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The rediscovery of *Dioscorea rockii* Prain & Burkill, endemic to Northern Thailand

CHIRDSAK THAPYAI*, PAUL WILKIN & KONGKANDA CHAYAMARIT*****

ABSTRACT. *Dioscorea rockii* Prain & Burkill was known from a single specimen from Northern Thailand collected in 1922 with immature capsules. The discovery of male plants and its underground organs renders its full description and illustrations. It is restricted to the lower montane evergreen forests between 1000 and 1700 m altitude. A preliminary conservation assessment is given. The tendency for control of sex expression in the flowers with male flowers on female plants (and *vice versa*) of some individuals of this species, particularly at Doi Phu Kha in Nan is noted.

INTRODUCTION

In Prain & Burkill (1936), the only specimen of *Dioscorea rockii* Prain & Burkill cited is the type from Doi Chang, near Huai San, south-west of Chiang Rai. This female specimen lacking underground parts was collected by Joseph Rock in 1922 and was the basis of an incomplete description of the species (Prain & Burkill 1927, 1936). It was placed by Prain & Burkill in *D*. sect. *Stenophora* Uline, typically possessing a branching rhizome and thin leaf blades. When research began on the treatment of the Dioscoreaceae for the Flora of Thailand the only known specimen of *D. rockii* was Rock's collection. During the first spell of botanical surveys in September 1996, male and female specimens of a pubescent member of *D.* sect. *Stenophora* with entire to shallowly lobed leaves were collected at Doi Phu Kha and Doi Suthep in Northern Thailand. They were tentatively referred to *D. panthaica* Prain & Burkill or *D. althaeoides* R. Knuth (two Chinese species). The same taxon was collected again at Phu Soi Dao in Uttaradit Province in late October 1998 and in fruit at Doi Phu Kha in early November. It was not until the first author visited Kew in 2003 that these specimens, plus others collected by him and by J.F. Maxwell, were reconciled with the type of *D. rockii*. This discovery allowed the complete description of the species and the better understanding of its distribution and conservation status.

MATERIALS & METHODS

The Dioscoreaceae treatment for the Flora of Thailand is based on examination of 1220 specimens from Thailand at the following herbaria or on loan: AAU, B, BK, BKF, BM, CMU, E, K, L, P, Biology Department, Naresuan University, Phitsanulok (PNU) and QBG. Abbreviations (except PNU) follow Holmgren & Holmgren (1990). Comparative morphology was used to delimit species in all cases.

*Department of Biology, Faculty of Science, Naresuan University, Phitsanulok, Thailand.
**Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB,UK.
***The Forest Herbarium (BKF), National Park, Wildlife and Plant Conservation Department, 61 Phahonyothin Rd., Chatuchak, Bangkok 10900 Thailand.

DESCRIPTION

Dioscorea rockii Prain & Burkill, Bull. Misc. Inform. Kew 1927: 229. 1927; Prain & Burkill in Ann. Roy. Bot. Gard. (Calcutta) 14(1): 58.1936. Type: Thailand, Chiang Rai, Doi Chang, near Huai San (Hui San),E young fr. 10 Jan. 1922, *Rock* 1721 (holotype K!; isotype US): Figs. 1–3.

