

A synopsis of *Goniothalamus* species (Annonaceae) in Thailand, with descriptions of three new species

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A comprehensive taxonomic revision of *Goniothalamus* species (Annonaceae) occurring in Thailand is presented for the first time. Twenty-five species are recognized, including three that are described as new to science (*Goniothalamus aurantiacus* from South-Western Thailand, *Goniothalamus maewongensis* from Northern Thailand, and *Goniothalamus rongklanus* from Northern and North-Eastern Thailand). Several taxonomic and nomenclatural misunderstandings are corrected. The name *G. griffithii* is shown to be widely misapplied for populations in Northern Thailand, for which the name *G. calvicarpus* should be applied; ‘true’ *G. griffithii* is restricted to South-Western Thailand and Myanmar. In addition, the widely used name *G. marcanii* is shown to be a synonym of *G. tamirensis*, and the name *G. latestigma*, previously regarded as a synonym of *G. undulatus*, is reinstated. *Goniothalamus cheliensis* is furthermore newly recorded from Thailand. Most species are restricted to Peninsular Thailand and represent a Malesian floristic component. © 2008 The Linnean Society of London, *Botanical Journal of the Linnean Society*, 2008, 156, 355–384.

ADDITIONAL KEY WORDS: biogeography – classification – distribution – systematics – taxonomy.

INTRODUCTION

Goniothalamus (Blume) Hook. f. & Thomson is one of the largest palaeotropical genera in the Annonaceae (with over 130 species), and the largest in Thailand. The centre of diversity of the genus lies in western Malesia, particularly Borneo (Mat-Salleh, 2001), Sumatra (Saunders, 2002) and Peninsular Malaysia (Saunders, 2003). As with most Annonaceae, *Goniothalamus* flowers have a whorl of three sepals and two whorls of three petals each. The inner petals are smaller than the outer, and are apically connivent to form a mitriform dome that covers the reproductive organs. This dome acts as a pollination chamber, with access by floral visitors (generally small beetles) via small apertures between the basal claws of the inner petals (Saunders, in press). The flowers are bisexual, with numerous free stamens and carpels. The staminal connectives are variably truncate to apiculate; the

thecae are transversely divided by septae, and the pollen is released as tetrads. The fruits are apocarpous, with individual monocarps variably sessile or borne on stipes.

Craib (1925a) published an annotated checklist of the Thai flora, which included nine *Goniothalamus* species: *G. calvicarpus* Craib, *G. expansus* Craib, *G. giganteus* (Wall. ex) Hook. f. & Thomson, *G. griffithii* Hook. f. & Thomson, *G. macrophyllus* (Blume) Hook. f. & Thomson, *G. marcanii* Craib, *G. saigonensis* Pierre ex Finet & Gagnep., *G. subevenius* King and *G. undulatus* Ridl. Chalermglin (2001, 2005) recently published an illustrated guide to Thai Annonaceae which included photographs and descriptions of 22 species, including four unnamed taxa. Although *Goniothalamus* has been relatively poorly studied in Thailand, there are several relevant taxonomic revisions of the genus from neighbouring regions, including China (Tsiang & Li, 1979; Yuan, 1991), Indochina (Finet & Gagnepain, 1906, 1907; Ast, 1938; Hô, 1991; Bán, 2000), Myanmar (Hooker & Thomson, 1855, 1872; Kurz, 1877; King, 1892, 1893),

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Peninsular Malaysia (Ridley, 1922, 1925; Sinclair, 1955; Saunders, 2003), and Sumatra (Saunders, 2002).

International collaboration is currently underway to prepare a treatment of the Annonaceae for the *Flora of Thailand* project. This publication is a precursor to the treatment of *Goniothalamus* for this Flora (Saunders & Chalermglin, in press).

TAXONOMIC TREATMENT

1. *GONIOTHALAMUS AURANTIACUS* R. M. K.

SAUNDERS & CHALERMGLIN, SP. NOV. (FIGS 1–3)

Type: Thailand: Liew Long hill, near Khao Ngai Yai, E of Sangkhla, Kanchanaburi Province, South-Western Thailand, 1.iv. 1968, C. F. van Beusekom & C. Phengkhilai 256 (holotype: K!; isotypes: AAH, BKF, C, E, KYO, P).

Goniothalamus 'sp.': P. Chalermglin, Fam. Annon., 194–195 (2001).

Species *G. laotico* (Finet & Gagnep.) Bân similis, sed foliis latioribus (5.5–8.5 cm), venis foliorum percurrentibus, pedicellis florum longioribus (10–14 mm), sepalis connatis basi et reflexis, petalis externis adaxialiter subglabris, et seminibus grandioribus (19–27 × 13–16.5 mm) differt.

Treelets or small trees, to 9 m tall, 10 cm d.b.h. Young branches subglabrous to hairy. Leaf laminas 23–32 cm long, 5.5–8.5 cm wide, length/width ratio 3–4.3, elliptic to obovate, apex acuminate, base acute(–attenuate) to obtuse, papyraceous, 50–60 µm thick, matt adaxially, subglabrous to very sparsely hairy abaxially, glabrous adaxially; midrib subglabrous to sparsely hairy and prominent abaxially, glabrous and (slightly) impressed adaxially; secondary veins 14–21 pairs per leaf, ± plane to impressed adaxially; tertiary veins percurrent, distinct; petioles 7.5–11 mm long, 1.9–2.7 mm in diameter (very) sparsely hairy. Flowers axillary, solitary, on trunk, older branches or young growth, pendent; flowering pedicels c. 10–13 mm long, c. 2–3 mm in diameter (sparsely) hairy; pedicel bracts c. 5–9. Sepals 5.5–7.5 mm long, 7–9.5 mm wide, length/width ratio 0.7–1, reflexed at anthesis, basally connate, ovate(–triangular), c. 200–400 µm thick (sparsely) hairy abaxially (sub)glabrous adaxially, green, venation indistinct. Outer petals 18–28 mm long, 20–22 mm wide, length/width ratio 0.8–1.3, elliptic to ovate, 600–1100 µm thick, glabrous to hairy (densely hairy towards base) abaxially, subglabrous to woolly adaxially, with glabrous region at base of adaxial surface, yellowish, venation indistinct. Inner petals 12–19 mm long, 5.5–9 mm wide, length/width ratio 1.3–2, 700–1000 µm thick, sparsely to densely hairy (glabrous towards base) abaxially (densely) hairy (glabrous towards base) adaxially, orange. Stamens 50–160 per flower, 2.4–2.8 mm long, 0.6–0.9 mm

wide; connectives truncate, 0.3–0.5 mm long, papillate-hairy. Carpels 4–11 per flower; ovary c. 2.5–3.8 mm long, c. 0.6–1 mm wide, sparsely hairy, with lines of golden hairs; stigma and style c. 2.8–3.6 mm long; style absent; stigma fusiform or funnel-shaped, glabrous or sparsely hairy, warty. Fruits with persistent calyx; fruiting pedicels c. 14 mm long, c. 4 mm in diameter, very sparsely hairy. Monocarps c. 27–34 mm long (one-seeded monocarps), 40–47 mm long (two-seeded monocarps), 45–56 mm long (three-seeded monocarps), 14.5–22 mm wide, length/width ratio c. 1.9 (one-seeded monocarps), 2–3.1 (two-seeded monocarps), 2.4–2.7 (three-seeded monocarps), irregularly ellipsoid to slightly moniliform, base attenuate, apex apiculate, ± smooth, matt or glossy, glabrous, olive-green, pericarp medium-thick, 0.8–1.4 mm thick when dried; stipes 2–6 mm long, 3–5.5 mm in diameter, glabrous. Seeds 1–3 per monocarp, 19–27 mm long, 13–16.5 mm wide, length/width ratio 1.5–1.7, flattened-ellipsoid, testa smooth or slightly rugulose, hairy, mid red-brown, endostome sunken or protruding, c. 2.8 mm long, seeds with surrounding mucilage.

Distribution and habitat: Endemic to South-Western Thailand (Kanchanaburi Province: Fig. 14A). Shaded understory of mixed evergreen-deciduous forests at base of limestone cliffs; 250–900 m.

Notes: *Goniothalamus aurantiacus* is clearly associated with *G. laotico* (Figs 16, 17) and two newly described species, *G. maewongensis* (Figs 22, 23, 29) and *G. rongkhanus* (Figs 32, 33, 43), all of which have a very rounded mitriform inner petal dome (Figs 1B, 2). *Goniothalamus aurantiacus* differs from *G. laotico* as it has broader leaves (5.5–8.5 cm vs. 3.5–6 cm), percurrent (vs. reticulate) leaf venation, longer pedicels (10–14 mm vs. 5–11.5 mm), basally connate and reflexed sepals, outer petals that are less hairy adaxially, and larger seeds (19–27 × 13–16.5 mm vs. 13–16 × 11–13.5 mm). The differences between *G. aurantiacus* and the two newly described species, *G. maewongensis* and *G. rongkhanus*, are listed in Table 1.

The specific epithet reflects the colour of the inner petals.

Additional specimens examined (paratypes): Thailand. SOUTH-WESTERN: Phuye, Thong Pha Phum, Kanchanaburi Province, *Bunnak & Tanee 3161* (BKF); Phuye, c. 35 km N of Thong Pha Phum, Khao Laem, Kanchanaburi Province, *P. Chalermglin 430209-2* (HKU); Toong Yai Naresuan Wildlife Reserve, Lai Wo Subdistrict, Ban Saneh Pawng (Karen Village) area, Kanchanaburi Province, *J. F. Maxwell 93-868* (BKF); Phuye, Kanchanaburi Prov-

KEYS TO SPECIES
FLOWERING SPECIMENS

1. Stamen connectives apiculate.....2
 1'. Stamen connectives truncate.....11
 2. Young branches velutinous; sepals 30–40 mm long, 28–30 mm wide; inner petals *c.* 35 mm long, *c.* 17 mm wide
 3. *G. cheliensis*
 2'. Young branches glabrous to hairy; sepals 3.5–31 mm long, 3–26 mm wide; inner petals 7–20 mm long, 2.5–9.5 mm
 wide 3
 3. Flowers in large fascicles, exclusively from woody tubercles at base of trunk; flowers often erect.. 14. *G. ridleyi*
 3'. Flowers solitary or in pairs, not exclusively from base of trunk; flowers pendent.....4
 4. Adaxial surface of outer petals with glabrous or sparsely hairy region facing apertures between inner petals...
5
 4'. Adaxial surface of outer petals with velutinous region facing apertures between inner petals.....6
 5. Leaf laminas 14.5–25.5 cm long, with 11–16 pairs of secondary veins; petioles 4.5–11.5 mm long; sepals 3.5–
 10 mm long..... 20. *G. tapis*
 5'. Leaf laminas 32–48 cm long, with 24–35 pairs of secondary veins; petioles 10–18(–35) mm long; sepals 12–16 mm
 long..... 25. *G. uvarioides*
 6. Flowering pedicels 20–37 mm long; carpels 50–100 per flower..... 23. *G. tortilipetalus*
 6'. Flowering pedicels 5–13(–19) mm long; carpels 8–50 per flower.....7
 7. Leaves with 9–12 pairs of secondary veins; stamen connectives distinctly tapered; carpels 8–10 per flower.....
 21. *G. tavoyensis*
 7'. Leaves with 12–26(–32) pairs of secondary veins; stamen connectives not distinctly tapered; carpels 11–50 per
 flower.....8
 8. Leaves with secondary venation (very) prominent adaxially, tertiary venation reticulate; ovaries glabrous to
 sparsely hairy.....9
 8'. Leaves with secondary venation ± plane to impressed adaxially, tertiary venation percurrent; ovaries densely
 hairy.....10
 9. Sepals 11–18.5 mm long, 8–15.5 mm wide; outer petals 21–46 mm long, 4.5–18 mm wide, yellow; inner petal
 length/width ratio 3–6.5; stamens 95–120 per flower..... 2. *G. calvicarpus*
 9'. Sepals 14–29 mm long, 12–26 mm wide; outer petals 36–104 mm long, 14–24 mm wide, green; inner petal
 length/width ratio 1.8–3.6; stamens 100–200 per flower..... 7. *G. griffithii*
 10. Leaf laminas (sub)coriaceous, with fine 'granular' texture abaxially (because of immersion of tertiary and lower
 order veins); leaves with 12–23 pairs of secondary veins..... 10. *G. macrophyllus*
 10'. Leaf laminas papyraceous, without fine 'granular' texture abaxially; leaves with (18–)21–26(–32) pairs of
 secondary veins..... 18. *G. scortechinii*
 11. Inner petal claws with distinct glabrous lateral flange..... 12
 11'. Inner petal claws without glabrous lateral flange..... 17
 12. Flowering pedicels 7–23 mm long; stigma subulate..... 13
 12'. Flowering pedicels 2–11.5 mm long; stigma fusiform or funnel-shaped..... 14
 13. Outer petals 23–43 mm long, 12–23 mm wide; carpels 40–100 per flower..... 17. *G. sawtehii*
 13'. Outer petals 10.5–32 mm long, 5.5–17.5 mm wide; carpels 10–54 per flower..... 24. *G. undulatus*
 14. Young branches densely hairy to velutinous..... 19. *G. tamirensis*
 14'. Young branches glabrous to hairy..... 15
 15. Flowering pedicels 5–11.5 mm long; sepal venation generally indistinct; outer petals 12.5–73 mm long; stigma
 fusiform..... 8. *G. laoticus*
 15'. Flowering pedicels 2–6 mm long; sepal venation distinct; outer petals 8.5–39 mm long; stigma funnel-shaped...
 16
 16. Leaf laminas 8–14 cm long, 1.5–4 cm wide; petioles 3.5–7 mm long; sepals 3–9 mm long, 3.5–6 mm wide; outer
 petals 8.5–15 mm long, 3.5–8 mm wide, very densely hairy ab- and adaxially; inner petals 6.5–10 mm long,
 3–4.5 mm wide; ovary glabrous..... 4. *G. elegans*
 16'. Leaf laminas 12.5–24.5 cm long, 4–8.5 cm wide; petioles 5–15 mm long; sepals 7.5–12.5 mm long, 5.5–11 mm wide;
 outer petals 23–39 mm long, 7–15 mm wide, glabrous to hairy ab- and adaxially; inner petals 10–16 mm long,
 5.5–9 mm wide; ovary sparsely hairy..... 9. *G. latestigma*
 17. Leaf venation generally reticulate; outer petals with velutinous region at base of adaxial surface (facing aperture
 between inner petals); inner petals velutinous adaxially..... 18
 17'. Leaf venation percurrent; outer petals with glabrous or sparsely hairy region at base of adaxial surface (facing
 aperture between inner petals); inner petals glabrous to densely hairy adaxially..... 21

18. Sepals 2.5–3.5 mm long, basally connate, venation indistinct; outer petal venation distinct; stigma fusiform..... 13. *G. repevensis*
- 18'. Sepals 4.5–19 mm long, free, venation distinct; outer petal venation indistinct; stigma subulate or funnel-shaped..... 19
19. Young branches glabrous; outer petal length/width ratio 3.4–5.2; stigma and style 1.8–3.6 mm long..... 5. *G. expansus*
- 19'. Young branches very sparsely to densely hairy; outer petal length/width ratio 1.6–3.8; stigma and style 0.9–1.8 mm long..... 20
20. Leaves with fine 'granular' texture abaxially (because of immersion of tertiary and lower order veins); flowers slightly supra-axillary..... 16. *G. rotundisepalus*
- 20'. Leaves without fine 'granular' texture abaxially; flowers axillary..... 22. *G. tenuifolius*
21. Flowering pedicels 20–48 mm long; sepals 7–15 mm long, free; outer petals 68–113 mm long, 28–63 mm wide.. .. 6. *G. giganteus*
- 21'. Flowering pedicels 8–16(–21) mm long; sepals 2–8 mm long, basally connate; outer petals 16–50(–62) mm long, 7–22(–32) mm wide..... 22
22. Inner petals glabrous adaxially; ovaries densely hairy..... 12. *G. malayanus*
- 22'. Inner petals (densely) hairy adaxially (sometimes glabrous towards base); ovaries glabrous to sparsely hairy... .. 23
23. Leaf laminae 23–32 cm long, with 14–21 pairs of secondary veins; stamens 50–160 per flower; carpels 4–11 per flower..... 1. *G. aurantiacus* sp. nov.
- 23'. Leaf laminae 17–25.5 cm long, with 13–16 pairs of secondary veins; stamens c. 180–200 per flower; carpels c. 18–20 per flower..... 24
24. Flowering pedicels densely hairy; outer petals densely hairy abaxially, very densely hairy adaxially, venation indistinct; inner petals very densely hairy abaxially..... 11. *G. maewongensis* sp. nov.
- 24'. Flowering pedicels very sparsely hairy; outer petals subglabrous abaxially, glabrous adaxially, venation distinct; inner petals sparsely hairy abaxially..... 15. *G. rongklanus* sp. nov.

