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A.C. Church

P.F. Stevens

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## AN ANALYSIS OF THE VARIATION WITHIN *CRATOXYLUM* *ARBORESCENS* (CLUSIACEAE) IN MALESIA

A.C. CHURCH & P.F. STEVENS

The Arnold Arboretum of Harvard University, 22 Divinity Avenue, Cambridge, MA 02138, U.S.A.

### SUMMARY

The variation within the widespread West Malesian species *Cratoxylum arborescens* (Vahl) Blume was analyzed and three distinctive variants were found. These are recognized formally as varieties, var. *arborescens*, var. *miquelii* King, and var. *borneense* A.C. Church & P.F. Stevens. A key and full descriptions are given. The characters employed to delimit the three taxa are discussed and the selection of varietal rank is justified.

### INTRODUCTION

The most recent revisions of *Cratoxylum* Blume are by Gogelein (1967) and Robson (1974). Gogelein recognized six species, and observed substantial variation in the leaf morphology of *C. arborescens* (Vahl) Blume. He noted that *C. cuneatum* Miq., later reduced by King to *C. arborescens* var. *miquelii*, was only "an extreme pararmorph connected with the average population by many intermediates" (Gogelein, 1967: 473), and was marked by its rather slender petioles, elliptic leaves and long acumen. Corner (1939) had earlier suggested that foliar variation in *C. arborescens* was correlated with habitat: a robust form grew in lowland swamps in Indochina and West Malaysia generally, while a more gracile form, var. *miquelii*, was found on hill-sides and mountain ridges in Sumatra, Malaya, and Borneo. Although he found that the two forms could be well characterized by features of the leaves, including petiole width and shape of the lamina apex, he believed that there were intermediates and that in both flower and size of the tree there were no differences.

Two modes of growth of *C. arborescens* that seemed to correlate with the variation just mentioned were noted in the course of studying growth patterns in the Clusiaceae, and this prompted further examination of the problem. In some specimens all the internodes immediately below the inflorescence are approximately equal in length and have associated leaves that at most become gradually reduced in size towards the inflorescence (Fig. 1a), and the lowest branches of the inflorescence are often subtended by almost full-sized leaves. Other specimens have one or more very short internodes immediately below the inflorescence; these lack associated, expanded leaves (Fig. 1b), although there may be reduced leaves subtending the lowest branches of the inflorescence. This distinction can be phrased in a rather different way: in the first form the innovation consists of an inflorescence which is borne terminally on a leafy axis, while in the second the innovation bearing the inflorescence consists only of scale leaves and then a more or less branched, flower-bearing axis. Elsewhere on plants of both forms there are terminal buds with scales. Although Ruth van Crevel



Fig. 1. *Cratoxylum arborescens* (Vahl) Blume. Flowering twig showing internode length and bud scales. — a. *C. arborescens* var. *miquelii* (FRI 1139), lacking scars below the inflorescence; b. *C. arborescens* var. *arborescens* (SAN 91289), with bud scales below the inflorescence. Arrow head = lowest branch of inflorescence; arrows = buds in the axils of deciduous reduced leaves (scales).

(in Gogelein, 1967: fig. 7a and in Robson, 1974: fig. 8a) illustrated *C. arborescens* with scale leaves immediately below the inflorescence (see also Stevens, 1990), Robson himself made no mention of bud scales in his account; and the drawing accompanying the original description of *Hypericum arborescens* Vahl omits such scars (see Vahl, 1791: t. 43); such variation has not been used taxonomically before. All species have buds with scales, as does the closely related monotypic genus *Eliea* Cambess., from Madagascar (Baas, 1970).

## RESULTS

To understand the variation, herbarium material from the Arnold Arboretum (A), Gray Herbarium (GH), Herbarium Bogoriense (BO), and Rijksherbarium (L) was examined and 169 particularly intact specimens were studied in more detail. Characters from the flower and fruit, taken from rehydrated herbarium material, were examined, as were several vegetative characters — petiole width, lamina length and width, acumen length, and venation prominence.

Below we show how the characters of leaf scar, internode length, petiole width, and lamina apex can be used to circumscribe three infraspecific entities within *Cratoxylum arborescens*. Within the area from Myanmar to the Banka Archipelago the two forms observed by Corner can be recognized, while in the island of Borneo there

are also two forms, the 'lowland Malayan' form of Corner and an undescribed form which combines characters of Corner's two forms. The 'lowland Malayan' form, which we recognize below as *C. arborescens* var. *arborescens*, is robust in habit and can be recognized by its coriaceous lamina, winged petioles and shortened internodes below the inflorescence. It is distributed from Myanmar to Sumatra and Borneo. The other two entities are gracile and have a chartaceous lamina and slender petioles. They differ in growth pattern, ecology and geography. One, corresponding to Corner's gracile form, is recognized below as *C. arborescens* var. *miquelii*; it grows at high altitudes along mountain ridges and hillsides, and is restricted to Sumatra and Peninsular Malaysia. The other, *C. arborescens* var. *borneense*, grows at a variety of altitudes and is known only from Borneo.

