
SYSTEMATIC STUDIES OF BORNEAN *ZINGIBERACEAE*: III. *TAMIJIA*: A NEW GENUS

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A new monotypic genus, *Tamijia* (*Zingiberaceae*), and its species *T. flagellaris* are described from Sarawak, Borneo. *T. flagellaris* is quite unique with the lateral staminodes connate to the labellum, the plane of distichy of the leaf shoot transverse to the rhizome, long trailing inflorescences and ovary unilocular with parietal placentation. Although the species is placed in *Alpineae* based on the plane of distichy, it is quite distinctive from most of the species in the tribe in some other characters, and is important in considering the current system of tribes and genera of the family.

Keywords. *Alpineae*, *Hedychieae*, Sarawak, *Tamijia flagellaris*.

INTRODUCTION

Smith's excellent works (1985, 1986, 1987, 1988, 1989) give us an overview of Bornean *Zingiberaceae*, and have stimulated studies on the family. Smith also noted that collections were still far from sufficient to understand the diversity of the family in the area, indicating many species that remained to be described because of the lack of good materials.

One of these species is '?*Elettariopsis* sp. (Smith, 1986: 460, specimen: *Burt* 11503 and 11631 [erroneously cited as 11681])' collected at Lambir Hills, Sarawak. The species has few-leaved shoots, recalling *Elettariopsis*, but its trailing inflorescences subtending cincinni of flowers are quite similar to those of *Elettaria*. The generic position of the species was uncertain without good flowering materials, and Smith could not describe the species at that time.

In the course of studies on Bornean gingers at Lambir Hills (Sakai & Nagamasu, 1998; Sakai et al., 1999), good flowering materials of the plant were collected at the same locality as *Burt* 11503 and 11631. Detailed examination revealed that the species is quite unique, and it is thought to be important in considering the current system of tribes and genera of the family. Here we describe the species of a new genus *Tamijia*, and discuss its characteristics in relation to known taxonomic groups.

***Tamijia flagellaris* S. Sakai & Nagam., gen. et sp. nov. Figs 1, 2.**

Herba rhizomatosa; folia disticha transverse ad rhizoma; pseudocaulis debiliter evolutus. Inflorescentia radicalis vel in surculo foliato terminalis flagelliformis prostrata, bracteis aristatis distichis cincinnum subtendentibus, bracteolis ad basin apertis. Staminodia petaloidea labello connata; anthera conspicue cristata sine calcaribus

