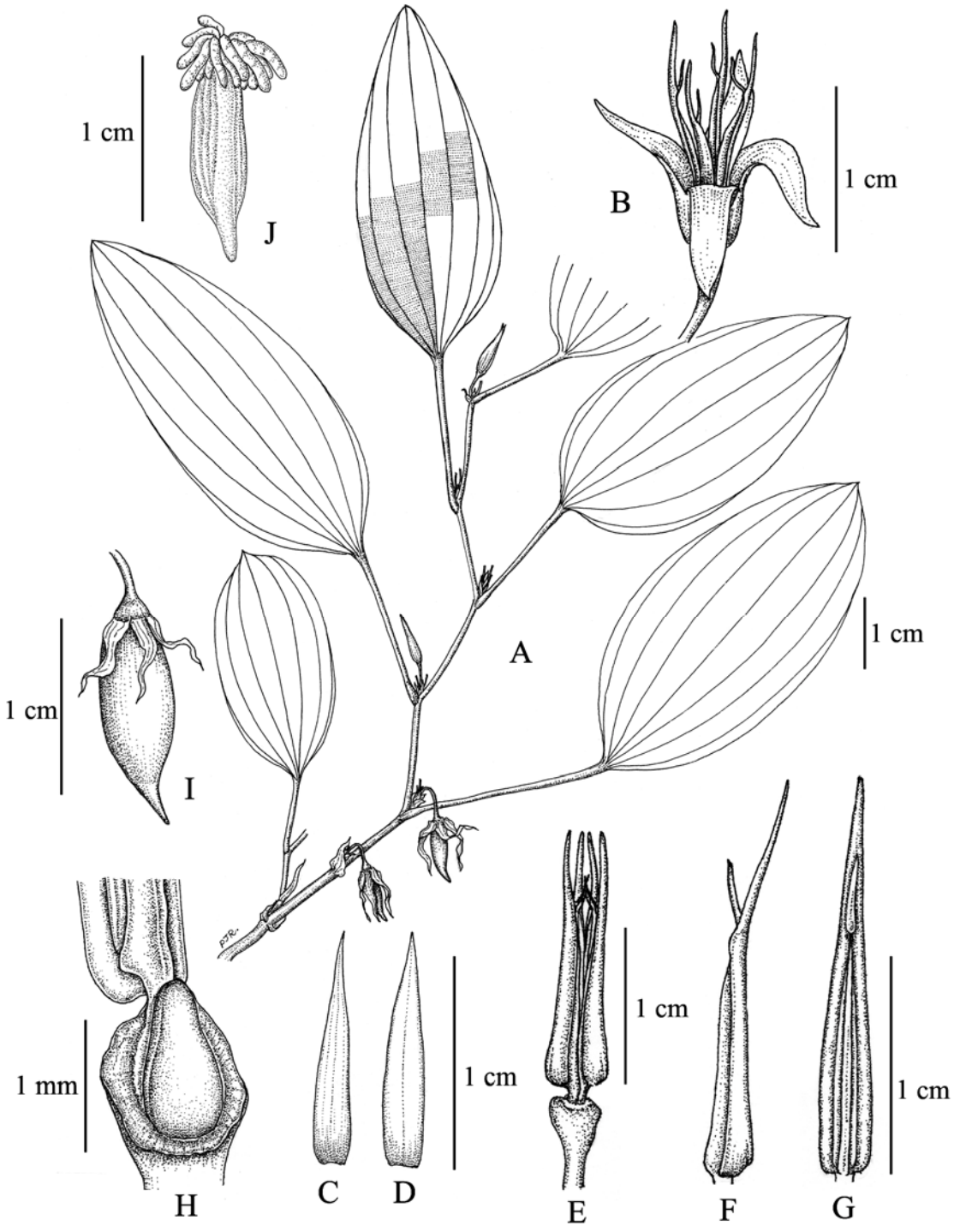

Figure 29 *Stemona* sp. 1: A. flowering and fruiting stem; B. flower; C. outer tepal; D. inner tepal; E. androecium; F-G. stamen; H. ovary; I. fruit; J. seed. Drawn by P. Inthachub.

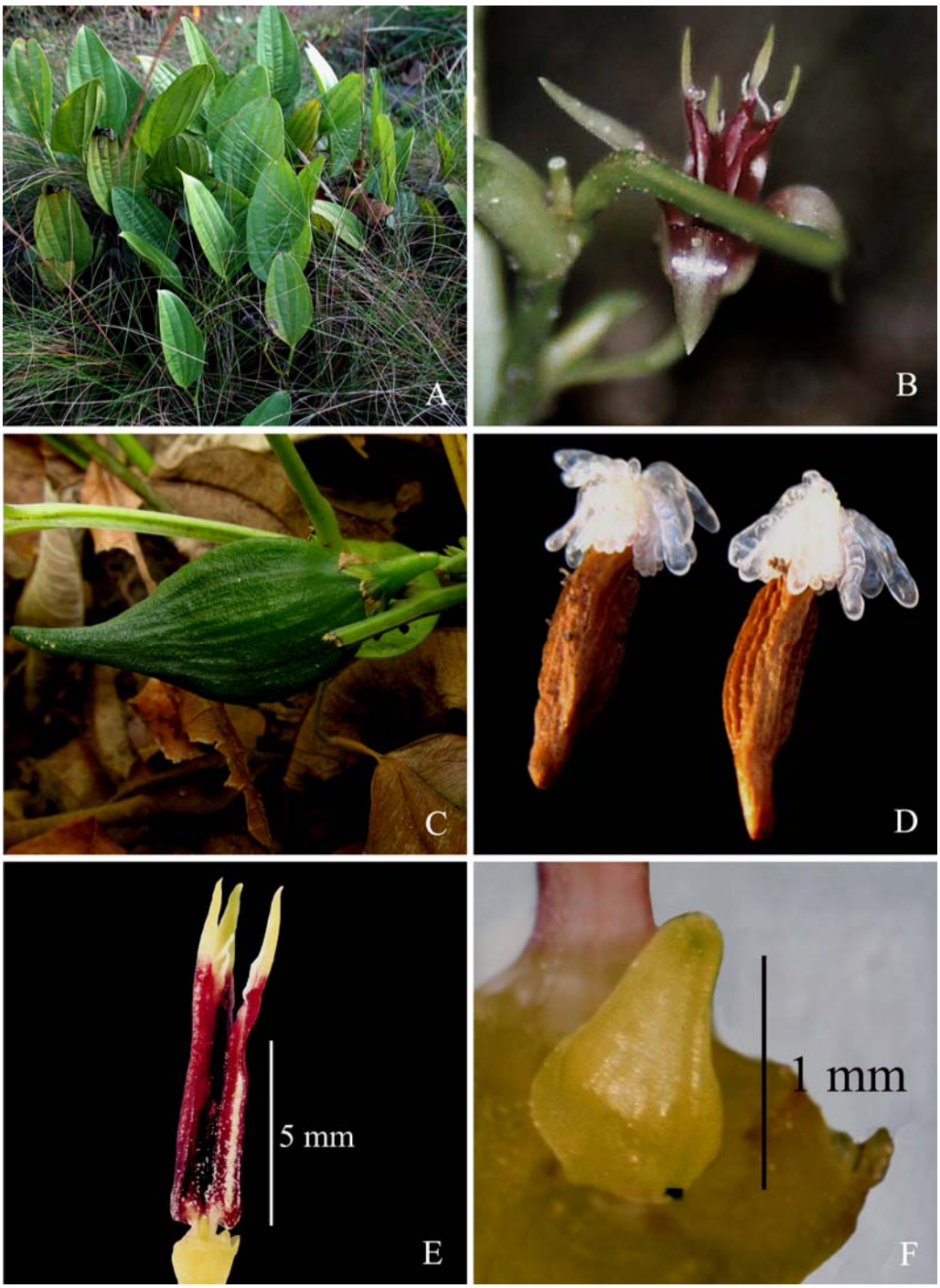

Figure 30 *Stemona* sp. 1: A. habit; B. flower; C. fruit; D. mature seed; E. stamen; F. ovary. Photographed by P. Inthachub.

11. Stemona sp. 2

Twining or trailing, up to 1 m, glabrous; short rhizome. *Roots* tuberous, spindle shape, 10-30 cm long, ca 1 cm diameter. *Leaves* alternate, scale at lower part of stem 3-4 by 10-14 mm; blade cordate or deltoid, 4-6.7 by 5-11 cm; base shallow cordate or truncate; apex acute; margins entire; basal nerves 9(7); petiole slender, 3.5-6.5 cm long. *Solitary* borne in the axil of leaf scales or leaf, sessile; bracts narrow, 7 mm long. *Flowers*: pedicels 5-17 mm long; tepal pink or dark purple inside, pink or dark purple with green stripe outside, lanceolate, 3-5 by 15-19 mm, nerves 7-13. *Stamen*s dark pink or dark purple, 13-15 mm long, ca 2 mm broad; filament ca 1 mm long, basally connate; anther 5 mm long, ridge smooth, toward at apex; terminal of connective involute; thecae appendage absent; connective appendage absent. *Ovary* urceolate, 1 by 2 mm; style absent; stigma inconspicuous. *Fruits* 1 by 1.3 cm. *Seeds* 3-6, ellipsoid, light brown, 3-4 x 7-8 mm, base surrounded by finger-like and hollow aril.

Thailand. — NORTHERN: Sukhothai; NORTH-EASTERN: Khon Kaen; EASTERN: Nakhon Ratchasima.

Ecology. — In Deciduous Forest.

Notes. — *Stemona* sp. 2 has same habit as *S. aphylla*, but flower size are small and the terminal of connective involute. Whereas, the connective of *S. aphylla* has wide spread.