FRUITING SPECIMENS

1. Adaxial surface of leaves with very prominent secondary and tertiary veins..... 2
- 1'. Adaxial surface of leaves with impressed or only slightly prominent secondary and tertiary veins..... 7
2. Leaf laminae 50–76 cm long, 13–22 cm wide, with 24–32 pairs of secondary veins; leaf midrib densely hairy to velutinous; petioles 17–30 mm long, velutinous; monocarps densely hairy..... 3. *G. cheliensis*
- 2'. Leaf laminae 12.5–39.5 cm long, 3.5–9.5(–11.5) cm wide, with 10–22 pairs of secondary veins; leaf midrib glabrous to sparsely hairy; petioles 4–16 mm long, glabrous to hairy; monocarps glabrous to hairy..... 3
3. Monocarps distinctly warty..... 6. *G. giganteus*
- 3'. Monocarps smooth or finely rugulose..... 4
4. Fruits restricted to trunk; fruiting pedicels 19–36 mm long..... 23. *G. tortilipetalus*
- 4'. Fruits not restricted to trunk; fruiting pedicels 10–19 mm long..... 5
5. Leaf venation percurrent; fruits without persistent calyx; monocarps 16–40 mm long, 8–13(–17) mm wide; pericarp 0.7–1.1 mm thick when dried; seeds 13–20 mm long, with (sparsely) hairy testa..... 12. *G. malayanus*
- 5'. Leaf venation reticulate; fruits with persistent calyx; monocarps 10–14 mm long, 7–8 mm wide; pericarp 0.1–0.3 mm thick when dried; seeds 10–12 mm long, with glabrous testa..... 6
6. Monocarps red; seeds slightly rugose..... 2. *G. calvicarpus*
- 6'. Monocarps yellow-brown; seeds smooth..... 7. *G. griffithii*
7. Monocarps 14–29 mm wide; pericarp 0.7–2.8 mm thick when dried; seeds (10–)11–19 mm wide..... 8
- 7'. Monocarps 6–11 mm wide; pericarp 0.1–0.9 mm thick when dried; seeds 6–10 mm wide..... 13
8. Leaf laminae 32–48 cm long, with 24–35 pairs of secondary veins; seeds 11–13.5 mm long..... 25. *G. uvarioides*
- 8'. Leaf laminae 14–32 cm long, with 11–21 pairs of secondary veins; seeds 13–27 mm long..... 9
9. Fruits restricted to base of trunk; fruiting pedicels 30–130 mm long..... 14. *G. ridleyi*
- 9'. Fruits not restricted to base of trunk; fruiting pedicels 8–22 mm long..... 10
10. Leaf venation reticulate; fruiting pedicels c. 8–9 mm long; monocarps with conspicuous longitudinal ridge..... 8. *G. laoticus*
- 10'. Leaf venation percurrent; fruiting pedicels 10–22 mm long; monocarps lacking or with inconspicuous longitudinal ridge..... 11
11. Monocarps sessile or with stipe \leq 1 mm long; seeds 18–19 mm wide, rugose..... 11. *G. maewongensis* sp. nov.

- 11'. Monocarps distinctly stipitate with stipe 2–8 mm long; seeds 13–17 mm wide, smooth or slightly rugulose....12
12. Leaf laminas 23–32 cm long, with 14–21 pairs of secondary veins; fruiting pedicels c. 14 mm long; seeds 19–27 mm long, length/width ratio 1.5–1.7.....1. *G. aurantiacus* sp. nov.
- 12'. Leaf laminas 17–25 cm long, with 13–16 pairs of secondary veins; fruiting pedicels 16–22 mm long; seeds 15–22 mm long, length/width ratio 1.1–1.5.....15. *G. rongklanus* sp. nov.
13. Leaves with fine 'granular' texture abaxially (because of immersion of tertiary and lower order veins).....14
- 13'. Leaves without fine 'granular' texture abaxially.....15
14. Leaf laminas (26–)32–45(–59) cm long, 6–11(–15.5) cm wide (sub)coriaceous, venation percurrent.....10. *G. macrophyllus*
- 14'. Leaf laminas 10.5–23.5 cm long, 3.5–6.5(–8.5) cm wide, papyraceous, venation reticulate.....16. *G. rotundisepalus*
15. Young branches (sub)glabrous.....16
- 15'. Young branches very sparsely to very densely hairy.....19
16. Leaves with 18–32 pairs of secondary veins; leaf venation percurrent.....18. *G. scortechinii*
- 16'. Leaves with 9–16 pairs of secondary veins; leaf venation reticulate.....17
17. Fruits without persistent calyx; seeds subglabrous to hairy.....20. *G. tapis*
- 17'. Fruits with persistent calyx; seeds glabrous.....18
18. Monocarps ovoid, with cuneate base, length/width ratio c. 1.7; seeds ovoid, c. 15 mm long, c. 10 mm wide, length/width ratio c. 1.6.....5. *G. expansus*
- 18'. Monocarps narrowly ellipsoid, with attenuate base, length/width ratio c. 2.2; seeds ellipsoid, 17–18 mm long, 7–8 mm wide, length/width ratio 2.2–2.5.....21. *G. tavoyensis*
19. Fruiting pedicels \geq 12 mm long.....20
- 19'. Fruiting pedicels \leq 11 mm long.....22
20. Monocarps distinctly stipitate with stipe 6.5–16 mm long.....24. *G. undulatus*
- 20'. Monocarps subsessile or with stipe \leq 6 mm long.....21
21. Leaf midrib sparsely to very densely hairy abaxially; petioles (very densely) hairy; fruiting pedicels c. 20 mm long; monocarps 15–18 mm long.....17. *G. sawtehhii*
- 21'. Leaf midrib (sub)glabrous abaxially; petioles glabrous to sparsely hairy; fruiting pedicels 4–16 mm long; monocarps 10–14 mm long.....20. *G. tapis*
22. Leaf laminas 1.5–4 cm wide, apex acute.....4. *G. elegans*
- 22'. Leaf laminas 2.5–8.5 cm wide, apex short to long acuminate.....23
23. Seeds subglabrous to hairy.....20. *G. tapis*
- 23'. Seeds glabrous.....24
24. Leaf midrib and petiole (very densely) hairy abaxially.....19. *G. tamirensis*
- 24'. Leaf midrib and petiole glabrous to sparsely hairy abaxially.....25
25. Monocarps comparatively narrow (length/width ratio 2.2–2.6); seeds c. 17.5 mm long, length/width ratio c. 2.8, with protruding endostome.....9. *G. latestigma*
- 25'. Monocarps comparatively broad (length/width ratio 1.1–1.7); seeds 8–11.5 mm long, length/width ratio 1–1.5, with flush endostome.....26
26. Sepals (persistent in fruit) 2.5–3.5 mm long; monocarps 10–26 mm long.....13. *G. repevensis*
- 26'. Sepals (persistent in fruit) 6.5–19 mm long; monocarps 7–13 mm long.....22. *G. tenuifolius*

ince, R. M. K. Saunders & P. Chalermglin 04/33 (HKU), 04/34 (HKU); Phuye, c. 35 km N of Thong Pha Phum, Khao Laem, Kanchanaburi Province, R. M. K. Saunders et al. 99/3 (BKF, C, HKU, K, L).

2. *GONIOTHALAMUS CALVICARPUS* CRAIB (FIGS 4, 5) Bull. Misc. Inform. 1922: 227 (1922), as '*calvicarpa*'. Type: Thailand: Sukotai, Kao Luang, Sukhothai Province, Northern Thailand, 4.v. 1922, A. F. G. Kerr 5946 (holotype: K!; isotypes: BK!, K!).

Goniothalamus griffithii auctt. non Hook. f. & Thomson; Ast in Humbert, Fl. Gén. Indo-Chine, suppl. 1: 99 (1938); Y. Tsiang & P.-T. Li, Fl. Reipubl. Popul. Sin. 30(2): 73 (1979); S. H. Yuan, Fl. Yunnan

5: 29–31 (1991); P. T. Li & Z. K. Li, Higher Pl. China 3: 172 (2000); S. Gardner et al., Field Guide For. Trees N. Thail., 39 (2000); P. Chalermglin, Fam. Annon., 162–163 (2001).

Distribution and habitat: Northern Thailand (Chiang Mai, Chiang Rai, Lampang, Nan and Sukhothai Provinces: Fig. 14B) and China (Tsiang & Li, 1979; as '*G. griffithii*'; Yuan, 1991; as '*G. griffithii*'). Evergreen or deciduous forests, often growing by streams; (250–) 600–850(–1250) m.

Notes: There has been considerable taxonomic confusion between *G. calvicarpus* (Figs 4, 5) and *G. griffithii* (Figs 12, 13). Craib (1922) described

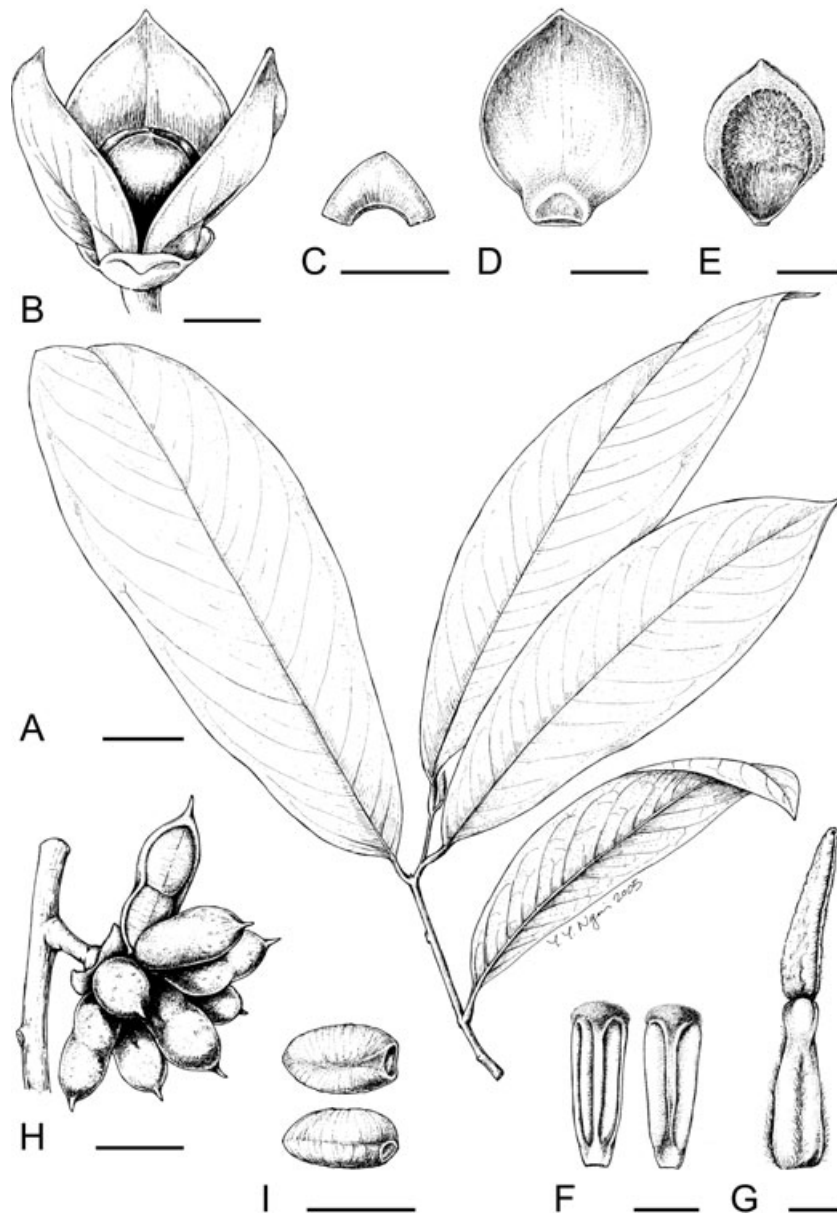
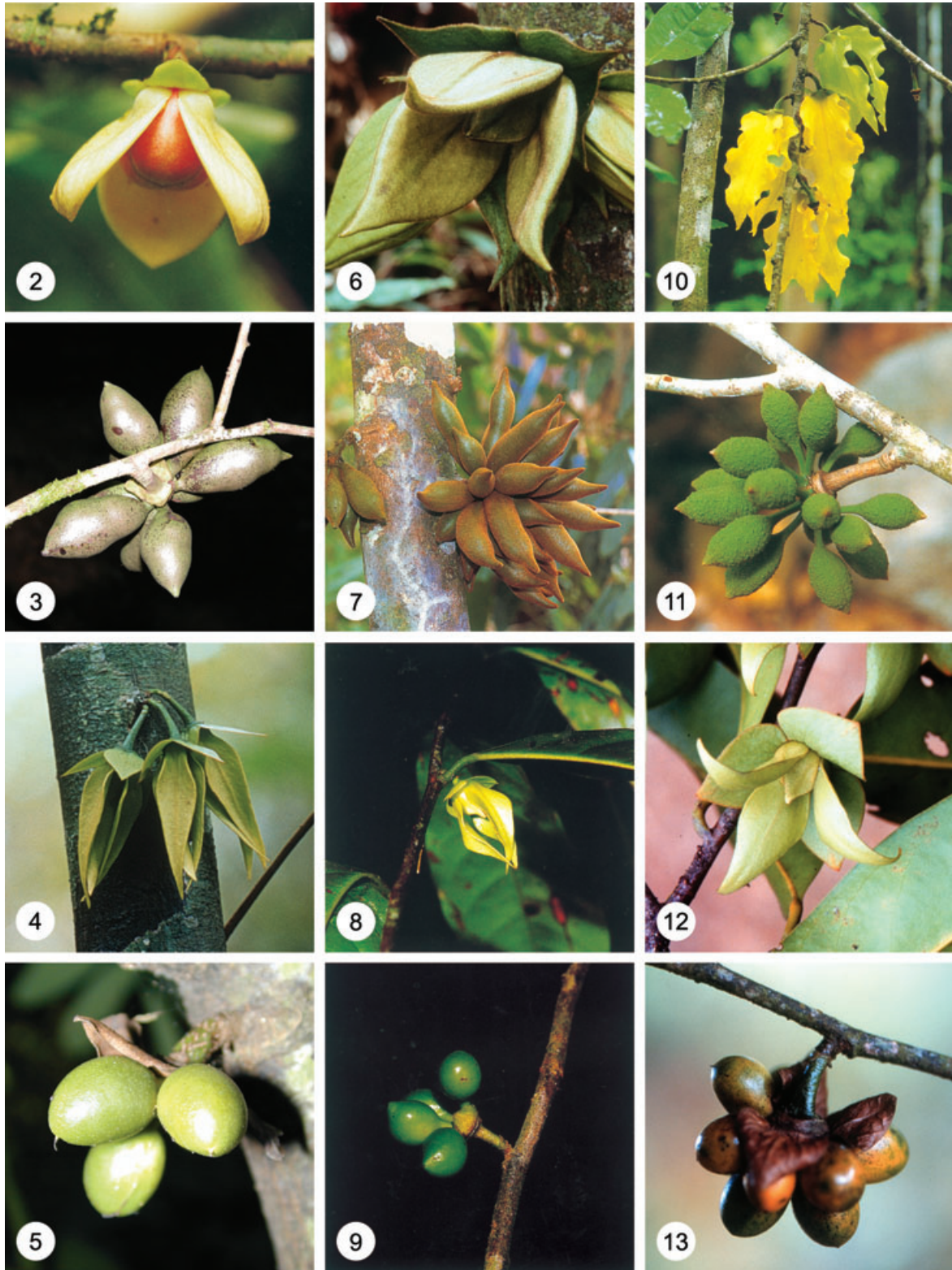


Figure 1. *Goniotalamus aurantiacus*, sp. nov. A, vegetative branch. B, flower. C, sepal (adaxial). D, outer petal (adaxial). E, inner petal (adaxial). F, stamens (abaxial and adaxial). G, carpel. H, fruit. I, seeds. Scale bars: A, H, 3 cm; B–D, 10 mm; E, 5 mm; F, G, 1 mm; I, 2 cm (A, I, Maxwell 93–868; B–G, Chalermglin 430209–2; H, Saunders & Chalermglin 04/33). Drawing by Ngai Yuen Yi.

G. calvicarpus from an isolated population in Sukhothai Province, using type material that included slightly immature flowers with petals that had not fully enlarged. Presumably as a result of this, subsequent collections of *G. calvicarpus* were misidentified as *G. griffithii*, which typically has larger flowers. This error first appeared in one of Craib's own publications (Craib, 1925a), and has recurred repeatedly since (Ast, 1938; Bân, 1974; Tsiang & Li, 1979; Yuan, 1991; Gardner, Sidisunthorn & Anusarnsunthorn, 2000; Li &

Li, 2000; Chalermglin, 2001, 2005). *Goniotalamus calvicarpus* and *G. griffithii* also resemble *G. tortilipetalus*; major differences between these species are listed in Table 2.

3. *GONIOTHALAMUS CHELIENSIS* H. H. HU (FIGS 6, 7)
Bull. Fan Mem. Institute Biol., Peiping, Bot. Ser., 10: 122–123 (1940); Tsiang & Li, Fl. Reipubl. Popul. Sin. 30(2): 64–66 (1979); S. H. Yuan, Fl. Yunnan. 5: 27



Figures 2–13. Flowers and fruits of *Goniothalamus* species from Thailand. Figs 2, 3. *G. aurantiacus*. Figs 4, 5. *G. calvicarpus*. Figs 6, 7. *G. cheliensis*. Figs 8, 9. *G. expansus*. Figs 10, 11. *G. giganteus*. Figs 12, 13. *G. griffithii*. (Figs 2, 4, 6–13: P. Chalermglin; Figs 3, 5: R. M. K. Saunders). Figs 2, 8–11 and 13 reproduced from Chalermglin (2001); Fig. 7 reproduced from Chalermglin (2005).

