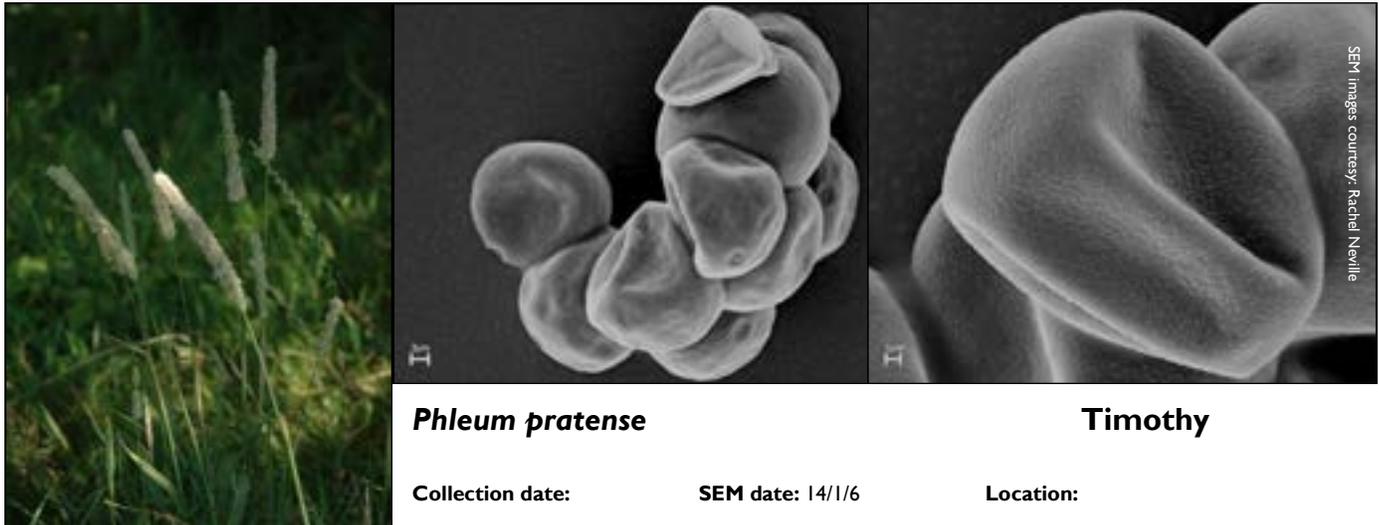


Family: *Poaceae****Phleum pratense*****Timothy**

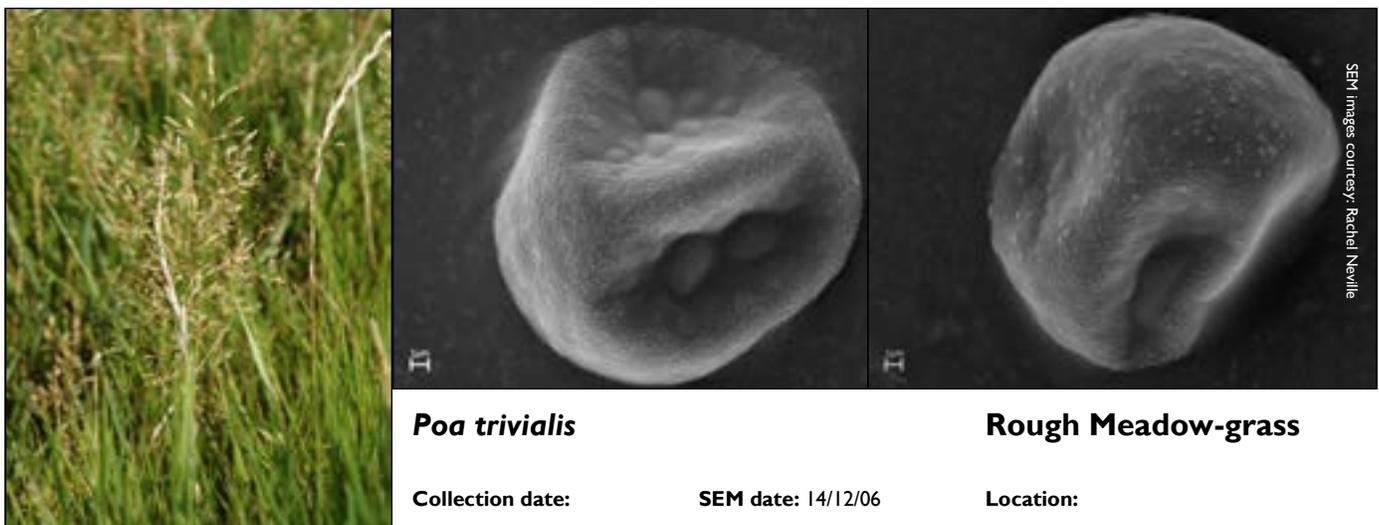
Collection date:

SEM date: 14/1/16

Location:

Phleum pratense is a monoporate grain with the exine verrucate. Porus is circular, well defined and prominent. The nexine is thickened around the porus to form the costa.

A native plant common to both agricultural land and waste places. Height: 1.5m.

***Poa trivialis*****Rough Meadow-grass**

Collection date:

SEM date: 14/12/06

Location:

Poa trivialis is a monoporate grain with the exine verrucate to micro-verrucate with a greater portion of micro-verrucae than verrucae. Porus is circular, well defined and prominent. The nexine is thickened around the porus to form the costa.

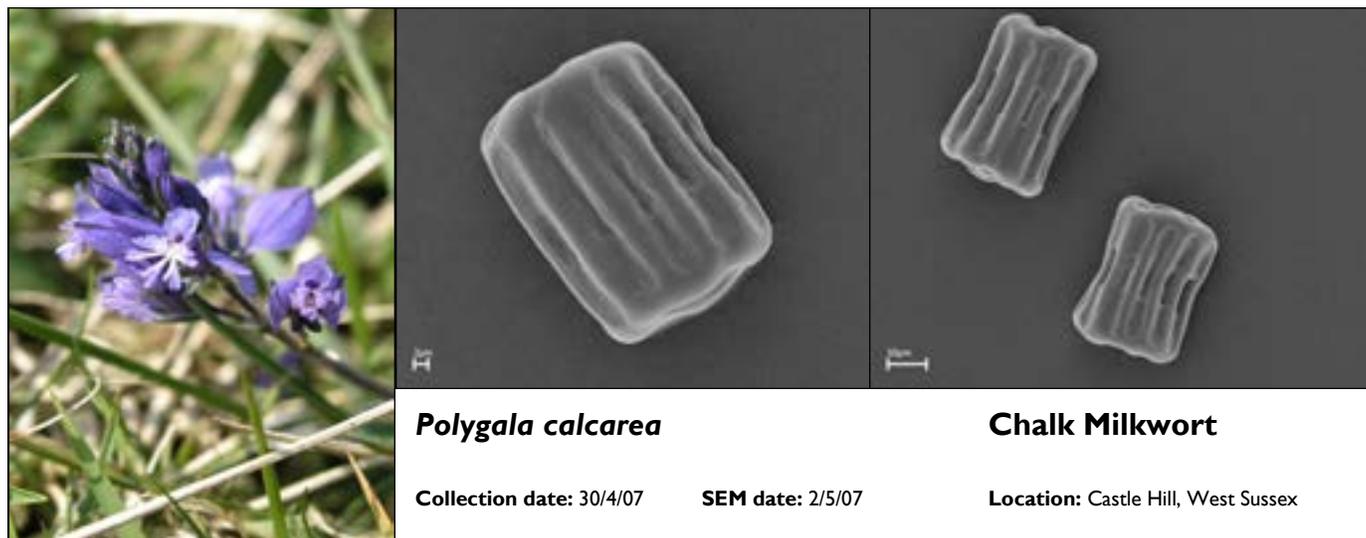
A native plant common to open areas such as rough grassy places, wasteland and cultivated ground preferring moist situations. Height: 75cm.

Poaceae family summary.

There have been many attempts to distinguish between pollen grains of members of the *Poaceae* (formerly *Graminaceae*) family, attempts have been made by Beug (1961); Grohne (1957); Gourham (1969); Anderson (1979); all have met with limited success (Fageri and Iversen, 1989). The general consensus of these researchers was that the size of the pollen grains varied between that of cultivated cereals and wild grasses; the cereal crops produced large pollen grains on average but there was also variability in size amongst species also (Moore *et al*, 1991, p9 100).

To determine size accurately and develop a solid analysis of pollen grains care needs to be taken that the pollen grains do not collapse as many did during this analysis. Moore *et al* (1991) cites Anderson and Iversen (1989) that success in determining pollen grain size was possible using silicone oil under light microscopes and that they were able to group many members of the *Poaceae* family into genus categories based on size. Other less intrusive methods of microscopic analysis such as confocal microscopy might alleviate the grain 'collapse syndrome' and thus provide accurate sizes for individual grains hopefully further defining individual species.

Family: *Polygalaceae*



Polygala calcarea

Collection date: 30/4/07

SEM date: 2/5/07

Chalk Milkwort

Location: Castle Hill, West Sussex

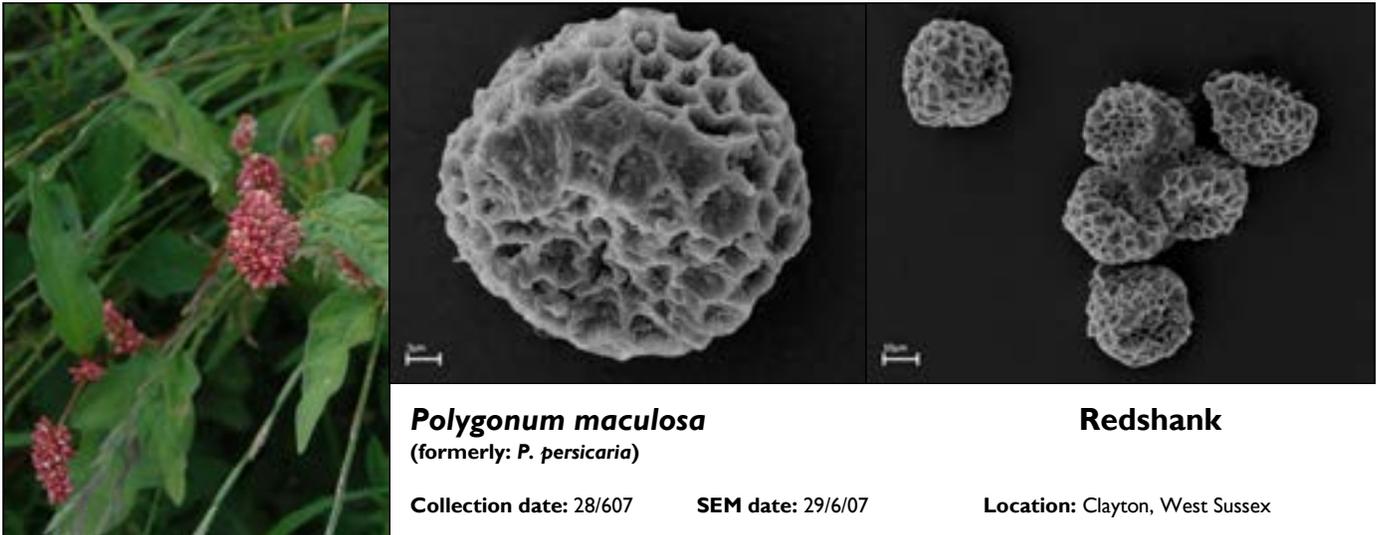
Polygala calcarea pollen grains are polyzonocolporate, psillate and with a clear endopori centered around the equator but not exceeding one quarter the length of the grain. The apocolpia are designated with large somewhat irregular shaped depressions. The colpi are quite wide and obtuse-ended forming a equatorial girdle. The grains are flat to slightly depressed at the poles while retaining a rectangular appearance equatorially.

A native plant found only on calcareous grassland. Height: 10cm.

***Polygalaceae* family summary.**

Polygala calcarea pollen grains are polyzonocolporate, psillate and with a clear endopori centered around the equator but not exceeding one quarter the length of the grain. The pollen grain shape is oblong in equatorial view and elliptic-obtuse in polar views. The pollen grain shape and the arrangement of the colpi makes this an easily identifiable species, with only one plant similar in character but still easily identifiable from *Polygala*: *Viola arvensis*.

Moore *et al* (1991, pp. 160) identifies *Polygala* to the species level only, although Stace (1997. pp. 467) identifies 7 other species, hybrids or subspecies. Further study is warranted to determine is there are distinct differences in the remainder of the genera found in the British Isles.

Family: *Polygonaceae*

Polygonum maculosum
(formerly: *P. persicaria*)

Redshank

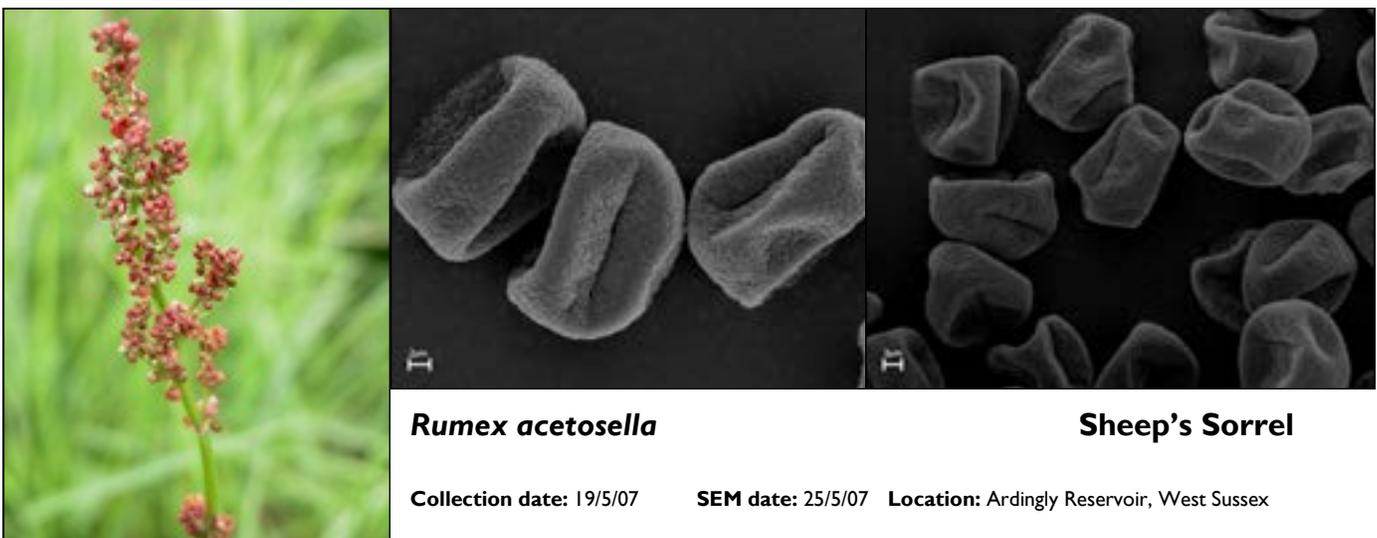
Collection date: 28/6/07

SEM date: 29/6/07

Location: Clayton, West Sussex

Polygonum persicaria is an orbicular polypantoporate, foveolate, eureticolate pollen grain. Each porus is small but filling the bottom of the lumina in the reticulum, thus the exine sculpturing is not interrupted by the pori. The lumina are not-porate but appear to have baculate to granulate floors.

A native weed, occasional to field margins, waste ground and other marginal areas. Height: 75cm, but usually procumbent spreading more than its height.



Rumex acetosella

Sheep's Sorrel

Collection date: 19/5/07

SEM date: 25/5/07

Location: Ardingly Reservoir, West Sussex

Rumex acetosella is a tetrapantocolpate grains with each ectocolpus with a more or less circular endoporus in the middle. Ectocolpi are longer often nearly or actually synocolpate. The pori are distinct. Pollen grains are small usually <math><28\mu\text{m}</math> in size. Sculpture is sometimes contrasting with winding or sinuous duplicolumellate muri.

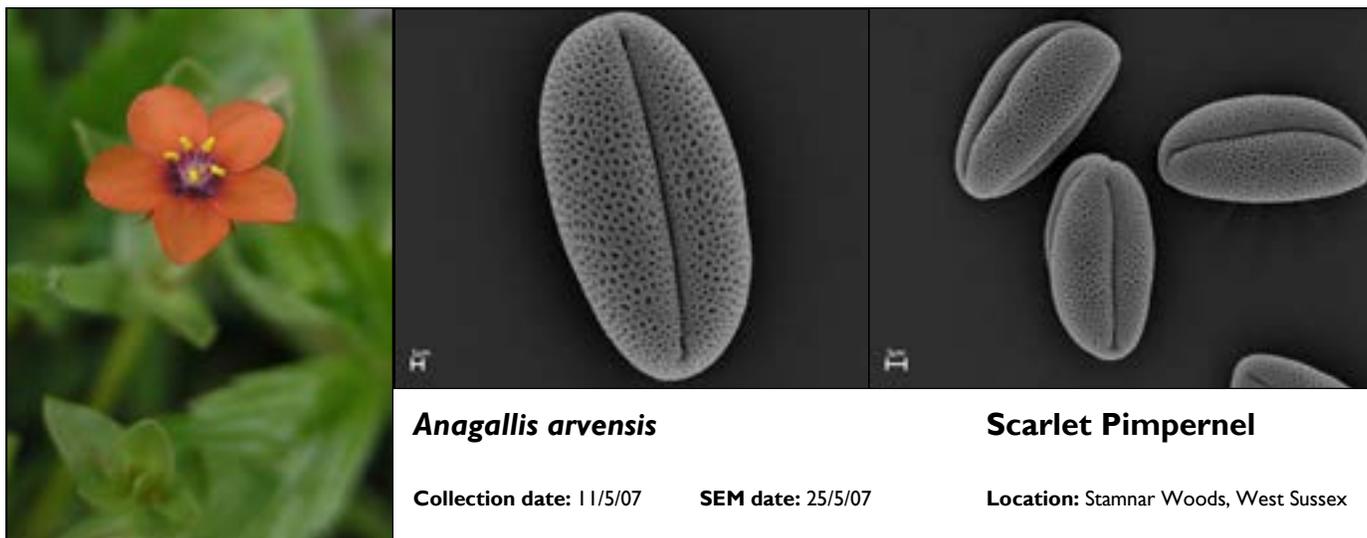
A native plant commonly found on heaths, short grassland and wasteland; to about 1m in height.

***Polygonaceae* family summary.**

Polygonum persicaria is an orbicular polypantoporate, foveolate, eureticulate grain while *Rumex acetosella* is a tetrapantocolpate pollen grain. The two species are quite distinct both morphologically and floristically. *P. maculosa* has similar pollen morphological characteristics to *G. molle*.

Moore *et al* (1991, pp. 162) does define the pollen morphological characteristics of *R. obtusifolius*, *R. longifolius*, *R. palustris*, *R. aquaticus*, and *R. hydrolapathum* and expects identification may be possible of *R. aquaticus* based on its grain dimensions but not sculptural details while *Polygonum* pollen grains according to Moore cannot be identified beyond the genus level.

Stace (1997, pp. 184-196) lists 17 species, hybrids or subspecies of *Polygonum* and 69 species, hybrids, varieties and subspecies of *Rumex*, thus intonating the complexity of this family; the family also includes a further five genera; although with only a few species per genera. These numbers and familial relationships demonstrate the complexity of this family questioning the validity of pollen analysis beyond perhaps the species level for the hybrids, varieties and subspecies as it is anticipated that little differentiation would occur in pollen morphology beyond that phase.

Family: *Primulaceae****Anagallis arvensis*****Scarlet Pimpernel**

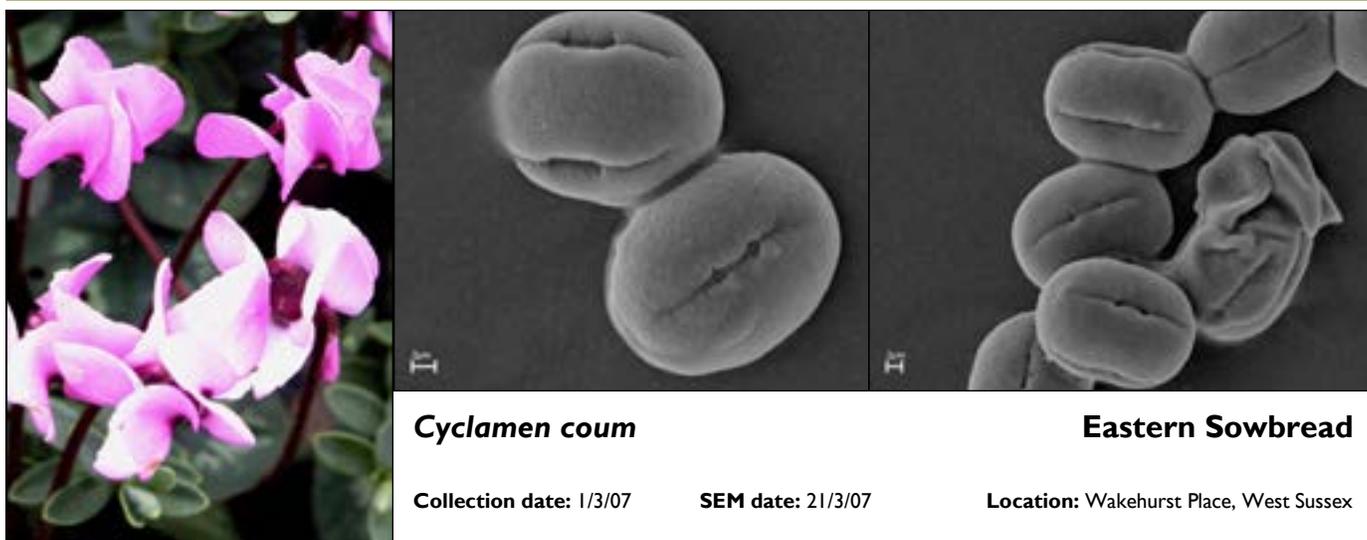
Collection date: 11/5/07

SEM date: 25/5/07

Location: Stannar Woods, West Sussex

Anagallis arvensis pollen grains are $< 36\mu\text{m}$ in size, elliptic-obtuse, trizonocolpate, eurate with the colpi almost running the full length of the grain and terminating in the pole. The colpi is narrow, slit like, sunken, with no differentiation at the equator or the poles. Exine is porate-rugulate with the lumina sizing decreasing towards the colpi.