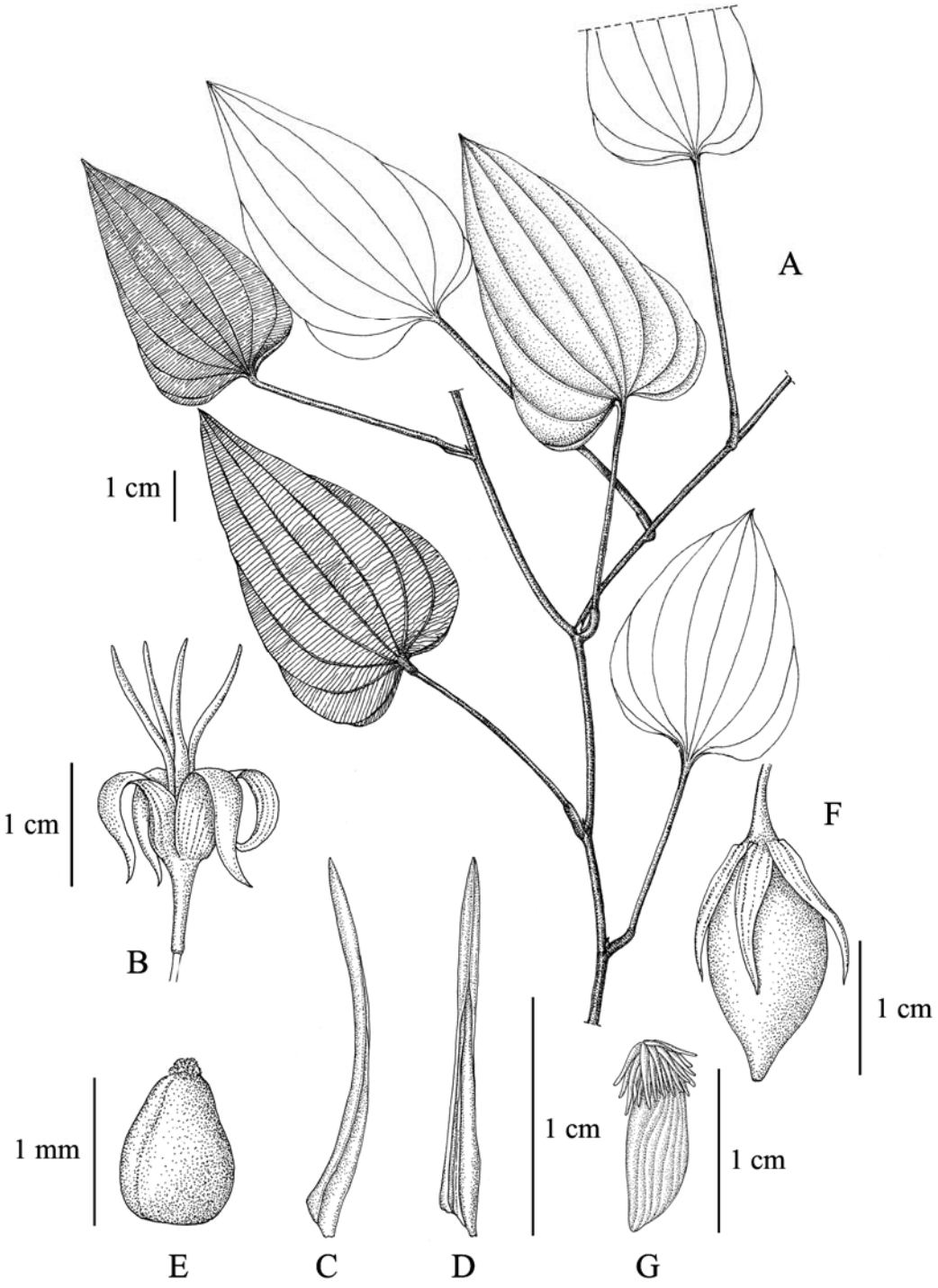

Figure 31 *Stemona* sp. 2: A. leaves stem; B. flower; C-D. stamen; E. ovary; F. fruit; G. seed. Drawn by P. Inthachub.

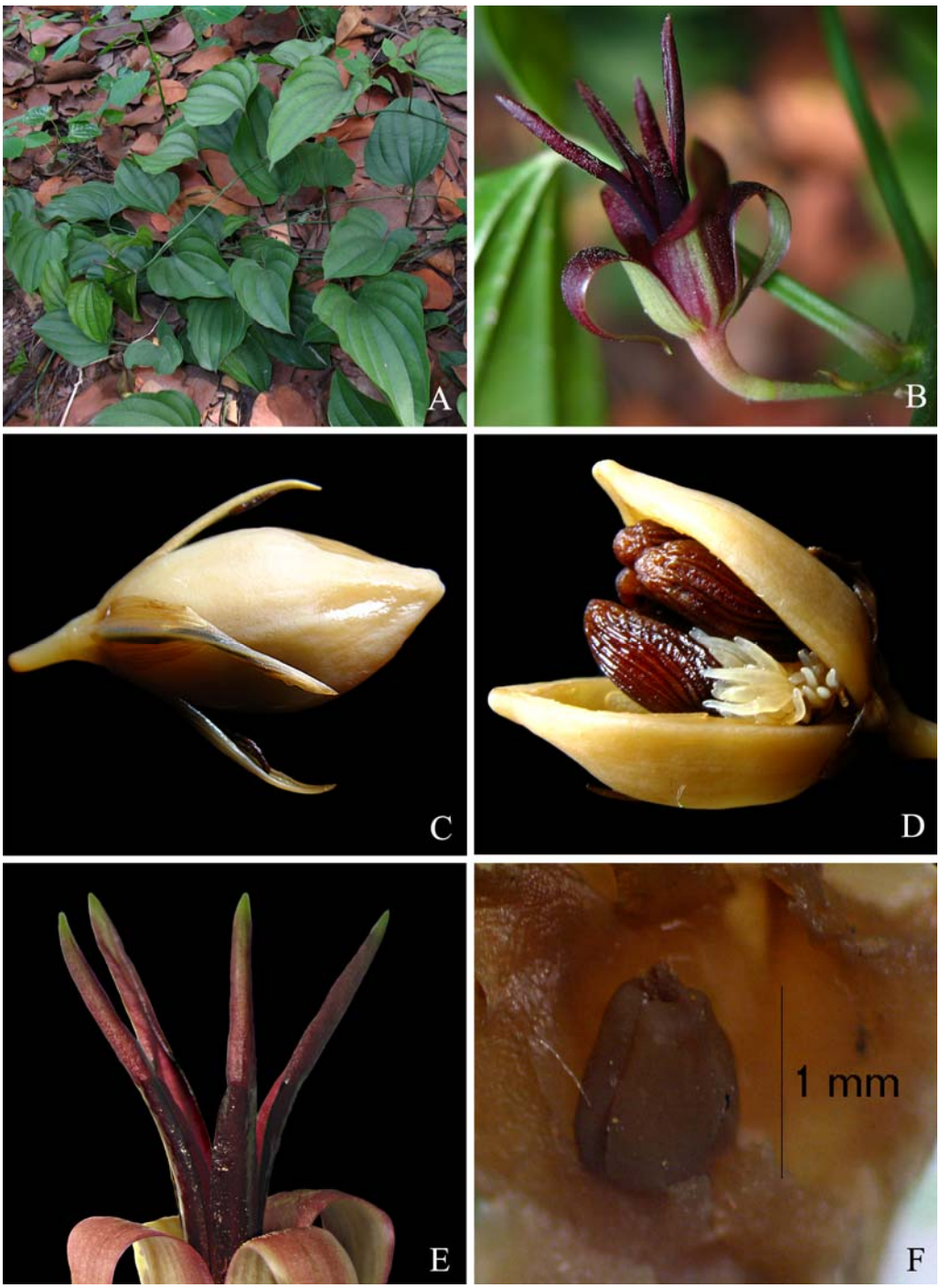

Figure 32 *Stemona* sp. 2: A. habit; B. flower; C. fruit; D. seeds with aril; E. showing terminal of connective; F. ovary. Photographed by P. Inthachub.

STICHONEURON

Hook.f., in Benth. & Hook.f., Gen. Pl. 3: 747. 1880; Fl. Brit. Ind. 6: 299. 1894; Prain, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 73: 39-44. 1904; Ridl., Fl. Malay. Penin 4: 320. 1967; K. Krause, in Engler., Nat. Pflanzenfam. 15a: 227. 1930; Duyfjes, Fl. Males., Ser. 1. 11(2): 408. 1993. — Type species: *Stichoneuron membranaceum* Hook.f..

Erect or decumbent, branched, herbs with rhizome. *Leaves* simple, alternate; blades ovate-oblong, elliptic or lanceolate; lateral nerves 2-4 pairs; petiole slightly sheathing at base or not. *Inflorescences* axillary, peduncled, flowers densely raceme-like. *Flowers* small; hermaphrodite; pedicels filiform, stiff, articulate; perianth 4, imbricate, free. *Stamens* 4, free; filaments 4, base shortly adnate to tepals; anther consisting of two dorsifixed thecae, without appendage. *Ovary* minute, superior or haft-inferior; style absent; stigma minute; one-celled, ovules few, apically attached. *Fruits* elongate, apex acute or beaked. *Seeds* broad-ellipsoid, longitudinally ridge; aril (elaiosome), wide and hollow aril; funicle long.

Two species, *S. membranaceum* in South-East Asia, India and *S. caudatum* in Thailand and Malesia (Malay Peninsula).

Key to species of Stichoneuron in Thailand

1. Herbs decumbent; leave blade orbiculate or heart shaped, basally nerved; petioles without sheath; flowers reddish ***Stichoneuron* sp. 2**

1. Herbs erect; leave blade ovate, lanceolate or elliptic; petioles slightly sheathing

    2. Peduncles decurved , 4-7 cm long, glabrous; petals recurved, reddish purple, outside glabrous, inside papillose ***S. caudatum***

    2. Peduncles stiff, 0.7-1.5(2) cm long, hairy; petals straight, outside green, inside yellowish green with violet or dark purple hair ***Stichoneuron* sp. 1**

1. Stichoneuron caudatum Ridl., J. Straits Branch Roy. Asiat. Soc. 57: 107. 1911; Ridl., Fl. Malay. Penin 4: 321. 1967; Wilson, C. G. 1972. Kew Bulletin 26: 150. 1972; Steenis, Blumea 28:151. 1982; Duyfjes, Fl. Males., Ser. 1. 11(2): 408. 1993.

Erect herb, slender, hairy, up to 80 cm high, few branches; short rhizome. *Leaves* alternate, hairy, lower part of stem reduced to scales, hairy, 2-6 by 7-15 mm, margin fimbriate; blade elliptic, ovate-oblong or lanceolate, 3-4 by 9-10 cm; base rounded, cuneate or obtuse; apex acuminate; margin entire; nerves 3-4 pairs; petioles slightly sheathing at base, hairy, 5-10 mm long. *Inflorescences* axillary, panicle, few or densely flowered; peduncle slender, decurved, 4-7 cm long, hair absent; bracts fimbriate, ca 2 mm long. *Flowers* small; pedicels filiform, 2-12 mm long, hairy absent, 2-3 by 7-8 mm; tepals lanceolate, recurved, reddish-purple, outside glabrous, inside papillose, lanceolate, 2 by 8 mm long. Stamens 4, stout, reddish-purple, 2 mm long, ca 1 mm diameter; filament base adnate to tepals, consisting of two dorsifixed thecae, papillose, 1.7 mm long; anther yellow, apically, without appendage. *Ovary* minute. *Fruits* capsule, thin pericarp, green, 0.7-1 by 3.5-4.5 cm, apex acute, 5 mm long. *Seeds* 1-2, broad- ellipsoid, longitudinal ridged, 4 by 7 mm, base surrounded by 5 or 6 wide-celled aril.

