

รายงานฉบับสมบูรณ์

โครงการ “อนุกรมวิธานของ *Goniothalamus* (Blume) Hook. f. & Thoms. (Annonaceae)
ในประเทศไทย (Taxonomy of *Goniothalamus* (Blume) Hook. f. & Thoms. (Annonaceae)
in Thailand”

โดย รศ. ดร. วิไลวรรณ อนุสารสุนทร และชัชยา อยู่เย็น
เดือน เมษายน ปี 2551 ที่เสร็จโครงการ

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ในประเทศไทย (โครงการ BRT)

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ABSTRACT

Twenty specimens of *Goniothalamus* in Thailand were collected, 16 identifiable species and 4 unidentified species. Among these are 5 new records for Thailand, namely *G. elegans*, *G. cheliensis*, *G. repevensis*, *G. sawtehi* and *G. umbrosus*.

Many characters are taxonomically important, with variation evident in size, shape, colour and indumenta. The characters that were used taxonomically for Thai *Goniothalamus* taxa are the presence or absence of hairs on the surface of leaves, sepals, outer petals and inner petals. The whole dome shape needs to be considered as a unit for taxonomic analysis. Its morphology is diverse for the genus, with at least six distinct types. Another notable structure is the pistil, including stigmas shape and indumenta. There were six types of stigmas. Moreover, ovule number is taxonomically important as well. The staminal connectives are very variable in shape, with truncate, convex, short apiculate, long apiculate and sharply apiculate forms. Elements of both Boerlage's and Bân's infrageneric classifications are reflected in Thai *Goniothalamus* although many species could not be classified into the sectional level of Bân's classification. Thai *Goniothalamus* cannot be classified into sectional levels using Bân's classification because they have more diverse character than Bân proposed.

However, if more samples from wider distribution of the genus and tribe are available, it would be useful for further study. This preliminary study can be used for further research of *Goniothalamus*.

บทคัดย่อ

จากการสำรวจพืชสกุล *Goniothalamus* ในประเทศไทย พบพืชสกุลดังกล่าวจำนวน 20 ชนิด โดยในจำนวนนี้มี 16 ชนิดที่สามารถระบุชื่อวิทยาศาสตร์ได้ ในขณะที่อีก 4 ชนิด ไม่สามารถระบุชื่อวิทยาศาสตร์ได้ พบว่ามี 5 ชนิด ที่ไม่เคยมีรายงานว่าพบในประเทศไทยมาก่อน ได้แก่ *G. elegans*, *G. cheliensis*, *G. repevensis*, *G. sawtehii* and *G. umbrosus*

เมื่อนำมาศึกษาลักษณะทางสัณฐานวิทยาพบว่า มีลักษณะที่มีความสำคัญทางอนุกรมวิธานหลายลักษณะที่สามารถนำมาใช้ในการจัดจำแนกพืชในสกุลนี้ได้ คือ การมีหรือไม่มีขนปกคลุมบนส่วนต่างๆ เช่นผิวใบ กลีบเลี้ยง กลีบดอกวงนอก และกลีบดอกวงใน รูปร่างโคนของกลีบดอกวงใน ซึ่งมีความหลากหลายภายในสกุลมากถึง 6 แบบด้วยกัน นอกจากนี้ ลักษณะของเกสรตัวเมียยังมีความสำคัญในการนำมาใช้เพื่อจัดจำแนกพืชในสกุล *Goniothalamus* เช่น รูปร่างยอดเกสรตัวเมีย การมีสิ่งปกคลุม และจำนวนของอวุล เป็นต้น โดยรูปร่างของยอดเกสรตัวเมียของพืชสกุลนี้มีความหลากหลายภายในสกุลมากถึง 6 แบบ ลักษณะที่สำคัญทางอนุกรมวิธานของพืชสกุล *Goniothalamus* อีกอย่างหนึ่งคือ รูปร่างของยอดเกสรตัวผู้ ซึ่งพบว่ามีหลากหลายของรูปร่างภายในสกุลสูง ได้แก่ แบบตัด (truncate) แบบโค้งมน (convex) แบบแหลมสั้น (short apiculate) แบบแหลมยาว (long apiculate) และแบบแหลมเป็นติ่ง (sharply apiculate) เป็นต้น เมื่อนำมาเปรียบเทียบกับระบบการจัดจำแนกพืชสกุล *Goniothalamus* ในระดับต่ำกว่าสกุลของ Boerlage และ Bân พบว่า ระบบการจัดจำแนกทั้งสองสามารถนำมาใช้จัดจำแนกพืชสกุลดังกล่าวในประเทศไทยได้ แต่อย่างไรก็ตามในระบบการจัดจำแนกของ Bân นั้น พบว่ามีพืชสกุล *Goniothalamus* ในประเทศไทยบางชนิด ไม่สามารถจำแนกลงไปถึงระดับ section ได้ เนื่องจากพืชสกุลดังกล่าวในประเทศไทยมีลักษณะทางสัณฐานวิทยาที่หลากหลายมากกว่าระบบการจัดจำแนกที่ Bân ได้เสนอเอาไว้

จากการศึกษาอนุกรมวิธานของ *Goniothalamus* (Blume) Hook. f. & Thoms. (Annonaceae) ในประเทศไทยในครั้งนี้ทำให้ได้ข้อมูลเบื้องต้นของพืชในกลุ่มดังกล่าวมากยิ่งขึ้น อย่างไรก็ตามหากมีการสำรวจและรวบรวมข้อมูลของพืชสกุล *Goniothalamus* และสกุลอื่นๆ ในเผ่า Mitrephoreae เพิ่มเติมมากยิ่งขึ้น จะทำให้ได้ข้อมูลที่มีประโยชน์สำหรับการศึกษาพืชในกลุ่มดังกล่าวต่อไปในอนาคต

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CHAPTER 1

INTRODUCTION

Goniothalamus is one of the largest genera of palaeotropical Annonaceae, with over 120 species distribution throughout tropical south-east Asia. It is widely distributed in lowland and submontane tropical forest in south-east Asia, with the centre of diversity in Indochina and western Malesia (Sumatra, Penninsular Malaysia and Borneo) (Saunders, 2003).

The genus is characterized by axillary (or slightly supra axillary) flowers that are generally pendant. As with most Annonaceae, the flowers have three sepals and two whorls of three petals. The outer petals are typically larger than the inner ones (although sometimes only slightly so), and the inner petals are connivent over the reproductive organs, forming a distinctive mitreform dome. The flowers are bisexual, with numerous free stamens and carpels. The stamens have a broad apical connective that varies in shape, ranging from truncate to apiculate, and thecae that are septate. The pollen is released as tetrads (Saunders, 2002 and 2003).

The name *Goniothalamus* was first proposed by Blume (1830) in *Flora Javae* as a section of the genus *Polyalthia* to accommodate *Polyalthia macrophylla*. Hooker and Thomson (1855) later elevated this section to a genus in their *Flora Indica*. Boerlage (1899) incorporated *Beccariodendron*, a monospecific New Guinean genus, into *Goniothalamus*. The section *Beccariodendron* of Boerlage was found to accommodate *Beccariodendron grandiflorus* and the multi-ovulate *Goniothalamus* species. Other *Goniothalamus* species, with only one or two ovules, were then grouped into the section *Eu-Goniothalamus*.

Bân (1974) proposed a more hierarchical infrageneric classification based mainly on stamen characters. He divided the genus into two subgenera: subgenus *Goniothalamus* (apiculate stamens) and subgenus *Truncatella* (truncate stamens). He also suggested that the subgenus *Goniothalamus* could be divided into two sections: section *Goniothalamus* (with subsections *Goniothalamotypus* and *Pleiospermi*) and section *Longistigma*. The other subgenus *Truncatella* was also divided into two sections: section *Infundibulistigma* (with subsections *Polyspermi* and

Infundibuliformes) and section *Truncatella* (with subsections *Multiseminales* and *Pauciseminales*). However, Mat-Salleh (1993, 2001) in studying *Goniothalamus* species from Borneo, suggested that an infrageneric classification would be more natural if based on floral/leaf characters and habit.

There was a report of the collection of *Goniothalamus* in the adjacent area of Thailand in the past. Ridley (1922) studied the Malayan Annonaceae. He found 30 genera, 180 native species and mentioned 4 cultivated exotics making a total of 184 with 6 varieties, including 14 species of *Goniothalamus*. Thirty – three years later, Sinclair (1955) revised the Malayan Annonaceae of Ridley's. He recognized 38 genera, 198 native and 5 cultivated exotic species making a total of 203 species besides 17 varieties, including 21 species of *Goniothalamus*. In addition, he reported the distribution of seven species in Thailand (*G. subevenius*, *G. macranii*, *G. giganteus*, *G. undulatus*, *G. tortilipetalus*, *G. scortechinii* and *G. tavoyensis*).

Recently, there have been many revisions of *Goniothalamus* in the adjacent areas of Thailand. Many new species and new records have been reported and some of them have a distribution throughout the southern part of Thailand. Several treatments of the genus have been published, including Mat – Salleh's (1993, 2001) revision of *Goniothalamus* in Borneo and adjacent areas based on herbarium specimens and field observations of natural populations. A total of 30 species including 11 new species. In this study *G. macrophyllus* was reported for Thailand. Furthermore, Mat – Salleh studied stamens and pistils using SEM. It was found that stamen and pistil characteristics have been among the most important traits used in taxonomy and evolutionary interpretations, although these organs are very small and much distorted in dried specimens. Four leaf types, five inner – petal dome types, eleven stamen types and nine pistil types were illustrated and described.

Saunders (2003) had made many revisions of *Goniothalamus* in Southeast Asia and stated that *Goniothalamus* is widely distributed in Southeast Asia, with a centre of diversity in Indochina and Western Malaysia. The first revision of *Goniothalamus* in the Malaysian Peninsular, Sumatra and Java (Saunders, 2001), classified approximately 21 species in the Malaysian Peninsular (including one new species), 15 species in Sumatra (including approximately seven new species) and two species in

Java. Most species are comparatively narrowly distributed, with only five species (*G. giganteus*, *G. malayanus*, *G. ridleyi*, *G. tapis* and *G. uvarioides*) occurring in both the Malaysian Peninsular and Sumatra, and only one species (*G. macrophyllus*) occurring in all three regions. His research has highlighted the importance of fruit and seed characters in the taxonomy of the genus, and suggests that several characters (most notably staminal connective shape) are not as useful as previously believed. He (Saunders, 2002) published a revision of the species of *Goniothalamus* in Sumatra and adjacent islands. Fourteen species are recognized, including six endemics and two species are newly recorded from Sumatra. The utility of specific taxonomic characters was also discussed, with particular emphasis on petal indumentum, staminal connective shape, ovary indumentum, stigma shape, monocarp size and shape, and seed indumentum. Moreover he found five species in Southern Thailand (*G. tapis*, *G. macrophyllus*, *G. malayanus*, *G. ridleyi*, and *G. giganteus*). Additionally, he revised the species of *Goniothalamus* in the Malaysian Peninsular and Singapore (Saunders, 2003), updating the previous taxonomic treatment by Sinclair (1955). A total of 18 species was recognized, including a new species, *G. tomentosus*. Collections referable to *G. tomentosus* were previously determined as "*G. marcanii*". Other important nomenclatural changes include the reduction of *G. umbrosus* to synonymy with *G. tapis*. Furthermore he reported 7 species that occur in Southern Thailand namely *G. tortilipetalus*, *G. tapis*, *G. macrophyllus*, *G. rotundisepalus*, *G. subevenius*, *G. malayanus* and *G. giganteus*.

There have been few collections of *Goniothalamus* in Thailand. Craib (1925) made a study of Polypetalae in Thailand. He found 9 species of *Goniothalamus* namely *G. calvicarpus*, *G. expansus*, *G. giganteus*, *G. griffithii*, *G. macrophyllus*, *G. marcanii*, *G. saigonensis*, *G. subevenius* and *G. undulatus*.

A more recent checklist (Bygrave, 1997) listed 21 species of *Goniothalamus*. Additionally, Chalermglin (2001) reported a preliminary survey and collection of the Annonaceae in Thailand. Twenty three species of *Goniothalamus* were enumerated. Most species have a centre of diversity in the south of Thailand. Bygrave(1997) and Chalermglin (2001) showed that Thailand has a high diversity of Annonaceae,

especially the genus *Goniothalamus*. Therefore, botanical surveys of *Goniothalamus* should be made in Thailand.

RESEARCH OBJECTIVES

To study the taxonomy of the genus *Goniothalamus* in Thailand.

CHAPTER 2

MATERIALS AND METHODS

The taxonomic literature of *Goniothalamus* and related genera in Thailand and adjacent areas was searched. The fundamental data of study sites such as location, topography, climate and flora was studied.

Goniothalamus was collected from different parts of Thailand. The photographs were taken for each species. Ecological data, habit and some diagnostic characters of each species were noted.

Dry and spirit herbarium specimens were made and deposited at CMU herbarium. Morphological characters were studied. Plant specimens were identified to species using both keys and descriptions from taxonomic literature. Specimens of each species were identified by comparison with voucher herbarium specimens deposited at CMU, BCU, BKF, BKK and overseas herbaria. The study included detailed studies of the size, shape and habitats of various species; their floral, fruit and seed morphology illustrations and key to species were included. Each species was described in detail.

CHAPTER 3
RESULTS

Twenty specimens of *Goniothalamus* in Thailand were collected. They form 16 identifiable species and 4 unidentified species which have names referring to their locality. The scientific names, vernacular name and localities are shown in Table 3.1

Table 3.1 List of *Goniothalamus* in Thailand.

Taxon	Vernacular name	Locality (province)
<i>G. aurantiacus</i> R. M. K. Saunders & Chalermglin	ป่าหน้เมืองกาญจน์	Thong Pha Phum (Kanchanaburi)
<i>G. cheliensis</i> Hu	ป่าหน้ยัณฑ์	Doi Phu Kha (Nan)
<i>G. elegans</i> Ast	ป่าหน้จิว	Phu Phan (Sakon Nakhon)
<i>G. giganteus</i> Hook. f. & Thoms.	ป่าหน้ช้าง	Khao Chong (Trang)
<i>G. griffithii</i> Hook. f. & Thomson	สับนงป่า	Doi Saket (Chiang Mai)
<i>G. laoticus</i> (Finet & Gagnep.) Bân	ข้าวหลามดง	Khao Yai (Nakhon Ratchasima)
<i>G. macrophyllus</i> (Blume) Hook. f. & Thomson	กิ่งเดี่ยวดอกเดี่ยว	Khao Pho Ta Luang Kaew (Ranong)
<i>G. maewongensis</i> R. M. K. Saunders & Chalermglin	-	Chong Yen (Kamphaeng Phet)
<i>G. marcanii</i> Craib	ข้าวหลาม	Phu Mu (Mukdahan)
<i>G. malayanus</i> Hook. f. & Thomson	ป่าหน้พรุ	Ba Cho (Narathiwat)

Table 3.1 List of *Goniothalamus* in Thailand (continued)

Taxon	Thai name	Locality (province)
<i>G. repevensis</i> Pierre ex Finet & Gagnep.	เสียดสยาม	Khao Soi Doaw (Chanthaburi)
<i>G. sawtehii</i> Fischer	บุหงาหยิก	Phanoenthung (Phetchaburi)
<i>G. tapis</i> Miq.	บุหงาลำเจียก	Sai Buri (Pattani)
<i>G. tortilipetalus</i> Henderson	ป่าหน่นมรกต	Thong Pha Phum (Kanchanaburi)
<i>G. umbrosus</i> J. Sinclair	ป่าหน่นพอม	Khlong Thom (Krabi)
<i>G. undulatus</i> Ridl.	ลำเหล้าต้น	Khlong Na Kha (Ranong)
<i>G. sp.</i> Aunglaeonai	-	Aunglaeonai (Chachoengsao)
<i>G. sp.</i> Maerim	-	Kanchanaburi
<i>G. sp.</i> Narathiwat	ป่าหน่นสร้อย	Mueng (Narathiwat)
<i>G. sp.</i> Sunyataram	-	Thong Pha Phum (Kanchanaburi)

GONIOTHALAMUS (BLUME) HOOK. F. & THOMS.

Goniothalamus (Blume) Hook. f. & Thoms., Fl. Ind. 1: 105. 1855. *Polyalthia* Blume Sect. *Goniothalamus* Blume, Fl. Javae 28 – 29: 71, tab. 39 & 52B. 1830. - Type: *Goniothalamus macrophyllus* (Blume) Hook. f. & Thoms.

Arutegia Bedd., Madras J. Lit. Sci. ser. 3. 1: 37, pl. 1. 1864.- Type: *Atrugia wynadensis* Bedd. (= *Goniothalamus wynadensis* (Bedd.) Bedd.).

Beccariodendron Warb., Bot. Jahrb. Syst. 13: 452. 1891.- Type *Beccariodendron grandiflorum* Warb.(= *Goniothalamus grandiflorus* (Warb.) Boerl.)

Tree, shrub or monocaulous treelets. *Leaves* coriaceous, subcoriaceous or chartaceous, typically ovate or oblong, occasionally elliptic or oblanceolate; venation consistency brochidodromous or slightly eucamptodromous; secondary veins prominent or inconspicuous, straight, parallel, normally in 10 – 15 pairs, 20 – 25 pairs or 30 – 40 pairs; intersecondary veins prominent or inconspicuous; tertiary veins prominent or inconspicuous, random-reticulate, weakly percurrent or percurrent (if percurrent, tertiaries are sinuous, oblique to mid-vein and parallel to each other); petiole short (less than 1 cm long) or long (2 – 3 cm long), normal or inflated. *Flower* axillary or supra-axillary, terminal, cauliferous or clumped at the base of the trunk; pedicel with several imbricate at the base, triangular, ovate, lanceolate or elliptic; sepal 3, valvate, chartaceous, free with broad truncate base or clawed or connate to form a cup, sometimes persistent in fruit; petals 6, in two whorls, valvate, coriaceous, outer petals 3, often longer than inner, or just slightly longer or more or less equal in length, free, boat-shaped, flat and convex, clawed or truncate at the base, inner petals 3, very often clawed, cohering above to form a vaulted dome-shaped cap or over the stamens and pistils; stamens numerous, laminar, linear or oblong, connectives prominent, apiculate, blunt-acute, broadly acute, truncate or capitate, mostly glandular or sparsely pubescent throughout, or glandular pubescent at the tip of the apex only and scurfy papillate at base; pollen grains large, 50 – 70 μm in diameter, globose, bound together in tetrads by an irregularly patterned material and cover with sticky pollenkit; ovaries numerous, cylindrical-obclavate, pubescent or glabrous; ovules 1-2 or (3-) 5-10; styles

tubular or cylindrical, more or less the same diameter as the ovary, or less than half of the diameter of the ovary, longer than the ovary or very short and insignificant, glabrous, warty or hairy, grooved adaxially; stigma integral, crateriform, fusiform or club-shaped, upright, slightly curved to the outside or curled 360° to the inside, glabrous, warty or with trichomes. *Fruits* apocarpous. Pedicel stout or slender, sometimes with sepal remnants; carpel subsessile or sessile, or with longer stalk; mature carpels orbicular, ovate, elliptic, oblong or moniliform, rarely linear, seeds 1-2 or 3-10, endosperm ruminant.

KEY TO THAI *GONIOTHALAMUS* SPECIES

1. Apiculate stamen connective, ovule 1

2. Stigma minute; sepal reticulation distinct; leaves with minute brown dots

3. Sepal ovate; petiole glabrous

4. Sepal glabrous; leaves about 22 – 26 x 5 -6 cm

5. *G. griffithii*

4. Sepal hairy both sides; leaves about 35 – 42 x 8.5 -10 cm

20. *G. sp. Sunyataram*

3. Sepal triangular; petiole hairy

5. Sepal hairy both sides; outer petal lanceolate, apex gradually
aristate, about 6.5 x 2.3 cm

14. *G. tortilipetalus*

5. Sepal hairy inside; outer petal broadly lanceolate, apex
acuminate, about 4.5 x 2 cm

18. *G. sp. Maerim*

2. Stigma broad; cylindrical, clavate or funnel shape, sepal reticulation
indistinct; leaves without minute brown dots

6. Leaves up to 14 – 17 cm long, 4.5 – 5.5 cm broad, chartaceous or
subcoriaceous; stigma cylindrical or funnel shape

7. Stamen sharply apiculate; stigma cylindrical shape; outer petal long acuminate at apex, greenish or yellowish

15. *G. umbrosus*

7. Stamen bluntly apiculate; stigma funnel shape; outer petal acute at apex, green or creamy, sometimes tinged with purple

13. *G. tapis*

6. Leaves up to 37 – 40.5 cm long, 7.5 – 10 cm broad, coriaceous; stigma claviform

7. *G. macrophyllus*

1. Truncate or convex stamen connective, ovule 1 or more

8. Ovule 1-2

9. Stigma minute or coiled

10. Stigma minute; outer petal up to 2 – 3.5 x 1.1 – 2 cm

11. Ovary hairy; stigma glabrous; outer petal reflexed to inside; inner petal hairy outside, glabrous inside

17. *G. sp. Aunglaeonai*

11. Ovary glabrous; stigma warty outer petal reflexed to outside; inner petal hairy both sides

12. *G. sawtehii*

10. Stigma coiled; outer petal very large up to 12 x 6 cm

4. *G. giganteus*

9. Stigma claviform or cylindrical

12. Stigma claviform

13. Ovary hairy

14. Outer petal glabrous, ovate, coriaceous, 2.2 x 1.3 cm; leaves elliptic, 10 – 11.5 x 4 – 4.7 cm

19. *G. sp. Narathiwat*

14. Outer petal hairy, lanceolate, more succulent, 3.2 x 1.9 cm, leaves oblong, 18 x 5.5 cm

16. *G. undulatus*

13. Ovary glabrous

15. Outer petal elliptic, 1.5 cm long; inner petal hairy both sides; leaves lanceolate; thin, 12 – 15 x 3 – 4 cm

3. *G. elegans*

15. Outer petal ovate, 2 cm long; inner petal hairy outside; leaves oblong, coriaceous, 12 – 23 x 4.5– 6.5 cm

10. *G. marcanii*

12. Stigma cylindrical; outer petal yellowish and becoming pink-red with age

11. *G. repevensis*

8. Ovule more than 2

16. Stigma fusiform

17. Inner petal broadly obtuse toward apex, claw shaped rather broad; dome orbicular; petal triangular

18. Ovary hairy, ovule 2-3; petiole hairy

1. *G. aurantiacus*

18. Ovary glabrous, ovule 5; petiole glabrous

8. *G. maewongensis*

17. Inner petal acute at the apex, claws rather slender, gradually broad about 1/2 part of inner petals to apex, dome bluntly acute; petal suborbicular

6. *G. laoticus*

16. Stigma cylindrical or coiled

19. Leaves 55 – 66 x 16 – 20 cm, coriaceous; outer petal ovate, more succulent; stigma cylindrical

2. *G. cheliensis*

19. Leaves 14 – 15 x 4 – 5 cm, chartaceous; outer petal lanceolate, thinly coriaceous, stigma coiled **9. *G. malayanus***

1. *Goniothalamus aurantiacus* R. M. K. Saunders & Chalermglin, Botanical Journal of the Linnean Society 156: (2008) 356 – 359, Figs. 1 - 3. Figure 3.1; 3.2.

Small tree about 4 - 7 m high; bark pale brown; branchlets straight, pale brown, glabrous, striate. *Leaves* simple, alternate; blades oblong, thinly chartaceous; bluntly acuminate at the apex, broadly acute at the base; glabrous above, sparsely rusty puberulous below; midrib grooved above, raised below; secondary nerves 12 - 15 pairs, fine but visible above, raised below, anastomosing in loop near the margin, 16 - 21 cm long, 5 - 6.5 cm broad. *Petioles* grooved above, sparsely rusty puberulose, dark, 10 mm long. *Flowers* solitary, axillary or on mainstem and branches; pedicel about 0.8 - 1 cm long, rusty puberulous, with 4 scale-like, green bracts at the base. *Sepals* triangular, nearly free, coriaceous, acute at the apex; rusty puberulous outside, glabrous inside; 1 cm long, 0.7 cm broad, green. *Petals* 6, yellowish; outer 3, orbicular, apex acute, one - veined distinct, raised outside, faint inside, several lateral grooved arising from base both sides, margin curve reflexed to inside, coriaceous, densely rusty puberulous both sides, except at base inside, 2.8 x 2.3 cm; inner 3, smaller, orange, densely rusty puberulous outside, with densely pale brown hairs inside, except at the base, claw; 14 x 10 mm, coriaceous. *Stamens* numerous, 2.5 mm long, connectives truncate. *Pistils* several, vertically grooved, 7 mm long; stigma fusiform, warty, canaliculate; style short; ovary cylindrical, pale brown hairs; ovule 2 - 3, parietal.

