sucipto hariyanto <sucipto-h@fst.unair.ac.id>

[biodiv] Submission Acknowledgement

1 message

Ahmad Dwi Setyawan <smujo.id@gmail.com> Wed, Sep 18, 2019 at 6:47 AM
Reply-To: Ahmad Dwi Setyawan <editors@smujo.id>
To: Sucipto Hariyanto <sucipto-h@fst.unair.ac.id>

Sucipto Hariyanto:

Thank you for submitting the manuscript, "Variations in seed micromorphology and morphometry of native Indonesian Orchids Phalaenopsis and Paphiopedilum" to Biodiversitas Journal of Biological Diversity. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

Submission URL: https://smujo.id/biodiv/authorDashboard/submission/4466
Username: hariyanto

If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

Ahmad Dwi Setyawan

Biodiversitas Journal of Biological Diversity

sucipto hariyanto <sucipto-h@fst.unair.ac.id>

[biodiv] Editor Decision

2 messages

Smujo Editors <smujo.id@gmail.com> Fri, Oct 18, 2019 at 1:25 PM
Reply-To: Smujo Editors <editors@smujo.id>
To: Sucipto Hariyanto <sucipto-h@fst.unair.ac.id>

Sucipto Hariyanto:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Variations in seed micromorphology and morphometry of native Indonesian Orchids Phalaenopsis and Paphiopedilum".

Our decision is: Revisions Required

Smujo Editors
editors@smujo.id

Reviewer C:
Recommendation: Revisions Required

Reviewer G:

1.Title - change to "Variations in seed micromorphology and morphometry of native Indonesian Phalaenopsis and Paphiopedilum orchid.

2.p48 - plant material change to "plant materials"

3.Figure 1 - It looks like no embryo in several seeds, including B, C, E, J.

4.Fig. 2-11 - Too many figures. Combine them into one panel.

5.There is a lack of significant difference between means in all data.

6.The authors claim that "the results of the study indicate that morphological and morphometric features can serve to identify live forms and distinguish between species and phylogeny", but how to use them to identify these species of orchids? Please specify at least one example in detail.

7.M&M - Please describe the maturaty of capsules in detail, e.g. how long is the period from pollination to maturation, morphology and size, etc.

Recommendation: Revisions Required

Biodiversitas Journal of Biological Diversity

C-Edit_4466-Article Text-11784-1-4-20190920 (1).doc

3094K

---

sucipto hariyanto <sucipto-h@fst.unair.ac.id> Mon, Nov 11, 2019 at 9:28 PM
To: Smujo Editors <editors@smujo.id>

Dear Smujo Editors,
I apologize for the delay in completing the revision in accordance with the reviewer recommendations.

Following, I send an article that I have revised and a list of revisions / answers from the review (attached),

besides that I have also sent via the system (smujo).

Hopefully it is in accordance with the editor and review

Best regards,
Sucipto Hariyanto

[Quoted text hidden]

---

2 attachments

C-Edit_4466-Article Text-11784-1-4-20191019 (1) (f).doc
13888K

List of Revisions 20191019.docx
22K

sucipto hariyanto <sucipto-h@fst.unair.ac.id>

[biodiv] New notification from Biodiversitas Journal of Biological Diversity

1 message

Smujo Editors <smujo.id@gmail.com> Thu, Nov 14, 2019 at 5:12 PM
Reply-To: Smujo Editors <editors@smujo.id>
To: Sucipto Hariyanto <sucipto-h@fst.unair.ac.id>

You have a new notification from Biodiversitas Journal of Biological Diversity:

You have been added to a discussion titled "Uncorrected Proof" regarding the submission "Variations in seed micromorphology and morphometry of native Indonesian Orchids Phalaenopsis and Paphiopedilum".

Link: https://smujo.id/biodiv/authorDashboard/submission/4466

Ahmad Dwi Setyawan

Biodiversitas Journal of Biological Diversity

UNTUK INDONESIA ADIL & BERADAB

sucipto hariyanto <sucipto-h@fst.unair.ac.id>

[biodiv] New notification from Biodiversitas Journal of Biological Diversity

2 messages

DEWI NUR PRATIWI <smujo.id@gmail.com> Fri, Nov 15, 2019 at 10:19 AM
Reply-To: DEWI NUR PRATIWI <biodiv07@gmail.com>
To: Sucipto Hariyanto <sucipto-h@fst.unair.ac.id>

You have a new notification from Biodiversitas Journal of Biological Diversity:

You have been added to a discussion titled "BILLING" regarding the submission "Variations in seed micromorphology and morphometry of native Indonesian Orchids Phalaenopsis and Paphiopedilum".

Link: https://smujo.id/biodiv/authorDashboard/submission/4466

Ahmad Dwi Setyawan

Biodiversitas Journal of Biological Diversity

Smujo Editors <smujo.id@gmail.com> Fri, Nov 15, 2019 at 10:47 AM
Reply-To: Smujo Editors <editors@smujo.id>
To: Sucipto Hariyanto <sucipto-h@fst.unair.ac.id>

You have a new notification from Biodiversitas Journal of Biological Diversity:

There is new activity in the discussion titled "Uncorrected Proof" regarding the submission "Variations in seed micromorphology and morphometry of native Indonesian Orchids Phalaenopsis and Paphiopedilum".
[Quoted text hidden]

sucipto hariyanto <sucipto-h@fst.unair.ac.id>

[biodiv] New notification from Biodiversitas Journal of Biological Diversity

2 messages

Smujo Editors <smujo.id@gmail.com> Sat, Nov 16, 2019 at 8:17 AM
Reply-To: Smujo Editors <editors@smujo.id>
To: Sucipto Hariyanto <sucipto-h@fst.unair.ac.id>

You have a new notification from Biodiversitas Journal of Biological Diversity:

There is new activity in the discussion titled "Uncorrected Proof" regarding the submission "Variations in seed micromorphology and morphometry of native Indonesian Orchids Phalaenopsis and Paphiopedilum".

Link: https://smujo.id/biodiv/authorDashboard/submission/4466

Ahmad Dwi Setyawan

Biodiversitas Journal of Biological Diversity

sucipto hariyanto <sucipto-h@fst.unair.ac.id> Sat, Nov 16, 2019 at 1:11 PM
To: Smujo Editors <editors@smujo.id>

Dear Setyawan,
Thanks you for notice to me.

Best regards,
Sucipto Hariyanto
[Quoted text hidden]

UNTUK INDONESIA ADIL & BERADAB

sucipto hariyanto <sucipto-h@fst.unair.ac.id>

[biodiv] New notification from Biodiversitas Journal of Biological Diversity

1 message

DEWI NUR PRATIWI <smujo.id@gmail.com> Sun, Nov 17, 2019 at 2:35 PM
Reply-To: DEWI NUR PRATIWI <biodiv07@gmail.com>
To: Sucipto Hariyanto <sucipto-h@fst.unair.ac.id>

You have a new notification from Biodiversitas Journal of Biological Diversity:

There is new activity in the discussion titled "BILLING" regarding the submission "Variations in seed micromorphology and morphometry of native Indonesian Orchids Phalaenopsis and Paphiopedilum".

Link: https://smujo.id/biodiv/authorDashboard/submission/4466

Ahmad Dwi Setyawan

Biodiversitas Journal of Biological Diversity

sucipto hariyanto <sucipto-h@fst.unair.ac.id>

[biodiv] Editor Decision

2 messages

Smujo Editors <smujo.id@gmail.com> Mon, Nov 18, 2019 at 1:59 PM
Reply-To: Smujo Editors <editors@smujo.id>
To: SUCIPTO HARIYANTO <sucipto-h@fst.unair.ac.id>

SUCIPTO HARIYANTO :

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Variations in seed micromorphology and morphometry of native Indonesian Phalaenopsis and Paphiopedilum orchids".

Our decision is to: Accept Submission

Smujo Editors
editors@smujo.id

Biodiversitas Journal of Biological Diversity

Smujo Editors <smujo.id@gmail.com> Mon, Nov 18, 2019 at 2:01 PM
Reply-To: Smujo Editors <editors@smujo.id>
To: SUCIPTO HARIYANTO <sucipto-h@fst.unair.ac.id>

SUCIPTO HARIYANTO :

The editing of your submission, "Variations in seed micromorphology and morphometry of native Indonesian Phalaenopsis and Paphiopedilum orchids," is complete. We are now sending it to production.

Submission URL: https://smujo.id/biodiv/authorDashboard/submission/4466

Smujo Editors
editors@smujo.id

[Quoted text hidden]

REVIEWER RECOMMENDATIONS AND COMMENTS & RESPONSES TO REVIEWER COMMENTS

SMART UNIVERSITY

sucipto hariyanto <sucipto-h@fst.unair.ac.id>

[biodiv] Editor Decision

2 messages

Smujo Editors <smujo.id@gmail.com> Fri, Oct 18, 2019 at 1:25 PM
Reply-To: Smujo Editors <editors@smujo.id>
To: Sucipto Hariyanto <sucipto-h@fst.unair.ac.id>

Sucipto Hariyanto:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Variations in seed micromorphology and morphometry of native Indonesian Orchids Phalaenopsis and Paphiopedilum".

Our decision is: Revisions Required

Smujo Editors
editors@smujo.id

Reviewer C:
Recommendation: Revisions Required

Reviewer G:

1.Title - change to "Variations in seed micromorphology and morphometry of native Indonesian Phalaenopsis and Paphiopedilum orchid.

2.p48 - plant material change to "plant materials"

3.Figure 1 - It looks like no embryo in several seeds, including B, C, E, J.

4.Fig. 2-11 - Too many figures. Combine them into one panel.

5.There is a lack of significant difference between means in all data.

6.The authors claim that "the results of the study indicate that morphological and morphometric features can serve to identify live forms and distinguish between species and phylogeny", but how to use them to identify these species of orchids? Please specify at least one example in detail.

7.M&M - Please describe the maturaty of capsules in detail, e.g. how long is the period from pollination to maturation, morphology and size, etc.

Recommendation: Revisions Required

Biodiversitas Journal of Biological Diversity

C-Edit_4466-Article Text-11784-1-4-20190920 (1).doc
3094K

Variations in seed micromorphology and morphometry of native Indonesian Orchids *Phalaenopsis* and *Paphiopedilum*

Abstract. Seeds of ten taxa of the genera *Phalaenopsis* and *Paphiopedilum* were studied using light and scanning electron microscopy (SEM). Quantitative[WU1] characters (seed and embryo shape, seed and embryo colour, ornamentation of testa cell, testa cell wall shape) as well as quantitative data (seed and embryo length, seed and embryo width, seed and embryo volume, seed length/seed width, embryo length/embryo width, seed volume/embryo volume and air space) were analysed. Seeds of all studied taxa were fusiform in shape and had smooth testa surfaces. *Phalaenopsis* testa cells were elongated with cylindrical cell walls, while *Paphiopedilum* testa cells were polygonal with thin and flat rectangular cell walls. The shape of the embryos was generally ovoid in *Phalaenopsis* and prolate in *Paphiopedilum.* Seed colours ranged from brown to dark brown. Embryo colours varied from light yellow, yellowish brown, dark brown, black and white. Based on our investigation, there are variations in seed and embryo length, seed and embryo width, seed and embryo volume as well as the percentage of the air space, both in *Phalaenopsis* and *Paphiopedilum*. In general, the values of seed volume, embryo volume and air space in *Paphiopedilum* are higher than in *Phalaenopsis*. Together, the results of the study indicate that morphological and morphometric features can serve to identify live forms and distinguish between species and phylogeny[WU2].

Keywords: testa cell shapes, testa cell wall shapes, seed volume, seed air spaces, epiphytic versus terrestrial habitats

INTRODUCTION

Phalaenopsis Blume and *Paphiopedilum* Pfitzer are orchids whose members are very popular and are commercialised as the most traded potted and cut flower plants in the world. Wild populations are under threat of extinction due to high rates of habitat modification, deforestation, forest fires, illegal harvesting and trade as a consequence of rapid economic development, high population growth and corrupt institutions (Sodhi et al. 2004). All *Paphiopedilum* species are listed by the Conservation on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Appendix I and *Phalaenopsis* are listed in Appendix II. This is in spite of the fact that, according to the CITES, all species from the genus *Paphiopedilum* are prohibited for trade.

Seeds occupy the first rank in the life history of plants. Orchid seeds disperse, germinate and grow into mature plants, and reproduce in a suitable place on certain parts of the tree or on the ground. In general, seeds are responsible for the regeneration and distribution of a species, even playing an important role in the conservation of orchids. Verma et al. (2014) and Tsutsumi et al. (2007) explain that seed dispersal mode and seed size are important factors in regulating the growth of new populations.

Seed morphology varies greatly in shape, colour, size, volume of the embryo and testa structure, and some of these characters have been used to establish the phylogeny of species in the genus (Gamarra et al. 2008, 2010, 2015; Cela et al. 2014; Guler, 2016). In addition, some seed characters can be related to germination and dispersal, especially in their ecological adaptation (Chaudhary et al. 2014; Zhang et al. 2015). According to research by Chaudhary et al. (2014) in the *Dendrobium* orchid, the volume of the embryo and the percentage of the air space are directly related to the climate and this is reflected in seed ultrastructure.

Previous studies on the morphology of orchid seeds in tropical areas have demonstrated the importance of the seed coat, related to the taxonomy and ecology (Chase and Pippen, 1988; Tsutsumi et al. 2007; Akçin et al. 2009; Verma et al. 2012), as demonstrated with scanning electron microscopy (SEM).

Not much is known about how certain seed characteristics may correlate with ecological adaptations. The aim of this study is to reveal the qualitative and quantitative characteristics of the seeds of several species of epiphytic and terrestrial orchids native to Indonesia from different genera, thus contributing to a better understanding of the differences and similarities in their adaptation strategies for seeds in the tropics.

MATERIALS AND METHODS

Plant material and seed collection

Ten different orchid species were collected from Simanis and DD Orchids Nursery, East Java, Indonesia. The collection for the present study included *Phal. amabilis*, *Phal. tetraspis*, *Phal. bellina*, *Phal. gigantea*, *Phal. amboinensis*, *Phal. venosa*, *Paph. kolopakingii*, *Paph. liemianum*, *Paph. baccanum*, *Paph. Primulinum*; these plants were then hand pollinated during their normal period of flowering. The seeds of mature capsules [WU3]were collected between 2016 to 2019[WU4]. The capsules were washed using 10% sunlight detergent solution for 3 minutes to eliminate dust particles, then rinsed 3 times with sterile distilled water. The surface of the capsules was sprayed with 70% alcohol, put on a Petri dish, placed into a laminar flow cupboard and passed over a Bunsen flame; this was repeated 3 times. The capsule was cut into four parts transversally and longitudinally using a sterile scalpel in a sterile Petri dish. The mature seeds were released from the capsules and collected with the help of a sterile spatula. Fresh seeds were dried for at least 2 weeks [WU5]and stored in small-cap vials at 4^0C [WU6]in dry conditions. ….[WU7] All species within *Phalaenopsis* in this study are epiphytic orchids while all species within *Paphiopedilum* are terrestrial orchids.

Morphological and statistical analyses

Seed samples were observed and photographed under a Light Microscope (LM) and Scanning Electron Microscope (SEM). Our morphological parameters included seed shape (SS), seed colour (SC), seed length (SL), seed width (SW), seed length/seed width (SL/SW), seed volume (SV). For embryos, the parameters included embryo shape (ES), embryo colour (EC), embryo length (EL), embryo width (EW), embryo length/embryo width (EL/EW), embryo volume (EV), seed volume/embryo volume (SV/EV), and air space (AS). The SV (mm^3 x 10^{-3}) was calculated using the formula $2\ [\ (^{L}/2)\ (^{W}/2)^2\ (^{\pi}/3)\ ]$, where L = length, W = width, $\pi = {}^{22}/7$ and embryo volume (mm^3 x 10^{-3}) with the formula $4/3\,\pi\,(L/2)\,(W/2)^2$, where L = length, W = width (adapted from Arditti et al. 1980). The SV/EV values were calculated following the described method (Arditti et al. 1979). For calculating AS (%), the following formula was applied: (seed volume-embryo volume)/seed volume)) x 100% (adapted from Arditti and Ghani, 2000). To analyse each species statistically, we used the mean for each quantitative character.

LM study

Seeds were spread on a slide with a drop of water and covered with a cover glass. Values for SL, SW, EL and EW (at the longest and widest axis) were obtained from an average of thirty seeds and were observed for each species and measurement using a light microscope (Olympus CH 20, Olympus Japan) and standardised ocular meter. Characteristics such as SC, SS, EC and ES were observed under Tension stereomicroscope (Nikon SMZ-1, Japan). The SC and EC was described in subjective terms.

SEM study

For SEM preparations, the samples (seeds) were mounted on SEM stubs. The samples were then sputter-coated with palladium/gold (SEM coating system Q150R S mini sputter Coater). Detailed seed coat (testa cells) surface studies were conducted by observing under a Hitachi TM3000, with a filament voltage of 15 kV. The parameters considered were seed coat sculpturing and thickenings.

RESULTS AND DISCUSSION[WU8]

Qualitative character of seed and embryos

Qualitative characters were analysed by LM, and this showed the seeds [WU9]were generally uniform i.e. fusiform in shape with colours from brown to dark brown. Brown transparent seeds were found in *Phal. amabilis*, *Phal. tetraspis*, *Phal. bellina*, *Phal. gigantea*, *Phal. Amboinensis* and *Phal. venosa*. Dark brown seeds were recorded in *Paph. kolopakingii* and *Paph. liemianum*. Brown seeds were observed in *Paph. baccanum* and *Paph. primulinum* (Table 1, Figure 1). The shape of the embryos was generally ovoid in *Phalaenopsis* and prolate in *Paphiopedilum*, and embryos were distinct and present in the centre. Embryo colour in the observed species varied from light yellow, yellowish brown to dark brown, black and white. Light yellow embryos were found in *Phal. venosa*. Yellowish brown embryos were recorded in *Phal. amabilis* and *Phal. tetraspis*. Brown embryos were common in *Phal. bellina*, *Phal. gigantea and Paph. kolopakingii*. Dark brown embryos were found in *Paph. Baccanum* and yellow embryos were noticed in *Phal. amboinensis*. White embryos characterised *Paph. liemianum* and black embryos were seen in *Paph. primulinum* (Table 1, Figure 1).

Molvray and Chase (1999) announced that features of the seed ornamentation can be based at higher taxonomic ranks. In the present work, the testa surface of *P*[WU10]. *amabilis* did not have any ornamentation. The testa cells were elongated, longitudinally oriented, parallel to the long seed axis and irregular. The testa cell walls were cylindrical, and exhibited overlap (Figure 2B arrow), becoming round and rising at the end of the meeting between two testa cells [WU11](Figure 2D arrow). Certain parts of the testa formed deep furrows (Figure 2C arrow). There were no differences in the shape of the testa cells at the two poles[WU12].

Table 1. Qualitative data of the analysed species [WU13]of the genus *Phalaenopsis and Paphiopedilum*

Species name	Seed Shape	Seed Colour	Ornamentation of the periclinal walls	Testa cell shape	Testa cell walls shape	Embryo Shape	Embryo Colour
Phal. amabilis[WU14]	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Yellowish brown
Phal. tetraspis	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Yellowish brown
Phal. bellina	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Brown
Phal. gigantea	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Brown
Phal. amboinensis	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Yellow
Phal. venosa	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Light yellow
Paph. kolopakingii [WU15]	Fusiform	Dark brown	Smooth	Polygonal	Flat rectangular	Prolate	Brown
Paph. liemianum	Fusiform	Dark brown	Smooth	Polygonal	Thin rectangular	Prolate	White
Paph. baccanum	Fusiform	Brown	Smooth	Polygonal	Thin rectangular	Prolate	Dark brown
Paph. primulinum	Fusiform	Brown	Smooth	Polygonal	Flat rectangular	Prolate	Black

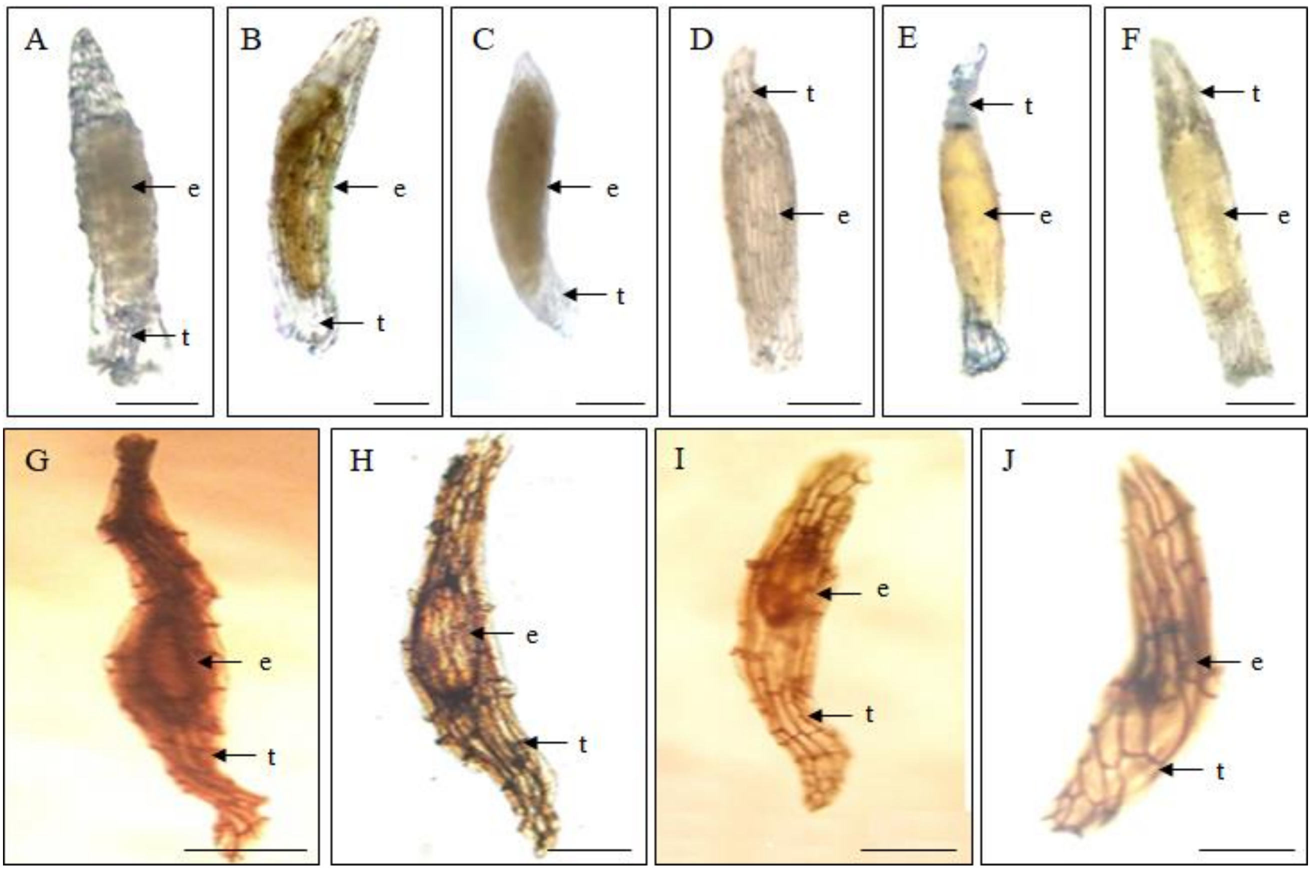


Figure 1. LM photographs of (A-F) *Phalaenopsis* and (G-J) *Paphiopedilum.* A. *Phal. amabilis* (scale bar=72 µm), B. *Phal. tetraspis* (scale bar=49 µm), C. *Phal. bellina* (scale bar=65 µm), D. *Phal. gigantea* (scale bar=51 µm), E. *Phal. amboinensis* (scale bar=59 µm), F. *Phal. venosa* (scale bar=55 µm), G. *Paph. kolopakingii* (scale bar=206 µm), H. *Paph. liemianum* (scale bar=162 µm), I. *Paph. baccanum* (scale bar=185 µm), J. *Paph. primulinum* (scale bar=161 µm). e= embryo, t=testa.

