SYSTEMATIC STUDIES OF BORNEAN *ZINGIBERACEAE*: II. *ELETTARIA* OF SARAWAK

S. SAKAI* & H. NAGAMASU†

Elettaria (*Zingiberaceae*) of Sarawak are studied, and eight species are recognised including four new species: *E. linearicrista*, *E. longipilosa*, *E. brachycalyx* and *E. kapitensis*. *Elettaria surculosa* and *E. stolonifera,* which have previously been included in *E. multiflora*, are treated as independent species. Examination of recent collections reveal that characters such as anther dehiscence patterns, form of the labellum and anther crest are taxonomically important. A key to all species of Bornean *Elettaria* is provided.

Keywords. *Alpineae*, Borneo, *Elettaria*, Sarawak.

INTRODUCTION

The genus *Elettaria* (*Zingiberaceae*) is characterized by frond-like leaf shoots, long, prostrate inflorescences born from the rhizome, and flowers in cincinni with tubular bracteoles. Including cardamom *E. cardamomum* Maton, about seven species are known from Sri Lanka to Malaysia and Indonesia (Smith, 1986). Although many species were described under *Elettaria* after the genus had first been described in 1811, currently most of them are regarded to be members of other genera such as *Etlingera*, *Hornstedtia* and *Amomum*, and only two species, *E. cardamomum* and *E. major*, were included in the genus by Schumann (1904). He considered that lax inflorescences, absence of anther crest, and floral colour were important characters to distinguish *Elettaria*. However, Holttum (1950) recognised that inflorescence structure with flowers in cincinni was the most important character of the genus, and indicated that several other species should belong to the genus because they had identical inflorescence structure with *E. cardamomum* and *E. major*.

After the monograph by Schumann (1904) and Ridley's study of the *Scitamineae* of Borneo (Ridley, 1906), Smith (1986) was the next to revise Bornean *Elettaria*. Although Holttum (1950) revised *Zingiberaceae* in Peninsular Malaysia and gave important suggestions about the genus, only one species of *Elettaria*, *E. longituba*, was included in his list. Smith (1986) recognised three species of *Elettaria* from Borneo: *E. rubida* R.M. Sm., *E. longituba* (Ridl.) Holttum, and *E. multiflora* (Ridl.) R.M. Sm. *E. rubida* was distinguished by yellow-orange flowers, while the flowers are usually white and yellow in the other species. *E. longituba* was characterized by fusion of the calyx and corolla tube above the ovary into a solid elongation, and robust leaf shoots with leaves up to 80cm long. The third species, *E. multiflora*, has

* Smithsonian Tropical Research Institute, Apartado 2072, Balboa, Ancón, Panama.
† The Kyoto University Museum, Kyoto University, Sakyo, Kyoto 606–8501, Japan.

white and yellow flowers, and free calyces and corolla tubes, according to the key provided by Smith.

Elettaria multiflora (Ridl.) R.M. Sm. was originally described from Sumatra. Bornean components of *E. multiflora* were first described as *Amomum surculosum* K. Schum. and *A. stoloniferum* K. Schum. in 1899, based on plants from Sarawak. After a few changes in generic position, these two taxa were united as *Elettaria surculosa* (K. Schum.) B.L. Burtt & R.M. Sm. (1972: 312), and later *E. surculosa* was subsumed under *E. multiflora* (Smith, 1986). At that time Smith noted great variation in leaf size within the species (Smith, 1986), and we found that hairiness of inflorescence axes, length of pedicels and calyx, bract size and intervals between bracts varied among the plants that she cited as *E. multiflora* or *E. surculosa* (Burtt & Smith, 1972; Smith, 1986). However, further investigation should await the availability of better material, because most specimens (including types) lack flowers for examination, and the descriptions by Schumann were not satisfactory.

Here we study *Elettaria* of Sarawak, which consists of eight species. We found that anther dehiscence pattern and fusion and elongation of corolla tube with calyx above the ovary have variation within the genus, and are useful characters to distinguish species. Based on examination of these characters in recent collections, we treat *E. surculosa* and *E. stolonifera* as independent species. In addition, four species, *E. linearicrista*, *E. longipilosa*, *E. brachycalyx* and *E. kapitensis* are described for the first time.

METHODS

Plant collections and observation were made from July 1994 to June 1995, from April 1996 to July 1996, and from December 1998 to January 1999 in Lambir Hills National Park (4°20′N, 113°50′E) and Kubah National Park (1°35′N, 110°15′E), Sarawak, Malaysia. Collected plants were pressed for herbarium specimens, and parts of flowers and inflorescences were preserved in 60% alcohol as suggested by Burtt & Smith (1976). Additional material was examined at the following herbaria: E, FI, K, KYO, SAR, and SING.

IMPORTANT CHARACTERS

Although variation in the two characters, anther dehiscence pattern and fusion and elongation of corolla tube and calyx above the ovary, within the genera have been noticed (Holttum, 1950; Burtt & Smith, 1972; Smith 1986), these characters were sometimes overlooked. Anther dehiscence pattern is one of a few floral characters that is preserved well in dried specimens. Fusion and elongation of corolla tube with calyx above the ovary can be observed in flower buds, calyx remaining after flowering, and in immature and mature fruits.

Apparently more than one species remains to be described from Sarawak, and

specimens from other area of Borneo are scarce or poorly studied. For further studies on the genus, the two characters may prove to be most useful.

Anther dehiscence pattern

Considerable variation in anther dehiscence patterns were found among species, and they are very useful to distinguish species. In *E. kapitensis*, the thecae are c.5mm long, and dehisce throughout their length (Figs 1A, 3D). Dehiscence by a slit much shorter than the thecae (or elongated pores) is observed in *E. stolonifera* (Figs 1B, 2E) and *E. rubida*. The other five species show anther dehiscence by pores. The pore of *E. surculosa*, *E. linearicrista*, *E. longipilosa* and *E. brachycalyx* is covered with a hairy flap (Figs 1C, 4F, 5A, 6B), which often seems to be a tuft of hairs just under the pore in the dried state. The pore of *E. longituba* is simple, and is not covered with a flap (Fig. 1D).

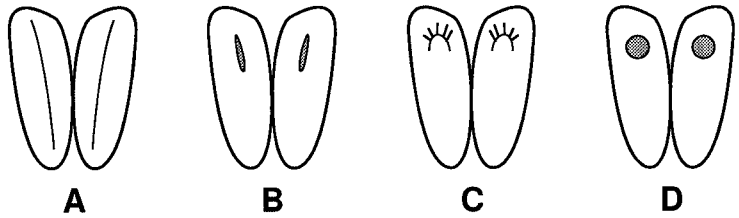

FIG. 1. A diagram showing different anther dehiscence patterns observed in *Elettaria*: A, anther dehiscence throughout the thecae (*E. kapitensis*); B, by slits much shorter than the thecae (*E. rubida* and *E. stolonifera*); C, by pores covered with hairy flaps (*E. brachycalyx*, *E. linearicrista*, *E. longipilosa*, and *E. surculosa*); and D, by pores without flap (*E. longituba*).