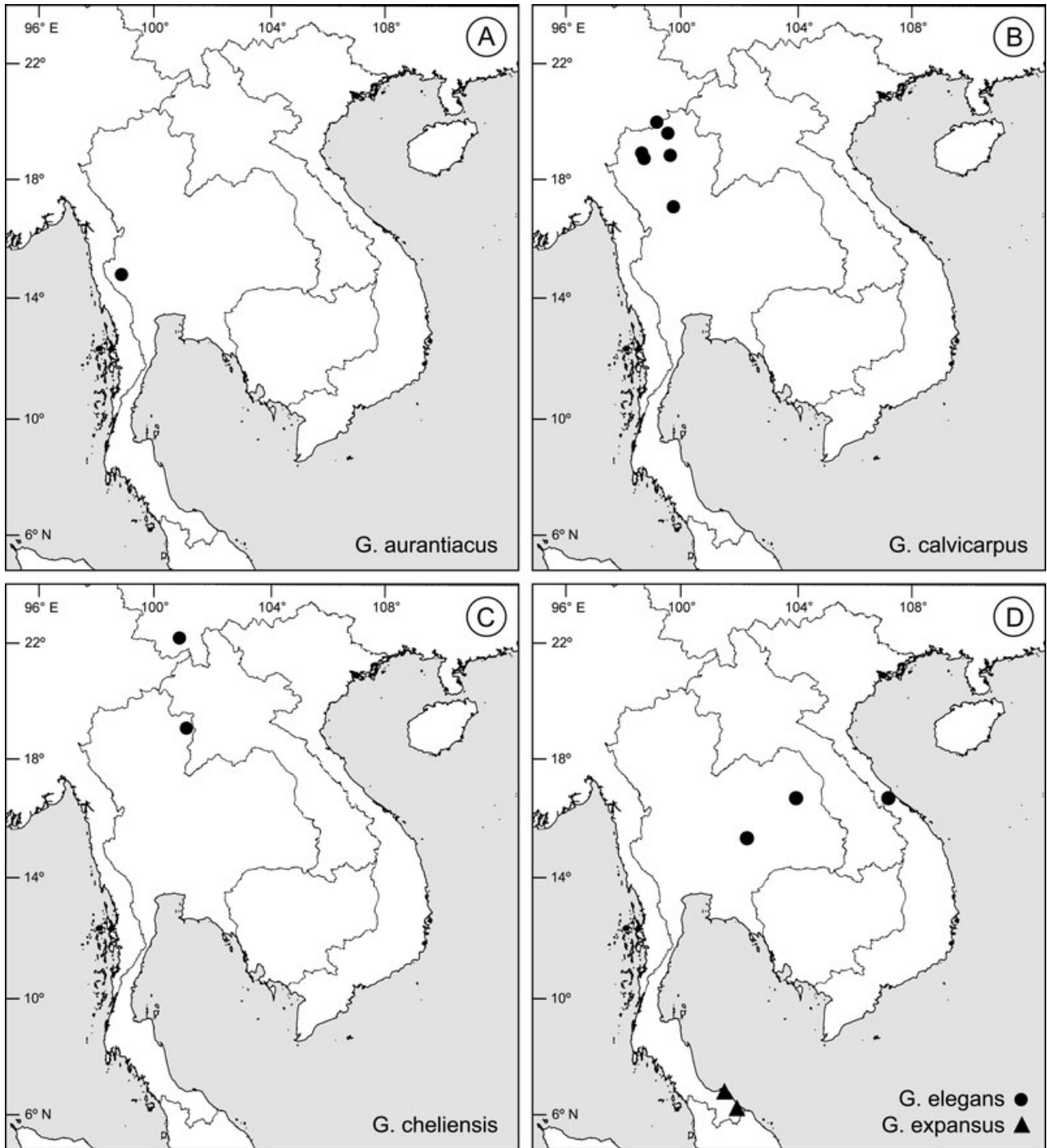


Figure 14. Distributions of (A) *G. aurantiacus*, (B) *G. calvicarpus*, (C) *G. cheliensis*, and (D) *G. elegans* and *G. expansus* in Thailand and surrounding areas.

(1991); P. T. Li & Z. K. Li, Higher Pl. China 3: 172 (2000). *Type*: China: Che-Li Hsien, Maan-Shang, Yunnan, ix. 1936, C. W. Wang 78573 (holotype: PE; isotypes: A!, IBSC ($\times 2$)!, UPS].

Goniothalamus 'sp.'; P. Chalermglin, Fam. Annon., 196–197 (2001).

Distribution and habitat: Northern Thailand (Nan Province: Fig. 14C) and China (Tsiang & Li, 1979; Yuan, 1991). Montane forests; 1000–1300 m.

Notes: *Goniothalamus cheliensis* is one of the most distinctive species in the genus in Thailand. The leaves are very large (50–76 \times 13–22 cm) and are very

Table 1. Comparison of morphological characteristics of *Goniothalamus aurantiacus*, *G. maewongensis* and *G. rongklanus*

	<i>G. aurantiacus</i>	<i>G. maewongensis</i>	<i>G. rongklanus</i>
Leaf size	23–32 × 5.5–8.5 cm	19.5–25.5 × 5–7 cm	17–25 × 5–7.5 cm
Flowering pedicel indument	(Sparsely) hairy	Densely hairy	Very sparsely hairy
Outer petal indument (abaxially)	Glabrous to hairy	Densely hairy	Subglabrous
Outer petal indument (adaxially)	Subglabrous to woolly	Very densely hairy	Glabrous
Outer petal venation	Indistinct	Indistinct	Distinct
Inner petal size	12–19 × 5.5–9 mm	9–13 × 6.5–7 mm	16–17 × 11–12 mm
Inner petal indument (abaxially)	Sparsely to densely hairy	Very densely hairy	Sparsely hairy
Stamen number per flower	~50–160	c. 200	c. 180
Carpel number per flower	~4–11	c. 20	c. 18
Stipe length	2–6 mm	Subsessile to 1 mm	3–8 mm
Seed size	19–27 × 13–16.5 mm	18–21 × 18–19 mm	15–22 × 13–17 mm
Seed testa	Smooth or slightly rugulose	Rugose	Smooth or slightly rugulose

Table 2. Comparison of morphological characteristics of *Goniothalamus calvicarpus*, *G. griffithii* and *G. tortilipetalus*

	<i>G. calvicarpus</i>	<i>G. griffithii</i>	<i>G. tortilipetalus</i>
Flower and fruit position	On main trunk, older branches and young growth	On main trunk, older branches and young growth	On main trunk only
Pedicel length	8–19 mm	8–13 mm	20–37 mm
Sepal size	11–18.5 × 8–15.5 mm	14–29 × 12–26 mm	19–31 × 15–26 mm
Outer petal size	21–46 × 4.5–18 mm	36–104 × 14–24 mm	35–100 × 10–25 mm
Inner petal length/width ratio	3–6.5	1.8–3.6	2.2–3.1
Stamen number per flower	~75–120	~100–200	~170–260
Carpel number per flower	~15–35	~20–50	~50–100
Ovary indument	Glabrous to sparsely hairy	Sparsely hairy	(Very) densely hairy
Seed testa ornamentation	Slightly rugose	Smooth	Smooth

densely hairy abaxially, although *G. macrophyllus* leaves can be as large as 59 × 15.5 cm, and *G. tamirensis* leaves are also densely hairy. The flowers are also exceptionally large (Fig. 6), with sepals that are 30–40 × 28–30 mm, outer petals that are 60–80 × 30–40 mm, and inner petals that are c. 35 × 17 mm; *G. giganteus* (Fig. 10), *G. griffithii* (Fig. 12) and *G. tapis* (Fig. 45) also have large outer petals, although the petals are much thinner (less than 0.8 mm) than those of *G. cheliensis* (c. 3.4 mm). The monocarps of *G. cheliensis* are also distinctive as they are exceptionally large (3–9 cm long) and densely hairy (Fig. 7), although several other *Goniothalamus* species in Thailand have monocarps up to 5.5 cm long (e.g. *G. aurantiacus*, *G. laoticus* and *G. rongklanus*).

The type specimens of *G. cheliensis* were annotated with the name '*G. gigantifolius*' by H. H. Hu, although this name was not adopted as it would have been a later homonym of *G. gigantifolius* Merr. (Merrill, 1915). The protologue description was based on fruiting material only and the flowers were not described until recently (Chalermglin, 2001).

4. *GONIOTHALAMUS ELEGANS* AST

Bull. Soc. Bot. France 85: 52 (1938); Ast in Humbert, Fl. Gén. Indo-Chine, suppl. 1: 96–97 (1938); P.-H. Hô, *Cây cỏ Việt Nam* 1(1): 343 (1991); Bân, *Thực vật chí Việt Nam* 1: 246 (2000); P. Chalermglin, *Fam. Annon.*, 156–157 (2001). *Type*: Vietnam: Quang-tri Province, Annam, 13.v. 1887, *E. Poilane* 13332 (holotype: P!; isotype: HM).

Distribution and habitat: North-Eastern and Eastern Thailand (Sakon Nakhon and Chaiyaphum Provinces: Fig. 14D) and Vietnam. Mixed deciduous forests; 300–600 m.

Notes: *Goniothalamus elegans* belongs to the *G. latestigma*-*G. repevensis*-*G. tamirensis* group, characterized by inner petals with a glabrous lateral margin to the basal claw, truncate staminal connectives, and broad funnel-shaped stigmas. It typically has much smaller and narrower leaves than other

members of the group (8–14 × 1.5–4 cm; length/width ratio 3.7–6.2).

5. *GONIOTHALAMUS EXPANSUS* CRAIB (FIGS 8, 9)

Bull. Misc. Inform. 1925: 11 (1925); *Bản, Thực vật chí Việt Nam* 1: 233 (2000). *Type*: Thailand: Banang Sta., Pattani Province, Peninsular Thailand, 28.vii. 1923, A. F. G. Kerr 7387 (holotype: K!; isotype: BK!).

Goniothalamus subevenius auct. non King; P. Chalermglin, *Fam. Annon.*, 180–181 (2001).

Distribution and habitat: Endemic to Peninsular Thailand (Narathiwat and Pattani Provinces: Fig. 14D). Evergreen forests; altitude unknown.

Notes: Craib (1925b) described *G. expansus* from a single flowering specimen from Pattani Province, Peninsular Thailand, which is distinctive in possessing a very long flowering pedicel (c. 25 mm long), very narrowly ovate outer petals (length/width ratio c. 4.2) and strongly acuminate inner petals. *Bản* (2000) subsequently determined another two collections as *G. expansus*; although we have been unable to examine these collections, it is doubtful whether they truly represent this species as they originate from Gia Lai Province in Vietnam.

Two further collections of *G. expansus* have been identified during this revision: *Kitamura MN22* (BCU!; flowering) and *Sathaphon et al. 205* (BKF!, K!; fruiting). Both collections originate from Narathiwat Province in Peninsular Thailand, very close to the type locality (Fig. 14D). Although neither collection shows the long pedicel observed in the type collection (the flowering pedicels in *Kitamura MN22* are c. 6.5 mm long, and the fruiting pedicels in *Sathaphon et al. 205* are c. 8.5 mm long), we cannot identify any other character to distinguish these collections from the type of *G. expansus*. Significantly, *Kitamura MN22* has the strongly acuminate inner petals observed in the type specimen. We therefore regard the elongate pedicel of the type collection as merely an extreme form.

The fruits of *G. expansus* (Fig. 9), which have not been described before, have a persistent calyx; the monocarps are smooth, ovoid, c. 16 × 10 mm, with a subglabrous indument, borne on stipes that are c. 5 mm long. Each monocarp contains a single seed, c. 15 × 10 mm, with a glabrous testa.

Goniothalamus expansus shows closest affinities with *G. latestigma* (Figs 18, 19), although there are differences in young shoot, petiole and pedicel indument (glabrous in *G. expansus*, hairy in *G. latestigma*) and inner petal shape (markedly acuminate in *G. expansus* but not in *G. latestigma*).

6. *GONIOTHALAMUS GIGANTEUS* (WALL. EX)

HOOK. F. & THOMSON (FIGS 10, 11)

Fl. Ind. 1: 109 (1855); Miq., Fl. Ind. Bat. 1(2): 28 (1858); Hook. f. & Thomson, Fl. Brit. Ind. 1: 74 (1872); King, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 73–74 (1892); King, Ann. Roy. Bot. Gard., Calcutta 4: 93–94 (1893); Ridl., Fl. Malay Penins. 1: 65–66 (1922); J. Sinclair, Gard. Bull., Singapore 14: 431–432 (1955); P. Chalermglin, *Fam. Annon.*, 160–161 (2001); R. M. K. Saunders, Bot. J. Linn. Soc. 139: 233–234 (2002). *Uvaria gigantea* Wall., Numer. List 6469A (1832), nom. nud. *Oxymitra gigantea* (Hook. f. & Thomson) Lotsy, Vortr. Bot. Stammesg. 3: 463 (1911). *Type*: Peninsular Malaysia: Penang, without date, *G. Porter [N. Wallich 6469A]* (holotype: K!; isotypes: BM!, CAL).

Distribution and habitat: Peninsular Thailand (Trang Province: Fig. 15A), Peninsular Malaysia (Saunders, 2003) and Sumatra (Saunders, 2002). Primary evergreen forests, often in swampy lowlands or on hillsides, commonly in sandstone areas; sea level to 900 m.

Notes: *Goniothalamus giganteus* is not liable to be confused with any other species as it possesses exceptionally large, yellow flowers (Fig. 10) and markedly warty monocarps (Fig. 11). It is similar to the Bornean endemic species *G. borneensis* Mat-Salleh (Mat-Salleh, 2001), although the fruits of the latter species are smooth.

Within the Thai flora, *G. giganteus* is most similar to *G. malayanus* (Figs 24, 25), although the latter species has shorter pedicels (8–21 mm vs. 20–48 mm), shorter sepals (2–8 mm vs. 7–15 mm), smaller outer petals (16–62 × 7–32 mm vs. 68–113 × 28–63 mm), smaller inner petals (7–14 × 4–7.5 mm vs. 15–22 × 7.5–12 mm), and fewer stamens per flower (80–250 vs. 220–570). *Goniothalamus malayanus* furthermore lacks the warty monocarp ornamentation characteristic of *G. giganteus*.

7. *GONIOTHALAMUS GRIFFITHII* HOOK. F. &

THOMSON (FIGS 12, 13)

Fl. Ind. 1: 110 (1855); Hook. f. & Thomson, Fl. Brit. Ind. 1: 73 (1872); Kurz, For. Fl. Brit. Burma 1: 42 (1877); King, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 75–76 (1892); King, Ann. Roy. Bot. Gard., Calcutta 4: 97 (1893). *Type*: Myanmar: Mergui, Tenasserim, without date, *W. Griffith 98* [= *Herb. East India Company 404*] (lectotype: K!, designated here).

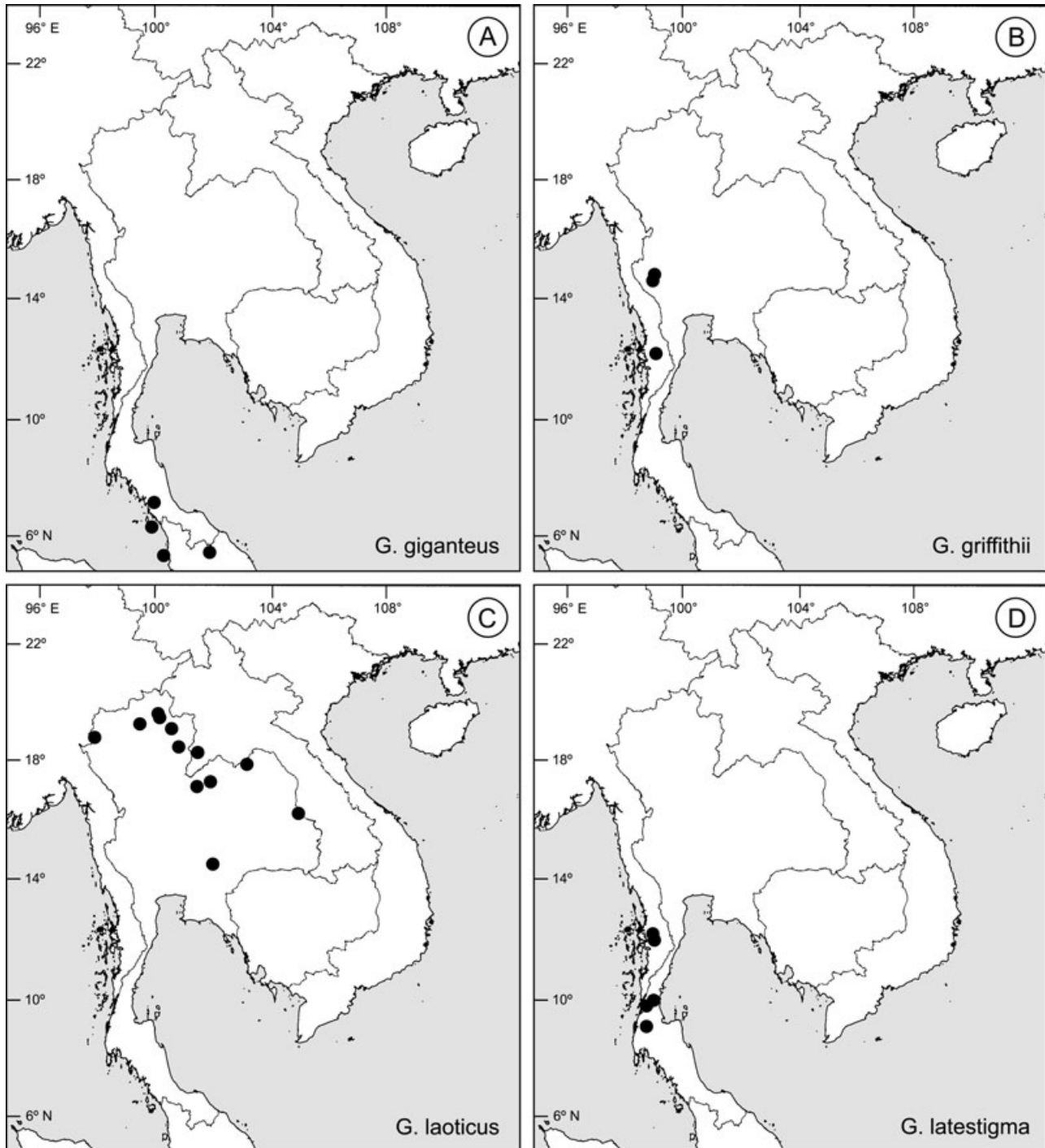


Figure 15. Distributions of (A) *G. giganteus*, (B) *G. griffithii*, (C) *G. laoticus*, and (D) *G. latestigma* in Thailand and surrounding areas.