Thailand – southwestern: Kanchanaburi, Thong Pha Phum

Distribution – Endemic to South-Western Thailand (Kanchanaburi Province)

Ecology – Evergreen forest, 300 m elevation

Phenology – Flowering January - March

Specimens examined - Yuyen 219 (CMU)

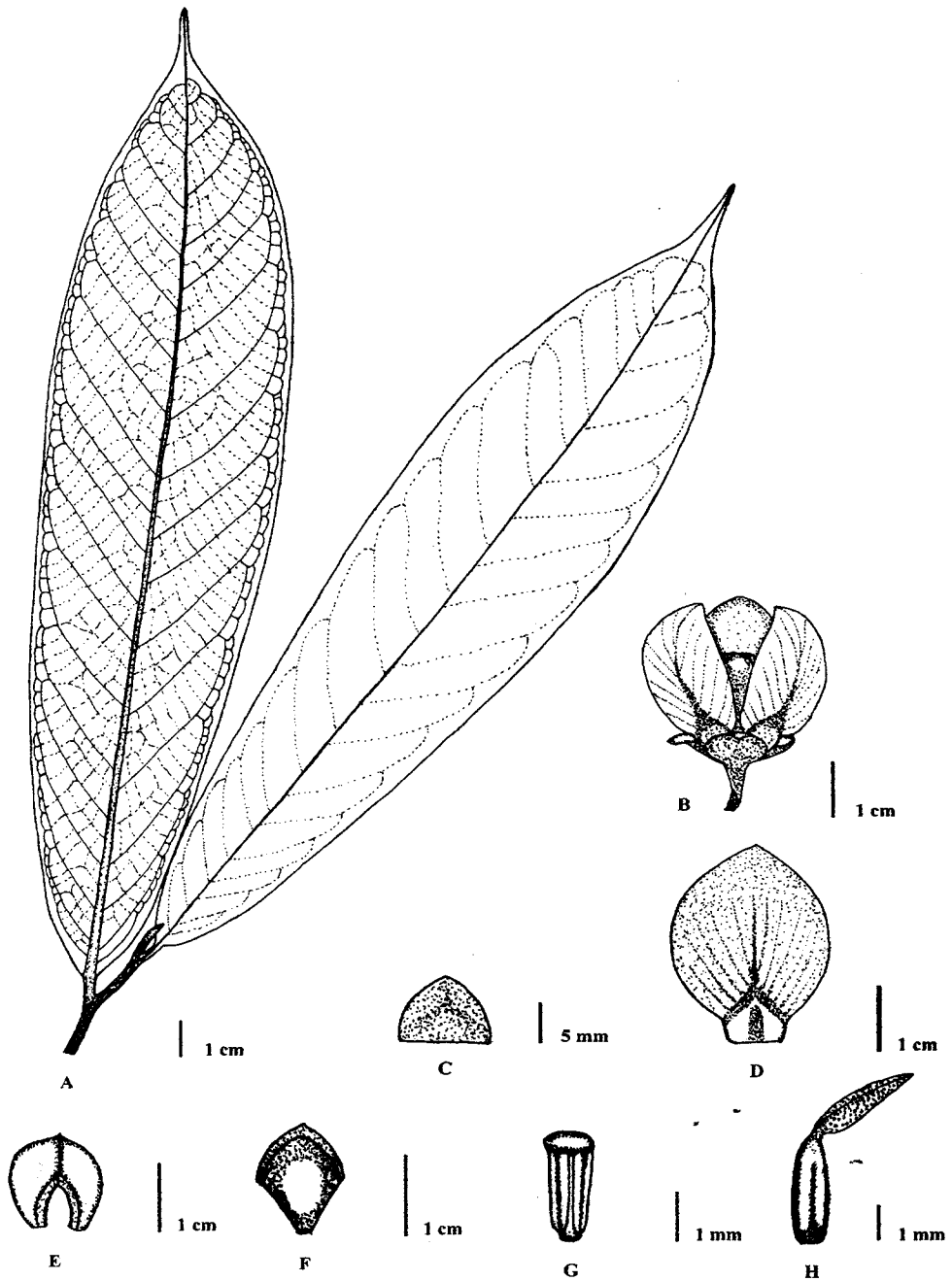


Figure 3.1 *Goniothalamus aurentiacus* R. M. K. Saunders & Chalermglin: A. twig; B. flower; C. outside of sepal; D. inside of outer petal; E. connate of inner petals; F. inside of inner petal;



Figure 3.2 *Goniiothalamus aurentiacus*: Flower (Photograph by Chalermglin).

2. *Goniothalamus cheliensis* Hu, Bull. Fan Mem. Inst. Biol. 10 (1940)121-128. Figure 3.3; 3.7 (A).

Evergreen treelet about 3 m high; bark striate, pale grey; branchlets straight, brown, densely brown tomentose. *Leaves* simple, alternate; blades coriaceous, obovate, apex caudate, broadly acute at the base; dull glossy brown above when dry, brown below; glabrous above, with some brown tomentum on the midrib, midrib densely brown tomentose below, especially so on veins and margins; main nerves *c.* 24 - 32 pairs, secondary nerves arching, anastomosing, fine above, prominent and raised below, 56 - 66 cm long, 16 - 20 cm broad; margins entire, revolute. *Petioles* dorsally grooved, densely brown tomentose, 2.5 - 3 cm long. *Flowers* solitary or in groups from woody tubercles on the main stem or main branches; pedicels about 1.5 cm long, densely brown tomentose, with 4 - 5 bracts at the base. *Sepals* coriaceous, broadly ovate, apex acuminate; brown sericeous on both sides, especially on the main veins outside, except at the base inside; green, 4 cm long, 2.5 cm broad. *Petals* 6, coriaceous, greenish-yellowish, outer 3 ovate, apex acute; rusty puberulous on both sides, especially on the main veins outside, except at the base inside; veins prominent inside; claw broad, 6.5 cm long, 3.5 cm broad; inner 3 velutinous outside, especially on main veins, glabrous inside; claws; 3.3 cm long, 1.8 cm broad. *Stamens* numerous, 3 mm long, connectives convex. *Pistils* several, vertically grooved, 8 mm long; ovary cylindrical, densely brown tomentose; stigma cylindrical, incurved, canaliculate, glabrous; ovules 4; placentation parietal.

Thailand - North: Chiang Rai, Doi Tung; Nan, Doi Pu Kah

Distribution - Southwestern Yunnan

Habitat - Primary, evergreen, seasonal, hardwood forest at 1,000 m elevation

Phenology - Flowering March - April; fruits September (Yunnan)

Specimens examined - Yuyen 220 (CMU)

Note: Hu's description indicates that the branchlets of *G. cheliensis* are black hirsute (specimen collected by C. W. Wang from Che-Li Hsien, Maan-Shang, southwestern Yunnan), but in my specimens the branchlets are densely brown tomentose. The specific epithet refers to the place where the type material was collected. This species has the biggest leaves for *Goniothalamus* in Thailand.

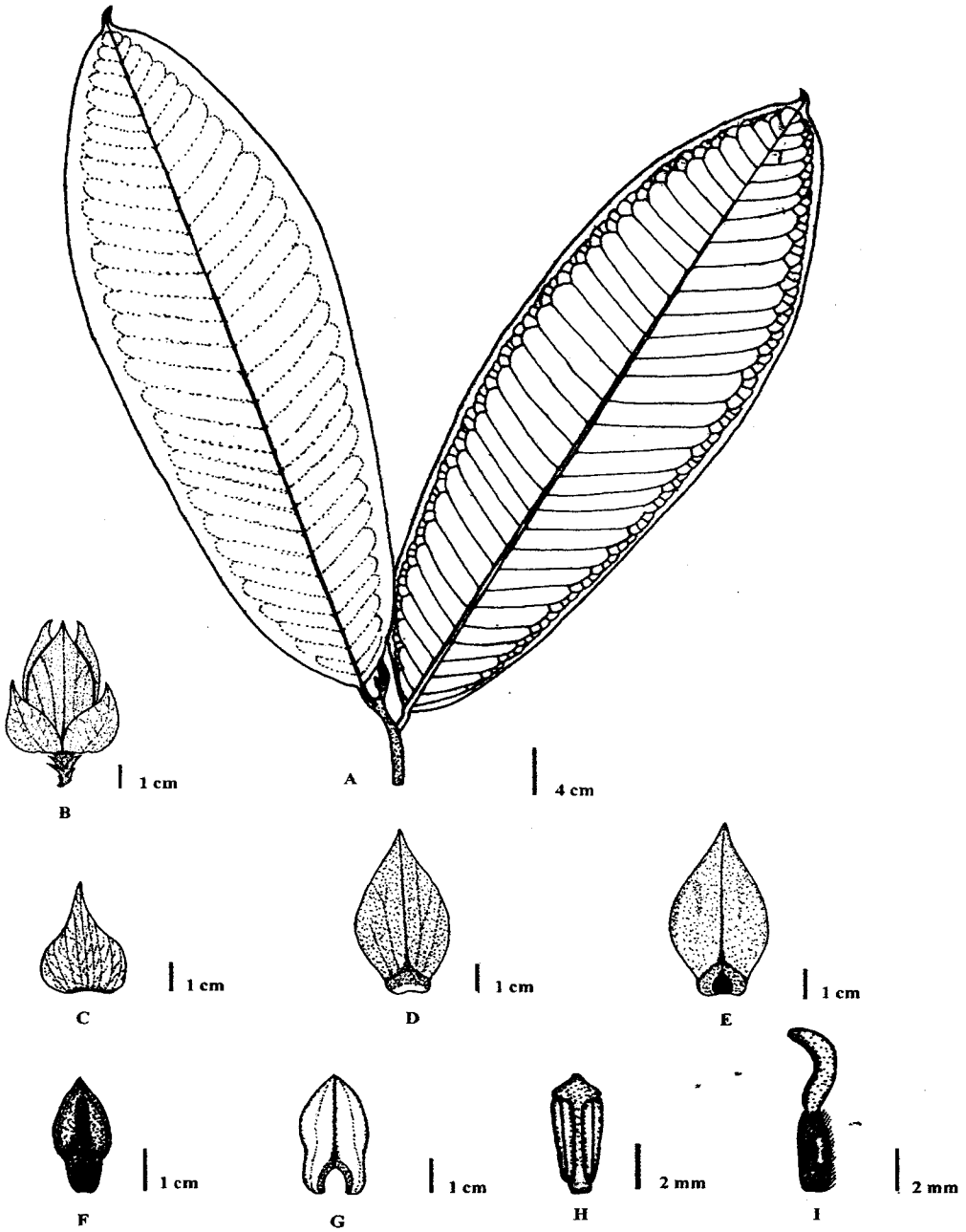


Figure 3.3 *Goniothalamus cheliensis* Hu, A. twig; B. flower; C. outside of sepal; D. outside of outer petal; E. inside of outer petal; F. inside of inner petal; G. connate inner petals; H. stamen; I. pistil. (A-I Yuyen 220) drawn by Y. Yuyen.

3. *Goniothalamus elegans* Ast, Bull. Soc. Bot. France 85 (1938) 52 and Fl. Gén. de l'Indo-Chine Supplément (1938) 97 and Fig. 8, 1 – 6 (p. 96). Figure 3.4; 3.7 (C-D).

Evergreen treelet about 2 m high; bark glabrous, brown; branchlets straight, brown, densely rusty puberulous, becoming sparsely rusty puberulous to glabrous when older. *Leaves* simple, alternate; blades lanceolate, thin; apex acute, base acute; green above, pale green below; young blades densely rusty puberulous on both sides, especially ventrally, older blades sparsely rusty puberulous, especially on the ventral midrib and nerves; midrib grooved above, raised below; secondary nerves 14 – 15 pairs, fine, indistinct above, obscure below, curving and anastomosing near the margin, finer venation reticulate; 12 – 15 x 3 – 4 cm. *Petioles* dorsally grooved, sparsely rusty puberulous, 4 – 5 mm long. *Flowers* axillary, solitary; pedicel about 4 mm long, densely rusty puberulous, with 4 scale-like, green bracts at the base, 1 – 2 mm long. *Sepals* suborbicular, coriaceous, shortly acute at the apex; finely rusty puberulous outside, glabrous inside, greenish; 7 mm long, 6 mm broad. *Petals* 6, coriaceous, greenish – yellow; outer 3, elliptic, apex acute, medially keeled and brown sericeous outside, brown velutinous inside except at the base, 1.5 x 0.9 cm; inner 3, similar to the outer 3, but smaller, 12 x 6 mm, united. *Stamens* numerous, 2 mm long, connectives convex. *Pistils* several, vertically grooved; stigma claviform, canaliculate, warty toward apex; style linear, 4 mm long; ovary cylindric, glabrous; ovule 1, basal. *Monocarp* 5 – 10, ellipsoid, glabrous, green becoming orange when ripe, 1.5 x 1 cm; stalks 5 mm long, *Seed* 1, ellipsoid, testa brown, endosperm ruminant.

Thailand – north-eastern: Sakon Nakhon, Phu Phan; eastern: Ubon Ratchatani, Phu Chong Na Yoi

Distribution – Annam

Ecology – Seasonal deciduous or mixed evergreen + deciduous forest, 300 -500 m elevation

Phenology – Flowering April-May, fruiting July

Specimens examined - Yuyen 226 (CMU), Yuyen 224 (CMU)

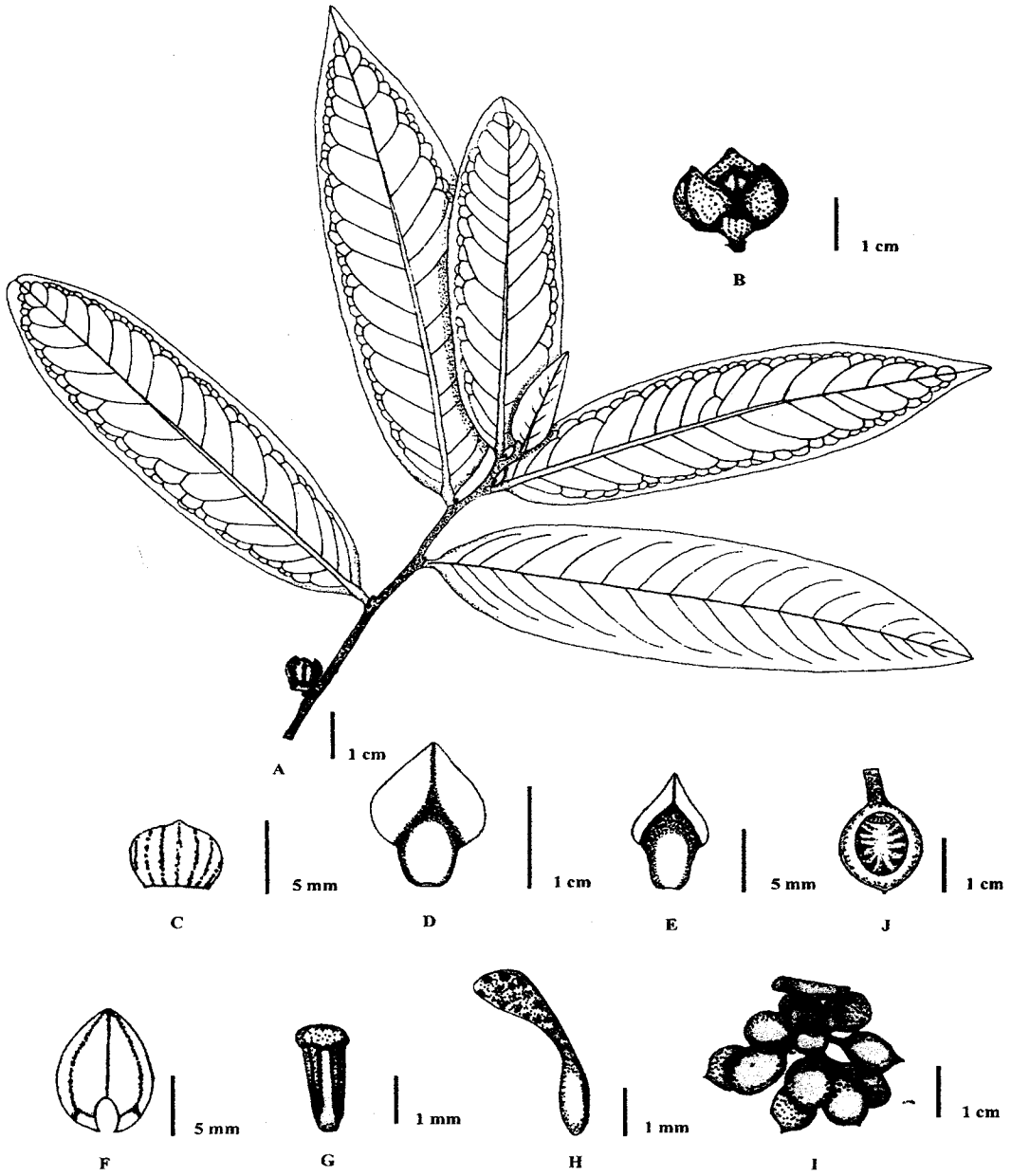


Figure 3.4 *Goniothalamus elegans* Ast: A. flowering twig; B. flower; C. outside of sepal; D. inside of outer petal; E. inside of inner petal; F. connate inner petals; G. stamen; H. pistil; I. monocarps; J. monocarp L. S., showing one seed. (A-J Yuyen 226) Drawn by Y. Yuyen.

Note: Ast's description indicates that the mature leaf blades of *G. elegans* are glabrous and the stigma is funnellform (specimen collected by E. Poilane from Annam, N. Vietnam), but in my specimens the mature leaf blades are rusty puberulous on the midrib and secondary nerves ventrally. The stigmas are claviform.

4. *Goniothalamus giganteus* Hook. f. & Thoms. Flora Indica 1: (1855) 109., Fl. Brit. India 1: (1872) 75; King, Ann. Roy. Bot. Grad. (Calcutta) 4: (1893) 93 – 94, pl.130; Ridley, Fl. Malay Penins. 1 (1922) 65 – 66; Craib, Fl. Siam. Enum. 1 (1925) 50; J. Sinclair, Grad. Bull., Singapore 14 (1955) 431 – 432; R. M. K. Saunders, Bot. J. Linn. Soc. 139: (2002) 233 – 234., Bot. J. Linn. Soc. 142: (2003) 336. *Uvaria gigantea* Wall., Pl. Asiat. Rar. 3 no 6469 A (1832) nom. Nud. *Oxymitra gigantea* (Wall.) Lotsy, Votr. Bot. Stammesg. 3: (1911) 463. Figure 3.5; 3.7 (B).

Evergreen small tree about 10 - 18 m high; bark brown, striate; branchlets straight, pale brown, striate. *Leaves* simple, alternate; blades oblong, coriaceous; acuminate at the apex, cuneate at the base, edges slightly recurved; brown shining above when dry, pale brown below, glabrous above, sparsely brown hairs below; midrib grooved above, sharply raised below, secondary nerves 18 pairs, fine, raised on both surfaces, interarching 6 mm from margin, reticulation fine, distinct; 20 – 24 x 6 – 6.5 cm. *Petioles* stout, dark brown, deeply grooved above, wrinkled, sparsely rusty hairs below, 9 mm long. *Flowers* solitary from the axil of fallen leaves or from woody tubercles on the main stem; pedicel about 1.7 - 3.5 cm long, thickening towards base of calyx, rusty puberulous, with 2 scale-like, green bracts at the base. *Sepals* triangular, coriaceous, acute at the apex, rusty puberulous both sides, greenish; 10 mm long, 9 mm broad. *Petals* 6, coriaceous, greenish then becoming yellowish when older; outer 3, broadly ovate, apex acute, twisted, margin undulate; rusty puberulose both sides, with densely rusty puberulose at the base outside, one main vein and several lateral ones arising from base, 12 x 6 cm; inner 3, smaller, 2.5 x 1.2 cm, broadly lanceolate, coriaceous, shortly clawed, densely pale brown puberulose outside, glabrous inside, united by the margin above the claws. *Stamens* numerous, 2.5 mm long, connectives convex. *Pistils* several, vertically grooved, 7 mm long; stigma

minute, canaliculated, coiled; style linear, warty toward apex; ovary cylindrical, densely pale brown hairs; ovule 1-2.

Thailand – southern: Narathiwat, Su Ngai Padeé, Tak Bai; Trang, Khao Chong

Distribution – Peninsular Malaysia, Sumatra and lower Siam

Ecology – Evergreen forest, 150 – 400 m elevation

Phenology – Flowering July – August

Specimens examined - Chalermglin 20 – 08 – 1996 (CMU), and Yuyen 248 (CMU), H. A. Ridley 005310 (S.), E. J. H. Corner 28739 (S.), C. Niyomdham et al. 1111 (BKF), C. Niyomdham 965 (BKF), Kiah 24380 (BK)

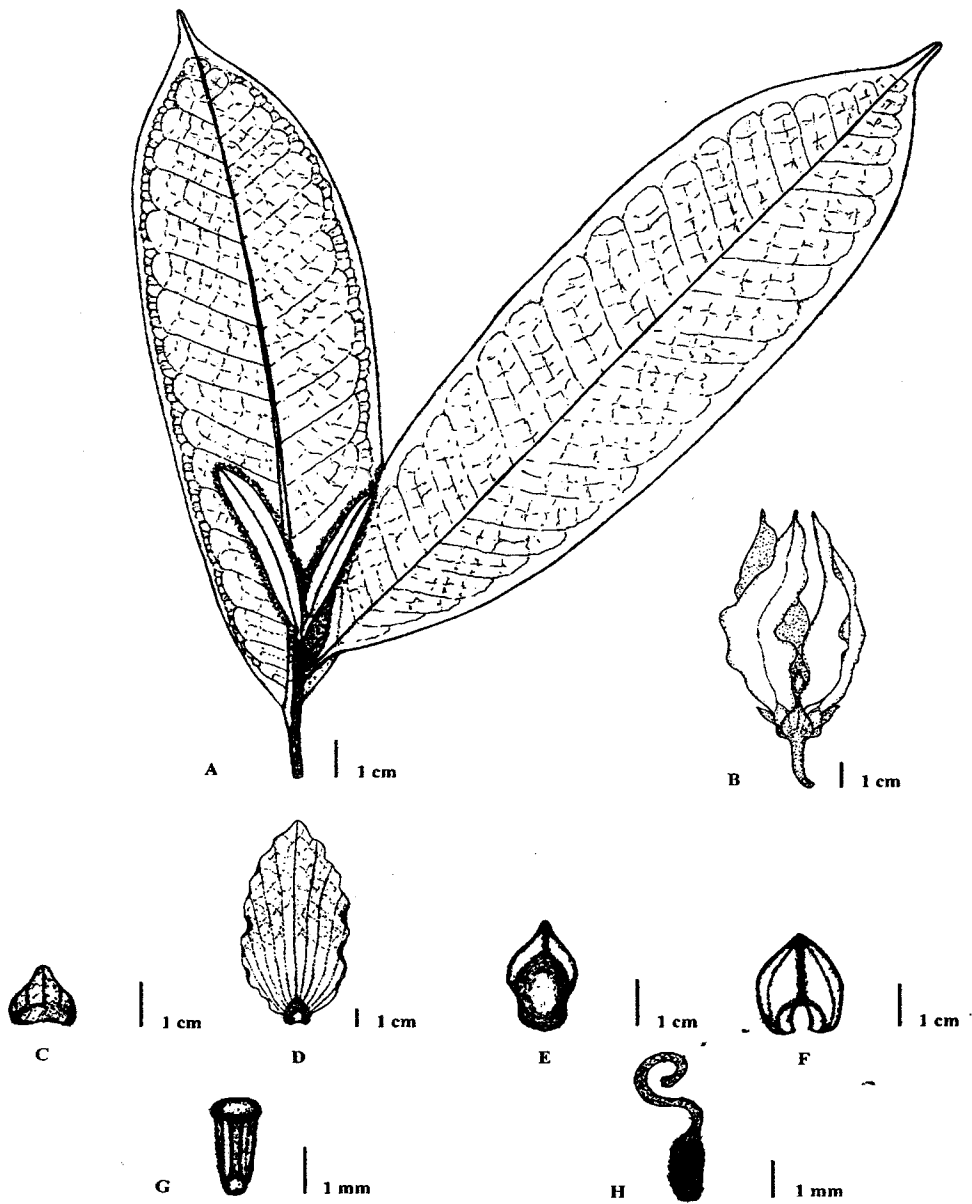


Figure 3.5 *Goniothalamus giganteus* Hook. f. & Thoms.: A. twig; B. flower; C. outside of sepal; D. inside of outer petal; E. inside of inner petal; F. connate of inner petals; G. stamen; H. pistil. (A Yuyen 248; B-H Chalermglin 20-08-1996) Drawn by Y. Yuyen.

5. *Goniothalamus griffithii* Hook. F. & Thoms. Fl. Ind. 1: (1855) 110., Fl. Brit. India 1: (1872) 73; King, Ann. Roy. Bot. Grad. (Calcutta) 4: (1893) 97, pl.136; Ast, Fl. Gén. de l'Indo-Chine Supplément (1938) 99. Figure 3.6; 3.7 (E).