The testa surface of *P*[WU16]. *tetraspis* was smooth. The testa cells were elongated, longitudinally oriented, parallel to the long axis and irregular. The testa cell walls were cylindrical, and very close together [WU17](Figure 3). At the end of the meeting between two testa cells the cell walls became wider, rounder and rose up (Figure 3C arrow)[WU18]. There was a difference in the shape of the testa cells at the two poles. Cells at the basal pole were smaller than cells at the apical pole[WU19].

P[WU20]. *bellina* did not have any ornamentation on the surface of its testa cells; the cells were elongated, longitudinally oriented, parallel to the long seed axis and irregular. The testa cell walls were cylindrical, and the distance between two cells formed a slit in a row (Figure 4B). The meeting point between the two ends of the testa cells was curved, thickened and raised to form a bulge (Figure 4B arrow). There was a difference in the shape of the testa cells at the two poles. Cells of the basal pole were bigger and rounder than cells of the apical pole [WU21](Figure 4C and D).

Figure 2[WU22]**.** SEM photographs of *Phal. amabilis.* A. Fusiform seed shape, B. Pattern of testa cells [WU23]of the medial, C. Cells of the basal pole[WU24], D. Cells of the apical pole[WU25]. Scale bars: A=100 µm, B-D=10 µm

In *P.*[WU26] *gigantea*, the testa surface was smooth. The testa cells were elongated, longitudinally oriented, parallel to the long seed axis and highly irregular. Ridges were elevated with a deep groove (Figure 5B black arrow). The testa cell walls were cylindrical. At the meeting point the two ends of the testa cells were curved and raised (Figure 5B white arrow). Cells of the basal pole were different to cells at the apical pole; cells at the basal pole had an appendage at the end and become pointed (Figure 5C arrow).[WU27]

Figure 3[WU28]. SEM photographs of *Phal. tetraspis*. A. seed shape[WU29], B. Pattern of testa [WU30]cells of the medial, C. Cells of the basal pole[WU31], D. Cells of the apical pole[WU32]. Scale bars: A=100 µm, B-D=10 µm.

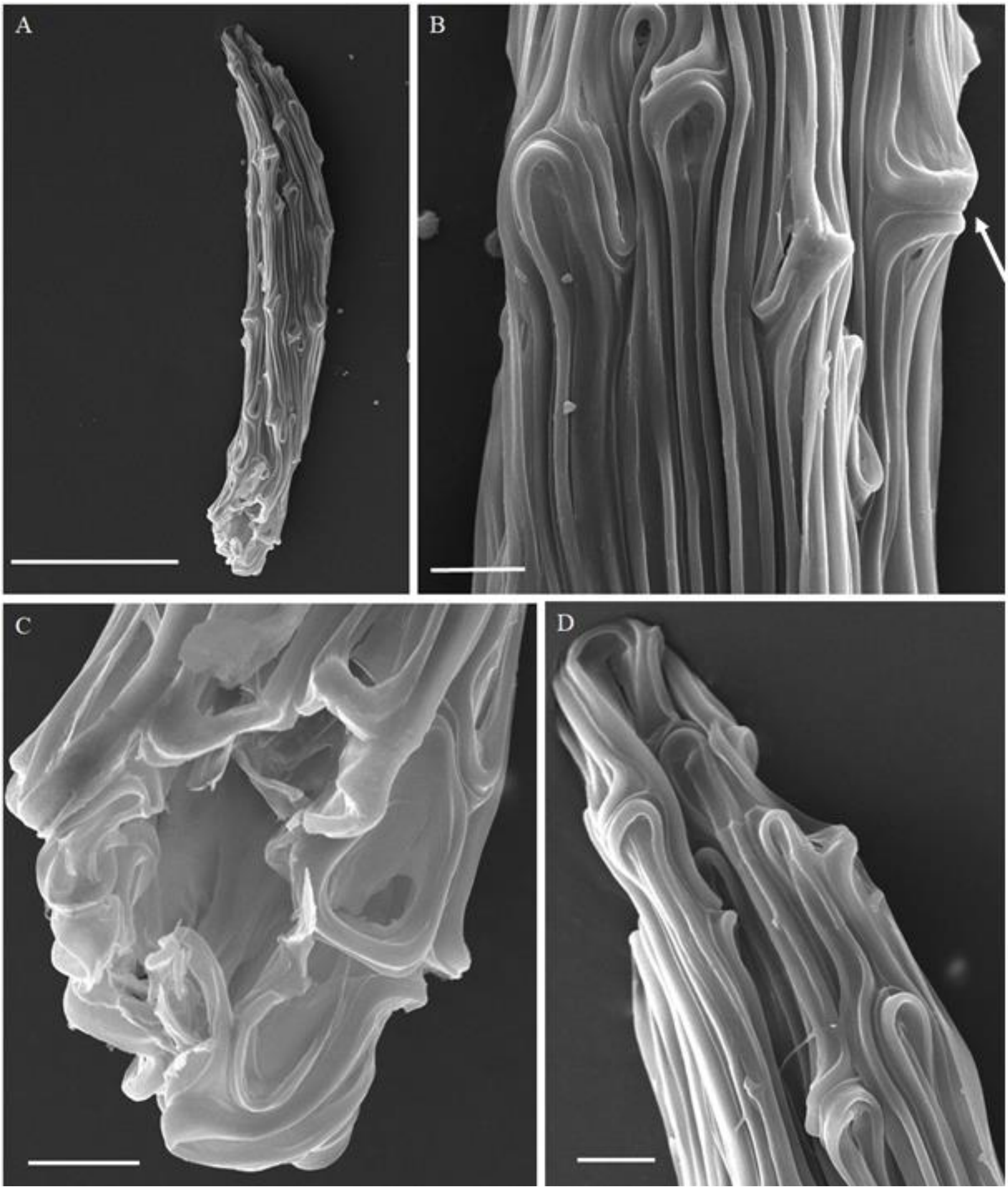


Figure 4[WU33]. SEM photographs of *Phal. bellina.* A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=10 µm.

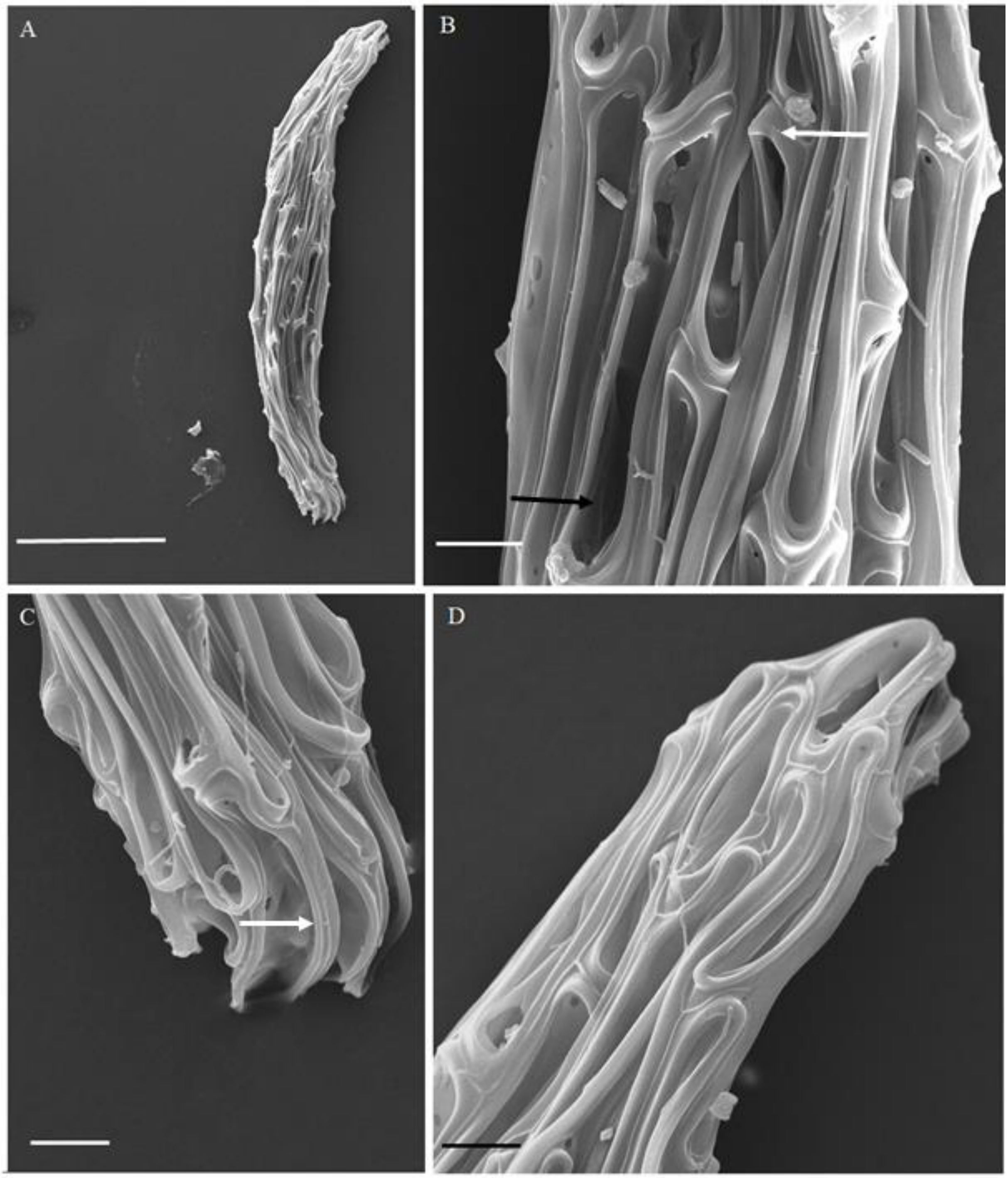


Figure 5. [WU34]SEM photographs of *Phal. gigantea.* A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=10 µm.

The testa cells on the surface of *P. amboinensis* did not have any ornamentation. The testa cells were elongated, longitudinally oriented, parallel to long axis and irregular. The testa cells walls were cylindrical. Part of the meeting at the end of the two cells was rounded and slightly raised (Figure 6B arrow). The end of the basal pole was blunt (Figure 6C), while the end of the apical pole became pointed (Figure 6D).

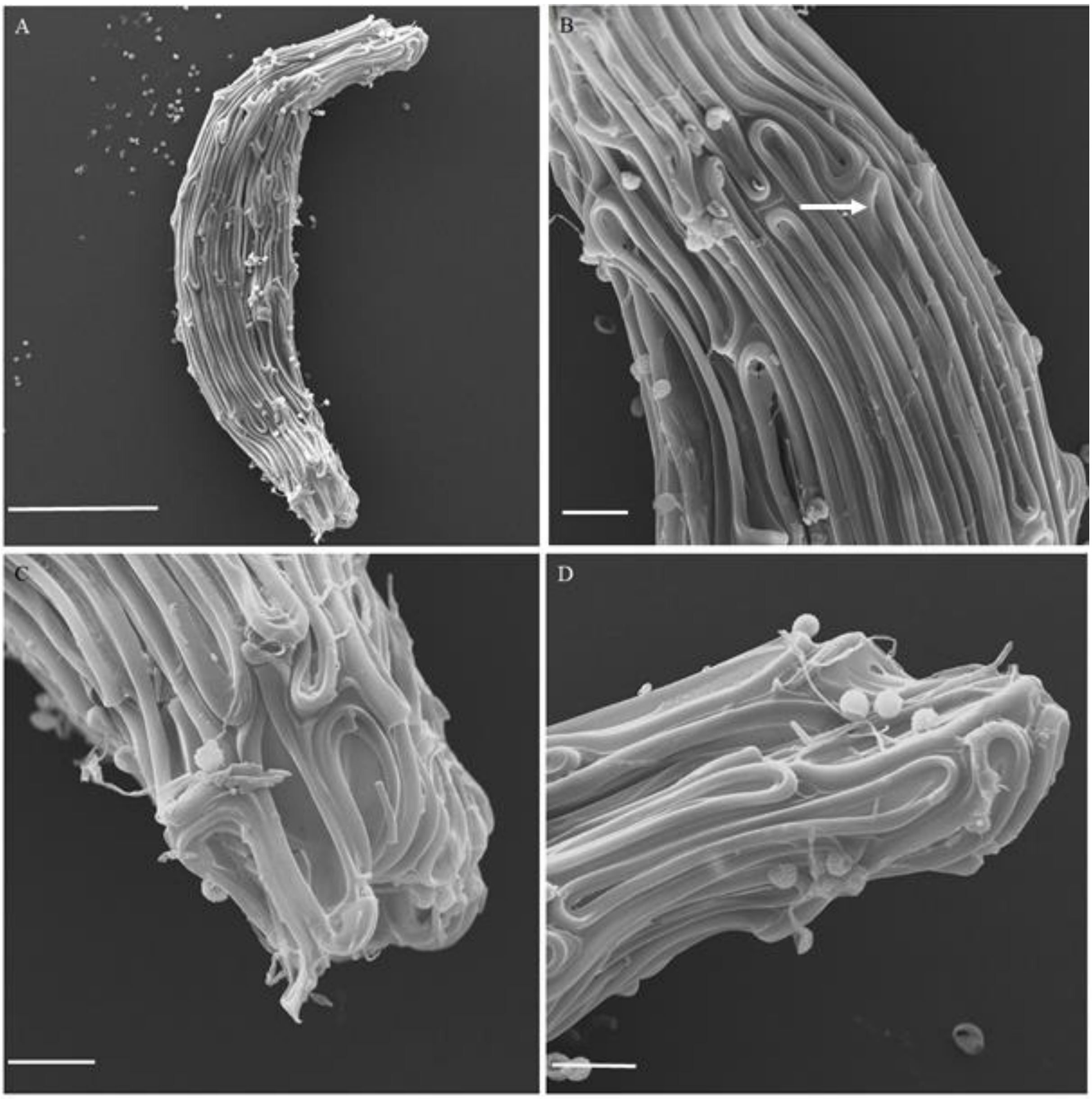


Figure 6. [WU35]SEM photographs of *Phal. amboinensis*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=80 µm, B-D=10 µm.

In the case of *P. venosa*, the testa surface was smooth. The testa cells were elongated and longitudinally oriented, parallel to the long axis, irregular, and raised at the end of the meeting between two cells (Figure 7B arrow). The testa cells walls were cylindrical. Testa cells at the end of the basal pole were widened and rounded (Figure 7C arrow), but testa cells at the apical pole were more elongated (Figure 7D). The end of the basal pole was rounded (Figure 7C), while the end of the apical pole was pointed (Figure 7D).

In the case of *Paph. kolopakingii*, testa cells were polygonal, longitudinally oriented with a deep groove, parallel to the long axis and irregular. The testa cell walls were flat and rectangular (Figure 8B arrow). The testa surfaces were smooth. The shape of the basal cell pole was larger and more dented than the cells of the apical pole (Figures 8C and D). The testa surfaces of *Paph. liemianum* were smooth. The testa cells were polygonal, longitudinally oriented with a deep groove, parallel to the long axis and irregular (Figure 9). The testa cell walls were thin and rectangular (Figure 9B arrow). The medial region was wider than the two poles. The basal cells were short, polygonal and more numerous than the apical cells (Figure 9C arrow).

In the case of *Paph. baccanum*, the testa surface was smooth. Generally, the testa cells were polygonal, longitudinally oriented with a deep groove, parallel to the long axis and irregular (Figure 10). The testa cell walls were thin and rectangular (Figure 10B arrow). Cells at the basal pole were longer compared to cells at the apical pole. The end of the basal pole became pointed, while the end of the apical pole became rounded (Figures 10C and D).

In Paph. primulinum, the testa surface was smooth. Generally, testa cells were polygonal, longitudinally oriented with a deep groove, parallel to the long axis and irregular (Figure 11). The testa cell walls were flat and rectangular (Figure 11B arrow). The end of the basal pole was blunt, while the end of the apical pole was suppressed (Figures 11C and D).

In this study, we did not observe any sculpturing on the cell walls or smooth in any species of the two different genera. This is probably because all of these species are equally alive and come from the tropics, despite their different living forms (epiphyte and terrestrial). This observation corresponds with the opinion of Chaudhary et al. (2014), who noted that seed ornamentations are directly related to the climatic preference of the species rather than its phylogeny. Similarly, according to Shimizu (2012), seed coat forms that are independent of plant habitat have a wider seed dispersal. The images we observed with SEM showed that different species in the genus *Phalaenopsis* had the same shape of testa cells and cell walls, namely elongated with cylindrical cell walls. Similarly, different species in the genus *Paphiopedilum* had testa cells and cell walls with the same shape, namely polygonal and with thin/flat rectangular cells walls. However, these results contradict with the results of previous research by Arditti et al. (1979, 1980) and Swamy et al. (2004), who showed that testa cells of different species can vary significantly in shape.

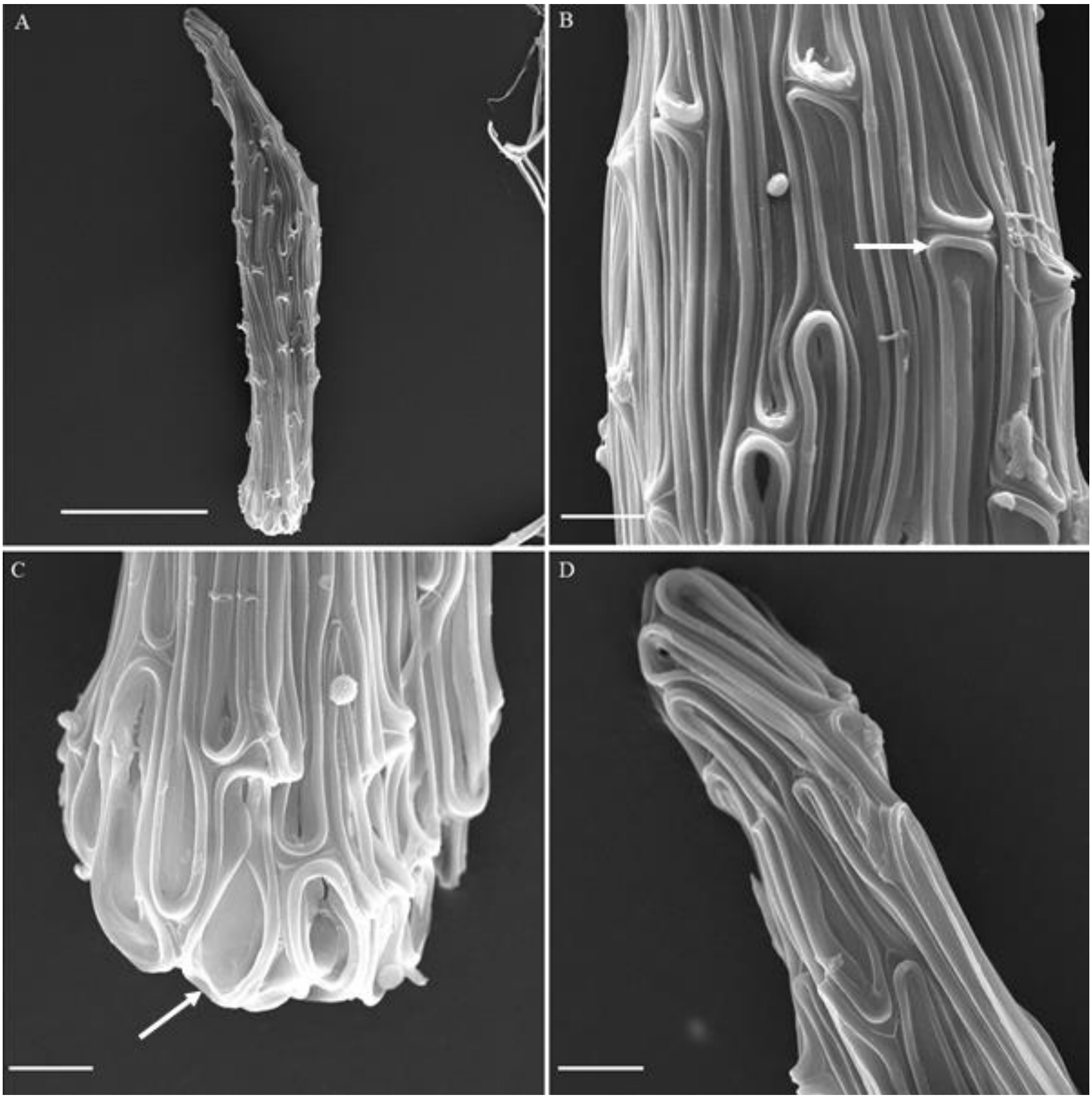


Figure 7. [WU36]SEM photographs of *Phal. venosa*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=80 µm, B-D=10 µm.

Figure 8[WU37]. SEM photographs of *Paph. kolopakingii* . A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=20 µm.

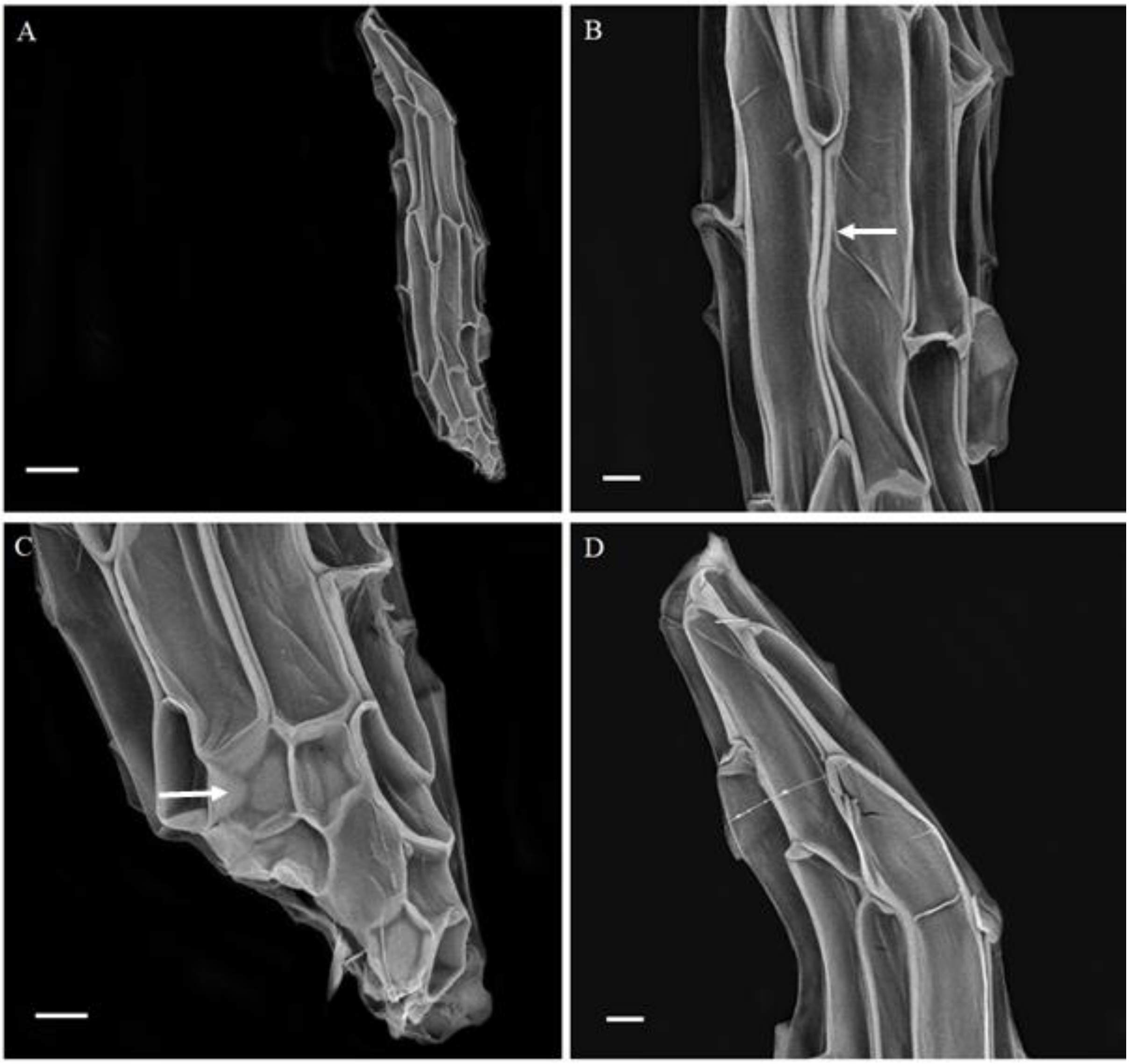


Figure 9. [WU38]SEM photographs of *Paph. liemianum.* A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=20 µm.

