Pollen morphological studies on five species of the family Nyctaginaceae in Amarapura Township

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Abstract

The pollen morphology of five species belonging to four genera was studied by light microscope. The pollens were obtained from fresh specimens. The pollen grains are generally monads. Grains of *Boerhavia*, *Commicarpus* and *Mirabilis* are polyporate, pantoporate, spheroidal and spinulose sculpture, and those of *Bougainvillea* is tricolpate, zonocolpate, oblate and reticulate sculpture. According to the resulted pollen characters, an artificial pollen key was constructed. The phylogeny of the collected species was studied which are based on the ten distinct characters.

Key words: Pollen morphology, phylogeny, five species of Nyctaginaccae

Introduction

The Nyctaginaceae is small family and distributed in all warmer parts of the world, mostly in the New World, with about 31 genera and 40 species (Bittrich and Kuhn, 1993). In Myanmar, the family is represented by 4 genera and 8 species (Kress *et al.*, 2003). The family is commonly called "Four o' Clock" family because the flowers of *Mirabilis jalapa* usually open from late afternoon or dusk. This species is the most commonly grown ornamental plant, and is available in a range of colours. *Bougainvillea spectabilis*, a shrubby climber, is one of the most popular ornamental plants in Myanmar. This species is grown all over the world mainly for their colorful bracts. The genera *Boerhavia* and *Commicarpus* are a fast-growing weed and a tropical species growing in various soil types in waste places and along roadsides.

Palynology is the study of pollen and spores. The size and shape of pollen and spore (the principle characters) , are being increasingly used in systematic studies along with type, number and position of the apertures and pollen wall architecture (Heywood, 1976). Moreover, pollen morphology has provided great useful information to trend among the related plant taxa.

The pollen morphology of family Nyctaginaceae has been examined by Erdtman (1952), Struwig, Siebert and Jordaan (2013) and Pramanick, Mondal and Maiti (2015). However, no information is available on the pollen morphology of various species of Nyctaginaceae found in this area. Thus in the present paper, pollen morphology characters with the aid of light microscope on five species of Nyctaginaceae was investigated. There are two objectives of present paper: (1) to provide palynological information in Nyctaginaceae and (2) to examine the phylogenetic relationship among the species based on pollen characters.

Materials and Methods

The specimens are collected from Amarapura Township, Mandalay Region. All the collected species were recorded by photographs while flowering. Identification of specimen was carried out by referring the books of Flora of British India (Hooker 1872), Flora of Java (Baker 1968) and Flora of China (Dequan, 1996). The samples were collected in the month of July to January 2018-2019. Pollen samples were obtained from fresh specimens. The pollen grains were prepared for light microscopy by the standard methods described by Erdtman (1952). A pollen morphological character, including aperture, shape, size, exine thickness and ornamentation of collected species is mentioned in table 2. The morphological characters of

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pollen analyzed following terminology: Erdtman (1952), Hoen (1999), Paldat (2005) and Hesse *et al.*, (2009).

Phylogeny

According to Ying Yu (2018), the phylogenetic relationships were based on the ten distinct characters that can be used in score making for the preparation dendrogram. These ten characters are (A) Dispersal unit (B) Polarity (C) Symmetry (D) Shape class (E) Size of pollen grain (F) Aperture number (G) Aperture position (H) Type of apertures (I) Endoaperture and (J) Sculptures. The primitive and advanced characters used for scores were shown in Table (1).

