UNIVERSITI PUTRA MALAYSIA

AGRICULTURE • INNOVATION • LIFE

Pollen Morphology of Selected *Heritiera* Aiton. (Sterculioideae - Malvaceae *s.l.*) Species in Malaysia and Its Taxonomic Significance

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OUTLINE

- Introduction
- Objective
- Materials and Methods
- Results and Discussions
- Conclusion and Recommendation

INTRODUCTION

- Hyde and Williams (1944) introduce the term palynology :
  - can be understood as the study of pollen, spore and any other biological materials studied by using the palynological method and other applications.

- The pollen and spores are characterized by highly variable pollen morphological features, which help in their precise identification (Agashe & Coulton 2009).

- Pollen morphological aspects studies are very useful in many fields such as paleobotany, aeropalynology, forensics science, study on allergies, pharmacopalynology, archaeology, melisopalynology and also taxonomy (Talip 2008).

INTRODUCTION

- The outermost layer of pollen is exine and variations in pollen morphology largely relate to details of the exine (Shivanna & Rangaswamy 1992).

- The exine is acetolysis resistant (Müller 1979) and often provided with a distinctive ornamentation, so that most pollen grains can be recognized to family and genus and occasionally even to species (Hedberg 2000).

- Pollen morphological characteristics: play an important role in plant taxonomy due to its unique morphological diversity and variations such as the shape, differences in ornamention structure and others morphological characteristics that can be used for the plant classification and identification.

HERITIERA

- A tropical and subtropical African, Asian and Pacific islands genus in the subfamily Sterculioideae (Malvaceae s.l).

- Its species are mainly trees of forests and mangroves at altitudes below 1000 m.

- Important as a commercial logging source and such as Mengkulang and Dungun (Wilkie & Berhaman 2011).

HERITIERA

- *Heritiera littoralis* has been used for traditional medicinal purposes (Wilkie & Berhaman 2011).

- Dungun in Malaysia or Ngon Kai in Thailand.

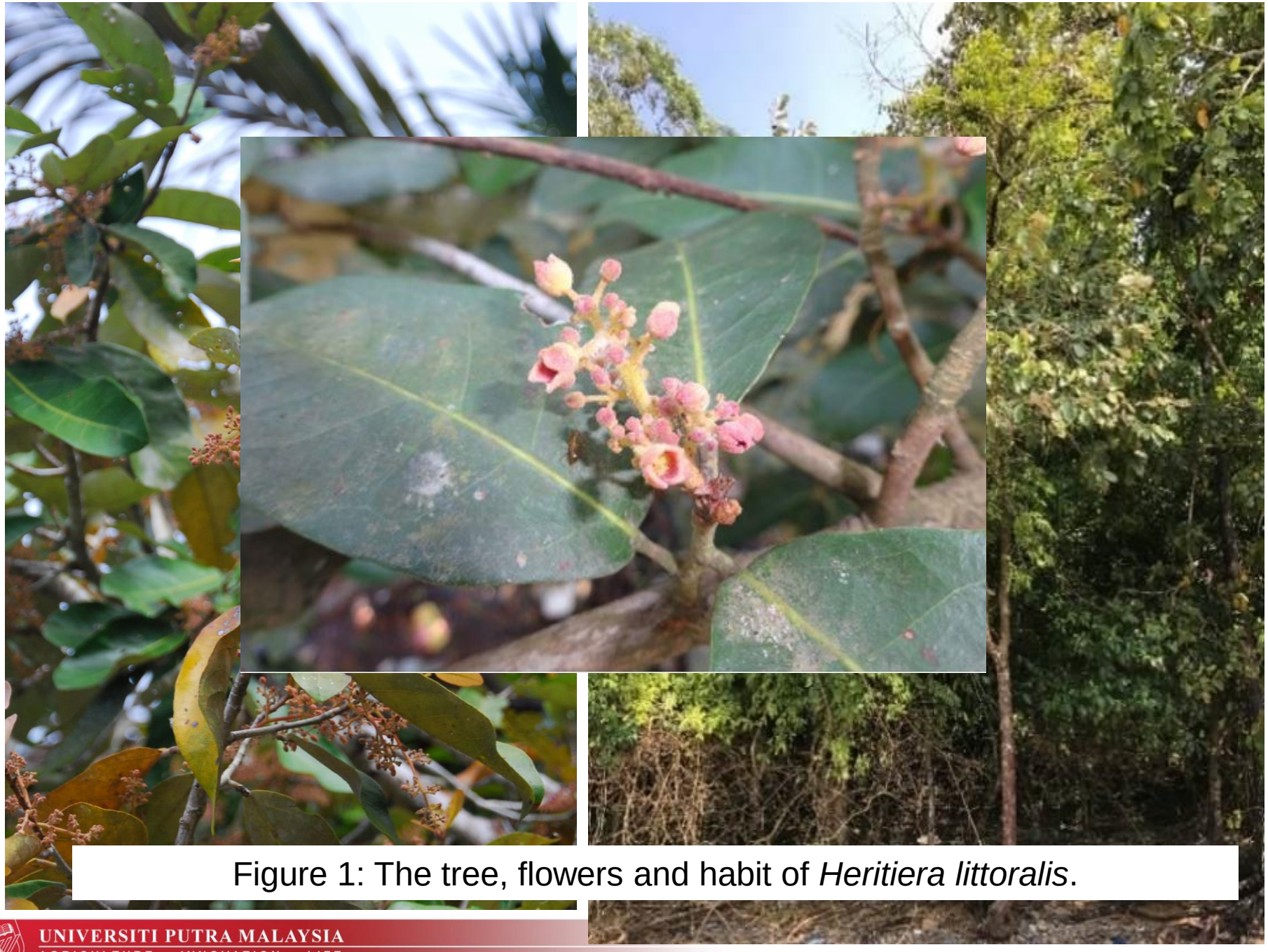


Figure 1: The tree, flowers and habit of *Heritiera littoralis*.

Use of Microscopy for Taxonomy

- The use of microscopy for the aid of taxonomy has long been done by many plant taxonomist.

- The microscopic techniques are used for the identification of species in different plant groups, i.e: using seed morphology, anatomical as well as palynological characters and useful for the authentication of medicinal plant groups (Ashfaq et al. 2019).

- The use of microscopic for taxonomical study in Malaysia have been done by many researchers: Ummu-Hani et al. (2014) on leaf venation of species in Moraceae, Nurul-Aini et al. (2017) on pollen morphology of selected species of Acanthaceae, Noraini et al. (2017) on pollen morphology of selected species of Rhizophoraceae in Peninsular Malaysia and few other researchers.

Pollen Wall Structure

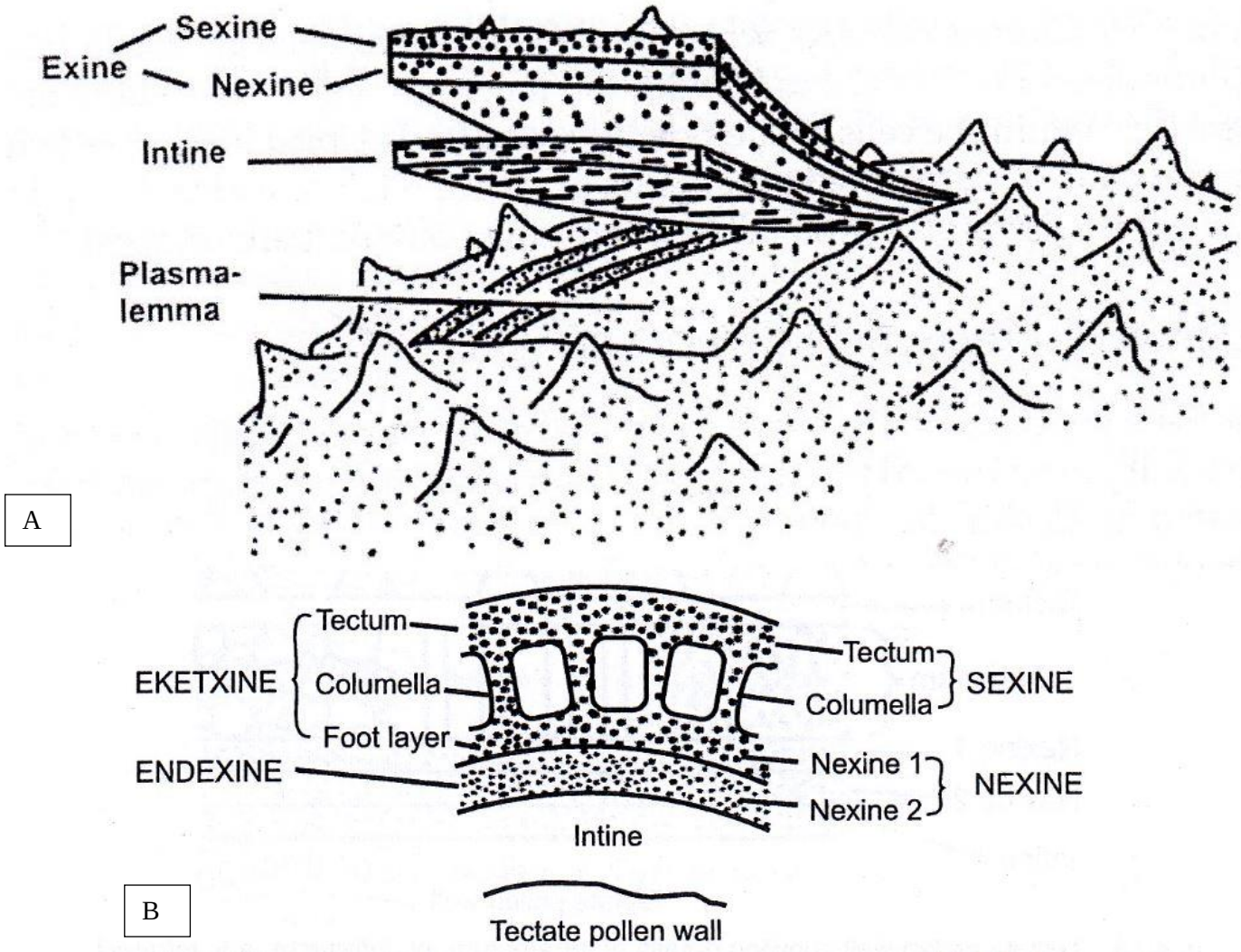


Figure 3. Structure of pollen wall.

Harmomegathic Effects

- Harmomegathy refers to the alterations in form of pollen or the changes in the degree of hydrations of pollen grains (Wodehouse 1935)

- Harmomegathic effects, occurs in all parts of the pollen walls, and not only on the apertures, but the thin aperture membranes will usually show the more obvious changes (Payne 1972).

- According to Payne (1972), pollen grain is a structure subject to rapid change in size and shape through the process of loss and uptake of water. Harmomegathy refers to the mechanism that permit the changes in the shape and size of pollen grains by varying the hydration status.

- Most angiosperm pollen grains undergo a phase of dehydration during the final maturation of the anther and are dispersed with a reduced water content (Stanley & Linskens 1974, Heslop-Hamson 1979)

Harmomegathic Effects

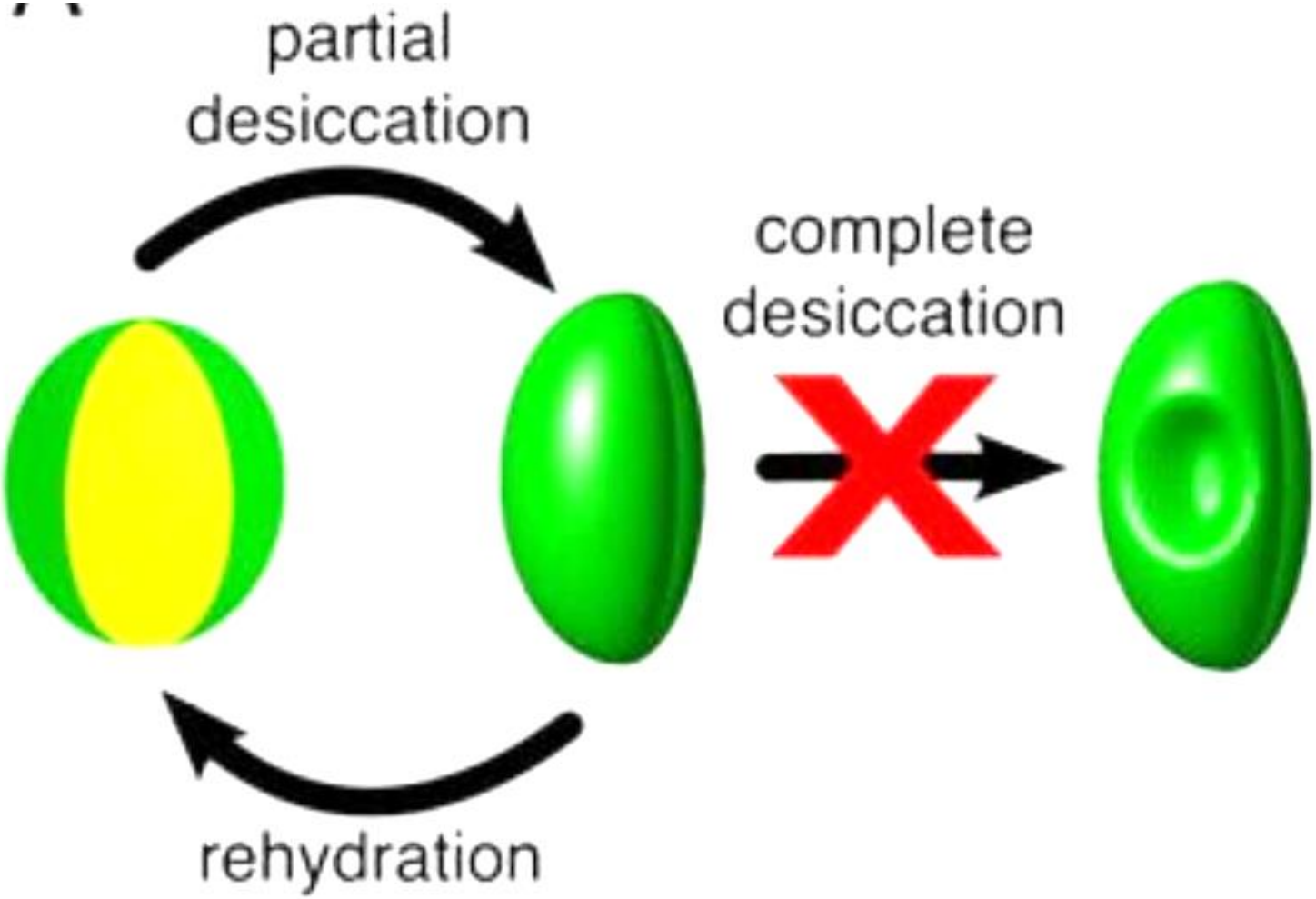


Figure 2: Dehydration process that leads to harmomegathic effects in pollen.

PROBLEM

- Malvaceae s.l is a large family (244 genera, c. 4225 species (Kew Science 2021).

- The delimitation of families within Malvales has puzzled systematists for years (Cronquist, 1981).

- Molecular data has shown phylogenetic relationships within Malvaceae (s.l.), a clade that includes members of four previously recognized families: Malvaceae (s.s.), Bombacaceae, Sterculiaceae, and Tiliaceae (Alverson et al., 1999; Bayer et al., 1999; Nyffeler and Baum, 2000; Whitlock et al., 2001; Pfeil et al., 2002).

PROBLEM

- Based on evidences on molecular data by Bayer and Kubitzki (2003), the families of the Malvales order were re-positioned into nine subfamilies: **Byttnerioideae** (26 genera, 650 species), **Grewioideae** (25 genera, 770 species), **Sterculioideae** (formerly Sterculiaceae, in part; 12 genera, 430 species), **Tilioideae** (formerly Tiliaceae, in part; three genera, 50 species), **Dombeyoideae** (*c.* 20 genera, *c.* 380 species), **Brownlowioideae** (*c.* eight genera, *c*. 70 species), **Helicteroideae**: (8-12 genera, 10-90 species), **Malvoideae** (formerly Malvaceae; 78 genera, 1,670 species) and **Bombacoideae** (formerly Bombacaceae, in part; 12 genera, 120 species) .

- However, the rearrangement was still unable to explain the relationship between the taxa.

OBJECTIVES

- To understand the variation in micromorphological characteristics of pollen in *Heritiera* species by using microscopic technique.

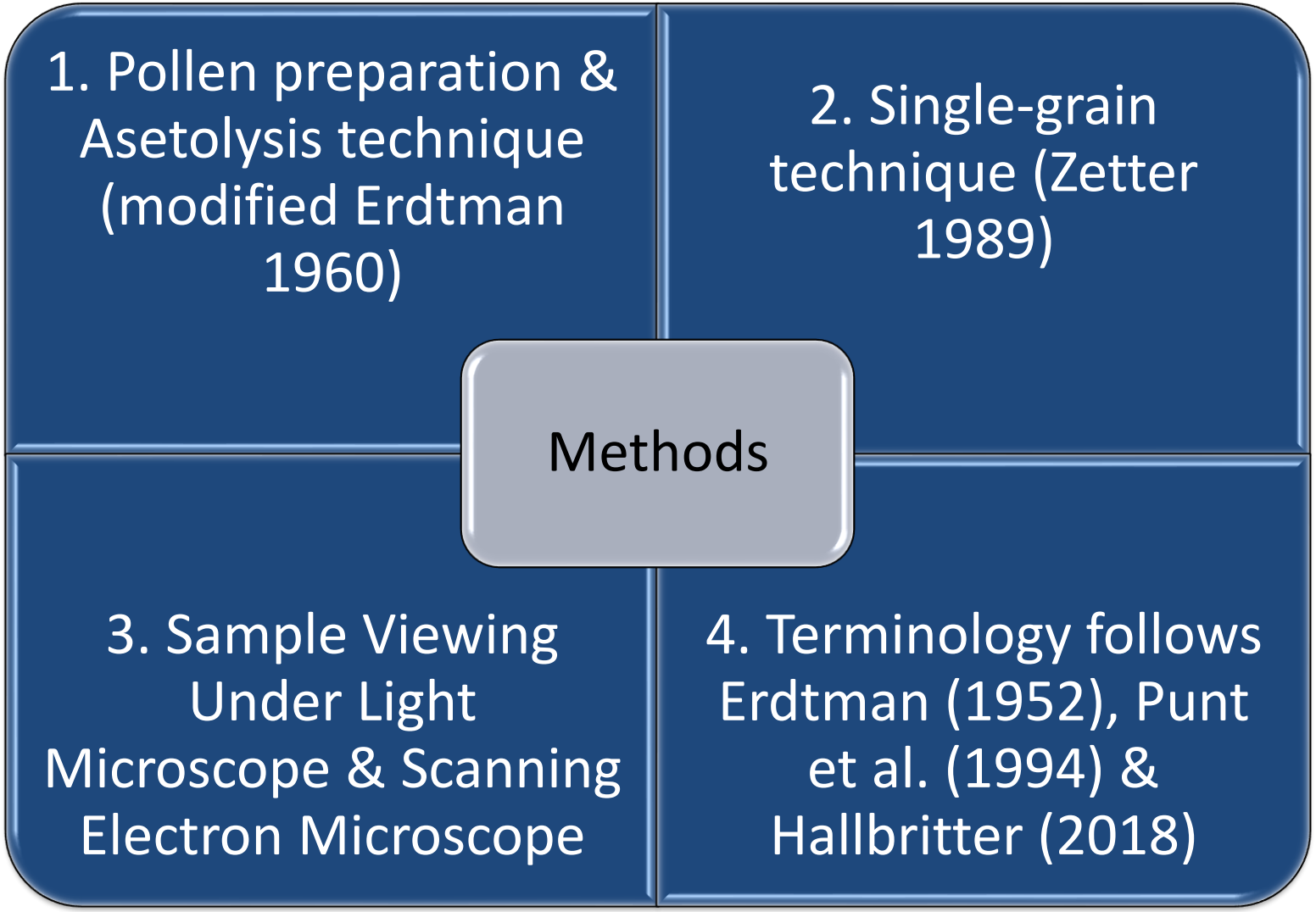
- To add more pollen information on the species under the Malvaceae *s.l.* family. Especially Sterculiaceae *s.s.*

MATERIALS - List of Samples

SPECIES	LOCATION, DATE, COLLECTOR(S), CODE	HERBARIUM
Heritiera borneensis (Merr.) Kosterm.	Labis, Johor, 19.02.1971, T.C. Whitmore, FRI 15919	KEP
Heritiera elata Ridl.	Sungai Teku, Pahang Tahan Woods, 21.02.1968, T.C. Whitmore, FRI 4785	KEP & SING
Heritiera littoralis Dryand.	Perak, 1883, Pooloo ganajali, FMP No 4959	SING
	Sungai Kerteh, Terengganu, 24.07.2006, Y.W. Low, K.M. Wong, C, Puff, I.S. Shanmugaraj, Wan Asmadi, Ahmad Azri & I. Zulkapli, LYW 98	KLU
	Pulau Singa Besar, Langkawi, Kedah, 14.12.2016, Amirul-Aiman, Ruzi Abdul Rahman, MAA 189	Fresh specimen
Heritiera simplicifolia (Mast.) Kosterm.	Seremban, N. Sembilan, 12.04.1934, Fosten, C., KEP 18890	K & SING
	Temerloh, Pahang, 8.05.1934, Abdul Rahman, KEP 29979	KEP
Heritiera sumatrana (Miq.) Kosterm.	Pulau Pinang, 19.02.1907, Fox, 12713	K
	Government Hill, Penang, Julai 1894, H. Dull red, FOP 2229	SING

K – Herbarium Kew Botanical Garden, Richmond
SING – Herbarium Singapore Botanical Garden
KEP – Herbarium FRIM Kepong
KLU – Herbarium University of Malaya

METHODS


1. Pollen preparation & Asetolysis technique (modified Erdtman 1960)
2. Single-grain technique (Zetter 1989)
Methods
3. Sample Viewing Under Light Microscope & Scanning Electron Microscope
4. Terminology follows Erdtman (1952), Punt et al. (1994) & Hallbritter (2018)

METHODS OF PALYNOLOGICAL STUDY

Pollen characteristics (Overview)

Acetolysis

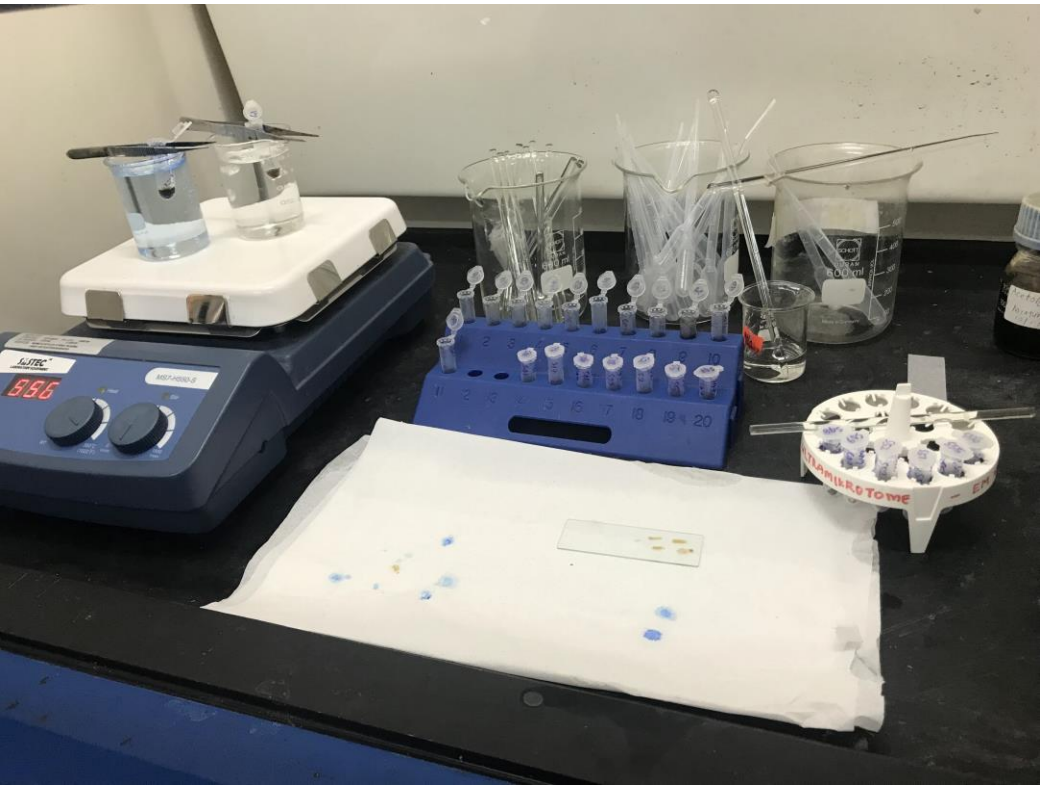
Glycerine Jelly (single grain technique)

Viewing Under The Light Microscope Olympus DP72

Gold/Platinum Coating

Viewing Under The Scanning Electron Carl Zeiss Supra 55vp & Quanta 400

Acetolysis Technique



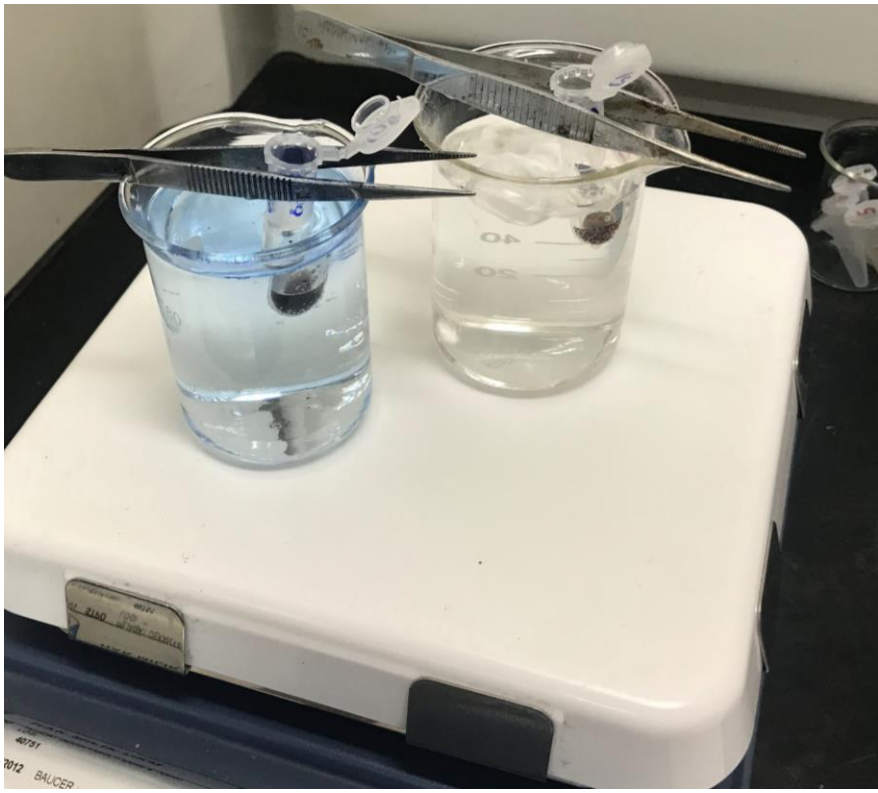


Figure 4. Acetolysis technique was used to clean the pollen and to remove the pollen kit that covers the pollen exine.

