

Palynology of family Convolvulaceae in Thailand

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Abstract - The pollen morphology of 45 taxa, seven genera of Convolvulaceae is based on observations from a light microscope, but the features seen in the scanning electron microscope are also mentioned where appropriate. The pollen of Thai Convolvulaceae can be divided into six pollen types based on their aperture, namely Polyantoporate, Hexacolpate, Tricolpate, Periporate, Pantoporate and Zonocolpate. Five subtypes were recognized in the Pantoporate type, which are *Evolvulus*, *Aquatica*, *Quamoclit*, *Obscura* and *Pes-tigridis* pollen subtypes. Moreover, the spines of all taxa can be divided into six spine types based on Hsiao and Kouth's (1995) data. The pollen features of *Argyreia* and *Ipomoea* are isolated from the other genera in long spine. The pollen morphology of the genus *Merremia* and *Operculina* are similar. *Evolvulus*, *Hewittia* and *Jacquemontia* have close pollen features. Thai Convolvulaceae pollen can be grouped into three classes based on size, which are medium, large and very large based on Erdtman's (1952) data.

Keywords: Pollen, palynology, convolvulaceae, Thailand

1. Introduction

The Convolvulaceae, known commonly as the bindweed or morning glory family, is a group of about 60 genera and more than 1,650 species of mostly herbaceous vines, but also trees, shrubs and herbs. Plants that may be weeds in their native country are sometimes grown as ornamentals, and there are now many hybrids of *Ipomoea purpurea* grown in gardens. The sweet potato (*Ipomoea batatas*) is an important food plant in the tropics, and some species have medicinal uses. Palynology is important for studying plant taxonomy. Many characteristics of pollen grains can be used in identification, such as shape, size, symmetry and polar aperture (Erdtman, 1966; Nairs, 1971 and Moore *et al.*, 1991). Therefore, pollen morphology has been used to elucidate taxonomic relationships in many angiosperm taxa (Erdtman, 1972). Many workers have studied the pollen morphology of the Convolvulaceae. Erdtman (1952) divided the pollen of Convolvulaceae into two types based on pollen morphology, namely "Ipomoea" type and "other types". Sengupta (1966) investigated the pollen morphology of nine Indian species of *Ipomoea*. Ferguson *et al.* (1977) studied pollen morphology in 55 species of *Merremia* and *Operculina*, which are prolate-spheroidal and spheroidal in shape; tricolpate, 5-6 colpate, 9-12 colpate, 12-rugulate

and pantoporate in aperture; and regulate in exine sculpturing. Nayar (1990) studied seven *Ipomoea* species by light microscopy. Hsiao and Kuoh (1995) studied the pollen of 18 *Ipomoea* species in Taiwan, which can be divided into two groups based on the presence of spines and extraporal regions as well as tetragonal to hexagonal areas. Menemen *et al.* (2002) investigated *Convolvulus* pollen in Morocco. The pollen morphology of Convolvulaceae is known to be highly diverse and has taxonomic importance (Telleria and Daners, 2003). Liao *et al.* (2005) reported the pollen morphology of five taxa of *Cuscuta*. Rajurkar *et al.* (2011) studied the pollen morphology of four *Ipomoea* species; *I. fistulosa* (Mart. Ex Choisy), *I. palmata* Forssk, *I. quamoclit* L. and *I. triloba* L. The aims of this work was to study the pollen morphology of the family Convolvulaceae in Thailand using Light Microscope (LM) and Scanning Electron Microscope (SEM) and to compare Thai Convolvulaceae pollen the difference or similarity between genus.

2. Materials and methods

The pollen of 45 taxa including seven genera of Thai Convolvulaceae was taken from either living plants, dried or spirit preserved materials (Table 1). Samples were

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analyzed using an alcohol series, 70%, 80%, 95% and 100%. The pollen was studied using a light microscopy (LM) and scanning electron microscopy (SEM). In the LM specimens, two-three drops of silicone oil were dropped onto the pollen grains. Then the pollen grains in the silicone oil were mounted on slides and sealed with paraffin. In the SEM, the pollen in absolute alcohol was transferred, mounted and affixed on aluminum stubs with double-sided cellophane tape. Samples were sputter-coated with a gold-palladium, examined and then photographed on a SEM (LEO 1450 VP). The measurements were based on 20 pollens from each specimen.

3. Results and discussions

The pollen types of 45 taxa with seven genera of Convolvulaceae are based on observations from a LM and SEM. The pollen from Thai Convolvulaceae in seven genera and 45 taxa can be divided into six pollen types (Figs. 1-9; Table 1) based on the aperture, namely Aperturate, Hexacolpate, Tricolpate, Periporate, Pantoporate and Zonocolpate pollen types. Five subtypes were recognized in the Pantoporate type, which are *Evolvulus*, *Aquatica*, *Quamoclit*, *Obscura* and *Pes-tigridis* pollen subtypes. Moreover, the spines of all taxa can be divided into six spine types (Table 1; Fig. 9).

3.1 General description of Convolvulaceae pollen morphology in Thailand:

The pollen grains are polypantoporate, pantoporate, hexacolpate, tricolpate, periporate, pantocolpate, 5-zonocolpate; apolar, isopolar; radial or bilateral symmetry; spheroidal, prolate-spheroidal, oblate-spheroidal. Exine sculpturing is smooth and rough, metarecticate, microrecticate with granulate, microechinate-perforate. The spine is granulate, micro-echinate, spine with blunt spices, irregularly distributed, echinate with knob-like structure.

3.2 General description pollen morphology of each genus in Convolvulaceae:

Genus *Argyria*: The pollen grains are pollen grain polypantoporate, apolar, radial symmetry, spheroidal. Exine sculpturing is metarecticate. The spine is echinate with knob-like structure.

Genus *Evolvulus*: The pollen grains are pollen grain pantocolpate, polar, radial symmetry, prolate-spheroidal or spheroidal. Exine sculpturing is granulate or metarecticate-echinate.

Genus *Hewittia*: The pollen grains are pollen grain periporate, polar, radial symmetry, prolate-spheroidal. Exine sculpturing is rough and microrecticate with granulate. The spine is granulate, micro-echinate, spine with blunt spices, irregularly distributed.

Genus *Ipomoea*: The pollen grains are pantoporate; apolar; radial symmetry; spheroidal. Exine sculpturing is granulate or metarecticate-echinate, globular knob-like structure.

Genus *Jacquemontia*: The pollen grains are pollen grain 5-zonocolpate, isopolar, radial symmetry, oblate-spheroidal. Exine sculpturing is microechinate-perforate,

irregularly distributed.

Genus *Merremia*: The pollen grains are pollen grain hexacolpate, tricolpate, isopolar, bilateral symmetry, prolate-spheroidal. Exine sculpturing is smooth and rough, microrecticate with granulate. The spine is granulate, micro-echinate, spine with blunt spices, irregularly distributed.

Genus *Operculina*: The pollen grains are pollen grain tricolpate, isopolar or polar, bilateral symmetry, prolate-spheroidal. Exine sculpturing is smooth, microrecticate with granulate. The spine is granulate, micro-echinate, spine with blunt spices, irregularly distributed.

3.3 Morphological description of pollen types:

The pollen of Convolvulaceae in Thailand can be divided into six pollen type base on aperture.

3.4 Type polypantoporate (Table 1; Figs. 1A-II, 3A-3I, 5A-5I)

Description: Pollen grain polypantoporate, apolar, radial symmetry, spheroidal. Exine sculpturing is metarecticate. The spine is echinate with knob-like structure. This type is found only in nine species of Thai *Argyria*. The type can be divided into two subtypes based on types of spine, namely subtype A and subtype B.

Subtype A: Echinate and knob-like structure; it is separated into two groups based on spine, namely Group A1 and Group A2 (Table 1; Figs. 1A-1D, 3A-3D, 5A-5D).

Group A1: The largest pollen is *A. capitiformis*. The spine is broad at the base, gradually tapering towards the apex with a more or less acute tip combined with knob-like structure, regularly distributed.

Group A2: The largest pollen is *A. laotica*, *A. thorelii* and *A. mollis*, respectively. The spine is broad at the base, gradually, tapering towards the apex with a blunt tip and combined with knob-like structure, regularly distributed.

Subtype B: Only echinate; the largest pollen is *A. osyrensis*. The spine is broad at the base, gradually tapering towards the apex with a more or less acute tip, regularly distributed (Table 1; Figs. 1E-1I, 3E-3I, 5E-5I).

3.5 Type Hexacolpate (Table 1; Figs. 1J-1M, 3J-3M, 5J-5M)

Description: Pollen grain hexacolpate, isopolar, bilateral symmetry, prolate-spheroidal. The largest pollen is *Merremia tonkinensis*. Exine sculpturing is smooth and rough, microrecticate with granulate. The spine is granulate, micro-echinate, spine with blunt spices, irregularly distributed.