Evergreen treelet about 2 - 4 m high; bark pale brown, striate; branchlets straight, pale brown, striate. *Leaves* simple, alternate; blades oblong, coriaceous; acuminate at the apex, acute at the base; brown above when dry, pale brown below, glabrous both side, with densely brown glandular dots; midrib grooved above, raised below; secondary nerves 11 – 21 pairs, prominent both side, curving and anastomosing some distance from the midrib, reticulation faint; 22 – 26 x 5 – 6 cm. *Petioles* stout, grooved above, wrinkled, glabrous, 1 – 1.2 cm long. *Flowers* solitary, axillary or in groups from woody tubercles on the main stem; pedicel about 10 - 12 mm long, broadening towards base of calyx, sparsely puberulous, with 3 - 4 scale-like, green bracts at the base. *Sepals* ovate, chartaceous, acute at the apex, nearly free to base; glabrous both sides, except rusty pubescent at the margins; several veins, reticulation distinct; 1.5 - 2 cm long, 1.1 – 1.7 cm broad, green. *Petals* 6, coriaceous, densely rusty glandular hairs both side, except at the base inside, greenish - yellowish; outer 3, lanceolate, apex acute, one – prominent veined outside; claw rather broad; 3.5 – 4.5 x 1.1 – 1.3 cm; inner 3, smaller, coriaceous, rusty glandular hairs with one vein outside, scurfy inside, except at the base; 20 x 5 - 7 mm, lanceolate, long acuminate at the apex. *Stamens* numerous, 3 mm long, connectives apiculate. *Pistils* several, vertically grooved, 6 mm long; stigma minute, canaliculate; style linear, warty toward apex; ovary cylindrical, densely rusty hairs; ovule 1, basal.

Thailand – northern: Chiang Mai, Doi Saket

Distribution – Thailand, Myanmar

Ecology – Evergreen forest, 700 – 900 m elevation

Phenology – Flowering April

Specimens examined - Yuyen 247 (CMU), R. Pooma 158 (BKF)

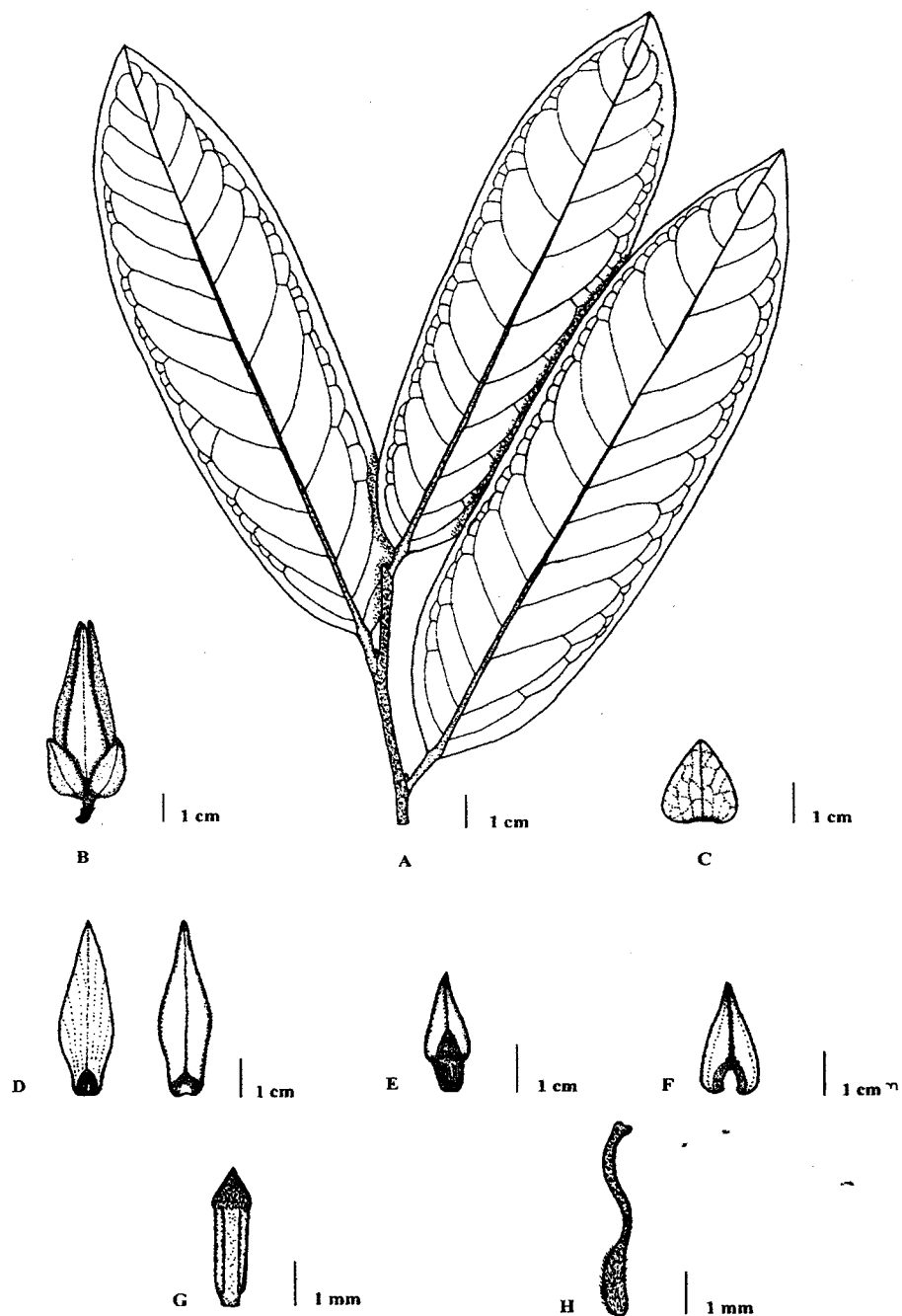
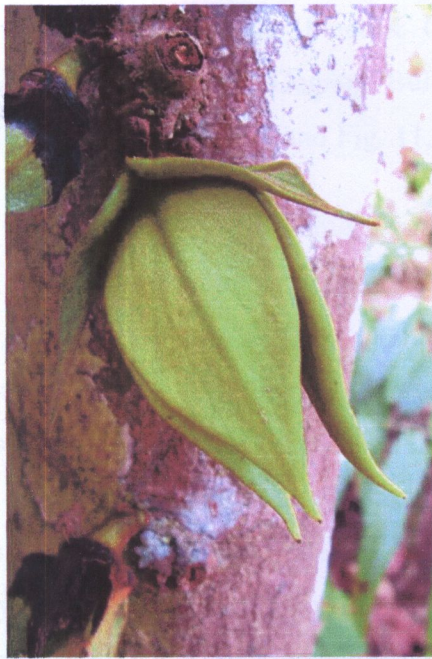


Figure 3.6 *Goniothalamus griffithii* Hook. F. & Thoms.: A. twig; B. flower; C. outside of sepal; D. inside and outside of outer petal; E. inside of inner petal; F. connate inner petals; G. stamen; H. pistil. (A-H Yuyen 247)
 Drawn by Y. Yuyen.



A



C



D



B



E

Figure 3.7 *Goniiothalamus* spp.: A. *G. cheliensis*; B. *G. giganteus*; C. *G. elegans*; D. Monocarps of *G. elegans*; E. *G. griffithii*.

6. *Goniothalamus laoticus* (Finet & Gagnep.) Bân, Bot. Zhurn. 59: (1974) 554; *Mitrephora laotica* Finet & Gagnep, Bull. Soc. Bot. de Fr.: (1907) 87 and Fl. Gén. de l'Indo-Chine I (1907) 92 - 93 and Fig. 11, 1 - 7 (p. 93). Figure 3.8; 3.9 (A-C).

Treelet about 4 - 8 m high; bark glabrous, dark brown; branchlets straight, brown, sparsely rusty puberulous, becoming glabrous when older, striate. *Leaves* simple, alternate; blades oblong, chartaceous; apex bluntly acuminate, base acute; green above, pale green below, glabrous above, sparsely rusty puberulous below, especially on the ventral midrib; midrib grooved above, raised below; secondary nerves 15 - 20 pairs, fine but visible both sides, curving and anastomosing near the margin, finer venation reticulate; 17 - 20 x 3.5 - 4.5 cm. *Petioles* dorsally grooved, densely rusty puberulous, 5 mm long. *Flowers* axillary, solitary or in group on main stem or main branches; pedicel about 1 - 1.5 cm long, sparsely rusty puberulous, with 3 - 5 scale-like, green bracts at the base. *Sepals* suborbicular, coriaceous, acute at the apex; rusty puberulous outside, glabrous inside, greenish; 12 mm long, 14 mm broad. *Petals* 6, coriaceous, greenish - yellow; outer 3, ovate, apex acute, 1 faint vein both side, with several parallel veins rising from the base both side, rusty velutinous inside except at the base, sparsely brown velutinous outside, 5.2 x 2.3 cm; inner 3, similar to the outer 3, but smaller, densely brown puberulous outside, scurfy, with brown hairs inside, except at the base; 14 x 8 mm, united. *Stamens* numerous, 2 mm long, connectives convex. *Pistils* several, vertically grooved; stigma fusiform, canaliculate, warty; style short; ovary cylindrical, glabrous; ovule 3 - 9, marginal. *Monocarp* 10 - 12, ellipsoid, glabrous, green becoming yellowish when ripe, 6 x 2.2 cm; stalks short, *Seed* 3 - 9, ellipsoid, brown.

Thailand - eastern: Nakhon Ratchasima, Khao Yai

Distribution - Laos

Ecology - Seasonal deciduous or mixed evergreen + deciduous forest, 200 - 900 m elevation

Phenology - Flowering April, fruiting July

Specimens examined - Yuyen 250 (CMU)

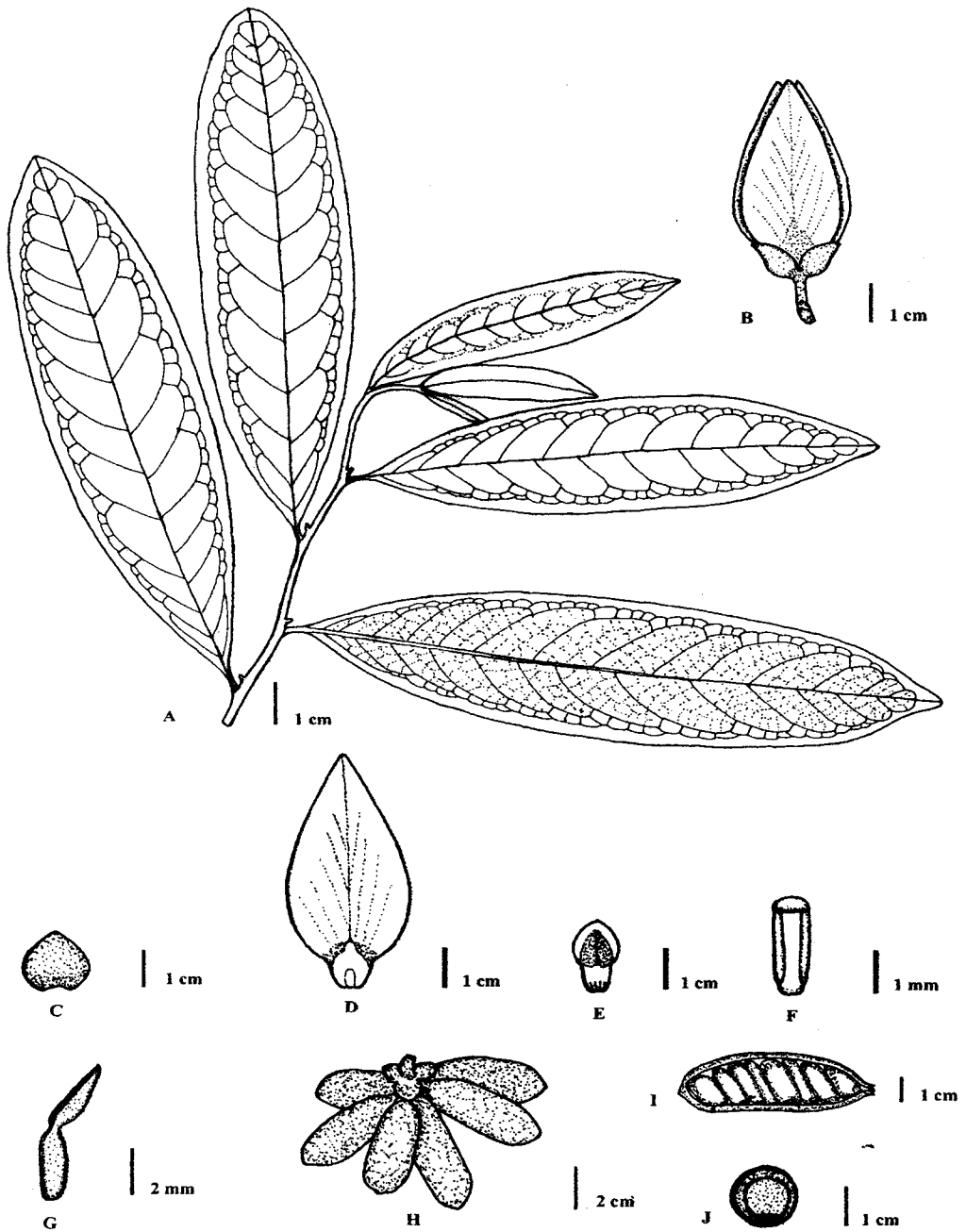
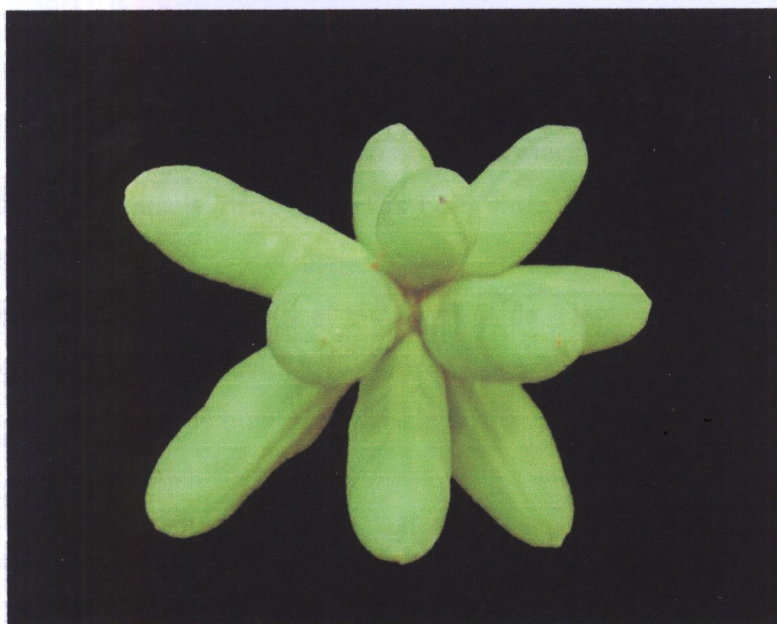


Figure 3.8 *Goniothalamus laoticus* (Finet & Gagnep.) Bân: A. twig; B. flower; C. outside of sepal; D. inside of outer petal; E. inside of inner petal; F. stamen; G. pistil; H. monocarp; I. monocarp L. S. ; J. seed T. S. (A-J Yuyen 250) Drawn by Y. Yuyen.



A

B



C

Figure 3.9 *Goniotalamus laoticus* (Finet & Gagnep.) Bân: A-B. Flowers; C. Monocarps of *G. laoticus*.

7. *Goniothalamus macrophyllus* (Blume) Hook. f. & Thoms. Fl. Indica 1: (1855) 109., Fl. Brit. India 1: (1872) 74; King. Ann. Roy. Bot. Gard. (Calcutta) 4: (1893) 97 – 98, pl. 132; Ridley, Fl. Malay Penins. 1 (1922) 66; Sinclair, James. The Gardens' Bulletin Singapore 14: (1955) 446 – 447; Mat – Salleh, K, B. Revision of the Genus *Goniothalamus* (Annonaceae) of Borneo: (1993) 194 – 195; Saunders, R. M. K. Bot. J. Linn. Soc. 139: (2002) 248 – 250., Botanical Journal of the Linnean Society 142: (2003) 330 – 331. *Unona macrophylla* Blume. Bijdr.: (1825) 17. *Polyalthia macrophylla* (Blume) Blume. Fl. Javae (Annon.): (1830) 79. fig. 39. Figure 3.10; 3.11

Treelet or shrub about 1 - 3 m high; bark dark brown, striate. *Leaves* simple, alternate; blades oblong, coriaceous; bluntly acuminate at the apex, acute at the base; pale brown above when dry, brown below, glabrous both surfaces, margin slightly recurved; midrib grooved above, raised below; secondary nerves 23 – 28 pairs, prominent below, fine but visible above, anastomosing about 5 – 7 mm from the margin; 37 – 40.5 x 7.5 – 10 cm. *Petioles* stout, dark brown – black, deeply grooved above, wrinkled, glabrous, 1.5 – 2.5 cm long. *Flowers* axillary or on the main stem; pedicel about 8 - 10 mm long, thickening towards base of calyx, glabrous, with 3 - 4 scale-like, green bracts at the base. *Sepals* ovate, coriaceous, acute at the apex, slightly cohering at base; sparsely rusty dot hairs both sides, greenish; 1.7 cm long, 1.4 cm broad. *Petals* 6, coriaceous, greenish; outer 3, lanceolate, acute at the apex, sparsely rusty dot hairs both sides, except at the base inside, claw, concave inside, one main vein and several faint lateral ones arising from base, 3 x 1 cm; inner 3, smaller, 13 - 15 x 7 - 8 mm, rusty dot hairs outside with pale brown puberulous at the margin near the apex, densely pale brown hairs at the apex inside, coriaceous, united by the margin above the claws. *Stamens* numerous, slightly incurved, 4 mm long, connectives apiculate. *Pistils* several, vertically grooved, 5 mm long; stigma claviform, bilobed; style short; ovary cylindrical, sparsely rusty hairs at base; ovule 1, basal.

Thailand – south-western: Ranong, Khao Pho Ta Luang Kaew; southern: Nakhon Si Thammarat, Kung Ching Waterfall; Narathiwat, Sukirin; Phangnga

Distribution – Thailand, Peninsular Malaysia, Sumatra, Java and Borneo

Ecology – Evergreen forest, 300 – 1,000 m elevation

Phenology – Flowering January - April

Specimens examined - Yuyen 211 (CMU) and Chalermglin 15 – 01 – 2001 (CMU), H. N. Ridley 1577 (S.), J. Sinclair 39980 (S.), C. Niyomdham et al 4728, 4675, 2253 (BKF), A. F. G. Kerr 18452 (BK)

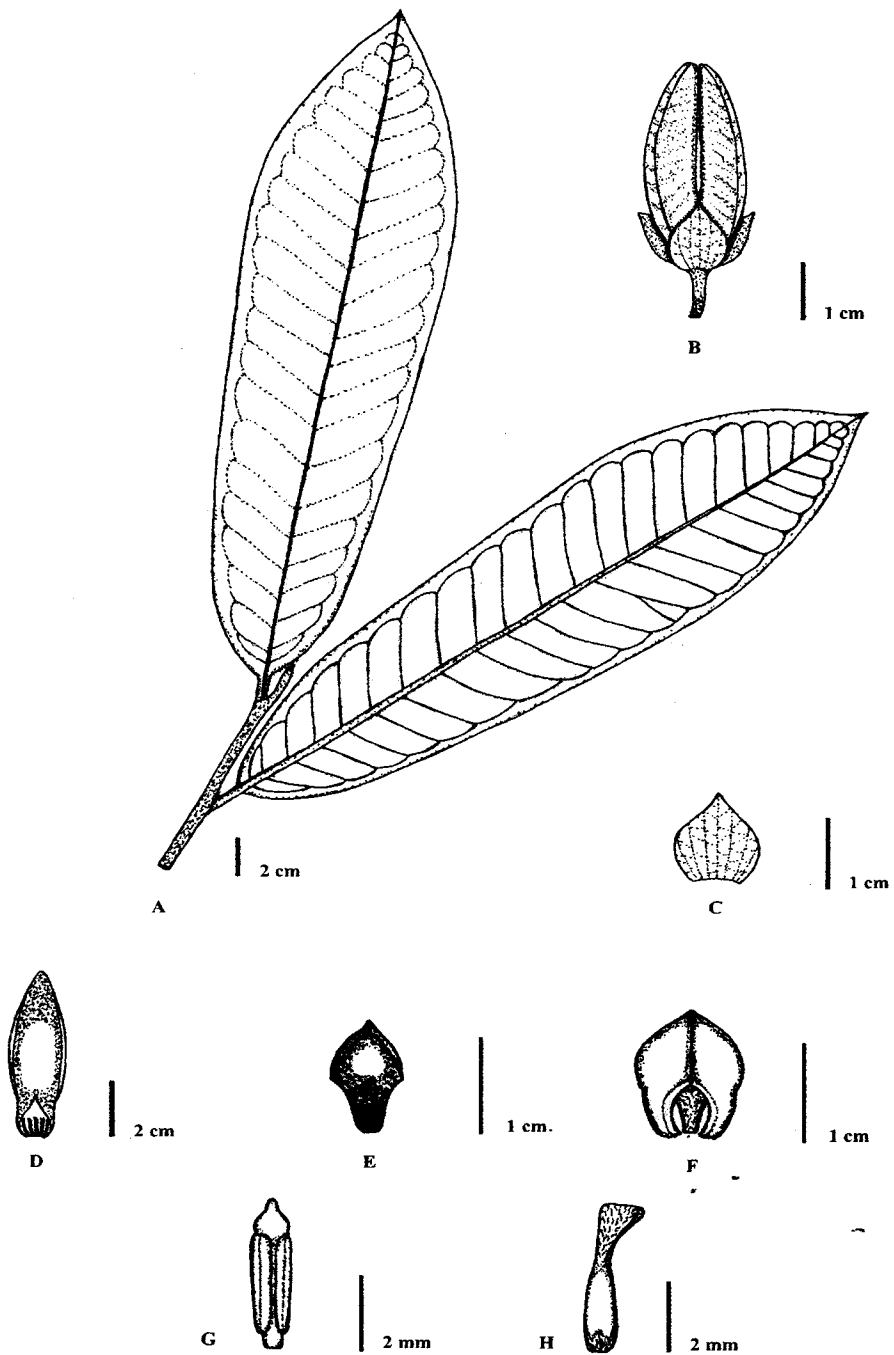


Figure 3.10 *Goniothalamus macrophyllus* (Blume) Hook. f. & Thoms.: A. twig; B. flower; C. outside of sepal; D. inside of outer petal; E. inside of inner petal; F. connate inner petals; G. stamen; H. pistil; (A: Yuyen 211; B – H: Chalermglin 15-01-2001) Drawn by Y. Yuyen.



Figure 3.11 *Goniotalamus macrophyllus*: Flower (Photograph by Chalermglin).

8. *Goniothalamus maewongensis* R. M. K. Saunders & Chalermglin, Botanical Journal of the Linnean Society 156: (2008) 368 – 371, Figs. 22, 23, 29. Figure 3.12; 3.14 (A).

Small tree about 4 - 6 m high; bark pale grey; branchlets straight, pale grey, sparsely rusty puberulous, striate. *Leaves* simple, alternate; blades oblong, thinly chartaceous; bluntly acuminate at the apex, acute at the base; glabrous above, sparsely rusty puberulous below; midrib grooved above, raised below; secondary nerves 15 - 16 pairs, fine but visible above, raised below, anastomosing in loop near the margin, 19 - 24 cm long, 4.5 - 5.5 cm broad. *Petioles* grooved above, glabrous, dark, 1 - 1.5 cm long. *Flowers* solitary, axillary or on main stem and branches; pedicel about 1 cm long, rusty puberulous, with 4 scale-like, green bracts at the base. *Sepals* triangular, united at the base, coriaceous, acute at the apex; densely rusty puberulous outside, glabrous inside; 1 cm long, 0.7 cm broad, green. *Petals* 6, yellowish; outer 3, orbicular, apex acute, one - veined distinct, raised outside, faint inside, several lateral grooved arising from base both sides, margin slightly curve reflexed to outside, coriaceous, densely rusty puberulous both sides, except at base inside, 2.5 x 2 cm; inner 3, smaller, densely rusty puberulous outside, with densely pale brown hairs inside, except at the base, claw; 17 x 11 mm, coriaceous. *Stamens* numerous, 3 mm long, connectives truncate. *Pistils* several, vertically grooved, 6 mm long; stigma fusiform, warty, canaliculate; style short; ovary cylindric, slightly glabrous; ovule 5, parietal.

Thailand – northern: Kamphaeng Phet, Chong Yen

Distribution – Endemic to Northern Thailand (Kamphaeng Phet Province).