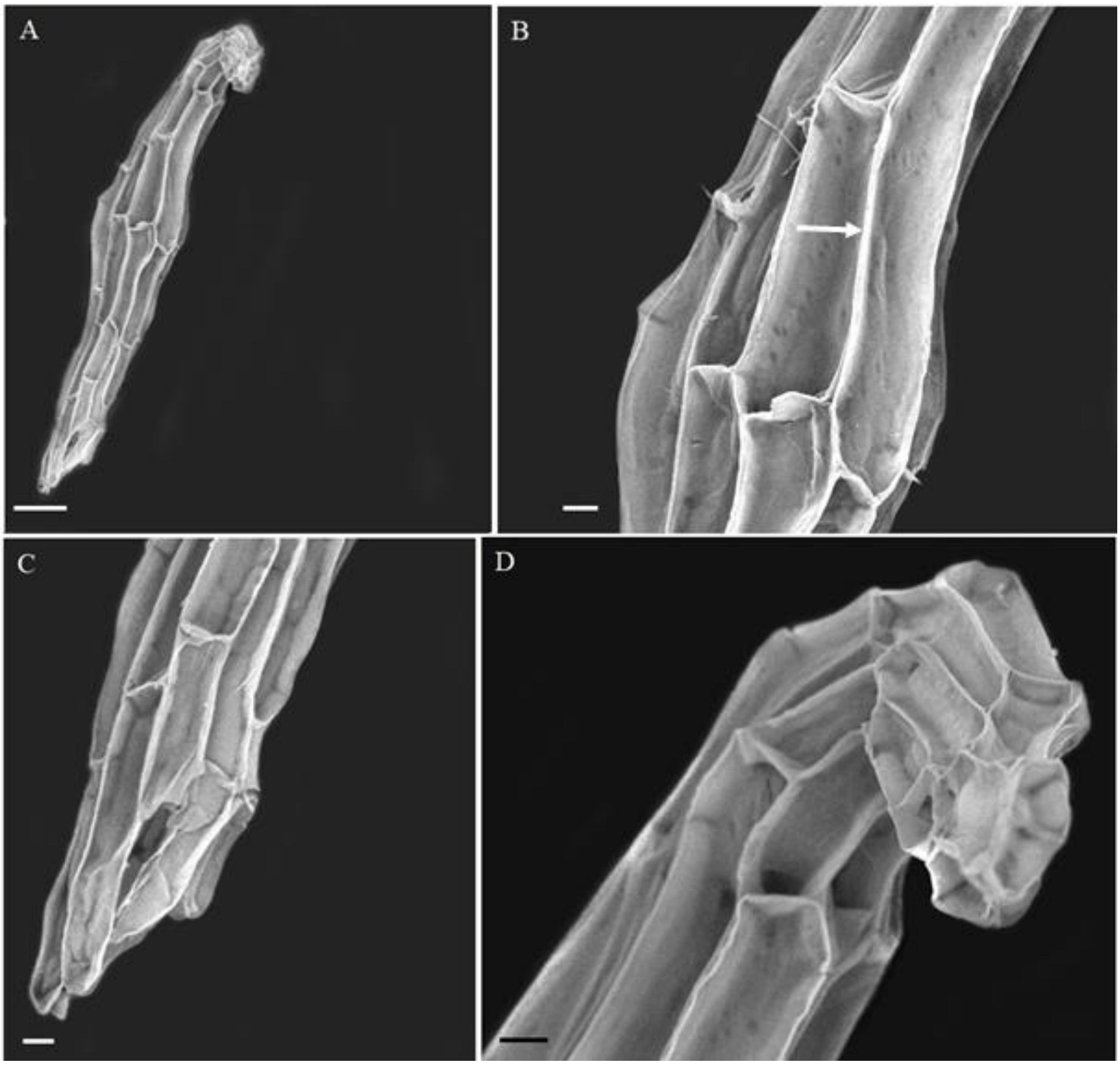


Figure 10[WU39]. SEM photographs of *Paph. baccanum.* A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=20 µm.

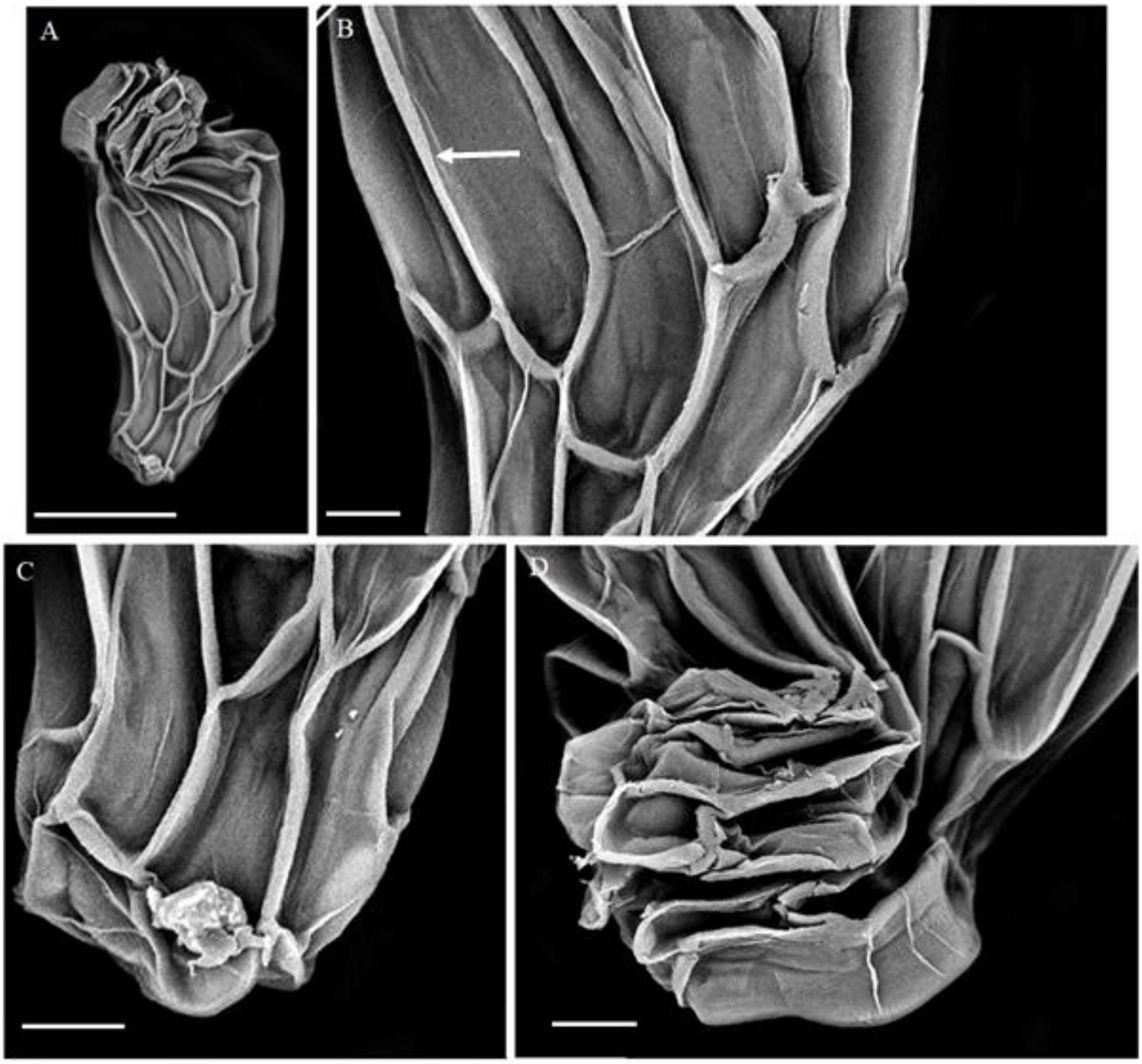


Figure 11[WU40]. SEM photographs of *Paph. primulinum.* A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=20 µm.

Seeds size, ratio SL/SW and seed volume

The table 2 exhibits the size of seeds from ten species of the genus *Phalaenopsis* and *Paphiopedilum*. In spite of the fact that the seeds are microscopic, the result of the investigation showed a great diversity in their size. Seed length ranged between 0.302±0.0079 mm (*Phal*. *bellina*) and 0.983±0.0035 mm (*Paph*. *liemianum*), and width ranged from 0.049±0.0039 mm (*Phal*. *tetraspis*) to 0.206±0.0016 mm (*Paph*. *kolopakingii*). According to Verma et al. (2014), the SL/SW ratio provides information on the degree of seed truncation and is a good taxonomic character (Arditti et al. 1979 and Vij et al. 1992). In the present work, the species with seeds that were truncated (SL/SW < 6) were *Phal. bellina*, *Phal. amboinensis*, *Paph. kolopakingii*, *Paph. baccanum* and *Paph. primulinum*. The following species had elongated seeds (SL/SW > 6): *Phal. amabilis*, *Phal. tetraspis*, *Phal. gigantea*, *Phal. venosa* and *Paph. liemianum* (Table 2). The most truncated seeds (SL/SW = 4.254±0.0494 mm) were recorded in *Paph. kolopakingii* and the most elongated seeds (SL/SW = 7.472±0.6574 mm) in *Phal. tetraspis,* both of which are members of different genus. The seed volume showed significant variations in both *Phalaenopsis* and *Paphiopedilum* orchids. On average, low seed volume was found in *Phal. gigantea* (0.240±0.0327 mm^3x10^{-3}), *Phal. tetraspis* (0.242±0.0363 mm^3x10^{-3}), *Phal. venosa* (0.272±0.0316 mm^3x10^{-3}), *Phal. amboinensis* (0.318±0.0196 mm^3x10^{-3}), *Phal. bellina* (0.333±0.0268 mm^3x10^{-3}) and *Phal. amabilis* (0.589±0.0497 mm^3x10^{-3}). When compared with epiphytic species, the seed volume was found to be higher in the terrestrial species [9.668±0.1768 mm^3x10^{-3} (the highest) in *Paph. kolopakingii*, 7.324± 0.1283 mm^3x10^{-3} in *Paph. baccanum*, 6.755±0.2672 mm^3x10^{-3} in *Paph. liemianum* and 5.532±0.6396 mm^3x10^{-3} in *Paph. primulinum*]. Clifford and Smith (1969), Rasmussen (1995), Swamy et al. (2004) and Verma et al. (2012) stated that seed size shows a direct correlation with plant habitat, and terrestrial orchids generally possess larger seeds as compared to epiphytic orchids. Yoder et al. (2010) also stated that the seeds of terrestrial orchids are bigger as compared to epiphytic orchids.

Table 2. Micro-morphometric data of seeds related characters from species of the genus *Phalaenopsis and Paphiopedilum*

Species name	SL[WU41] (mm)	SW (mm)	SL/SW (mm)	SV ($mm^3 x10^{-3}$)
Phalaenopsis				
Phal. amabilis	0.433 ± 0.0084[WU42]	0.072 ± 0.0030	6.029 ± 0.2851	0.589 ± 0.0497
Phal. tetraspis	0.370 ± 0.0086	0.049 ± 0.0039	7.472 ± 0.6574	0.242 ± 0.0363
Phal. bellina	0.302 ± 0.0079	0.065 ± 0.0024	4.646 ± 0.1999	0.333 ± 0.0268
Phal. gigantea	0.348 ± 0.0095	0.051 ± 0.0034	6.823 ± 0.4870	0.240 ± 0.0327
Phal. ambonensis	0.349 ± 0.0062	0.059 ± 0.0018	5.915 ± 0.2214	0.318 ± 0.0196
Phal. venosa	0.345 ± 0.0069	0.055 ± 0.0032	6.305 ± 0.3947	0.272 ± 0.0316
Paphiopedilum				
Paph. kolopakingii	0.874 ± 0.0077	0.206 ± 0.0016	4.254 ± 0.0494	9.668 ± 0.1768
Paph. liemianum	0.983 ± 0.0035	0.162 ± 0.0033	6.074 ± 0.1291	6.755 ± 0.2672
Paph. baccanum	0.815 ± 0.0022	0.185 ± 0.0017	4.401 ± 0.0429	7.324 ± 0.1283
Paph. primulinum	0.815 ± 0.0435	0.161 ± 0.0088	5.083 ± 0.3878	5.532 ± 0.6396

.....[WU43]

Table 3. Micro-morphometric data of embryos related characters from species of the genus *Phalaenopsis and Paphiopedilum*

Species name	EL [WU44] (mm)	EW (mm)	EL/EW (mm)	EV ($mm^3 x10^{-3}$)	SV/EV ($mm^3 x10^{-3}$)	AS (%)
Phal. amabilis[WU45]	0.187 ± 0.0044	0.072 ± 0.0030	2.607 ± 0.1322	0.509 ± 0.0433	1.158 ± 0.0333	13.554 ± 2.4693
Phal tetraspis	0.171 ± 0.0081	0.046 ± 0.0034	3.739 ± 0.3049	0.191 ± 0.0301	1.273 ± 0.0821	21.128 ± 5.0900
Phal bellina	0.211 ± 0.0132	0.051 ± 0.0022	4.149 ± 0.3611	0.286 ± 0.0244	1.168 ± 0.0305	14.294 ± 2.2379
Phal gigantea	0.192 ± 0.0074	0.043 ± 0.3022	4.496 ± 0.3022	0.184 ± 0.0241	1.308 ± 0.0745	23.291 ± 4.3589
Phal ambonensis	0.203 ± 0.0046	0.051 ± 0.0019	3.993 ± 0.1897	0.274 ± 0.0200	1.165 ± 0.0529	14.245 ± 3.6410
Phal venosa	0.183 ± 0.0029	0.047 ± 0.0018	3.929 ± 0.1922	0.209 ± 0.0141	1.309 ± 0.1718	22.338 ± 10.0278
Paph. kolopakingii [WU46]	0.270 ± 0.0032	0.157 ± 0.0038	1.726 ± 0.0416	3.466 ± 0.1863	2.797 ± 0.1499	64.150 ± 1.9360
Paph. liemianum	0.271 ± 0.0044	0.083 ± 0.0045	3.267 ± 0.2025	0.797 ± 0.1031	6.974 ± 0.7653	85.501 ± 1.5279
Paph. baccanum	0.223 ± 0.0030	0.115 ± 0.0018	1.933 ± 0.0367	1.557 ± 0.0539	4.709 ± 0.2083	78.725 ± 0.9214
Paph. primulinum	0.274 ± 0.0111	0.105 ± 0.0090	2.636 ± 0.2165	1.590 ± 0.3090	3.608 ± 0.8454	70.898 ± 6.3436

.......[WU47]

Seed to embryo volume and free air space

According to Verma et al. (2014), EV is an important character as it directly affects the percentage of the procurable air space inside the seed. Like their EL/EV ratios, EV were observed in various *Phalaenopsis* species; it was lowest in *Phal. gigantea* (0.184±0.0241 mm^3 x 10^{-3}) and highest in *Phal. amabilis* (0.509±0.0433 mm^3 x10^{-3}). In *Paphiopedilum*, EV the ranged between 0.797±0.1031 mm^3 x 10^{-3} (*Paph. liemianum*) and 3.466±0.1863 mm^3 x 10^{-3} (*Paph. kolopakingii*).

Our data showed that variation was observed in SV/EV. In the species of *Phalaenopsis*, the SV/EV ratio never exceeded two (Table 3), but in the species of *Paphiopedilum* measurements peaked at 6.974±0.7653 mm^3 x 10^{-3} in *Paph. liemianum*. This was followed by *Paph. baccanum* (4.709±0.2083 mm^3 x 10^{-3}), *Paph. primulinum* (3.608±0.8454 mm^3 x 10^{-3}) and *Paph. kolopakingii* (2.797±0.1499 mm^3 x 10^{-3}). Burgeff (1936) experimentally demonstrated the relationship between SV/EV ratio and seed buoyancy. Seeds with a high SV/EV ratio are more buoyant because they possess a greater air space.

Swamy et al. (2004, 2007) stated that AS is an important character because the seeds of most orchids are wind dispersed, implying that seeds with a greater AS percentage will float in the air for a longer time and thus spread to more distant places. We observed that terrestrial species possessed a comparatively greater percentage of air space in their seeds as compared with epiphytic species. A greater percentage of air space for *Paph. kolopakingii*, *Paph. liemianum*, *Paph.baccanum* and *Paph. primulinum* was shown more than 60% of seed i.e. (64.150±1.9360), (85.501±1.5279), (78.725±0.9214) and (70.898±6.3436). Zhang et al. (2015) informed that higher AS values in seeds of terrestrial species can help spread them further along the forest floor where wind speeds are lower. Seeds with a greater percentage of air space in *Paphiopedilum* are expected to be more widely distributed and, in fact, we found it difficult to collect their seeds.

.........[WU48]

The results of this study can be concluded that species within *Paphiopedilum* produce larger seeds with smaller embryos and a bigger percentage of air space (AS) than those of *Phalaenopsis* species. Likewise, the volume of seeds and seed volume/embryo volume in *Paphiopedilum* are larger than in *Phalaenopsis*. Large air spaces will increase seed buoyancy and seeds can be dispersed further. Testa cells are elongated in shape, with cylindrical cells walls, in *Phalaenopsis* but they are polygonal, with thin or flat rectangular cell walls, in *Paphiopedilum*. There are some similarities in character that might be related to adaptation to the tropical area, because in all species studied, both epiphytic and terrestrial orchids have the same form of fusiform seeds and a smooth testa surface. The general results of this study inform us that the morphological and morphometric properties of orchid seeds could be utilised as a means of distinguishing between life forms and habitat similarity and aid in identification.

……….[WU49]

REFERENCES[WU50]

Akçin TA, Ozdener Y, Akçin A. 2009. Taxonomic Value of Seed Characters in Orchids from Turkey. Belg. J. Bot[WU51]. 142 (2):124-139. http://dx.doi.org/ 10.2307/41427182.

Arditti J, Ghani AKA. 2000. Numerical and physical properties of orchid seeds and their biological implications. New Phytol. 145:367-421. DOI: 10.1046/j.1469-8137.2000.00587.x.

Arditti J, Michaud JD, Healey PL. 1979. Morphometry of orchid seeds. I. Paphiopedilum and native Californian and related species of Cypripedium. American Journal of Botany[WU52]. 66:1128-1137. http://dx.doi.org/10.2307/2442211.

Arditti J, Michaud JD, Healey PL. 1980. Morphometry of Orchid Seeds. II. Native California and Related Species of Calypso, Cephalanthera, Corallorhiza and Epipactis. Amer. J. Bot. 67 (3):347-360. http://dx.doi.org/10.2307/2442345.

Burgeff H. 1936. Samenkeimung der Orchideen und Entwicklung ihrer Keimpflanzen, Jena: Gustav Fischerr Verlag.

Cela PG, Seligrat I, Ortúñez E, Gamarra R, Vivar A, Scrugli A. 2014. A study of seed micromorphology in the genus Ophrys (Orchidaceae). Anales del Jardín Botánico de Madrid. 71 (2):1-6. http://dx.doi.org/10.3989/ajbm.2370.

Chase MW, Pippen JS. 1988. Seed morphology in the Oncidiinae and related subtribes orchidaceae. Systematic Botany. 13 (3):313-323.

Chaudhary B, Chattopadhyay P, Banerjee N. 2014. Modulations in seed micromorphology reveal signature of adaptive species-diversification in Dendrobium (Orchidaceae). Open Journal of Ecology. 4 (2):33-42. http://dx.doi.org/10.4236/oje.2014.42005.

Clifford HT, Smith WK. 1969. Seed morphology and classification of Orchidaceae. Phytomorphology. 19:133-139.

Gamarra R, Galán P, Herrera I, Ortúñez E. 2008. Seed micromorphology supports the splitting of Limnorchis from Platanthera (Orchidaceae). Nordic Journal of Botany. 26:61-65. DOI: 10.1111/j.1756-1051.2008.00135.x

Gamarra R, Galan P, Pedersen HE, Ortunez E, Sanz E. 2015. Seed micromorphology in Dactylorhiza Necker ex Nevski (Orchidaceae) and allied genera. Turkish Journal of Botany. 39:298-309. DOI: 10.3906/bot-1401-66.

Gamarra R, Ortúñez E, Sanz E, Esparza I, Galán P. 2010. Seeds in subtribe Orchidinae (Orchidaceae): the best morphological tool to support molecular analyses. In: Nimis P. L., R. Vignes-Lebbe (eds.). Tools for Identifying Biodiversity: Progress and Problems. 323-326. ISBN 978-88-8303-295-0. EUT.

Guler N. 2016. Seed micromorphology of Orchis Tourn. Ex L. (Orchidaceae) and allied genera growing in Edirne province, Turkey. Phyto Keys. 69:9-25. http://dx.doi.10.3897/phyto keys.68.8746.

Molvray M, Chase M. 1999. Seed morphology. In: Pridgeon AM, Cribb PJ, Chase MW, Rasmussen FN (eds.). Genera Orchidacearum, General Introduction, Apostasioideae, Cypripedioideae. Oxford University Press, Oxford, 59-66.

Rasmussen HN. 1995. Terrestrial orchids from seed to mycotrophic plant. Cambridge, UK: Cambridge University Press.

Shimizu N. 2012. Adaptation and evolution of seed shape on bleeding area in Japanese orchids. International Journal of Biology. 4: 47-53.

Sodhi NS, Koh LP, Brook BW, Ng PKL. 2004. Southeast Asian biodiversity: An impending disaster. Trends in Ecology & Evolution. 19 (12):654-660. DOI: 10.1016/j.tree.2004.09.006

Swamy KK, Kumar HNK, Ramakrishna TM, Ramaswamy SN. 2004. Studies on Seed Morphometry of Epiphytic Orchids from Western Ghats of Karnataka. Taiwania. 49 (2):124-140. DOI: 10.6165/tai.2004.49 (2).124.

