

## SYSTEMATIC STUDIES OF BORNEAN ZINGIBERACEAE I. *AMOMUM* IN LAMBIR HILLS, SARAWAK

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Twelve species of *Amomum* (Zingiberaceae) are reported from Lambir Hills, Sarawak, with systematic and ecological notes based on field observations for more than one year. Five species, *Amomum angustipetalum*, *A. bilabiatum*, *A. calyptatum*, *A. durum* and *A. somniculosum*, are described as new to science. A key to all species of *Amomum* in Borneo is provided. The first report of andromonoecy and sexual dimorphism of inflorescence in Zingiberaceae is given for *A. polycarpum*.

*Keywords.* *Amomum*, andromonoecy, Borneo, pollination, sexual dimorphism, Zingiberaceae.

### INTRODUCTION

Zingiberaceae, comprising c.1200 species, are widely distributed in the tropics, and all but three out of 46 genera of the family occur in the Indo-Malesian region (Dahlgren et al., 1985). Seventeen genera, including an endemic *Burbridgea*, and 150 species have been reported so far from Borneo. They are well reviewed by Smith (1985, 1986, 1987, 1988, 1989b), while many species remain undescribed (e.g. Ibrahim, 1995a, b; Poulsen, 1996).

Lambir Hills is located in north-east Sarawak (4th Division), Malaysia (4°20'N, 113°50'E, Fig. 1). Most of the area is covered by intact mixed dipterocarp forest with emergent trees up to 70m high, including kerangas vegetation around the two highest points, Bukit Lambir (465m) and Bukit Pantu (350m).

During the study of pollination ecology of gingers in Lambir National Park, more than 40 ginger species were found, about a third of which were new to science. We thought it worthwhile to present the list of ginger species in Lambir Hills, including the description of new species, and provide a revised key to all species so far described from Borneo. While results of the study of pollination ecology will be more fully reported in a forthcoming paper by Sakai et al. (in prep.), short notes are added in the present paper where appropriate.

The ginger flora in any particular area of Borneo was studied most intensely in the Gunung Mulu National Park, about 100km east of Lambir Hills National Park, by Smith (1982). However, the two parks are quite different in geography and

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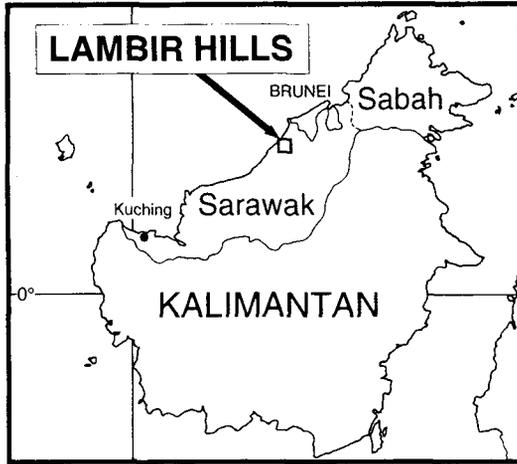


FIG. 1. Location of Lambir Hills National Park, Sarawak, Borneo.

vegetation. Gunung Mulu National Park is covered by montane forests in a limestone area, where the family shows the highest species diversity in the genera of small herbs, *Boesenbergia* and *Globba*, whereas Lambir Hills National Park is lowland dipterocarp forest on clayey or sandy soils, where the most diverse genera are *Amomum* and *Etingera*, generally with tall leaf shoots up to 4m.

## METHODS

Plant collections and observations were made from July 1994 to June 1995, and from April 1996 to July 1996. Collected plants were pressed for herbarium specimens, and if flowers and inflorescences were available, they were preserved in 60% alcohol as suggested by Burtt & Smith (1976). Additional material was examined at the following herbaria: E, K, KYO, SAR. Methods of observations and identification of pollinators, and detailed data, are given in Sakai et al. (in prep.).

## RESULTS

From Lambir Hills, fertile specimens of more than 40 ginger species were collected. The Zingiberaceae comprises four tribes as below, all of which are represented in Lambir Hills. Seventeen genera are known from Borneo (Smith, 1985, 1986, 1987, 1988, 1989b) and the following 10 genera were found in Lambir Hills:

Tribe *Alpinieae*: *Alpinia*, *Amomum*, *Elettaria*, *Elettariopsis*, *Etingera*, *Hornstedtia*, *Plagiostachys*

Tribe *Hedychieae*: *Boesenbergia*

Tribe *Globbeae*: *Globba*

Tribe *Zingibereae*: *Zingiber*

This first paper deals with *Amomum* in tribe *Alpinieae*, the largest representative of the family in Lambir Hills. In succeeding parts, the list of the family in Lambir Hills will be completed.

### Amomum

*Amomum* is the largest representative of Zingiberaceae in Lambir Hills. The genus is characterized by radical cone-like inflorescences without an involucre of sterile bracts. Flowers of all species observed are diurnal. The typical habitats of *Amomum* are wet and light forest edges and gaps. The plants often have tall, frond-like leaf shoots up to 4m, and sometimes their rhizome is held above the ground with stilt roots. However, the genus also includes epiphytes and species with few bladed shoots growing on the forest floor.

Here we adopt the informal grouping of *Amomum* proposed by Smith (1985, 1989a) as a convenience in dealing with this varied group.

*Group I.* Flowers borne in cincinni; bracteoles always tubular; corolla tube equal to the calyx; lateral petals free from the labellum; lateral staminodes absent; anther thecae dehiscing in the upper half only, connective crested or not.

From Lambir Hills: 1. *A. polycarpum*, 2. *A. lambirensis*.

*Group II.* Flowers borne singly; bracteoles open to the base; corolla tube long exerted from the calyx; lateral petals centrally connate to each other and to the labellum in the lower part; lateral staminodes absent or not; anther thecae dehiscing throughout their length; connective ecristate.

From Lambir Hills: 3. *A. angustipetalum* sp. nov.

*Group III.* Flowers borne singly; bracteoles open to the base; corolla tube long exerted from the calyx; lateral petals free; lateral staminodes absent; anther thecae dehiscing throughout their length but with basal spurs which are adnate to the broad filament; connective crested.

The single species classified into the group by Smith (1985), *A. sarawacense*, is not known from Lambir Hills.

*Group IV.* Flowers borne singly; bracteoles open to the base or tubular; corolla tube more or less equal to or shorter than the calyx; lateral petals free; lateral staminodes almost always present; anther thecae dehiscing throughout their length; connective usually crested.

From Lambir Hills: 4. *A. coriaceum*, 5. *A. gyrolophos*, 6. *A. oliganthum*, 7. *A. calyptratum* sp. nov., 8. *A. somniculosum* sp. nov., 9. *A. durum* sp. nov., 11. *A. xanthophlebium*.

*Group V.* Flowers borne singly; bracteoles open to the base; corolla tube long exerted from the calyx; lateral petals free; lateral staminodes absent; anther thecae dehiscing throughout their length; connective crested; capsule flattened laterally.

Smith (1989a) adds this group including *A. borneense* and *A. epiphyticum*, neither of which is known from Lambir Hills.

*Species incertae sedis.* 10. *A. roseisquamosum*, 12. *A. bilabiatum* sp. nov.

**1. *Amomum polycarpum* (K. Schum.) R.M. Sm. in Notes Roy. Bot. Gard. Edinburgh 42: 300 (1985). Fig. 7A–C.**

Type: Sarawak, 4th Division, Tubao, Bintulu, 1867, *Beccari* 3729 (K!).

Syn.: *Alpinia polycarpa* K. Schum. in Bot. Jahrb. 27: 298 (1899) & Pflanzenr. Zing. 367 (1904).

*Languas polycarpa* (K. Schum.) Merr. in Univ. Calif. Publ. Bot. 15: 35 (1929).