1. Samples were placed with acetolysis mixture & “cooked” with boiling water (100°C).
2. Until the solution turn to brownish-blackish colour.
3. Samples need to be stirred using glass rod.

Light Microscope

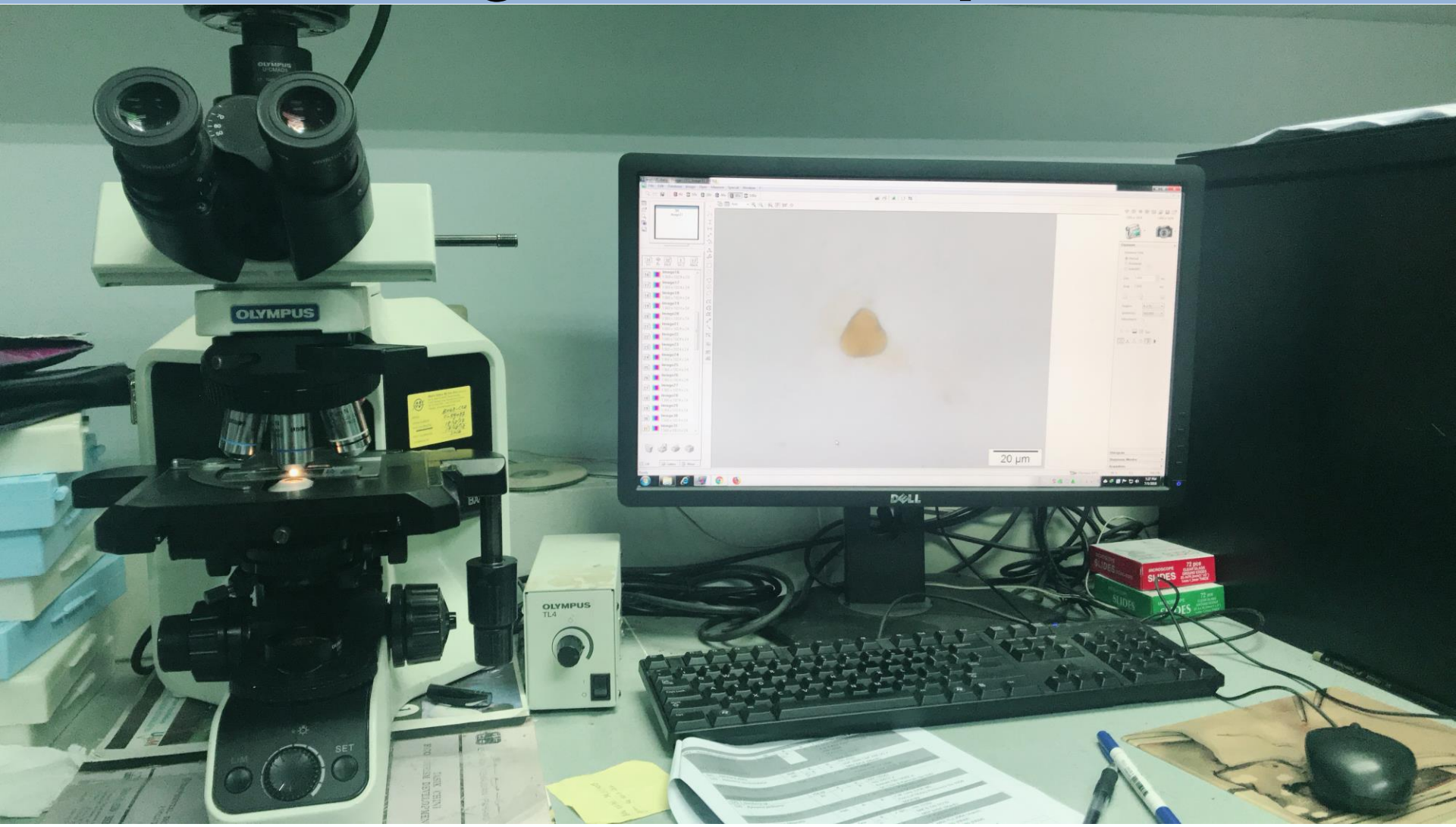


Figure 5. Pollen analysis under the light microscope Olympus BX43 with camera model Olympus DP72 and Canon EOS 700D attached (60x mag.).

Single Grain Technique

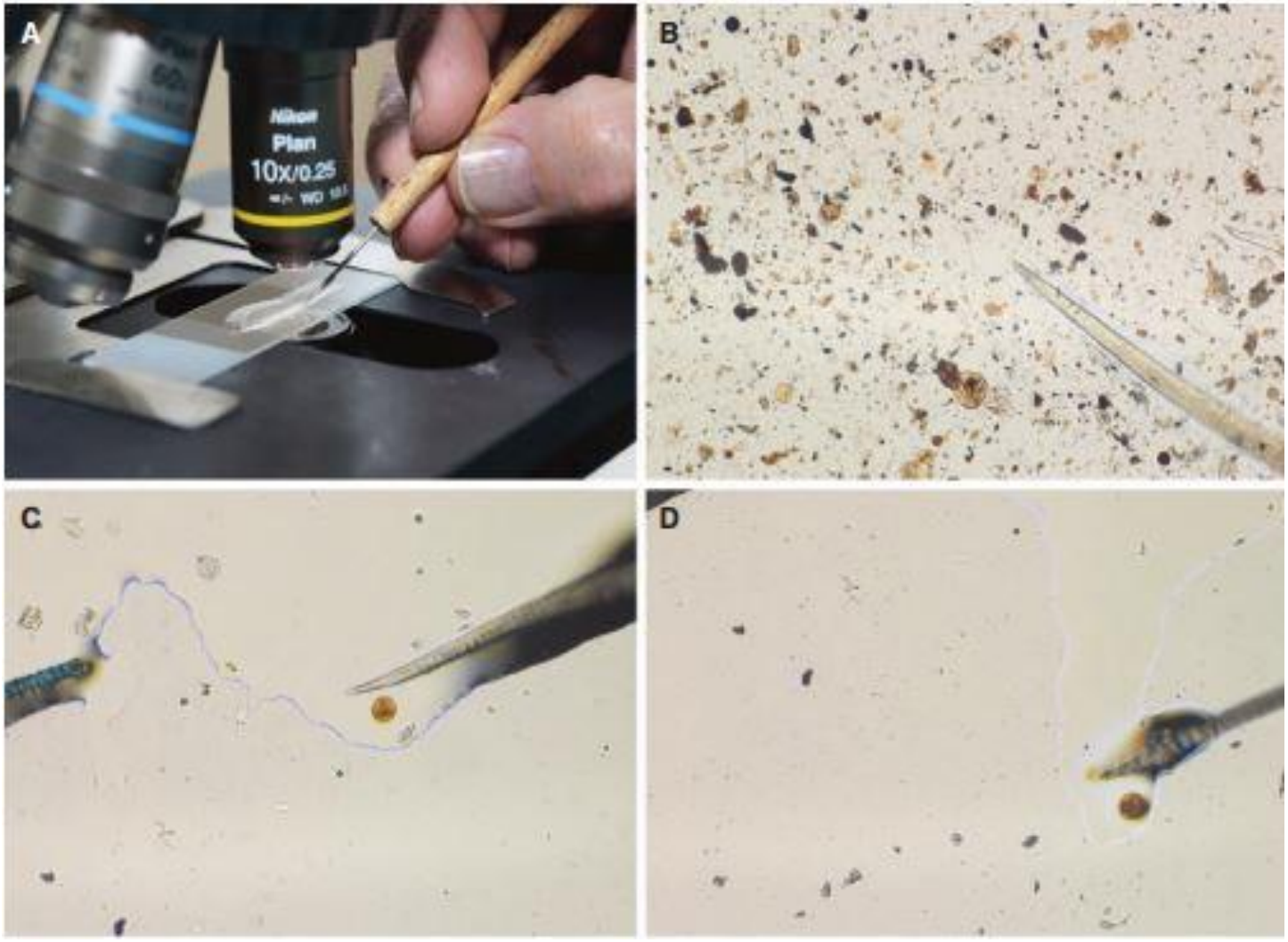
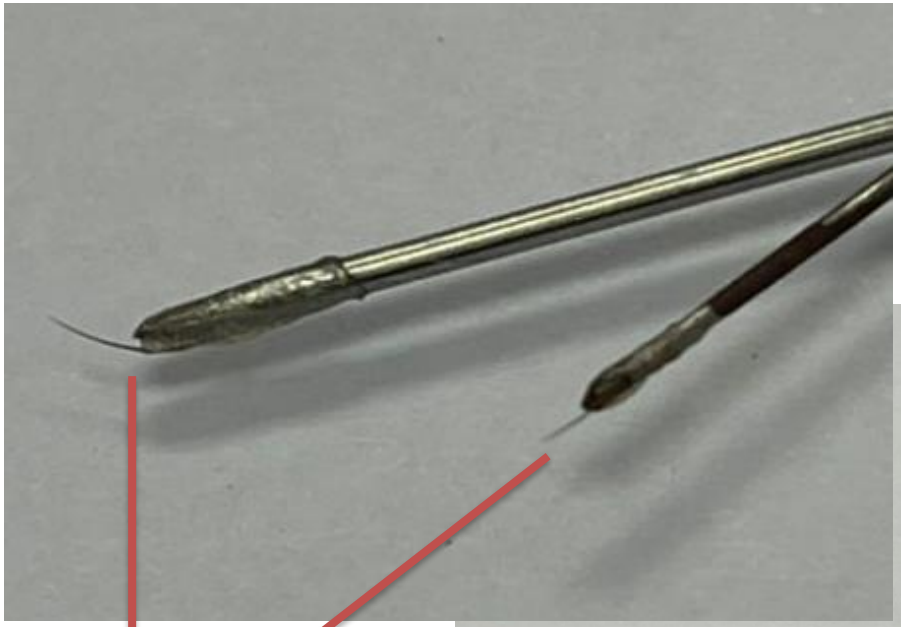
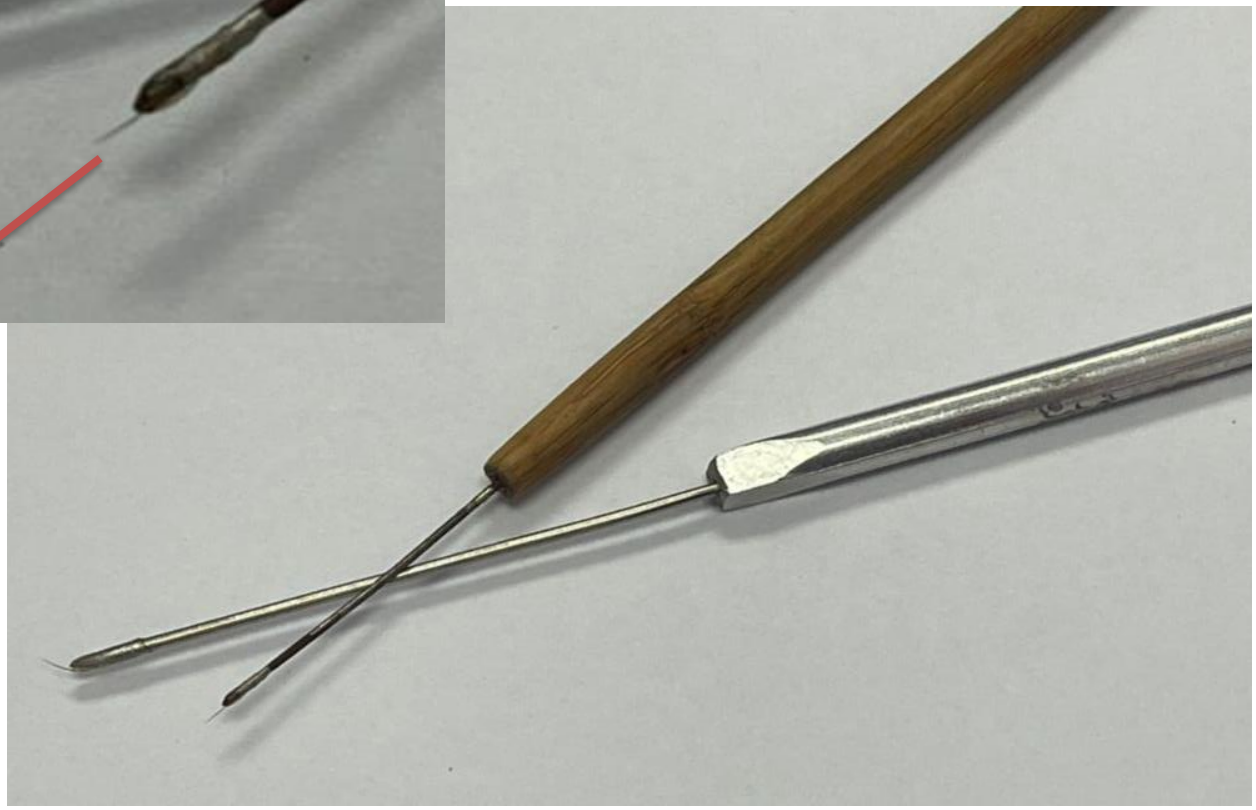


Figure 6. Single grain technique. Following Halbritter et al. (2018)

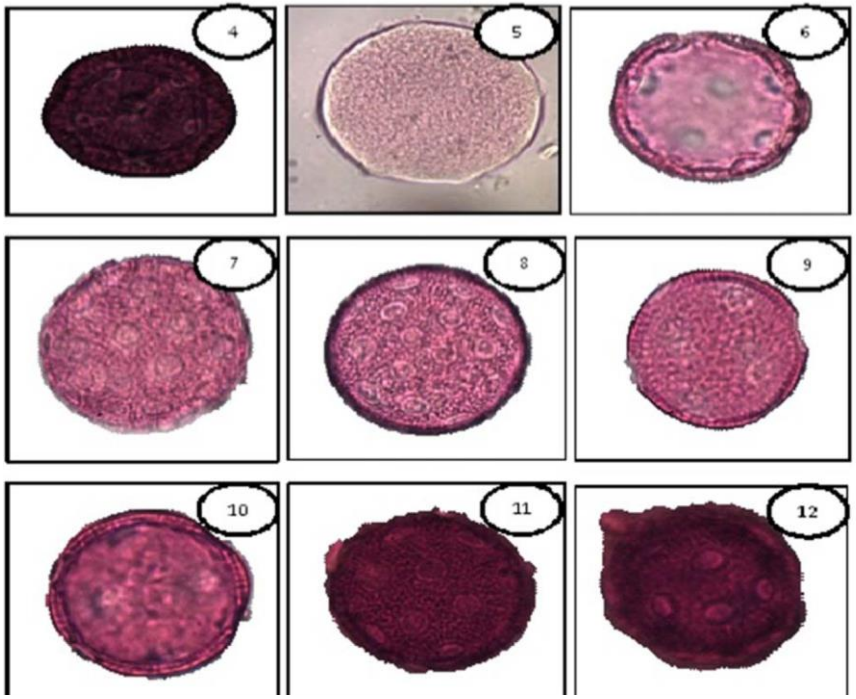


Nasal hair



Why Single-Grain Technique?

- Able to shift the pollen position.
- Able to get the correct pollen position.
- Correct Position = Correct Measurement = Correct Interpretation.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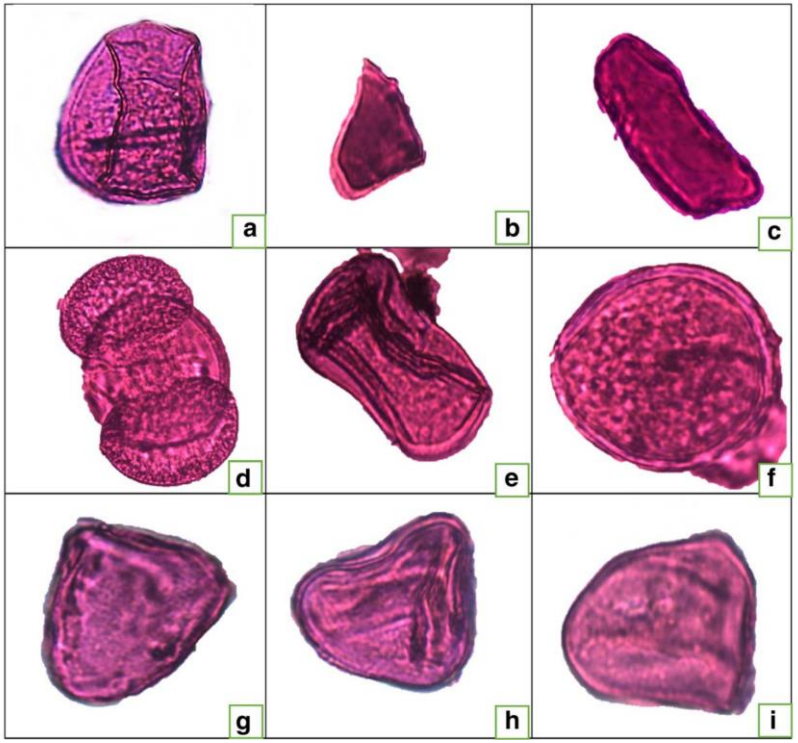
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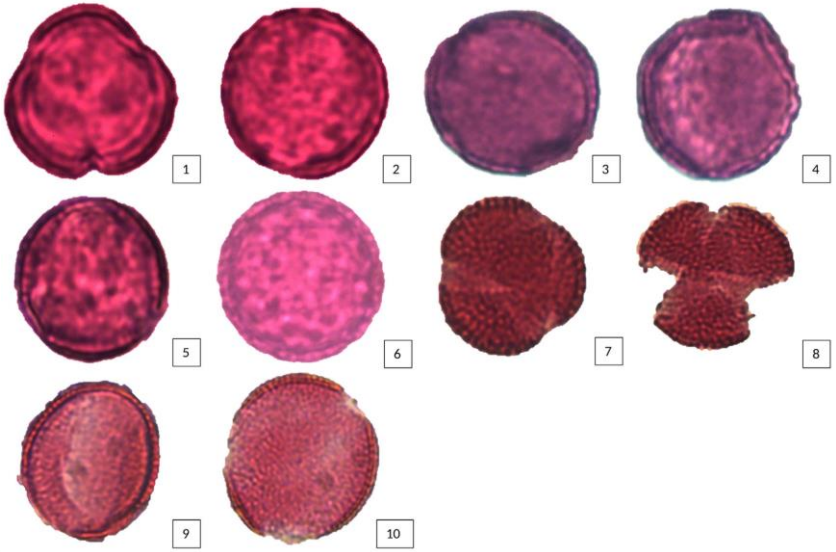
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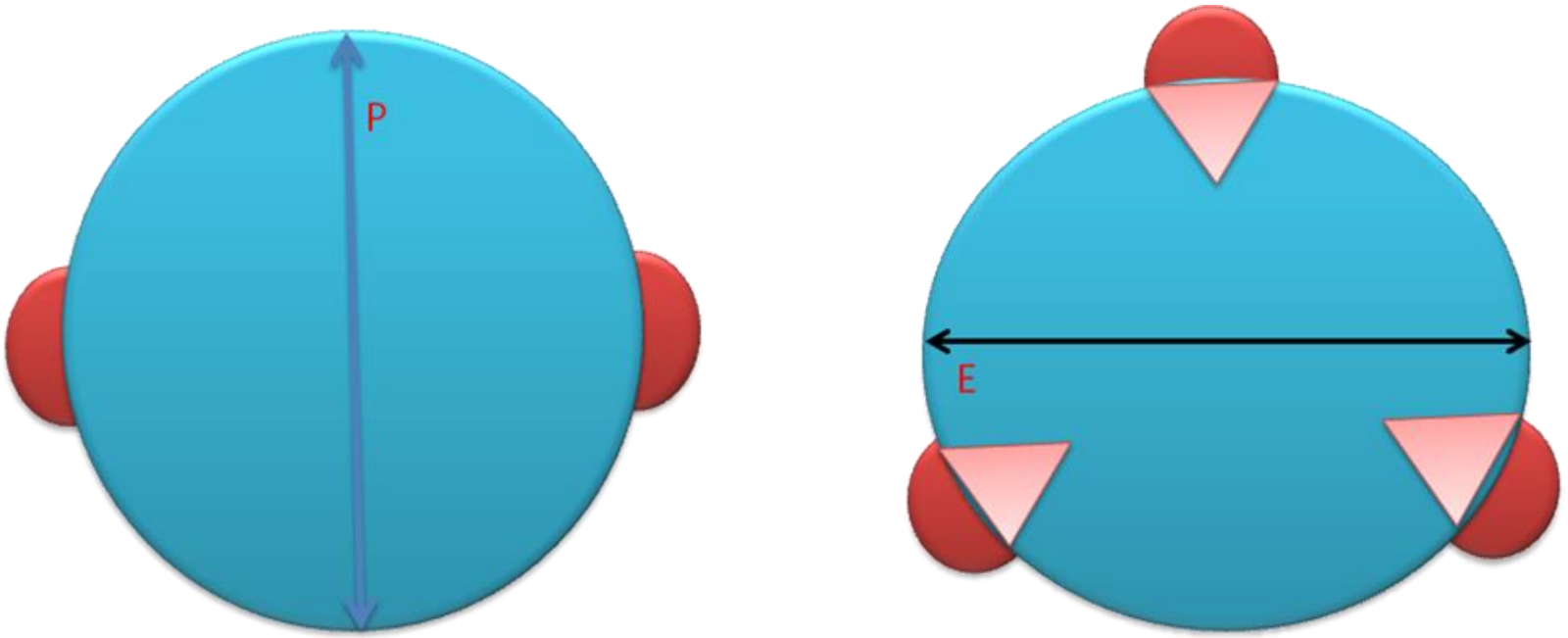


Figure 7. Illustration for the measurement of length for polar axis (P) and diameter of pollen (E).

At least 30-40 pollen grains were measured under the light microscope to avoid biases in pollen size and shape determination.

Analyses were done using Analysis DoCu and EOS Utility 2 software.

Coating & Viewing (Scanning Electron Microscope)

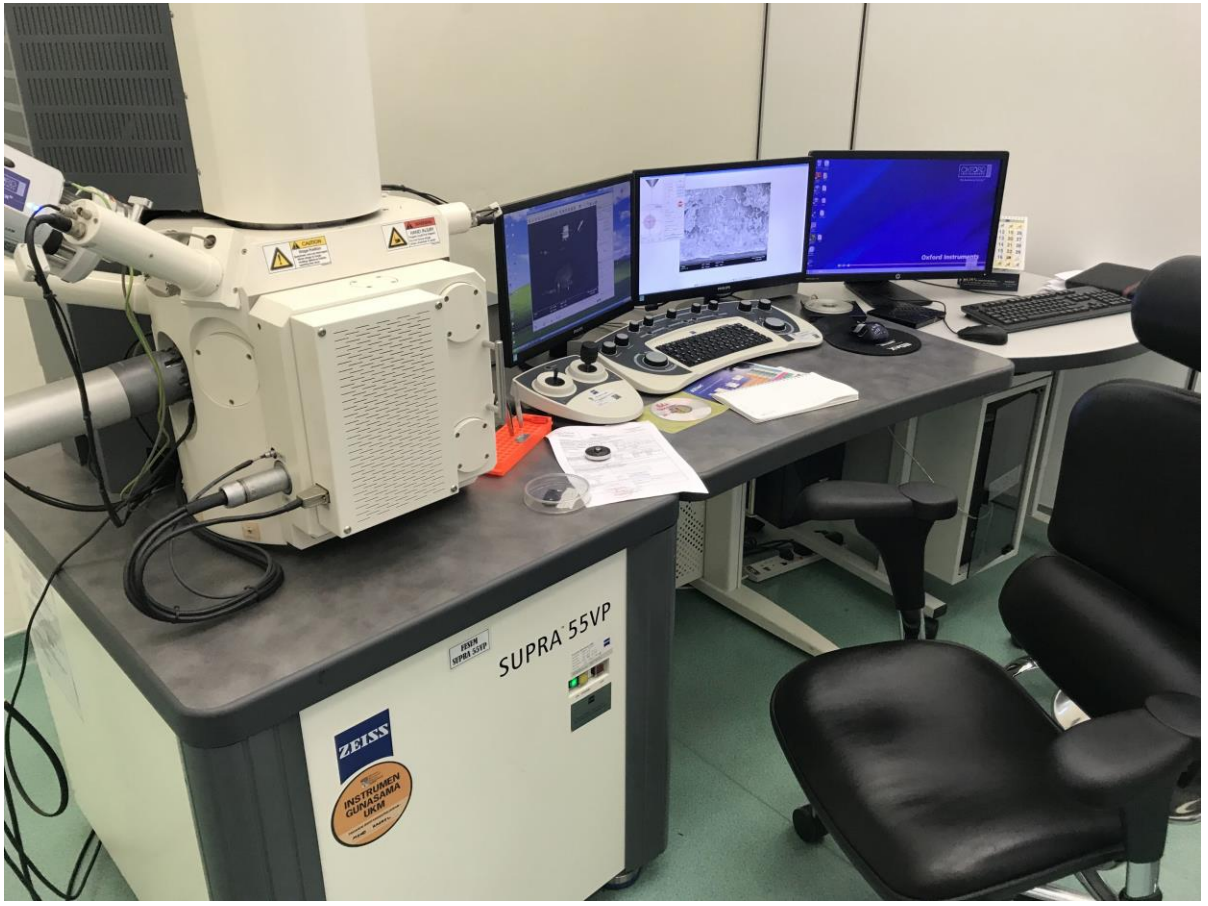


Figure 8. Samples coating and viewing under SEM model Supra 55VP and Quanta 400

Quanta 400

RESULTS AND DISCUSSION

- Findings have shown some similarities and differences in pollen morphological characteristics in the five *Heritiera* species studied.
- Dispersal unit of the pollen grain is monad.
- All species studied have tricolporate pollen grains and rounded to lobate amb.
- The pollen size under the light microscope and scanning electron microscope found out to be different.

RESULTS AND DISCUSSION

- The *Heritiera* species studied could be separated on the basis of few characteristics such as:
  - Size of pollen grain
  - Exine ornamentation
  - Exine thickness
  - Shape of the pollen grain
  - Echini arrangement and density
  - Lumen and Murus

- The subprolate shape of *H. sumatrana* separate the species from the other four *Heritiera* species.

RESULTS AND DISCUSSION

- This character can be considered as diagnostic characteristics that is very useful for identification and taxonomical classification.

- Beside that, the granulate exine ornamentation on the exine of *H. littoralis* could also be useful for the identification as it is a diagnostic character that separate this species from the other *Heritiera* studied.