Table 1. Characters of pollen grain used in score making for the preparation of Phylogenetic Scheme

No.	Characters	Primitive Score = 0	Advanced Score = 1
A.	Dispersal unit	Monads	Polyads
B.	Polarity	Isopolar	Apolar
C.	Symmetry	Bilateral	Radial
D.	Shape Class	Oblate	Spheroidal
E.	Size of pollen grains	Medium, Large	Very large
F.	Aperture number	Three	Numerous
G.	Aperture position	Equatorial	Global
H.	Types of Apertures	Colpate	Porate
I.	Endoaperture	Absent	Present
J.	Sculptures	Spinulose	Reticulate

Results

General pollen characters of the family Nyctaginaceae

The pollen grains are usually apolar or isopolar, radially symmetrical, spheroidal or oblate, polyporate, pantoporate, tricolpate, zonocolpate; pori circular; colpi longicolpate; sexine thicker or thinner than nexine and sexine as thick as nexine; exine sculpture mostly spinulose and rarely reticulate.

Pollen morphology of each species

1. *Boerhavia diffusa* L. Sp. Pl. 1. 3. 1753. (Figure 1. A, B)

Myanmar name : Payan-na-war
English name : Spreading Hogweed
Flowering period : July to February

Monads, apolar, radially symmetrical, polyporate, pantoporate (apertures globally arranged), spheroidal, 60 – 70 μm in diameter, large; pores operculum absent, circular, 2.0 –2.5 μm in diameter, endoapertures absent; exine 3.5 – 4.0 μm thick; sexine thinner than nexine; sculpturing spinulose.

2. *Boerhavia erecta* L. Sp. Pl. 1. 3. 1753. (Figure 1. C, D)

Myanmar name : Payan-na-war
English name : Erect Spiderling
Flowering period : July to February

Monads, apolar, radially symmetrical, polyporate, pantoporate (apertures globally arranged), spheroidal, 55 – 65 μm in diameter, large; pores operculum absent, circular, 3.5 – 4.5 μm in diameter, endoapertures absent; exine about 5 μm thick; sexine thicker than nexine; sculpturing spinulose.

3. *Bougainvillea spectabilis* Willd. Sp. Pl. ed. 4. 2. 348. 1799. (Figure 1. E, F, G)

Myanmar name : Sekku-pan
English names : Great bougainvillea; Paper flower
Flowering period : Throughout the year

Monads, isopolar, radially symmetrical, tricolpate, zonocolpate (apertures located at equator), oblate, 30 – 40 x 46 - 55 μm in length and breadth, medium; amb circular; colpi longicolpate, 15 – 20 x 2.5 – 5.0 μm in length and breadth, endoapertures absent; exine about 5.5 μm thick; sexine thinner than nexine; sculpturing reticulate, the lumina heterobrochate, 2.5 – 7.5 μm in width, the muri simplibaculate, about 1.25 μm wide.

4. *Commicarpus chinensis* (L.) Heimerl. Nat. Pflanzenfam. ed. 2. 117. 1934. (Figure 2. A, B)

Myanmar name : Payan-na-war
English names : Diffuse Hogweed
Flowering period : July to February

Monads, apolar, radially symmetrical, polyporate, pantoporate (apertures globally arranged), spheroidal, 75 – 95 μm in diameter, large; pores operculum present, circular, 2.5 – 5.0 μm in diameter, endoapertures absent; exine 3.5 -5.0 μm thick; sexine thicker than nexine; sculpturing spinulose.

5. *Mirabilis jalapa* L. Sp. Pl. 1. 177. 1753. (Figure 2. C, D)

Myanmar names : Lay-naryi-pan; Myitzu-pan-pin
English name : Four o'clock flower
Flowering period : July to February

Monads, apolar, radially symmetrical, polyporate, pantoporate (apertures globally arranged), spheroidal, 105 – 135 μm in diameter, very large; pores operculum absent, circular, 3.5 – 5.0 μm in diameter, endoapertures absent; exine 5.5 - 8.5 μm thick; sexine as thick as nexine; sculpturing spinulose.