*Plagiostachys polycarpa* (K. Schum.) Loes. in Pflanzenfam. Aufl. 2, 15a: 627 (1930).

LAMBIR HILLS. Ht. 3m, near the Second Water Fall, flower white, fruits round shape, 19 vii 1994, *S. Sakai* 82 (KYO); Sungai Liam Libau, streamside, rock crevices, flower white with yellow centre to lip below tip, 22 ix 1978, *Burt* 11589 (E, n.v.).

This species is recognized by its c.2.5m high shoots with linear-lanceolate leaves and its elevated rhizome with stilt roots. It has small white flowers with a yellow blotch on the centre of the lip, and plants in good condition seem to flower almost all year round (Fig. 7A–B).

The most interesting character of this species is sexual differentiation. Two types of flower can be recognized by their ovary size (Fig. 7C). The flower with a larger ovary (3.9–6.3 × 2.4–3.3mm [mean 5.9 × 3.0mm;  $n=8$ ]) is hermaphrodite; it has a fertile anther and the ovary can grow into a fruit. The flower with a smaller ovary (3.2–4.2 × 1.5–1.6mm [mean 3.5 × 1.5mm;  $n=8$ ]) never produces a fruit, although it still has ovules reduced in size, i.e. it functions as a male flower. It has a stigma with a mouth fringed by hairs, but is more delicate than that in the hermaphrodite flower. No differences were found between the two types of flower with regard to either visits of pollinators (halictid bees, mainly *Nomia* sp.), or nectar production. It is interesting that anther thecae of the male flower are smaller and thinner than those of the hermaphrodite one, although the number of their pollen grains, counted with a counting chamber under a microscope after suspension, was not different. No physical difference in their pollen was observed under a light microscope. A possible difference in germination ability remains to be examined.

Most of the inflorescences have either hermaphrodite or male flowers, and hermaphrodite inflorescences and male inflorescences usually occur on the same plant at the same time (i.e. andromonoecious). In the field, hermaphrodite and male inflorescences can be readily distinguished: in hermaphrodite ones many fruits start to develop soon after flowering, even before other flowers on the same inflorescence open, while the male ones have only withered flowers without developing ovaries. Male inflorescences have more (from 5 to 12) flowers per cincinnus and a longer flowering period than hermaphrodite ones with about three flowers per cincinnus. However, some individuals of this species have hermaphrodite and male flowers within a several-flowered cincinnus. In such cases, the hermaphrodites flower first, then the males flower within a cincinnus.

That flowers of Zingiberaceae may not be hermaphrodite was first suggested for *Kaempferia natalensis* by K. Schumann (1904: 72), who thought the species was dioecious because, in an examination of herbarium specimens, he could not find male flowers. Wood & Franks (1911: pls 560, 561) placed the species under a new

genus, *Siphonochilus*, on the basis of their observation of living plants with female and hermaphrodite flowers (i.e. gynodioecy), but no fruits of the species are known. The first clear description of sexual dimorphism in Zingiberaceae is the report of floral dimorphism in six *Alpinia* species from the Solomon Islands by Burt & Smith (1972). Only the first (lowermost) and, occasionally, the second flower in each cincinnus of their inflorescence are female and produce fruits. The account above regarding *Amomum polycarpum* is the first report of andromonoecy and sexual dimorphism of inflorescence in the family.

**2. *Amomum lambirens*** R.M. Sm. in Notes Roy. Bot. Gard. Edinburgh 42: 298 (1985).

Type: Sarawak, 4th Division, Lambir Hills National Park, Sungai Liam Libau, pale yellow flower, centre of lip deeper yellow, 19 ix 1978, *Burt* 11525 (E, n.v.; iso. K!).

LAMBIR HILLS. Ht. 2.0m, ridge along the trail to Bt. Pantu, flower white, centre of the lip yellow, 21 iv 1995, *S. Sakai* 217 (KYO).

This rare species was collected only once, on the ridge of Bt. Pantu, during the study.

**3. *Amomum angustipetalum*** S. Sakai & Nagam., *sp. nov.* Figs 2, 8F.

Species nova *Amomum pungenti* R.M. Sm. similis, sed bractea minore dense pubescenti petalo dorsali anguste oblongo labello rhomboideo differt.

Type: Sarawak, Lambir Hills National Park, Canopy Biology Plot, height 1.5m, flower white, 26 iii 1995, *S. Sakai* 192 (KYO).

Perennial herb c.1.2m tall with a rhizome elevated above ground with stilt roots. *Leaves* distichously arranged; lamina c.40 × 5cm, linear-lanceolate, markedly striate, apex acuminate, base attenuate, subsessile to petiolate up to 5mm long, upper surface glabrous, pubescent below especially on the main vein, margin more or less pubescent; ligule 2–4mm long, obtuse to truncate, with dense hairs; sheath striate, hairy especially around the base of the blades and on the margin. *Inflorescence* radical, c.7 × 3cm, ellipsoid to ovoid, with a peduncle c.5cm long; bracts c.27 × 15mm, ovate, apex cuspidate and the apical tip curved inwards, with dense hairs on marginal two-thirds of upper part; bracteole c.7mm long, barely open to the base, sparsely hairy outside. *Flowers* borne singly, white; calyx c.15mm long, tubular, split unilaterally, apex unequally 2- or 3-toothed, glabrous; corolla tube c.25mm long, dorsal petal c.10 × 3mm, narrowly oblong and rolled inward halfway, lateral petals c.9.5 × 3mm, linear, centrally connate to each other and to the labellum in the lower half; labellum c.12 × 5mm, rhomboid to lanceolate; anther sessile, thecae c.4.5mm long, glabrous, dehiscing throughout their length; anther crest very small, thin, shallowly 3-lobed; staminodes 0.5–1.5mm long, triangular to linear, sometimes 2-toothed; stigma cup-shaped with an apical opening, ciliate around the mouth; ovary sparsely hairy; epigynous glands c.2.5mm high. *Fruits* unknown.

LAMBIR HILLS. Canopy Biology Plot on the ridge, height 1m, flower cream, preserved in alcohol, rhizome elevated above ground by stilt roots, 18 ix 1994, *S. Sakai* 95 (KYO); S Liam