A native plant found on waste ground and arable land. Height: 35cm.

***Cyclamen coum*****Eastern Sowbread**

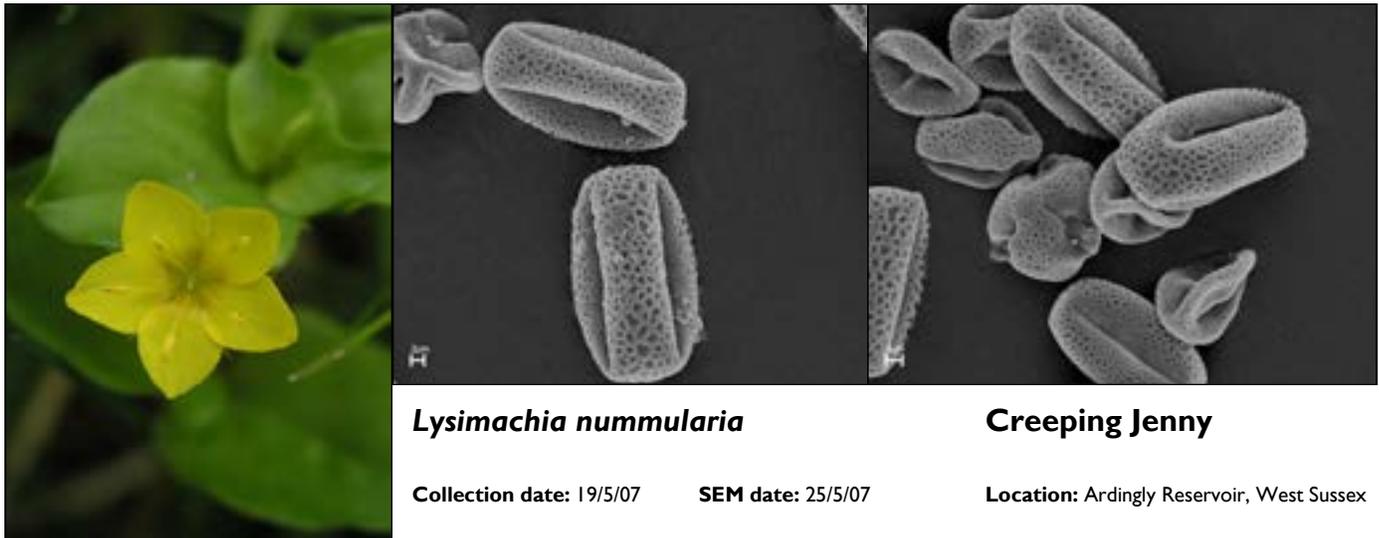
Collection date: 1/3/07

SEM date: 21/3/07

Location: Wakehurst Place, West Sussex

Cyclamen coum pollen grains are elliptic-obtuse, trizonocolpate, psilate with the colpi almost running the full length of the grain and terminating in the pole. The colpi is narrow, slit like, sunken at the equator but also wider at this point. The colpi membrane is granulate, although finely so. Grain shape is quite distinct, circular to circular-oblong in equatorial view and circular in polar view.

An introduced plant that may be seen along roadsides and as an escapee from the garden where it is still commonly cultured. Height: 25cm.

Family: *Primulaceae****Lysimachia nummularia*****Creeping Jenny**

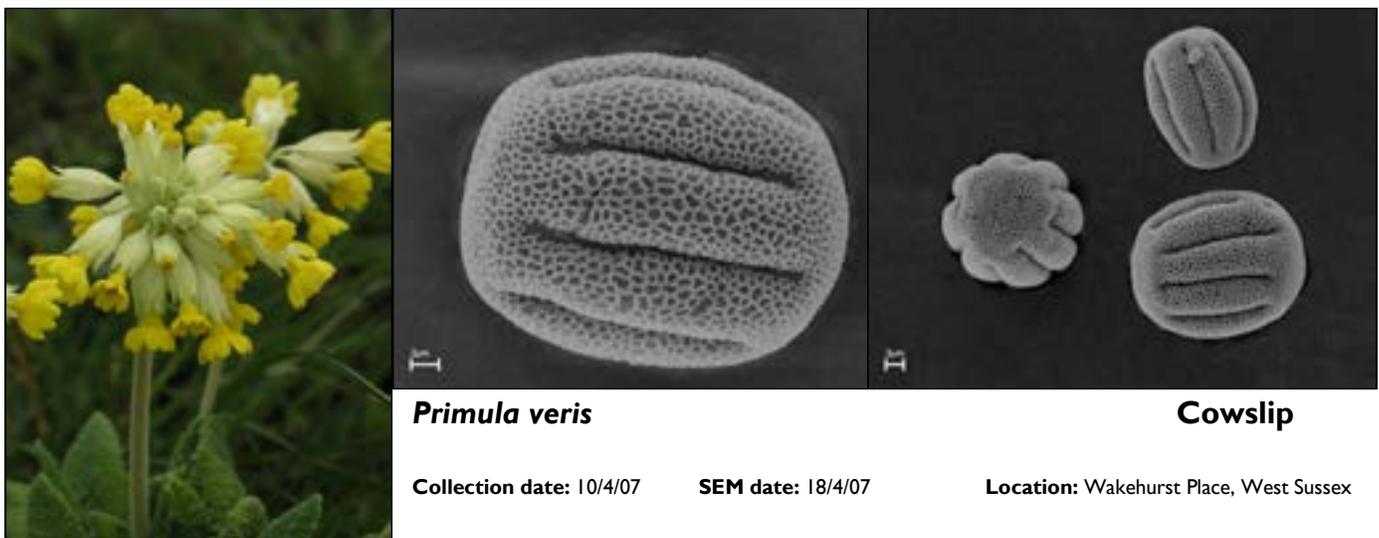
Collection date: 19/5/07

SEM date: 25/5/07

Location: Ardingly Reservoir, West Sussex

Lysimachia nummularia pollen grains are $< 36\mu\text{m}$ in size rhombic-obtuse trizonocolpate, eureticate with the colpi almost running the full length of the grain and terminating before the poles. The colpi is wide, opening towards the equator. The exine is porate-rugulate with the lumina sizing decreasing towards the colpi. This particular sample shows extensive pollen grain collapse.

A native procumbent plant common to damp woods and other similar situations, often used in the garden as a groundcover from which it may escape and naturalize. Height: 5cm.

***Primula veris*****Cowslip**

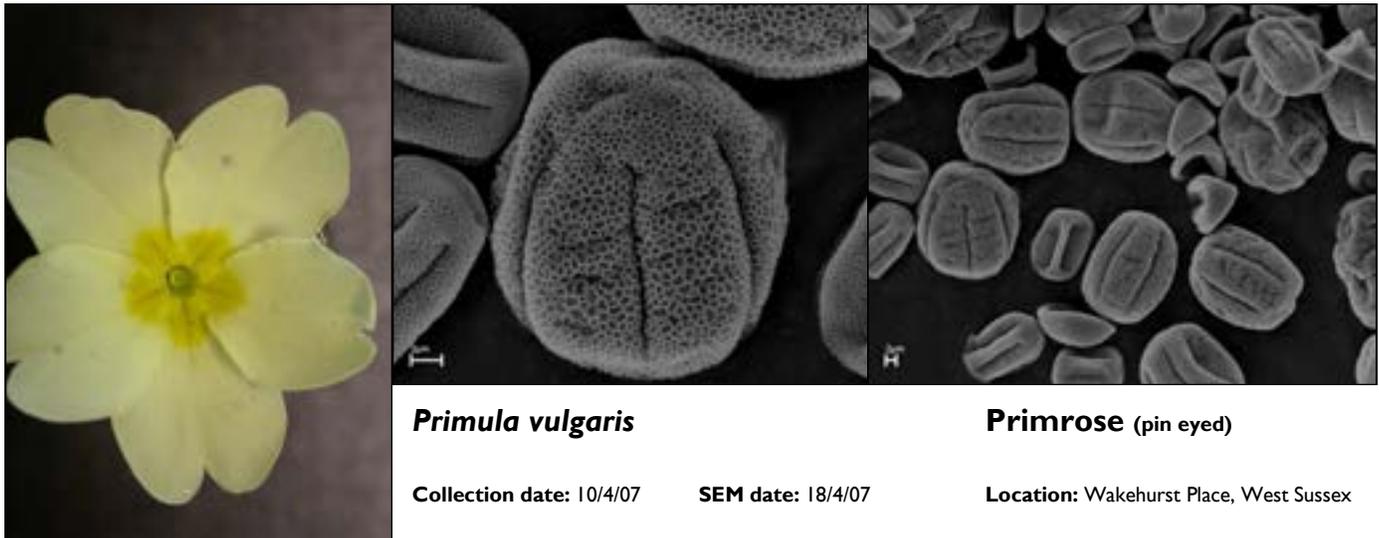
Collection date: 10/4/07

SEM date: 18/4/07

Location: Wakehurst Place, West Sussex

Primula veris pollen grains are rhombic-orbicular polyzonocolpate grains with flattened poles but slightly wider at the equator in equatorial view. The sculpture is eureticate to suprareticulate and consistently scattered across the exine with small lumina and possible perforations in the floor of these. The mesocolpia is slightly convex with a wide colpi sunken and sinuous and terminating obtusely before the poles.

P. veris is a native plant commonly occurring on grassland that has rich calcareous soils. Height: 30cm.

Family: *Primulaceae****Primula vulgaris*****Primrose (pin eyed)**

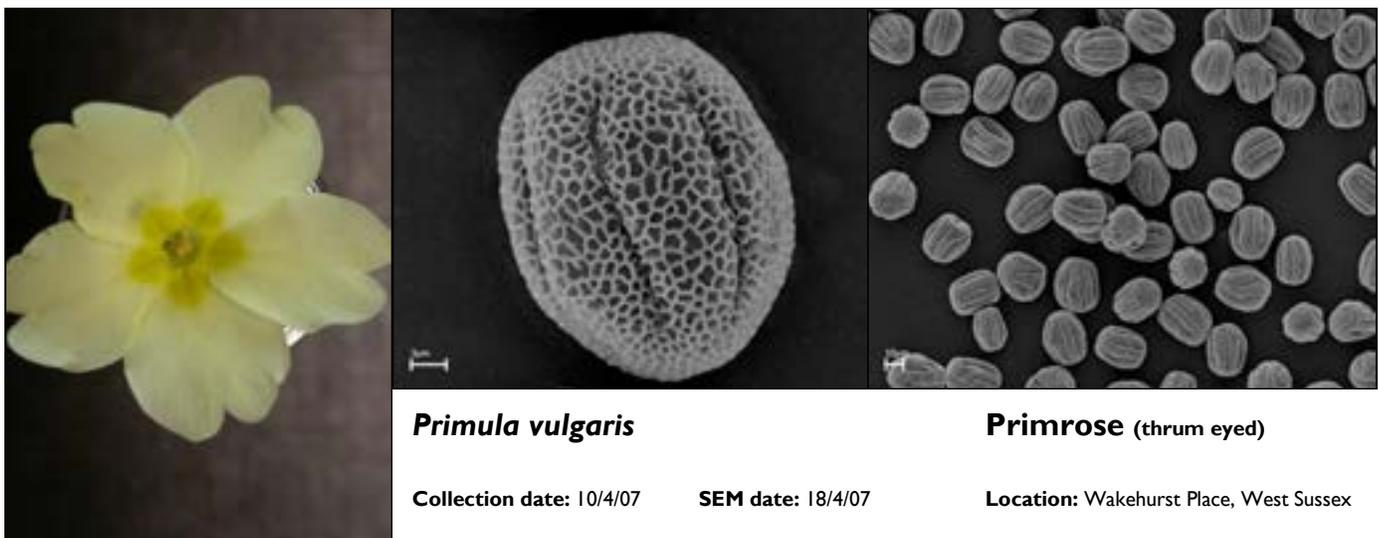
Collection date: 10/4/07

SEM date: 18/4/07

Location: Wakehurst Place, West Sussex

Primula vulgaris pollen grains (pin eyed) are rhombic-orbicular polyzonocolpate grains with flattened poles. The sculpture is eureticate to supareticulate and consistently scattered across the exine with small lumina and possible perforations in the floor of these. The mesocolpia is slightly convex with a wide colpi sunken and sinuous and terminating obtusely before the poles. A number of the grains show extensive collapse.

A native of woods, damp meadows and hedges. Height: 35cm.

***Primula vulgaris*****Primrose (thrum eyed)**

Collection date: 10/4/07

SEM date: 18/4/07

Location: Wakehurst Place, West Sussex

Primula vulgaris pollen grains (thrum eyed) rhombic-orbicular polyzonocolpate grains with flattened poles but slightly wider at the equator in equatorial view. The sculpture is eureticate to supareticulate and consistently scattered across the exine with small lumina and possible perforations in the floor of these. The mesocolpia is slightly convex with a wide colpi sunken and sinuous and terminating obtusely before the poles.

A native of woods, damp meadows and hedges. Height: 35cm.

Primulaceae family summary.

Primula vulgaris pollen grains (pin eyed and thrum eyed) are rhombic-orbicular, polyzonocolpate grains with flattened poles. The sculpture is eureticulate to suprareticulate and consistently scattered across the exine with small lumina and possible perforations in the floor of these. The mesocolpia is slightly convex with a wide colpi sunken and sinuous and terminating obtusely before the poles. A number of the *Primula vulgaris* pollen grains (pin eyed) grains show extensive collapse. According to Moore *et al* (1991, pp. 131) the pin eyed type pollen grains should be > 20µm in size while the thrum eyed types should be < 20µm in size, this should also hold true for other *Primula* species including *P. veris* and *P. elatior*. Moore's analysis of the *P. vulgaris* pollen types concurs with the findings of the research here. The sizing however is not absolute but covers a majority of the pollen grains through three collections of each type were made (*P. vulgaris*). Only one collection of *P. veris* was made and it is not known if this was a pin or thrum eyed type.

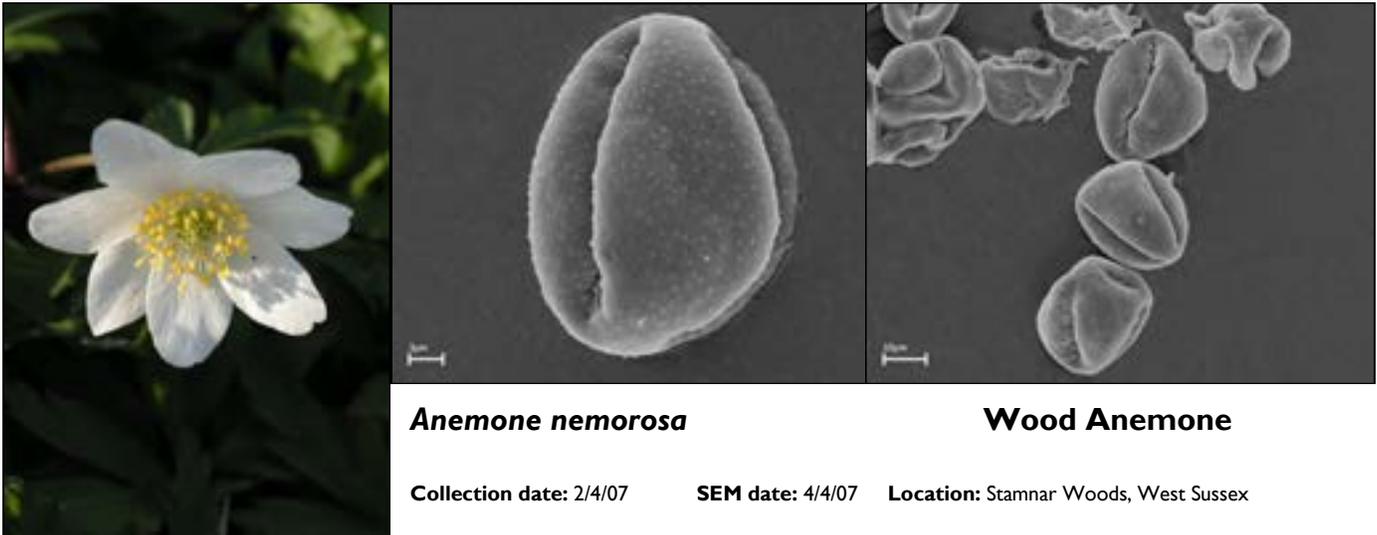
The pollen grain collapse of *P. vulgaris* (pin eyed) is a unique anomaly and warrants further investigation to determine if this was a 'one time event' or a regular occurrence. If it is a normal feature of the pin eyed types of *P. vulgaris* then the populations should reflect this.

P. veris pollen grains are rhombic-orbicular polyzonocolpate grains with flattened poles but slightly wider at the equator in equatorial view. The sculpture is eureticulate to suprareticulate and consistently scattered across the exine with small lumina and possible perforations in the floor of these. They are identical to *P. vulgaris* pollen with Moore *et al* (1991, pp. 131) making no distinction in pollen morphology between the two species other than the flower style/pollen grain size.

Lysimachia nummularia and *Anagallis arvensis* pollen grains are < 36µm, rhombic obtuse trizonocolpate, eureticulate with the colpi almost running the full length of the grain and terminating before the poles. *L. nummularia* shows extensive pollen grain collapse in the sample presented. *A. arvensis* has smaller lumina than *L. nummularia* and is elliptic-obtuse in shape while *L. nummularia* is rhombic-obtuse. *A. arvensis* pollen grains are < 36µm in size, elliptic, trizonocolpate, eureticulate with the colpi almost running the full length of the grain and terminating in the pole.

Primulaceae family summary continued

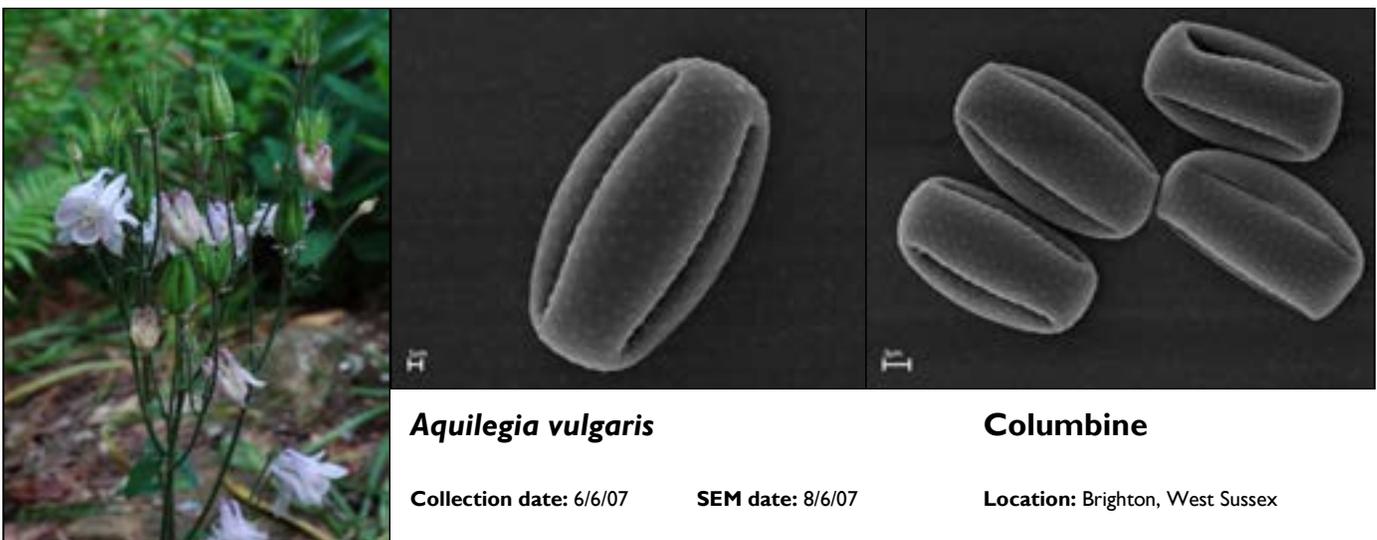
Cyclamen coum pollen grains are elliptic-obtuse, trizonocolpate, psilate with the colpi almost running the full length of the grain and terminating in the pole. The colpi is narrow, slit like, sunken at the equator but also wider at this point. The colpi membrane is granulate, although finely so. Grain shape is quite distinct, circular to circular-oblong in equatorial view and circular in polar view.

Family: *Ranunculaceae****Anemone nemorosa*****Wood Anemone**

Collection date: 2/4/07 SEM date: 4/4/07 Location: Stannar Woods, West Sussex

Anemone nemorosa is a trizonocolpate grain, circular in both polar and equatorial views with the exine traversed by infratectal bacula. The colpi are long and wide, terminating at the poles, with what appears to be a coarsely granulate membrane. Overall grain shape is broadly elliptic to rhombic-obtuse with a distinct widening at the equator. Grains show extensive variation in size and degree of collapse.

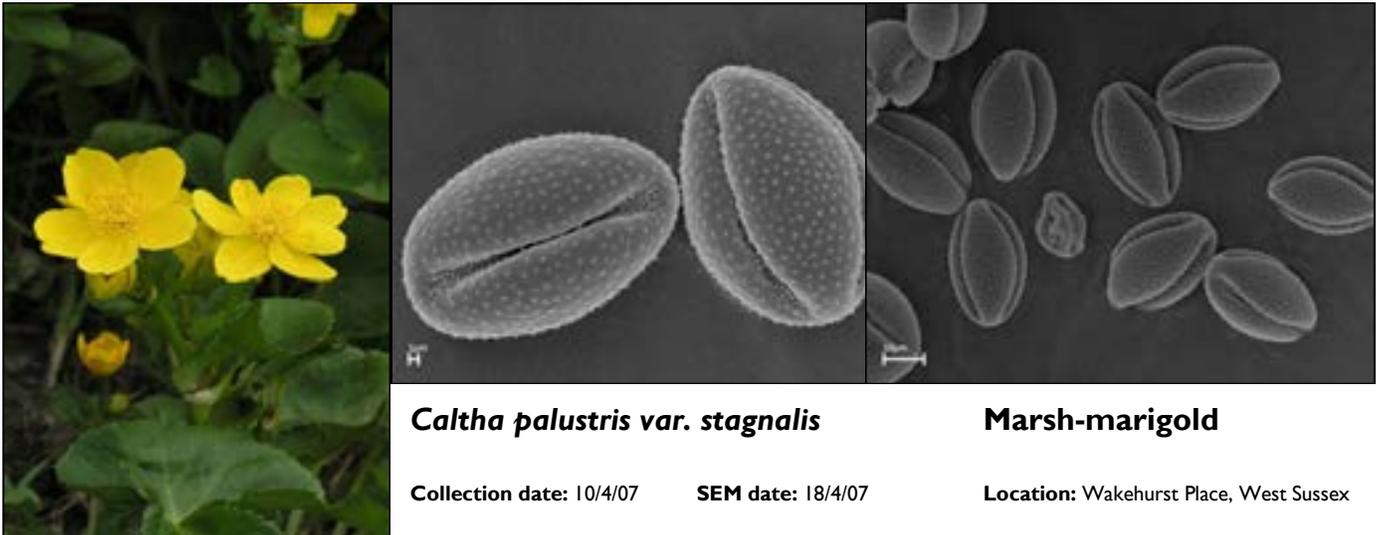
A native plant found in woods and open areas where it typically forms large colonies. Height: 25cm.