Climber to 15 m in height. Underground parts rhizomatous (Fig. 3I), approximately 0.5–2 cm in diam., often branched, shallowly and horizontally buried, epidermis grey-brown to dark brown, parenchyma pale yellow to white in colour. *Indumentum* present as fine, white, simple hairs, 0.15–0.6 mm long, usually dense on young shoots, leaves (Fig. 3B) and inflorescences. *Stems* 2–5 mm in diam., twining to the left, annual, often spiny toward base, unarmed on upper stem, terete with shallow longitudinal grooves, yellow-green to green in colour. *Leaves* (Fig. 1A, 3B) simple, alternate, blades 3–16.5 by 2.5–13(–19) cm, ovate to broadly ovate, base often cordate but sometimes obtuse or rounded on reproductive shoots, sinus (where present) to 23(–60) mm deep, apex to 20 mm long, acute to acuminate, margin of vegetative shoot leaves often shallowly 3–5 lobed, sometimes irregularly so or more deeply, occasionally entire, fertile shoot leaves usually entire, blade thinly to very thinly chartaceous, dark green to yellow-green above, paler and pubescent below, most dense on veins towards base, elsewhere glabrescent, 7–9-nerved with only main vein and first vein pair reaching the apex; *petioles* (1.5–)3.3–6.5(–12) cm long, terete with a shallow longitudinal channel above, pubescent, coloured as stem, pulvinii at base and apex. *Cataphylls* and *bulbils* absent. *Lateral nodal spines* (Fig. 3D) straight or curved, 0.5–3.3 mm long, on either side of each node, sometimes absent. *Inflorescences* pendent, all parts pubescent except inner whorl tepals, axes terete, finely tuberculate, coloured as stems; all bracts and tepals membranous; tepals fused at base, erect to spreading, inserted on a cup-shaped torus, pale green to yellow-green in colour, apex recurved. *Male inflorescences* (Fig. 1A, 3C, D) usually compound, 4–20(–50) cm long, 1(–2) per axil, primary bracts 1–2.8 by 0.7–1.3 mm, ovate, coloured as tepals, apices 0.7–1.2 mm long, acuminate, occasionally leaf-like towards inflorescence base (Fig. 1A); partial inflorescences (Fig. 3C) 1 per node, racemose with a cymule of 1–3 flowers at each node (Fig. 1B), peduncles 0.3–2 cm long, axes 2–10 cm long. *Female inflorescences* (Fig. 2A, 3D) simple, spicate, 1 per axil, peduncles 2–4.5 cm long, axes (2.3–)5–12(– 20) cm long; flowers orientated at angle of 20°–45° to axis when receptive. *Male flowers* 2–3.3 mm in diameter at anthesis, pedicels 0.8–1.2 mm long (Fig. 1D), floral bracts (Fig. 1F) 1.6–1.8 by 0.8–0.9 mm, ovate to broadly lanceolate, apices 0.8–1.2 mm, acuminate; bracteoles (Fig. 1G) 1.0–1.2 by 0.5–0.6 mm, ovate-elliptic to elliptic-oblong or narrowly oblong, apex acute; outer tepals (Fig. 1H) 1.9–2.0 by 1.0–1.7 mm, ovate to ovate-oblong, apex obtuse; inner tepals (Fig. 1J) 1.9–2.1 by 0.4–0.6 mm, apex obtuse to rounded; stamens 6 (Fig. 1E), inserted on tepal bases, filaments 0.5–0.6 mm long, filiform, ascending but apex fully reflexed so anthers are borne "upside down" (Fig. 1E), anthers 0.2–0.35 by 0.25–0.3 mm, ovate; pistillodes (Fig. 1E) 0.5–0.6 by 0.25–0.7 mm, an erect column with 3 shallow longitudinal grooves. *Female flowers* with floral bracts (Fig. 2C, E) 1.5–3.0 by 0.7–1.2 mm, narrowly ovate to ovate-lanceolate, apices 0.1–0.25 mm long, acuminate; bracteoles (Fig. 2F) 1.5–2.1 by 0.7–0.8 mm, ovate to lanceolate, apex acute; outer tepals (Fig. 2G) 1.2–1.8 by 0.6–0.9 mm, oblong to narrowly obovate, apex obtuse; inner tepals (Fig. 2H) 1.2–1.8 by 0.5–1.1 mm, broadly obovate, apex

