International Journal of Botany Studies
ISSN: 2455-541X; Impact Factor: RJIF 5.12
Received: 03-12-2020; Accepted: 05-01-2021: Published: 28-01-2021
www.botanyjournals.com
Volume 6; Issue 1; 2021; Page No. 289-295

Heteropolarity, di-polymorphism and multi-orate features along with a detailed palynomorphological analysis of some members of bignoniaceae

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Abstract
The present palynological investigation of Bignoniaceae in India highlights the presence of heteropolarity, multi-orate colpi, dimorphism & polymorphism among the members. These palynological characters are not common among the dicots and studies on them are quite meagre. So, the present study has been undertaken to explore more of them as they are significant in taxonomic deductions, in recognizing several taxons & also throws light on the evolutionary relationships. The freshly collected polleniferous material of 13 species of Bignoniaceae, belonging to 12 genera, from West Bengal were acetolysed & thoroughly investigated using bright field light microscopy and their respective photographs were taken. The surface pattern of the pollen grains is mostly reticulate & few are psilate. The apertural pattern ranges from inaperturate to tri-tetrazonocolpate to tri-zonocolpor (oid) ate to hexazonocolpate, thereby exhibiting a high degree of eurypalyny in the taxon. Multi-orate colpi are observed in *Fernandoa adenophylla*, *Jacaranda obtusifolia*, *Markhamia lutea*, *Parmentiera cereifera*, *Tabebuia heterophylla* and *Tabebuia aurea.* Polymorphic pollen (*Parmentiera cereifera* & *Pyrostegia venusta*), dimorphic pollen (*Oroxylum indicum*) & heteropolarity (*Pyrostegia venusta*) has been observed in the family. Pollen grains of *Fernandoa adenophylla*, *Jacaranda obtusifolia*, *Mansoa alliaceae* and *Tabebuia heterophylla* has been investigated for the first time in the present study. Heteropolarity in *Pyrostegia venusta*, multi-orate colpate pollen grains in *Fernandoa adenophylla*, *Jacaranda obtusifolia*, *Markhamia lutea*, *Parmentiera cereifera*, *Tabebuia heterophylla*, *Tabebuia aurea* & polymorphism in *Parmentiera cereifera* & *Pyrostegia venusta* has been surfaced for the first time in the present study. Few suggestions are made regarding the significance and evolutionary trend of the multi-orate features of the pollen grains. The presence of both types of grain in *Parmentiera cereifera*, i.e. a) pancolpate apertural pattern, lacking ora and b) pancolpate with multi-orate features, indicates that the latter might have evolved from the previous one.

Keywords: bignoniaceae, pollen, heteropolarity, multi-orate, polymorphism

Introduction
The family Bignoniaceae belongs to the order Lamiales of angiosperms and is cosmopolitan in distribution, occupying mainly the tropical regions of the world. It comprises of 810 species which are distributed among 82 genera (Mebberley, 2008) [13]. Majority of the members are woody trees, shrubs and vines and very few are herbaceous bearing showy, ornamental flowers. In India there are 58 species of Bignoniaceae which are distributed among 34 genera (Madhukar *et al*., 2012) [14]. Majority of the introduced taxa have naturalized in the Indian habitat and have become a part of the native flora, like genera *Tabebuia*, *Sphathodea*, *Pyrostegia* and many more.
The palynological investigation of Bignoniaceae has been carried out by many workers (Mitra, 1968; Ferguson and Santisuk, 1973; Gentry and Tomb, 1979; Bove, 1993; Harley and Banks, 1994; Ugbabe *et al*., 2007, 2013; Burelo-Ramos *et al*., 2009; Rajurkar *et al*., 2018; Neves de Souza *et al*., 2019) [15, 8, 11, 2, 12, 26, 27, 3, 21, 17] from time to time. The pollen grains exhibit heteropolarity, multi-orate features, dimorphism and polymorphism in few genera of the family, as reported by previous authors also, are not commonly prevalent among the dicotyledonous angiosspermous taxa. The palynomorphological characters not only help in taxonomic deductions, in recognizing particular genera or species but also throw light on the evolutionary relationships (Gentry and Tomb, 1979) [11]. So, the present palynological investigation has been undertaken to study in detail the members of Bignoniaceae in India, giving more attention to the presence of heteropolarity, multiple endoapertures in a single colpi and di-polymorphic forms of pollen grains.
The variety of palynomorphological characters exhibited by the members of Bignoniaceae, specially the presence of multi-orate colpi, heteropolarity and di-polymorphism should be considered as a tool in the taxonomy and evolution of Bignoniaceae. It will also help in delimiting certain genera and species and in recognizing several taxons of Bignoniaceae. The efficiency of different kinds of aperturate pollen grains in this family should be explored more for a better understanding of the evolution and origin of the grains, specially about the multi-orate grains which is quite dominant in several genera of the family.
Among the investigated species, the palynomorphological characters of four species has been investigated for the first time, namely, *Fernandoa adenophylla*, *Jacaranda obtusifolia*, *Mansoa alliaceae* and *Tabebuia heterophylla*.