***Aquilegia vulgaris*****Columbine**

Collection date: 6/6/07 SEM date: 8/6/07 Location: Brighton, West Sussex

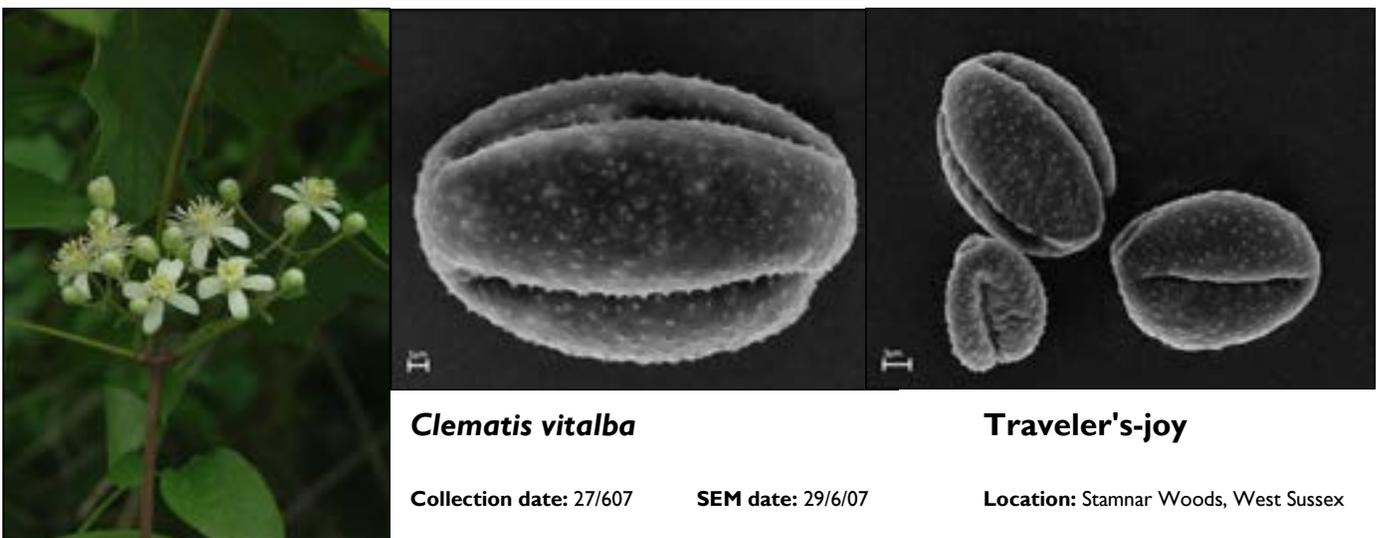
Aquilegia vulgaris is a trizonocolpate grain with the exine traversed by micro-echinae equally spaced across the tectum. The colpi are long and wide, terminating before poles, with what appears to be a granulate membrane. Overall grain shape is broadly elliptic to elliptic-obtuse with a slight widening at the equator and with the poles being almost flat in equatorial view. Grain size, shape and sculpturing is consistent.

A. vulgaris is a native plant common to moist woods, fens and similar damp locations. A popular garden plant it hybridizes frequently and many garden cultivars are in existence. Height: 75cm.

Family: *Ranunculaceae*

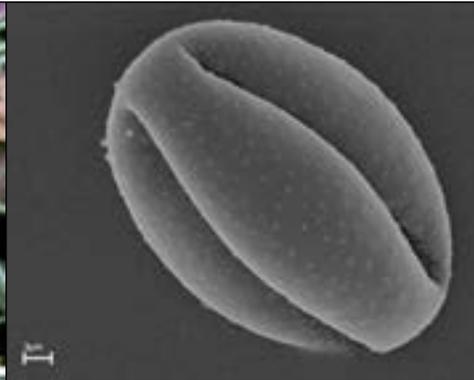
Caltha palustris is a trizonocolpate grain with the exine traversed by regularly spaced microechinae on top of the tectum. The colpi are long, terminating at the poles, wide, with what appears to be a coarsely granulate membrane. Overall grain shape is elliptic in equatorial view. The colpi are wide, narrowing towards the equator but not so that an equatorial girdle is present. The colpi are obtuse ended, touching the poles and contain a granulate membrane.

A common, clump forming native occurring in most ditches and beside streams and ponds. Height: 70cm.



Clematis vitalba is a trizonocolpate grain with the exine traversed by infratectal bacula, while the tectum appears mottled and scabrate. The grains are of varying sizes and show some deterioration, immaturity or possible collapse. The colpi are long and wide, terminating at the poles, wide, with what appears to be a coarsely granulate membrane. Overall grain shape is broadly elliptic to rhombic-obtuse with a distinct widening at the equator.

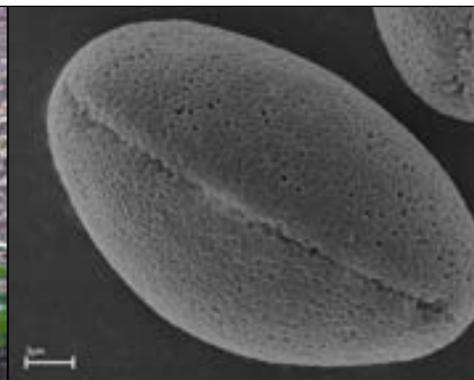
A native vine common in hedgerows, woodland margins and wasteland.

Family: *Ranunculaceae****Eranthis hyemalis*****Winter Aconite**

Collection date: 25/2/07 SEM date: 26/2/07 Location: Preston Park, Brighton, West Sussex

Eranthis hyemalis is a trizonocolpate grain with the exine traversed by micro-echinae. The colpi are long and wide, terminating at the poles with what appears to be a coarsely granulate membrane. Overall grain shape is broadly elliptic to rhombic-obtuse with a very distinct widening at the equator.

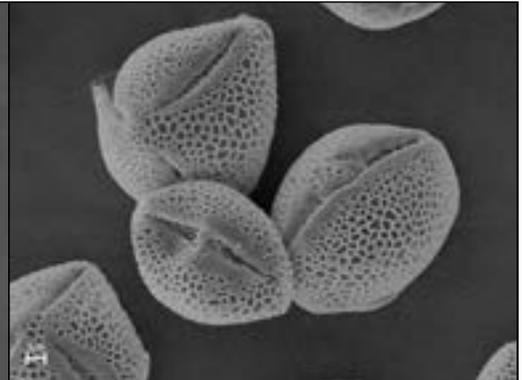
An introduced geophyte that has naturalized in wooded and waste areas. To about 10cm in height.

***Helleborus foetidus*****Stinking Hellebore**

Collection date: 25/2/07 SEM date: 26/2/07 Location: Preston Park, Brighton, West Sussex

Helleborus foetidus pollen grains are trizonocolpate, eurenticulate (the muri of the reticulum are the walls which join the heads of the columellae). Distribution of the columellae commonly dependent of the pattern of the reticulum. Grains usually <math><29\mu\text{m}</math> in size. The reticulum is small bordering on microscopic. Colpi are always obtuse ended, with a jagged edge and with a granulate membrane with the colpus curving around the end of the grains. Lumina are rather variable in size, small and occasionally perforate. Grains are somewhat elliptical in equatorial and polar view.

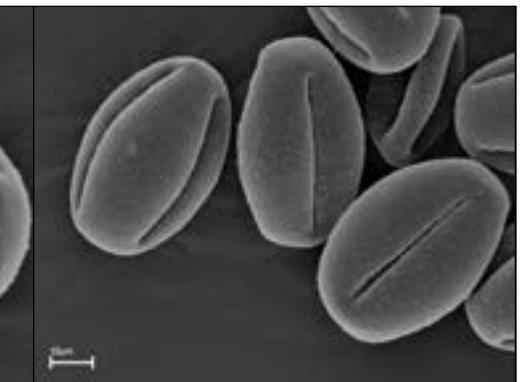
A native plant to woods and scrub on calcareous soils. Height: 75cm.

Family: *Ranunculaceae****Helleborus orientalis*****Lenten-rose**

Collection date: 25/2/07 SEM date: 26/2/07 Location: Preston Park, Brighton, West Sussex

Helleborus orientalis pollen grains are trizonocolpate, eurericulate (the muri of the reticulum are the walls which join the three heads of the columellae). Distribution of the columellae commonly is dependent of the pattern of the reticulum. Grains usually <math><29\mu\text{m}</math> in size. The reticulum is large and somewhat variable. Colpi are always obtuse ended, very wide (often wider in the middle) with coarsley granulate membranes and the colpus curving around the end of the grains. Lumina are rather variable in size, large but decreasing in size towards the colpus margins and poles. Grains are somewhat elliptical in equatorial and polar view, with colpi at times being boat shaped (widest in the middle).

An introduced plant common to gardens and occasionally seen as a garden escapee. Height: 50cm.

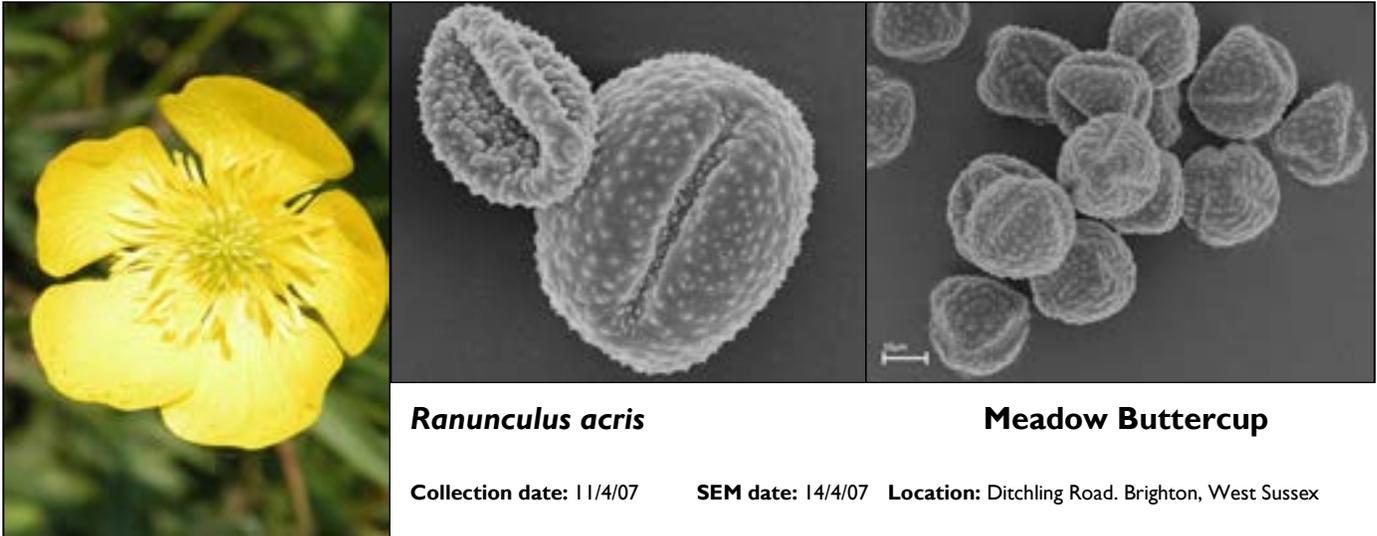
***Nigella damascena*****Love-in-a-mist**

Collection date: 3/5/07 SEM date: 16/5/07 Location: Tongdean Road, Brighton, West Sussex

Nigella damascena is a trizonocolpate grain with the exine traversed by micro-echinae with a psilate tectum between. The colpi are long, terminating at the poles, wide, with what appears to be a coarsely granulate membrane and a slight widening at the poles. Overall grain shape is broadly elliptical to rhombic-obtuse.

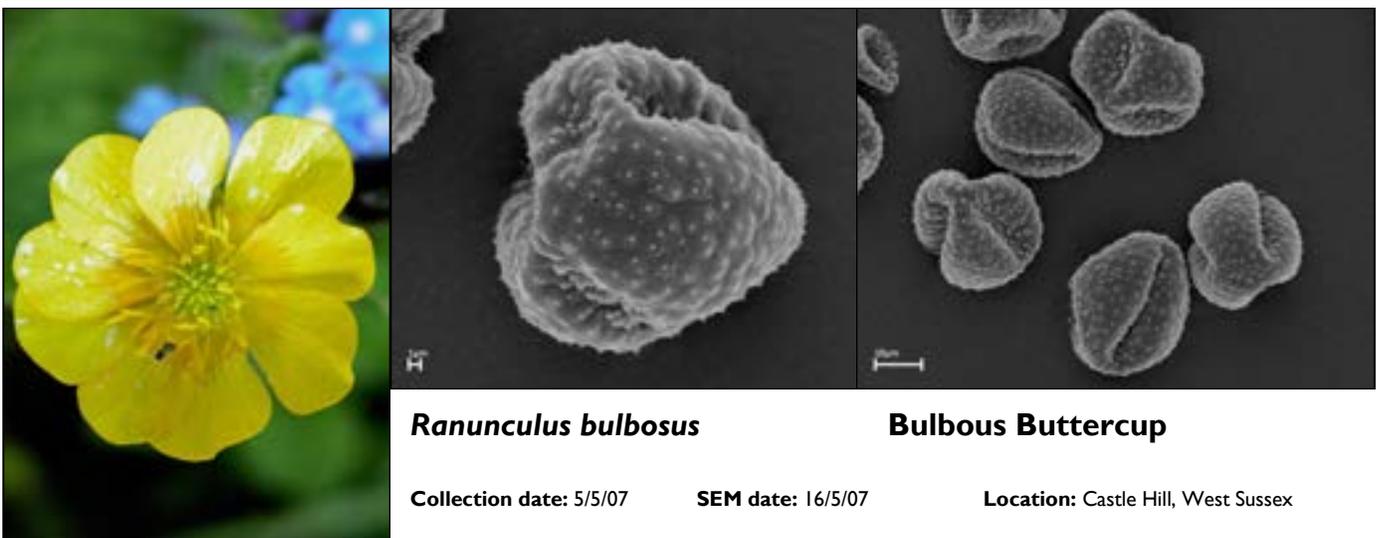
Nigella damascena is a commonly grown garden annual plant with variable flower colour (white and blue) and can be identified when out of bloom by its characteristic seed capsules. Height: 40cm.

Family: Ranunculaceae



Ranunculus acris is a trizonocolpate grain with the exine traversed by regularly spaced microechinae on top of the tectum, the tectum appears more or less slightly undulating, rising up over the coarse columellae and diving down between them. The colpi are long, broad, terminating obtusely at the poles, with what appears to be a coarsely granulate membrane. Overall grain shape is orbicular-elliptic to orbicular in equatorial view while in polar view the shape is orbicular dissected by the deep colpi.

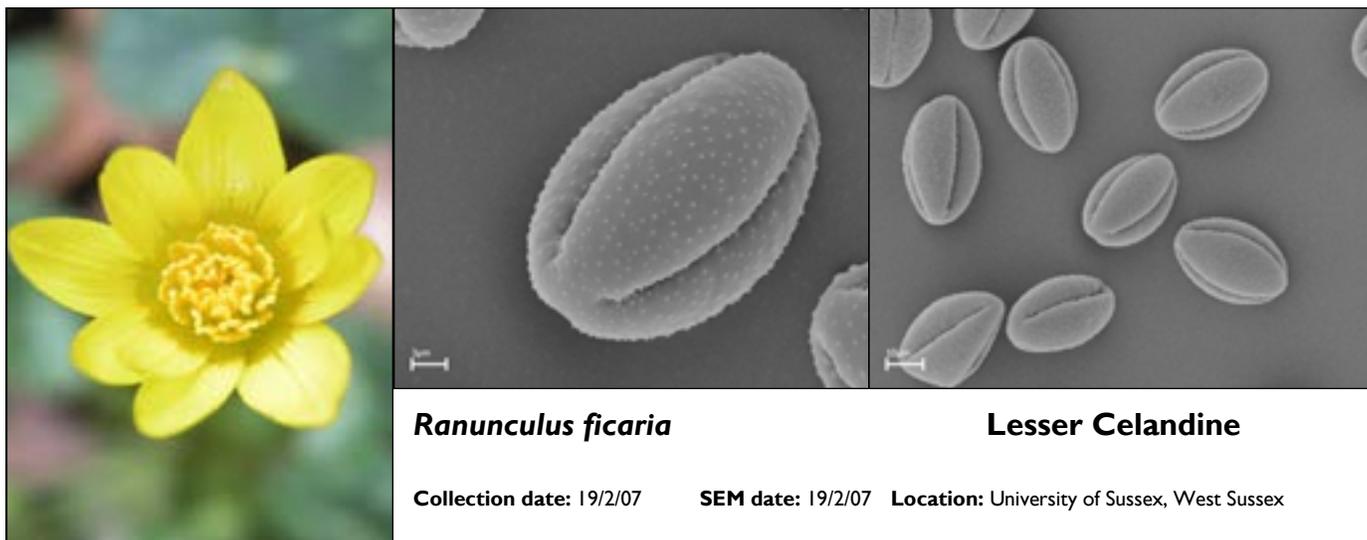
R. acris is a common native plant found in meadows, fields, pastures and waysides. Height: 75cm.



Ranunculus bulbosus a trizonocolpate grain with the exine traversed by regularly spaced microechinae on top of the tectum, the tectum appears more or less undulating, rising up over the coarse columellae and diving down between them. The colpi are long, terminating at but wider in the poles, with what appears to be a coarsely granulate membrane. Overall grain shape is elliptic to orbicular in equatorial view with many grains showing signs of collapse.

A low growing native perennial plant found on low, dry grassland. Height: 30cm.

Family: Ranunculaceae



Ranunculus ficaria is a trizonocolpate grain with the exine traversed by regularly spaced microechinae on top of the tectum. The colpi are long, terminating at the poles, wide, with what appears to be a coarsely granulate membrane. Overall grain shape is elliptic in equatorial view.

A common, native plant often found in lawns and short grassy areas, especially in moist locales. Height: 20cm.

***Ranunculaceae* family summary.**

Both *Helleborus foetidus* and *Helleborus oreintalis* pollen grains are trizonocolpate, eurenticulate. The colpi of *H. foetidus* are always obtuse ended with a jagged edge and with a granulate membrane while the colpi of *H. oreintalis* is obtuse ended as well but is very wide (often wider in the middle) with a coarsely granulate membrane. The lumina of *H. foetidus* are rather variable in size but small and occasionally perforate while the lumina of *H. oreintalis* are variable in size but are large, decreasing in size towards the colpus margins and poles; they are not perforate.

Nigella damascena is a trizonocolpate grain with the exine traversed by micro-echinae with a psilate tectum between. The colpi are long, terminating at the poles, wide, with what appears to be a coarsely granulate membrane and a slight widening at the poles. Overall grain shape is broadly elliptic to rhombic-obtuse.

***Ranunculaceae* family summary continued.**

Anemone nemerosa is a trizonocolpate grain, circular in both polar and equatorial views with the exine traversed by infratectal bacula. The colpi are long and wide, terminating at the poles, with what appears to be a coarsely granulate membrane. Overall grain shape is broadly elliptic to rhombic-obtuse with a distinct widening at the equator. Grains show extensive variation in size and degree of collapse. The pollen grain morphology is similar to that of *Aquilegia vulgaris*, *Clematis vitalba*, *Eranthis hyemalis* and *Ranunculus ficaria* but a major difference being the grain width of *A. nemerosa* which is broader at the equator. *C. vitalba* tectum is mottled and scabrate with micro-echinae sparsely scattered over the surface.

Ranunculus acris and *R. bulbosus* are trizonocolpate grains with the exine traversed by regularly spaced microechinae on top of the tectum, the tectum appears more or less slightly undulating, rising up over the coarse columellae and diving down between them. The colpi are long, broad, terminating obtusely at the poles, with what appears to be a coarsely granulate membrane.

This is a complex family with many genera and subgenera and over 100 species, varieties, subspecies and hybrids (Stace, 1997, pp. 77-96). Thus the classification of pollen types becomes complicated. Many similarities exist between the pollen grains examined here, in some cases the differences are so subtle that according to Moore *et al* (1991, pp. 133) classification is doubtful beyond the genus level and where in his book, *Pollen Analysis*, grains are grouped under the classification of "Ranunculus types".

Family: *Resedaceae****Reseda lutea*****Wild Mignonette**

Collection date: 30/4/07

SEM date: 2/5/07

Location: Castle Hill, West Sussex

Reseda lutea pollen grains are trizonocolpate, eureticolate (the muri of the reticulum are the walls which join the heads of the columellae). Distribution of the columellae is commonly dependent of the pattern of the reticulum. The colpi are wide with granulate membranes, long, curving around the poles of the grains. Pollen grains are elliptic to rhombic-obtuse in equatorial view. The colpi are boat shaped, widest at the equator and narrowing to acute ends at the poles.

Usually found on disturbed land and in fields especially on calcareous soils. Height: 1m.

***Reseda luteola*****Weld**

Collection date: 21/6/07

SEM date: 29/6/07

Location: Sussex University, West Sussex

Reseda luteola pollen grains are trizonocolpate, eureticolate (the muri of the reticulum are the walls which join the heads of the columellae). Distribution of the columellae commonly dependent of the pattern of the reticulum. The colpi are wide with granulate membranes, long, curving around the poles of the grains. Pollen grains are elliptic to rhombic-obtuse in equatorial view. The colpi are slightly boat shaped, widest at the equator and narrowing to acute ends at the poles but less so than *R. lutea* pictured above.

