

A taxonomic revision of the genus *Rothia* (Crotalariaeae, Fabaceae)

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Abstract. *Rothia* Pers. is a genus of papilionoid legumes that consists of two species, *R. indica* (L.) Druce and *R. hirsuta* (Guill. & Perr.) Baker. The genus is a member of the tribe Crotalariaeae and is widely distributed in Africa, Asia and Australia. Recent molecular systematic studies have shown the genus to be closely related to *Robynsiophyton* Wilczek and *Pearsonia* Dümmer; however, it is easily distinguished from these by its 10 small, rounded anthers and subequally lobed calyx (as opposed to the large, elongate anthers of *Pearsonia* or the 9 stamens of *Robynsiophyton*). These three genera share characters such as uniform anthers, straight styles and the presence of angelate esters of lupanine-type alkaloids. Leaf and fruit anatomy of *Rothia* and *Robynsiophyton* were also studied but revealed no informative differences. Both genera have dorsiventral leaves with mucilage cells in the epidermis and thin-walled fruits. A taxonomic revision of *Rothia* is presented, including a key to the species, correct nomenclature, descriptions, illustrations and distribution maps.

Introduction

The genus *Rothia* Pers. was described in 1806 and comprises two species, *R. hirsuta* (Guill. & Perr.) Baker and *R. indica* (L.) Druce. The species have been treated in several floristic studies (e.g. The Flora of Tropical Africa (Baker 1926), Flora of West Tropical Africa (Hepper 1958), Flora of Tropical East Africa (Milne-Redhead 1971), Flora Zambesiaca (Polhill 2003), A revised Handbook of the Flora of Ceylon (Rudd 1991)); however, no comprehensive revision of the genus exists. An Australian-endemic subspecies of *R. indica*, namely *R. indica* (L.) Druce subsp. *australis* A.E.Holland, was described by Holland (1997). It is morphologically distinct from the typical Asian subspecies.

The genus is a member of the Papilionoideae and is placed within the tribe Crotalariaeae. The Crotalariaeae form part of a monophyletic assemblage of tribes, the ‘core’ genistoid legumes (Crisp *et al.* 2000; Boatwright *et al.* 2008a), which comprises the Crotalariaeae, Euchrestae, Genisteae, Podalyrieae, Sophoreae (in part) and Thermopsidae. The Crotalariaeae are subendemic to Africa, with a few species of *Crotalaria* L., *Lotononis* (DC.) Eckl. & Zeyh. and *Rothia* extending to other continents. A recent study of the tribe by Boatwright *et al.* (2008b), based on gene sequences (ITS and *rbcL*) and morphological data, showed *Rothia* to be in a well supported clade along with *Pearsonia* Dümmer and *Robynsiophyton* Wilczek, i.e. the *Pearsonia* clade. A sister relationship between *Robynsiophyton* and *Rothia* was strongly supported (Fig. 1). This confirmed hypotheses by Polhill (1976), Van Wyk (1991a) and Van Wyk and Schutte (1995) who suggested an affinity between these genera. The close relationship between *Pearsonia*, *Robynsiophyton* and *Rothia* is

supported by three synapomorphies, i.e. uniform anthers, straight or down-curved styles and the presence of angelate esters of lupanine-type alkaloids. *Rothia* can be distinguished from *Pearsonia* and *Robynsiophyton* by its 10 small, rounded anthers and subequally lobed calyx.

In this paper we present a taxonomic account of *Rothia*, with illustrations, descriptions and distribution maps of the species. The results of anatomical studies of the leaves and fruits of *Rothia* and *Robynsiophyton* are also presented.

Materials and methods

Morphology

Morphological characters were assessed through the study of material from the following herbaria: BM, BOL, K, MEL, NBG (including SAM), PRE, S, UPS (abbreviations according to Holmgren *et al.* 1990). Drawings of reproductive features (all by JSB) were done by using a stereoscope (WILD M3Z) with a camera *lucida* attachment.

Anatomy

Two or three samples per species of the leaves and fruits of *Rothia* and *Robynsiophyton* were studied. Dried material was first rehydrated and then fixed in formaldehyde:acetic acid:96% alcohol:water (10:5:50:35; FAA) for 24 h. The method of Feder and O’Brien (1968) for embedding in glycol methacrylate (GMA) was used except that the final infiltration in GMA was done for a minimum of 5 days. Sections were stained according to the periodic acid Schiff/toluidine blue (PAS/TB) staining method and mounted. Photographs were taken with a JVC KY-F1030 digital camera.

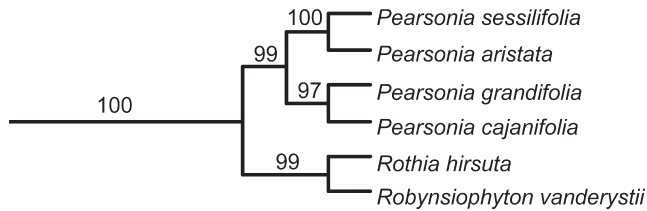


Fig. 1. The *Pearsonia* clade taken from a strict consensus of 370 trees, showing the relationship between *Pearsonia*, *Robynsiophyton* and *Rothia*, based on the combined analysis of molecular (ITS and *rbcL*) and morphological data (from Boatwright *et al.* 2008b; tree length=1166; consistency index=0.53; retention index=0.84). Numbers above the branches are bootstrap percentages above 50%.

Results and discussion

Generic relationships

In the study of Boatwright *et al.* (2008b), the *Pearsonia* clade is well separated from the ‘Cape’ group of the Crotalariaeae (*Aspalathus* L., *Lebeckia* Thunb., *Rafnia* Thunb., *Spartidium* Pomel and *Wiborgia* Thunb.) and placed closer to *Lotononis*, a genus with which they share the lotononoid or zygomorphic calyx. However, the three genera of the *Pearsonia* clade possess a 17 base-pair deletion at positions 179–196 in the aligned ITS matrix and unique floral characters such as straight styles and uniform anthers. The *Crotalaria* clade (*Bolusia* Benth., *Crotalaria* and *Lotononis* section *Euchlora* (Eckl. & Zeyh.) B.-E.van Wyk) is early diverging within the Crotalariaeae and all members of this clade have strongly inflated pods (Boatwright *et al.* 2008b).