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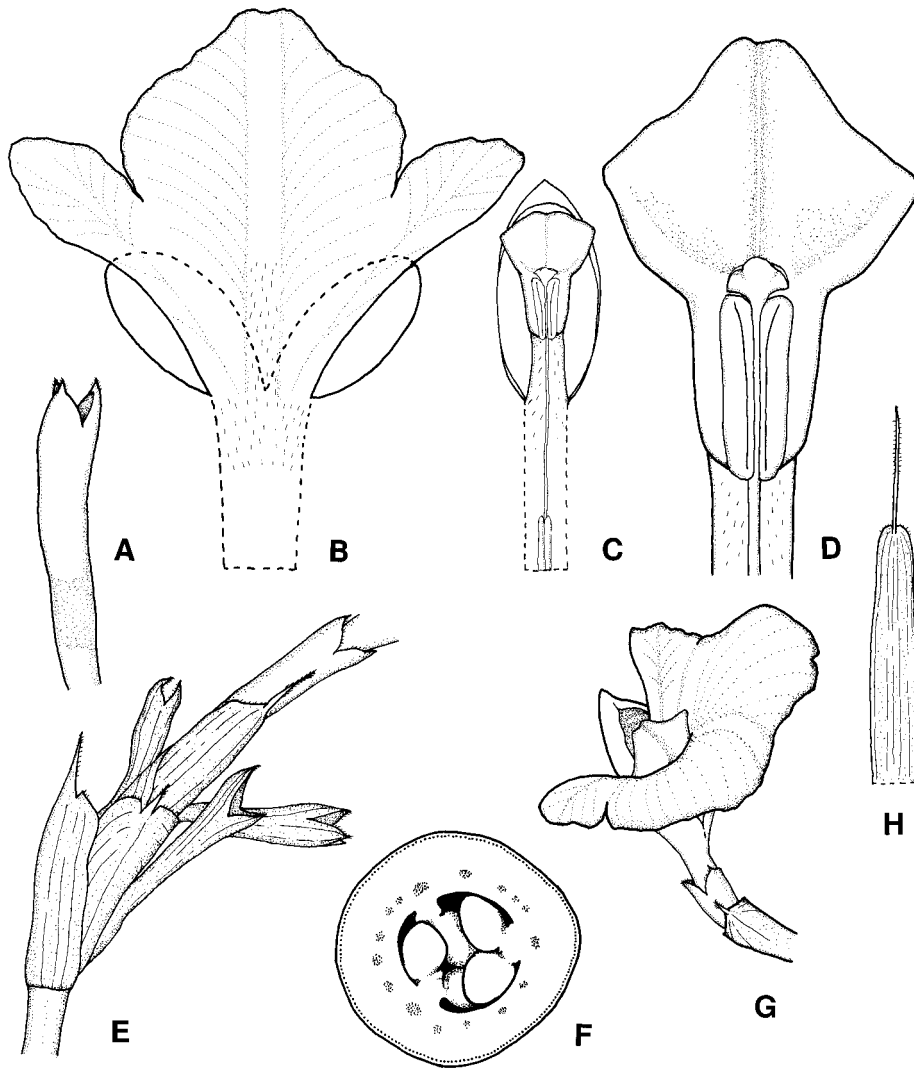


FIG. 1. *Tamijia flagellaris*: A, calyx and ovary, $\times 2.1$; B, C, flower with staminal tube dissected longitudinally, $\times 2.1$; D, anther and stigma, $\times 7$; E, cincinnus, $\times 2.8$ (from spirit material of S. Sakai 122); F, ovary in transverse section $\times 14$ (from spirit material of Nagamasu 6719); G, flower and bracteole, $\times 2$; H, bract, $\times 1$ (from spirit material of S. Sakai 122).

basalibus, filamento brevi; stigma bilabiatum margine glabrum; ovarium uniloculare placentatione parietali.

Type: Sarawak, 4th division, Lambir Hills National Park, along trail to the 3rd waterfall, flowers white, lip with green centre line, petals often tinged pink, 26 ii 1999, Nagamasu 6719 (holo. KYO, iso. SAR).

Syn.: ?*Elettariopsis* sp. R.M. Smith in Notes Roy. Bot. Gard. Edinb. 43: 460 (1986).



FIG. 2. *Tamijia flagellaris* (A, B, D, Nagamasu 6719): A, leaf shoot and long inflorescence with flower $\times 0.15$; B, longitudinal section of ovary, showing parietal placentation, $\times 7$; C, flower from the front, $\times 0.8$; D, inflorescence and flower $\times 1$.

The following is an English diagnosis for the new genus:

Rhizomatous herb. Plane of distichy of the leaves transverse to the rhizome. Pseudostem poorly developed. Inflorescence radical or terminal on the leafy shoots, long, prostrate on the ground. Primary bracts distichous, subtending cincinni of flowers. Bracteole open to the base. Stamines petaloid, connate to the labellum. Anther conspicuously crested, without basal spur. Anther filament short. Stigma two-lipped with glabrous rim. Ovary unilocular with parietal placentation.

