# Diversity and Palynology of Araceous Plants on Limestone Mountains in Lop Buri and Saraburi Provinces, Thailand

**Sutida Maneeanakekul[1] and Duangchai Sookchaloem[2*]**

[1] School of Agriculture and Cooperatives, Sukhothai Thammathirat Open University, Pakkret, Nonthaburi 11120

[2]Department of Forest Biology, Kasetsart University, Chatuchak, Bangkok 10900

*Corresponding author: ffordcs@ku.ac.th

**Abstract**

A study on diversity and palynology of Araceous plants in Lop Buri and Saraburi provinces, Thailand was carried out between February 2011 and December 2017. The purposes of this study are to report on species diversity and to investigate the morphological characteristics and pollen characteristics of some plants with threatened status. Fifty-five specimens were collected from various limestone areas in Lop Buri and Saraburi provinces. Twenty species were identified i.e. *Aglaonema cochinchinense*, *A. simplex*, *Alocasia acuminata*, *Amorphophallus paeoniifolius*, *A. albispathus*, *A. saraburensis*, *A. lacourii*, *Cryptocoryne crispatula* var. *balansae*, *Hapaline kerri*, *Lasia spinosa*, *Pothos scandens*, *Pycnospatha arietina*, *Rhaphidophora peepla*, *Scindapsus* sp., *Typhonium laoticum*, *T. orbifolium*, *T. saraburiense*, *T. trilobatum*, *T. supraneeae* and *T. muaklekense*. Five species are new locality records. The pollen characteristics of 14 species were investigated using a scanning electron microscope (SEM) technique. Most pollen grains were inaperture (except *Pothos scandens and Pycnospatha arietina*: monosulcate aperture). The polar axis diameter and equatorial axis diameter of pollen grains were 18-60 µm and 11-50 µm, respectively. Four pollen shapes were identified: oblate spheroidal, spheroidal, subprolate, and prolate. Exine sculpturings were perforate, psilate, striate, spinose, areolate and reticulate. *Pothos scandens*, *Pycnospatha arietina*, *Alocasia acuminata*, *Aglaonema simplex*, *A. cochinchinense*, *Hapaline kerrii*, *T. saraburiense*, *T. orbifolium*, *T. laoticum* and *T. muaklekense* were newly examined. A key to species was provided based on morphological characters and pollen features (shape and sculpturing).

**Keywords:** Araceae, Diversity, Limestone mountains, Lopburi and Saraburi provinces, Palynology, Thailand

## Introduction

Araceous plants belong to the monocot plant family Araceae Juss. comprising 105 genera (Mayo *et al.*, 1997; Mabberley, 2008) and 3,250 species. They are mostly distributed in tropical and subtropical forests, and are also found to some extent in temperate forests (Mabberley, 2008). Members of the family are highly diverse concerning life forms, leaf morphology and inflorescence characteristics (International Aroid Society, 1996). The distinctive characteristic of the Araceae family is a compound inflorescence composed of numerous tightly packed florets on a rod shaped "spadix," which is often surrounded or subtended by “a leaf-like bract” or "spathe" (Beath, 2011). Members of the Araceae family are best known as commercial and ornamental plants because of their beautiful and unusual diverse leaf forms and textures (Croat 1994; Mayo *et al*., 1997). The value of Araceaeous species is not limited to ornamental plants as they are also used as food and internally for an even broader array of medicinal purposes (Croat, 1994). They are also often an integral part of local culture, especially as some of them are important in rituals (Bown, 2000).

Information on the Araceae in Thailand was published in the Flora of Thailand. Thirty genera and 210 species were described (Boyce *et al.*, 2012), among which, 43 species were reported as threatened plants. They are consisting of 36 endemic species and 27 rare plant species classified following the IUCN pre-1994 categories. Nineteen species were categorized as having both endemic status and rare status (Santisuk *et al*., 2006). Twenty-nine endemic species were found in limestone areas (Sangrit *et al*., 2013). Bulut and Yilmaz (2010) mentioned that plant endemism is a major concern in the critical status since endemics are dependent on a single area for their survival and have a limited distribution range. Similarly, species under risk of extinction need efficient action to develop a better conservation plan.

Limestone areas are continuously threatened by land-use changes, especially in the central region of Thailand. There are more 200 limestone mining licenses in Saraburi and Lop Buri provinces (Sookchaloem and Maneeanakekul, 2016). Although the

loss of biodiversity has become a matter of urgent concern and a better understanding of local drivers is crucial for conservation (Dufour *et al*., 2006), knowledge of the species diversity, ecology, and palynology of Araceous plants in limestone areas is very limited.

Consequently, the present study focused on researching the morphology and palynology of Araceous plants in the limestones mountains of Lop Buri and Saraburi provinces. Specifically, this study considered species diversity and investigated the morphological and pollen characteristics of some plants with threatened status. The results from this study could provide information on species diversity and important insights into ecological habitats useful for *in-situ* and *ex-situ* conservation and management of threatened species in these specific areas.