RESULTS AND DISCUSSION

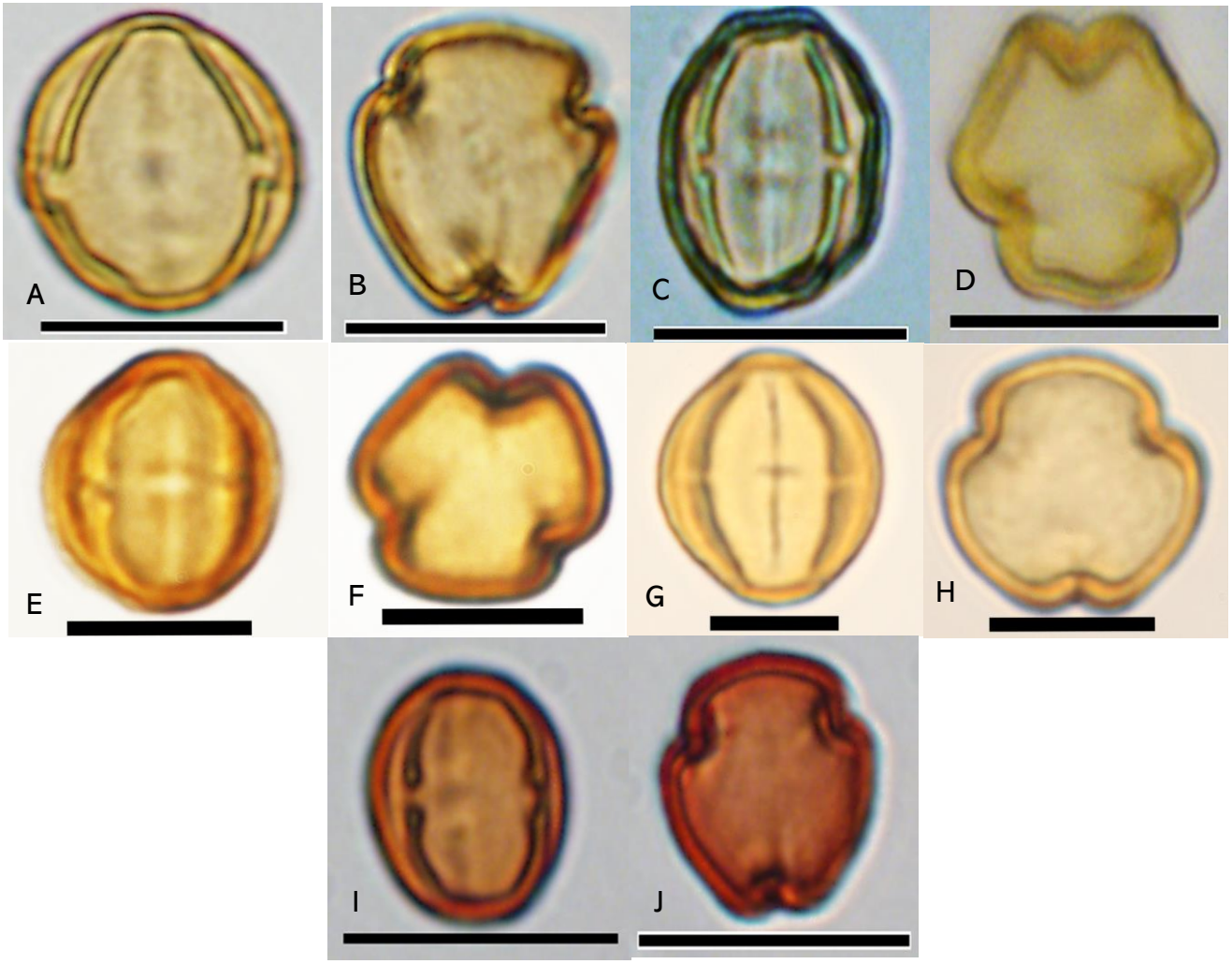


Figure 9. Pollen morphology under the light microscope (Equatorial & Polar View). A-B. *H. littoralis*, C-D. *H. elata*, E-F. *H. simplicifolia*, G-H. *H. sumatrana*, I-J. *H. borneensis*.

RESULTS AND DISCUSSION

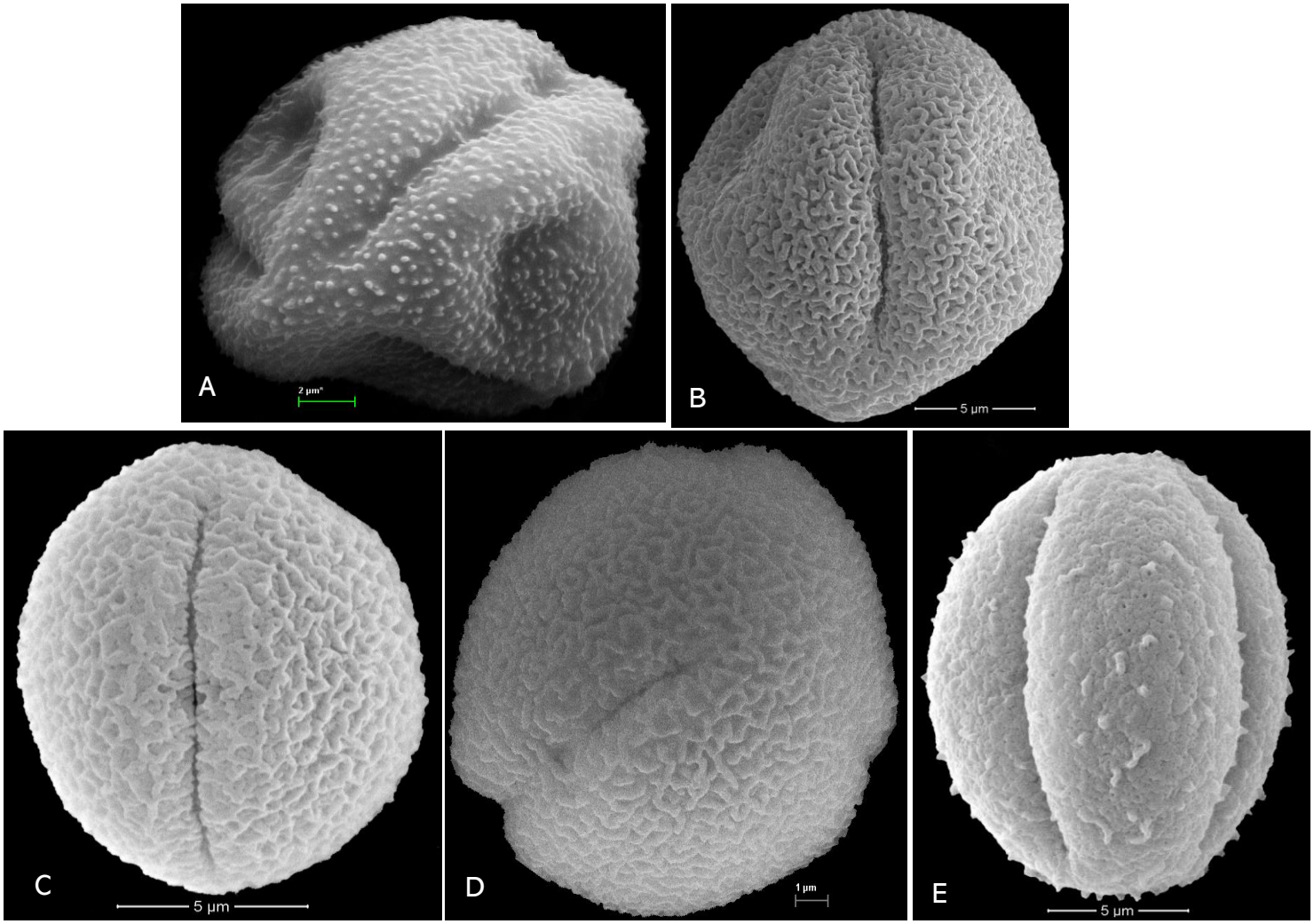


Figure 10. Pollen morphology under the scanning electron microscope. **A**. *H. littoralis*, **B**. *H. elata*, **C**. *H. simplicifolia*, **D**. *H. sumatrana*, **E**. *H. borneensis.*

RESULTS AND DISCUSSION

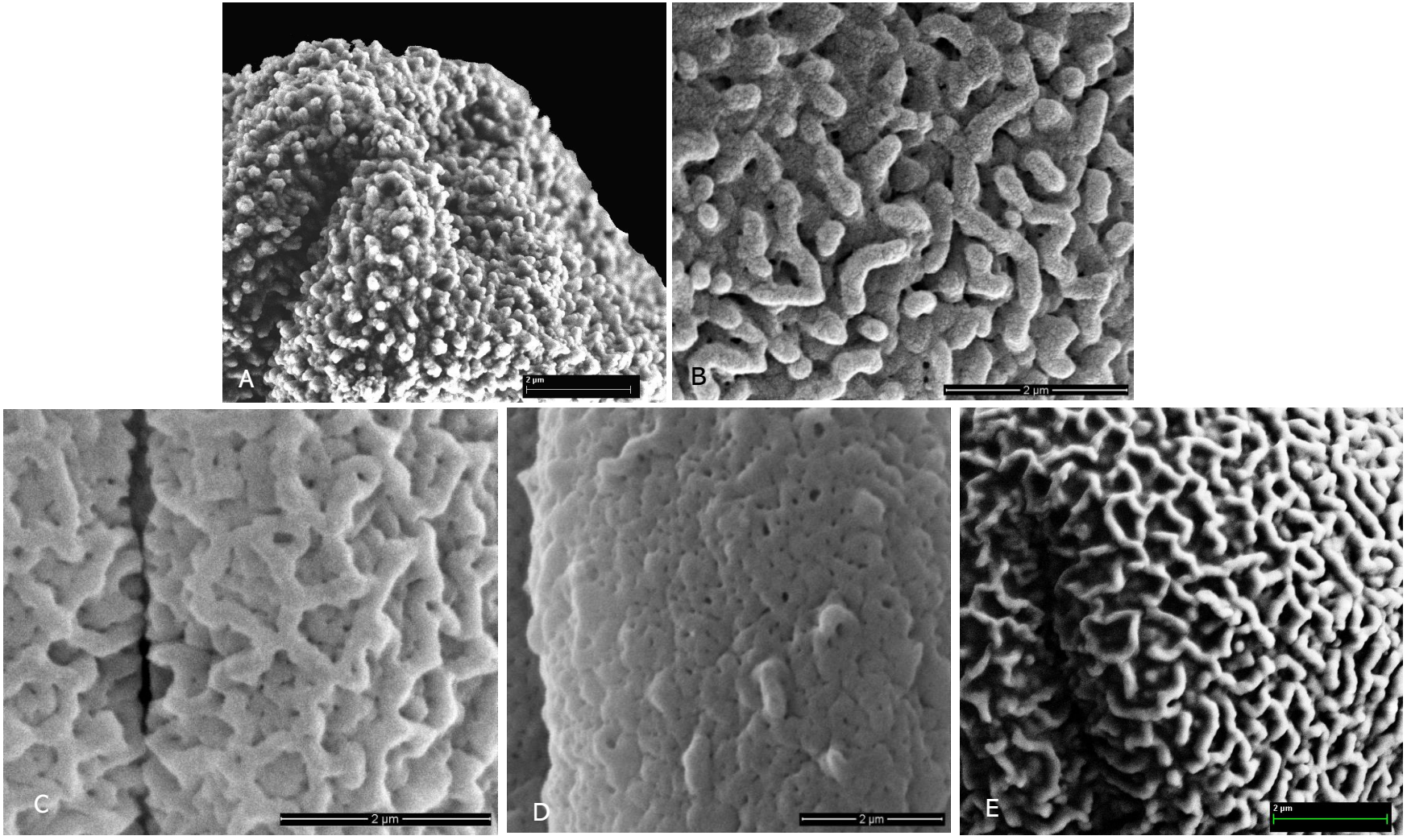
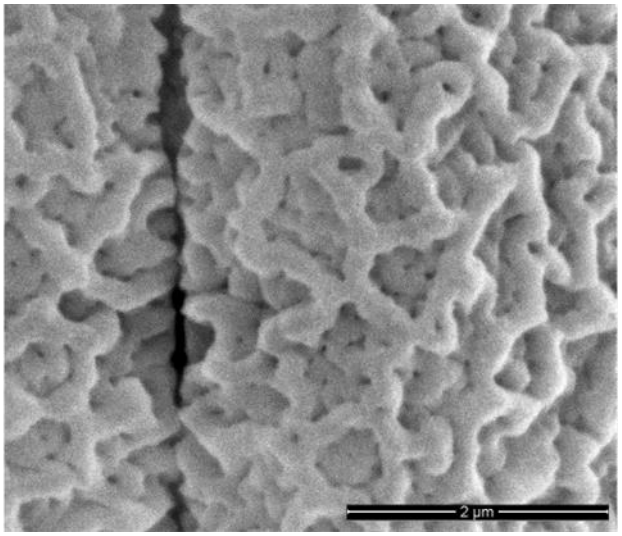


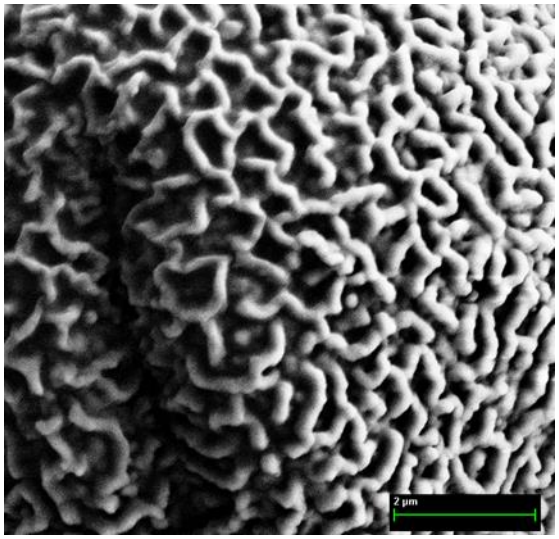
Figure 11. Pollen exine ornamentation under the scanning electron microscope. **A**. *H. littoralis*, **B**. *H. elata*, **C**. *H. simplicifolia*, **D**. *H. sumatrana*, **E**. *H. borneensis.*

LUMEN & MURUS

- Lumen and murus are important structures present on the surface of pollen. the lumen is a part of space surrounded by muri, where the murus is the ridge that forms part of the pollen ornamentation pattern (Punt et al. 2006). The murus that produces the striate ornamentation pattern is called valla (Iversen & Troels-Smith 1950) or lirae (Erdtman 1952).

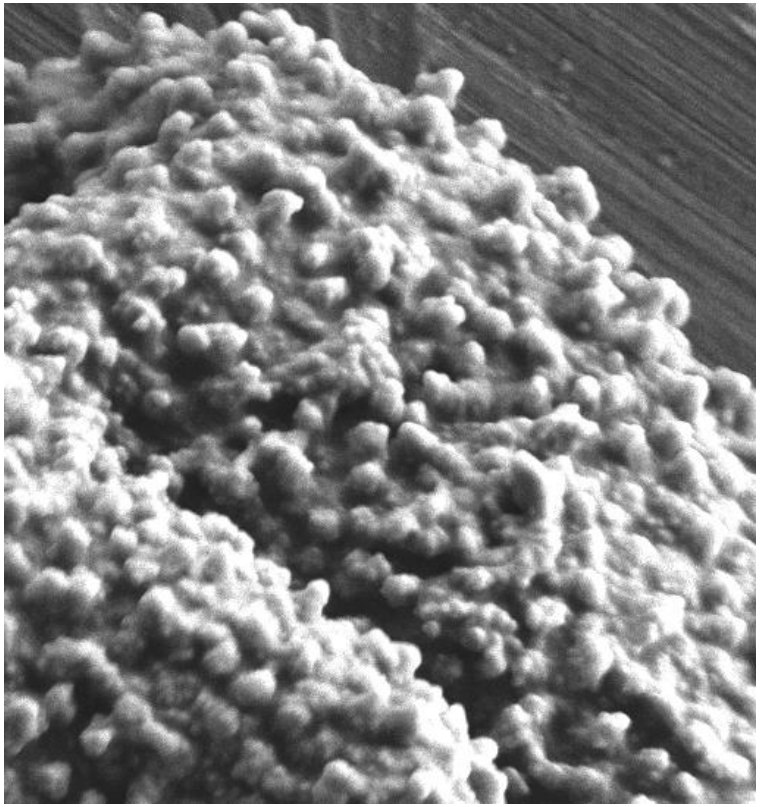


H. simplicifolia

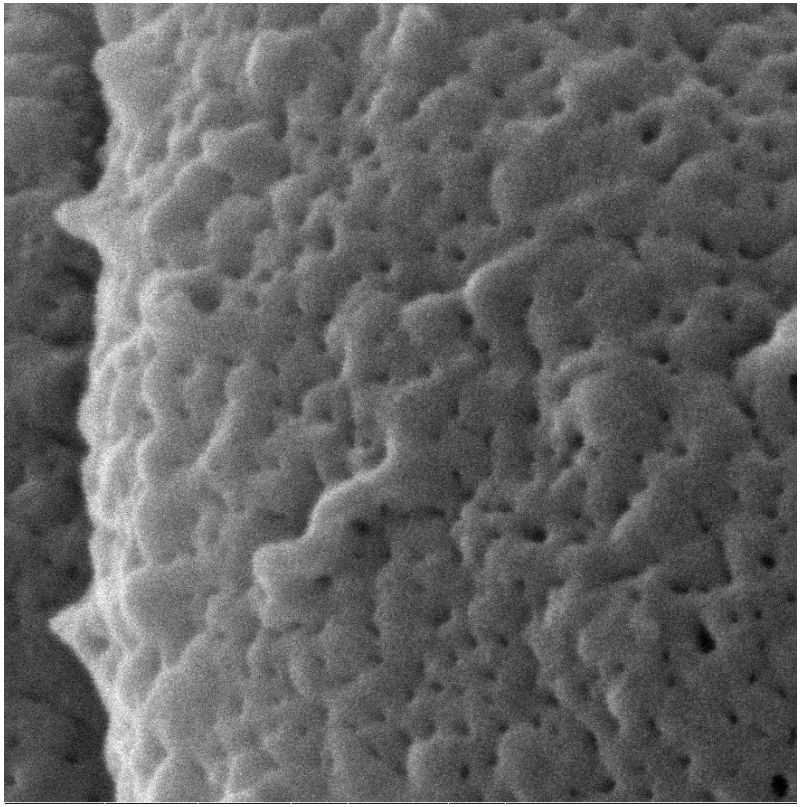


H. borneensis

ECHINI ARRANGEMENT & DENSITY

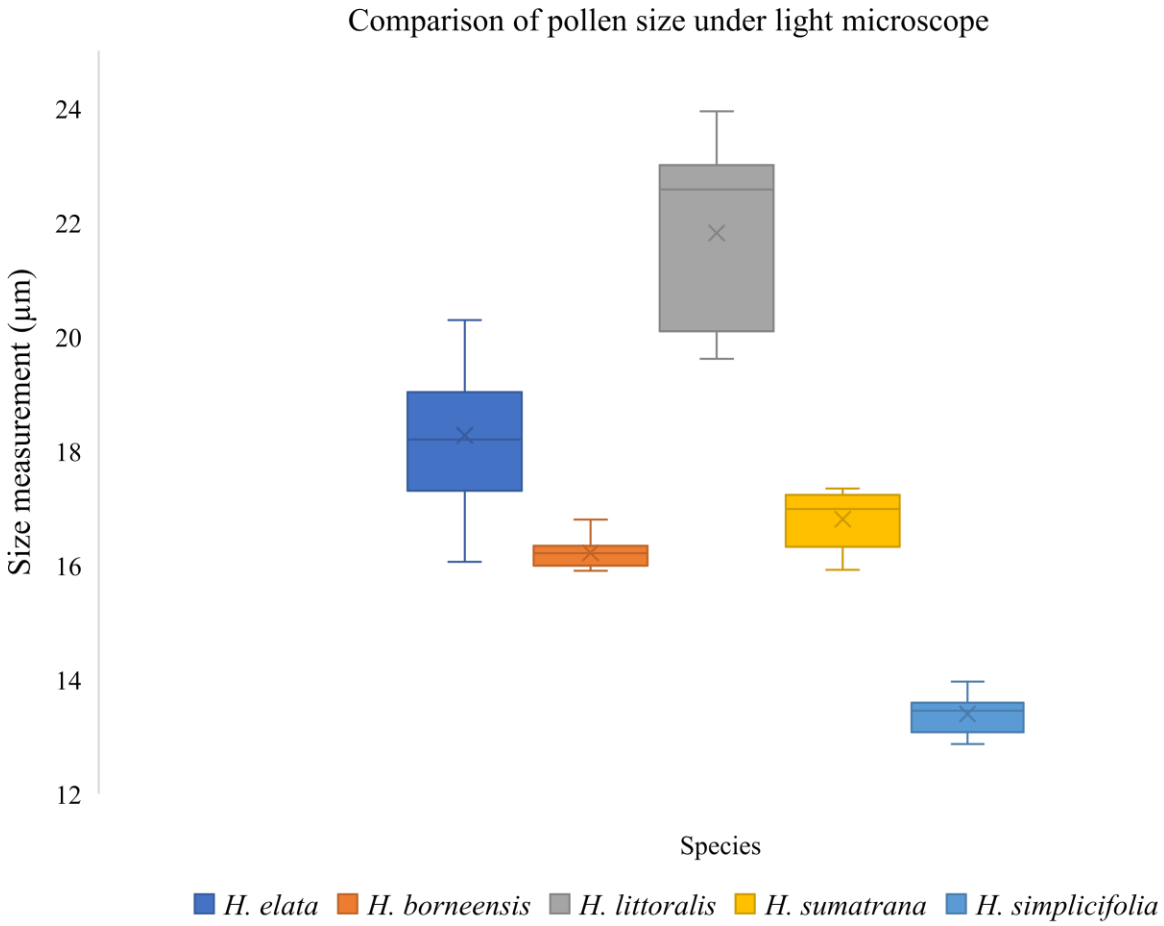


H. littoralis



H. sumatrana

Pollen Size


Comparison of pollen size under light microscope
Size measurement (µm)
24
22
20
18
16
14
12
Species
H. elata
H. borneensis
H. littoralis
H. sumatrana
H. simplicifolia

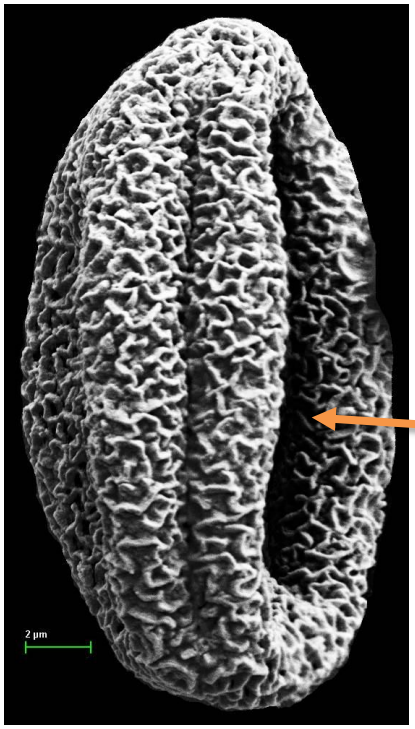
SUMMARY OF VARIATION IN POLLEN CHARACTERISTICS

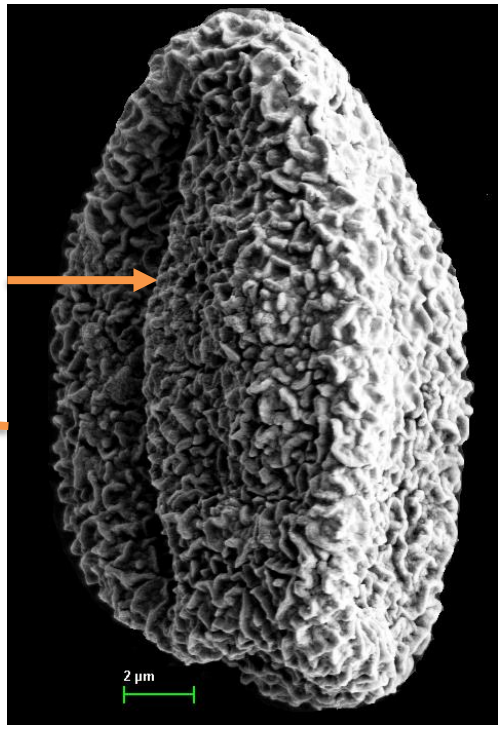
Species	Shape & Class (Erdtman, 1952)	*Size (µm)	Colpus Index (C/P)	Colpus Width (lc/E)	Polar Index (d/D)	Exine ornamentation	Lumen (µm)	Murus (µm)	Exine Thickness Index
H. elata	Colporate, Tricolporate, Prolate-Spheroid	Small	0.70	Small (0.02)	Medium (0.47)	Reticulate, Perforate	-	-	Large (0.10)
H. simplicifolia	Colporate, Tricolporate, Prolate-Spheroid	Small	0.81	Small (0.04)	Large (0.56)	Reticulate, Perforate	0.22 (0.45±0.30) 0.91	0.16 (0.24±0.08) 0.31	Medium (0.08)
H. littoralis	Colporate, Tricolporate, Prolate-Spheroid	Small	0.85	Small (0.04)	Small (0.21)	Microechinate, Granulate	-	-	Medium (0.06)
H. borneensis	Colporate, Tricolporate, Prolate-Spheroid	Small	np	np	Medium (0.38)	Reticulate	0.45 (0.74±0.26) 1.06	0.16 (0.23±0.08) 0.30	Medium (0.07)
H. sumatrana	Colporate, Tricolporate, Subprolate	Small	0.76	Small (0.03)	Medium (0.34)	Perforate, Microechinate	-	-	Medium (0.08)

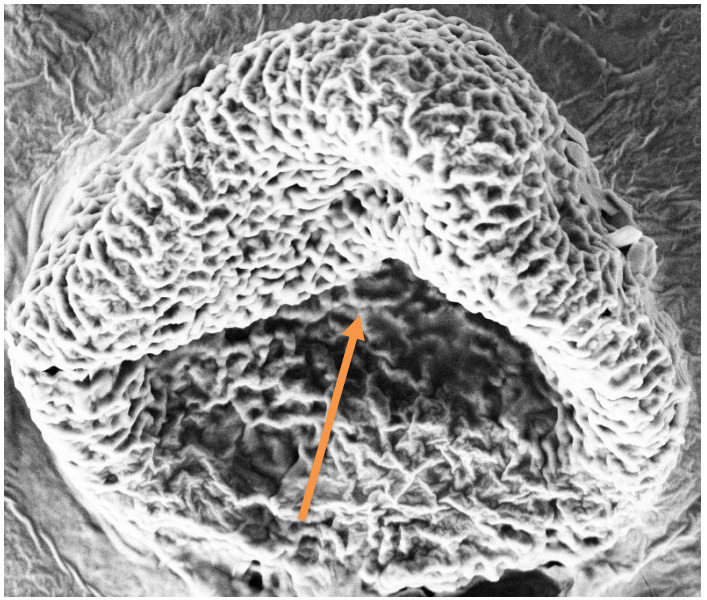
*Np = cannot be determined

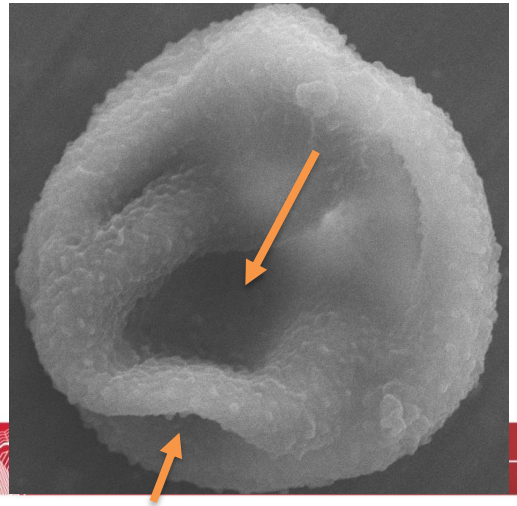
*Small = (10-25 µm)