Elongation of corolla tube and calyx. In *E. longituba* and *E. stolonifera*, the corolla tube and calyx are fused together into a solid elongation for up to 5cm above the ovary (arrow in Fig. 2D). This condition was not found in the other species. The free part of the calyx varied from c.6mm in *E. brachycalyx* to c.20mm long in *E. rubida*, and is as long as or somewhat longer than the free part of the corolla.

Key to Bornean Elettaria *species*

1a. Inflorescence red with yellow-orange flowers; anther ecristate; leaves broadly obovate with attenuate base ——— **1. E. rubida**

1b. Inflorescence never red, flowers white and yellow; anther crested; leaves narrowly obovate, elliptic, or oblong with cuneate base ——— 2

2a. Anther dehiscing by pores without a hairy flap; petiole c.2.5cm long; robust plant with leaves up to 80cm long ——— **2. E. longituba**

2b. Anther dehiscing by slits or by pores covered with a hairy flap; leaves sessile or with very short petiole; more delicate plant with leaves up to 40cm long — 3

3a. Anther dehiscing by slits, never covered with a hairy flap; bract and calyx glabrous except for hairs around apex or on the margin, and calyx c.10mm or longer; pedicel very short ——— 4
3b. Anther dehiscing by pores with a hairy flap; at least part of bract or calyx ± pubescent, if not, calyx < 10mm long; pedicel elongate to c.10mm or longer ——— 5

4a. Anther dehiscing in upper half only; calyx 8–10mm long; corolla tube and calyx fused together into a solid elongation for up to 1.5cm above the ovary ——— **3. E. stolonifera**
4b. Anther dehiscing throughout their length; calyx 17mm long; corolla tube and calyx free above the ovary ——— **4. E. kapitensis**

5a. Labellum 16–28mm wide, broadly obovate; bracts 20–60mm long; leaf shoots totally glabrous ——— **5. E. surculosa**
5b. Labellum narrower, spathulate; bracts not exceeding 23mm; leaf shoots not totally glabrous ——— 6

6a. Anther crest with three linear lobes; main inflorescence axis densely pubescent; calyx pubescent ——— **6. E. linearicrista**
6b. Anther crest 3-lobed not linear; main inflorescence axis ± glabrous; calyx almost glabrous except at apex ——— 7

7a. Leaves prominently pubescent on the lower surface with long hairs; calyx 10–14mm long, fissured less than half of its length ——— **7. E. longipilosa**
7b. Leaves glabrous except for minute pubescence on the midrib of the lower surface; calyx c.6mm long, fissured for two thirds of its length ——— **8. E. brachycalyx**

1. Elettaria rubida R.M. Sm. in Bot. J. Linn. Soc. 85: 66, fig. 17a (1982).
Type: Sarawak, 4th division, G. Mulu National Park, N of camp 1, on clayey slope in hills in lowland rainforest, 200m, 13 ii 1978, *Hansen* 328 (holo. C; iso. E!, SAR!).

Other specimen examined. SARAWAK. 4th division, G. Mulu National Park, 2km of NE of camp 1, 250m, 7 iii 1978, *Nielsen* 582 (SAR).

2. Elettaria longituba (Ridl.) Holttum in Gard. Bull. Sing. 13: 238 (1950); R.M. Sm. in Bot. J. Linn. Soc. 85: 66 (1982) & Notes Roy. Bot. Gard. Edinb. 43: 462, fig. 4b (1986). **Fig. 8A.**
Type: Malay Peninsula, Pahang, streams and wet spots, Tahan, *Ridley* 2403 (K!, SING!).
Syn.: *Elettariopsis longituba* Ridl. in Trans. Linn. Soc. 3: 382 (1893) & in J. Str. Br. Roy. Asiat. Soc. 32: 156 (1899).
Cyphostigma longituba (Ridl.) K. Schum. in Pflanzenr. Zing., 274 (1904).
Elettariopsis aquatilis Ridl. in Kew Bull. 1925: 92 (1925). Type: Sumatra, Lubok Tandai, vii 1922, *Brooks* 7923 (K!).

Other specimens examined. SARAWAK. 4th division, Lambir Hills National Park, ht 2.5m, flower white, centre of the lip yellow, *S. Sakai* 201 (KYO, SAR); G. Mulu National Park, S. Melinau to S. Tarikan, petals and calyx reddish outside, white inside, lip white with frilly margin, central base yellow, 15 vi 1975, *Burtt* 8284 (E, SAR); 7th division, Ulu Belaga, S. Semawat, c.250m, hill dipterocarp forest, clayey river-bank in riverine forest, pedicel and calyx light green, tinged with red, lip white, with a yellow line down the throat, 21 x 1981, *Hansen* 741 (E, SAR).

3. Elettaria stolonifera (K. Schum.) S. Sakai & Nagam. **comb. nov. Figs 2, 8B.**

Type: Sarawak, 1st division, near Kuching, viii 1865, *Beccari* 365 (FI!).

Syn.: *Amomum stoloniferum* K. Schum. in Bot. Jahrb. 27: 323 (Oct. 1899).

Cyphostigma stoloniferum (K. Schum.) K. Schum. in Pflanzenr. Zing., 273 (1904).

Elettariopsis stolonifera (K. Schum.) Ridl. in J. Str. Br. Roy. As. Soc. 46: 242 (1906), ut 'stoloniferum'; Loesen. in Pflanzenfam. 2 Aufl., 15A: 603 (1930).