acute; ovaries (Fig. 2C) 3–4.5 by 1.4–1.9 mm, cylindric to narrowly elliptic in outline, pale green to yellow-green in colour; staminodes 6 (Fig. 2D) 0.2–0.5 mm, staminiform, inserted on tepal base; styles (Fig. 2D) 0.5–0.8 mm long, fused for most of their length; stigmas (Fig. 2D) 0.2–0.5 mm long, recurved. *Infructescences* (Fig. 2J, 3E, F) 10–15(– 55) cm long; *capsules* (Fig. 2J) 18–25 by 18–40 mm, broadly obovate in outline, base acute to truncate or sub-cordate, sinus (where present) to 2.5 mm deep, apex retuse to emarginate, sinus–3 mm deep; persistent tepals 1–1.5 mm long, capsular stipes 4–8 by 1–2.2 mm, narrowly obconic; immature capsules fleshy, translucent, especially near ovules, dull green to yellowish green with dark green along axis and margin; mature capsules reflexed at an angle of 120°–160° to axis. *Seeds* (Fig. 2J, K, 3H) 3.5–4 by 5–6 mm, ovoid to lenticular, wings 16–8 by 13–14 mm, extending all around seed margin, rounded with a straight edge along capsule axis, membranous, translucent.

Thailand.— NORTHERN: Chiang Mai [Doi Suthep-Pui National Park, East side of Chang Khian Valley, G fl. 22 Oct. 1988, *Maxwell* 88-1233 (AAU, BKF), E fr. 22 Oct. 1988, *Maxwell* 88-1229 (BKF), trail to Ruesi Cave off road to summit of Doi Suthep, 18° 48.40' N 98° 55.09' E, G fl. 27 Sept. 1996, *Wilkin* 915 (BKF, K)]; Lampang [Chae Son National Park, G fl. 21 Oct. 1995, *Maxwell* 95-945 (BKF, CMU)]; Phayao [Doi Pha Chang, E fr. 31 July 1998, *Maxwell* 98-733 (CMU)]; Nan [Doi Phu Kha National Park, two small limestone outcrops on either side of road, 19° 12.43' N, 101° 04.40' E, G fl. 22 Sept. 1996, *Wilkin* 901 (AAU, BKF, K), E fl. 22 Sept. 1996, *Wilkin* 900 (AAU, BKF, K); circular trail from HQ buildings, 19° 12.22' N, 101° 04.85' E,G &E fl. 23 Sept. 1996, *Wilkin* 903, (BKF, K); 16 km from Bow Kluea from Park HQ on road to Chom Phu Phu Ka, 19° 10.51' N 101° 06.38 E, E young fr. 1 Nov. 1998, *Wilkin*, *Suddee*, *Puudjaa*, *Paton*, *Muasya* & *Esser* 1061 (BKF, K); 12.5 km from Bow Kluea from Park HQ at Chom Phu Phu Ka, 19° 10.49' N 101° 06.38 E,G fl. & E young fr. 1 Nov. 1998, *Wilkin*, *Suddee*, *Puudjaa*, *Paton*, *Muasya* & *Esser* 1062 (BKF, K); 12.5 km from Bow Kluea from Park HQ at Chom Phu Phu Ka, 19° 10.49' N 101° 06.38 E,G fl. & E young fr. 1 Nov. 1998, *Wilkin*, *Suddee*, *Puudjaa*, *Paton*, *Muasya* & *Esser* 1063 (BKF, K); limestone outcrop on LHS of road from HQ to Pua, ca. 2 km from HQ, 19° 12.43' N 101° 04.40' E, G fl. 2 Nov. 1998, *Wilkin*, *Suddee*, *Puudjaa*, *Paton*, *Muasya* & *Esser* 1064 (BKF, K); limestone outcrop on LHS of road from HQ to Pua, ca. 2 km from HQ, 19° 12.43' N 101° 04.40' E, E young fr 2 Nov. 1998, *Wilkin*, *Suddee*, *Puudjaa*, *Paton*, *Muasya* & *Esser* 1065 (BKF, K)]; Uttaradit [Phu Soi Dao National Park, along trail to pine-rich plateau, 17° 44.25' N, 100° 59.41' E, G fl. 29 Oct. 1998, *Wilkin*, *Suddee*, *Puudjaa*, *Paton*, *Muasya* & *Esser* 1036 (BKF, K); E fr. 19 Nov. 2001, *Thapyai* 294 (BK, BKF, PNU, QBG)].

