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POLLEN MORPHOLOGY OF SOME THAI GESNERIACEAE

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ABSTRACT

The Gesneriaceae (African violet family) is a large pantropical family with about 3,000 species, mostly herbs or, rarely, shrubs. Pollen grains of 34 species in 16 of the 26 known Thai genera, all of which are in the subfamily Cyrtandroideae, were examined by scanning electron microscopy and many by light microscopy. The investigation was undertaken to discover the taxonomic value of pollen morphology in the Thai members of the family which has received little previous study and to compare our results with Gesneriaceae in other parts of the world. Five different types of pollen grains were found among the Thai species in addition to the ten types of pollen found in a study of other Gesneriaceae (Cyrtandroideae) by Luegmayr in 1993. It was concluded that the pollen of some genera and species can be identified by differences in size, shape, pattern of exine sculpturing, or aperture type—all of which have probable taxonomic importance, although all species in each genus need to be examined to verify this. Differences in the pollen morphology of 3 collections of *Aeschynanthus hildebrandii* Hemsl. and subsequent examination of herbarium specimens, revealed other differences indicating that further taxonomic studies may lead to the distinction of two different species here.

Keywords: African violet, Cyrtandroideae, palynology, taxonomy

INTRODUCTION

The family Gesneriaceae is a member of the Order Scrophulariales, which consists of 12 families and more than 11,000 species (CRONQUIST, 1988). About 75% of the species belong to Scrophulariaceae (4000 species), Acanthaceae (2500 species), and Gesneriaceae (2500 species). Gesneriaceae is taxonomically closely allied to the Scrophulariaceae, Bignoniaceae, and Orobanchaceae. It differs from Scrophulariaceae in having parietal placentation and sometimes an inferior ovary and Orobanchaceae which has a parasitic habit.

BURTT (1962) reclassified the Gesneriaceae into two subfamilies. The first, Gesnerioideae, occurs in the New World and has two tribes, Mitrarieae and Coronanthereae. The second subfamily, Cyrtandroideae, occurs only in the Old World. All Southeast Asian species are in the subfamily Cyrtandroideae, which BURTT (1962) divided into 5 tribes: Cyrtandreae, Didymocarpeae, Klugieae, Loxonieae, and Trichosporeae.

This study summarizes the results of a study of Gesneriaceae pollen from Thailand and one species from Laos, using scanning electron microscopy. The study is based on pollen

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samples from 34 species obtained from 16 genera of the 26 known Thai genera, including representative members of all 5 tribes.

There have been several recent studies on the pollen of the subfamily Cyrtandroideae using electron microscopy. LUEGMAYR (1993b) studied the pollen of 30 species and 12 hybrids (88 samples) of Cyrtandroideae. She recognized 10 exine types. Sometimes a type of exine was characteristic for a particular genus and, therefore, of taxonomic value, but in other cases several different types of exine occurred in the same genus, e.g. *Didymocarpus*. Studies by LUEGMAYR (1993a) and more recently SCHLAG-EDLER and KIEHN (2001) on *Cyrtandra*, the largest genus in the family with more than 600 species, revealed that in this case, pollen morphology did not provide characters directly suitable for generic subdivisions and was of limited taxonomic value.

Pollen of the other subfamily, Gesnerioideae, was studied by FRITZE & WILLIAMS (1988). They studied 67 species in the five genera in the *Columnea* alliance and found that the pollen was of several distinct types, based on its shape, pattern of exine sculpturing, as well as aperture shape and size. They concluded that pollen morphology confirmed the distinctiveness of some genera, but not others. WOODS (1964) studied 180 species in over 50 genera and concluded that pollen grains tended to be larger in the Gesnerioideae than in the Cyrtandroideae.

As pollen of Thai Gesneriaceae has received little study, our investigation was undertaken to establish the taxonomic significance of pollen morphology and to relate this to the pollen of Gesneriaceae in other parts of the world.

METHODS

Pollen samples were collected from dry herbarium material from Chiang Mai University (CMU) and Chulalongkorn University (BCU). Pollen grains were also obtained from material preserved in 70% alcohol (CMU) and from fresh material found in the forest. Taxa and collections used for detailed investigations are listed in Table 1. Specific names follow the classification of BURTT (2001) and the number of species worldwide was obtained from WEITZMAN & SKOG (1998).

For light microscope (LM) study, the specimens used were already preserved in 70% alcohol with a small amount of glycerol added. Pollen was then acetolysed (ERDTMAN, 1960) and stained with safranin and examined under compound microscope. Up to 50 grains were measured for each taxon.

For scanning electron microscopy (SEM) investigation, pollen grains, whether dry, preserved in alcohol, or fresh, were dried in a desiccator. The material was then spread on brass specimen stubs covered with double-sided adhesive tape. All specimens were sputter-coated with a thin layer of gold and viewed with a JEOL JSM–840 SEM at 15–20 kV.

SEM photos were used to measure the number of lumina per 25 μm^2 in mesocolpial regions. Pollen terminology follows ERDTMAN (1972), WALKER & DOYLE (1975), and PUNT *ET AL.* (1994).