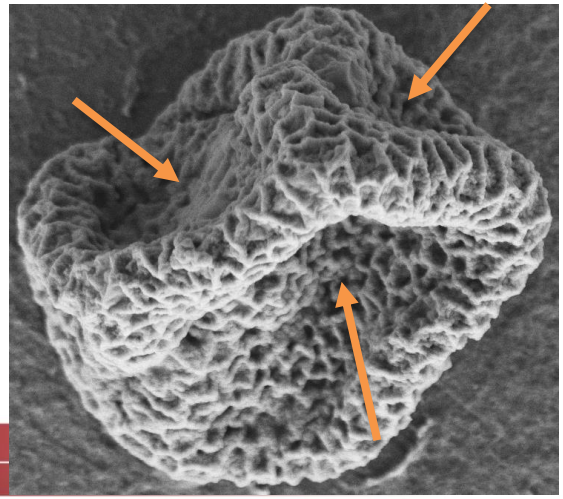
Harmomegathic of Pollen

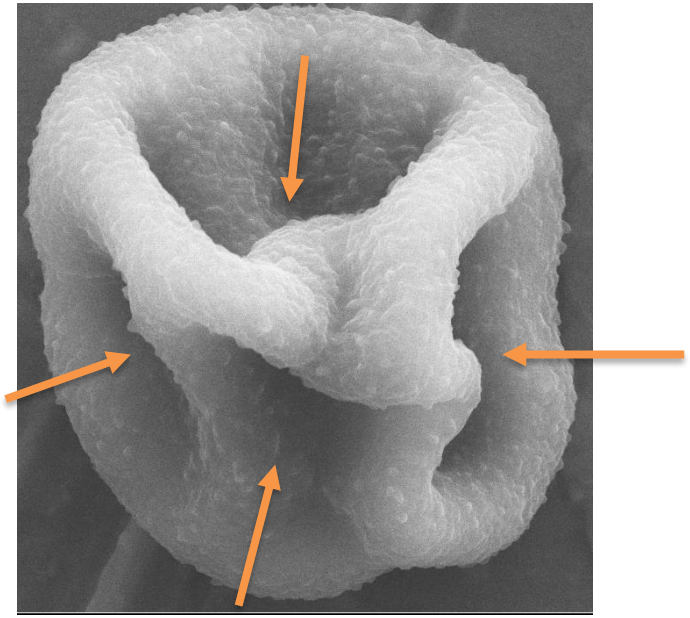












Pollen Reduction in Size

Polar

Species	Reduction LM-SEM (%)
Heritiera littoralis	33.18
Heritiera borneensis	22.75
Heritiera simplicifolia	13.25
Heritiera sumatrana	8.90
Heritiera elata	6.68

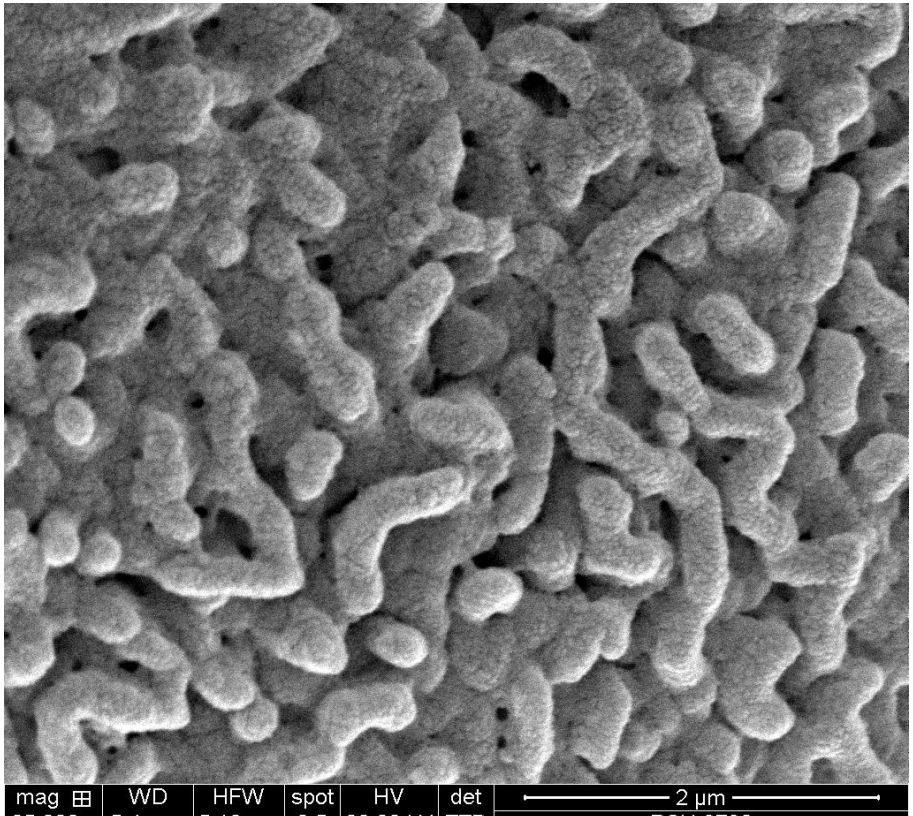
Equatorial

Species	Reduction LM-SEM (%)
Heritiera littoralis	20.68
Heritiera borneensis	20.05
Heritiera sumatrana	17.01
Heritiera simplicifolia	16.13
Heritiera elata	9.298

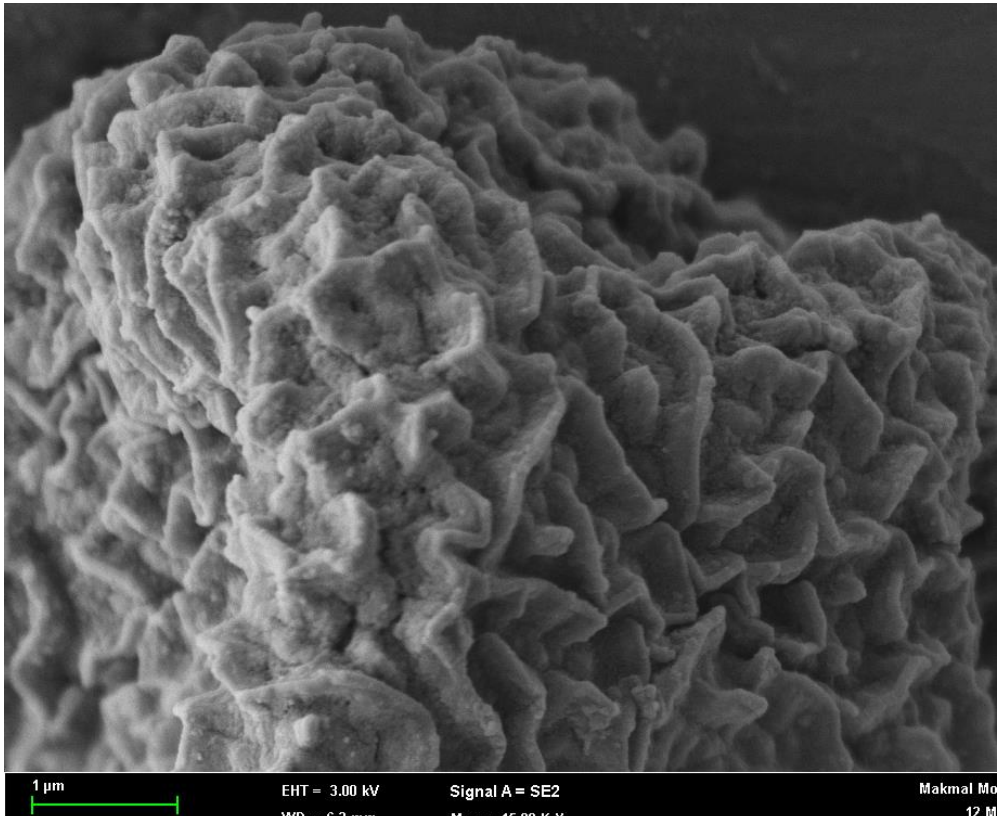
Pollen Coating

- In this study, we found that using Gold as the coating agent is the best for the pollen to be viewed under the SEM.
- Platinum was also used but the images produced were charging and many characters of the pollen cannot be seen clearly.
- Thus, it will limit the interpretation of the pollen structures.
- By using Gold as coating agent, the accelerating voltage (kV) used should be 15 kV– 20kV in order to get great images.
- However, by using Platinum coating, low kV will produce darker image (sometimes overcharged) and high kV will produce overexposure image.

Different Coating Yield Different Results

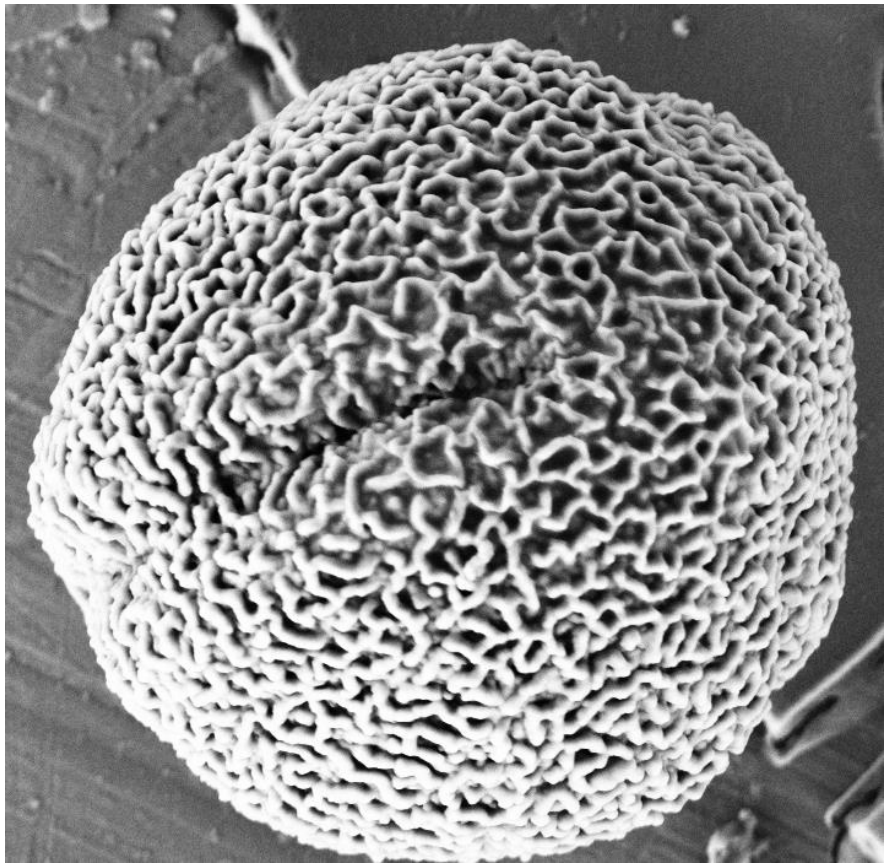


Coating: Gold
kV: 20kV

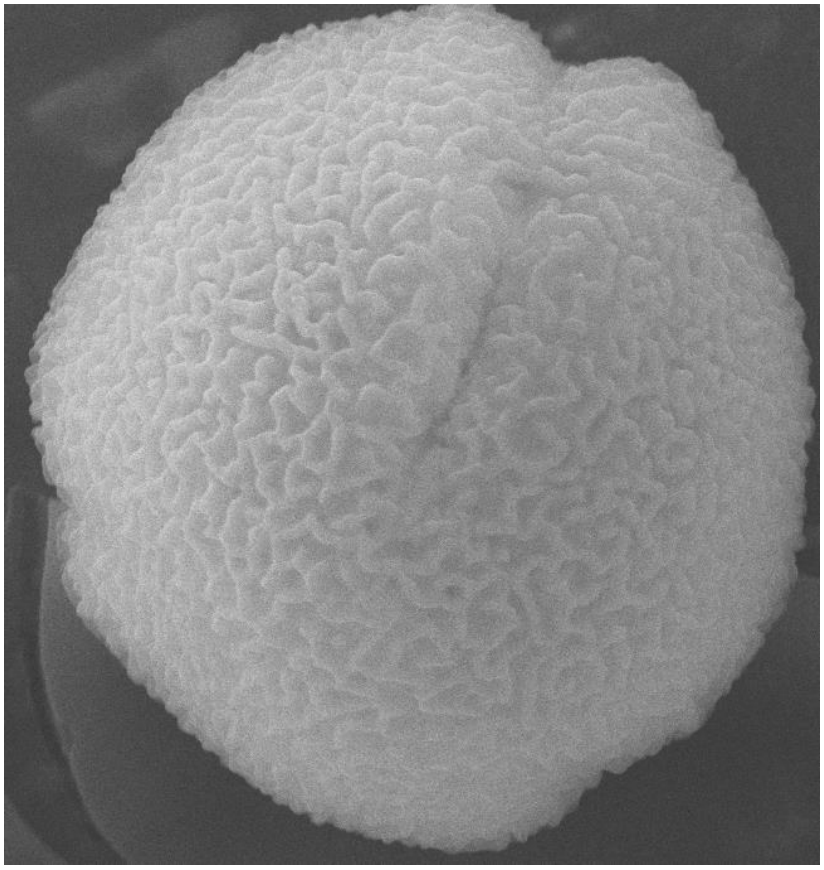


Coating: Platinum
kV: 3kV

Different kV Yield Different Results

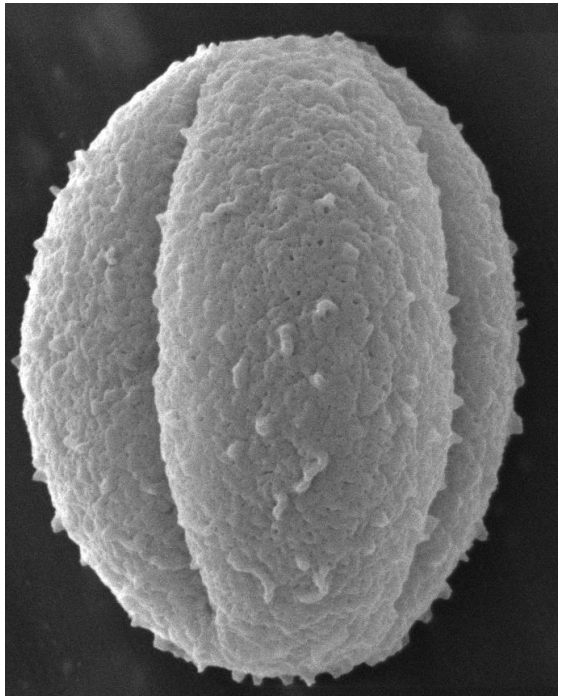


Coating: Platinum
kV: 3kV

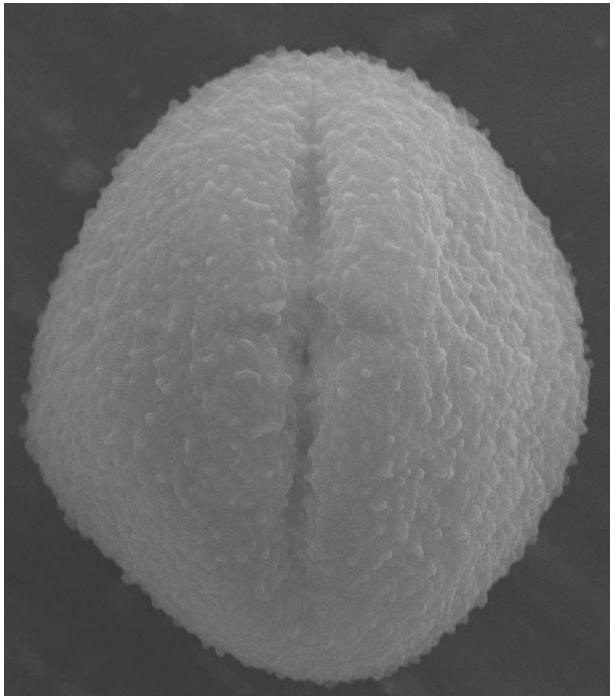


Coating: Platinum
kV: 20kV

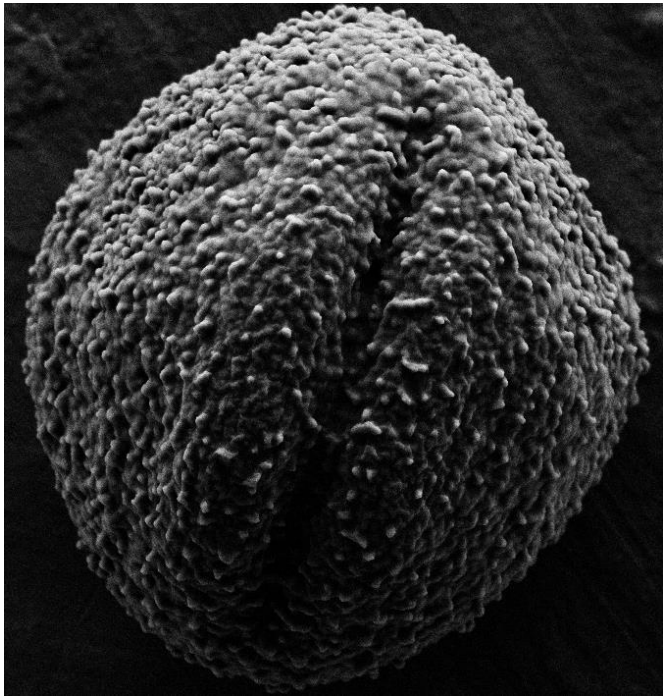
Different Coating, Different kV Yield Different Results



Coating: Gold
kV: 20kV



Coating: Platinum
kV: 15kV



Coating: Platinum
kV: 3kV

These 3 pollen grains are from the same species. But If the wrong material were used, the pollen description will be wrong and the analysis afterwards will be wrong too.

CONCLUSION & RECOMMENDATION

- As a conclusion, this study has proven that pollen morphological characteristics of *Heritiera* have taxonomic value that can be used especially in identification and differentiation of species and genus under the subfamily Sterculioideae.

- More species and genera under the Sterculiaceae *s.s* (Malvaceae *s.l*) need to be added in order to support or discard the treatment of Sterculiaceae as a separate family rather than its merging to family Malvaceae, Tiliaceae and Bombacaceae as observed by Judd and Manchester (1997), Bayer et al. (1999) and Bayer and Kubitzki (2003) based on molecular data.

- The use of correct microscopic technique is a must in order to get precise and correct results/interpretation

CONCLUSION & RECOMMENDATION

- Gold coating is the most suitable agent for pollen analysis. Few palynologists also suggested to use gold-palladium as coating agent. It is not suggested to use Platinum and Argentum.

- Study using Transmission Electron Microscope (TEM) should be included to understand the whole structures of the pollen wall.

- Study on pollen's structure and hydrodynamics also should be given attention in order to understand more on the nature of pollen.

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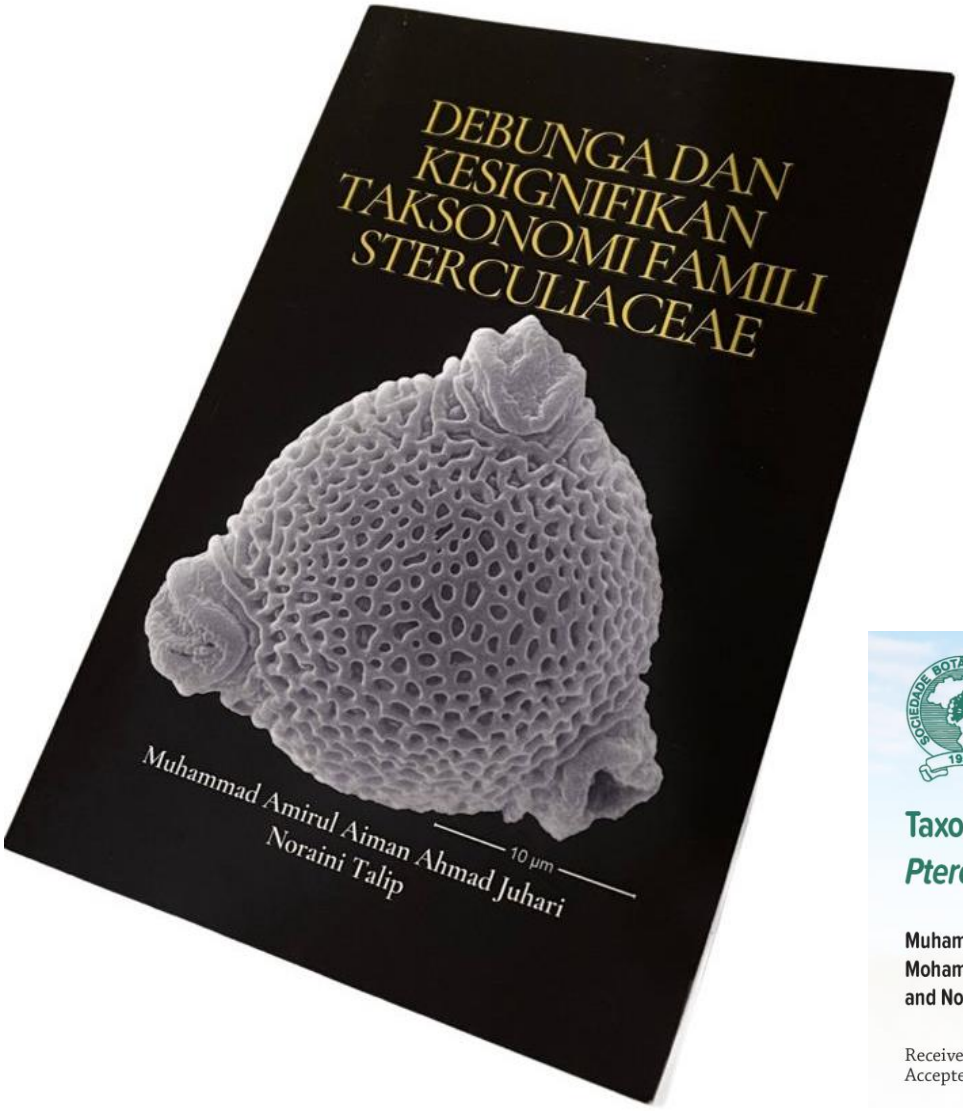

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POLLEN MORPHOLOGY AND HARMOMEGATHIC CHARACTERS OF *Byttneria* LÖFL. SPECIES (STERCULIACEAE *S. S:* SUBFAM. BYTTNERIOIDEAE)

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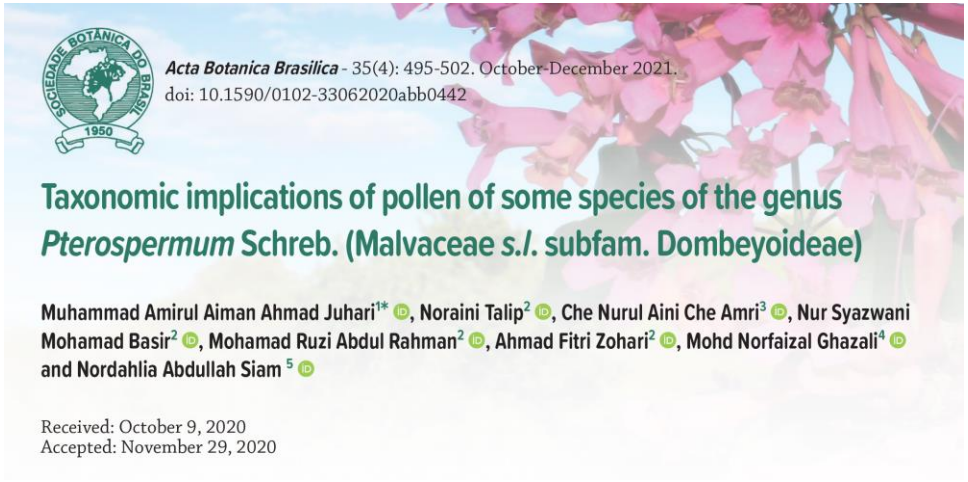

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  - Ministry of Higher Education Malaysia
- This study was funded by research grant RIGS 16-095-0259 (IIUM) & GUP-2017-035 (UKM)

TERIMA KASIH / *THANK YOU* /

ขอบคุณครับ

Flora of Thailand

18th Conference

Plants without borders
connections to Malesia

Programme & abstracts

18-22 July 2022

Flora of Thailand

18th Conference

Plants without borders
connections to Malesia

Singapore Botanic Gardens
18-22 July 2022

Organised by
Singapore Botanic Gardens
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The 18th Flora of Thailand Conference main visual is *Codonoboea rugosa* (Ridl.) C.L.Lim (Gesneriaceae); drawn by Claire Banks.

Contents

General information

Presentations and venue

The conference will be held in the beautiful setting of a UNESCO World Heritage Site, at the Singapore Botanic Gardens. All the conference venues are located at the Botany Centre, in the Tanglin Core which is at the southernmost end of the Botanic Gardens near the Tanglin Gate.

The opening ceremony and the subsequent academic programme will take place in the Function Hall (Botany Centre, ground floor). Virtual presenters must submit their pre-recorded presentations by 11 July to floraofthailand18@gmail.com. In-person participants must submit their Powerpoint presentations at least two days before their talk, preferably in the week before the conference starts, to floraofthailand18@gmail.com.

The posters will be on display for the entire duration of the conference in Ridley Hall which is near the Function Hall. There will be one dedicated Poster Session on Wednesday 20th July at 1120–1230. The presenting authors who are in Singapore are requested to stand by their posters and be available for enquiry and discussion during this session and those attending virtually are requested to be available to respond to emailed queries.

Transportation

The Botany Centre is the main building at the Tanglin Core at the southern end of the Singapore Botanic Gardens. It is located on Cluny Road, near Gleneagles Hospital. It is easily reachable by:

Taxi – Alight at Singapore Botanic Gardens, Tanglin Gate (near Gleneagles Hospital), 1 Cluny Road, Singapore 259569.

Bus – Bus services (bus stop 13019, S'pore Botanic Gdns) or (bus stop 13011, Opp. S'pore Botanic Gdns): 7, 75, 77, 105, 106, 123, 174, 174e
Both stops are less than 5 minutes' walk from the Botany Centre.

MRT – Four stations are listed for the Gardens (but none of them are close to the Botany Centre):

- **Singapore Botanic Gardens MRT station:**
  This station is located at the northern end of the Gardens. It is a 15–20 minutes' pleasant walk for almost the entire length of the Gardens to reach the Botany Centre. Follow the signs for National Orchid Garden and from there follow the signs for Botany Centre/Tanglin Gate.

- **Farrer Road MRT Station**
  Board bus 174 from bus stop 11119 (Farrer Rd Stn Exit A) and alight in front of Gleneagles Hospital (bus stop 13019, S'pore Botanic Gdns).

- **Orchard MRT Station**
  Board buses 7, 77, 106, 123, 174, 174e from bus stop 09022 (Bef Orchard Stn Exit

B) and alight at bus stop 13011 (Opp S'pore Botanic Gdns).