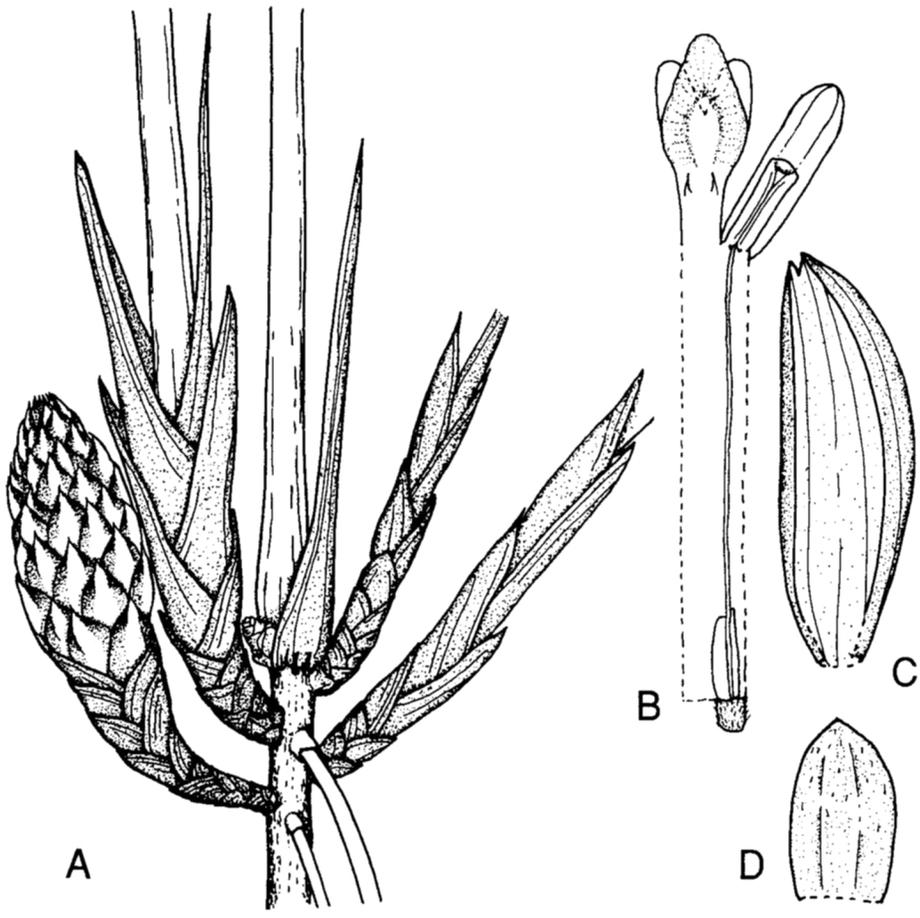


FIG. 2. *Amomum angustipetalum*. A, radical inflorescence,  $\times 0.7$ ; B, flower dissected,  $\times 2.5$ ; C, calyx dissected showing adaxial face,  $\times 3.5$ ; D, bracteole,  $\times 3.5$ . From S. Sakai 192.

Libau, streambank, flower cream, the tip of a little darker, some stilt roots, 18 ix 1978, *Burt* 11500 (SAR).

Smith (1985) determined *Burt* 11500 as *Amomum pungens* but its densely pubescent bracts are doubtless ones of this species.

*Amomum angustipetalum* occurs on the darker wet forest floors. It is distinguished by its well-formed stilt roots and striate glabrous leaves. One or two flowers open per day for a period of a few months. Although they secrete nectar, field observation for 14 hours in total recorded only one visit by a possible pollinator, an *Amegilla* bee.

**4. *Amomum coriaceum*** R.M. Sm. in Bot. J. Linn. Soc. 85: 61 (1982) & Notes Roy. Bot. Gard. Edinburgh 42: 304 (1985). **Fig. 7D.**

Syntypes: Sarawak, 1st Division, Mt. Matang, *Beccari* 2947 (n.v.); *Beccari* 2162 (FI, n.v.).

Syn.: *Alpinia cylindrostachys* K. Schum. in Bot. Jahrb. 27: 299 (1899) & Pflanzenr. Zing. 366 (1904). Syntypes as above.

LAMBIR HILLS. Ht. 3.5m, inflorescence mucilaginous, radical, flower white, 30 viii 1994, *S. Sakai* 88 (KYO); inflorescence mucilaginous, 12 vii 1994, *S. Sakai* 72 (KYO); Sungai Liam Libau, stream bank, frond 2m with some stilt roots, 13 ix 1978, *Burt* 11497 (SAR).

*Other material seen.* 7th Kapit district, Belaga, faintly aromatic, 2m, inflorescence very slimy, bracts red margined, green tipped, calyx reddish, corolla very thin, pale reddish-white towards top, lip bright yellow, paler toward the top, stamen very pale yellow reddish, 24 viii 1958, *Jacobs* 5263 (SAR).

*Amomum coriaceum*, one of the most common species along the trails, has a mucilaginous inflorescence with small white flowers. The flowers are visited and pollinated mainly by halictid bees.

**5. *Amomum gyrolophos*** R.M. Sm. in Notes Roy. Bot. Gard. Edinburgh 42: 305 (1985). **Fig. 7E–F.**

Type: Sarawak, 1st Division, Semangoh Forest Reserve, labellum frilled at edges, centre orange, anther-crest a rounded hood, 26 viii 1867, *Burt & Martin* B4756 (holo. E!).

LAMBIR HILLS. Near the second bridge to the Third Water Fall, flower orange, 15 x 1994, *S. Sakai* 75 (KYO); Ht. 2m, hillside, flower orange with red petal, 13 iii 1995, *S. Sakai* 172 (KYO).

*S. Sakai* 75 and 172 have much denser hairs on the lower sides of leaves and longer petioles than *Burt & Martin* B4756. The plants from Lambir have flowers with conspicuous red dorsal petals hooded over the anthers, although the type specimen and protologue have no colour description for the dorsal petals.

The flowers are pollinated by *Amegilla* bees and grow into echinate, round fruits partly embedded in the ground (Fig. 7E–F.).

**6. *Amomum oliganthum*** K. Schum. in Bot. Jahrb. 27: 321 (1899) & Pflanzenr. Zing. 244 (1904); *Burt & Smith* in Notes Roy. Bot. Gard. Edinburgh 31: 310 (1972); R.M. Smith in Notes Roy. Bot. Gard. Edinburgh 42: 307 (1985). **Fig. 8A.**

Type: Sarawak, 1st Division, Mt. Matang, xii 1866, *Beccari* 2946 (holo. FI, n.v.; iso. E!).

Syn.: *Amomum hewittii* Ridl. in J. Str. Br. Roy. As. Soc. 46: 238 (1906). Syntypes: Mt. Matang, *Ridley* s.n. (n.v.); Mt. Santubong, *Hewitt* s.n. (K!).

LAMBIR HILLS. Near Third Water Fall, soil plane alluvial, flower orange, frt. green, 25 iii 1995, *S. Sakai* 187 (KYO).

*Other material seen.* 1st Division, Semangoh Forest Reserve, bracts green, flowers dull orange yellow, base and apex of lip somewhat darker, 13 viii 1962, *Burt & Woods* B2478 (SAR).

The plant from Lambir Hills agrees well in the glabrous leaves and floral detail with the description of *Amomum oliganthum*. However, it has more robust leaf shoots,

sessile leaves, and a less verrucose ovary which, nevertheless, also grows into an echinate fruit. The species can be recognized by its vivid green glabrous leaves, but only two individuals have been found. The species has a few flowers open per day from a total of about 20 flowers per inflorescence. Flowering episodes were observed twice during the study.

**7. *Amomum calyptratum* S. Sakai & Nagam., sp. nov. Figs 3, 8B.**

Species nova *A. paucifolio* R.M. Sm. fronde paucifoliata et floribus aurantiacis similis, sed bracteola minore ad basin sperta labello obovato non bilobo et staminodiis brevioribus differt.