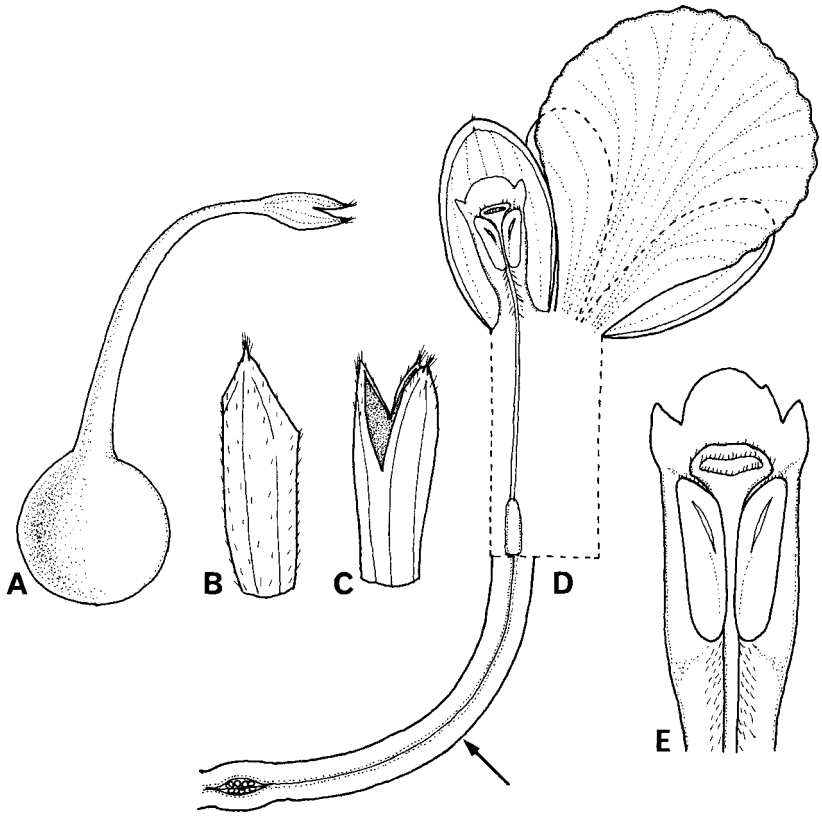

FIG. 2. *Elettaria stolonifera*: A, immature fruit, ×1.7; B, bracteole, ×2.8; C, free part of calyx, ×2.8; D, flower, dissected, ×2.8 (arrow: a solid elongation formed by corolla tube and calyx fused together between epigynous gland and ovary); E, anther and stigma, ×7 (from spirit material of *S. Sakai* 435).

Elettaria surculosa auct. non (K. Schum.) B.L. Burtt & R.M. Sm.: B.L. Burtt & R.M. Sm. in Notes Roy. Bot. Gard. Edinb. 31: 312 (1972), quoad syn. *Amomum stoloniferum.*

Elettaria multiflora auct. p.p., non (Ridl.) R.M. Sm.: R.M. Sm. in Notes Roy. Bot. Gard. Edinb. 43: 462 (1986), quoad syn. *Amomum stoloniferum.*

Perennial herb, 0.8–1.5m tall. *Leaves* c.9 pairs per shoot, congested in upper ⅓–½ of the shoot; lamina 20–30 × 1.7–3.5cm at the middle of the frond, linear to narrowly oblong, apex acuminate, base cuneate, sessile or with up to 3mm long petiole covered with minute hairs, glabrous on the upper surface, sparsely and minutely pubescent on the lower, denser on the midrib; ligule up to 3mm long, entire to shallowly bilobed, almost glabrous or sparsely pubescent with thick hairs, margin ciliate; sheath pubescent around the leaf base, margin ciliate near the base of the ligule. *Inflorescence* radical, 25–60cm long, linear, trailing on or near the ground surface; main inflorescence axis c.1mm diam. when dried, glabrous; scales 9–18mm long, tubular for varying length at the base, apex obtuse, glabrous or slightly pubescent near the apex only, margin sparsely ciliate; bracts 12–32mm long, distichously arranged at 10–40mm intervals, open to the base or tubular for basal c.2mm only, oblong, glabrous, apex apiculate, margin ciliate, subtending up to 6 flowers; secondary axis between bract and the first bracteole up to 10mm long, glabrous; bracteole c.11mm long, tubular at the base for c.5mm long, pubescent, apex obtuse and mucronate, long tufted hairs on the apical point; pedicel very short. *Flowers* white, corolla tube and calyx fused together into a solid elongation of various length up to 1.5cm long above the ovary; free part of the calyx c.10mm long, tubular for the basal half, glabrous, apex 3-toothed, mucronate and with long tufted hairs on the top of the teeth; free part of the corolla tube c.10mm long, glabrous; petals c.9mm long, c.6mm wide for the dorsal, c.5mm wide for the laterals, elliptic, almost glabrous; labellum c.16 × 13mm, obovate, pubescent on the centre of the basal half, white except central green line; filament c.2mm long, with hairs on the adaxial face at the centre; anther c.3mm long, dehiscing in upper half only, minutely pubescent at the apex; anther crest 3-lobed, central lobe semicircular c.1.5mm long, lateral lobes minute; style c.15mm long, glabrous; stigma c.1.5mm wide, with a dorsal opening, hair-fringed around the mouth, sparsely hairy outside; ovary c.3mm long, pubescent; epigynous gland c.1.5mm tall. *Fruit* unknown.

Other specimens examined. SARAWAK. 1st division, Kubah National Park, Sungai Layu, dipterocarp forest, along the trail near HQ, ht 1.2m, inflorescence creeping on the ground, flower white with green on the centre of the lip, 3 i 1999, *S. Sakai* 435 (KYO, SAR); ibidem, along a trail near Matang Wildlife Centre, on the edge of the forest, on humid, sandstone soil, flowers whitish yellow, 20 xii 1998, *Nishida* et al. 1331 (KYO, SAR).

This species is recognised by small leaves congested in upper half of the shoots in the field. In this species the corolla tube and calyx are fused into a solid elongation above the ovary, but the length varies from 0–1.5cm long. Within the genus this condition has previously been known only in *E. longituba.*

4. Elettaria kapitensis S. Sakai & Nagam., **sp. nov. Fig. 3.**
Haec species nova *Elettariae stoloniferae* (K. Schum) S. Sakai & Nagam. dehiscentia antherae lineari similis, sed differt anthera fere totam longitudinem dehiscentis, calyce longiore, tubo corollae et calyce non connati et non formantis elongatione supra ovarium.
Type: Sarawak, 7th division, Kapit district, Bukit Batu Tiban, Ulu Balleh Protected Forest, submontane forest 1000m a.s.l., terrestrial ginger, 70cm tall, runners and bracts dark brown, flowers white, 17 iv 1986, *Yii Puan Ching* et al. S52286 (holo. SAR, iso. E).

Perennial herb, 0.7m tall. *Leaves* 6–9 pairs per shoot, up to 22 × 5cm, narrowly oblong to obovate, apex acuminate, base cuneate, sessile, almost glabrous on the upper surface, pubescent on the lower on the midrib towards the base; ligule up to 3mm long, entire, glabrous or slightly pubescent; sheath glabrous. *Inflorescence* 40–60cm long, radical; main inflorescence axis c.1.0mm diam. when dried, slightly pubescent; bracts 17–30mm long, arranged at 12–35mm intervals, oblong, glabrous, apex obtuse and mucronate, glabrous, subtending up to 5 flowers; secondary axis between bract and the first bracteole 6–16mm long, slightly pubescent; bracteole c.11mm long, glabrous, apex obtuse and mucronate, with hairs on the apical point; pedicel very short. *Flowers* white, calyx c.17mm long, tubular, glabrous except around the apex, apex 3-toothed with tufted hairs on top of the teeth; corolla tube c.8mm long, glabrous; petals c.12mm long, linear to elliptic, glabrous; labellum white