Goniiothalamus tortilipetalus auct. non M. R. Hend.; P. Chalermglin, *Fam. Annon.*, 188–189 (2001).

Distribution and habitat: South-Western Thailand (Kanchanaburi Province: Fig. 15B) and southern

Myanmar (Taninthayi). Evergreen forests; 900–1300 m.

Notes: As discussed in the treatment of *G. calvicarpus*, there has been considerable confusion regarding

the application of the names *G. griffithii* and *G. calvicarpus*, with most herbarium collections determined as *G. griffithii* actually representing *G. calvicarpus*. The distinguishing characteristics between the two species are listed in Table 2. *Goniothalamus griffithii* also resembles *G. tortilipetalus*, although the latter species can easily be distinguished as it is invariably cauliflorous (Table 2).

8. *GONIOTHALAMUS LAOTICUS* (FINET & GAGNEP.)
BÂN (FIGS 16, 17)

Bot. Žurn. 59: 554 (1974); S. Gardner *et al.*, Field Guide For. Trees N. Thailand, 39 (2000); P. Chalermglin, Fam. Annon., 164–165 (2001). *Mitrephora laotica* Finet & Gagnep., Bull. Soc. Bot. France 54: 87 (1907). Type: Laos: Pak-lay, 1866–68, *C. Thorel 3364* (holotype: P!).

Distribution and habitat: Eastern, North-Eastern and Northern Thailand (Chiang Mai, Chiang Rai, Lamphang, Loei, Mae Hong Son, Mukdahan, Nakhon Ratchasima, Nan, Nong Khai, Phayao, and Phetchabun provinces: Fig. 15C) and Laos. Primary, secondary/disturbed deciduous and evergreen forests, often, although not exclusively, near limestone; 200–1150 m.

Notes: *Goniothalamus laoticus* was originally described as a species of *Mitrephora* (Finet & Gagnepain, 1907) and, although Sinclair (1953a) suggested that its true affinities lay with *Goniothalamus*, it was not until 1974 that the new nomenclatural combination was validated (Bân, 1974). Although the flowers of *G. laoticus* (Fig. 16) bear little resemblance to *Mitrephora*, the fruits (Fig. 17) are large, slightly elongate and have a longitudinal ridge as seen in several *Mitrephora* species (Weerasooriya & Saunders, 2005; Weerasooriya, Chalermglin & Saunders, 2006).

Flowering material of *G. laoticus* is easily recognized as the outer petals are pale yellow (rarely pale yellow–orange) with inwardly curved margins at maturity (Fig. 16). Fruiting material is equally easily determined because of the shape of the fruit, with its longitudinal ridge (Fig. 17), although a similar ridge is observed in some other species, such as *G. malayanus* (Fig. 25). *Goniothalamus laoticus* has several similarities with three newly described species, *G. aurantiacus*, *G. maewongensis* and *G. rongklanus*, as all four species have markedly rounded mitriform inner petal domes. *Goniothalamus laoticus* differs from these species in having reticulate leaf venation, shorter pedicels (5–11.5 vs. 10–22 in the other species collectively), and generally larger sepals (4–14.5 × 6–14 mm vs. 5–7.5 × 5–10 mm) that are not reflexed and

are not basally connate. Other taxonomic differences are given under *G. aurantiacus*, *G. maewongensis* and *G. rongklanus*, as appropriate.

9. *GONIOTHALAMUS LATESTIGMA* C. E. C. FISCH.
(FIGS 18, 19)

Bull. Misc. Inform. 1927: 204 (1927). Type: Myanmar: Banlamut, Zawe Chuang, Tenasserim, 2.iii. 1926, *C. E. Parkinson 1962* (holotype: K!; isotype: K!).

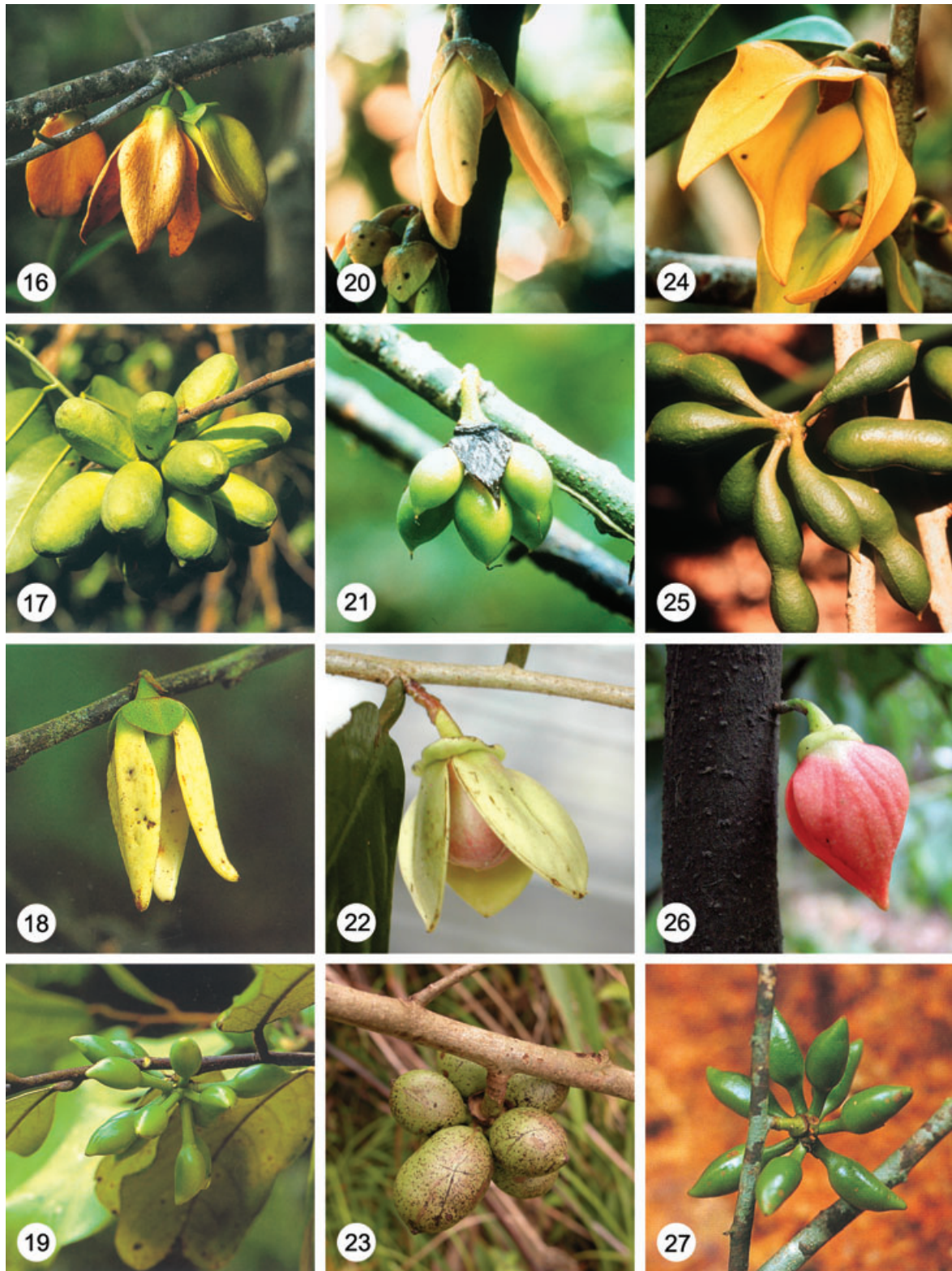
Goniothalamus undulatus auct. non Ridl.; P. Chalermglin, Fam. Annon., 192–193 (2001).

Distribution and habitat: Peninsular Thailand (Phangnga, Ranong, and Surat Thani provinces: Fig. 15D) and Myanmar. Wet evergreen forests, sometimes recorded near limestone; 50–400 m.

Notes: Sinclair (1953b, 1955) regarded the name *G. latestigma* as a synonym of *G. undulatus*, an approach which was adopted by several subsequent taxonomists (Bân, 1974, 2000; Chalermglin, 2001). As the specific epithet indicates, however, *G. latestigma* possesses a broad stigma, a feature which is not observed in *G. undulatus*. Examination of the type specimen has revealed that *G. latestigma* represents a distinct species, although with affinities with the *G. elegans*–*G. expansus*–*G. tamirensis* group with which it shares the following features: inner petals with a glabrous lateral margin to the basal claw; truncate staminal connectives; and broad funnel-shaped stigmas. *Goniothalamus latestigma* is distinct within this group as it has (densely) hairy flowering pedicels (shared with *G. tamirensis*), and large flowers (sepals 7.5–12.5 mm long, outer petals 23–39 mm long, inner petals 10–16 mm long).

10. *GONIOTHALAMUS MACROPHYLLUS* (BLUME)
HOOK. F. & THOMSON (FIGS 20, 21)

Fl. Ind. 1: 109 (1855), in nota; Miq., Fl. Ind. Bat. 1(2): 28 (1858); Miq., Ann. Mus. Bot. Ludguno-Batavum 2: 35–36 (1865); Scheff., Natuurk. Tijdschr. Ned.-Indië 31: 13–14 (1870); Hook. f. & Thomson, Fl. Brit. Ind. 1: 74 (1872); King, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 76 (1892); King, Ann. Roy. Bot. Gard., Calcutta 4: 97–98 (1893); Backer, Schoolf. Java, 33 (1911); Ridl., Fl. Malay Penins. 1: 66 (1922); J. Sinclair, Gard. Bull., Singapore 14: 446–447 (1955); Backer & Bakhuizen van den Brink, Fl. Java 1: 112 (1963); P. Chalermglin, Fam. Annon., 166–167 (2001); R. M. K. Saunders, Bot. J. Linn. Soc. 139: 248–250 (2002). *Unona macrophylla* Blume, Bijdr. 17 (1825). *Polyalthia macrophylla* (Blume) Blume, Fl. Jav. [Anon.] 79, fig. 39 (1830). Type: Java, without date, *C. L. Blume s.n.* (holotype: L!).



Figures 16–27. Flowers and fruits of *Goniothalamus* species from Thailand. Figs 16, 17. *G. laoticus*. Figs 18, 19. *G. lat-estigma*. Figs 20, 21. *G. macrophyllus*. Figs 22, 23. *G. maewongensis*. Figs 24, 25. *G. malayanus*. Figs 26, 27. *G. repe-vensis*. (Figs 16–21, 24, 25, 27: P. Chalermglin; Fig. 22: M. Nakkuntod; Fig. 23: R. M. K. Saunders; Fig. 26: Y. C. F. Su). Figs 16, 17, 18, 25: reproduced from Chalermglin (2001); Fig. 19 reproduced from Chalermglin (2005).

Goniothalamus macrophyllus var. *siamensis* J. Sinclair, Gard. Bull., Singapore 15: 17 (1956); P. Chalermglin, Fam. Annon., 168–169 (2001). *Type*: Thailand: Khao Luang, Nakhon Si Thammarat Province, Peninsular Thailand, 2.viii.1951, *T. Smitinand* 821 [= *Roy. For. Department, Fl. Thail.* 7392] (holotype: BKF!).

Goniothalamus macrophyllus var. *kerrii* Bân, Bot. Žurn. 59: 670 (1974), as '*kerrii*'. *Type*: Thailand: Klawng Kampuam, Ranawng [Ranong Province, Peninsular Thailand?], 30.i.1929, *A. F. G. Kerr* 16887 (holotype: BM!).

Distribution and habitat: Peninsular Thailand (Nakhon Si Thammarat, Narathiwat, Phangnga, Ranong, Satun, Songkhla and Trang Provinces: Fig. 28A), Peninsular Malaysia (Saunders, 2003), Sumatra (Saunders, 2002), Java (Backer & Bakhuizen van den Brink, 1963) and Borneo (Mat-Salleh, 2001). Variably dry or wet, primary and secondary, lowland to submontane forests, with loamy, clay or sandy soils, over granite; sea level to 1300 m.

Notes: *Goniothalamus macrophyllus* is the most widespread species in the genus, and is very well represented in herbaria. The leaves have a characteristic and diagnostically important 'granular' appearance abaxially because of the immersed tertiary and lower order veins. This character alone is sufficient to distinguish *G. macrophyllus* from almost all other *Goniothalamus* species in Thailand, although the same feature is observed in *G. rotundisepalus* and *G. tavoyensis*. *Goniothalamus rotundisepalus* can be distinguished from *G. macrophyllus* as it has smaller leaves (10.5–23.5 cm long vs. 26–59 cm long), smaller inner petals (4–9 × 2.5–5.5 mm vs. 7–15 × 4–9 mm) and distinct stamen connectives (truncate vs. apiculate); other distinguishing characters are listed in an earlier publication (Saunders, 2003). *Goniothalamus tavoyensis* can similarly be distinguished from *G. macrophyllus* as it has smaller leaves (12.5–25.5 cm long vs. 26–59 cm long), fewer secondary veins per leaf (9–12 pairs vs. 12–23 pairs), distinctly tapered staminal connectives and fewer carpels per flower (8–10 vs. 11–36).

There is considerable diversity in leaf shape within *G. macrophyllus*, ranging from narrowly to broadly elliptic and obovate. Sinclair (1956) described a new variety, var. *siamensis*, solely on the basis of differences in leaf shape. We do not believe that this is warranted given the range of variation exhibited in the species, and have accordingly reduced this varietal name to synonymy.

11. **GONIOTHALAMUS MAEWONGENSIS** R. M. K. SAUNDERS & CHALERMGLIN, **SP. NOV.** (FIGS 22, 23, 29)

Type: Thailand: Chong Yen, Mae Wong National Park, Kamphaeng Phet Province, Northern Thailand, 17.iv.2004, *P. Chalermglin* 470417 (holotype: BKF!; isotypes: AAU!, C!, HKU!, K!, L!, QBG!)

Species *G. laotico* (Finet & Gagnep.) Bân similis, sed venis foliorum percurrentibus, pedicellis florum longioribus (10–18 mm) et pubescentibus dense, sepalis connatis basi et reflexis, staminibus numerosis (c. 200), stipitibus brevibus (subsessilibus ad 1 mm), et seminibus grandibus (18–21 × 18–19 mm) et rugosis differt.

Small tree, to 8 m tall, 10 cm d.b.h. Young branches (very sparsely) hairy. Leaf laminas 19.5–25.5 cm long, 5–7 cm wide, length/width ratio 3.3–4.3, elliptic to obovate, apex (short) acuminate, base acute to cuneate, papyraceous, 40–60 µm thick, matt adaxially, subglabrous to sparsely hairy abaxially, glabrous adaxially; midrib glabrous to sparsely hairy and (very) prominent abaxially, glabrous and (slightly) impressed adaxially; secondary veins 13–15 pairs per leaf, (slightly) impressed adaxially; tertiary veins percurrent, distinct; petioles 7–14 mm long, 1.7–2.4 mm in diameter, glabrous to sparsely hairy. Flowers axillary, solitary, on young growth, pendent; flowering pedicels 12–14 mm long, 1.7–2 mm in diameter, densely hairy; pedicel bracts c. 5. Sepals c. 5 mm long, c. 5 mm wide, length/width ratio c. 0.9, reflexed at anthesis, basally connate, broad ovate-triangular, c. 400 µm thick, sparsely hairy abaxially, glabrous adaxially, yellowish-cream, venation indistinct. Outer petals c. 19 mm long, c. 15 mm wide, length/width ratio c. 1.3, oblong-ovate, 800–900 µm thick, densely hairy abaxially, very densely hairy adaxially, with glabrous region at base of adaxial surface, yellowish-cream, venation indistinct. Inner petals 9–13 mm long, 6.5–7 mm wide, length/width ratio 1.4–1.8, c. 1100 µm thick, very densely hairy abaxially, densely hairy adaxially, yellowish, tinged with pale pink. Stamens c. 200 per flower, 2.3–2.5 mm long, 0.6–0.7 mm wide; connectives truncate, 0.5–0.6 mm long, papillate. Carpels c. 20 per flower; ovary 2.7–2.9 mm long, 0.3–0.5 mm wide, glabrous except for lines of golden hairs; stigma and style 3.2–3.6 mm long; style glabrous; stigma fusiform, glabrous, warty. Fruits with persistent calyx; fruiting pedicels 10–18 mm long, 2.7–2.8 mm in diameter, hairy. Monocarps 21–35 mm long, 16–26 mm wide, length/width ratio 1.2–1.4, subglobose to ellipsoid, base cuneate, apex subrounded to acuminate, smooth to slightly rugulose, matt, (sub)glabrous, green, pericarp medium-thick, 0.8–2 mm thick when dried; stipes