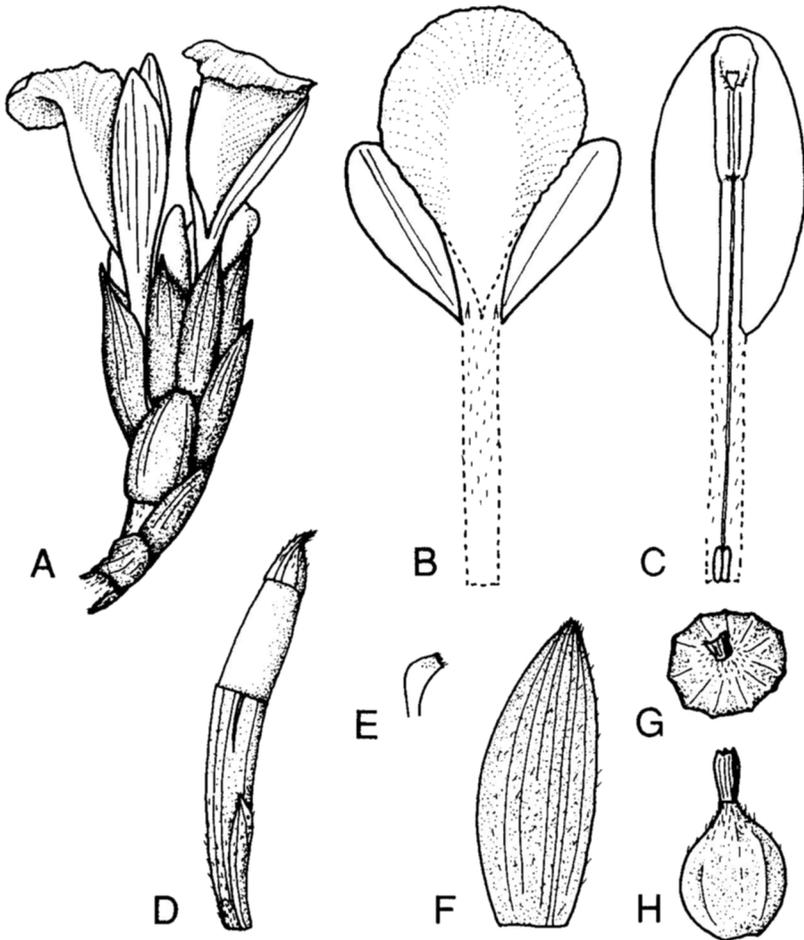


FIG. 3. *Amomum calyptratum*. A, inflorescence,  $\times 0.7$ ; B, ventral part of dissected flower,  $\times 1$ ; C, dorsal part of dissected flower,  $\times 1$ ; D, flower bud with calyptrate calyx and bracteole,  $\times 1.5$ ; E, lateral view of stigma,  $\times 3.5$ ; F, bract,  $\times 1$ ; G, capsule in ventral view,  $\times 1$ ; H, capsule in lateral view,  $\times 1$ . From S. Sakai 156.

Type: Sarawak, Lambir Hills National Park, Ht. 0.8–1.0m, flower yellowish orange, 26 xii 1994, S. Sakai 156 (holo. KYO).

Perennial herb 0.5–0.7m tall. *Leaves* 2–5 per shoot, distichously arranged; lamina 20–35 × 4–8cm, oblanceolate, with short hairs on the lower surface; apex acuminate, base attenuate, margin entire, ciliate; petioles up to 15mm long; ligules 2–3mm long, shallowly bilobed, papery with membranous ciliate margin; sheath glabrous or slightly hairy with membranous margin. *Inflorescence* radical, c.8 × 3cm, obovoid to narrowly obovoid, with a 2–5cm peduncle; bracts light brown, 35–43 × 14–17mm, ovate, papery, sparsely pubescent outside, apex obtuse, margin entire; bracteoles 13–20mm long, linear, pubescent, open to the base. *Flowers* orange, one per bract; calyx 17–20mm long, tubular, truncate (the upper part of the calyx is split off and caducous as a calyptra and the lower part is left as a truncate calyx split about a third of its length as the flower emerges), pubescent; corolla tube 26–28mm long, both outside and inside pubescent; dorsal petal ovate, 31–36 × 17–23mm; laterals 30–35 × 8–12mm, obovoid, free from the labellum; labellum orange, 45–50 × 31–38mm, obovate; stamen c.32mm long; filament 15–16mm long; thecae c.11mm long, dehiscing throughout their length; anther crest c.7mm long, 5–6mm wide, 3-lobed but lateral lobes not so developed, central lobe truncate; lateral staminodes c.3mm, linear; stigma cup-shaped, open ventrally, with hairs on the mouth; ovary c.7 × 4mm, trilocular with axile placentation, pubescent; epigynous glands c.6mm high. *Fruits* c.15mm diam., c.12-ribbed ampulliform with a short neck, pubescent.

LAMBIR HILLS. Ht. 0.6m, flower orange, preserved in alcohol, 2 ix 1994, S. Sakai 90 (KYO); Ht. 0.5m, ridge, with fruits, on the way to Bt. Pantu, 3 xii 1994, S. Sakai 147 (KYO); Ht. c.1.0m, valley, near the Third Water Fall, flower orange, 19 vi 1995, S. Sakai 251 (KYO).

*Amomum calyptratum* is distinguished by few bladed leaf shoots and leaves pubescent on the lower surface. Although few bladed leaf shoots are a common feature of *A. paucifolium* and ‘almost unique in *Amomum*’ (Smith, 1985), *A. calyptratum* has open bracteoles and a lanceolate rather than a clawed and bilobed labellum.

*A. gyrolophos*, *A. oliganthum* and this species all have an orange flower with a large lip, which functions as a platform for their pollinators, *Amegilla* bees, and a broad filament that blocks the entrance of the corolla against nectar robbers.

#### 8. *Amomum somniculosum* S. Sakai & Nagam., sp. nov. Figs 4, 8C.

Species nova *A. calyptrato* S. Sakai & Nagam. bracteola ad basin aperta forma cristae antherae et calice secedenti ad partim superiorem calyptratam et partim inferiorem tubulalem similis, sed foliis per frondis pluribus inflorescentia fusiformi floribus parvioribus albis et labello trilobo differt.

Type: Sarawak, Lambir Hills National Park, Ht. 1m, flower white with red and yellow on the centre of the lip, 20 ii 1995, S. Sakai 178 (holo. KYO, iso. E).

Perennial herb 0.7–1.5m tall. *Leaves* distichously arranged; lamina gradually narrowing upwards from lanceolate to linear, 20–35 × 3.5–6.5cm (at the middle of the stem), glabrous except marginal short hairs, apex acuminate, base attenuate; sessile;

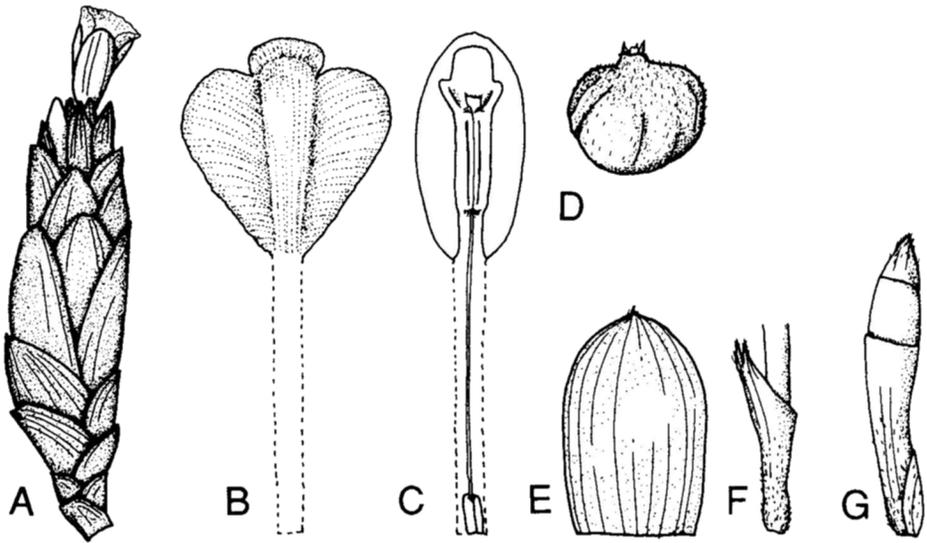


FIG. 4. *Amomum somniculosum*. A, inflorescence,  $\times 0.7$ ; B, ventral part of dissected flower,  $\times 1.3$ ; C, dorsal part of dissected flower,  $\times 1.3$ ; D, capsule in lateral view,  $\times 1.3$ ; E, bract,  $\times 0.8$ ; F, fissured calyx,  $\times 1.5$ ; G, flower bud with calytrate calyx,  $\times 1.5$ . From S. Sakai 178.

ligules 3–5mm long, papery with membranous margin, margin entire or shallowly bilobed, glabrous; sheath glabrous with membranous margin. *Inflorescence* radical, c.80  $\times$  25mm, fusiform, with an up to 4cm long peduncle; bracts light brown, 30–35mm long and 25mm wide, oblong, glabrous except the tip, papery, apex obtuse to emarginate, often with an apicule, entire; bracteoles 3–11mm long, linear, glabrous, open to the base. *Flowers* white, borne singly; calyx 14–18mm long, tubular and truncate or fissured at the side up to half of the length, with two or three teeth at the apex in the latter case, pubescent on the lower part of the tube; corolla tube 30mm long, pubescent outside and glabrous inside; dorsal petal 18–22  $\times$  11–12mm, oblong, pubescent outside; lateral petals 18–20mm long, c.6mm wide, glabrous, free from the labellum; labellum white with a central yellow line fringed red, c.21  $\times$  23mm, 3-lobed; filament c.4.5mm long; anther thecae c.7.5mm long, dehiscing throughout their length; anther crest c.5.5mm long, 3-lobed, central lobe longer than laterals and curved backward; lateral staminodes 1mm long, linear; stigma cup-shaped, open upward, with hairs on the edges of their opening; ovary c.3  $\times$  3mm, trilocular with axile placentation, pubescent; epigynous glands c.3.5mm high. *Fruits* 12–14mm diam., c.15-ribbed, flask-shaped with a short neck, pubescent.