- **Dhoby Ghaut Station**
  Board buses 7, 77, 106, 123, 174, 174e from bus stop 08031 (Dhoby Ghaut Stn) at Dhoby Ghaut MRT Station Exit B Penang Road and alight at bus stop 13011 (Opp S'pore Botanic Gdns).

Meals

Buffet-style lunches and light refreshments during the tea breaks will be offered throughout the duration of the conference outside the Function Hall (for timings refer to the programme). All food served is Halal certified and includes a selection of vegetarian dishes.

Excursions

The excursions shall be on Tuesday and Thursday mornings. On both mornings, various complimentary tours of the Botanic Gardens will be offered, including to attractions such as the Botanical Art Gallery, the Centre for Ethnobotany, the National Orchid Garden, and the Seed Bank. On Thursday morning, a tour of Sungei Buloh Wetland Reserve will be offered (with a cost of $20). Please sign up for the tours at Registration.

18th Flora of Thailand Conference Organising Committee

National Parks Board, Singapore

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Bazilah Ibrahim
Serena Lee
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Jana Leong-Škorničková
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Thereis Choo

We thank the senior management and staff of the National Parks Board (NParks) for their support in the organisation of this conference. In particular, we thank the staff of all branches of Singapore Botanic Gardens for their tireless effort to ensure the success of the conference. We also thank Mr Tan Jiew Hoe for sponsorship.

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Tim Utteridge
Royal Botanic Gardens Kew,
Richmond, UK

Programme

(P) = presented in Singapore live
(V) = presented virtually

Sunday, 17th July

1600–1800 REGISTRATION (Botany Centre, Green Pavilion)

Monday, 18th July

0730–0800 REGISTRATION (Botany Centre, Green Pavilion)
0830–0855 OPENING CEREMONY (everyone to be seated by 0815)
0855–0930 WELCOME LECTURE
0930–1000 Break
1000–1230 ORAL PRESENTATIONS
1230–1330 Lunch
1330–1510 ORAL PRESENTATIONS
1510–1545 Break
1545–1700 ORAL PRESENTATIONS
1800–1930 RECEPTION (Botany Centre, Green Pavilion)

Tuesday, 19th July

0900–1230 EXCURSIONS
1230–1330 Lunch
1330–1510 ORAL PRESENTATIONS
1510–1545 Break
1545–1635 ORAL PRESENTATIONS
1635–1735 KEYNOTE LECTURE

Wednesday, 20th July

0900–1040 ORAL PRESENTATIONS
1040–1120 Break
1120–1230 POSTER SESSION
1230–1330 Lunch
1330–1510 ORAL PRESENTATIONS
1510–1545 Break
1545–1635 ORAL PRESENTATIONS
1635–1735 KEYNOTE LECTURE
1830–2030 CONFERENCE DINNER (Burkill Hall, National Orchid Garden)

Thursday, 21st July

0900–1230 EXCURSIONS
1230–1330 Lunch
1330–1510 ORAL PRESENTATIONS
1510–1545 Break
1545–1635 ORAL PRESENTATIONS
1635–1735 KEYNOTE LECTURE

Friday, 22nd July

0900–1040 ORAL PRESENTATIONS
1040–1115 Break
1115–1230 ORAL PRESENTATIONS
1230–1330 Lunch
1330–1510 BOARD REPORT & ORAL PRESENTATIONS
1510–1545 Break
1545–1610 ORAL PRESENTATIONS
1610–1710 KEYNOTE LECTURE
1710–1720 CLOSING REMARKS

Sunday, 17th July

1600–1800 **REGISTRATION** (Botany Centre, Green Pavilion)

Monday, 18th July

0730–0800 **REGISTRATION** (Botany Centre, Green Pavilion)

0830–0855 **OPENING CEREMONY** (everyone to be seated by 0815)

0855–0930 **WELCOME LECTURE: Plants without borders: Connections to Malesia**
Presenter: David Middleton (P; page 15)

0930–1000 **BREAK**

1000–1230 **ORAL PRESENTATIONS** (Chaired by: Stuart Lindsay)

1000 **Thai Vitaceae: final update**
Presenter: Anna Trias-Blasi (P; page 21)

1025 **The James Franklin Maxwell collections**
Presenter: Peter van Welzen (P; page 22)

1050 **Developing the orchid account for *Flora of Thailand*: update and lessons learnt**
Presenter: Henrik Ærenlund Pedersen (P; page 23)

1115 **A taxonomic revision of *Dendrobium* sect. *Pedilonum* (Orchidaceae) in Thailand**
Presenter: Wirata Rujichaipimon (P; page 24)

1140 **Update on the Rutaceae of Thailand**
Presenter: Hans-Joachim Esser (P; page 25)

1205 **The Zingiberaceae for the *Flora of Thailand***
Presenter: Sunisa Sangvirotjanapat (P; page 26)

1230–1330 **LUNCH**

1330–1510 **ORAL PRESENTATIONS** (Chaired by: Piyakaset Suksathan)

1330 **The genus *Artabotrys* (Annonaceae) in Thailand**
Presenter: Junhao Chen (P; page 27)

1355 **An update on the genus *Begonia* (Begoniaceae) for the *Flora of Thailand***
Presenter: Thamarat Phutthai (P; page 28)

1420 **Bamboo puzzles from Thailand**
Presenter: Khoon Meng Wong (P; page 29)

1445 ***Flora of Thailand* non-bambusoid Poaceae: progress or lack of due to a pandemic**
Presenter: David Simpson (V; page 30)

1510–1545 BREAK

1545–1700 ORAL PRESENTATIONS (Chaired by: Voradol Chamchumroon)

1545 ***Flora of Thailand* progress 2022**
Presenter: Henrik Balslev (P; page 30)

1610 **An introduction to the *e-Flora of Thailand***
Presenter: Sawita Yooprasert (V; page 32)

1635 **Taxonomic publications for the *Flora of Thailand*: observations from *Thai Forest Bulletin* and *Kew Bulletin***
Presenter: Timothy Utteridge (P; page 33)

1800–1930 RECEPTION (Botany Centre, Green Pavilion)

Tuesday, 19th July

0900–1230 EXCURSIONS

1230–1330 LUNCH

1330–1510 ORAL PRESENTATIONS (Chaired by: Chong Kwek Yan)

1330 **Species diversity of the epiphytic bryophytes in framework species restoration plots**
Presenter: Puwadol Chawengkul (V; page 34)

1355 **Plant community analysis and ecological niche modelling of *Diospyros rhodocalyx* at a local scale for conservation**
Presenter: Yaowaret Jantakat (P; page 35)

1420 **Pollination biology of an endemic rare morning glory species, *Argyreia versicolor* (Convolvulaceae)**
Presenter: Awapa Jirabunjongkij (V; page 36)

1445 **Study of the mating system in a rare Thai species, *Blinkworthia lycioides* (Convolvulaceae)**
Presenter: Matchapon Anchaleepornssan (V; page 37)

1510–1545 BREAK

1545–1635 ORAL PRESENTATIONS (Chaired by: Chortip Kantachote)

1545 **Investigation into the association between *Periglandula* fungi and *Ipomoea asarifolia* (Convolvulaceae)**
Presenter: Yanisa Olaranont (V; page 38)

1610 **A study of leaf anatomy for taxonomic delimitation of two varieties of *Pavetta tomentosa* in Thailand**
Presenter: Siriyakorn Sookcharoen (V; page 39)

1635–1735 **KEYNOTE LECTURE: The Thai-Malay peninsula: a phytogeographic junction and a filter between the Himalayas and Malesia**
Presenter: Kitichate Sridith (P; page 16)

Wednesday, 20th July

0900–1040 **ORAL PRESENTATIONS** (Chaired by: Gillian Khew)

0900 **Taxonomy and molecular systematics of *Artocarpus* (Moraceae) in Thailand**
Presenter: Elliot Gardner (V; page 40)

0925 **Towards an understanding of the phylogeny, biogeography and the role of hybridisation in the evolution of the genus *Sindora* (Fabaceae: Detarioideae)**
Presenter: Le Min Choo (P; page 41)

0950 **Phylogeny of Marsdenieae (Apocynaceae, Asclepiadoideae) and an updated classification of Thai taxa**
Presenter: Michele Rodda (P; page 42)

1015 **Phylogeny of *Clerodendrum* (Lamiaceae) and a redefinition of the infrageneric classification**
Presenter: Jiratthi Satthaphorn (V; page 43)

1040–1120 **BREAK**

1120–1230 **POSTER SESSION** (pages 66–83)

1230–1330 **LUNCH**

1330–1510 **ORAL PRESENTATIONS** (Chaired by: Somran Suddee)

1330 **Species delimitation and evolutionary history of the genus *Peliosanthes* (Asparagaceae)**
Presenter: Minoru Tamura (V; page 44)

1355 **Plastome phylogeny of *Diospyros* (Ebenaceae)**
Presenter: Nattanon Meeprom (V; page 45)

1420 **The role of data aggregators in the taxonomy and conservation of *Diospyros* (Ebenaceae)**
Presenter: Carmen Puglisi (P; page 46)

1445 **Systematics and biogeography of the genus *Maesa* (Primulaceae)**
Presenter: Pirada Sumanon (P; page 47)

1510–1545 **BREAK**

1545–1635 **ORAL PRESENTATIONS** (Chaired by: Henrik Balslev)

1545 **Meliaceae for the *Flora of Thailand***
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1610 **Impatiens of Thailand: the final episode**
Presenter: Piyakaset Suksathan (V; page 49)

1635–1735 **KEYNOTE LECTURE: Global Tree Assessment - mobilising action for the world's threatened trees**
Presenter: Malin Rivers (V; page 17)

1830–2030 **CONFERENCE DINNER** (Burkill Hall, National Orchid Garden)

Thursday, 21st July

0900–1230 **EXCURSIONS**

1230–1330 **LUNCH**

1330–1510 **ORAL PRESENTATIONS** (Chaired by: Rachun Pooma)

1330 **'Bract' or 'Bracteole'? Revisiting the terminology for the diagnostic character of *Neuropeltis* (Convolvulaceae)**
Presenter: Pantamith Ratanakrajang (P; page 50)

1355 **Pollen morphology of selected *Heritiera* (Malvaceae) species in Malaysia and its taxonomic significance**
Presenter: Muhammad Amirul Aiman Bin Ahmad Juhari (P; page 51)

1420 **Essential oil composition of traditional medicinal *Litsea* species in northern Thailand**
Presenter: Natcha Chaisoung (P; page 52)

1445 **The *Flora of Nepal*: a born-digital Flora**
Presenter: Colin Pendry (P; page 53)

1510–1545 **BREAK**

1545–1635 **ORAL PRESENTATIONS** (Chaired by: Jana Leong-Škorničková)

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Presenter: Stuart Lindsay (P; page 54)

1610 **Generating baseline genomic data for a Flora: a case study from Singapore**
Presenter: Gillian Khew (P; page 55)

1635–1735 **KEYNOTE LECTURE: Think local, act global – uniting plant taxonomy across borders**
Presenter: Sandy Knapp (V; page 18)

Friday, 22nd July

0900–1040 **ORAL PRESENTATIONS** (Chaired by: Kitichate Sridith)

0900 **Diversity of Araceae in Namtok Mae Surin National Park, Mae Hong Son Province, northern Thailand**
Presenter: Oraphan Sungkajanttranon (P; page 56)

0925 **Morphological flower adaptations in Phyllantheae (Phyllanthaceae) due to obligate pollination by *Epicephala* moths (Gracillariidae)**
Presenter: Peter van Welzen (P; page 57)

0950 **Floral visitor observation and histochemistry of two floral secretory structures in *Blinkworthia lycioides* (Convolvulaceae)**
Presenter: Manita Watanachariya (V; page 58)

1015 **Synopsis of the genus *Erycibe* (Convolvulaceae) in mainland Southeast Asia and Singapore**
Presenter: Phongsakorn Kochaiphat (V; page 59)

1040–1115 **BREAK**

1115–1230 **ORAL PRESENTATIONS** (Chaired by: Michele Rodda)

1115 **Taxonomy of Cyanotinae (Commelinaceae) in Thailand**
Presenter: Boonchuang Boonsuk (P; page 60)

1140 **Preliminary studies on the phylogeny and taxonomy of Commelinaceae in Thailand**
Presenter: Chung-Kun Lee (V; page 61)

1205 **Morpho, phylo, and eco: The Three Musketeers of Systematics – Revisiting the savanna-dominating genera *Heteropogon* and *Themeda* (Poaceae: Andropogoneae)**
Presenter: Watchara Arthan (P; page 62)

1230–1330 **LUNCH**

1330–1510 **ORAL PRESENTATIONS** (Chaired by: Tim Utteridge)

1330 **Report from the *Flora of Thailand* Board**
Presenter: Henrik Balslev (P)

1420 **A quest to understand the morphological and cytological variation in *Curcuma* subg. *Hitcheniopsis* (Zingiberaceae)**
Presenter: Eliska Zaveska (P; page 63)

1445 **Phylogeny and species delimitation of the genus *Ophiopogon* (Asparagaceae) based on chloroplast and nuclear genomes**
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1510–1545 **BREAK**

1545–1610 **ORAL PRESENTATIONS** (Chaired by: Hajo Esser)

1545 **Distribution of *Thismia* species (Thismiaceae), mycoheterotrophic herbs in Peninsular Malaysia**
Presenter: Siti Munirah Mat Yunoh (P; page 65)

1610 **KEYNOTE LECTURE: Development of bryophyte studies in Thailand: Connections to the world, especially Malesia**
Presenter: Phiangphak Sukkharak (P; page 19)

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Distinguishing characters of Thai *Chloris* and *Cynodon* species
W. Chaisongkram, P. Chantaranothai & B. Boonsuk (page 68)

Functional ecology of external secretory structures in *Rivea ornata* (Convolvulaceae) as interpreted from micromorphology and histochemistry
N. Chitchak, A.B. Stewart & P. Traiperm (page 69)

Preliminary study on comparative anatomy and systematics of tribe Vernonieae (Asteraceae) in Thailand
M. Duangchan & P. Pornpongrungrueng (page 70)

An overview of *Murdannia* (Commelinaceae) in Thailand
C. Kantachot, B. Boonsuk & P. Chantaranothai (page 71)

Current taxonomic understanding of the genus *Strobilanthes* and allied genera (Acanthaceae) in Thailand
P. Kladwong & P. Chantaranothai (page 72)

The Malvaceae-Grewioideae in Thailand
P. Kunasit & P. Chantaranothai (page 73)

Plant diversity of a natural mangrove forest, Rama IX International Mangrove Botanical Garden, Chanthaburi Province, Thailand
S. Maneeanakekul, A. Rueangket, J. Wongprom, D. Duangnamon, A. Tara, D. Wechakit & C. Maknual (page 74)

Welcome & keynote lectures

Plants without borders: Connections to Malesia

D.J. Middleton

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In 1910, H.N. Ridley, the Director of the Singapore Botanic Gardens, went on an expedition to what he called "Lower Siam" to collect specimens and to find the "boundary line" demarcating what he perceived to be a sharp difference between the floras of the northern and southern parts of the Thai/Malay Peninsula. He wrote that on the west coast this boundary was at Alor Setar in Kedah and that the Thai flora to the north may have formerly been separated from the Malay flora to the south by higher sea levels, a theory inconclusively discussed in the more than a century since. In 1950, Van Steenis suggested the eastern end of this boundary was at Songkhla in Thailand. A variation on this idea has also been proposed with a line from Kangar in Perlis to Pattani. This Kangar – Pattani line has become more entrenched in biogeographic studies than Ridley's line beginning at Alor Setar but these lines, and suggestions from other researchers of lines at the Isthmus of Kra across Ranong and Chumphon in Thailand, and from Mergui in Myanmar to Samut Songkhram in Thailand, all point to a perception that the Thai flora is fundamentally different to the Malay flora despite the lack of agreement on just where this shift has occurred.

Most Flora projects are developed by national agencies to better understand the plant diversity of particular countries. Although this makes sense and is entirely necessary because conservation and sustainable utilisation of natural resources must necessarily be bound by national legislation, plant distributions do not observe national borders and research on plant diversity must always maintain a wider focus. That the Kangar – Pattani line is almost on the Thailand – Malaysia border proved very convenient to demarcate the northern boundary on the Peninsula for one of the few transnational Asian Flora projects, *Flora Malesiana*, but may also have inadvertently solidified the notion that the Thai and Malay floras, and more widely the Thai and Malesian floras, are more different than they really are.

In this lecture we shall examine the connections between the plant diversities of Thailand and Malesia, focusing on Peninsular Malaysia and Singapore; how our understanding of the diversity of the entire region has been shaped by collecting effort and research; and how regional and international collaboration in research on the plants of Thailand and Malesia will lead to better conservation outcomes for the region's plant species.

Keywords: biogeography, collaboration, collecting, conservation, taxonomy

The Thai-Malay peninsula: a phytogeographic junction and a filter between the Himalayas and Malesia

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The Thai-Malay peninsula, separating the South China Sea of the Pacific Ocean to the east from the Andaman Sea of the Indian Ocean to the west, plays an essential role in our interpretation of distribution patterns of plants and animals in the northern and southern hemispheres of Asia. Geologically, the Thai-Malay peninsula is part of the landmass comprising the eastern part of the Himalayas, i.e., eastern Tibet, Bhutan and northern Myanmar (in Shan state), called the Shan-Thai or Sibumasu Terrane, a mass of continental crust extending from Tibet into Southeast Asia. It is therefore to be expected that there will be affinities in the plants and animals found along this terrane from Tibet to the present Thai-Malay peninsula. There are continuous connections from the Himalayan ranges, through the Tenasserim ranges on the border between Thailand and Myanmar, and then continuing into the Malay Archipelago. Nevertheless there are climatic barriers to species distributing freely along this terrane, most noticeably between the non-seasonal climates of the far south of Thailand and Peninsular Malaysia on the one hand and the seasonal climates of mainland continental Asia on the other. In this lecture, the various habitats through the Shan-Thai terrane from the Himalayas to the Thai-Malay peninsula are discussed and compared. Selected plant taxa distributions are discussed, including through the use of some unusual methods to assess former plant distributions such as from ancient traditional paintings in old documents. Conservation needs and measures across the region are also discussed.

Keywords: biogeography, habitats, Shan-Thai terrane, Tenasserim range

Kitichate Sridith studied for his Bachelor's and Master's degrees at Chulalongkorn University in Bangkok and then his doctoral degree at the University of Vienna, graduating in 1997. His research and teaching career has been in the Department of Biology, Faculty of Science, Prince of Songkhla University where he is also Curator-in-charge of the Herbarium. His principal research topics have been on the taxonomy of the genus *Argostemma* in the Rubiaceae; plant communities on the coastal sandbars in peninsular Thailand; and phytogeographical relationships between Eastern Himalaya and Southeast Asia. He has supervised many of the younger generation of Thai botanists through their undergraduate and postgraduate degrees and in more recent years has also been supervising students from Bhutan and drawing parallels in plant diversity and conservation challenges between the two kingdoms.

Global Tree Assessment – mobilising action for the world's threatened trees

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The Global Tree Assessment (www.globaltreeassessment.org) aims to assess the conservation status of every known tree species by the year 2023, focusing attention and directing efforts for ongoing tree conservation assessments where it is needed the most. The outcomes of these analyses provide prioritisation information to ensure that conservation efforts are focused on the right species so that no tree species becomes extinct. In autumn 2021, we published the first global summary of this work in the *State of the World's Trees* report, which highlights that at least 30% of the world's trees are threatened with extinction. For the first time, we now have information on the conservation status of all the world's tree species and can answer the following questions: which species are at risk of extinction, where are those species found, and why are they threatened?

This talk will include a global overview as well as a regional angle for Southeast Asia, as one-fifth of all the world's trees are found here (>12,000 tree species).

Combining information on conservation status of tree species with up-to-date information on conservation action currently being undertaken, we can better inform and prioritise further conservation needs on a global, regional and national scale. The results from red list assessments help to effectively guide, plan for, and raise awareness of the need for conservation on the ground. They can be used for i) prioritisation of conservation action in situ and ex situ; ii) monitoring of conservation action; iii) facilitating education and public awareness of conservation issues; iv) supporting international conservation policy; and v) influencing funding allocations. In this presentation, we explore further how the results in the *State of the World's Trees* report can be used to catalyse better-informed conservation action for the world's most threatened trees. We also provide inspiring success stories of successful conservation and practical ways to take action.

Keywords: conservation action, conservation status, extinction, red list, Southeast Asia, *State of the World's Trees* report, threatened species

Malin Rivers is Head of Conservation Prioritisation at Botanic Gardens Conservation International. There she leads the Red List team with the current global project, the Global Tree Assessment, assessing the conservation status of the world's tree species. She has worked in the field of plant conservation for over 15 years, which has taken her to meet experts, do field work or lead workshops around the world, including in Ecuador, Fiji, Borneo, Madagascar and many other places. In addition, she is the secretary and Red List Authority Coordinator of the IUCN SSC Global Tree Specialist Group.

Think local, act global – uniting plant taxonomy across borders

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The global endeavour to conserve plant diversity is of the utmost urgency and importance, particularly in the tropics, where most plant diversity resides. We are often urged to think globally and act locally, but to truly develop an integrative view of plant diversity and plans for its conservation to enable future plant evolution I would argue we must think locally, but act globally – only with transborder cooperation and truly international collaboration will we ever achieve a sustainable future for the plants we love and study, and ourselves. Open Science and linked data are central to this vision of a global future for plant diversity. I will draw on my experiences through *Flora Mesoamericana* – a multi-year project that brought together the floras of the many different countries of Central America and southern Mexico and my work on *Solanum* (Solanaceae), a globally distributed, mega-diverse angiosperm genus, to illustrate the many advantages to working together across barriers of language, culture and nationality. It is only by working together that we will make progress, even though it might seem difficult at times. Human beings are dependent upon plants for our daily lives, but although plants might not seem to need us – they truly do – it is up to us to ensure their future.

Keywords: collaboration, conservation, *Flora Mesoamericana*, *Solanum*

Sandy Knapp is a specialist on the taxonomy and evolution of the nightshade family, Solanaceae, and she has spent much time in the field collecting plants, mostly in South America. Her work in Solanaceae spans biodiversity from taxonomy to phylogenetics and evolution, with a focus on the wild relatives of important crops like tomatoes, potatoes and eggplants. Current work includes a worldwide monograph of the genus *Solanum*, and the species of *Lycianthes* from New Guinea. She is the author of more than 200 peer-reviewed scientific papers and several popular books on the history of science and botanical exploration, including the award-winning *Potted Histories* (2004), and more recently *Extraordinary Orchids* (2021). She is actively involved in promoting the role of taxonomy and the importance of science for conservation and sustainable development worldwide. Sandy is the current President of the Linnean Society of London. She has received numerous awards for her work in outreach (Peter Raven Outreach Award by the American Society of Plant Taxonomists), biodiversity conservation (UK National Biodiversity Network's John Burnett Medal), and botanical science (Rolf Dahlgren Prize, David Fairchild Medal); she holds honorary professorships at University College London and Stockholm University. She has been elected to the American Academy of Arts and Sciences, the Academia Nacional de Ciencias of Argentina, Academia Europeana, and is a Fellow of the Royal Society.

Development of bryophyte studies in Thailand: Connections to the world, especially Malesia

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The development of bryophyte studies in Thailand and how these studies have been integrated into research elsewhere in the world is presented. Two periods are recognised: the first one from 1899–1977 and the second from 1977–present. During the first period, most contributions to our knowledge of Thai bryophytes were made by European and Japanese botanists/bryologists through their collections, sometimes jointly with Thai collectors, and latterly through their research for the *Flora of Thailand* project. From 1977 to the present day, most research has been carried out by Thai bryologists, often in collaboration with bryologists in China, the USA and Malesian countries through fieldtrips, workshops, and projects with common goals such as the *Flora of Singapore* project. A significant recent development was the decision in 2017 to include bryophytes in the *Flora of Thailand* project. Eight volumes, covering an estimated 1356 species, are planned and will be published in the printed book format. The progress made so far and the challenges of completing this task are shared and discussed.

Keywords: collaboration, hornwort, liverwort, moss, taxonomy, worldwide

Phiangphak Sukkharak is an Associate Professor of Botany at the Department of Biology at Burapha University, Chonburi, Thailand. She has been working on the taxonomy of bryophytes, especially liverworts, for more than 17 years. Her interest in bryophytes began with a study of the bryophytes of Kun Wang community forest in Chiang Mai, followed by a study of the liverworts of Khao Nan in Nakhon Si Thammarat for her Master's thesis at Chulalongkorn University in Bangkok. In 2008, she began a PhD in Göttingen, Germany, under the supervision of Prof. Stephan Robbert Gradstein, a foremost authority on liverworts. Her thesis resulted in a monograph of the liverwort genus *Thysananthus* in which morphological, chemical and genetic analyses were employed. Questions that arose during the course of this research over the status of the genus *Mastigolejeunea* were subsequently investigated, leading to the treatment of *Mastigolejeunea* as a subgenus of *Thysananthus* based on morphological and molecular evidence. Recently, she has been working on a revision of the liverwort genera in Thailand. The genera *Frullania*, *Pleurozia* and *Metzgeria* in Thailand have been revised and *Porella*, *Acrobulbus* and *Syzygiella* have been updated. She is also working on *Thysananthus* and *Frullania* for the *Flora of Singapore* project. In 2015, she received the Young Scientist Award from the Foundation for the Promotion of Science and Technology under the Patronage of His Majesty the King. In 2020, she was awarded the title of Young Rising Star by the Thai Government Scholarship Student Award in recognition of her achievements and for her service to the scientific and educational community.

Oral presentations

(presented in the same order as in the programme)

Thai Vitaceae: final update

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The family Vitaceae contains 18 genera and c. 950 species, with 11 genera and 78 species occurring in Thailand. The largest genera in Thailand are *Tetrastigma* (29 spp.) and *Cissus* (22 spp.), followed by *Ampelocissus* (12 spp.) and *Cayratia* (four spp.), *Causonis* (three spp.) and *Pterisanthes* (three spp.), and with another five genera containing only one species each. Five species new to science, 11 endemics and five new records are reported. Additionally, 66 typifications have been carried out. Phylogenetic research suggests *Cyphostemma*, *Tetrastigma* and *Vitis* are monophyletic, while *Ampelopsis* and *Cayratia* are paraphyletic and *Cissus* is polyphyletic. The author's progress in Thai Vitaceae research over the last 10 years is reported here. Emphasis is given to the outcomes of this research in the form of publications.

Keywords: endemic, new record, new species, nomenclature, phylogenetics, taxonomy

The James Franklin Maxwell collections

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The J.F. Maxwell collections are among the best ever made in Thailand because of their high quality, abundant material, wide distribution and highly informative labels. Maxwell's working life shows the evolution in his labels, from very simple in the early days to extremely complicated at the end. Did anybody know that some labels contain coordinates? There are also problems with the labels, mainly caused by the carbon paper used to make copies while typing one label. Various examples will be given. Maxwell used his very own transliteration of Thai characters and usually it is difficult to interpret the collecting localities. John Parnell and Thai PhD students found that it was often possible to clarify the collecting localities if John pronounced the names in American English and the students translated back to Thai. In this way many collecting localities have been georeferenced. The labels have a sequence in the descriptive part, following that of a typical published species description, except that leaf characters are always placed at the end. Also, parts with the same colour are described together to keep the description as short as possible, in which case the usual sequence is not kept. Maxwell's considerable knowledge of the Thai flora, likely supported by some kind of database, is shown in his use of terms like 'Topotype'. He was also well aware of names used outside Thailand and managed to identify many imported cultivars which he collected in (private) gardens.