This type has only four taxa of *Merremia*, namely *M. kingii*, *M. tonkiensis*, *M. umbellata* and *M. vitifolia*.

Type Tricolpate (Table 1; Figs. 1N-1X, 3N-3X, 5N-5O, 6A-6I)

Description: Pollen grain tricolpate, isopolar or polar, bilateral symmetry, prolate-spheroidal. The largest pollen are *M. sp. 2*, *M. sp. 1*, *M. gemella*. Exine sculpturing is smooth and rough, microrecticate with granulate. The spine is granulate, micro-echinate, spine with blunt spices, irregularly distributed.

Most taxa of *Merremia* and all taxa of *Operculina* are recognized in this pollen type.

Type Periporate (Table 1; Figs. 2A, 4A, 6J)

Description: Pollen grain periporate, polar, radial symmetry, prolate-spheroidal. Exine sculpturing is rough and microreticulate with granulate. The spine is granulate, micro-echinate, spine with blunt spines, irregularly distributed.

Only *Hewittia malabarica* is a member of this type.

Type Pantoporate (Table 1; Figs. 2B-2W, 4B-4W, 6K-6O, 7A-O)

Description: Pollen grain pantocolpate, polar, radial symmetry, prolate-spheroidal or spheroidal. Exine sculpturing is granulate or metareticulate-echinate.

The biggest pollen type is pantoporate type. It has two genera: *Evolvulus* (subtype *Evolvulus* in two taxa) and all taxa of *Ipomoea*.

Pollen morphology of *Ipomoea* in Thailand can be divided into four pollen subtypes based on the characteristics of the spines, the extraporal regions and ornamentations, which are discussed in relation to Austin's infrageneric classification.

Subtype Evolvulus (Table 1; Figs. 2B-2C, 4B-4C, 6K-6L)

Description: Pollen grain pantocolpate, polar, radial symmetry, prolate-spheroidal or spheroidal. Exine sculpturing is granulate. Only genus *Evolvulus* is recognized in the subtype.

Subtype Alba (Table 1; Figs. 2D, 4D, 6M)

Description: Pollen grain pantocolpate, apolar, radial symmetry, spheroidal. Exine sculpturing is metareticulate-echinate.

The subtype has a globular knob-like structure and the ridges of the bacula around the extraporal region form a distinct tetragonal to hexagonal area and a granule is present in the center; fine reticular are present all over the surface. These characteristics belong to pollen Group 1 of Hsiao & Kouth (1995). Only *I. alba* is included the sub type.

Subtype Aquatica (Table 1; Figs. 2E-2L, 4E-4L, 6N-6O, 7A-7E)

Description: Pollen grain pantocolpate, apolar, radial symmetry, spheroidal. Exine sculpturing is metareticulate-echinate.

The subtype has spines and the ridges of the bacula around the extraporal region form a distinct tetragonal to hexagonal area and a granule is present in the center; fine reticular are present all over the surface. These characteristics belong to pollen Group 1 of Hsiao & Kouth (1995). Six taxa are included in the type, namely *I. aquatica* (purple flower), *I. aquatica* (white flower), *I. babatas*, *I. carnea* ssp. *fistulosa*, *I. purpurea*, *I. nil* 1, *I. nil* 2 and *I. triloba*.

Subtype Quamoclit (Table 1; Figs. 2M, 4M, 7G)

Description: Pollen grain pantocolpate, apolar, radial symmetry, spheroidal. Exine sculpturing is metareticulate-echinate. Only *I. quamoclit* is in the subtype.

The subtype has spines and the ridges of the

bacula around the extraporal region form a distinct tetragonal to hexagonal area and a granule is absent in the center; fine reticular are present all over the surface. These characteristics belong to pollen Group 1 of Hsiao & Kouth (1995).

Subtype Obscura (Table 1; Figs. 2N-2U, 4N-4U, 7H-7O)

Description: Pollen grain pantocolpate, apolar, radial symmetry, spheroidal. Exine sculpturing is metareticulate-echinate.

The subtype has the extraporal region and hexagonal area absent; only the spine is present; fine reticular are also present all over the surface of the region. These characteristics belong to pollen Group 1 of Hsiao & Kouth (1995). Six taxa are included in this type. This is the biggest subtype. The six taxa included in this type are *I. obscura*, *I. obscura* 1, *I. obscura* 2, *I. asarifolia*, *I. cairica*, *I. pes-caprae*, *I. ochracea* and *I. cambodiensis*.

Subtype Pes-tigridis (Table 1; Figs. 2V-2W, 4V-4W, 8A-8B)

Description: Pollen grain pantocolpate, apolar, radial symmetry, spheroidal. Exine sculpturing is metareticulate-echinate.

The subtype has the extraporal region and hexagonal area absent; spine and granule are present; fine reticular are also present all over the surface of the region. These characteristics belong to pollen Group 1 of Hsiao & Kouth (1995). Only two taxa, namely *I. pes-tigridis* and *I. piliata*, are recognized in the subtype.

3.6 Type Zonocolpate (Table 1; Figs. 2X-2Z, 4X-4Z, 8C-8E)

Description: Pollen grain 5-zonocolpate, isopolar, radial symmetry, oblate-spheroidal. Exine sculpturing is micro-echinate-perforate, irregularly distributed.

Only genus *Jacquemontia* is recognized in this type.

The spines of the Convolvulaceae taxa from Thailand can be divided into six spine types base on Hsiao and Kouth's (1995) data (Table 1; Fig. 9).

Spine type-1: The characteristic is broad at the base, gradually tapering towards an apex with a blunt tip (Fig. 9A). *A. laotica*, *A. mollis*, *A. thorelii*, *I. nil* 1 and *I. nil* 2 are recognized in this spine type.

Spine type-2: The characteristic is broad and bulbous at the base, gradually tapering towards the apex with a blunt tip and a faint, constricted neck. (Fig. 9B). *I. batatus*, *I. purpurea*, *I. cambodiana* and *I. pes-caprae* are recognized in this spine type.

Spine type-3: The characteristic is broad at the base, gradually tapering towards the apex with a more or less acute tip (Fig. 9C). Fifteen taxa are recorded in the type, namely *A. collinsae*, *A. nervosa*, *A. osyensis*, *A. splendens*, *I. aquatica* (white and purple flowers), *I. carnea* ssp. *fistulosa*, *I. asarifolia*, *I. cairica*, *I. obscura* 1, *I. obscura* 2, *I.*

obscurza 3 and *I. pes-carprae*.

Spine type-4: The characteristic is a globular knob-like structure (Fig. 9D). *A. capitiformis*, *A. laotica*, *A. mollis*, *A. thorelii*, *I. alba*, *I. triloba*, *I. pes-tigridis* and *I. piliata* are in this spine type.

Spine type-5: The characteristic is broad at the base, cylinder-shaped, apex with a flattened tip (Fig. 9E). *I.*

quamoclit, *I. pes-tigridis* and *I. piliata* are recognized in the type.

Spine type-6: Granulate; the characteristic is micro-echinate; spines with blunt apices, irregular distribution (Fig. 9F). This spine type is the largest type, which is all of the taxa of *Merremia*, *Evolvulus*, *Hewittia*, *Jacquemontia* and *Operculinum*.