Materials and Methods
The polleniferous material of 13 species of Bignoniaceae was freshly collected from their natural habitats growing in and around Burdwan district of West Bengal. The pollen grains were acetolysed following the acetolysis method of Erdtman (1952) [7] and were thoroughly investigated using bright field light microscopy**.** The acetolysed pollen grains were mounted in glycerine jelly on glass slides with 0 no.

coverslip and were studied under a Leitz laborlux S (Germany) microscope with Leica DFC 295 digital camera attachment.

The pollen morphological features with respect to polarity, symmetry, size, shape, aperture and sculpture were described using the standard terminologies based on Punt *et al*. (2007) [19]. The measurements of the palynomorphological features were taken using stage and ocular micrometer.

The scientific names of the studied plant species have been consulted with the websites The International Plant Name Index [23] and The Plant List [24].

Results and Discussion

Micromorphological details of the selected taxa belonging to the family Bignoniaceae are as follows:

***Anemopaegma chamberlaynii* (Sins) Bureau & K. Schum.** (Figure 1A, B)

Pollen grains are radially symmetrical, isopolar, spheroidal, 72 µm in diameter, amb circular; hexa-zonocolpate, colpi narrowly elliptic with acute ends, 9 µm in length and 4.7 µm in diameter, tenuimarginate; exine tegillate, 3 µm in thickness, crassisexinous; surface broadly reticulate, simplibaculate, lumina 4.5 µm in diameter, heterobrochate.

***Fernandoa adenophylla* (Wall. ex G.Don) Steenis (Figure 1C, D)**

Pollen grains are radially symmetrical, isopolar, P × E is 74.8 × 59.2 µm, sub-prolate, amb slightly hexagonal; tri-zonocolporoidate, colpi broadly elliptic with acute apex, 64 µm in length and 7.8 µm wide at the equator, crassimarginate, colpi multi-orate, tri-tetraorate, oroid faint, lalongately elliptic, narrow with irregular margins, 9.6 µm wide at the equator; exine tegillate, 3 µm in thickness, crassisexinous; surface reticulate, the reticulations present at the apocolpium are smaller than that of the mesocolpium, lumina irregularly polygonal, heterobrochate, maximum diameter of the lumina is 3.2 µm.

***Jacaranda obtusifolia* Bonpl. (Figure 1E-G)**

Pollen grains are radially symmetrical, isopolar, sub-oblate, P × E is 53 × 64.4 µm, amb triangular, anguloaperturate; tri-zonocolporoidate, colpi mul-tiorate, colpi narrowly elliptic with pointed apex, 43.4 µm in length and 8 µm wide at the equator, crassimarginate, oroid 2-4 in number, faint, lalongate, narrowly elliptic with highly tapering pointed ends, 20.5 µm in diameter at the equator, margins fragmented, tenuimarginate; exine tegillate, 3 µm in thickness, crassisexinous or nexine as thick as sexine; surface psilate.

***Mansoa alliacea* (Lam.) A.H.Gentry** (Figure 1H, I)

Pollen grains are radially symmetrical, isopolar, spheroidal, 70 µm in diameter, amb circular, inaperturate, areolate, forming pentagonal patches of exine, diameter of grooves between exinal patches is 4.5 µm; exine tegillate, crassisexinous, 1.3 µm in thickness; surface reticulate, lumina irregularly polygonal, heterobrochate, lumina diameter extends upto 3 µm.