Ecology – Evergreen forest, 700 - 900 elevation

Phenology – Flowering March

Specimens examined - Chalermglin 6-3-47 (CMU)

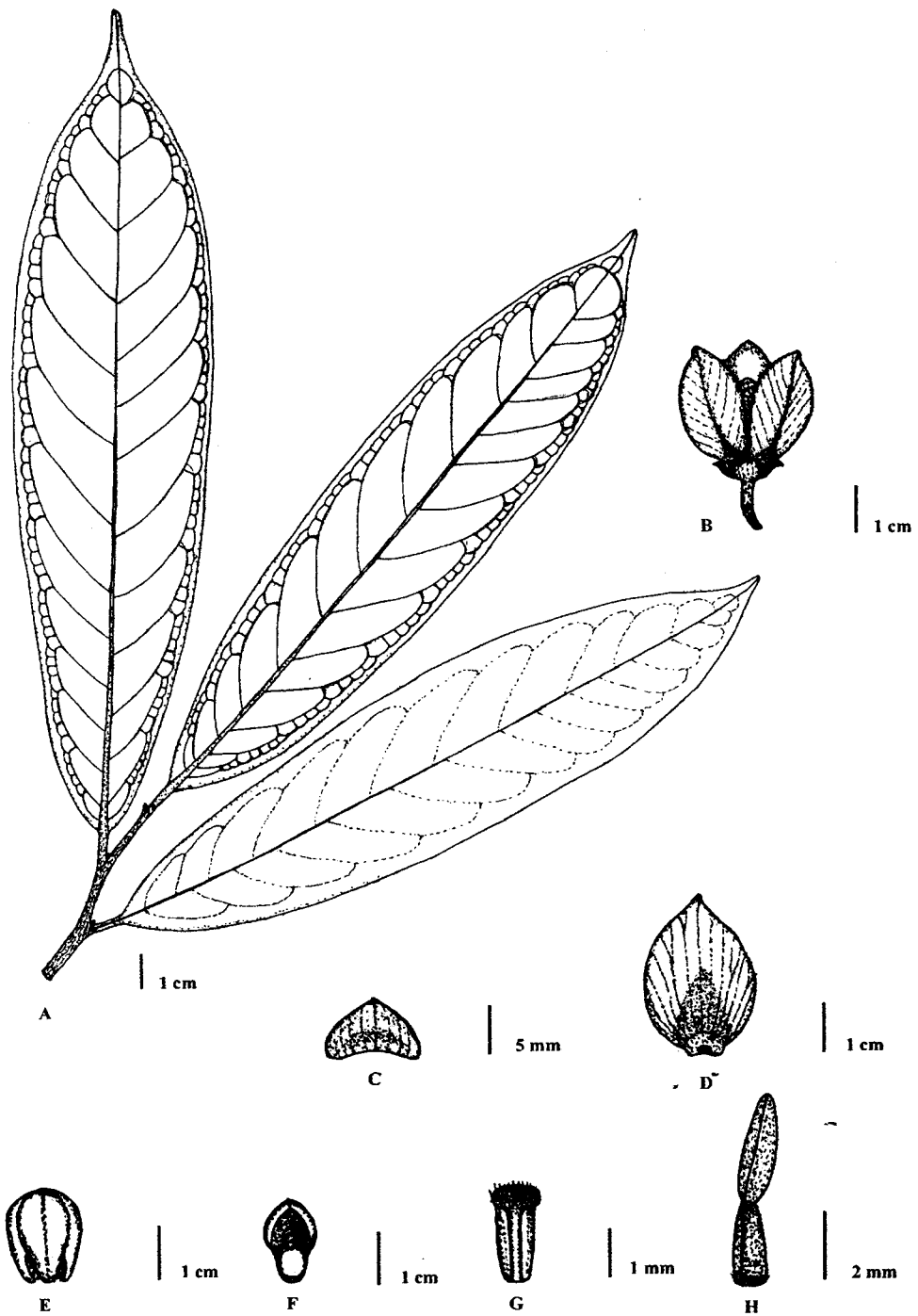


Figure 3.12 *Goniothalamus maewongensis*: A. twig; B. flower; C. outside of sepal; D. inside of outer petal; E. connate of inner petals; F. inside of inner petal; G. stamen; H. pistil; (A – H Chalermglin 6-3-47) Drawn by Y. Yuyen.

9. *Goniothalamus malayanus* Hook. f. & Thoms., Fl. Indica 1: (1855) 107 and Fl. Brt. India 1: (1872) 75; King, Ann. Roy. Bot. Gard. (Calcuta) 4: (1893) 94, pl. 128B; Ridley, Fl. Malay Penins. 1: (1922) 66 - 67; J. Sinclair, Gard. Bull. Singapore 14: (1955) 432 - 433; R. M. K. Saunders, Bot. J. Linn. Soc. 139: (2002) 227 - 233 and Bot. J. Linn. Soc. 142: (2003) 321 - 339. Figure 3.13; 3.14 (B).

Small tree about 5 - 6 m high; bark glabrous, brown; branchlets straight, pale brown, glabrous, striate. *Leaves* simple, alternate; blades oblong, chartaceous; bluntly acuminate at the apex, cuneate at the base; pale green above when dry, pale brown below, glabrous above, sparsely rusty puberulous below, especially on midrib; midrib grooved above, raised below; secondary nerves 18 - 20 pairs, fine, but visible both sides, reticulation faint; 14 - 15 x 4 - 5 cm. *Petioles* grooved above, densely rusty puberulous, 5 mm long. *Flowers* solitary, axillary; pedicel about 7 mm long, sparsely rusty puberulous, with several scale-like, green bracts at the base. *Sepals* ovate, coriaceous, acute at the apex; rusty puberulose both sides, except at the base inside; 5 mm long, 4 mm broad, green. *Petals* 6; outer 3, lanceolate, apex long acuminate, one - veined distinct outside, rusty puberulous both sides, except at the base inside; 5.7 x 2 cm; inner 3, smaller, densely pale hairs outside, glabrous inside, claw; 8 x 4 mm. *Stamens* numerous, 1 mm long, connectives truncate. *Pistils* several, vertically grooved, 2 mm long; stigma coiled; style linear, densely pale brown hairs; ovary cylindrical, densely pale brown hairs; ovule 2 - 5, marginal.

Thailand - southern: Narathiwat, Ba Cho

Distribution - Andaman, Nicobar Island, Thailand, Peninsular Malaysia, Sumatra and Borneo

Ecology - Swamp forest

Phenology - Flowering through the year

Specimens examined - Yuyen 209 (CMU), J. A. R. Anderson 8512 (S.), J. Sinclair & Kadin Bintassim 10458 (S.), K. M. Kochummen 97768 (S.)

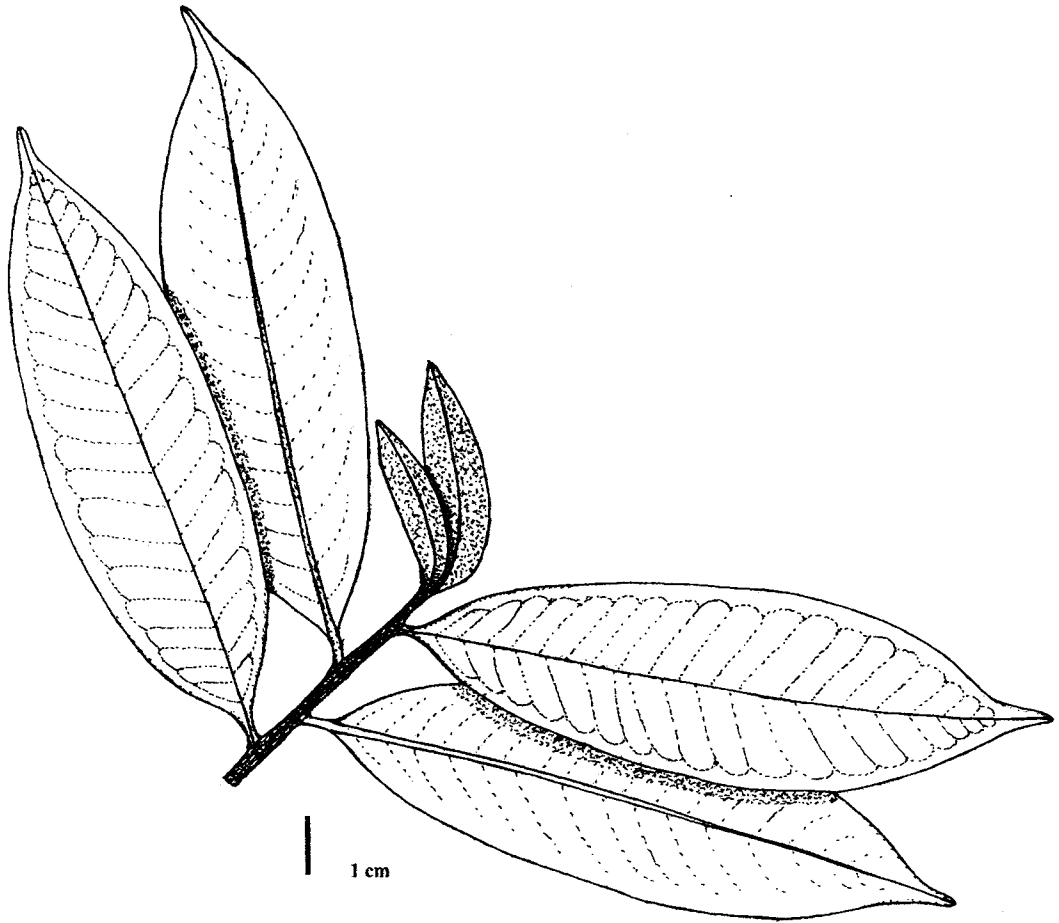


Figure 3.13 *Goniiothalamus malayanus* Hook. f. & Thoms.: twig (Yuyen 209)

Drawn by Y. Yuyen.



A



B

Figure 3.14 *Goniiothalamus* spp.: A. *Goniiothalamus maewongensis*;
B. *Goniiothalamus malayanus* (Photograph by Chalermglin).

10. *Goniothalamus marcanii* Craib. Bull. Misc. Inform. (1922) 167; Ast. Fl. Gén. de l'Indo-Chine Supplément (1938) 97 – 98; J. Sinclair, Gard. Bull. Singapore 14: (1955) 429 – 431. Figure 3.15; 3.18 (A).

Shrub about 2 - 3 m high; bark glabrous, dark; branchlets straight, brown, strait, densely rusty puberulous, becoming sparsely rusty puberulous to glabrous when older. *Leaves* simple, alternate; blades oblong, thinly coriaceous; apex acuminate, base obtuse; green above, pale green below; glabrous above, with sparsely rusty pubescent on the midrib, becoming glabrous with age, densely rusty puberulous on midrib below, with sparsely rusty pubescent on nerves and lamina; midrib grooved above, raised below; secondary nerves 8 – 10 pairs, prominent below, faint above, curving and anastomosing near the margin, reticulation distinct below; 12 – 23 x 4.5 – 6.5 cm. *Petioles* dorsally grooved, densely rusty puberulous, 0.5 – 1.5 cm long. *Flowers* axillary, solitary; pedicel about 5 mm long, densely rusty puberulous, with 4 – 6 scale-like, green bracts at the base. *Sepals* suborbicular, coriaceous, bluntly acuminate at the apex; rusty puberulous outside, glabrous inside, greenish; 7 – 9 mm long, 9 - 10 mm broad. *Petals* 6, coriaceous, greenish – yellowish; outer 3, ovate, apex acute, 1 prominent vein outside, rusty puberulous both sides, except at the base inside, claw rather broad, 2 x 1.2 cm; inner 3, rusty puberulous outside, glabrous inside, 12 x 8 mm, united. *Stamens* numerous, 2 mm long, connectives convex. *Pistils* several, vertically grooved, 3 mm long; stigma claviform, canaliculate, warty toward apex; style short; ovary cylindrical, glabrous; ovule 1, basal.

Thailand – north-eastern: Mukdahan, Phu Mu; eastern: Ubon Ratchatani, Phu Chong Na Yoi; south-eastern: Chanthaburi, Preaw Waterfall; Trat, Kho Kood; southern: Phangnga, Ta Kau Pa

Distribution – Pahang, Selangor and Thailand

Ecology – Seasonal deciduous or mixed evergreen + deciduous forest, 50 - 400 m elevation

Phenology – Flowering April

Specimens examined - Chalermglin 25-4-47 (CMU), Yuyen 225 (CMU), J. Wyatt-Smith 65530 (S), C. Pheng Klai et al 13134 (BKF), Sakol 769 (BK), Maxwell 75-449, 71-234 (BK)

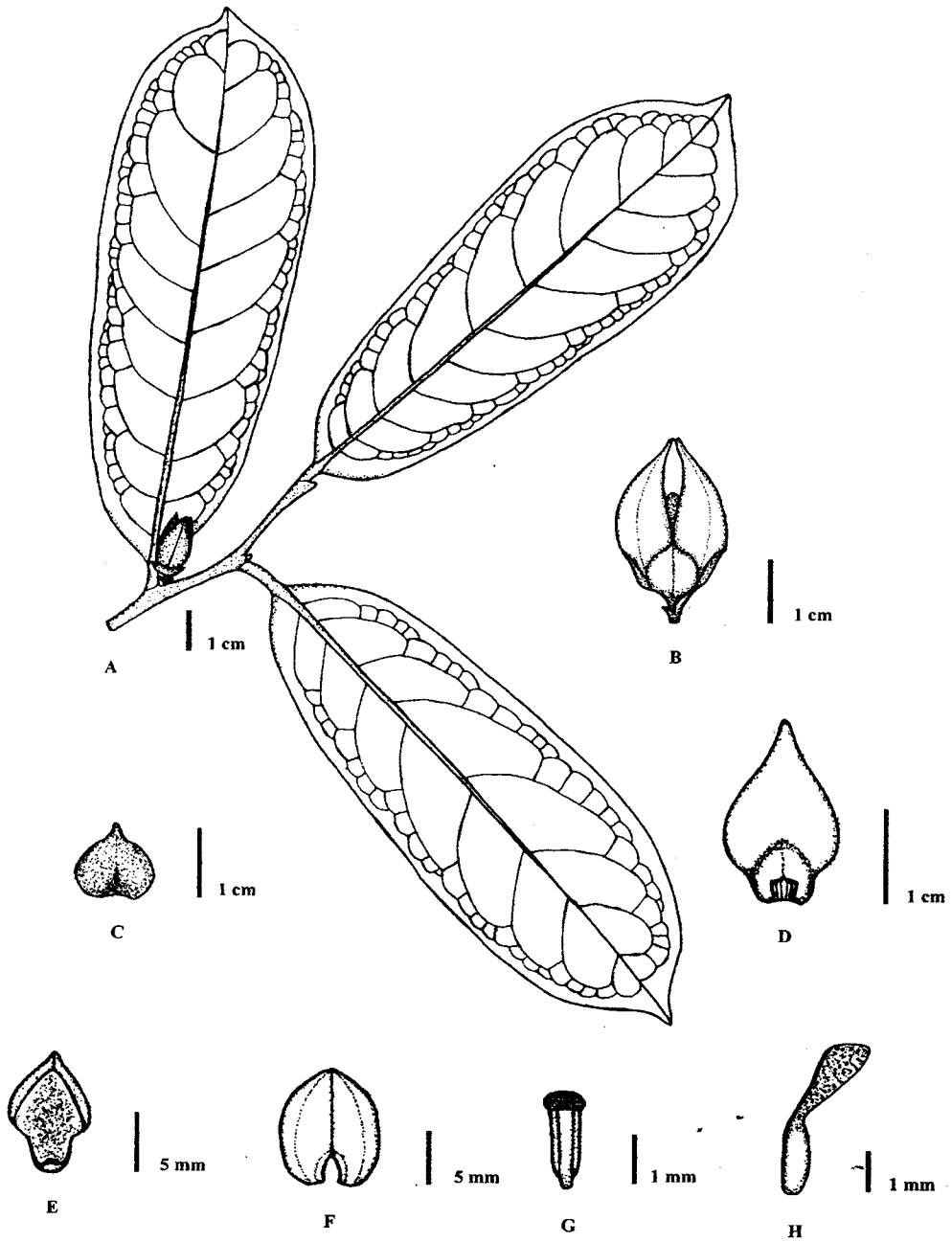


Figure 3.15 *Goniothalamus marcanii* Craib.: A. flowering twig; B. flower; C. outside of sepal; D. inside of outer petal; E. inside of inner petal; F. connate of inner petals; G. stamen; H. pistil; (A – H Yuyen 225) Drawn by Y. Yuyen.

11. *Goniothalamus repevensis* Pierre *ex* Fin. & Gagnep., Bull. Soc. Bot. France 53 Mem. 4 (1906) 117; Finet & Gagnepain, Fl. Gén. de l'Indo-Chine I (1907), 89 and plate 1XB; Ast, Fl. Gén. de l'Indo-Chine Supplément (1938) 98. Figure 3.16; 3.18 (B-C).

Evergreen shrub about 1 m high; bark glabrous, finely striate, brown; branchlets straight, sparsely rusty puberulous, glabrescent, brown. *Leaves* simple, alternate; blades thin; lanceolate; apex acuminate, base cuneate, margins entire; young blades densely rusty puberulous, older blades glabrous; midrib sunken and grooved above, raised below; secondary nerves 10 – 11 pairs, obscure on both sides, fine, arching and anastomosing 5 mm below the margin, finer venation reticulate, almost invisible, but visible in transmitted light; green above, pale green below; 9 – 9.5 x 3 – 3.5 cm. *Petioles* dorsally grooved, glabrous, 4 – 5 mm long. *Flowers* solitary, axillary; pedicels thickened apically, sparsely rusty puberulous to glabrous, about 8 mm long; bracts 5 - 6 basal, scale-like, green. *Sepals* coriaceous, triangular, apex acute; sparsely adpressed rusty puberulous outside, glabrous inside, greenish; 4 mm long, 7 mm broad. *Petals* 6, coriaceous, yellowish and becoming pink-red when older; outer 3 ovate – elliptic, apex acuminate, with sparse indumentum as on the outside of the sepals on both sides, venation obscure, reticulate, 3 – 3.5 x 1.5 – 1.8 cm; inner 3 similar to the outer 3, but smaller, 10 x 5 mm, marginally connate above the claws. *Stamens* numerous, 1 mm long; connectives thick, truncate, papillose. *Pistils* numerous, vertically grooved, 4 mm long; stigma cylindric, curved, canaliculate, glabrous; style short; ovary cylindric, densely rusty tomentose; ovules 1 - 2. *Monocarps* 5 – 11, oblong, glabrous, green and becoming orange when ripe, 1.5 – 2 x 0.8 – 0.9 cm; stalks 6 mm, *Seeds* 1 – 2, ellipsoid .

Thailand – South-eastern: Chanthaburi, Kao Soi Dao

Distribution - Cambodia and Laos

Habitat – Seasonal, primary, evergreen hardwood forest; 600 – 900 m elevation

Phenology - Flowering April – May, fruiting April – May

Specimens examined - Yuyen 232 (CMU), Pierre 172 (S.), Nai noe 72 (BK)

Note: The distinguishing feature of *G. repevensis* is the long cylindrical stigma which is as long as the ovary. The specific epithet refers to the place where the type material was collected.

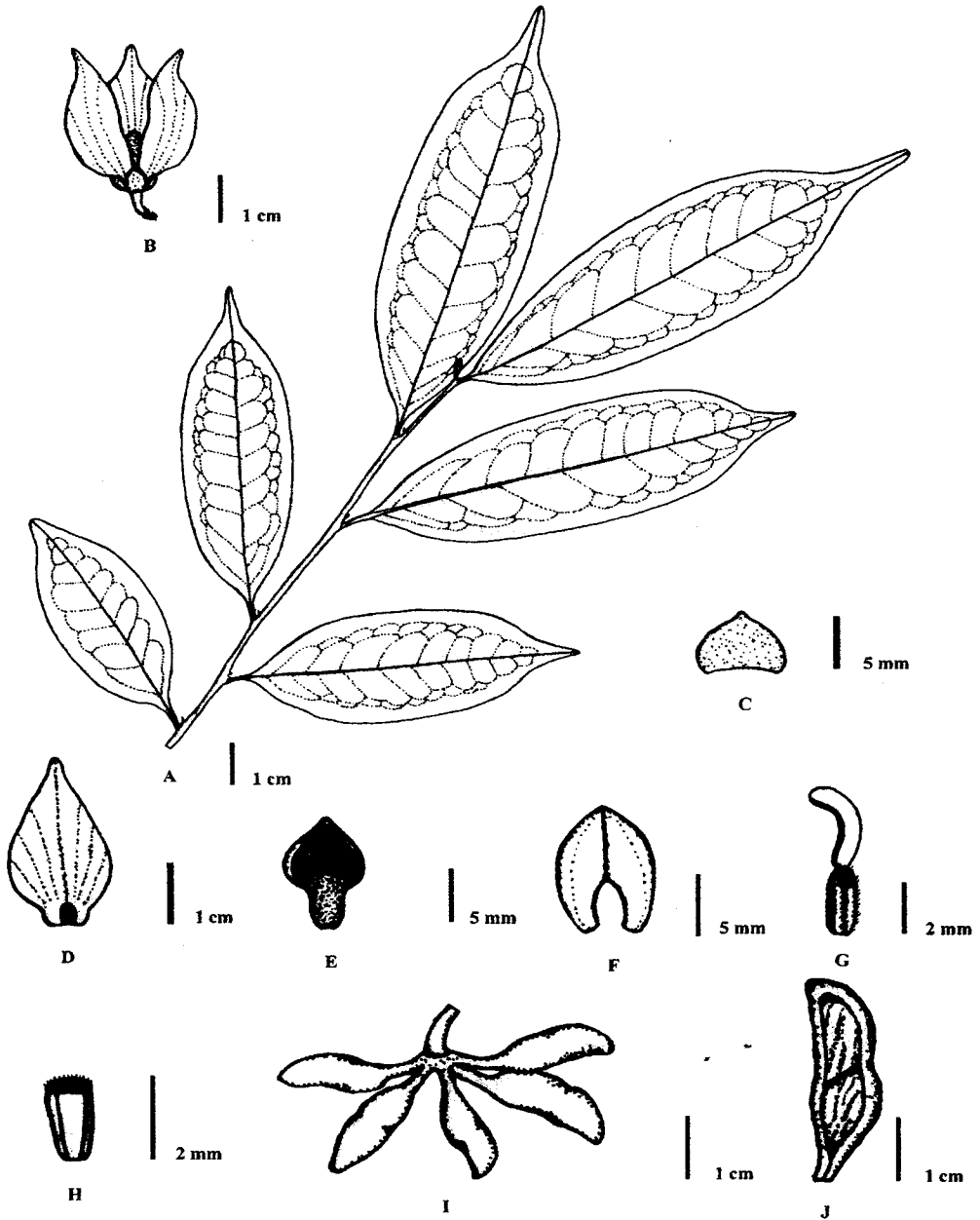


Figure 3.16 *Goniothalamus repevensis* Pierre ex Fin. & Gagnep., A. twig; B. flower; C. outside of sepal; D. inside of outer petal; E. inside of inner petal; F. connate inner petals; G. pistil; H. stamen; I. monocarps; J. monocarp L. S., showing 2 seeds. (Yuyen 232). Drawn by Y. Yuyen.

12. *Goniothalamus sawtechii* Fischer. Bull. Misc. Inform: (1927) 203. Figure 3.17; 3.18 (E).

Small tree about 4 - 6 m high; bark dark brown, striate; branchlets straight, brown, densely rusty puberulous, then become glabrous when older, striate. *Leaves* simple, alternate; blades oblong, thinly chartaceous; bluntly acuminate at the apex, acute at the base; sparsely pale brown hairs both sides, especially on midrib both sides; midrib grooved above, raised below; secondary nerves 15 pairs, fine but visible both sides, anastomosing in loop near the margin, 22 cm long, 7.5 cm broad. *Petioles* grooved above, densely rusty puberulose, dark brown, 7 - 12 mm long. *Flowers* solitary, axillary or on mainstem; pedicel about 1.3 cm long, densely rusty puberulous, with 3 scale-like, green bracts at the base. *Sepals* suborbicular, nearly free, coriaceous, bluntly cuspidate at the apex; rusty puberulous both sides, except at base inside; 1 cm long, 1 cm broad, green. *Petals* 6, yellowish; outer 3, ovate, apex acute, one - veined distinct, raised outside, grooved inside, several lateral grooved arising from base in side, margin curve reflexed to outside, coriaceous, densely rusty puberulous both sides, except at base at base inside, 3.5 x 2 cm; inner 3, smaller, densely rusty puberulous outside, brown hairs inside, except at the base, claw; 17 x 6 mm, coriaceous. *Stamens* numerous, 2 mm long, connectives truncate. *Pistils* several, vertically grooved, 4 mm long; stigma minute, canaliculate; style linear, warty toward apex; ovary cylindric, few hairs or glabrous; ovule 1, basal.