The most obvious quantitative characters separating these three varieties are internode length, petiole width, and the length of the acumen on the lamina (Fig. 2). When these characters are examined in the context of geography, and the division of the specimens into a group with shortened internodes immediately below the inflorescence and a group lacking such internodes, a striking set of correlations is seen (Fig. 2–5). Although at one level – that is, when geographical considerations are excluded – there appears to be a continuum of variation (Fig. 2), the group of specimens with broad petioles, short acumen, and scars (var. *arborescens*) forms a coherent group easily delimited from the others (Fig. 3–5). They are also distinguished by less easily quantifiable differences – the leaves generally have inconspicuous fine venation and the lower surface of the lamina is often glaucous. These specimens, found from

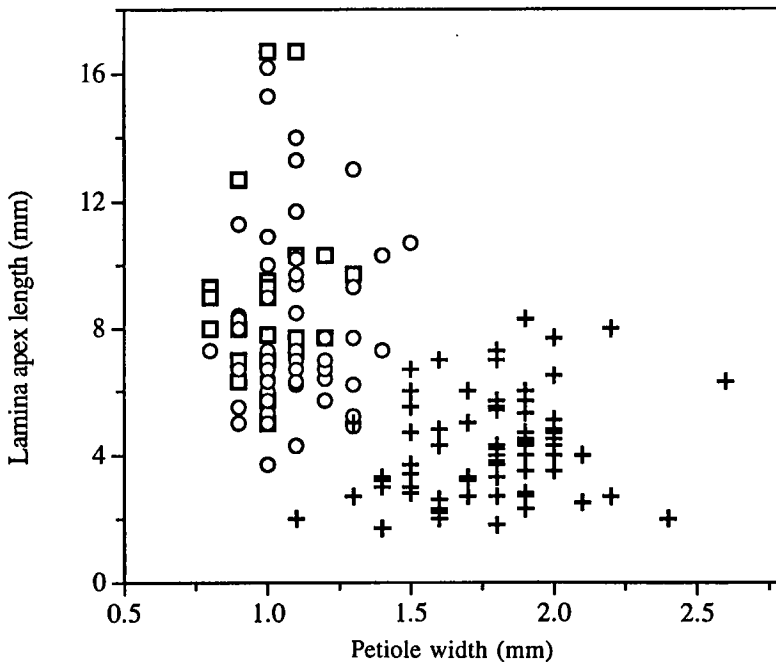


Fig. 2. Variation in lamina apex length and petiole width in *Cratogeomys arborescens* (Vahl) Blume: var. *arborescens* (+), var. *borneense* (O), var. *miquelii* (□).

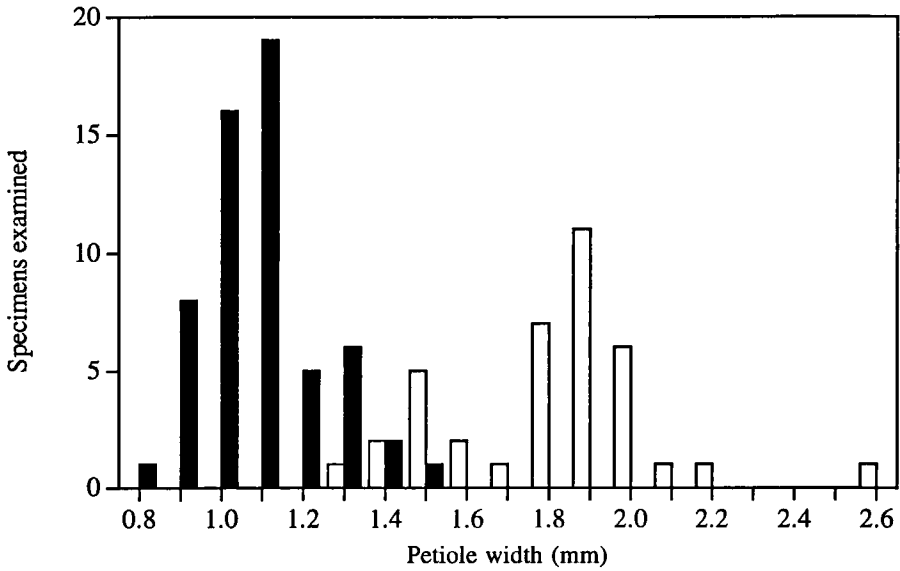


Fig. 3. Variation in petiole width in Bornean specimens of *Cratoxylum arborescens* var. *borneense* (■) and var. *arborescens* (□).