***Markhamia lutea* K.Schum.** (Figure 1J, K)

Pollen grains are radially symmetrical, isopolar, prolate to subprolate, apiculate, P × E is 78 × 67 µm, amb sub-triangular, planoaperturate; tri-zonocolporoidate, colpi narrowly elliptic with pointed ends, crassimarginate, multi-orate, oroid 3-5 in number, slit like, narrow, lalongately elliptic with pointed ends; exine tegillate, 2.5 µm in diameter, crassisexinous; surface reticulate, lumina irregularly polygonal, reaches to a maximum diameter of 2.8 µm, heterobrochate, lumina diameter gradually decreases towards the margin of the colpi and at the apocolpium.

***Millingtonia hortensis* L.f. (Figure 1L-N)**

Pollen grains are radially symmetrical, isopolar, sub prolate, P × E is 84 × 64 µm, amb circular-subtriangular; tri-zonocolpate, colpi narrowly elliptic with obtuse ends, 43 µm in length and 4.4 µm wide at the equator, crassimarginate, apocolpium triangular; exine tegillate, 2.4 µm in thickness, crassisexinous; surface coarsely reticulate, irregularly polygonal, luminal diameter extends upto 2.6 µm, heterobrochate.

***Oroxylum indicum* (L.) Benth. ex Kurz (Figure 1O-R)**

Pollen grains are radially symmetrical, isopolar, sub prolate, P × E is 128.8 × 96.6 µm, apiculate, amb sub-triangular, anguloaperturate; tri-zonocolpate, colpi broadly elliptic with acute ends, 77.5 µm in length and 3.4 µm wide at the equator, crassimarginate; exine tegillate, 4.7 µm in thickness, crassisexinous; surface reticulate, hetrobrochate, lumina size gradually decreases towards the margin of the aperture and extends upto 3 µm at the mesocolpium.

Another type of pollen grain has been encountered in this species which is bilaterally symmetrical, heteropolar, tetra-zonocolpate, amb more or less sub-rectangular, colpi are present at the corners of the grain, the tips of the adjacent colpi in each pair which are present along the longer equatorial axis, fuses at one pole, thereby forming three mesocolpium divisions at that pole, while on the other pole there is an extra colpi situated at the center of the pole and the tips of all the five colpi fuses with each other at this pole.

***Parmentiera cereifera* Seem. (Figure 1S-Y)**

Pollen grains are radially symmetrical, isopolar, spheroidal, 48.3 µm in diameter, amb circular; tri-zonocolporate, colpi narrowly elliptic with acute ends, 25.7 µm in length and 2.5 µm wide at the equator, multiorate, ora narrowly elliptic, slit like with pointed ends, tenuimarginate; exine tegillate, 2.2 µm in thickness, crassisexinous; surface reticulate**.**

A second type of pollen grain has been observed which differs from the previous one in being pancolpate where the colpi is devoid of any ora.

The third type of pollen grain is bilaterally symmetrical, isopolar, oblate spheroidal, P × E1 × E2 is 48 × 52 × 51 µm, amb sub-rectangular; anguloaperturate, pancolporate, colpi multi-orate, total number of colpi six, four colpi are situated at the corners of the amb while two are present at each pole, among the four equatorially placed colpi, the pairs that are situated along the shorter equatorial axis, are oriented diagonally and are loxocolpate in nature, each colpi consists of three to eight narrowly elliptic, slit like, lalongate endoapertures with acute ends.

***Pyrostegia venusta* Miers (Figure 2A-H)**

Pollen grains are radially symmetrical, heteropolar, prolate spheroidal to subprolate, P × E is 66 × 56 µm, amb square;

planoaperturate, tetra-zonocolpate, at one pole it is simply colpate while at the other pole it is parasyncolpate forming a square apocolpium, colpi narrowly elliptic with gradually tapering pointed ends, 64.4 µm in length and 6.1 µm in diameter across the equator, associated with margo, margo psilate, crassimarginate; exine tegillate, 2.8 µm in thickness, crassisexinous; surface reticulate, heterobrochate, lumina diameter is 3.7 µm which decreases towards the apertural margins, lumina polygonal-circular.

A second type of grain has been observed which is similar to the first one but differs in being a tri-zonocolpate pollen grain exhibiting heteropolarity in a similar manner, i.e. at one pole it is simply colpate while at the other pole it is parasyncolpate forming a triangular apocolpium.

The third type is a tri-zonosyncolpate one where the remaining sculptural pattern of the grain is similar to the previously discussed ones.