Thailand - southwestern: Phetchaburi, Phanoenthung; southern: Narathiwat, Ba Cho

Distribution - South Tenasserim

Ecology - Evergreen forest, 200 - 800 m elevation

Phenology - Flowering May

Specimens examined - Yuyen 235 (CMU), Prayad 1747 (BK)

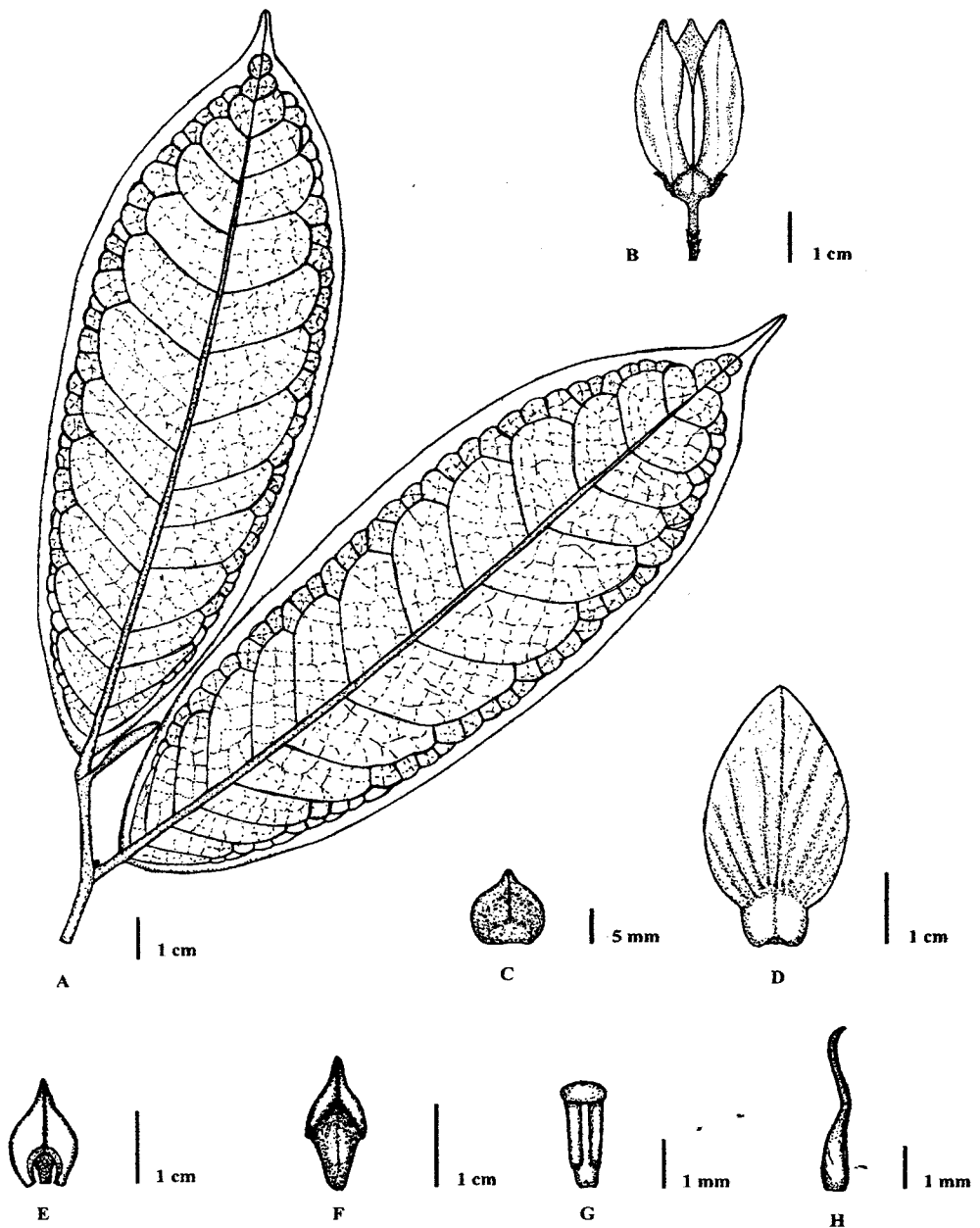


Figure 3.17 *Goniothalamus sawtechii* Fischer: A. twig; B. flower; C. outside of sepal; D. inside of outer petal; E. connate of inner petals; F. inside of inner petal; G. stamen; H. pistil; (A – H Yuyen 235) Drawn by Y. Yuyen.



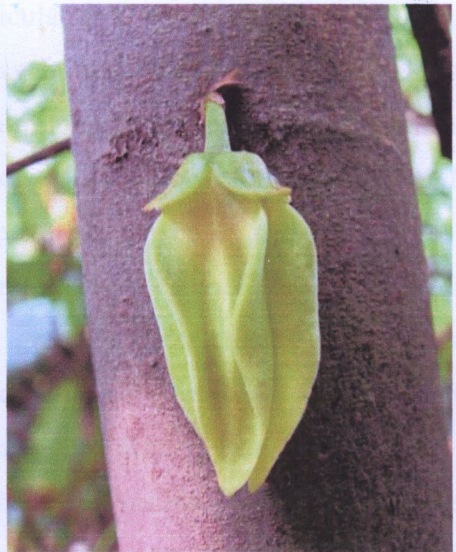
A



B



C



D

Figure 3.18 *Goniiothalamus* spp.: A. *G. marcanii*; B. Monocarps of *G. repevensis*; C. *G. repevensis*; D. *G. sawtechii*.

13. *Goniothalamus tapis* Miq. Fl. Ind. Bat. Suppl. 1 (1861) 371; King, Ann. Roy. Bot. Gard. (Calcuta) 4: (1893) 9, pl. 140; Ridley, Fl. Malay Penins. 1: (1922) 67; J. Sinclair, Gard. Bull. Singapore 14: (1955) 444 – 445; Corner, Wayside Trees Malaya 3rd ed., 1: (1988) 144; R. M. K. Saunders, Bot. J. Linn. Soc. 139: (2002) 237 – 38. Figure 3.19; 3.20 (A-B).

Evergreen treelet about 2 - 3 m high; bark glabrous, pale grey; branchlets straight, brownish or pale, sparsely brown hairs, striate. *Leaves* simple, alternate; blades oblong, subcoriaceous; bluntly acuminate at the apex, cuneate at the base, edges recurved when dry; brown above when dry, pale brown below, glabrous above, sparsely brown hairs below; midrib grooved above, raised below; secondary nerves 12 – 13 pairs, slender, faint above, raised below, reticulation faint; 16 – 17 x 4.5 – 7 cm. *Petioles* stout, grooved above, wrinkled, sparsely brown hairs below, 7 mm long. *Flowers* solitary, axillary; pedicel about 10 - 12 mm long, broadening towards base of calyx, sparsely rusty hairs, with 3 - 4 scale-like, green bracts at the base. *Sepals* suborbicular, coriaceous, broad acute at the apex, free to base; rusty puberulose outside, glabrous inside; 6 mm long, 7 mm broad, green, sometimes tinged with purple, venation indistinct. *Petals* 6, coriaceous, greenish, later creamy white, often tinged with pink; outer 3, lanceolate, apex gradually acute, one – veined distinct, raised outside, grooved inside, several faint lateral ones arising from base, sparsely rusty pubescent outside, sparsely rusty glandular hairs at apex inside; 5 x 2.5 cm; inner 3, smaller, brown hairs, with one veined outside, one veined distinct inside, with several shallow grooved, sparsely pale brown hairs; 17 x 8 mm, lanceolate, coriaceous, acuminate at apex. *Stamens* numerous, incurved, 3 mm long, connectives apiculate. *Pistils* several, vertically grooved, 4 mm long; stigma funnel - shape, with the two lobes of the funnel mouth undulate; style linear, warty toward apex; ovary cylindrical, densely pale brown hairs; ovule 1, basal.

Thailand – southern: Pattani, Sai Buri

Distribution – Peninsular Malaysia, Sumatra and lower Thailand

Ecology – Evergreen forest, 30 – 300 m elevation

Phenology – Flowering February – May

Specimens examined - Yuyen 205 (CMU), H. N. Ridley 6757 (S.), E. J. H. Corner
33403 (S.)

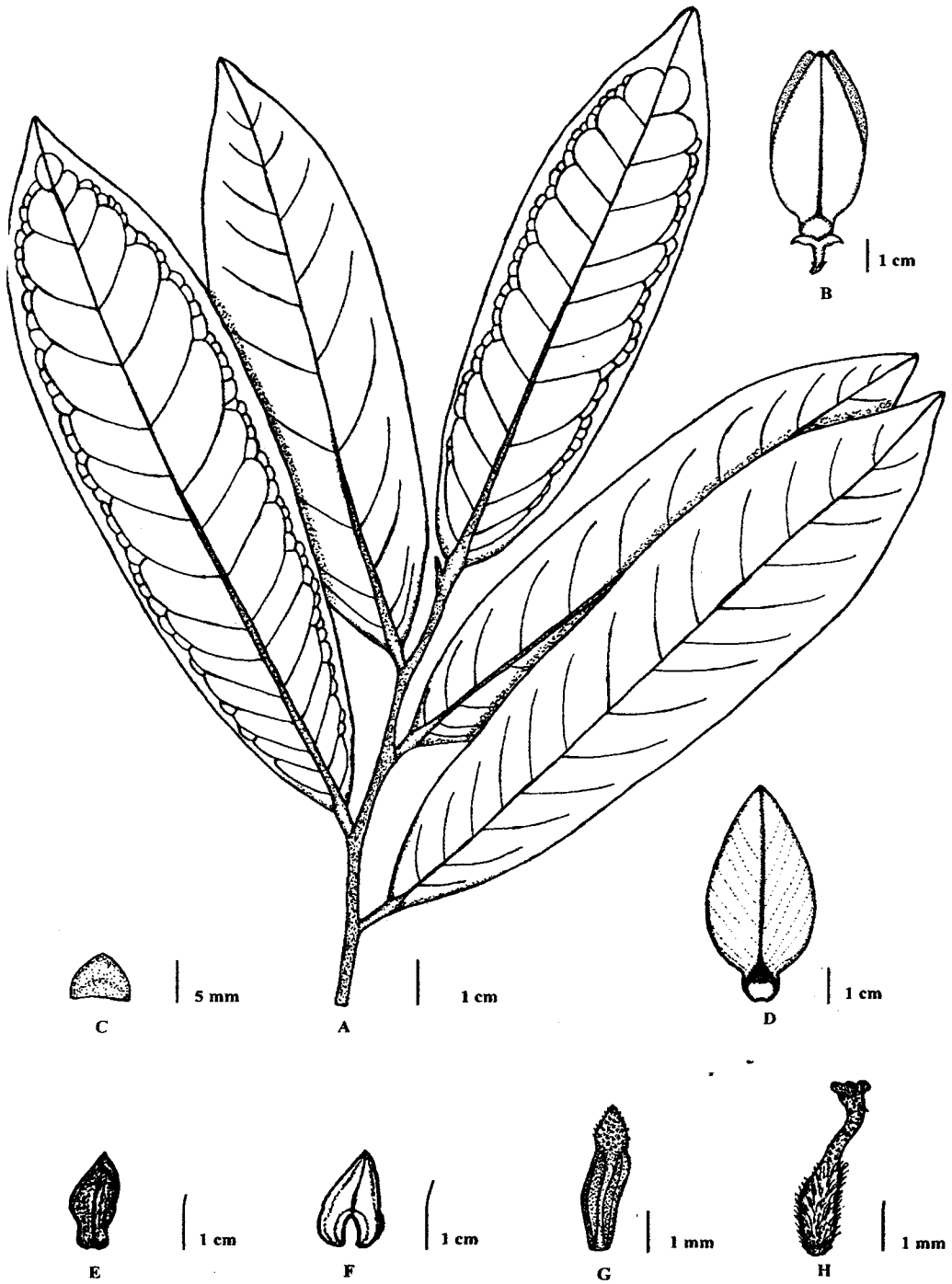


Figure 3.19 *Goniothalamus tapis* Miq.: A. twig; B. flower; C. outside of sepal; D. inside of outer petal; E. inside of inner petal; F. connate inner petals; G. stamen; H. pistil; (A – H Yuyen 205) Drawn by Y. Yuyen.



A



B

Figure 3.20 *Goniotalamus tapis* Miq.: A - B. Flowers.

14. *Goniothalamus tortilipetalus* M. R. Hend. Grad. Bull. Straits Settlement Vol. 7. No. 2; (1933) 88 – 89. Pl. 15; Sinclair, James. The Gardens' Bulletin Singapore Vol. XIV Part 2; (1955) 436 – 437. Saunders, R. M. K. Botanical Journal of the Linnean Society 142; (2003) 328. Figure 3.21; 3.23 (A-B).

Evergreen treelet about 1.5 m high; bark pale grey, finely striate; branchlets straight, pale grey, striate. *Leaves* simple, alternate; blades oblong, coriaceous; bluntly acuminate at the apex, acute at the base, edges slightly recurved; pale brown olivaceous shining above when dry, pale brown below, glabrous, both surfaces with minute brown dots; midrib grooved above, raised below, sparsely brown dot hairs; secondary nerves 13 – 18 pairs, raised on both surfaces, anastomosing about 6 – 10 mm from the margin, finer venation wide and more distinct reticulate above than below; 20 – 21 x 5.5 – 6.5 cm. *Petioles* stout, dark brown – black, deeply grooved above, wrinkled, sparsely brown rusty hairs, 1 cm long. *Flowers* solitary or in groups from woody tubercles on the main stem; pedicel about 1 - 1.5 cm long, thickening towards base of calyx, sparsely rusty puberulous, with 3 - 4 scale-like, green bracts at the base, 4 – 7 mm long. *Sepals* triangular, coriaceous, broad acute at the apex, slightly cohering at base; sparsely rusty puberulous both sides, rusty hairs on the apex and margins near the apex, greenish; 2 cm long, 2.5 cm broad; nerves and reticulation strongly marked. *Petals* 6, coriaceous, greenish; outer 3, lanceolate, apex gradually aristate, slightly twisted, sparsely rusty glandular hairs both sides, one main vein and several faint lateral ones arising from base, 6.5 x 2.3 cm; inner 3, smaller, 2 x 1.1 cm, oblong – lanceolate, coriaceous, united by the margin above the claws. *Stamens* numerous, incurved, 4 mm long, connectives apiculate. *Pistils* several, vertically grooved, 5 mm long; stigma minute, canaliculate; style linear, warty toward apex; ovary cylindrical, densely pale brown hairs; ovule 1, basal.

Thailand – south-western: Kanchanaburi, Thong Pha Phum

Distribution – Pahang, Perak and lower Thailand

Ecology – Hill evergreen forest, 800 – 1,000 m elevation

Phenology – Flowering May

Specimens examined - Yuyen 234 (CMU), K. M. Kochummen 98699 (S.), T. C. Whitmore 12514 (S.), Kiah 24290 (S.), Henderson, M. R. 24543 (Isotype)

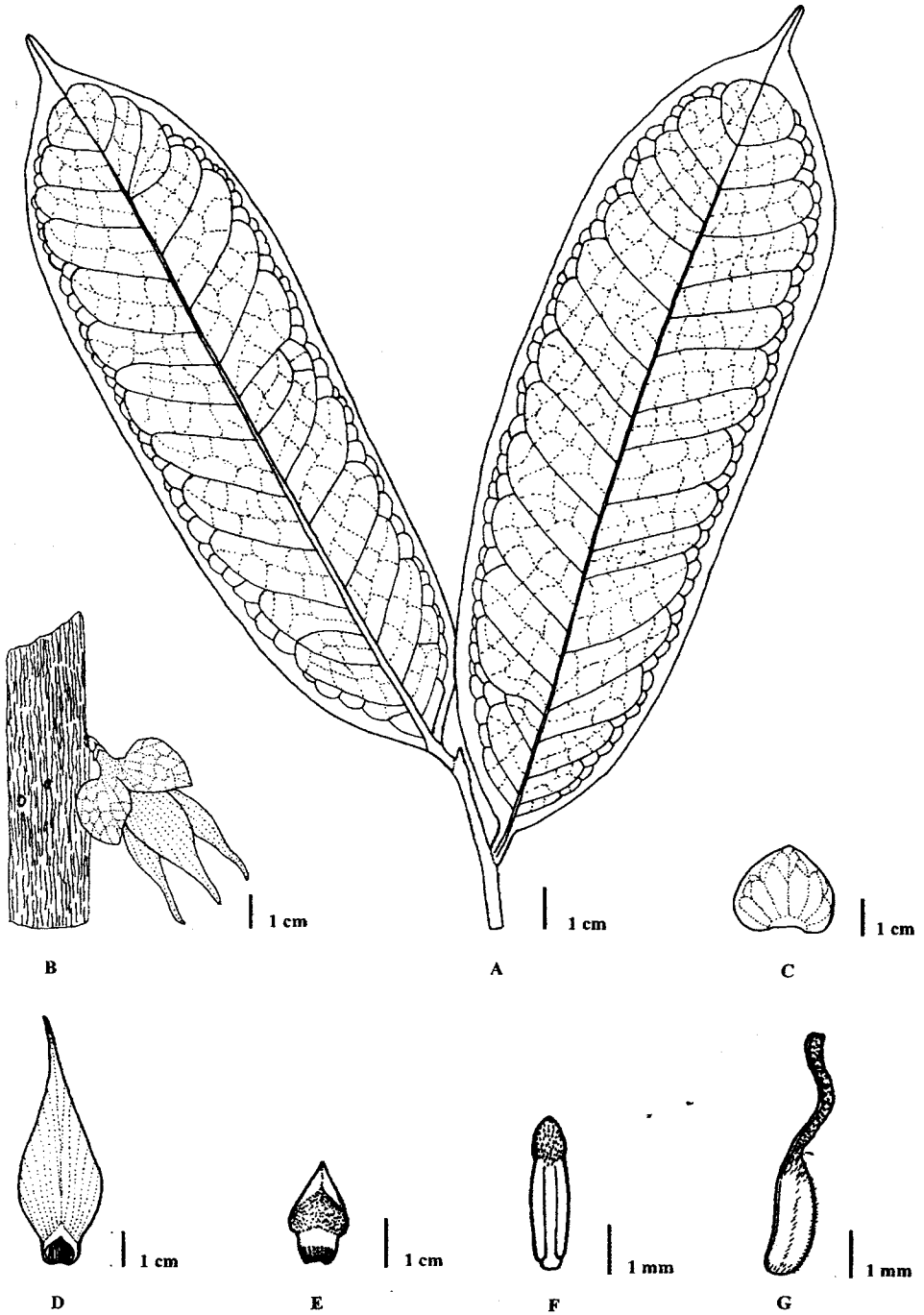


Figure 3.21 *Goniothalamus tortilipetalus* M. R. Hend.: A. twig; B. flower; C. outside of sepal; D. inside of outer petal; E. inside of inner petal; F. stamen; G. pistil; (A – G Yuyen 234) Drawn by Y. Yuyen.

15. *Goniothalamus umbrosus* J. Sinclair, Gard. Bull. Singapore 14: (1955) 445. Figure 3.22; 3.23 (C).

Treelet about 2 - 3 m high; bark glabrous, dark brown; branchlets straight, dark brown, strait, glabrous. *Leaves* simple, alternate; blades oblong, chataceous; apex acuminate, base acute; pale green above when dry, brown below; glabrous both sides; midrib grooved above, raised below; secondary nerves 9 – 10 pairs, prominent below, faint above, curving and anastomosing near the margin, reticulation faint; 14 - 15 x 5 - 5.5 cm. *Petioles* dorsally grooved, glabrous, wrinkled, 8 mm long. *Flowers* solitary, axillary; pedicel about 5 mm long, glabrous, with 1 – 2 scale-like, green bracts at the base. *Sepals* ovate, nearly free, coriaceous, acute at the apex; glabrous both sides; 8 mm long, 6 mm broad. *Petals* 6, coriaceous, greenish - yellowish; outer 3, coriaceous, lanceolate, apex long acuminate, 1 prominent vein both side, with several parallell veins rising from the base inside, glabrous both side, claw, 3.5 x 1.5 cm; inner 3, coriaceous, lanceolate, sparsely rusty dot hairs outside, glabrous inside, claw; 2.2 x 0.9 cm, united. *Stamens* numerous, 1.5 mm long, connectives apiculate. *Pistils* several, vertically grooved, 5 mm long; stigma cylindric, longer than ovary 3 times, sparsely rusty hairs, canaliculate; style short; ovary cylindric, densely rusty hairs; ovule 1, basal.

Thailand – southern: Krabi, Khlong Thom

Distribution – Penang, Kelantan, Trengganu, Borneo

Ecology – Evergreen forest, 200 - 600 m elevation

Phenology – Flowering October - November

Specimens examined - Yuyen 248 (CMU)

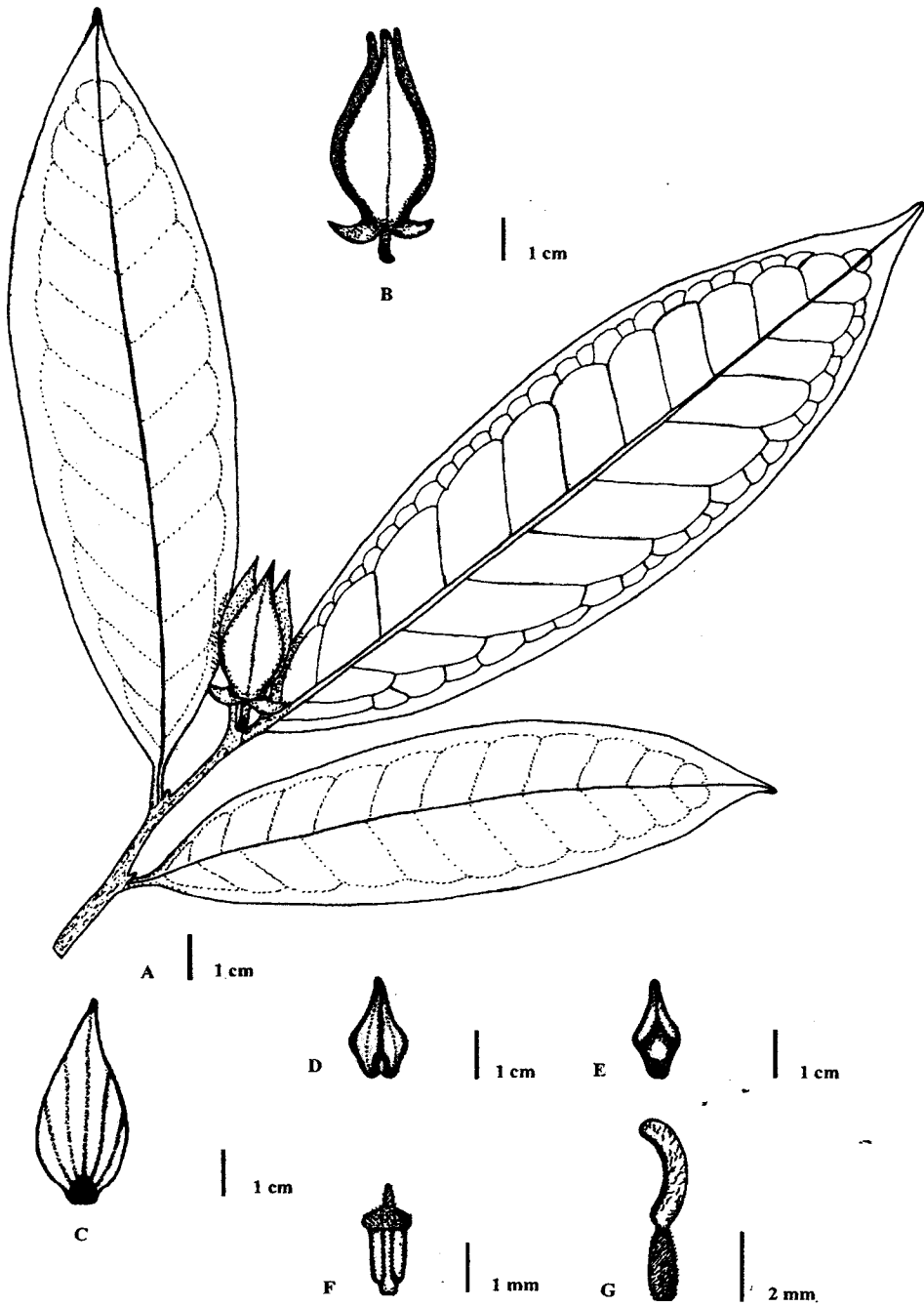


Figure 3.22 *Goniothalamus umbrosus* J. Sinclair: A. flowering twig; B. flower; C. inside of outer petal; E. connate of inner petals; F. inside of inner petal; G. stamen; H. pistil; (A – H Yuyen 248) Drawn by Y. Yuyen.



A



B



C

Figure 3.23 *Goniotalamus* spp.: A. Isotype of *G. tortilipetalus*, Henderson, M. R. 24543 (21 May 1931, S.); B. Flowers of *G. tortilipetalus*; C. *G. umbrosus* (Photograph by Chalermglin).

16. *Goniothalamus undulatus* Ridley, Journ. Fed. Mal. States Mus. 10: (1920) 81; Craib, Fl. Siam. Enum. 1: (1925) 51; J. Sinclair, Gard. Bull. Singapore 14: (1955) 434. Figure 3.24; 3.25 (A-B).