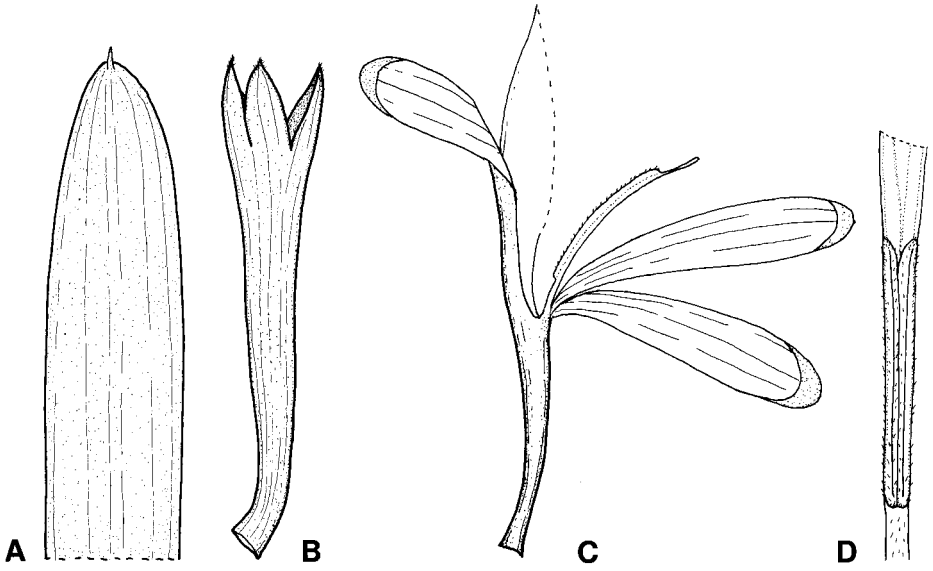

FIG. 3. *Elettaria kapitensis*: A, bract, × 3.5; B, calyx, × 3.8; C, flower, × 3.8; D, anther, × 7 (from dry material of *Yii Puan Ching* et al. S52286). The labellum and anther crest could not be drawn throughout because of the lack of flowers in good condition.

with yellow spot in the throat; filament c.2mm long, pubescent on the adaxial surface; anther c.5mm long, thecae dehiscing throughout their length, pubescent; anther crest c.2mm long, entire? *Fruit* unknown.

Other specimen examined. SARAWAK. 7th division, Kapit district, Balang/Balleh watershed ridge, extreme headwaters of Balleh river, foot-hills of Bukit Batu Tibang, primary forest, shallow valley along ridge, moderate slope, damp, igneous (andesitic) derived soils, 2500ft, flowers arising singly on underground runners, corolla white with yellow spot in throat, fruit geocarpic, orange red, 6 vi 1969, *J.A.R. Anderson* S28473 (SAR).

Among Bornean *Elettaria*, this is the only species with anther thecae dehiscing throughout their length, and the calyx (c.17mm long) is much longer than the other white-flowered Bornean *Elettaria*.

5. Elettaria surculosa (K. Schum.) B.L. Burtt & R.M. Sm. in Notes Roy. Bot. Gard. Edinb. 31: 312 (1972). **Figs 4, 8D.**

Type: Sarawak, 1st division, Mt Matang, v 1868, *Beccari* 1586 (FI!).

Syn.: *Amomum surculosum* K. Schum. in Bot. Jahrb. 27: 323 (Oct. 1899).

Cyphostigma surculosum (K. Schum.) K. Schum. in Pflanzenr. Zing., 273 (1904).

Elettariopsis surculosa (K. Schum.) Ridl. in J. Str. Br. Roy. As. Soc. 46: 242 (1906), ut 'surculosum'; Loesen., Pflanzenfam. 2 Aufl., 15A: 603 (1930).

Elettaria multiflora auct. p.p., non (Ridl.) R.M. Sm.: R.M. Sm. in Notes Roy. Bot. Gard. Edinb. 43: 462 (1986), quoad syn. *Amomum surculosum.*

Perennial herb, 1.2–2.0m tall; leaf shoots up to 2.5m long with to 15 pairs of leaves per shoot. *Leaves* up to 35 × 7cm, narrowly obovate, base cuneate, petiole to c.5mm long, apex obtuse and acuminate, glabrous on both surfaces; ligule 2–7mm long, shallowly bilobed or entire, glabrous; sheath glabrous. *Inflorescence* radical, up to 2m long, creeping on/under the ground, linear; main inflorescence axis 1–1.5mm diam. when dried, pubescent; scales 12–50mm long, tubular for a varying length or open to the base; bracts 20–60mm long, arranged at intervals of 10–50mm, pubescent at the base only, apex obtuse and mucronate, upper margin slightly ciliate, subtending up to 7 flowers; secondary axis between bract and the first bracteole 10–40mm long, pubescent; bracteole 12–20mm long, tubular for a varying length at the base, pubescent, apex obtuse and mucronate with tufted hairs on the spine; pedicel up to 30mm long. *Flowers* white, calyx 8–11mm long, tubular for the basal half, minutely pubescent, apex 3-toothed, mucronate and with long tufted hairs on the top of the teeth; corolla tube c.11mm long, glabrous; dorsal petal c.10.5 × 8mm, elliptic, glabrous; laterals c.9 × 6mm, elliptic, glabrous; labellum 16–22 × 16–28mm, reniform, pubescent on the centre of the basal half, white except for central green line; filament 2–3mm long, with hairs at the centre on the adaxial surface; anther 2.5–3mm long, dehiscing by small pores; pore covered with a flap with long hairs; anther crest up to 2mm long, 3-lobed, central lobe sometimes 2- or 3-toothed unequally; style c.14mm long, glabrous; stigma up to 1.5mm wide, with a dorsal

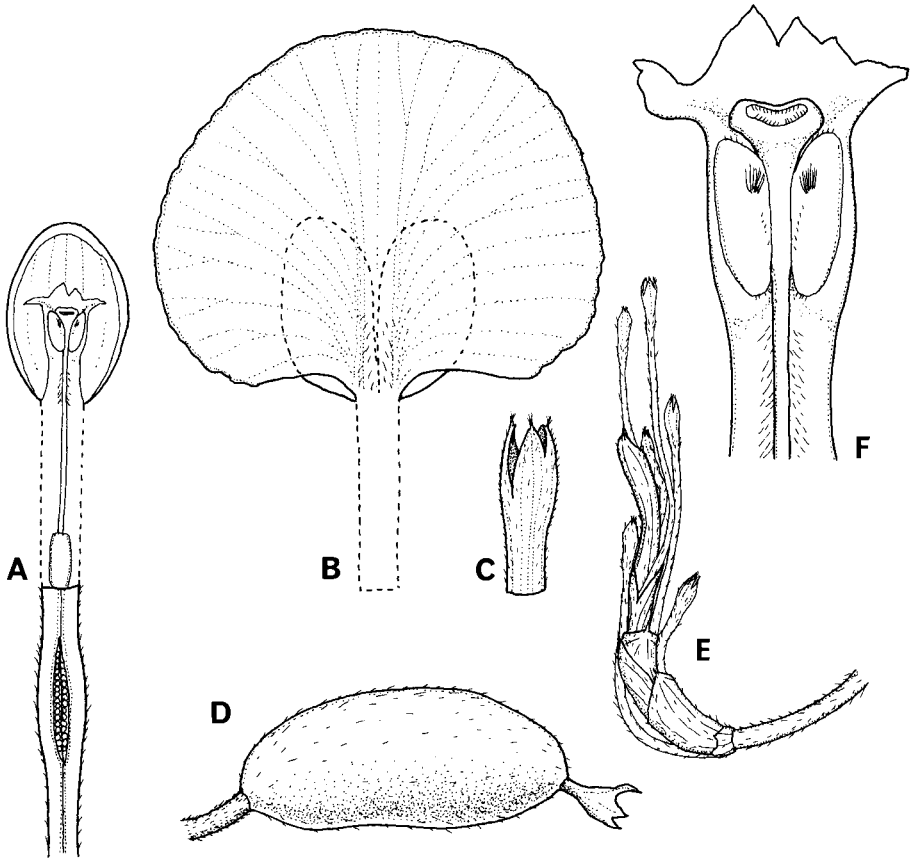

FIG. 4. *Elettaria surculosa*: A, B, flower, dissected, ×2.1; C, calyx, ×2.1; D, fruit, ×1.1; E, cincinnus, ×1; F, anther and stigma ×7 (from spirit material of *S. Sakai* 439).