Table 1. Taxa and specimens studied.*

Taxon	specimen	location
Aeschynanthus garrettii Craib	Palee 249	Chiang Mai
	Petrmitr 481	Chiang Mai
Aeschynanthus gracilis Cl.	Maxwell 94-77	Kanchanaburi
Aeschynanthus hildebrandii Hemsl.	Maxwell 92-836	Chiang Mai
	Maxwell 95-640	Chiang Mai
	Maxwell 97-1402	Chiang Rai
	Vial 39	Chiang Mai
Aeschynanthus hosseusii Pell.	Maxwell 94-865	Lampoon
Aeschynanthus lineatus Craib	Vial 24	Chiang Mai
Aeschynanthus macranthus (Merr.) Pell.	Pooma 1132	Kamphangphet
Chirita anachoreta Hance (sect. *Chirita*)	Maxwell 94-974	Lampoon
	Maxwell 95-822	Lampang
	Maxwell 96-1273	Lampoon
	Petrmitr 111	Payao
Chirita bimaculata D. Wood (sect. *Microchirita*)	Maxwell 99-279	LAOS
Chirita caerulea R. Br. (sect. *Microchirita*)	Palee 408	Chiang Mai
	Palee 310	Chiang Mai
Chirita hamosa Wall. *ex.* R. Br. (sect. *Microchirita*)	Maxwell 93-1040	Chonburi
	Maxwell 93-1269	Lampoon
	Maxwell 99-111	Mae Hong Sawn
	Palee 407	Chiang Mai
Chirita micromusa Burtt (sect. *Microchirita*)	Maxwell 94-905	Tak
	Maxwell 94-981	Lampoon
	Maxwell 97-1011	Chiang Mai
Chirita rotundata Barn. (sect. *Chirita*)	Vial 45	Chiang Mai
Didymocarpus aureo-glandulosus Cl.	Maxwell 92-496	Chiang Mai
Didymocarpus epithemoides Burtt	Maxwell 00-391	Nakorn Nayok
Didymocarpus insulsus Craib	Suddee 169	Chaiyaphum
	Maxwell 93-1098	Lampoon
Didymocarpus kerrii Craib	Maxwell 94-986	Chiang Mai
	Maxwell 96-1093	Lampang
	Panatkool 156	Lampang
Didymocarpus purpureo-pictus Craib	Maxwell 00-404	Nakorn Nayok
Didymocarpus aff. purpureo-pictus Cl.	Maxwell 99-82	Mae Hong Sawn
Epithema carnosum Bth.	Palee 73	Chiang Mai
	Maxwell 95-536	Chiang Mai
Kaisupeea herbacea (Cl.) Burtt	Pooma 1143	Chiang Mai
Leptoboea multiflora (Cl.) Gamb.	Maxwell 94-834	Lampang

*All specimens are from Chiang Mai University (CMU) except *Didymocarpus insulsus* (Suddee 169) which is from Chulalongkorn University (BCU)

Table 1. (continued)

Taxon	specimen	location
Lysionotus serratus D. Don	Maxwell 92-589	Chiang Mai
	Maxwell 96-1126	Lampang
	Maxwell 97-1017	Chiang Mai
	van de Bult 130	Kampang Phet
Oreocharis hirsuta Barn.	Vial 23	Chiang Mai
Ornithoboea arachnoidea (Diels) Craib	Maxwell 95-858	Chiang Ma
Ornithoboea wildeana Craib	Maxwell 92-651	Chiang Mai
Paraboea glabrisepala Burtt	Maxwell 96-857	Chiang Ma
Paraboea kerrii (Craib) Burtt	Maxwell 97-830	Lampang
Paraboea multiflora (R. Br.) Burtt	Palee 257	Chiang Mai
Paraboea sp.	Maxwell 96-966	Lampang
Petrocosmea kerrii Craib	Maxwell 95-859	Chiang Mai
	Maxwell 96-1115	Lampang
	Maxwell 97-794	Chiang Mai
Rhynchoglossum obliquum Bl.	Maxwell 97-1041	Chiang Mai
	Palee 327	Chiang Mai
Rhynchotechum obovatum (Griff.) Burtt	Maxwell 92-296	Chiang Mai
	Maxwell 94-618	Lampoon
	Maxwell 96-833	Lampang
Stauranthera grandiflora Bth.	Maxwell 93-622	Kanchanaburi
	Maxwell 96-1118	Lampang
Streptocarpus orientalis Craib	Maxwell 94-833	Lampang
Trisepalum birmanicum (Craib) Burtt	Maxwell 96-1058	Chiang Mai

RESULTS

General Pollen Description

All pollen grains studied are solitary, bisymmetric, isopolar and medium, small to very small, triaperturate (most species are tricolpate), and more or less circular in equatorial and polar views. Table 2 is a summary of our palynological results.

Exine patterns.—This includes reticulate-microreticulate, microreticulate, verrucate, scabrate or rugulate, with some species being intermediate between two types e.g. microreticulate-psilate. Supratectate sculptural elements are present or absent.

Exine types.—The greatest variability occurs in the exine patterns. In her study of the pollen of Old World Gesneriaceae, LUEGMAYR (1993b) recognized 10 types of exine. To enable us to compare pollen of the Thai species with other Old World species which she studied, we have followed her classification of exine types, illustrating examples from our study, and have added additional types for pollen grains which do not fit into her categories. From her illustrations, it is evident that LUEGMAYR (1993b) includes pollen with

microreticulate tecta in her types 2 and 3 and reticulate-microreticulate in types 4 and 5, which does not follow the meaning of reticulate, i.e. lumina larger than 1 μm, as defined by PUNT *ET AL.* (1994). We have, therefore, modified her types accordingly.

Luegmayr's Types (with Modifications)

Type 1.—Reticulate-microreticulate tectum, width of the lumina ± equal at the apo- and mesocolpia, supratectate sculptural elements absent, lumina irregular, luminal processes lacking. No examples in our material.

Type 2.—Reticulate or microreticulate tectum at mesocolpia, becoming perforate at the polar regions, conspicuously irregular lumina at mesocolpia, supratectal sculptural elements absent. No examples in our material.

Type 3.—Reticulate or microreticulate tectum at apocolpia and mesocolpia, lumina larger and more irregular in the polar regions, supratectate sculptural elements absent. No examples in our material.