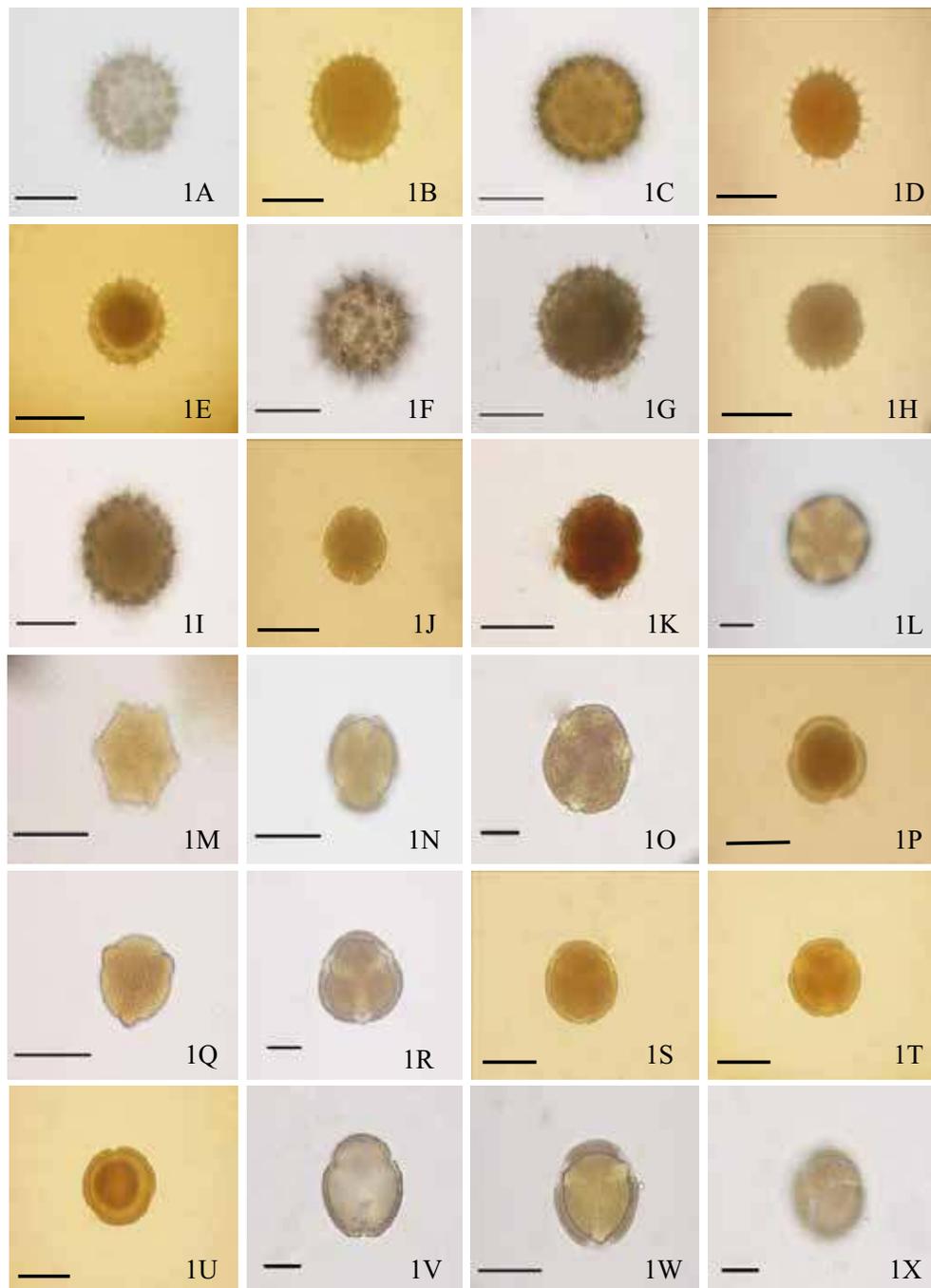


Figure 1. Type Polyantoporate Subtype - A 1A. *Argyrea capitiformis*, 1B. *A. laotica* 1C. *A. mollis*, 1D. *A. thorelii*; Type Polyantoporate Subtype - B 1E. *A. collinsae*, 1F. *A. nervosa*, 1G. *A. obtecta*, 1H. *A. osyrensis*, 1I. *A. splendens*; Type Hexacolpate 1J. *Merremia kingii*, 1K. *M. tonkinensis*, 1L. *M. umbellata*, 1M. *M. vitifolia*; Type Tricolpate 1N. *M. cissoides*, 1O. *M. collina*, 1P. *M. gemella*, 1Q. *M. hederacea*, 1R. *M. hirta* 1, 1S. *M. hirta* 2, 1T. *M. sp. 1*, 1U. *M. sp. 2*, 1v. *Operculina cf. petaloidea*, 1W. *O. petaloidea*, 1X. *O. turpethum*.

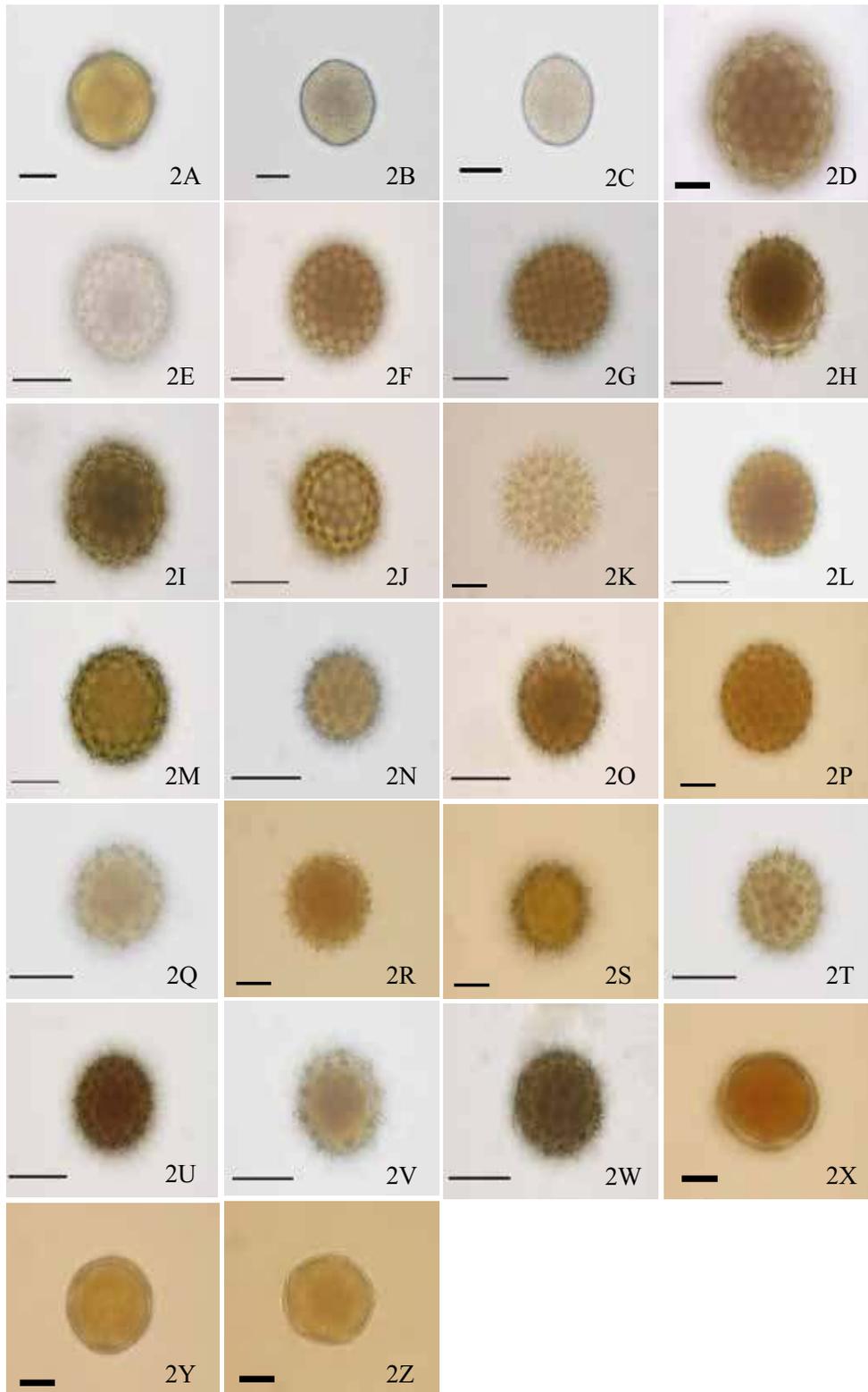


Figure 2. Type Periporate 2A. *Hewittia malabarica*; Type Pantoporate subtype Evolvulus 2B *Evolvulus glomeratus* ssp. *grandiflorus*, 2C. *E. nummularius*; Type Pantoporate subtype Alba 2D. *Ipomoea alba*; Type Pantoporate subtype Aquatica 2E. *I. aquatica* (purple flower), 2F *I. aquatica* (white flower), 2G. *I. batatas*, 2H. *I. carnea* ssp. *fistulosa*, 2I. *I. nil* 1, 2J. *I. nil* 2, 2K. *I. purpurea*, 2L. *I. triloba*; Type Pantoporate subtype Quamoclit 2M. *I. quamoclit*; Type Pantoporate subtype Obscura 2N. *I. asarifolia*, 2O. *I. cairica*, 2P. *I. maxima*, 2Q. *I. obscura* 1, 2R. *I. obscura* 2, 2S. *I. obscura* 3, 2T. *I. ochracea*, 2U. *I. pes-caprae*; Type Pantoporate subtype Pes-tigridis 2V. *I. pes-tigridis*, 2W. *I. pileata*; Type Zonocolpate 2X *Jacquemontia* aff. *paniculata*, 2Y. *J. paniculata*, 2Z *J. pentantha*

