

## **Eight new *Begonia* (Begoniaceae) species from the Lanjak Entimau Wildlife Sanctuary and Batang Ai National Park, Sarawak, Borneo**

S. Julia<sup>1</sup> & R. Kiew<sup>2</sup>

<sup>1</sup>Botanical Research Centre, Sarawak Forestry Corporation,  
Kuching, Sarawak, Malaysia  
juliasang@sarawakforestry.com

<sup>2</sup>Forest Research Institute Malaysia, Kepong 52109,  
Selangor, Malaysia  
ruth@frim.gov.my

**ABSTRACT.** Eight new *Begonia* (Begoniaceae) species, *Begonia addrinii* S.Julia & Kiew, *Begonia celata* S.Julia & Kiew, *Begonia crassa* S.Julia & Kiew, *Begonia devexa* S.Julia & Kiew, *Begonia fractiflexa* S.Julia & Kiew, *Begonia hirtitepala* S.Julia & Kiew, *Begonia jamilahanuiana* S.Julia and *Begonia ubahribuensis* S.Julia & Kiew, are described from Lanjak Entimau Wildlife Sanctuary and Batang Ai National Park in Sarawak, Malaysia. Two and four species are only known from Batang Ai National Park and Lanjak Entimau Wildlife Sanctuary respectively while two species are found in both sites. Seven species belong to *Begonia* sect. *Petermannia* and the placement of one (*Begonia fractiflexa*) is uncertain.

**Keywords.** *Begonia*, RIMBA, Sarawak, Totally Protected Area

### **Introduction**

In August 2015, the State Government of Sarawak launched the RIMBA SARAWAK (Research for Intensified Management of Bio-Rich Areas) project focusing on research in three of its Totally Protected Areas, i.e., Lanjak Entimau Wildlife Sanctuary (WS), Batang Ai National Park (NP) and Sebuyau National Park. This on-going RIMBA SARAWAK project was initiated through the Sarawak Forestry Corporation to provide a platform for research collaboration with international, regional and local researchers on biodiversity and forests in these bio-rich areas.

Lanjak Entimau WS (111°53'E to 112°28.5'E and 1°19'N to 1°51'N) covers approximately 192,000 ha of forest on rugged hilly topography in south western Sarawak. It was gazetted as a wildlife sanctuary in 1983 and its area extended in 2003 (Chai, 2011). It lies in four administrative districts, Lubok Antu District in the southern part, Julau and Sibu Districts in the northern part and Song District in the eastern part. In 1994, Lanjak Entimau WS became part of the Trans-boundary Biodiversity Conservation Area with Betung Kerihun National Park in Kalimantan, Indonesia, under a project supported by the International Tropical Timber Organisation (ITTO). As a sanctuary for the protection of wildlife and their habitats, under the National

Parks Ordinance, 1998, access to Lanjak Entimau WS is restricted to scientists and researchers with permits. Batang Ai NP, which is contiguous with the southern part of Lanjak Entimau WS, was gazetted as a Totally Protected Area in 1991 and, including a later extension, covers an area of 32,100 ha.

Recent field work focusing on begonias by the first author in two of the RIMBA SARAWAK's sites, Lanjak Entimau WS and Batang Ai NP, resulted in the collection and re-collection of materials used to describe eight new species in this paper. Of these eight species, five species were collected for the first time while three species had previously been collected but were not described. Meekiong et al. (2010) noted that 12 species were recorded from Lanjak Entimau WS including the newly described *Begonia kurakura* Tawan, Ipor & Meekiong (2009). In Batang Ai NP, nine species have been described (Lin et al., 2014; Julia & Kiew, 2016).

Seven new species described in this paper belong to *Begonia* sect. *Petermannia* and one (*Begonia fractiflexa*) is of uncertain placement. Of these eight species, two species (*B. hirtitepala* and *B. jamilahanuiana*) occur in both Lanjak Entimau WS and Batang Ai NP while four species are presently known only in Lanjak Entimau WS (*B. crassa*, *B. fractiflexa*, *B. devexa* and *B. ubahribuensis*) and two species (*B. addrinii* and *B. celata*) are known only from Batang Ai NP. As indicated by the discovery of new species, particularly from Batang Ai NP, more new species can be expected once more areas within these Totally Protected Areas are explored.

Although all species have narrow distribution ranges and only occur in one or few localities, all species are considered Least Concern (IUCN, 2012). Their habitats are well and legally protected within the Totally Protected Areas. The species are also commonly seen where they occur with populations comprising individuals in various life stages, including reproductive plants.

## Methodology

Materials used for the description of species are based mainly on specimens collected by the first author and her colleagues during field trips in March 2016 and May 2016, as well as the existing specimens available in the Sarawak Herbarium (SAR). All measurements are from freshly collected materials unless indicated otherwise. The diagnostic characters of all new species in this paper were compared with the characters of similar species based on the descriptions in their protologues unless indicated otherwise.

## Taxonomy treatment

### 1. *Begonia addrinii* S. Julia & Kiew, **sp. nov.** (Section *Petermannia*)

In its creeping habit and small obovate leaves, it is similar to *Begonia crockerensis* Rimi but it is different in its shorter internodes, 1.4–2 cm long (vs. 2.3–2.6 cm long), smaller stipule, 3–10 × 2–5 mm (vs. 14–23 × 5–7 mm), leaves usually growing flat against boulders (vs. upstanding or semi-erect), leaf base cordate with a relatively large

basal lobe, 0.3–0.7 cm long (vs. leaf base rounded with smaller basal lobe, c. 0.2 mm long), laminae that are always plain green and pilose above (vs. glabrous leaves with two colour forms, green or dark bronze-green), inflorescence in a 3-flowered cyme (vs. a thyrse), and 25–30 stamens (vs. c. 17). – TYPE: Malaysia, Borneo, Sarawak, Lubok Antu District, Batang Ai NP, Sungai Buan, 1°17'44"N 112°04'03"E, 153 m, 19 March 2016, *Julia et al.* SFC6653 (holotype SAR!; isotypes KEP!, SING!, SNP!). (Fig. 1)

Creeping herb, rooting at the nodes; stem, leaves and petiole pilose, hairs reddish to whitish. **Stems** to 15 cm long, unbranched, green, pilose, hairs brownish or reddish, c. 3 mm thick; internodes 1.4–2 cm long, slightly swollen at nodes. **Stipules** pale green, acute, 3–10 × 2–5 mm, margin entire, apex acute, caducous. **Leaves** closely arranged, flattened onto boulders, not oblique; petioles pale green, 1.1–2.2 cm long, succulent, terete; lamina plain green above, paler beneath, in life succulent, drying papery, slightly asymmetric, obovate or sometimes orbicular, 2.3–5 × 2.1–5 cm, base cordate, basal lobe 0.3–0.7 cm long, margin serrate, apex rounded; venation palmate, branching twice towards the margin, concolorous, slightly impressed above, prominent beneath. **Inflorescences** erect, axillary along the creeping stem, red-brown or greenish, unbranched, 4.5–10 cm long, topped by a cyme of 1 female and 2 male flowers. **Bracts** reddish or pale green, lanceolate, 4–7 × 2–3 mm, margin entire, keeled, apex acute, persistent; bracteoles greenish or reddish, ovate to lanceolate, 2–3 × 1–1.5 mm, margin entire. **Male flowers** with white pedicels, 5–17 mm long; tepals 4, white, margin entire, apex broadly acute, outer 2 tepals elliptic, 6–12 × 4–7 mm, inner 2 tepals narrowly elliptic, 6–8 × 1.5–4 mm; stamens 25–30, cluster loosely globose, sessile, filaments c. 1.2 mm long, anthers lemon yellow, obovate, c. 1 × 0.4 mm, apex emarginate. **Female flowers** with whitish or greenish pedicels, 6–8 mm long; tepals 5, white, pinkish or whitish green, broadly ovate, outer 4 tepals 4–12 × 4–5 mm, inner tepal 5–6 × 3 mm, margin entire, apex broadly acute; ovary white, pinkish or greenish tinged reddish, 5–7 × 6–9 mm, wings 3, unequal, 2–5 mm wide, locules 3, placentas 2 per locule; styles 3, lemon yellow, 2–3 mm long; stigma lemon yellow, anchor-shaped, papillose. **Capsules** single, pale green, 5–7 × 12 mm, locules 3, wings 3, unequal, 3–4 mm wide, acute proximally and distally, dehiscing between the locules and wings; pedicel in fruit pendent, green, stiff, 4–8 mm long.

*Etymology.* Named for Addrin anak Kemarau, the Park Ranger at Batang Ai National Park who first discovered this new species.

*Distribution.* Endemic in Sarawak, as yet known only from the Batang Ai NP.

*Habitat.* Riparian forest at 153 m elevation, growing on a thin soil layer on sandstone boulders in shaded area.

*Notes.* Among begonias that grow in the Batang Ai NP (Julia & Kiew, 2016), this pretty creeping begonia shares a similar habit and small leaf size with *Begonia tebiang* S. Julia & Kiew, but this latter species is different in its ovate leaves, 5.5–10.5 × 4.5–8.5 cm, and its thyrse with persistent and larger bracts, 7–17 × 4–11 mm.