Van Wyk (2003) discussed the importance of chemical characters in genistoid legumes and mentioned that their distribution is not random, but in fact provides reliable information supporting phylogenetic relationships retrieved by studies of DNA sequence data. The *Pearsonia* clade is chemically distinct within the tribe Crotalariaeae in having unique alkaloids (Van Wyk and Verdoorn 1990; Van Wyk 1991a, 2005; Van Wyk and Schutte 1995). *Pearsonia*, *Robynsiophyton* and *Rothia* produce tetracyclic quinolizidine alkaloids such as lupanine, together with angelate esters such as lupanine-13 α -angelate, cajanifoline, sessilifoline and pearsonine (Hussain *et al.* 1988; Van Wyk and Verdoorn 1989, 1991). These chemical characters are especially useful in distinguishing this clade from the morphologically similar genus *Lotononis* where pyrrolizidine and quinolizidine alkaloids are present but where no esters of lupanine-type alkaloids are found (Van Wyk 1991b). Also, some sections of *Lotononis* are cyanogenic, a trait which is unique within Crotalariaeae (Van Wyk 1991b).

Vegetative morphology and anatomy

The species of *Rothia* are prostrate to procumbent or erect annuals. They share this life history with the monotypic African *Robynsiophyton*. This character lends support to the sister relationship found between these genera by Boatwright *et al.* (2008b) and distinguishes them from the closely related genus *Pearsonia* which consists of perennial herbs or shrubs.

The leaves of *Rothia* are digitately trifoliolate as in many of the Crotalariaeae, and pubescent both adaxially and abaxially.

R. indica subsp. *australis* has densely pubescent leaves with long whitish hairs that are more or less spreading. In contrast, the leaves of *R. indica* subsp. *indica* are moderately hairy with shorter, more or less appressed hairs. The stipules of *R. hirsuta* are linear to slightly falcate and single at each node, whereas those of *R. indica* are elliptic to lanceolate or ovate and invariably paired.

Anatomical studies of the lamina (Fig. 2a, b) and petiole (Fig. 2c, d) revealed no informative differences between *R. hirsuta* and *R. indica*, or even between these and *Robynsiophyton vanderystii* Wilczek. The leaves are dorsiventral with mucilage cells present in the epidermis in both *Rothia* and *Robynsiophyton* (Fig. 2a, b). These cells are thought to contribute to the retention of water and reduction of transpiration, although their function has not been accurately ascertained (Gregory and Baas 1989).

Reproductive morphology and anatomy

Both species of *Rothia* have axillary racemes. *R. hirsuta* has up to seven flowers per raceme as opposed to *R. indica* where up to four flowers per raceme are found, although the flowers are often solitary or in pairs. Terminal racemes are found in most genera of the Crotalariaeae (Polhill 1976) and they are either terminal or axillary in *Pearsonia* and strictly axillary in *Rothia* and *Robynsiophyton*. Bracts are present in *Rothia*, but bracteoles are lacking. Bracteoles are also absent in *Robynsiophyton* and most species of the genus *Lotononis*, but present in almost all *Pearsonia* species.

The flowers of *Rothia* and its relatives are relatively unspecialised compared with the rest of the Crotalariaeae. *Rothia*, *Robynsiophyton* and *Pearsonia* have a ‘gullet’-type flower where the style is straight or down-curved and the anthers uniform and/or further reduced, as opposed to the more specialised and reflexed floral parts found in the other crotalarioid genera (Polhill 1976). In *Rothia* the two upper calyx lobes are larger than the other three lobes and distinctly falcate. The calyces of *Pearsonia* species have the upper sinus often shallower than the others or in some species the lateral sinus is the shallowest with the carinal lobe always narrower than the other lobes (Polhill 1974). *Robynsiophyton* differs from both these genera in having an equally lobed calyx (J. S. Boatwright and B.-E. van Wyk, unpubl. data).

The most useful generic character to distinguish among *Pearsonia*, *Robynsiophyton* and *Rothia* is the androecium. These genera are unique within the Crotalariaeae in having uniform anthers, as opposed to the dimorphic anthers found in other genera of the tribe with alternating basifix and dorsifix anthers (Polhill 1976). The anthers of *Pearsonia* are elongate and large, whereas in *Rothia* and *Robynsiophyton* they are small and rounded (Fig. 3). *Robynsiophyton* has a reduced number of stamens (9 rather than 10) and four anthers are infertile (Fig. 3). Although the generic concepts of *Rothia* and *Robynsiophyton* have been questioned by previous authors, the informative value of androecial characters (the main distinction among these three genera) at both tribal and generic level is usually closely correlated with relationships suggested by both molecular and morphological data (Polhill 1976; Boatwright *et al.* 2008b) and should be taken at face value as strong, sound generic apomorphies.