Swamy KK, Kumar HNK, Ramaswamy SN. 2007. Studies on seed morphometry of Dendrobium species. Phytomorphology. 57:33-43.

Tsutsumi C, Yukawa T, Lee NS, Lee CS, Kato M. 2007. Phylogeny and comparative seed morphology of epiphytic and terrestrial species of Liparis (Orchidaceae) in Japan. Journal of Plant Research. 120 (3):405-412. DOI: 10.1007/s10265-007-0077-0

Verma J, Kusum K, Thakur K, Sembi JK, Vij SP. 2012. Study on seed morphometry of seven threatened Himalayan orchids exhibiting varied life modes. Acta Botanica Gallica: Botany Letters. 159 (4):443-449. DOI: 10.1080/12538078.2012.750582.

Verma J, Sharma K, Thakur K, Sembi JK, Vij SP. 2014. Study on Seed Morphometry of Some Threatened Western Himalayan Orchids. Turkish Journal of Botany. 38:234-251. DOI: 10.3906/bot-1307-14.

Vij SP, Kaur P, Kaur S, Kaushal PS. 1992. The Orchid Seeds: Taxonomic, Evolutionary and Functional Aspects. J. Orchid Soc. 6:91-107.

Yoder JA, Imfeld SM, Heydinger DJ, Hart CE, Collier MH, Gribbins KM, Zettler LW. 2010. Comparative water balance profiles of Orchidaceae seeds for epiphytic and terrestrial taxa endemic to North America. Plant Ecol. 211:7-17. DOI: 10.1007/s11258-010-9765-2.

Zhang FP, Zhang JJ, Yan N, Hu H, Zhang SB. 2015. Variations in seed micromorphology of Paphiopedilum and Cypripedium (Cypripedioideae, Orchidaceae). Seed Science Research. 25:395-401. DOI: 10.1017/S0960258515000276.

sucipto hariyanto <sucipto-h@fst.unair.ac.id>
to Smujo

Dear Smujo Editors,
I apologize for the delay in completing the revision in accordance with the reviewer re

Following, I send an article that I have revised and a list of revisions / answers from t

besides that I have also sent via the system (smujo).

Hopefully it is in accordance with the editor and review

Best regards,
Sucipto Hariyanto

2 Attachments • Scanned by Gmail

C-Edit_4466-Arti..

List of Revisions ...

Variations in seed micromorphology and morphometry of native Indonesian ~~Orchids~~ *Phalaenopsis* and *Paphiopedilum* orchid

~~mail: sucipto-h@fst.unair.ac.id~~

Abstract. Seeds of ten taxa of the genera *Phalaenopsis* and *Paphiopedilum* orchids were studied using light and scanning electron microscopy (SEM). Qualitative~~Morphological~~ ~~Quantitative~~[WU1] characters (seed and embryo shape, seed and embryo colour, ornamentation of testa cell, testa cell wall shape) as well as quantitative data (seed and embryo length, seed and embryo width, seed and embryo volume, seed length/seed width, embryo length/embryo width, seed volume/embryo volume and air space) were analysed. Seeds of all studied taxa were fusiform in shape and had smooth testa surfaces. *Phalaenopsis* testa cells were elongated with cylindrical cell walls, while *Paphiopedilum* testa cells were polygonal with thin and flat rectangular cell walls. The shape of the embryos was generally ovoid in *Phalaenopsis* and prolate in *Paphiopedilum.* Seed colours ranged from brown to dark brown. Embryo colours varied from light yellow, yellowish brown, dark brown, black and white. Based on our investigation, there are variations in seed and embryo length, seed and embryo width, seed and embryo volume as well as the percentage of the air space, both in *Phalaenopsis* and *Paphiopedilum*. In general, the values of seed volume, embryo volume and air space in *Paphiopedilum* are higher than in *Phalaenopsis*. Together, the results of the study indicate that morphological and morphometric features can serve to identify live forms and distinguish between species. ~~**Together, the results of the study indicate that morphological and morphometric features can serve to identify live forms and distinguish between species. and phylogeny**~~[WU2]~~**.**~~

Keywords: testa cell shapes, testa cell wall shapes, seed volume, seed air spaces, epiphytic versus terrestrial habitats

INTRODUCTION

Phalaenopsis Blume and *Paphiopedilum* Pfitzer are orchids whose members are very popular and are commercialised as the most traded potted and cut flower plants in the world. Wild populations are under threat of extinction due to high rates of habitat modification, deforestation, forest fires, illegal harvesting and trade as a consequence of rapid economic development, high population growth and corrupt institutions (Sodhi et al. 2004). All *Paphiopedilum* species are listed by t~~T~~the Conservation on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Appendix I and *Phalaenopsis* are listed in Appendix II. This is in spite of the fact that, according to the CITES, all species from the genus *Paphiopedilum* are prohibited for trade.

Seeds occupy the first rank in the life history of plants. Orchid seeds disperse, germinate and grow into mature plants, and reproduce in a suitable place on certain parts of the tree or on the ground. In general, seeds are responsible for the regeneration and distribution of a species, even playing an important role in the conservation of orchids. Verma et al. (2014) and Tsutsumi et al. (2007) explain that seed dispersal mode and seed size are important factors in regulating the growth of new populations.

Seed morphology varies greatly in shape, colour, size, volume of the embryo and testa structure, and some of these characters have been used to establish the phylogeny of species in the genus

(Gamarra et al. 2008, 2010, 2015; Cela et al. 2014; Guler, 2016). In addition, some seed characters can be related to germination and dispersal, especially in their ecological adaptation (Chaudhary et al. 2014; Zhang et al. 2015). According to research by Chaudhary et al. (2014) in the *Dendrobium* orchid, the volume of the embryo and the percentage of the air space are directly related to the climate and this is reflected in seed ultrastructure.

Previous studies on the morphology of orchid seeds in tropical areas have demonstrated the importance of the seed coat, related to the taxonomy and ecology (Chase and Pippen, 1988; Tsutsumi et al. 2007; Akçin et al. 2009; Verma et al. 2012; Molvray and Chase, 1999), as demonstrated with scanning electron microscopy (SEM).

Not much is known about how certain seed characteristics may correlate with ecological adaptations. The aim of this study is to reveal the qualitative and quantitative characteristics of the seeds of several species of epiphytic and terrestrial orchids native to Indonesia from different genera, thus contributing to a better understanding of the differences and similarities in their adaptation strategies for seeds in the tropics.

MATERIALS AND METHODS

Plant materials and seed collection

Ten different orchid species were collected from Simanis and DD Orchids Nursery, East Java, Indonesia. The collection for the present study included *Phal. amabilis*, *Phal. amboinensis*~~*Phal. tetraspis*~~, *Phal. bellina*, *Phal. gigantea*, ~~*Phal. amboinensis*,~~*Phal. tetraspis*, *Phal. venosa*, *Paph. baccanum*, *Paph. kolopakingii*, *Paph. liemianum*, ~~*Paph. baccanum*,~~ *Paph. p*~~*P*~~*rimulinum*; these plants were then hand pollinated during their normal period of flowering. The seeds of mature capsules were ~~2-3 mature capsules each species~~ [WU3]~~were~~ collected from~~between~~ 2016 to 2019[WU4]. The seed samples were ~~are~~ taken ~~randomly~~ from -1-2 capsule(s) for each species. The matured capsules that are ~~Age of mature *Phalaenopsis* capsules is~~ 3.5-4 months old for *Phalaenopsis* and~~dan mature *Phapiopedilum* capsules is~~ 8.5-9 months for *Phapiopedilum* ~~after handself- pollination~~ were used in~~for~~ this study.~~.The capsulesperiod from pollination to maturation of *Phalaenopsis*, which are between 3.5 – 4 moths and *Phapiopedilum* between 8.5-9 months after self-pollination .~~ The capsules were washed using 10% sunlight detergent solution for 3 minutes to eliminate dust particles, then rinsed 3 times with sterile distilled water. The surface of the capsules was sprayed with 70% alcohol, put on a Petri dish, placed into a laminar flow cupboard and passed over a Bunsen flame; this was repeated 3 times. The capsule was cut into four parts transversally and longitudinally using a sterile scalpel in a sterile Petri dish. The mature seeds were released from the capsules and collected with the help of a sterile spatula. The specimens used for SEM were dried for at least 4 weeks [WU5]at room temperature and stored in small paper envelope. ~~The seeds obtained from mature and opened capsules were used morphology investigations. The seedspecimens used for SEMFresh seeds were dried for at least 42 weeks [WU6]at room temperature and stored in small paper envelopes. Al cap vials at 4⁰C [WU7]in dry conditions.~~ ….[WU8] ~~Al~~l species within *Phalaenopsis* in this study are epiphytic orchids while all species within *Paphiopedilum* are terrestrial orchids.

Morphological and statistical analyses

Seed samples were observed and photographed under a Light Microscope (LM) and Scanning Electron Microscope (SEM). Our morphological parameters included seed shape (SS), seed colour (SC), seed length (SL), seed width (SW), seed length/seed width (SL/SW), seed volume (SV). For embryos, the parameters included embryo shape (ES), embryo colour (EC), embryo length (EL), embryo width (EW), embryo length/embryo width (EL/EW), embryo volume (EV), seed volume/embryo volume (SV/EV), and air space (AS). The SV ($mm^3 \times 10^{-3}$) was calculated using the formula $2 [(^{L}/2) (^{W}/2)^2 (^{\pi}/3)]$, where L = length, W = width, $\pi = {}^{22}/7$ and embryo volume ($mm^3 \times 10^{-}$

[3]) with the formula 4/3 π (L/2) (W/2)^2, where L = length, W = width (adapted from Arditti et al. 1980). The SV/EV values were calculated following the described method (Arditti et al. 1979). For calculating AS (%), the following formula was applied: (seed volume-embryo volume)/seed volume)) x 100% (adapted from Arditti and Ghani, 2000). To analyse each species statistically, we used the mean for each quantitative character.

LM study

Seeds were spread on a slide with a drop of water and covered with a cover glass. Values for SL, SW, EL and EW (at the longest and widest axis) were obtained from an average of thirty seeds and were observed for each species and measurement using a light microscope (Olympus CH 20, Olympus Japan) and standardised ocular meter. Characteristics such as SC, SS, EC and ES were observed under Tension stereomicroscope (Nikon SMZ-1, Japan). The SC and EC was described in subjective terms.

SEM study

For SEM preparations, the samples (seeds) were mounted on SEM stubs. The samples were then sputter-coated with palladium/gold (SEM coating system Q150R S mini sputter Coater). Detailed seed coat (testa cells) surface studies were conducted by observing under a Hitachi TM3000, with a filament voltage of 15 kV. The parameters considered were seed coat sculpturing and thickenings.

RESULTS AND DISCUSSION[WU9]

Qualitative character of seed and embryos

~~Qualitative characters were analysed by LM, an~~T~~d this showed t~~the characteristics of *Phalaenopsis* seeds ~~[WU10]that can be~~ distinguished from *Paphiopedilum* seeds are elongated testa cell shape, cylindrical testa cell wall shape, ~~and~~ ovoid embryo shape and ~~, and~~ brown transparent seeds colour are showed in ~~(~~Table 1~~) seeds~~.~~of two genera~~

Phal. amabilis, *Phal. amboinensis*, *Phal. bellina*, *Phal. gigantea*, *Phal. tetraspis* and *Phal. venosa* show similar character i.e fusiform seed shape, brown and transparent seed colour, smooth ornamentation of the periclinal walls, elongated testa cell shape, cylindrical testa cell walls shape and ovoid embryo shape (Table 1).

~~*Phal. amabilis*, *Phal. amboinensis* , *Phal. bellina*, *Phal. gigantea*, *Phal. tetraspis* and *Phal. venosa* show similar character i.e fusiform seed shape, brown and transparent seed colour, smooth ornamentation of the periclinal walls, elongated testa cell shape, cylindrical testa cell walls shape and ovoid embryo shape (Table 1). The seeds were generally uniform i.e. fusiform in shape with colours from brown to dark brown. Brown transparent seeds were found in *Phal. amabilis*, *Phal. tetraspis*, *Phal. amboinensis*, *Phal. bellina*, *Phal. gigantea*, *Phal. Amboinensis* *Phal. tetraspis* and *Phal. venosa* . Dark brown seeds were recorded in *Paph. kolopakingii* and *Paph. liemianum*. Brown seeds were observed in *Paph. baccanum* and *Paph. primulinum* (Table 1, Figure 1). The shape of the embryos was generally ovoid in *Phalaenopsis* and prolate in *Paphiopedilum*, and embryos were distinct and present in the centre. Embryo colour in the observed species varied from light yellow, yellowish brown to dark brown, black and white. Light yellow embryos were found in *Phal. venosa*. Yellowish brown embryos were recorded in *Phal. amabilis* and *Phal. tetraspis*. Brown embryos were common in *Phal. bellina* and , *Phal. giganteantea and Paph. kolopakingii*. Dark brown embryos were found in *Paph. bBaccanum* and yellow embryos were noticed in *Phal. amboinensis*. White embryos characterised *Paph. liemianum* and black embryos were seen in *Paph. primulinum* (Table 1, Figure 1).~~

~~Molvray and Chase (1999) announced that features of the seed ornamentation can be based at higher taxonomic ranks. In the present work, the~~ embryo colour ~~testa surface of~~ ~~P~~[WU11]*~~hal. amabilis~~* was yellowish brown~~did not have any ornamentation. The testa cells were elongated,~~

~~longitudinally oriented, parallel to the long seed axis and irregular. The testa cell walls were cylindrical shape and cylindrical, and exhibited overlaph (Figure 2.1B arrow), becoming circleround and rising at the end of the meeting between two testa cells~~ [WU12]~~(Figure 2. 1D arrow). Certain parts of the testa formed deep furrows (Figure 2. 1C arrow).~~

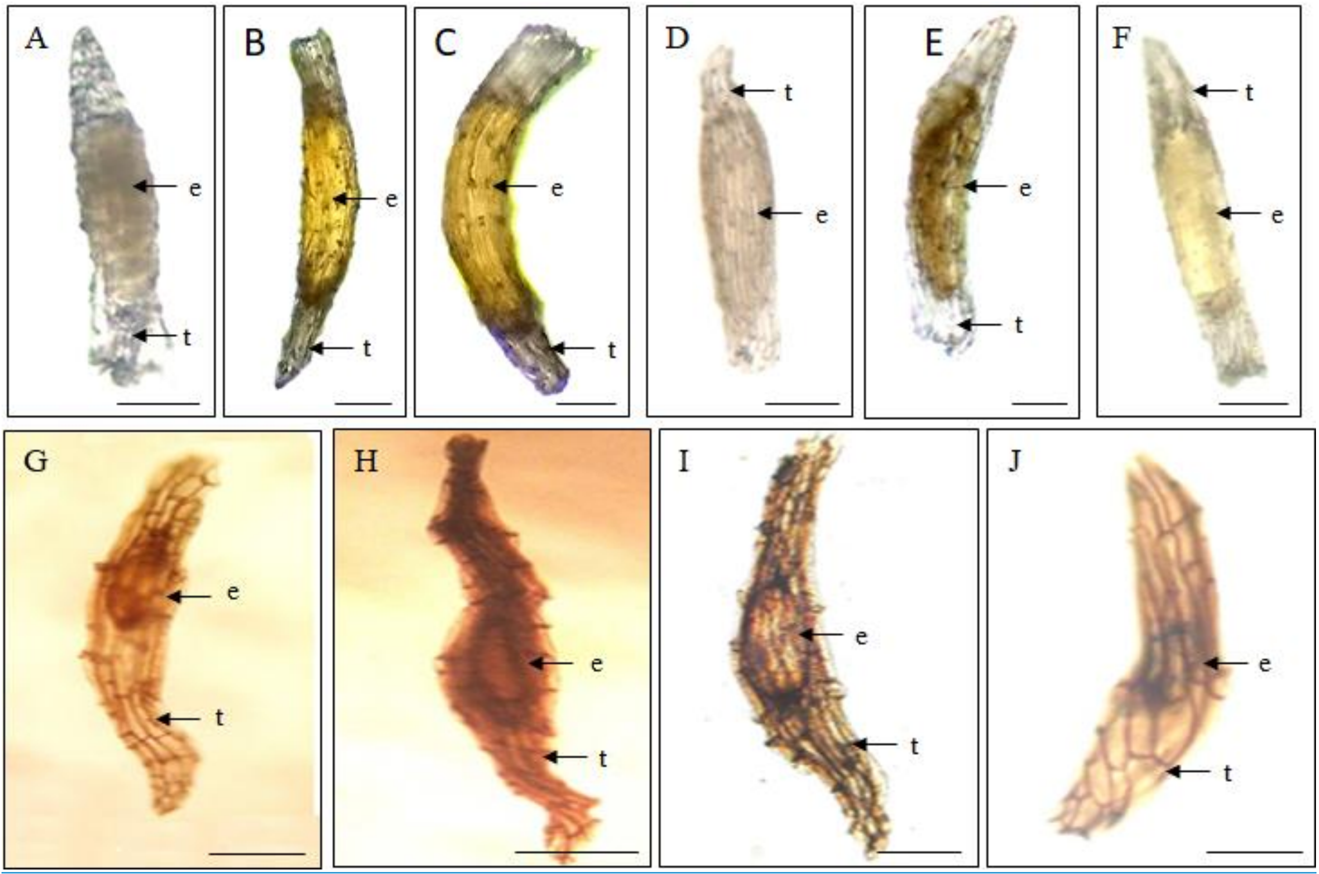
~~There were no differences in the shape of the testa cells at the two poles~~[WU13]~~.~~

Table 1. Morphological characteristics~~Qualitative data of the analysed species~~ [WU14]of the genus *Phalaenopsis and Paphiopedilum*

Species name	Seed Shape	Seed Colour	Ornamentation of the periclinal walls	Testa cell shape	Testa cell walls shape	Embryo Shape	Embryo Colour
Phalaenopsis							
Phal. amabilis[WU15]	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Yellowish brown
Phal. amboinensis	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Yellow
Phal. bellina	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Brown
Phal. gigantea	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Brown
Phal. tetraspis	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Yellowish brown
Phal. venosa	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Light yellow
Paphiopedilum							
Paph. baccanum	Fusiform	Brown	Smooth	Polygonal	Thin rectangular	Prolate	Dark brown
Paph. kolopakingii [WU16]	Fusiform	Dark brown	Smooth	Polygonal	Flat rectangular	Prolate	Brown
Paph. liemianum	Fusiform	Dark brown	Smooth	Polygonal	Thin rectangular	Prolate	White
Paph. primulinum	Fusiform	Brown	Smooth	Polygonal	Flat rectangular	Prolate	Black

In the present work, the embryo colour of *P*[WU17]*hal. amabilis* was yellowish brown. The testa cells were elongated, longitudinally oriented, parallel to the long seed axis and irregular. The testa cell walls were cylindrical shape and exhibited overlap (Figure 2.1B arrow), becoming circle and rising at the end of the meeting between two testa cells [WU18](Figure 2.1D arrow). Certain parts of the testa formed deep furrows (Figure 2.1C arrow).

The embryo colour of *Phal. amboinensis* was yellow. The testa cells were elongated, longitudinally oriented and parallel to long axis and irregular. The testa cells walls were cylindrical. Part of the meeting at the end of the two cells was rounded and slightly raised (Figure 2.2B arrow). The end of the basal pole was blunt (Figure 2.2C), while the end of the apical pole became pointed (Figure 2.2D).



Species name	Seed Shape	Seed Colour	Ornamentation of the periclinal walls	Testa cell shape	Testa cell walls shape	Embryo Shape	Embryo Colour
Phalaenopsis							
Phal. amabilis[WU19]	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Yellowish brown
Phal. tetraspis	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Yellowish brown
Phal. bellina	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Brown
Phal. gigantea	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Brown
Phal. amboinensis	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Yellow
Phal. venosa	Fusiform	Brown and transparent	Smooth	Elongated	Cylindrical	Ovoid	Light yellow
Paphiopedilum							
Paph. kolopakingii [WU20]	Fusiform	Dark brown	Smooth	Polygonal	Flat rectangular	Prolate	Brown
Paph. liemianum	Fusiform	Dark brown	Smooth	Polygonal	Thin rectangular	Prolate	White
Paph. baccanum	Fusiform	Brown	Smooth	Polygonal	Thin rectangular	Prolate	Dark brown
Paph. primulinum	Fusiform	Brown	Smooth	Polygonal	Flat rectangular	Prolate	Black

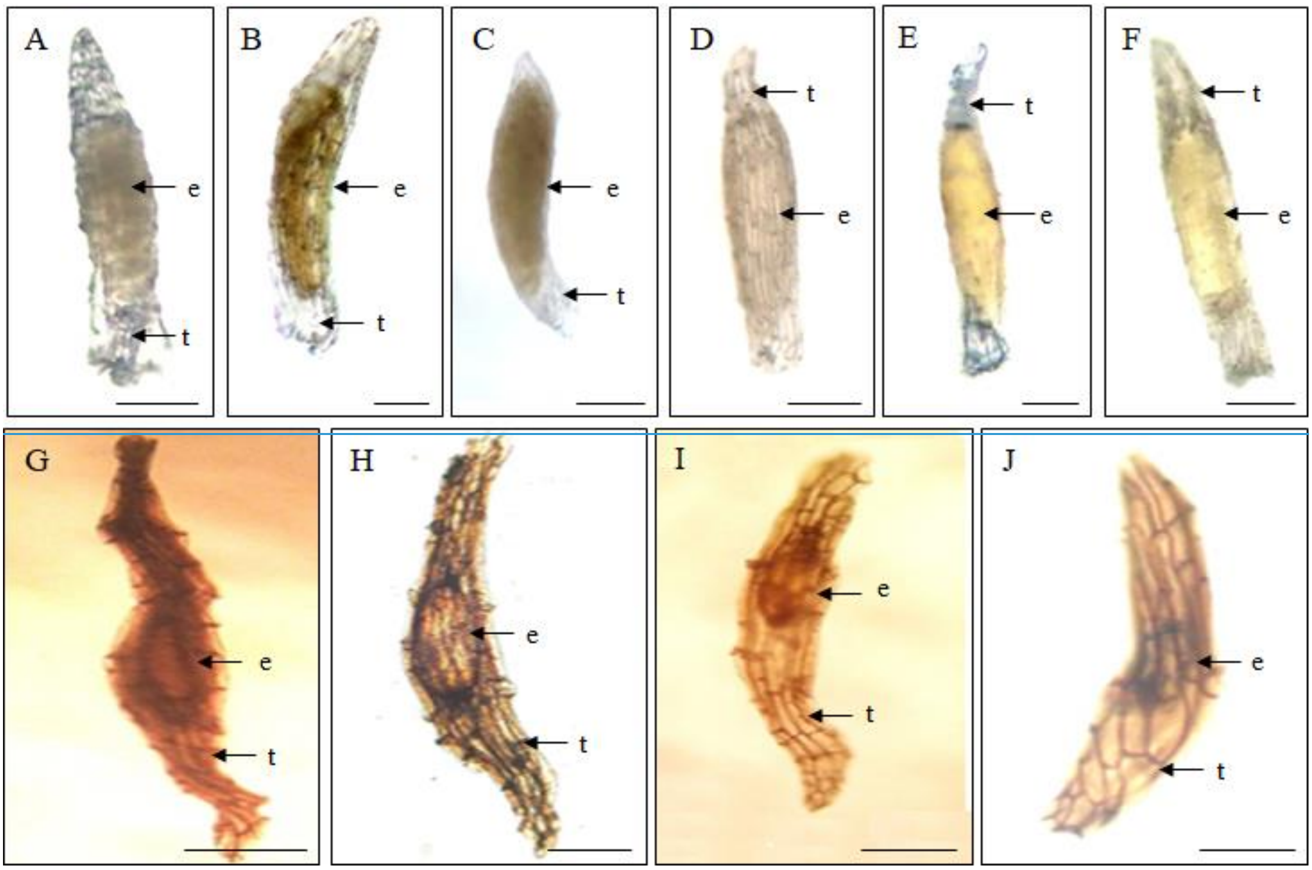


Figure 1. LM photographs. of (A-F) *Phalaenopsis* and (G-J) *Paphiopedilum.* A. *Phal. amabilis* (scale bar=72 µm), B. *Phal. amboinensis* (scale bar=59 µm), B. *Phal. tetraspis* (scale bar=49 µm), C. *Phal. bellina* (scale bar=65 µm), D. *Phal. gigantea* (scale bar=51 µm), E. *Phal. tetraspis* (scale bar=49 µm), *Phal. amboinensis* (scale bar=59 µm), F. *Phal. venosa* (scale bar=55 µm), G. *Paph. baccanum* (scale bar=185 µm), H. *Paph. kolopakingii* (scale bar=206 µm), IH. *Paph. liemianum* (scale bar=162 µm), I. *Paph. baccanum* (scale bar=185 µm), J. *Paph. primulinum* (scale bar=161 µm). e= embryo, t=testa.