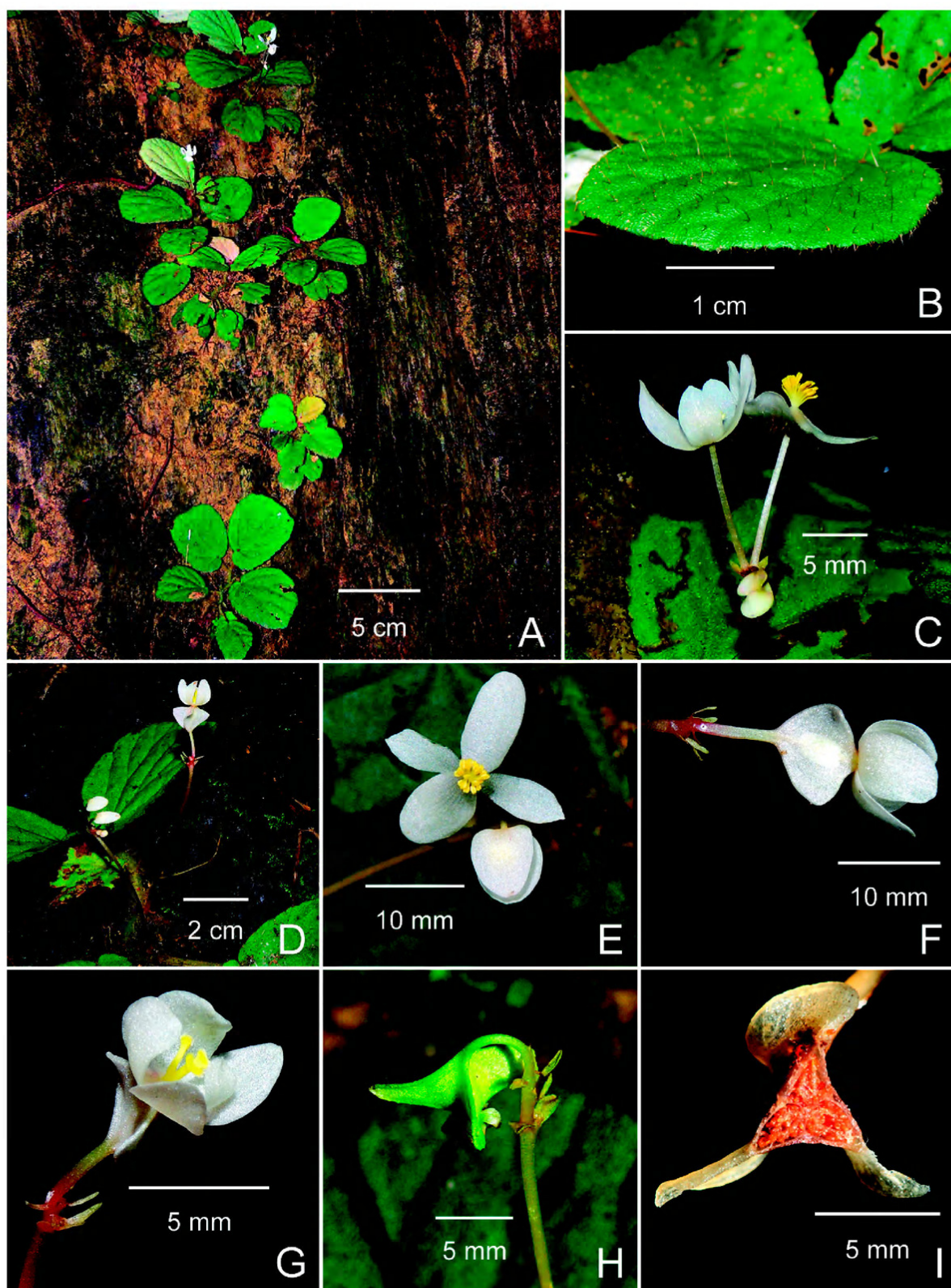
**2. *Begonia celata* S. Julia & Kiew, sp. nov.** (Section *Petermannia*)

In its small creeping habit, small hairy, broadly ovate leaves it is similar to *Begonia baik* C.W. Lin & C.-I. Peng but it is different in its smaller, lanceolate stipules  $7\text{--}12 \times 2.5$  mm (vs. ovate and  $17\text{--}20 \times 8$  mm), longer and grooved petiole 3.3–6 cm long (vs. 1.5–2.5 cm long in upper leaves, to 7.5 cm in lower leaves), and its shorter and broader capsules  $6\text{--}7 \times 10\text{--}11$  mm (vs. c.  $9 \times 6$  mm). – TYPE: Malaysia, Borneo, Sarawak, Lubok Antu District, Batang Ai NP, Sungai Bebiyong Mit,  $1^{\circ}18'01''\text{N}$   $112^{\circ}04'24''\text{E}$ , 163 m, 19 March 2016, *Julia et al.* SFC6661 (holotype SAR!; isotypes KEP!, SING!, SNP!). (Fig. 2)

Herb to 5–30 cm tall, stem and leaves pilose, hairs purplish. **Stems** sparsely branched, green, 4–5 mm thick; internodes 0.7–2 cm long, slightly swollen at nodes. **Stipules** pale green, lanceolate,  $7\text{--}12 \times 2\text{--}5$  mm, keeled, margin entire, apex setose, seta to c. 1 mm long, persistent. **Leaves** sometimes flattened against the steep earth bank, oblique; petioles reddish brown, 3.3–6 cm long, slightly grooved; lamina plain green to coppery green above, deep red-brown beneath, in life slightly succulent, drying papery, asymmetric, broadly ovate to orbicular,  $6\text{--}7.5 \times 5.5\text{--}8.5$  cm, broad side 3.6–5.4 cm, base unequal, cordate, sometimes overlapping, basal lobe 0.7–1.5 cm long, margin dentate, apex acute; venation palmate-pinnate, 3–4 veins on each side, 2–4 veins on basal lobe, branching twice towards the margin, impressed above, prominent beneath. Inflorescences erect, axillary on the upper leaf axil, dichasium 4.5–9 cm long, red-brown with reddish hairs, peduncle 2.3–5 cm long. **Bracts** pale green, ovate,  $6\text{--}11 \times 3\text{--}5$  mm, keeled, margin ciliate, apex acuminate, acumen to 1 mm long, persistent; bracteoles up to 12 pairs per partial inflorescence, lower bracteoles ovate, pale green,  $8\text{--}9 \times 4$  mm, slightly keeled, margin ciliate, apex setose, seta to 1 mm long, upper bracteoles reddish or pinkish, ovate,  $4\text{--}5 \times 2\text{--}3$  mm, margin ciliate, persistent; margin toothed, teeth tipped by a hair. **Male flowers** with white or reddish pedicels, 6–10 mm long; tepals 4, completely white or pinkish outside, white inside, sprinkled with white hairs outside, glabrous inside, margin entire, apex broadly acute or rounded, outer 2 tepals broadly ovate,  $9\text{--}11 \times 6\text{--}9$  mm, inner 2 tepals oblanceolate,  $7\text{--}9 \times 2\text{--}3$  mm; stamens 28–35, cluster globose, subsessile, filaments c. 1 mm long, anthers lemon yellow, obovate, c.  $1 \times 0.5$  mm, apex emarginate. **Female flowers** with pale green hispid pedicels, 7–10 mm long; tepals 5–6, bright red, pinkish or white outside, white inside, hairy outside, glabrous inside, margin entire, apex rounded, outer 3–4 tepals obovate,  $7\text{--}10 \times 4\text{--}6$  mm, inner 2 tepals oblanceolate,  $8\text{--}9 \times 2\text{--}3$  mm; ovary bright red, pink or green with red wings,  $6\text{--}7 \times 8\text{--}9$  mm, covered with white hairs, hairs 2–3 mm long, wings 3, equal, 2–3 mm wide, locules 3, placentas 2 per locule; styles 3, lemon yellow, 2–3 mm long; stigma lemon yellow, anchor-shaped, papillose. **Capsules** (old) single or 2–3 capsules per infructescence,  $6\text{--}7 \times 10\text{--}11$  mm, locules 3, wings 3, equal, broadly acute proximally and acute distally, 2–3 cm wide, dehiscing between the locules and wings; pedicel in fruit pendent, glabrous, 8–12 mm long.

*Etymology.* Latin, *celatus* = hidden; referring to the habitat where it grows hidden below tree roots or rocky boulders.





**Fig. 1.** *Begonia addrinii* S.Julia & Kiew. **A.** Habit. **B.** Hairy upper leaf surface. **C.** Male inflorescence. **D.** Male and female inflorescences. **E.** Male flower. **F, G.** Female flower. **H.** Fruit. **I.** Cross-section of ovary. From the type *SFC6653*. (Photos: A–H, S. Julia; I, C.Y. Ling)

*Distribution.* Endemic in Sarawak, as yet known only from Batang Ai NP.

*Habitat.* Riparian forest below 200 m elevation, growing in shaded areas under rocky boulders, near tree buttresses or tree roots on a gentle slope.