Type 4.—Coarsely reticulate or coarsely reticulate-microreticulate, apo- and mesocolpia with numerous rod-like luminal processes, supratectate sculptural elements absent. *Stauranthera grandiflora* (Fig. 17).

Type 5.—Coarsely reticulate-microreticulate mesocolpia with numerous rod-like luminal processes, width of lumina grading to perforate at the polar regions, supratectate sculptural elements absent. No examples in our material.

Type 6.—Microreticulate at apo-and mesocolpia, lumina circular to elliptical, conical supratectate sculptural elements present. *Chirita micromusa* (Fig. 3).

Type 7.—Microreticulate at apo-and mesocolpia, irregular lumina, occasionally rod-like luminal processes present, numerous conical supratectate sculptural elements present. No examples in our material.

Type 8.—Perforate at apo- and mesocolpia, supratectate sculptural elements absent. No examples in our material.

Type 9.—Perforate at apo-and mesocolpia, numerous conical-scabrate supratectate sculpturing elements present. *Chirita hamosa* (Fig. 4).

Type 10.—Rugulate apo-and mesocolpia. *Epithema carnosum* (Fig. 9). *Didymocarpus insulsus* is also rugulate, but differs from *Epithema* in having small conical supratectal elements (Fig. 7).

Additional Types from This Study

Type 11.—Microreticulate tectum at apo- and mesocolpia, with regular luminar ± equal width at the apo- and mesocolpia, supratectate sculptural elements absent, luminal processes lacking. *Oreocharis hirsuta* (Fig. 13).

Type 12.—This type resembles Type 5 in having a coarsely reticulate-microreticulate mesocolpia with numerous rod-like luminal processes, width of lumina grading to perforate

at the polar regions, supratectate sculptural elements absent, except that the width of the lumina does not grade to perforate at the polar regions, although some lumina are smaller at the poles. *Chirita anachoreta* (Fig. 5).

Type 13.—This type resembles type 9 in having numerous conical-scabrate supratectate sculpturing elements present, but it is not perforate at apo- and mesocolpia. *Kaisupeea herbacea* (Fig. 10).

Type 14.—Pollen has verrucate sculpturing, a type not recorded by LUEGMAYR (1993a, 1993b) or SCHLAG-EDLER & KIEHN (2001). *Paraboea glabrisepala* (Fig. 14).

Type 15.—Pollen is perforate-scabrate, supratectate sculptural elements absent. *Aeschynanthus hildebrandii* (Fig. 1).

Aperture types.—All pollen is tricolpate e.g. *Chirita micromusa* (Fig. 3) with *Aeschynanthus hildebrandii* (Fig. 1) and *Epithema carnosum* being tricolporoidate, but we did not find true tricolporate apertures with an endoaperture. There is considerable variation between taxa in the length of apertures. FRITZE & WILLIAMS (1988) described apertures in the *Columnea* alliance as long, intermediate, or short and we have followed this terminology. A **long** aperture extends beyond half the distance from the equatorial margin to the centre of the pole (in polar view). An aperture of **intermediate** length reaches about half this distance and a **short** one is less than half this distance. Most species we examined have long apertures, e.g. *Chirita anachoreta* (Fig. 5), some have intermediate apertures, e.g. *Rhynchoglossum obliquum* (Fig. 16), and a few have short apertures, e.g. *Leptoboea multiflora* (Fig. 11).

The aperture membranes in all species except *Epithema carnosum* have ectexinous granules on them. LUEGMAYR (1993b) also found a smooth aperture membrane only in *Epithema*. *Rhynchoglossum obliquum*, the only Thai species in this genus, has granules of a unique type, which to our knowledge have never been recorded in the literature. Each granule resembles a sphere with spikes on it (Fig. 16B).

Pollen Morphology of Each Genus

1. *Aeschynanthus* Jack (*c.* 100 spp. worldwide; *c.* 20 spp. in Thailand, 6 spp. studied).

Pollen is spheroidal, tricolpate (5 spp.) or tricolporoidate (1 sp.), (Fig. 1) with long apertures and three different types of sculpturing, *viz.* microreticulate, microreticulate-psilate and perforate-scabrate. The grains are small (14–25 μm) and the colpi (apertures) are long, elliptic, and with pointed ends. The borders of the colpi are wide and smooth—a characteristic feature of the genus. The aperture membranes have ectexinous granules of a more or less rod-like (pilate) shape (Fig. 1). One species, *A. hildebrandii* from three different collections had pollen of three somewhat different types (Table 2). One type of pollen (Vial 39) is very scabrate with small reticula (Fig. 2), another (MAXWELL 97–1402, Fig. 1) has not such twisted scabrate pollen, and the third (MAXWELL 95–640) lacks scabrate sculpturing. Examination of herbarium specimens from which the three kinds of pollen were taken shows some differences between them. One collection (Vial 39) keys to *A. persimilis* Craib, according to an unpublished key by Dr. Mary Mendum (Royal Botanic Garden, Edinburgh), which BARNETT (1962) merged with *A. hildebrandii* and BURTT (2001) maintioned as *A. persimilis*. Further taxonomic studies are necessary here. The

Table 2. Palynological results.