LAMBIR HILLS. Ridge, secondary forest, flower white, centre of lip yellow and white, preserved in alcohol, c.20 leaves per shoot, 20 vi 1994, S. Sakai 46 (KYO); in Canopy Biology Plot, height 1.2m, white flower and fruit preserved in alcohol, 29 vi 1994, S. Sakai 57 (KYO).

*Amomum somniculosum* shares morphological similarities with *A. calyptratum* in the

open bracteole, the shape of the anther crest, and the way in which the calyx splits into the basal tubular part and the calyprate one.

This species often occurs in the forest. Its flowers open between 9:00 and 11:00 in the morning, later than most of the flowers of Zingiberaceae. Halictid bees, the pollinators of the species, were observed to force the flower open and collect floral nectar impatiently. The epithet 'somniculosum' is selected in relation to this habit.

**9. *Amomum durum* S. Sakai & Nagam., sp. nov. Figs 5, 8D–E.**

Species nova robusta labello lato et peticarpio duro; similis *A. macroglosso* K. Schum. sed differt planta robustiore cum foliis majoribus ligula parviore et crista antherae 3-lobata.

Type: Sarawak, Lambir Hills National Park, valley, Ht. 2.5m, flower creamy white

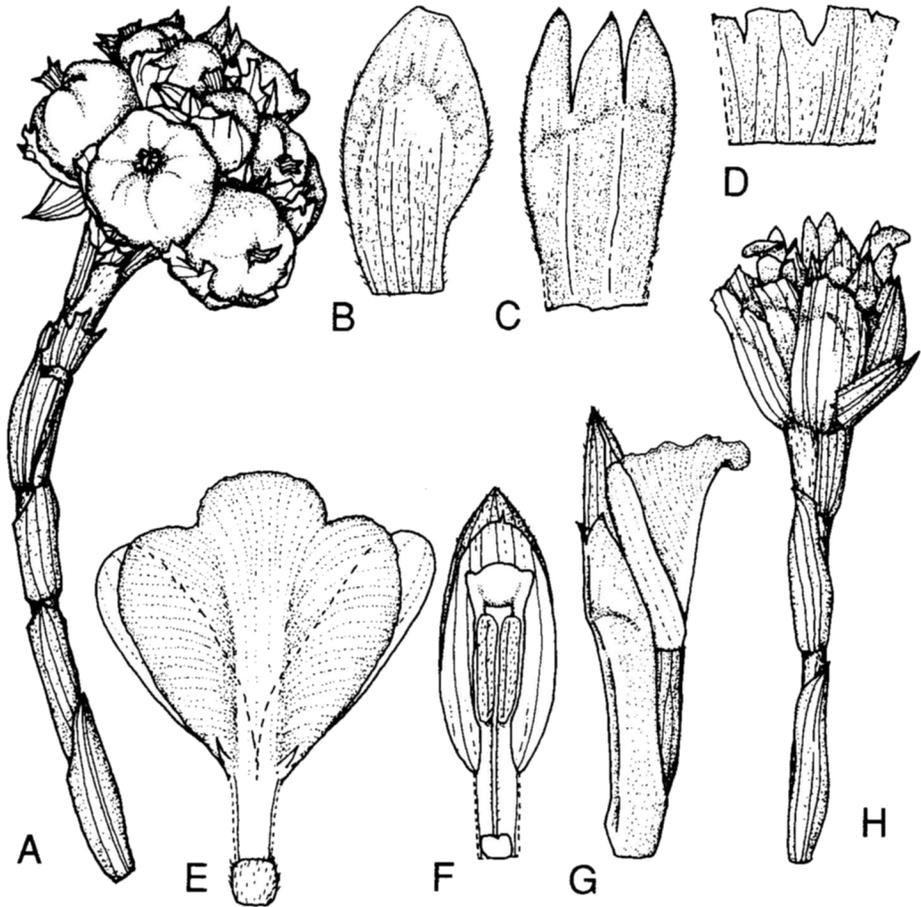


FIG. 5. *Amomum durum*. A, infructescence,  $\times 0.7$ ; B, bract,  $\times 3.5$ ; C, bracteole,  $\times 1.8$ ; D, calyx,  $\times 1.6$ ; E, dorsal part of dissected flower,  $\times 2$ ; F, ventral part of dissected flower,  $\times 2$ ; G, lateral view of flower,  $\times 2$ ; H, inflorescence,  $\times 0.7$ . From S. Sakai 191.

with a yellow line on the centre of the lip, 26 iii 1995, *S. Sakai* 191 (holo. KYO, iso. E).

Perennial herb c.2.5m tall. *Leaves* distichously arranged; lamina 30–70 × 8–11cm, lanceolate to linear, glabrous except on the midrib below, apex acuminate, base attenuate, sessile; ligules 20–35mm long, deeply bilobed, membranous, pubescent; sheath reticulate, pubescent with membranous margin. *Inflorescence* radical, c.45 × 40mm, obovate with 15–20cm peduncle; bracts light brown, c.35 × 15mm, narrowly obovate, pubescent outside glabrous inside, papery, margin membranous and fragile with dense hairs, apex obtuse; bracteoles c.21mm long, tubular at the base only, 3-lobed, pubescent outside on the lower part. *Flowers* creamy white, borne singly; calyx c.11mm long, tubular and truncate with two or three slits, pubescent outside and glabrous inside; corolla tube c.7mm long, glabrous; dorsal petal c.17 × 8mm, boat-shaped, slightly pubescent outside, margin hairy; lateral petals c.17 × 6mm, narrowly oblong, free from the labellum, margin hairy; labellum creamy white with a central yellow line, c.19 × 20mm, obovate, 3-lobed; filament c.3mm long; thecae c.7mm long, pubescent, dehiscing throughout their length, the connective prolonged into a crest; crest c.3.5mm long, 3-lobed; lateral staminodes c.2.5mm long, linear or 2-toothed; style pubescent; stigma cup-shaped open upward, with hairs on the rim of the opening; ovary c.3.5 × 3.5mm, trilocular with axile placentation, pubescent, epigynous glands c.2mm long. *Fruits* 15–30mm diam., spherical with a depression at the base of remaining calyx before drying while c.15-ribbed after being dried.

LAMBIR HILLS. Near the Second Water Fall, 4 ix 1994, *S. Sakai* 94 (KYO).

One of the outstanding characters of this species is its large fruits with a thick wall. The inflorescences, which arise from a rhizome held above the ground on stilt roots, are erect while flowering, pollinated by halictid bees, and hang down as the fruits mature.

**10. *Amomum roseisquamosum* Nagam. & S. Sakai, *Edinb. J. Bot.* 53: 39 (1996). Fig. 8G–H.**

Type: Sarawak, Miri, Lambir Hills National Park, in mixed dipterocarp forest, near the Third Water Fall, epiphyte at 7m above ground, bracts pink, flower white with a pink patch in the centre of lip, 23 iii 1995, *S. Sakai* 188 (holo. KYO).