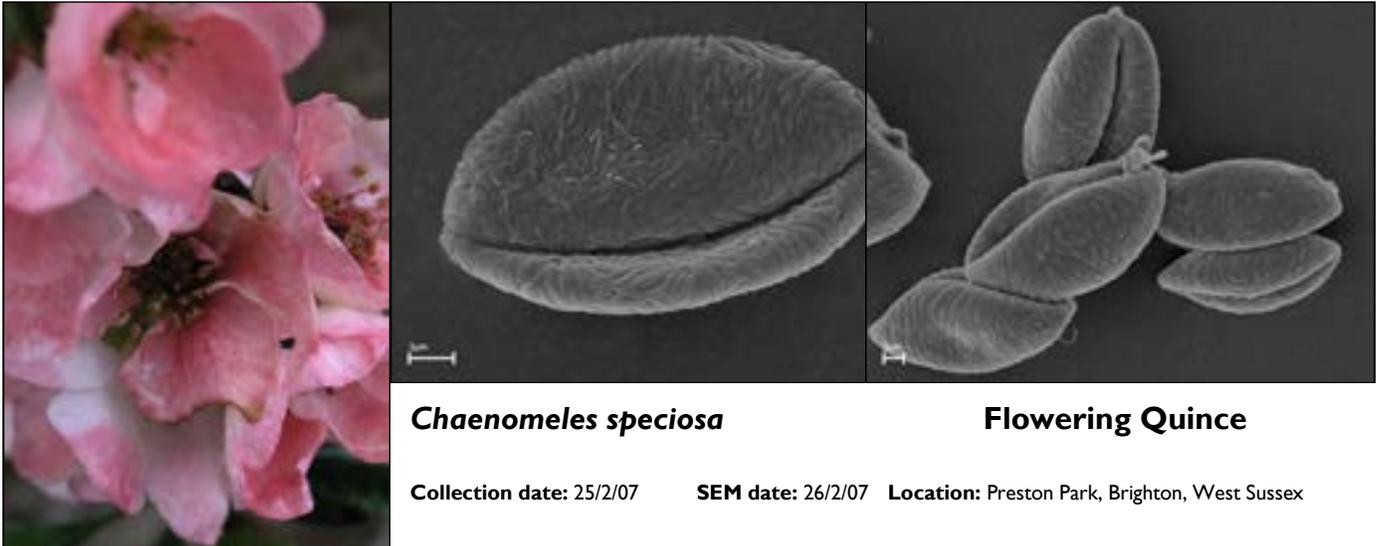
A native plant common to open grassland, disturbed ground and waste places. Height: 1.5m.

Resedaceae family summary.

Reseda luteola and *R. lutea* pollen grains are trizonocolpate, eureticulate (the muri of the reticulum are the walls which join the heads of the columellae). Distribution of the columellae is typically dependent of the pattern of the reticulum. The colpi are wide with granulate membranes, long, curving around the poles of the grains. Pollen grains are elliptic to rhombic-obtuse in equatorial view. A slight difference between the two are the colpi, they are slightly boat shaped, widest at the equator and narrowing to acute ends at the poles but less so in *R. lutea*.

Moore *et al*, (1991, pp. 120) keys *Resedaceae* family members to *Reseda lutea* types only and includes *R. lutea*, *R. luteola*, and *R. phyteuma* but suggests that some distinction may be possible based on lumina size; this did not appear to be so in the two examples presented here, however further analysis is warranted. Moore *et al* (199, pp. 120) makes no mention of the colpi widening discovered here, this might suggest it is an anomaly based on the limited sample set but comparison and analysis of a type collection is recommended.

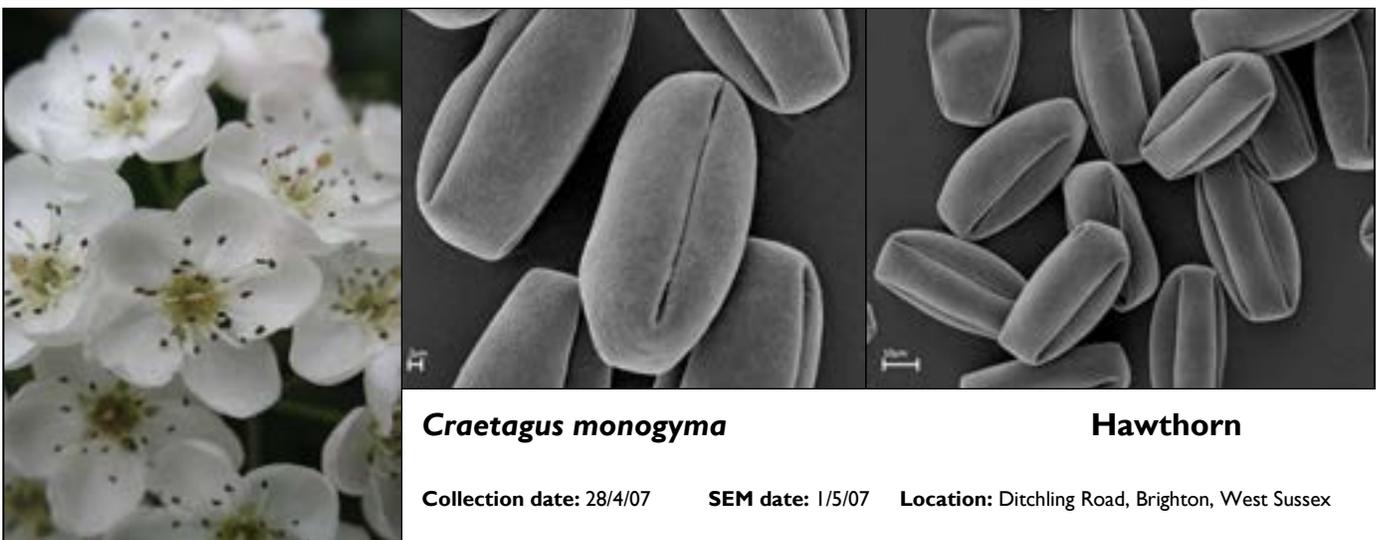
Family: Rosaceae

***Chaenomeles speciosa*****Flowering Quince**

Collection date: 25/2/07 SEM date: 26/2/07 Location: Preston Park, Brighton, West Sussex

Chaenomeles speciosa is a monocolpate pollen grain and is elliptic-ovoid in shape. Surface sculpture is rugulate, coarsely so with no apparent variation towards the poles of the colpus margins. The colpus is broad, closing towards the poles and terminating there, it has what appears to be a granulate membrane.

A popular shrub grown for its blooms, it may be found as a remnant or the occasional transplant. To about 2m in height by about a 2m spread.

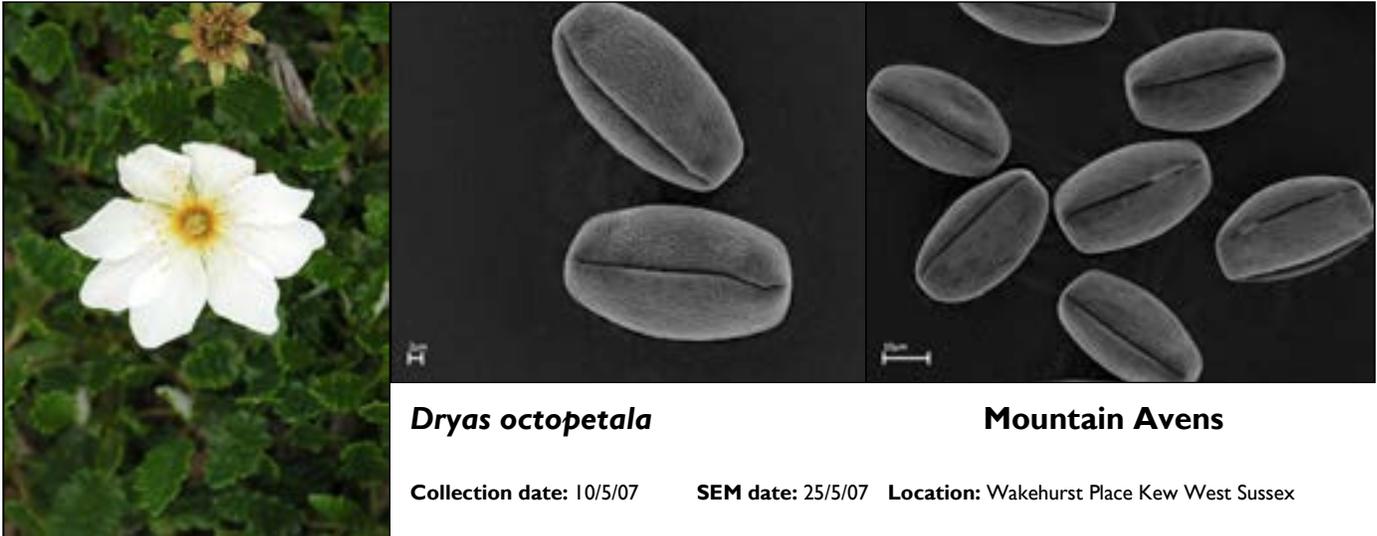
***Craetagus monogyma*****Hawthorn**

Collection date: 28/4/07 SEM date: 1/5/07 Location: Ditchling Road, Brighton, West Sussex

Craetagus monogyma pollen grains are, trizonolcolporate, >25 µm with some >40 µm in size, only slightly longer than broad. Sculpturing features coarse striae that maybe curved, but are short and wide, these may become a conglomeration of finer striae. Overall individual collections may be quite variable with tentative definition dependent on a type slide collection (see family summary). Surface patterning is similar to *Dryas octapetala*.

A variable formed small tree, it is very common throughout Britain and is often seen in hedge rows and along scrub and wasteland. Height: 10m and often as broad.

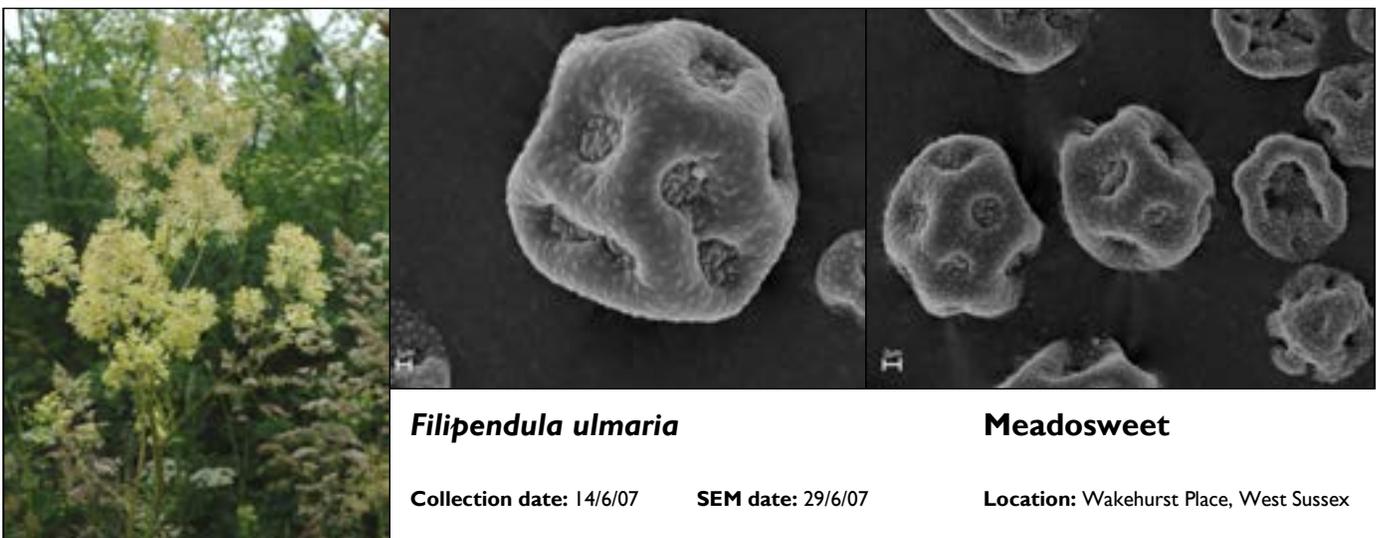
Family: Rosaceae

***Dryas octopetala*****Mountain Avens**

Collection date: 10/5/07 SEM date: 25/5/07 Location: Wakehurst Place Kew West Sussex

Dryas octopetala grains are non-operculate, trizonolcolporate, rhombic-obtuse in shape with a possible slight constriction at the colpus and absent a bridge or rupture. Pollen grains have distinct curved and branched striae similar to *Craetagus monogyma* with muri varying in width, considerably so, but thickest at the junctions. Colpus is deep, inward rolled and terminates at the poles. There may be variability between the grain size although the image above demonstrates consistent grain size.

A native plant found growing in rock crevices along and around mountains, height: 15cm.

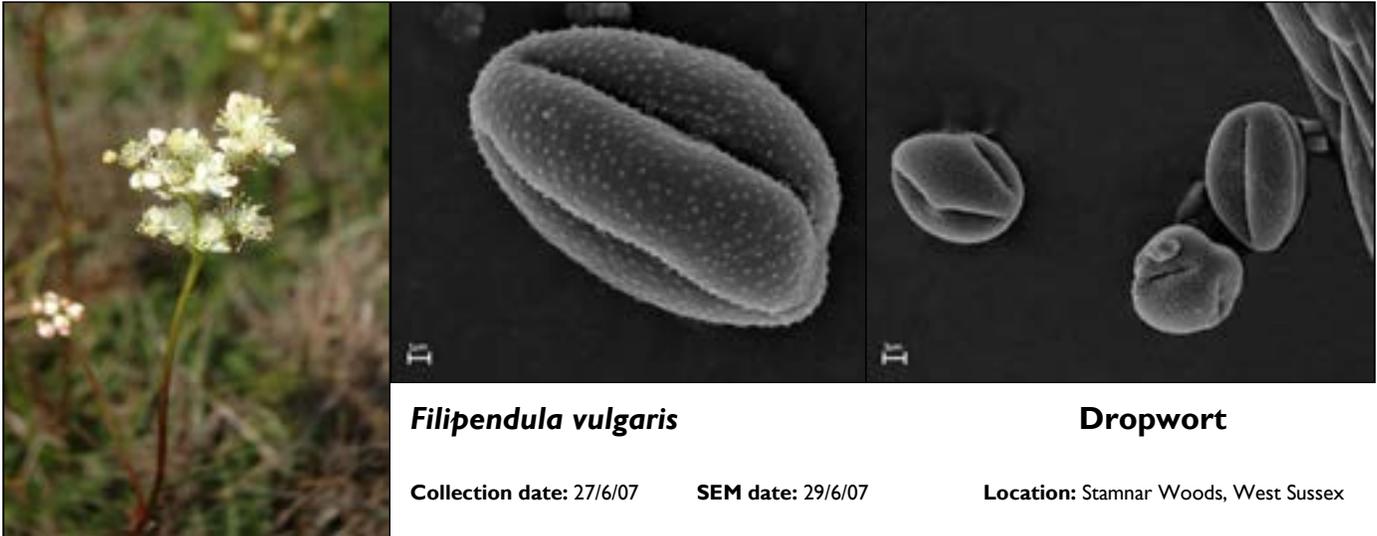
***Filipendula ulmaria*****Meadosweet**

Collection date: 14/6/07 SEM date: 29/6/07 Location: Wakehurst Place, West Sussex

Filipendula ulmaria is a polyantoporate pollen grain. Exine is echinate forming two or more rows between the pori. Pori are sunken with granulate membranes. Grain shape is orbicular, although the sample shows extensive collapse.

A native plant particular to moist grounds and damp places, common throughout Britain. Height: 1m.

Family: Rosaceae

***Filipendula vulgaris*****Dropwort**

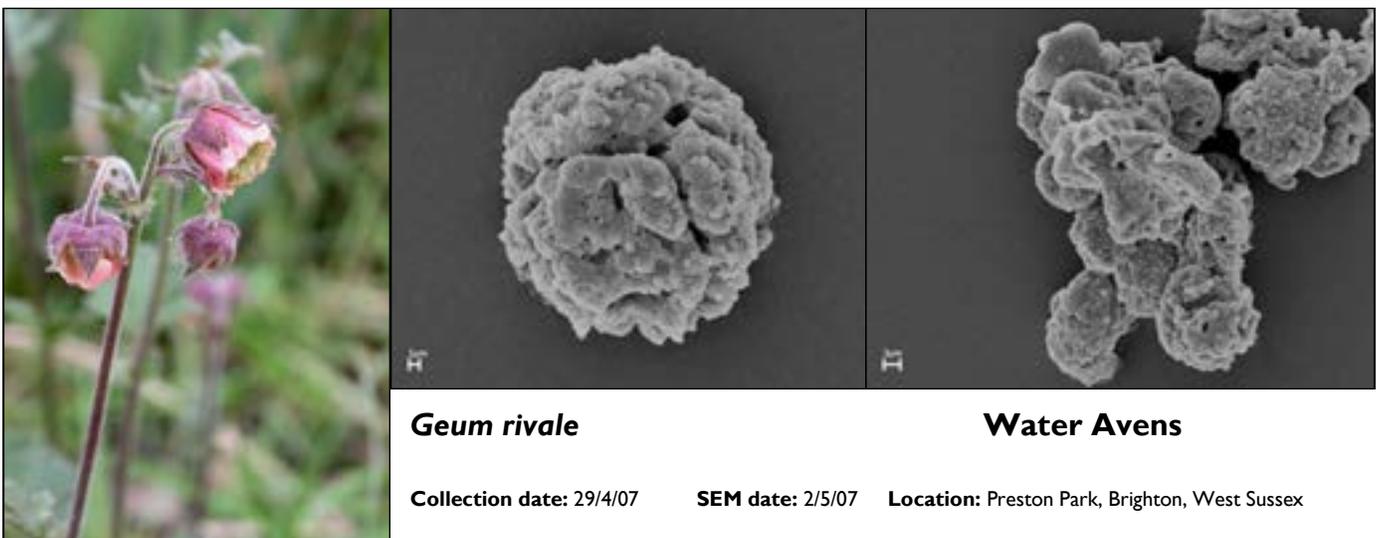
Collection date: 27/6/07

SEM date: 29/6/07

Location: Stamnar Woods, West Sussex

Filipendula vulgaris is a trizonocolporate pollen grain that is commonly elliptical to obovate in equatorial view and orbicular in polar view. The colpi are wide and deep appearing quite distinct and appear to fuse to complete an equatorial girdle with the colpi terminating at the poles. Grain sculpture is finely echinate, consistent across the exine appearing psillate between.

A native plant common to calcareous grassland. Height: 40cm.

***Geum rivale*****Water Avens**

Collection date: 29/4/07

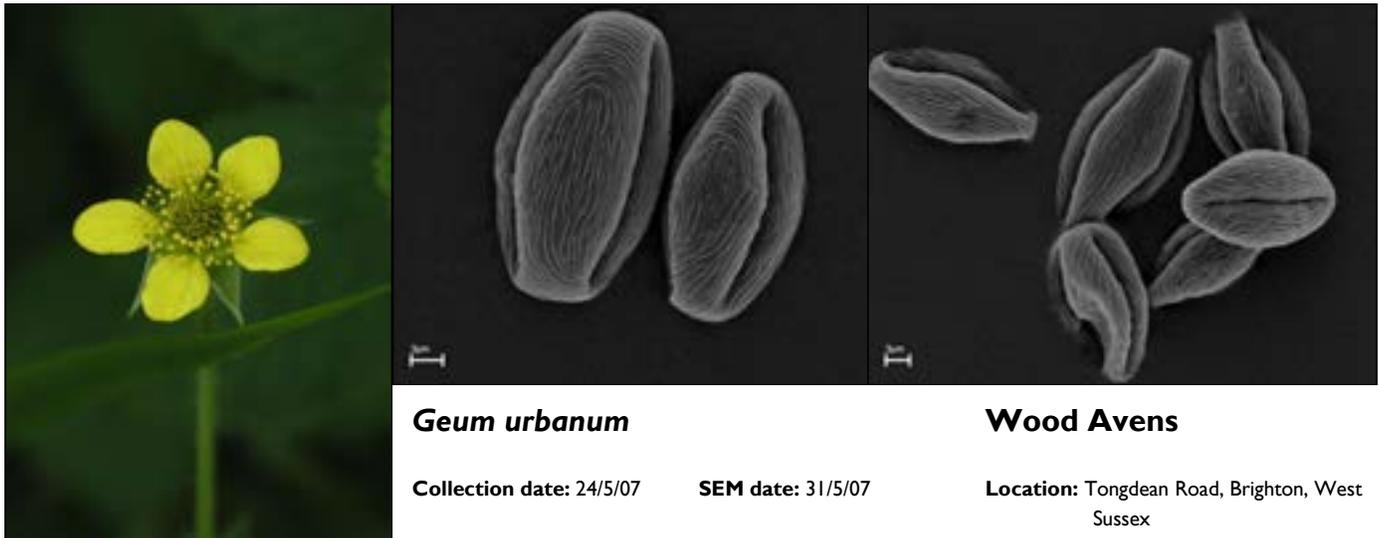
SEM date: 2/5/07

Location: Preston Park, Brighton, West Sussex

Geum rivale, is difficult to determine exact pollen grain morphological characteristics without 'washing' the grain to remove the tectum and reveal detail. It is however orbicular in shape and appears trizonoporate, perforate with granulate membranes.

G. rivale is a native plant commonly found in marshes and swamps. The flowers are quite large in relationship to the plant itself. Height: 50cm.

Family: Rosaceae

***Geum urbanum***

Collection date: 24/5/07

SEM date: 31/5/07

Wood Avens

Location: Tongdean Road, Brighton, West Sussex

Geum urbanum is a rectangular– obtuse, trizonolcolporate grain with the pori represented as constrictions to the colpi. *G. urbanum* pollen grains are trizonolcolporate, with rigid striae (rugulate) sculpturing that is short and numerous, running both meridionally and transversely or in curves and swirls and irregularly across the mesocolpia. There may or may not be perforations between the striae.

A native plant common to woods and hedgerows found throughout England. Height: 75cm.