A fourth type of pollen grain is encountered in this species which is bilaterally symmetrical, heteropolar, tetrazonocolpate, amb more or less sub-rectangular, colpi are present at the corners of the grain being loxocolpate in nature, the tips of the adjacent colpi in each pair which are present along the longer equatorial axis, fuses at one pole, thereby forming three mesocolpium divisions at that pole, while on the other pole there is an extra colpi situated at the center of the pole and the tips of all the five colpi fuses with each other at this pole.

The first two types of grain, i.e. tri-zonocolpate and tetra-zonocolpate grains are also observed without exhibiting heterpolarity.

***Spathodea campanulata* P.Beauv. (Figure 2I-K)**

Pollen grains are radially symmetrical, isopolar, apiculate, subprolate, P × E is 62 × 45 µm, amb subtriangular, planoaperturate; tri-zonocolpate, colpi narrowly elliptic with acute ends, 50 µm in length and 7.4 µm wide at the equator, tenuimarginate; exine tegillate, 2.9 µm in thickness, crassisexinous; surface coarsely reticulate, lumina irregularly polygonal, reaches to a maximum diameter of 2.7 µm, heterobrochate, lumina diameter gradually decreases towards the margin of colpi.

***Tabebuia aurea* Benth. & Hook. F. Ex S. Moore (Figure 2L-N)**

Pollen grains are radially symmetrical, isopolar, oblate-spheroidal to sub-oblate, P × E is 55 × 64 µm, amb circular to sub-triangular, planoaperturate, tri-zonocolporoidate, colpi narrowly elliptic with acute ends, 43 µm in length and 6.7 µm in diameter across the equator, colpi 2-3 oroidate, oroid lalongately elliptic with pointed ends, crassimarginate; exine tegillate, 2.4 µm in thickness, crassisexinous; surface coarsely reticulate, irregularly polygonal, luminal diameter extends upto 2.9 µm, heterobrochate.

***Tabebuia heterophylla* Britton (Figure 2O-Q)**

Pollen grains are radially symmetrical, isopolar, spheroidal, 59.2 µm in diameter, amb hexagonal, planoaperturate; tri-zonocolporoidate, colpi broadly elliptic with acute ends, 37 µm in length and 19.3 µm in diameter at the equator, tenuimarginate, margins irregular, colpi 2-3 oroidate, oroid lalongately elliptic, slit like with acute ends; exine tegillate, 2.9 µm in thickness, crassisexinous; surface coarsely reticulate, lumina irregularly polygonal, extends upto 2.7 µm, heterobrochate, lumina diameter gradually decreases towards the margin of colpi.

***Tecoma Stans* (L.) Griseb. (Figure 2R-U)**

Pollen grains are radially symmetrical, isopolar, apiculate, prolate, P × E is 69 × 49 µm, amb circular, tri-zonocolporoidate, colpi linear with acute apex, 45.5 µm, crassimarginate, oroid lolongate, 6.2 µm in length and 4 µm wide; exine tegillate, 2 µm in thickness, crassisexinous; surface microreticulate.

P=polar diameter, E=equatorial diameter, E1=longest equatorial axis and E2=smaller equatorial axis of the pollen grain.

The surface pattern is reticulate in majority of the investigated species while very few are of psilate type (*Jacaranda obtusifolia*). Variations in the luminal diameter of the members have been noticed, majority of them are moderately reticulate while *Anemopaegma chamberlaynii* is broadly reticulate and *Tabebuia aurea* and *Tecoma stans* are minutely reticulate. The members depict a wide variety of apertural pattern, ranging from inaperturate type (*Mansoa alliacea*) to tri-tetrazonocolpate type (*Pyrostegia venusta*, *Oroxylum indicum*, *Millingtonia hortensis*, *Spathodea campanulata*) to tri-zonocolpor(oid)ate type (*Parmentiera cereifera*, *Tecoma stans*, *Tabebuia heterophylla*, *Tabebuia aurea*, *Markhamia lutea*, *Jacaranda obtusifolia*, *Fernandoa adenophylla*) to hexazonocolpate type (*Anemopaegma chamberlaynii*), thereby exhibiting a high degree of eurypalyny in the taxon. The present observation exhibits similarity as well as variations regarding the morphology of the pollen grains when compared to the prior published works of various authors (Erdtman, 1952; Mitra, 1968; Gentry and Tomb, 1979; Nair, 1990; Bove, 1993; Ugbabe *et al*., 2007; Sarkar *et al*., 2015; Rajurkar *et al*., 2018; De Souza *et al*., 2019) [7, 15, 11, 16, 2, 27, 22, 21, 17].