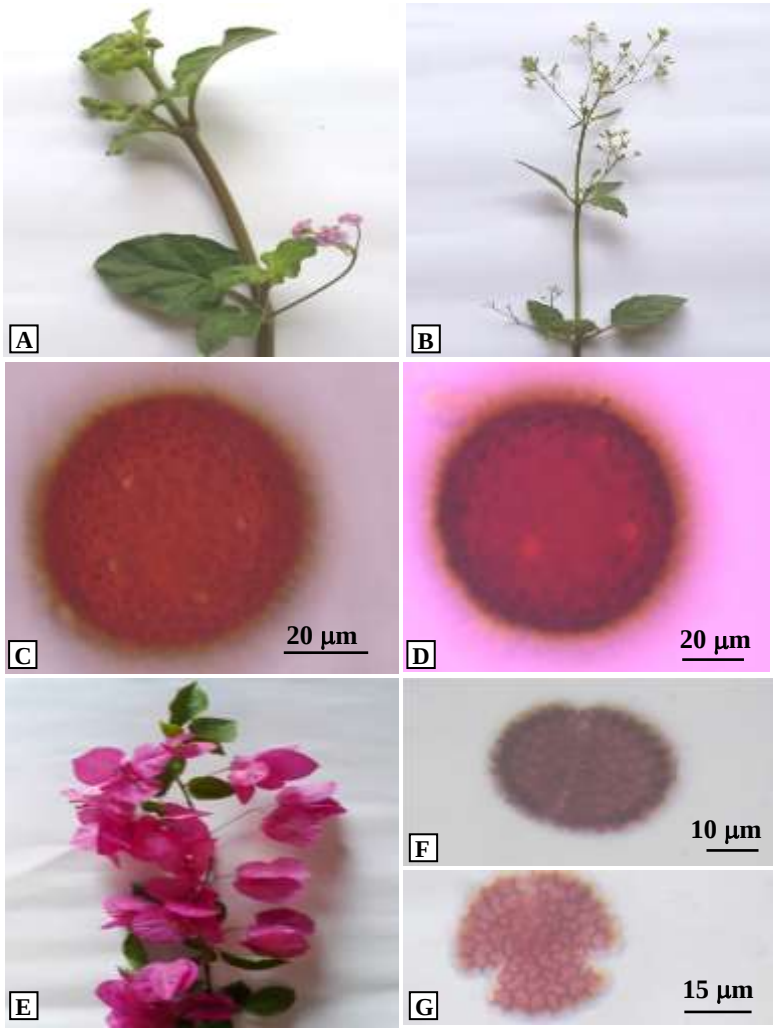

Figure 1. **A. Inflorescence of *Boerhavia diffusa* L.**
B. Surface view of pollen grain
C. Inflorescence of *Boerhavia erecta* L.
D. Surface view of pollen grain
E. Inflorescence of *Bougainvillea spectabilis* Willd.
F. Equatorial view of pollen grain
G. Polar view of pollen grain