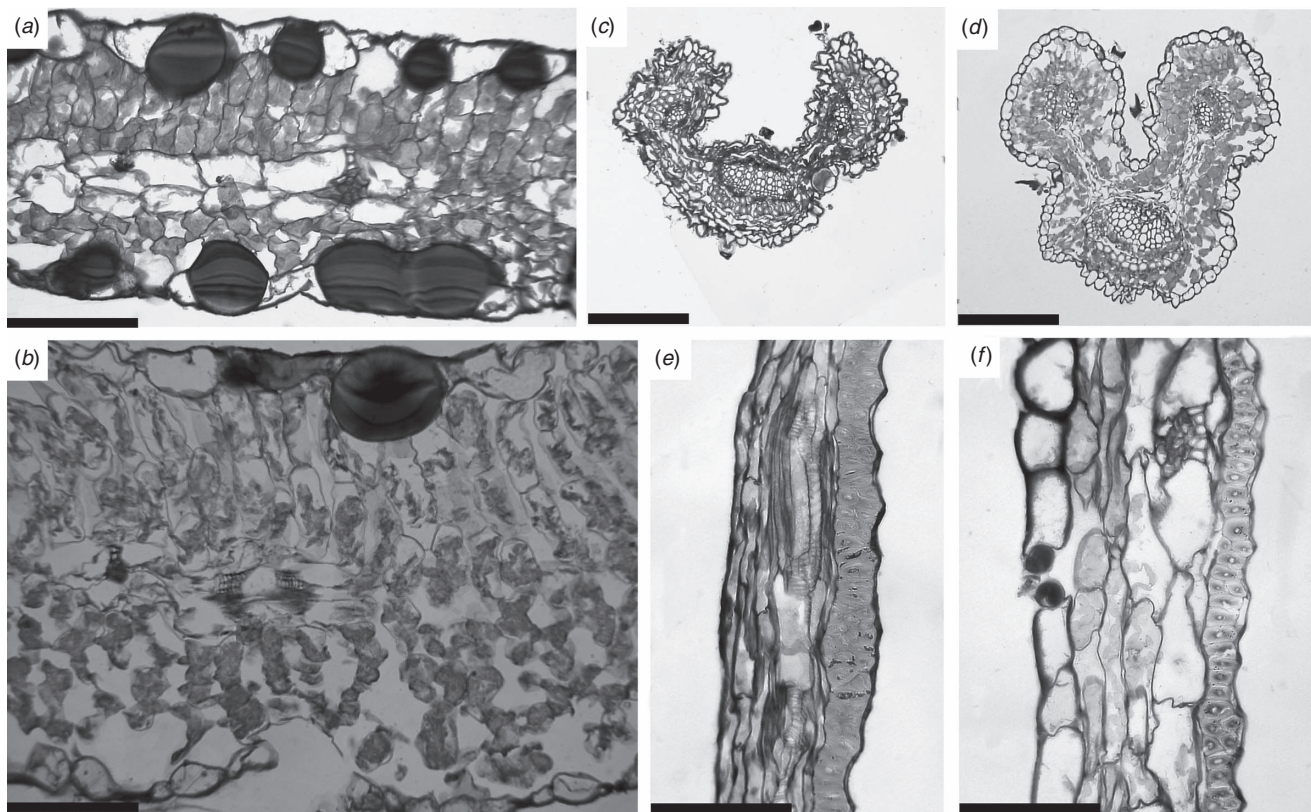


Fig. 2. Transverse sections through the leaves and fruit of *Rothia* and *Robynsiophyton*. (a) Portion of leaf of *Robynsiophyton vanderystii* (scale bar = 0.1 mm). (b) Portion of leaf of *Rothia indica* (scale bar = 0.1 mm). (c) Petiole of *Robynsiophyton vanderystii* (scale bar = 0.2 mm). (d) Petiole of *Rothia indica* (scale bar = 0.2 mm). (e) Portion of fruit wall of *Robynsiophyton vanderystii* (scale bar = 0.07 mm). (f) Portion of fruit wall of *Rothia indica* (scale bar = 0.07 mm). Voucher specimens. (a, e) Lisowski 20326 (K). (b, d, f) Latz 16126 (MEL). (c) Exell & Mendonça 657 (K).

The pods of *Rothia hirsuta* are ovate to falcate and much shorter and fewer-seeded (up to 18 mm long with ± 25 seeds) than the linear pods of *R. indica* that are up to 55 mm long with ± 35 seeds. The pods of *Rothia* and *Robynsiophyton* are thin-walled and sclerified on the inner surface, with no apparent anatomical differences (Fig. 2e, f).

Rothia indica and *Robynsiophyton* have similar-sized seeds that are larger than those of *Rothia hirsuta* (J. S. Boatwright and B.-E. van Wyk, unpubl. data). The seeds of the latter are light brown with dark mottling and have a rugose surface, in contrast to the brown, smooth seeds of *Rothia indica* and *Robynsiophyton vanderystii*.

Taxonomic treatment

Key to the genus *Rothia*

1. Anthers dimorphic, styles upcurved..... other *Crotalariaeae*
Anthers uniform, styles straight or down-curved..... 2
2. Perennial herbs or small shrubs, anthers large and elongate*Pearsonia*
Annual herbs, anthers small and rounded..... 3
3. Upper two calyx lobes larger than others (calyx subequally lobed),
stamens 10, all fertile..... *Rothia*
Upper two calyx lobes similar to others (calyx equally lobed), stamens
nine, five fertile, four reduced and infertile*Robynsiophyton*

Rothia Pers., *Syn. Pl.* 2: 302, 638 (1807). *nom. conserv.*;
Benth. in Hook., *Lond. J. Bot.* 3: 338 (1844); Benth. & Müller,
Fl. Austral. 2: 185 (1864); Baker, *Fl. Trop. Africa*: 7 (1871);
Trimen, *Handb. Fl. Ceylon*: 7 (1894); Thonner, *Flowering
Plants of Africa*: 274 (1915); Baker, *Leg. Trop. Africa*:
21 (1926); Hutchinson & Dalziel, *Fl. West Trop. Africa*:
543 (1954); Hutchinson, *The Genera of Flowering Plants*:
361 (1964); D'Orey & Liberato, *Fl. Guine Portuguesae*:
71 (1971); Polhill in *Bot. Syst.* 1: 326 (1976); Thulin in *Op.
Bot.* 68: 153 (1983); Hedberg & Edwards, *Fl. Ethiopia*:
195 (1989); Rudd, *A Revised Handbook to the Flora
of Ceylon*: 184 (1991); Van Wyk & Schutte, *Advances in
Legume Systematics* 7, M. D. Crisp & J. J. Doyle (Eds): 306
(1995); Leistner, *Seed Plants of Southern Africa: Families and
Genera*: 295 (2000); Du Puy et al., *The Leguminosae of
Madagascar*: 671 (2002); Polhill, *Fl. Zambesiaca*: 64
(2003); Leistner, *Seed Plants of Southern Tropical Africa:
Families and Genera*: 202 (2005); Van Wyk in *Legumes
of the World*, Lewis et al. (Eds), 281 (2005)

Type species: *R. trifoliata* (Roth) Pers. (= *Dillwynia trifoliata* Roth).

Dillwynia Roth, *Catal. Bot.* 3: 71 (1806) non *Dillwynia* Sm.
in Koenig & Sims, *Ann. Bot.* 1: 510 (1805). *Type species*:
D. trifoliata Roth.

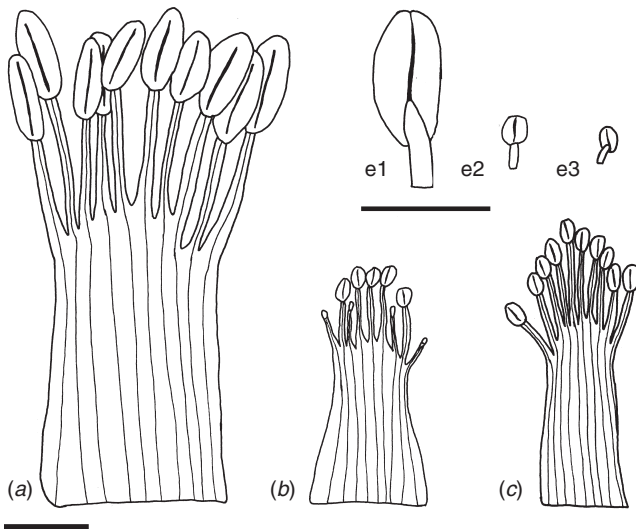


Fig. 3. (a, e1) Androecia and anthers of *Pearsonia*, (b, e2) *Robynsiophyton* and (c, e3) *Rothia*. Voucher specimens: (a, e1) *Swanepoel 1* (JRAU), (b, e2) *McCallum Weston 717* (K), (c, e3) *Greenway & Kanuri 14269* (K). All scale bars represent 1 mm.