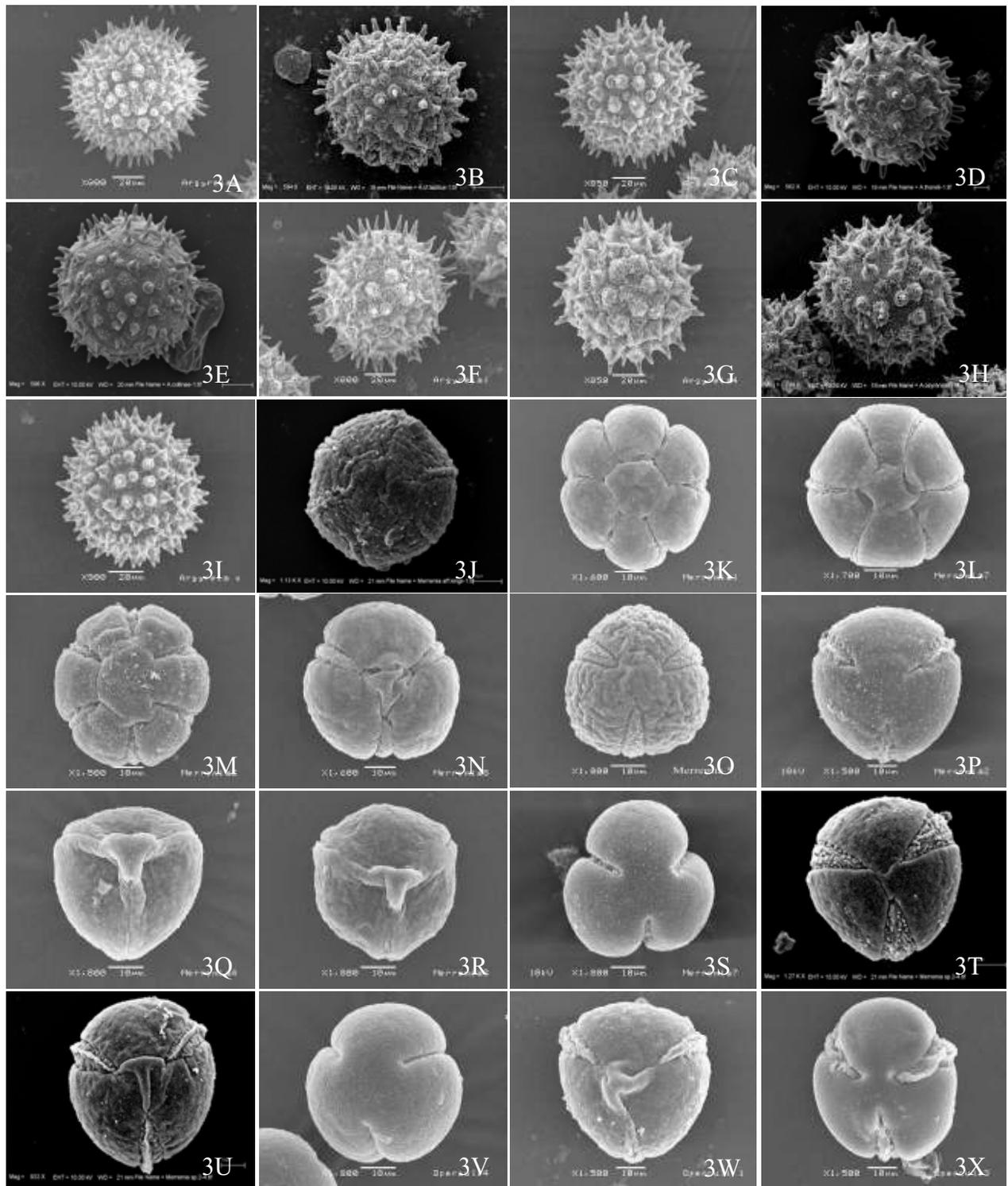


Figure 3. Type Polyantoporate Subtype - A 3A. *Argyrea capitiformis*, 3B. *A. laotica*, 3C. *A. mollis*, 3D. *A. thorelii*; Type Polyantoporate Subtype - B 3E. *A. collinsae*, 3F. *A. nervosa*, 3G. *A. obtecta*, 3H. *A. osyrensis*, 3I. *A. splendens*; Type Hexacolpate 3J. *Merremia kingii*, 3K. *M. tonkinensis*, 3L. *M. umbellata*, 3M. *M. vitifolia*; Type Tricolpate 3N. *M. cissoides*, 3O. *M. collina*, 3P. *M. gemella*, 3Q. *M. hederacea*, 3R. *M. hirta* 1, 3S. *M. hirta* 2, 3T. *M. sp. 1*, 3U. *M. sp. 2*, 3V. *Operculina cf. petaloidea*, 3W. *O. petaloidea*, 3X. *O. turpethum*

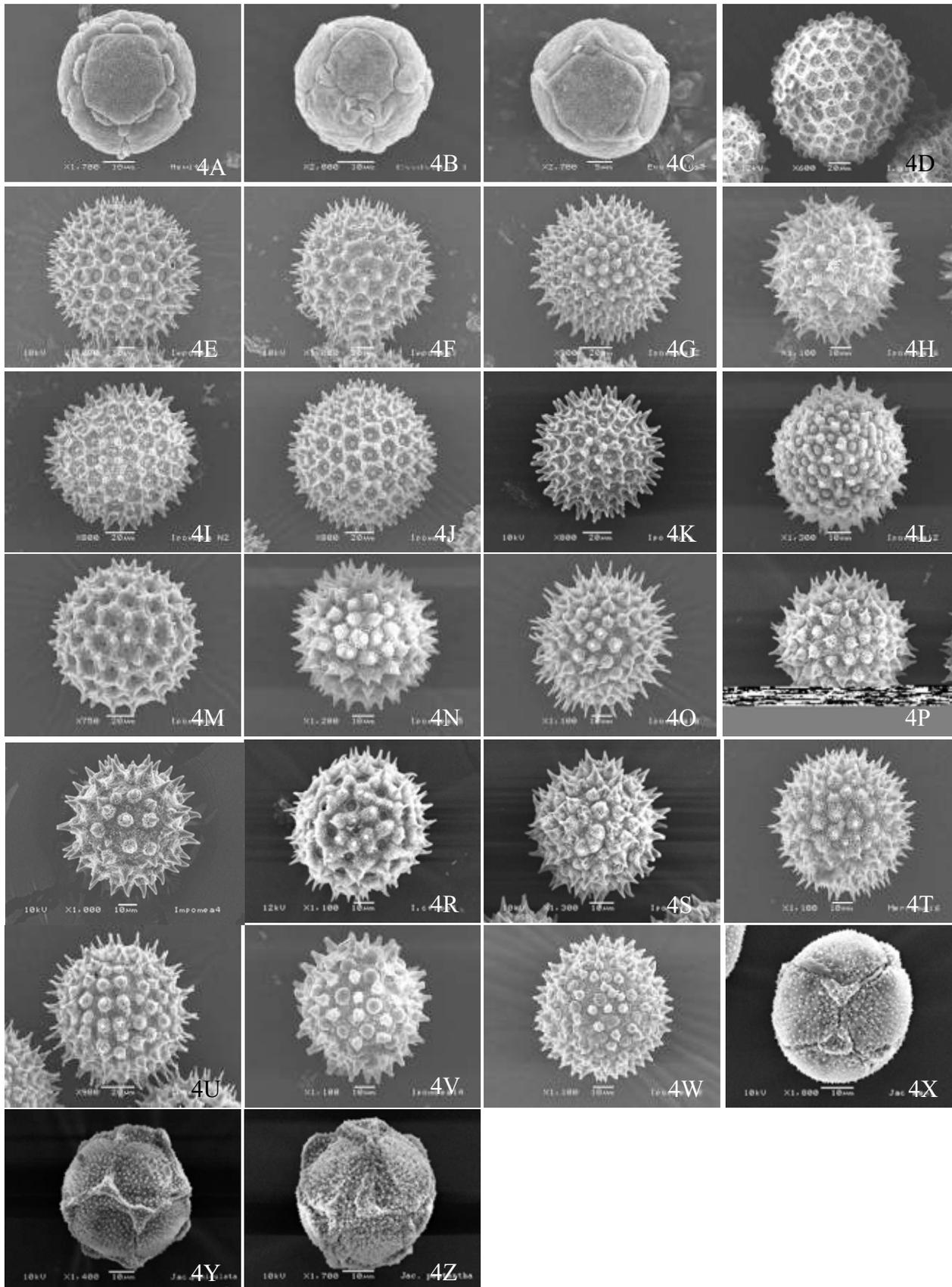


Figure 4. Type Periporate 4A. *Hewittia malabarica*; Type Pantoporate subtype Evolvulus 4B *Evolvulus glomeratus* ssp. *grandiflorus*, 4C. *E. nummularius*; Type Pantoporate subtype Alba 4D. *Ipomoea alba*; Type Pantoporate subtype Aquatica 4E. *I. aquatica* (purple flower), 4F *I. aquatica* (white flower), 4G. *I. batatas*, 4H. *I. carnea* ssp. *fistulosa*, 4I. *I. nil*, 4J. *I. aff. nil*, 4K. *I. purpurea*, 4L. *I. triloba*; Type Pantoporate subtype Quamoclit 4M. *I. quamoclit*; Type Pantoporate subtype Obscura 4N. *I. asarifolia*, 4O. *I. cairica*, 4P. *I. maxima*, 4Q. *I. obscura* 1, 4R. *I. obscura* 2, 4S. *I. obscura* 3, 4T. *I. ochracea*, 4U. *I. pes-caprae*; Type Pantoporate subtype Pes-tigridis 4V. *I. pes-tigridis*, 4W. *I. pileata*; Type Zonocolpate 4X *Jacquemontia* aff. *paniculata*, 4Y. *J. paniculata*, 4Z *J. pentantha*