Taxon	Size[1] (μm) 50 grains/ species	Exine pattern	Exine type (Luegmayr & present authors)	Aperture type	Lumina density[2]	Aperture length	Supratectal sculpturing[3]	Rod-like luminal elements[3]	Granular elements on colpi[3]
Tribe: Cyrtandreae									
Rhynchotechum obovatum (Griff.) Burtt	17–18 s	m.retic	11	tricolpate	5	long	-	-	+
Tribe: Didymocarpeae									
Chirita anachoreta Hance (sect. *Chirita*)	16–20 s	reti-m.retic	12	tricolpate	1	long	-	+	+
Chirita bimaculata D. Wood (sect. *Microchirita*)	17–18 s	m.retic	6	tricolpate	5	long	+	-	+
Chirita caerulea R. Br. (sect. *Microchirita*)	10–11 s	m.retic	6	tricolpate	3	short	+	-	+
Chirita hamosa Wall. *ex.* R. Br. (sect. *Microchirita*)	16–17 s	perf-scab	9	tricolpate	3	long	+	-	+
Chirita micromusa Burtt (sect. *Microchirita*)	18–22 s	m.retic	6	tricolpate	4	short	+	-	+
Chirita rotundata Barn. (sect. *Chirita*)	14–15 s	reti-m.retic	12	tricolpate	2	long	-	+	+
Didymocarpus aureo-glandulosus Cl.	11–12 s	m.retic	6	tricolpate	3	short	+	-	+
Didymocarpus epithemoides Burtt	11–12 s	m.retic	6	tricolpate	1	long	+	-	+
Didymocarpus insulsus Craib (Suddee 169)	12–13 s	rugulate	10	tricolpate	1	intermediate	+	-	-
Didymocarpus insulsus Craib (Maxwell 93-1098)	10–11 s	m.retic	11	tricolpate	5	long	-	-	+
Didymocarpus kerrii Craib	10–13 s	m.retic-scab	11	tricolpate	3	long	-	+	-
Didymocarpus purpureo-pictus Craib	13–14 s	m.retic	11	tricolpate	1	long	-	-	+
Didymocarpus aff. purpureo-pictus Craib	12–14 s	m.retic	9	tricolpate	1	long	-	-	+
Kaisupeea herbacea (Cl.) Burtt	10–11 s	scabrate	13	tricolpate	-	long	-	-	-
Leptoboea multiflora (Cl.) Gamb.	10–11 s	m.retic	9	tricolpate	3	short	-	-	+
Lysionotus serratus D. Don	13–17 s	m.retic	11	tricolpate	2	long	-	+	-
Oreocharis hirsuta Barn.	14–15 s	m.retic	11	tricolpate	1	long	-	-	+

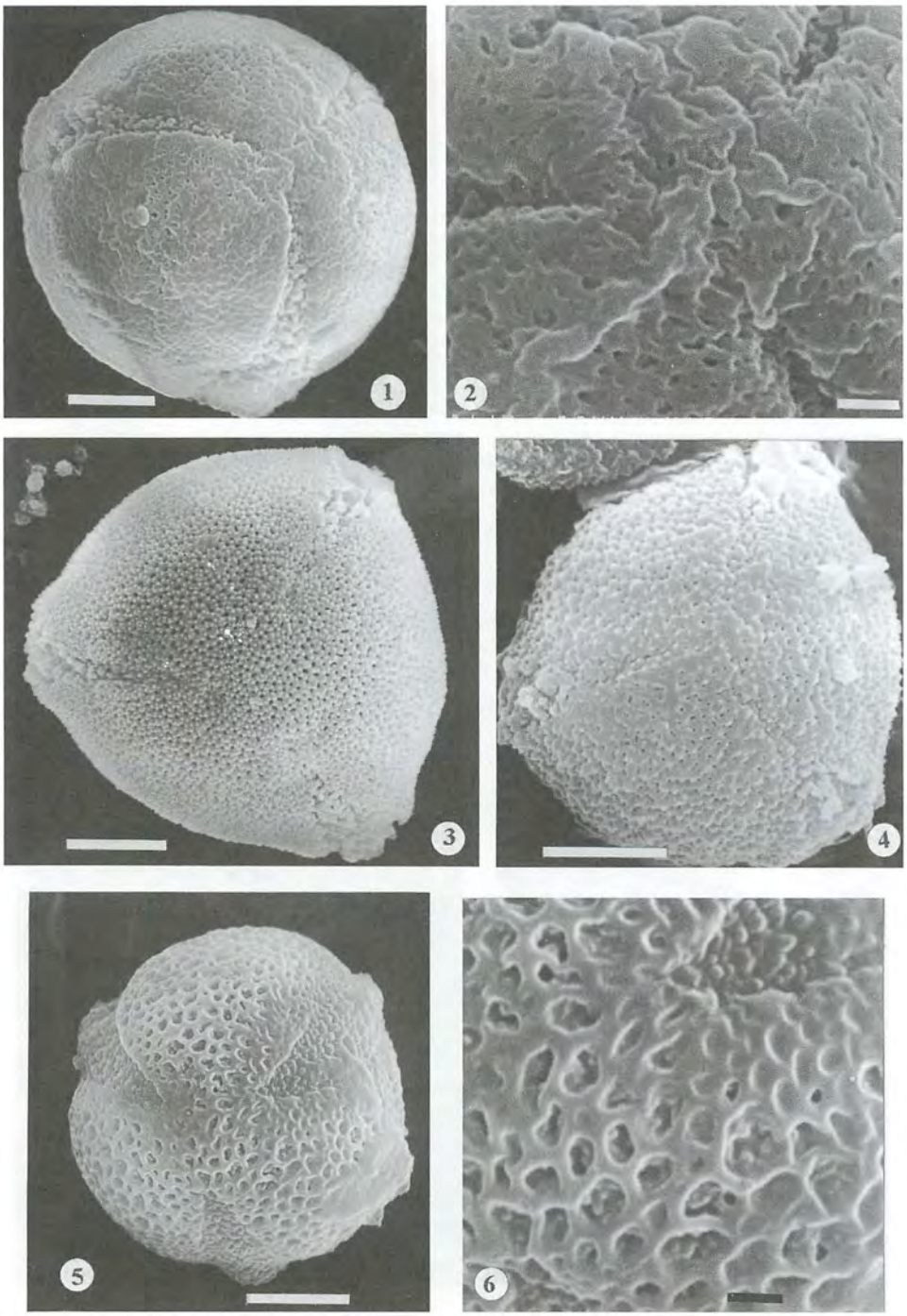
Table 2. (continued)