Thailand. — PENINSULAR: Pattani (Bachaw, Batong, To-Mo), Yala (Tan-To), Narathiwat (Hala-Bala Wildlife Sanctuary, Weang).

Distribution. — Malay Peninsula (type).

Ecology. — In Evergreen Forest and near stream; altitude: 30-500 m.

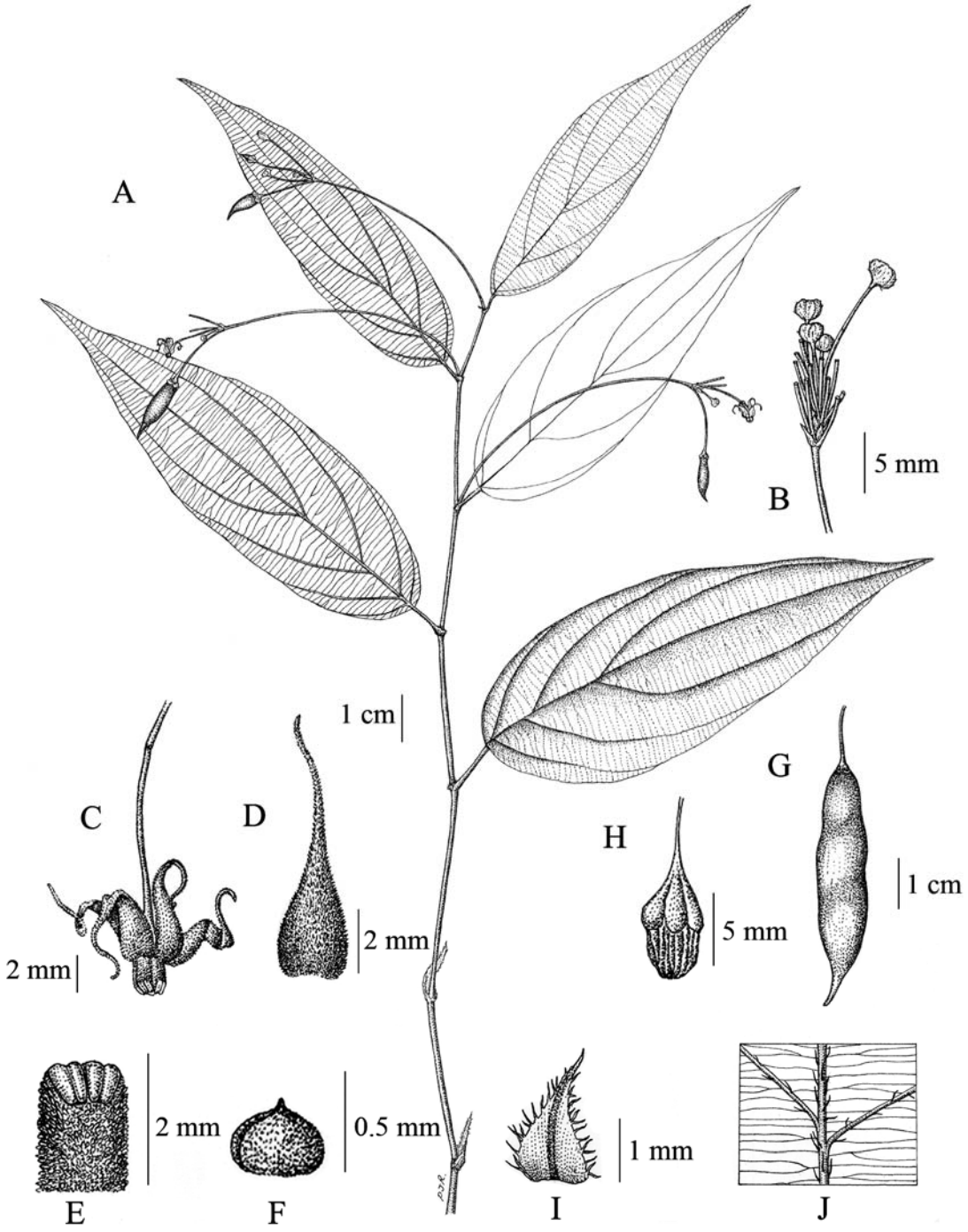

Figure 33 *Stichoneuron caudatum* Ridl.: A. flowering and fruiting stem; B. inflorescence buds; C. flower; D. tepal; E. stamen; F. ovary; G. fruit; H. seed with wide-aril; I. bracteolate; J. blade surface. Drawn by P. Inthachub.

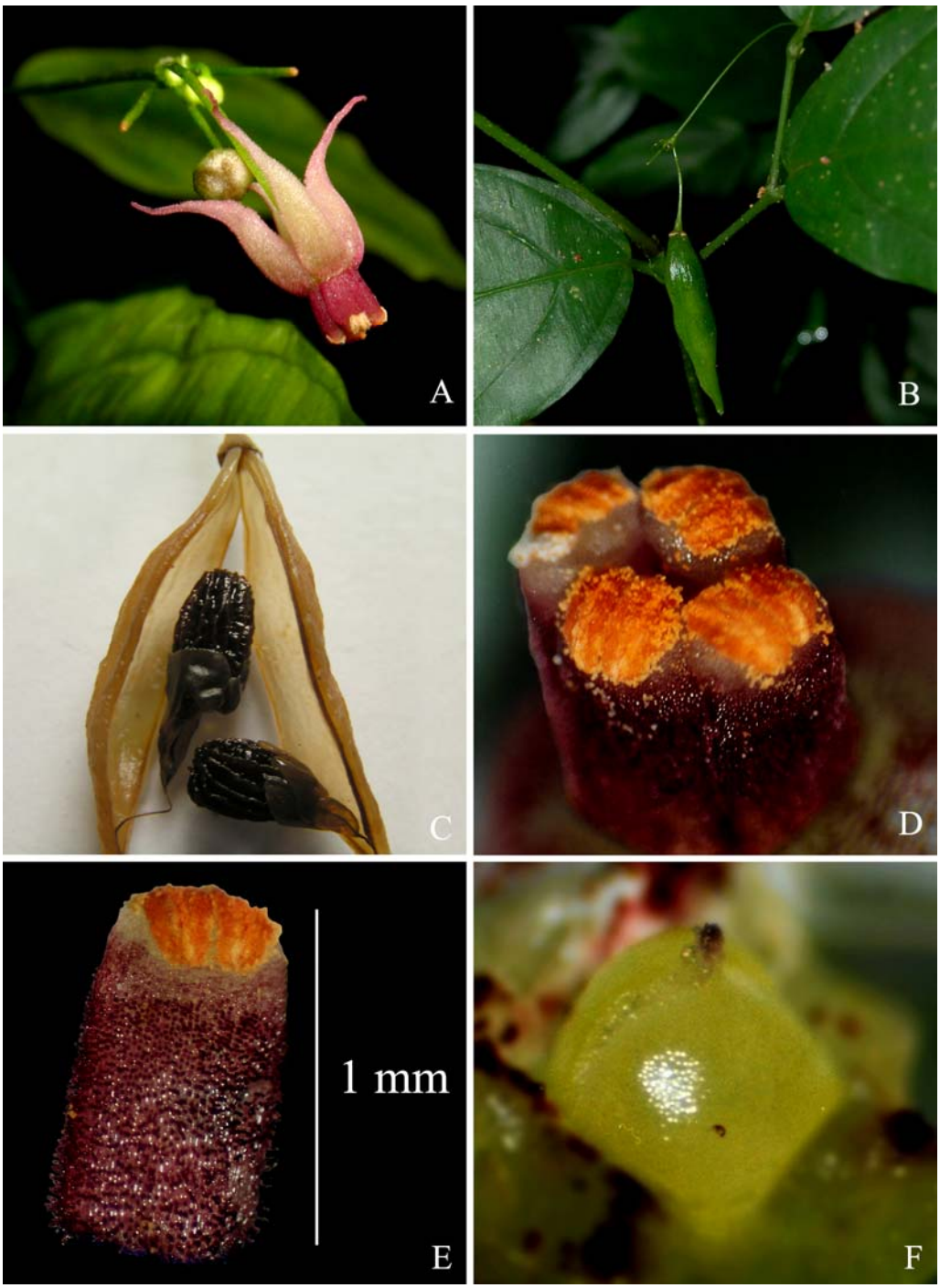

Figure 34 *Stichoneuron caudatum* Ridl.: A. inflorescence; B. fruit; C. seed; D. androecium; E. stamen; F. ovary. Photographed by P. Inthachub (A, C-F) and M. Poopath (B).

2. Stichoneuron sp. 1

Erect, stem with hairy, up to 60 cm, rarely branched. *Roots* storage present. *Leaves* alternate; lower part of stem reduced to scales, margin fimbriate, 5-7 by 10 mm; blade ovate, elliptic or lanceolate, 2.5-5.5 by 6.5-12 cm; base obtuse or rounded; apex acuminate; margins entire; lateral nerves 3 pairs, hairy; petioles slightly sheathing at base, hairy, 7-10mm long. *Inflorescences* raceme, axillary, densely stiff pedicels, usually one or two flowers in full bloom; bracts hyaline, hairy, ca 2 mm long; peduncles stiff, 0.7-1.5(2) cm long, few hair at base, each plant presented to be equal peduncle. *Flowers* small; pedicel filiform, stiff, ca 2-7 mm long; tepals 4, ca 1 by 3 mm, outside green, inside yellowish-green with densely violet or dark purple hairy, lanceolate, apex acuminate. *Stamens* 4, ca 1.5 mm long; filament, glabrous, dark purple, basally adnate to tepals; anthers orange, dorsifixed. *Ovary* minute, haft-inferior, ovoid, green; style absent. *Fruits* capsule, green, thin pericarp, slightly, 1 by 3 cm, beak 5 mm long. *Seeds* 1-2, dark brown, broad-ellipsoid, sharply ridged lengthwise, 5-6 by 9 mm; funiculous long, insert to apical of fruit; base surrounded by wide-cell, flat aril; aril surrounding the seed up to halfway.

Thailand.— PENINSULAR: Narathiwat (Weang, Hala-Bala Wildlife Sanctuary).

Distribution.— Endemic.

Ecology.— In Evergreen Forest and near stream; altitude: 40-50 m.

Notes.— *Stichoneuron* sp. 1 occurred same areas with *Stichoneuron caudatum*.