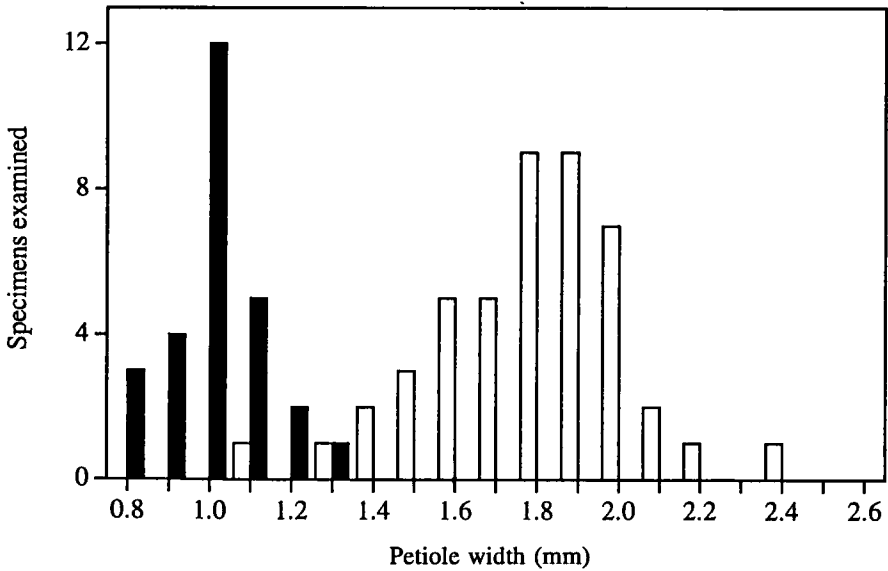


Fig. 4. Variation in petiole width in Malaysian and Sumatran specimens of *Cratoxylum arborescens* var. *miquelii* (■) and var. *arborescens* (□).

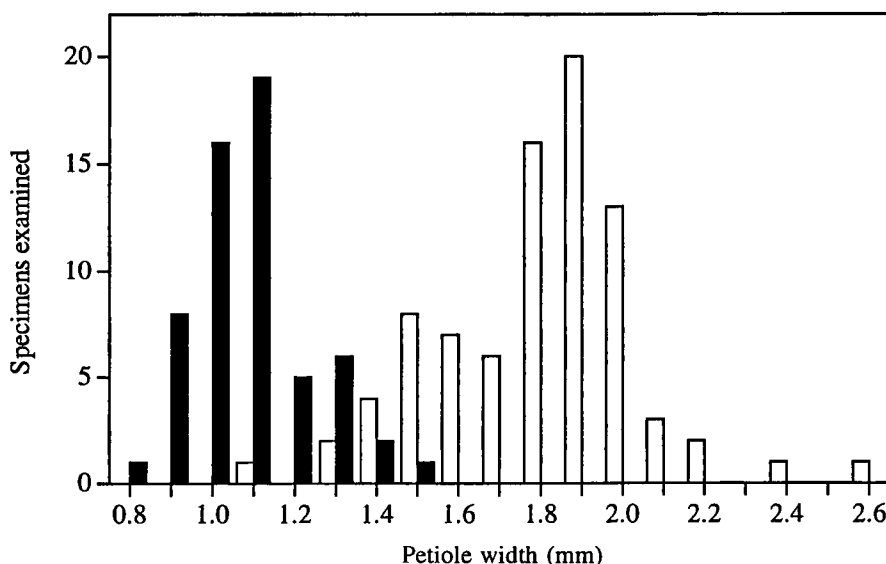


Fig. 5. Variation in petiole width in the varieties of *Cratoxylum arborescens* with bud scales present immediately below the inflorescence; var. *borneense* (■), var. *arborescens* (□).

Myanmar to Borneo, tend to grow almost exclusively at low altitudes and are often recorded as being a component of peat-swamp forests. However, *S 20124* (1070 m), *S 34844* (1100 m), and *Jacobs 5555* (750–900 m), all from Northwest Borneo, were collected at higher altitudes, yet were not recorded as growing in kerangas or other acid vegetation types. Specimens otherwise assignable to var. *arborescens* may very occasionally lack scars, e.g. *King 6152, 8610*, from the Malay Peninsula.