Taxon	Size[1] (μm) 50 grains/ species	Exine pattern	Exine type (Luegmayr & present authors)	Aperture type	Lumina density[2]	Aperture length	Supratectal sculpturing[3]	Rod-like luminal elements[3]	Granular elements on colpi[3]
Ornithoboea arachnoidea (Diels) Craib	11–12 s	perf-scab	9	tricolpate	1	long	-	-	+
Ornithoboea wildeana Craib	10–11 s	perf-scab	9	tricolpate	1	long	-	-	+
Paraboea glabrisepala Burtt	13–14 s	verrucate	14	tricolpate	1	long	-	-	-
Paraboea kerrii (Craib) Burtt	9–10 vs	perf-scab	9	tricolpate	-	long	-	-	+
Paraboea multiflora (R. Br.) Burtt	10–11s	verrucate	14	tricolpate	1	long	-	-	-
Paraboea sp.	13–14 s	m.retic	11	tricolpate	4	long	-	-	+
Petrocosmea kerrii Craib	10–11 s	scabrate	13	tricolpate	-	long	-	-	-
Streptocarpus orientalis Craib	13–14 s	m.retic	11	tricolpate	3	long	-	-	+
Trisepalum birmanicum (Craib) Burtt	13–14 s	m.perf	9	tricolpate	1	long	-	-	+
Tribe: Klugieae									
Epithema carnosum Bth.	17–18 s	rugulate	10	tricolporoidate	2	long	+	-	+
Rhynchoglossum obliquum Bl.	12–13 s	m.retic	11	tricolpate	3	intermediate	-	-	+
Tribe: Loxonieae									
Stauranthera grandiflora Bth.	13–15 s	reti-m.retic	4	tricolpate	3	intermediate	-	+	+
Tribe: Trichosporeae									
Aeschynanthus garrettii Craib	17–18 s	m.retic - psil	11	tricolpate	4	long	-	-	+
Aeschynanthus gracilis Cl.	14–15 s	m.retic - psil	11	tricolpate	3	long	-	-	+
Aeschynanthus hildebrandii Hemsl (Vial 39)	18-19 s	perf-scab	15	tricolporoidate	2	long	-	-	+
Aeschynanthus hildebrandii Hemsl (Maxwell 95–640)	17-18 s	m.retic	11	tricolporoidate	4	long	-	-	+
Aeschynanthus hildebrandii Hemsl. (Maxwell 97–1402)	18-19 s	perf-scab	15	tricolporoidate	3	long	-	-	+
Aeschynanthus hosseusii Pell.	16–17 s	m.retic	11	tricolpate	3	long	-	-	+
Aeschynanthus lineatus Craib	20–25 s	m.retic	11	tricolpate	3	long	-	-	+
Aeschynanthus macranthus (Merr.) Pell.	16–20 s	m.retic - psil	11	tricolpate	3	long	-	-	+

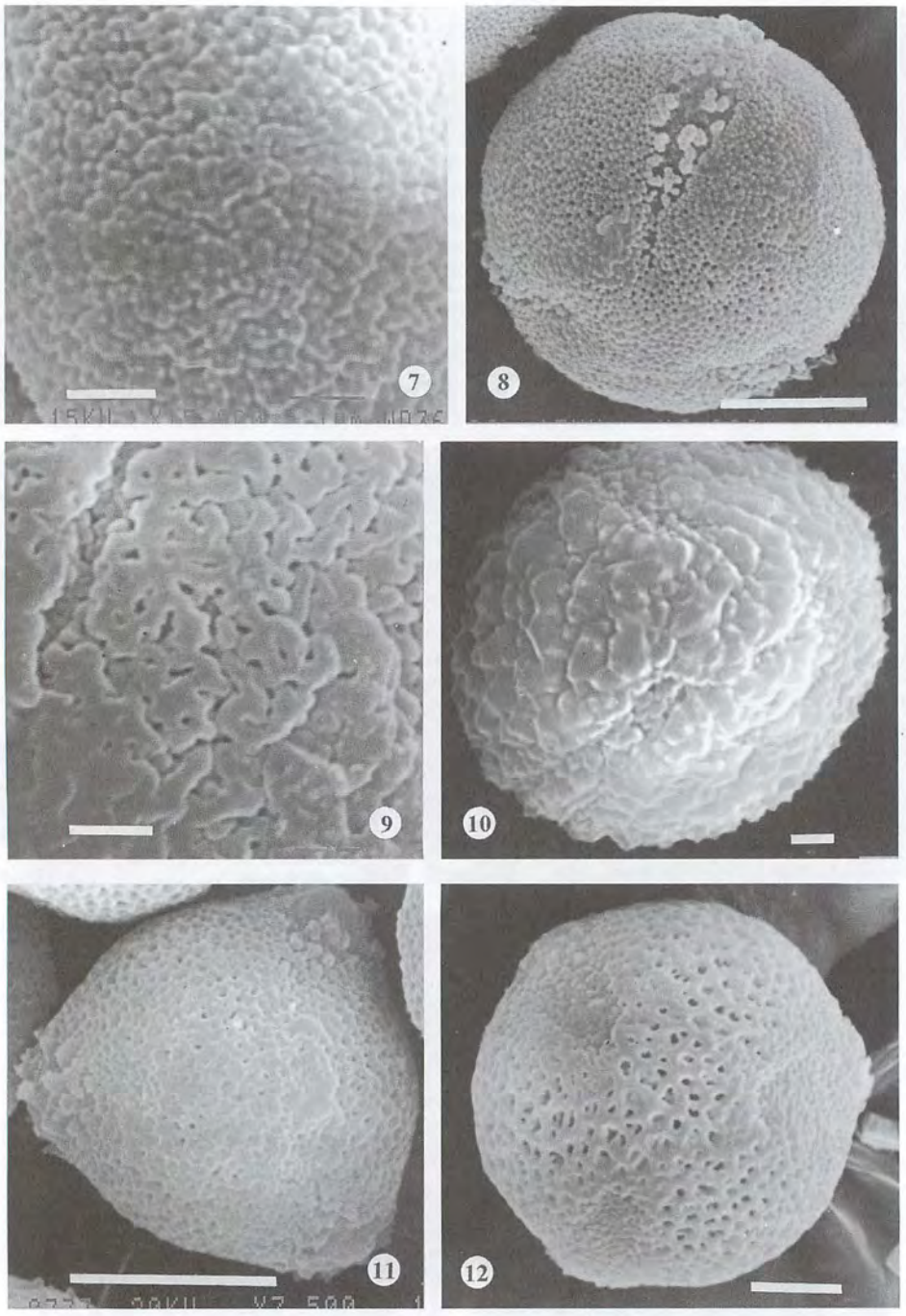
[1] vs = very small < 10 μm
s = small = 10–25 μm