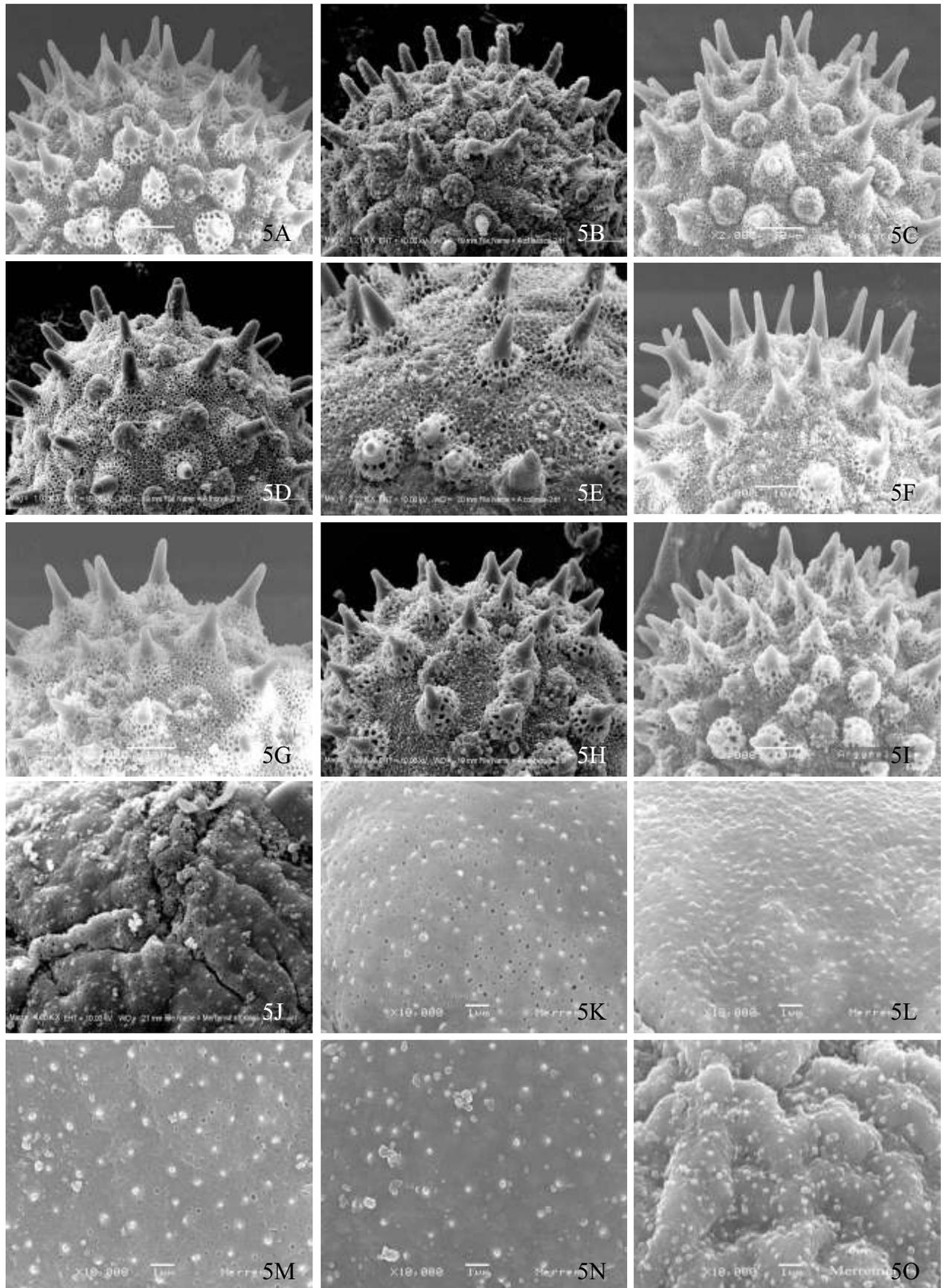


Figure 5. Type Polypantoporate Subtype - A 5A. *Argyreia capitiformis*, 5B. *A. laotica* 5C. *A. mollis*, 5D. *A. thorelii*; Type Polypantoporate Subtype - B 5E. *A. collinsae*, 5F. *A. nervosa*, 5G. *A. obtecta*, 5H. *A. osyrensis*, 5I. *A. splendens*; Type Hexacolpate 5J. *Merremia* aff. *kingii*, 5K. *M. tonkinensis*, 5L. *M. umbellata*, 5M. *M. vitifolia*; Type Tricolpate 5N. *Merremia cissoides*, 5O. *M. collina*.

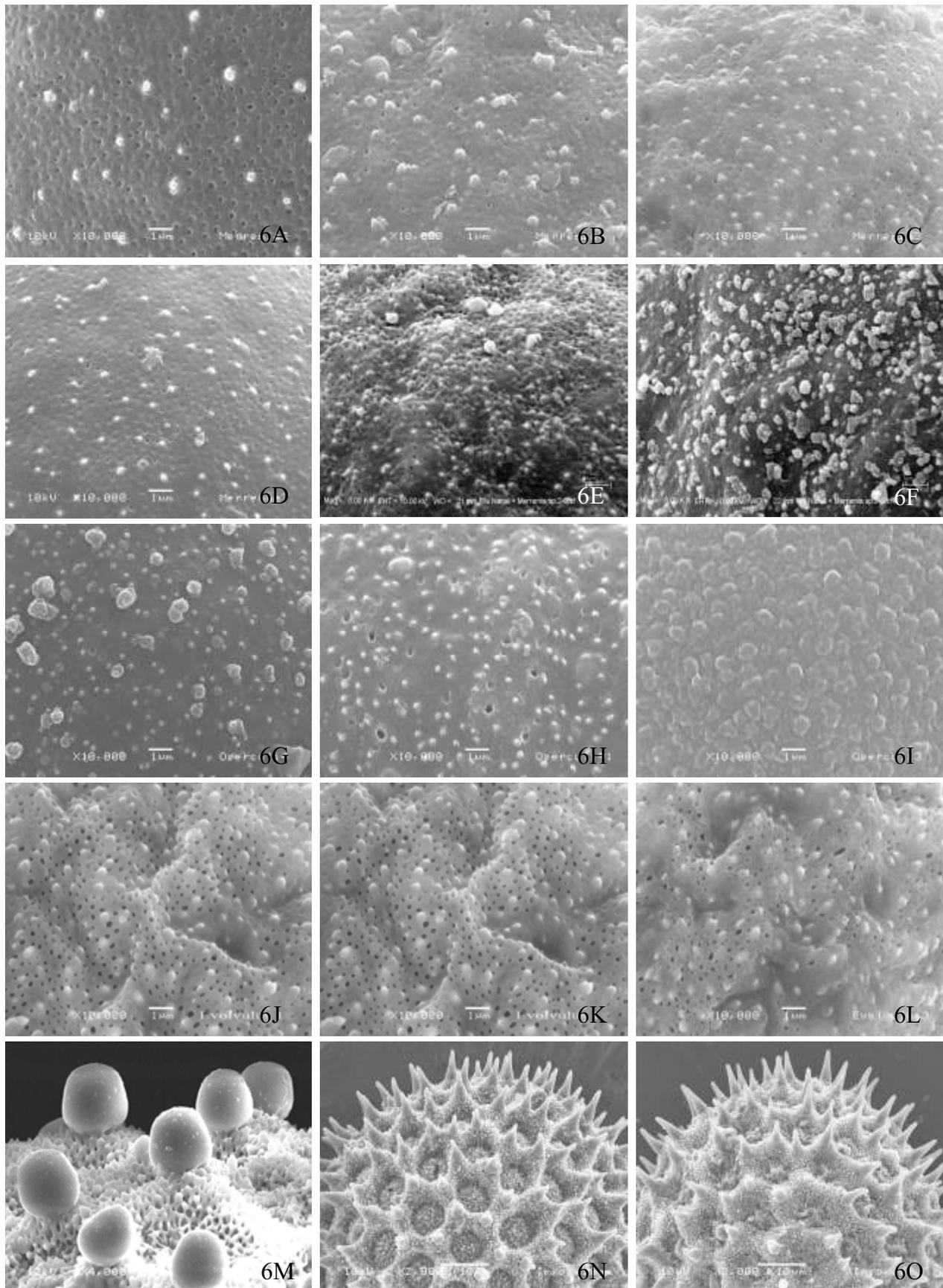


Figure 6. Type Tricolpate 6A. *Merremia gemella*, 6B. *M. hederacea*, 6C. *M. hirta* 1, 6D. *M. hirta* 2, 6E. *M. sp.* 1, 6F. *M. sp.* 2, 6G. *Operculina cf. petaloidea*, 6H. *O. petaloidea*, 6I. *O. turpethum*; Type Periporate 6J. *Hewittia malabarica*; Type Pantoporate subtype Evolvulus 6K. *Evolvulus glomeratus* ssp. *grandiflorus*, 6L. *E. nummularius*; Type Pantoporate subtype Alba 6M. *Ipomoea alba*; Type Pantoporate subtype Aquatica 6N. *I. aquatica* (purple flower), 6O *I. aquatica* (white flower).