## Materials and Methods

Data of Araceous plants, such as flora textbooks, journals, and survey reports of this family, were collected and compiled. The herbarium specimens of Araceous plants, which are deposited in the Forest Herbarium (BKF) (Department of National Parks, Wildlife and Plants Conservation) and the Bangkok Herbarium (BK). Department of Agriculture, were studied in order to prepare a surveying plan. Surveying and collecting of Araceae specimens were carried out between October, 2011 – May, 2015 in many areas. These areas were at Praphuttabat Mountain, Khao Praphuttabat Noi Mountains, Wat Thum Krabog Mountain, Khao Pha Lad Mountain, Muak Lek Waterfall in Saraburi Province, and Pa Wang Plaeng Ta Muang, Lumnarai National Forest, Khao Wong Prachan Mountain, and Wat Pa Chumchon in Lop Buri Province. Flowering periods and plant ecological habitat were recorded. Plant photographs were taken. Herbarium specimens were processed according to Bridson and Forman (1998). An identification of plants at the species level was done by observing morphological characteristics, checking references, and comparing with herbarium specimens. The names were verified to the accepted botanical nomenclature.

Pollen morphological characteristics were studied between January 2015 - May 2017 by the scanning electron microscope (SEM) technique. Pollen grains from all species except *Cryptocoryne crispatula* Engl. var. *balansae*, *Lasia spinosa* (L.) Thwaites, *Rhaphidophora peepla* (Roxb.) Schott, *Scindapsus* sp. and *T. supraneeae* (lacking of pollen grain specimens) were suspended and directly transferred with a fine pipette to a clean stub with double-sided tape. The samples were then coated with gold using a JFC-1100E Ion Sputter manufactured by JEOL. Pollen morphological characteristics were observed and photographs were taken by means of JSM-5410LV scanning electron microscopes at various magnifications. Descriptions of the pollen size and exine sculpturing were adopted from Hesse et al. (2009).

A key to the species was constructed based on the taxonomic and pollen features. Ecological habitats were identified, analyzed and summarized. The threatened category of all species was analyzed based on Thailand Red Data Plant Book (Santisuk et al., 2006) and Limestone Flora: Conservation Status and Threats book (Sangrit et al., 2013). All data were interpreted. Final report was summarized.

## Results and Discussions

Fifty-five Araceae specimens were collected from various limestone areas in Lop Buri and Saraburi provinces including Pra Phut Tabat, Khao Pra Phut Tabat Noi, Wat Thum Krabog, Pha Lad, Muak lek Waterfall in Saraburi province, Wat Thum Chang Phuk, Wat Khao Samo Khon, Khao Wong Prachan and Wat Pa Chumchon in Lop Buri province.

Seventeen Araceous species were studied palynology by SEM technique. Pollen characteristics were identified as inaperture except *Pothos scandens* L. and *Pycnospatha arietina* Gagnep. (monosulcate aperture). The diameter of pollen grains ranged 18-60 X 11-50 μm. Five pollen shapes were identified by the ratio of polar axis length per equatorial diameter length these are; oblate spheroidal (0.88-0.99), spherical (1), subprolate (1.14-1.33) and prolate (1.34-2.00). Exine sculpturing were psilate, striate, spinose, areolate and reticulate. *Pothos scandens*, *Pycnospatha arietina, Alocasia acuminata*, *Aglaonema simplex*,

*A. cochinchinense*, *Hapaline kerrii*, *T. saraburiense*, *T. orbifolium*, *T. laoticum* and *T. muaklekense* were newly examined using SEM. pollen shape and exine sculpturing characteristics are beneficial for taxonomic use.

**Species diversity and conservation status**

Based on the taxonomic features, 20 species of Araceous plants (Fig. 1) were identified from limestone sites in Lop Buri and Saraburi provinces according to Boyce *et al*., (2012): *Pothos scandens* L, *Rhaphidophora peepla* (Roxb.) Schott., *Scindapsus* sp., *Pycnospatha arietina* Gagnep., *Aglaonema cochinchinense* Engl., *A. simplex* (Blume) Blume, *Alocasia acuminata* Schott, *Amorphophallus paeoniifolius* (Dennst.) Nicolson, *A. albispathus* Hett, *A. saraburensis* Gagnep., *A. lacourii* Linden & André, *Hapaline kerrii* Gagnep., *Lasia spinosa* (L.) Thwaites, *Typhonium laoticum* Gagnep., *T. orbifolium* Hett. & Sookchaloem, *T. saraburiense* Sookchaloem Sookch., Hett. & J. Murata, *T. trilobatum* (L.) Schott, *T. muaklekense* D. Sookchaloem & S. Maneeanakekul, *T. supraneeae* A. Galloway, Petra Schmidt & Sinhab. and *Cryptocoryne crispatula* Engl. var. *balansae* (Gagnep.) N. Jacobsen.