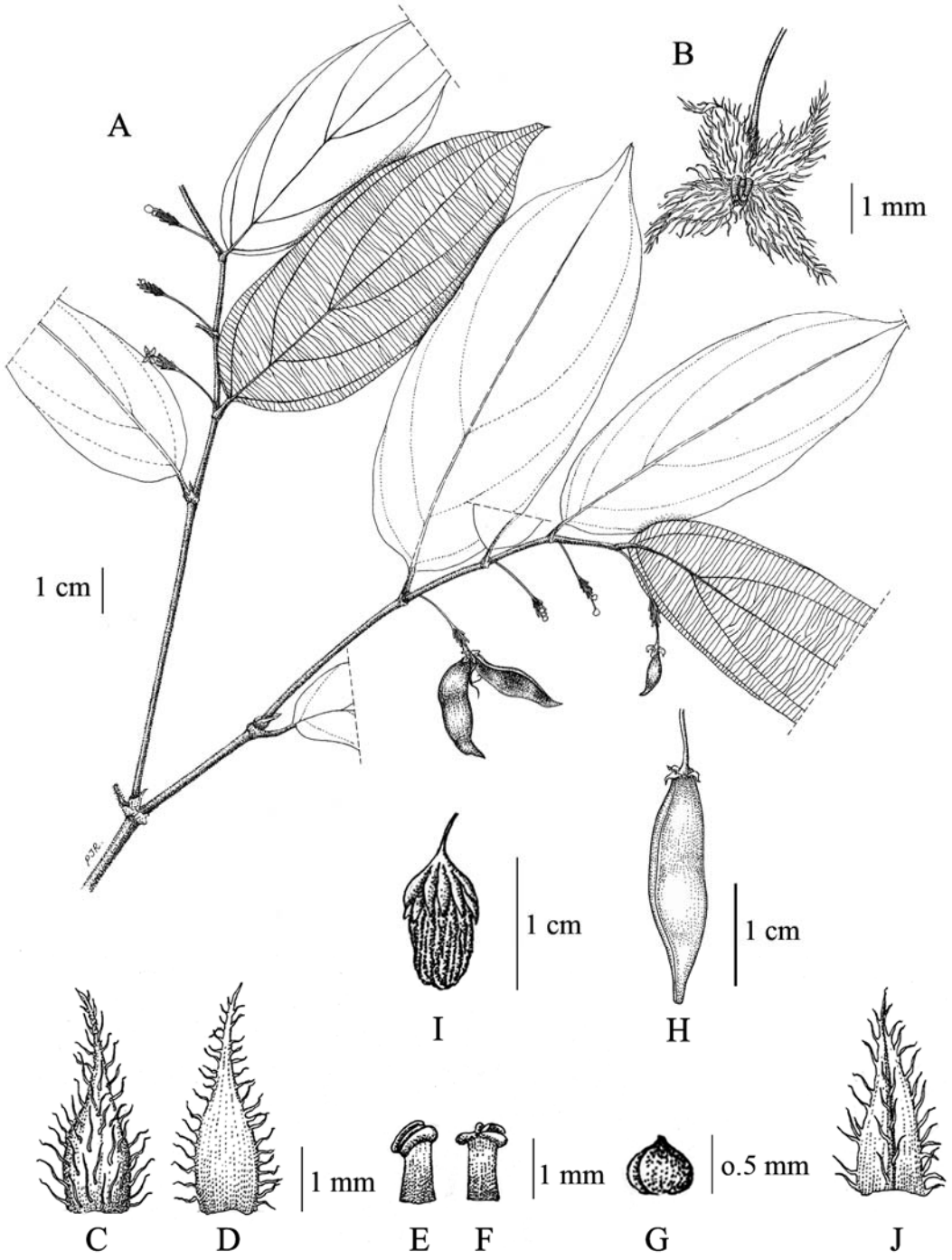

Figure 35 *Stichoneuron* sp. 1: A. flowering and fruiting stem; B. flower; C. inside of tepal; D. outside of tepal; E-F. stamen; G. ovary; H. fruit; I. seed with wide-aril; J. bract. Drawn by P. Inthacub.

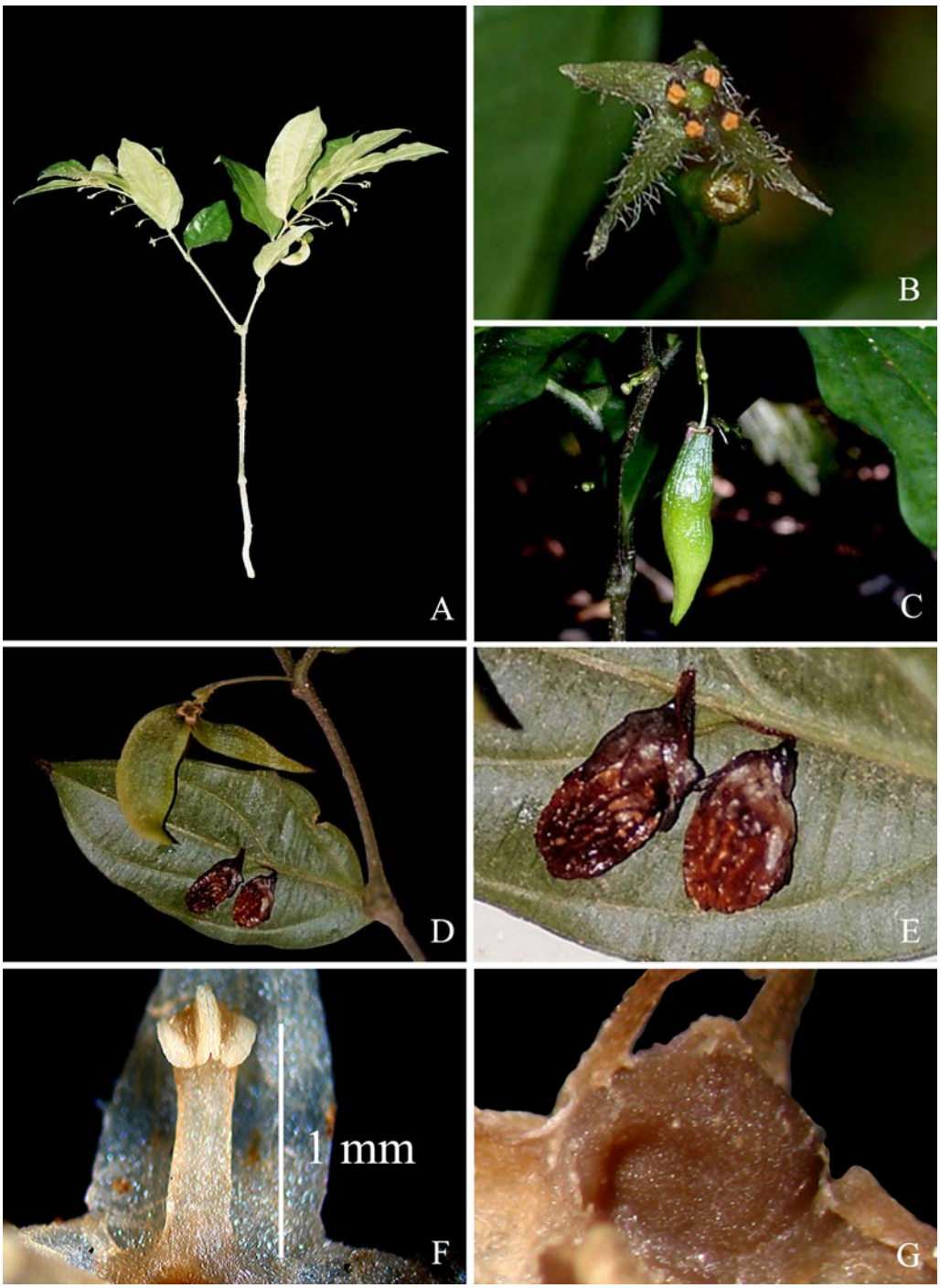

Figure 36 *Stichoneuron* sp. 1: A. flowering and fruiting stem; B. inflorescence; C. fruit; D. opened fruit; E. mature seeds; F. stamen; G. ovary. Photographed by P. Inthachub (A, D-G) and M. Poopath (B-C).

3. Stichoneuron sp. 2

Herb; decumbent, hanging, shortly hairs all part, branched, 60 cm long; shortly rhizome. *Roots* not tuberous. *Leaves* alternate; blade orbiculate or heart shaped, upper surface glabrous, lower surface shortly hairs, 1.5-5 by 1.6-6 cm; base shallowly cordate; apex acute; margin entire, shortly hairs; basal nerves, 5-7 longitudinally parallel; petiole not slightly sheathing at base, 5-10 mm long. *Inflorescences* axillary, raceme, compound raceme, densely flowered at terminal; peduncles slender, glabrous, 2 -4.5 cm long; bracts fimbriate. *Flowers* small; pedicel glabrous, articulated, 5-10 mm long; tepals reddish, outside glabrous, inside cover with red hair, lanceolate, 2 by 3 mm. *Stamens* 4, stout, reddish, 1 mm long, ca 0.5 mm diameter; filament basal adnate to tepals, hairly; anther dorsifixed, orange, without appendage. *Ovary* minute. *Fruit* glabrous, with thin pericarp, green, 4-7 by 4-12 mm; apex acute, separate. *Seeds* 1-2, long funiculous, inserted to apical, reddish, broad- ellipsoid, longitudinal ridged, 3 by 5 mm, base surrounding by aril consisting of wide-celled appendage.

Thailand. — PENINSULAR: Surat Thani (Khlongphanom).

Distribution. — Endemic.

Ecology. — Evergreen Forest on limestone, herb hanging from in rock. Altitude 50-300 m.

Notes. — *Stichoneuron* sp. 2 affinity with *Croomia* and *Stemona*, which basal curved.