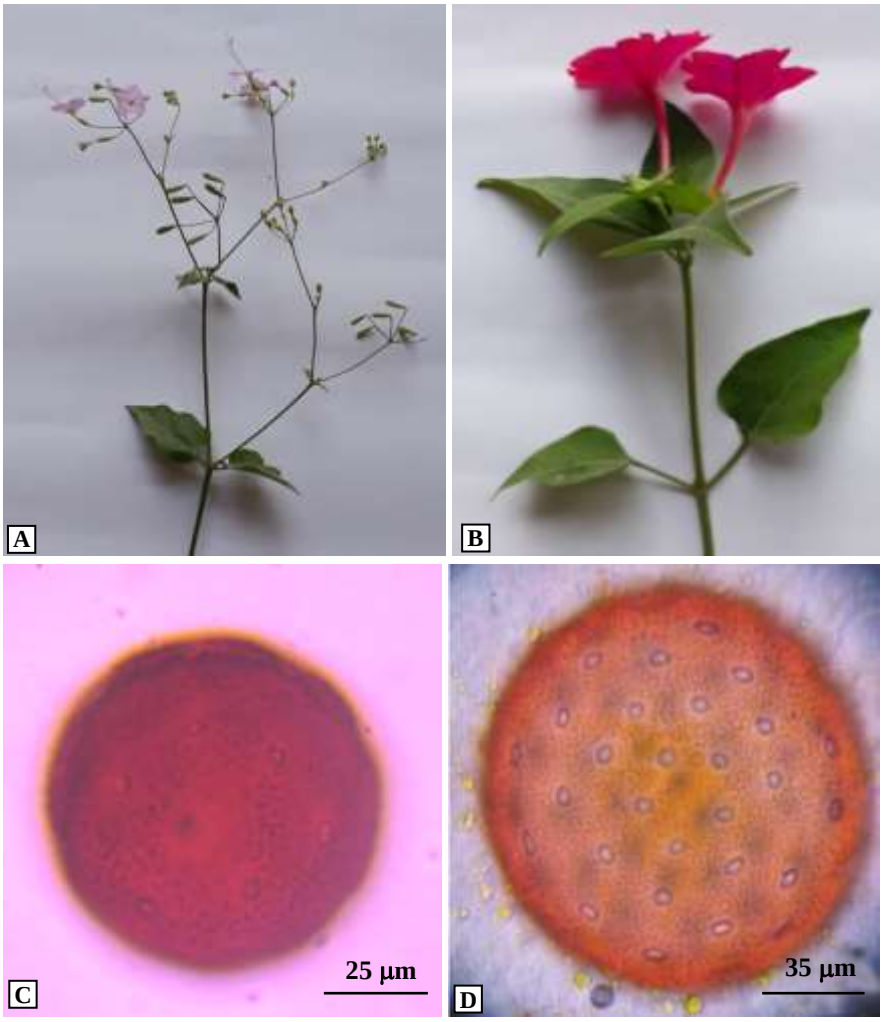

Figure 2. **A. Inflorescence of *Commicarpus chinensis* (L.) Heimerl.**

B. Surface view of pollen grain

C. Inflorescence of *Mirabilis jalapa* L.

D. Surface view of pollen grain

An Artificial Pollen Key to the species

1. Tricolpate; sculpturing reticulate ---------- *Bougainvillea spectabilis*
1. Polyporate; sculpturing spinulose ---------- 2
    2. Pollen grains very large, 105-135 μm in diameter; sexine as thick as nexine---------- ---------- *Mirabilis jalapa*
    2. Pollen grains large, less than 100 μm in diameter; sexine thicker or thinner than nexine---------- 3
3. Grains 75 – 95 μm in diameter; operculum present---------- ---------- *Commicarpus chinensis*
3. Grains less than 70 μm in diameter; operculum absent----------4
    4. Pori more than 3.5 μm in diameter; exine about 5 μm thick, sexine thicker than nexine ----------*Boerhavia erecta*
    4. Pori less than 2.5 μm in diameter; exine 3.5 - 4.0 μm thick, sexine thinner than nexine ---------- *Boerhavia diffusa*

Phylogeny

In the present paper, representing the collected species were studied for phylogenetic relationship. The score of primitive and advanced were 0 and 1 respectively. The results were calculated and presented in Tables.

The value for the collection species was documented and the total scores were presented. According to the study, characters among the genera *Boerhavia diffusa*, *Boerhavia erecta*, *Commicarpus chinensis* and *Mirabilis jalapa* were polyporate, spheroidal, very large or large size and sculpture spinulose while the *Bougainvillea spectabilis* was tricolpate, oblate, medium size and sculpture reticulate (Table. 3). According to the resulting data the total score for genera *Boerhavia diffusa*, *Boerhavia erecta*, *Bougainvillea spectabilis*, *Commicarpus chinensis* and *Mirabilis jalapa* 6, 6, 2, 6 and 7. The total score for advanced characters were higher in *Mirabilis jalapa* (Table. 4). Basing on overall selected characters, *Bougainvillea spectabilis* and the rest four species possess 38% similarity and *Commicarpus chinensis*, *Boerhavia diffusa* and *Boerhavia erecta* were in 100% similarity (Figure 3).