Multi-orate colpi, i.e. colpi dissected with more than two ora (endoapertures) are observed in six out of thirteen investigated members in the present study. They are *Fernandoa adenophylla* (3), *Jacaranda obtusifolia* (2-3), *Markhamia lutea* (4-6), *Parmentiera cereifera* (3-9), *Tabebuia heterophylla* (2-3) and *Tabebuia aurea* (3) where the colpi is dissected by numerous lalongately elliptical ora, having highly tapering pointed ends. In *Tabebuia* sp. the multiple ora of the colpi are quite faint and indistinct in nature. In all the above mentioned species the presence of multi-orate features has been surfaced for the first time. Multi-orate colpi in pollen grains are not so common in occurrence and are restricted to few angiospermous families. It is witnessed in the present study as well as reported by previous authors (Bove, 1993; Mitra, 1968; Ferguson and Santisuk, 1973; Harley and Banks, 1994; Rajurkar *et al*., 2018; Urban, 1916)[2,15,8,12,21,28] in Bignoniaceae (*Jacaranda micrantha*, *J. puberula*, *Heterophragma* sp., *Barnettia* sp., *Radermachera* sp., *Fernandoa lutea*, *F. magnifica*, *F. ferdinandi* and *Spathodea campanulata*) and few other angiospermous families like Scrophulariaceae (Erdtman, 1952) [7] and Verbenaceae (Raj, 1983)[20]. So, the idea of suggesting them as an artefact during acetolysis could not be supported. Different authors have interpreted the multi-orate features in different ways and regarded them as ‘ruptures’ or ‘slits’, thereby not considering them as proper endoapertures (Mitra, 1968; Bove, 1993; Harley and Banks, 1994) [15, 2, 12], but in our

opinion, they should be considered as distinct, lalongate type of endoapertures as they form a dominant feature in many genera of Bignoniaceae and the colpi should be regarded as multi-orate one. The present investigation of the Indian species of Bignoniaceae supports the presence of multi-orate pollen grains in genera *Jacaranda*, *Tabebuia* (Bove, 1993) [2] and *Fernandoa* (Harley and Banks, 1994) [12]. Species of *Fernandoa* from Australasia are said to lack these multi-orate features (Buurman, 1977) [4]. Rajurkar *et al*. (2018) [21] has observed di-orate type of colpi in *Spathodea campanulata*, whereas the present study reveals only the tri-zonocolpate pollen grains in the species without multi-orate features.

Polymorphic pollen grains in *Parmentiera cereifera* (3 types) and *Pyrostegia venusta* (4 types) has been observed for the very first time in the present study**.** There is no report of polymorphism in *Parmentiera cereifera* in prior studies made by Mitra (1968) [15]. *Pyrostegia venusta* (4 types) has also exhibited heteropolarity in the present investigation which has not been surfaced so far. Dimorphic pollen grains have been reported earlier in the species being trizonocolpate and tetra-zonocolpate (Bove, 1993; Gentry and Tomb, 1979) [2, 11].

Pollen grains of *Oroxylum indicum* in the present study exhibits dimorphism with heteropolar nature which supports the observation of Nair (1990) [16].