***Malus x domestica***

Collection date: 21/4/07

SEM date: 25/4/07

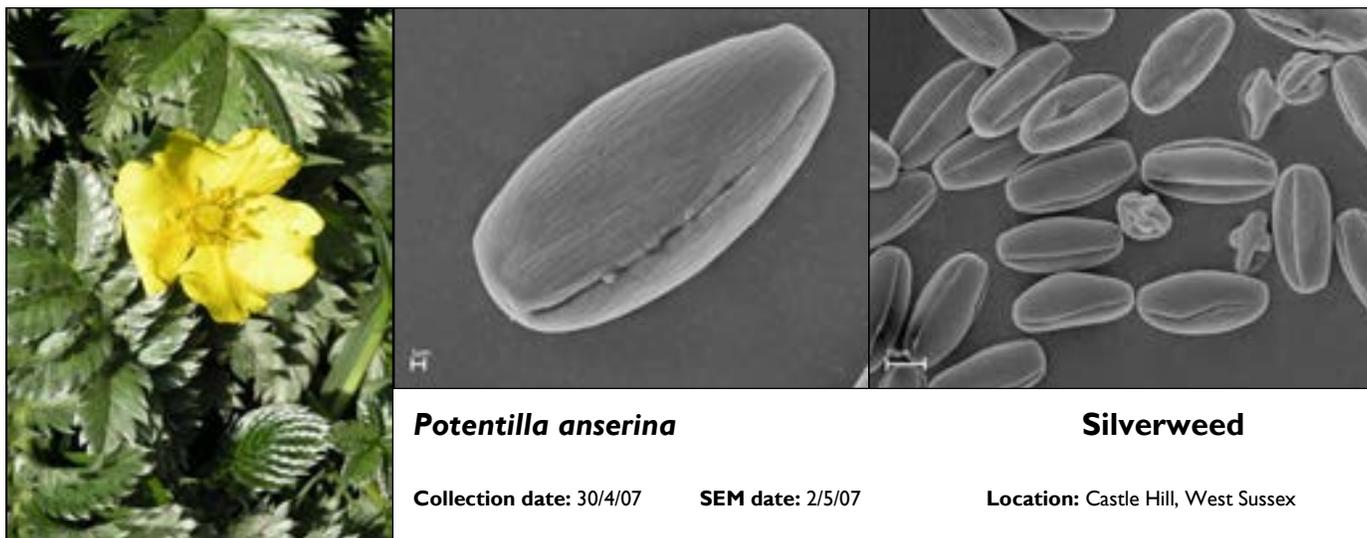
Wild Apple

Location: Ditchling Beacon, West Sussex

Malus x domestica is a non-operculate, trizonolcolporate pollen grain that is narrowly elliptic to rhombic-obtuse. Sculpturing can be finely rugulate to somewhat striate. Colpus is deep but terminating at the poles but widening slightly at this point also.

A small tree common to hedgerows and scrub land throughout Britain. Height: 10m.

Family: Rosaceae

**Potentilla anserina****Silverweed**

Collection date: 30/4/07

SEM date: 2/5/07

Location: Castle Hill, West Sussex

P. anserina pollen grain is trizonolcolporate, operculate, < 35 μm in size. Grain shape is rhombic-obtuse with flattened poles in equatorial view and with the margins of the colpi protruding at the equator. Sculpture consists of thin, long, straight striae (almost rugulate) running parallel towards the poles and consistent both on the apocolpia and mesocolpia. Operculum is long and prominent, running almost the length of the colpus and frequently protruding. The colpus terminates at the poles.

A common native plant typically found in dry areas such as open grassland, waysides and dunes. Height: 20cm.

**Potentilla reptans****Creeping Cinquefoil**

Collection date:

SEM date: 16/11/06

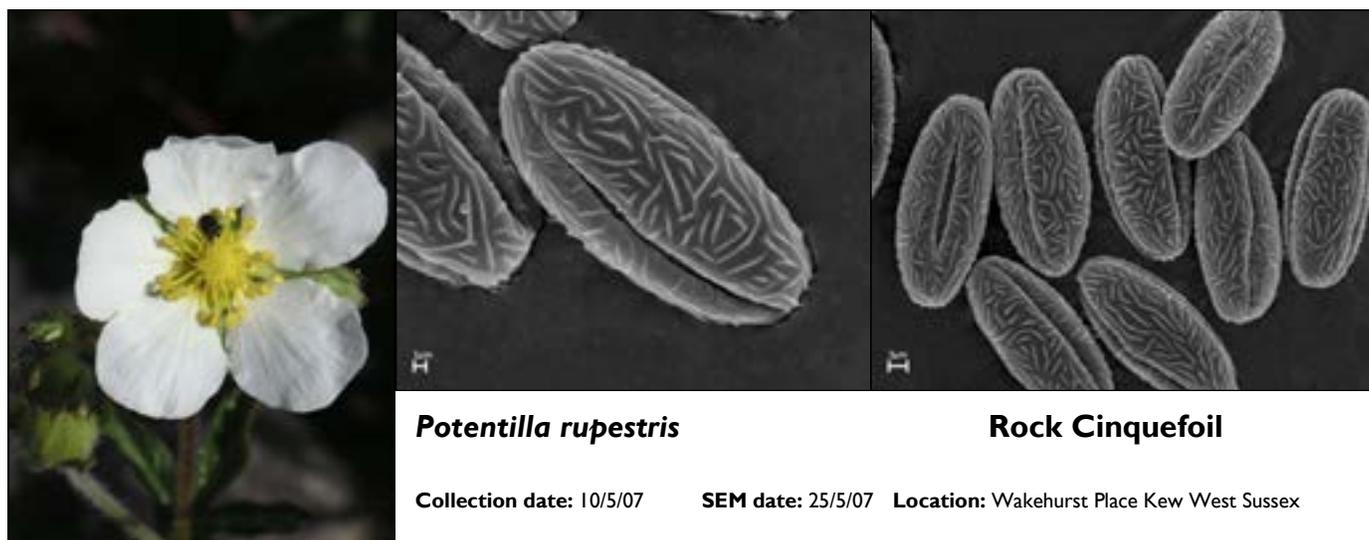
Location:

P. reptans pollen grain is operculate, trizonolcolporate, < 35 μm , rhombic-obtuse with distinctly rounded poles in equatorial view and with the margins of the colpi protruding at the equator. Sculpture consists of thin, long, straight striae (almost rugulate) running parallel towards the poles and consistent both on the apocolpia and mesocolpia. Operculum is long and prominent, running almost the length of the colpus and frequently protruding or near so.

A common native plant typically found in dry areas such as open grassland, waysides and dunes. Height: 10cm.

Flower Image courtesy: http://www.floracyberia.net/spermatophyta/angiospermae/dicotyledoneae/rosaceae/potentilla_reptans.jpg

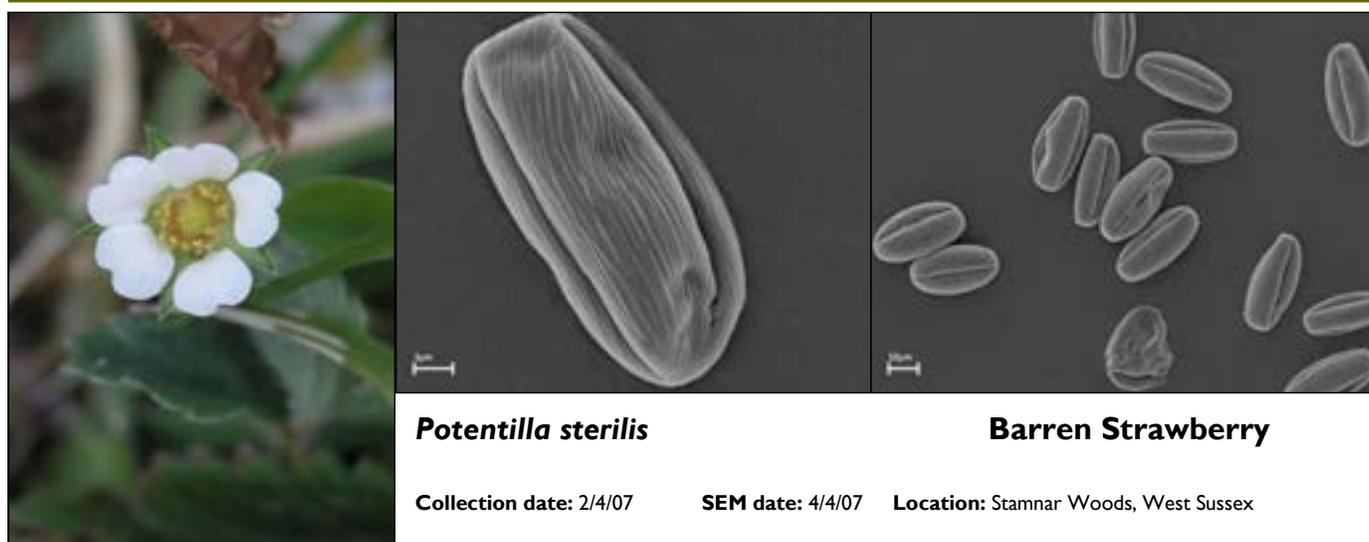
Family: Rosaceae

***Potentilla rupestris*****Rock Cinquefoil**

Collection date: 10/5/07 SEM date: 25/5/07 Location: Wakehurst Place Kew West Sussex

P. rupestris pollen grain is operculate, trizonolcolporate, < 35 µm in size, elliptic with distinctly rounded poles in equatorial view and with the margins of the colpi protruding at the equator. Sculpture consists of thin, long, straight striae (almost rugulate) running randomly both equatorially and meridionally, but broadly spaced but consistent both on the apocolpia and mesocolpia. Operculum is long and prominent, running almost the length of the colpus and frequently protruding or near so. The colpus is wide, appearing wider at the equator and terminating before the poles.

A native plant found growing in rock crevices along and around mountains, height: 75cm.

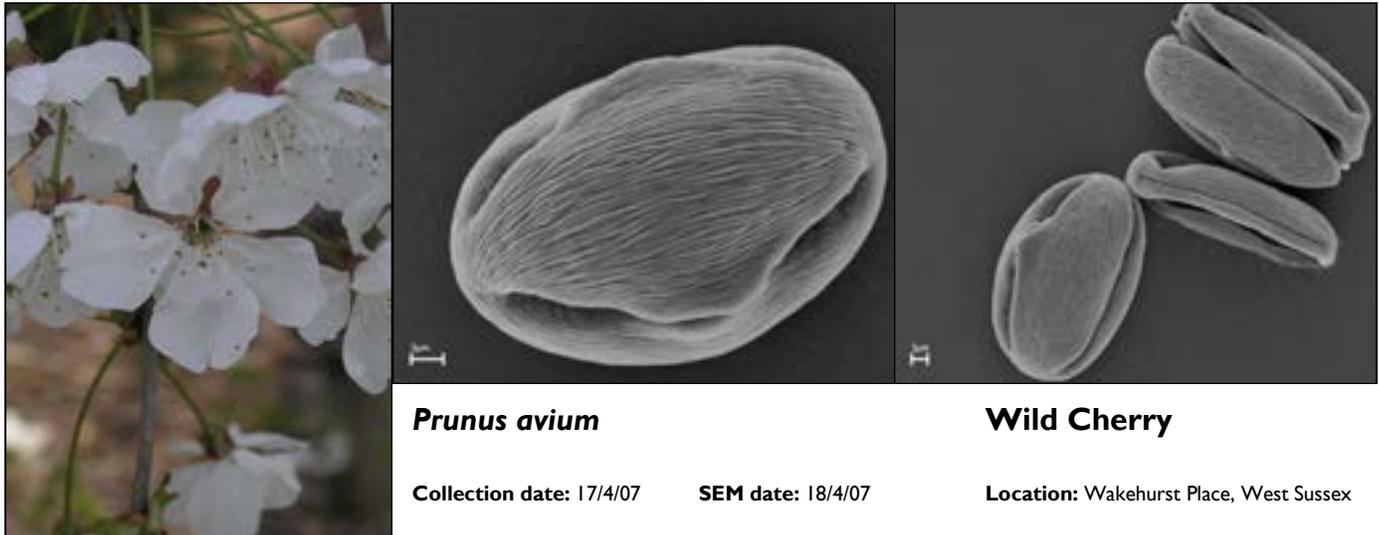
***Potentilla sterilis*****Barren Strawberry**

Collection date: 2/4/07 SEM date: 4/4/07 Location: Stamnar Woods, West Sussex

P. sterilis pollen grain is operculate, trizonolcolporate < 35 µm in size, rhombic-obtuse with flattened to obtuse poles in equatorial view and with the margins of the colpi protruding at the equator. Sculpture consists of thin, long, straight striae (almost rugulate) running parallel towards the poles and consistent both on the apocolpia and mesocolpia but broadly spread. Operculum is long a prominent, running almost the length of the colpus and frequently protruding, while the colpus rounds the poles and termination..

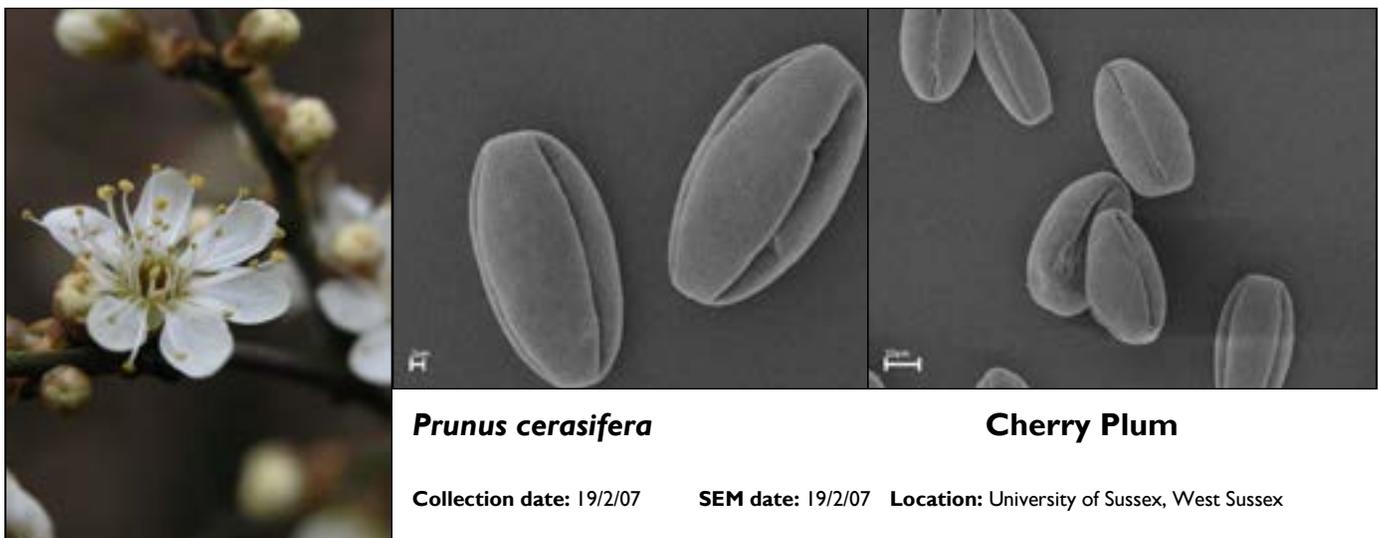
A native plant found along the edges of woods, clearings, hedge banks and other open undisturbed areas. Height: 10cm.

Family: Rosaceae



Pollen grains of *P. avium* are non-operculate, trizonolcolporate and consist of sculpturing that is very coarse, with wide striae which abruptly taper towards their ends. The striae run predominantly parallel in the mesocolpia showing a slight degree of branching but terminating towards the apex of the poles. The colpus is quite pronounced, deep, terminating at the top of the poles and bridged equatorially.

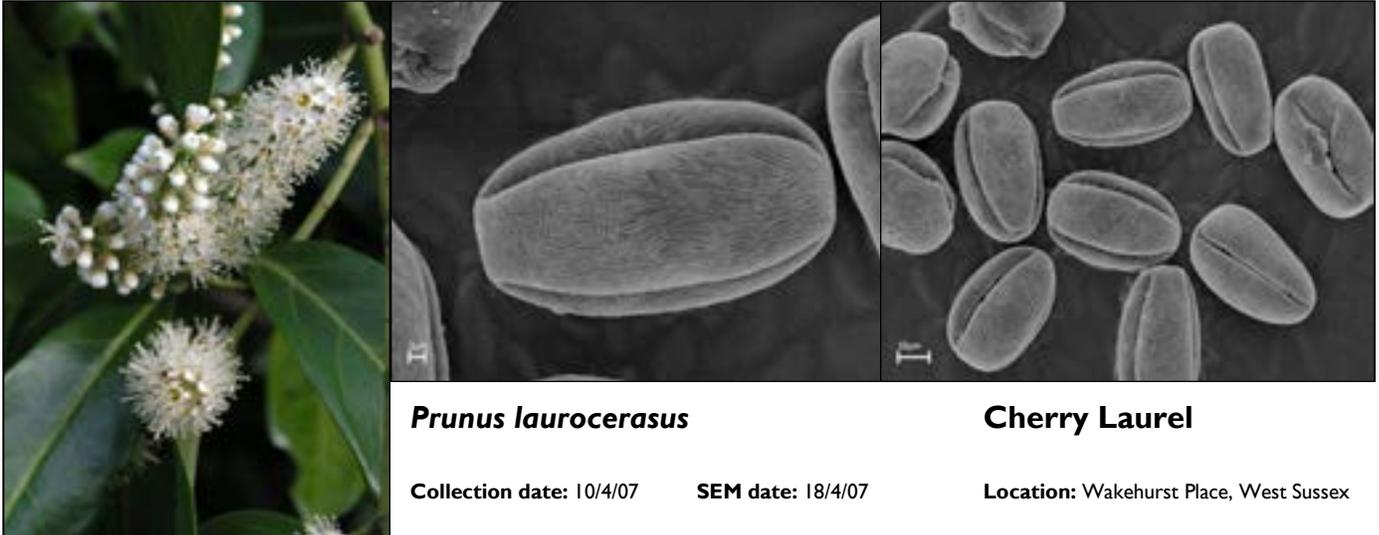
Found in hedgerows, woods and byways. A native it can reach a height of 30m.



Prunus cerasifera are non-operculate, trizonolcolporate pollen grains and consist of sculpturing that is very fine. The striae run predominantly parallel in the mesocolpia showing a slight degree of branching but terminating towards the apex of the poles and are possibly perorate. The colpus is quite pronounced, deep, terminating at the top of and widening at the poles.

An introduced plant commonly planted as a hedging material. Height: 15m.

Family: Rosaceae

***Prunus laurocerasus*****Cherry Laurel**

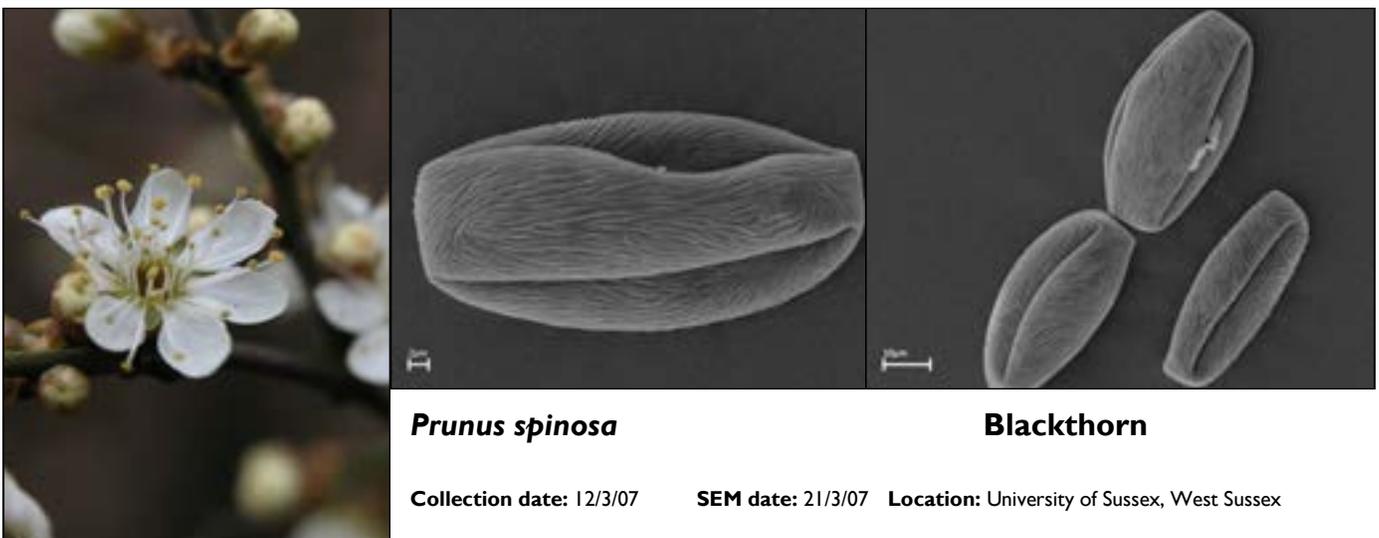
Collection date: 10/4/07

SEM date: 18/4/07

Location: Wakehurst Place, West Sussex

Pollen grains of *P. laurocerasus* are non-operculate with very coarse sculpture and wide striae which abruptly taper towards their ends. The striae do not run parallel in the mesocolpia showing a great degree of branching and variability in thickness and length, in some cases the striae create a swirl effect. The colpus is quite pronounced, very deep, terminating at the poles, with the presence in some cases of an equatorial bridge or rupture. The grain is flattened at the poles but is oblong-rhombic in equatorial view.

An introduced evergreen, commonly found naturalized in woods. Also used as hedging. It can reach a height of 15m and can be as broad spreading.