The following is an English description for the new species:

Perennial herb, 30–50cm tall; pseudostem poorly developed, with 2–7 leaves per shoot (Fig. 2A). *Leaves* distichously arranged; lamina 24–48 × 4–8cm, obliquely and narrowly obovate, glabrous on both surfaces except for minute hairs on the apex and around the midrib on the lower surface; apex acute; base attenuate; petiole 6–17cm long, glabrous; ligule up to 3mm long, bilobed, glabrous; sheath papery and fragile, glabrous. *Inflorescence* radical or less frequently terminal, up to more than 3m long, prostrate on the ground (Fig. 2D); main inflorescence axes c.1.5mm diam. when dry, glabrous; scales 10–40mm long, open to the base, glabrous, apex obtuse and sometimes mucronate; bracts distichously arranged at 20–50mm intervals, 17–50mm long except the arista, open to the base, glabrous except apical margin and around the base of the arista, subtending up to 9 flowers; apex obtuse or retuse with an arista formed by the elongated central vein; arista up to 15mm long, minutely pubescent toward apex (Fig. 1H); secondary axes between bract and first bracteole up to 6mm, glabrous; the first bracteole lying at right angles to the bract; bracteole 7–13mm long except the apical arista, open to the base, convolute, glabrous except at the apex; apex obtuse or retuse with an arista formed by the elongated central vein, sometimes minutely pubescent; arista 2.5–3.5mm long, minutely pubescent; pedicel short, glabrous (Fig. 1E). *Flower* white, calyx c.11.5mm long, tubular, unilaterally fissured for c.5mm, glabrous or minutely hairy at the base, white tinged pink, apex 3-toothed, margin and apical teeth with minute hairs (Fig. 1A); corolla tube c.10mm long, glabrous outside, pubescent inside for upper half; dorsal petal c.12.5 × 6mm, elliptic, glabrous; lateral petals c.11 × 5.5mm, elliptic, glabrous (Fig. 1B,C); labellum c.24 × 18mm except lateral staminodes, obovate, shallowly bilobed at the apex or entire, very minutely pubescent at the throat, the pubescence extending into the upper half of the corolla tube, white with a yellow or green central line; lateral staminodes c.20 × 5mm, petaloid, linear to obovate, glabrous, connate to the labellum for more than two thirds of their length, white (Figs 1B,G, 2C); filament c.4mm long, minutely pubescent on the adaxial surface; anther thecae c.3.5mm long, dehiscent throughout their length, glabrous; anther crest 5–7 × 4–6mm, rhomboid to broadly obovate, with longitudinal depression at the centre, apex reflexed (Fig. 1D); style c.19mm long, glabrous; stigma c.1.3mm wide, two-lipped, glabrous, adaxial lip shallowly 3-lobed, abaxial lip entire (Fig. 1D); ovary unilocular with parietal placentation (Fig. 1F), with remnant septa at the upper and basal part of the ovary, 4–6mm long, glabrous or minutely pubescent in upper part (Fig. 2B); ovules c.15; epigynous glands c.3.5mm, 2-lobed. *Fruit* unknown.

Etymology. *Tamijia* is named after Prof. Tamiji Inoue (1947–1997), Kyoto University. He founded the Canopy Biology Program in Sarawak as a joint project with the Sarawak Forest Department at Lambir Hills National Park, type locality of *T. flagellaris*. He was killed in an air crash at Bt. Lambir in September 1997. In the program great efforts have been made to collect botanical specimens and carry out field observation to investigate biodiversity and plant–animal interactions in

tropical forests. We wish to pay respect to his contribution to studies of the ecology and taxonomy of *Zingiberaceae* and of tropical biology.

Distribution and habitat. Sarawak (Lambir Hills) and Brunei (Belait). On sandy soil in primary lowland tropical forests, 20–200m alt (Fig. 3).

Other materials examined. SARAWAK. 4th division, Lambir Hills National Park, Sungai Liam Libau, 18 ix 1978, *Burt* 11503 (E, SAR); *ibidem*, ridge SW of Bt. Lambir, 26 ix 1978, *Burt* 11631 (E, SAR); *ibidem*, Sg. Liku, on the slope of the river-bank, ht 30–50cm, 27 xii 1998, *S. Sakai* 410 (KYO, SAR); *ibidem*, 8 xi 1994, *S. Sakai* 122 (KYO, SAR); *ibidem*, along trail to Bt. Lambir, rather common ginger in understory of mixed dipterocarp forest, 28 ii 1999, *Nagamasu* 6753 (KYO, SAR).