Keywords: J.F. Maxwell

Developing the orchid account for *Flora of Thailand*: update and lessons learnt

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Following the *Flora of Thailand* Conference in 2017, development of the orchid account for the Flora has been focused on completing instalment 3 and on promoting work on instalments 4 and 5. Instalment 3 is strongly dominated by three large genera in tribe Malaxideae (viz., *Crepidium*, *Liparis* and *Oberonia*), and by tribe Podochileae subtribe Eriinae that presented considerable challenges at the generic level. For any difficult taxonomic complex, a dilemma exists between *either* including a less convincing treatment in the Flora, based on current knowledge only, *or* waiting for a separate in-depth study to be published before the Flora account is prepared. The former choice speeds up publication of the orchid volume, whereas the latter improves its quality. The taxonomically difficult groups indicated above were managed in different ways in connection with instalment 3. Lessons were learnt, and these are currently being utilised in instalments 4 and 5 that will comprise the very large genera *Bulbophyllum* sensu lato and *Dendrobium* sensu lato, respectively. Whereas instalment 3 can be considered done, instalments 4 and 5 are in progress, and initial plans are being made for the final instalment 6 (covering tribe Vandeae).

Keywords: *Bulbophyllum*, *Crepidium*, *Dendrobium*, *Liparis*, Malaxideae, *Oberonia*, Podochileae, Vandeae

A taxonomic revision of *Dendrobium* sect. *Pedilonum* (Orchidaceae) in Thailand

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The latest critical taxonomic study of Thai *Dendrobium* (Orchidaceae), including *D.* sect. *Pedilonum*, was published by Gunnar Seidenfaden in 1985. In our new revision of *Dendrobium* sect. *Pedilonum* in Thailand, we examined all the Thai material and some related specimens from adjacent areas deposited at the main herbaria in Thailand and Europe (i.e., AAU, BCU, BK, BKF, BM, C, K, L, PSU, and QBG), and as many digitised specimens as possible from other herbaria (i.e., B, BO, E, HBG, P, SING, and W). Moreover, some living plants were collected in the field. Type specimens of accepted names and their synonyms were compared with descriptions and any illustrations in the original publications. Against this background, we present and discuss 15 already known species, one new species, and four dubious taxa from *Dendrobium* sect. *Pedilonum* in Thailand. A diagnostic key to the species is provided together with an indication of important distinguishing characters and species distributions. Elementary data are briefly explained for two complex cases in the section: 1) *Dendrobium lamellatum* (Blume) Lindl., *D. compressum* Lindl. and *D. ypsilon* Seidenf. sensu lato and 2) *D. cumulatum* Lindl., *D. calicopis* Ridl. and *D. eoum* Ridl. sensu lato. In addition, although commonly assigned to *Dendrobium* sect. *Pedilonum*, we tentatively exclude *D. parcum* Rchb.f., from this section. We do so based on its combination of a decurved saccate mentum and a labellum lamina that does not embrace the column – aberrant traits in *Dendrobium* sect. *Pedilonum*. *Dendrobium parcum* might be better placed in *D.* sect. *Herbacea* as previously proposed by Howard Wood.

Keywords: *Dendrobium* sect. *Herbacea*, morphological study, orchid, Thai orchids

Update on the Rutaceae of Thailand

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The current status of the revision of Rutaceae for the *Flora of Thailand* is reported. At this stage, 21 indigenous genera with c. 70 species are included, with an additional four genera and c. 10 species occasionally cultivated. Recent, mostly phylogenetic, studies have resulted in some changes in the taxonomy at the species and genus level, e.g., in *Citrus*. The level of endemism in Thailand is low; most endemics are found in Peninsular and South-Western Thailand. Only two new species have been discovered in recent years, both in *Glycosmis*, which is the most diverse Thai genus with c. 20 species, also including most of the endemic taxa. New records can still be expected with more field work, particularly from Peninsular Thailand.

Keywords: *Citrus*, *Glycosmis*, Rutaceae, taxonomy

The Zingiberaceae for the *Flora of Thailand*

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The Zingiberaceae is widely distributed in the tropics and subtropics and comprises about 55 genera and 1800 species. Our revision of this family for the *Flora of Thailand* will be published soon. Twenty-eight genera and 392 species are recognised in Thailand, one quarter of them endemic. We divide the study of the gingers in Thailand into three periods, the beginning, classical and modern. The beginning period (1779–1957) includes the work of A.F.G. Kerr and Tem Smitinand. The classical period (1958–1995) covers the working life of Prof. Kai Larsen who encouraged Thai botanists to study gingers and who also made the highest number of ginger herbarium collections. In the modern period (1996–present) molecular systematics play an important role. Two subfamilies occur in Thailand, each with two tribes: subfamily Alpinioideae, (Alpinieae and Riedelieae) and Zingiberoideae (Zingibereae and Globbeae). Four genera, *Globba* (66 spp.), *Curcuma* (61 spp.), *Zingiber* (58 spp.), and *Kaempferia* (32 spp.), account for about half of the species, while eight genera are each represented by a single species and are restricted to certain habitats (*Camptandra*, *Cautleya*, *Haniffia*, *Lanxangia*, *Plagiostachys*, *Pommereschea*, *Siamanthus* and *Sundamomum*). Our project illustrates the importance of cross-border taxonomy and more species records and new taxa will definitely be added in years to come. We hope that this *Flora of Thailand* volume will be helpful to users for identification and will raise awareness of the need for conservation. Further research is still needed into the delimitation of species and on reproductive biology. New results will be included in the *e-Flora of Thailand*.

Keywords: Alpinioideae, biodiversity, gingers, Southeast Asia, taxonomy, Zingiberales, Zingiberoideae

The genus *Artabotrys* (Annonaceae) in Thailand

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The genus *Artabotrys* has been recently revised for the *Flora of Thailand*, revealing a total of 20 species for the country. *Artabotrys* can be immediately distinguished from other Annonaceae lianas by their iconic inflorescence hooks that facilitate climbing. Notwithstanding the easy recognition of the genus, identification at the species level is often challenging. When fresh material is available, petal morphology is occasionally helpful but a suite of more subtle characters is often needed for the identification of dried herbarium specimens. In this talk, the characters of taxonomic utility in *Artabotrys*, such as indumentum, leaf morphology, pedicel length, sepal size, petal shape and size, shape of anther connective apex, monocarp shape and seed morphology, along with habitat information, will be discussed. Also, the geographic distribution of the species will be presented.

Keywords: herbarium taxonomy, inflorescence hooks, lianas, Ylang Ylang Vine

An update on the genus *Begonia* (Begoniaceae) for the *Flora of Thailand*

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The family Begoniaceae has only two genera, the monotypic Hawaiian endemic genus *Hillebrandia* and the pantropical genus *Begonia* which is the sixth largest genus of flowering plants in the world. The *Begonia Resource Centre* at the Royal Botanic Garden Edinburgh currently reports 2083 accepted species in 70 sections. In 2019, 59 species were reported in the *Flora of Thailand* 14(3) following a taxonomic revision. However, Thailand has many unexplored areas, especially in limestone habitats and on the borders between Thailand and neighbouring countries. For example, *Begonia sirindhorniana* Phutthai et al., a recently described new species, was discovered on a tree trunk on a high mountain in Western Thailand close to the border with Myanmar. Moreover, additional field surveys in all types of habitats have been planned in order to prepare a new book on *Begonia* in Thailand. Already, several unknown *Begonia* species have been collected in remote areas during these expeditions.

Keywords: Begoniaceae, *Begonia Resource Centre*, *Begonia sirindhorniana*, field surveys, new taxa, pantropical

Bamboo puzzles from Thailand

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The last general survey of bamboo diversity in Thailand was undertaken more than 50 years ago. At that time, 42 species and 1 variety belonging to 10 genera were reported by Lin (1968). However, despite much recent advances in the general classification of the Bambusoideae, including clarification of some tribal, subtribal and generic limits, comparatively little fieldwork has been carried out with the consequence that the number of bamboo genera and species in Thailand remains unclear. Based on ongoing discoveries of novel or interesting taxa by specialists through the years, we expect some 15–20 genera and 80–100 species of bamboo to occur naturally. A few recent findings demonstrate the taxonomic problems we are up against, as well as the satisfaction of being able to work these out. These include the 'rediscovery' of *Neohouzeaua mekongensis* A.Camus, an enigma for a long time until we researched the type locality and mounted a search there to better understand this plant. This opportunity also brought a better understanding of supra-annual flowering in the seasonal subtropics vs other types of flowering behaviour, including continuous flowering of clumps in the wet tropics. Another is the demonstration and realisation that a much-used bamboo in horticulture is in fact an inter-generic hybrid, × *Thyrsocalamus liang* Sungkaew & W.L.Goh, that was selected in Thailand and has become more widely planted in Southeast Asia, including Singapore, over the last several decades but without a name. Still, more mysteries await, including 'SBG Indet. No. 1', a bamboo installed when the Singapore Botanic Gardens developed its Botany Centre, and which was eventually traced to Chiang Mai, but still to be taxonomically placed.

Keywords: Bambusoideae, hybrids, *Neohouzeaua mekongensis*, taxonomy, *Thyrsocalamus liang*

Flora of Thailand non-bambusoid Poaceae: progress or lack of due to a pandemic

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Poaceae are one of the largest plant families in Thailand with the current estimate of the non-bambusoid taxa being 437 species in 119 genera. Work on the *Flora of Thailand* account was initiated in 2004, with the intention of it being a significant training opportunity for Thai MSc and PhD level taxonomists under the supervision of experienced researchers. The arrangement of genera will follow Kellogg's classification in Kubitzki's *Families and Genera of Flowering Plants* published in 2017, with the species in alphabetical order. Steady progress was being made in both the writing and editing of accounts until early 2020 when the Covid pandemic hit. Regrettably, this was a serious setback to the work, with physical access to collections being prohibited for long periods in many institutions. Accounts for 38 genera and c. 115 species are still to be received and a planned publication date in 2022 will not be achieved. However, it is expected that the accounts will be completed for publication by 2024.

Keywords: Gramineae, grass, grasses, revision, taxonomy

Flora of Thailand progress 2022

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The *Flora of Thailand* was initiated in order to produce an up-to-date treatment of the taxonomy of all vascular plants in Thailand. The first volume was published in 1970 and by 2014, after 44 years, 4708 species out of the estimated total of 11,000 species had been published. At that point a grant from the Carlsberg Foundation was obtained to help speed up production of the Flora. The editorial team and board were strengthened in order to achieve the goal of completing the project within a 10-year period. Three years later at the *Flora of Thailand* meeting in Krabi, Thailand, an additional 898 species had been published and the number of published species was up to 5686. In 2022 — as we meet in Singapore — an additional 1274 species have been published and 792 are awaiting publication, bringing the total number up to 7750 species. There are around 3250 species to be published in the remaining two and a half years of the project. This daunting task may be less impossible than it appears because many of the remaining families have already been completed in manuscript form and, in other families, many genera have already been completed and the family treatment only awaits a few additional descriptions to be completed. Still, finishing the *Flora of Thailand* by the end of 2024 will require an extraordinary effort from all contributors and the editorial team.

Keywords: Carlsberg Foundation, publication, taxonomic revision

An introduction to the *e-Flora of Thailand*

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The *Flora of Thailand* has published hard-copy volumes since 1970. Its purpose is to document the vascular plants of Thailand, an estimated 11,000 species. To date, multiple parts in volumes up to volume 15 (2021) have been published, mostly with four parts per volume, covering 6454 species in 251 families. Three upcoming parts treating Annonaceae, Leguminosae and Orchidaceae, including more than 600 species, are under production and due to be published within this year (2022) or early next year (2023). Approximately 1000 species in five families (Gesneriaceae, Lamiaceae, Pentaphragmataceae, Rubiaceae and Zingiberaceae) are more than 80% complete. With these upcoming publications, the total number of treated species in the Flora will reach c. 8000 species by the end of 2023, leaving approximately 3000 species remaining to be treated. With the rapid growth of internet usage and its advantage in promoting wider accessibility, an online version of the *Flora of Thailand*, under the name of '*e-Flora of Thailand*', has been initiated following the recommendation at the Flora's Editorial Board meeting in 2017. This online version provides the data from the published volumes and, in addition, includes updated information, additional images, corrected authorities and currently accepted names based upon *Plants of the World Online* and the *Angiosperm Phylogeny Website*. Recently, the *e-Flora of Thailand* has also been contributing data to the *World Flora Online* (WFO) project. There are now 4493 species available to search online, accounting for treatments up to volume 12 of the hard-copy versions of the Flora. In this presentation, we shall demonstrate the usefulness of the *e-Flora of Thailand*, its present platform, as well as discuss upcoming features.

Keywords: *Angiosperm Phylogeny Website*, online flora, *Plants of the World Online*, *World Flora Online*

Taxonomic publications for the *Flora of Thailand*: observations from *Thai Forest Bulletin* and *Kew Bulletin*

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Many of the *Flora of Thailand* accounts have precursor taxonomic treatments and, after the *Flora* account has been published, additional systematic studies continue as additional specimens and data are accumulated. In addition, many Thai botanists are now working on monophyletic groups with much wider distributions than Thailand. Publication in a journal is still the most acceptable way to disseminate taxonomic research. Many journals are now publishing online as well as, or sometimes instead of, hard copy journals – aiming to submit the best quality manuscripts will give authors quicker turnaround times for online publication. In this talk, we will discuss the different types of papers we have edited over the years for *Thai Forest Bulletin (Botany)* and *Kew Bulletin*, to give an idea of the range of taxonomic outputs, such as checklists, new records, revisions, synopses and monographs. We will outline some of the key elements that are needed for papers and highlight some of the hurdles that authors often encounter. We hope the talk will provide inspiration and guidance for *Flora of Thailand* botanists and encourage them to submit their work for publication with confidence, especially the early career researchers at the start of their taxonomic journey.

Keywords: checklist, monograph, new record, online publication, taxonomic revision

Species diversity of the epiphytic bryophytes in framework species restoration plots

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Forest restoration includes the re-establishment of forest in disturbed areas. The framework species method involves planting 20–30 carefully selected tree species that grow rapidly. As these trees grow, they will attract wild animals including seed dispersers. Gradual increase in biodiversity is therefore a critical indicator of successful restoration. The research presented here tested this concept with respect to bryophyte diversity, which has not been tested before. Epiphytic bryophyte communities of framework species restoration plots, aged 13 and 21 years since initiation of restoration, were compared with those of nearby old-growth forest in the upper Mae Sa Valley, northern Thailand. Bryophyte surveys were carried out in June 2019. Fifteen species representing 14 genera and 12 families of epiphytic bryophytes were found on the bark of three tree species that grew in every study plot: *Archidendron clypearia* (Jack) I.C.Nielsen (Thai name: Mah Kham Pae), *Erythrina subumbrans* (Hassk.) Merr. (Thai name: Tawng Lahng Bah) and *Sarcosperma arboreum* Hook.f. (Thai name: Mah Yang). The bryophytes were divided into three groups, i.e., four species of acrocarpous mosses, five species of pleurocarpous mosses and six species of leafy liverworts. By 13–21 years after restoration initiation, bryophyte species richness had already increased to the same level as that of old-growth forest, since differences in bryophyte species richness between the restoration and old-growth forest were not significant (P=0.92). In terms of species composition, the bryophyte community of the older restoration forest was more similar to that of natural forest (five shared species) than was the bryophyte community of young restoration forest (four shared species). In conclusion, the framework species method of forest restoration increases bryophyte species richness to levels similar to those of natural forest (within 13 years) and gradually directs the species composition of the epiphytic bryophyte community towards that of old-growth forest.

Keywords: conservation, framework species method, liverwort, moss, species richness

Plant community analysis and ecological niche modelling of *Diospyros rhodocalyx* at a local scale for conservation

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Conservation of native species is critical for the development of a green university at the Rajamangala University of Technology Isan (RMUTI), Nakhon Ratchasima, Thailand. This paper focuses on 361 trees of *Diospyros rhodocalyx* Kurz, or 'Takona' in the vernacular, in RMUTI, covering almost 13 hectares or about 24% of the RMUTI campus. In 2021, the vegetation profile and crown cover of this area were analysed. Maximum entropy modelling (MaxEnt) was employed to examine the geographical distribution and niche of Takona in RMUTI. Variables used for modelling Takona occurrence included topography and distance to water bodies in addition to the usual bioclimatic variables, e.g., rainfall and temperature. To validate the model, the Takona distribution in RMUTI in 2017 was generated from a MaxEnt model, and then compared with that in 2021. If the two niche models from data collected in 2017 and 2021 show similar patterns, then MaxEnt modelling is considered to be able to accurately predict Takona distribution from environmental and landscape factors.

Results showed that Takona is mostly found near the southern waterway of RMUTI. MaxEnt modelling is possible for studying locally specific patterns but the issue of very small geographical extents should be considered. Further, a temporal series of these models provides a method for examining how the Takona distribution changes over time.

Keywords: distribution pattern, MaxEnt, maximum entropy modelling, native species, spatial analysis, Takona

Pollination biology of an endemic rare morning glory species, *Argyreia versicolor* (Convolvulaceae)

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Argyreia versicolor (Kerr) Staples & Traiperm is an endemic and rare species in Thailand. It was first discovered in 1924 and first published in 1941. However, after its discovery, the species was not reported again until 2018, when two individuals were discovered in Sa Kaeo province. Consequently, knowledge about the pollination biology of this species is critical for its conservation. The objectives of this study were (1) to determine the mating system of *Argyreia versicolor* and (2) to observe its potential pollinators. To determine the mating system, a pollination experiment was performed with five treatments: open, open-emasculated, closed, cross-pollinated by hand, and self-pollinated by hand. Three months after the pollination experiment, fruits were collected from the plants and dried. The dried fruits and seeds were weighed, and seed number per fruit was counted. To determine potential pollinators, animal visitors were recorded via action cameras placed in front of open flowers. Our results reveal that *Argyreia versicolor* is self-incompatible and dependent on pollinators, and that *Xylocopa* carpenter bees are likely effective pollinators. However, while we have observed successful fruit set under natural conditions, seedlings have not been observed in the wild, which indicates that there are other factors impeding the reproductive success of this extremely rare plant species.

Keywords: carpenter bee, mating system, pollinators, reproductive success, self-incompatible, *Xylocopa*

Study of the mating system in a rare Thai species, *Blinkworthia lycioides* (Convolvulaceae)

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The objective of this study is to investigate the breeding system of *Blinkworthia lycioides* Choisy which is a rare and unstudied species in Thailand that belongs to the morning glory family (Convolvulaceae). We divided our study into two parts. The first part focused on bagging experiments in representative populations in Kanchanaburi, Sra Keow and Chiang Mai. The fruits and seeds that were obtained from these experiments will be statistically analysed. The second part of this study, on the pollen biology of *Blinkworthia lycioides*, was designed to inform the results that were obtained from the bagging experiments. The results from both parts of this study revealed that *Blinkworthia lycioides* has a mixed mating system, which allows it to reproduce thorough both inbreeding and out-crossing. The low rate of fruit set in each treatment, however, also revealed that sexual reproduction might not be a main form of propagation in this species and it is possible that it relies primarily on vegetative reproduction; a method common in the morning glory family. In conclusion, this study provides insights on the reproduction of *Blinkworthia lycioides*, which might help explain its limited distribution and rarity. Moreover, findings from this study may also facilitate the assessment and conservation of this species in the future.

Keywords: breeding system, pollen biology

Investigation into the association between *Periglandula* fungi and *Ipomoea asarifolia* (Convolvulaceae)

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Ergot alkaloids are a class of indole derivative mycotoxins that play important roles in both pharmaceutical and agricultural industries. Numerous species of Convolvulaceae have been reported to contain ergot alkaloids since the nineteenth century. Recently, the fungal genus *Periglandula* (Clavicipitaceae) was discovered to be responsible for ergot alkaloid production in Convolvulaceae. The fungi were previously reported to mainly associate with the young unfolded leaves and seeds of Convolvulaceae species. In order to more thoroughly understand the source of beneficial ergot alkaloids from ergot-alkaloid producing fungi, this research aimed to reveal where and how *Periglandula* fungi interact with their host plants via molecular, anatomical and micromorphological investigation in different plant parts and growth stages. Our results confirm the presence of the fungus, *Periglandula ipomoeae* Steiner et al, in six parts of *Ipomoea asarifolia* (Desr.) Roem. & Schult.: young unfolded leaves, mature leaves, young flowers, mature flowers, young seeds, and mature seeds. We found that plant glandular trichomes and plant growth stage affect the density of the plant-associated fungi. Our novel discovery of the *Periglandula* fungi on flowers further improves our understanding of how vertical transmission of the unique fungi occurs.

Keywords: epibiont, ergoline, mycelium, *Periglandula ipomoeae*, secondary metabolites

A study of leaf anatomy for taxonomic delimitation of two varieties of *Pavetta tomentosa* in Thailand

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According to the latest revision of the genus *Pavetta* in Thailand, 14 species and two varieties are recognised. However, this work was based mainly on morphological data and included some species with considerable morphological variation. Therefore, the taxonomic status of some species and infraspecific taxa is still uncertain and a re-evaluation is needed for clarification. For example, one problematic situation is whether the two varieties of *Pavetta tomentosa* Roxb. ex Sm., *P. tomentosa* var. *tomentosa* and *P. tomentosa* var. *glabrescens* (Kurz) Bremek., are sufficiently distinct as they are distinguished only on the degree of pubescence of various parts with unclear boundaries between the character states. To clarify and confirm the status of these taxa, leaf anatomical data from 10 individuals of each taxon from different locations in Thailand using peeling and clearing techniques have also been assessed. Our results revealed that *Pavetta tomentosa* var. *tomentosa* and *P. tomentosa* var. *glabrescens* have similar leaf anatomy. We found no good leaf anatomical characters to support the continued recognition of these two varieties.

Keywords: *Pavetta tomentosa* var. *glabrescens*, *Pavetta tomentosa* var. *tomentosa*, plant anatomy, taxonomic status

Taxonomy and molecular systematics of *Artocarpus* (Moraceae) in Thailand

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Artocarpus contains approximately 70 species of trees, including several economically important crops such as breadfruit (*A. altilis* (Parkinson) Fosberg)) and jackfruit (*A. heterophyllus* Lam.) with a centre of diversity in Southeast Asia. We review the taxonomic history of *Artocarpus* as well as recent taxonomic changes supported by molecular evidence, with a focus on the 16 species found in Thailand and their distinguishing characters. We also present a newly updated phylogenomic reconstruction of the genus based on 517 nuclear genes and explore molecular evidence for hybridisation within the taxonomically difficult *Artocarpus* subg. *Pseudojaca*, highlighting complexes that require further investigation.

Keywords: breadfruit, crop wild relatives, hybridisation, jackfruit, phylogenomics, species delimitation

Towards an understanding of the phylogeny, biogeography and the role of hybridisation in the evolution of the genus *Sindora* (Fabaceae: Detarioideae)

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Sindora is a paleotropical genus with about 20 species in tropical and subtropical Asia and with one species in West Central Africa. Recent taxonomic work and field surveys in Singapore have found five species to be present, four of which are native. *Sindora siamensis* Teijsm. ex Miq., a species present in Thailand, is cultivated with a long history dating back to the colonial era. A new hybrid, *Sindora* x *changiensis* L.M.Choo et al., has also been described from Singapore. Its hybrid status was uncovered by a combination of ddRADseq and morphological methods, with the two parent species identified as *Sindora coriacea* (Baker) Prain and *S. echinocalyx* Prain, both of which are also present in Peninsular Thailand. Further studies in the genus are being planned, with a focus on the phylogeny and biogeography of the genus across its entire distribution in Asia and Africa. The prevalence of hybridisation across various time scales will be studied, from detecting the presence of ancient introgression in the history of the genus, to the possible ecological roles and impacts of hybridisation.

Keywords: Caesalpinioideae, Detarieae, heritage, history, Leguminosae, Sepetir, *Sindora coriacea*, *Sindora echinocalyx*, *Sindora siamensis*

Phylogeny of Marsdenieae (Apocynaceae, Asclepiadoideae) and an updated classification of Thai taxa

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Over the last three decades the classification of Marsdenieae genera (Apocynaceae, Asclepiadoideae) has changed dramatically. The genus *Marsdenia*, for instance, has ranged from about 10 to more than 300 species. In Thailand, Marsdenieae include more than 100 species. We present a recently published phylogeny of Marsdenieae obtained by traditional Sanger sequencing of nuclear and chloroplast loci. *Marsdenia* sensu stricto is now reduced to a small clade of Asian species, and numerous genera formerly considered synonyms of *Marsdenia* are reinstated. Most relevant for Thailand is evidence that *Gymnema* is monophyletic and distinct from *Marsdenia*, that *Dregea* is subsumed under *Stephanotis*, that *Marsdenia tenacissima* (Roxb.) Moon has been reclassified in the new genus *Gongronemopsis* (as *Gongronemopsis tenacissima* (Roxb.) S.Reuss et al.) and *Gongronema filipes* Kerr has been be classified in the new *Gongreos* (as *Gongreos filipes* (Kerr) Rodda et al.). We also present a preliminary densely sampled phylogeny of *Hoya* sensu lato obtained using NGS data which provides a framework for the untangling of species complexes such as these of *Hoya verticillata* (Vahl) G.Don and *Hoya lacunosa* Blume, which occur in Thailand.

Keywords: *Dregea*, *Gongreos*, *Gongronemopsis*, *Gymnema*, *Hoya*, *Marsdenia*, *Stephanotis*

Phylogeny of *Clerodendrum* (Lamiaceae) and a redefinition of the infrageneric classification

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Clerodendrum is one of the largest genera in the family Lamiaceae comprising approximately 250 species distributed in Asia, Australia and Africa. The phylogenetic relationships and infrageneric classification of the genus have been highly problematic due to different concepts and subdivisions being applied to the Asian and African species. Previous morphology-based classifications and phylogenetic frameworks have been complex and incongruent due to morphological plasticity and limited sampling using few molecular markers to construct the phylogenetic trees. High-throughput DNA sequencing provides more information and allows more robust phylogenetic reconstruction at a larger scale. This study aims to clarify the phylogenetic relationships and thereby establish an infrageneric classification of *Clerodendrum*, with an emphasis on Asian species, using targeted sequencing data obtained from the Angiosperms353 probes. Our studies have resulted in the identification of monophyletic groups within Asian and African *Clerodendrum*. Thirteen sections, six in Asia and seven in Africa, based on both morphology and molecular phylogenetic evidence, are recognised. The infrageneric classification includes three new sections: *Clerodendrum* sect. *Albiflora*, *C.* sect. *Fortunata* and *C.* sect. *Megaflora*. The phylogenetic position of *Clerodendrum phlomidis* L.f. implies a possible continental disjunction event between Asia and Africa. The origins of some synapomorphic characters such as pendulous inflorescences and red flowers are discussed.