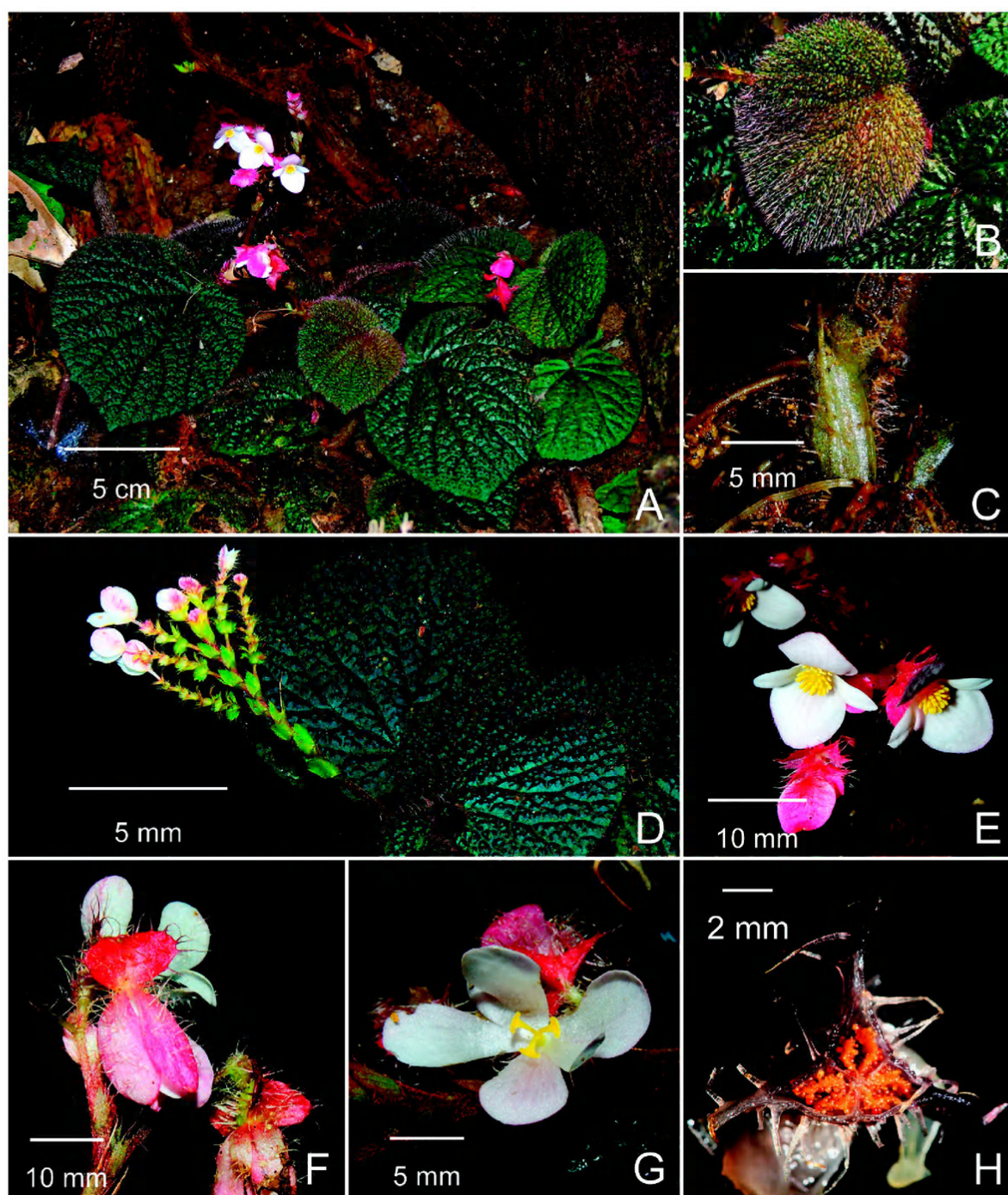
*Notes.* Its habitat is unique in that it was only found growing below tree roots or boulders, perhaps indicating that it is intolerant of its leaves being soaked by rain or the soil being waterlogged. Among begonias in Batang Ai NP (Julia & Kiew, 2016), *Begonia celata* is close to *B. tebiang* in having small leaves, but *B. tebiang* has a creeping habit with longer internodes (2.5–8.5 cm long), a glabrous lamina, fewer bracteole pairs, glabrous female flowers with a shorter pedicel (c. 1 mm long) and a wider ovary (14–15 mm wide). *Begonia celata* is rather localised and only found in a few patches along the stream banks.

### 3. *Begonia crassa* S. Julia & Kiew, **sp. nov.** (Section *Petermannia*)

Similar to *Begonia conniegeriae* S. Julia & Kiew in its cane-like habit and dense clusters of many male flowers but it is different in its thick, succulent ridged stem, its lack of hairs, veins only slightly impressed above compared with *B. conniegeriae* that has a slightly woody terete stem, reddish brown indumentum and veins deeply impressed above. – TYPE: Malaysia, Borneo, Sarawak, Julau District, Ng. Biladayat, Ulu Sg. Sugai, Mujok, Lanjak Entimau WS, 1°44'03"N 112°05'52"E, 198 m, 3 March 2003, *Rantai et al.* S 90832 (holotype SAR!; isotypes K!, KEP!). (Fig. 3)

Cane-like begonia. **Stems** to 70 cm tall, unbranched, glabrous, translucent, pale green, very succulent, 10–15 mm thick, ridged; internodes 4–9(–11) cm long, swollen at nodes. **Stipules** translucent green, tinged reddish, broadly lanceolate, 20–25 × 8 mm, reflexed, margin entire, apex sharply acute, persistent. **Leaves** distant, held more or less horizontally, oblique; petioles pale green, 1.2–3.5 cm long, 3–6 mm thick, succulent, ridged, grooved above; lamina plain green and glossy above, hirsute between the veins above, paler and glabrous beneath, in life succulent, drying papery, asymmetric, broadly ovate, 16–23 × 9–15 cm, broad side (4–)7–10.5 cm long, base cordate, unequal, basal lobe 2–2.5 cm long, margin dentate, apex acuminate, acumen 0.5–2 cm long; venation palmate-pinnate with 4–5 veins at the base and 2–3 veins on either side of the midrib, branching twice towards the margin, concolorous, slightly impressed above, prominent beneath; lower leaf smaller, ovate, c. 8.2 × 5.3 cm, broad side c. 3.5 cm long, base cordate, unequal, basal lobe 0.8–1 cm long. **Male inflorescences** axillary in upper leaf axils, a compact cluster of cymules, c. 3 cm long, peduncle c. 1.3 cm long, reddish green. **Bracts** reddish with greenish base or sometimes green with red edges, ovate, c. 20 × 15 mm, margin entire, apex acute, persistent; bracteoles red, orbicular, 10–14 × 10–14 mm, margin irregularly toothed, each pair of bracteoles enfolding cymules of 6–12 male flowers. **Male flowers** with white pedicels, 5–10 mm long; tepals 2, white, margin entire, apex broadly acute, oval, 6–7 × 4–5 mm, reflexed; stamens 31–35, cluster conical, sessile, filaments 0.6–0.8 mm long, anthers pale yellow, obovate, c.





**Fig. 2.** *Begonia celata* S.Julia & Kiew. **A.** Habit. **B.** Hairy upper leaf surface. **C.** Stipule. **D.** Inflorescences. **E.** Male flowers. **F & G.** Female flower. **H.** Cross-section of ovary. From the type *SFC6661*. (Photos: A–G, S. Julia; H, C.Y. Ling)

0.6 × 0.2 mm, apex emarginate. **Female flowers** not seen. **Capsules** in pairs, oblong in outline, 15–26 × 10–17 mm, locules 3, wings 3, equal, rounded or truncate proximally, truncate distally, 5–6 mm wide, dehiscent between the locules and wings; pedicel in fruit pendent, stiff, 4–6 mm long.

*Etymology.* Latin, *crassus* = thick, referring to the stem.

*Distribution.* Endemic in Sarawak, as yet known only from Lanjak Entimau WS.

*Habitat.* Usually in riparian forest at 110–390 m elevation, growing below a cascading waterfall on a thin layer of soil on constantly wet sandstone boulders or on rocky banks of small streams; sometimes on slopes in mixed dipterocarp forest.

*Notes.* *Begonia crassa* was first collected in 1998 and is apparently widespread in the Lanjak Entimau WS. However, the species appears to grow in very small localised populations. Measurement of the fruit is based on dried herbarium specimens (*S79226* and *S90774*). Locally, its young leaves are used for flavouring when boiling fish. Among Bornean begonias, it is remarkable for its extremely thick, succulent (not woody), angled stem to 1.5 cm thick. The only other species with a ridged stem is *Begonia papyraptera* Sands from Brunei, but it is quite different. Its ridged stem is conspicuously winged, it has broadly ovate, spotted leaves, and much larger capsules. Nor do these two species occupy an unusual or specific habitat that could be associated with this type of stem.

*Additional specimens examined.* MALAYSIA: **Sarawak:** Julau District, Lanjak Entimau WS, Sg. Merinum via Pakan, 2 Nov 1998, *Julaihi et al.* *S79226* (SAR!, K, KEP, L); Lanjak Entimau WS, Ng. Biladayat, Ulu Sg. Sugai, Mujok, 3 Mar 2003, *Rantai et al.* *S90774* (SAR!, KEP, K, L, SAN); Sg. Mujok, Sg. Sugai, 24 May 2016, *Ling & Dino* *SFC5952* (SAR!); Mujok, Lanjak Entimau WS, Sg. Sengkadang, 22 May 2016, *Ling & Dino* *SFC5941* (SAR!); Lubok Antu District, Ulu Engkari, Lanjak Entimau WS, Sungai Jela, 14 Mar 2016, *Julia et al.* *SFC3467* (SAR!); Song District, Hulu Katibas, Sg. Sedin, *Mohizah et al.* *ITTO/BC0083* (SAR!).