The embryo colourtesta cells on the surface of *PhalP. amboinensis* was yellow.did not have any ornamentation. The testa cells were elongated elongated, longitudinally oriented and, parallel to long axis and irregular. The testa cells walls were cylindrical. The testa cells walls were cylindrical. Part of the meeting at the end of the two cells was rounded and slightly raised (Figure 2.2 3B arrow). The end of the basal pole was blunt (Figure 2.2 3C), while the end of the apical pole became pointed (Figure 2.23D).

The testa surface of *Phal*[WU21]. *tetraspis* was smooth. The testa cells were elongated, longitudinally oriented, parallel to the long axis and irregular. The testa cell walls were cylindrical, and very close together [WU22](Figure 3). At the end of the meeting between two testa cells the cell walls became wider, rounder and rose up (Figure 3C arrow)[WU23]. There was a difference in the shape of the testa cells at the two poles. Cells at the basal pole were smaller than cells at the apical pole[WU24].

P[WU25]*hal. bellina* did not have any ornamentation on the surface of its testa cells; the cells were elongated, longitudinally oriented, parallel to the long seed axis and irregular. The testa cell walls were cylindrical, and the distance between two cells formed a slit in a row (Figure 4B). The meeting point between the two ends of the testa cells was curved, thickened and raised to form a bulge (Figure 4B arrow). There was a difference in the shape of the testa cells at the two poles. Cells of the basal pole were bigger and rounder than cells of the apical pole [WU26](Figure 4C and D).

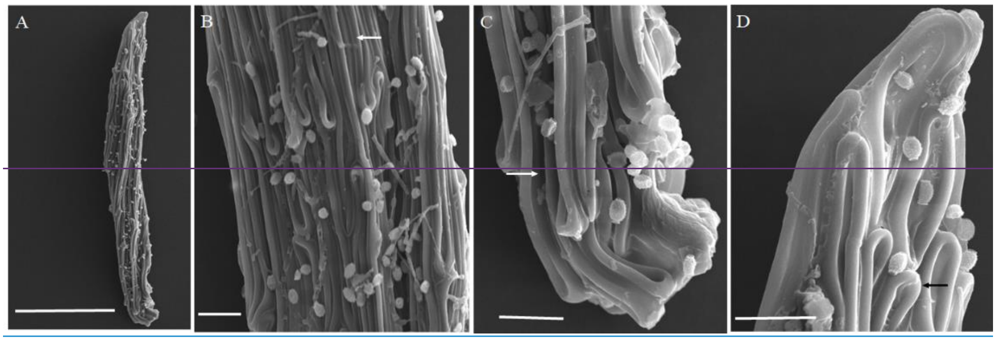


Figure 2[WU27]**.** SEM photographs of *Phal. amabilis*. A. Fusiform seed shape, B. Pattern of testa cells [WU28]of the medial, C. Cells of the basal pole[WU29], D. Cells of the apical pole[WU30]. Scale bars: A=100 µm, B-D=10 µm.

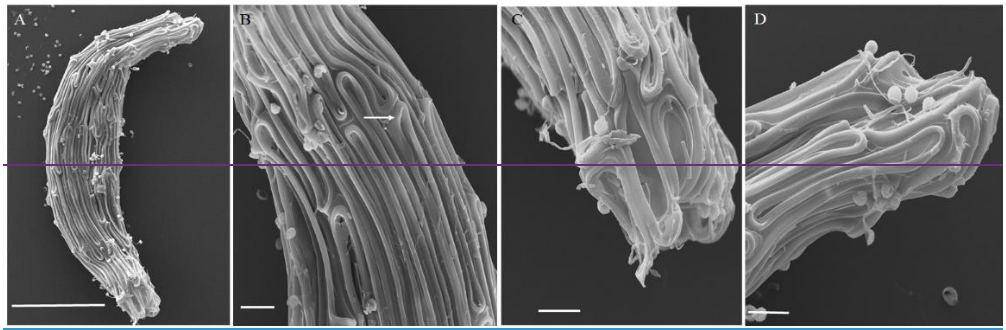


Figure 36. [WU31]SEM photographs of *Phal. amboinensis*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=80 µm, B-D=10 µm.

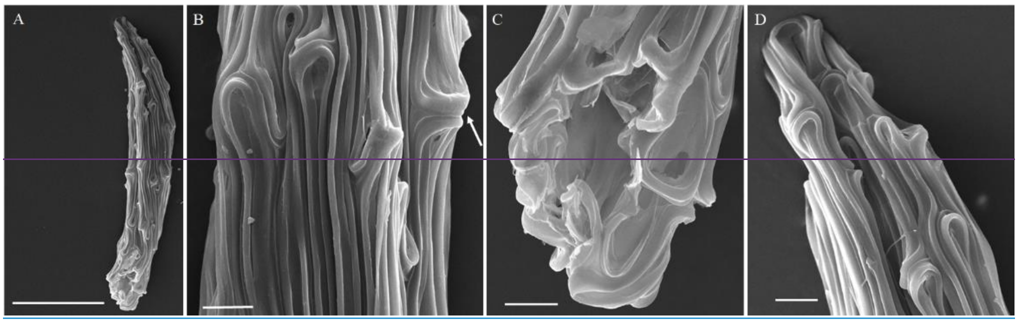


Figure 4[WU32]. SEM photographs of *Phal. bellina*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=10 µm.

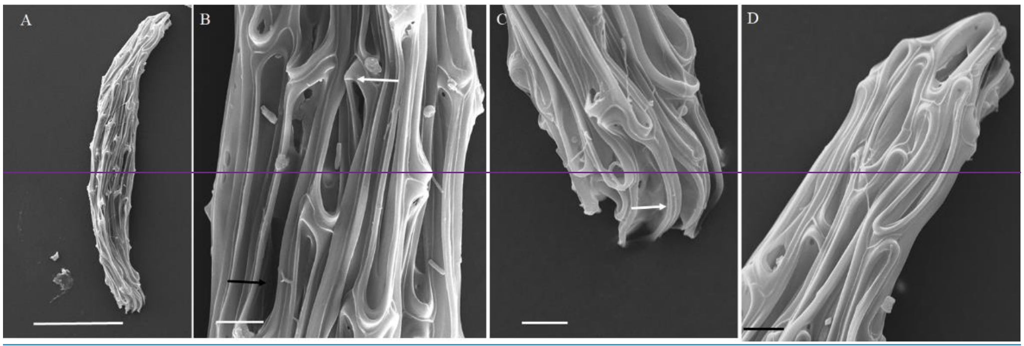


Figure 5. [WU33]SEM photographs of *Phal. gigantea*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=10 µm.

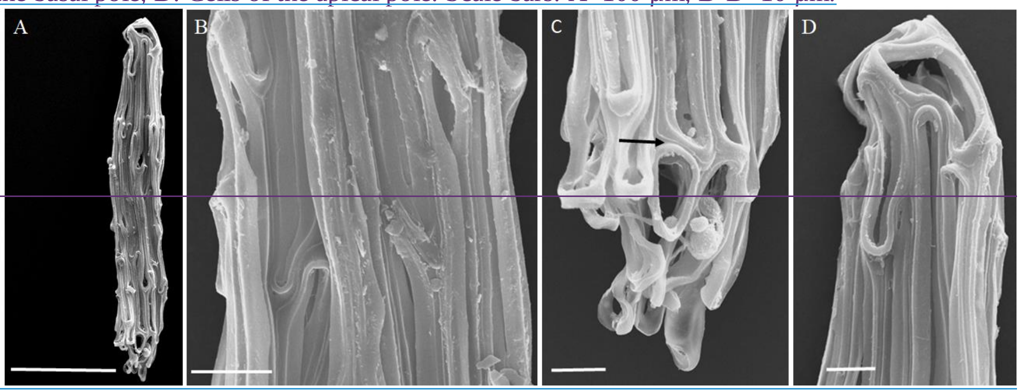


Figure 3[WU34].6 SEM photographs of *Phal. tetraspis*. A. seed shape[WU35], B. Pattern of testa [WU36]cells of the medial, C. Cells of the basal pole[WU37], D. Cells of the apical pole[WU38]. Scale bars: A=100 µm, B-D=10 µm.

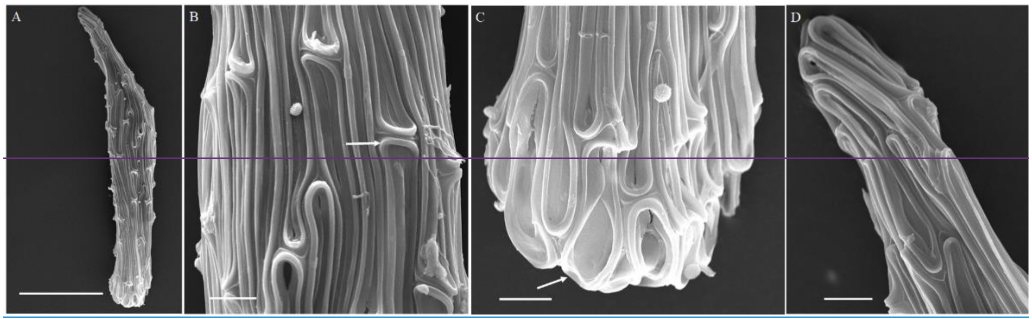


Figure 7. [WU39]SEM photographs of *Phal. venosa*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=80 µm, B-D=10 µm.

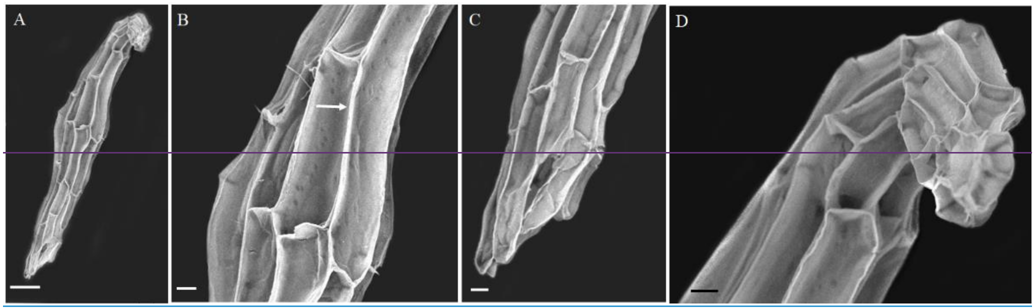


Figure 810[WU40]. SEM photographs of *Paph. baccanum*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=20 µm.

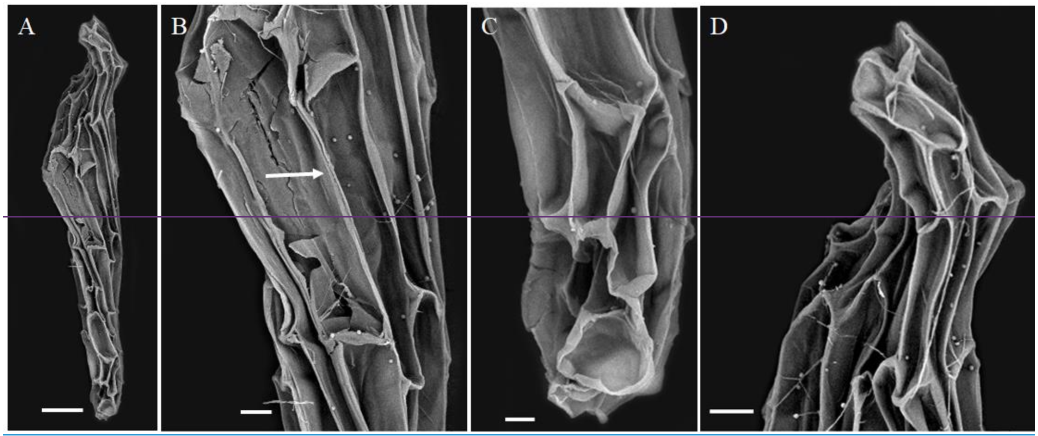


Figure 8[WU41].9 SEM photographs of *Paph. kolopakingii* . A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=20 µm.

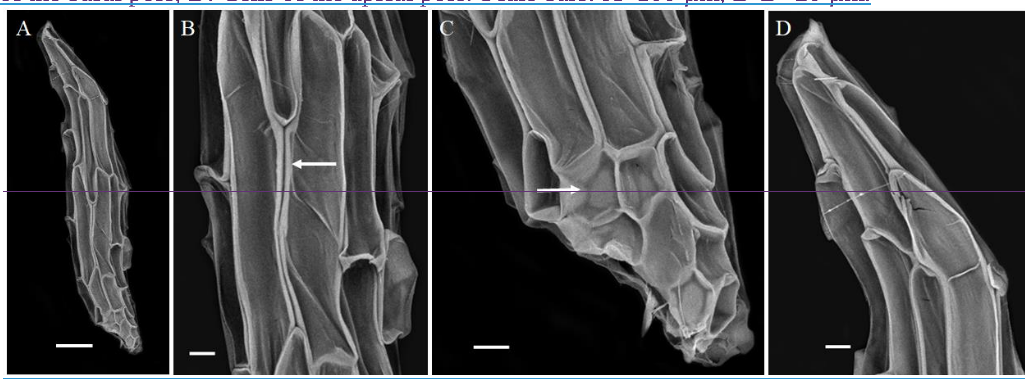


Figure 109. [WU42]SEM photographs of *Paph. liemianum*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=20 µm.

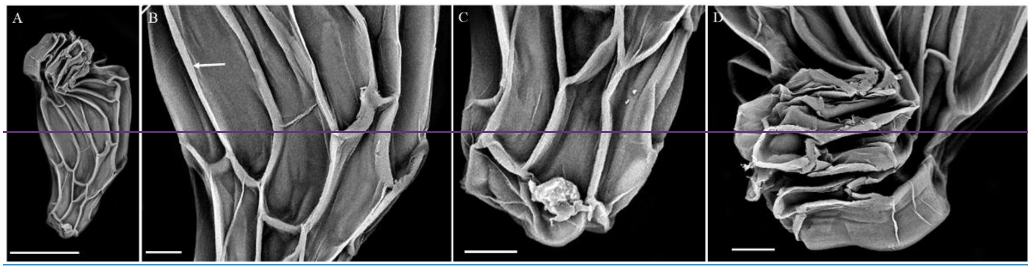


Figure 11[WU43]. SEM photographs of *Paph. primulinum.* A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=20 µm.

P[WU44]*hal. bellina* have brown embryo colour. The testa cells were elongated, did not have any ornamentation on the surface of its testa cells; the cells were elongated, longitudinally oriented, parallel to the long seed axis and irregular. The testa cell walls were cylindrical, and the testa cells walls were cylindrical and the distance between two cells formed a slit in a row (Figure 3.14B). The meeting point between the two ends of the Ttesta cells was curved, thickened and raised to form a bulge at the meeting point between the two ends (Figure 3. 14B arrow). There was a difference in the shape of the testa cells at the two poles. Cells of the basal pole were bigger and rounder than cells of the apical pole [WU45](Figure 3.1 4C and D).

In *Phal.*[WU46] *gigantea*, the embryo colour was browntesta surface was smooth. The testa cells were elongated, longitudinally oriented, parallel to the long seed axis and highly irregular. Ridges were elevated with a deep groove (Figure 3. 25B black black arrow). The testa cell walls were cylindrical. At the meeting point the Ttwo ends of the testa cells were curved and raised at the meeting point (Figure 3.25B white white arrow). Cells of the basal pole were different to cells at the apical pole; cells at the basal pole had an appendage at the end and become pointed (Figure 3. 25C arrow).[WU47]

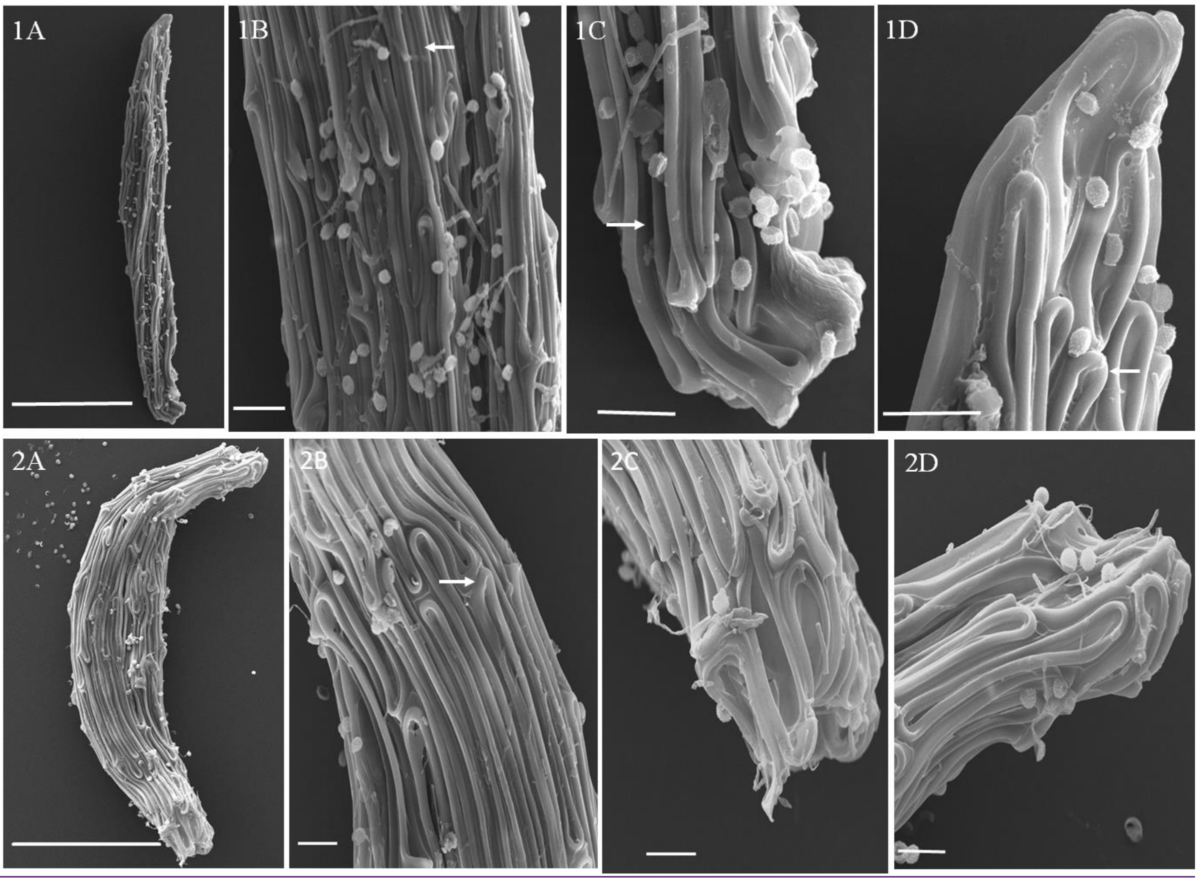


Figure 2[WU48]. SEM photographs. 1. *Phal. amabilis*, 2. *Phal. amboinensis*, A. Seed shape, B. Testa cells [WU49]of the medial,(1B. arrow indicate the testa cell overlap, 2B. arrow indicate the end of two cells was rounded and slightly raised) C. Basal pole[WU50],(1C. arrow indicate the testa formed deep furrow) -D. Apical pole[WU51] (1D. arrow indicate the end of the meeting between two testa cells becoming round and rising). Scale bars: A=100 µm, B-D=10 µm.

P[WU52]*hal. bellina* have brown embryo colour. The testa cells were elongated, longitudinally oriented, parallel to the long seed axis and irregular. The testa cells walls were cylindrical and the distance between two cells formed a slit in a row (Figure 3.1B). Testa cells was curved, thickened and raised to form a bulge at the meeting point between the two ends (Figure 3. 1B arrow). There was a difference in the shape of the testa cells at the two poles. Cells of the basal pole were bigger and rounder than cells of the apical pole [WU53](Figure 3.1C and D).

In *Phal.*[WU54] *gigantea*, the embryo colour was brown. The testa cells were longitudinally oriented, parallel to the long seed axis and highly irregular. Ridges were elevated with a deep groove (Figure 3. 2B black arrow). Two ends of the testa cells were curved and raised at the meeting point (Figure 3.2B white arrow). Cells of the basal pole were different to cells at the apical pole; cells at the basal pole had an appendage at the end and become pointed (Figure 3. 2C arrow).[WU55]

The embryo colour of *Phal*[WU56]. *tetraspis* was yellowish brown. The testa cells were elongated, longitudinally oriented and parallel to the long axis and irregular. The testa cell walls were cylindrical and close proximity [WU57](Figure 4.1). At the end of the meeting between two testa cells the cell walls became wider, rounder and rose up (Figure 4. 1C arrow)[WU58]. There was a difference in the shape of the testa cells at the two poles. Cells at the basal pole were smaller than cells at the apical pole[WU59].

In the case of *Phal. venosa*, the embryo colour was light yellow. The testa cells were longitudinally oriented, parallel to the long axis, irregular, and raised at the end of the meeting between two cells (Figure 4. 2B arrow). Testa cells at the end of the basal pole were widened and rounded (Figure 4. 2C arrow), but testa cells at the apical pole were more elongated and pointed (Figure 4. 2D).