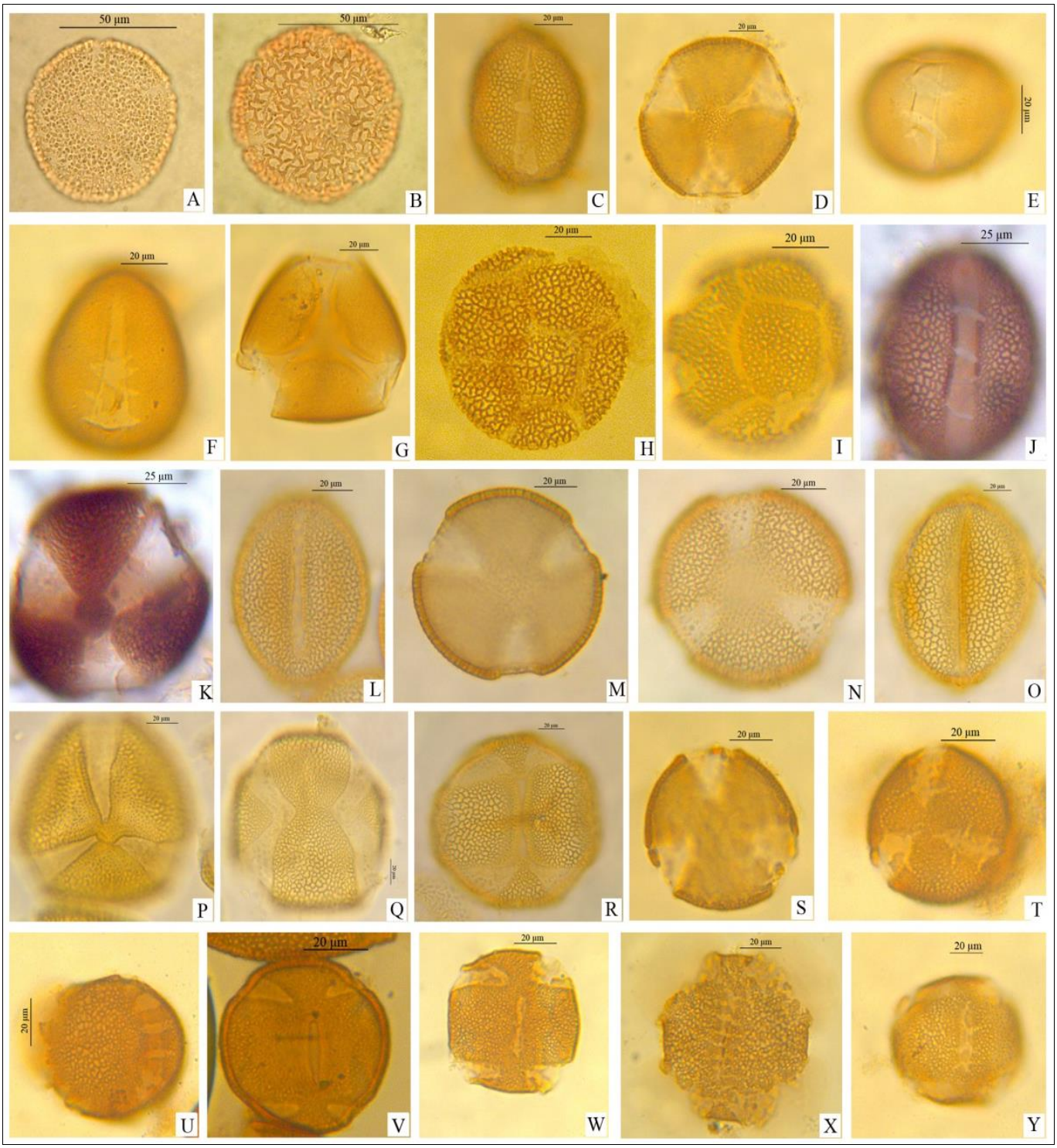

Fig 1

Figure 1. Pollen grains of the respective species of Bignoniaceae. A–B. *Anemopaegma chamberlaynii*. A. polar view of the grain exhibiting the hexazonocolpate apertural pattern. B. broadly reticulated surface view of the grain. C-D. *Fernandoa adenophylla*. C. equatorial view of the grain showing the tri-orate colpi and surface reticulations. D. polar view of the grain with the apocolpium and exine stratification in focus. E-G. *Jacaranda obtusifolia*. E. equatorial view of the grain showing colpi with two ora. F. colpi with multiple ora. G. polar view of the tri-zono-colporoidate grain. H-I. *Mansoa alliacea*. H. reticulate surface pattern of the grain. I. grain showing single areoli in focus. J-K. *Markhamia lutea*. J. equatorial view of the grain showing a single colpi with four ora and surface reticulations. K. polar view of the grain showing the tri-zonocolporoidate aperture of the grain. L-N. *Millingtonia hortensis*. L. equatorial view of the grain showing a single colpi. M. polar view of the grain showing the exine. N. polar view of the grain showing the surface reticulations. O-R. *Oroxylum indicum*. O. equatorial view of the grain showing a single colpi. P. polar view of the tri-zonocolpate grain. Q-R. Polar view of both the poles of the same grain, exhibiting heteropolarity. S-Y. *Parmentiera cereifera*.
S. polar view of the grain depicting the exinous wall. T. tri-zonocolporate grain with multiple ora. U. a single colpi of the tri-zonocolporate grain in focus with multiple ora. V-W. Pancolpate grain without any ora, wall view and surface view respectively. X-Y. Pancolpate grain with multiple ora.