This epiphytic species does not agree with the diagnosis of Group V proposed by Smith (1989a) in several points, such as the condition of the lateral petals and corolla tube length as discussed in Nagamasu & Sakai (1996).

A labellum of its flower rolls up to form a slender tube and allows only little spiderhunters its nectar. This species is the only *Amomum* pollinated by birds (little spiderhunters) in the Lambir Hills, and only one individual has been found. Its pink bracts, in common with *A. bilabiatum*, may have something to do with its bird-pollinated habit.

The two species below have not been observed by the authors in the field.

**11. *Amomum xanthophlebium*** Baker, in Hook.f., Fl. Brit. Ind. 6: 241 (1892); Ridley in J. Str. Br. Roy. As. Soc. 32: 133 (1899).

Type: Malay Peninsula, Malacca, *Maingay*, Kew distribution No. 1585 (K, n.v.).

Syn.: *Amomum stenoglossum* Baker in Hook.f., Fl. Brit. Ind. 6: 234 (1892); K. Schum. in Pflanzenr. Zing. 251 (1904). Type: Perak, alt. 500–1000ft., *King's Collector* (n.v.).

LAMBIR HILLS. Ridge of Bukit Lambir, 2m, spent heads only, 25 ix 1978, *Burt* 11614 (E).

**12. *Amomum bilabiatum*** S. Sakai & Nagam., sp. nov. Fig. 6.

Species nova *A. roseisquamoso* Nagam. & S. Sakai planta epiphytica bracteis roseis floribus albis valde similis, sed inflorescentia cylindrica bractea in cincinno saltem 2 flores subtendenti et crista antherae minuta differt.

Type: Sungai Liam Libau, above main waterfall, on trunk over stream, no sterile involucre, bracts pink, inner white tipped, flower white, red at base of lip and lower down, upper petal forming a hood, recurved at tip so flower seemingly bilabiate, 22 ix 1978, *Burt* 11590 (E).

*Gen. ignota*, R.M. Sm. in Notes Roy. Bot. Gard. Edinburgh 42: 314 (1985).

Epiphytic herb, c.0.7m tall. *Leaves* distichously arranged; lamina 15–30cm long, 4–7cm wide, oblanceolate, glabrous, apex acuminate, base attenuate, sessile to

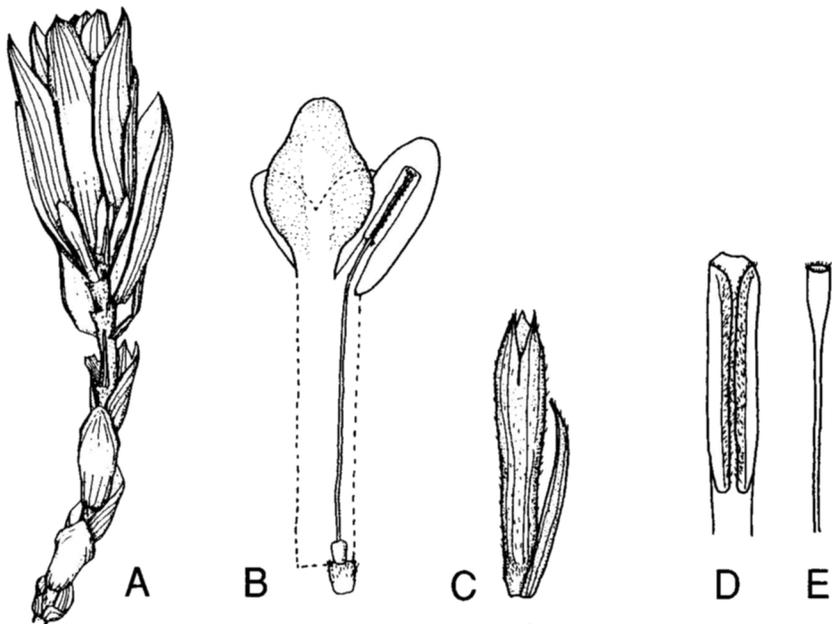


FIG. 6. *Amomum bilabiatum*. A, inflorescence, several bracts and flowers removed,  $\times 0.6$ ; B, dissected flower,  $\times 1.4$ ; C, bracteole and calyx,  $\times 1.5$ ; D, anther,  $\times 3.5$ ; E, stigma,  $\times 3.5$ . From *Burt* 11590.

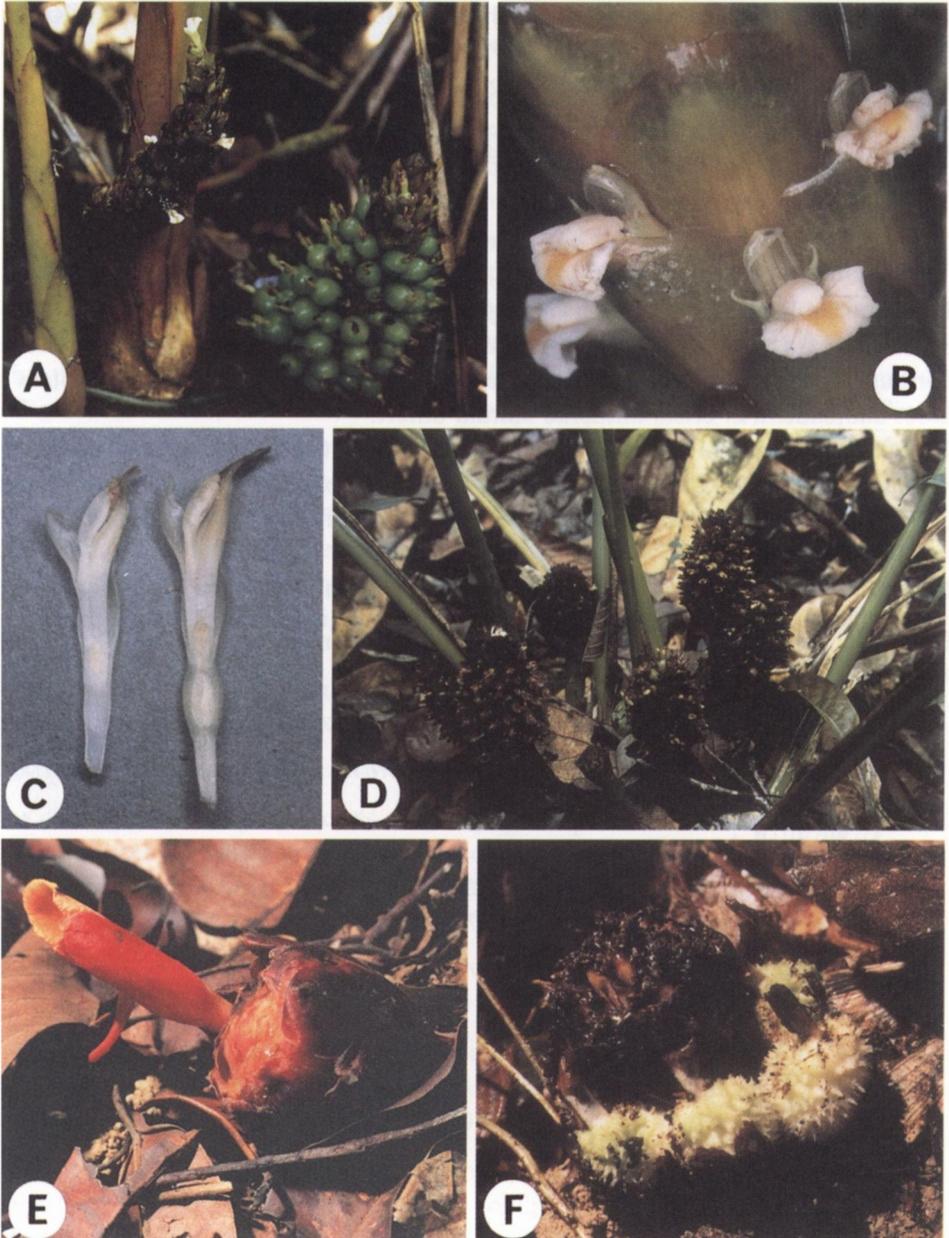


FIG. 7. A–C *Amomum polycarpum* (S. Sakai 82): A, inflorescence and infructescence; B, close-up of flower; C, dissected male (left) and hermaphrodite (right) flowers (no specimen); D, *Amomum coriaceum*: inflorescence and infructescence (no specimen); E–F *Amomum gyrolophos* (S. Sakai 75): E, inflorescence embedded in the ground; F, infructescence.