***Prunus spinosa*****Blackthorn**

Collection date: 12/3/07

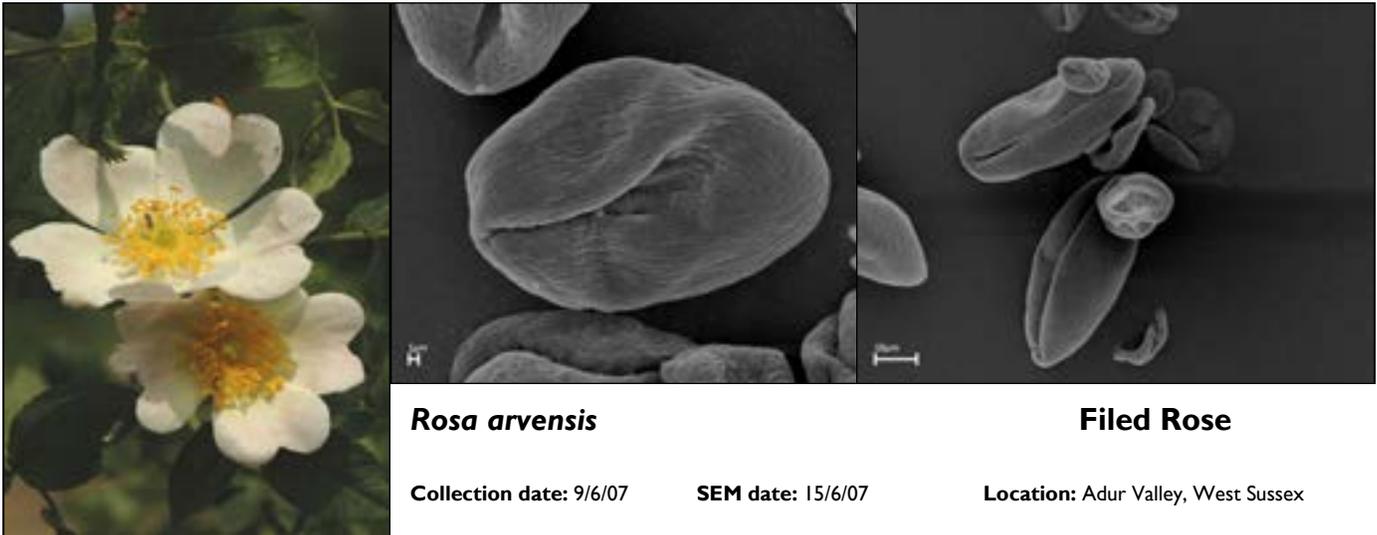
SEM date: 21/3/07

Location: University of Sussex, West Sussex

Pollen grains of *P. spinosa* are non-operculate with a sculpture of very coarse, wide striae which abruptly taper towards their ends. The striae do not run parallel in the mesocolpia showing a degree of branching and variability in thickness and length.. The colpus is quite pronounced, very deep, terminating at the poles . The grain is flattened at the poles but is oblong-rhombic in equatorial view.

A native plant to hedges, scrub and wasteland. Height: 10m.

Family: Rosaceae



Rosa arvensis pollen grains are operculate, elliptic to rhombic-obtuse in equatorial view, but egg shaped in polar view. The sculpture is consistent both in the apocolpia and mesocolpia with the striae either running equatorially, meridionally or in various directions (variable from grain to grain). The striae are short, fine, but variable in both distribution and length. The colpus margins are often found with small undulations towards the in-rolled edge. Pollen collapse has made acute determination of morphological characteristics difficult.

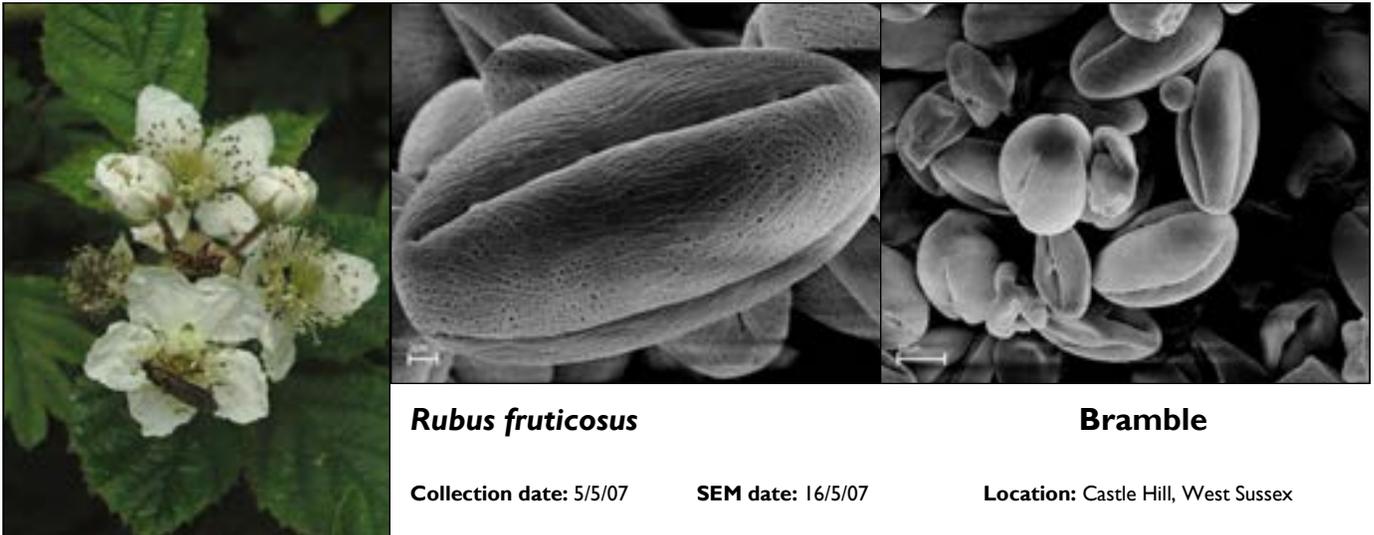
A native plant to hedgerows and scrub areas. Height: 3m.



Rosa canina pollen grains are operculate, elliptic to rhombic-obtuse in equatorial view, but egg shaped in polar view. The sculpture is consistent both in the apocolpia and mesocolpia with the striae either running equatorially, meridionally or in various direction (variable from grain to grain). The striae are short, fine but variable in both distribution and length. The colpus margins are often found with small undulations towards the in rolled edge.

A native plant to hedgerows and scrub areas. Height: 3.5m.

Family: Rosaceae

***Rubus fruticosus*****Bramble**

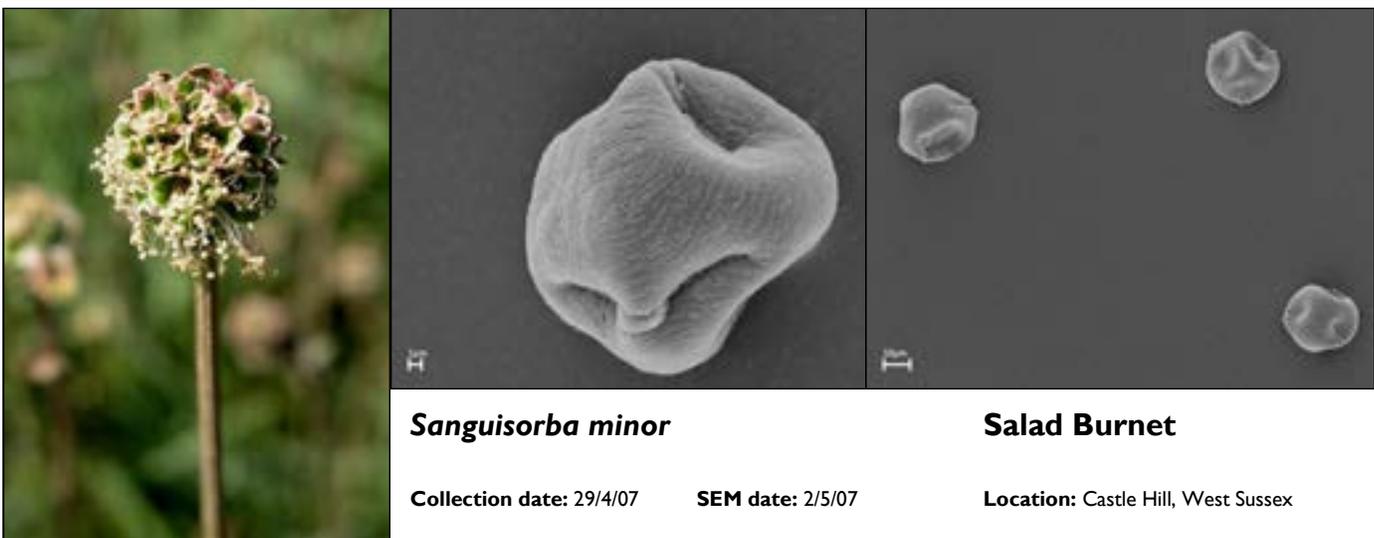
Collection date: 5/5/07

SEM date: 16/5/07

Location: Castle Hill, West Sussex

R. fruticosus is a no-operculate pollen grain that is oblong-rhombic in shape with obtuse, rounded poles. The colpi are long and quite in-rolled with an absence of granular membranes (similar to *Rosa* and *Sorbus* species) and terminate at the poles. Thin but distinct rugulate striae cover the surface running more or less parallel to the poles but frequently sinuous. Surface is consistently perforate.

A native vine common throughout the British Isles.

***Sanguisorba minor*****Salad Burnet**

Collection date: 29/4/07

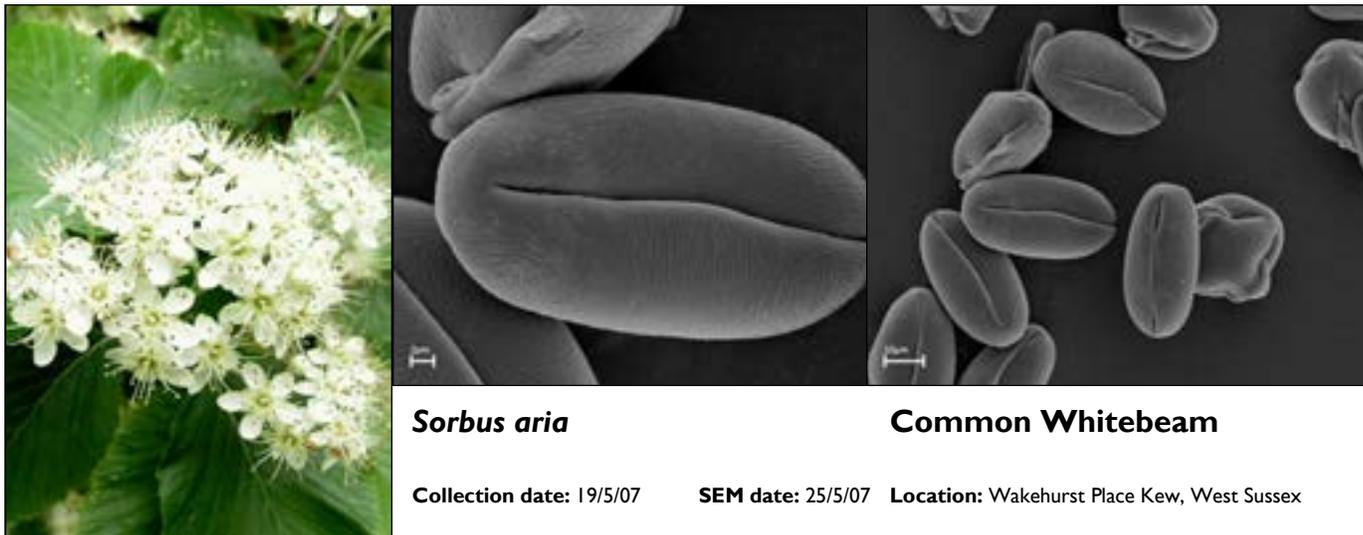
SEM date: 2/5/07

Location: Castle Hill, West Sussex

S. minor is a operculate pollen grain that is circular both in polar and equatorial views. The margins of the colpi may protrude from the grain at the equator (see center image above). The sculpture consists of very fine striae in the apocolpia with coarser, undulating rugulae possibly present at the equator of the mesocolpia.

A native plant of calcareous grasslands. Height: 75cm.

Family: Rosaceae



Sorbus aria

Common Whitebeam

Collection date: 19/5/07 SEM date: 25/5/07 Location: Wakehurst Place Kew, West Sussex

Sorbus aria pollen grains are $>25\ \mu\text{m}$ with some $>40\ \mu\text{m}$ in size although many *Sorbus* species are known to have a grain size at the upper end of the spectrum. Only slightly longer than broad. Sculpturing is very faintly rugulate-striate and uniform across the grain. Overall individual collections may be quite variable with tentative definition dependent on a type slide collection (see family summary).

An introduced tree, to about 10m in height and commonly found in hedgerows.

Rosaceae family summary.

Chaenomeles speciosa is a monocolpate pollen grain, elliptic-obovate in shape. Surface sculpture is rugulate, coarsely so with no apparent variation towards the poles of the colpus margins. The colpus is broad, closing towards the poles and terminating there, it has what appears to be a granulate membrane.

Craetagus monogyma and *Dryas octopetala* pollen grains are very similar. Only slightly longer than broad. Sculpturing features coarse striae that maybe curved, short and wide, there maybe a conglomeration of finer striae present as well. Overall individual collections may be quite variable with tentative definition dependent on a type slide collection. *C. mongyma* pollen grains though are variable in size, $>25\ \mu\text{m}$ with some as large as $>40\ \mu\text{m}$.

Filipendula ulmaria is a polyantoporate pollen grain and is in itself distinct amongst members of the Rosaceae family since it is

Rosaceae family summary continued.

the only polyaperturate grain represented here in what is a very large family. It is also very dissimilar from one of its apparent direct relatives *F. vulgaris* which has a trizonocolporate pollen grain, which has characteristics more typical of the *Rosaceae* family. Stace (1997, pp. 329) puts all *Filipendula* sp. In the *Rosoideae* subfamily which may explain some pollen morphological differences from other members of the *Rosaceae* family. This does not however, explain the distinct difference between the two related pollen species/grains in the same subfamily. Further inquiry is needed and should possibly include DNA analysis to determine if the two species are in actuality directly related. *Filipendula vulgaris* is a trizonocolporate pollen grain, sculpture is prominently finely echinate, consistent across the exine with the exine appearing psillate between. This is an unusual characteristic amongst the *Rosaceae* family members since most pollen grains are striate to rugulate.

Geum rivale, it is difficult to determine exact pollen grain morphological characteristics without 'washing' the grain to remove the tectum and reveal detail. Moore *et al* (1991, pp. 57) recommends an acetolysis wash similar to that used in the preparation of slides for LM analysis. *G. rivale* is however orbicular in shape and appears trizonoporate, perforate with granulate membranes. These characteristics are in contrast to *Geum urbanum* which is a rectangular– obtuse grain with the pori represented as constrictions to the colpi and is trizonocolporate. *G. urbanum* pollen grains are also rigidly striate (rugulate) with sculpturing that is short and numerous running both meridionally and transversely or in curves and swirls and irregularly across the mesocolpia. There may or may not be perforations between the striae.

Malus x domestica is a non-operculate, trizonocolporate pollen grain that is narrowly elliptic to rhombic-obtuse. Sculpturing can be finely rugulate to somewhat striate. Colpus is deep but terminating at the poles but widening slightly at this point also.

P. anserina and *P. reptans* pollen grains are operculate, < 35 µm, rhombic-obtuse with flattened poles in equatorial view and with the margins of the colpi protruding at the equator. Sculpture consists of thin, long, straight striae (almost rugulate) running parallel towards the poles and consistent both on the apocolpia and mesocolpia. These characteristics, specifically the sculpturing differ from the two other species of *Potentilla* presented. *P. rupestris* pollen sculpture consists of thin, long, straight striae (almost rugulate) running randomly both equatorially and meridionally, but broadly spaced making this the most distinct striae of the four species of *Potentilla* represented here. *P. sterilis* pollen sculpture consists of thin, long, straight striae that are

Rosaceae family summary continued.

the longest of the four species presented.

Pollen grains of *P. avium* are non-operculate and consist of sculpturing that is very coarse, with wide striae which abruptly taper towards their ends. The striae run predominantly parallel in the mesocolpia showing a slight degree of branching but terminating towards the apex of the poles. The colpus is quite pronounced, deep, terminating at the top of the poles and bridged equatorially, much so and distinct amongst the *Rosaceae* family as well as *Prunus* species represented here. *Prunus cerasifera* consist of sculpturing that is very fine, while the colpus is quite pronounced, deep, terminating at the top of and widening at the poles. *P. laurocerasus* sculpture is coarse with wide striae which abruptly taper towards their ends. The striae do not run parallel in the mesocolpia showing a great degree of branching and variability in thickness and length, in some cases the striae create a swirl effect. *P. spinosa* is similar in sculpture to *P. laurocerasus* although the striae swirl less and although do not run parallel they are straighter than those found on *P. laurocerasus* pollen grains.

Rosa arvensis and *Rosa canina* pollen grains are operculate, elliptic to rhombic-obtuse in equatorial view, but egg shaped in polar view. The sculpture is consistent both in the apocolpia and mesocolpia with the striae either running equatorially, meridionally or in various direction (variable from grain to grain). The striae are short and fine but variable in both distribution and length. The colpus margins are often found with small undulations towards the in rolled edge. Pollen collapse has made acute determination of morphological characteristics difficult, this could be attributable to hybridization and pollen that is not viable. Stace (1991, pp. 358-362) lists 9 naturally occurring hybrids of *R. arevensis* and 8 of *R. canina*.

R. fruticosus is a no-operculate pollen grain that is oblong-rhombic in shape with obtuse, rounded poles. Thin but distinct rugulate striae cover the surface running more or less parallel to the poles but frequently sinuous while the surface is consistently perforate marking this feature a distinct identification characteristic separating it from other members of the *Rosaceae* family examined here.

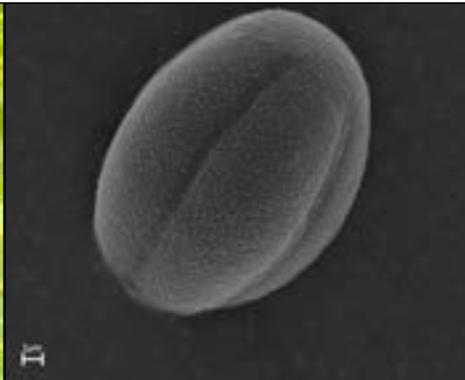
S. minor is a operculate pollen grain that is circular both in polar and equatorial views. A unique feature of this type of pollen grain is that the margins of the colpi may protrude from the grain at the equator. The sculpture consists of very fine striae in the apocolpia with coarser, undulating rugulae possibly present at the equator of the mesocolpia again different from others

Rosaceae family summary continued.

grains posed here.

Sorbus aria pollen grains $>25\ \mu\text{m}$ with some $>40\ \mu\text{m}$ although many *Sorbus* species are known to have a grain size at the upper end of the spectrum. Only slightly longer than broad. Sculpturing is very faintly rugulate-striate and uniform across the grain. Overall individual collections may be quite variable with tentative definition dependent on a type slide collection.

Members of the *Rosaceae* family are known by horticulturists and botanist to be sexually permissive due to the fact that many members are polyploidy and frequently hybridize. Non-operculate members of the *Rosaceae* family are particularly difficult to identify because of this variability within each of the specific genera. Often considerable variation can occur within a single pollen collection thus comparison to a type collection is recommended yet will not ensure exact results according to Moore *et al* (1991).

Family: *Rubiaceae****Crucjata laevipes***

Collection date: 9/6/07

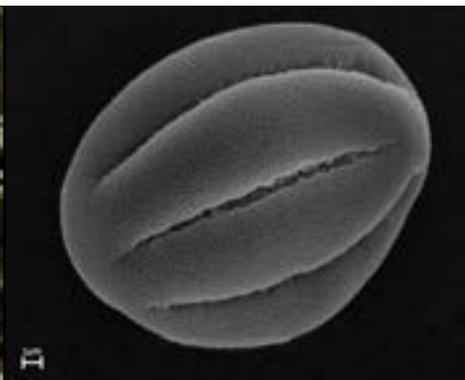
SEM date: 15/6/07

**Crosswort**

Location: Adur Valley, West Sussex

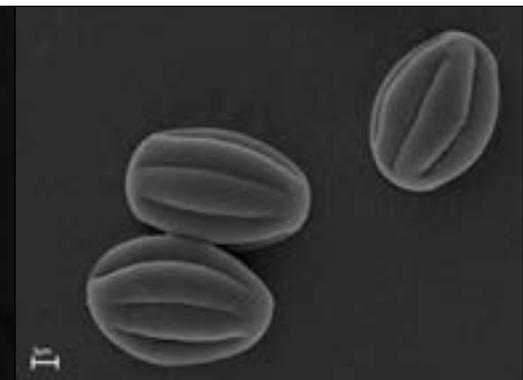
Crucjata laevipes pollen grains are rhombic-orbicular polyzonocolpate grains with somewhat flattened poles. The sculpture is micro-echinate and consistently so, scattered across exine. The mesocolpia is slightly convex with a wide sunken colpi and terminating obtusely before the poles. The colpus membrane is granulate with the colpi edges irregular.

A native plant common to calcareous soils. Height: 75cm.

***Galium constrictum***
(formerly *G. debile*)

Collection date: 10/6/07

SEM date: 15/6/07

**Slender Marsh-bedstraw**

Location: Ashdown Forest, East Sussex

Galium constrictum pollen grains are rhombic-orbicular polyzonocolpate grains with somewhat flattened poles. The sculpture is micro-echinate and consistently so, scattered across exine. The mesocolpia is slightly convex with a wide sunken colpi and terminating obtusely before the poles. The colpus membrane is granulate and the colpi edges are irregular.

A native plant found in damp and marshy places. Height: 40cm.

***Rubiaceae* family summary**

Galium constrictum and *Cruciata laevipes* pollen grains are rhombic-orbicular polyzonocolpate grains with somewhat flattened poles. The sculpture is micro-echinate and consistently so scattered across exine. The mesocolpia is slightly convex with a wide colpi sunken and terminating obtusely before the poles. The colpus membrane is granulate. There seems to be little determinable distinction between the two species.

Moore *et al* (1991, pp 131) suggest that identification beyond the general grouping with members of the *Rubiaceae* family may be difficult and in fact groups *Galium*, *Asperula*, *Rubia* and *Sherardia* under the final pollen classification heading of *Galium* type.