Westonia Spreng., *Syst. Veg.* 3: 152, 230 (1826) *nom. illeg.* *Type species:* *W. humifusa* (Willd.) Spreng.

Goetzea Reichb., *Consp. Regn. Veg.*: 150 (1828) *nom. rej.*

Xerocarpus Guill. & Perr., *Fl. Seneg. Tent.*: 169 (1832). *Type species:* *X. hirsutus* Guill. & Perr.

Harpelema J.Jacq., *Ecl. Pl. Rar.* 2: t. 129 (1844). *Type species:* *H. dillwynia* J.Jacq.

Prostrate, annual herbs. Branches up to 40 cm long, densely to sparsely pubescent. Leaves digitately trifoliolate, elliptic to oblanceolate or obovate, pubescent; leaflets sessile, apex apiculate, obtuse or slightly acute, base cuneate; petioles shorter than leaflets, pubescent. Stipules linear to slightly falcate or elliptic to lanceolate or ovate, single in *R. hirsuta*, paired in *R. indica*, pubescent. Inflorescence axillary, racemose, flowers solitary or up to 7 per raceme; pedicel up to 2 mm long; bract linear, pubescent, caducous; bracteoles absent. Flowers pale yellow to white. Calyx pubescent, subequally lobed; lobes triangular to lanceolate, upper lobes wider than others, falcate, carinal lobe slightly narrower than others, tips minutely pubescent inside. Standard elliptic to ovate, pilose along dorsal midrib; claw linear; apex obtuse. Wing petals oblong to obovate, glabrous, with 2 or 3 rows of sculpturing, as long as keel; apex obtuse. Keel boat-shaped, glabrous, pocket sometimes present; apex obtuse. Stamens 10, anthers uniform, sub-basifixed. Pistil sessile, pubescent; ovary linear to narrowly ovate; style straight, glabrous. Pods linear to ovate or falcate, laterally compressed, sessile, many-seeded, pubescent, dehiscent. Seeds oblique-cordiform, brown or brown mottled with dark brown, surface smooth or rugose.

Etymology: the genus is named in honour of the German physician and botanist Albrecht Wilhelm Roth (1757–1834).

Diagnostic characters: *Rothia* can be distinguished from *Robynsiophyton* in that the latter has an equally lobed calyx (in *Rothia* the upper two lobes are larger than the others) and in that there are 10 stamens with 10 fertile anthers in *Rothia* (in *Robynsiophyton* the stamens are reduced to nine and only five anthers are fertile). Furthermore, it differs from *Pearsonia* by its subequally lobed calyx and small, rounded anthers in contrast to the 'lotoonoid' calyx (zygomorphic owing to the fusion of the upper and lateral lobes on either side) and large, elongate anthers of *Pearsonia*.

Chromosome number: a count of $n=7$ has been reported for *Rothia indica* (Goldblatt 1981; Bairiganjan and Patnaik 1989).

Distribution: the genus occurs in tropical Africa, Asia and Australia (Figs 5 and 7). It appears to have been well collected in areas for which regional floras have been compiled, e.g. the Flora of Tropical East Africa and Flora of West Tropical Africa.

Key to the species of *Rothia*

1. Stipules linear and single at each node, up to 7 flowers per inflorescence, pods ovate to falcate and up to 18 mm long, seeds light brown with dark mottling and a rugose surface, Africa and Madagascar.... 1. *R. hirsuta*
Stipules elliptic to lanceolate or ovate and paired at each node, up to 4 flowers per inflorescence, pods linear or slightly falcate and up to 55 mm long, seeds brown with a smooth surface, Asia and Australia..... 2. *R. indica*

1. *Rothia hirsuta* (Guill. & Perr.) Baker in *Fl. Trop. Africa* 2: 7 (1871); Eyles in *Trans. Roy. Soc. South Africa* 5: 369 (1916); E.G. Baker, *Leg. Trop. Africa*: 21 (1926); Broun & Massey, *Fl. Sudan*: 176 (1929); Andrews, *The Flowering Plants of the Anglo-Egyptian Sudan*: 230 (1952); Hepper in *Fl. West Trop. Africa*, ed. 2, 1: 543 (1958); Torre, *Consp. Fl. Angolensis* 3: 5 (1962); White, *Forest Fl. Northern Rhodesia*: 164 (1962); Schreiber in Merxmüller, *Prodr. Fl. SW. Africa*, fam. 60: 107 (1970); Milne-Redhead, *Fl. Trop. East Africa*, Leguminosae, Pap.: 811 (1971); Drummond in *Kirkia* 8: 226 (1972); Thulin in *Op. Bot.* 68: 153 (1983); Hedberg & Edwards, *Fl. Ethiopia*: 195 (1989); Du Puy *et al.*, *The Leguminosae of Madagascar*: 671 (2002)

Xerocarpus hirsutus Guill. & Perr. in Guillemin, Perrottet & Richard, *Fl. Seneg. Tent.*: 44 (1832). *Type:* Senegal, *Leprieur s.n.* lecto (here designated) P (photo seen).

[Note: according to Stafleu and Cowan (1983) the type material of Perrottet is housed in P or G. No specimens were traced in G and we therefore designate the Paris specimen as lectotype.]

Amphinomia desertorum (Dümmer) Schreiber in *Mitt. Bot. München* 2: 286 (1957); *Lotononis desertorum* Dümmer in *Trans. Roy. Soc. S. Africa* 3: 316 (1913). *Type:* Great Barmen, Buschsteppe, 23. iv. 1907, *Dinter 518*; lecto (here designated) Z (photo seen), isolecto BM!, BOL!, NBG!, K!

[Note: Dümmer was based at K during his revision of *Lotononis*. However, the K isotype is a small piece taken from the specimen in Z (as annotated by Dümmer himself). The Z specimen is therefore chosen as lectotype.]