The specimens with narrower petioles and longer acumen can be subdivided into two groups. *Cratoxylum arborescens* var. *borneense* is known only from Borneo. It grows over a wide altitudinal range and has shortened internodes immediately below the inflorescence (*Hallier 1065*, a poor specimen collected in Kalimantan, lacks these internodes). The other taxon, *Cratoxylum arborescens* var. *miquelii*, is known only from Sumatra and the Malay Peninsula and grows at moderate elevations; it lacks these shortened internodes. Other than internode length and geographic distribution, the two are indistinguishable (Fig. 2). There are, however, two Sumatran specimens, *bb 5770* (collected at 880 m) and *bb 2929* (800 m), which both have bud scales below the inflorescence. However, they differ from var. *arborescens* in their venation and in the absence of a glaucous underside to the lamina (as well as in the altitude at which they were growing), and they seem to be correctly assigned to var. *miquelii*.

Other characters were examined to see what variation they showed within *Cratoxylum arborescens*. Petal appendages, staminodial fascicles, and seed shape have been previously used to distinguish between other species in the genus. Quantitative data were taken from 32 specimens to see if the first two characters, and also seed size, showed any correlation with the presence or absence of bud scales. Variation in these characters did not correlate with that of the other characters discussed.



- b. Petiole 0.8–1.4 mm wide, rarely winged; lamina chartaceous, obovate-oblong to elliptic; apex acute-acuminate, acumen 4.5–17.0 mm long. [Restricted to Borneo.] ..... **b. var. borneense**

**Cratoxylum arborescens** (Vahl) Blume

*Cratoxylum arborescens* (Vahl) Blume, Mus. Bot. Lugd. Bat. 2 (1852) 17. — *Hypericum arborescens* Vahl, Symb. 2 (1791) 86, t.4 3. — Type: *Koenig s.n.*, 1778 (cf.: Fl. Males. I, 1, 1950, 288) (holo C, n.v.), Malaya; see Robson, Fl. Males. I, 8 (1974) 11, for synonymy.

**a. var. arborescens**

Internodes immediately below the inflorescence much shortened, bud scales present there; petiole 1.3–2.6 mm wide, often almost winged; lamina broadly obovate-oblong or obovate-elliptic, coriaceous, drying yellowish brown to dark brown; apex shortly cuspidate to acuminate, acumen 1.0–10.0 mm; reticulation above barely visible.

Distribution — Myanmar, Thailand, Peninsular Malaysia, Sumatra, and Borneo.

Ecology — Peat and freshwater swamp forests, kerangas; 10–100(–1100) m altitude.

**b. var. borneense** A.C. Church & P.F. Stevens, *var. nov.*

A varietatibus aliis *C. arborescenti* in cicatricibus infra inflorescentes proxime praeditis et petiolis gracilibus 0.8–1.4 mm latis, differt. — Typus: *Kostermans 4335* (holo A; iso BO), Kalimantan, Sg. Wain region, N of Balikpapan, 10 m, Oct. 1950.

Internodes immediately below the inflorescence much shortened, bud scales present there; petiole 0.8–1.4 mm wide, seldom winged; lamina obovate-oblong to elliptic, chartaceous, drying golden yellow to greenish brown; apex acute to acuminate, acumen 4.5–17.0 mm; reticulation above slightly visible to prominent.

Distribution — Borneo.

Ecology — Primary forest, including hillsides and ridges of mountains, sometimes peat and freshwater swamp forests, 10–1200(–1900) m altitude.

Note— A few specimens with axillary inflorescence are known, e.g. *D.G. Frodin & O. Ismawi 2066*, Sarawak. *Clemens 40463* was collected from 1830 m on the Mt. Kinabalu massif.

**c. var. miquelii** King

*Cratoxylum arborescens* var. *miquelii* King, J. Asiat. Soc. Bengal 59, ii (1890) 146. — *Cratoxylum cuneatum* Miq., Fl. Ind. Bat. I, 2 (1859) 517. — Type: *Teijsmann HB 636* (holo U, n.v.; iso L, fragm.), Sumatra, near Loeboe, Sikkeppeng.

Internodes immediately below inflorescence not congested, bud scales absent there; petiole 0.8–1.3 mm wide, seldom winged; lamina elliptic, chartaceous, drying golden yellow to greenish brown; apex acute to acuminate, acumen 6.0–17.0 mm; reticulation above and below raised.

Distribution — Peninsular Malaysia, Sumatra.

Ecology — Primary forest on hillsides and mountain ridges, 300–1500 m altitude.