Table 2. Pollen Morphological Characters of Studied Species

No.	Scientific Name	Aperture Types	Shape Class	Size (µm)	Pori Types	Exine	
						thickness (µm)	Sculpture
1.	*Boerhavia diffusa* L.	Polyporate	Sphero- idal	60-70	Circular	3.5–4.0	spinulose
2.	*Boerhavia erecta* L.	Polyporate	Sphero- idal	55-65	Circular	5	spinulose
3.	*Bougainvillea spectabilis* Willd.	Tricolpate	Oblate	30-40 × 46-55	–	5.5	reticulate
4.	*Commicarpus chinensis* (L.) Heimerl.	Polyporate	Sphero- idal	75-95	Circular	3.5-5.0	spinulose
5.	*Mirabilis jalapa* L.	Polyporate	Sphero- idal	105-135	Circular	5.5-8.5	spinulose

Table 3. Comparable characteristic of selected categories among the Species of family Nyctaginaceae

No.	Species	Dispersal Unit	Polarity	Symmetry (Polar View)	Shape class	Size of pollen grain	Aperture number	Aperture Position	Aperture type	Endo-aperture	Sculpturing
1.	*Boerhavia diffusa* L.	Monad	Apolar	Radially	Spheroidal	Large	Numerous	Global	Polyporate	Absent	Spinulose
2.	*Boerhavia erecta* L.	Monad	Apolar	Radially	Spheroidal	Large	Numerous	Global	Polyporate	Absent	Spinulose
3.	*Bougainvillea spectabilis* Willd.	Monad	Isopolar	Radially	Oblate	Medium	Three	Equatorial	Tricolpate	Absent	Reticulate
4.	*Commicarpus chinensis* (L.) Heimerl.	Monad	Apolar	Radially	Spheroidal	Large	Numerous	Global	Polyporate	Absent	Spinulose
5.	*Mirabilis jalapa* L.	Monad	Apolar	Radially	Spheroidal	Very Large	Numerous	Global	Polyporate	Absent	Spinulose

Table 4. The phylogenetic data matrix for the Species of family Nyctaginaceae

No.	Species	Dispersal Unit	Polarity	Symmetry (Polar View)	Shape class	Size of pollen grain	Aperture number	Aperture Position	Aperture type	Endo-aperture	Sculpturing	Total
1.	*Boerhavia diffusa* L.	0	1	1	1	0	1	1	1	0	0	6
2.	*Boerhavia erecta* L.	0	1	1	1	0	1	1	1	0	0	6
3.	*Bougainvillea spectabilis* Willd.	0	0	1	0	0	0	0	0	0	1	2
4.	*Commicarpus chinensis*(L.) Heimerl.	0	1	1	1	0	1	1	1	0	0	6
5.	*Mirabilis jalapa* L.	0	1	1	1	1	1	1	1	0	0	7

Table 5. Data matrix representing the matching coefficients of the family Nyctaginaceae based on overall selected characters

Species	*Boerhavia diffusa* L.	*Boerhavia erecta* L.	*Bougainvillea spectabilis* Willd.	*Commicarpus chinensis* (L.) Heimerl.	*Mirabilis jalapa* L.
Boerhavia diffusa L.	-				
Boerhavia erecta L.	10	-			
Bougainvillea spectabilis Willd.	4	4	-		
Commicarpus chinensis (L.) Heimerl.	10	10	4	-	
Mirabilis jalapa L.	9	9	3	9	-