Family: Rutaceae



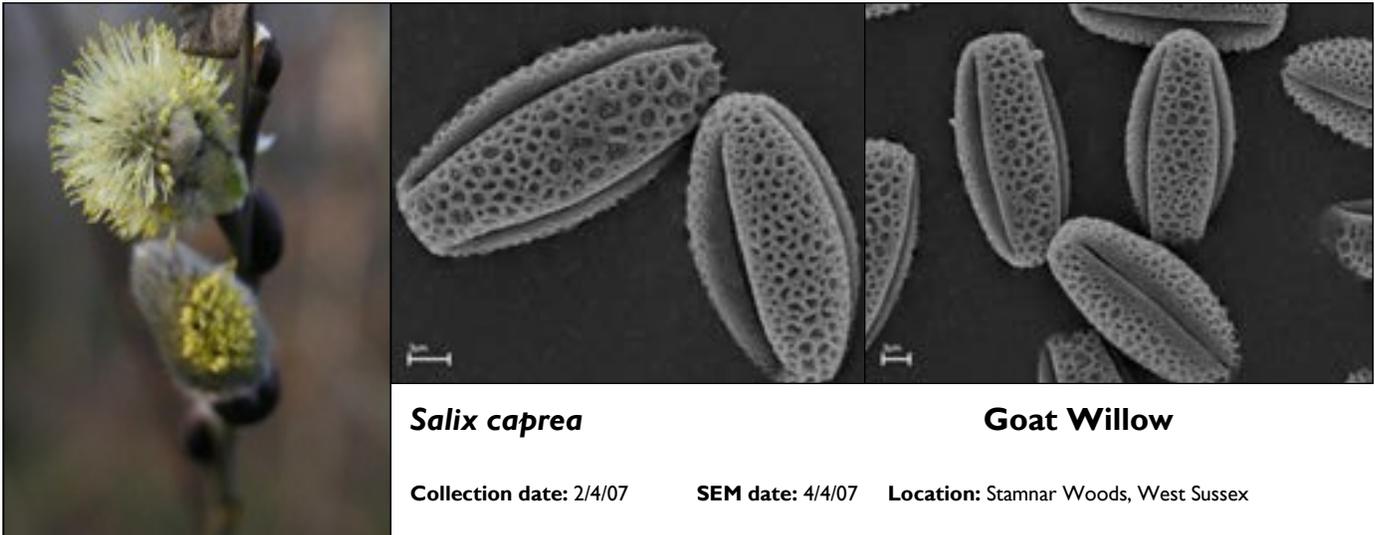
Skimmia confusa 'Kew Green' pollen grains are rhombic-orbicular polyzonocolpate grains with somewhat flattened poles. The sculpture is coarsely rugulate and consistently so scattered across exine, and appears to be porous through the lumina. The mesocolpia is slightly convex with a wide colpi sunken and terminating obtusely before the poles.

A popular evergreen landscape shrub planted in mass since it is suitable for industrial and commercial landscapes. Height: 2m.

Rutaceae family summary.

Skimmia confusa 'Kew Green' pollen grains are quite distinct because of its sculpture. It is coarsely rugulate and consistently so scattered across exine, and appears to be porous through the lumina, which has only been seen in this one example of the 267 presented.

Family: Salicaceae



Salix caprea

Goat Willow

Collection date: 2/4/07

SEM date: 4/4/07

Location: Stannar Woods, West Sussex

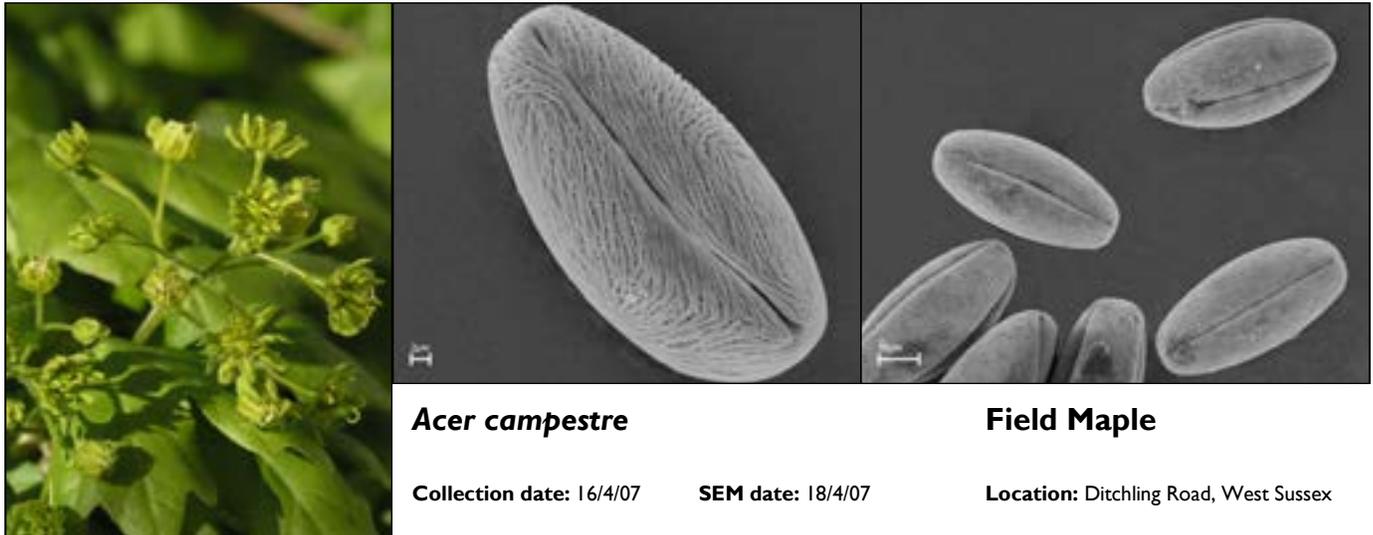
Salix caprea is a trizonocolpate eureticate grain, elliptic in equatorial view with blunt poles but elliptic in polar view. The lumina size decreases markedly towards the colpus edge such that a clear line of delineation occurs. The edge of the colpus appears tectate without lumina. The colpi is very wide and somewhat in-rolled.

A native small tree common to low ground and damp places throughout Britain. Height: 10m.

***Salicaceae* family summary.**

Salix caprea is a trizonocolpate eureticate grain, elliptic in equatorial view with blunt poles but elliptic in polar view. The lumina size decreases markedly towards the colpus edge such that a clear line of delineation occurs. Of note are that the lumina which are distinct also have granulate floors, this is a rare occurrence and makes classification simplistic. Although according to Moore *et al* (1991, pp. 147) this characteristic is common in most *Salix* species. Obviously more comparative analysis is required and could include the closely allied and commonly occurring *Populus* genus.

Family: Sapindaceae

***Acer campestre***

Collection date: 16/4/07

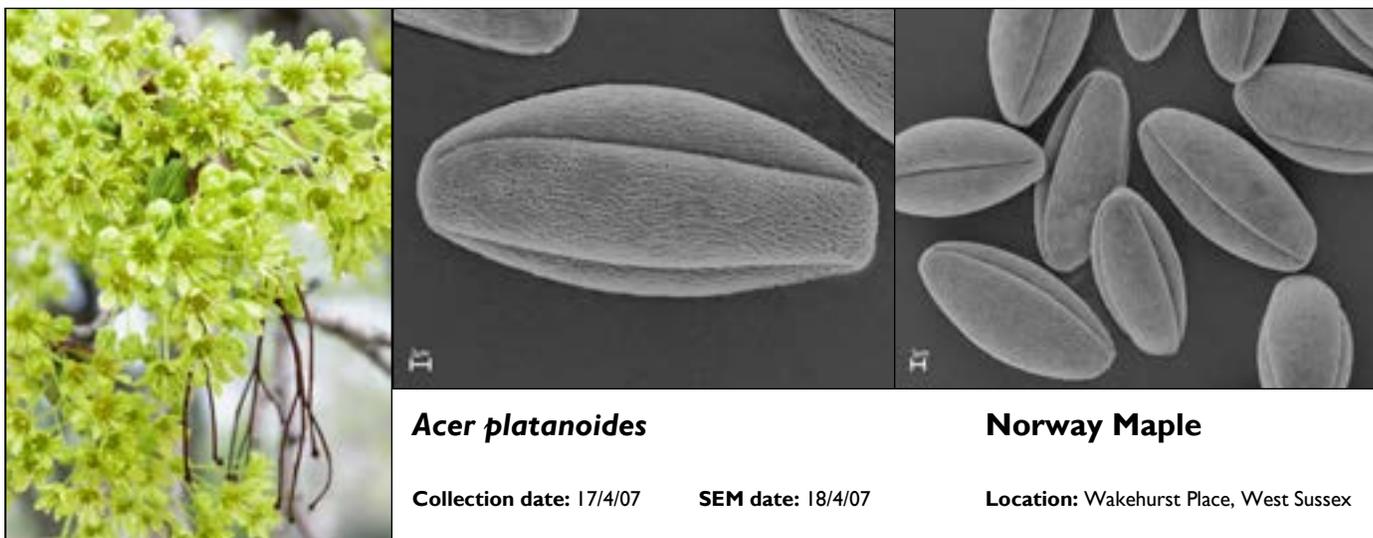
SEM date: 18/4/07

Field Maple

Location: Ditchling Road, West Sussex

Acer campestre is a trizonocolpate grain with striate-rugulate sculpturing. The muri is long, running parallel (meridionally) sided and running parallel with each other with some undulation especially at or towards the poles, but running smoothly over the poles. The muri are well defined and very distinct and organized and consistent in width. Grain size is variable and can be $<>25 \mu\text{m}$. The grain is narrowly elliptic but with a blunt or flattened pole with the colpi terminating and widening at the poles.

A native tree found in hedgrows on calcareous soils. Height: 20m.

***Acer platanoides***

Collection date: 17/4/07

SEM date: 18/4/07

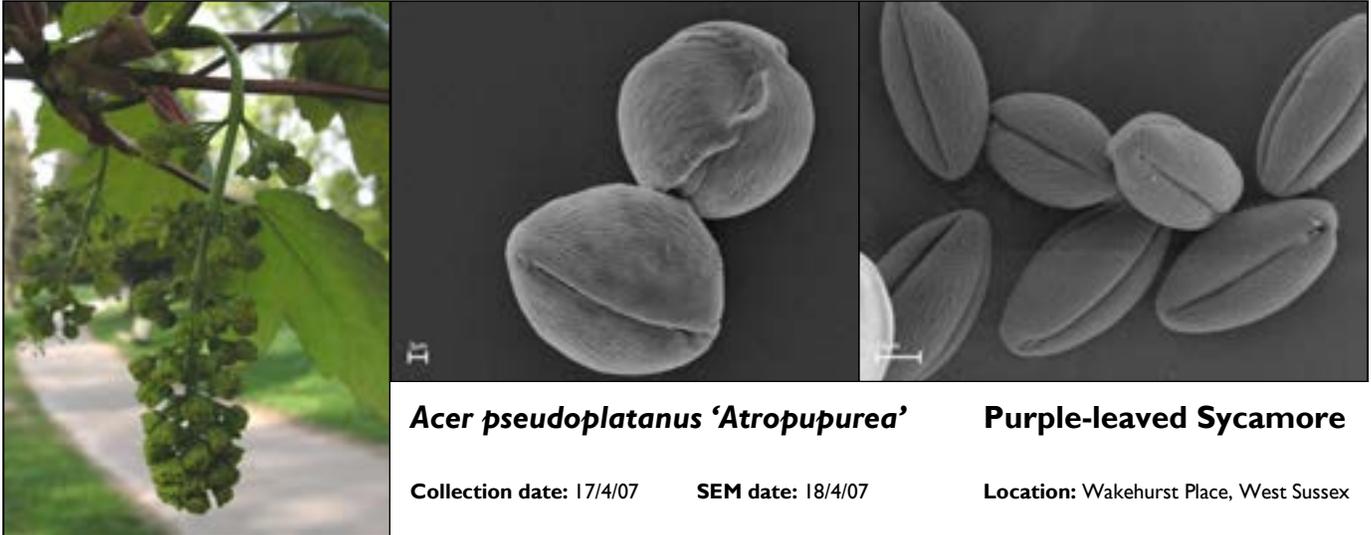
Norway Maple

Location: Wakehurst Place, West Sussex

Acer platanoides is a trizonocolpate grain with striate sculpturing. The muri being long, mostly parallel (meridionally) sided and running parallel with each other with some undulation but running smoothly over the poles. The muri are well defined and very distinct and organized and consistent in width, the exine is consistently perforate. Grain size is variable and can be $<>25 \mu\text{m}$. The grain is narrowly elliptic but with a blunt or flattened pole. Colpi are narrow and terminate in the poles.

An introduced tree, that is planted still but has naturalised occasionally Height: 30m.

Family: Sapindaceae

***Acer pseudoplatanus* 'Atropurpurea'****Purple-leaved Sycamore**

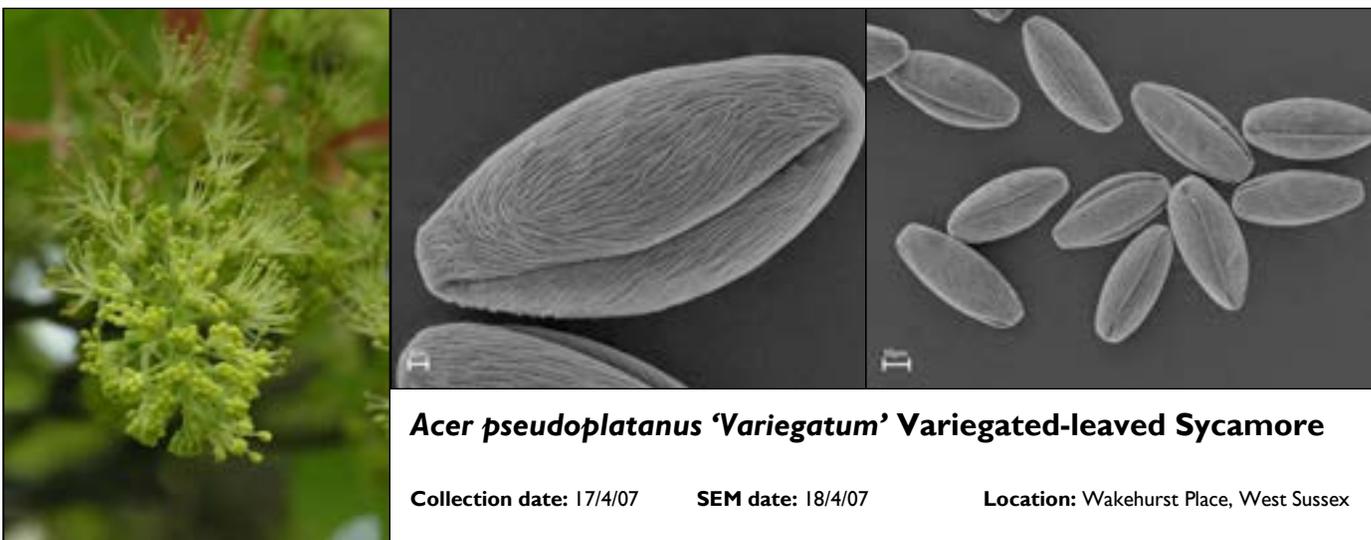
Collection date: 17/4/07

SEM date: 18/4/07

Location: Wakehurst Place, West Sussex

Acer pseudoplatanus 'Atropurpurea' is a trizonocolpate grain with striate sculpturing. The muri being long, mostly parallel (meridionally) sided and running parallel with each other with some undulation but running smoothly over the poles. Viewed from the poles the grain shape is oblique-orbicular. The muri are well defined and very distinct and organized and consistent in width, the exine is consistently perforate. Grain size is variable and can be $<>25 \mu\text{m}$. The grain is narrowly elliptic but with a blunt or flattened pole. Colpi are narrow and terminate in the poles.

An introduced tree that has naturalised and is now well established at the species level with this cultivar commonly planted
Height: 30m.

***Acer pseudoplatanus* 'Variegatum' Variegated-leaved Sycamore**

Collection date: 17/4/07

SEM date: 18/4/07

Location: Wakehurst Place, West Sussex

Acer pseudoplatanus 'Variegatum' appears to be a mirror image of *A. pseudoplatanus* 'Atropurpurea' above and is a trizonocolpate grain with striate sculpturing. The muri being long, mostly parallel (meridionally) sided and running parallel with each other with some undulation but running smoothly over the poles. Viewed from the poles the grain shape is oblique-orbicular. The muri are well defined and very distinct and organized and consistent in width, the exine is consistently perforate. Grain size is variable and can be $<>25 \mu\text{m}$. The grain is narrowly elliptic but with a blunt or flattened pole. Colpi are narrow and terminate in the poles.

An introduced tree that has naturalised and is now well established at the species level with this cultivar commonly planted
Height: 30m.

Family: *Sapindaceae****Aesculus carnea*****Red Horse-chestnut**

Collection date: 29/4/07

SEM date: 2/5/07

Location: Wakehurst Place, West Sussex

Aesculus carnea is a trizonocolporate, elliptic pollen grain with no visible opercula present. It has meridionally elongate endopori each surrounded by a clear costa. Fine transverse striae are found in the mesocolpia. The colpi are deep, acute ended but wider at the equator. Each colpus membrane is covered by very prominent echinae, bacula or verrucae. Surface striate with numerous short muri running meridionally and transversely cross the mesocolpia. The muri are interwoven, often complexly so especially at the poles.

An introduced landscape tree frequently planted in parks and open spaces. Height: 30m.

***Aesculus hippocastanum*****Horse-chestnut**

Collection date: 17/4/07

SEM date: 18/4/07

Location: Wakehurst Place, West Sussex

A trizonocolporate, elliptic to oblong-rhombic pollen grain with no visible opercula present and with flattened poles. The meridionally elongate endopori are each surrounded by a clear costa. Fine transverse striae are found in the mesocolpia. The colpi are deep, acute ended but wider at the equator. Each colpus membrane is covered by very, very prominent echinae, Surface striate with numerous short muri running meridionally and transversely cross the mesocolpia. The muri are interwoven, often complexly so especially at the poles.

An introduced tree that has been frequently planted on estates, parkland and farmland. Height: 35m.

Sapindaceae family summary.

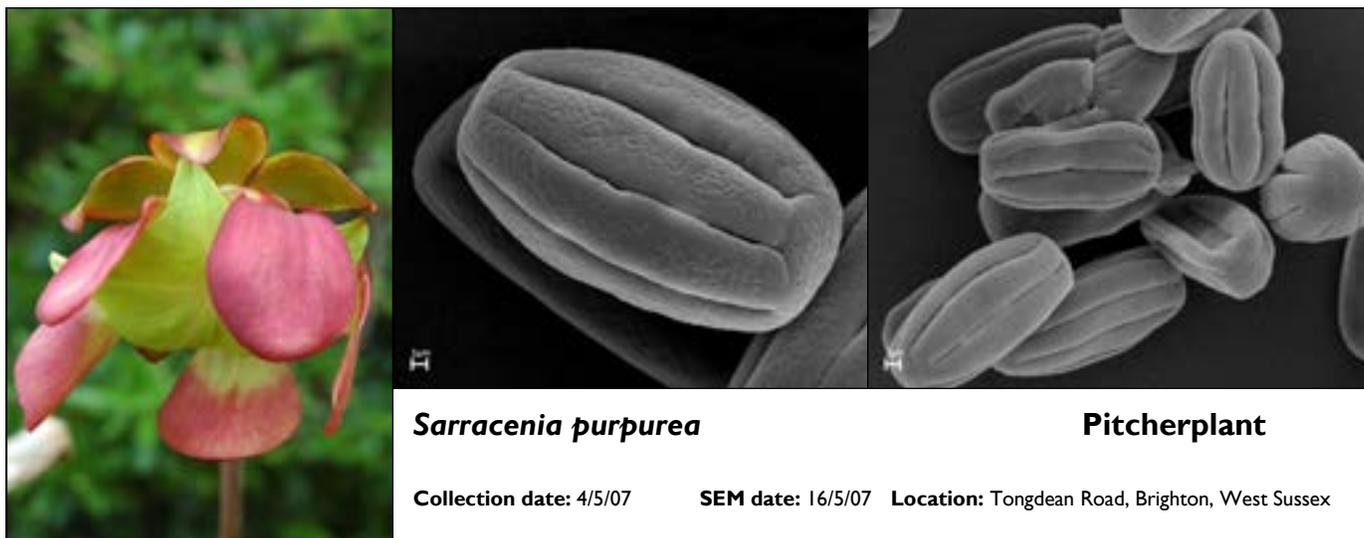
Both *Acer* and *Hippocastanum* have been recently re-classified and moved to the *Sapindaceae* family, although each still remains under their subfamilies *Aceraceae* and *Hippocastanaceae* which were their original family classifications.

Acer campestre, *Acer platanoides*, *Acer pseudoplatanus* 'Atropurpurea' and *Acer pseudoplatanus* 'Variegata' are trizonocolpate pollen grains with striate-rugulate sculpturing, the muri being long, mostly parallel (meridionally) sided and running parallel with each other with some undulation especially at or towards the poles, but running smoothly over the poles. The muri are well defined and very distinct and organized and consistent in width. Grain size is variable and can be $<25\ \mu\text{m}$. The grain is narrowly elliptic but with a blunt or flattened pole with the colpi terminating and widening at the poles. There are no discernable differences between the four plants represented here. This finding is reinforced by Moore *et al* (1991, pp. 129) where the pollen key groups *A. campestre*, *A. pseudoplatanus*, *A. platanoides*, *A. opalus* and *A. monosperulanum* under the general grouping of "Acer campestre type".

Aesculus hippocastanum is a trizonocolporate, elliptic to oblong-rhombic pollen grain while *Aesculus carnea* is a trizonocolporate, elliptic pollen grain. In *A. carnea* each colpus membrane is covered by very prominent echinae, bacula or verrucae while in *A. hippocastanum* it is covered with very prominent echinae. In both species the muri are interwoven, often complexly so especially at the poles.

The two species presented here are quite distinct but amongst similar species the differences are indeed limited if they exist at all as in the *Acer* genera.

Family: Sarraceniaceae



Sarracenia purpurea

Pitcherplant

Collection date: 4/5/07

SEM date: 16/5/07

Location: Tongdean Road, Brighton, West Sussex

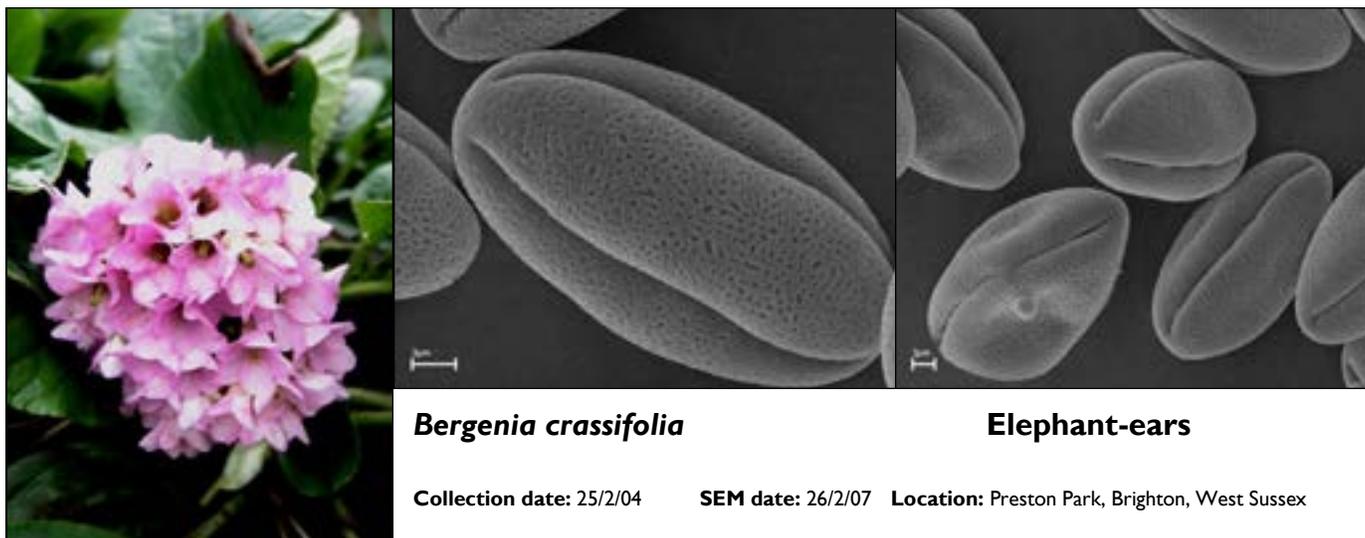
Sarracenia purpurea pollen grains are rhombic-orbicular polyzonocolpate grains with somewhat flattened poles. The sculpture is psilate-verrucate, consistently so across the exine. The mesocolpia is slightly convex with wide colpi sunken and terminating at 45° in the poles. The colpi edges are irregular but only slightly so with some variability in the width of the colpus opening. Some pollen grain collapse is evident.