Keywords: Angiosperms353, Africa, Asia, infrageneric classification, section, taxonomy

Species delimitation and evolutionary history of the genus *Peliosanthes* (Asparagaceae)

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Peliosanthes (Asparagaceae) is a genus of perennial evergreen herbs, distributed mostly through Southeast Asia. The relationship of this genus to *Ophiopogon* and *Liriope* is supported by molecular phylogenetic data and morphological characters such as having fruits that rupture in early development and seeds that possess a sarcotesta. The number of species in *Peliosanthes* is quite controversial, ranging from 1 to 72 depending on the species concept of authors, and thus a study of species delimitation in this genus is needed. From 1999 (11th *Flora of Thailand* Conference, where Tamura had a talk on *Peliosanthes*) until now, the number of generally accepted species has rapidly increased from about 15 to more than 50, mainly because of the discoveries of new species based on morphology. On the other hand, based on chloroplast genome data reported in 2014 and 2017 (16th and 17th *Flora of Thailand* Conferences), the genus includes two main clades: a northern clade and a southern clade, with the boundary between the two being around the Isthmus of Kra. However, based on nuclear ITS data, this result was not supported, although the reason was not clear. In the present study, we used Multiplexed ISSR (Inter-Simple Sequence Repeat) Genotyping by sequencing (MIG-seq) and Restriction site-associated DNA sequencing (RAD-seq) methods as genome-wide approaches to elucidate the boundary between the northern and southern lineages of *Peliosanthes*. By comparing phylogenetic relationships resulting from chloroplast and nuclear sequence data, we try to reveal the evolutionary history of *Peliosanthes*, and by performing neighbor-net and STRUCTURE analyses based on MIG-seq and RAD-seq data, we try to understand species delimitation in *Peliosanthes*.

Keywords: Asparagales, MIG-seq, Ophiopogoneae, phylogenetics, RAD-seq, species recognition

Plastome phylogeny of *Diospyros* (Ebenaceae)

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Diospyros is a large pantropical genus that comprises over 700 species and dominates in Southeast Asia. A resolved phylogenomic backbone is not yet available for the genus as previous studies focused either on few loci across a wide species sampling or the plastomes of few species. In this study, the DNA of fresh material and exsiccatae was sequenced using genome skimming techniques. A total of 50 circular plastomes of 46 *Diospyros* species were newly assembled and annotated. The phylogenetic relationships were analysed using 79 plastid protein-coding genes of *Diospyros* from different geographic regions. The resulting clades are mostly congruent with the morphology, geography, or ecology. Although this whole-plastid genome data provides high resolution to resolve some species at the population level (e.g., samples of *Diospyros ferrea* (Willd.) Bakh. from different geographic areas group in different clades), the shallower relationship of some Southeast Asian clades remains unclear.

Keywords: ebony, genome skimming, herbarium DNA, phylogenomics, species complex

The role of data aggregators in the taxonomy and conservation of *Diospyros* (Ebenaceae)

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Diospyros is a large genus of over 700 tropical and subtropical species. Many are used locally for construction, food, drugs, or in horticulture, and some are economically important on a global scale, especially in the timber and fruit trade. There is a critical need to assess the threats to *Diospyros* and other valuable timbers, and efforts are greatly aided by the large-scale digitisation programmes across the world's herbaria. Collection records are uploaded to biodiversity data aggregators (e.g., the *Global Biodiversity Information Facility*, *Atlas of Living Australia*, etc.) and made available to a wide range of users. However, these data are often used with little critical evaluation of its quality, especially as its quantity increases. Here, we use *Diospyros* as a case study to take a snapshot of the data environment at this moment in time. We assess the accuracy of the most used datasets and see the impact they might have on conservation strategies in Thailand and Malesia, at a time when taxonomic investigations are still underway.

Keywords: *Atlas of Living Australia*, collections, conservation, data, *Global Biodiversity Information Facility*, taxonomy, timber

Systematics and biogeography of the genus *Maesa* (Primulaceae)

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Taxonomic uncertainty can cause inaccurate inferences in evolutionary analyses. The lack of distinct qualitative characters or discontinuities in quantitative characters is one source of the uncertainty that complicates species delimitation and identification. *Maesa*, a tropical member of the Primulaceae, is one such taxon that has been avoided and overlooked due to the difficulties in its systematics. The genus comprises almost 200 species of woody shrubs, trees and scramblers distributed in the Old World Tropics. Here, for the first time, we reconstruct a species-level phylogenetic tree of *Maesa* from target sequence capture data covering 60% of species across the entire distribution range of the genus. A species-level phylogeny inferred from 310 gene trees divides *Maesa* into African and Asian-Pacific clades. The former is further divided into two subclades, while the latter into three; all are well-supported. Thus, we propose five subgenera of *Maesa*, namely *Maesa*, *Monotaxis*, *Ramentacea*, *Indica* and *Papuana*. We then dated the phylogeny, estimated the ancestral range, and reconstructed dispersal events of *Maesa* focusing on the Malesian region - the species diversity hotspot of the group. Our investigation into biogeographic history reveals the events that shaped the current distribution of *Maesa* and the connectivity between the complex Malesian archipelago and neighbouring islands and continents. This study demonstrates the potential of using a phylogenomic framework and covering the whole distribution range to untangle taxonomic problems and investigate evolutionary history. It also lays the foundation for further detailed studies in trait evolution and population genetics, especially to unravel species complexes that we are unable to resolve in this study.

Keywords: Ericales, Malesia, Myrsinaceae, phylogeny, taxonomy

Meliaceae for the *Flora of Thailand*

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The family Meliaceae is an ecologically and morphologically diverse family of trees with c. 90 species in 21 genera in Thailand. They are found in lowland wet and dry rainforests, limestone outcrops, mangroves and beaches. Most genera are represented by 1–3 species. There are 12 species of *Chisocheton* and 11 species of *Dysoxylum* sensu lato. *Dysoxylum* has recently been resolved into several genera, each with a smaller number of species. There are now six species of *Dysoxylum* sensu stricto, one species of *Goniocheton*, two species of *Epicharis* and two species of *Prasoxylon*. By far the largest genus in the family and in Thailand is *Aglaia*, with 40 species in Thailand, including one new species discovered by BKF staff during fieldwork on limestone in NE Thailand. There are contrasting fruit morphologies and vertebrate dispersers in the two main sections in the genus *Aglaia*. This presentation will give an overview of the family in Thailand and will provide an introduction to its diversity and to the revision of *Dysoxylum* at the generic level, as it relates to Thailand.

Keywords: *Aglaia*, *Chisocheton*, dispersal, *Dysoxylum*, *Epicharis*, generic diversity, *Goniocheton*, *Prasoxylon*

Impatiens of Thailand: the final episode

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Impatiens is one of the top twenty largest plant genera, comprising about 1100 species distributed mainly in the Old World tropics and subtropics. In this talk we present a taxonomic account of the genus for the *Flora of Thailand*, resulting from almost 15 years or exploration and revision of this highly diverse plant group. Currently, 91 species and one variety are recognised, including 21 newly described taxa. Of these, 43 species and 1 variety are endemic to the country. The molecular phylogenetic results suggest that Thai *Impatiens* species belong to both of the two subgenera and to five different sections in a system proposed by Yu et al. in 2015. The majority (more than 50%) belong to *Impatiens* sect. *Semeiocardium* within *Impatiens* subg. *Impatiens*. However, some morphological characters used by Yu et al. (2015) to define *Impatiens* sect. *Semeiocardium* are not synapomorphic. Our presentation will also briefly review previous taxonomic works, beginning with the first Thai species named by J.D. Hooker in 1891 up to T. Shimizu's last account in 2004. We shall also review ecology and general morphology which are used to define Thai species into 13 informal groups. The talk will briefly mention pollination biology, molecular phylogeny, their threats and proposed IUCN conservation status. We recognise 31 taxa as Critically Endangered (CR), 34 taxa as Endangered (EN), 3 taxa as Vulnerable (VU), 2 taxa as Near Threatened (NT), 11 taxa as Least Concern (LC), and 10 taxa as Data Deficient (DD). In addition, we will also discuss findings on some morphological characters that were not formerly highlighted as useful for the genus, e.g., a sticky-waxy seed coat in *Impatiens tribounii* T.Shimizu & Suksathan that possibly helps the seeds to be dispersed by animals, peculiar projections inside the lower sepal in *I. tribounii*, and a closed floral chamber in *I. kingdon-wardii* Nob.Tanaka & T.Sugaw. Further investigation of these novel characters could inform future pollination and dispersal studies.

Keywords: balsam, endemic species, *Impatiens tribounii*, *Impatiens kingdon-wardii*, Southeast Asia, taxonomy

‘Bract’ or ‘Bracteole’? Revisiting the terminology for the diagnostic character of *Neuropeltis* (Convolvulaceae)

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One of the most important diagnostic characters for the genus-level recognition of *Neuropeltis*, an anemochoric genus of Convolvulaceae, is an accrescent leaf-like organ subtending the flowers that becomes extremely enlarged in fruit giving the diaspores a wind-dispersal capability. Nonetheless, this enlarged organ has been inconsistently defined as both *bract* and *bracteole*, resulting in mixed usage in previous terminological applications. The confusion over these terms has greatly troubled *Neuropeltis* studies until now, ranging from the misconception of terms to the misinterpretation of inflorescence branches by various authors. This issue has also been observed for other genera in the Neuropeltoid group, highlighting problems of homology. Therefore, the need to thoroughly understand, describe, characterise and propose a stable terminology is crucial for future studies in *Neuropeltis* and its allies. Based on living, spirit and herbarium collections, we thoroughly examined the morphology, position and function of each laminar organ in the synflorescence. Our study allows us to propose a new, more logical and standardised application for the two problematic terms *bract* and *bracteole*. Furthermore, we also propose the use of the term *pherophyll* for the leaf-like organs found in the synflorescence at the terminal shoots or branch apices. Our recommendations for the application of these terms will ensure consistency and prevent confusion regarding these characters’ homology and taxonomic value in *Neuropeltis* and related genera for future revisionary and systematic studies.

Keywords: inflorescence architecture, *Neuropeltopsis*, Paleotropics, pherophyll, phyllome, prophyll

Pollen morphology of selected *Heritiera* (Malvaceae) species in Malaysia and its taxonomic significance

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Heritiera is a tropical and subtropical African, Asian and Pacific islands genus in the subfamily Sterculioideae (Malvaceae s.l). Its species are mainly trees of forests and mangroves at altitudes below 1000 m. This talk presents a palynological study of five species of *Heritiera* (*H. littoralis* Aiton, *H. elata* Ridl., *H. simplicifolia* (Mast.) Kosterm., *H. sumatrana* (Miq.) Kosterm., *H. borneensis* (Merr.) Kosterm.) by light microscopy (LM) and a scanning electron microscopy (SEM). Quantitative and qualitative data on pollen micromorphological characteristics were evaluated for taxonomic identification and species relationship using acetolysis single-grain technique. The effects of different types of coating and accelerating voltages during electron microscopy were also investigated. Pollen morphological features studied in this work included pollen ornamentation, echini arrangement, echini density, size, number and ornamentation of pores, polar and equatorial diameter, P/E ratio, exine thickness, colpus width and dimensions of lumen and murusPollen grains of all five species were colporate with tricolporate apertures and had rounded to lobate outlines. All species were monads and belonged to the same pollen class. Nevertheless, variations were observed in these features: ratio of exine thickness, pollen size, pore width and height, shape, colpus width and length, polar region index, exine ornamentation and size of lumen and murus. For example, *Heritiera sumatrana* can be differentiated from other species by its subprolate pollen shape, *H. littoralis* by its granulate ornamentation on the exine and small polar region index, and *H. simplicifolia* by its large polar region index. These diagnostic characteristics, specifically pollen surface, structure, size, shape, morphology, and texture, are valuable for the identification of taxa and can be used for delimitation of species. Hence, we developed a taxonomic key for a quick and accurate identification of *Heritiera* species. However, it was observed that different interpretations of pollen characteristics are possible based on the types of coating and accelerating voltage used. We found that gold coating was the best agent compared to others.

Keywords: exine sculpture, micromorphology, scanning electron microscope, Sterculioideae, taxonomy

Essential oil composition of traditional medicinal *Litsea* species in northern Thailand

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Litsea is the largest genus in the family Lauraceae in Thailand. Many ethnic groups in northern Thailand use *Litsea* species as spices and ingredients in traditional remedies. Moreover, *Litsea cubeba* (Lour.) Pers. has been developed as an industrial crop due to its traditional use as a substitute for tea or air freshener. The oil from its fruits and leaves are rich in three major chemical compounds (estragole, geranial and neral) classified in the citrus aromatic group. There have been few comparative studies of the chemical compounds from leaves of different *Litsea* species. Therefore, the aims of this study were to analyse the composition of volatile substances of medicinal *Litsea* spp. The composition of the volatile oils of *Litsea* spp. could potentially be used for plant identification and chemical screening for uses in traditional medicine. Ethnobotanical field surveys were conducted from November 2019 to December 2021 in ten villages of five major ethnic groups including Karen, Hmong, Lahu, Akha and Lawa. Semi-structured interviews were performed with 50 key informants. The Use Values (UV) of medicinal *Litsea* spp. were calculated. Fresh samples of *Litsea* spp., with high UV scores were collected for essential oil analysis. HS-SPME were used to describe chemical composition of the oils. Estragole, eugenol and methyl eugenol were the major volatiles found in the essential oils of the *Litsea* spp. samples. Principal Component Analysis (PCA) classified the *Litsea* spp. samples into two main groups: i) distinctive anise, citrus aroma (estragole, geranial and neral), or ii) spice-like aroma (methyl eugenol, β-caryophyllene, and α-cubebene). Furthermore, this study will be used to tentatively narrow down the number of species chosen for early-stage drug discovery screening, potentially leading to alternative sources of medicines for the treatment of, for example, digestive system disorders and infections/infestations.

Keywords: aromatic plants, aromatic profiles, ethnobotany, Lauraceae, medicinal plant, Use Value

The *Flora of Nepal*: a born-digital Flora

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The *Flora of Nepal* is the first full account of the country's estimated 7000 species of vascular plants. The Flora is the world's first 'born-digital' Flora, with all data, images and outputs managed in the custom-designed *Padme* database. The Flora is being published in 10 volumes with the families arranged in a modified Englerian order, but with the families following the APG4 circumscription. One volume has been published to date, with a further three volumes currently being worked on. In addition to the physical publication of the accounts, families are published online as they are completed. This presentation will discuss the Flora's progress, current activities and the wider programme of Himalayan research at RBGE. An overview of the floristic links between Nepal and Thailand will be presented and the potential for collaboration between the Flora projects will be discussed.

Keywords: APG4, collaboration, *Padme*, taxonomic database

The *Flora of Singapore* project

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The *Flora of Singapore* is a project to catalogue and describe all species of bryophytes, lycophytes, ferns, gymnosperms and angiosperms that are native, naturalised or casual in Singapore. The *Flora* will be published in 14 volumes over 10 years of which volumes 1, 7 and 13 were published in 2019. Volume 1 is an introductory volume focusing on the history of plant taxonomic research in Singapore, the vegetation of Singapore, and conservation in Singapore. Volumes 7 and 13 are dedicated to the Poales and Gentianales respectively. Manuscripts have already been received for many of the remaining volumes with those for volume 4 (gymnosperms and basal angiosperms) scheduled to be published next, followed by volume 2 (bryophytes).

As part of the *Flora of Singapore* project a new checklist and bibliography has also recently been published. This has greatly clarified the numbers of native, naturalised and casual plant species in Singapore and has helped to highlight taxonomic and nomenclatural issues to be addressed in future *Flora* volumes. We now believe that there are 2654 species of native plants, including bryophytes, and about 580 species that are naturalised or casual or for which the status is uncertain. Approximately 630 native plant species are thought to be nationally extinct. However, over the last 10 years or so, more than 100 species thought to be extinct have been rediscovered.

It is remarkable and encouraging that, despite Singapore's size and being one of the most densely collected countries in the world, new species, new records and rediscoveries of species previously presumed extinct are still being found.

Keywords: checklist, conservation, introduced species, native species, taxonomy

Generating baseline genomic data for a Flora: a case study from Singapore

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Genomic investigations into tropical plant diversity are important because they provide us with a better understanding of species relationships, gene diversity and ancient population dynamics. Alongside the *Flora of Singapore* project, we embarked on a parallel effort to sequence the genomes of the flora of Singapore. This project aims to generate baseline genomic data for Singapore's flora for future applications in areas such as species identification, population genomics and phylogenomics. For the first phase of the project, we focused our efforts on Bukit Timah Nature Reserve (BTNR), a 1.64 km^2 patch of rainforest in which approximately half of Singapore's native plant diversity resides. Between 2019 to 2022 we collected and vouchered 882 angiosperm species from BTNR. Illumina shotgun short-read sequencing was carried out for each species to obtain a minimum of 30Gb of data, followed by genome assembly and gene prediction. For the first stage of the project, we focused our analysis on 501 good quality genomes. A set of 1000 conserved single-copy genes were used to generate a high-resolution phylogeny of the BTNR species, illustrating that when compared with APG IV, there were differences in the position of Santalales and the relationships within the families in Malpighiales and some orders in the malvids and fabids. Gene predictions allowed us also to study ancestral whole genome duplication events, to look for evidence of introgression and to chart the proteomic diversity present in a rainforest.

Keywords: genome diversity, phylogenomics, phylogeny, population genomics, whole genome sequencing

Diversity of Araceae in Namtok Mae Surin National Park, Mae Hong Son Province, northern Thailand

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Documentation of species diversity in protected areas is vital to ensure that these areas are appropriately managed to ensure conservation of threatened species. As the Araceae species along the Mae Sakut Nature Trail in Namtok Mae Surin National Park, Mae Hong Son province have not previously been documented, a transect 10 m wide and 8.5 km long from 384 to 669 m above sea level, was surveyed for its Araceae diversity from May 2020 to April 2021.Twenty-two species in 12 genera were recorded: six *Amorphophallus* species, three *Colocasia* species, two species each in *Arisaema*, *Hapaline* and *Steudnera*, and one species in each of *Aglaonema*, *Alocasia*, *Englerarum*, *Pothos*, *Remusatia*, *Schismatoglottis* and *Scindapsus.* Nine species were found only in dry evergreen forest, five species only in mixed deciduous forest, and eight species in both forest types. Eight species were evergreen, while 14 species were deciduous. For life form types, there were 15 geophytic species, two helophytic-lithophytic species, and one species each that are lithophytic, helophytic, epiphytic-lithophytic, geophytic-lithophytic and geophytic-lithophytic-epiphytic. The dominant species, which had the highest importance value index in the rainy season (July 2020) was *Colocasia affinis* Schott. In the winter (November 2020), 12 species in nine genera were found. Of these, the dominant species was *Hapaline benthamiana* Schott. In the dry season (March 2021), eight species in seven genera were found along the stream and Mae Sakut Waterfall. Of these, *Steudnera discolor* W.Bull ex T.Moore & Mast. was the dominant species. Drought and forest fires in the summer are the greatest threats to many evergreen species on this nature trail.

Keywords: aroid, dominant species, life form, Mae Sakut Nature Trail, transect

Morphological flower adaptations in Phyllantheae (Phyllanthaceae) due to obligate pollination by *Epicephala* moths (Gracillariidae)

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Within tribe Phyllantheae of the plant family Phyllanthaceae obligate moth pollination exists, effected by *Epicephala* moths. This is the third obligate pollination system now known, next to figs and fig wasps and *Yucca* and *Yucca* moths. It was discovered and extensively investigated by Kato and Kawakita. Female moths collect pollen from staminate flowers and pollinate the pistillate flowers after which they deposit an egg against or in the ovary. The benefits are mutual, the flowers are pollinated and develop seeds and the caterpillars can feed on part of the seeds and have shelter. The moths, from a family of leaf miners, have developed the mutual relationship at least five times independently within the Phyllantheae. The Phyllantheae, mainly the genus *Phyllanthus* sensu lato, but also *Breynia* and *Glochidion*, all present in Thailand, are annual herbs to big trees that have as a typical feature unisexual flowers usually (mixed) in axillary fascicles. For part of *Breynia*, and the whole of *Glochidion*, it is now known that they are moth pollinated. Phylogenetic reconstructions show that both groups are embedded within other genera, but were recognised as distinct because of differently shaped flower structures. This talk will show that the likely morphological flower adaptations to moth pollination are largely similar in all the different groups of Phyllantheae. The moths locate the flowers by olfactory stimuli, different for staminate and pistillate flowers, and often typical per plant species. The system exhibits several unexpected reversals, also present in Thailand.

Keywords: *Breynia*, *Glochidion*, moth pollination, mutualism, *Phyllanthus*, seed, unisexual flowers

Floral visitor observation and histochemistry of two floral secretory structures in *Blinkworthia lycioides* (Convolvulaceae)

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Insects play an important role in pollination, particularly for most angiosperms. Plants in the family Convolvulaceae are mainly considered to be pollinator-dependent due to the appearance of showy flowers and the existence of nectar secreting structures. *Blinkworthia lycioides* Choisy has unique flowers that are less showy than most other morning glory species and we still lack information about its pollinators. Therefore, the aims of this study were to observe the floral visitors of *Blinkworthia lycioides* and investigate chemical groups produced in two secretory structures, viz. the nectary disk, and staminal trichomes. This study was carried out in three localities, one each in Kanchanaburi province, Chiang Mai province, and Sa Kaeo province in Thailand. The visitation rates of potential insect pollinators were determined by recording the flowers via an action camera. Moreover, the first author used histochemical techniques to examine the presence of four chemical groups in the floral secretory structures, which were lipids, terpenes, flavonoids and polysaccharides. The results show that insects within the order *Hymenoptera* were the most common visitors, although other floral visitors were also observed, including taxa from *Araneae*, *Diptera*, *Lepidoptera*, and *Orthoptera*. Additionally, all chemical groups were found to be present in both the nectary disk and staminal trichomes. The findings from this study improve our understanding of the interactions between insects and flowers of *Blinkworthia lycioides* and can help with evaluating its status for further management in terms of conservation and sustainable uses.

Keywords: Morning Glory, phytochemistry, plant-insect interaction, pollination ecology

Synopsis of the genus *Erycibe* (Convolvulaceae) in mainland Southeast Asia and Singapore

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A comprehensive synopsis of the genus *Erycibe* (Convolvulaceae) in mainland Southeast Asia and Singapore is presented based on morphological study of herbarium specimens. A total of 31 taxa are recognised. A new species from Chiang Mai, Lamphun, Nan and Tak in northern Thailand is discussed. Diagnostic characters will be highlighted and an identification key to species will be presented. For each species, a morphological description, phenology, ecology, species distribution and preliminary IUCN conservation assessments will be provided.

Keywords: Erycibeae, new species, plant taxonomy, systematics

Taxonomy of Cyanotinae (Commelinaceae) in Thailand

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A taxonomic revision of subtribe Cyanotinae Faden & D.R.Hunt (Commelinaceae – Commelinoideae – Tradescantieae) for the *Flora of Thailand* account is presented. The Cyanotinae are characterised by being succulent herbs with a single cincinnus or aggregated cincinni (inflorescences) subtended by leafy or spathaceous bracts, actinomorphic and bisexual flowers with large foliaceous bracteoles, six fertile stamens with bearded filaments, sometimes bearded styles or frequently swollen at the subterminal part, a capsule with three locules, and seeds with a punctiform hilum and terminal embryotega. Two genera, *Belosynapsis* with one species and *Cyanotis* with seven species, were recognized in Thailand. The former genus differs from the latter by having shortly pedicellate flowers held free from minute bracteoles, free petals, and non-swollen apical filaments. The position of the inflorescences, the presence of rosette leaves, the features of cauline leaves, the indumentum of the plants, the numbers of flowers and bracteoles in cincinni, and the seed surface sculpturing are particularly useful characters for identifying the *Cyanotis* species. *Cyanotis* cf. *fasciculata* (B.Heyne ex Roth) Schult. & Schult.f. could be a new record for Thailand but further investigation is required.

Keywords: *Belosynapsis*, Commelinoideae, *Cyanotis*, revision, taxonomy

Preliminary studies on the phylogeny and taxonomy of Commelinaceae in Thailand

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The monocot family Commelinaceae is distributed mainly in the tropics. Previous studies by various authors showed the family to comprise 41 genera and 650 species with 13 genera and 52 species in Thailand. A recent study has reorganised the family into two subfamilies, six tribes, seven subtribes and 37 genera. Based on the previous studies and our recent surveys, there are c. 60 species of Commelinaceae in Thailand, including some undescribed species. They are distributed between one subfamily (Commelinoideae), three tribes, four subtribes and 11 genera. Tribe Streptolirieae includes *Streptolirion* (one sp.), *Spatholirion* (two spp.) and *Aetheolirion* (one sp.). Tribe Tradescantieae includes *Cyanotis* (seven spp.) in subtribe Cyanotinae and *Amischotolype* (10 spp.) in subtribe Coleotrypinae. Tribe Commelineae includes *Aneilema* (one sp.), *Commelina* (10 spp.), *Pollia* (five spp.), and *Dictyospermum* (two spp.) in subtribe Commelininae together with *Floscopa* (one sp.) and *Murdannia* (19 spp.) in subtribe Murdanniinae. Some species show cpDNA variation which is supported by morphological differences, especially in *Amischotolype*, *Commelina*, and *Murdannia*. Whether these findings should result in the recognition of distinct taxa is still being investigated. Among them, a formal description of a new species of *Commelina* from western Thailand (Kanchanaburi), is currently in preparation.

Keywords: Commelinid, new species, revision, subtribe, taxonomy, tribe

Morpho, phylo, and eco: The Three Musketeers of Systematics – Revisiting the savanna-dominating genera *Heteropogon* and *Themeda* (Poaceae: Andropogoneae)

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Species delimitation is crucial to enable species to be compared across various biological disciplines. However, problems arise in the delimitation of species due to various factors: complexity of organisms (e.g., cryptic species), insufficient criteria to define species, biased usage of biological data, or lack of proper methodology for the data. Biological data (e.g., morphology, molecular data and ecological data) are separately applied in several taxonomic/systematic studies; however, biological data should be incorporated to explain underlying speciation processes. *Heteropogon* and *Themeda* are dominant genera of savanna grasses and frequent subjects in evolutionary and ecological studies. Yet, species delimitation within these genera is not well established. Previous taxonomic and systematic revisions depended exclusively on morphology to delimit species due to insufficient molecular and ecological data. However, the use of such limited criteria may not be sufficient to clarify species complexes. The pantropical species *Heteropogon contortus* (L.) P.Beauv. and *Themeda triandra* Forssk. may rather be species complexes that include morphologically similar endemic or narrowly distributed species. Here, integrative approaches using morphological, phylogenetic and ecological data provide robust species delimitation in the *Heteropogon-Themeda* group. Inflorescence architecture, spikelet characteristics and vegetative parts are consistent with phylogenetic and ecological evidence. New findings suggest that *Heteropogon* sensu stricto comprises three species: *H. contortus*, *H. polystachyos* (Roxb.) Schult. and *H. triticeus* (R.Br.) Stapf ex Craib, as supported by morphology, phylogenetic analyses and ecological data. The other two *Heteropogon* species, *H. melanocarpus* (Elliott) Benth. and *H. ritchiei* (Hook.f.) Blatt. & McCann, belong to the *Themeda* lineage based on congruent evidence from inflorescence morphology and phylogenetic position. The hyperdominant species *Heteropogon contortus* and *Themeda triandra* are each considered single species with variations in glume hairiness and inflorescence structure, phylogenetically intermixing, and with continuous climatic niche occupation. Furthermore, some apparently-endemic species are combined and treated as subspecies due to indistinguishable biological data. This integrative method improves our understanding of morphological and ecological diversity in relation to the species boundaries of these savanna grasses.