Sookchaloem and Maneeanakekul (2016) reported five new locality records in Lop Buri and Saraburi provinces i.e. *Pothos scandens* L., *Rhaphidophora peepla* (Roxb.) Schott, *Alocasia acuminata* Schott, *Amorphophallus albispathus* Hett. and *Typhonium laoticum* Gagnep. are new locality records in Lop Buri and Saraburi provinces. Seven species were reported as threatened plants. Three plant species were classified as having both endemic and vulnerable status: *Amorphophallus albispathus* Hett., *T. orbifolium* Hett. & Sookchaloem, and *T. saraburiense* Sookch., Hett. & J. Murata. *Hapaline kerrii* Gagnep. was classified as having endemic status and near threatened status, while *Pothos scandens* L. had near threatened status. *Amorphophallus saraburensis* Gagnep. had endemic status and *Pycnospatha arietina* Gagnep. had rare status (Santisuk et al., 2006; Sangrit et al., 2013). All these plants need an efficient action plan for future conservation.

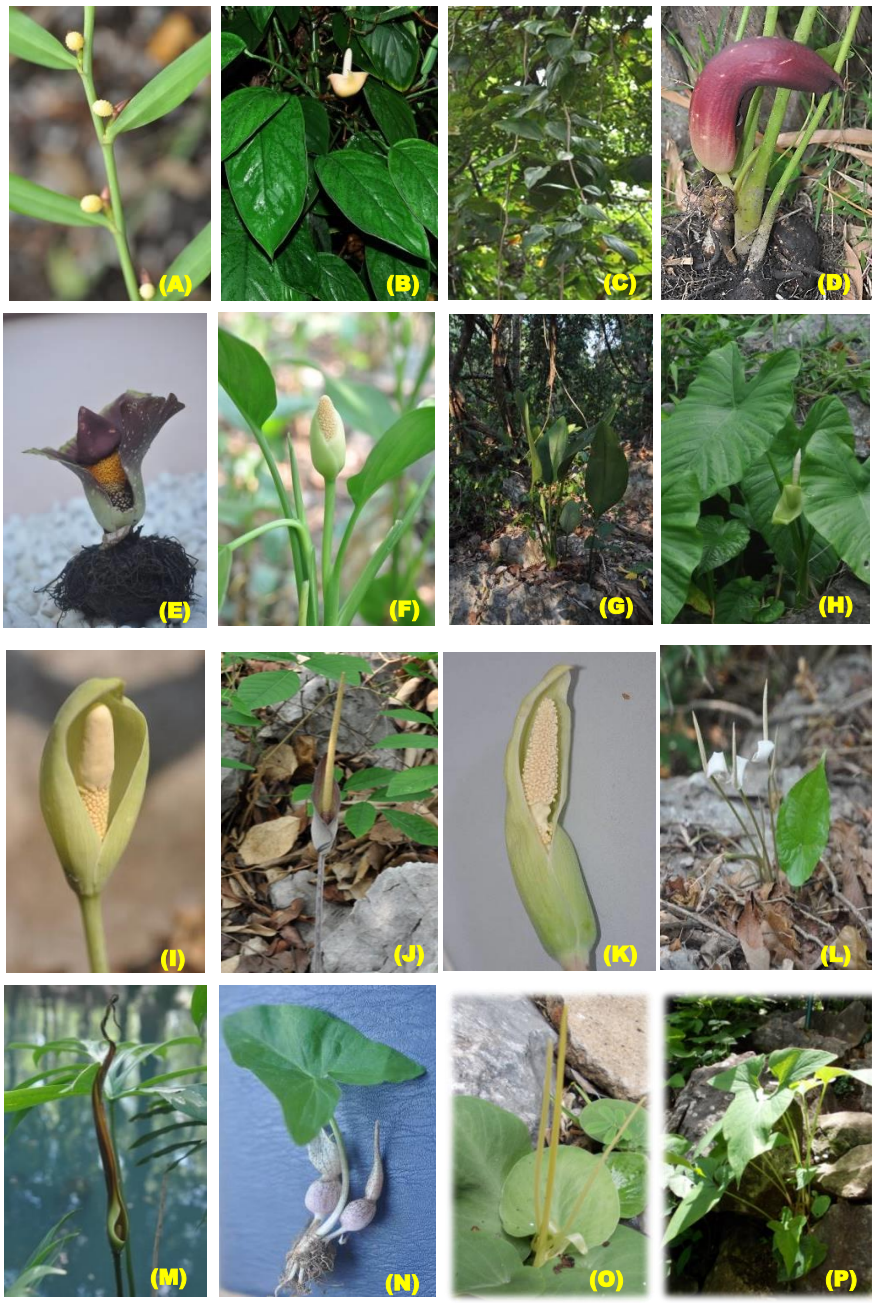


**Figure 1**. Araceous plants on limestone sites in Saraburi and Lop Buri provinces.

(A) *Pothos scandens*, (B) *Rhaphidophora peepla*, (C) *Scindapsus* sp., (D) *Pycnospatha arietina*, (E) *Amorphophallus paeoniifolius*, (F) *Aglaonema simplex*, (G) *A. cochinchinense*, (H) *Alocasia acuminata*, (I) *Amorphophallus albispathus*, (J) *A. saraburensis*, (K) *A. lacourii*, (L) *Hapaline kerrii*, (M) *Lasia spinose*, (N) *Typhonium laoticum*, (O) *T. orbifolium*, (P) *T. saraburiense*