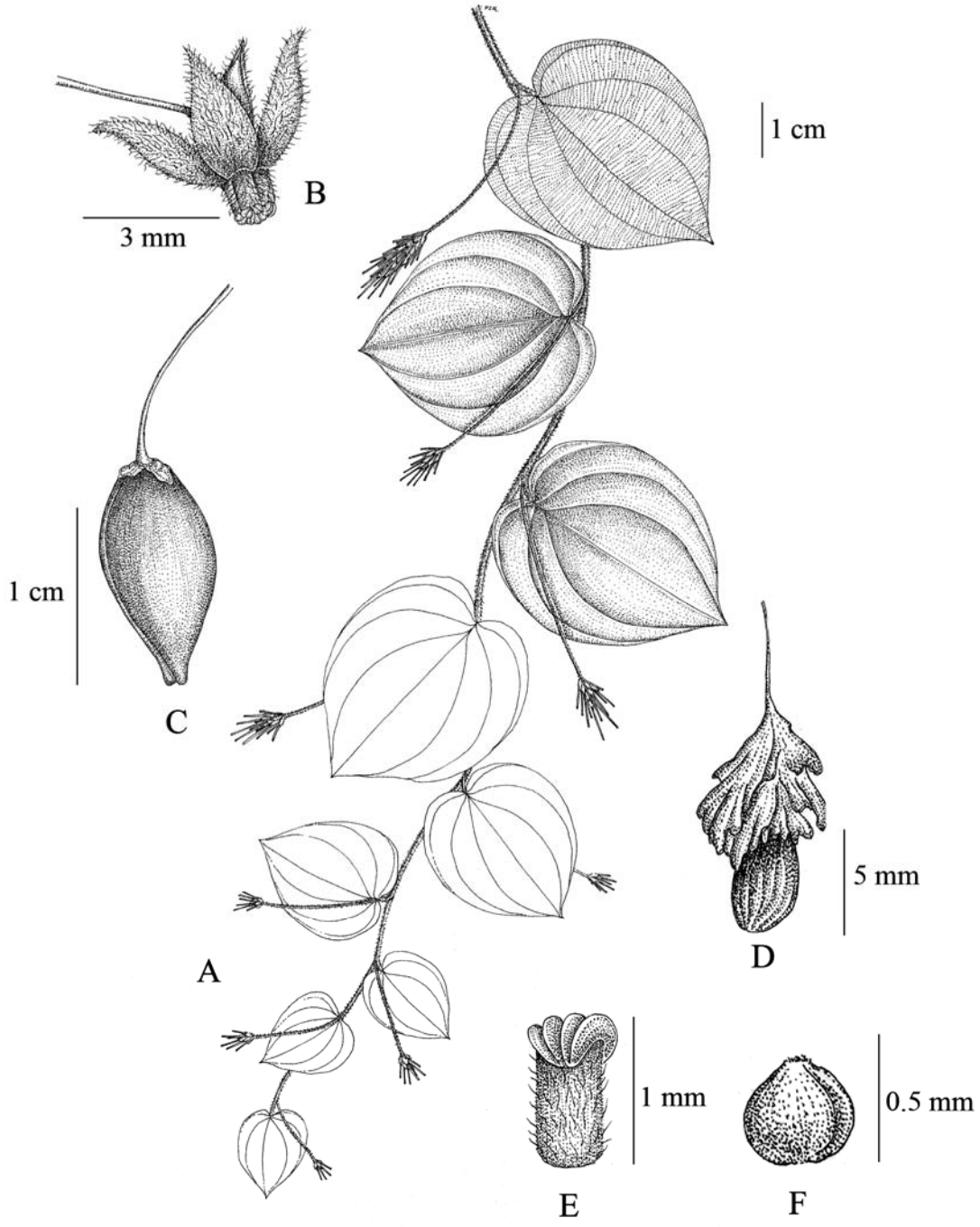

Figure 37 *Stichoneuron* sp. 2: A. flowering stem; B. flower; C. fruit; D. seed; E. stamen; F. ovary. Drawn by P. Inthachub.

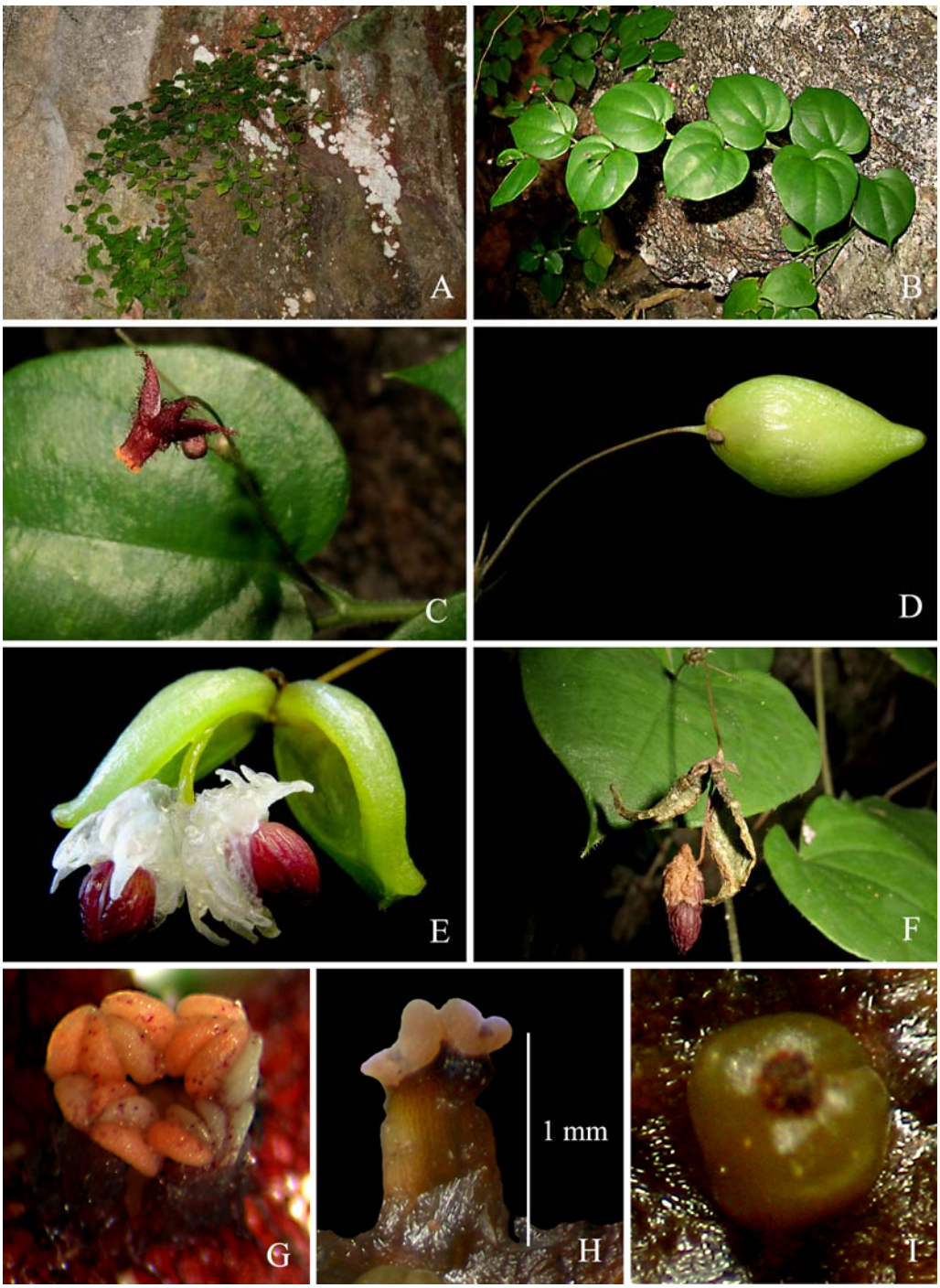

Figure 38 *Stichoneuron* sp. 2: A. habitat; B. habit; C. inflorescence; D. fruit; E. seeds with aril; F. dehiscent fruit with seed; G. androecium; H. stamen; I. ovary. Photographed by P. Inthachub.

CONCLUSION AND RECOMMENDATION

Taxonomic revision on the family Stemonaceae in Thailand were conducted by specimens examined from BKF, BK, CMU, QBG and KEW herbarium and literatures searched. Additional field surveys and specimen collected of the family were made throughout the country. The family has 2 genera, *Stemona* Lour. and *Stichoneuron* Hook.f. The total number of species are 10 species and 4 taxa belong to the genus *Stemona* 9 species and 2 taxa. Genus *Stichoneuron* has one species and 2 taxa. The species in this treatment are as followed: *Stemona aphylla, S. burkilli, S. cochinchinensis, S. collinsiae, S. curtisii, S. kerrii, S. phyllantha, S. pierrei, S. tuberosa* and *Stichoneuron caudatum*. Four taxa are unknown, two taxa belong to *Stemona* and two taxa belong to *Stichoneuron*.

Character analysis and a key to the species were studied based on flowering plant (*i.e.* flower colour, flower size, connective of stamen, connective of theca), habit, leaves shape and size, indumentum, fruit, seed and aril form.

Four taxa in the family Stemonaceae may be new to science which are: *Stemona* sp. 1, found in Mukdahan and Sakon Nakhon; *Stemona* sp. 2 found in Khon Kaen, Nakhon Ratchasima and Sukhothai; *Stichoneuron* sp. 1 was found in Narathiwat and *Stichoneuron* sp. 2 was found in Surat Thani.

Two species are endemic to Thailand *i.e. Stemona aphylla* and *S. collinsiae*. *Stichoneuron caudatum* is endermic to Malay Peninsular. Two species *i.e. Stemona cochinchinensis* and *S. pierrei* are newly recorded in Thailand.

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APPENDICES

Appendix A

Specimens examined

SPECIMENS EXAMINED

Stemona aphylla Gagnep.

Anonymous, 14 Mar 1924, Loei, Wang Sapung (BK).

A.F.G. Kerr 2351, 10 Feb 1912, Phrae, Mae Ta (K-Type.).

A.F.G.Kerr 4792, 5 Feb 1921, Lampang, Phrae (BK, K).

A.F.G.Kerr 5813, 26 Mar 1924, Loei, Tali (BK).

A.F.G.Kerr 5979, 18 May 1922, Nakhon Sawan (BK).

A.F.G. Kerr 8948, 4 Mar 1924, Udon Thani, Nong Bua (K).

A.F.G.Kerr 8954, 6 Mar 1924, Udon Thani (BK).

A.F.G. Kerr 19999, 5 Feb 1931, Khon Khaen, Phu Wieng (BK, K).

A.F.G. Kerr 20035, 10 Feb 1931, Loei, Kao Krading (BK, K).

A.F.G.Kerr 20157, 15 Feb 1931, Loei, Sitan (BK).

A.F.G. Kerr 20398, 9 Mar 1931, Phetchabun, Chon Den (BK, K).

A.F.G.Kerr 20494, 14 Jun 1931, Phetchabun (Bangkok) (BK).

Bertel Hansen, Gunnar Seidenfaden & *Tem Smitinand* 11275, 29 Feb 1964, Loei, Udon Thani (BKF).