Shrub about 2 - 3 m high; bark glabrous, dark; branchlets straight, brown, strait, densely rusty puberulous, becoming sparsely rusty puberulous to glabrous when older. *Leaves* simple, alternate; blades oblong, membranous; apex long acuminate, base acute; greenish above, pale green below; glabrous above, sparsely rusty puberulous below, with rusty puberulous on midrib below; midrib grooved above, raised below; secondary nerves 12 – 13 pairs, prominent below, fine but visible above, curving and anastomosing near the margin, reticulation faint and lax; 18 x 5.5 cm. *Petioles* dorsally grooved, densely rusty puberulous, 1 cm long. *Flowers* solitary, axillary; pedicel about 5 mm long, coriaceous, densely rusty puberulous, with 5 – 6 scale-like, green bracts at the base. *Sepals* broadly ovate, nearly free, membranous, acute at the apex; rusty puberulous outside, glabrous inside, 1 prominent vein outside, greenish; 9 mm long, 9 mm broad. *Petals* 6, coriaceous, creamy - yellowish; outer 3, coriaceous, lanceolate, apex acuminate, 1 prominent vein outside, rusty puberulous outside, sparsely rusty puberulous at apex inside, except at the base, claw, 3.2 x 1.9 cm; inner 3, coriaceous, densely rusty puberulous outside, brown silky hairs inside, except at the base, claw; 14 x 8 mm, united. *Stamens* numerous, 1.5 mm long, connectives convex. *Pistils* several, vertically grooved, 3 mm long; stigma claviform, canaliculate; style short; ovary cylindrical, sparsely brown hairs; ovule 1, basal.

Thailand – southern: Ranong, Khlong Nakha; Trang, Khao Chong

Distribution – Kelantan, Lower Myanmar and Lower Thailand

Ecology – Evergreen forest, 300 - 700 m elevation

Phenology – Flowering March - June

Specimens examined - Yuyen 217 (CMU), Chew Wee Lek 158 (S.), Forester Hamid 3855 (S.), Kerr 11749 (BK), Chira 1657 (BK)

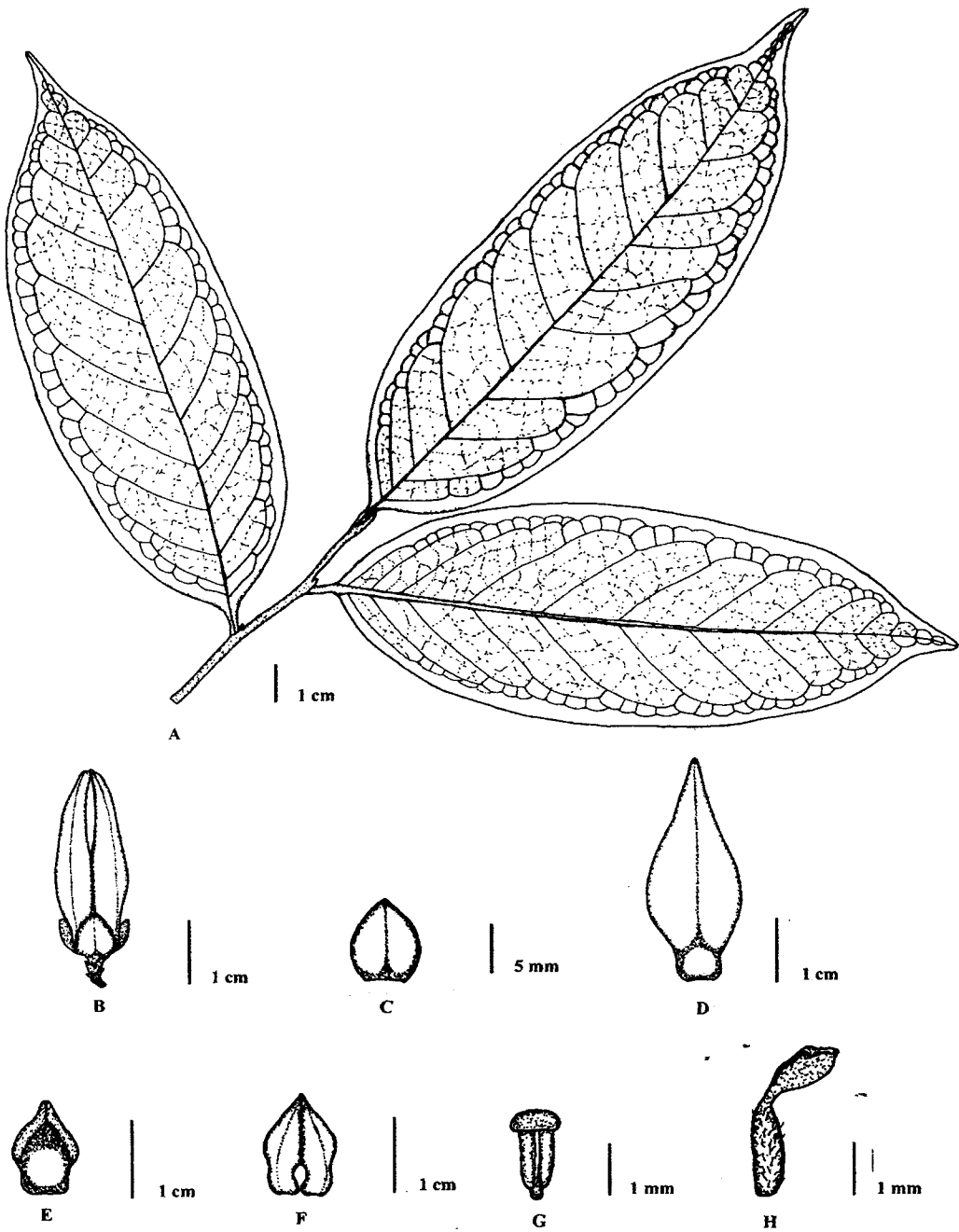


Figure 3.24 *Goniothalamus undulatus* Ridley: A. twig; B. flower; C. outside of sepal; D. Inside of outer petal; E. inside of inner petal; F. connate of inner petals; G. stamen; H. pistil; (A – H Yuyen 217) Drawn by Y. Yuyen.



A



B

Figure 3.25 *G. undulatus* Ridley: A. Isotype of *G. undulatus*, Kloss, C. B.6836 (5 November 1919, S.); B. Flowers of *G. undulatus* (Photograph by Chalermglin).

17. Goniothalamus sp. Aunglaoenai Figure 3.26; 3.27.

Shrub about 1 - 2 m high; bark brown, striate; branchlets straight, brown, striate, densely rusty puberulous, becoming sparsely rusty puberulous to glabrous when older, striate. *Leaves* simple, alternate; blades oblong, chartaceous; apex bluntly acuminate, base broadly acute; green above, pale green below; glabrous above, densely rusty puberulous on midrib below, with sparsely rusty puberulous on lamina; midrib grooved above, raised below; secondary nerves 13 – 16 pairs, fine both sides, but visible, curving and anastomosing near the margin, reticulation faint; 16 – 18 x 3.7 – 5.5 cm. *Petioles* dorsally grooved, densely rusty puberulous, 9 – 10 cm long. *Flowers* axillary, solitary; pedicel about 5 – 7 mm long, inflected, densely rusty puberulous, with 1 – 4 scale-like, green bracts at the base, the biggest bract lanceolate, 7 mm long. *Sepals* triangular, coriaceous, acute at the apex; densely rusty puberulous outside, glabrous inside, with 1 prominent vein outside, greenish; 7 mm long, 8 mm broad. *Petals* 6, coriaceous, greenish – yellowish; outer 3, ovate, apex acute, 1 prominent vein outside, pale brown puberulous both sides, except at the base inside, claw rather broad, 2 x 1.1 cm; inner 3, pale brown puberulous outside, glabrous inside, 10 x 6 mm, united. *Stamens* numerous, 1.5 mm long, connectives convex. *Pistils* several, vertically grooved, 3 mm long; stigma minute, canaliculate; style linear; ovary cylindrical, pale brown hairs; ovule 1, basal.

Thailand – southeastern: Chachoengsao, Aunglaoenai

Distribution – unknown

Ecology – Evergreen forest

Phenology – Flowering February

Specimens examined - Yuyen 213 (CMU)

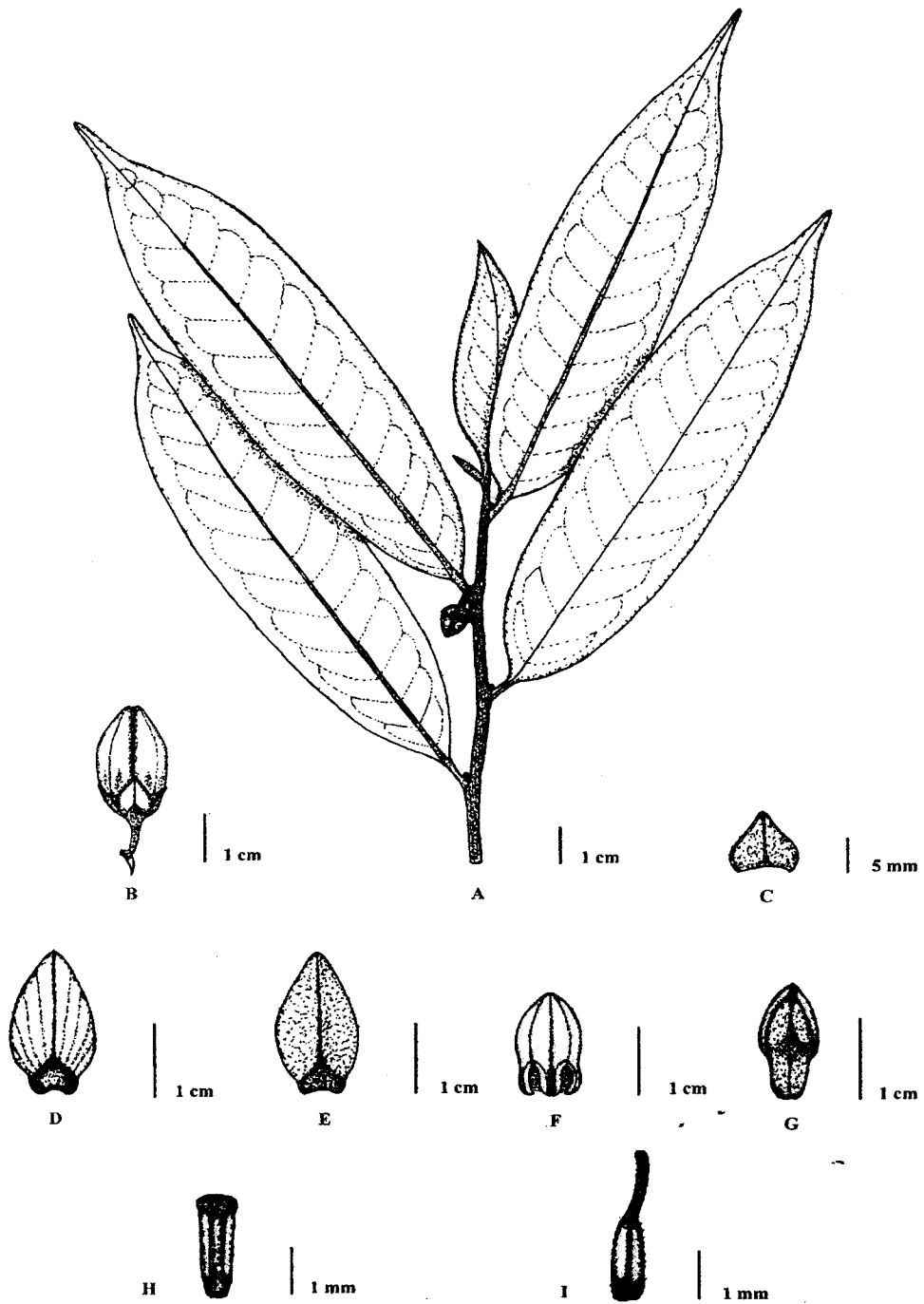


Figure 3.26 *Goniotalamus* sp. Aunglaoenai: A. flowering twig; B. flower; C. outside of sepal; D. inside of outer petal; E. outside of outer petal; F. connate of inner petals; G. inside of inner petal; H. stamen; I. pistil; (A – I Yuyen 213) Drawn by Y. Yuyen.



Figure 3.27 *Goniotalamus* sp. Aunglaoenai: Flower.

18. *Goniothalamus* sp. Maerim. Figure 3.28; 3. 31 (C).

Shrub about 2 - 3 m high; bark pale brown, striate; branchlets straight, brown, glabrous, striate. *Leaves* simple, alternate; blades oblong, coriaceous; bluntly acuminate at the apex, acute at the base; glabrous both sides, with with densely brown glandular dots, sparsely rusty puberulous on midrib below; midrib grooved above, raised below; secondary nerves 16 - 17 pairs, fine but visible above, raised below, anastomosing in loop near the margin, 24 - 28 cm long, 6 - 8 cm broad. *Petioles* stout, grooved above, sparsely rusty puberulose, wrinkled, 8 - 10 mm long. *Flowers* solitary, axillary or on main stem; pedicel about 1 cm long, sparsely rusty puberulous, with 1 - 3 scale-like, green bracts at the base, the largest bract lanceolate, 7 mm long. *Sepals* triangular, nearly free, coriaceous, bluntly acute at the apex; glabrous outside, sparsely rusty dot hairs inside; 1.5 cm long, 2 cm broad, reticulation distinct, green. *Petals* 6, yellowish; outer 3, broadly lanceolate, apex acuminate, one - veined distinct, raised outside, margin curve reflexed to outside, coriaceous, rusty dot hairs both sides, except at base at base inside, 4.5 x 2 cm; inner 3, smaller, densely rusty puberulous outside, scurfy inside, except at the base, claw; 15 x 7 mm, coriaceous. *Stamens* numerous, 3 mm long, connectives apiculate. *Pistils* several, vertically grooved, 4 mm long; stigma minute, canaliculate; style linear, warty toward apex; ovary cylindrical, densely rusty hairs; ovule 1, basal.

Thailand - southwestern: Kanchanaburi

Distribution - unknown

Ecology - Evergreen forest

Phenology - Flowering April - June

Specimens examined - Yuyen 239 (CMU)

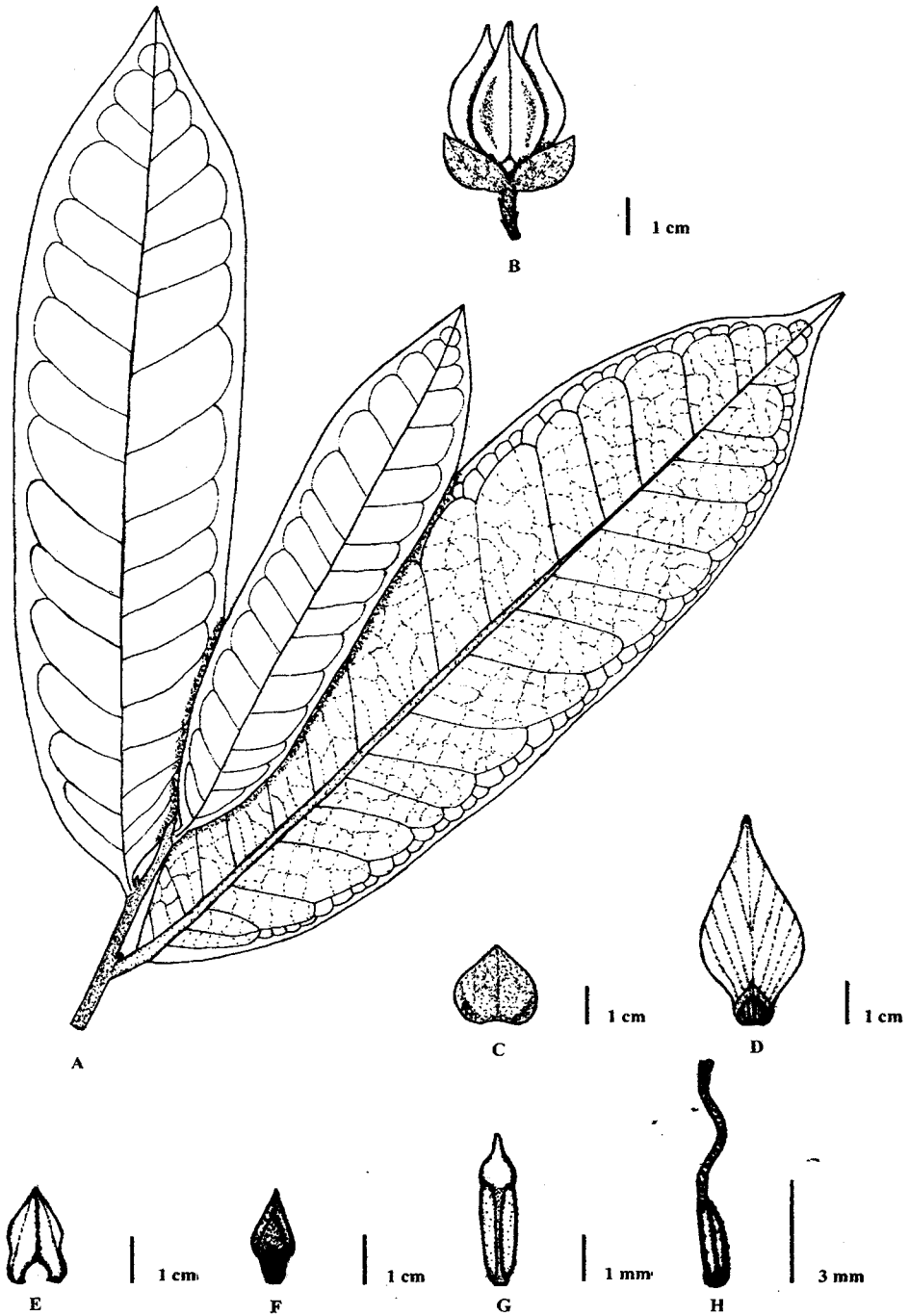


Figure 3.28 *Goniothalamus* sp. Maerim: A. twig; B. flower; C. outside of sepal; D. inside of outer petal; E. connate of inside petals; F. inside of inner petal; G. stamen; H. pistil; (A – H Yuyen 239) Drawn by Y. Yuyen.

19. *Goniothalamus* sp. Narathiwat. Figure 3.29; 3.31 (B).

Shrub about 1 – 1.5 m high; bark glabrous, dark brown, striate; branchlets straight, dark brown, striate, densely rusty puberulous, then becoming to sparsely rusty puberulous or glabrous when older. *Leaves* simple, alternate; blades elliptic, chartaceous; apex long acuminate, base broadly acute; green above, pale green below; glabrous both sides, with sparsely rusty puberulous on midrib below; midrib grooved above, raised below; secondary nerves 10 pairs, fine but visible both sides, curving and anastomosing near the margin, reticulation faint; 10 – 11.5 x 4 – 4.7 cm. *Petioles* dorsally grooved, sparsely rusty puberulous, wrinkled, 5 mm long. *Flowers* solitary, axillary; pedicel about 3 mm long, sparsely rusty puberulous, with 2 – 3 scale-like, green bracts at the base. *Sepals* orbicular, nearly free, chartaceous, acute at the apex; sparsely rusty puberulous outside, glabrous inside; 8 mm long, 10 mm broad. *Petals* 6, coriaceous, greenish - yellowish; outer 3, coriaceous, ovate, apex acuminate, several parallel veins rising from the base both sides, slightly glabrous both sides, with rusty puberulous on the base outside, claw rather broad, 2.2 x 1.3 cm; inner 3, coriaceous, ovate, acuminate at the apex, sparsely rusty puberulous outside, with rusty puberulous on the margin, glabrous inside, claw; 1.3 x 0.8 cm, united. *Stamens* numerous, 1 mm long, connectives convex. *Pistils* several, vertically grooved, 2 mm long; stigma claviform, glabrous, canaliculate; style short; ovary cylindrical, densely rusty hairs; ovule 1, basal.

Thailand – southern: Narathiwat

Distribution – unknown

Ecology – Evergreen forest

Phenology – Flowering January - May

Specimens examined - Yuyen 206 (CMU)

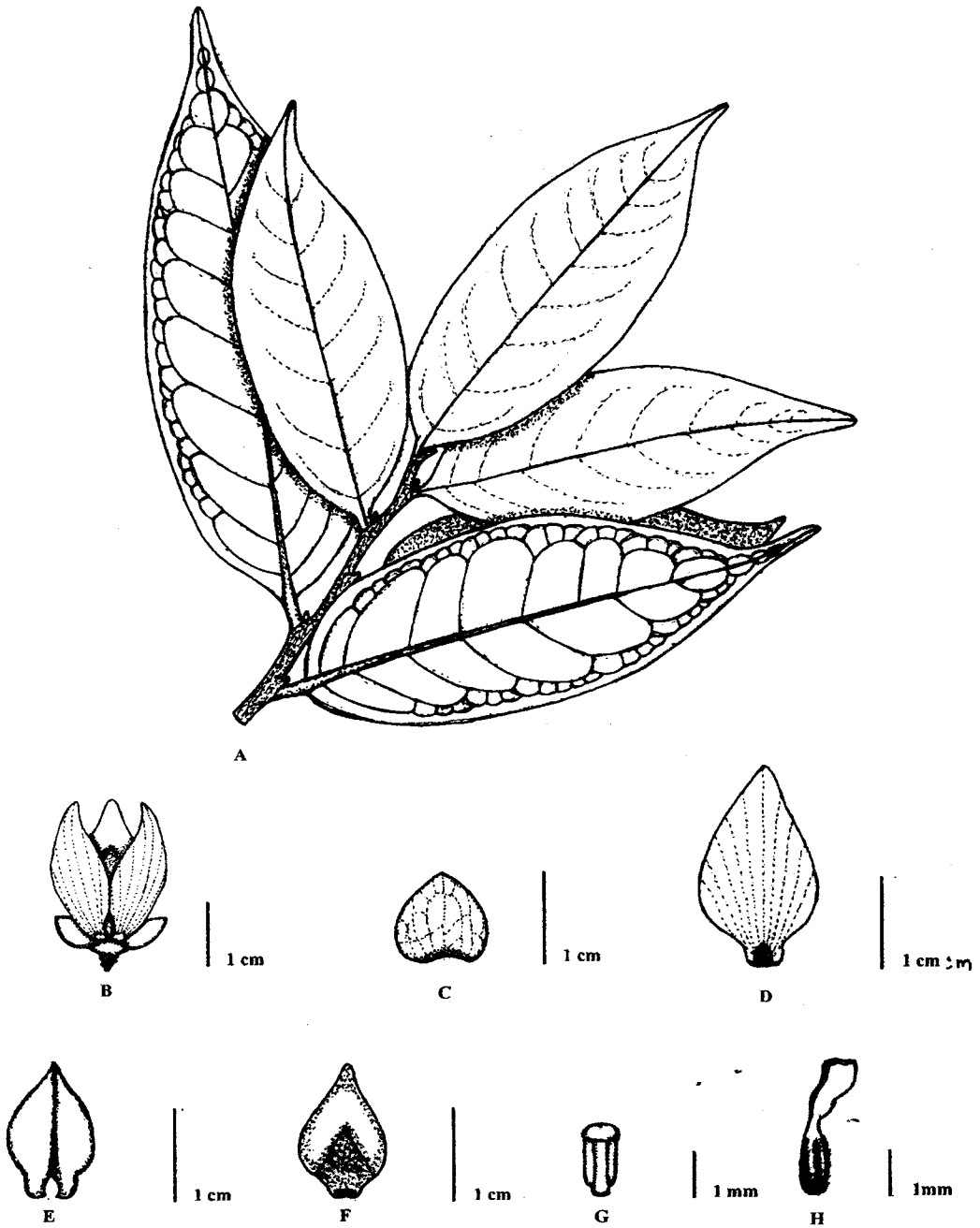


Figure 3.29 *Goniothalamus* sp. Narathiwat: A. twig; B. flower; C. outside of sepal; D. inside of outer petal; E. connate of inner petals; F. inside of inner petal; G. stamen; H. pistil; (A – H Yuyen 206) Drawn by Y. Yuyen.

20. Goniotalamus sp. Sunyataram. Figure 3.30; 3.31 (A).

Treelet about 1 - 2 m high; bark brown, striate; branchlets straight, brown, glabrous, striate. *Leaves* simple, alternate; blades oblong, coriaceous; bluntly acuminate at the apex, broadly acute at the base; pale green above when dry, paler below, glabrous both sides, with sparsely dot hairs on midrib below, densely brown glandular dots below, faint above; midrib grooved above, raised below; secondary nerves 14 - 17 pairs, fine above, prominent below, curving and anastomosing some distance from the midrib, reticulation faint; 35 - 42 x 8.5 - 10 cm. *Petioles* stout, grooved above, wrinkled, glabrous, 1 cm long. *Flowers* solitary, axillary from fall leaves on the main stem; pedicel about 12 - 14 mm long, broadening towards base of calyx, sparsely rusty puberulous, with 2 scale-like, green bracts at the base. *Sepals* ovate, chartaceous, acute at the apex, nearly free to base; rusty pubescent both sides, except at the base inside; several veins, reticulation distinct; 2 cm long, 1.6 cm broad, green. *Petals* 6; outer 3, lanceolate, apex acute, one - prominent veined outside coriaceous, densely rusty glandular hairs both side, except at the base inside, greenish; claw rather broad; 4.8 x 1.1 cm; inner 3, smaller, coriaceous, rusty glandular hairs with one vein outside, scurfy inside, except at the base; 15 x 5 mm, lanceolate, long acuminate at the apex. *Stamens* numerous, 3.5 mm long, connectives apiculate. *Pistils* several, vertically grooved, 6 mm long; stigma minute, canaliculate; style linear, warty toward apex; ovary cylindrical, densely pale brown hairs; ovule 1, basal.