**Figure 1**. Continued.

(Q) *T. trilobatum*, (R) *T. muaklekense,* (S) *T. supraneeae*, (T) *Cryptocoryne crispatula* Engl. var. *balansae*

According to Sookchaloem and Maneeanakekul (2017), one collection of *Typhonium* (deviating from the hitherto-known species) was collected from the Muak Lek district, Saraburi province. Morphologically, the spathe of this species resembles *T. roxburghii* Schott and *T. varians* Hett. & Sookch., but the leaves are distinctly different with orbicular leaf blades. Critical observation and analysis of the specimens indicated that they represent a previously unrecognized species that we are naming *T. muaklekense* based on its occurrence in the Muak Lek district, Saraburi province, Thailand.

**Pollen morphological characteristics**

The pollen morphological characteristics of 14 Araceous species were identified based on SEM observations. The descriptions are shown in Table 1 and Fig. 2. All pollen grains were inaperture except for *Pothos scandens* L. and *Pycnospatha arietina* (monosulcate aperture). The polar axis diameter and equatorial axis diameter of pollen grains were 18-60 µm and 11-50 µm, respectively. Four pollen shapes were identified by the ratio of the polar axis length per equatorial axis length: oblate spheroidal (0.88-0.99), spheroidal (1), subprolate (1.14-1.33), and prolate (1.34-2.00). Exine sculpturing was psilate, striate, spinose, areolate, perforate and reticulate sculpturing.

**Table 1** Pollen morphological characteristics of Araceous plants found on limestone in Lop Buri and Saraburi provinces.

| Botanical name | Type of Aperture | diameter (µm) | | P/E Ratio | Pollen shape | Exine sculpturing |
|---|---|---|---|---|---|---|
| | | Polar axis (P) | Equatorial axis (E) | | | |
| 1. *Pothos scandens L.* | monosulcate | 22 | 11 | 2 | prolate | perforate |
| 2. *Pycnospatha arietina* Gagnep. | monosulcate (Mayo et al,1997) | 30 | 25 | 1.2 | subprolate | reticulate |
| 3. *Aglaonema simplex* (Blume) Blume | inaperture | 38 | 38 | 1 | spheroidal | psilate |
| 4. *A. cochinchinense* Engl | inaperture | 40 | 40 | 1 | spheroidal | psilate |
| 5. *Amorphophallus albispathus* Hett | inaperture | 35 | 35 | 1 | spheroidal | striate |
| 6. *A. paeoniifolius* (Dennst.) Nicolson | inaperture | 60 | 50 | 1.2 | subprolate | psilate |
| 7. *A. saraburensis Gagnep*. | inaperture | 46 | 33 | 1.39 | prolate | striate |
| 8. *Alocasia acuminata* Schott | inaperture | 30 | 25 | 1.2 | subprolate | spinose |
| 9. *Hapaline kerrii* Gagnep. | inaperture | 35 | 30 | 1.16 | subprolate | spinose |
| 10. *Typhonium. saraburiense* Sookchaloem, Hett. & J.Murata | inaperture | 30 | 30 | 1 | spheroidal | spinose |

**Table 1** Continued.

| Botanical name | Type of Aperture | diameter (µm) | | P/E Ratio | Pollen shape | Exine sculpturing |
|---|---|---|---|---|---|---|
| | | Polar axis (P) | Equatorial axis (E) | | | |
| 11. *T. orbifolium* Hett. | inaperture | 20 | 22 | 0.9 | oblate-spheroidal | areolate |
| 12. *T. trilobatum* (L.) Schott | inaperture | 26 | 26 | 1 | spheroidal | spinose |
| 13. *T. laoticum* Gagnep. | inaperture | 21 | 21 | 1 | spheroidal | areolate |
| 14. *T. muaklekense* D. Sookchaloem & S. Maneeanakekul | inaperture | 18 | 20 | 0.9 | oblate spheroidal | areolate |