opening, glabrous except fringed hairs on the mouth; ovary 3–10mm long, densely pubescent; epigynous gland c.3mm long. *Fruit* c.40 × 16mm, ellipsoid, sparsely pubescent to glabrous, reddish brown when alive, with c.6 longitudinal ribs when dried.

Other specimens examined. SARAWAK. 1st division, Matang, stem many leaved about 4ft, flower white, lip blotched green in centre, vi 1893, *Ridley* 11799 (SING); ibidem, viii 1893, *Ridley* 12361 (SING); ibidem, 1400ft, inflorescence trailing along the ground, *Haviland* 559/447 (SAR); ibidem, 1400ft, iv 1907, *Hewitt* 576 (SAR); ibidem, inflorescence prostrate to 1.3m, leafy shoot to 2m, 14 vii 1962, *Burtt & Woods* B2504 (SAR); ibidem, dipterocarp forest, along the main trail, on the slope near small stream, ht 1.2m, inflorescence trailing on/under the ground, bracts dark red, flower white with central green line on the lip, fruit reddish brown, 2 i 1999, *S. Sakai* 420 (KYO, SAR); ibidem, ht 2m, shoots 2.5m long, with 10 pairs of leaves per shoot, inflorescence creeping on the ground, bracts reddish brown, flower white with a central green line on the labellum, 11 i 1999, *S. Sakai* 439 (KYO, SAR); Kubah National Park, Sungai Layu, along the trail near HQ, ht 2.0m, fronds up to 2.4 by 0.6m, with 11 pairs

of leaves, inflorescence creeping on the ground, flower white with yellowish green on the centre of the lip, 3 i 1999, *S. Sakai* 434 (KYO, SAR); 3rd division, Sungai Melinau near Nanga Tunoh, white labellum with yellowish green band in lower part, 3 viii 1967, *Burtt & Martin* B4773 (SAR); 7th division, Dulit Range, Belaga, submontane mossy forest, soil, yellow podsol, 820m a.s.l., terrestrial ginger, 1m tall, stems and leaves green, runner pale brown, calyx red, fruits white turning red when ripe, 20 x 1983, *Dyg. Awa & Yii P. C.* S46897 (SAR).

The species is recognised by inflorescences creeping just below the ground surface and totally glabrous leaf shoots up to 2m high with shortly petiolate leaves in the field.

This species shows variation in floral characters, especially size of labellum and size and form of anther crest. However, anthers dehiscing by small pores covered with a long-haired flip and labellum reniform rather than spathulate were common to all three specimens *S. Sakai* 439, 420, 434, of which flowers in alcohol were examined. Considerable variations within individuals were also found in size of stigma and ovary. The differences may be related to position of the flower within an inflorescence, and potential ability to develop into a fruit.

Elettaria stolonifera and *E. surculosa* are different in anther dehiscing habit, pubescence of main inflorescence axes and presence or absence of fusion of calyx and corolla tube above the ovary. They are considered to represent different species. This also suggests that variation in morphological characters within the species is more limited than was previously considered, and that Sumatran *E. multiflora* with small bracts arranged at rather shorter intervals on the inflorescence, pubescent calyces, and white labellum with red marking, is apparently out of the range of either Bornean species.

6. Elettaria linearicrista S. Sakai & Nagam., **sp. nov. Figs 5, 8C.**
Haec species *E. surculosae* (K. Schum.) B.L. Burtt & R.M. Sm. thecis antherae valvula elliptica pilosa dehiscentibus similis, sed labello spathulato, lobis cristae antherae linearibus, bracteis minoribus 11–20mm longis plerumque imbricatis differt. Type: Sarawak, Lambir Hills National Park, near the Third Waterfall. Height 1.2m, flower white, with a yellow green line on the centre of the lip, 26 iii 1984, *S. Sakai* 189 (holo. KYO, iso. SAR).

Perennial herb, 0.6–1.5m tall. *Leaves* c.10 pairs per shoot, up to 22×4.5cm, narrowly oblong to obovate, apex acuminate, base cuneate, periole to 5mm, covered with dense short hairs, almost glabrous on the upper surface except pubescence on the midrib, more or less pubescent on the lower with short hairs especially on the midrib, margin ciliate; ligule to 5mm long, truncate, covered with dense short hairs, margin ciliate; sheath shortly pubescent especially near the base. *Inflorescence* radical, c.40cm long, somewhat erect or trailing on the ground; main inflorescence axis 1.0–1.5mm diam. when dried, pubescent with long hairs; scales 9–17mm long, tubular or open to the base, apex entire and ciliate; bracts 11–20mm long, distichously arranged at 6–12mm intervals overlapping each other, oblong, pubescent, apex entire or mucronate, upper margin ciliate, subtending up to 7 flowers; secondary axis between bract and the first bracteole to 6mm long, pubescent; bracteole c.9mm long, tubular at the