Distribution.— Endemic to Northern Thailand.

Ecology.— Lower montane evergreen forest between 1,000 and 1,700 m in elevation. It flowers from September–October, and fruits from November–January.

Vernacular name.— Not known.

Conservation.— Restricted to hill evergreen forests in northern Thailand, where it has been collected in five areas in recent years. It therefore appears vulnerable due to habitat loss the destruction of hill evergreen forest in Northern Thailand through shifting cultivation by hill people. Fortunately the populations at Doi Phu Kha and Doi Pha Chang are in protected areas. IUCN rating VU B2ab(iii) (IUCN 2001).

Notes.— *Dioscorea rockii* differentiated from the other three rhizomatous species (members of *D.* sect. *Stenophora*) in Thailand using indumentum and leaf texture. Both *D. membranacea* Pierre and *D. prazeri* Prain & Burkill are glabrous, and the latter also has thickly chartaceous to subcoriaceous leaves (not thinly chartaceous). The indumentum of *D. collettii* Hook. f. is formed by papillae (Thapyai et al., in press/2005) and it has just three fertile stamens. The Chinese species *D. althaeoides* Knuth is similar in overall appearance to *D. rockii* but its leaves are shallowly to deeply 5 or 7-lobed, and more densely pubescent. A sterile specimen collected from Doi Khun Sathan, Nan Province (*Thapyai et al.* 385) has deeply 3–5 lobed leaves which are densely pubescent on the lower surface like *D. althaeoides*, but being sterile it is not possible to assign it to a species. It is possible that it is a form of *D. rockii* or that *D. althaeoides* and *D. rockii* intergrade, but further research is needed to test these hypotheses.

Prain & Burkill (1936) recorded the locality of the type specimen as "Circle of Payap in the rainforests of the lower slopes of Doi Suthep called Doi Chem Chang, near Hui San". This label information is not present on the holotype specimen at Kew and was perhaps taken from the isotype sheet at US.

BREAKDOWN IN CONTROL OF SEX EXPRESSION

Dioscorea rockii was collected by the second author in 1996 and 1998 at Doi Phu Kha National Park in Nan. In both years, unusual plants were found in which, for example, one fruit was developing on a male inflorescence (Fig. 1C; *Wilkin* 1062) and male flowers (with apparently fertile stamens) on female inflorescences (Fig. 2B; *Wilkin* 1063). It appears that in these plants the genetic or developmental control of sex expression is breaking down. *Dioscorea zingiberensis* Prain & Burkill in China is also said to exhibit the same phenomenon (M. Gilbert, pers. comm). It has not yet been observed outside *D.* sect. *Stenophora*. All phylogenetic studies to date place this section as the first branch of dioecious *Dioscorea* (e.g. *Wilkin et al.*, 2005), so it may be that the sex expression control mechanisms of the genus are prone to breakdown in the first lineage to develop them, but evolution has acted to prevent this breakdown occurring in subsequent clades. Possible mechanisms for the breakdown in taxa such as *D.* sect. *Stenophora* are discussed by Ainsworth (2000). *D*ioscorea sect. *Stenophora* must therefore have a vital role to play in studies of the evolution of dioecy in *Dioscorea*, a critical step in developing the current diversity of the genus.