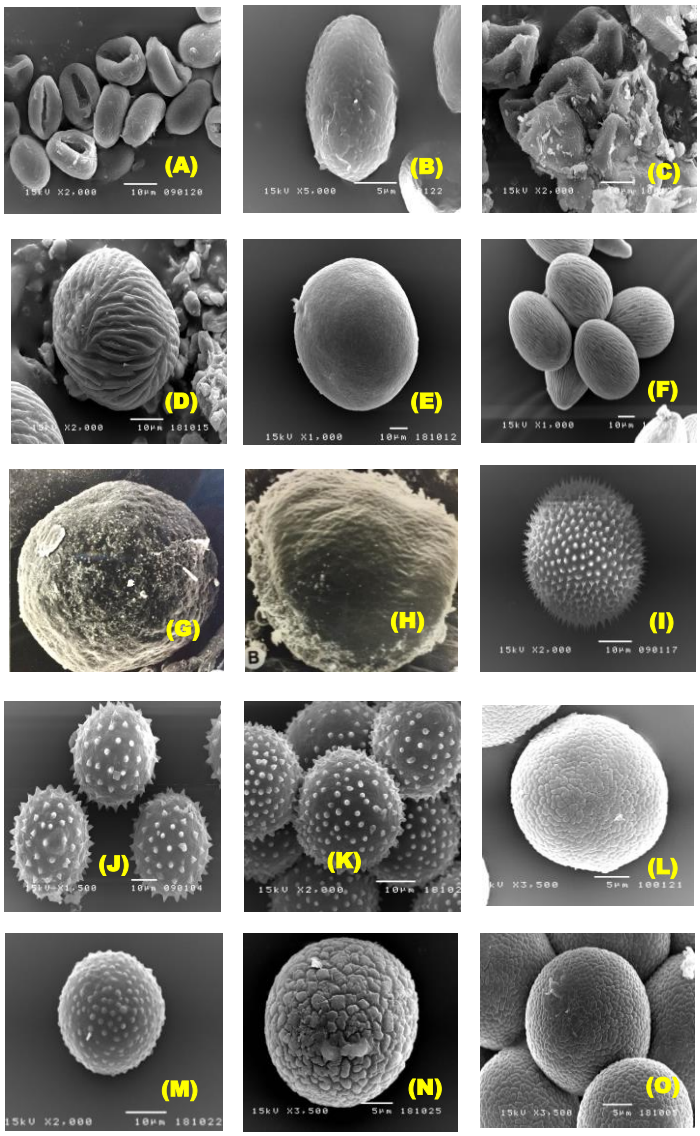


**Figure 2**. Electron SEM micrographs of Araceous pollen grains found on limestone in Lop Buri and Saraburi provinces.

(A) – (B) *Pothos scandens L.*, (C) *Pycnospatha arietina* Gagnep., (D) *Amorphophallus albispathus* Hett., (E) *A. paeoniifolius* (Dennst.) Nicolson, (F) *A. saraburensis* Gagnep, (G) *Aglaonema simplex* (Blume) Blume, (H) *A. cochinchinense* Engl., (I) *Hapaline kerrii* Gagnep., (J) *Alocasia acuminata* Schott, (K) *T. saraburiense* Sookch., Hett. & J. Murata, (L) *T. orbifolium* Hett. & Sookch., (M) *T. trilobatum* (L.) Schott, (N) *T. laoticum* Gagnep., (O) *T. muaklekense* D. Sookchaloem & S. Maneeanakekul

Pollen grains varied considerably: large sizes (50-60 µm polar axis diameter) were found in *Amorphophallus paeoniifolius* (60 µm)*;* medium sizes (26-50 µm polar axis diameter) were found in *A. saraburiense* (46 µm), *Amorphophallus albispathus* (35 µm), *Aglaonema simplex* (38 µm)*, A. cochinchinense* (40 µm), *Hapaline kerrii* (35 µm), *Alocasia acuminata* (30 µm)*, Pycnospatha arietina* (30 µm), *Typhonium saraburiense* (30 µm) and *T. trilobatum* (26 µm); and small sizes (10-25 µm polar axis diameter) were found in *Pothos scandens* (22 µm), *T. orbifolium* (20 µm) *T. laoticum* (21 µm), and *T. muaklekense.* The smallest size in this study (18 µm polar axis diameter) was recorded for *T. muaklekense*.

The results indicated that most species have an inaperture type of grain except for *Pothos scandens* and *Pycnospatha arietina*. The results were consistent with Grayum (1992) who reported that bisexual-flowered genera have monosulcate, extensive-sulcate, meridionosulcate grains, but monoecious genera have inaperturate grains. *Pothos scandens* (bisexual flower) showed monosulcate aperture while the other unisexual flowers showed inaperturate grains.

There were two main groups of pollen shape found in this study. The first group had a subprolate to prolate: *Pothos scandens*, *Pycnospatha arietina*, *Alocasia acuminata*, *Hapaline kerrii, Amorphophallus paeoniifolius*, and *A. saraburensis.* The second group had spheroidal to oblate-spheroidal shapes: *Amorphophallus albispathus*, *Aglaonema simplex*, *A. cochinchinense*, and all *Typhonium* species.

Six main ornamentations were discriminated: psilate (smooth), perforate, striate, spinose, areolate, and reticulate. Perforate exine sculpturing was found in *Pothos scandens*. Psilate exine sculpturing was found in *Aglaonema simplex*, *A. cochinchinense* and *A. paeoniifolius*. Striate, exine sculpturing was found in *Amorphophallus albispathus* and *A. saraburensis*. Spinose, exine sculpturing was found in simple leaf species: *Alocasia acuminata*, *Hapaline kerrii*, *Typhonium saraburiense* and *T. trilobatum*. Areolate, exine sculpturing was found in *T. orbifolium*, *T. laoticum* and *T. muaklekense*.