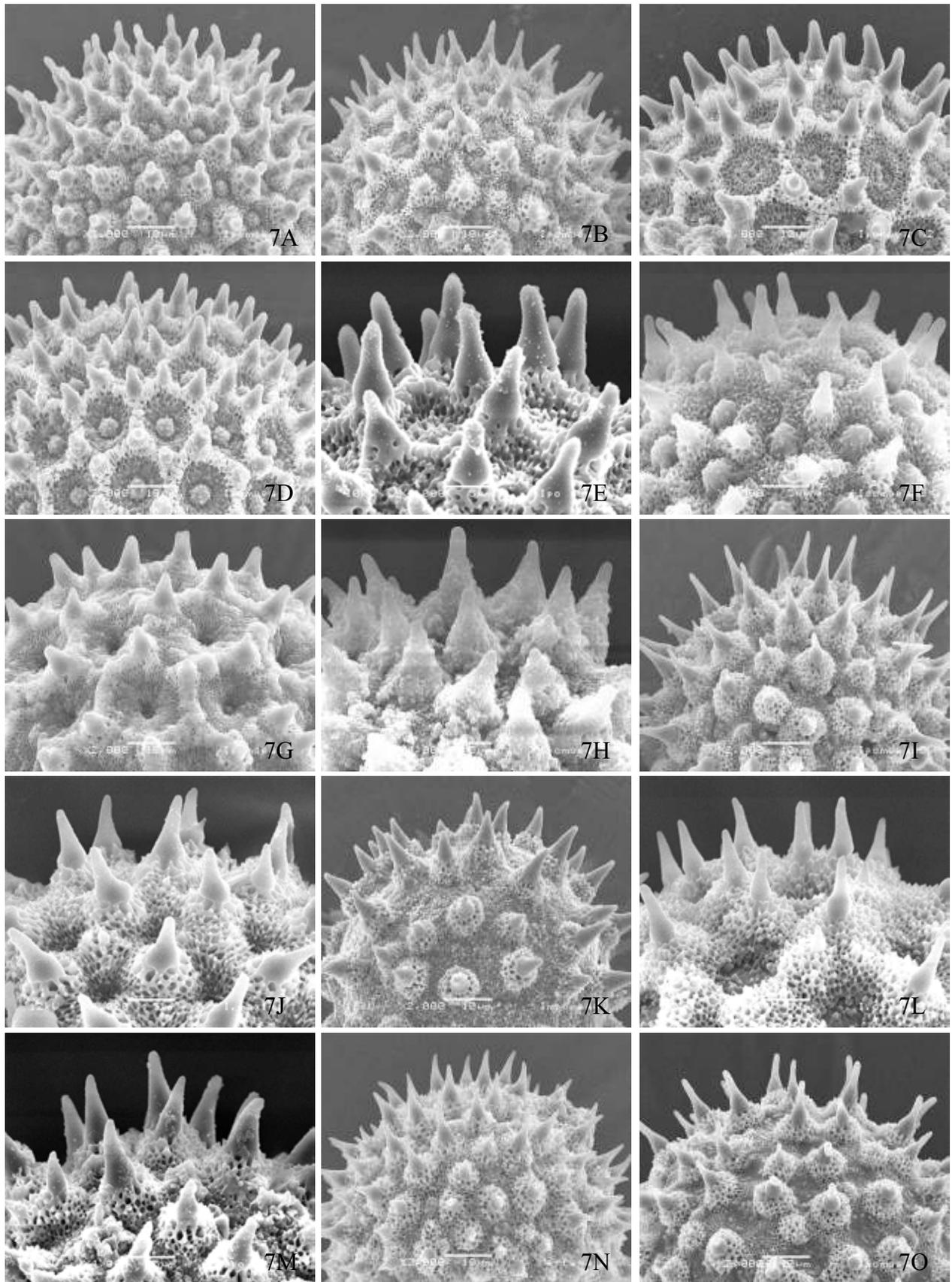


Figure 7. 7A. *Ipomoea batatas*, 7B. *I. carnea* ssp. *fistulosa*, 7C. *I. nil* 1, 7D. *I. nil* 2, 7E. *I. purpurea*, 7F. *I. triloba*; Type Pantoporate subtype Quamoclit 7G. *I. quamoclit*; Type Pantoporate subtype Obscura 7H. *I. asarifolia*, 7I. *I. cairica*, 7J. *I. maxima*, 7K. *I. obscura* 1, 7L. *I. obscura* 2, 7M. *I. obscura* 3, 7N. *I. ochracea*, 7O. *I. pes-caprae*.

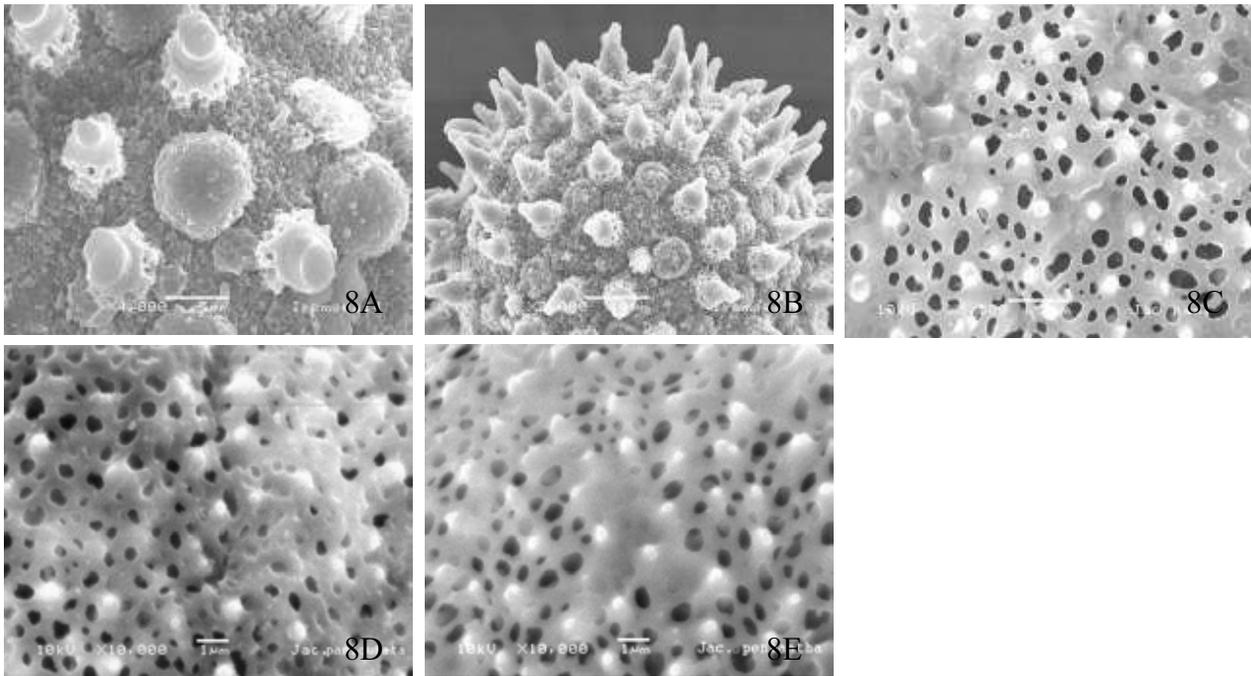


Figure 8. Type Pantoporate subtype Pes-tigridis 8A.. *I. pes-tigridis*, 8B. *I. pileata*; Type Zonocolpate 8C *Jacquemontia* aff. *paniculata*, 8D. *J. paniculata*, 8E *J. pentantha*.