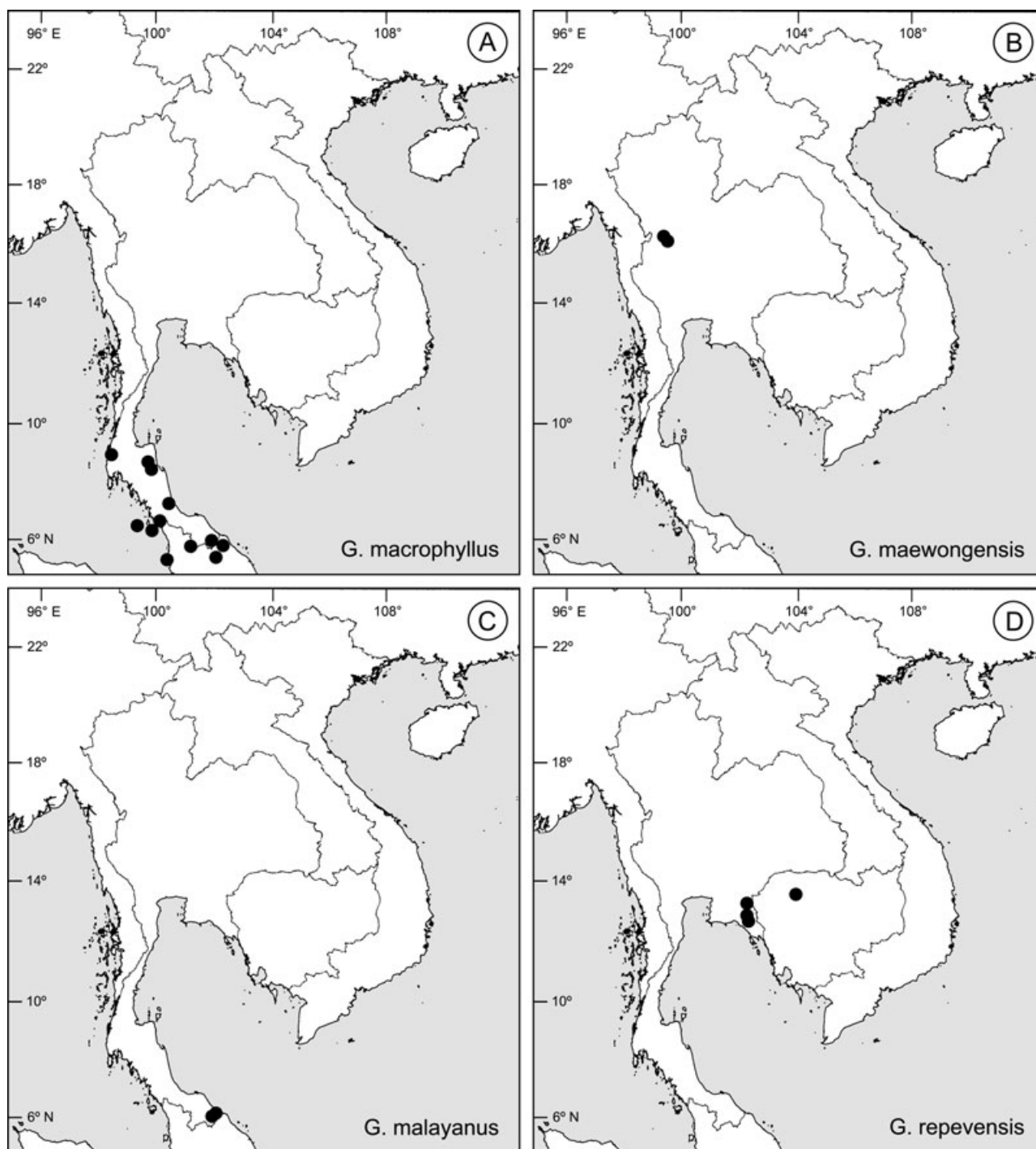


Figure 28. Distributions of (A) *G. macrophyllus*, (B) *G. maewongensis*, (C) *G. malayanus* and (D) *G. repevensis* in Thailand and surrounding areas.

subsessile to 1 mm long, c. 2.3 mm in diameter, glabrous. Seeds 1–4 per monocarp, 18–21 mm long, 18–19 mm wide, length/width ratio 1–1.1, ellipsoid, testa rugose, sparsely hairy, pale brown, endostome flush with exotesta, seeds with surrounding mucilage.

Distribution and habitat: Endemic to Northern Thailand (Kamphaeng Phet Province: Fig. 28B). Lower montane rainforest; c. 1300 m.

Notes: *Goniothalamus maewongensis* resembles *G. aurantiacus* (Figs 1–3), *G. laoticus* (Figs 16, 17)

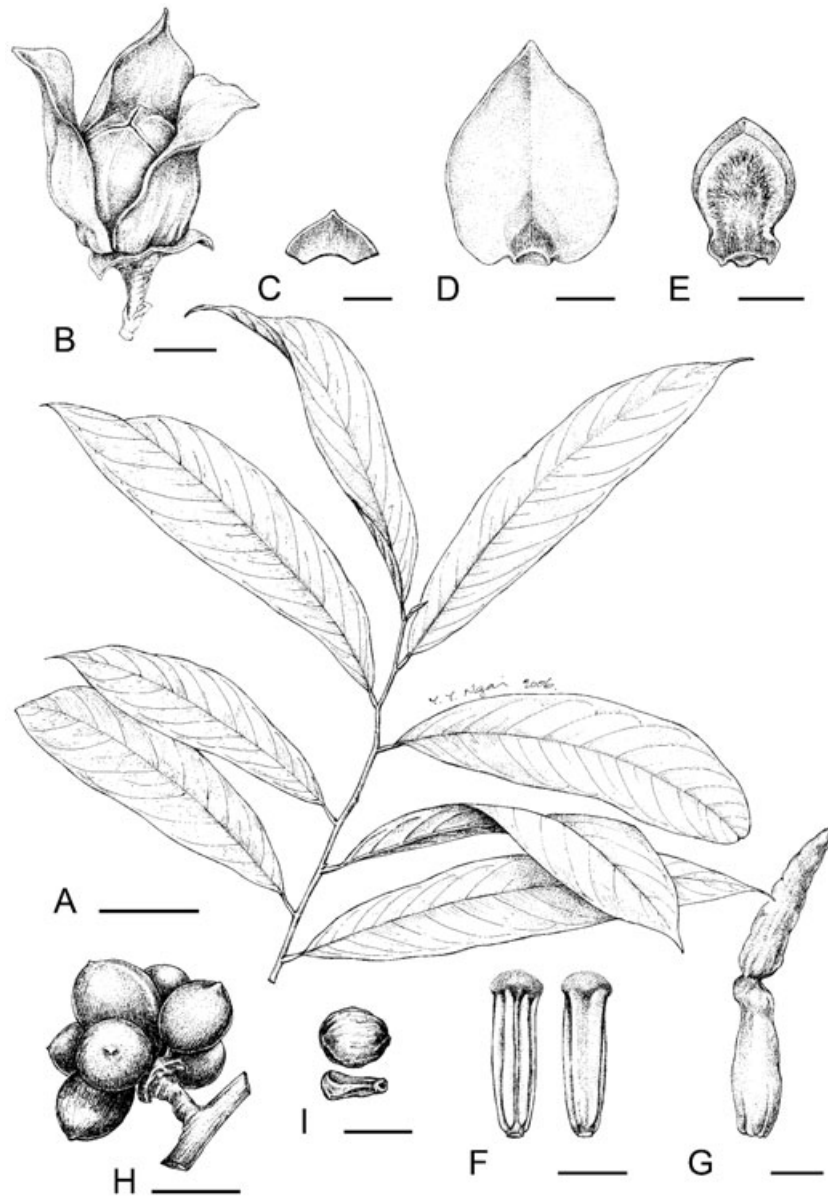


Figure 29. *Goniothalamus maewongensis*, sp. nov. A, vegetative branch. B, flower. C, sepal (adaxial). D, outer petal (adaxial). E, inner petal (adaxial). F, stamens (abaxial and adaxial). G, carpel. H, fruit. I, seeds. Scale bars: A, 5 cm; B–E, 5 mm; F, G, 1 mm; H, I, 20 mm (A, H, I, *Saunders et al.* 04/36; B–G, *Chalermglin* 470417). Drawing by Ngai Yuen Yi.

and *G. rongklanus* (Figs 32, 33, 43), as all four species possess a very rounded mitriform inner petal dome (Figs 22, 29B). It differs from *G. laoticus* as it has percurrent leaf venation (reticulate in *G. laoticus*), hairier and longer pedicels (10–18 mm vs. 5–11.5 mm), basally connate and reflexed sepals, more stamens per flower (c. 200 vs. 30–96), shorter stipes (subsessile to 1 mm vs. 3–5.5 mm), and larger seeds (18–21 × 18–19 mm vs. 13–16 × 11–13.5 mm) with a rugose testa (smooth in *G. laoticus*). Differences between *G. maewongensis* and two other newly

described species, *G. aurantiacus* and *G. rongklanus*, are given in Table 1. Distinctions between these species have also been confirmed by phylogenetic analysis of ITS, *trnK/matK* and *trnL-F* sequences (M. Nakkuntod *et al.*, unpubl. data).

The specific epithet is derived from the name of the type locality, Mae Wong National Park.

Additional specimens examined (paratypes): Thailand. NORTHERN: Chong Yen, near Huay Nam Yen, Kamphaeng Phet Province, *R. M. K. Saunders*

et al. 04/35 (BKF), 04/36 (BKF); Maewong National Park, Chongyen, Maewong District, Kamphaeng Phet Province, *T. Wongprasert* 997–48 (BKF).

12. *GONIOTHALAMUS MALAYANUS* HOOK. F. & THOMSON (FIGS 24, 25)

Fl. Ind. 1: 107 (1855); Miq., Fl. Ind. Bat. 1(2): 28–29 (1858); Hook. f. & Thomson, Fl. Brit. Ind. 1: 75 (1872); King, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 74 (1892); King, Ann. Roy. Bot. Gard., Calcutta 4: 94 (1893); Ridl., Fl. Malay Penins. 1: 66–67 (1922); J. Sinclair, Gard. Bull., Singapore 14: 432–433 (1955); M. K. V. Rao, J. Econ. Tax. Bot. 7: 635 (1985); D. Mitra, Fl. India 1: 236 (1993); P. Chalermglin, Fam. Annon., 170–171 (2001); R. M. K. Saunders, Bot. J. Linn. Soc. 139: 227–233 (2002). *Type*: Peninsular Malaysia: Melaka [= Malacca], without date, *W. Griffith s.n.* [= *Herb. East India Company* 402] (lectotype: K!, designated by Saunders, 2003: 335; isolectotype: K!).

Distribution and habitat: Peninsular Thailand (Narathiwat Province: Fig. 28C), Nicobar Islands (Rao, 1985), Peninsular Malaysia (Saunders, 2003), Sumatra (Saunders, 2002) and Borneo (Mat-Salleh, 2001). Mixed peat swamp forests; sea level to 100 m.

Notes: Within the Thai flora, *G. malayanus* is most similar to *G. giganteus* (Figs 10, 11); the differences between these two species are given in the treatment of the latter species. Confusion also occurs between *G. malayanus* and *G. tapis* (Figs 45, 46), although the similarities are likely to be superficial rather than reflecting phylogenetic relatedness; again the differences between the two are discussed in the treatment of the latter species.

13. *GONIOTHALAMUS REPEVENSIS* PIERRE EX FINET & GAGNEP. (FIGS 26, 27)

Bull. Soc. Bot. France, Mém. IV 53: 120–121 (1906); Finet & Gagnep. in Lecomte, Fl. Gén. Indo-Chine 1: 89 (1907); Ast in Humbert, Fl. Gén. Indo-Chine, suppl. 1: 98–99 (1938); P. Chalermglin, Fam. Annon., 174–175 (2001). *Type*: Kampuchea: Mt. Knangkrepeuth, Thepong Province v.1870, *J. B. L. Pierre* 607 (lectotype: A!, designated here; isotypes: A!, NY!, P [× 2]!).

Distribution and habitat: South-Eastern Thailand (Chanthaburi Province: Fig. 28D) and Kampuchea. Evergreen forests; 600–900 m.

Notes: *Goniothalamus repevensis* is easily distinguished as it is the only species in the genus in Thailand that possesses small, pink flowers (Fig. 26). It grows in comparatively dry evergreen forests in South-Eastern Thailand, where only one other *Goniothalamus* species, *G. tamirensis* (Figs 40, 41) occurs. Even in the absence of flowers, these two species can easily be distinguished, as *G. tamirensis* has densely hairy to velutinous shoots and petioles.

14. *GONIOTHALAMUS RIDLEYI* KING (FIGS 30, 31)

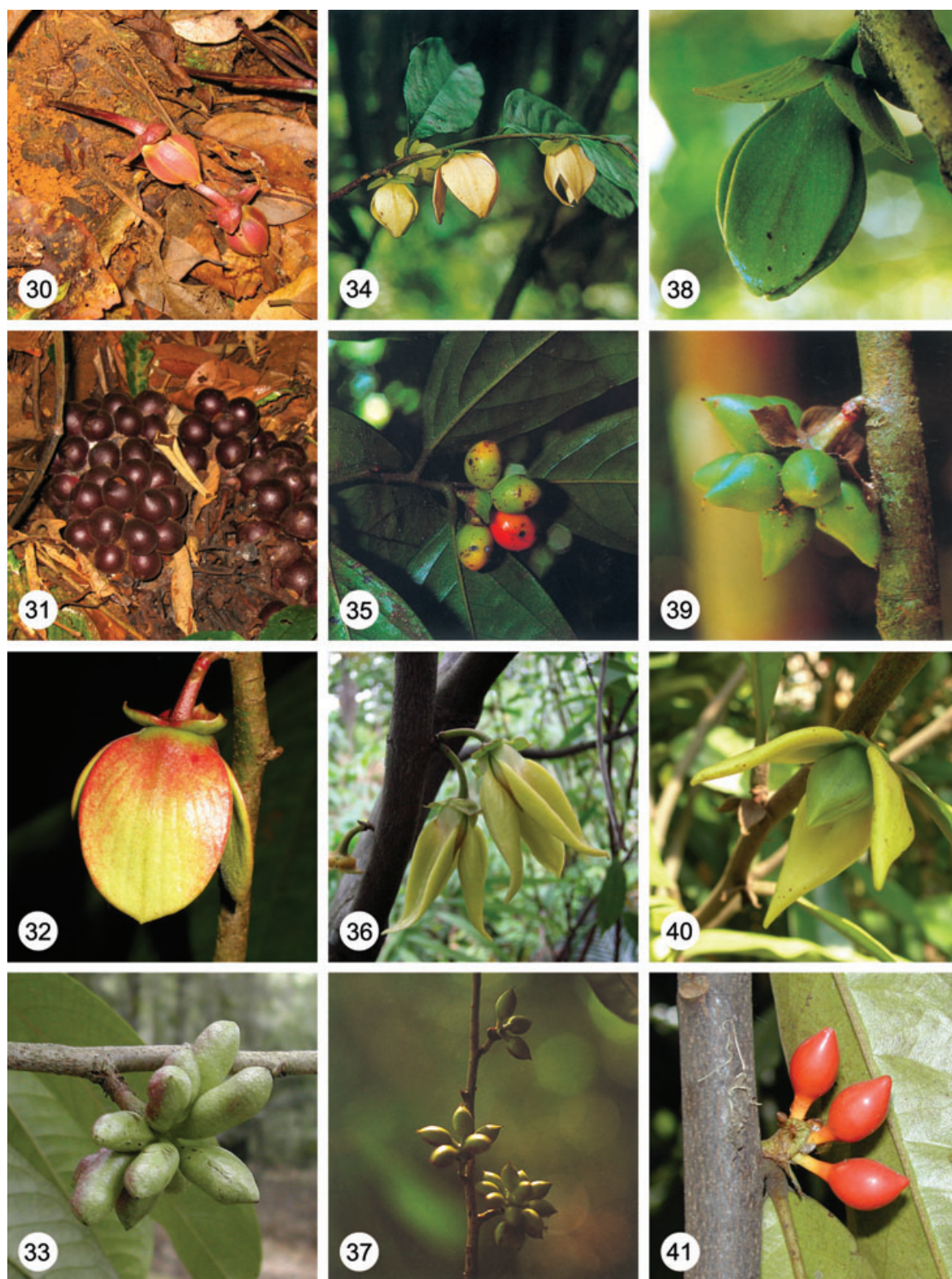
J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 76–77 (1892); King, Ann. Roy. Bot. Gard., Calcutta 4: 98 (1893); Ridl., Fl. Malay Penins. 1: 68–69 (1922); J. Sinclair, Gard. Bull., Singapore 14: 437–438 (1955); R. M. K. Saunders, Bot. J. Linn. Soc. 139: 238–240 (2002). *Type*: Singapore: Sungei Murai, 15.ii.1890, *J. S. Goodenough* 2118 (lectotype: K!, designated by Saunders, 2002: 238; isolectotypes: CAL, SING!).

Goniothalamus prainianus King, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 72–73 (1892); King, Ann. Roy. Bot. Gard., Calcutta 4: 90 (1893). *Type*: Peninsular Malaysia: Perak, [iii.1884], *King's collector* 5745 (lectotype: K!, designated by Saunders, 2003: 326; isolectotypes: BM [× 2]!, CAL).

Goniothalamus prainianus var. *angustipetalus* King, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 72–73 (1892), as '*angustipetala*'; King, Ann. Roy. Bot. Gard., Calcutta 4: 90 (1893), as '*angustipetala*'. *Type*: Peninsular Malaysia: Perak, [xii.1885], *King's collector* [8348] (lectotype: K!, designated by Saunders, 2003: 326; isolectotypes: BM!, CAL, MO!, SING!).

Distribution and habitat: Thailand (Narathiwat Province: Fig. 42A), Peninsular Malaysia (Saunders, 2003) and Sumatra (Saunders, 2002). Primary swamp forests and lowland and submontane rainforests, on hillsides, often by streams; 50–1000 m.

Notes: *Goniothalamus ridleyi* is the only Thai representative of a species group characterized by flowers and fruits that are borne on very long pedicels, developing exclusively from woody tubercles at the base of the trunk, close to soil level. The flowers are furthermore often borne erect (rather than pendent as in most other *Goniothalamus* species), and there is therefore little possibility of misidentification if fertile material is available. This species is closely related to *G. fasciculatus* Boerl. from Borneo [Mat-Salleh K., 1993. *Revision of the genus Goniothalamus (Annonaceae) of Borneo*. Unpublished PhD thesis. East Lansing, Michigan State University].