[2] Lumina no./25μm²
1 = <40
2 = 41-60
3 = 61-80
4 = 81-100
5 = >100

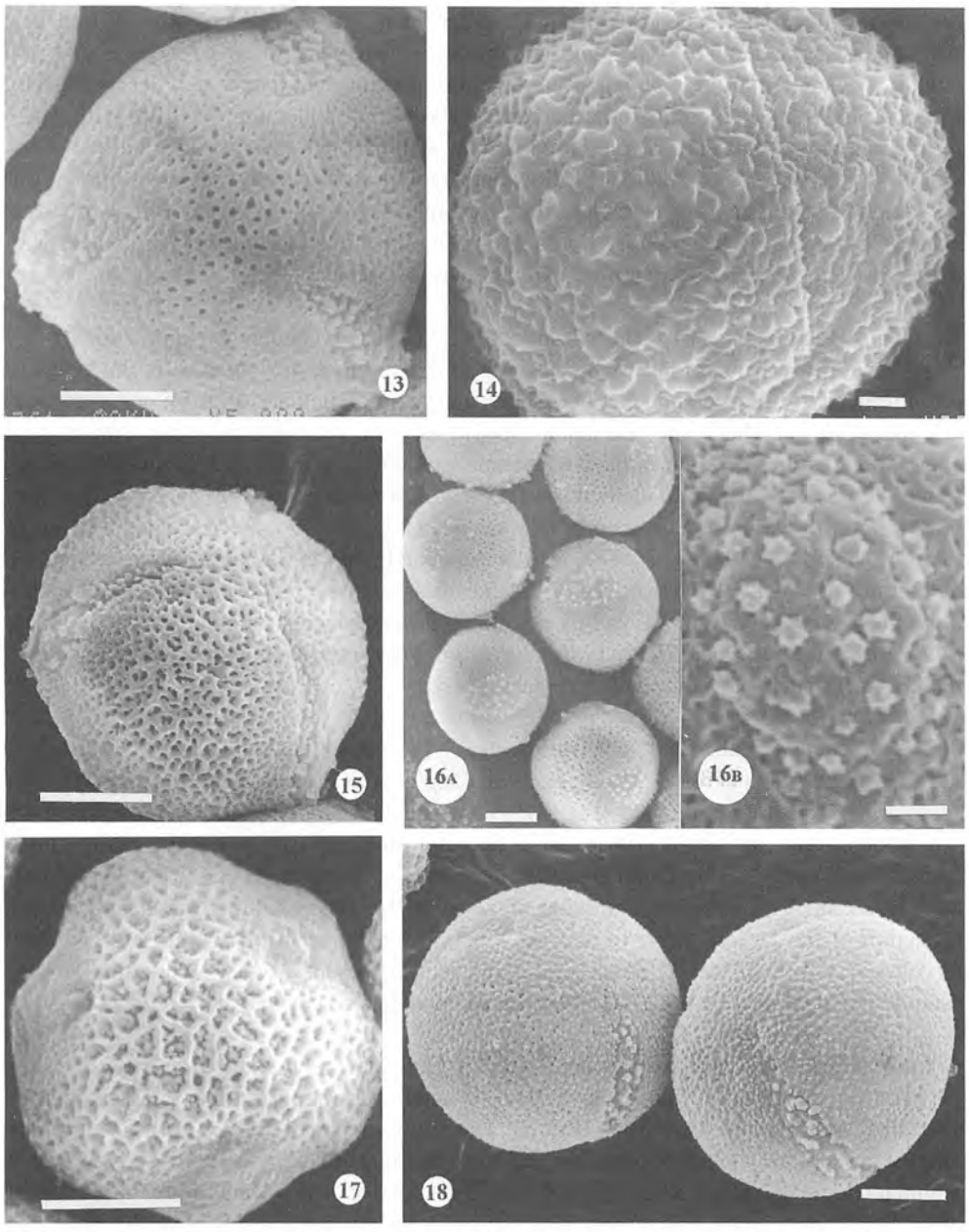
[3] - = absent, + = present



Figures 1–6. SEM micrographs of pollen grains. 1, *Aeschynanthus hildebrandii* (MAXWELL 97–1402). 2, A. *hildebrandii* (Vial 39). 3, *Chirita micromusa* (MAXWELL 94–905). 4, *C. hamosa* (PALEE 407). 5–6, *C. anachoreta* (MAXWELL 95–822). Figures 1, 3, 4, 5 bars = 5 μm; Figures 2, 6 bars = 1 μm.