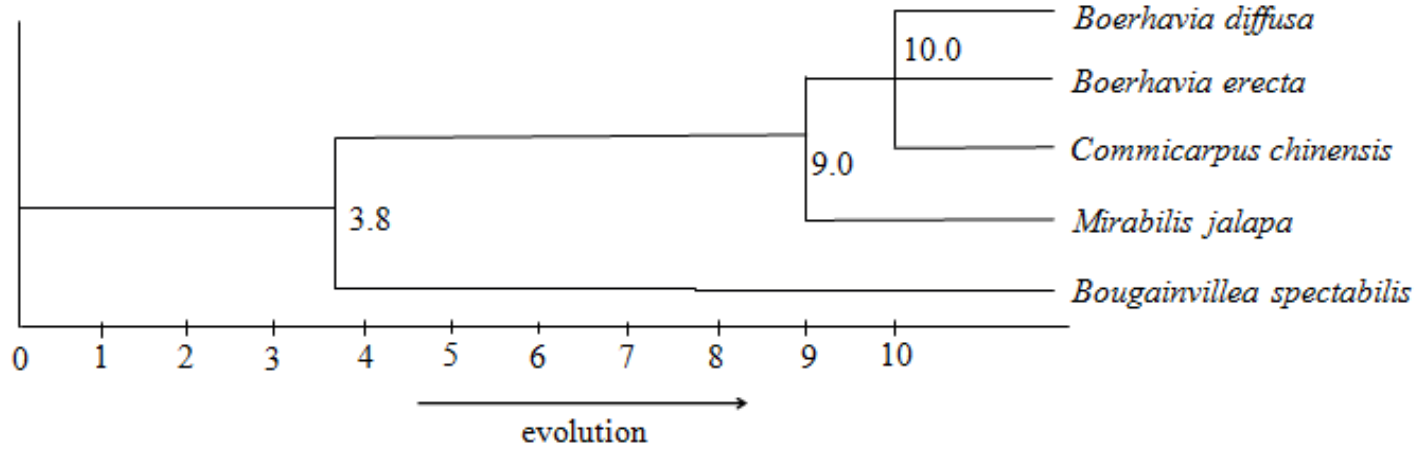

Figure 3. The phenogram among the species of family Nyctaginaceae base on overall selected characters

Discussion and Conclusion

In the present paper, the pollen morphology of five species in Nyctaginace was studied. The family Nyctaginaceae is more or less eurypalynous. Significant variation in exine pattern and aperture types has been observed. Two types of shape class have been found; i.e. spheroidal and oblate. Two types of apertures i.e. porate and colpate are found. Exine ornamentation commonly spinulose and reticulate is examined.

A considerable variation in pollen morphology was observed among the investigated species, particularly exine ornamentation and characters of the apertures. *Boerhavia diffusa*, *Boerhavia erecta* and *Commicarpus chinensis* was found to be polyporate, spheroidal and sculpture spinulose. This findings are similar exactly to that of Pramanick, Mondal and Maiti (2015) observations. *Bougainvillea spectabilis* showed tricolpate and reticulate exine pattern which is in accordance with Pramanick *et. al.* (2015) observations.

In order to the phylogenetic data matrix for genera of the family Nyctaginaceae, the total score for species *Boerhavia diffusa*, *Boerhavia erecta, Bougainvillea spectabilis*, *Commicarpus chinensis* and *Mirabilis jalapa* were 6, 6, 2, 6 and 7 respectively. Among these characters of exine sculpture was found in *Bougainvillea* while the size of grains was possessed in *Mirabilis*. The genera *Boerhavia diffusa*, *Boerhavia erecta*, *Commicarpus chinensis* and *Mirabilis jalapa* were closely related and possessed the advanced characters of shape class. The most advanced total score 7.0 was found in the genus *Mirabilis jalapa*. It appears *Bougainvillea spectabilis* is sisters to other species in this study as it separates out at the lowest level at similarity.

In conclusion, this study has provided additional pollen characters and phylogenetic relationships are already known about this family. The similarities in their structure showed interspecies relationships and the reason for then to be in the same genus, while the differences in their pollen characters tell about their existence a distinct genus.

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