#### 4. *Begonia devexa* S.Julia & Kiew, **sp. nov.** (Section *Petermannia*)

In its leaves with long erect hairs on the upper surface and the erect unbranched inflorescences with 2-tepaled male flowers, it is similar to *Begonia corrugata* Kiew & S.Julia but it differs in its smaller and sometimes slightly falcate leaves, 9.5–13.5 × 4.5–5.2 cm (vs. 14–25 × 9–16 cm), its smaller basal lobe 0.8–1 cm long (vs. 1.5–4 cm long), glabrous tepals (vs. hairy tepals) and smaller capsules 9–10 × 12 mm (vs. 15–20 × 12–15 mm). – TYPE: Malaysia, Borneo, Sarawak, Lubok Antu District, Lanjak Entimau WS, Sungai Segerak, 1°24'34"N 112°00'13"E, 371 m, 13 March 2016, *Julia et al.* *SFC3457* (holotype SAR!; isotypes KEP!, SING!, SNP!). (Fig. 4)

Erect herb 20–35 cm tall, whole plant pilose, hairs white or rarely reddish to 5 mm long. **Stems** sometimes with one or two slender branches, pale green, 4–5 mm thick; internodes 2–3.5 cm long, slightly swollen at nodes. **Stipules** pale green, ovate, 9–15 × 5–11 mm, keeled, margin entire, apex setose, seta to c. 2 mm long, persistent. **Leaves** sometimes flattened against the steep earth bank, oblique; petioles pale green, (0.8–)3–3.7 cm long, slightly grooved; lamina plain green above, paler beneath, upper surface sprinkled with white or rarely reddish hairs 3–5 mm long, margin ciliate, beneath veins





**Fig. 3.** *Begonia crassa* S. Julia & Kiew. **A.** Habit. **B.** Stipule. **C.** Upper leaf surface. **D, E.** Male inflorescence. **F.** Fruit. A–E from *SFC3467*; F from *S90832*. (Photos: A–E, S. Julia; F, C.Y. Ling)

pilose, in life succulent, drying papery, asymmetric, ovate to slightly falcate, 9.5–13.5 × 4.5–5.2 cm, broad side 2.5–3.5 cm, narrow side in falcate leaves slightly concave, base cordate, unequal, basal lobe 0.8–1 cm long, margin finely serrate, apex acuminate, acumen 4–15 mm long; venation palmate-pinnate, c. 4 veins on each side, 4 veins on basal lobe, branching 1–2 times towards the margin, concolorous, slightly impressed above, prominent beneath. **Inflorescences** erect, from the upper leaf axils, greenish, unbranched, 3–5.5 cm long, peduncle c. 1.5 cm long. **Bracts** pale green, ovate, c. 12 × 7–9 mm, margin fringed by hairs to 2 mm long, persistent; bracteoles up to 9 pairs per inflorescence, pale green, ovate, lower bracteoles 10–12 × 7–9 mm, upper ones c. 8 × 7 mm, margin fringed by hairs to 2 mm long, persistent. **Male flowers** with white

glabrous pedicels, 8–12 mm long; tepals 2, white, glabrous, margin entire, apex acute, 6–8 × 5–6 mm; stamens 7–10, cluster loosely globose, stalked to 1 mm long, filaments 0.8–1 mm long, anthers pale yellow, obovate, 0.6–1 × 0.2–0.5 mm, apex emarginate. **Female flowers** with pale green and pilose pedicels, 7–10 mm long; tepals 5, greenish white, hairy outside, glabrous inside, margin toothed on the upper half, apex broadly acute, outer 3 tepals elliptic, 8–11 × 5–7 mm, inner 2 tepals narrowly elliptic, c. 9 × 5 mm; ovary pale green, slightly darker and pilose on the wings, 12–16 × 9–14 mm, wings 3, equal, 3–4 mm wide, locules 3, placentas 2 per locule; styles 3, pale yellow, 4–5 mm long; stigma pale yellow, deeply Y-shaped, papillose, forming a continuous twisted band. **Capsules** single, pale green, 9–14 × 8–12 mm, locules 3, wings 3, equal, acute proximally and truncate distally, 2–4 mm wide, dehiscing between the locules and wings; pedicel in fruit straight, pale green, glabrous, 6–7 mm long.

**Etymology.** Latin, *devexus* = sloping downwards; referring to the leaves that point downwards against the steep slope on which they grow.

**Distribution.** Endemic in Sarawak, as yet known only from Lanjak Entimau WS.

**Habitat.** Steep earth or rocky slopes in riparian forest at 370 m elevation, in semi-shaded area.

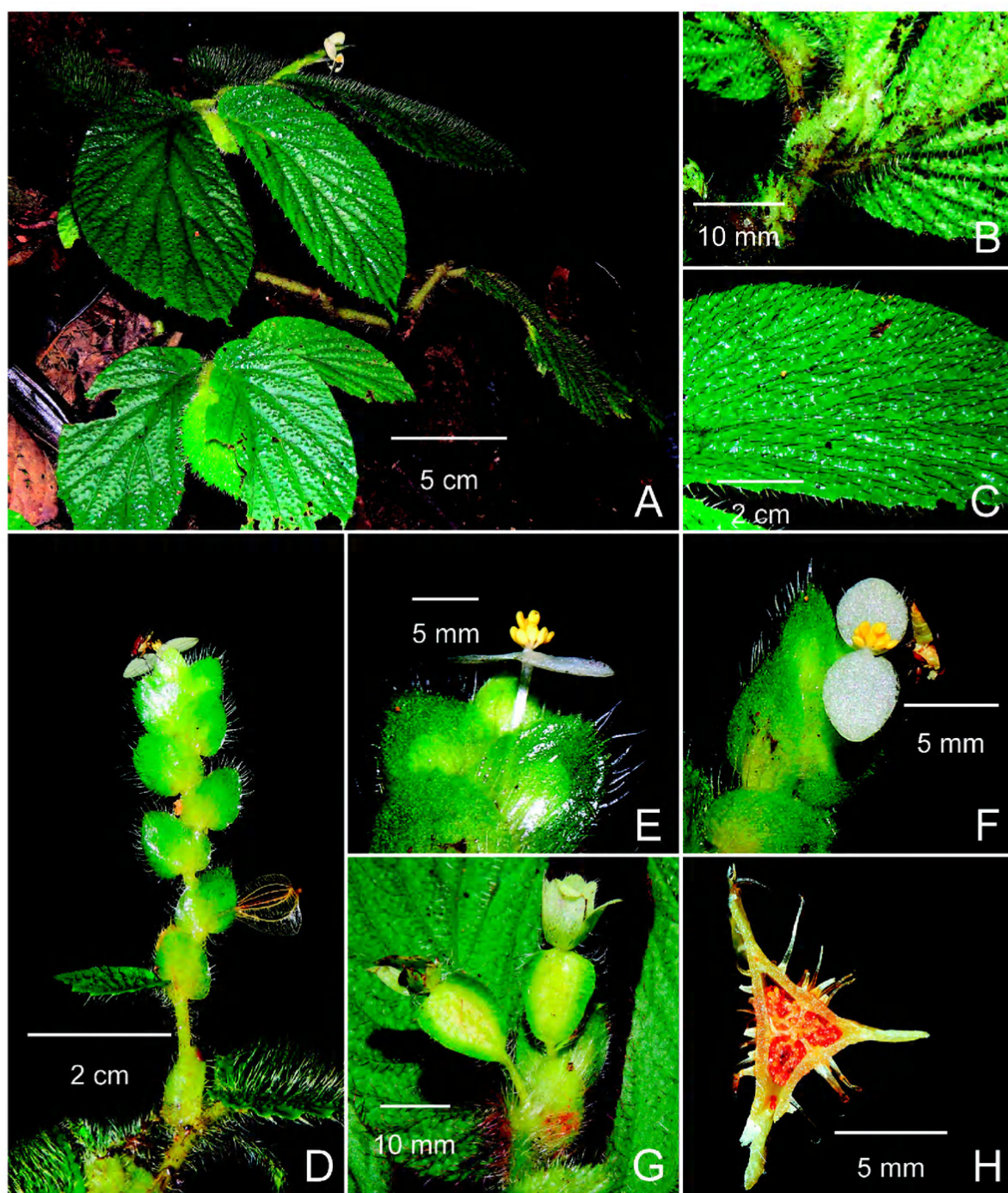
**Notes.** Falcate leaves are unusual among Bornean begonias and are only seen in narrow-leaved species, like *Begonia eutricha* Sands and *B. melanosticta* F.Y.Chong & V.S.Guanh. Even so, the curvature is not pronounced and nor are all leaves on a single plant noticeably falcate. *Begonia devexa* is also notable in having very few stamens compared with most species that have at least ten and frequently more than twenty. *Begonia baramensis* has the most, 49–84 stamens.

### 5. *Begonia fractiflexa* S.Julia & Kiew, **sp. nov.** (Section Uncertain)

Similar to *Begonia bosuangiana* S.Julia in its rounded, hairy leaves but it differs in its long creeping wiry stem (vs. stem to 4 cm long), its very small stipule c. 4 × 2 mm and lamina 1.5–3 × 2–2.5 cm (vs. stipule c. 6 × 4 mm and lamina c. 5 × 5.3 cm), larger tepals, 5–6 × 5 mm in the female flower (vs. 3 × 2 mm), and capsule 5–6 × 5 cm with narrower wings 1–1.5 mm wide (vs. capsule broader than long, 5–6 × 9–12 mm with wider wings 6–9 mm wide). –**TYPE:** Malaysia, Borneo, Sarawak, Lubok Antu District, Ulu Engkari, Lanjak Entimau WS, Sungai Jela, 1°25'50"N 112°00'07"E, 366 m, 14 March 2016, *Julia et al.* SFC3466 (holotype SAR!; isotypes KEP!, SING!, SNP!). (Fig. 5)

Creeping wiry herb to 28 cm long. **Stem** and petiole densely woolly, dark or reddish brown, c. 2 mm thick, unbranched; internodes 1.5–2.6 cm long, slightly thicker at nodes. **Stipules** brownish green, lanceolate, c. 4 × 2 mm, margin ciliate, apex setose, seta to 1 mm long, persistent. **Leaves** alternate, distant, not oblique, held horizontally;