Thailand - southwestern: Kanchanaburi, Thong Pha Phum

Distribution - unknown

Ecology - Evergreen forest

Phenology - Flowering April

Specimens examined - Yuyen 218 (CMU)

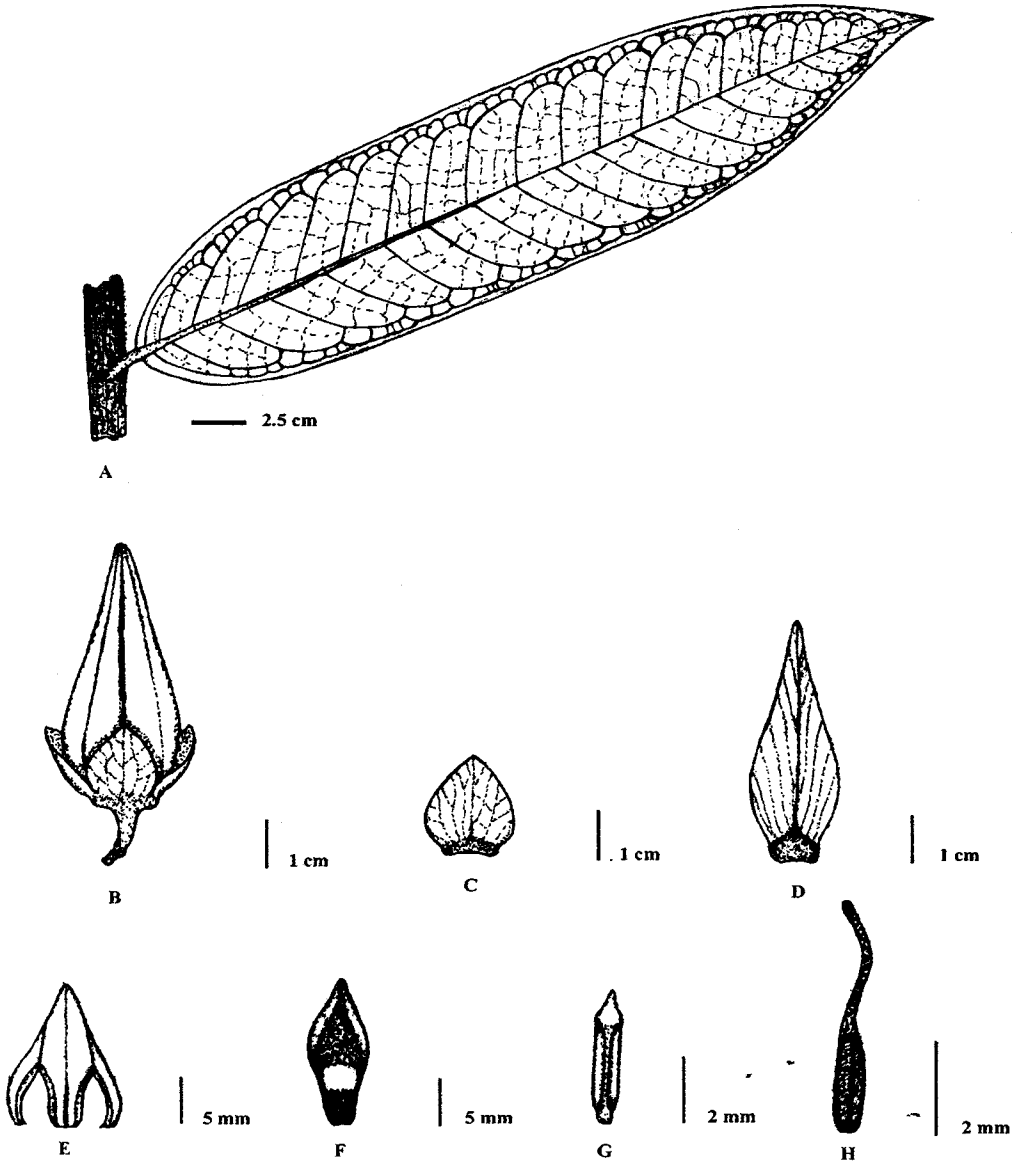
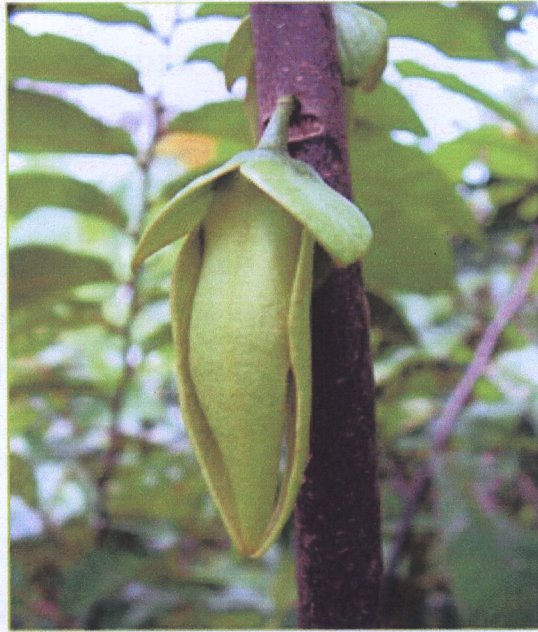
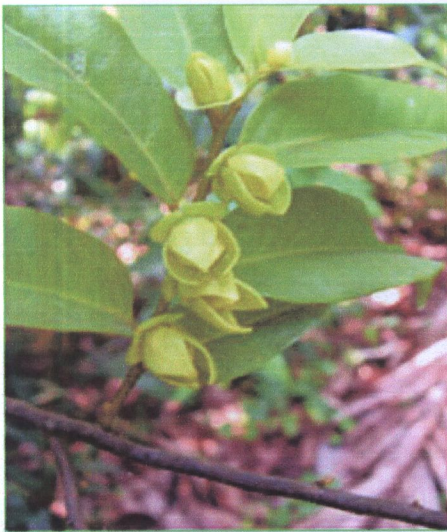


Figure 3.30 *Goniothalamus* sp. Sunyataram: A. upper side of leaf; B. flower; C. outside of sepal; D. inside of outer petal; E. connate of inner petals; F. inside of inner petal; G. stamen; H. pistil; (A – H Yuyen 218) Drawn by Y. Yuyen.



A



B



C

Figure 3.31 *Goniothalamus* spp.: A. *G.* sp. Sunyataram; B. *G.* sp. Narathiwat;
C. *G.* sp. Maerim.

CHAPTER 4

DISCUSSION

Mat-Salleh in 1993 reported that Boneo *Goniothalamus* have many characters that are taxonomically important and more varies within the genus. Four leaf types, 5 inner-petal dome types, 11 stamen types and 9 pistil types were recognized. As Mat-Salleh reported, Thai *Goniothalamus* have more varies of the characters within the genus too. Each character was described below.

4.1 VEGETATIVE MORPHOLOGY

Most species of *Goniothalamus* are small-stemmed monocaulous treelets 5-10 m high, normally growing in shady areas. The treelets become shrubby if left undisturbed. Some species, however, become relatively large.

The characteristics of the leaves of *Goniothalamus* are taxonomically important. In general there are various types of leaves, but when considering the hairs on the leaf surface, four leaf types were classified. The first type is represented by *G. griffithii*, *G. tortilipetalus*, *G. sp.* Sunyataram, *G. macrophyllus*, *G. umbrosus*, *G. sp.* Narathiwat, *G. repevensis* and *G. sp.* Maerim. The leaves are glabrous, most of them have densely glandular brown dots, coriaceous or chartaceous, oblong or elliptic, with the main veins usually straight and distinct.

The second leaf type is found in *G. maewongensis*, *G. aurantiacus*, *G. undulatus*, *G. laoticus*, *G. malayanus*, *G. tapis*, *G. sp.* Aunglaeonai and *G. giganteus*. This type is hairy on the lower side, glabrous above, oblong, or obovate, chartaceous, or coriaceous.

The third leaf type is common in *G. elegans*, *G. marcanii* and *G. sawtehii*. The leaves of this type are hairy both sides, oblong or lanceolate, chartaceous, or coriaceous.

The fourth leaf type is found in *G. cheliensis* is hairy below like type two, but the leaf is extremely large, sometime gigantic. Leaves are up to 55-66 x 16-20 cm.

4.2 REPRODUCTIVE MORPHOLOGY

Goniothalamus flowers have typical annonaceous floral features. They are normally solitary, at times in pairs, with the pedicel subtended by imbricate bracts. The showy perianth consists of three chartaceous or coriaceous sepals and six petals borne on a slightly convex torus. The petals are arranged in two whorls of three each. The outer petals are spreading and alternate with the sepals. The inner petals are joined in the upper half to form a dome-shape structure enclosing the androecium and gynoecium. The lower part of the inner petals tapers to the base, thus leaving the lower part of the dome with three openings.

From field observation the inner petal dome protects the sexual organs from foraging beetles, which serve as pollinators in the Annonaceae. The arrangement of the outer petals in relation to the inner petals makes it possible for the three opening at the base of the dome to remain closed until the flower reaches full maturity. In immature flowers the outer petals are erect and pressed to this opening, thus blocking the entrance to the inside. During anthesis the outer petals spread out slightly, exposing the dome openings as passages to the inside through which pollinating insects must enter to reach the stamen and stigmas. At anthesis the flowers emit sweet-pungent fragrances.

4.3 SEPAL MORPHOLOGY

The sepal characters of *Goniothalamus* are diverse, but have some taxonomic value such as sepal shape, sepal hair types and sepal reticulation:

The sepal shapes of *Goniothalamus* are triangular, ovate, orbicular or suborbicular. Members of this triangular group are *G. aurantiacus*, *G. sp. Aunglaeonai*, *G. tortilipetalus*, *G. repevensis*, *G. sp. Maerim* and *G. giganteus*. The size depends on each species.

Another type of sepal shape is ovate, which is found in *G. cheliensis*, *G. griffithii*, *G. undulatus*, *G. sp. Sunyataram*, *G. malayanus*, *G. macrophyllus* and *G. umbrosus*.

G. elegans, *G. marcanii*, *G. laoticus*, *G. tapis*, *G. sp.* Narathiwat and *G. sawtechii* have orbicular or suborbicular sepal shapes.

The species of *Goniothalamus* which have distinct reticulation on the sepals are *G. griffithii*, *G. tortilipetalus*, *G. sp.* Sunyataram and *G. sp.* Maerim. This *Goniothalamus* group shares other similar characters such as leaves, stamen or pistil characters.

Goniothalamus can be divided into three types using sepal hairs. They are hairy both sides, or hairy outside, or glabrous. The species which are hairy on both sides are *G. cheliensis*, *G. tortilipetalus*, *G. sp.* Sunyataram, *G. macrophyllus*, *G. sawtechii* and *G. giganteus*.

The second type is hairy outside. This type are found in most of the Thai *Goniothalamus* species, i.e. *G. aurantiacus*, *G. sp.* Aunglaeonai, *G. elegans*, *G. macarnii*, *G. undulatus*, *G. laoticus*, *G. repevensis*, *G. tapis*, *G. sp.* Narathiwat and *G. maewongensis*.

The third type with glabrous sepals occurs in *G. griffithii* and *G. umbrosus*. However from this study it was also found that *G. sp.* Maerim also has hairs on the inside of the sepals.

4.4 OUTER PETAL MORPHOLOGY

The three outer petals of *Goniothalamus* are diverse and often used as distinguishing characters. They can be very large in some species. The largest is found in *G. giganteus*, and petals can reach up to 12 cm long and 6 cm wide. The smallest is found in *G. elegans* (1.5 x 0.9 cm).

Some species such as *G. sp.* Sunyataram have long outer petals (4.8 cm long) but they are very narrow (1.1 cm wide). *G. cheliensis* has large petals which are more succulent. The petal size is 6.5 x 3.5 cm.

Most species have coriaceous outer petals, ovate, or lanceolate. The outer petals are fleshy when fresh or succulent. The colour ranges from greenish, yellowish to orange, rarely red (*G. repevensis*). All of the outer petals of Thai *Goniothalamus* are hairy on both sides except in *G. sp.* Narathiwat which is glabrous.

The outer petals of *Goniothalamus* usually have one prominent vein. However, in this study it was also found that parallel veins arise from the base with one prominent vein. The species with parallel veins are *G. tortilipetalus*, *G. aurantiacus*, *G. laoticus*, *G. tortilipetalus*, *G. repevensis*, *G. macrophyllus*, *G. tapis*, *G. sp. Narathiwat*, *G. maewongensis*, *G. umbrosus*, *G. sawtehii*, *G. sp. Maerim* and *G. giganteus*.

4.5 INNER PETAL MORPHOLOGY

The inner petals of *Goniothalamus* are generally smaller than the outer. The mitreform domes in this genus stay intact after anthesis and drop off as a single unit.

The whole dome needs to be considered as a unit for taxonomic analysis. Its morphology is diverse for the genus, with at least six distinct types (Figure 4.1) the most common type, designated here as dome type A, is well represented in *G. elegans*, *G. giganteus* and *G. repevensis*. This dome is bluntly acute apex and the claw is broad to form a narrow opening at the base.

Dome type B is characterized by being rather broadly obtuse, with the apex of the inner petals forming an orbicular dome, and a wide opening at the base. This type is found in *G. maewongensis* and *G. aurantiacus*.

Dome type C occurs in *G. laoticus*, *G. macrophyllus* and *G. marcanii*. In this group the inner petals are acute at the apex, the claw is rather slender, and about half the length of the inner petals and forms a rather broad opening at the base.

Dome type D is found in a group of species with inner petals of an acute shape acute, and a claw rather broad, which is about a third the length of the inner petals, forming a narrow opening at the base. The species of dome type D include *G. cheliensis*,

G. tapis, *G. tortilipetalus*, *G. undulatus*, *G. sp. Aunglaeonai* and *G. sp. Narathiwat*.

Dome type E is very rare and so far is known in only two species, *G. sawtehii* and *G. umbrosus*. It has an acuminate apex, a rather slender claw at its base and gradually toward the broad apex to form a wide opening at the base.

Dome type F is more or less similar to that of type E, but the inner petal is quite narrow and lanceolate at the apex, the claw is rather broad and short to form a narrow opening at the base. Species of dome type E are *G. griffithii*, *G. sp. Maerim* and *G. sp. Sunyataram*.

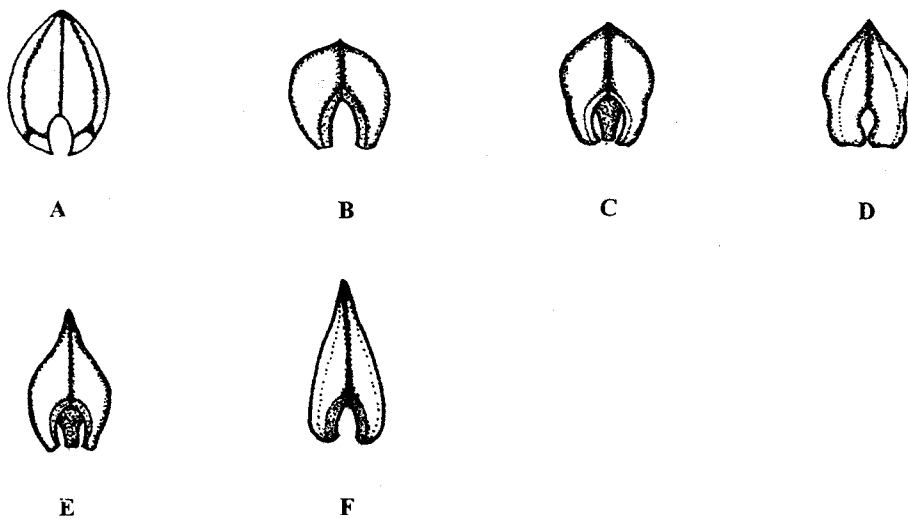


Figure 4.1 The main types of mitreform domes of *Goniothalamus* species in Thailand.

4.6 STAMENS MORPHOLOGY

Stamens of *Goniothalamus* are of a primitive nature for angiosperms in general. They are numerous, laminar, and spirally arranged on an elevated torus surrounding the pistils in the centre of the torus. The large pollen grains are produced in two pairs of oblong elongated thecae separated by a woody connective.

The taxonomically important part of the stamen is the connective, especially the tip. In fact, stamen connectives have been widely utilized in traditional classifications to divide *Goniothalamus* into subgenera or sections (Bân, 1974). *Goniothalamus* species have been reported to have either apiculate or flat-topped connectives.

From the study of *Goniothalamus* in Thailand, at least 7 types of stamens can be seen (Figure 4.2). The first type, designated here as stamen type A is found in *G. repevensis*, *G. maewongensis*, *G. sawtehii*, *G. malayanus* and *G. aurantiacus*. These stamens are short, with truncate connective covered with a glandular echinate indumentum all over the apex.

Stamen type B is similar to type A. The stamens have a convex connective with glandular echinate indumenta all over the apex. Type B stamens are found in *G. elegans*, *G. giganteus*, *G. marcanii*, *G. sp. Narathiwat*, *G. sp. Aunglaeonai* and *G. laoticus*.

Stamen type C seems to represent the apex of truncate connective becoming more bluntly apiculate. So far, type C stamens are found only in *G. cheliensis*.

Stamen type D is found in *G. tapis* and *G. tortilipetalus*, where broad connectives are apiculate with glandular echinate indumenta all over the apex.

Stamen type E found in *G. griffithii*, *G. sp. Maerim* and *G. sp. Sunyataram*. The stamens are long and have an apiculate connective gradually narrow to the apex.

Stamen type F is similar to the stamen type E, but has a shorter connective. Type F is found in *G. macrophyllus*.

Stamen type G is only found in *G. umbrosus*, and has a shapely connective which is covered with echinate indumenta all over the apex.

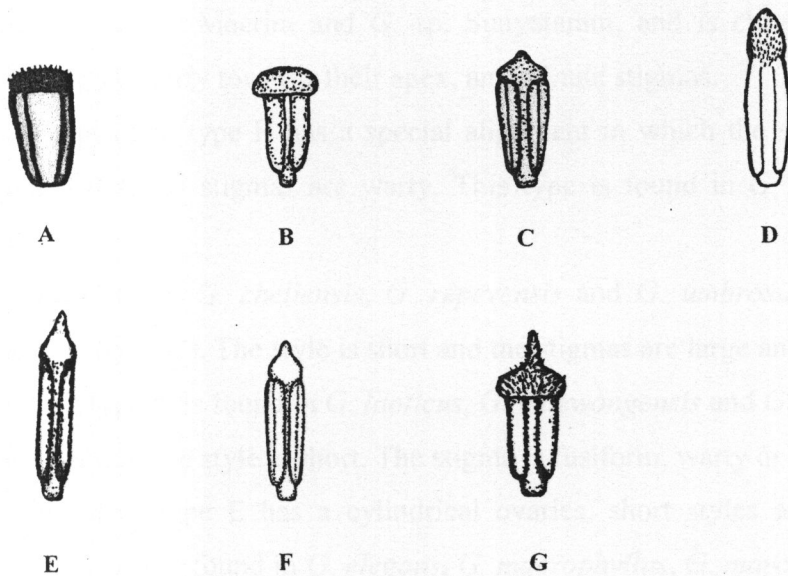


Figure 4.2 The main types of stamens of *Goniiothalamus* species in Thailand.

4.7 PISTIL MORPHOLOGY

Goniiothalamus flowers have numerous apocarpous pistils arranged in the centre of the torus. The ovaries are cylindrical, and pubescent or glabrous with hairs confined to the base. Taxonomically, the most interesting part of the pistil is the stigma. The stigmas have various shapes and surface characteristics. Additionally, ovule number is taxonomically significant as well. Ovule number has been utilized to classify *Goniiothalamus* into subgenera (Boerlage, 1899). The ovaries in most species normally have a single basal ovule. Ovaries in *G. laoticus* have up to 9 ovules per ovary.

As in the case of stamens, *Goniiothalamus* pistils can be categorized into several types (Figure 4.3)

Type A is found in *G. griffithii*, *G. sawtehii*, *G. tortilipetalus*, *G. sp. Aunglaeonai*, *G. sp. Maerim* and *G. sp. Sunyataram*, and is characterized by long styles, which are warty towards their apex, and minute stigmas.

The pistil of type B has a special alignment in which the stigma is incurved 360°, and styles and stigmas are warty. This type is found in *G. giganteus* and *G. malayanus*.

The pistil of *G. cheliensis*, *G. repevensis* and *G. umbrosus* is considered a separate type (type C). The style is short and the stigmas are large and cylindrical.

Pistil type D is found in *G. laoticus*, *G. maewongensis* and *G. aurantiacus*. The ovary is glabrous, the style is short. The stigma is fusiform, warty or glabrous.

The pistil type E has a cylindrical ovaries, short styles and clavate, warty stigmas. This type is found in *G. elegans*, *G. macrophyllus*, *G. marcanii*, *G. undulatus* and *G. sp. Narathiwat*.

Pistil of *G. tapis* (type F) has a unique character of all *Goniothalamus* taxa in Thailand. It has a warty linear style and a funnel shaped stigma.

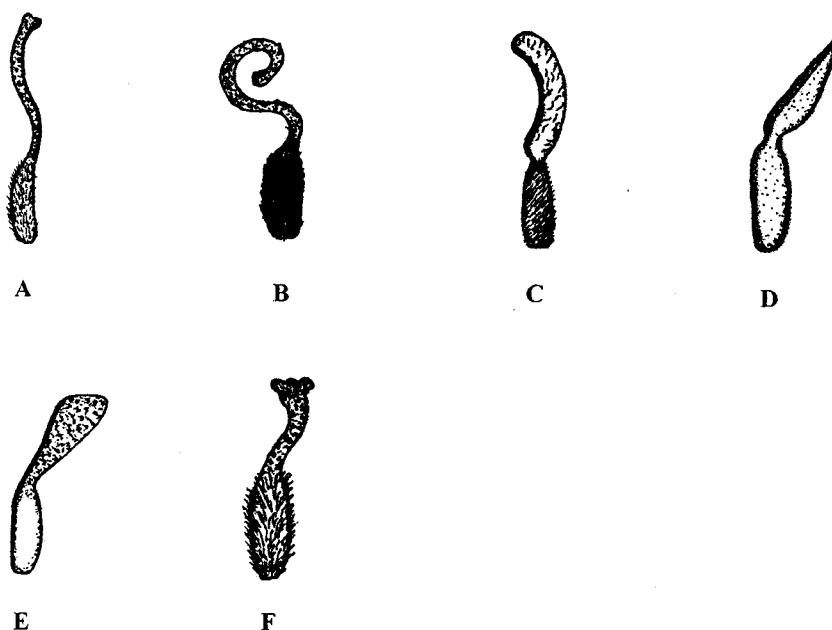


Figure 4.3 The main types of pistils of *Goniothalamus* species in Thailand.

4.8 PHENOLOGY

In an attempt to observe general phenological conditions of *Goniothalamus* in Thailand, developmental stages of flowering and fruiting herbarium specimens of all species were noted. It appears that the genus as a whole has two flowering seasons. The first season's peak, is around March - May and is found in most *Goniothalamus* taxa and the second October - November is found in only *G. umbrosus*. Some species flower throughout the year such as *G. malayanus*.

4.9 INFRAGENERIC CLASSIFICATION

The first author to formalize the infrageneric classification of *Goniothalamus* was Boerlage (1899), when he appropriately decided to incorporate Warburg's *Beccariodendron* into *Goniothalamus*, which had been separated from *Goniothalamus* on the basis of its carpels having 4 ovules rather than 1 or 2 as commonly found in *Goniothalamus*. The section *Beccariodendron* was proposed by Boerlage to accommodate *Beccariodendron grandiflorus* and other multi-ovulate species of *Goniothalamus*. Species of *Goniothalamus* with one or two ovules were grouped in to section "*Eu-Goniothalamus*".

When Bân (1974) proposed his infrageneric classification, he did not consider the number of ovules as important; rather he used this distinction only at the subsectional level. Bân divided the genus into two subgenera: subgenus *Goniothalamus* (apiculate stamens) and subgenus *Truncatella* (truncate stamens). He also suggested that subgenus *Goniothalamus* could be divided into two sections: section *Goniothalamus* (with subsections *Goniothalamotypus* and *Pleiospermi*) and section *Longistigma*. The other subgenus *Truncatella* was also divided into two sections: section *Infundibulistigma* (with subsections *Polyspermi* and *Infundibuliformes*) and section *Truncatella* (with subsections *Multiseminales* and *Pauciseminales*).