Table 1. Characters and measurements (μm) of pollen grains examined.

Types and Taxa	Symmetry	Polar	Aperture	Shape (P/E)	Size (μm)		Exine Sculpturing	Type of Spine	Coll. and No.*
					P/E	Diameter			
Type polyantoporate									
Type polyantoporate Subtype - A									
1. <i>Argyrea capitiformis</i> (Group A1)	Radial	Apolar	Polyantoporate	Spheroidal	-	125.58 \pm 6.73	Metarecticate & echinate with knob-like	Type-3 Type-4	S. Saensouk <i>et al.</i> 1/2010
2. <i>A. laotica</i> (Group A2)	Radial	Apolar	Polyantoporate	Spheroidal	-	106.75 \pm 2.16	Metarecticate & echinate with knob-like	Type-1 Type-4	S. Saensouk <i>et al.</i> 2/2010
3. <i>A. mollis</i> (Group A2)	Radial	Apolar	Polyantoporate	Spheroidal	-	93.98 \pm 5.60	Metarecticate & echinate with knob-like	Type-1 Type-4	S. Saensouk <i>et al.</i> 3/2010
4. <i>A. thorelii</i> (Group A2)	Radial	Apolar	Polyantoporate	Spheroidal	-	99.88 \pm 0.99	Metarecticate & echinate with knob-like	Type-1 Type-4	S. Saensouk <i>et al.</i> 4/2010
Type polyantoporate Subtype - B									
1. <i>Argyrea collinsae</i>	Radial	Apolar	Polyantoporate	Spheroidal	-	85.25 \pm 2.13	Metarecticate & echinate	Type-3	S. Saensouk <i>et al.</i> 5/2010
2. <i>A. nervosa</i>	Radial	Apolar	Polyantoporate	Spheroidal	-	92.92 \pm 4.46	Metarecticate & echinate	Type-3	S. Saensouk <i>et al.</i> 6/2010
3. <i>A. obtecia</i>	Radial	Apolar	Polyantoporate	Spheroidal	-	95 \pm 6.03	Metarecticate & echinate	Type-3	S. Saensouk <i>et al.</i> 7/2010
4. <i>A. osyrensis</i>	Radial	Apolar	Polyantoporate	Spheroidal	-	98.50 \pm 2.35	Metarecticate & echinate	Type-3	S. Saensouk <i>et al.</i> 8/2010
5. <i>A. splendens</i>	Radial	Apolar	Polyantoporate	Spheroidal	-	87.92 \pm 4.10	Metarecticate & echinate	Type-3	S. Saensouk <i>et al.</i> 9/2010
Type Hexacolpate									
1. <i>Merremia kingii</i>	Bilateral	Isopolar	Hexacolpate	Prolate-spheroidal	61.13 \pm 1.28/ 62.03 \pm 2.05	-	Rough, microrecticate & granulate	Type-6	S. Saensouk <i>et al.</i> 10/2010

Remark: * Specimens are deposited at Mahasarakham University Herbarium.

Table1. Characters and measurements (μm) of pollen grains examined. (Cont.)

Types and Taxa	Symmetry	Polar	Aperture	Shape (P/E)	Size (μm)		Exine Sculpturing	Type of Spine	Coll. and No.*
					P/E	Diameter			
Type Hexacolpate (Cont.)									
2. <i>M. tonkinensis</i>	Bilateral	Isopolar	Hexacolpate	Prolate-spheroidal	*61.67±3.10/ 61.75±3.16	-	Smooth, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 11/2010
3. <i>M. umbellata</i> ssp. <i>orientalis</i>	Bilateral	Isopolar	Hexacolpate	Prolate-spheroidal	*50.08±1.67/ 49±1.94	-	Smooth, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 12/2010
4. <i>M. vitifolia</i>	Bilateral	Isopolar	Hexacolpate	Prolate-spheroidal	*59.42±4.06/ 59.83±3.58	-	Rough, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 13/2010
Type Tricolpate									
1. <i>Merremia cissooides</i>	Bilateral	Isopolar	Tricolpate	Prolate-spheroidal	*53.67±4.63/ 51.25±2.43	-	Smooth, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 14/2010
2. <i>M. collina</i>	Bilateral	Isopolar	Tricolpate	Prolate-spheroidal	*45±1.74/ 44.33±2.93	-	Rough, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 15/2010
3. <i>M. gemella</i>	Bilateral	Isopolar	Tricolpate	Prolate-spheroidal	69.00±1.25 P/E	-	Smooth, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 16/2010
4. <i>M. hederacea</i>	Bilateral	Isopolar	Tricolpate	Prolate-spheroidal	55.25±4.13/ 56±3.43	-	Smooth, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 17/2010

Remark: * Specimens are deposited at Mahasarakham University Herbarium.

Table 1. Characters and measurements (μm) of pollen grains examined. (Cont.)

Types and Taxa	Symmetry	Polar	Aperture	Shape (P/E)	Size (μm)		Exine Sculpturing	Type of Spine	Coll. and No.*
					P/E	Diameter			
Type Tricolpate (Cont.)									
5. <i>M. hirta</i> 1	Bilateral	Isopolar	Tricolpate	Prolate-spheroidal	*46.5 \pm 2.33/ 47.33 \pm 2.62	-	Rough, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 18/2010
5.1 <i>M. hirta</i> 2	Bilateral	Isopolar	Tricolpate	Prolate-spheroidal	59.54 \pm 3.20/ 57.33 \pm 2.40	-	Smooth, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 19/2010
6. <i>M. sp.</i> 1	Bilateral	Isopolar	Tricolpate	Prolate-spheroidal	65.67 \pm 2.07/ 66.33 \pm 2.50	-	Rough, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 20/2010
7. <i>M. sp.</i> 2	Bilateral	Isopolar	Tricolpate	Prolate-spheroidal	72.75 \pm 1.01/ 73.53 \pm 2.33	-	Rough, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 21/2010
8. <i>Operculina cf. petaloidea</i>	Bilateral	Isopolar	Tricolpate	Prolate-spheroidal	*47.5 \pm 2.89/ 45.58 \pm 2.86	-	Smooth, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 22/2010
9. <i>O. petaloidea</i>	Bilateral	Isopolar	Tricolpate	Prolate-spheroidal	*58.75 \pm 1.94/ 49.08 \pm 3.91	-	Smooth, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 23/2010
10. <i>O. turpethum</i>	Bilateral	Isopolar	Tricolpate	Prolate-spheroidal	*45.5 \pm 4.37/ 47.83 \pm 4.57	-	Smooth, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 24/2010

Remark: * Specimens are deposited at Mahasarakham University Herbarium.

Table1. Characters and measurements (μm) of pollen grains examined. (Cont.)

Types and Taxa	Symmetry	Polar	Aperture	Shape (P/E)	Size (μm)		Exine Sculpturing	Type of Spine	Coll. and No.*
					P/E	Diameter			
Type Periporate									
1. <i>Hewittia malabarica</i>	Bilateral	Isopolar	Periporate	Prolate-spheroidal	*50.92 \pm 2.76/ 53.83 \pm 4.49	-	Rough, microreticulate & granulate	Type-6	S. Saensouk <i>et al.</i> 25/2010
Type Pantoporate									
Type Pantoporate subtype Evolvulus									
1. <i>Evolvulus glomeratus</i> ssp. <i>grandiflorus</i>	Bilateral	Isopolar	Pantocolpate	Prolate-spheroidal	*40.83 \pm 5.74/ 38.09 \pm 7.65	-	Rough, microreticulate & Granulate	Type-6	S. Saensouk <i>et al.</i> 26/2010
2. <i>E. nummularius</i>	Bilateral	Isopolar	Pantocolpate	Prolate-spheroidal	*35.33 \pm 2.60/ 35.25 \pm 3.68	-	Rough, microreticulate & Granulate	Type-6	S. Saensouk <i>et al.</i> 27/2010
Type Pantoporate subtype Alba									
1. <i>Ipomoea alba</i>	Radial	Apolar	Pantoporate	Spheroidal	-	146 \pm 16.13	Globular knob-like structure	Type-4	S. Saensouk <i>et al.</i> 28/2010
Type Pantoporate subtype Aquatica									
1. <i>I. aquatica</i> (purple flower)	Radial	Apolar	Pantoporate	Spheroidal	-	75.25 \pm 2.73	Metarecticate-echinate	Type-3	S. Saensouk <i>et al.</i> 29/2010
1.1 <i>I. aquatica</i> (white flower)	Radial	Apolar	Pantoporate	Spheroidal	-	93.58 \pm 2.93	Metarecticate-echinate	Type-3	S. Saensouk <i>et al.</i> 30/2010
2. <i>I. batatas</i>	Radial	Apolar	Pantoporate	Spheroidal	-	95.17 \pm 9.78	Metarecticate-echinate	Type-2	S. Saensouk <i>et al.</i> 31/2010
3. <i>I. carnea</i> ssp. <i>fistulosa</i>	Radial	Apolar	Pantoporate	Spheroidal	-	73.25 \pm 6.74	Metarecticate-echinate	Type-3	S. Saensouk <i>et al.</i> 32/2010
4. <i>I. nil</i> 1	Radial	Apolar	Pantoporate	Spheroidal	-	109.92 \pm 6.96	Metarecticate-echinate	Type-1	S. Saensouk <i>et al.</i> 33/2010

Remark: * Specimens are deposited at Mahasarakham University Herbarium.