## ACKNOWLEDGEMENTS

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## LIST OF COLLECTIONS

Numbers between brackets refer to the three accepted varieties of *Cratoxylum arborescens*: *C. arborescens* var. *borneense* (1), var. *miquelii* (2) and var. *arborescens* (3).

- A 361 (1), 368, 490, 1035, 1305, 1331, 1345, 1608, 4073 (3) — Afriastini, J. J. 1009 (1), 9989 (3) — Anderson 4238 (3), 4353, 12579 (1), 13257 (3) — Ashton 21346 (3).
- bb 2866, 2897, 2919, 2929, 3986, 5166, 5679, 5770 (2), 6188 (3), 6339, 6398 (1), 6530 (2), 7062, 7090, 7131 (1), 7389 (2), 10231, 10483 (1), 13925, 13945 (3), 15799, 16057, 16058, 16064, 16474 (1), 17778 (1), 17830, 18185 (3), 18204 (1), 18266 (3), 18366 (2), 18640, 20609, 20722, 21169, 21194, 21233 (1), 23001, 23002, 23003, 23020, 23023, 23880 (3), 24627, 24667 (1), 25252, 25786 (3), 26166, 27011 (1), 27592 (3), 27725 (1), 28533, 28678, 29156, 30085, 30179, 33094, 33096 (3), 35356 (1) — Beguin 304, 484 (3) — BNB, see SAN — BRUN 639 (3) — Buwalda 6387, 6742 (3), 7691 (1).
- Clemens 26882, 40463 (1) — Coode, M. J. E. 6817 (1).
- Forman 444 (1) — FRI 0722 (3), 1139, 1285 (2) 2803 (3), 6175 (2), 6663, 8902 (3), 14243 (2), 15615, 15865, 16875 (3), 17084 (2), 18436 (3), 20423 (2), 24875 (3) — Frodin & Ismawi, 2066 (1) — Fuchs 21290 (2), 21346 (3).
- Grashoff 46 (3) — Griffith 839 (3).
- Hallier 2975 (1) — Hansen 1308 (3) — Hou 569 (1).
- Jacobs 5555 (3).
- Kadim & Noor 155, 312 (3) — Kandalis 9045 (1) — Kasim 748 (2) — KEP 5248, 24875, 30494, 32561 (3), 35937 (2), 36387, 36480, 36990, 51940 (3), 76498 (2), 80178, 80230 (3), 80424 (1), 98391, 99440 (3) — Keßler et al. 524 (1) — King 3041, 5251, 6072, 6152, 8610, 10105 (3) — Kirkup et al. 276 (1) — KL 3016 (2) — Kostermans 17 (1), 92, 112 (3), 4335, 6484, 6683, 7105, 9016 (1), 9196, 10354, 12889 (3) — Kostermans & Anta 385, 569, 590, 592 (3) — Kostermans & Sabana 9 (2).

Lörzing 17223 (2).

Maxwell 87-532 (3) — Melegrito 1566, 2602 (3), 3301 (1) — Mikil 37751 (1).

Native Collector 378, 1132, 5141 (3) — Nedi 749 (1) — Niyom 829 (3).

Ogata 10155 (3).

Rahmat si Boeea 7976, 8037, 9218, 9276 (2) — Rahmat si Toroos 2012, 2143, 3015, 4859 (3) — Ridley 3611a (3).

S 12841 (3), 14989 (1), 20124 (3), 23921, 28155, 28441, 30369 (1), 33085, 34517, 34844, 43013 (3) — SAN 2602, 15855, 15868, 19192, 23821 (3), 25594, 25821 (1), 27305, 27731, 28170 (3), 28790, 30283 (1), 31260 (3), 32272 (1), 34564 (3), 35159, 40214, 40356 (1), 50661, 51729, 55280 (3), 55764 (1), 61320 (3), 65113 (1), 65329, 72307, 72491, 72536, 80760, 80814, 84062, 84247, 84278, 84326 (3), 84800, 89495, 89499, 90091 (1), 91289 (3) — SFN 3470 (3), 3705, 11392 (2), 19289 (3), 21428 (2), 34002, 34759 (3), 35679 (1), 36280, 36387, 36754, 37347 (3) — Shah 891 (2) — Shea 26259, 27541 — Soepadmo 127 (3) — van Steenis 9984 (2) — Stone 9601, 13757 (2) — Stone & Weber 15954 (2).

Tandum 2826 (3) — Teijsmann HB 636 (2) — Thorenaar 9 T 1910, 9 T 1 P 177 (3).

van Valkenburg 1239 (3) — de Voogd 1132 (2).

Whitmore 3316 (2) — de Wilde 15138 (2) — Winkler 2919 (1) — Wong 918 (3).