Figures 30–41. Flowers and fruits of *Goniotalamus* species from Thailand. Figs 30, 31. *G. ridleyi*. Figs 32, 33. *G. rongklanus*. Figs 34, 35. *G. rotundisepalus*. Figs 36, 37. *G. sawtehii*. Figs 38, 39. *G. scortechinii*. Figs 40, 41. *G. tamirensis*. (Figs 30, 31, 33: S. Kitamura; Fig. 32: P. Suksathan; Figs 34, 35, 37–39: P. Chalermglin; Fig. 36: Y. C. F. Su; Figs 40, 41: R. M. K. Saunders). Figs 34, 35, 39–41 reproduced from Chalermglin (2001).

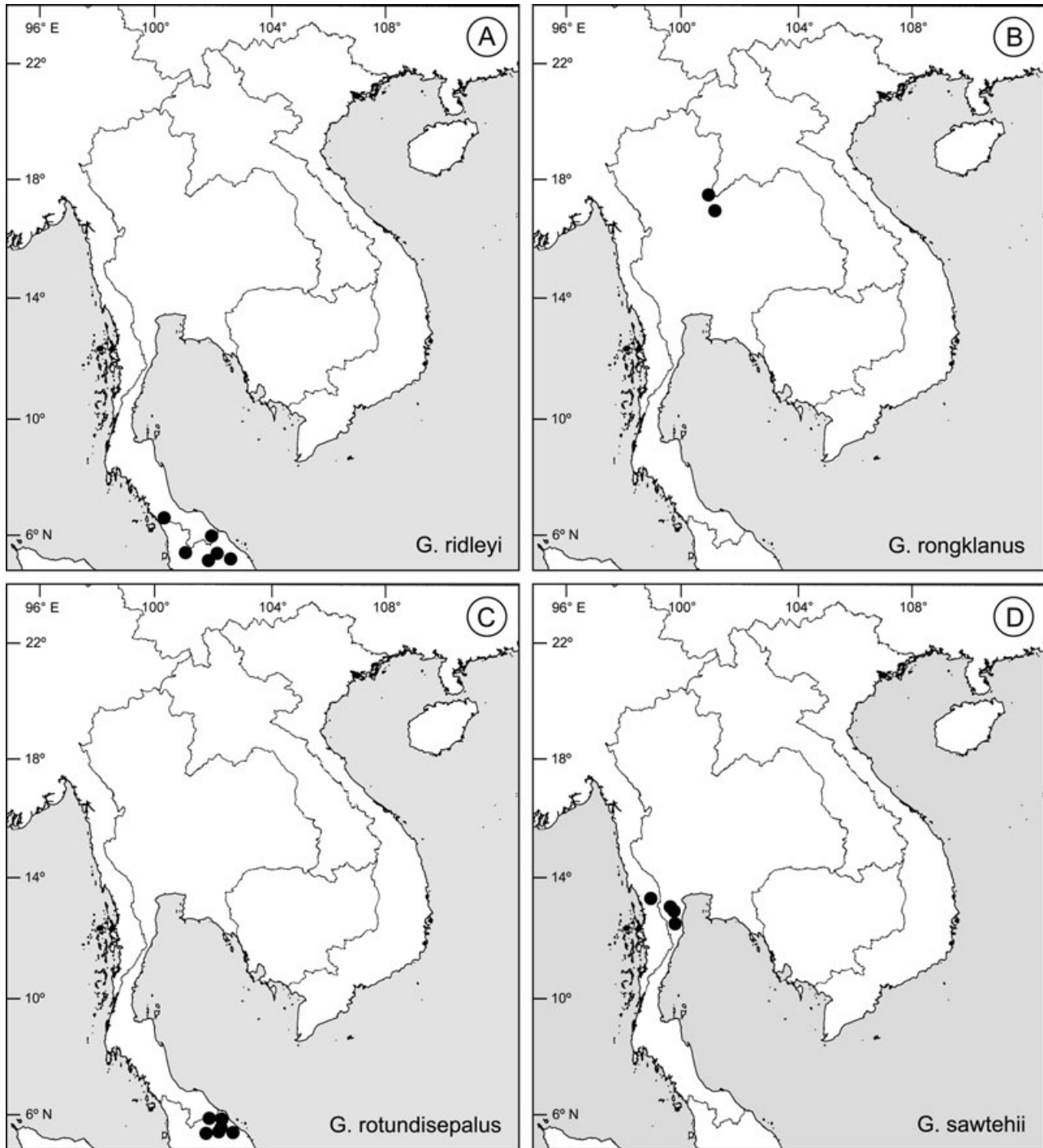


Figure 42. Distributions of (A) *G. ridleyi*, (B) *G. rongklanus*, (C) *G. rotundisepalus*, and (D) *G. sawtehii* in Thailand and surrounding areas.

15. *GONIOTHALAMUS RONGKLANUS* R. M. K.
SAUNDERS & CHALERMGLIN, SP. NOV. (FIGS 32, 33,
43)

Type: Thailand: Phu Hin Rongkla National Park,
Amphoe Nakhonthai, Phitsanulok Province, Northern

Thailand, 11.ii.2007, *P. Chalermglin 500211* (holo-
type: BKF!; isotypes: AAU!, C!, HKU!, K!, L!, QBG!).
Goniotalamus 'sp.'; *P. Chalermglin, Fam. Annon.*,
198–199 (2001).

Species *G. laotico* (Finet & Gagnep.) Bân similis,
sed venis foliorum percurrentibus, pedicellis florum

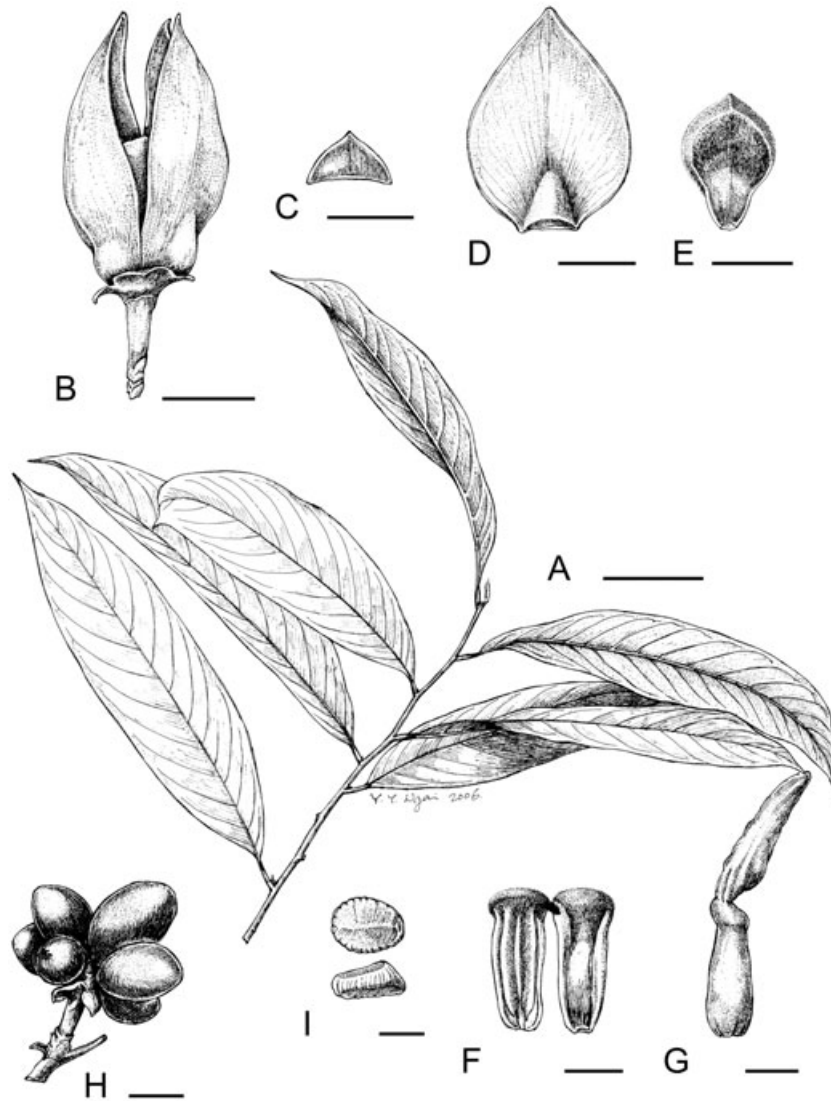


Figure 43. *Goniothalamus rongklanus*, sp. nov. A, vegetative branch. B, flower. C, sepal (adaxial). D, outer petal (adaxial). E, inner petal (adaxial). F, stamens (abaxial and adaxial). G, carpel. H, fruit. I, seeds. Scale bars: A, 5 cm; B–E, I, 10 mm; F, G, 1 mm; H, 20 mm (A, H, *Saunders et al.* 04/41; B–G, *Chalermglin* 420220; I, *Saunders et al.* 04/43). Drawing by Ngai Yuen Yi.

longibus (13–22 mm), sepalis connatis basi et reflexis, petalis externis adaxialiter glabris, petalis internis abaxialiter pubescentibus sparsim, staminibus numerosis (c. 180), et seminibus grandibus (15–22 × 13–17 mm) differt.

Small trees, to 8 m tall, slender. Young branches subglabrous. Leaf laminas 17–25 cm long, 5–7.5 cm wide, length/width ratio 2.9–3.9, elliptic to obovate, apex acuminate, base acute(–attenuate), papyraceous, 50–70 µm thick, matt to slightly glossy adaxially, sparsely hairy abaxially, (sub)glabrous adaxially; midrib very sparsely hairy and prominent abaxially, glabrous and slightly impressed adaxially; secondary veins 13–16 pairs per leaf, (slightly) impressed adaxi-

ally; tertiary veins weakly percurrent, (very) distinct; petioles 8–18 mm long, 2–2.4 mm in diameter, subglabrous to very sparsely hairy. Flowers axillary, solitary, on young growth, pendent; flowering pedicels 13–16 mm long, c. 2.5 mm in diameter, very sparsely hairy; pedicel bracts c. 5. Sepals c. 6 mm long, c. 9–10 mm wide, length/width ratio c. 0.6, not reflexed at anthesis, basally connate, broad ovate, c. 150 µm thick, sparsely hairy abaxially, glabrous adaxially, green, tinged with red, venation indistinct. Outer petals c. 29 mm long, c. 22 mm wide, length/width ratio c. 1.3, ovate, c. 650 µm thick, subglabrous abaxially, glabrous adaxially, with essentially glabrous (sparsely hairy towards apex) region at base of

adaxial surface, greenish–yellow, tinged with red basally, venation distinct. Inner petals *c.* 16–17 mm long, *c.* 11–12 mm wide, length/width ratio *c.* 1.4, 1250–1350 µm thick, sparsely hairy abaxially, hairy adaxially, pale grey. Stamens *c.* 180 per flower, 2.4–2.5 mm long, 0.6–0.7 mm wide; connectives truncate, 0.2–0.3 mm long, papillate-hairy. Carpels *c.* 18 per flower; ovary 2.4–2.8 mm long, 0.6–0.8 mm wide, glabrous; stigma and style 2.6–2.8 mm long; stigma fusiform, glabrous, warty. Fruits with persistent calyx; fruiting pedicels 16–22 mm long, 3.5–4.5 mm in diameter, (sparsely) hairy. Monocarps 17–54 mm long, 15–24 mm wide, length/width ratio 1.1–2.6, subglobose or ellipsoid to elongate, base cuneate to attenuate, apex rounded to acuminate, occasionally with a small apicule, ± smooth, glossy to ± matt, glabrous, green tinged with purple–pink, pericarp medium-thick, 0.8–1.8 mm thick when dried; stipes 3–8 mm long, 3–5.5 mm in diameter, glabrous. Seeds 1–6 per monocarp, 15–22 mm long, 13–17 mm wide, length/width ratio 1.1–1.5, flattened ellipsoid, testa smooth to slightly rugulose, hairy, orange–brown, endostome flush or slightly sunken, seeds with surrounding mucilage.

Distribution and habitat: Endemic to Northern and North-Eastern Thailand (Phetchabun and Phitsanulok Provinces: Fig. 42B). Lower montane forests; 900–1200 m.

Notes: *Goniothalamus rongkhanus* flowers have a very rounded mitriform inner petal dome, a feature shared with *G. laoticus* and two newly described species, *G. aurantiacus* and *G. maewongensis*. *Goniothalamus rongkhanus* differs from *G. laoticus* in having percurrent leaf venation (reticulate in *G. laoticus*), longer pedicels (13–22 mm), basally connate and reflexed sepals, adaxially glabrous outer petals, abaxially sparsely hairy inner petals, more stamens per flower (*c.* 180 vs. 30–96 in *G. laoticus*), and wider seeds (13–17 vs. 11–13.5 mm). Differences between *G. rongkhanus* and two other newly described species, *G. aurantiacus* and *G. maewongensis*, are given in Table 1. Distinctions between these species have also been confirmed by phylogenetic analysis of ITS, *trnK/matK* and *trnL-F* sequences (M. Nakkuntod *et al.*, unpubl. data).

The specific epithet is derived from the name of the type locality, Phu Hin Rong Kla National Park.

Additional specimens examined (paratypes): Thailand. NORTH-EASTERN: Phu Hin Rong Kla National Park, Phetchabun Province, *R. M. K. Saunders et al.* 04/43 (BKF). – NORTHERN: Phuhin Rongkhla National Park, Amphoe Nakhonthai, Phitsanulok Province, *P. Chalermglin* 420220 (HKU), 420816

(BKF); Phu Soi Dao, near Laos border, Phitsanulok Province, *R. M. K. Saunders et al.* 04/41 (BKF).

16. *GONIOTHALAMUS ROTUNDISEPALUS* M. R. HEND.
(FIGS 34, 35)

Gard. Bull., Straits Settlem. 4: 48 (1927); J. Sinclair, Gard. Bull., Singapore 14: 435–436 (1955). *Type:* Peninsular Malaysia: Sungei Renong, Kelantan, 28.ii.1924, *M. Nur & F. W. Foxworthy SFN 12157* (holotype: SING!; isotype: K!).

Goniothalamus expansus auct. non Craib; P. Chalermglin, *Fam. Annon.*, 158–159 (2001).

Distribution and habitat: Peninsular Thailand (Narathiwat Province: Fig. 42C) and Peninsular Malaysia (Saunders, 2003). Lowland forests; 60–370 m.

Notes: *Goniothalamus rotundisepalus* is similar to *G. tenuifolius*, but differs in having leaves with a distinctive ‘granular’ appearance of the abaxial surface of the leaf laminae, because of the immersion of the tertiary and lower order veins. Henderson (1927) and Sinclair (1955) both commented on the shape of the sepals, which are typically very broad in *G. rotundisepalus*; the variation in this character is not diagnostically very useful, however, as many specimens of *G. tenuifolius* have similarly shaped sepals.

The ‘granular’ appearance of the leaves is also observed in *G. macrophyllus* and *G. tavoyensis*. The differences between *G. macrophyllus* and *G. rotundisepalus* are described under the treatment of the former species. *Goniothalamus tavoyensis* differs from *G. rotundisepalus* as it has glabrous branches, longer inner petals (9–21 vs. 4–9 mm), and distinctly tapered long acuminate staminal connectives (truncate in *G. rotundisepalus*).

17. *GONIOTHALAMUS SAWTEHII* C. E. C. FISCH.
(FIGS 36, 37)

Bull. Misc. Inform. 1927: 203 (1927); P. Chalermglin, *Fam. Annon.*, 176–177 (2001). *Type:* Myanmar: Kyein chuang, Tenasserim, 11.vi.1926, *Mang Saw Teh* (‘for *C. E. Parkinson*’) 1380 (holotype: K!).

Distribution and habitat: South-Western Thailand (Phetchaburi and Prachuap Khiri Khan Provinces: Fig. 42D) and southern Myanmar. Evergreen forests; 30–900 m.

Notes: *Goniothalamus sawtehii* and *G. undulatus* form a very coherent and easily identified group, characterized by outwardly revolute lateral margins to the outer petals (Figs 36, 49). Distinctions between

the two species are more problematic, however, because of overlap in many characters: *G. sawtehii* typically has larger flowers (outer petals 23–43 × 12–23 mm, with 40–100 carpels per flower) than *G. undulatus* (outer petals 10.5–32 × 5.5–17.5 mm, with 10–54 carpels per flower); and has shorter stipes in the fruit (3–6 vs. 6.5–16.5 mm). This pattern of variation is strongly correlated with a north–south distributional difference (Figs 42D, 51C), which presumably reflects differences in length of the annual dry season.

18. *GONIOTHALAMUS SCORTECHINII* KING (FIGS 38, 39)

J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 59: 77–78 (1892); King, Ann. Roy. Bot. Gard., Calcutta 4: 99 (1893); Ridl., Fl. Malay Penins. 1: 67–68 (1922); J. Sinclair, Gard. Bull., Singapore 14: 441–442 (1955); P. Chalermglin, Fam. Annon., 178–179 (2001). *Type*: Peninsular Malaysia: Perak, iv. 1885, *King's collector 7448* (lectotype: K!, designated by Saunders, 2003: 325; isoelectotypes: BM!, L!).

Distribution and habitat: Peninsular Thailand (Narathiwat and Yala Provinces: Fig. 44A) and Peninsular Malaysia (Saunders, 2003). Lowland rainforests, often disturbed; 30–500 m.

Notes: Within the Thai flora, *G. scortechinii* is most similar to *G. tavoyensis* (Figs 47, 48), although the two species differ in staminal connective shape (distinctly tapered in *G. tavoyensis*, but not so in *G. scortechinii*). Other differences include: leaf lamina size (22–50 cm long in *G. scortechinii* vs. 12.5–25.5 cm long in *G. tavoyensis*); number of pairs of secondary veins per leaf (18–32 vs. 9–12); pattern of tertiary venation (percurrent vs. reticulate); and seed size (8–11 vs. 17–18 mm long).