BRUNEI. Belait, Labi, Sg. Rampayoh, c.5km upriver from Road, 4°22'N, 114°38'E, 60–80m, disturbed riverside forest, sandstone, easily eroded to sandy soil, 20 iii 1993, *M.J.E. Coode* 7275 (BRUN, K); *ibidem*, Parampayoh, trail to Parampayoh Waterfall, besides river, secondary forest, Lambir formation, sandstone and shale, 4°22'N, 114°28'E, 40–150m, 30 vi 1993, *J. Cowley* 419 (BRUN, K); *ibidem*, Kg. Teraja, on the ridge and near river-bank, 24 xii 1991, *Jangarun anak Eri* 22 (BRUN); Melias, Ulu Ingei, trail along Ingei river, towards Batu Melintang primary forest clay/sand Pleistocene terrace, alluvial flood plain forest floor, in leaf litter, 25m, 23 xi 1993, *J. Cowley* 122 (BRUN, K); *ibidem*, Ulu Ingei, trail to Batu

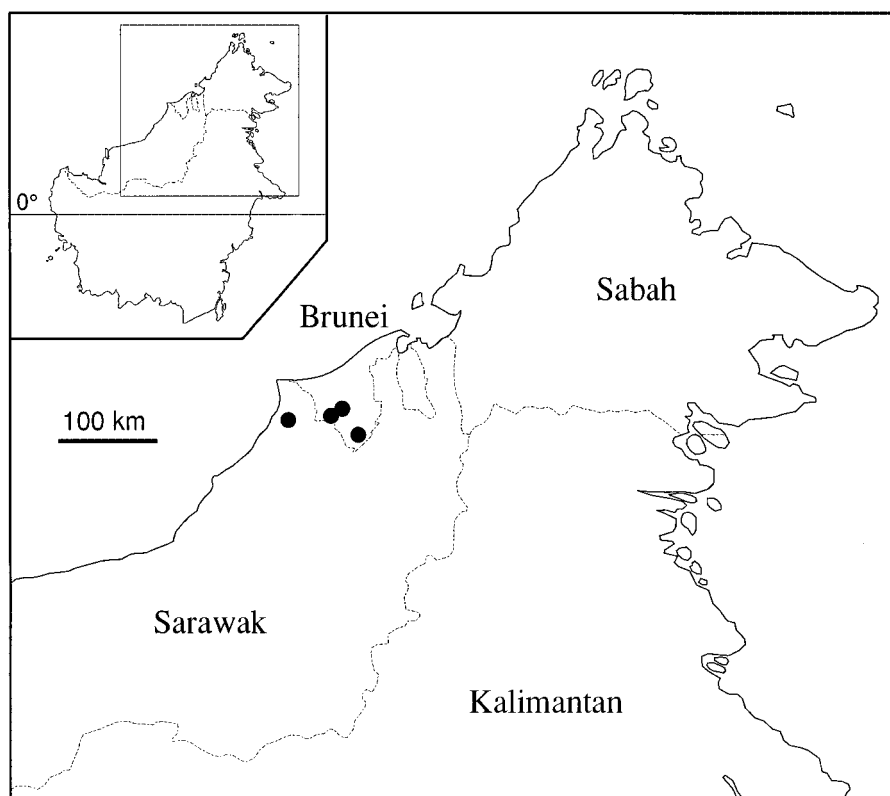


FIG. 3. Distribution of *Tamija flagellaris*.