Keywords: *Heteropogon contortus*, *Heteropogon melanocarpus*, *Heteropogon polystachyos*, *Heteropogon ritchiei*, *Heteropogon triticeus*, pantropical species, species delimitation, *Themeda triandra*

A quest to understand the morphological and cytological variation in *Curcuma* subg. *Hitcheniopsis* (Zingiberaceae)

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The Indochinese floristic region is a known centre of diversity of the genus *Curcuma* (Zingiberaceae). Recent extensive work in herbaria combined with field exploration of the region has resulted in descriptions of more than 20 new species, mainly from Thailand, in the last five years, confirming the incredible richness of *Curcuma* there. One of its three subgenera, *Curcuma* subg. *Hitcheniopsis*, has its centre of diversity in Thailand. The 27 currently recognised species represent only about 20% of the total *Curcuma* diversity yet are morphologically the most diverse in vegetative and floral morphology. However, some of the species seem to be poorly delimited. The high variability and a suspicion of the existence of cryptic species in the *Curcuma parviflora* complex was previously highlighted based on herbarium studies, with several separate species subsequently recognised based on living flowering material. Interestingly, the chromosome numbers recorded so far are also highly variable within *Curcuma* subg. *Hitcheniopsis* and even within a single species. The mechanisms that are causing this variation likely differ from those acting in *Curcuma* subg. *Curcuma* (i.e., polyploidy) but are poorly understood. Interspecific hybridisation between species of this subgenus which grow sympatrically has been observed. We therefore suspect that hybridisation, and possibly also aneuploidy, may play a role in speciation processes in *Curcuma* subg. *Hitcheniopsis*. Following previous case studies in *Curcuma* subg. *Curcuma*, our current work aims to better understand speciation processes and species boundaries in *Curcuma* subg. *Hitcheniopsis* by combining NGS (target sequencing) data and cytogenetic approaches based on thorough sampling between and within species. With the support of a robust phylogeny, we plan to thoroughly explore chromosome numbers through a broad sampling of populations of species in the *Curcuma parviflora* Wall., *C. thorelii* Gagnep., *C. involucrata* (King ex Baker) Škorničk and *C. rhabdota* Sirirugsa & M.F.Newman alliances to establish if some of the chromosome numbers might be specific to the newly described species.

Keywords: aneuploidy, chromosome number, cryptic species, hybridisation, phylogeny, polyploidy, speciation

Phylogeny and species delimitation of the genus *Ophiopogon* (Asparagaceae) based on chloroplast and nuclear genomes

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The genus *Ophiopogon* (Asparagaceae) includes about 65 species, distributed in temperate to tropical regions of East Asia and Southeast Asia. They are perennial evergreen herbs with fruits that split irregularly at an early stage of development to expose seeds with a sarcotesta. As the range of morphological variation of some presently recognised *Ophiopogon* species (e.g., *O. intermedius* D.Don and *O. siamensis* M.N.Tamura) is too wide to identify the species precisely, the identification of *Ophiopogon* species is quite controversial. Further, as most diagnostic characters for *Ophiopogon* species are in the flowers and the flowering period is much shorter than the fruiting period, it is often difficult to identify the species, especially in the field. Possibly due to the difficulty of identification, molecular phylogenetic studies of *Ophiopogon* are few. In the present study, we analysed both chloroplast and nuclear genome data for *Ophiopogon* species. We used Sanger sequencing and constructed a maximum likelihood phylogenetic tree for the chloroplast and the MIG-seq (Multiplexed ISSR Genotyping by sequencing), a PCR-based genome-wide sequencing method amplifying multiplexed ISSR (inter-simple sequence repeat) regions by next-generation sequencing, for the nuclear genome analyses. The results of this work shall be presented.

Keywords: next-generation sequencing, *Ophiopogon intermedius*, *Ophiopogon siamensis*, Sanger sequencing, variation

Distribution of *Thismia* species (Thismiaceae), mycoheterotrophic herbs in Peninsular Malaysia

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Thismia is a genus of tiny mycoheterotrophic monocot plants found primarily in tropical and subtropical forests. There are c. 95 described species, with 37 in Malaysia, 20 in Borneo (Sabah and Sarawak), and 19 in Peninsular Malaysia. Two species are found in both Borneo and Peninsular Malaysia. Seven species found in Peninsular Malaysia are shared with Thailand, and two with Singapore. Most of the Peninsular Malaysian species are only known from their type localities and several have only ever been seen by their discoverers, in extreme cases only from a single individual. Five Peninsular Malaysian species are widespread throughout the Malay Peninsula. *Thismia* species are typically considered extremely rare and narrowly endemic. However, because of their inconspicuous appearance and ephemeral growth, they may be overlooked in the field. Progress on a revision of the family Thismiaceae for the *Flora of Peninsular Malaysia* project is presented.

Keywords: endemic, *Flora of Peninsular Malaysia*, monocot

Posters

Two newly discovered Thai *Derris* species (Fabaceae)

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Derris is one of the most problematic genera in the tribe Millettieae (Fabaceae). According to the 2020 account in the *Flora of Thailand*, there are 17 species in Thailand. However, unknown specimens from Thailand continue to be discovered. Two previously unknown taxa that can be distinguished in both morphology and molecular phylogenetic analyses have recently been found and will be described as new species. One of them is only the third known calciphilous species in the genus, found on a limestone hill in Ratchaburi province (South-Western Thailand). Even though this species is extremely similar to *Derris solorioides* Sirich. & Adema in its vegetative characters, it is distinct in fertile characters. It has the longest (up to c. 150 cm) hairy pseudoraceme-pseudopanicle inflorescence with the highest number of flowers per brachyblast (up to 16 flowers) which have ever been recorded in the genus. The second species is found in Peninsular Thailand. It is morphologically most similar to *Derris pubipetala* Miq. but differs from this and all other *Derris* species in the region in, for example, the presence of a reddish midrib in the mature leaflets, sparsely hairy filaments, and presence of prominent hairs at the base of the anthers. Anatomical characters have also been surveyed in Thai *Derris*. The leaf epidermal characters of the two new species are not taxonomically significant, being similar to other *Derris* species, but they are distinct in transverse sections of the leaflets when surveyed for characters such as the presence of glandular trichomes, bicellular trichomes, and accumulation of darkly coloured substances in the palisade mesophyll cells.

Keywords: brachyblast, Millettieae, molecular phylogeny, morphology, new species, trichome

Distinguishing characters of Thai *Chloris* and *Cynodon* species

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Chloris and *Cynodon* belong to Poaceae, tribe Cynodonteae, subtribe Eleusininae. *Chloris* comprises 63 species distributed mainly in warm regions of the world, six of which have been recognised in Thailand; *Cynodon* contains 12 species distributed in Old World tropic regions, three of which have been recorded for Thailand. Both genera are characterised by their digitate or subdigitate spike and one fertile floret in each spikelet. *Chloris* is further characterised by having one fertile floret spikelet with one or two reduced florets or with a naked rhachilla extension and with all florets awned. The presence of a common axis, the number of awns and the length of the rhachilla internode between the first and the second florets are used to distinguish the Thai *Chloris* species. *Cynodon* is characterised by its one fertile floret spikelet with reduced or absent distal floret and all florets are awnless. The distinctive characteristics for species identification of Thai *Cynodon* species are the presence of a common axis, the length of the digitate spike and the length of the rhachilla extension.

Keywords: Cynodonteae, Eleusininae, grass

Functional ecology of external secretory structures in *Rivea ornata* (Convolvulaceae) as interpreted from micromorphology and histochemistry

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Rivea ornata (Roxb.) Choisy is the only species of a small genus *Rivea* (Convolvulaceae) that is native to Thailand, but its occurrence in the country is seemingly rare. The plants possess external secretory organs that are taxonomically significant and may have ecological-associated roles. This study, therefore, aimed to investigate five secretory structures, i.e., nectary disc, petiolar nectaries, calycinal glands, staminal hairs, and foliar glands, using approaches of micromorphology, histochemistry, and plant-animal interaction, in order to assess the contributions of these structures on functional ecology. Light and scanning electron microscopies demonstrated that the nectary disc and petiolar nectaries were complex units consisting of the epidermis, ground tissue, and vasculatures, while the other structures were only glandular trichomes. The results of histochemical assays revealed that various groups of metabolites (lipids, phenolic compounds, polysaccharides, terpenoids, flavonoids, and alkaloids) were detected in all structures, and starch grains were only found in tissues related to the nectary disc and petiolar nectaries. Integrating preliminary observations of animal visitors, two hypotheses concerning the functions of the examined secretory organs were established for this species: (1) a role in pollination was found for the nectary disc and staminal hairs as they potentially attracted and rewarded floral visitors (e.g., hawk moths, skipper butterflies, and cockroaches) and (2) defense mechanisms were found in the petiolar nectaries, calycinal glands, and foliar glands, with possibilities varying from self-protection from herbivores via guarding ants or plant metabolites to the prevention of tissue damage from dehydration and insolation.

Keywords: anatomy, plant-animal interaction, plant defense, pollination

Preliminary study on comparative anatomy and systematics of tribe Vernonieae (Asteraceae) in Thailand

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Tribe Vernonieae is a member of the subfamily Cichorioideae in the Asteraceae, comprising c. 1500 species worldwide. This tribe has been classified into two lineages corresponding to Old World and New World taxa, and is likely to have originated in southern Africa and Madagascar. The morphological characters of this tribe are highly variable and overlapping, with few synapomorphic characters, resulting in problems when attempting to classify taxa from the subtribal to species level. This has created difficulties in providing a robust circumscription of the genera within the tribe. In Thailand, 17 genera and 48 species are recognised in four subtribes based on morphological characters: Centrapalinae, Erlangeinae, Gymnantheminae and Elephantopinae. However, the Thai species belonging to Centrapalinae, Erlangeinae and Gymnantheminae are morphologically different from the African taxa, sowing doubt as to the taxonomic status of the subtribes and the relationships within the tribe. To better understand this variation, anatomical characters were surveyed and, with the morphological characters, were used to help clarify the taxonomy of the tribe Vernonieae in Thailand.

Keywords: Cichorioideae, Compositae, plant anatomy, systematics

An overview of *Murdannia* (Commelinaceae) in Thailand

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An account of *Murdannia* in Thailand based on field collections, literature study and the examination of herbarium specimens from Thai and international herbaria (i.e., AAU, BK, BKF, K, KKU and QBG) is nearing completion. The genus is one of the largest genera in Commelinaceae and is widely distributed in tropical and subtropical regions, mainly in Asia. *Murdannia* is distinguished from other members of the family by its bearded filaments, 2−3 fertile stamens, 3−4 staminodes and pedicellate flowers. In Thailand, 18 species have been enumerated, three of which, *Murdannia clandestina* (Ridl.) Faden *M. divergens* (C.B.Clarke) G.Brückn. and *M. pauciflora* G.Brückn. are reported as new records. So far, two unknown species have been discovered. A revised checklist of the Thai *Murdannia* is presented.

Keywords: key, new record, revision

Current taxonomic understanding of the genus *Strobilanthes* and allied genera (Acanthaceae) in Thailand

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The Acanthaceae genera *Diceratotheca*, *Dyschoriste*, *Eranthemum*, *Phaulopsis*, *Sanchezia* and *Strobilanthes* have been revised for the *Flora of Thailand.* The revision was based on extensive field observations in Thailand, the examination of herbarium specimens, including type materials, from many herbaria (i.e., AAU, BCU, BK, BKF, BM, C, CMU, CMUB, FHO, G, GZU, K, KKU, KYO, K-W, L, LD, M, P, PSU and QBG), and the consultation of protologues and other taxonomic literature. A total of six genera in the *Strobilanthes* alliance are recognised, comprising c. 93 species. The genera *Diceratotheca*, *Dyschoriste*, *Phaulopsis* and *Sanchezia* are represented by one species each. *Eranthemum* has six species, two of which are newly recorded for Thailand, and one species, *E. decumbens* Kladwong & Chantar., is new to science. There are c. 83 species of *Strobilanthes* in Thailand, five of which are new species and 17 are new records. Most species of these genera are native although some species such as *Eranthemum pulchellum* Andrews, *Sanchezia parvibracteata* Sprague & Hutch. and *S. reptans* (G.Forst.) Moylan ex Y.F.Deng & J.R.I.Wood are introduced and cultivated as ornamental plants. Twelve species are endemic to the country, one in *Diceratotheca* (*D. bracteolata* J.R.I.Wood & Scotland) and 11 in *Strobilanthes* (*S. articulata* J.B.Imlay, *S. bilabiata* J.R.I.Wood, *S. chiangdaoensis* Terao, *S. consors* C.B.Clarke, *S. corrugata* J.B.Imlay, *S. fragrans* J.R.I.Wood, *S. graminea* J.B.Imlay, *S. maxwellii* J.R.I.Wood, *S. phyllocephala* J.R.I.Wood & Scotland, *S. ranongensis* Terao and *S. rivularis* J.R.I.Wood & J.R.Benn.).

Keywords: endemic, floristic, new record, new species

The Malvaceae-Grewioideae in Thailand

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As the four previously recognised plant families Bombacaceae, Malvaceae, Sterculiaceae and Tiliaceae are not all monophyletic, they are now best classified together in a single family, Malvaceae sensu lato. Malvaceae sensu lato comprises nine subfamilies. The Thai genera of the former Tiliaceae are now placed into three subfamilies, Brownlowioideae, Dombeyoideae and Grewioideae. The pantropical Grewioideae is characterised by having a leaf-opposed inflorescence, sepals without nectaries at the ventral base, nectaries on the clawed petal or on the androgynophores, and numerous, often free, dithecal stamens. Six genera of subfam. Grewioideae have been recorded in Thailand: *Colona*, *Corchorus*, *Grewia*, *Microcos*, *Trichospermum* and *Triumfetta*. These genera (along with the other Thai genera of the former Tiliaceae) were last revised in 1993 but are in need of a new revision due to changes in taxonomic status and the discovery of new species. Some doubtful species based on morphologically variable and frequently misidentified specimens are discussed. A practical morphological character for identification is also mentioned.

Keywords: enumeration, Malvaceae sensu lato, morphology, taxonomy, Tiliaceae

Plant diversity of a natural mangrove forest, Rama IX International Mangrove Botanical Garden, Chanthaburi Province, Thailand

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Mangrove forests provide several valuable ecosystem services which contribute to human well-being, including tidal regulation, food and building materials. Some are also culturally important or provide opportunities for recreation and education. At present, most Thai mangroves are deteriorating, particularly due to the conversion of land to aquaculture with consequent physical and chemical impacts on soil and water, leading to changes in biology and impacts on ecosystem balance. The Rama IX International Mangrove Botanical Garden project in Chanthaburi province is in one of the areas that has been transformed from a rich mangrove ecosystem to an aquaculture area. Subsequently, government agencies have taken action to recover the area and work with various community groups to gradually restore the mangrove ecosystem. A study on plant species diversity at this site was carried out between June 2021 and April 2022 with 37 square plots (10×10 m^2) along a gradient from the river onto land in a direction perpendicular to the river. Fifty-three specimens were collected from the plots and identified as 28 species from 21 genera and 14 families. This is the first reported study of plant diversity in this mangrove ecosystem. The results will be useful for the planning and management of the Rama IX International Mangrove Botanical Garden.

Keywords: ecosystem services, plots

Comparative leaf anatomy of the genus *Canthium* sensu lato (Rubiaceae: Vanguerieae) in Thailand

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The leaf anatomical characteristics of *Canthium* sensu lato (Rubiaceae) species in Thailand were studied. Seventeen species in four genera, comprising nine species of *Canthium* sensu stricto, two species of *Canthiumera*, three species of *Meyna*, and three species of *Psydrax*, were investigated. Epidermal peels were stained with safranin and transverse sections of leaves were prepared by the paraffin method and stained with safranin and fast green. The anatomical data cluster similarity analysis was examined using R and R studio program statistics. The cluster dendrogram resulted in a cophenetic correlation coefficient of 0.95. The results showed that leaf anatomical features could be used to categorise the examined plants into two groups based mainly on the number of palisade mesophyll layers. The first group, with only one palisade mesophyll layer, correlates with the thorny plant group. This group can be further separated into two subgroups by leaf type: hypostomatic leaves in the genus *Canthium* sensu stricto, and amphistomatic leaves in the genus *Meyna*. The second group, with multiple palisade mesophyll layers, is congruent with the thornless plant group. This group can be separated into two subgroups based on the presence/absence of a hypodermis. A hypodermis is present in *Psydrax* and absent in *Canthiumera*. Leaf anatomical evidence in the *Canthium* complex is entirely congruent with the morphological characters used to define *Canthium* sensu stricto, *Canthiumera*, *Meyna* and *Psydrax*.

Keywords: *Canthiumera*, epidermal peel, hypodermis, *Meyna*, *Psydrax*

DNA barcoding of endemic, rare, endangered and valuable plant species in Thailand using the chloroplast gene, *matK*

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DNA barcoding of endemic, rare, endangered and valuable plant species in Thailand provides information for comparative and classification studies, and species identification. The objective of this study is to use nucleotide sequence regions that are suitable for species identification. Fifty-eight samples from 21 localities were collected. A 550 bp region of *matK* was sequenced representing 51 species across 43 genera and 29 families. The DNA nucleotide data were used to construct a phylogenetic tree using the Neighbor-Joining method in MEGA 11. The phylogeny supports the identification of various threatened tree species.

Keywords: cpDNA

Boraginaceae sensu APG for the *Flora of Thailand*

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According to APG IV, the Boraginaceae sensu lato consists of c. 135 genera and 2535 species of largely tropical trees and shrubs, although herbaceous genera are common in the Mediterranean region and warm-temperate Asia. Twelve genera and 49 species are recognised in Thailand. *Cordia* and *Ehretia* are the largest genera with 16 and 10 species respectively. *Euploca* and *Tournefortia* each have five species, *Cynoglossum* and *Trichodesma* each have three species, *Heliotropium* has two, and *Carmona*, *Coldenia*, *Maharanga*, *Onosma* and *Rotula* each have one species. Revisions of all the genera except *Cordia* are more or less complete. One unknown specimen of *Ehretia* is possibly an undescribed species.

Keywords: Boraginales, distribution, morphology, taxonomy

Ethnobotany of Karen in Le Tong Ku, Tak Province, Thailand

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Ban Le Tong Ku is a Karen village located in the Umphang Wildlife Sanctuary, Tak. The inhabitants consist of Pwo and Sgaw Karens. Though each has its own culture and traditions, both practice the same Talaku faith, which is a different belief system to that found in other Karen villages elsewhere in Thailand. Therefore, it is of interest to study whether their knowledge of plant uses is the same or not. Our research objectives were to (1) record ethnobotanical knowledge in Ban Le Tong Ku, (2) to quantify the ethnobotanical knowledge and important plant use, and (3) to investigate factors affecting traditional plant use knowledge and knowledge erosion. Thus far, three ethnobotanical surveys conducted by the walk-in-the-wood method were carried out in December 2021 and February and April 2022 with four key informants (two Pwo's and two Sgaw's).

In total, 117 plant specimens used by Pwo were collected, representing 84 species from 82 genera and 52 families. For those used by the Sgaw, 104 plant specimens belonging to 68 species from 66 genera and 42 families were collected. Arecaceae, Asteraceae, Euphorbiaceae, Fabaceae, Malvaceae and Rubiaceae were the families with most species used by both Karen groups. Trees and shrubs were common among the documented species. Leaves were commonly used by both Karen groups. Most of the collected plants were used for food and traditional medicine. Plants or their parts are consumed either uncooked or, when cooked, as a concoction of plant parts. Pwo and Sgaw have common traditional plant use knowledge for as many as 33 species, e.g., the seeds of *Areca catechu* L. for betel nuts, the tubers of *Amorphophallus muelleri* Blume for food, and the rhizomes of *Tacca chantrieri* André as a remedy for toothache. Remarkably, house roofs in Le Tong Ku are thatched with *Calamus arborescens* Griff. leaves, which are different from houses of other Karen communities, which in northern Thailand are made of *Imperata cylindrica* (L.) P.Beauv. leaves. From these three field explorations, it is evident that changes in livelihood, e.g., compulsory education, language shifts, modernised healthcare practice, household vocation, food availability, conversion to Christianity, and the loss of faith in hermit practices, may affect the traditional plant use knowledge in both Karen groups.

Keywords: Pwo, Sgaw, traditional plant use knowledge, Umphang Wildlife Sanctuary

Anatomical evidence reveals differentiation within a population of *Laggera* species (Asteraceae) in Thailand

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Two species of *Laggera* are reported for Thailand, *L. alata* (D.Don) Sch.Bip. ex Oliv. and *L. crispata* (Vahl) Hepper & J.R.I.Wood. Although they are distinct in stem wing characters (entire wing in *L. alata* and deeply incised wing in *L. crispata*), various stem wing patterns have been found in populations of *L. crispata*, defined as Types A, B, C, D, E and F. To clarify the taxonomic status of these patterns, a comparative anatomical study of the six morphological types of *Laggera crispata*, as well as one morphological type of *L. alata*, was conducted. Based on the anatomical characters, the plants could be distinguished into three groups. Group I consists of *Laggera alata* plants and is characterised by sessile multicellular multiseriate glandular trichomes, curly multicellular uniseriate non-glandular trichomes and a dorsiventral mesophyll. Group II includes plants of *Laggera crispata* with wing types A–D and is characterised by short-stalked multicellular biseriate glandular trichomes. Finally, Group III includes plants of *Laggera crispata* with wing types E and F and is characterised by short-stalked multicellular biseriate glandular and straight multicellular uniseriate non-glandular trichomes, these being markedly different from those of Group II. However, Groups II and III share many morphological characters although Group III has some characters intermixed between *Laggera alata* and *L. crispata*. More information is required before it can be concluded whether Group III should be recognised as a variety under *Laggera crispata* or whether these plants may be a hybrid between *L. alata* and *L. crispata*.

Keywords: Compositae, *Laggera alata*, *Laggera crispata*, taxon delimitation

Species delimitation of *Argyreia breviscapa* (Convolvulaceae) in Thailand

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Argyreia is a large genus belonging to the bindweed family (Convolvulaceae). In Thailand, more than 40 species, or almost one-third of all *Argyreia* species, have been reported. However, several species are similar in morphology, leading to difficulties in identification. Although some problem species have been resolved, there are still several species that remain unclear. *Argyreia breviscapa* (Kerr) Ooststr. is found in dry dipterocarp forest in the Indochinese region. In general, this species is characterised by whitish, tubular-funnelform corollas and broadly ovate outer bracts. However, variation in some morphological characters, such as leaf shape, bract shape and flower form, are observed in different populations within their natural habitat. This observation led to the question of what the true *Argyreia breviscapa* morphology should be. The aim of this study was to investigate the species delimitation of *Argyreia breviscapa* using two phenetic analyses: principal component analysis (PCA) and cluster analysis (CA). From examining 15 populations of *Argyreia breviscapa*, the two methods revealed two distinct groups. One group clearly matches the protologue of *Argyreia breviscapa*, and the other group is currently undergoing further examination to determine its taxonomic status.

Keywords: classification, cluster analysis, phenetic analysis, plant taxonomy, principal component analysis

Botanical exploration of Gunung Ulu Temin and Gunung Tan Hain in the Royal Belum State Park, Perak, Malaysia

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The Royal Belum State Park (RBSP) is located in Hulu Perak, Malaysia, and was officially gazetted as State Park on 3rd May 2007. It is bordered by the Hala Bala Wildlife Sanctuary and the Bang Lang National Park, in Yala province, Thailand, to the north. The Royal Belum State Park is an important tropical rainforest, home to various rare species. In recent years, the RBSP has been preparing for nomination as a UNESCO World Heritage Site, under the Natural Heritage category. Several scientific studies have therefore been organised, including botanical expeditions to poorly known areas such as Gunung Ulu Temin (1424 m) and Gunung Tan Hain (1500 m), both in north-western RBSP. A general botanical survey following existing tracks was conducted in March 2022 to document the diversity of vascular plants and forest types of the two mountains. This resulted in a total of 618 herbarium collections of flowering and fruiting plants in 110 families and 213 genera based on preliminary results. Most collections belong to the Rubiaceae, Dipterocarpaceae, and Palmae/Arecaceae. Details of the plant diversity and forest types from this botanical study will not only contribute to the dossier of the nomination of the RBSP as a UNESCO World Heritage Site but will also further enrich the existing collections of the Kepong herbarium (KEP). The baseline data is also important for biodiversity conservation management, the development of education and nature-based tourism programs in the RBSP, and for use in biogeographical studies in the Malaysia/Thailand border region.

Keywords: Peninsular Malaysia, species

The science behind NParks' *Flora & Fauna Web*

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Plant taxonomy is a complex technical topic that depends on domain knowledge to be fully appreciated and utilised. Science communication helps to provide this by synthesising, simplifying and re-packaging complex data (often in innovative ways) to make it more accessible, more interesting and more useful to the general public. The National Parks Board's (NParks') *Flora & Fauna Web* is a good example. Launched in 2008 and continuously updated, it is a user-friendly one-stop information portal that allows users to search for information on both plants grown in this region and animals that can be found in Singapore. It caters to growing horticultural interest and biodiversity awareness in Singapore by translating and consolidating research and technical knowledge on native and exotic plants, including morphology, taxonomy, geography, ecology, conservation statuses and propagation notes, into useful and comprehensive information for public consumption.

Keywords: database, horticulture, information portal, outreach, science communication, Singapore

Mapping habitat suitability of *Sirindhornia* orchids in Thailand under climate change

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Sirindhornia orchids comprise three species in Thailand, of which two are local endemics, *S. mirabilis* H.A.Pedersen & Suksathan and *S. pulchella* H.A.Pedersen & Indham., and the third is the widespread *S. monophylla* (Collett & Hemsl.) H.A.Pedersen & Suksathan. Because of their restricted distribution on limestone mountains, these orchids are threatened by habitat degradation and from over-collection. Species distribution modelling (SDM) can be used to assess habitat suitability under climate change scenarios. MaxEnt was used to predict the potential current and future (2050 and 2070) suitable habitats using the HadGEM2-ES general circulation model and one Representative Concentration Pathway scenario (RCP 2.6). The results indicated that habitat suitability would potentially expand and there would be a shift into the north and west in the future, although whether dispersal would be possible or not is another question. According to habitat suitability maps, Mean Temperature of Wettest Quarter (BIO8), Precipitation of Warmest Quarter (BIO18), and Mean Diurnal Range (BIO2), were found to be the most important climatic variables influencing the distribution in the current period while Mean Temperature of Wettest Quarter (BIO8) was found to be the most important climatic variable influencing the distribution in both future periods.

Keywords: general circulation model, habitat suitability, MaxEnt, maximum entropy modelling, Representative Concentration Pathway, species distribution modelling