Outside Thailand, *G. scortechinii* bears a closest resemblance to the Peninsular Malaysian species *G. curtisii* King (Saunders, 2003) and the Sumatran species *G. dewildei* R. M. K. Saunders (Saunders, 2002).

19. *GONIOTHALAMUS TAMIRENSIS* PIERRE EX FINET & GAGNEP. (FIGS 40, 41)

Bull. Soc. Bot. France, Mém IV 53: 119 (1906); Finet & Gagnep. in Lecomte, Fl. Gén. Indo-Chine 1: 88 (1907); P.-H. Hô, Cây cỏ Việt Nam 1(1): 345 (1991); Bân, Thực vật chí Việt Nam 1: 239–240 (2000). *Type*: Kampuchea: Mt. Camire, Thepong Province, v. 1870, *J. B. L. Pierre 744*, pro parte (lectotype: P!, designated

by Bân (2000: 239); isoelectotypes: A, LE, NY [photo!]). [Type erroneously cited as '*Pierre 144*' by Finet & Gagnepain (1906): 119]

Goniothalamus tamirensis var. *kamputensis* Finet & Gagnep., Bull. Soc. Bot. France, Mém IV 53: 119–120 (1906); Finet & Gagnep. in Lecomte, Fl. Gén. Indo-Chine 1: 88–89 (1907). *Type*: Kampuchea: Mt. Kamchay (Mts de l'Éléphant), Kampot Province, vii. 1874, *J. B. L. Pierre 744b* (lectotype: P!, designated here).

Goniothalamus marcanii Craib, Bull. Misc. Inform. 1922: 167 (1922); Ast in Humbert, Fl. Gén. Indo-Chine, suppl. 1: 97–98 (1938); P. Chalermglin, Fam. Annon., 172–173 (2001). *Type*: Thailand: Srirācha, Bandan, Prachinburi, Chachoengsao Province, South-Eastern Thailand, 30.iii.1920, *A. Marcan 143* (lectotype: K!, designated here).

Distribution and habitat: Eastern, North-Eastern and South-Eastern Thailand (Chachoengsao, Chanthaburi, Chon Buri, Nakhon Ratchasima, Nong Khai and Trat Provinces: Fig. 44B), Kampuchea and Vietnam. Dry evergreen forests; 10–500 m.

Notes: Examination of the type material of the names *G. tamirensis* and *G. marcanii* reveal that they represent the same taxon, and the latter name is reduced to synonymy here for the first time. One explanation for the continued use of the name *G. marcanii* is that Sinclair misapplied the name (erroneously citing it as '*macranii*') in his influential *Revision of the Malayan Annonaceae* (1955). As shown in a previous publication (Saunders, 2003), specimens that Sinclair has determined as *G. marcanii* represent *G. tomentosus* R. M. K. Saunders.

Within the Thai flora, *G. tamirensis* resembles *G. elegans*, *G. expansus* and *G. latestigma* (Figs 18, 19); features common to all these species include: inner petals with a glabrous lateral margin to the basal claw; truncate staminal connectives; and large funnel-shaped stigmas. *Goniothalamus tamirensis* can easily be distinguished, however, as it has densely hairy to velutinous shoots and petioles.

20. *GONIOTHALAMUS TAPIS* MIQ. (FIGS 45, 46)

Fl. Ind. Bat. Suppl. 1: 371 (1860); Miq., Ann. Mus. Bot. Ludguno-Batavum 2: 35 (1865); King, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 77 (1892); King, Ann. Roy. Bot. Gard., Calcutta 4: 99 (1893); Ridl., Fl. Malay Penins. 1: 67 (1922); J. Sinclair, Gard. Bull., Singapore 14: 444–445 (1955); P. Chalermglin, Fam. Annon., 182–183 (2001); R. M. K. Saunders, Bot. J. Linn. Soc. 139: 237–238 (2002). *Type*: Sumatra: Priaman Province, Sumatera Barat, without date, *H. Diepenhorst s.n.* [2125] (lectotype: U!, designated by Saunders, 2002: 237).

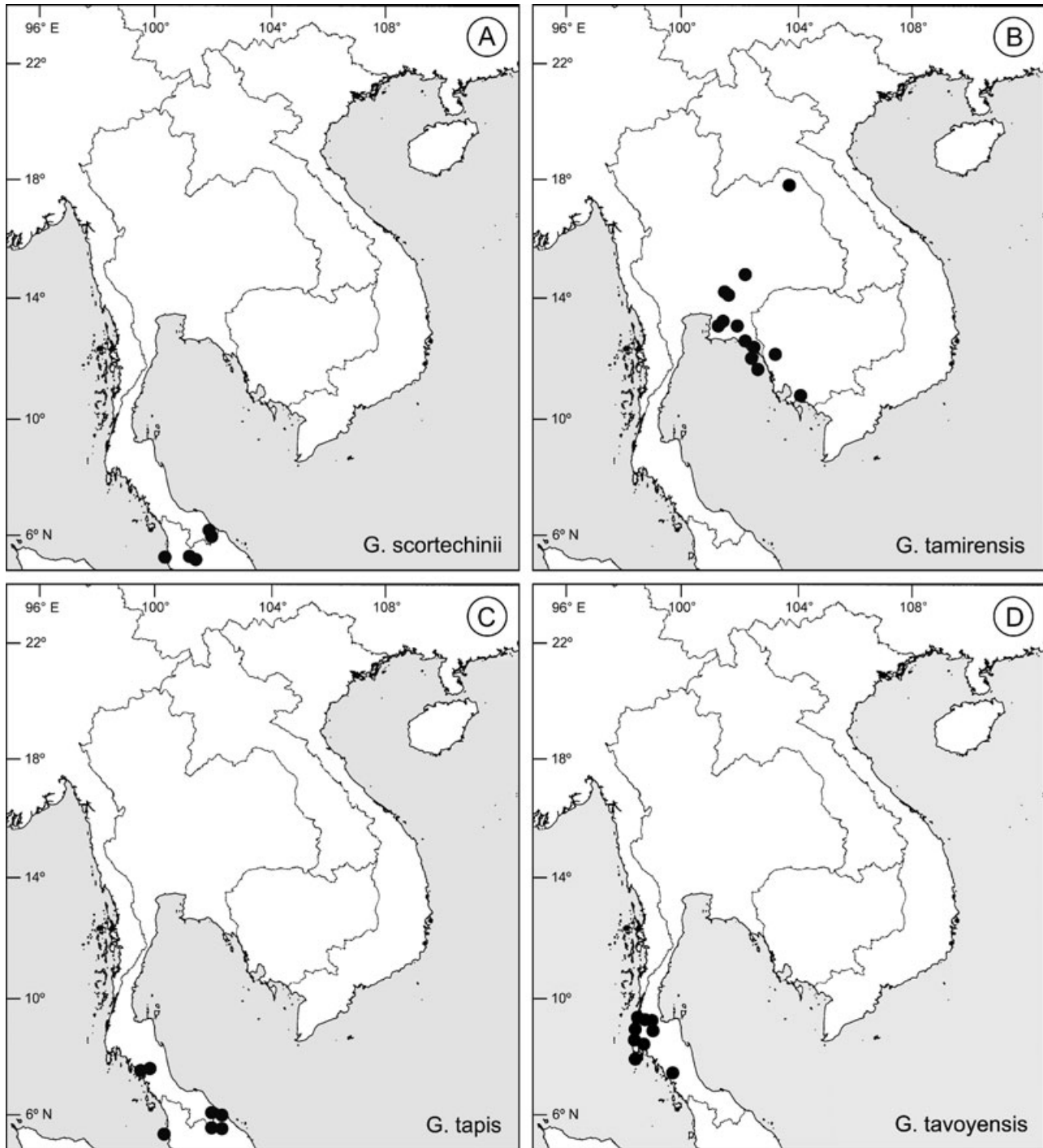
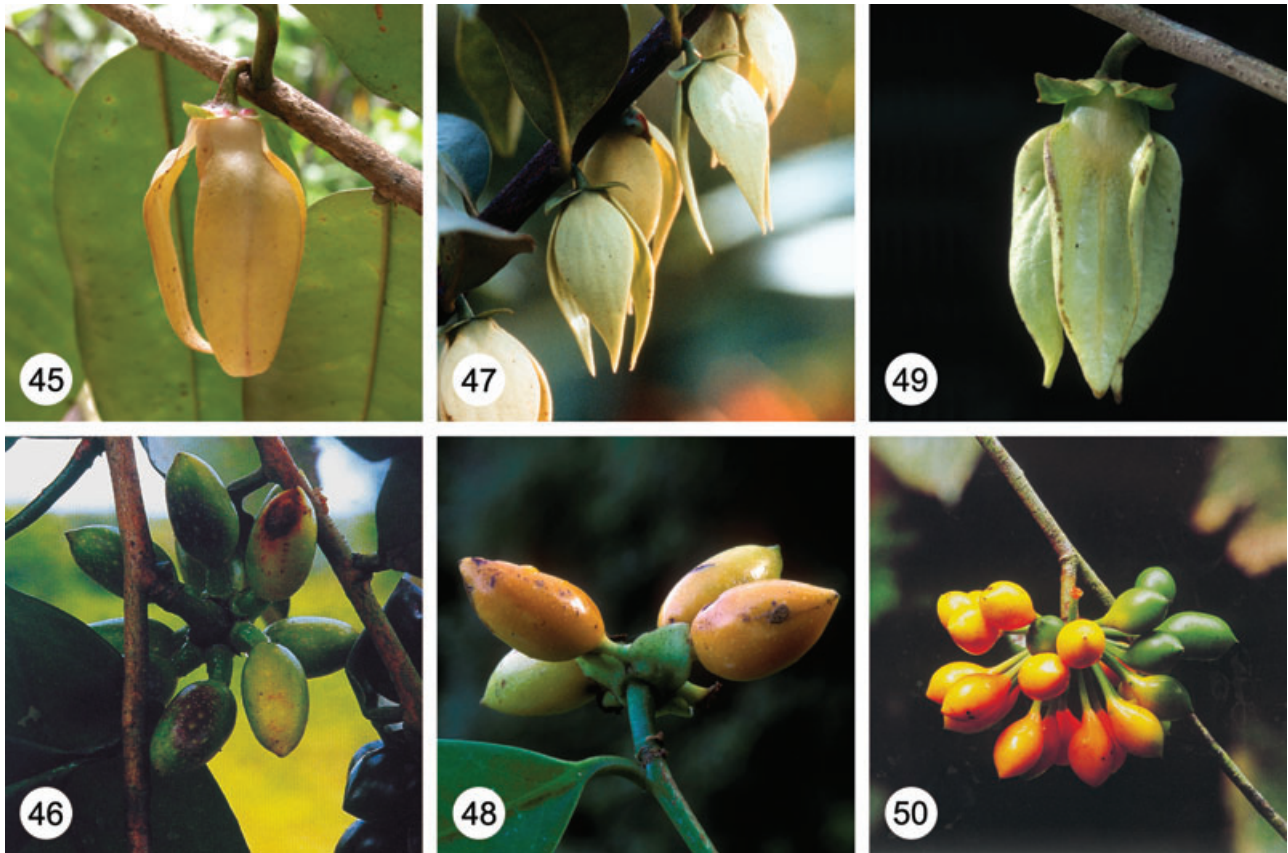


Figure 44. Distributions of (A) *G. scortechinii*, (B) *G. tamirensis*, (C) *G. tapis*, and (D) *G. tavoyensis* in Thailand and surrounding areas.

Goniiothalamus umbrosus J. Sinclair, Gard. Bull., Singapore 14: 445 (1955). *Type*: Peninsular Malaysia: jungle behind no. 2 Plant House, Waterfall Gardens, Penang, 19.x.1951, *J. Sinclair SFN 39356* (holotype: K!; isotypes: E!, K!, SING).

Distribution and habitat: Peninsular Thailand (Narathiwat and Trang Provinces: Fig. 44C), Peninsular Malaysia (Saunders, 2003) and Sumatra (Saunders, 2002). Primary lowland rainforests; sea level to 900 m.



Figures 45–50. Flowers and fruits of *Goniothalamus* species from Thailand. Figs 45, 46. *G. tapis*. Figs 47, 48. *G. tavoyensis*. Figs 49, 50. *G. undulatus*. (Fig. 45: R. M. K. Saunders; Figs 46, 47, 50: P. Chalermglin; Figs 48, 49: S. Gardner & P. Sidisunthorn). Fig. 50 reproduced from Chalermglin (2001).

Notes: Several previous authors have commented on the superficial similarity between *G. tapis* and *G. malayanus* (Airy Shaw, 1939; Corner, 1939; Sinclair, 1955), although these comparisons are confused because of the failure to distinguish between the Bornean species *G. tapisoides* Mat-Salleh (Mat-Salleh, 2001) and *G. tapis* s.s., which is restricted to Sumatra, Peninsular Malaysia and Peninsular Thailand. Although the leaves of the two species are very similar, they can easily be distinguished if flowering material is available, as *G. tapis* stamens have a long apiculate connective, whereas those of *G. malayanus* are truncate. In addition, *G. tapis* monocarps are smaller than those of *G. malayanus* (10–14 × 7–11 vs. 16–40 × 8–17 mm), and invariably contain only one seed each.

21. *GONIOTHALAMUS TAVOYENSIS* CHATTERJEE
(FIGS 47, 48)

In Chatterjee & Mukerjee, *J. Ind. Bot. Soc.* 19: 77 (1940). *Type:* Myanmar: Heinze camp, Tavoy, Tenasserim [= Taninthayil], date unknown, *P. T. Russel 2025* (holotype: CAL).

Distribution and habitat: Endemic to Peninsular Thailand (Nakhon Si Thammarat, Phangnga, Phuket, Ranong, Surat Thani and Trang Provinces: Fig. 44D). Evergreen forests; sea level to 500(–1000) m.

Notes: The protologue description of *G. tavoyensis* (Chatterjee & Mukerjee, 1940) indicated that the leaves have 14–20 pairs of secondary veins, although this was not reflected in the accompanying illustration; Sinclair (1955) subsequently clarified that there are only 10–12 pairs. The leaves furthermore possess a ‘granular’ appearance because of the immersed tertiary and lower order veins. This feature is also observed in *G. macrophyllus* and *G. rotundisepalus*, although there are significant differences between these species (detailed under the treatments of these species).

Goniothalamus tavoyensis is most similar to *G. wrayi* King, which occurs in Peninsular Malaysia (Saunders, 2003) and Sumatra (Saunders, 2002): both species possess very distinctive stamens in which the connective is noticeably tapered to a long acuminate apex. *Goniothalamus wrayi* differs, however, in

having leaves with (13–)16–22 pairs of secondary veins, and smaller flowers with sepals that are only 2–5.5(–13) × 2.5–5 mm and inner petals that are only 7.5–13 × 3.5–6 mm. The fruits of *G. wrayi* are also distinctive as they lack the persistent calyx found in *G. tavoyensis*, and the monocarps are smaller (11–17 × 4.5–6 mm) with smaller seeds (9.5–12.5 × 4.5–5.5 mm) that are hairy.

22. *GONIOTHALAMUS TENUIFOLIUS* KING

J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 71–72 (1892); King, Ann. Roy. Bot. Gard., Calcutta 4: 89–90 (1893); Ridl., Fl. Malay Penins. 1: 64–65 (1922); J. Sinclair, Gard. Bull., Singapore 14: 434–435 (1955); Bân, Thực vật chí Việt Nam 1: 233–234 (2000). *Type*: Peninsular Malaysia: Perak, v. 1882, *King's collector 3019* (lectotype: K!, designated by Saunders, 2003: 331; isolectotypes: BM!, CAL, K!).

Goniothalamus tenuifolius var. *arborescens* King, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 72 (1892); King, Ann. Roy. Bot. Gard., Calcutta 4: 89 (1893). *Type*: Peninsular Malaysia: (Larut), Perak, [x. 1883], *King's collector [5073]* (holotype: K!; isotypes: BM!, CAL, L [× 2]!).

Goniothalamus kunstleri King, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 73 (1892); King, Ann. Roy. Bot. Gard., Calcutta 4: 90–91 (1893); Ridl., Fl. Malay Penins. 1: 67 (1922). *Type*: Peninsular Malaysia: Goping, Perak, without date, *B. Scortechini 1803* (lectotype: K!, designated by Saunders, 2003: 331; isolectotypes: CAL, L!).

Goniothalamus kunstleri var. *macranthus* King, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 73 (1892), as '*marcantha*'; King, Ann. Roy. Bot. Gard., Calcutta 4: 91 (1893). *Type*: Peninsular Malaysia: Province Wellestley, Penang, vi. 1890, *C. Curtis 2447* (lectotype: SING!, designated by Saunders, 2003: 331; isolectotypes: BM!, CAL, E!, US [× 2]!).

Goniothalamus caudifolius Ridl., Bull. Misc. Inform. 1914: 324 (1914); Ridl., Fl. Malay Penins. 1: 65 (1922). *Type*: Peninsular Malaysia: Pondok Tanjong, Perak, 1909, *A. M. Burn-Murdoch 180* (holotype: K!; isotype: K!). [The K isotype bears the name Hashim as collector; according to van Steenis-Kruseman (1950: 218) Hashim acted as collector on behalf of Burn-Murdoch].

Distribution and habitat: Peninsular Thailand (Narathiwat Province: Fig. 51A) and Peninsular Malaysia (Saunders, 2003). Dense, primary lowland to submontane forests; 50–900 m.