**Fig. 4.** *Begonia devexa* S.Julia & Kiew. **A.** Habit. **B.** Stipule and lower leaf surface. **C.** Upper leaf surface. **D.** Male inflorescence and old fruit. **E, F.** Male flower. **G.** Female flowers. **H.** Cross-section of ovary. From the type *SFC3457*. (Photos: A–G, S. Julia; H, C.Y. Ling)

petioles red brown, 1.5–3.4 cm long, terete; lamina plain mid-green and hirsute above, hairs blackish, pale green and glabrous beneath, in life succulent, sometime iridescent, more or less symmetric, rounded,  $1.5\text{--}3 \times 2\text{--}2.5$  cm, base cordate, margin finely serrate, apex rounded; venation palmate, veins 6, prominent above, raised below. Inflorescences protogynous, axillary on upper parts of the stem, with one female

flower on a lower branch and up to 3 male flowers on upper branch, zig-zag, erect, 4.5–7.5 cm long, red or pinkish or white towards apex. **Bracts** deep red, lanceolate, c.  $4 \times 2$  mm, margin ciliate, persistent; bracteoles white or reddish (lower bracteoles of female inflorescence), ovate, c.  $3 \times 2$  mm, margin toothed, up to 5 pairs, persistent. **Male flowers:** pedicel white, c. 8 mm long, glabrous; tepals 4, completely white, glabrous, outer 2 tepals oblong, c.  $8 \times 5$  mm, margin entire, apex rounded, inner 2 tepals lanceolate, c.  $7 \times 3$  mm, margin entire, apex acute; stamens c. 14, cluster conical, sessile, filaments pale yellow, c. 1 mm long, anthers pale yellow, obovate, c.  $0.8 \times 0.3$  mm, apex emarginate. **Female flowers:** pedicel pale pink, 1–3 mm long, glabrous; tepals 5, white, outer 4 tepals elliptic, c.  $6 \times 4$  mm, margin entire, apex acute, innermost tepal lanceolate, c.  $5 \times 2$  mm; ovary pinkish, wings white, c.  $6 \times 8$  mm, glabrous, wings 3, equal, locules 3, placenta 1 per locule; styles 3, pale yellow, c. 2 mm long, divided to base, anchor-shaped; stigma pale yellow, papillose, forming a continuous twisted band. **Capsules** (old) 2 per stalk, single on the lower branch,  $5\text{--}6 \times 5$  mm, glabrous, locules 3, wings 3, equal, acute proximally and distally, 1–1.5 mm wide, thinly fibrous, dehiscing between locule and wing; pedicel in fruit pendent, thread-like, 5–7 mm long.

*Etymology.* Latin, *fractiflexus* = zig-zag, referring to the shape of the rachis in the male inflorescence.

*Habitat.* Riparian forest below 400 m elevation. Growing on steep earth slopes or on sandstone boulders with thin layer of soil, in semi-shaded area.

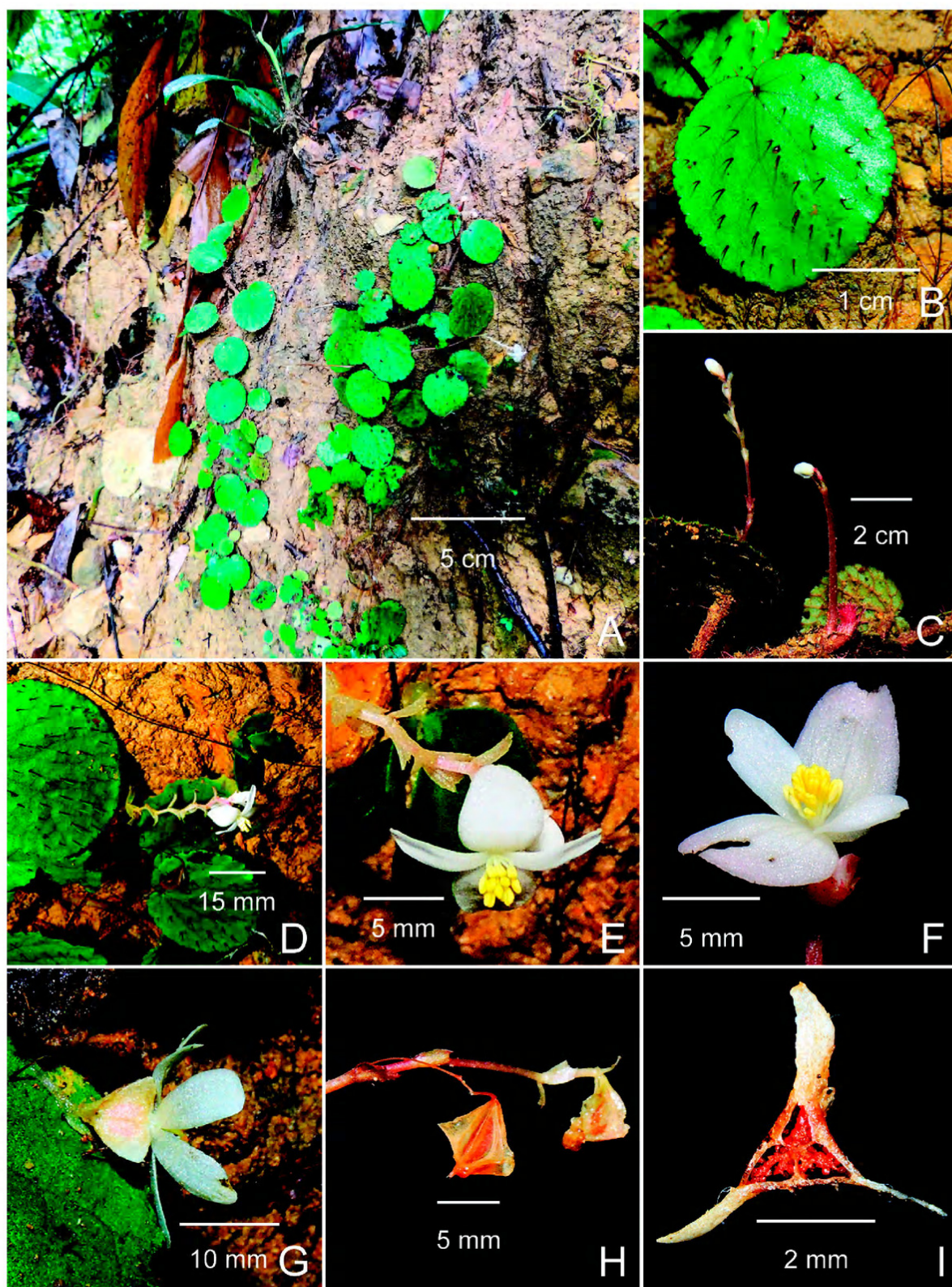
*Distribution.* Endemic to Sarawak and so far only known from the type locality.

*Note.* Doorenbos et al. (1998) highlighted the importance of the number of placentas per locule in assigning species to sections. Bornean species with one placenta, as in this species, are placed in *Begonia* sect. *Reichenheimia*. However, *Begonia fractiflexa* is anomalous for this section in being protogynous and lacking a rhizome, both diagnostic characters for *Begonia* sect. *Petermannia*. In addition, many species in *Begonia* sect. *Reichenheimia* have peltate leaves. More specimens in all stages of development of the ovary and fruit are needed to ascertain whether the single placenta in *Begonia fractiflexa* is the result of the failure of one placenta to develop.

#### 6. *Begonia hirtitepala* S.Julia & Kiew, **sp. nov.** (Section *Petermannia*)

In its cane-like habit, broad obovate leaves and male flowers with 2 tepals, it is similar to *Begonia flavovirens* Kiew & S.Julia but it differs in the hispid indumentum on its stem, leaves, flowers and fruits, in its broader lamina  $12.5\text{--}18 \times 5.5\text{--}11$  cm (vs. laminae  $11\text{--}18 \times 5.5\text{--}9$  cm), smaller stipule  $8\text{--}18 \times 3\text{--}4$  mm (vs. c.  $20 \times 7$  mm), female flower with 3, rarely 4 tepals (vs. 5 tepals) and smaller capsules wider than long, c.  $9 \times 16$  mm (vs. capsules  $10\text{--}24 \times 10\text{--}19$  mm). – **TYPE:** Malaysia, Borneo, Sarawak, Lubok Antu District, Batang Ai NP, Sungai Kenaban,  $1^{\circ}18'42''\text{N}$   $112^{\circ}04'22''\text{E}$ , 19 March 2016, Julia et al. SFC6614 (holotype SAR!; isotypes KEP!, SING!, SNP!). (Fig. 6)





**Fig. 5.** *Begonia fractiflexa* S.Julia & Kiew. **A.** Habit. **B.** Hairy upper leaf surface. **C.** Young inflorescence. **D.** Male inflorescence. **E, F.** Male flower. **G.** Female flower. **H.** Fruits. **I.** Cross-section of ovary. From the type *SFC3466*. (Photos: A–H, S. Julia; I, C.Y. Ling)

Erect begonia to 1.6 m tall. **Indumentum** of stem, stipules, petioles, bract and bracteoles densely hispid, hairs dark brown to whitish towards apex, 3–6 mm long. **Stem** much-branched, dark brown or blackish, succulent, slender, 5–9 mm thick, internodes (2–)4.5–9 cm long, thicker at nodes. **Stipules** pale green, lanceolate, 8–18 × 3–4 mm, margin entire, keeled, apex setose, seta 2–5 mm long, caducous. **Leaves** alternate, distant, held vertically, slightly oblique; petiole greenish, 0.9–1.8 cm long, slightly grooved above; lamina plain dark green above, paler beneath, sprinkled with hairs above, hairs c. 1 mm long, in life slightly succulent, matt, slightly asymmetric, obovate, 12–18 × 5–10 cm, broad side 3–6 cm wide, base unequal, basal lobe rounded, 0.6–0.8 cm long, margin hispid, minutely dentate, apex acuminate, acumen 5–1.3 mm long; venation pinnate, veins 5–6 pairs, concolorous on both surfaces, densely pilose, 1–2 veins in basal lobe, impressed above, raised below. **Inflorescences** protogynous, dense panicle, densely hispid, 3–7 cm long. **Bracts** pale green, lanceolate, 15–22 × 4–8 mm, keeled, margin hispid, apex setose, seta to 1 mm long, persistent; bracteoles similar to bracts, lanceolate, persistent, lower bracteoles 11–18 × 2–5 mm, upper ones 5–9 × 2 mm. **Male flowers** with white pedicels, 2–7 mm long; tepals 2, white, densely hispid outside, hairs white, to 2 mm long, glabrous inside, oval, 5–7 × 4–5 mm, margin entire, apex acute; stamens 30–34, cluster conical, stalked to 0.8 mm long, filaments 0.8–1 mm long, anthers pale yellow, obovate, 0.8–1 × 0.3–0.5 mm, apex emarginate. **Female flowers** with greenish pedicels 3–5 mm long, sparsely hairy; tepals 3, rarely 4, white or greenish, hirsute outside, glabrous inside, ovate, 7–8 × 4–5 mm, margin toothed, teeth tipped by a hair, apex acute; ovary greenish, reddish in the centre, sparsely hairy, ovate, 10–11 × 12–13 mm, wings 3, equal, locules 3, placentas 2 per locule; styles 3, pale green; stigma shallowly Y-shaped, 2–3 mm long, divided to base, papillose, forming a continuous twisted band. **Capsules** single or in pairs, axillary, hispid, 7–12 × 8–13 mm, truncate proximally, distally with pointed tip, locules 3, wings 3, equal, wings 4–7 mm wide, papery, dehiscing between the locule and wing; pedicel in fruit 2–6 mm long, pale green.