Figures 7–12. SEM micrographs of pollen grains. 7, *Didymocarpus insulsus* (SUDDEE 169). 8, *D. aureo-glandulosus* (MAXWELL 92–496). 9, *Epithema carnosum* (MAXWELL 95–536). 10, *Kaisupeea herbacea* (POOMA 1143). 11, *Leptoboea multiflora* (MAXWELL 94–834). 12, *Lysionotus serratus* (MAXWELL 96–1126). Figures 8, 11, 12 bars = 5 μm; Figures 7, 9, 10 bars = 1 μm.



Figures 13–18. SEM micrographs of pollen grains. 13, *Oreocharis hirsuta* (VIAL 23). 14, *Paraboea glabrisepala* (MAXWELL 95–857). 15, *Paraboea* sp. (MAXWELL 96–66).16A–B, *Rhynchoglossum obliquum* (MAXWELL 97–1041). 17, *Stauranthera grandiflora* (MAXWELL 93–622).18, *Trisepalum birmanicum* (MAXWELL 96–1058). Figures 13, 15, 16A, 17, 18 bars = 5 μm; Figures 14, 16B bars = 1 μm.

other two collections can be identified as *A. hildebrandii*. We noted some other differences, for example collection 97–1402 had leaf blades which were more coriaceous and had slightly crenulate margins in contrast to the entire margins and longer petioles of 95–640. In addition, Maxwell noted on the herbarium sheets that collection 97–1402 had a pale light green calyx with dark purple, a red corolla with dark red vertical lines on both sides and was orange-red inside and had yellow anthers with light-purple filaments. In contrast, collection 95–640 had a light-green, turning dull reddish-brown calyx, a corolla which was bright red outside with the upper lip orange on the inside, and dark greyish anthers with dark red filaments. Here too further studies seem desirable.

2. *Chirita* Buch.-Ham. (140 spp. worldwide, *c.* 25 spp. in Thailand, 6 spp. studied).

The pollen is spheroidal, tricolpate with long apertures, and three different types of sculpturing, *viz.* microreticulate (Fig. 3), reticulate-microreticulate (Fig. 5), and perforate-scabrate (Fig. 4). The grains are small (10–19 μm) and the colpi are long with pointed ends. The aperture membranes have ectexinous granules of a more or less rod-like (pilate) shape. Supratectal sculptural elements are present in some species (Fig. 3). Numerous rod-like luminal processes occur in only two species (Fig. 6). Two species examined are in section *Chirita* (WOOD, 1974). They can be separated from the other 5 species which are in section *Microchirita* (WOOD, 1974) on the basis of their pollen morphology because only these two species have rod-like luminal processes and reticulate-microreticulate sculpturing. Further species in sections *Chirita* and *Microchirita* should be examined to see if these differences are invariably present.

3. *Didymocarpus* Wall. (180 spp. worldwide, *c.* 18 spp. in Thailand, 5 spp. studied).

The pollen is spheroidal, tricolpate with long apertures, and three different types of sculpturing, *viz.* microreticulate (Fig. 8), microreticulate-scabrate, and rugulate (Fig. 7). The pollen grains are small (10–15 μm), the colpi long and narrow-elliptic with pointed ends, and are partly covered with granular elements (Fig. 8). Supratectal sculptural elements are present in some species. The wide range of pollen types within *Didymocarpus* is a reflection of the large number of species which are included in this genus and, as noted by WEBER & BURTT (1997) there is no agreement at present as to whether some groups "should stand as sections of *Didymocarpus* or as independent genera".

4. *Epithema* Bl. (10 spp. worldwide, 3 spp. in Thailand, 1 sp. studied).

The pollen of this genus is spheroidal to angulaperturate, tricolporoidate with long apertures, and rugulate sculpturing (Fig. 9). The grains are small (17–18 μm); the colpi are long, with a central expanded region, and with aperture membranes partly covered with granular elements. The pollen of *Epithema* is distinctive and differs from the pollen of other Thai genera studied (see Type 10). The pollen of other species needs to be examined before it is possible to say whether or not the genus can be identified from its pollen.

5. *Kaisupeea* Burtt (3 spp. worldwide, 3 spp. in Thailand, 1 sp. studied).

The pollen is spheroidal, tricolpate, with scabrate sculpturing and long apertures (Fig. 10). The grains are small (10–11 μm) and the narrow aperture membranes have approximately spherical-shaped granular elements. Supratecal elements are present.

6. *Leptoboea* Bth. (3 spp. worldwide, 1 sp. in Thailand, 1 sp. studied).

The pollen is spheroidal to angulaperturate, tricolpate with short apertures, and perforate-scabrate sculpturing (Fig. 11). The grains are small (10 μm), the colpi are short, and the aperture membranes are partly covered with granular elements. The pollen differs from other Thai genera in Type 9 because of its short apertures. There are two subspecies of *L. multiflora* (BURTT, 2001), but only one (ssp. *multiflora*) has been examined and it will be necessary for the pollen of the other (ssp. *grandifolia*) to be studied to see if it differs from the material we examined.

7. *Lysionotus* D. Don (25 spp. worldwide, 1 sp. in Thailand, 1 sp. studied).