Notes: As noted by Saunders (2003), *G. tenuifolius* is taxonomically problematic because of its great morphological variability in many characters, including

degree of pubescence of leaves, length of flowering pedicels (3–18 mm), size of sepals (6.5–19 × 5–14.5 mm), size of outer petals (10–40 × 4–15 mm), size of inner petals (5–14 × 3–8 mm), and pubescence of ovaries. This variability is presumably the cause of the comparatively complex synonymy: King (1892) and Ridley (1914) were responsible for publishing several new names on the basis of differences in these characters. In general, there is little correlation in the variation, however: individuals with larger sepals, for example, do not necessarily have larger petals.

Goniothalamus tenuifolius bears a close resemblance to *G. rotundisepalus* (Figs 34, 35), but can easily be distinguished by the lack of the 'granular' appearance of the abaxial leaf surface, typical of the latter species.

23. *GONIOTHALAMUS TORTILIPETALUS* M. R. HEND.

Gard. Bull., Straits Settlements 7: 88 (1933), as '*tortilipetalum*'; J. Sinclair, Gard. Bull., Singapore 14: 436–437 (1955). *Type*: Peninsular Malaysia: Tembeling, Pahang, 21.v.1931, *M. R. Henderson SFN 24543* (holotype: SING!; isotypes: BO!, K [× 2]!, NY!).

Distribution and habitat: Peninsular Thailand (Narathiwat Province: Fig. 51B) and Peninsular Malaysia (Saunders, 2003). Primary and disturbed lowland forests; 60–300 m.

Notes: *Goniothalamus tortilipetalus* is a very distinctive species, with flowers and fruits that are borne exclusively on the main trunk, at various heights above soil level. Most other cauliflorous species in the genus are variably cauli- and ramiflorous, and sometimes also with flowers developing on young growth (e.g. *G. aurantiacus*, *G. laoticus*, *G. macrophyllus*, *G. malayanus*, *G. repevensis*, *G. scortechinii* and *G. uvarioides*). There are two other *Goniothalamus* species in Thailand that are exclusively cauliflorous (*G. cheliensis* and *G. ridleyi*), although they are easily distinguished: *G. cheliensis* (Figs 6, 7) has much larger leaves (50–76 × 13–22 cm) than *G. tortilipetalus* (20–39 × 6–11.5 cm) and has a generally much more densely hairy indument; and *G. ridleyi* (Figs 30, 31) is distinctive as it bears flowers and fruits that are restricted to the base of the trunk, close to soil level.

Goniothalamus tortilipetalus has clear affinities with *G. calvicarpus* and *G. griffithii*; the morphological distinctions between these species are listed in Table 2.

24. *GONIOTHALAMUS UNDULATUS* RIDL. (FIGS 49, 50)

J. Fed. Mal. States Mus. 10: 81 (1920); J. Sinclair, Gard. Bull., Singapore 14: 434 (1955); Bân, Thực vật chí Việt Nam 1: 238–239 (2000). *Type*: Thailand:

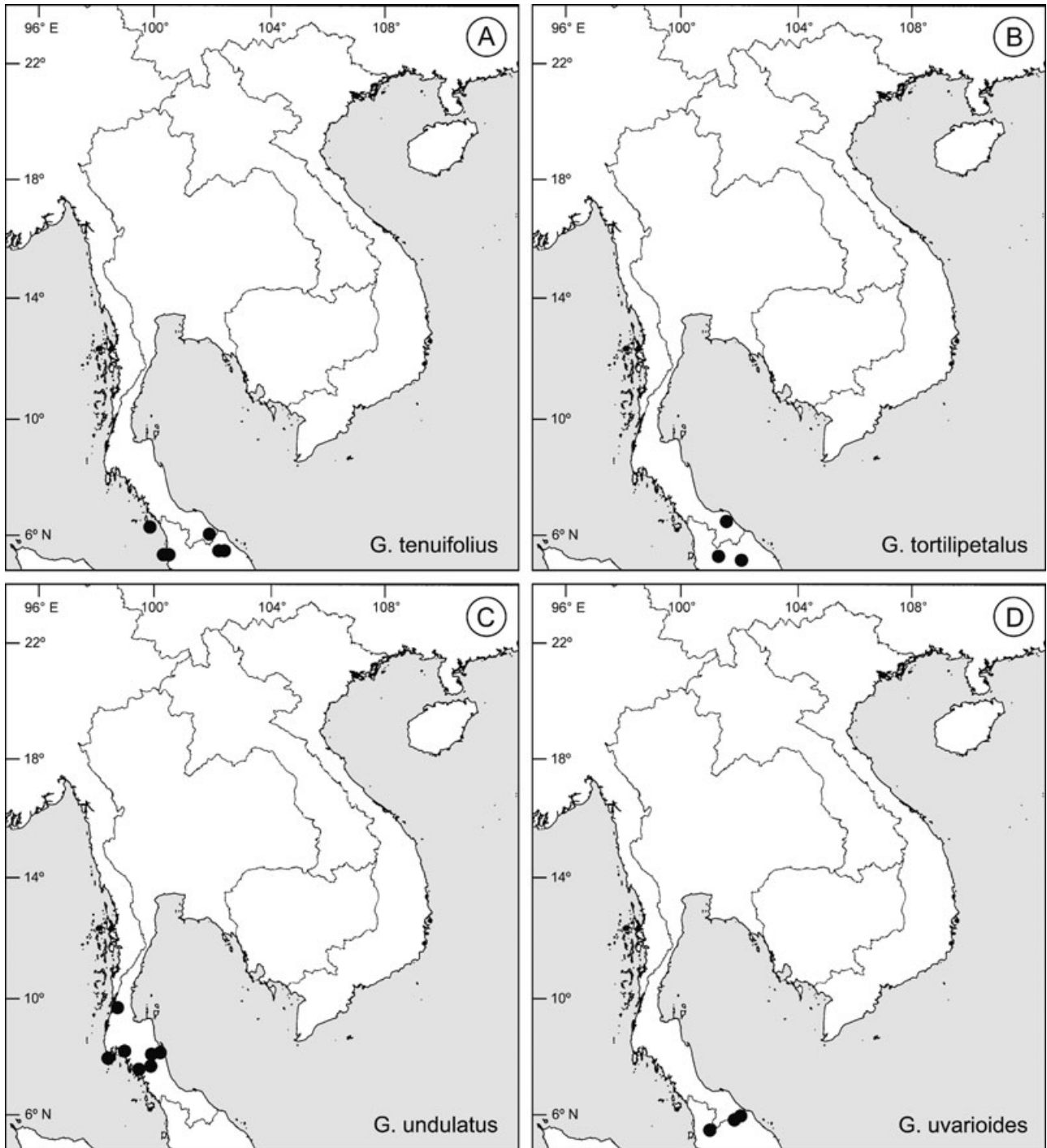


Figure 51. Distributions of (A) *G. tenuifolius*, (B) *G. tortilipetalus*, (C) *G. undulatus*, and (D) *G. uvarioides* in Thailand and surrounding areas.

Tasan, Puket [= Phuket] Province, Peninsular Thailand, 5.xi. 1919, C. B. Kloss FMS 6836 (holotype: K!; isotype: SING!).

Goniotalamus tenuifolius auct. non King; P. Chalermglin, Fam. Annon., 186–187 (2001).

Distribution and habitat: Peninsular Thailand (Krabi, Nakhon Si Thammarat, Phattalung, Phuket, Ranong, Surat Thani and Trang Provinces: Fig. 51C). Evergreen forests, sometimes over limestone; 50–700 m.

Notes: *Goniothalamus undulatus* shows a clear relationship with *G. sawtehhii* (Figs 36, 37); distinctions between the two species are discussed in the treatment of the latter species.

25. *GONIOTHALAMUS UVARIOIDES* KING

J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61: 78–79 (1892); King, Ann. Roy. Bot. Gard., Calcutta 4: 100–101 (1893); Ridl., Fl. Malay Penins. 1: 69 (1922); J. Sinclair, Gard. Bull., Singapore 14: 442–443 (1955). *Type:* Peninsular Malaysia: Ulu Slim, Perak, 5.viii.1886, *King's collector 10664* (lectotype: K!, designated by Saunders, 2003: 326; isolectotypes: BM!, CAL).

Goniothalamus pendulifolius Ridl., Fl. Mal. Penins. 5: 287 (1925). *Type:* Peninsular Malaysia: 6 miles N of Bentong, Pahang, 5.xi. 1924, *I. H. Burkill & M. Haniff SFN 16501* (lectotype: K!, designated by Saunders, 2003: 326; isolectotypes: K!, SING [× 2]!).

Distribution and habitat: Peninsular Thailand (Narathiwat Province: Fig. 51D) and Peninsular Malaysia (Saunders, 2003). Lowland forests; 100–450 m.

Notes: *Goniothalamus uvarioides* does not appear to be closely related to any other species in the Thai flora, although it resembles several species in Sumatra and Borneo (see discussion by Saunders, 2003), particularly *G. parallelevenius* Ridl.

Goniothalamus uvarioides characteristically has numerous pairs of secondary veins per leaf (24–35); only two Thai representatives of the genus have similarly large numbers of secondary veins, namely, *G. cheliensis* (24–32 veins) and *G. scortechinii* (18–32 veins). *Goniothalamus cheliensis* is easily distinguished from *G. uvarioides* because of its much larger leaves (50–76 cm long), whereas *G. scortechinii* differs in having a velutinous patch at the base of the adaxial surface of the outer petals (vs. glabrous to hairy in *G. uvarioides*), much smaller monocarps (9–18 × 6–10 vs. 31–44 × 15–18 mm in *G. uvarioides*), and shorter stipes (1.5–11 vs. 12.5–17.5 mm in *G. uvarioides*).

As previously noted (Saunders, 2003), the protologue of *G. uvarioides* was based on fruiting specimens collected in Peninsular Malaysia and flowering specimens collected in Borneo (King, 1892, 1893). Although most subsequent authors accepted that these specimens are conspecific (Ridley, 1922; Sinclair, 1955; Bân, 1974; Mat-Salleh, 1993, 2001; Beaman, Anderson & Beaman, 2001; Mat-Salleh K, 1993. *Revision of the genus Goniothalamus (Annonaceae) of Borneo*. Unpublished PhD thesis. East Lansing, Michigan State University) it has also been suggested that this is not the case (Saunders, 2003). Lectotypification of the name using a Peninsular

Malaysian syntype (Saunders, 2003) has clarified the application of the name for continental Asian populations, but further study is necessary to determine whether the Bornean specimens represent a new taxon.

EXCLUDED NAME

Goniothalamus desmoides Craib, Bull. Misc. Inform. 1922: 167 (1922). *Type:* Thailand: Cultivated, Chiang-mai [= Chiang Mai], A. F. G. Kerr 3312 (holotype: K). = *Friesodielsia desmoides* (Craib) Steenis (Annonaceae), fide van Steenis (1964).

BIOGEOGRAPHICAL CONSIDERATIONS

The *Goniothalamus* flora of Thailand can be classified into approximately five essentially distinct biogeographical groups. The largest group consists of 14 species (*G. expansus*, *G. giganteus*, *G. latestigma*, *G. macrophyllus*, *G. malayanus*, *G. ridleyi*, *G. rotundisepalus*, *G. scortechinii*, *G. tapis*, *G. tavoyensis*, *G. tenuifolius*, *G. tortilipetalus*, *G. undulatus* and *G. uvarioides*) occurring in Peninsular Thailand south of the Isthmus of Kra (c. 10–11°N), although two of these species (*G. latestigma* and *G. tavoyensis*) extend slightly north of this boundary into South-Western Thailand and southern Myanmar. Species in this group occur in tropical lowland evergreen rainforests that experience very limited dry periods. The group represents the Malesian component of the flora, with most species also occurring in Peninsular Malaysia (Saunders, 2003). Several of these species (particularly *G. giganteus*, *G. macrophyllus*, *G. malayanus*, *G. ridleyi* and *G. tapis*) are comparatively widespread in western Malesia, and their presence in the Thai flora represents the northernmost limit of their distribution.

The second and third biogeographical groups consist of species growing in seasonally dry evergreen and/or deciduous forests. The second group includes species occurring in South-Western Thailand, often extending into southern Myanmar and/or Peninsular Thailand (*G. aurantiacus*, *G. griffithii*, *G. latestigma* and *G. sawtehhii*), whereas the third group consists of species in Northern Thailand, extending into northern Myanmar, southern China and Laos (*G. calvicarpus*, *G. cheliensis*, *G. laoticus* and *G. rongkhanus*). The newly described species *G. maewongensis* occurs near the border between these rather artificially defined groups.

The remaining species all occupy generally drier habitats. *Goniothalamus laoticus* has a wider distribution than most species in northern Thailand, and extends into the comparatively dry Khorat plateau of North-Eastern and Eastern Thailand. Only two other

Goniothalamus species, *G. elegans* and *G. tamirensis*, occur in this region. The final group consists of two species, *G. repevensis* and *G. tamirensis*, which grow in dry evergreen forests in South-Eastern Thailand, both extending into Indochina.

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APPENDIX

INDEX TO NUMBERED COLLECTIONS EXAMINED
(THAILAND ONLY)

- Adisai 437 (*G. laoticus*).
Beusekom, C. F. van & C. Charoenphol 1860 (*G. tamirensis*); Beusekom, C. F. van & C. Phengkhilai 256 (*G. aurantiacus*), 554 (*G. latestigma*), 805 (*G. macrophyllus*); Beusekom, C. F. van & T. Santisuk 3164 (*G. tamirensis*); Beusekom, C. F. van *et al.* 3698 (*G. griffithii*); Boonnab, C. 8 (*G. giganteus*); Boyce, P. C. 907 (*G. tamirensis*); Bunchuay, K. 927 [= 23035] (*G. calvicarpus*), 1876 (*G. macrophyllus*); Bunchuay, K. & B. Nimanong 1414 [= BKF 46194] (*G. calvicarpus*); Bunnab, C. 50 (*G. undulatus*); Bunnak & Tanee 3161 (*G. aurantiacus*).
Chalermglin, P. 390820 (*G. giganteus*), 400711–1 (*G. sawtehi*), 400902–1 (*G. calvicarpus*), 410506 (*G. giganteus*), 410726–1 (*G. griffithii*), 420220 (*G. rongkklanus*), 420408 (*G. cheliensis*), 420417–1 (*G. repevensis*), 420523 (*G. laoticus*), 420816 (*G. rongkklanus*), 421010 (*G. undulatus*), 430209–2 (*G. aurantiacus*), 450223 (*G. cheliensis*), 470417 (*G. maewongensis*), 470626 (*G. griffithii*), 490601 (*G. griffithii*), 520210 (*G. rongkklanus*); Chamchumroon, V. 267 (*G. elegans*), 879 (*G. tavoyensis*); Chantaranonthai, P. *et al.* 1324 (*G. undulatus*); Charoenphol, C. *et al.* 3466 (*G. undulatus*), 3590 (*G. undulatus*),

- Parnell, J. *et al.* 95–519 (*G. sawtehii*); Phengkhlai, C. 1274 (*G. tamirensis*); Phengkhlai, C. & N. Fukuoka 10009 (*G. undulatus*); Phengkhlai, C. *et al.* 12891 (*G. tamirensis*), 13134 (*G. tamirensis*); Phusomsaeng, S. 133 (*G. undulatus*); Phusomsaeng, S. & S. Pinnin 62 (*G. tapis*); Pooma, R. 23 (*G. calvicarpus*), 158 (*G. calvicarpus*); Pooma, R. *et al.* 2558 (*G. laoticus*), 2685 (*G. tamirensis*); Prapad, D. 17 (*G. tavoyensis*); Prayad 910 (*G. calvicarpus*); Premrasnin, A. 7 (*G. malayanus*); Put, N. 571 (*G. tamirensis*).
- Ramsri, W. 3 (*G. undulatus*).
- Sangkhachand, P. 43 [= BKF 40481] (*G. repevensis*), 1667 [= BKF 51179] (*G. laoticus*); Sangkhachand, P. *et al.* 1028 (*G. scortechinii*); Santisuk, T. 1222 (*G. lat-estigma*); Santisuk, T. *et al.* 339 (*G. undulatus*); Sathaphon, S. *et al.* 205 (*G. expansus*); Saunders, R. M. K. & P. Chalermglin 04/30 (*G. griffithii*), 04/33 (*G. aurantiacus*), 04/34 (*G. aurantiacus*); Saunders, R. M. K. *et al.* 99/3 (*G. aurantiacus*), 99/5 (*G. calvicarpus*), 04/7 (*G. tapis*), 04/8 (*G. repevensis*), 04/9 (*G. laoticus*), 04/11 (*G. tavoyensis*), 04/13 (*G. calvicarpus*), 04/14 (*G. sawtehii*), 04/22 (*G. cheliensis*), 04/23 (*G. tamirensis*), 04/35 (*G. maewongensis*), 04/36 (*G. maewongensis*), 04/37 (*G. calvicarpus*), 04/38 (*G. calvicarpus*), 04/39 (*G. calvicarpus*), 04/41 (*G. rongklanus*), 04/43 (*G. rongklanus*), 04/46 (*G. laoticus*); Shimizu, T. *et al.* T-8024 (*G. tavoyensis*); Sirirugsa, P. 968 (*G. undulatus*); Smith, E. 717 (*G. macrophyllus*); Smitinand, T. 551 (*G. laoticus*), 821 (*G. macrophyllus*), 3020 (*G. macrophyllus*), 5676 (*G. tamirensis*), 6831 [= BKF 24507] (*G. calvicarpus*), BKF 69902 (*G. laoticus*); Snan 705 [= BKF 14869] (*G. undulatus*); Soejarto, D. D. *et al.* 5983 (*G. giganteus*); Sørensen, T. *et al.* 3414 (*G. calvicarpus*), 5155 (*G. calvicarpus*), 5868 (*G. calvicarpus*).
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- Williams, L. 17177 (*G. tamirensis*); Winit, K. 1406 (*G. laoticus*), 1742 (*G. laoticus*), 1780 (*G. calvicarpus*); Wongprasert, T. 997–48 (*G. maewongensis*).