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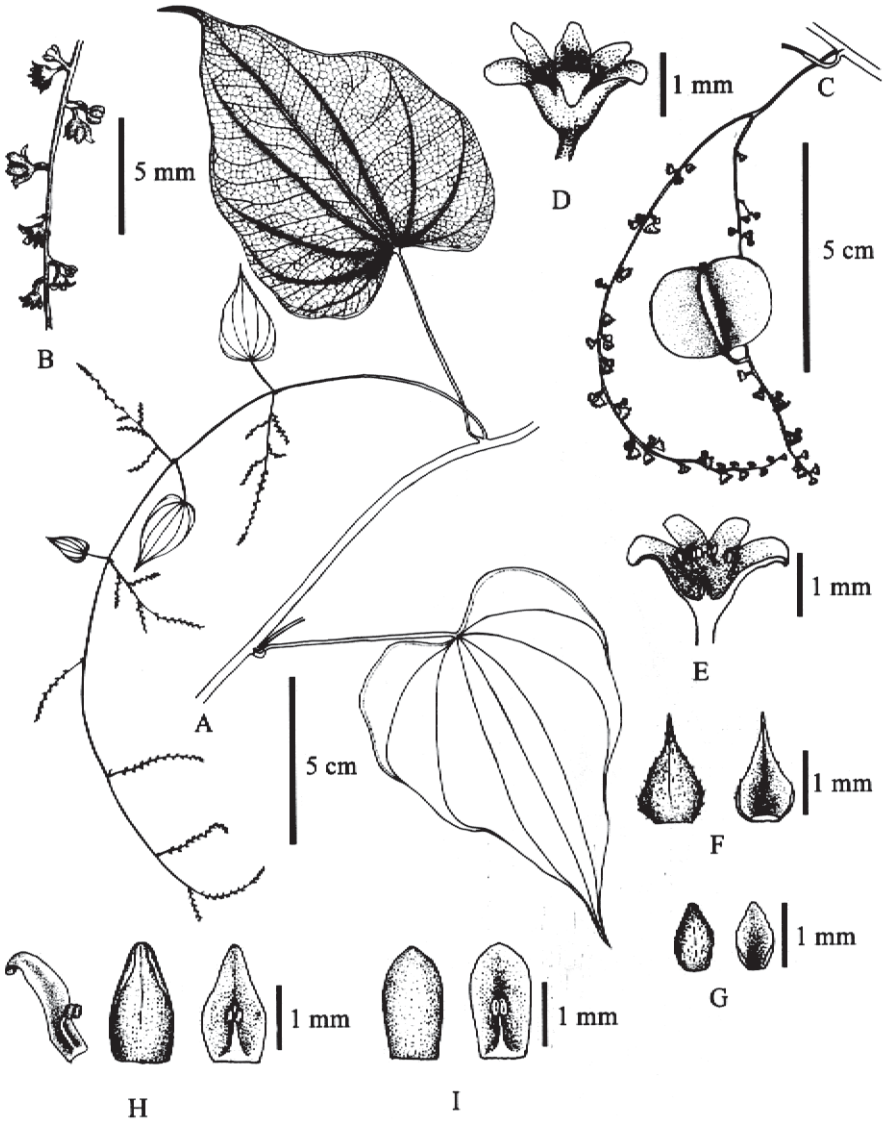

Figure 1. The morphology of *Dioscorea rockii* (male plant):A. habit, with leaves and immature inflorescences; B. part of partial inflorescence showing the flowers in cymules; C. inflorescence with a single capsule, an example of sex expression breakdown; D.–J. flower; D. side view showing the torus and erect to spreading tepals; E. longitudinal section showing the stamens with ascending filaments with reflexed apices, their point of insertion, the pistillode and the inner surface of the cup-shaped torus; F., G. floral bract and bracteole dorsal and ventral view respectively; H., K. outer and inner tepal dorsal and ventral surfaces respectively, showing the range of variation in tepal shape and position of stamen insertion. A. from *Wilkin* 901; B., D.–K. from *Thapyai* 498; C. from *Wilkin* 1062. Drawn by C. Thapyai.