P. Chantaranothai, D. Middleton, J. Parnell & *D. Simpson* 984, 26 Feb 1993, Sakon Nakhon, Phuphan NP. (K).

P. Inthachub 25-30, 21 Mar 2004, Udon Thani, Nong Wua So, Hin Tang waterfall (BKF).

P. Inthachub 129, 23 Feb 2005, Bangkok, Kasetsart University (collected from Saraburi, Phra Put Tha Bat) (BKF).

P. Inthachub 169, 25 Apr 2006, Bangkok, Kasetsart University (collected from Udon Thani) (BKF).

P. Inthachub 171, 25 Apr 2006, Bangkok, Kasetsart University (collected from Nakhon Sawan) (BKF).

S. Vajrodaya, 19 Mar 2001, Sakon Nakhon, Phu phan Palace (BKF).

S. Vajrodaya, 28 Mar 2001, Nakhon Sawan, Mueang (BKF).

Smitinand 2458, 16 Apr 1955, Loei, Wang Sapung (BKF).

Suphachai Yodkeelee 5, 2 Mar 2005, Udon Thani, Nawng Wua Saw, Kahm Mahk Koon (CMU).

Vacharapong, 24 Jan 1969, Phetchabun, Chon Daen (BK).

Phra Winit 1680, 27 Mar 1926, Phrae (BK, BKF).

Stemona burkillii Craib

Arom Phuakan 10, 22 Apr 1993, Chiang Mai, Muang, Doi Sutep-Pui NP. (BKF, CMU).

A.F.G. Kerr 1403, 17 Sep 1910, Chiang Mai, Doi Sutep (K).

A.F.G. Kerr 1403A, 25 Jun 1911, Chiang Mai, Doi Sutep (K).

A.F.G. Kerr 8761, 16 Mar 1924, Loei, Wang Sapung (BK, K).

BGO Staff, 27 Apr 1995, Loei, Na Haew (QBG).

BGO Staff 3637, 24 May 1995, Chiang Mai, Mae Rim, Botanical Garden (QBG).

BGO. Staff 6497, 11 May 1996, Khon Khaen, Phu Wiang, Phu Wiang NP. (QBG).

C. Suwanpakdee, 20 Oct 2003, Lamphun, Doi Khun Tan NP. (BKF).

D. Sookchaloem, 24 Nov 1999, Loei, Phu Hin Lek Fai (BKF).

J.F. Maxwell 87-671, 18 Jul 1987, Chiang Mai, Doi Sutep (BKF).

J.F. Maxwell 92-370, 9 Jul 1992, Chiang Mai, Muang, Doi Sutep-Pui NP. (CMU).

J.F. Maxwell 93-558, 4 Jun 1993, Lamphun, Mae Tah, Doi Kuhn Dahn NP. (CMU.

J.F. Maxwell 94-404, 30 Mar 1994, Lamphun, Mae Tah, Doi Kuhn Dahn NP. (CMU).

J.F. Maxwell 96-647, 29 Apr 1996, Lampang, Wahng Nua, Jae Sawn NP. (CMU).

J.F. Maxwell 96-697, 20 May 1996, Chiang Mai, Sahn Kahm Pang, Doi Lohn (BKF, CMU).

K. Larsen & *Supee S. Larsen* 3123, 28 Apr 1958, Chiang Mai, Doi Sutep (BKF).

Karem 538, 9 Aug 1967, Kanchanaburi, Srisawad (BK).

Martin van de Bult 656, 11 May 2003, Kanchanaburi, Thong Pha Phum (CMU).

Nobuyuki Fukuoka T-62015, 16 Jul 1988, Chiang Mai, Doi Sutep (BKF)

Noi Mao, 4 Oct 1964, Chiang Mai (BK).

P. Inthachub 2-5, 3 May 2003, Kanchanaburi, Khuean Srinagarindra NP., Huay Mae Kamin waterfall (BKF).

P. Inthachub 22-24, 15 Nov 2003, Lamphun, Doi Khun Tan NP. (BKF).

P. Inthachub 45-50, 22 Apr 2004, Phitsanulok, Chattrakarn (BKF).

P. Inthachub 52, 22 Apr 2004, Phitsanulok, Chattrakarn (BKF).

P. Inthachub 55-61, 10 May 2004, Chiang Mai, Mae Rim, Queen Sirikit Botanic Garden (BKF).

P. Inthachub 62-66, 11 May 2004, Chiang Mai, Huai-Mae-Nai (BKF).

P. Inthachub 67-68, 11 May 2004, Chiang Mai, Huai-Tueng-Thao (BKF).

P. Inthachub 71-76, 12 May 2004, Lamphun, Doi Khun Tan NP. (BKF).

P. Inthachub 77, 14 May 2004, Phitsanulok, Kaeng Chet Khwae NP. (BKF).

P. Inthachub 79, 15 May 2004, Phitsanulok, Kaeng Chet Khwae NP. (BKF).

Paul Wilkin, Alan Paton, Hajo Esser, Somran Suddee, A. Muasya, Thanongsak Jonganurak & *Voradol Chamchumroon* T- 956, 8 Oct 1998, Phetchabun, NamNoa (BKF).

Paul Wilkin, Somran Suddee & *Pachok Paudjaa* 1085, 7 Nov 1998, Tak, Um Phang (K).

R. Geesink, D. Phanichapol & *T. Santisuk* 5517, 29 May 1973, Tak, Larn Sarng (BKF).

R. Methee & *J. Araya* 3, 12 Oct 2000, Chiang Mai, Muang, Mae Hin (CMU).

S. Phengnaren 588, 30 Aug 1968, Loei, Phu Krading (BKF).

Th. Sørensen, Kai Larsen and *Bertel Hansen* 2451, 22 Mar 1958, Pha Nok Khao (K).

Th. Sørensen, K. Larsen & *Bertel Hansen* 2451, 23 Mar 1958, Pha Nok Khao (BKF).

Th. Sørensen, Kai Larsen and *Bertel Hansen* 3123, 28 Apr 1958, Chiang Mai, Doi Sutep (K).

Stemona cochinchinensis Gagnep.

A.F.G. Kerr 7030, 31 May 1923, Thailand (K).

A.F.G. Kerr 21335, 1 May 1932, Nong Khai, Chaiyaburi (Bueng Kan) (BK, K).

Adisai 530, 18 Jun. 1963, Nong Khai (BK).

M.C. Laksanakara 959, 17 Jun. 1932, Mukdahan (BK, K).

P. Inthachub 31-36, 22 Mar 2004, Nong Khai, Bueng Kan (BKF).

R. Pooma, W.J.J.O. de Wilde. B.E.E. Duyfjes, V. Chamchumroon & *K. Phattarahirankanok* 2220, 21 Aug 2001, Ubon Ratchathani, Phibun Mangsahan (BKF).

S. Vajrodaya, 27 Feb 2001, Nong Khai, Bueng Kan (BKF).

S. Vajrodaya, 30 Apr 2002, Nong Khai, Phu Tok (BKF).

T. Smitinand 579, 4 Jun 1954, Si Sa Ket, Kanthalom (BKF).

Th. Sørensen, K. Larsen & *B. Hansen* 2450, 23 Mar 1958, Pha Nok Khao (BKF).

Wongsatit Chuakul 274, 10 Sep 1997, Ubon Ratchathani, Pa Ban Dong (RAMA 9).

Stemona collinsiae Craib

A.F.G. Kerr 4241, 12 May 1920, Chon Buri, Sriracha (K-Type).

A. Marcan 134, 20 Mar 1920, Chon Buri, Sriracha, Bandaw (K).

C. Chermsirivathana & *Prayad* 2023, 29 Jan 1975, Chon Buri, Khao Khiao (BK).

C. Phengklai 14634, 8 Mar 2002, Trat, Ko Chang (BKF).

D. J. Collins 131, Apr 1913, Chon Buri, Siracha (K-Type).

D.J. Collins 399, 20 May 1913, Chon Buri, Siracha (BK, K-Type).

J.F. Maxwell, 28 Mar 1972, Chon Buri, Sattahip (BK).

J.F. Maxwell 73-685, 26 Nov 1973, Saraburi, Sahm Lahn (BK).

J.F. Maxwell 74-182, 16 Mar 1974, Saraburi, Sahm Lahn (BK).

J.F. Maxwell 75-94, 1 Feb 1975, Chon Buri, Siracha (BK).

J.F. Maxwell 93-402, 9 May 1993, Chon Buri, Siracha, Sichang Island (CMU).

K. Kertsawang 294, 10 May 2004, Rayong, Klaeng, Chak Phong (QBG).

*P. Inthachu*b 37-43, 8 Apr 2004, Chon Buri, Siracha (BKF).

P. Inthachub 93, 6 Aug 2004, Nakhon Ratchasima, Pakthongchai, Sakaerat (BKF).

P. Phonsena, K. Bunpha & *P. Kan-urai* 4883, 29 May 2006, Sa Kaeo, Khlong Hat (BKF).

Phra Winit 1680, 27 Mar 1926, Phrae (BK).

Put 2752, 25 Feb 1930, Rayong, Ban Pe (K).

S. Vajrodaya, Apr 2000, Chon Buri, Khao Khieo (BKF).

S. Vajrodaya, 10 Apr 2002, Saraburi, Samlan waterfall (BKF).

S. Vajrodaya, 11 Apr 2004, Chon Buri, Khao Khieo, Chantathen waterfall (BKF).

T. Smitinand, 3 Mar 1986, Nakhon Ratchasima, Pakthongchai (BKF).

T. Smitinand & H. ST. John 6847, 17 Jun 1960, Chon Buri, Siracha (BKF).

Th. W. 103, 17 Mar 1926, Nakhon Ratchasima, Pakthongchai (BKF).

Umpae 528, 13 Feb 1975, Saraburi (BK).

Vacharee, 8 Apr 1976, Chon Buri, Ban Bung (BK).

Stemona curtisii Hook.f.

Allean, 14 Apr 1927, Surat Thani (BK).

Anonymous, 10 Feb 1931, Prachuap Khiri Khan, Hualin (BK).

A.F.G. Kerr 10729, 2 Jul 1926, Prachuap Khiri Khan (BK, K).

A.F.G. Kerr 10755, 2 Jul 1926, Prachuap Khiri Khan, Hui Jang (BK, K).

A.F.G. Kerr 11189, 3 Dec 1926, Surat Thani, Kao Tao (BK, K).

A.F.G. Kerr 11966, 15 Feb 1927, Chumphon, Langsuan (BK, K).

A.F.G. Kerr 13876, 4 Jan 1928, Satun, Tang Wa (K).

A.F.G. Kerr 13876, 4 Jun 1928, Surat Thani (BK).

A.F.G. Kerr 15252, 25 Feb 1930, Surat Thani (BK).

A.F.G. Kerr 15613, 7 May 1928, Nakhon Si Thammarat, Krung Zing (BK, K).

A.F.G. Kerr 18252, 25 Feb 1936, Surat Thani, Sanyao (K).

A.F.G. Kerr 20494, 14 Jun 1931, Bangkok (K).