The pollen is spheroidal, tricolpate with long apertures, and microreticulate sculpturing. The grains are small (13–17 μm) with long elliptic colpi having slightly bluntly rounded ends (Fig. 12). The aperture membranes have many ectexinous granular elements on their surface. The pollen is a little different from other species of Type 11 because of its slightly bluntly rounded ends.

8. *Oreocharis* Bth. (28 spp. worldwide, 1 sp. in Thailand, 1 sp. studied).

The pollen is spheroidal, tricolpate, and with microreticulate sculpturing (Fig. 13). The grains are small (14–15 μm) and the colpi are long with pointed ends. The aperture membranes have numerous granular elements. The pollen does not appear to differ from species of some other genera.

9. *Ornithoboea* Parish *ex* Cl. (11 spp. worldwide, 7 spp. in Thailand, 2 spp. studied).

The pollen grains are spheroidal and tricolpate with perforate-scabrate sculpturing. The grains are small (10–12 μm) with long pointed apertures partly covered with granular elements. The pollen does not appear to differ from the species of some other genera.

10. *Paraboea* (Cl.) Ridl. (87 spp. worldwide, *c.* 29 spp. in Thailand, 4 spp. studied).

The pollen grains are spheroidal, tricolpate with long apertures and verrucate sculpturing in *Paraboea glabrisepala* (Fig. 14) and *P. multiflora*, but in *P. kerrii* the sculpturing is perforate-scabrate. and the fourth species, *Paraboea* sp., has microreticulate sculturing (Fig. 15). The grains are very small to small (9–14 μm). The colpi are long and covered with granular elements. There are differences between the pollen of the three species examined so the pollen has no generic distinction.

11. *Petrocosmea* Oliv. (27 spp. worldwide, 4 spp. in Thailand, 1 sp. studied).

The pollen is spheroidal and tricolpate with scabrate sculpturing and long apertures. The grains are small (10–11 μm) and the narrow aperture membranes have approximately spherical-shaped granular elements. Supratectal sculptural elements are present.

12. *Rhynchoglossum* Bl. (12 spp. worldwide, 1 sp. in Thailand, 1 sp. studied).

The pollen is spheroidal, tricolpate, with apertures of intermediate length, and microreticulate sculpturing. The grains are small (12–13 μm). The colpi are moderately wide without sharply pointed ends and are dotted with very distinctive granules which resemble a sphere with spikes (Fig. 16A, 16B). It will be interesting to see, when further species are examined, if their pollen has the same distinctive granules.

13. *Rhynchotechum* Bl. (13 spp. worldwide, 3 spp. in Thailand, 1 sp. studied).

The pollen grains are spheroidal, tricolpate, with long apertures, and microreticulate sculpturing. The colpi are long, elliptical with pointed ends, and granular. It resembles some other genera of Type 11.

14. *Stauranthera* Bth. (10 spp. worldwide, 1 sp. in Thailand, 1 sp. studied).

The pollen is spheroidal, tricolpate, and has reticulate-microreticulate sculpturing (Fig. 17). Numerous rod-like luminal processes are present. The apertures are of intermediate length and the colpi are covered with numerous granular elements. The borders of the colpi are comparatively wide with small reticula, a feature of this species illustrated by LUEGMAYR (1993b). The single Thai species of this genus is readily distinguished by this feature.

15. *Streptocarpus* Lindl. (120 spp. worldwide, 1 sp. in Thailand, 1 sp. studied)

The pollen is spheroidal, tricolpate, and has microreticulate sculpturing. The long apertures have many granular elements. It resembles some other genera of Type 11.

16. *Trisepalum* Cl. (13 spp. worldwide, *c.*11 sp. in Thailand, 1 sp. studied)

The pollen is spheroidal, tricolpate, and has microperforate sculpturing with numerous conical-scabrate supratectate sculpturing elements (Fig. 18). The long narrow apertures contain granular elements. Supratectal sculptural elements are present. It resembles the species of some other genera of Type 9.

DISCUSSION

Our study of samples of the pollen of 16 of the 26 known genera of the family in Thailand has shown that they can be placed into 4 of the 10 types which LUEGMAYR (1993b) used to classify the pollen of Old World Gesneriaceae. We found an additional 5 types which differed from those of Luegmayr.

The pollen of some genera studied, e.g. *Stauranthera*, *Rhynchoglossum*, and *Epithema* is distinctive and it is possible to identify these genera on the basis of their pollen morphology. We have not studied the pollen of all species in each genus to establish whether or not the generic differences found would apply to all species in these genera. In contrast, some of the genera we studied did not have distinctive pollen and it is not possible to identify a genus from its pollen morphology, e.g. *Oreocharis*, *Petrocosmea*, and *Streptocarpus*.

We found that some genera had several different types of pollen morphology, e.g. *Aeschynanthus*, *Chirita*, and *Didymocarpus*. Such a result is not unexpected, since these are large genera each containing a hundred or more species. It has been suggested by some taxonomists that they should be generically divided. Their different types of pollen morphology may assist in such a reclassification. For example, although we studied only two of the three sections of *Chirita*, the species studied in each section have a different type of pollen morphology (Table 2).

A final and unexpected result of our study was to find different types of pollen in different collections of *Aeschynanthus hildebrandii*. As noted above, examination of herbarium material of these collections raised the possibility that what has been classified

as a single species may not actually be so. Further taxonomic studies are definitely required here.

The most important diagnostic feature in our study was exine patterns. Pollen size (Table 2) was not an important distinguishing feature between species. Aperture length (Table 2) differed between species of some genera, e.g. *Chirita caerulea* has short apertures, but *C. hamosa* has long apertures which extended almost to the poles. Exine granules on the surface of apertures did not differ significantly between taxa studied, except in *Rhynchoglossum*, with its striking star-shaped granules which apparently have not been recorded in this family.

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