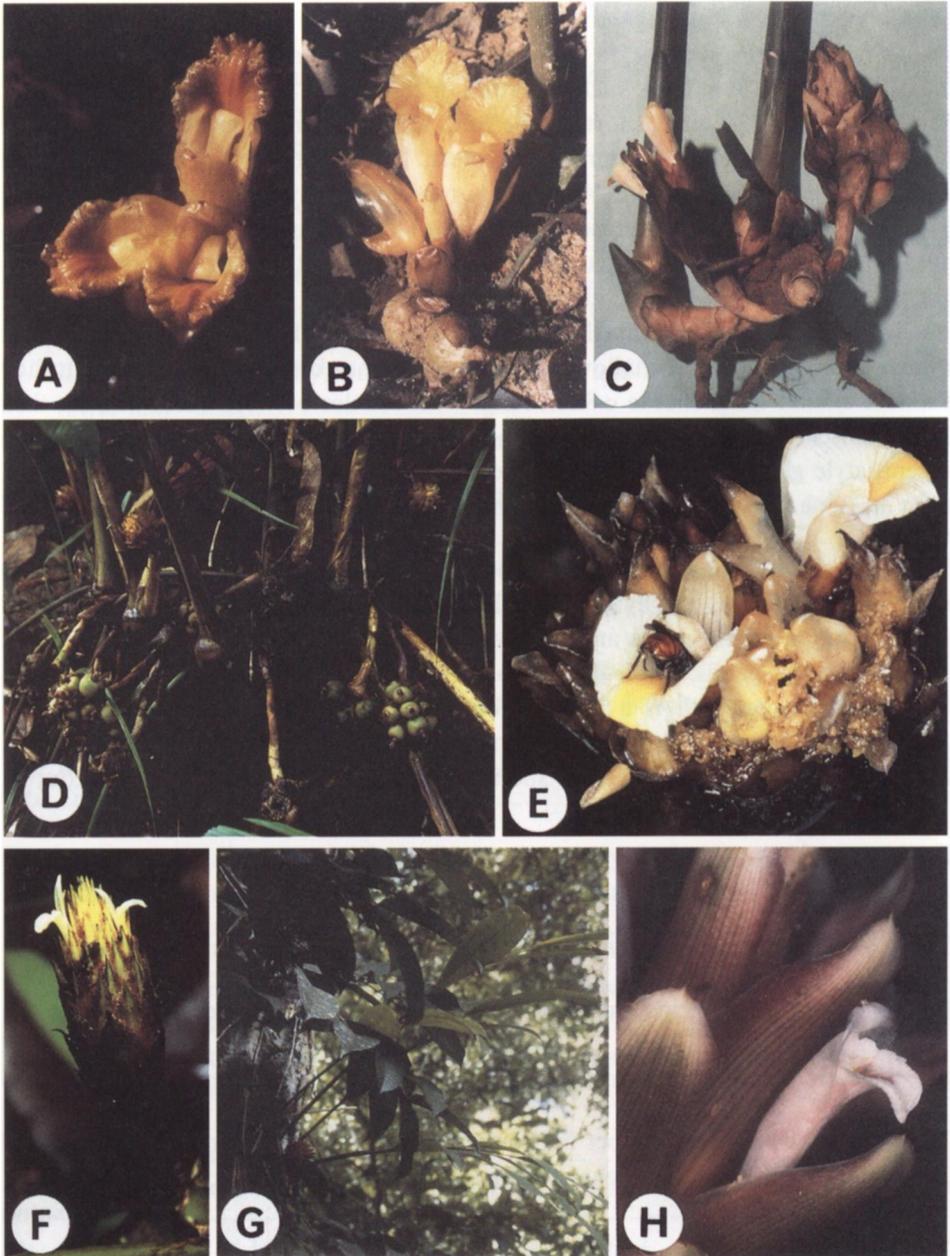


FIG. 8. A, *Amomum oliganthum*: inflorescence (S. Sakai 187); B, *Amomum calyptratum*: inflorescence and infructescence (S. Sakai 156); C, *Amomum somniculosum*: rhizome with inflorescence and infructescence (S. Sakai 57); D–E *Amomum durum* (no specimen): D, inflorescence and infructescence; E, close-up of inflorescence visited by halictid bee (*Nomia* sp.); F, *Amomum angustipetalum*: inflorescence (no specimen); G–H *Amomum roseisquamosum* (same plant with S. Sakai 188): G, epiphytic habit; H, close-up of flower.

petiolate up to 4cm long; ligules c.5mm long, entire, glabrous, margin membranous; sheath striate, glabrous, margin membranous. *Inflorescence* radical, c.8 × 3cm, cylindrical; peduncle c.9cm long; rachis angular or flattened?; bracts pink, c.45mm long, 15–25mm wide, lanceolate, shortly pubescent outside glabrous inside, papery, margin membranous; bracteoles c.18mm long, linear, hairy especially at the top. *Flowers* white, two per bract; calyx c.24mm long, tubular, unilaterally fissured for c.7mm long, 3-toothed, pubescent outside glabrous inside; corolla tube c.26mm long, glabrous; dorsal petal c.16 × 9mm, narrowly oblong, pubescent outside in the apical part; lateral petals c.12.5 × 4.5mm, elliptic, centrally connate to each other and to the labellum in the lower part; labellum white with red centrally and lower down, c.15 × 10mm, rhombic to ovate, shallowly 3-lobed, slightly pubescent on the lower surface; filament c.5mm long; thecae c.8mm long, with bristles between them and on their tops, dehiscent throughout their length, crest thin and minute; lateral staminodes absent; style glabrous; stigma cup-shaped, ciliate at the mouth; ovary c.4 × 3.5mm, hairy upper half; epigynous glands c.3mm high. *Fruits* unknown.

Though Smith (1985) mentioned that the specimen above may lie between *Amomum* and *Elettariopsis*, this epiphytic species has a radical cone-like inflorescence without an involucre of sterile bracts and its few bladed leaf shoots do not deviate from the characters of the genus. While its position in the genus is unclear, its cincinni-bearing inflorescence suggests it is a member of Smith's Group I, but its anther thecae dehiscent throughout their length does not agree with the diagnosis of the group. In addition, in its epiphytic habit this species seems to be related to Smith's Group V.

#### KEY TO SPECIES

The key to species of *Amomum* from Borneo by Smith (1986) is revised as below.