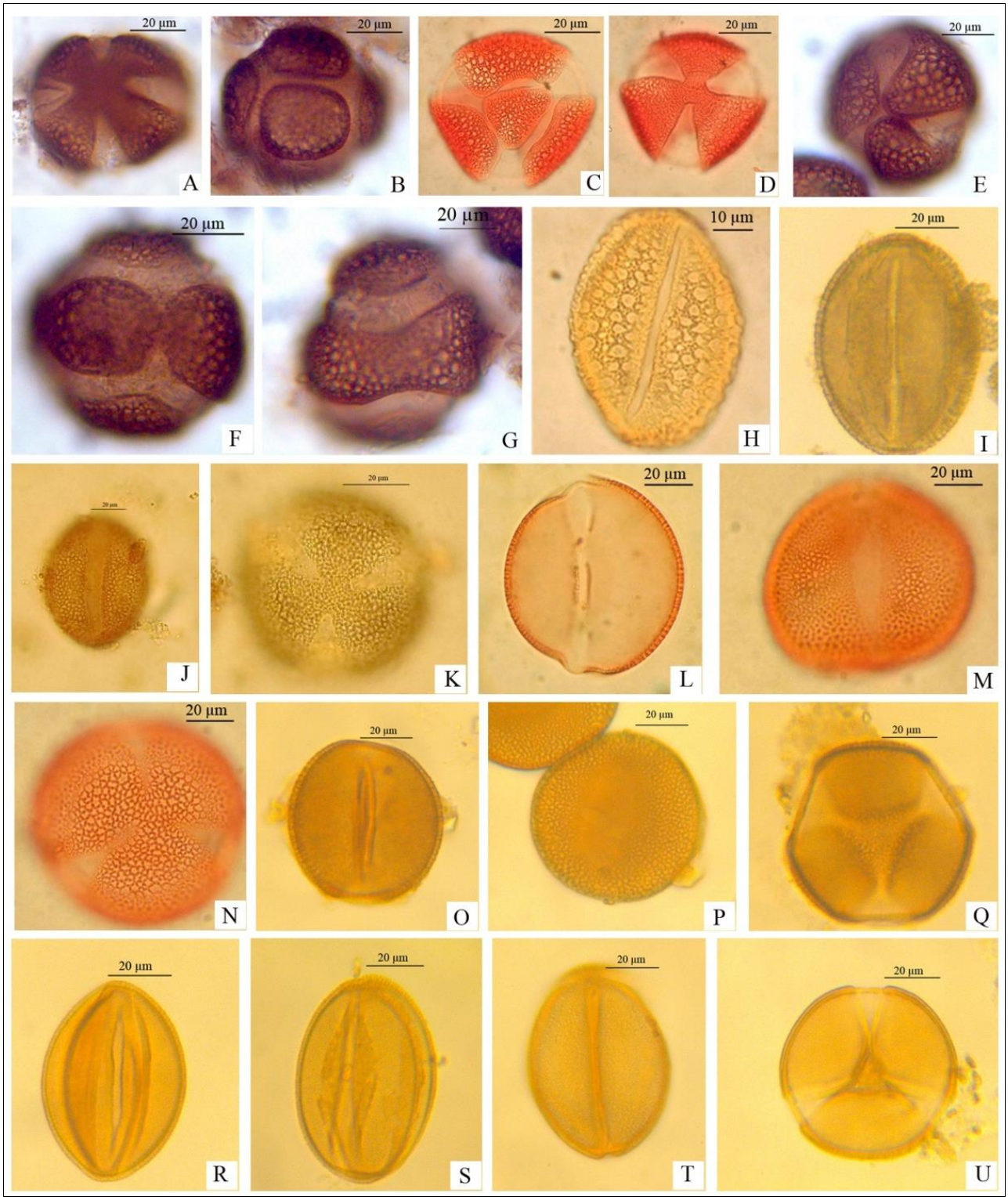

Fig 2

Figure 2. Pollen grains of the respective species of Bignoniaceae. A-H. *Pyrostegia venusta*. A. polar view of tetra-zonocolpate grain where the colpi ends are free from each other at one pole. B. colpi forming a para-syncolpate apertural pattern at the other pole of the tetra-zonocolpate grain pollen grain. C. polar view of tri-zonocolpate pollen grain where the colpi forms a para-syncolpate apertural pattern at one pole. D. colpi ends are free from each other at the other pole of the tri-zonocolpate pollen grain. E. tri-zono-syncolpate pollen grain. F-G. Polar view of both the poles of the same grain, exhibiting heteropolarity. H. equatorial view of the grain showing a single diagonally placed colpi. I-K. *Sphathodea campanulata*. I-J. Equatorial view of the grain showing the wall and colpi respectively. K. polar view of the tri-zonocolpate grain with reticulate surface pattern. L-N. *Tabebuia aurea*. L. wall view of the grain. M. colpi of the grain. N. polar view of the grain with reticulate surface pattern. O-Q. *Tabebuia heterophylla*. O. wall view of the grain. P. equatorial view of grain showing colpi with faint ora. Q. polar view of the grain. R-U. *Tecoma stans*. R. wall view and colpi of the grain. S. colpi with insconspicuous ora. T. surface pattern. U. polar view of the grain.

Conclusions

The previously published works on the multi-orate and di-orate features of the pollen grains have been consulted for drawing suggestions regarding their significance and evolutionary trend. Considering the evolutionary trend of angiosperms, more number of apertures are said to be favoured as they are thought to be functionally significant, resulting in rapid germination due to an increase in the number of germinating sites, as they maximizes the chance of contact between the apertural area of the pollen and the surface of stigma, thereby enhancing the rate of fertilization (Dajoz *et al*., 1991, 1993; Till-Bottraud *et al*., 1994; Furness and Rudall, 2004) [5, 6, 25, 10].

Therefore, the presence of multiple endo-apertures on the colpi in our present study should be considered as an advanced, evolved characteristic feature of the pollen grain as it supports the above mentioned view. The tri-zonocolpor (oid) ate apertural pattern with multiple ora might indicate towards an advanced characteristic feature of the pollen grain. It may be an adaptation of the colpate kind of pollen grain to develop more endoapertures to carry on the process of harmomegathy more efficiently during stressed conditions and give rise to more pollen tubes during germination. Although multi-orate features have been recognized by several authors in Bignoniaceae, very little or negligible amount of knowledge has been provided about their evolution and origin and their impact (positive or negative) on the grain. So, these aspects needs much more attention and should be explored thoroughly as multi-orate features seems to be an important palynomorphological character in Bignoniaceae, being dominant in quite a few number of genera.

