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Palynological contribution to the systematics and taxonomy of *Bauhinia s.l.* (Leguminosae: Cercideae)

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ABSTRACT

Pollen grains of 250 samples of taxa in the Cercideae clade have been studied using light microscopy, scanning electron microscopy and transmission electron microscopy. This study examines how pollen morphological structures can be used as taxonomic characters in systematic studies. Pollen grains of the first branching taxa in the Cercideae phylogeny, such as *Cercis* and *Adenolobus*, are unspecialised; they are isopolar, tectate, tricolporate, and released in monads. Surface ornamentation may be micro-reticulate or perforate, and psilate to rugulate. Aperture membranes are granular to coarsely granular. More specialised pollen grain structures are found in *Schnella*, *Lasiobema*, *Phanera*, *Piliostigma* and most of *Bauhinia s.s.* Pollen morphology is presented in a table for comparative purposes and illustrated, discussed and compared. Six specialised pollen structures described and identified are diagnostic for groups of related species in the Cercideae. These include a granular infratectum, syncolporate apertures, pororate apertures, spiny opercula, tetrads, and non-supratectal spines. Porate apertures occur in *Phanera*, *Piliostigma* and *Bauhinia picta.* Five pollen structures have been identified within the Cercideae clade that is restricted to *Bauhinia s.s.* These include striate ornamentation, having more than three apertures per grain, apertures that are indistinct, and colpate apertures. Supratectal ornamentation, structures such as gemmae, verrucae and striae, occur in many species in the Cercideae, as well as throughout subfamily Caesalpinioideae, and the functional implications of this are discussed. Pollen morphological structures are discussed with regard to systematic significance, taxonomic utility, and in relation to functional and developmental considerations.

1. Introduction

Tribe Cercideae, which contains *Bauhinia sensu lato*, forms one of the first branching lineages in the Leguminosae. Many analyses, based on both morphological (Wunderlin et al., 1987; Zhang, 1995) and molecular characters (Bruneau et al., 2001, 2008; Hao et al., 2003; Lewis and Forest, 2005), show different relationships between taxa in the Cercideae. The taxonomic history of *Bauhinia s.l.* is especially complex. It has been the subject of a large number of taxonomic studies in which it has been recognized either as a single large genus comprising 300 to 350 species (e.g. Wunderlin et al., 1987), or as several distinct genera (e.g. Lewis and Forest, 2005; Sinou et al., 2009). Recent molecular phylogenetic studies (Sinou et al., 2009; Tu et al., 2013) are adding support to the paraphyly of *Bauhinia s.l.*

The pollen of the Cercideae has long been known to be diverse and variable. Until recently, it has been difficult to unravel the taxonomic significance of these diverse pollen structures due to the unresolved species level taxonomy. With the recent publication of a molecular phylogeny (Sinou et al., 2009), we are now able to better interpret the significance of the distribution of pollen structures within tribe Cercideae, and to assess morphological variation in a systematic context. The aims of this study are to identify pollen characters that are putative synapomorphies for segregates of *Bauhinia s.l.*, as well as to examine the evolution of pollen structures within the group.

2. Materials and methods

About 250 pollen samples (Table 1) were examined using light microscopy (LM), scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The taxonomy follows that of Lewis and Forest (2005) and Sinou et al. (2009). Pollen material was obtained from specimens housed in the Herbarium of the Royal Botanic Gardens, Kew (K); a list of all specimens studied is available upon request.

Mature unopened buds from herbarium specimens were dissected in a 1% solution of Libsorb wetting agent. Pollen was acetolysed according to Erdtman (1960) and prepared for LM by mounting in glycerol jelly. Light micrographs were taken using a Leica DMLB microscope with an Axiocam digital camera. For SEM, acetolysed pollen exines in 95% ethanol were pipetted onto specimen stubs and allowed to air dry. Specimens were sputter coated with platinum and examined

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Table 1
Table of pollen aperture, ornamentation and wall structure morphology in the Cercideae.

Group	Apertures	Ornamentation	Wall structure	Species included	Figs.
Unspecialised type for comparison	Tricolporate, granular aperture membranes	Microreticulate	Foot layer, columellae and tectum present		Figs. 1A, B, C
Cercis	Tricolporate, granular aperture membranes	Microreticulate	Foot layer, columellae and tectum present	*C. canadensis*, *C. chinensis*	
Adenolobus	Tricolporate, granular aperture membranes	Microreticulate	Foot layer, columellae and tectum present	*A. garipensis*, *A. pechuellii*	Fig. 1B, C
Griffonia	Tricolporate, granular aperture membranes	Microreticulate	Foot layer, columellae and tectum present	*G. physocarpa*	Fig. 1A
Gigasiphon macrosiphon	Tricolporate	Microreticulate	Foot layer, columellae and tectum present	*Gigasiphon macrosiphon*	Fig. 1D
Gigasiphon gossweileri		Gemmate	Supratectal gemmae	*Gigasiphon gossweileri*	
Tylosema	Tricolporate, annulus present around endoaperture	Microreticulate	Thick foot layer, complex infratectum	*T. esculentum*, *T. fassoglensis*	
Barklya	Tricolporate	Microreticulate, rugulate		*B. syringifolia*	
Lysiphyllum	Tricolporate	Microreticulate, rugulate with variations between species, some have smoother areas around poles	Foot layer, columellae and tectum present	*L. cunninghamii*, *L. binata*, *L. hookeri*, *L. winitii*	
Schnella type 1	Tricolporate, granular aperture membrane	Microperforate, psilate or finely rugulate	Thick foot layer, thick tectum and granular infratectum	*S. outimouta*, *S. hymenaeifolia*, *S. guianensis*, *S. angulosa*, *S. coronata*, *S. erythrantha*, *S. platycalyx*, *S. rutilans*	Fig. 1E
Schnella type 2	Tricolporate	Gemmate	Thick endexine, complex infratectum, supratectal gemmae	*S. microstachya*, *B.* (*S.*) *raddiana*, *S. smilacina*	Fig. 1F
Lasiobema and Asian *Phanera* type 1	Tricolporate, granular aperture membranes	Microreticulate-rugulate, smoother areas around poles		*Lasiobema pencilliloba*, *Phanera yunnanensis*	
Lasiobema and Asian *Phanera* type 2	Tricolporate, granular aperture membranes	Microreticulate with larger lumina at poles		*Phanera vahlii*, *P. ornata*	
Lasiobema and Asian *Phanera* type 3	Triporate, finely granular aperture membranes	Microperforate-psilate	Foot layer, columellae and tectum present, narrow infratectum	*Phanera bidentata*, B. (*Phanera*) *endertii*, *P. foraminifera P. fulva*, *P. kockiana*	Fig. 1H, I
Lasiobema and Asian *Phanera* type 4	Tricolporate, syncolporate	Rugulate-verrucate, with larger verrucae along aperture margins and over aperture membranes		*Phanera glauca* ssp. *tenuiflora* *P. corymbosa* *B. damioshanensis* *P. touranensis* *B.* (*Phanera*) *clemensiorum*	Fig. 1G