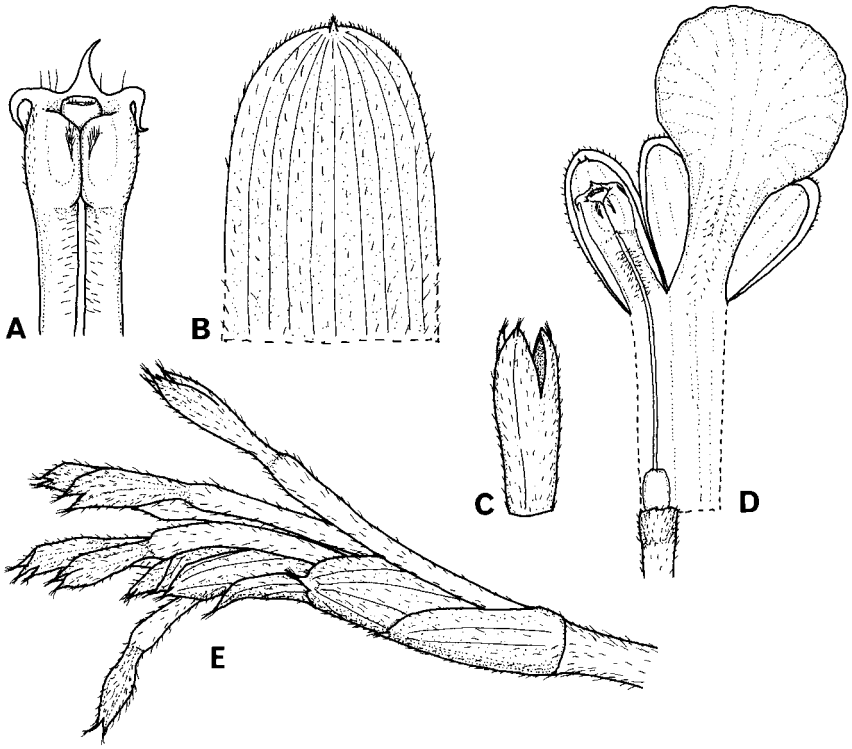

FIG. 5. *Elettaria linearicrista*: A, anther and stigma, ×7; B, bract, ×3.5; C, calyx, ×3.5; D, flower, dissected, ×3.5; E, cincinnus, ×2 (from spirit material of *S. Sakai* 189).

base for c.5mm, pubescent, apex mucronate, long tufted hairs on the apical point; pedicel to 10mm long, pubescent. *Flowers* white, calyx c.7mm long, tubular, open for apical c.3mm, pubescent, apex 3-toothed, mucronate and with long tufted hairs on the top of the teeth; corolla tube c.8mm long, outside pubescent on the upper half, glabrous inside; petals c.7mm long, c.4mm wide for dorsal, c.3mm wide for laterals, elliptic, pubescent outside, glabrous inside; labellum spathulate, c.12 × 8mm, pubescent on the centre of the basal limb, white except for the central greenish-yellowish line; filament c.2.5mm long, with long hairs at the centre on the adaxial surface; anther c.2mm long, dehiscing by longitudinally elongated pores at the upper middle of the thecae, minutely pubescent; pore covered with a flap with long hairs; anther crest minute, with three linear lobes, the lateral lobes bending downwards, the central lobe erect, with several long hairs on the margin between the lobes; style c.13mm long, glabrous; stigma with a dorsal opening, fringed with hairs on the mouth; ovary c.1.5mm long, pubescent; epigynous gland c.1.5mm long. *Fruit* unknown.

Other specimens examined. SARAWAK. 4th division, Lambir Hills National Park, ridge E of B. Lambir, 1200–1500ft, flower white with yellow central line to lower part of lip, 25 ix 1978, *Burtt* 11612 (SAR).

BRUNEI. Beleit, Labi, 4°20′N, 114°27′E, Bt. Teraja, south of summit, 390m, hill dipterocarp forest, rhizome stout, with distinct rhizomes giving rise to inflorescence with white flowers, 20 iii 1991, *B.J. Johns* 6885 (K); ibidem, 4°18′N, 114°26′E, Bt. Teraja, rest house to summit and south of summit, by trail, 350m, hill dipterocarp forest, leaves dark green above, paler below, fruit pale to mid-green, 16 x 1991, *D. A. Simpson* 2043 (K).

Burtt 11612 has wider leaves (up to 22 × 4.5cm) and shorter leaf shoots (0.4–0.6m) than the type specimen (leaves up to 20 × 2.3cm, 1.5m high). The inflorescence of the type specimen was observed to be erect from the ground when flowering, but it is not certain whether this is the usual habit of the species.

7. Elettaria longipilosa S. Sakai & Nagam., **sp. nov. Figs 6, 8E.**
Elettariae linearicristae S. Sakai & Nagam. labello spathulato, thecis antherae valvula pilosa dehiscentibus similis, sed differt foliis infra longipilosis, rachidi inflorescentiae fere glabra, tubo et lobis corollae glabris, lobis cristae antherae non linearibus.
Type: Sarawak, 4th division, Lambir Hills National Park, Sungai Liku, on the slope of river-bank, ht 1.3m, fronds 2 × 0.8m including the stalk 65cm long, elliptic, leaves c.12 pairs, narrowly oblong, apex long acuminate, base cuneate, to 40 by 6cm, sessile, inflorescence long prostrating on the ground, rachis white, scales red-brown, flower half embedded in the ground, white except the central yellow on the labellum, younger fruits pale pink, 27 xii 1998, *S. Sakai* 413 (holo. KYO, iso. SAR).

Perennial herb, 1–1.3m tall. *Leaves* c.12 pairs per shoot, distichously arranged; lamina up to 40 × 6cm, narrowly oblong, glabrous on the upper surface, with long soft hairs on the lower especially around the midrib, apex long acuminate, base cuneate, sessile; ligule up to 5mm long, truncate, covered with long dense hairs; sheath pubescent especially near the base of the leaf. *Inflorescence* radical, c.50cm long, creeping just below the ground; main inflorescence axes c.2.5mm diam. and white when alive, c.1.5mm and pale reddish brown in the dried state, almost glabrous; scales c.15mm long, tubular at the base, with a lateral fissure of varying length, usually minutely pubescent; bract 10–16mm long, laxly arranged at 15–20mm intervals, sometimes overlapping each other, tubular for the lower third, minutely pubescent, apex obtuse, mucronate, margin ciliate, usually subtending up to 5(–15) flowers; secondary axes between bract and first bracteole 5–45mm, almost glabrous; bracteole 11–16mm long, tubular, very minutely pubescent, laterally fissured for c.5mm long, apex obtuse, acuminate, with long hairs on the apical point; pedicel 5–25mm long, almost glabrous. *Flower* white, calyx 10–14mm long, tubular, unilaterally fissured for c.4mm, scarcely pubescent outside, apex 3-lobed, with long hairs on the apices of the lobes; corolla tube 13–16mm long, dorsal and lateral petals 7–8 × 3–4mm, elliptic, glabrous; labellum spathulate, distal expanded part c.6.5mm long c.12mm wide, reniform, glabrous, white with a central yellow line, the limb c.5.5mm long c.3mm wide at the base c.5mm wide at the apex, with long hairs at the centre, white; filament 2–3mm long, with long hairs at the centre on the adaxial surface; anther c.2.5mm long, shortly pubescent; anther thecae dehiscing by a small