BGO. Staff 3593, 27 May 1995, Nakhon Si Thammarat (QBG).

C. Niyomdham 2983, 14 Aug 1992, Prachuap Khiri Khan, Sam Roi Yod (BKF).

C. Phengklai 12131, Sep 1999, Satun, La-ngu, Kabeng (BKF).

C. Phengklai et al. 13659, 11 Apr 2003, Satun, Rangu (BKF).

C. Phengklai et al. 13866, 8 Apr. 2003, Satun, La-ngu (BKF).

C. Suwanpakdee, 17 Oct 2001, Chumphon, Pra Teo (BKF).

Chirayupin 144, 1 Jun 1960, Surat Thani (BK).

David J. Middleton, S. Suddee & Chandee Hemrat 1271, 25 Aug 2002, Prachuap Khiri Khan, Thapsakae (BKF).

J.F. Maxwell 86-484, 20 Jul 1986, Songkhla (BKF).

K. Chayamarit, L. Phuphathanaphong, R. Pooma, S. Suddee & K. Phattarahirankanok 3084, 9 Jan 2002, Prachuap Khiri Khan, Thap Sa Kae (BKF).

K. Larsen & Supee S. Larsen 33628, 8 May 1974, Prachuap Khiri Khan, Sam Roi Yod (BKF, K).

K. Larsen & Supee S. Larsen 33974, 1 Jul 1974, Kanchanaburi (BKF).

K. Larsen, S. S. Larsen, A. S. Barfod & W. Nanakorn 41461, 16 Nov 1990, Trang, Khao Pina (BKF).

K. Larsen, S.S. Larsen, S.S. Renner, C. Niyomdham, W. Ucachirakan & P. Sirirugsa 42996, 18 Jan 1992, Narathiwat, Bacho (BKF).

K. Larsen, T. Smitinand & E. Warncke 1562, 13 Aug. 1966, Ratchaburi, south of Prachuap Khiri Khan (BKF).

Khantchai 1090, 18 May 1959, Chumphon (BKF).

M.C. Robinson 1914, Surat Thani (K).

N. Koonkhunthod, W.J.J.O. de Wilde & B.E.E. Duyfjes 329, 5 Dec 2002, Phetchaburi, Kaeng Kra Jan (BKF).

P. Inthachub 10-13, 28 Sep-2 Oct 2003, Chumphon, Langsuan (BKF).

P. Inthachub 133-135, 16 Feb 2005, Surat Thani, Samui, Kao Tan (BKF).

P. Inthachub 140-142, Sep 2005, Surat Thani, Samui (BKF).

P. Inthachub 172-173, 25 Apr 2006, Bangkok, Kasetsart University (collected from Chumphon, Kao Phao) (BKF).

P. Wilkin 844, 1 Sep 1996, Peninsular, Narathiwat, Su Ngai Padi NP. (BKF, K).

Put 267, 16 Sep 1926, Prachuap Khiri Khan (K).

Put Phrisurin 247, 16 Sep 1926, Prachuap Khiri Khan (BK).

Put Phrisurin 1476, 9 Mar 1928, Bang Son (BK, K).

R. Geesink, P. Hiepho & C. Phengklai 7758, 4 Dec 1974, Surat Thani (BKF).

R. Methee & J. Araya 1, 12 Oct 2000, Nakhon Si Thammarat, Bangkan, Wanghin (CMU).

R. Pooma, V. Chaemchumroon & P. Chantaboon 3548, 7 May 2002, Surat Thani, Vibhavadi (BKF).

S. Siriseree, 21 Mar 2002, Narathiwat, Taksin Rajaniveng Palace (BKF).

S. Siriseree, Apr 2003, Satun (BKF).

S. Siriseree, Phetchaburi, Kaeng Krachan NP. (BKF).

S. Vajrodaya, 4 Apr 2001, Satun, Lee Pae (BKF).

Sakol 1196, 3 Jul 1966, Surat Thani (BK).

Sakol Sutheesorn 1809, 5 Aug 1970, Pattani, Yarang (BK).

Singapore Field 4368, 17 May 1929, Chumpon (K).

T. Smitinand 3803, 8 Mar 1957, Surat Thani, Bangbao (BKF).

T. Smitinand 8525, 4 Feb 1964, Prachuap Khiri Khan, Pranburi (BKF).

Th. Sørensen, Kai Larsen & Bertel Hansen 710, 27 Jan 1958, Phatthalung, Khao Kaw (BKF, K).

Tyspan 225, 5 May 1974, Prachuap Khiri Khan, Kui Buri (BK).

Stemona kerrii Craib

A.F.G. Kerr 707, 27 Jun 1909, Chiang Mai, Doi Sutep (K-Type).

BGO. Staff 40, 12 Jul 1996, Chiang Mai, Proaw, Paa Mae Bon (QSBG).

BGO. Staff 669, 10 May 1994, Chiang Mai, Mae Rim, Botanical Garden (QBG).

BGO. Staff 4184, 8 Sep 1995, Chiang Mai, Mae Rim, Pong Yeang, Pong Taa Hoen (QBG).

Bjørnland/ Schumacher 156, 3 Aug 1978, Chiang Mai, Doi Sutep (BKF).

C. Niyomdham 6512, 8 Jun 2001, Lampang, Ngao (BKF).

C. Phengklai et al. 6681, 21 Jul 1988, Chiang Mai, Doi Inthanon (BKF).

Gen Murata, Kunio Iwatsuki, Chamlong Phengklai & Charal Charamphol T-15515, 1 Oct 1971, Chiang Mai (BKF).

J.F. Maxwell 03-289, 16 Sep 2003, Chiang Mai, Hauy Dong (CMU).

Kai Larsen, T. Santisuk & E. Warncke 2351, 11 Jul 1968, Mae Hong Son, Mae Sariang, Ban Mae Pang (BKF, K).

K. Larsen, T. Santisuk & E. Warncke 2726, 26 Jun 1968, Chiang Mai, Fang (BKF).

Lao, 2 Aug 1921, Chiang Mai, Doi Sutep (BK).

M.N. Tamura T-60326, 30 Jun 1988, Chiang Mai, Doi Inthanon (BKF).

M.N. Tamura T-60334, 31 Jul 1988, Chiang Mai, Doi Inthanon (BKF).

M.N. Tamura T-60376, 3 Aug 1988, Chiang Mai, Doi Inthanon (BKF).

Nobuyuki Fuku Oka T-62018, 16 Jul 1988, Chiang Mai, Doi Sutep (BKF).

P. Inthachhub 16-18, 1 Nov 2003, Chiang Mai, Mae Rim, Queen Sirikit Botanic Garden (BKF).

P. Inthachub 19-20, 3 Nov 2003, Chiang Mai, Mae Rim, Doi Mon Long (BKF).

P. Inthachub 52-53, 10 May 2004, Chiang Mai, Mae Rim, Queen Sirikit Botanic Garden (BKF).

P. Inthachub 54, 10 May 2004, Chiang Mai, Mae Rim, Queen Sirikit Botanic Garden (BKF).

P. Inthachub 69-70, 12 May 2004, Lamphun, Doi Khun Tan NP. (BKF).

P. Inthachub 174, July 2006, Bangkok, Kasetsart University (collected from Tak, Lan Sang NP. (BKF).

P. Palee 318, 4 Sep 1995, Chiang Mai, Sankampang, Doi Muang Awn (CMU).

R. Methee & J. Araya 2, 12 Oct 2000, Chiang Mai, Muang, Mae Hin (CMU).

S. Vajrodaya, 31 Jan 2002, Chiang Mai, Mae Rim, Queen Sirikit Botanic Garden, Huai Dee Mee (BKF).

Th. Sørensen, K. Larsen & B. Hansen 1131, 15 Feb 1958, Chiang Mai, Doi Chieng Dao (BKF).

Th. Sørensen, K. Larsen & B. Hansen 3124, 29 Apr 1958, Chiang Mai, Doi Sutep (BKF).

Umnat 93, 9 Mar 1954, Lampang, Huay Tao (BKF)

W. Boonchai 11, 26 Jul 1997, Chiang Mai, Mae Rim, Botanical Garden (BKF, QBG).

W. Dejtisak, 9-12 Aug 2003, Chiang Mai, Mae Rim, Queen Sirikit Botanic Garden (BKF).

W.J.J.O. de Wilde & B.E.E. Duyfjer 22151, 25 Aug 2000, Chiang Mai, Doi Inthanon (BKF).

Stemona phyllantha Gagnep.

A. Marcan 2326, 26 Feb 1928, Trat, Koa Chang (K).

A.F.G. Kerr 5979, 18 May 1922, Nakhon Sawan (BK, K).

A.F.G. Kerr 8957, 16 Mar 1924, Loei, Wang Sapung (K).

A.F.G. Kerr 20157, 15 Feb 1931, Loei, Sitan (BK, K).

A.F.G. Kerr 20687, 18 Mar 1932, Khon Kaen (K).

C. Phengklai 12849, 10 Dec 2000, Chon Buri, Kao Khieo (BKF).

Ch. Chaloenphol 96, 20 Apr 1971, Chaiyaphum, Huai Bak Daeng (BKF, K).

L. Pierre 82, Jun 1868, Siam (Thailand), Phetchabun (K).

P. Inthachub 01, 3 May 2003, Kanchanaburi, Khuean Srinagarindra NP., Huay Mae Kamin waterfall (BKF).

P. Inthachub 138, 22 May 2005, Kanchanaburi, Khuean Srinagarindra NP., Huay Mae Kamin waterfall (BKF).

P. Inthachub 148-152, 11 Mar 2006, Rayong, Ban Chang, Had Play (BKF).

P. Inthachub 153-154, 11 Mar 2006, Chanthaburi, Khao Cha Mao waterfall (BKF).

T. Smitinand 1071, 5 Mar 1952, Thailand, Khon Kaen, Chumpae (BKF, K).

T. Smitinand 2458, 16 April 1955, Loei (BKF).

T. Smitinand 5492, 10 Feb 1959, Chon Buri (BKF).

Voradol Chamchumroon & C. Puff V.C.-1427, 16 Mar 2002, Loei, Phuluang WS. (BKF).

Stemona pierrei Gagnep.

R. Pooma, W. J. J. O de Wilde, B. E. E. Duyfjes, V. Chamchumroon and K. Phattarahirankanok 136138, 20 Aug 2001, Haui Thabthan, Surin (BKF).

S. Vajrodaya, 24 Apr 2002, Buri Ram to Si Sa Ket (BKF).

Stemona tuberosa Lour.

Anonymous 106, May 1959, Tak (BK).

A.F.G. Kerr 3599, 22 May 1915, Lamphun (K).