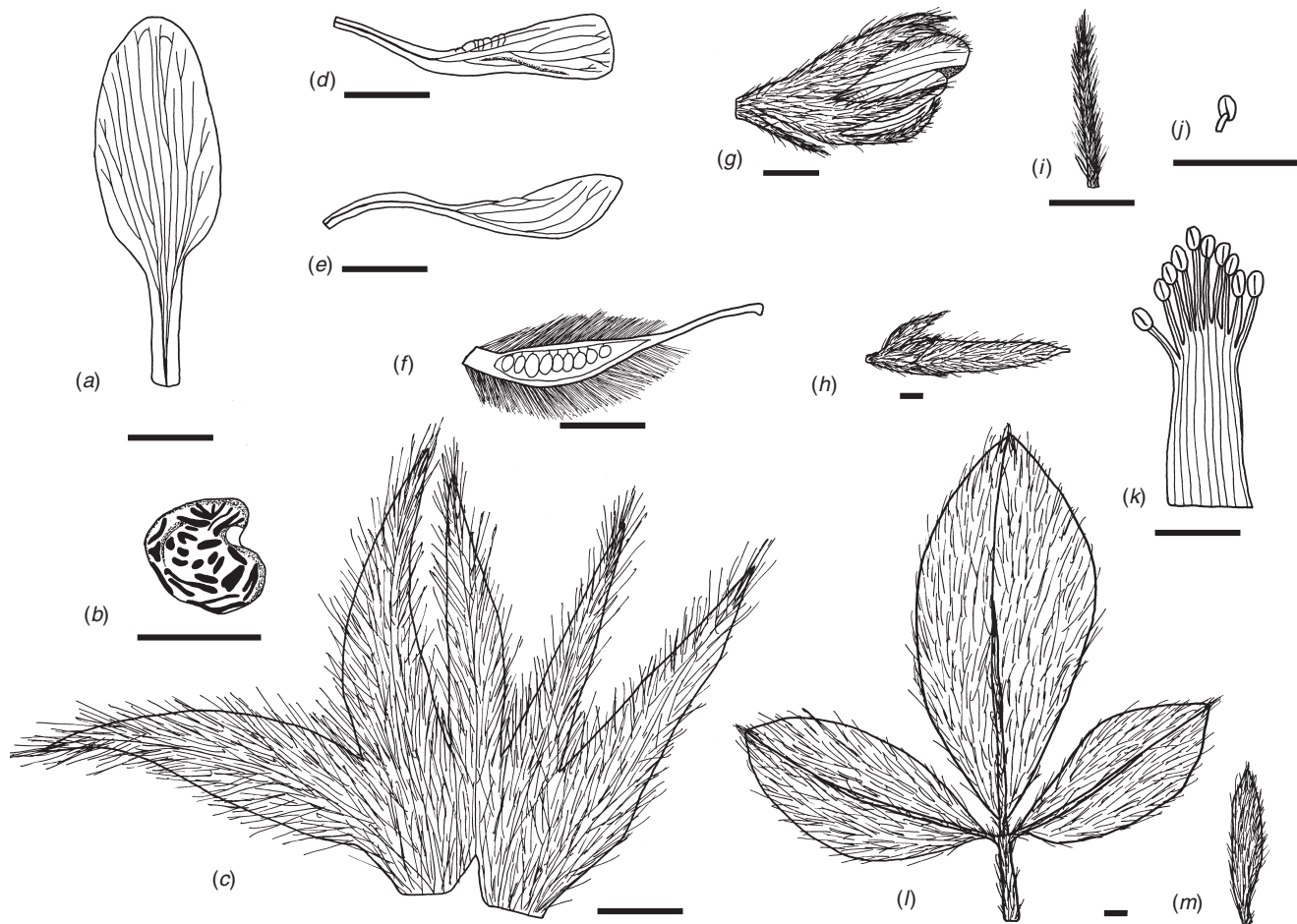


Fig. 4. Morphology of *Rothia hirsuta*. (a) Standard petal. (b) Seed in lateral view. (c) Outer surface of the calyx (upper lobes to the left). (d) Wing petal. (e) Keel petal. (f) Pistil. (g) Flower in lateral view. (h) Pod in lateral view. (i) Bract. (j) Anther. (k) Androecium. (l) Leaf in abaxial view. (m) Stipule. Voucher specimens. (a, c) Davey 173 (K). (b) Milne-Redhead & Taylor 11245 (K). (d, g, h, j, k) Greenway & Kanuri 14269 (K). (e) Jackson & Apejoye 413973 (K). (f) Hepper 1021 (K). (i) Polhill & Paulo 2089 (K). (l, m) Siame 162 (K). All scale bars represent 1 mm.

Small, pubescent, prostrate or semi-erect to procumbent herb. Branches $\pm 10\text{--}40$ cm long, brown, sparsely hairy (pilose). Leaves with leaflets elliptic to oblanceolate, terminal leaflet 10–30 mm long, 3.5–12.0 mm wide, lateral leaflets 6–20 mm long, 2–7 mm wide; apex apiculate; base cuneate; petiole 3–13 mm long. Stipules linear to slightly falcate, 2–8 mm long, single. Inflorescence with 2–7 flowers; pedicel up to 1 mm long; bract 1.0–2.5 mm long. Flowers 4–8 mm long. Calyx 5–7 mm long; tube 1.5–2.0 mm long; lobes 3–4 mm long. Standard 4.0–5.5 mm long; claw 1.0–1.5 mm long; lamina 3.0–4.5 mm long, 1–2 mm wide. Wings 4–5 mm long; claw 1.5–2.0 mm long; lamina 2.5–4.0 mm long, 0.5–0.7 mm wide. Keel 2.5–4.0 mm long; claw 1.5–2.0 mm long; lamina 1–3 mm long, 0.5–1.0 mm wide. Pistil with ovary narrowly ovate, 2–3 mm long, 0.5–0.7 mm wide with $\pm 7\text{--}13$ ovules; style 1.3–1.6 mm long. Pods ovate, falcate, tapering towards apex, 10–18 mm long, 2–3 mm wide with up to ± 25 seeds per pod. Seeds 1.1–1.5 mm long, 0.8–1.1 mm wide, mature seeds light brown with dark mottling, surface rugose (Fig. 4).

Distribution and ecology: widespread in the dry parts of tropical Africa from South Africa north to Eritrea and west up to Guinea (Fig. 5). Occurs on sandy loam or clay soils, often in grassland or forest openings. Common on sandy soils along watercourses or disturbed roadsides.

Diagnostic characters: the linear stipules are invariably single at each node in *Rothia hirsuta*, whereas they are paired and elliptic to ovate in *R. indica*. The inflorescences are more densely flowered (up to 7 flowers) in *R. hirsuta* than in *R. indica* where the flowers are often solitary or up to 4 per inflorescence. The linear pods of *R. indica* are three times longer (up to 55 mm) than the ovate pods of *R. hirsuta* that are only up to 18 mm long. In *R. hirsuta* the seeds are brown with dark mottling and have a rugose surface, whereas those of *R. indica* are brown (unmottled) with a smooth surface.

Flowering period: *R. hirsuta* flowers mainly from February to November, but flowering and fruiting specimens have been recorded throughout the year.