Reticulate, exine sculpturing was reported only in *Pycnospatha arietina* (bisexual flowers).

The evolution of pollen ornamentation and the ultrastructure in *Amorphophallus* and *Pseudodracontium* was studied by Ham et al., (2005) who reported 18 species of *Amorphophallus* and *Pseudodracontium* in Thailand of which 4 species (*A. albispathus*, *A. paeoniifolious*, *A. saraburensis* and *Pseudodracontium lacourii*) had pollen grain ornamentation that was striate, psilate, areolate and striate, respectively. The differentiation of pollen ornamentation found in *A. saraburensis* Gagnep. was reported by Ham et al. (2005) as areolate, exine sculpturing, whereas this study identified striate, exine sculpturing. Ham et al. (2005) mentioned that their result was based on Kerr 7037 specimens. Revision of pollen exine sculpturing needs to be investigated in this species.

According to Sriboonma *et al.* (1994), the pollen morphology of *Typhonium trilobatum*, *T. blumei*, *T. roxburghii*, *T. albidinervum*, *T. flagelliforme*, *T. inopinatum*, *T. diversifolium*, *T. horsfieldii*, *T. omeiense* and *T. giganteum* has been examined using SEM but not for other species. As the result of the present study, the pollen grains of four species i.e. *T. saraburiense*, *T. orbifolium*, *T. laoticum*, and *T. muaklekense.* They were newly examined using SEM (Fig. 2). *Typhonium* pollens are generally, spheroidal, inaperturate and spinose (Sriboonma *et al.,* 1994) but in the present study, areolate exine sculpturing was observed for *T. orbifolium*, *T. laoticum*, *T. muaklekense* and spinose sculpturing was observed for *T. saraburiense.*

*Pothos scandens*, *Pycnospatha arietina*, *Alocasia acuminata*, *Aglaonema simplex*, *A. cochinchinense*, *Hapaline kerrii*, *T. saraburiense*, *T. orbifolium*, *T. laoticum* and *T. muaklekense* were newly examined using SEM. However, there is considerable variation in the size of the pollen grains, their shape, and the exine sculpturing, which may be useful.

According to Sriboonma et al. (1994), the pollen morphology of *Typhonium trilobatum*, *T. blumei*, *T. roxburghii*, *T. albidinervum*, *T. flagelliforme*, *T. inopinatum*,

*T. diversifolium*, *T. horsfieldii*, *T. omeiense* and *T. giganteum* has been examined using SEM but not for other species. As the result of the present study, the pollen grains of four species i.e. *T. saraburiense*, *T. orbifolium*, *T. laoticum*, and *T. muaklekense* were newly examined using SEM (Fig. 2). *Typhonium* pollens are generally, spheroidal, inaperturate, and spinose (Sriboonma et al., 1994) but in the present study, areolate exine sculpturing was observed for *T. orbifolium*, *T. laoticum*, *T. muaklekense* and spinose sculpturing was observed for *T. saraburiense*.

**Key to the species of Araceous plants on Limestone Mountains in Lop Buri and Saraburi Provinces, Thailand base on morphological and pollen features.**

1. Flower bisexual 2
1. Flowers unisexual 6
2. Flowers each with a perigone of conspicuous tepals 3
2. Flower without a perigone of conspicuous tepals 4
3. Spiny helophytes with hastate to pinnates leaves *Lasia spinosa* (L.) Thwaites
3. Climbing hemiepiphytes with elliptic leaves *Pothos scandents* L.
4. Geophytes with “dracontioid” leaves *Pycnospatha arietina* Gagnep
4. Not geophytic; leaves not “dracontioid” 5
5. Placentation parietal; fruits with more than one seed *Rhaphidophora peepla* (Roxb.) Schott.
5. Placentation basal; fruits with a solitary seed *Scindapsus* sp.
6. Leaves variously divided, leaf blade decompound; inflorescences mostly appearing before leaf emergence 7
6. Leaves simple, ranging from linear-lanceolate to hastate 10
7. Appendix surface brain-like *Amorphophallus lacourii* Linden & André
7. Appendix surface never brain-like 8
8. Peduncle shorter than spathe; spathe campanulate, limb undulate, reflexing; pollen subprolate and psilate *Amorphophallus paeoniifolius* (Dennst.) Nicolson

8. Peduncle moderately exceeding to much longer than spathe; spathe triangular-ovate, not reflexing; pollen striate 9

9. Flattened or subglobose staminodes (synandrodes) present between staminate and pistillate flower zones; spathe exterior base pale grey with blackish green or greyish black spots; pollen prolate *A. saraburensis* Gagnep.

9. Staminate and pistillate flower zone contiguous; spathe exterior uniformly pale green or dirty white with scattered pale or dark grey-green spots; pollen spheroida *A. albispathus* Hett.