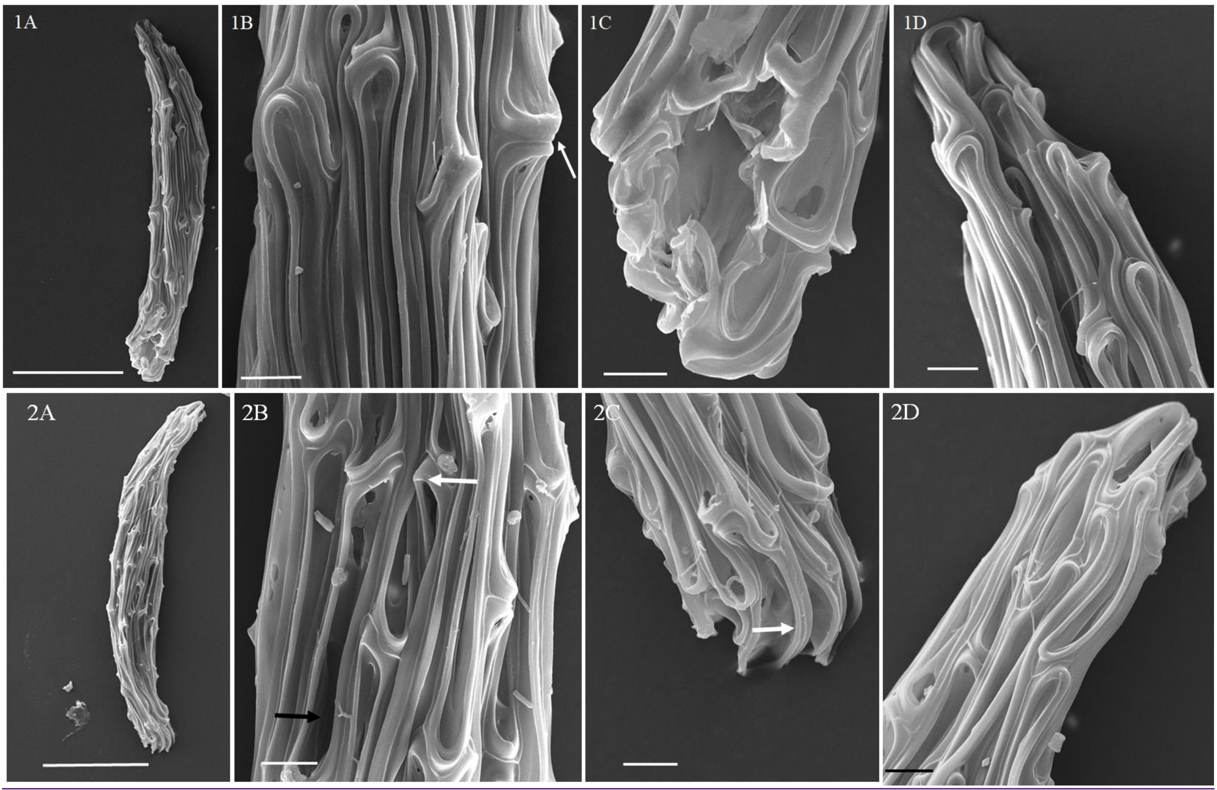


Figure 3. SEM photographs. 1. *Phal. bellina*, 2. *Phal. gigantea*, A. Seed shape, B. Testa cells [WU60]of the medial (1B. arrow indicate cells are rounded and slightly raised, 2B white arrow indicate the testa cell are curved and raised at the end of two testa cells, black arrow indicate ridge with deep groove) , C. Basal pole[WU61] (2C. arrow indicate the end testa cells at the basal pole had appendage with pointed of the end), D. Apical pole[WU62]. Scale bars: A=100 µm, B-D=10 µm.

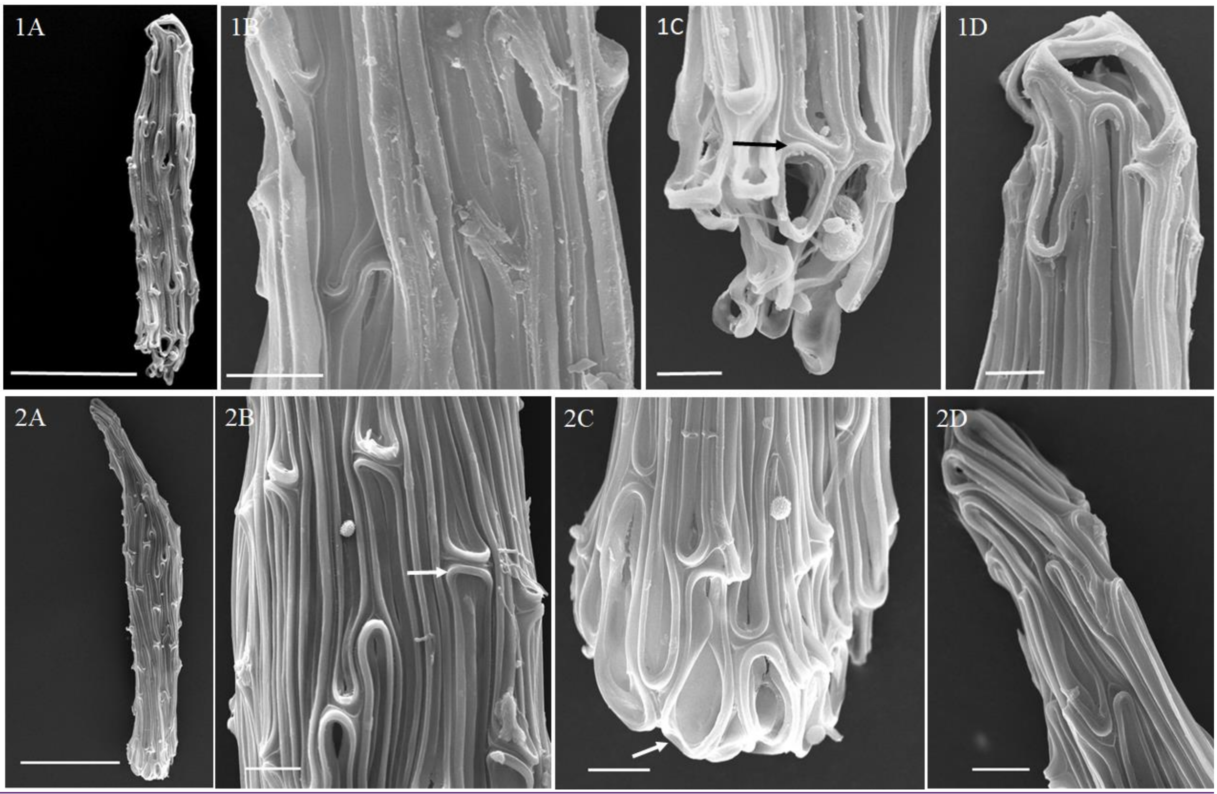


Figure 4. [WU63]SEM photographs. 1.*Phal. tetraspis*. 2. *Phal. venosa*.. A. seed shape, B. Testa cells of the medial (2B. arrow indicate the testa cell walls are raised at the end of the meeting between two cells) , C. Basal pole (1C. black arrow indicate the testa cell become wider, rounder, and rose up, 2C. arrow indicate the testa cells at the end of basal pole were widened and rounded), D. Apical pole. Scale bars: A=100 µm; B-D = 10 µm.

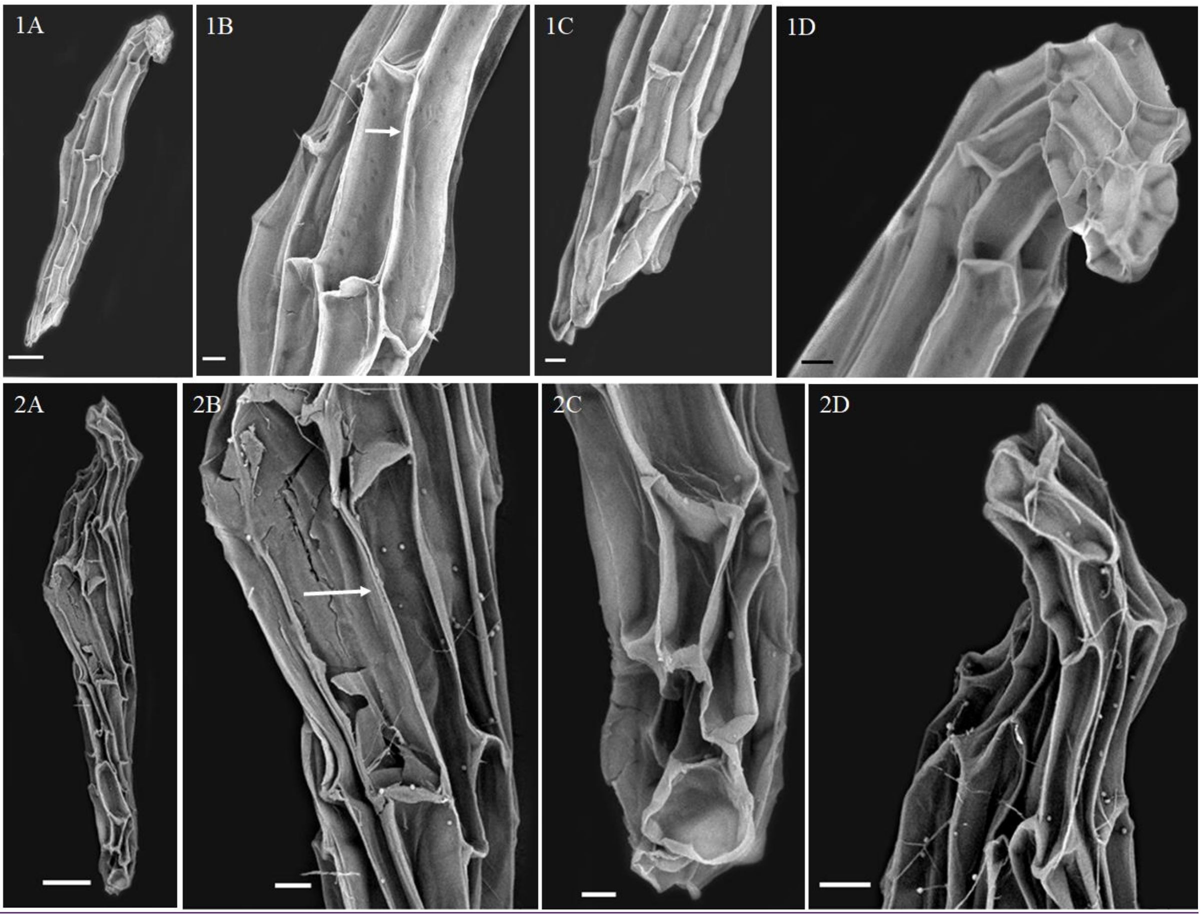


Figure 5. [WU64]SEM photographs. 1. *Paph. baccanum*.2. *Paph. kolopakingii*, A. Fusiform seed shape, B. Testa cells of the medial (1B. arrow indicate the testa cell walls are thin, 2B. arrow indicate the cell walls were flat), C. Basal pole, D. Apical pole. Scale bars: A=80 µm, B-D = 20 µm.

Paphiopedilum seeds can be differentiated with seeds of *Phalaenopsis* in terms of polygonal testa cell shape, rectangular testa cell walls and prolate embryo shape. *Paph. baccanum*, *Paph. kolopakingii*, *Paph. liemianum* and *Paph. primulinum* have same character i.e fusiform seed shape, smooth ornamentation of the periclinal walls, polygonal testa cell shape, rectangular testa cell walls shape and prolate embryo shape (Table 1).

In the case of *Paph. baccanum*, the seed colour was brown and embryo colour was dark brown. Generally, the testa cells were longitudinally oriented with a deep groove, parallel to the long axis and irregular (Figure 5.1). The testa cell walls were thin (Figure 5.1B arrow). Cells at the basal pole were longer compared to cells at the apical pole. The end of the basal pole became pointed, while the end of the apical pole became rounded (Figures 5. 1C and D).

In *Paph. kolopakingii*, the seed colour was dark brown and embryo colour was brown. Testa cells were longitudinally oriented with a deep groove, parallel to the long axis and irregular. The testa cell walls were flat (Figure 5. 2B arrow).. The basal cell pole was larger and more dented than the cells of the apical pole (Figures 5.2C and D).

The seed colour of *Paph. liemianum* were dark brown and white embryo. The testa cells were longitudinally oriented with a deep groove, parallel to the long axis and irregular (Figure 6.1). The testa cell walls were thin (Figure 6.1B arrow). The medial region was wider than the two poles. The basal cells were short, polygonal and more numerous than the apical cells (Figure 6.1C arrow).


1A
1B
1C
1D
2A
2B
2C
2D

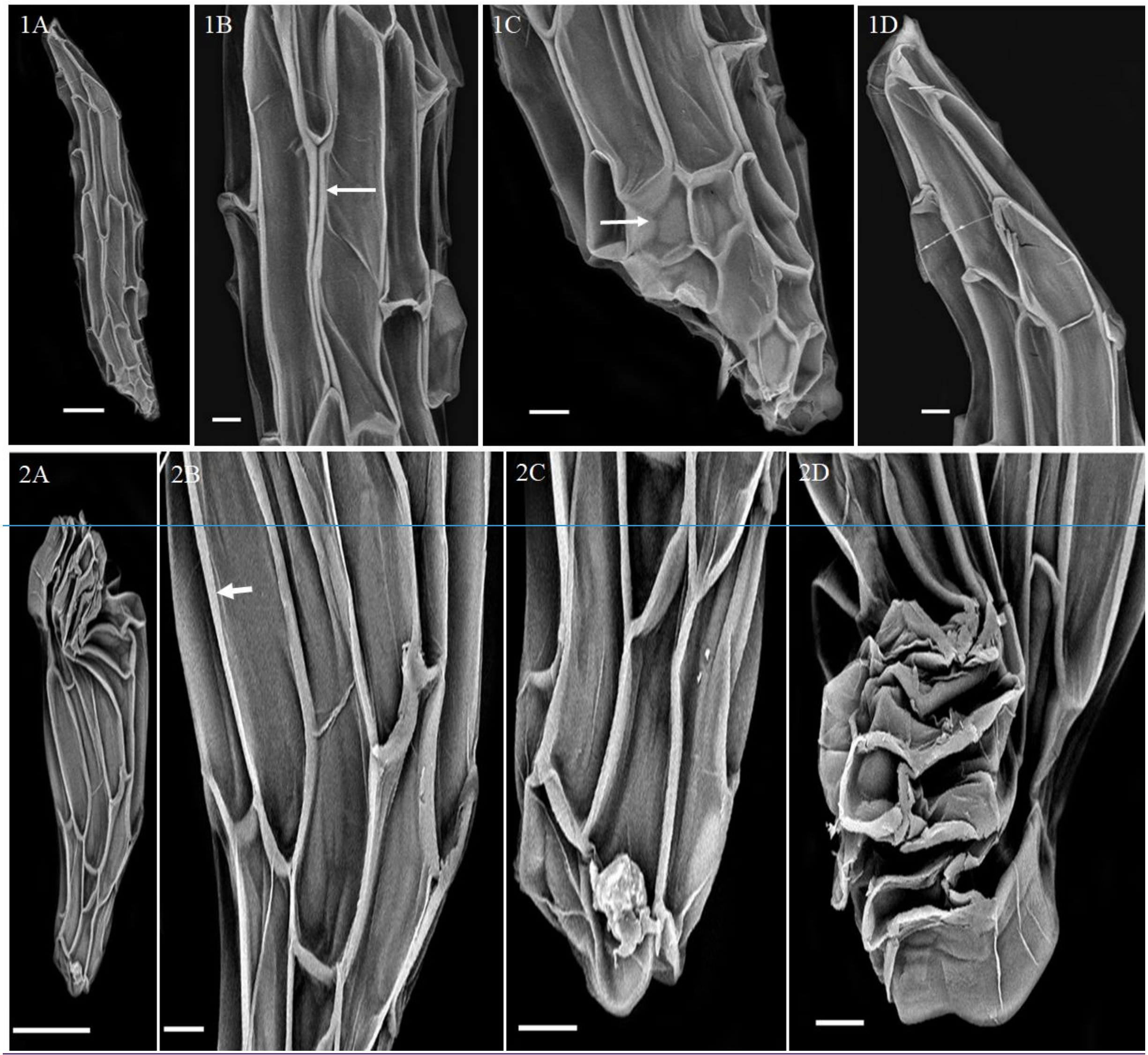


Figure 6. [WU65]SEM photographs. 1. *Paph. liemianum*. 2. *Paph. primulinum*. A. seed shape, B. Testa cells of the medial .(1B. arrow indicate the testa cell walls are thin, 2B. arrow indicate the testa cell walls were flat), C. Basal pole (1C arrow indicate the shape of testa cells at basal pole are polygonal), D. Apical pole. Scale bars: A=80 µm, B-D = 20 µm.

The embryo colourtesta surface of *Phal*[WU66]. *tetraspis* was yellowish brownsmooth. The testa cells were elongated, elongated, longitudinally oriented and, parallel to the long axis and irregular. The testa cell walls were cylindrical and cylindrical, and very close proximitytogether [WU67](Figure 4.16). At the end of the meeting between two testa cells the cell walls became wider, rounder and rose up (Figure 4. 16C arrow)[WU68]. There was a difference in the shape of the testa cells at the two poles. Cells at the basal pole were smaller than cells at the apical pole[WU69]. RW

Figure 3[WU70]. SEM photographs of *Phal. tetraspis*. A. seed shape[WU71], B. Pattern of testa [WU72]cells of the medial, C. Cells of the basal pole[WU73], D. Cells of the apical pole[WU74]. Scale bars: A=100 µm, B-D=10 µm.

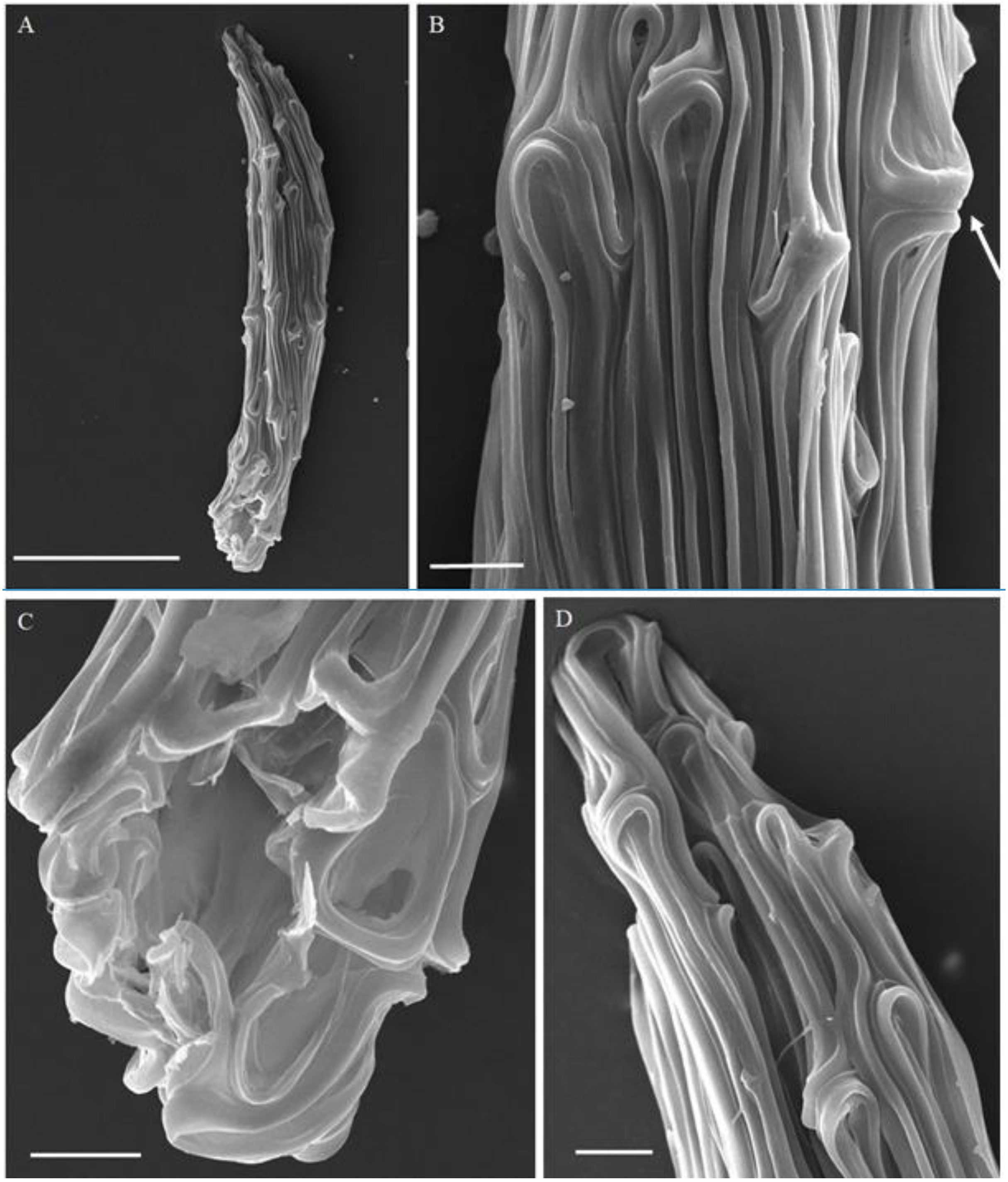


Figure 4[WU75]. SEM photographs of *Phal. bellina*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=10 µm.

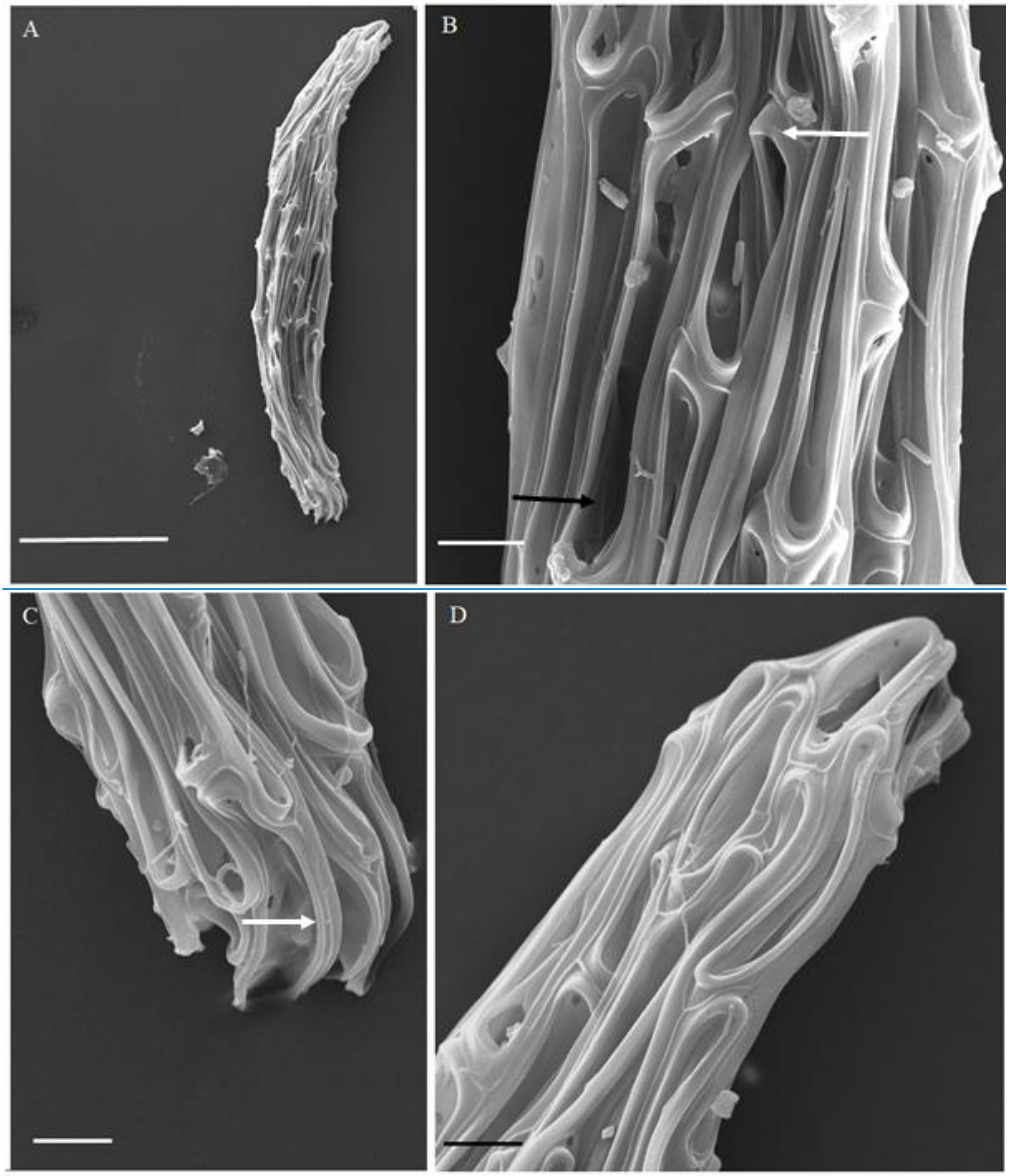


Figure 5. [WU76]SEM photographs of *Phal. gigantea*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=10 µm.