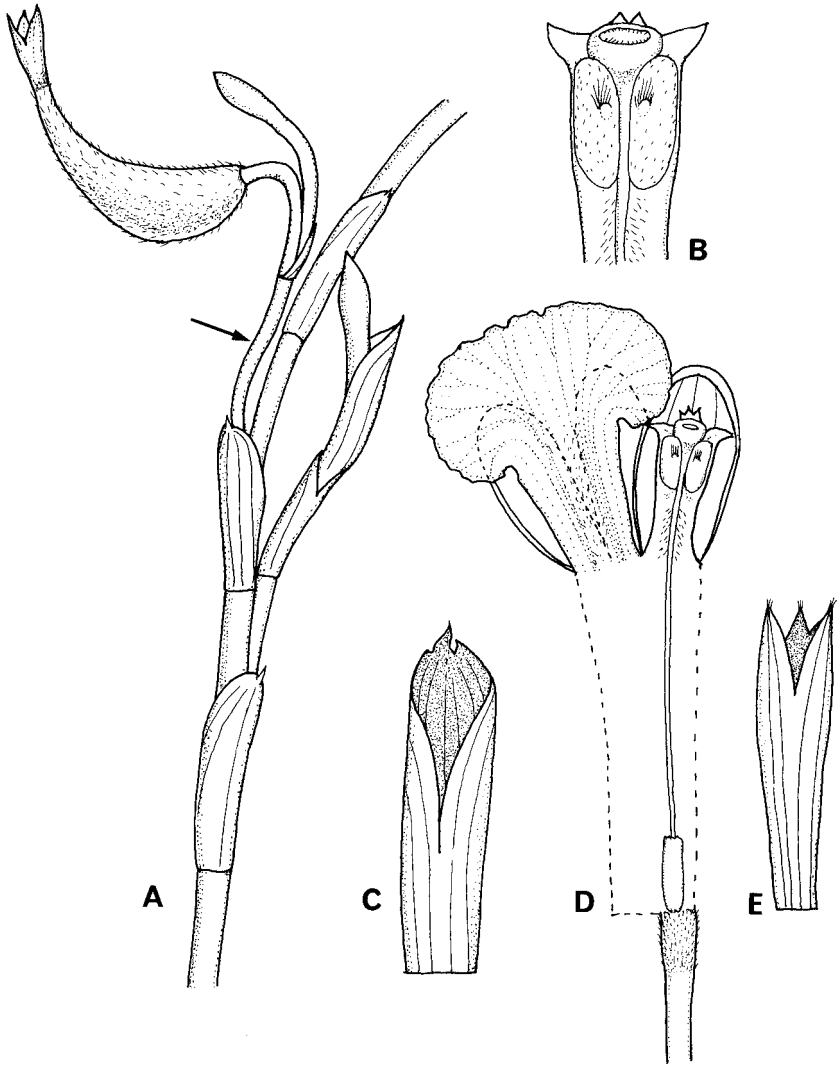

FIG. 6. *Elettaria longipilosa*: A, inflorescence with an immature fruit ×1.8 (arrow: secondary inflorescence axis between bract and the first bracteole); B, anther and stigma, ×7; C, bracteole, ×3; D, flower, dissected, ×3; E, calyx, ×3 (from spirit material of *S. Sakai* 413).

pore just above midpoint of the theca; pore covered with a flap with very long hairs; anther crest deeply 3-lobed, side lobes spreading, central lobe unequally 2- or 3-toothed; style c.19mm long, glabrous; stigma c.1.7mm wide, with a dorsal opening, ciliate around the mouth; ovary c.3mm long, with long hairs; epigynous glands c.3.5mm long. *Fruit* unknown.

Other specimens examined. SARAWAK. 4th division, Lambir Hills National Park, ridge along the trail to Bt. Pantu, ht 1.0m, flower bud white, inflorescence radical, 3 xii 1994, *S. Sakai*

146 (KYO, SAR); ibidem, inflorescences after flowering only, 3 xii 1994, *S. Sakai* 145 (KYO, SAR).

An immature fruit of *S. Sakai* 413 measures 20 × 7.5mm (not including calyx). It is obliquely long-ovoid with a beak at the apex by the persistent calyx, covered with long hairs, and coloured with pale pink.

S. Sakai 145 was collected almost at the same place and on the same day as *S. Sakai* 146, but the plant was different from type specimen or *S. Sakai* 146 in having inflorescences with more flowers per bract (more than 10 flowers) and a smaller flower size, while vegetatively the three collections are identical.

8. Elettaria brachycalyx S. Sakai & Nagam., **sp. nov. Fig. 7.**

Haec species *E. longipilosae* S. Sakai & Nagam. labello albo spathulato, thecis antherae valvula rotundata pilosa dehiscentibus similis, sed foliis fere glabris, calice breviore ad ultra ⅔ partibus fissurato differt.

Type: Sarawak, 4th district, G. Mulu National Park, S. Lansat, c.1000m, on side of ridge in submontane forest, inflorescence trailing on the ground, flower white, outer perianth green, inner pink, lip white, 8 x 1977, *Argent* et al. 705 (holo. SAR, iso. E).

Perennial herb, 1.0m tall. *Leaves* c.8 pairs per shoot, up to 18 × 2.6cm, narrowly elliptic, apex acuminate, base cuneate, shortly petiolate, glabrous except for minute pubescence on the midrib of the lower surface toward the base; ligule c.2mm long, shallowly and unequally bilobed, glabrous or pubescent with minute hairs; sheath striate, minutely pubescent in the grooves, margin partly ciliate. *Inflorescence* radical, c.60cm long; main inflorescence axis c.1.0mm diam. when dried, ± pubescent; bracts

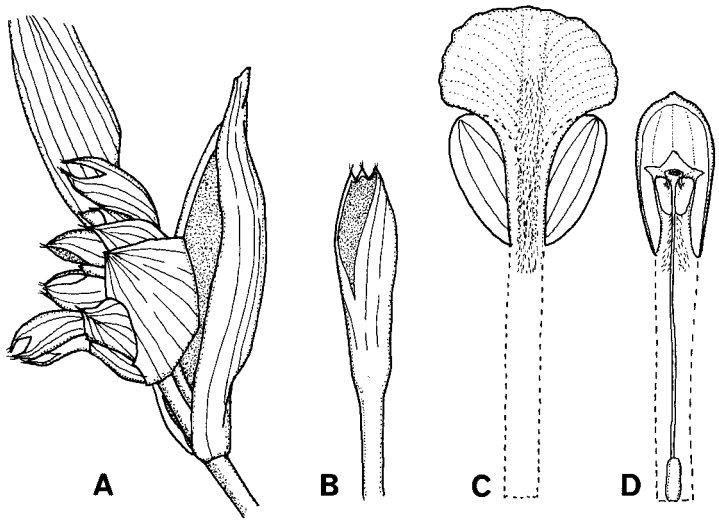

FIG. 7. *E. brachycalyx*: A, bracts and cincinnus, × 2.5; B, calyx, × 4; C, D, flower, dissected, × 3.5 (from dried material of *Argent* et al. 705).