10. Aquatic plants *Cryptocoryne crispatula* Engl. *var. balansae*

10. Plant not aquatic 11

11. Plants mostly suffruticose; fruits conspicuous green, red or pink berries not surrounded by a persistent spathe; pollen psilate 12

11. Plants not suffruticose; fruit surrounded by a persistent lower spathe; pollen spinose or areolate 13

12. Stem not exceeding 15 cm; venation undifferentiated; inflorescences 1-2 together; spathe semipersistent late into the fruit; pistillate flower zone with ca. 10 flowers *Aglaonema cochinchinense* Engl

12. Stem 15-120 cm; venation differentiated into primary and secondary veins; spathe caduceus during anthesis; pistillate flower zone with ca. 12-38 flowers *A. simplex* (Blume) Blume

13. Staminate flowers forming synandria 14

13. Staminate flowers not forming synandria 15

14. Spathe differentiated into an upper limb and a tubular or convolute lower part separated one constriction, spathe green *Alocasia acuminata* Schott

14. Spathe not differentiated into an upper limb and lower part by constrictions; spathe white *Hapaline kerrii* Gagnep.

15. Appendix distinctly conical, short or elongate, usually 4 mm thick or more, maroon or dark reddish, cream or yellowish 16

15. Appendix largely terete, narrow elongate to filiform, rarely thicker than 2 mm, white, creamish, pinkish or pale brownish 18

16. Staminodes subulate; spathe inside spotted or uniformly green; pollen spheroidal and spinose *T. saraburiense* Sookch. Hett. & J.Murata

16. Staminode filiform, subulate, spathulate, clavate, grooved, terete; spathe inside uniformly purple or with a green tip 17

17. Staminodes long filiform, covering the larger part of pistillate zone of entirely filling the space surrounding the pistillate zone; pollen spheroidal and spinose *Typhonium trilobatum* (L.) Schott

17. Staminodes subulate, spathulate and clavate, 0.5 cm long, tips curved in various directions; pollen oblate spheroidal and areolate *Typhonium muaklekense* D. Sookchaloem & S. Maneeanakekul

18. Leaf blade trifloliolate *Typhonium supraneeae* A. Galloway, P. Schmidt, & C. Sinhabaedya

18. Leaf blade orbicular or triangular 19

19. Leaf blade orbicular or suborbicular; staminodes grooved; pollen oblate spheroidal and areolate *T. orbifolium* Hett. & Sookchaloem

19. Leaf blade elliptic or triangular, staminodes terete, slightly obconical or slightly clavate; pollen spheroidal and areolate *T. laoticum* Gagnep.

## Conclusion

Fifty-five specimens were collected from various limestone areas. Twenty species of Araceous plants were identified using the characteristics of the underground stem, phyllotaxis and leaf blade, spathe and spadix. The species list consisted of *Aglaonema cochinchinense*, *A. simplex*, *Alocasia acuminata*, *Amorphophallus paeoniifolius*, *A. albispathus*, *A. saraburensis*, *A. lacourii*, *Cryptocoryne crispatula* var. *balansae*, *Hapaline kerri*, *Lasia spinosa*, *Pothos scandens*, *Pycnospatha arietina*, *Rhaphidophora peepla*, *Scindapsus* sp., *Typhonium laoticum*, *T. orbifolium*, *T. saraburiense*, *T. trilobatum*, *T. muaklekense*,

and *T. supraneeae*. Among these species, *Typhonium muaklekense* D. Sookchaloem and S. Maneeanakekul was reported as a new species in 2017.

Five species are new locality records in Lop Buri and Saraburi provinces including; *Pothos scandens* L., *Rhaphidophora peepla* (Roxb.) Schott., *Alocasia acuminata* Schott. *Amorphophallus albispathus* Hett. and *Typhonium laoticum* Gagnep. Seven species were reported as the threatened plants in Thailand Red Data Book and Limestone Flora: Conservation Status and Threats Book. Three species were classified as both endemic status and vulnerable status including; *Amorphophallus albispathus* Hett, *T. orbifolium* Hett. & Sookch., *T. saraburiense* Sookch. Hett. & J. Murata. *Hapaline kerrii* Gagnep was classified as endemic status and near threatened status. *Pothos scandens* L. was classified as near threatened. *Amorphophallus saraburense* Gagnep. was classified as endemic status and *Pycnospatha arietina* Gagnep. as rare status.

The palynology of 14 Araceous species was studied using an SEM technique. Pollen characteristics were identified as inaperture except for *Pothos scandens* L. and *Pycnospatha arietina* Gagnep. (monosulcate aperture). The polar axis diameter and equatorial axis diameter of pollen grains were 18-60 µm and 11-50 µm, respectively. Four pollen shapes were identified using the ratio of polar axis length per equatorial diameter length: oblate spheroidal (0.88-0.99), spheroidal (1), subprolate (1.14-1.33) and prolate (1.34-2.00). Exine sculpturing styles were perforate, psilate, striate, spinose, areolate and reticulate. *Pothos scandens*, *Pycnospatha arietina* , *Alocasia acuminata*, *Aglaonema simplex*, *A. cochinchinense*, *Hapaline kerrii*, *T. saraburiense*, *T. orbifolium*, *T. laoticum* and *T. muaklekense* were newly examined using SEM. The pollen shape and exine sculpturing are of taxonomic use.