The testa cells on the surface of *P. amboinensis* did not have any ornamentation. The testa cells were elongated, longitudinally oriented, parallel to long axis and irregular. The testa cells walls were cylindrical. Part of the meeting at the end of the two cells was rounded and slightly raised (Figure 6B arrow). The end of the basal pole was blunt (Figure 6C), while the end of the apical pole became pointed (Figure 6D).

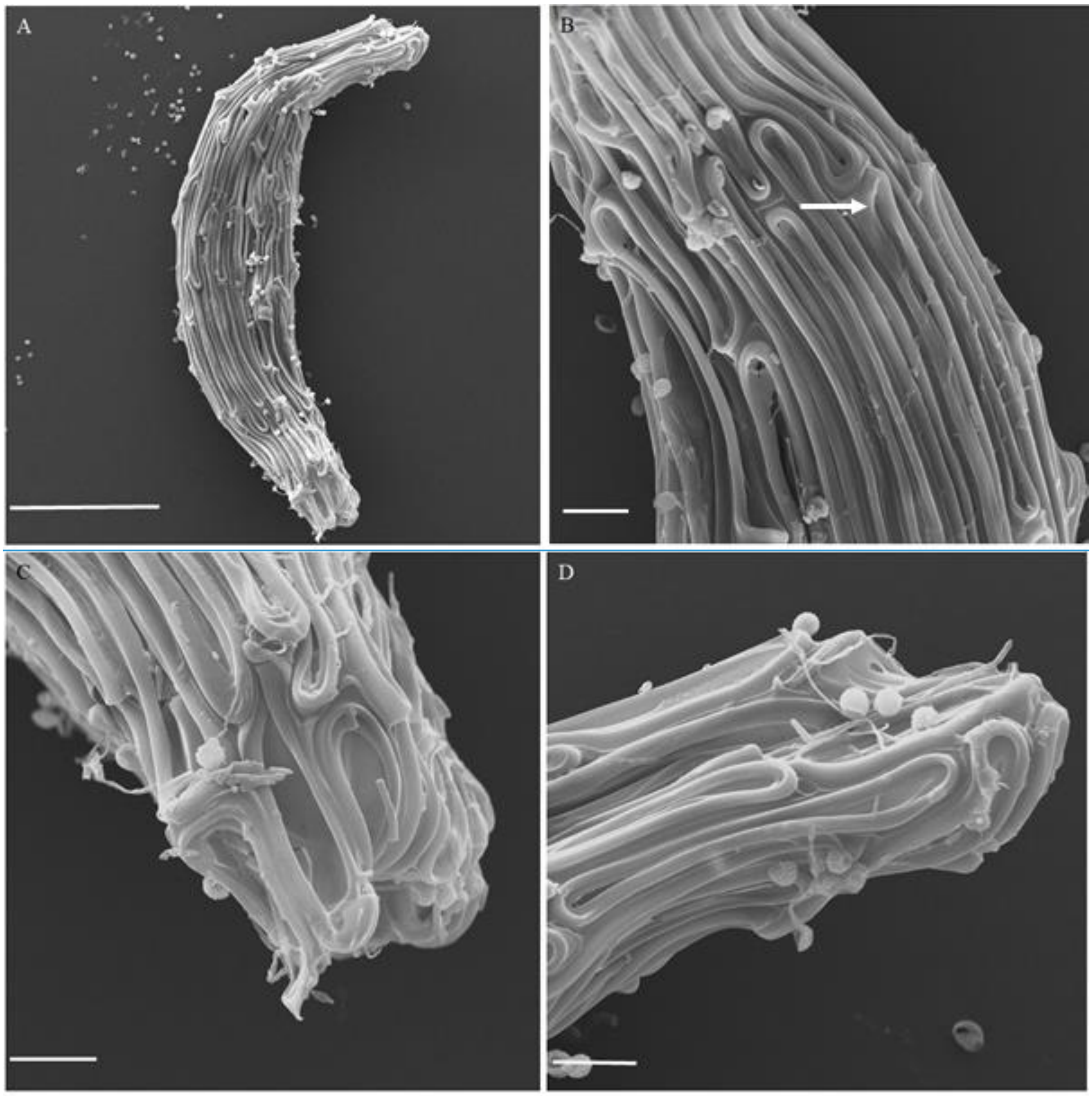


Figure 6. [WU77]SEM photographs of *Phal. amboinensis.* A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=80 µm, B-D=10 µm.

In the case of *Phal. venosa*, the embryo colour testa surface was light yellowsmooth. The testa cells were elongated and longitudinally oriented, parallel to the long axis, irregular, and raised at the end of the meeting between two cells (Figure 4. 27B arrow). The testa cells walls were cylindrical. Testa cells at the end of the basal pole were widened and rounded (Figure 4. 27C arrow), but testa cells at the apical pole were more elongated and pointed (Figure 4. 27D). The end of the basal pole was rounded (Figure 7C), while the end of the apical pole was pointed (Figure 7D).

In *Paphiopedilum* seeds can be differentiated with seeds of *Phalaenopsis* in terms of have polygonal testa cell shape, rectangular testa cell walls, and prolate embryo shape. *Paph. baccanum*, *Paph. kolopakingii*, *Paph. liemianum* and *Paph. primulinum* have same character i.e fusiform seed shape, smooth ornamentation of the periclinal walls, polygonal testa cell shape, rectangular testa cell walls shape and prolate embryo shape (Table 1).

The seeds were generally uniform i.e. fusiform in shape with colours from brown to dark brown. Dark brown seeds were recorded in *Paph. kolopakingii* and *Paph. liemianum*. Brown seeds were observed in *Paph. baccanum* and *Paph. primulinum*, embryos were distinct and present in the centre, Dark brown embryos were found in *Paph. baccanum*, White embryos characterised *Paph. Liemianum* and black embryos were seen in *Paph. Primulinum*

In the case of *Paph. baccanum*, the seed colour testa surface was brown and embryo colour was dark brownsmooth. Generally, the testa cells were polygonal, longitudinally oriented with a deep groove, parallel to the long axis and irregular (Figure 5.18). The testa cell walls were thin and rectangular (Figure 5.18B arrow). Cells at the basal pole were longer compared to cells at the apical pole. The end of the basal pole became pointed, while the end of the apical pole became rounded (Figures 5. 18C and D).

In the case of *Paph. kolopakingii*, the seed colour was dark brown and embryo colour was brown. Ttesta cells were polygonal, longitudinally oriented with a deep groove, parallel to the long axis and irregular. The testa cell walls were flat and rectangular (Figure 5. 298B arrow). The testa surfaces were smooth. The shape of the basal cell pole was larger and more dented than the cells of the apical pole (Figures 5.298C and D).

The seed colour testa surfaces of *Paph. liemianum* were dark brown and white embryosmooth. The testa cells were were polygonal, longitudinally oriented with a deep groove, parallel to the long axis and irregular (Figure 96.110). The testa cell walls were thin and rectangular (Figure 9B 6.110B arrow). The medial region was wider than the two poles. The basal cells were short, polygonal and more numerous than the apical cells (Figure 9C 6.110C arrow).

In the case of *Paph. baccanum*, the testa surface was smooth. Generally, the testa cells were polygonal, longitudinally oriented with a deep groove, parallel to the long axis and irregular (Figure 10). The testa cell walls were thin and rectangular (Figure 10B arrow). Cells at the basal pole were longer compared to cells at the apical pole. The end of the basal pole became pointed, while the end of the apical pole became rounded (Figures 10C and D).

In *Paph. primulinu*n had*m*, the brown seed colour and black embryo colour.smooth testa surfacee was smooth. Generally, testa cells werere polygonal, longitudinally oriented with a deep groove, parallel to the long axis and irregular (Figure 6.211). The testa cell walls were flat and rectangular (Figure 6.211B arrow). The end of the basal pole was blunt, while the end of the apical pole was suppressed (Figures 6.2 11C and D).

In this study, we did not observe any sculpturing on the cell walls or smooth in any species of the two different genera. This is probably because all of these species are equally alive and come from the tropics, despite their different living forms (epiphyte and terrestrial). This observation corresponds with the opinion of Chaudhary et al. (2014), who noted that seed ornamentations are directly related to the climatic preference of the species rather than its phylogeny. Similarly, according to Shimizu (2012), seed coat forms that are independent of plant habitat have a wider seed dispersal. The images we observed with SEM showed that different species in the genus *Phalaenopsis* had the same shape of testa cells and cell walls, namely elongated with cylindrical cell walls. Similarly, different species in the genus *Paphiopedilum* had testa cells and cell walls with the same shape, namely polygonal and with thin/flat rectangular cells walls. However, these results contradict with the results of previous research by Arditti et al. (1979, 1980) and Swamy et al. (2004), who showed that testa cells of different species can vary significantly in shape.

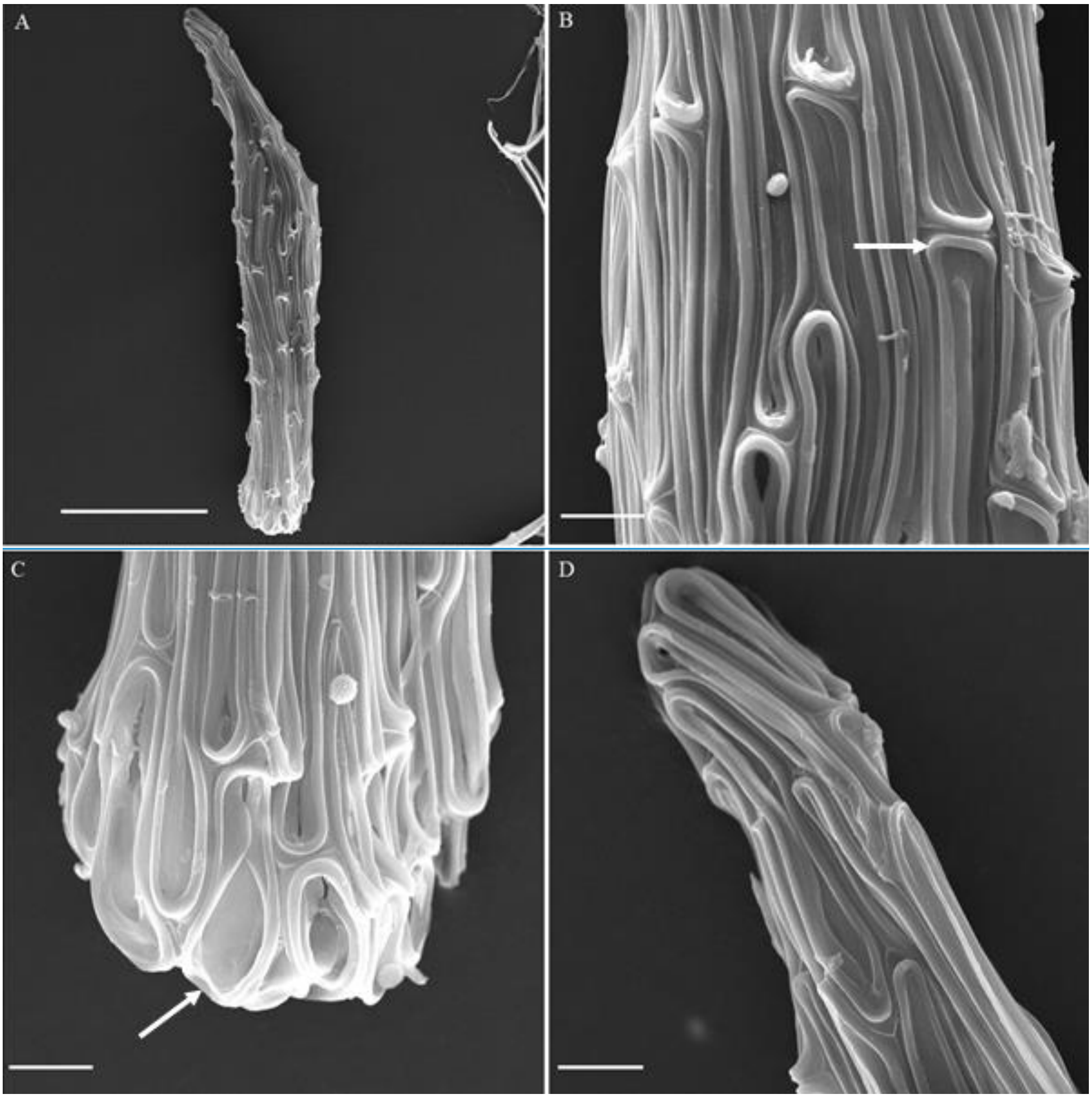


Figure 7. [WU78]SEM photographs of *Phal. venosa*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=80 µm, B-D=10 µm.

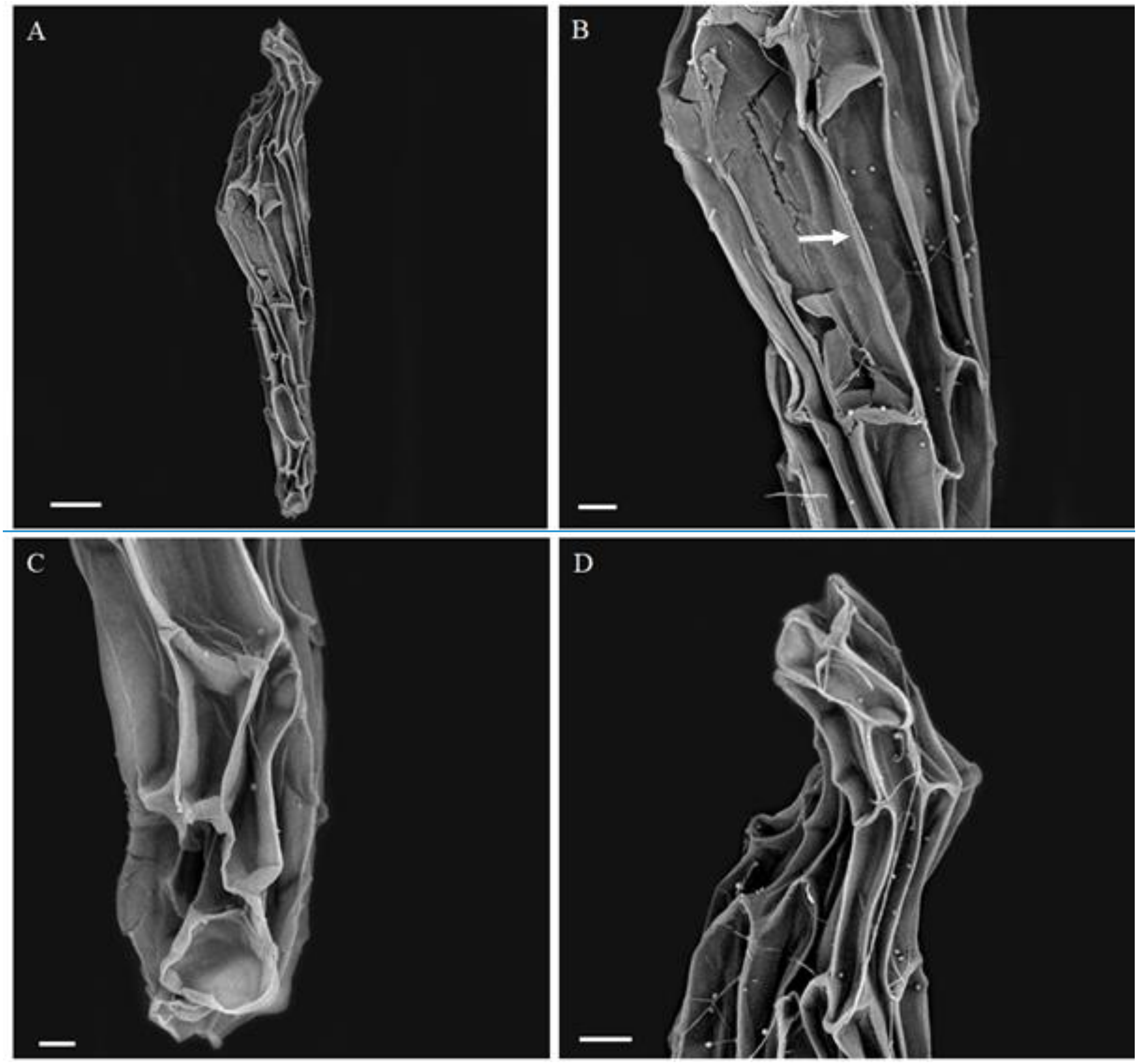


Figure 8[WU79]. SEM photographs of *Paph. kolopakingii* . A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=20 µm.

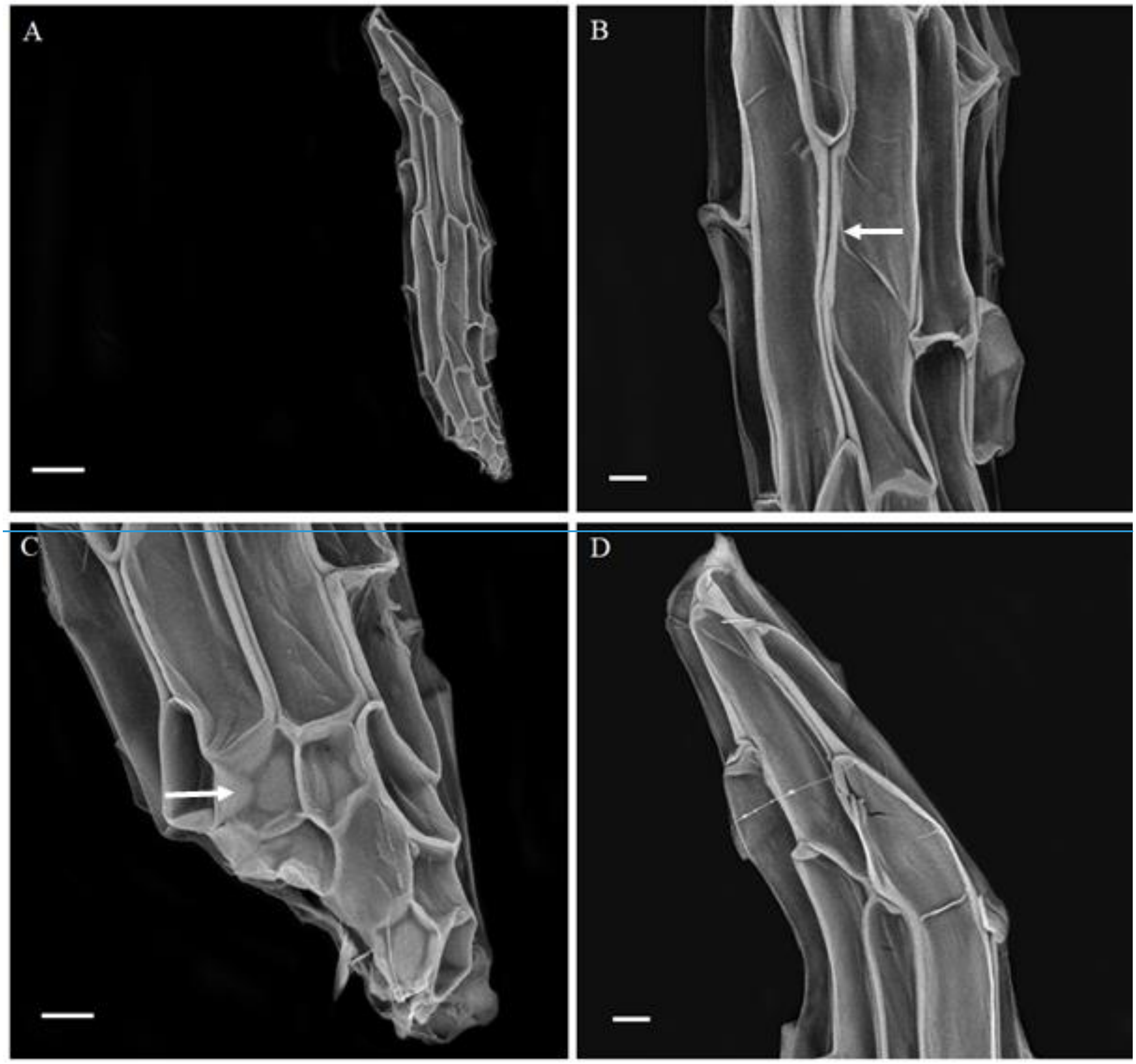


Figure 9. [WU80]SEM photographs of *Paph. liemianum.* A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=20 µm.