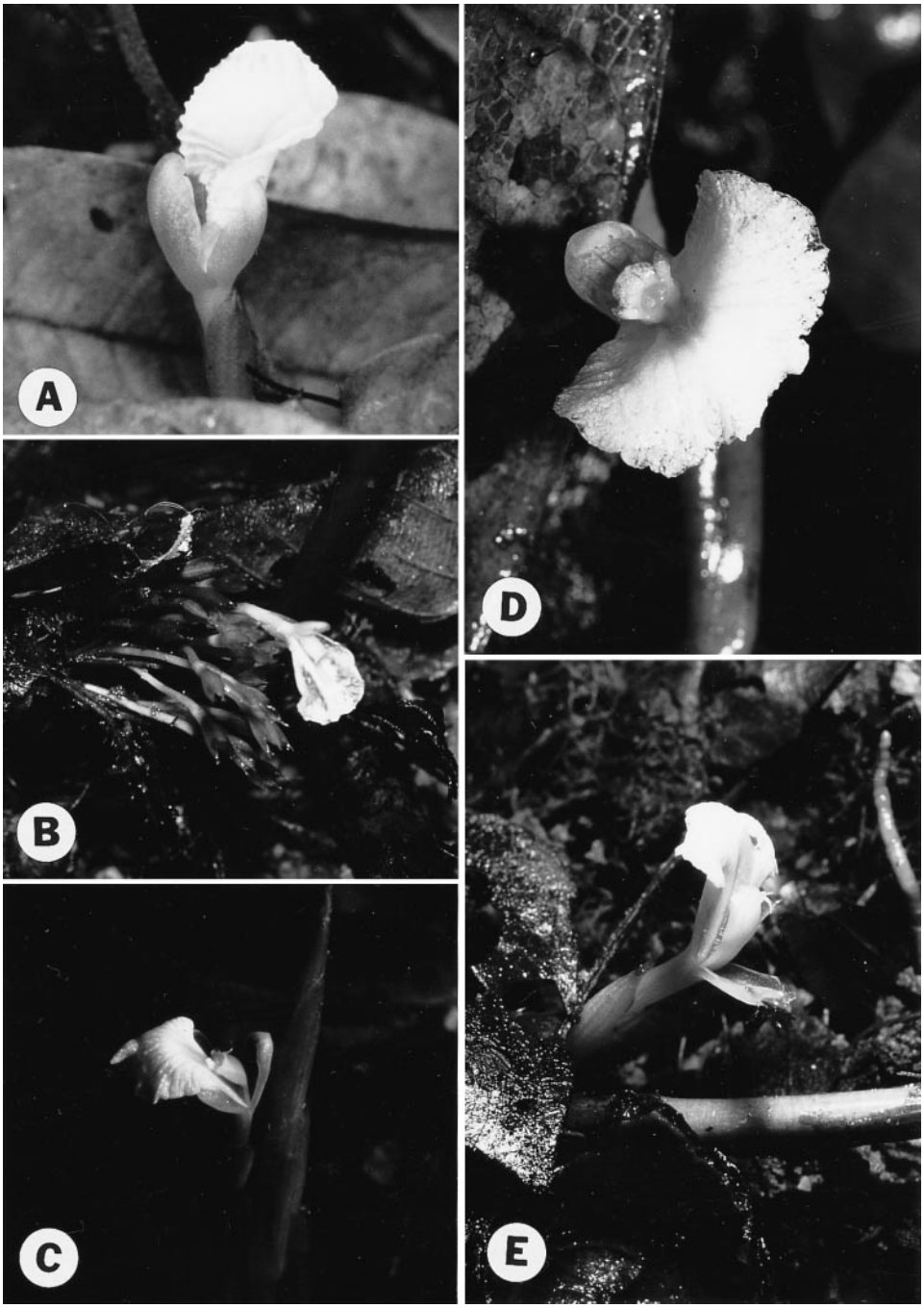

FIG. 8. A, *E. longituba* (*S. Sakai* 201), ×1.6; B, *E. stolonifera* (*S. Sakai* 435), ×0.8; C, *E. linearicrista* (*S. Sakai* 189), ×1.8; D, *E. surculosa* (*S. Sakai* 439), ×1.5; E, *E. longipilosa* (*S. Sakai* 413), ×2.

13–23mm long, arranged at intervals of 10–16mm, tubular for varying length or open to the base, apex obtuse and mucronate, pubescent to glabrous except minute pubescence at the base, subtending up to 5 flowers; secondary axis between bract and the first bracteole c.8mm long, ± pubescent; bracteole c.8mm long, glabrous, apex mucronate, with hairs on the apical point; pedicel up to 17mm long, glabrous or slightly pubescent. *Flower* white, calyx c.6mm long, tubular, unilaterally fissured for two thirds of its length, glabrous, apex 3-toothed, with hairs on top of the teeth; corolla tube c.9mm long, glabrous; dorsal petal c.6 × 3mm, elliptic to obovate, laterals c.5 × 2mm, elliptic, glabrous; labellum c.8 × 7mm, spathulate, densely hairy at the centre, white; filament c.1.5mm long, pubescent on the adaxial surface; anther thecae c.2mm long, dehiscing by pores covered with a flap with long hairs, pubescent at the apex; anther crest c.1mm long, 3-lobed; style c.12mm, glabrous; stigma ciliate around the mouth; ovary c.1.5mm long, glabrous; epigynous glands c.1.5mm tall. *Fruit* unknown.

This species is characterized the shortest calyx (c.6mm) in Bornean *Elettaria*. The intervals between the bracts on the inflorescence axis are generally shorter than bract length, and the bracts overlap each other. A similar condition is also found in *E. linearicrista*, but less pubescent inflorescence axes, pedicels and calyx, glabrous corolla tube and petals, and a non-linear anther crest distinguish it.

ACKNOWLEDGEMENTS

We are grateful to Prof. T. Inoue, Prof. T. Nakashizuka, Kyoto University, Mr Abang A. Hamid, Mr S. P. Teo, and other staff of the Forest Department Sarawak for permission and help during the study; Ms E.J. Cowley, Royal Botanic Gardens, Kew, for useful information and suggestions; the curators of E, FI, K, SAR and SING, who kindly permitted us to examine herbarium specimens; and the Royal Botanic Gardens, Kew for cibachromes. This study is partly supported by grants from the Japanese Ministry of Education, Science and Culture (#04041067, 06041013, 09NP1501 and 10041169) and by JSPS Research Fellowships for Young Scientists for S. Sakai.

REFERENCES

BURTT, B. L. & SMITH, R. M. (1972). Notes on Malaysian Zingiberaceae. *Notes Roy. Bot. Gard. Edinb.* 31: 307–316.

BURTT, B. L. & SMITH, R. M. (1976). Notes on collection of Zingiberaceae. *Flora Malesiana Bulletin* 29: 2599–2601.

HOLTTUM, R. E. (1950). The Zingiberaceae of Malay Peninsula. *Gard. Bull. Sing.* 13: 1–249.

RIDLEY, H. N. (1906). Scitamineae of Borneo. *J. Str. Br. Roy. As. Soc.* 46: 229–246.
SCHUMANN, K. (1904). Zingiberaceae. *Das Pflanzenreich* IV, Vol. 46. Leipzig, Germany: Verlag von Wilhelm Engelmann.
SMITH, R. M. (1986). A review of Bornean Zingiberaceae II: (Alpineae, concluded). *Notes Roy. Bot. Gard. Edinb.* 43: 439–466.

Received 7 April 1999; accepted with revision 6 December 1999