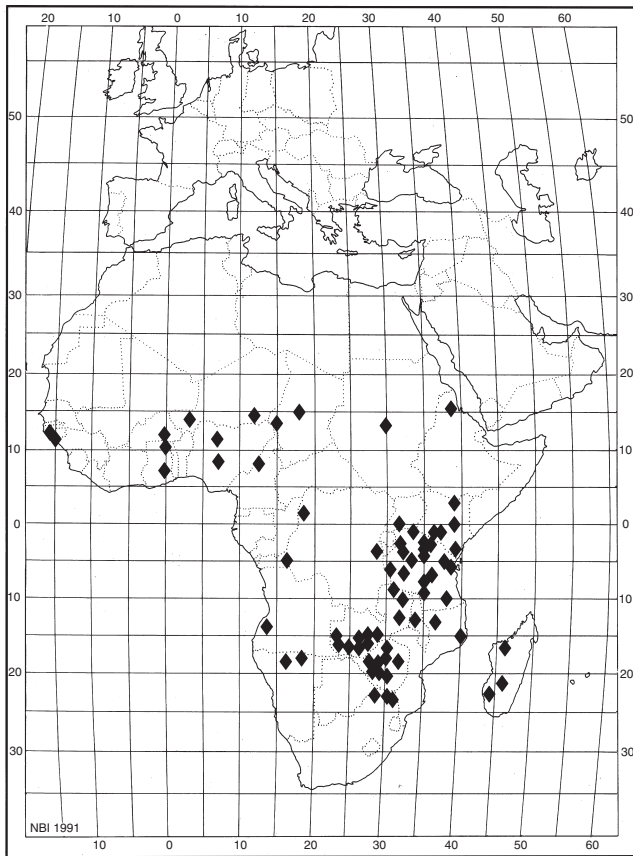


Fig. 5. Known geographical distribution of *Rothia hirsuta*.

Selected specimens (150 specimens examined)

ERITREA: Bocos, Cheren, *Pappi* 2527, 10.xi.1902 (BM 2 sheets, K). SUDAN: Kordofan, *Kotsch* 420, without date (K). CHAD: Dioura, Macina, *Davey* 173, Oct. 1954 (K). NIGER: Niamey, *Olufsen* 476, 8.x.1947 (BM, S). GUINEA: Guine-Bissau, Pussuli, *Santos* 1438, 17.xii.1942 (K). BURKINA FASO: Haute Volta, Lergo, *Ake Assi* 13587, 13.xi.1976 (K). GHANA: Tefle, on Volta River, *Akpabla* 1982, 13.8.1959 (K). NIGERIA: Naraguta, Jos Plateau, rough ground near Forestry Department, among grass, *Hepper* 1021, 14.x.1957 (K). CAMEROON: Ganglani village, 6 miles [9.65 km] from confluence of Kam and Kimiri Rivers, Vogel Peak area, *Hepper* 1441, 23.xi.1957 (K). DEMOCRATIC REPUBLIC OF CONGO: 50 km NE of Mokolo, on route to Mora, *Bounougou* 173, 18.ix.1964 (K, S). UGANDA: Matuga, *Robertson* 3312, 29.vii.1982 (K). KENYA: Thika–Garissa road, 2.6 km towards Garissa after junction with Kitui Rd, near Kongonde, *Faden & Faden* 74/737, 7.vi.1974 (K, PRE). TANZANIA: Imagi Hill, 1 mile [1.61 km] S of Dodoma, *Polhill & Paulo* 2089, 20.iv.1962 (K, PRE). ZAMBIA: Livingstone, Chief Mukuni area, 2.1 km along road to Chief Mukuni Palace from junction with Victoria Falls Rd in Baikiae forest, *Zimba et al.* 913, 19.ii.1997 (K). MALAWI: Lilongwe, *Banda* 250, 14.ix.1956 (BM). MOZAMBIQUE: Niassa, Mossuril para Lumbo, 4.5 km na estrada de Nampula, *Pedro & Pedrogao* 3131, 5.v.1948 (K, PRE). ANGOLA: Huilla, *Welwitsch* 1904, Apr. 1860 (K, BM). NAMIBIA: grey sandy flats below Musese Camp, W of Lupala Mission Station, *De Winter & Marais* 4978, 4.iii.1969 (K). ZIMBABWE: Gwanda, Sezane Reservoirs, *Davies* 1296, May 1955 (K, PRE). SOUTH AFRICA: Kruger NP, Punda Milia, *Van Rooyen* 494, 19.iii.1976 (PRE). MADAGASCAR: Ankazoabo, *Bosser* 17241, Feb. 1963 (K).

2. *Rothia indica* (L.) Druce in *Bot. Exch. Club Soc. Brit. Isles* 3: 423 (1914); Rudd, *A Revised Handbook to the Flora of Ceylon*: 184 (1991); Holland, *Austrobaileya* 5: 93 (1997); *Trigonella indica* L., *Sp. Pl.* 2: 778 (1753)

Type: Herb. Hermann 3: 24 no. 285 BM-000621888, lecto (designated by Rudd 1991) BM (photo seen).

Lotus indicus Desr. in Lam., *Encyc.* 3: 606 (1759). Type: as for *T. indica*.

Hosackia indica Graham in Wallich, *Numer. List* n. 5940 (1831–1832). *nom. nud.*

Glycine leptocarpa Graham in Wallich, *Numer. List* n. 5515 (1831–1832). *nom. nud.*

Rothia trifoliata (Roth) Pers., *Syn. Pl.* 2: 638 & 659 (1807); Benth. in Hook., *Lond. J. Bot.* 3: 339 (1844); Bentham & Müller, *Fl. Austr.* 2: 185 (1864); Trimen, *Handb. Fl. Ceylon*: 7 (1894); *Dillwynia trifoliata* Roth, *Catal. Bot.* 3: 71 (1806). Type: ‘horto medico Amstededamensi’ (B†?).

Small, pubescent, prostrate, herb. Branches up to 40 cm long, brown, either covered with dense, woolly hairs or sparsely hairy (pilose). Leaves with leaflets elliptic to obovate, terminal leaflet (7–)9–26 mm long, (2–)3–5 mm wide, lateral leaflets (5–)8–20 mm long, (1.5–)2.5–6.0 mm wide; apex obtuse or slightly acute; base cuneate; petiole 4–13 mm long. Stipules elliptic to lanceolate or ovate, 2–8(–10) mm long, paired. Inflorescence with flowers solitary or up to 4 per raceme; pedicel up to 2 mm long; bract 1–3 mm long. Flowers 5–8 mm long. Calyx 4–7 mm long; tube 1.5–4.0 mm long; lobes 1–4 mm long. Standard 4.0–6.5 mm long; claw 1.5–2.5 mm long; lamina 2.5–4.0 mm long, 2.0–2.5 mm wide. Wings 4.0–6.5 mm long; claw 2.0–2.5 mm long; lamina 2.5–4.5 mm long, 1.0–1.5 mm wide. Keel 4.0–6.5 mm long; claw 2.0–2.5 mm long; lamina 2.5–4.5 mm long, 1.0–1.5 mm wide. Pistil with ovary linear, 3.0–4.5 mm long, 0.5–1.0 mm wide with \pm 13–18 ovules; style 1.4–1.7 mm long. Pods linear or slightly falcate, (30–)35–55 mm long, 1.5–3.0 mm wide with up to \pm 35 seeds per pod. Seeds 1.3–1.8 mm long, 1.0–1.3 mm wide, mature seeds brown, surface smooth (Fig. 6).