**Etymology.** Latin, *hirtus* = softly hairy; *tepals* = tepal; referring to the conspicuously hairy tepals.

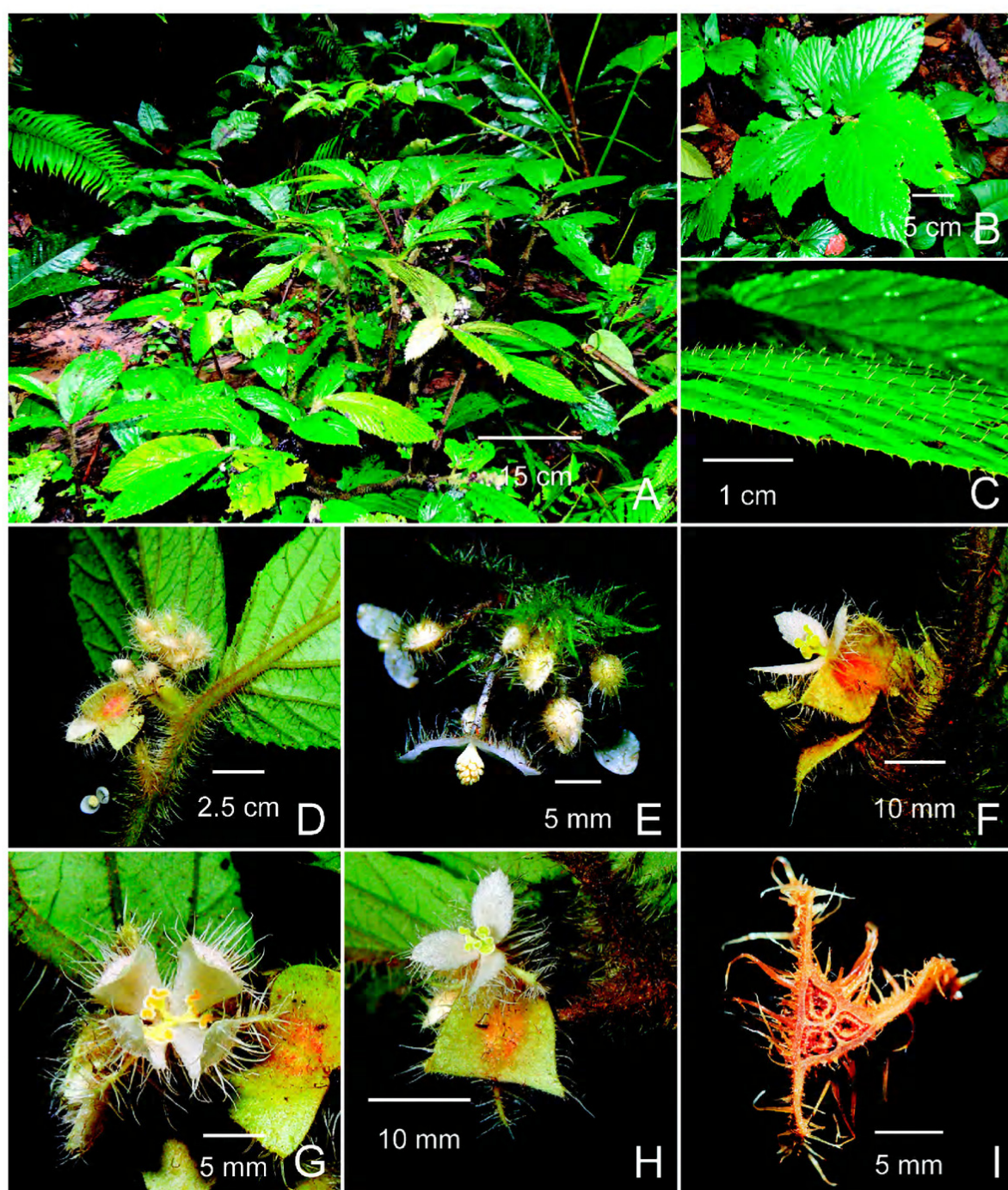
**Distribution.** Endemic in Sarawak, known from Batang Ai NP and Lanjak Entimau WS.

**Habitat.** Riparian forest below 200 m elevation on gentle slopes in deep shade along slightly disturbed riverbank.

**Additional specimen examined.** MALAYSIA: **Sarawak:** Song District: Ng. Biladajat, Ulu Sg. Mujok, Lanjak Entimau WS, 28 Feb 2003, *Rantai et al.* S90586 (SAR!, KEP, K, L).

**Notes.** Among begonias in Batang Ai NP (Julia & Kiew, 2016), in its habit and hispid leaves *Begonia hirtitepala* is most similar to *B. edgariana* S. Julia & Kiew but it is different in its longer petiole, much larger lamina (6–14 × 2.5–6.5 cm) and dense panicle inflorescence with 3 tepals in the female flowers.





**Fig. 6.** *Begonia hirtitepala* S.Julia & Kiew. **A, B.** Habit; **C.** Hairy upper leaf surface. **D.** Inflorescence. **E.** Male inflorescence. **F, G.** Female flower. **H.** Female flower and fruit. **I.** Cross-section of ovary. From the type *SFC6614*. (Photos: A–H, S. Julia; I, C.Y. Ling)

**7. *Begonia jamilahanuiana* S.Julia, *sp. nov.* (Section *Petermannia*)**

This species resembles *Begonia malachosticta* Sands in its habit and narrowly ovate leaves that are spotted in the adult plant but it differs in the spots being white (vs. bright pink in *B. malachosticta*), male flowers with 2 tepals (vs. 4 tepals), fewer stamens 27–32 (vs. stamens 75–85 in *B. malachosticta*) and smaller capsules 11–17 × 11–15 mm

with unequal wings (vs.  $20\text{--}25 \times 10\text{--}15$  mm with equal wings). – TYPE: Malaysia, Borneo, Sarawak, Lubok Antu District, Lanjak Entimau, Tinteng Kuap,  $1^{\circ}24'31''\text{N}$   $112^{\circ}00'18''\text{E}$ , 590 m, 12 March 2016, *Julia et al.* SFC3446 (holotype SAR!; isotypes KEP!, SING!). (Fig. 7)

Cane-like begonia, whole plant glabrous. **Stems** to 60 cm tall, little-branched, dark red, slender, 4–5 mm thick; internodes 3–7 cm long. **Stipules** caducous. **Leaves** distant, held more or less vertically, oblique; petioles red brown, 3.3–6 cm long, succulent; lamina dark green with white spots between veins above, white spots persistent on adult plant, pale green beneath, succulent, drying papery, asymmetric, broadly lanceolate,  $6\text{--}13 \times 2.5\text{--}5$  cm, broad side 1.5–4.7 cm long, base cordate, unequal, basal lobe 2.3–5 cm long, margin shallowly dentate, apex acuminate, acumen 1.3–2.5 cm long; venation palmate-pinnate with 3–4 veins at the base, to twice branching towards the margin and 3–4 veins on either side of the midrib, red brown on both surfaces, slightly raised above, prominent beneath. **Inflorescences** protogynous, axillary in upper leaf axils, paniculate, 7–15 cm long, peduncle 1.3–12 cm long. **Bracts** red, ovate,  $6\text{--}7 \times 3\text{--}4$  mm, margin entire, keeled, apex setose, seta to 2 mm long, caducous; bracteoles 3–6 pairs,  $2\text{--}6 \times 2\text{--}5$  mm, margin toothed, persistent. **Male flowers** with reddish pedicels, 6–11 mm long; tepals 2, reddish at base, otherwise yellowish, greenish or pinkish, ovate,  $6\text{--}7 \times 5$  mm; stamens 27–32, cluster globose, sessile, filaments yellow, c. 1 mm long, anthers yellow, obovate, c.  $0.8 \times 0.5$  mm, apex emarginate. **Female flowers** with reddish or reddish green pedicels, 5–6 mm long; tepals 5, yellowish, outer 3 tepals elliptic, c.  $7 \times 5$  mm, margin entire, apex acute, inner 2 tepals narrowly elliptic, c.  $6 \times 3$  mm; ovary pale green,  $17\text{--}20 \times 13\text{--}15$  mm, wings 3, unequal, 2–4 mm wide, locules 3, placentas 2 per locule; styles 3, yellowish, c. 2 mm long; stigma yellowish, deeply Y-shaped, papillose, forming a continuous twisted band. **Capsules** in life pale green or reddish green,  $11\text{--}17 \times 11\text{--}15$  mm, locules 3, wings 3, unequal, narrow wing acute to rounded proximally, narrowly to broadly rounded distally, c. 2 mm wide, two broader wings truncate proximally and distally, c. 4 mm wide, dehiscing between the locules and wings; pedicel in fruit pendent, reddish, 5–10 mm long.