C. Phengklai, M. Tamura, C. Niyomdham & B. Sangkachand 4193, 28 Jul 1978, Chiang Mai, Omkoi (BKF, K).

J.F. Maxwell 05-340, 25 May 2005, Mae Hong Son, Mae Sariang (CMU).

J. F. Maxwell 93-861, 5 Aug 1993, Chiang Mai, Doi Sutep-Pui (CMU).

J.F. Maxwell 94-773, 3 Jul 1994, Lamphun, Doi Khun Tan NP. (BKF, CMU).

J.F. Maxwell 95-743, 23 Sep 1995, Lampang, Chae Son NP. (CMU).

J.F. Maxwell 97-460, 6 May 1997, Phayao, Doi Luang NP. (BKF, CMU).

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O. Petrmitr 16, 24 May 1997, Phayao Doi Luang NP. (BKF, CMU).

O. Petrmitr 83, 25 Jul 1997, Payao, Muang, Doi Luang NP. (CMU).

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P. Inthachub 21, 15 Nov 2003, Lamphun, Doi Khun Tan NP. (BKF).

P. Inthachub 78, 16 May 2004, Phitsanulok, Kaeng Chet Khwae NP. (BKF).

P. Inthachub 80-84, 18 Jul 2004, Uttaradit, Phu Soi-dao NP. (BKF).

P. Inthachub 145-147, 12 Jan 2006, Loei, Phuluang WS. (BKF).

P. Wilkin 923, 28 Sep 1996, Lampang, Wang Nua (BKF, K).

R. Methee & J. Araya 6, 12 Oct 2000, Maha Sarakham (CMU).

S. Sirisaree, 6-17 Feb 2004, Chiang Rai, Doi Thung (BKF).

T. Smitinand, 30 Mar 1986, Nakhon Ratchasima, Pak Thong Chai (BKF).

T. Smitinand 1210, 19 Mar 1952, Loei, Wang Sa Pung (BKF).

T. Smitinand 1576, 16 May 1954, Lampang, Ngao (BKF).

Winit 711, 2 Apr 1922, Lamphun, Mae Ta (K).

Winit 853, 24 Apr 1923, Lampang (BKF, K).

Winit 1400, 29 Apr 1925, Khon Kaen (BK, BKF, K).

Stemona sp. 1

P. Inthachub 87-92, 1 August 2004, Sakon Nakhon, Phu Phan NP., Tham Seri Thai cave trail (BKF).

S. Siriseree, 12-13 August 2005, Mukdahan, Phu Pha Turb NP. (BKF).

Stemona sp. 2

P. Inthachub 96, 31 Aug 2004, Bangkok (collected from Khon Kaen, Nam Pong), Kasetsart University (BKF).

P. Inthachub 126, February 2005, Sukhothai (BKF).

P. Inthachub 127, 11 Feb 2005, Bangkok (collected from Nakhon Ratchasima), Kasetsart University (BKF).

P. Inthachub 130-132, 19 March 2005, Bangkok (collected from Nakhon Ratchasima), Kasetsart University (BKF).

P. Inthachub 136-137, 22 May 2005, Kanchanaburi, Khuean Srinagarindra NP., Huay Mae Kamin waterfall (BKF).

P. Inthachub 170, 24 Apr 2006, Bangkok (collected from Nakhon Ratchasima), Kasetsart University (BKF).

S.Vajrodaya, 6 May 2002, Sukhothai (BKF).

Supaporn, Apr 2001, Nakhon Ratchasima (BKF).

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Stichoneuron caudatum Rild.

A.F.G. Kerr 7172, 13 Jul 1923, Pattani, Bachaw (BK).

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M.C. Lakshnakara 775, 23 Apr 1931, Narathiwas, Ban Kaluli, To-Mo (BK).

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P. Inthachub 103-116, 124, 10 Sep 2004, Narathiwat, Waeng, Hala-Bala WS. (BKF).

P. Suksathan 2930, 2 Mar 2001, Yala, Betong, Chulaporn 10 (QBG).

S. Chougko 305, 20 Apr 2004, Narathiwat, Hala-Bala WS. (CMU).

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M. Poopath, 26 August 2006, Narathiwat, Waeng, Klong Ai Ka Pa. (BKF).

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Stichoneuron sp. 2

David J. Middleton , K. Chayamarit, R. Pooma, V. Chamchumroon & K. Phattarahirankanook 544, 21 Feb 2001, Surat Thani, Phanom (BKF).

David J. Middleton et al. 2142, 11 Apr 2003, Surat Thani, Klong Phanom NP. (BKF).

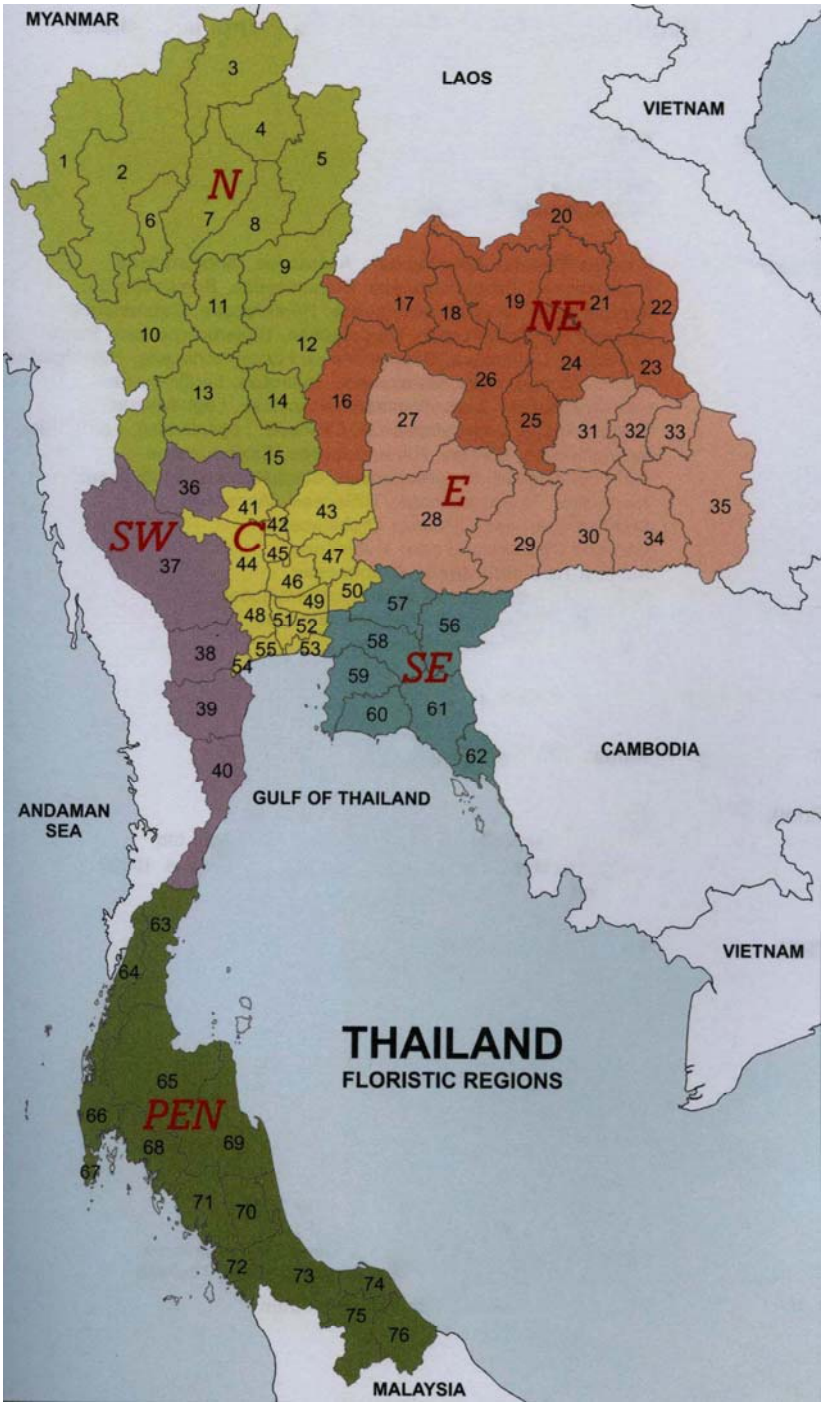
P. Inthachub 155-168, 24 March 2006, Surat Thani, Klongphanom NP. (BKF).

Sakol 1256, 9 Jul 1966, Surat Thani, Ta Chana, Kao Kom (BK).

Voradol Chamchumroon 865, 16 Jul 2000, Surat Thani, Klong Phanom National Park (BKF).

Appendix B

Floristic regions and provinces of Thailand



Appendix Figure B1 Floristic regions and provinces of Thailand: N= northern; NE= northeastern; E= eastern; SW= southwestern; C= central; SE= southeastern; Pen= peninsular.

Source: The Forest Herbarium, Royal Forest Department (2001).

Floristic regions and provinces of Thailand

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

NE (NORTHEASTERN)

16 Phetchabun
17 Loei
18 Nong Bua Lum Phu
19 Udon Thani
20 Nong Khai
21 Sakon Nakhon
22 Nakhon Phanom
23 Mukdahan
24 Kalasin
25 Maha Sarakham
26 Khon Kaen

E (EASTERN)

27 Chaiyaphum
28 Nakhon Ratchasima
29 Buri Ram
30 Surin
31 Roi Et
32 Yasothon
33 Amnat Charoen
34 Si Sa Ket
35 Ubon Ratchathani

SW (SOUTHWESTERN)

36 Uthai Thani
37 Kanchanaburi
38 Ratchaburi
39 Phetchaburi
40 Prachuap Khiri Khan

C (CENTRAL)

41 Chai Nat
42 Sing Buri
43 Lop Buri

Floristic regions and provinces of Thailand (Continued)

44 Suphan Buri
45 Ang Thong
46 Phra Nakhon Si Ayutthaya
47 Saraburi
48 Nakhon Pathom
49 Pathum Thani
50 Nakhon Nayok
51 Nonthaburi
52 Krung Thep Maha Nakhon (Bangkok)
53 Samut Prakan
54 Samut Songkhram
55 Samut Sakhon

SE (SOUTHEASTERN)

56 Sa Kaeo
57 Prachin Buri
58 Chachoengsao
59 Chon Buri
60 Rayong
61 Chanthaburi
62 Trat

PEN (PENINSULAR)

63 Chumphon
64 Ranong
65 Surat Thani
66 Phangnga
67 Phuket
68 Krabi
69 Nakhon Si Thammarat
70 Phatthalung
71 Trang
72 Satun
73 Songkhla
74 Pattani
75 Yala
76 Narathiwat

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