Distribution and ecology: occurs in India, Sri Lanka, China, Vietnam, Malaysia and Australia (Fig. 7).

Diagnostic characters: the paired, ovate stipules, sparse inflorescences, long, linear pods and smooth, brown seeds distinguish *Rothia indica* from *R. hirsuta*.

Flowering period: flowering and fruiting all year round from January to December.

Notes: two subspecies can be recognised based predominantly on their geographical distribution, size and pubescence of vegetative and reproductive parts.

1. Vegetative parts sparsely hairy, terminal leaflets (7–)10–26 \times (2–) 4–8 mm, lateral leaflets (5–)8–20 \times (1.5–)3.0–6.0 mm, petiole 5–13 mm long, stipules elliptic to lanceolate 2–8(–10) mm long, pods (–)33–55 \times (1.5–)2.0–3.0 mm, seeds 1.3–1.6 \times 1.0–1.3 mm, India, Sri Lanka, China, Vietnam and Malaysia 2a. subsp. *indica*
Vegetative parts covered with dense, woolly hairs, terminal leaflets 9–15 \times 3–5 mm, lateral leaflets 9–12 \times 2.5–4.0 mm, petiole 4–8 mm long, stipules elliptic to ovate 2–5 mm long, pods (30–)35–45 \times 1.5–2.0 mm, seeds 1.5–1.8 \times 1.2–1.3 mm, restricted to Australia 2b. subsp. *australis*

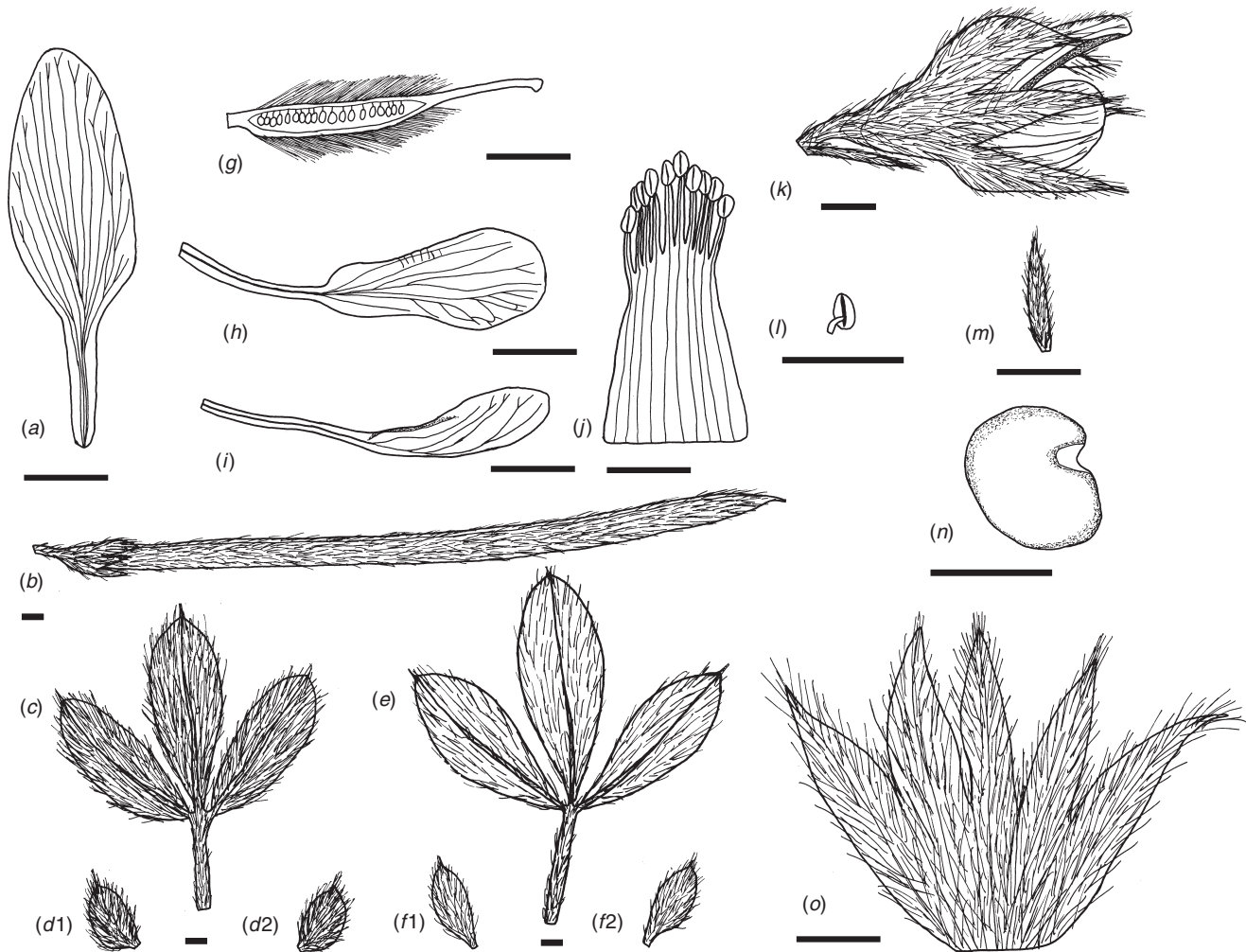


Fig. 6. Morphology of *Rothia indica*. (a) Standard petal. (b) Pod in lateral view. (c) Leaf of *R. indica* subsp. *australis* in abaxial view. (d1, d2) Stipules of *R. indica* subsp. *australis*. (e) Leaf of *R. indica* subsp. *indica* in abaxial view. (f1, f2) Stipules of *R. indica* subsp. *indica*. (g) Pistil. (h) Wing petal. (i) Keel petal. (j) Androecium. (k) Flower in lateral view. (l) Anther. (m) Bract. (n) Seed in lateral view. (o) Outer surface of the calyx (upper lobes to the left). Voucher specimens: (a, g, h, i, k) *Cooray 70020117R* (K). (b, n) *Gamble 13771* (K). (c, d1, d2) *Latz 16126* (MEL). (e, f1, f2) *Barber 55* (K). (j, l, o) *Wight 828*. (K). (m) *Wight 571* (K). All scale bars represent 1 mm.