The tri-zonocolpate pollen grain has already been considered as the most efficient type of grain by several authors (Albert *et al*., 2018) [1] as both, germination rate and longeivity is higher in this kind of grain and Buurman (1977) [4] have also mentioned that the multiple ora have a selective advantage during the process of germination. So, it calls for a detailed comparative analysis between the germination Process of the tri- zonocolpate and tri-zonocolpor (oid) ate, multi-orate kind of grain present in this family and determine which type proves to be more beneficial to the species. It is noteworthy in the present study that the presence of both types of grain in *Parmentiera cereifera*, i.e. a) pancolpate apertural pattern, devoid of any ora and b) pancolpate with multi-orate features, indicates that the pancolpate-multiorate pollen grain might have evolved from the pancolpate pollen grain by the development of numerous exinal bridges which may further suggests that multi-orate features are advanced morphological features.

Fischer (2004) [9] in his classification of Bignoniaceae had placed *Markhamia*, *Spathodea*, *Jacaranda*, *Fernandoa* and *Tecoma* within a single tribe Tecomeae while Olmstead (2009) [18].

Had grouped the above mentioned genera into three distinct tribes in his system of classification. He had placed *Tecoma* within the tribe Tecomeae, *Jacaranda* in Jacarandeae and Palaeotropical clade includes *Markhamia*, *Fernandoa* and *Spathodea*.

The present study reveals distinct palynomorphogical details of each of the three tribes. Pollen grains of *Tecoma* are trizonocolporoidate, ora insconspicuous, microreticulate; *Jacaranda* are trizonocolporoidate, colpi multiorate, psilate and that of *Markhamia*, *Fernandoa*, *Spathodea* are trizonocolpor (oid) ate, colpi multiorate, moderately reticulate. The observation of Rajurkar *et al*. (2018) [21] for *Spathodea* from India has been taken into account. So, it can be concluded that the present palynological investigation supports the classification of Olmstead (2009) [18] of Bignoniaceae at the tribal level.

Acknowledgments

Moulana Azad National Fellowship awarded by the UGC (Govt. of India) to first (S.H.) and second (M.T.A.) authors are gratefully acknowledged. The authors are thank Ful to UGC for financial assistance and infrastructure provided under the Department of Botany, The University of Burdwan.

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