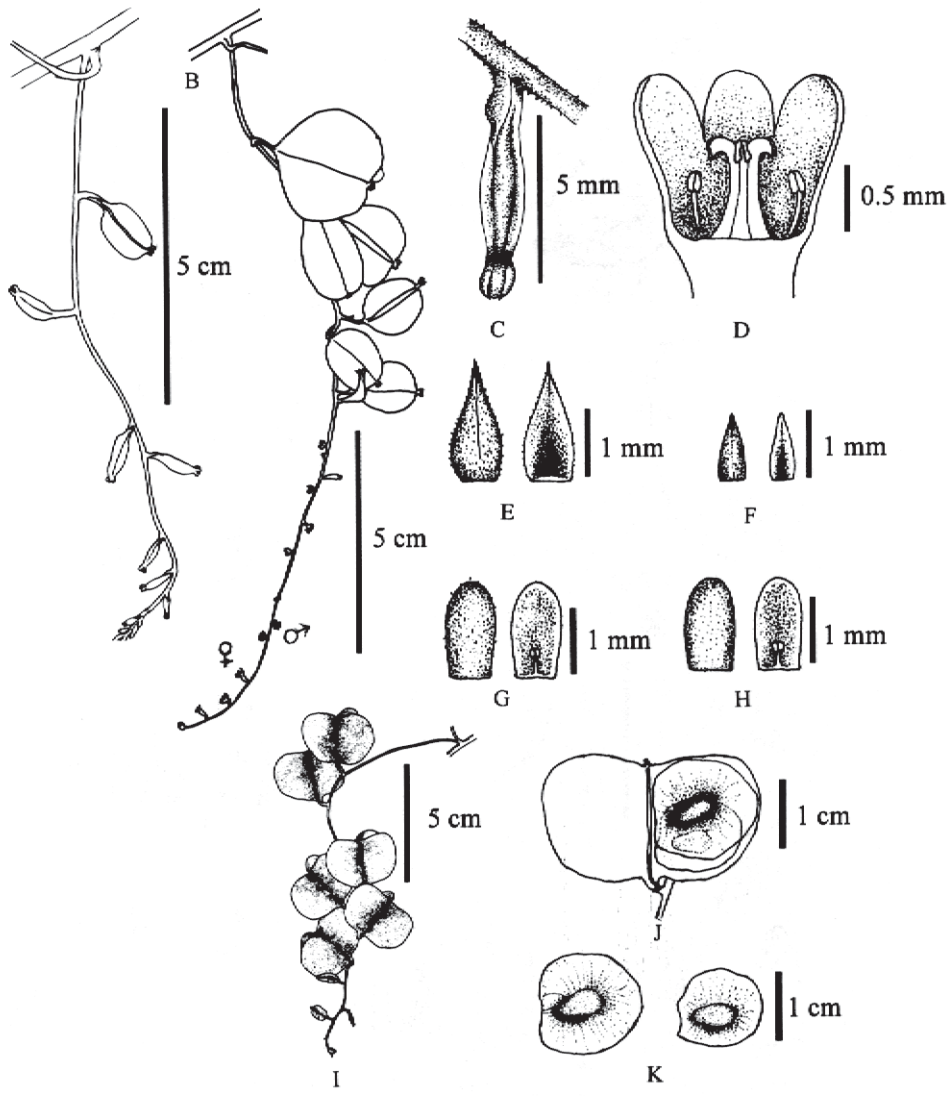

Fig. 2. The morphology of *Dioscorea rockii* (female plant): A. inflorescence with buds, receptive flowers and very early stages in capsule development (note the change in the angle relative to the axis at which the flower is borne as it develops); B. inflorescence with male flowers towards its apex, an example of sex expression breakdown; C.–H. flower; C. side view, showing its insertion on the tuberculate axis, ovary and tepals; D. longitudinal section, showing erect staminodes, fused styles and stigmas; E., F. floral bract and bracteole dorsal and ventral view respectively; G., H. outer and inner tepal dorsal and ventral surfaces respectively, showing position of stamen insertion; I. infructescence; J. mature capsule, longitudinal section showing position of the two seeds in the locule; K. seeds and their wings. A, C.–H. from *Thapyai* 497; J. from *Rock* 1721; K.–L. from *Thapyai* et al. 399: B. from *Wilkin* 1063. Drawn by C. Thapyai.