Melingtang 1.8–2.8km from camp, primary forest, clay/sand Pleistocene terrace, alluvial flood plain forest floor along trail, 25m, 25 vi 1993, *J. Cowley* 142 (BRUN, K); ibidem, Ulu Ingei, trail from Kuala Ingei to Batu Melintang, in primary forest on alluvial flood plain, 4°09'49"N, 114°42'46"E, c.30m, 10 vi 1999, *Nagamasu* 6824 (BRUN, KYO).

While collections from Ulu Ingei, Melias have shorter leaves with whitish lower surfaces and smaller flowers than materials from the type locality, we could not find clear differences between specimens from Lambir and those from Ulu Ingei.

TAXONOMIC POSITION OF *TAMIJIA FLAGELLARIS*

Currently, four tribes are recognised in the *Zingiberaceae* (Burt, 1972b; Burt & Smith, 1972). Among them, *Zingibereae* and *Globbeae* are well-defined tribes constituted by small numbers of genera: *Zingibereae*, with the single genus *Zingiber*, is characterized by its more or less sessile anther with the elongated anther crest embracing the upper part of the style, and petaloid staminodes connate to the labellum; and *Globbeae*, with the four genera, *Globba*, *Mantisia*, *Hemiorchis* and *Gagnepainia*, is characterized by its small or poorly developed rhizome, relatively large lateral staminodes, and ovaries unilocular with parietal placentation. Most members of the tribe have a long, arching filament exerted from the flower (Larsen et al., 1998). The other two tribes, *Hedychieae* and *Alpineae*, are more diverse, and they are distinguished by the plane of distichy of the leaves and lateral staminodes. *Alpineae* is the only tribe with distichy transverse to the rhizome. The lateral staminodes are absent or are represented by small teeth at the base of the labellum, rarely petaloid but then small. On the other hand, in *Hedychieae* the plane of distichy is parallel to the rhizome and the lateral staminodes are usually petaloid and free from the labellum (Table 1), although they are absent from some *Hedychieae* (Smith, 1980).

Tamijia flagellaris is difficult to place in any tribe of the current system. Although the petaloid lateral staminodes connate to the labellum are common in *Zingibereae*, and the unilocular ovaries with parietal placentation are similar to *Globbeae*, other characteristics of *T. flagellaris* are quite different from these two tribes. The conspicuous lateral staminodes of the species indicate affinity with *Hedychieae*, but the plane of distichy of the leaves is transverse to the rhizome in *T. flagellaris* and consistent with *Alpineae* (Table 1). Although the plane of distichy of the leaves to the rhizome is difficult to examine from herbarium specimens and is often overlooked in the field, it is thought to be the most reliable character to distinguish the tribe *Alpineae* from the other three tribes (Weisse, 1932, 1933; Burt, 1972a). If so, *T. flagellaris* with distichy transverse to rhizome is considered to be a member of *Alpineae*.

Inflorescences with many-flowered cincinni as in *T. flagellaris* look similar to those of *Elettaria* in *Alpineae*, as Smith (1986) noted. The long prostrate inflorescence born radically or terminally is one of the outstanding characters of the species. Position of the inflorescences is often constant at the generic level in the family, but both terminal and radical inflorescences are known in some species of *Renealmia* and *Alpinia* in the tribe. Long prostrate inflorescences are known in some genera of

TABLE 1. Characters distinguishing the four tribes of *Zingiberaceae*

	Ovary	Plane of distichy of leaves to rhizome	Lateral staminodes
<i>Tamijia</i>	Unilocular, parietal placentation	Transverse	Petaloid, connate to the labellum
<i>Alpineae</i>	Perfectly or imperfectly trilocular, axile placentation*	Transverse	Much reduced or absent
<i>Hedychieae</i>	Trilocular, rarely unilocular with basal or free placentation	Parallel	Petaloid, free from the labellum**
<i>Globbeae</i>	Unilocular, parietal placentation	Parallel	Petaloid, free from the labellum
<i>Zingibereae</i>	Trilocular	Parallel	Petaloid, connate to the labellum

* Except part of *Riedelia* with ovary trilocular or unilocular with parietal placentation, ** except *Siphonochilus* with petaloid lateral staminodes connate to the labellum and *Stadiochilus* without lateral staminodes.