Table 1. Characters and measurements (μm) of pollen grains examined. (Cont.)

Types and Taxa	Symmetry	Polar	Aperture	Shape (P/E)	Size (μm)		Exine Sculpturing	Type of Spine	Coll. and No.*
					P/E	Diameter			
Type Pantoporate subtype Aquatica (Cont.)									
4.1 <i>I. nil</i> 2	Radial	Apolar	Pantoporate	Spheroidal	-	128.33 \pm 6.74	Metarecticulate-echinate	Type-1	S. Saensouk et al. 34/2010
5. <i>I. purpurea</i>	Radial	Apolar	Pantoporate	Spheroidal	-	106 \pm 8.48	Metarecticulate-echinate	Type-2	S. Saensouk et al. 35/2010
6. <i>I. triloba</i>	Radial	Apolar	Pantoporate	Spheroidal	-	76 \pm 9.78	Metarecticulate-echinate	Type-2 Type-4	S. Saensouk et al. 36/2010
Type Pantoporate subtype Quamoclit									
1. <i>Ipomoea quamoclit</i>	Radial	Apolar	Pantoporate	Spheroidal	-	110.5 \pm 5.68	Metarecticulate-echinate	Type-5	S. Saensouk et al. 37/2010
Type Pantoporate subtype Obscura									
1. <i>Ipomoea asarifolia</i>	Radial	Apolar	Pantoporate	Spheroidal	-	74.5 \pm 8.57	Metarecticulate-echinate	Type-3	S. Saensouk et al. 38/2010
2. <i>I. cairica</i>	Radial	Apolar	Pantoporate	Spheroidal	-	73.25 \pm 7.29	Metarecticulate-echinate	Type-3	S. Saensouk et al. 39/2010
3. <i>I. maxima</i>	Radial	Apolar	Pantoporate	Spheroidal	-	101 \pm 15.97	Metarecticulate-echinate	Type-2	S. Saensouk et al. 40/2010
4. <i>I. obscura</i> 1	Radial	Apolar	Pantoporate	Spheroidal	-	72.17 \pm 14.45	Metarecticulate-echinate	Type-3	S. Saensouk et al. 41/2010
4.1 <i>I. obscura</i> 2	Radial	Apolar	Pantoporate	Spheroidal	-	82 \pm 5.94	Metarecticulate-echinate	Type-3	S. Saensouk et al. 42/2010
4.2 <i>I. obscura</i> 3	Radial	Apolar	Pantoporate	Spheroidal	-	72 \pm 7.96	Metarecticulate-echinate	Type-3	S. Saensouk et al. 43/2010

Remark: * Specimens are deposited at Maharakham University Herbarium.

Table1. Characters and measurements (μm) of pollen grains examined. (Cont.)

Types and Taxa	Symmetry	Polar	Aperture	Shape (P/E)	Size (μm)		Exine Sculpturing	Type of Spine	Coll. and No.*
					P/E	Diameter			
Type Pantoporate subtype Obscura (Cont.)									
5. <i>I. ochracea</i>	Radial	Apolar	Pantoporate	Spheroidal	-	77 \pm 4.73	Metarecticulate-echinate	Type-3	S. Saensouk <i>et al.</i> 44/2010
6. <i>I. pes-caprae</i>	Radial	Apolar	Pantoporate	Spheroidal	-	84.1 \pm 3.33	Metarecticulate-echinate	Type-2	S. Saensouk <i>et al.</i> 45/2010
Type Pantoporate subtype Pes-tigridis									
1. <i>Ipomoea pes-tigridis</i>	Radial	Apolar	Pantoporate	Spheroidal	-	80.08 \pm 5.02	Metarecticulate-echinate	Type-4 Type-5	S. Saensouk <i>et al.</i> 46/2010
2. <i>I. pileata</i>	Radial	Apolar	Pantoporate	Spheroidal	-	83 \pm 4.12	Metarecticulate-echinate	Type-4 Type-5	S. Saensouk <i>et al.</i> 47/2010
Type Zonocolpate									
1. <i>Jacquemontia</i> aff. <i>paniculata</i>	Radial	Isopolar	5-zonocolpate	Oblate-spheroidal	65 \pm 6.31/ 67 \pm 6.52	-	Microechinate-perforate	Type-6	S. Saensouk <i>et al.</i> 48/2010
2. <i>J. paniculata</i>	Radial	Isopolar	5-zonocolpate	Oblate-spheroidal	75 \pm 6.63/ 77 \pm 7.26	-	Microechinate-perforate	Type-6	S. Saensouk <i>et al.</i> 49/2010
3. <i>J. pentantha</i>	Radial	Isopolar	5-zonocolpate	Prolate-spheroidal	62 \pm 4.66/ 61 \pm 4.06	-	Microechinate-perforate	Type-6	S. Saensouk <i>et al.</i> 50/2010

Remark: * Specimens are deposited at Mahasarakham University Herbarium.

4. Conclusions

The pollen morphology of 45 taxa and seven genera of Convolvulaceae (Table 1 and Figs. 1-9) usually have radial symmetry. According to the results of this report, the pollen of Convolvulaceae in Thailand can be divided into six pollen types based on their aperture which was Polypantoporate, Hexacolpate, Tricolpate, Periporate, Pantoporate and Zonocolpate. The six spine types of the Convolvulaceae taxa from Thailand are based on Hsiao and Kouth's (1995) data. The pollen features of *Argyriaea* and *Ipomoea* are isolated from the other genera based on Staple (2010). The pollen morphology of the genus *Merremia* and *Operculina* are similar. *Evolvulus*, *Hewittia* and *Jacquemontia* have close pollen features. Convolvulaceae pollen in Thailand follow Erdtman's (1952) data can be grouped into three classes based on size, which are medium, large and very large.

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References

- Erdtman, G. 1952. Pollen morphology and plant taxonomy. Angiosperms. Almqvist & Wiksell, Stockholm.
- Erdtman, G. 1966. Pollen morphology and plant taxonomy. London, Hafner Publishing Company, pp. 127-129.
- Erdtman, G. 1972. Pollen morphology and plant taxonomy. London, Hafner Publishing Company.
- Ferguson, I. K., Verdcourt, B. and Poole, M. M. 1977. Pollen morphology in the genera *Merremia* and *Operculina* and its taxonomic significance. Kew Bulletin 31 (4), 763-773.
- Hsiao, L. and Kuoh, C. S. 1995. Pollen morphology of *Ipomoea* (Convolvulaceae) in Taiwan. Taiwania 40(3), 299-316.
- Liao, G. -I., Chen, M. -Y. and Kuoh, C. -S. 2005. Pollen morphology of *Cuscuta* (Convolvulaceae) in Taiwan. Botanical Bulletin Academia Sinica 46, 78-81.
- Menemen, Y. and Jury, S. L. 2002. Pollen studies on some species of the Genus *Convolvulus* L. (Convolvulaceae) from Morocco. Turkish Journal of Botany 26, 141-148.
- Moore, P. D., Webb, J. A. and Collinson, M. E. 1991. Pollen analysis, 2nd eds. Blackwell Scientific Publication, Oxford. pp. 1-216.
- Nairs, P. K. K. 1971. Pollen Morphology of Angiosperms, a Historical and Phylogenetic Study. Darnes &

Noble, New York.

- Nayar, T. S. 1990. Pollen flora of Maharashtra State India. Today and Tommorrow's Publishers. New Delhi (India).
- Rajurkar, A. V., Tidke J. A. and Patil, G. V. 2011. Studies on pollen morphology of *Ipomoea* species (Convolvulaceae). Research in Plant Biology 1(5), 41-47.
- Sengupta S. (1966) A contribution to the pollen morphology of *Ipomoea* with special reference to exine stratification. Transactions of the Bose Research Institutetute 29, 123-129.
- Staples, G. 2010. Convolvulaceae. Flora of Thailand 10(3), 330-468.
- Telleria, M. C. and Daners, G. 2003. Pollen types in Southern new world Convolvulaceae and their taxonomic significance. Plant Systematics and Evolution 243, 99-118.