2a. *Rothia indica* (L.) Druce subsp. *indica*

Leaves with terminal leaflet (7–)10–26 long, (2–)4–8 mm wide, lateral leaflets (5–)8–20 mm long, (1.5–)3.0–6.0 mm wide; petiole 5–13 mm long. Stipules elliptic to lanceolate, 2–8(–10) mm long. Inflorescence with flowers solitary or 2–4 per raceme. Calyx 5.0–6.5 mm long; tube 2–4 mm long; lobes 1–3 mm long. Standard 4.0–6.5 mm long; claw 1.5–2.0 mm long; lamina 2.5–4.0 mm long, 2.0–2.5 mm wide. Wings 4–6 mm long; claw 2.0–2.5 mm long; lamina 2.5–4.0 mm long, 1.0–1.5 mm wide. Keel 4–6 mm long; claw 2.0–2.5 mm long; lamina 2.5–4.0 mm long, 1.0–1.5 mm wide. Pistil with ovary 3–4 mm long, 0.5–0.7 mm wide with ± 14 –18 ovules; style 1.4–1.6 mm long. Pods (–33)35–55 mm long, (1.5–)2.0–3.0 mm wide with up to ± 35 seeds per pod. Seeds 1.3–1.6 mm long, 1.0–1.3 mm wide.

Distribution and ecology: collections from India, Sri Lanka, Vietnam and Malaysia were studied (Fig. 7); this subspecies has

also been recorded from China (Chen and Li 1997) and the specimens cited by these authors were included on the map. It favours sandy soils, grassy slopes or moist open fields. Common in disturbed areas such as roadsides.

Selected specimens (33 specimens examined)

INDIA: Chinglepul, *Barber 55*, 10.i.1899 (K); Bombay (Mumbai), *Dalzell s.n.*, iv.1878 (K); Ganjam district, Chennai, *Gamble 13771*, ii.1884 (K); Bengaluru, *Gough 162*, Dec 1937 (K); Tirunelveli, Tamil Nadu, *Matthew 16388*, 26.i.1979 (BM); Denkanikotta, Dharmapuri, Denkanikotta Rest House, *Matthew RHT 24647*, 15.xi.1979 (K); Kodaikanal, Dindigul, Law's Ghat Rd, *Matthew RHT 51949*, 4.xii.1987 (K); Mysore, *Mimso 607*, x.1837 (K); Hassan, Mysore, Belvathally, *Ramamoorthy 1956*, 13.xii.1971 (K); 70 km N of Munnar, Palani hills, Tamilnadu, *Van der Maesen 3453*, 20.i.1979 (K). VIETNAM: Tourane (now Da Nang), *Clemens & Clemens 4294*, v–vii.1927 (BM). SRI LANKA: Ruhuna NP, Block 1 near Buttawa Bungalow, *Cooray & Balakrishnan 69010909R*, 9.vi.1969 (BM);

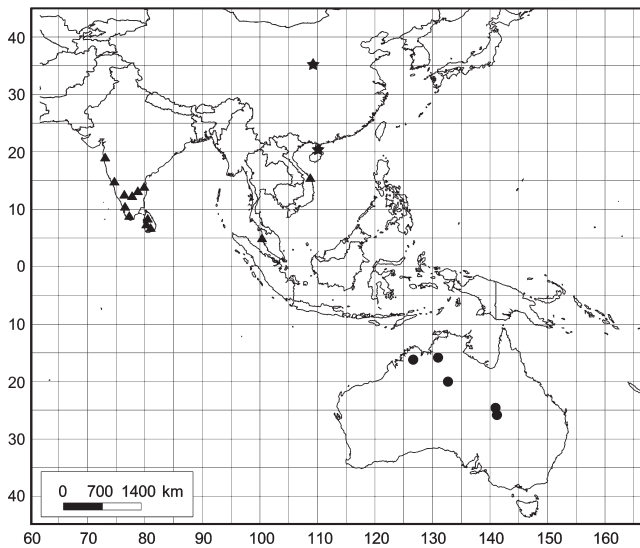


Fig. 7. Known geographical distribution of *Rothia indica* subsp. *indica* (triangles) and *R. indica* subsp. *australis* (dots). Specimens cited in Chen and Li (1997) from China are represented by stars.

Trincomalee, near China Bay Airport, *Rudd & Balakrishnan* 3134, 24. ii.1970 (K); Hambantota, Yala, *Fagerlind* 1695, i.1974 (S). MALAYSIA: Pulau Pinang, *Haihtmu* 2996, 21.xii.1917 (K).

2b. *Rothia indica* subsp. *australis* A.E.Holland, *Austrobaileya* 5: 94 (1997)

Type: Queensland, Gregory South District, Site 195, Warlus 1, 7 Aug. 1971, *Boylard* 4016; holo BRI (photo seen).

Leaves with terminal leaflet 9–15 mm long, 3–5 mm wide, lateral leaflets 9–12 mm long, 2.5–4.0 mm wide; petiole 4–8 mm long. Stipules elliptic to ovate, 2–5 mm long. Inflorescence with flowers solitary or 2 per raceme. Calyx 4–7 mm long; tube 1.5–3.0 mm long; lobes 3.5–4.0 mm long. Standard 4.0–6.5 mm long; claw 1.5–2.0 mm long; lamina 2.5–4.0 mm long, 2.0–2.5 mm wide. Wings 4.0–6.5 mm long; claw 2.0–2.5 mm long; lamina 2.5–4.5 mm long, 1.0–1.5 mm wide. Keel 4.0–6.5 mm long; claw 2.0–2.5 mm long; lamina 2.5–4.5 mm long, 1.0–1.5 mm wide. Pistil with ovary 4.0–4.5 mm long, 0.6–1.0 mm wide with ± 13 –17 ovules; style 1.5–1.7 mm long. Pods (30–)35–45 mm long, 1.5–2.0 mm wide with up to ± 30 seeds per pod. Seeds 1.5–1.8 mm long, 1.2–1.3 mm wide.

Distribution and ecology: restricted to Australia where it occurs on sandy hills and flats (Fig. 7).

Specimens examined

AUSTRALIA: 100 miles [160.9 km] W of Windorah, *Everist* 3898, 9.vi.1949 (K); Boomerang Waterhole, Lander River, 20°38'00"S 132°11'00"E, *Latz* 16126, 10.v.2000 (MEL); Upper Victoria River, *von Müller s.n.*, without date (K, MEL 2 sheets); near the Ord River, *O'Donnell s.n.*, without date (MEL 2 sheets).

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