Alpineae, such as *Elettaria*, *Elettariopsis*, *Cyphostigma* and *Geocharis*, among which only *Elettaria* produces many-flowered cincinni (Table 2).

The placement of the new species in *Elettaria*, however, seems problematic. *Tamijia* is different from the species of *Elettaria* known so far in two characters, which are important to distinguish the genus especially from *Elettariopsis*: bracteoles open to the base rather than tubular, and few-bladed leafy shoots without a well-developed pseudostem (Table 2). Changes of the circumscription of the genus to include the new species would obscure the limits of *Elettaria* and other genera. Although there are still other features that characterize *Elettaria*, such as flowers in cincinni, they may be not sufficient to define the genus. Species with two flowers per bract are known in *Elettariopsis*, in which most of the species have a single flower per bract, so the distinction between *Elettariopsis* and *Elettaria* would be unclear (Table 2). Union of *Elettaria* and *Elettariopsis* together with *Tamijia*, on the other hand, should be accompanied by union or reconsideration of a large array of *Alpineae* including *Amomum*, *Aframomum*, *Cyphostigma*, *Aulotandra*, *Geocharis*, *Renealmia*, and *Geostachys* (Table 2).

In addition, *T. flagellaris* has other characters quite different from other members of *Alpineae*: petaloid lateral staminodes connate to the labellum and unilocular ovary with parietal placentation. It indicates the possibility that the resemblance of the species to *Elettaria* in inflorescences is superficial.

In *Zingiberaceae*, petaloid lateral staminodes are easily recognised by their venation, and never confused with side lobes of the labellum. The central vein on a lateral staminode runs independently of those on the labellum (Fig. 1B), although

TABLE 2. Difference between *Tamijia* and some genera in *Alpineae*

	Inflorescence	Ovary	Flowers	Development of pseudostem	Bracteole	Anther crest	Lateral staminodes
<i>Tamijia</i>	Prostrate	Unilocular, parietal placentation	In cincinni	Poor	Open to the base	Petaloid	Connate to the labellum
<i>Amomum</i> , <i>Aframomum</i>	Forming a compact head	Trilocular, axile placentation	Single, or occasionally in cincinni	Well developed	Open to the base or tubular	Conspicuous or inconspicuous	Absent or very small, sometimes linear
<i>Elettaria</i>	Prostrate	Trilocular, axile placentation	In cincinni	Well developed	Tubular	Small	Absent, small or subulate
<i>Elettariopsis</i>	Prostrate	Trilocular, axile placentation	Single, rarely two	Poor	Open to the base	Conspicuous	Absent or very short
<i>Cyphostigma</i>	Prostrate	Trilocular, axile placentation	Single	Poor	Tubular	Conspicuous, almost equalling to the labellum	Absent
<i>Aulotandra</i>	Lax, erect	Trilocular, axile placentation	Single	Poor	Absent	Conspicuous, petaloid	Absent
<i>Geocharis</i>	Lax, more or less erect or long prostrate	Trilocular, axile placentation	Two	Well developed	Tubular	Small	Very small, tooth-like
<i>Renealmia</i>	Lax and erect, sometimes terminal	Trilocular, axile placentation	Single or in cincinni	Well developed	Tubular	Inconspicuous or absent	Very small, tooth-like
<i>Geostachys</i>	To 20cm long, lax, erect or bent downward	Trilocular, axile placentation	In cincinni	Well developed	Tubular	Absent or present, sometimes conspicuous	Absent or small lobe at the base of the labellum

veins on sidelobes of the labellum are branched from one of two central veins above the staminal tube (Burt, 1972b).