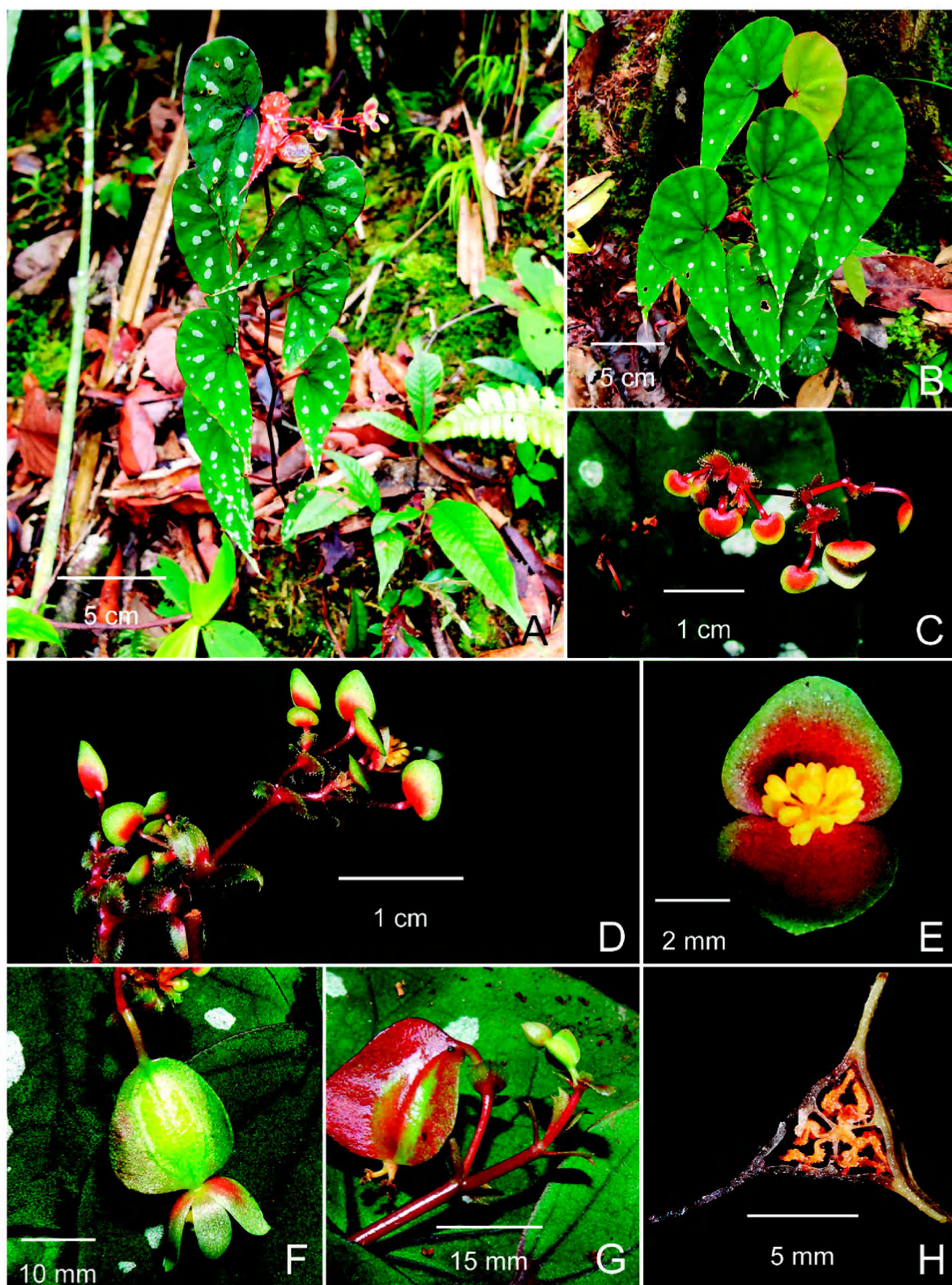
**Etymology.** Named in honour of YA Bhg. Datin Patinggi Dato Hajah Jamilah bt. Haji Anu, wife of the fifth and current Chief Minister of Sarawak.

**Distribution.** Endemic in Sarawak, as yet known only from Lanjak Entimau WS and Batang Ai NP.

**Habitat.** Hill mixed dipterocarp forest below 600 m elevation, on shaded ridges with a thick layer of leaf litter on loamy clay soils.

**Notes.** It is an attractive begonia unusual in retaining its white spots even in adult plants. Many begonias have spotted juvenile foliage but usually the spots gradually disappear in the older leaves. Distinctly unequal wing width in capsules in *Begonia* sect. *Petermannia* is extremely unusual. The most extreme case is seen in *Begonia*





**Fig. 7.** *Begonia jamilahanuiana* S. Julia. **A.** Habit of flowering plant. **B.** Habit of young plant. **C, D.** Male inflorescence. **E.** Male flower. **F.** Female flower. **G.** Fruit. **H.** Cross-section of ovary. From the type *SFC3446*. (Photos: A–G, S. Julia; H, C.Y. Ling)

*amphioxus* where one wing and one locule may not develop at all. However, an examination of *Begonia amphioxus* in the field shows that there is a complete continuum from capsules with three locules and three equal wings to those with three locules and two wings, the third being much reduced in size, to capsules with two locules and two wings (Kiew, 2001).

Among species in the Batang Ai NP (Julia & Kiew, 2016), it most resembles *Begonia acidulenta* that also has a cane-like habit, flowers in branched inflorescences and spotted leaves. *Begonia acidulenta* differs from *B. jambilahanuiana* in losing its spots in adult plants, in its much larger leaves  $14\text{--}22 \times 10.5\text{--}17$  cm with petioles 4.3–8.5 cm long and its male flowers with 4 tepals, not 2 as in *B. jambilahanuiana*.

The habitat of *B. jambilahanuiana* on shaded ridges is unusual because begonias usually grow in valleys or close to streams.

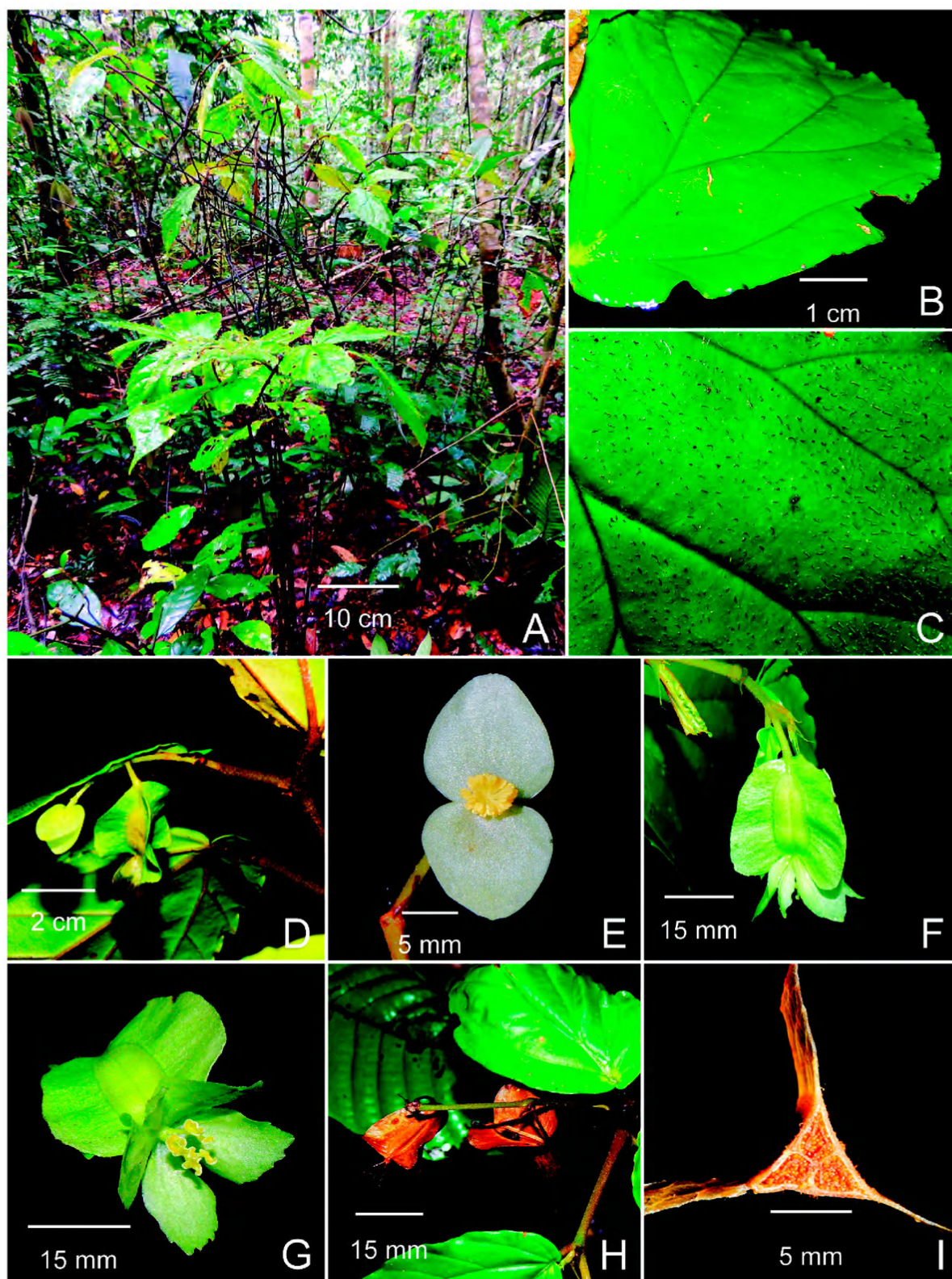
*Additional specimen examined.* MALAYSIA: **Sarawak:** Lubok Antu District: Batang Ai NP, Lubang Baya, Lubok Aping trail, 17 Mar 2016, *Shalih et al.* SFC6567 (SAR!, SING!).