**Acknowledgements**

We would like to express my appreciation to the Center for Advanced Studies in Tropical Natural Resources under the National Research Universities Program of Kasetsart University, Bangkok, Thailand for this research funding. The editor and

anonymous reviewers are also thanked for their useful and constructive comments on an earlier draft of this paper.

## References

Beath, D. (2011). *Introduction Pollination Ecology of the Araceae*, the International Aroid Society, South Miami, USA. Retrieved from: http://www.aroid.org/pollination/beath/index.phpJuly

Bown, D. (2000). *Aroids: Plants of the Arum Family*. Timber Press, Portland. 470 pp.

Boyce, P. C., Sookchaloem, D., Hetterscheid, W.L.A., Gusman, G., Jacobsen, N., Idei, T. & .Van Du, N. (2012). Acoraceae & Araceae. *Flora of Thailand,* 11 (2): 101–321.

Bridson, D. & Forman, L. (1998). *The Herbarium Handbook*. 3rd ed. The Royal Botanic Garden, Kew, Scotland. 346 pp.

Bulut, Z. & Yilmaz, H. (2010). The current situation of threatened endemic flora in Turkey: Kemaliye (Erzincan) case. *Pak. J. Bot*., *42*(2): 711–719.

Croat, T. (1994). The use of New World Araceae as drug plants. *Japanese Journal of Botany, 69*: 185–203.

Croat, T. (2004). *History and current status of systematic research with Araceae*, the International Aroid Society, South Miami, FL, USA, 299 pp. Retrieved from: http://www.aroid.org/literature/croat/history/history_contents.php

Dufour A., Gadallah, F., Wagner, H. H., Guisan, A. & Buttler, A. (2006). Plant species richness and environmental heterogeneity in a landscape: effects of variability and spatial configuration. *Ecography, 29*: 573–584.

Erdtman, G. (1952). *Pollen Morphology and Plant Taxonomy: Angiosperms*. Almqvist and Wiksell, Stockholm. 539 pp.

Grayum, M. H. (1992). Comparative external pollen ultrastructure of the Araceae and putatively related taxa. Monogr. Syst. Bot. 43. Missouri Botanical Garden., St. Louis MO.

Ham, R., Grob, G., Hetterscheid, W., Star, W. & Heuven, B.J. (2005). Notes on the genus *Amorphophallus* (Araceae). Evolution of pollen ornamentation and ultrastructure in *Amorphophallus* and *Pseudodracontium*. *Grana, 44*: 252–265.

Hay, A. (1993). The genus *Typhonium* (Araceae–Areae) in Australasia. *Blumea, 37*: 345–376.

Hesse M., Halbritter, H., Weber, M., Buchner, R., Frosch-Radivo, A., Ulrich, S. & Zetter, R. (2009). Pollen Terminology: An illustrated handbook. Springer-Verlag, Wein. 198 pp.

Hetterscheid, W & Claudel, C. (2012). The End of *Pseudodracontium* N.E. Br. *Aroideana, 35*: 40–46.

International Aroid Society. (1996). The Genera of Araceae. the International Aroid Society, South Miami, USA. Retrieved from: http://www.aroid.org/genera/

Mabberley, D. J. (2008). Mabberley's Plant-book: A Portable Dictionary of Plants, their Classifications, and Uses. University of Washington Botanic Gardens, Seattle. 1021 pp.

Mayo, S.J., Bogner, J. & Boyce, P.C. (1997). The Genera of Araceae. Continental Printing, Belgium. 380 pp.

Sangrit, S., Chamchumroon, V. & Supantee, S. (2013). Limestone Flora: Conservation Status and threats. Office of the Forest Herbarium. National Park Innovation Institute. National Park, Wildlife and Plant Conservation Department, Thailand. 144 pp.

Santisuk, T, Chayamarit, K., Pooma, R. & Suddee, S. (2006). Thailand Red Data: Plants. Office of Natural Resources and Environmental Policy and Planning, Bangkok. 256 pp.

Sookchaloem, D. & Maneeanakekul, S. (2016).Taxonomy of Araceous Plants on Limestone Mountains in Lop Buri and Saraburi Provinces, Thailand. World Academy of Science, Engineering and Technology, International Science Index, *Agricultural and Biosystems Engineering,* 10(7): 974.

Sookchaloem, D. & Maneeanakekul, S. (2017). *Typhonium muaklekense* sp. nov. (Araceae) from Thailand. *Nordic Journal of Botany*. *36*(5). https://doi:10.1111/njb.01619

Sriboonma, D., Murata, J. & Iwatsuki, K. (1994). A Revision of *Typhonium* (Araceae). *J. Fac. Sci. Univ. Tokyo III, 15*: 255–313.

Weber, M., Halbritter, H. & Hesse, M. (1999). The Basic Pollen Wall Types in Araceae. *International Journal of Plant Sciences, 160*(2): 415–423.