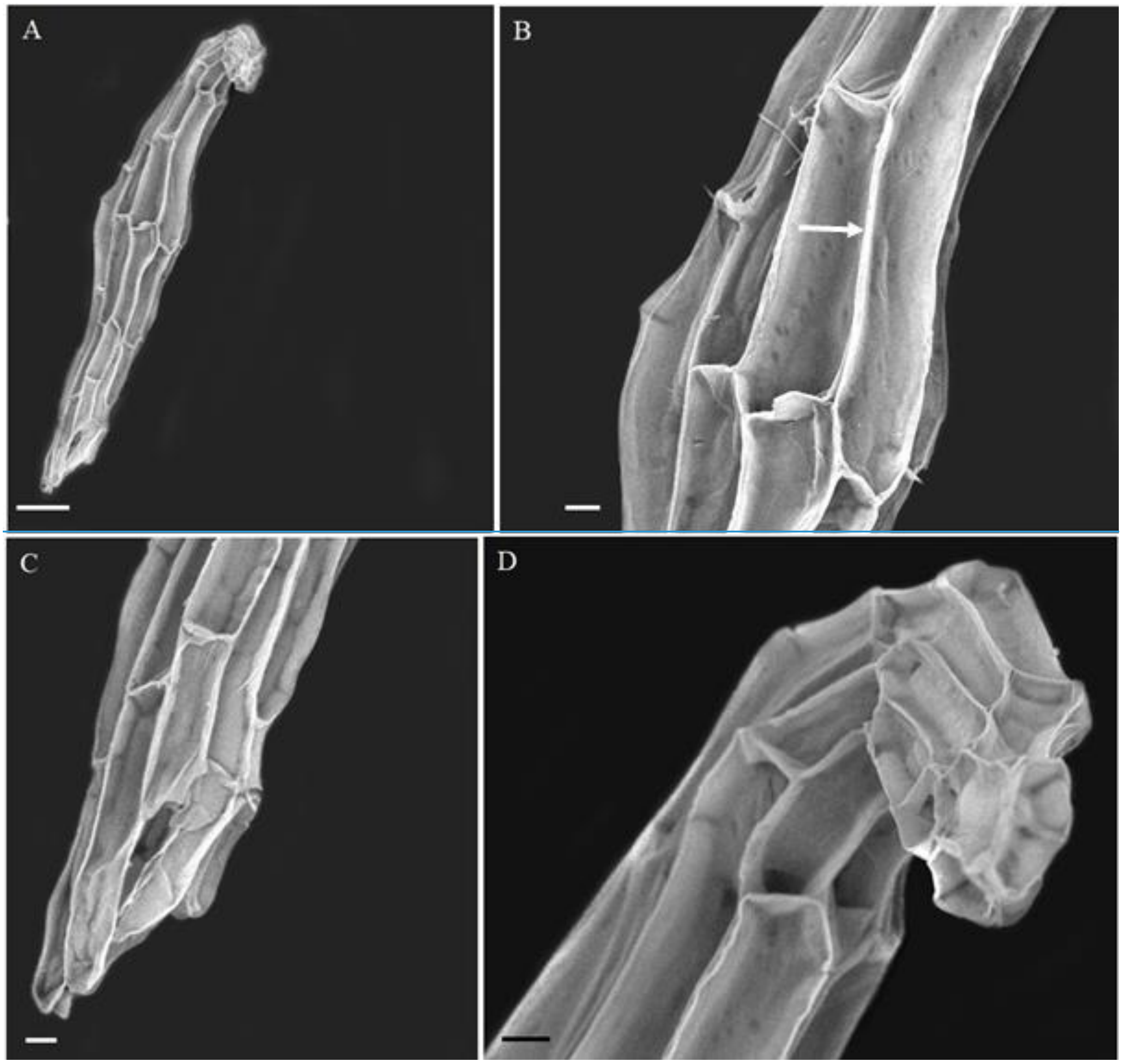


Figure 10[WU81]. SEM photographs of *Paph. baccanum*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 μm, B-D=20 μm.

~~Figure 11[WU82]. SEM photographs of *Paph. primulinum*. A. seed shape, B. Pattern of testa cells of the medial, C. Cells of the basal pole, D. Cells of the apical pole. Scale bars: A=100 µm, B-D=20 µm.~~

Seeds size, ratio SL/SW and seed volume

The table 2 exhibits the size of seeds from ten species of the genus *Phalaenopsis* and *Paphiopedilum*. In spite of the fact that the seeds are microscopic, the result of the investigation showed a great diversity in their size. Seed length ranged between 0.302±0.008~~79~~ mm (*Phal*. *bellina*) and 0.983±0.003~~5~~ mm (*Paph*. *liemianum*), and width ranged from 0.049±0.004~~39~~ mm (*Phal*. *tetraspis*) to 0.206±0.002~~16~~ mm (*Paph*. *kolopakingii*). According to Verma et al. (2014), the SL/SW ratio provides information on the degree of seed truncation and is a good taxonomic character (Arditti et al. 1979 and Vij et al. 1992). In the present work, the species with seeds that were truncated (SL/SW < 6) were *Phal. amboinensis,* *Phal*. *bellina*, *Paph. baccanum,* ~~*Phal. amboinensis,*~~ *Paph*. *kolopakingii*~~, *Paph. baccanum*~~ and *Paph*. *primulinum*. The following species had elongated seeds (SL/SW > 6): *Phal*. *amabilis*, ~~*Phal. tetraspis,*~~ *Phal*. *gigantea*, *Phal. tetraspis,* *Phal*. *venosa* and *Paph*. *liemianum* (Table 2). The most truncated seeds (SL/SW = 4.254±0.0494 mm) were recorded in *Paph*. *kolopakingii* and the most elongated seeds (SL/SW = 7.472±0.6574 mm) in *Phal*. *tetraspis*, both of which are members of different genus. The seed volume showed~~ significant~~ variations in both *Phalaenopsis* and *Paphiopedilum* orchids. On average, low seed volume was found in *Phal*. *gigantea*

(0.240±0.0327 mm^3x10^{-3}), *Phal. tetraspis* (0.242±0.0363 mm^3x10^{-3}), *Phal. venosa* (0.272±0.03216 mm^3x10^{-3}), *Phal. amboinensis* (0.318±0.020196 mm^3x10^{-3}), *Phal. bellina* (0.333±0.02768 mm^3x10^{-3}) and *Phal. amabilis* (0.589±0.050497 mm^3x10^{-3}). When compared with epiphytic species, the seed volume was found to be higher in the terrestrial species ([9.668±0.177768 mm^3x10^{-3} (the highest) in *Paph. kolopakingii*, 7.324± 0.1283 mm^3x10^{-3} in *Paph. baccanum*, 6.755±0.2672 mm^3x10^{-3} in *Paph. liemianum* and 5.532±0.640396 mm^3x10^{-3} in *Paph. primulinum*]. Clifford and Smith (1969), Rasmussen (1995), Swamy et al. (2004) and Verma et al. (2012) stated that seed size shows a direct correlation with plant habitat, and terrestrial orchids generally possess larger seeds as compared to epiphytic orchids. Yoder et al. (2010) also stated that the seeds of terrestrial orchids are bigger as compared to epiphytic orchids.

Table 2. Micro-morphometric data of seeds related characters (mean ± SD) from species of the genus *Phalaenopsis and Paphiopedilum*

Species name	SL[WU83] (mm)	SW (mm)	SL/SW (mm)	SV (mm^3x10^{-3})
Phalaenopsis				
Phal. amabilis	0.433 ± 0.0084[WU84]	0.072 ± 0.0030	6.029 ± 0.2851	0.589 ± 0.054097
Phal. ambonensis	0.349 ± 0.006	0.059 ± 0.002	5.915 ± 0.221	0.318 ± 0.020
Phal. tetraspis	0.370 ± 0.0080096	0.049 ± 0.0030049	7.472 ± 0.6574	0.242 ± 0.0363
Phal. bellina	0.302 ± 0.0070089	0.065 ± 0.0024	4.646 ± 0.2001999	0.333 ± 0.02768
Phal. gigantea	0.348 ± 0.0095	0.051 ± 0.0034	6.823 ± 0.4870	0.240 ± 0.03327
Phal. tetraspisPhal. ambonensis	0.370 ± 0.0090.349 ± 0.0062	0.049 ± 0.0040.059 ± 0.0010028	7.472 ± 0.6575.915 ± 0.2214	0.242 ± 0.0360.318 ± 0.020196
Phal. venosa	0.345 ± 0.0060079	0.055 ± 0.0032	6.305 ± 0.3943957	0.272 ± 0.03216
Paphiopedilum				
Paph. baccanum Paph. kolopakingii	0.815 ± 0.0020.874 ± 0.0070087	0.185 ± 0.0020.206 ± 0.0010026	4.401 ± 0.0434.254 ± 0.0494	7.324 ± 0.1289.668 ± 0.17768
Paph. kolopakingii	0.874 ± 0.008	0.206 ± 0.002	4.254 ± 0.049	9.668 ± 0.177
Paph. liemianum	0.983 ± 0.0035	0.162 ± 0.0033	6.074 ± 0.1291	6.755 ± 0.2672
Paph. baccanum	0.815 ± 0.0022	0.185 ± 0.0017002	4.401 ± 0.04329	7.324 ± 0.1283
Paph. primulinum	0.815 ± 0.0435	0.161 ± 0.0088009	5.083 ± 0.38878	5.532 ± 0.643096

Abbreviations: SL-: SSeed length,; SW-:-SSeed width,; SL/SW: Seed length/Seed width; SV-:-Seed volume

.....[WU85]

Table 3. Micro-morphometric data of embryos related characters (mean ± SD) from species of the genus *Phalaenopsis and Paphiopedilum*

Species name	EL [WU86] (mm)	EW (mm)	EL/EW (mm)	EV (mm^3x10^{-3})	SV/EV (mm^3x10^{-3})	AS (%)
Phalaenopsis						
Phal. amabilis[WU87]	0.187 ± 0.0044	0.072 ± 0.0030	2.607 ± 0.1322	0.509 ± 0.0433	1.158 ± 0.0333	13.554 ± 2.4693
Phal ambonensisPhal tetraspis	0.203 ± 0.0050.171 ± 0.0081	0.051 ± 0.0020.046 ± 0.0034	3.993 ± 0.1903.739 ± 0.30549	0.274 ± 0.0200.191 ± 0.0301	1.165 ± 0.0531.273 ± 0.0821	14.245 ± 3.64121.128 ± 5.0900
Phal bellina	0.211 ± 0.0132	0.051 ± 0.0022	4.149 ± 0.3611	0.286 ± 0.0244	1.168 ± 0.0305	14.294 ± 2.23879
Phal gigantea	0.192 ± 0.0074	0.043 ± 0.3022	4.496 ± 0.3022	0.184 ± 0.0241	1.308 ± 0.0745	23.291 ± 4.35989
Phal ambonensis	0.203 ± 0.00546	0.051 ± 0.00219	3.993 ± 0.190897	0.274 ± 0.0200	1.165 ± 0.05329	14.245 ± 3.6410
Phal tetraspis	0.171 ± 0.008	0.046 ± 0.003	3.739 ± 0.305	0.191 ± 0.030	1.273 ± 0.082	21.128 ± 5.090
Phal venosa	0.183 ± 0.00329	0.047 ± 0.00218	3.929 ± 0.1922	0.209 ± 0.0141	1.309 ± 0.17218	22.338 ± 10.02878
Paphiopedilum Paphiopedilum						
Paph. kolopakingii [WU88]	0.270 ± 0.0032	0.157 ± 0.00438	1.726 ± 0.04216	3.466 ± 0.1863	2.797 ± 0.150499	64.150 ± 1.9360
Paph. baccanum	0.223 ± 0.003	0.115 ± 0.002	1.933 ± 0.037	1.557 ± 0.054	4.709 ± 0.208	78.725 ± 0.921
Paph. kolopakingii	0.270 ± 0.003	0.157 ± 0.004	1.726 ± 0.042	3.466 ± 0.186	2.797 ± 0.150	64.150 ± 1.936

[WU89]

Paph. liemianum	0.271 ± 0.0044	0.083 ± 0.0045	3.267 ± 0.2025	0.797 ± 0.1031	6.974 ± 0.7653	85.501 ± 1.52879
Paph. baccanum	0.223 ± 0.0030	0.115 ± 0.00218	1.933 ± 0.03767	1.557 ± 0.05439	4.709 ± 0.2083	78.725 ± 0.9214
Paph. primulinum	0.274 ± 0.0111	0.105 ± 0.0090	2.636 ± 0.2165	1.590 ± 0.3090	3.608 ± 0.8454	70.898 ± 6.34436

Abbreviations: EL- Embryo length, EW- Embryo width, EV- Embryo volume, A; ……..[WU90] Air space.

Seed to embryo volume and free air space

According to Verma et al. (2014), EV is an important character as it directly affects the percentage of the procurable air space inside the seed. Like their EL/EV ratios, EV were observed in various *Phalaenopsis* species; it was lowest in *Phal. gigantea* (0.184±0.0241 mm^3 x 10^{-3}) and highest in *Phal. amabilis* (0.509±0.0433 mm^3 x10^{-3}). In *Paphiopedilum*, EV the ranged between 0.797±0.1031 mm^3 x 10^{-3} (*Paph. liemianum*) and 3.466±0.1863 mm^3 x 10^{-3} (*Paph. kolopakingii*).

Our data showed that variation was observed in SV/EV. In the species of *Phalaenopsis*, the SV/EV ratio never exceeded two (Table 3), but in the species of *Paphiopedilum* measurements peaked at 6.974±0.7653 mm^3 x 10^{-3} in *Paph. liemianum*. This was followed by *Paph. baccanum* (4.709±0.2083 mm^3 x 10^{-3}), *Paph. primulinum* (3.608±0.8454 mm^3 x 10^{-3}) and *Paph. kolopakingii* (2.797±0.150499 mm^3 x 10^{-3}). Burgeff (1936) experimentally demonstrated the relationship between SV/EV ratio and seed buoyancy. Seeds with a high SV/EV ratio are more buoyant because they possess a greater air space.

Swamy et al. (2004, 2007) stated that AS is an important character because the seeds of most orchids are wind dispersed, implying that seeds with a greater AS percentage will float in the air for a longer time and thus spread to more distant places. We observed that terrestrial species possessed a comparatively greater percentage of air space in their seeds as compared with epiphytic species. A greater percentage of air space for *Paph. kolopakingii*, *Paph. liemianum*, *Paph.baccanum* and *Paph. primulinum* was shown more than 60% of seed i.e. (64.150±1.9360), (85.501±1.52879), (78.725±0.9214) and (70.898±6.344)36). Zhang et al. (2015) informed that higher AS values in seeds of terrestrial species can help spread them further along the forest floor where wind speeds are lower. Seeds with a greater percentage of air space in *Paphiopedilum* are expected to be more widely distributed and, in fact, we found it difficult to collect their seeds.

Conclusion ………[WU91]

It can be concluded that species within *Paphiopedilum* produce larger seeds with smaller embryos and a bigger percentage of air space (AS) than those of *Phalaenopsis* species. Likewise, the volume of seeds and seed volume/embryo volume in *Paphiopedilum* are larger than in *Phalaenopsis*. Large air spaces will increase seed buoyancy and seeds can be dispersed further. Testa cells are elongated in shape, with cylindrical cells walls, in *Phalaenopsis* but they are polygonal, with thin or flat rectangular cell walls, in *Paphiopedilum*. There are some similarities in character that might be related to adaptation to the tropical area, because in all species studied, both epiphytic and terrestrial orchids have the same form of fusiform seeds and a smooth testa surface. The general results of this study inform us that the morphological and morphometric properties of orchid seeds could be utilised as a means of distinguishing between life forms and habitat similarity and aid in identification.

Acknowledgements

The Author would like to thank PT Dynatech and Institute Bioscience Brawijaya University for SEM photographs, and Mr. Amin Nurokhman, M.Si. for LM photographs. The author is grateful to Prof. Dr. Edy Setiti Wida Utami for their comments and advices.……….[WU92]

REFERENCES[WU93]

Akçin TA, Ozdener Y, Akçin A. 2009. Taxonomic Value of Seed Characters in Orchids from Turkey. Belgian Journal of Bot[WU94]any, 142 (2):124-139. http://dx.doi.org/ 10.2307/41427182.

Arditti J, Ghani AKA. 2000. Numerical and physical properties of orchid seeds and their biological implications. New Phytol. 145:367-421. DOI: 10.1046/j.1469-8137.2000.00587.x.

Arditti J, Michaud JD, Healey PL. 1979. Morphometry of orchid seeds. I. Paphiopedilum and native Californian and related species of Cypripedium. American Journal of Botany[WU95]. 66:1128-1137. http://dx.doi.org/10.2307/2442211.

Arditti J, Michaud JD, Healey PL. 1980. Morphometry of Orchid Seeds. II. Native California and Related Species of Calypso, Cephalanthera, Corallorhiza and Epipactis. American Journal of Botany, 67 (3):347-360. http://dx.doi.org/10.2307/2442345.

Burgeff H. 1936. Samenkeimung der Orchideen und Entwicklung ihrer Keimpflanzen, Jena: Gustav Fischerr Verlag.

Cela PG, Seligrat I, Ortúñez E, Gamarra R, Vivar A, Scrugli A. 2014. A study of seed micromorphology in the genus Ophrys (Orchidaceae). Anales del Jardín Botánico de Madrid. 71 (2):1-6. http://dx.doi.org/10.3989/ajbm.2370.

Chase MW, Pippen JS. 1988. Seed morphology in the Oncidiinae and related subtribes orchidaceae. Systematic Botany. 13 (3):313-323.

Chaudhary B, Chattopadhyay P, Banerjee N. 2014. Modulations in seed micromorphology reveal signature of adaptive species-diversification in Dendrobium (Orchidaceae). Open Journal of Ecology. 4 (2):33-42. http://dx.doi.org/10.4236/oje.2014.42005.

Clifford HT, Smith WK. 1969. Seed morphology and classification of Orchidaceae. Phytomorphology. 19:133-139.

Gamarra R, Galán P, Herrera I, Ortúñez E. 2008. Seed micromorphology supports the splitting of Limnorchis from Platanthera (Orchidaceae). Nordic Journal of Botany. 26:61-65. DOI: 10.1111/j.1756-1051.2008.00135.x

Gamarra R, Galan P, Pedersen HE, Ortunez E, Sanz E. 2015. Seed micromorphology in Dactylorhiza Necker ex Nevski (Orchidaceae) and allied genera. Turkish Journal of Botany. 39:298-309. DOI: 10.3906/bot-1401-66.

Gamarra R, Ortúñez E, Sanz E, Esparza I, Galán P. 2010. Seeds in subtribe Orchidinae (Orchidaceae): the best morphological tool to support molecular analyses. In: Nimis P. L., R. Vignes-Lebbe (eds.). Tools for Identifying Biodiversity: Progress and Problems. 323-326. ISBN 978-88-8303-295-0. EUT.

Guler N. 2016. Seed micromorphology of Orchis Tourn. Ex L. (Orchidaceae) and allied genera growing in Edirne province, Turkey. Phyto Keys. 69:9-25. http://dx.doi.10.3897/phytokeys.68.8746.

Molvray M, Chase M. 1999. Seed morphology. In: Pridgeon AM, Cribb PJ, Chase MW, Rasmussen FN (eds.). Genera Orchidacearum, General Introduction, Apostasioideae, Cypripedioideae. Oxford University Press, Oxford, 59-66.

Rasmussen HN. 1995. Terrestrial orchids from seed to mycotrophic plant. Cambridge, UK: Cambridge University Press.

Shimizu N. 2012. Adaptation and evolution of seed shape on bleeding area in Japanese orchids. International Journal of Biology. 4: 47-53.

Sodhi NS, Koh LP, Brook BW, Ng PKL. 2004. Southeast Asian biodiversity: An impending disaster. Trends in Ecology & Evolution. 19 (12):654-660. DOI: 10.1016/j.tree.2004.09.006

Swamy KK, Kumar HNK, Ramakrishna TM, Ramaswamy SN. 2004. Studies on Seed Morphometry of Epiphytic Orchids from Western Ghats of Karnataka. Taiwania. 49 (2):124-140. DOI: 10.6165/tai.2004.49 (2).124.

Swamy KK, Kumar HNK, Ramaswamy SN. 2007. Studies on seed morphometry of Dendrobium species. Phytomorphology. 57:33-43.

Tsutsumi C, Yukawa T, Lee NS, Lee CS, Kato M. 2007. Phylogeny and comparative seed morphology of epiphytic and terrestrial species of Liparis (Orchidaceae) in Japan. Journal of Plant Research. 120 (3):405-412. DOI: 10.1007/s10265-007-0077-0

Verma J, Kusum K, Thakur K, Sembi JK, Vij SP. 2012. Study on seed morphometry of seven threatened Himalayan orchids exhibiting varied life modes. Acta Botanica Gallica: Botany Letters. 159 (4):443-449. DOI: 10.1080/12538078.2012.750582.

Verma J, Sharma K, Thakur K, Sembi JK, Vij SP. 2014. Study on Seed Morphometry of Some Threatened Western Himalayan Orchids. Turkish Journal of Botany. 38:234-251. DOI: 10.3906/bot-1307-14.

Vij SP, Kaur P, Kaur S, Kaushal PS. 1992. The Orchid Seeds: Taxonomic, Evolutionary and Functional Aspects. Journal Orchid Society, 6:91-107.

Yoder JA, Imfeld SM, Heydinger DJ, Hart CE, Collier MH, Gribbins KM, Zettler LW. 2010. Comparative water balance profiles of Orchidaceae seeds for epiphytic and terrestrial taxa endemic to North America. Plant Ecology, 211:7-17. DOI: 10.1007/s11258-010-9765-2.

Zhang FP, Zhang JJ, Yan N, Hu H, Zhang SB. 2015. Variations in seed micromorphology of Paphiopedilum and Cypripedium (Cypripedioideae, Orchidaceae). Seed Science Research. 25:395-401. DOI: 10.1017/S0960258515000276.

List of Revisions in the manuscrip

Row	Reviewer suggestion/comment	Author revision/answer
1	Title-change	I am agree, I have already revised it
R9	Qualitative?	Yes qualitative characters
R18	Need/clarify some more reasons in results and discussion	I have deleted the sentence
R54	How old are the capsules of both genera?	Mature Phalaenopsis capsules aged 3.5 - 4 months, and mature Phapiopedilum capsules aged 8.5-9 months Each species
R54	Correct: between 2016 and 2019 or from 2016 to 2019	I am agree with you,…. From 2016 to 2019
R59-60	Fresh seed …. How do you do? Oven?, where?	The specimens used for SEM were dried for at least 4 weeks at room temperature and stored in small paper envelope
	How do you do? Oven?	
	Results and Discussion There are some more repeated sentences. (please try to reduce those sentences) It is possible, if the writing can be improved and corrected. For example, 1. (I) Describe the important characteristics of each genus , followed by in each species. Phal………………(characteristics of genus)…… Species……….(characteristics of each species) Paph……………… Species………… 2. (II) Characteristics related adaptation/evolution/ others	I have already revised as your suggestion
R-80	, and this showed the seed … Of 2 genera?	Yes, of 2 genera
R-95	*P. amabilis*	*Phal. amabilis*
R-96-97	Rewrite (rw)	Yes, I rewrite it already
R-99	.... two poles .... and how	I have rewrite
R-101 (WU13)	Change topic: For example Morphological characteristic	Ok, I am agree with you, I have changed
(WU14) (WU15)	Add genus name and rearranged in alphabetical	Ok, I am agree with you. I have changed
R.107	Font not italic	Ok …. I have corrected
R.114	*P. tetraspis*	*Phal. tetraspis*
R.118	*P. bellina*	*Phal. bellina*
R. 119-120	*RW*	Ok I have rewrite
R-128	Try to insert the important characteristics (in all figure)	I have inserted the important characteristics
	Indicating arrow	I have added of information at all figures
R283	Write a ... Conclusion	I am agree, already I have write a conclusion

No	Recommendation of reviewer	Author revision/answer
1	Title – change to ”Variations in seed micromorphology and morphometry of native Indonesian Phalaenopsis and Paphiopedilum orchid.	I am agree, I have changed it

2	p48 – plant material change to "plant materials"	I am agree**,** I have changed it
3	Figure 1 – It looks like no embryo in several seeds, including B, C, E, J.	I have changed it, in my opinion can already distinguished between embryos and testa
4	Fig. 2-11 – Too many figures. Combine them into one panel.	I have made three pages, if combine them into one panel, there are no visible characteristics of surface morphology of the seeds
5	There is a lack of significant difference between means in all data.	The word: significant, is deleted, I did not analyse statistically
6	The authors claim that "the results of the study indicate that morphological and morphometric features can serve to identify live forms and distinguish between species and phylogeny", but how to use them to identify these species of orchids? Please specify at least one example in detail.	Qualitative and quantitative characters can distinguished between two genus and Interspecies. Qualitative characters analysed by EM can distinguished live form
7	M&M - Please describe the maturaty of capsules in detail, e.g. how long is the period from pollination to maturation, morphology and size, etc.	The period from pollination to maturation of *Phalaenopsis* is 3.5-4 months, and of *Phapiopedilum* is 8.5-9 months. I did not measured of capsules. I have some photos collection of capsules