### 8. *Begonia ubahribuensis* S. Julia & Kiew, **sp. nov.** (Section *Petermannia*)

This species resembles *Begonia lailana* Kiew & Geri in its cane-like habit, glabrous female flower with toothed tepals and similar fruits but it differs in having shorter internodes, 3.5–4.5 cm long (vs. 7–11 cm long), smaller stipules,  $5\text{--}7 \times 2$  mm (vs.  $15\text{--}27 \times 6\text{--}10$  mm), shorter inflorescence, 2–5.5 cm long (vs. 10–15 cm long), smaller tepals in male flower,  $9\text{--}12 \times 9\text{--}12$  mm (vs.  $15\text{--}18 \times 9\text{--}10$  mm) and larger outer and inner tepals in female flower, respectively  $15\text{--}16 \times 6\text{--}10$  mm and  $15\text{--}16 \times 6\text{--}10$  mm (vs.  $6\text{--}12 \times 3\text{--}8$  mm and  $4\text{--}10 \times 3\text{--}7$  mm respectively). –TYPE: Malaysia, Borneo, Sarawak, Lubok Antu District, Ulu Engkari, Lanjak Entimau WS, Nanga Segerak, trail to Ubah Ribu,  $1^{\circ}25'12''\text{N}$   $112^{\circ}00'16''\text{E}$ , 506 m, 15 March 2016, *Julia et al.* SFC3462 (holotype SAR!; isotypes KEP!, SING!, SNP!). (Fig. 8)

Erect begonia to 1.57 m tall. **Stem** unbranched to much-unbranched, blackish or greenish, pubescent, slightly woody, slender, 6–8 mm thick, internodes 3.5–4.5 cm long, thicker at nodes. Stipules pale green, lanceolate,  $5\text{--}7 \times 2$  mm, margin entire, apex setose, seta to 2 mm long, caducous. **Leaves** alternate, distant, held more or less horizontally, slightly oblique; petiole dull red-brown, 0.4–0.8 cm long, slightly grooved above; lamina plain mid-green above, paler beneath, glabrous on both surfaces or hirsute above, hairs brownish or dark brown, glabrous below, in life slightly succulent, matt, slightly asymmetric, obovate, elliptic or ovate,  $10\text{--}17.5 \times 4.3\text{--}7$  cm, broad side 2.5–4.5 cm wide, base unequal, basal lobe rounded, 0.3–0.8 cm long, margin dentate and wavy, apex acuminate, acumen 10–20 mm long; venation pinnate, 3–5 veins on each side of the midrib, concolorous, glabrous, 2–3 veins in basal lobe, strongly impressed above, raised below. **Inflorescences** protogynous, glabrescent, racemose, 2–5.5 cm long, peduncle 1–2.5 cm long. **Bracts** pale green, lanceolate,  $7\text{--}12 \times 2$  cm, apex setose, seta to 3 mm long, caducous, bracteoles similar but slightly smaller,  $5\text{--}10 \times 2$  mm, caducous. **Male flowers** with pale green pedicels, 4–10 mm long; tepals 2,





**Fig. 8.** *Begonia ubahribuensis* S. Julia & Kiew. **A.** Habit. **B.** Glabrous upper leaf surface. **C.** Hairy upper leaf surface. **D.** Inflorescence and old fruit. **E.** Male flower. **F, G.** Female flower. **H.** Fruit. **I.** Cross-section of ovary. A, C–H from *SFC3462*; B from *SFC3460*; I from *SFC3462*. (Photos: A–H, S. Julia; I, C.Y. Ling)

pale green or greenish yellow, glabrescent outside, hairs whitish, glabrous inside, oval,  $9-12 \times 9-12$  mm, margin entire, apex broadly acute; stamens 38–46, cluster globose, sessile, filaments 0.8–1 mm long, anthers pale yellow, obovate,  $0.9-1 \times 0.5$  mm, apex emarginate. **Female flowers** with greenish pedicels, 5–7 mm long, glabrescent; tepals 5, greenish or greenish yellow, glabrescent outside, glabrous inside, ovate or elliptic, outer 4 tepals  $15-18 \times 9-10$  mm, inner tepal  $15-16 \times 6-10$  mm, margin entire or toothed on the upper half, apex acute; ovary greenish, glabrescent, obovate,  $14-18 \times 19-22$  mm, wings 3, equal, locules 3, placentas 2 per locule; styles 3, greenish yellow; stigma deeply Y-shaped, 3 mm long, divided to base, papillose, forming a continuous twisted band. **Capsules** up to 3 per infructescence, axillary, glabrescent,  $10-20 \times 11-20$  mm, acute proximally, truncate or rounded distally, locules 3, wings 3, equal, wings 7–14 mm wide, papery, dehiscing between the locule and wing; pedicel in fruit pendent, 6–12 mm long, pale green.

*Etymology.* Named for the Ubah Ribu trail in Lanjak Entimau WS where it was commonly found.

*Distribution.* Endemic in Sarawak, known only from the Lanjak Entimau WS.

*Habitat.* Mixed dipterocarp forest on gentle slope along the ridge in semi-shaded areas.

*Notes.* Individual plants observed in Lanjak Entimau WS vary in having blackish or greenish stems, lamina either completely glabrous on both sides or sprinkled with hirsute black hairs above, glabrous below and the margin of tepals in female flower either entire or toothed. It is common where it occurs.

*Additional specimens examined.* MALAYSIA: **Sarawak:** Lubok Antu District: Ulu Engkari, Lanjak Entimau WS, Tinting Jela along Ubah Ribu trail, 14 Mar 2016, *Julia et al.* SFC3460 (SAR!, SING!); Song District, Lanjak Entimau WS, 19 Mar 1998, *Pearce et al.* S77628 (SAR!).

**ACKNOWLEDGEMENTS.** We gratefully acknowledge financial assistance from Sarawak Forestry Corporation for supporting the field work under RIMBA SARAWAK project. We are indebted to the management team of Sarawak Forestry Corporation, Chief Executive Officer, Deputy General Managers and Regional Managers, for their continuous support and guidance. We thank our fellow colleagues from Lanjak Entimau WS, Batang Ai NP and AFSID for their valuable assistance and cooperation during the field work. Also thanks to the visiting researchers from Singapore Botanic Gardens (Michele Rodda and Paul Leong) for their participation during the first author's trip, to the Curator of Sarawak Herbarium, Hajjah Mohizah Mohamad, for allowing us to access the herbarium specimens in her care, and to Daniel C. Thomas for his helpful suggestions for improving the manuscript. Lastly, we thank Ling Chea Yiing for her assistance in preparing the plates and for providing the photographs.



## References

- Chai, P.P.K. (2011). *The Lanjak Entimau Story: Changing Landscape in Biodiversity Conservation*. 155 p. Sarawak, Kuching: International Tropical Timber Organisation and Forest Department Sarawak.
- Doorenbos, J., Sosef, M.S.M. & De Wilde, J.J.F.E. (1998). The sections of *Begonia* including descriptions, keys and species lists (Studies in Begoniaceae VI). *Wageningen Agric. Univ. Pap.* 98(2): 1–266.
- IUCN (2012). *IUCN Red List Categories and Criteria: Version 3.1*. Second edition. Switzerland, Gland & UK, Cambridge: IUCN.
- Julia, S. & Kiew, R. (2016). *Begonia* (Begoniaceae) from Batang Ai National Park and the adjacent area, Sarawak, Borneo, including six new species. *Phytotaxa* 252(1): 17–30.
- Kiew, R. (2001). The limestone begonias of Sabah, Borneo – Flagship species for conservation. *Gard. Bull. Singapore* 53: 241–286.
- Meekiong, K., Ampeng, A., Madeline, G.P., Ipor, I.B., Sapuan, A. & Mohamed, H. (2010). *The Heart of Borneo Series – Lanjak Entimau Wildlife Sanctuary: Sarawak's Hidden Jewel*. Kuching: Forest Department Sarawak & Universiti Malaysia Sarawak.
- Lin, C.W., Chung, S.W. & Peng, C.-I. (2014). *Begonia baik* and *B. padawanensis* spp. nov. (Begoniaceae) from sandstone areas in Sarawak, Malaysia. *Nordic J. Bot.* 33(5): 1–7.



Sang, Julia and Kiew, Ruth. 2016. "Eight new Begonia (Begoniaceae) species from the Lanjak Entimau Wildlife Sanctuary and Batang Ai National Park, Sarawak, Borneo." *The Gardens' bulletin, Singapore* 68(2), 257–277.

<https://doi.org/10.3850/s238258121600020x>.

**View This Item Online:** <https://www.biodiversitylibrary.org/item/223196>

**DOI:** <https://doi.org/10.3850/s238258121600020x>

**Permalink:** <https://www.biodiversitylibrary.org/partpdf/229553>

#### **Holding Institution**

Singapore Botanic Gardens, National Parks Board Singapore

#### **Copyright & Reuse**

Copyright Status: In copyright. Digitized with the permission of the rights holder.

License: <http://creativecommons.org/licenses/by-nc-sa/4.0/>

Rights: <https://biodiversitylibrary.org/permissions>

This document was created from content at the **Biodiversity Heritage Library**, the world's largest open access digital library for biodiversity literature and archives. Visit BHL at <https://www.biodiversitylibrary.org>.