Mat-Salleh (1993 and 2001) in studying *Goniothalamus* species from Borneo, suggested that an infrageneric classification would be more natural if based on floral/leaf characters and habits.

To further evaluate Boerlage and Bân's Classification, Thai *Goniothalamus* species are arranged into their classification and are listed in Table 4.1

Boerlage's classification is confined to *Goniothalamus* in Thailand. He divided them into two sections. The first section is *Beccariodendron*, with one or two ovules. The members of this section are *G. elegans*, *G. marcanii*, *G. sp. Narathiwat*, *G. sawtehii*, *G. sp. Aunglaeonai*, *G. undulatus*, *G. repevensis*, *G. tortilipetalus*, *G. umbrosus*, *G. griffithii*, *G. sp. Sunyataram*, *G. sp. Maerim*, *G. tapis* and *G. macrophyllus*.

The second section of Boerlage's classification is Section *Eu-Goniothalamus*, which have more than two ovules. They are *G. laoticus*, *G. marcanii*, *G. cheliensis*, *G. aurantiacus*, *G. maewongensis* and *G. malayanus*.

Bân's classification is not confined to *Goniothalamus* in Thailand. Many species could not be classified into sectional levels, because *Goniothalamus* taxa in Thailand have more diverse characters than Bân proposed. For example, *G. malayanus* has a truncate stamen connective. Therefore, it was placed in the subgenus *Truncatella*, but it could not be classified to a sectional level. The reason for this is coiled and not fusiform or funnel shaped like the section *Infundibulistigma* or minute like the section *Truncatella*. Two more species that were not classified into the sectional level of Bân are *G. tapis* and *G. macrophyllus*. Because section *Goniothalamus* has minute stigmas and section *longistigma* has filiform stigmas. While *G. tapis* and *G. macrophyllus* have funnel and clavate shaped stigmas respectively.

A problem with Bân's infrageneric classification is the stigma and style characters of Thai *Goniothalamus* may be more complex than detailed by Bân. For instance in the Thai species, six types of stigmas were noted (Figure 4.3). In addition to minute, fusiform and funnel-shaped stigmas, there are clavate stigmas of *G. elegans*, *G. marcanii*, and *G. sp. Narathiwat*, cylindrical stigmas of *G. repevensis*, *G. umbrosus*, and *G. undulatus* and the coiled stigmas of *G. malayanus*.

Table 4.1 *Goniothalamus* in Thailand in the infrageneric classification of Boerlage (1899) and Bân (1974).

Boerlage's classification (1899)	Bân's classification (1974)
Section <i>Becariodendron</i>	Subgenus <i>Truncatella</i>
<i>G. laoticus</i>	<i>G. malayanus</i>
<i>G. cheliensis</i>	<i>G. giganteus</i>
<i>G. aurantiacus</i>	Section 1. <i>Infundibulistigma</i>
<i>G. maewongensis</i>	<i>G. elegans</i>
<i>G. malayanus</i>	<i>G. marcanii</i>
Section <i>Eu-Goniothalamus</i>	<i>G. sp. Narathiwat</i>
<i>G. elegans</i>	<i>G. undulatus</i>
<i>G. marcanii</i>	<i>G. laoticus</i>
<i>G. sp. Narathiwat</i>	<i>G. cheliensis</i>
<i>G. sawtehii</i>	<i>G. repevensis</i>
<i>G. sp. Aunglaeonai</i>	<i>G. maewongensis</i>
<i>G. undulatus</i>	<i>G. aurantiacus</i>
<i>G. repevensis</i>	Section 2. <i>Truncatella</i>
<i>G. tortilipetalus</i>	<i>G. sawtehii</i>
<i>G. umbrosus</i>	<i>G. sp. Aunglaeonai</i>
<i>G. griffithii</i>	Subgenus <i>Goniothalamus</i>
<i>G. sp. Sunyataram</i>	<i>G. tapis</i>
<i>G. sp. Maerim</i>	<i>G. macrophyllus</i>
<i>G. tapis</i>	Section 3. <i>Goniothalamus</i>
<i>G. macrophyllus</i>	<i>G. tortilipetalus</i>
<i>G. giganteus</i>	<i>G. umbrosus</i>
	<i>G. griffithii</i>
	<i>G. sp. Sunyataram</i>
	<i>G. sp. Maerim</i>
	Section 4. <i>Longistigma</i>

4.10 GEOGRAPHIC DISTRIBUTION OF *GONIOTHALAMUS* IN THAILAND

This study indicates that *Goniothalamus* has a wide distribution throughout Thailand (Figure 4.4). A wide distribution of this genus may be due to effective fruit dispersal. Birds and mammals are the most likely seed vectors but studies of seed dispersal in the genus are lacking.

Saunders (2002 and 2003) suggested that *Goniothalamus* has a centre of diversity in Indochina and western Malesia. Accordingly, most *Goniothalamus* were found in the south of Thailand. For example, *G. undulatus*, *G. giganteus*, *G. umbrosus*, *G. tapis*, *G. malayanus*, *G. macrophyllus*. All of them were noted as members from the Malesian element.

Yuyen and Boonkerd (2002) suggested that Thailand (and particularly Prachuap Khiri Khan Province) has long been a meeting point of Malesian elements (Malay Archipelago and Malay Island to the Isthmus of Kra, in Ranong Province, Thailand), Indo-Burmese element (eastern Himalayas and Guinghai-Tibetan plateau and the subtropics of South China, the Ganges plain, eastern India, Bangladesh, Upper Myanmar and Thailand), and Indo-Chinese element (southern China and Indochina). Accordingly, the species that were reported from Malesian element were also found in this area (southwestern). For example, *G. sawtehii* (South Tenasserim, Burma), *G. tortilipetalus* (Pahang, Perak and lower Siam). Moreover some species that are unidentifiable were also found in this region (*G. sp. Sunyataram*, *G. sp. Maerim*). Further sample collecting should be continued in this area.

However, *Goniothalamus* species were found in other parts of Thailand too. The species found in northern regions are *G. griffithii* and *G. cheliensis*. They were noted as members of the Indo-Chinese element. *Goniothalamus* species from the northeastern and eastern parts of Thailand are *G. elegans* and *G. laoticus*. They were noted as members of Vietnam and Laos respectively.

Interestingly, *G. marcanii* which was noted from Pahang, Selangor was also found in the northeastern and southeastern region. This data suggests that *Goniothalamus* was distributed to Thailand from Malesian element longer than other elements.

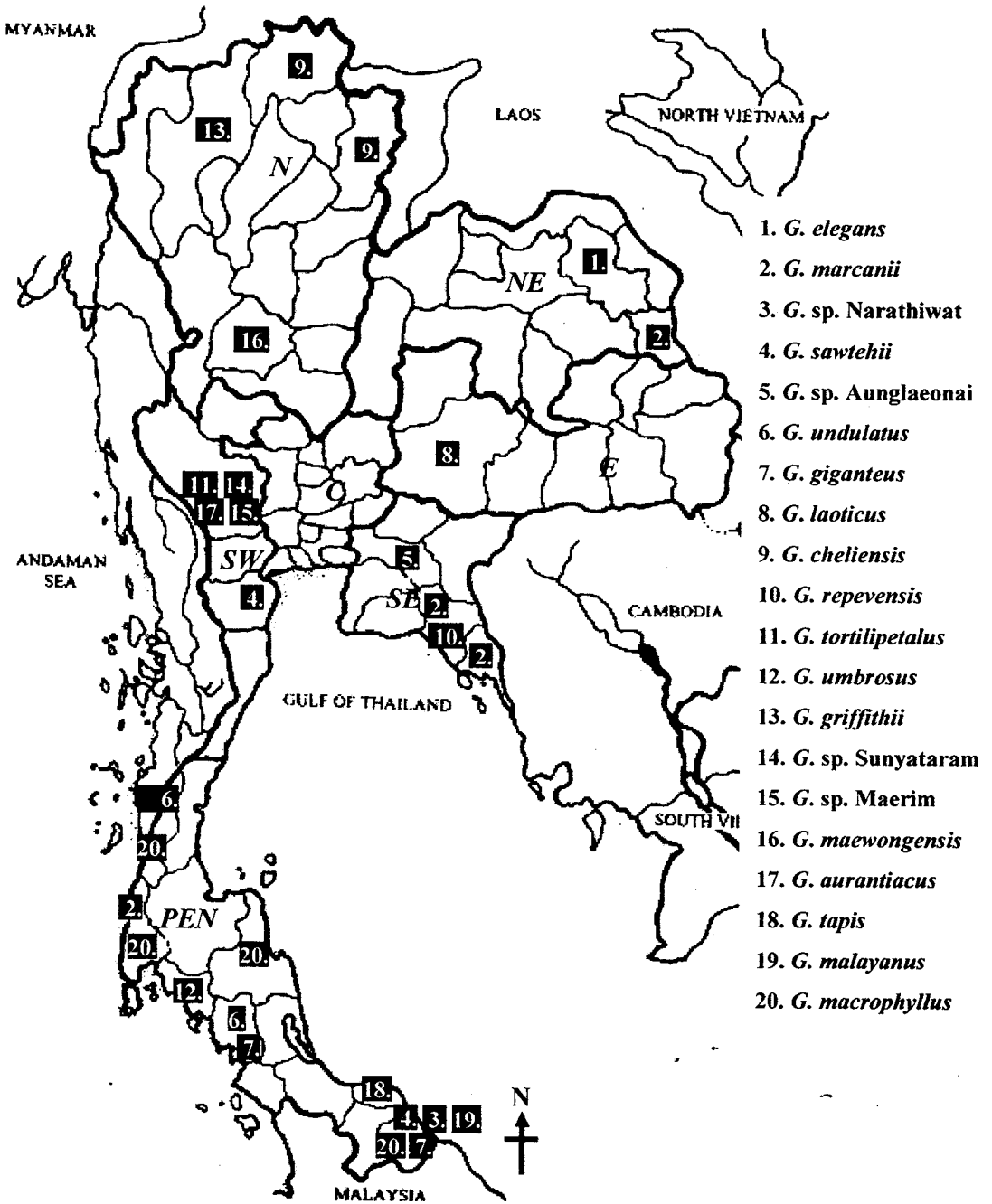


Figure 4.4 Collecting localities of 20 Thai *Goniiothalamus* specimens used in this study. The floristic-region map of Thailand is after Smitinand (2001). Abbreviations of the floristic-regions are as follows: *N* = North, *NE* = Northeast, *E* = East, *SW* = Southwest, *C* = Central, *SE* = Southeast, *PEN* = Peninsular.

4.11 TAXONOMIC IMPLICATIONS OF THE THAI *GONIOTHALAMUS* PHYLOGENY

From the combined *trnL* and *trnG* intron data set suggested that the genus *Goniothalamus* was found in this study to be a natural, monophyletic group. There are six groups of *Goniothalamus* in Thailand, but only Clade IV (Clade IV, *G. tortilipetalus*, *G. umbrosus*, *G. griffithii*, *G. sp.* Sunyataram, and *G. sp.* Maerim) has high bootstrap support (bootstrap values of 94%, 92%, and 95% on the MP, NJ, and ML trees, respectively).

The six clades suggested in this study to some extent reflect floral morphology including the number of ovules and the shape of the stamen connective, characteristics used in the infrageneric classification systems of Boerlage (1899) and Bân (1974) respectively, but not biogeography (Figure 4.5). Elements of both Boerlage's and Bân's infrageneric classifications are reflected in this analysis, although the results are not strictly congruent with either.

All taxa in the clades I, II, and IV had only one or two ovules (i.e. section *Eu-Goniothalamus* (one or two ovules). On the other hand, the clades III and V were the only two subgroups that had many ovules (i.e. section *Beccariodendron*). However, from the tree, section *Beccariodendron* appears to be a paraphyletic group, as *G. repevensis* and the clades I, II, and III are clustered together. However, support for this grouping (that suggests parphyly) is very weak, so a monophyletic section *Beccariodendron* cannot be ruled out. Additionally, there have Clade VI of *G. tapis* (1 ovule) and *G. malayanus* (2-5), has mixed ovule number characteristics.

Similarly six proposed clades can be compared to Bân's subgeneric classification using the character of truncate vs apiculate stamen connectives. It seems that the stamen connective of Thai *Goniothalamus* has an intermediate form between truncate and apiculate stamen connectives (e.g. convex stamen connectives). However, convex species were classified into the subgenus *Truncatella* as truncate connective stamens. Accordingly, from the topology, the species which has truncate and convex connective stamen were clustered together. For instance the clustering of the truncate or convex taxa, *G. repevensis* and clades I, II, and III, is possibly suggestive of a natural group of truncate or convex species (subgenus *Truncatella*), separated from the

subgenus *Goniothalamus* (exemplified by Clade IV). Likewise Boerlage classification, Clade VI of *G. tapis* (apiculate) and *G. malayanus* (truncate), were grouped together. The relationship of these two species is needed to investigate this problem further.

In addition to the importance of the stamen connective, Bân (1974) recommended using style and stigma features to further divide the two subgenera of *Goniothalamus* into four sections. It seems that stigma and style characters may be more complex than detailed by Bân. For instance in the Thai species, six types of stigmas were noted (Figure 4.3). In addition to minute, fusiform and funnel-shaped stigmas, there are clavate stigmas of *G. elegans*, *G. macranii*, and *G. sp.* Narathiwat, cylindrical stigmas of *G. repevensis*, *G. umbrosus*, and *G. undulatus* and the coiled stigmas of *G. malayanus*.

Finally, it is important to note that *Goniothalamus* is a large and complex genus and consequently this study is a preliminary one. The addition of further genes and further taxon sampling is clearly needed to further test the results reported here.

Region Ovule Boerlage's Sect. Stamen/Style/Stigma Bân's Subgen./Sect.

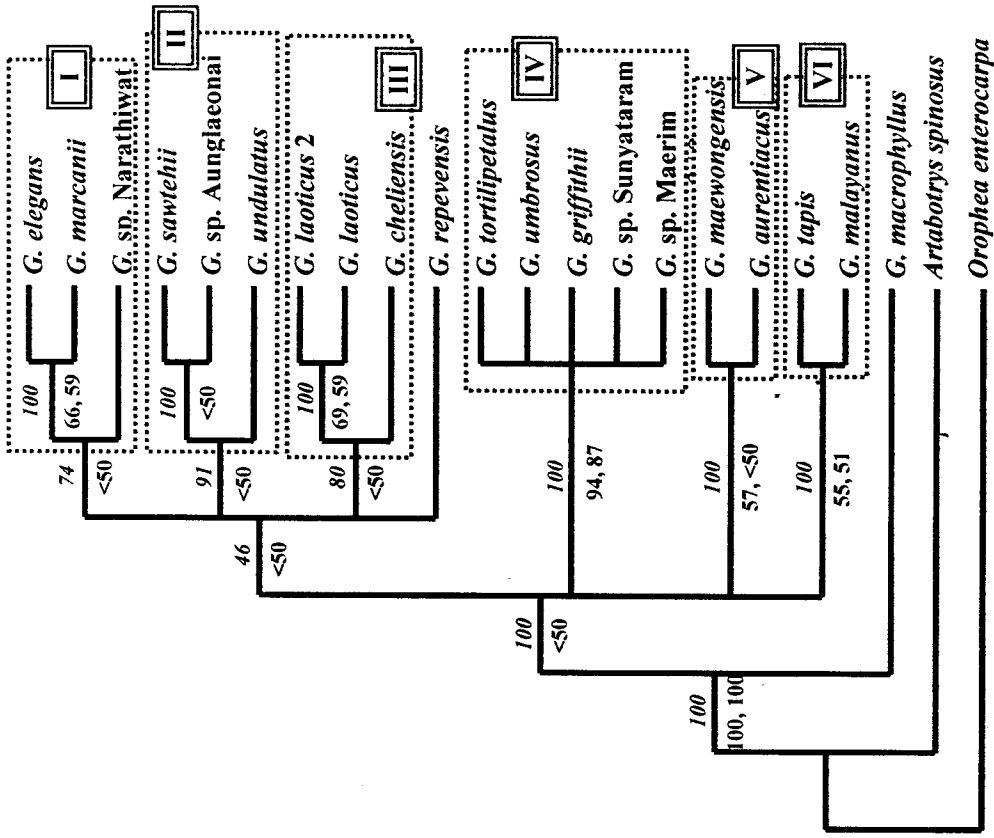


Figure 4.5 Semistrict consensus tree of 3273 equally most-parsimonious trees based on the 73-basepair combined *trnL/trnG* intron sequence matrix of 20 Thai *Goniothalamus* with two Annonaceae outgroups. Numbers above branches (in italics) are identical percentages of the branch among all congruent parsimonious trees. Numbers below branches designate bootstrap and jackknife support of 1,000 replicates, respectively. Collecting regions, important floral characteristics, and Boerlage's and Bân's taxonomic assignments were also indicated. Abbreviations of subgenera and sections as follow: *Eu-Go.* = section *Eu-Goniothalamus*, *Bec.* = section *Beccariodendron*, *TR.* = subgenus *Truncatella*, *GO.* = subgenus *Goniothalamus*, *In.* = section *Infundibulistigma*, *Tr.* = section *Truncatella*, *Go.* = section *Goniothalamus*, and *n.a.* = unable to classify to section.

4.12 COMPARISON OF *GONIOTHALAMUS* OF THAILAND AND ADJACENT AREAS

There have been many revisions of *Goniothalamus* in the adjacent areas of Thailand. Many new species and new records have been reported and some of them have a distribution throughout the southern part of Thailand. Several treatments of the genus have been published (Mat – Salleh, 2001; Saunders, 2001, 2002). Comparisons will be made from three sites (Table 4.2).

Borneo and adjacent areas (Mat – Salleh, 2001). The revision based on herbarium specimens and field observations of natural populations. A total of 30 species including 11 new species were reported. In this study *G. macrophyllus* was reported for Thailand.

Malaysian Peninsular, Sumatra and Java (Saunders, 2001). Saunders classified approximately 21 species of *Goniothalamus* in the Malaysian Peninsular (including one new species), 15 species in Sumatra (including approximately seven new species) and two species in Java.

Sumatra and adjacent islands (Saunders, 2002). Fourteen species are recognized, including six endemics and two species are newly recorded from Sumatra. Moreover five species were reported from Southern Thailand (*G. tapis*, *G. macrophyllus*, *G. malayamus*, *G. ridleyi*, and *G. giganteus*).

Table 4.2 Comparison of *Goniothalamus* of Thailand and three adjacent areas.

Studied site	Diversity of <i>Goniothalamus</i>
Borneo and adjacent areas (Mat – Salleh, 2001)	30 species
Malaysian Peninsular, Sumatra and Java (Saunders, 2001)	21, 15 and 2 species
Sumatra and adjacent islands (Saunders, 2002)	14 species
The present study in Thailand	14 species and 6 unknown

4.13 NEW RECORD OF *GONIOTHALAMUS* FOR THAILAND

There have been few collections of *Goniothalamus* in Thailand. Craib (1925) found 9 species of *Goniothalamus*. A more recent checklist (Bygrave, 1997) listed 21 species and Chalermglin (2001) reported a preliminary survey and collection of the Annonaceae in Thailand. Twenty three species of *Goniothalamus* were enumerated. So far no comprehensive treatment of the genus *Goniothalamus* in Thailand has been published.

Twenty *Goniothalamus* species were found from this study. Sixteen of these were identifiable. The other four were unknown. Five species were reported for the first time in Thailand, i.e. *G. elegans*, *G. cheliensis*, *G. repevensis*, *G. sawtehii* and *G. umbrosus*.

G. elegans was found in Annam. In this study it was collected from north-eastern and eastern Thailand. It is an evergreen treelet in seasonal deciduous or mixed evergreen + deciduous forest at 300 – 500 m elevation.

G. cheliensis, previously known from south-western Yunnan, is reported from northern Thailand. It occurs in primary, evergreen, seasonal, hardwood forest at 1,000 m elevation.

G. repevensis was found in Cambodia and Laos. In this study samples was from south-eastern Thailand. It occurs in seasonal, primary, evergreen hardwood forest; 600 – 900 m elevation.

G. sawtehii was noted from South Tenasserim, Myanmar, is reported from south-western Thailand in evergreen forest at 200 – 800 elevation.

The last new record species for Thailand is *G. umbrosus*, previously found in Penang, Kelantan, Trengganu, Borneo. In Thailand it was found in southern evergreen forest at 200 - 600 m elevation.

4.14 UNIDENTIFIEDABLE SPECIES OF *GONIOTHALAMUS* IN THAILAND

From field expeditions, there were four species unknown which were named following the collecting localities. The unidentifiable species are *G. sp. Narathiwat*, *G. sp. Aunglaeonai*, *G. sp. Sunyataram* and *G. sp. Maerim*

G. sp. Sunyataram and *G. sp. Maerim* were found in south-western of Thailand.

G. sp. Aunglaeonai was found in south-eastern of Thailand

G. sp. Narathiwat was found in southern of Thailand

4.15 UTILIZATION OF *GONIOTHALAMUS*

The genus is not normally recognised as an important forest product. However, some species are used as ornamental plants because of their small size and strongly fragrant flowers. The species most commonly cultivated are *G. griffithii*, *G. laoticus*, *G. macrophyllus*, *G. malayanus*, *G. repevensis*, *G. sawtehii*, *G. tapis*, *G. tortilipetalus*, *G. umbrosus* and *G. undulatus*.

Burkill (1935) reported that *G. macrophyllus*, *G. umbrosus*, and *G. tapis* were widely utilised by village midwives in the Malay Peninsula for their traditional practices. *Goniothalamus malayanus* and *G. macrophyllus* have been used too in Borneo for the same purpose (Mat-Salleh, 1993). Javanese mountain dwellers also treated patients suffering from fevers with aromatic roots of *G. macrophyllus* (Burkill, 1935).

More recently, there have been several phytochemical studies on *Goniothalamus* focusing on their potential for anti-cancer therapies. Styryl-pyrone and styryl lactone derivatives from *Goniothalamus* have been suggested to have anti-cancer activities (Umar-Tsafe *et al.*, 2004; Inayat-Hussain *et al.*, 2002; Li *et al.*, 1998; Tian *et al.*, 2006).

So, taxonomic study of the genus *Goniothalamus* provides basic knowledge of diversity in Thailand and uses of this plant, which will help to preserve plant life and knowledge for sustainable use in the future.

CHAPTER 5

CONCLUSIONS

Twenty specimens of *Goniothalamus* in Thailand were collected. They are 16 identifiable species and 4 unidentified species. Among these are 5 new records for Thailand, namely *G. elegans*, *G. cheliensis*, *G. repevensis*, *G. sawtehii* and *G. umbrosus*.

Many characters are taxonomically important, with variation evident in size, shape, colour and indumenta. The characters that were taxonomically significance for Thai *Goniothalamus* are the presence or absence of hairs on the surface of leaves, sepal, outer petals and inner petals. The whole dome shape needs to be considered as a unit for taxonomic analysis. Its morphology is diverse for the genus, with at least six distinct types.

Another notable character is pistil features, such as stigmas shape and indumenta. There were six types of stigmas. In addition to minute, fusiform and funnel-shaped stigmas, there are clavate, cylindrical and a coiled stigma. Ovule number is needed for classification as well.

The staminal connectives are very variable in shape, with truncate, convex, short apiculate, long apiculate and shapely apiculate forms. These differences are diagnostically important at the species level.

Elements of both Boerlage's and Bân's infrageneric classifications are reflected in Thai *Goniothalamus*, although many species could not be classified into the sectional levels of Bân's classification, because Thai *Goniothalamus* have more diverse characters than Bân proposed.

Results from the combined *trnL* and *trnG* intron data set suggested that the genus *Goniothalamus* was found in this study to be a natural, monophyletic group. There are six groups of *Goniothalamus* in Thailand, but only Clade IV (Clade IV, *G. tortilipetalus*, *G. umbrosus*, *G. griffithii*, *G. sp.* Sunyataram, and *G. sp.* Maerim) has high bootstrap support (bootstrap values of 94%, 92%, and 95% on the MP, NJ, and ML trees, respectively). The six suggested groups reflect similarities in floral morphology (e.g. ovule number, connective stamen characters and stigma shape

characters) but not biogeography. Elements of both Boerlage's and Bân's infrageneric classifications are reflected in this analysis, although the results are not strictly congruent with either.

As Saunders (2002 and 2003) suggested, *Goniothalamus* has a centre of diversity in Indochina and western Malesia. Accordingly, most *Goniothalamus* were found in the south of Thailand. Likewise, Yuyen and Boonkerd (2002) suggested that Thailand has long been a meeting point of Malesian elements, Indo-Burmese elements and Indo-Chinese elements. Accordingly, the species that were reported from these three elements are also found from this study. It's suggested that *Goniothalamus* was distributed in Thailand from Malesian elements longer than other elements.

Goniothalamus in Thailand has the same number of taxa as *Goniothalamus* from adjacent areas (Borneo, Sumatra, Java and Peninsular Malaysia). However, during this study there has been political violence in the south of Thailand, so the authors were not able to collect Thai *Goniothalamus* from this area. More surveys of this genus are need in the future.

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