- 1a. Flowers borne in cincinni; anthers dehiscent throughout their length or not \_\_\_\_\_ 2
- 1b. Flowers borne singly; anthers dehiscent throughout their length \_\_\_\_\_ 7
- 2a. Anthers dehiscent in upper half only; bracteole tubular (Smith's Group I) 3
- 2b. Anthers dehiscent throughout their length; bracteole linear, open to the base \_\_\_\_\_ **A. bilabiatum**
- 3a. Inflorescence globose (elongating later); bracts firm textured with a short pungent tip; fruit round with a short neck \_\_\_\_\_ **A. lambirensis**
- 3b. Inflorescence conical, even when young; bracts usually papery, without pungent tips; fruit flask-shaped or round and lacking a neck \_\_\_\_\_ 4
- 4a. Ligule to 3cm long; calyx lobes with prominent subapical spurs; filament present \_\_\_\_\_ 5

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- 4b. Ligule 1–2cm long; calyx lobes not subapically spurred; anther sessile \_\_\_\_\_ 6
- 5a. Flowers orange; peduncle bracts 5 × 3cm; leaves to 5cm wide \_\_\_\_\_ **A. ligulatum**
- 5b. Flowers white with yellow centre to labellum; peduncle bracts c.4 × 1.5cm; leaves 3cm wide or less \_\_\_\_\_ **A. polycarpum**
- 6a. Leaf tips acute or shortly caudate; flowers c.1.5cm long; anther connective more or less truncate \_\_\_\_\_ **A. anomalum**
- 6b. Leaf tips long caudate; flowers 2.5 × 3cm long; anther connective deeply emarginate with a small appendage in the cleft \_\_\_\_\_ **A. burttii**
- 7a. Lateral petals centrally connate to each other and to the labellum in the lower half \_\_\_\_\_ 8
- 7b. Lateral petals free; anther connective usually crested \_\_\_\_\_ 11
- 8a. Anther connective ecristate; corolla tube long exerted from the calyx (Smith's Group II) \_\_\_\_\_ 9
- 8b. Anther connective crested; corolla tube almost equal to the calyx \_\_\_\_\_ **A. roseisquamosum**
- 9a. Leaves lanceolate; inflorescence much longer than 4cm \_\_\_\_\_ 10
- 9b. Leaves linear (to 2cm wide); inflorescence up to 4cm long \_\_\_\_\_ **A. hansenii**
- 10a. Labellum as long as lateral petals \_\_\_\_\_ **A. pungens**
- 10b. Labellum longer than lateral petals \_\_\_\_\_ **A. angustipetalum**
- 11a. Corolla tube slender, long exerted from the calyx \_\_\_\_\_ 12
- 11b. Corolla tube more or less equal to or shorter than the calyx; bracts rarely pungent (Smith's Group IV) \_\_\_\_\_ 14
- 12a. Bracts pungent; anther thecae with basal spurs which are adnate to the broad filament; capsule not flattened (Smith's Group III) \_\_\_\_\_ **A. sarawacense**
- 12b. Bracts with acuminate or rotundate apex; anther thecae without basal spurs as above; capsule flattened (Smith's Group V) \_\_\_\_\_ 13
- 13a. Flower reddish pink; leaves 30–40 × 6–8cm \_\_\_\_\_ **A. borneense**
- 13b. Flower yellow; leaves up to 20 × 4.5cm \_\_\_\_\_ **A. epiphyticum**
- 14a. Leaf shoots 3–4-bladed; ligule more or less bilobed \_\_\_\_\_ 15
- 14b. Leaf shoots frond-like, many-bladed; ligule rarely bilobed \_\_\_\_\_ 16
- 15a. Bracteole tubular; labellum slightly bilobed \_\_\_\_\_ **A. paucifolium**
- 15b. Bracteole linear; labellum obovate \_\_\_\_\_ **A. calyptratium**
- 16a. Leaf shoot delicate (under 50cm tall); blades linear; fruit not echinate \_\_\_\_\_ **A. bicorniculatum**
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- 16b. Leaf shoot much more robust; blades rarely linear, if so, then fruit not echinate \_\_\_\_\_ 17
- 17a. Ligule up to 6cm long, entire; entire plant glabrous \_\_\_\_\_ **A. macroglossum**
- 17b. Ligule rarely exceeding 3cm, if so, then deeply bilobed; plant rarely totally glabrous \_\_\_\_\_ 18
- 18a. Ligule 2–3.5cm \_\_\_\_\_ **A. durum**
- 18b. Ligule not exceeding 3cm \_\_\_\_\_ 19
- 19a. Bracts frilled at margins with short pungent tips; inflorescence becoming mucilaginous \_\_\_\_\_ **A. coriaceum**
- 19b. Bracts not as above; inflorescence never becoming mucilaginous \_\_\_\_\_ 20
- 20a. Anther crest absent; petiole, leaf sheaths and sheaths of the peduncle with very conspicuous hairy reticulations \_\_\_\_\_ **A. dictyocoleum**
- 20b. Anther crest always well formed; leaf sheaths etc., if hairy reticulate, then not as conspicuously as above \_\_\_\_\_ 21
- 21a. Anther crest entire or shallowly 3-lobed; bracteole distinctly tubular and remaining so \_\_\_\_\_ 22
- 21b. Anther crest 3-lobed; bracteole open to the base or tubular at the base only \_\_\_\_\_ 27
- 22a. Flowers red and white \_\_\_\_\_ **A. cerasinum**
- 22b. Flowers orange \_\_\_\_\_ 23
- 23a. Peduncle much longer than 10cm \_\_\_\_\_ 24
- 23b. Peduncle c.7cm long \_\_\_\_\_ 25
- 24a. Bract pubescent with prominent reticulation, becoming skeletonized with age; labellum 3-lobed \_\_\_\_\_ **A. sceletescens**
- 24b. Bract not as above, glabrous; labellum entire \_\_\_\_\_ **A. oliganthum**
- 25a. Anther crest obscurely 3-lobed; staminodes present \_\_\_\_\_ 26
- 25b. Anther crest semi-lunar; staminodes absent \_\_\_\_\_ **A. gyrolophos**
- 26a. Ovary glabrous; mid-lobe of anther crest entire; petiole up to 2.5cm long \_\_\_\_\_ **A. laxisquamosum**
- 26b. Ovary pubescent, verrucose; mid-lobe of anther crest emarginate; lamina subsessile to shortly petiolate \_\_\_\_\_ **A. kinabaluense**
- 27a. Anther crest 3-lobed; the mid-lobes much longer than side-lobes; bracteole linear \_\_\_\_\_ **A. somniculosum**

- 27b. Anther crest 3-lobed with well-defined side-lobes or mid-lobe occasionally suppressed; bracteole open to the base or tubular at the base only \_\_\_\_\_ 28
- 28a. Bracteole open to the base, firm textured, enfolded round and almost as long as the bract; flowers predominantly orange \_\_\_\_\_ **A. xanthophlebium**
- 28b. Bracteole sometimes tubular at the base never approaching the length of the bract; flowers usually yellow and white \_\_\_\_\_ 29
- 29a. Peduncle to 35cm; ligule bilobed \_\_\_\_\_ **A. longipedunculatum**
- 29b. Peduncle under 15cm; ligule entire \_\_\_\_\_ 30
- 30a. Leaves distinctly petiolate (petioles to 3cm); leaves pubescent on or around the midrib below \_\_\_\_\_ **A. luteum**
- 30b. Leaves sessile or subsessile; glabrous or pubescent on or around the midrib below \_\_\_\_\_ 31
- 31a. Leaf sheaths reticulate \_\_\_\_\_ 32
- 31b. Leaf sheaths striate \_\_\_\_\_ 34
- 32a. Leaves up to 60 × 10cm; bracts narrowly triangular, papery, markedly striate \_\_\_\_\_ **A. testaceum**
- 32b. Leaves up to 40 × 6cm; bracts usually broadly triangular, firm, not markedly striate \_\_\_\_\_ 33
- 33a. Leaf sheaths pubescent; ligule pubescent \_\_\_\_\_ **A. ridleyi**
- 33b. Leaf sheaths glabrous; ligule glabrous \_\_\_\_\_ **A. flavidulum**
- 34a. Leaves pubescent on midrib below \_\_\_\_\_ **A. flavoalbum**
- 34b. Leaves glabrous \_\_\_\_\_ **A. sp. (Smith, 1985: 312)**

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