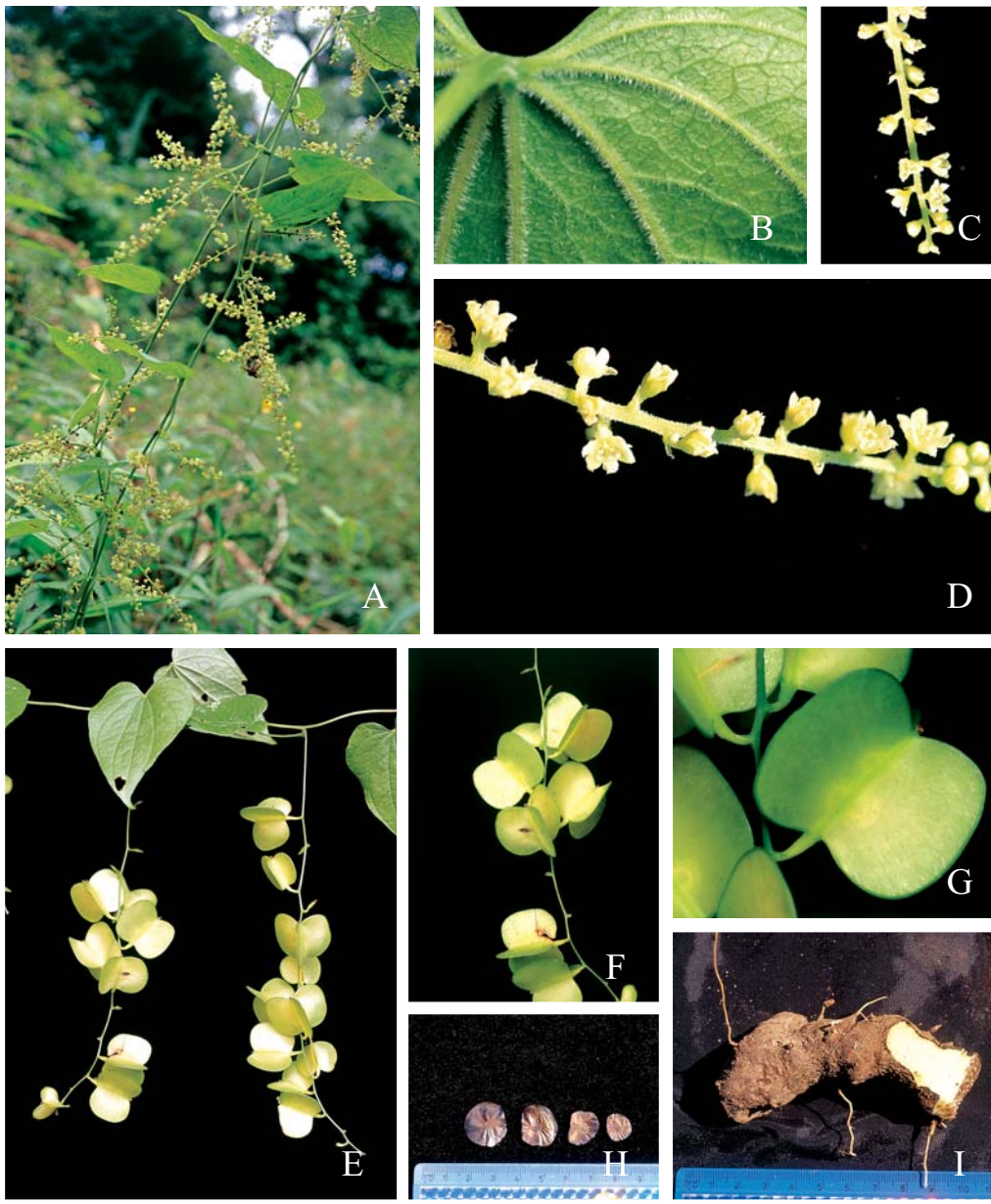

Figure 3. *Dioscorea rockii* Prain & Burkill: A. habit with mature compound male inflorescences; B. leaf, ventral surface showing dense pubescence on primary and secondary veins; C.–D. part of male inflorescence; E.–F. immature infructescences; G. immature capsules, showing translucent texture; H. seeds; I. pieces of rhizome, showing whitish parenchyma. Photographed by C. Thapyai.