Lateral staminodes connate to the labellum are found only in *Siphonochilus* in *Hedychieae*, and *Zingibereae*. *Siphonochilus* is an African genus formerly placed in *Kaempferia* (Kam, 1980; Burt, 1982). *Siphonochilus* and *T. flagellaris* share petaloid lateral staminodes connate to the labellum, stigma not ciliate along the rim, broad and petaloid anther crest and short filament. The first two characters are rarely found in other genera of the family, and we can not completely deny affinity with *Siphonochilus*, in spite of the considerable differences such as trilocular ovaries, flowers borne singly, and absence of bracteoles in *Siphonochilus* (Table 3).

The unilocular ovary with parietal placentation is one of the most important characters of this plant. In *Alpineae* ovaries of most species are trilocular with axile placentation, but trilocular or unilocular ovaries with parietal placentation are known in some *Riedelia*. On the other hand, no parietal placentation has been reported in *Hedychieae*, while some genera, such as *Boesenbergia*, *Scaphochlamys* and *Haplochorema*, have variation in ovary types within a genus from trilocular with axile placentation to unilocular with basal or free placentation (Table 3).

In conclusion, we place *Tamijia flagellaris* in *Alpineae* based on the plane of distichy of the leaves being transverse to the rhizome, although the species has many characters quite distinctive from others in the tribe. The species cannot be placed in any genera in *Alpineae*, and the widening of the generic limits is impossible without reconsideration of a large part of the tribe. We think that it justifies erection of a new genus.

Tamijia flagellaris is not the only species that does not fit the current system in the family. *Stadiochilus*, described from Burma, does not have petaloid lateral staminodes, while other floral characters of the genus indicate affinity with members of *Hedychieae* (Smith, 1980). Besides, many species that cannot be placed in known genera have been described as monotypic genera recently (*Cornukaempferia* [Mood & Larsen, 1998], *Distichochlamys* [Newman, 1995], and *Siamanthus* [Larsen & Mood, 1997]). It suggests that further research and examination of the current system in *Zingiberaceae* is needed.

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TABLE 3. Differences between *Tamijia* and some genera in *Hedychieae*

	Arrangement of bracts	Mode of flowering	Ovary	Flowers	1st bracteole	Lip	Thecae	Anther crest	Lateral staminodes
<i>Tamijia</i>	Distichous	Base-apex	Unilocular, parietal placentation	In cincinni	Keeled with apical spine, arising at right angle to bract	Shallowly bilobed	Spurs absent	Petaloid	Connate to the labellum
<i>Siphonochilus</i>	Spiral?	Base-apex	Trilocular	Single	Absent	Bilobed	Spurs absent	Petaloid	Connate to the labellum
<i>Caulokaempferia</i>	Distichous	Apex-base	Trilocular	In cincinni	Membrenous	Entire or bilobed, concave	Spurs absent	Petaloid	Free
<i>Distichochlamys</i>	Distichous	Base-apex	Trilocular	In cincinni	With two keels	Bilobed, not saccate	Spurs absent	Small	Free
<i>Scaphochlamys</i>	Spiral	Base-apex	Trilocular or unilocular with basal placentation	Usually in cincinni	Often more or less keeled; arising opposite bract	Bilobed or entire, never saccate	With very short, free, basal spurs	Small	Free
<i>Boesenbergia</i>	Distichous	Apex-base	Trilocular or unilocular with basal or free placentation	Single	Boat-shaped, arising at right angle to bract	Usually saccate, rarely bilobed, never flat	Spurs absent	Small or absent	Free
<i>Kaempferia</i>	Spiral	Base-apex	Completely or incompletely trilocular	Single	Deeply split, arising opposite bract	Deeply bilobed, often flat	Spurs absent	Petaloid	Free
<i>Cornukaempferia</i>	Spiral	Base-apex	Trilocular	Single	Absent	Broad, undivided	Spurs absent	Long, narrow and curved	Free
<i>Haplochorema</i>	Distichous	Apex-base	Trilocular or unilocular with basal placentation	Single	Boat-shaped or split, arising at right angle to bract	Bilobed or emarginate, flat	Spurs absent	Petaloid	Free

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