A plant from North America that has been planted and has now naturalized in a few scattered locations in England. Height: 30cm.

***Sarraceniaceae* family summary.**

In *Sarracenia purpurea* pollen grains the mesocolpia is slightly convex with a wide sunken colpi and terminating at 45° in the poles. The termination of 45° is unique and has not been observed in other pollen grains. Grains with similar morphology such as *Rubiaceae* family members lack this distinct characteristic. Stace (1991, pp. 216) notes that *S. flava* may also be found in localized parts of England, it warrants further investigation if *S. flava* carries the same distinct characteristic as *S. purpurea*: the termination of the colpus in the poles at 45°.

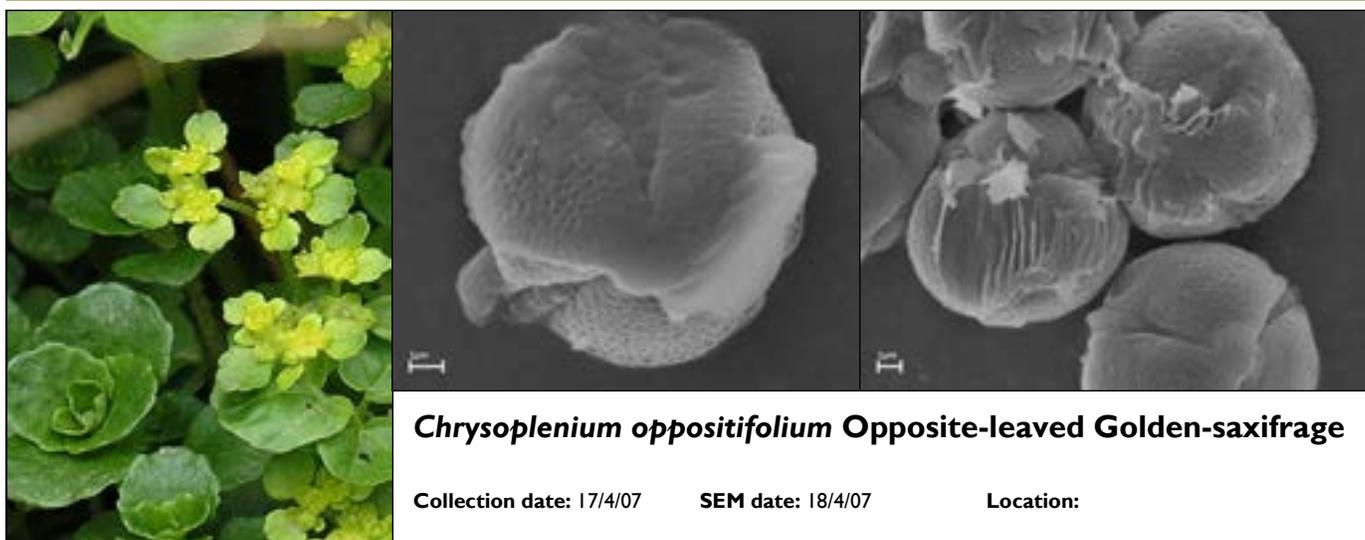
Family: Saxifragaceae

***Bergenia crassifolia*****Elephant-ears**

Collection date: 25/2/04 SEM date: 26/2/07 Location: Preston Park, Brighton, West Sussex

Bergenia crassifolia pollen grains are elliptic-obtuse in equatorial and polar views. The grain is trizonocolpate, eurenticulate with the colpi almost the full length and terminating in the poles. The colpi is consistent in width and depth. Exine is psillate reticulate-perforate with a gradual change in lumina sizing towards the colpi and poles. The exine at the poles is psilate. The colpi appear in many grains to widen towards the poles and the equator.

A plant that is introduced but may remain as a garden relic. Stace (1991, pp. 315) states that the plant rarely sets seed. Height: 30cm.

***Chrysplenium oppositifolium* Opposite-leaved Golden-saxifrage**

Collection date: 17/4/07 SEM date: 18/4/07 Location:

Grains, trizonocolpate, eurenticulate (the muri of the reticulum are the walls which join the heads of the columellae). Distribution of the columellae commonly dependent of the pattern of the reticulum. Pollen grains usually $<18\mu\text{m}$ in length with apocolpia reticulate and sometimes syncolpate at the poles. The columellae is indisnt with exine of consistent size and thickness over the grain surface. The colpi is narrow with no visible colpus membrane. The reticulum is very small, bordering on a micro-reticulum.

A native of damp places such as still stream edges and swamps, generally forming a large mat of foliage. Height: 20cm.

Saxifragaceae family summary.

Bergenia crassifolia and *Chrysopenium oppositifolium* pollen grains are both trizonocolpate, eureticate with the colpi almost the full length and terminating in the poles. It is difficult to determine more exact pollen grain morphological characteristics for comparison without 'washing' the grain (*C. oppositifolium*) to remove the tectum and reveal detail. Moore *et al* (1991, pp. 57) recommends an acetolysis wash similar to that used in the preparation of slides for LM analysis, this should be used on *C. oppositifolium* to reveal surface sculpture.

Family: *Scrophulariaceae****Digitalis grandiflora*****Yellow Foxglove**

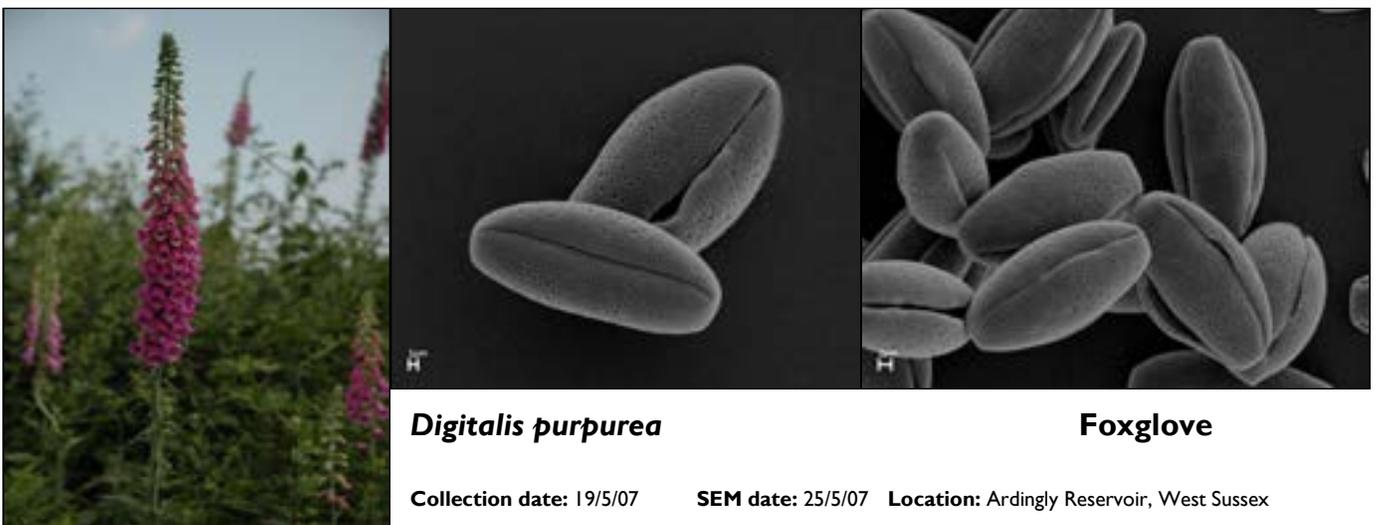
Collection date: 10/6/07

SEM date: 15/6/07

Location: Ashdown Forest, East Sussex

Digitalis grandiflora pollen grains are $< 36\mu\text{m}$ in size, elliptic in equatorial and polar views but with narrow obtuse poles. The grain is trizonocolpate, eureticolpate with the colpi almost running the full length and terminating at the poles. The colpi is consistent in width and depth. Exine is reticulate-perforate with the no change in lumina sizing towards the colpi.

An uncommon plant occasionally found growing in ditches and other moist or partially shaded locations. Height: 1.5-2m.

***Digitalis purpurea*****Foxglove**

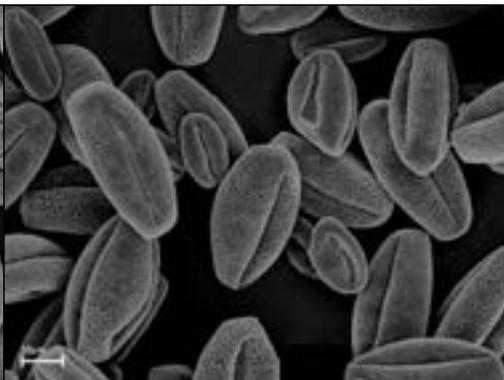
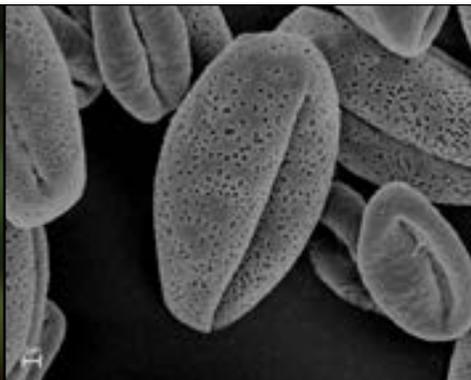
Collection date: 19/5/07

SEM date: 25/5/07

Location: Ardingly Reservoir, West Sussex

Digitalis purpurea pollen grains are $< 36\mu\text{m}$ in size, elliptic in equatorial and polar views but without a obtuse pole. The grain is trizonocolpate, eureticolpate with the colpi almost running the full length and terminating at the poles. The colpi is consistent in width and depth. Exine is psillate reticulate-perforate with the no change in lumina sizing towards the colpi. The colpi appear in many grains to widen towards the poles.

A native plant found growing in ditches, the edges of woods, meadows and other moist or partially shaded locations. Height: 1.5-2m.

Family: *Scrophulariaceae****Hebe buxifolia*****Hedge Veronica**

Collection date: 7/2/07

SEM date: 9/2/07

Location: University of Sussex, West Sussex

Hebe buxifolia is a trizonolcolporate reticulate pollen grain elliptic to obovate with blunt to flattened poles in equatorial view. The colpi are narrow and terminate in the poles. Lumina appear inconsistent in size with no differentiation at the poles or the equator in size although their numbers decrease. The muri are quite wide, wider more often than the lumina and appear psilate. As with other early collected pollen grains there is substantial grain collapse.

An introduced shrub very common in the cultured landscape and may be found in remnant hedgrows. Height: 2m.

***Linaria purpurea*****Purple Toadflax**

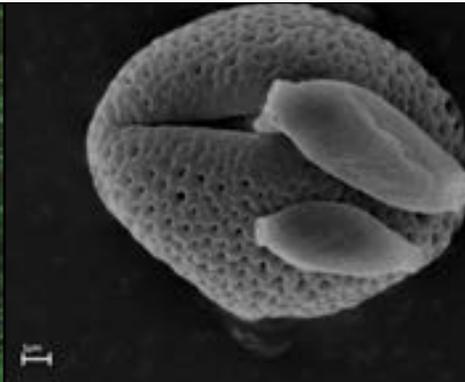
Collection date: 14/6/07

SEM date: 15/6/07

Location: Hollingbury Park Avenue, Brighton West Sussex

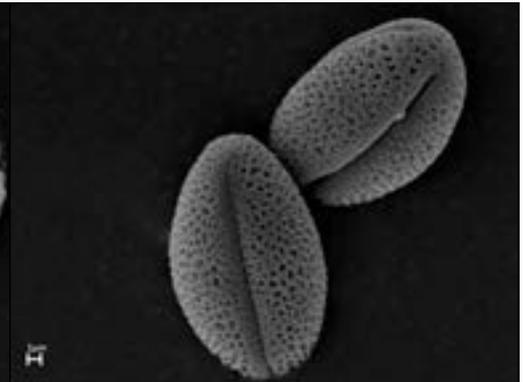
Linaria purpurea is a trizonolcolporate reticulate pollen grain that is > 18 μm in length, elliptic to obovate with blunt poles in equatorial view. The colpi are narrow and terminate at the poles. Lumina appear consistent in size with no differentiation at the poles or the equator.

An introduced plant that has naturalised on rough and waste ground. Height: 75cm and extremely floriferous for the better portion of the summer months.

Family: *Scrophulariaceae****Linaria vulgaris***

Collection date: 28/6/07

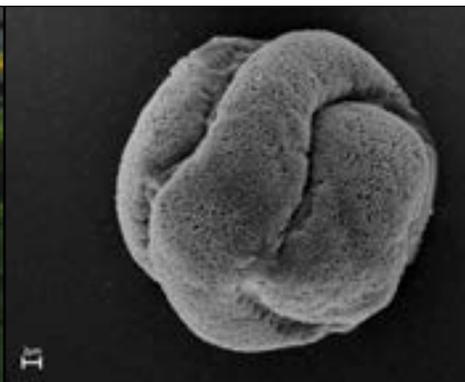
SEM date: 29/6/07

**Common Toadflax**

Location: Clayton, West Sussex

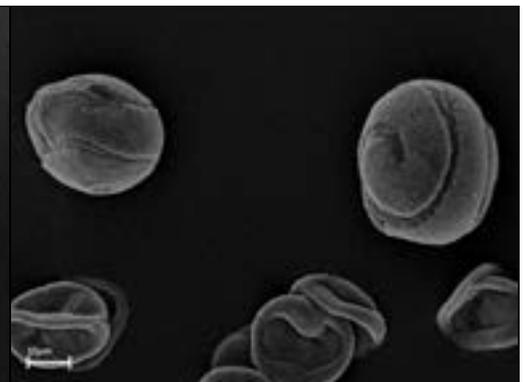
Linaria vulgaris is a trizonocolporate reticulate pollen grain that is $> 18 \mu\text{m}$ in length, elliptic to almost circular with poles rounded poles in equatorial view. The colpi are narrow and terminate at the poles. Lumina appear consistent in size with no differentiation at the poles or the equator, although in the SEM images above lumina appear perforate.

A native common to rough ground and waste places, such as the sides of roads and banks. Height: 30cm.

***Mimulus guttatus***

Collection date: 27/6/07

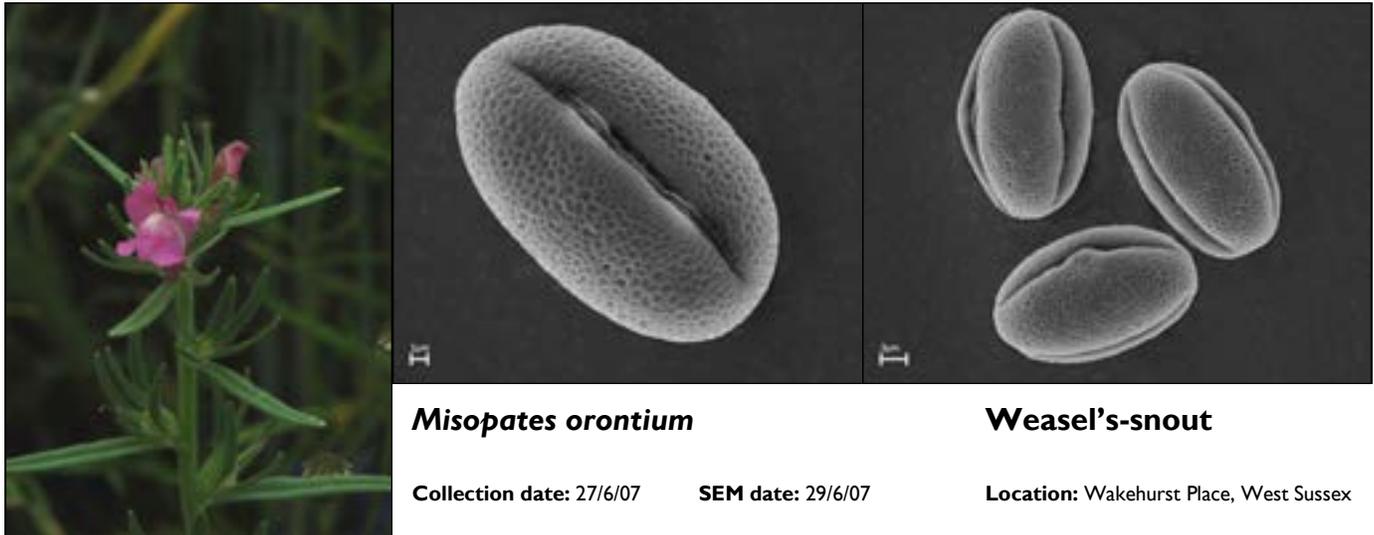
SEM date: 29/6/07

**Monkeyflower**

Location: Wakehurst Place, West Sussex

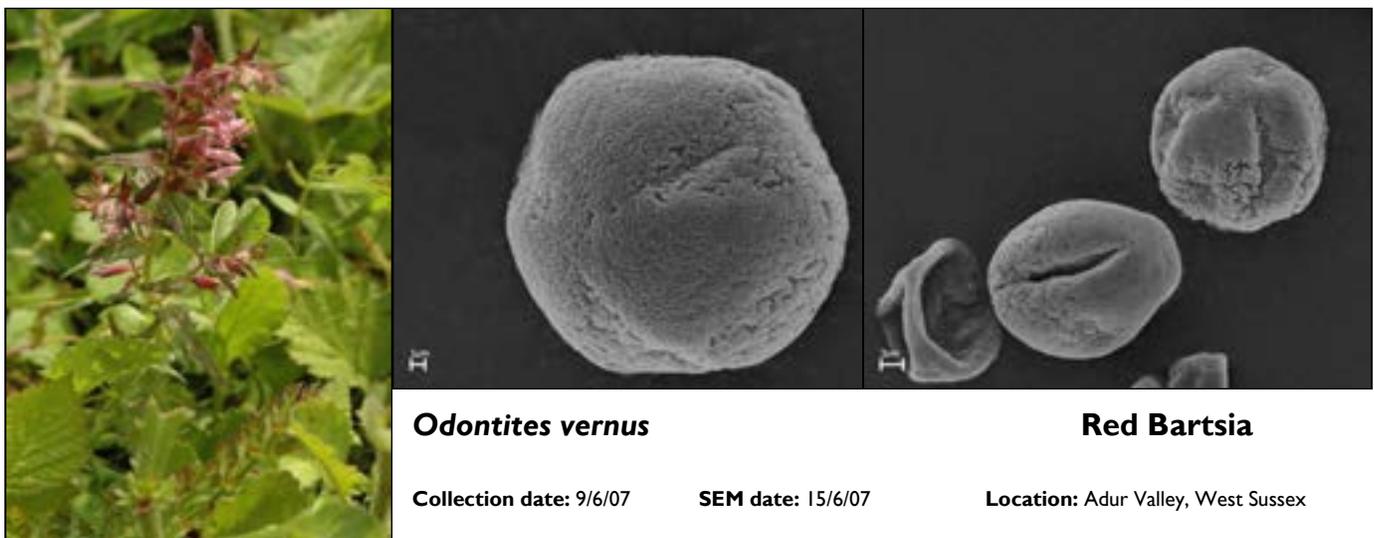
Mimulus guttatus is a 2 pantocolpate pollen grain, orbicular in polar views but appearing somewhat elliptic in equatorial views. The tectum is slightly verrucate– perforate with no distinct or clear endocracks although endosculptures are present. The colpi run straight over the surface but divide it into somewhat rounded plates with loops or spirals (much like a tennis ball), while the mesocolpia is microreticulate. Little sculpturing detail is seen because of the all encompassing tectum. Individual pollen grains are > 22 in length.

An introduced plant that is found scattered along stream edges and in swamps. Height: 75cm.

Family: *Scrophulariaceae*

Misopates orontium is a trizonolcolporate reticulate pollen grain that is elliptic to obovate with rounded poles in equatorial view and rounded in polar views. The colpi are wide and terminate before the poles, the colpus membrane is granulate. Lumina appear consistent in size with no differentiation at the poles or the equator with wide psilate muri equal in size to the lumina. There appears to be a widening of the colpi at the equator resulting in an equatorial girdle.

A weed of cultivated ground, possibly native. Height: 50-75cm.



Odontites vernus is a orbicular, trizonolcolporate pollen grain with a heavy tectum revealing little surface sculpturing. The tectum appears granulate and slightly perforate. The colpi are very wide at the equator with a granulate membrane.

A native plant found on lean grassland in meadows and on hedges. Height: 75cm.

Family: Scrophulariaceae



Schrophularia nodosa

Common Figwort

Collection date: 27/6/07

SEM date: 29/6/07

Location: Preston Park, West Sussex

Schrophularia nodosa is a trizonalcolporate reticulate pollen grain that is elliptic to obovate with rounded poles in equatorial view and rounded in polar views. The colpi are wide and terminate before the poles, the colpus membrane is granulate. Lumina appear consistent in size with a slight differentiation at the poles and the equator with wide psilate muri equal in size to the lumina. Lumina towards the colpus margins fade with the exine becoming psilate. There appears to be a slight narrowing of the grain at the equator but not so that it results in an equatorial girdle.

Typically this native plant is found in damp locations along the edges of woods, lakes and ponds and may reach a height of 1m.



Verbascum thapsus

Great Mullein

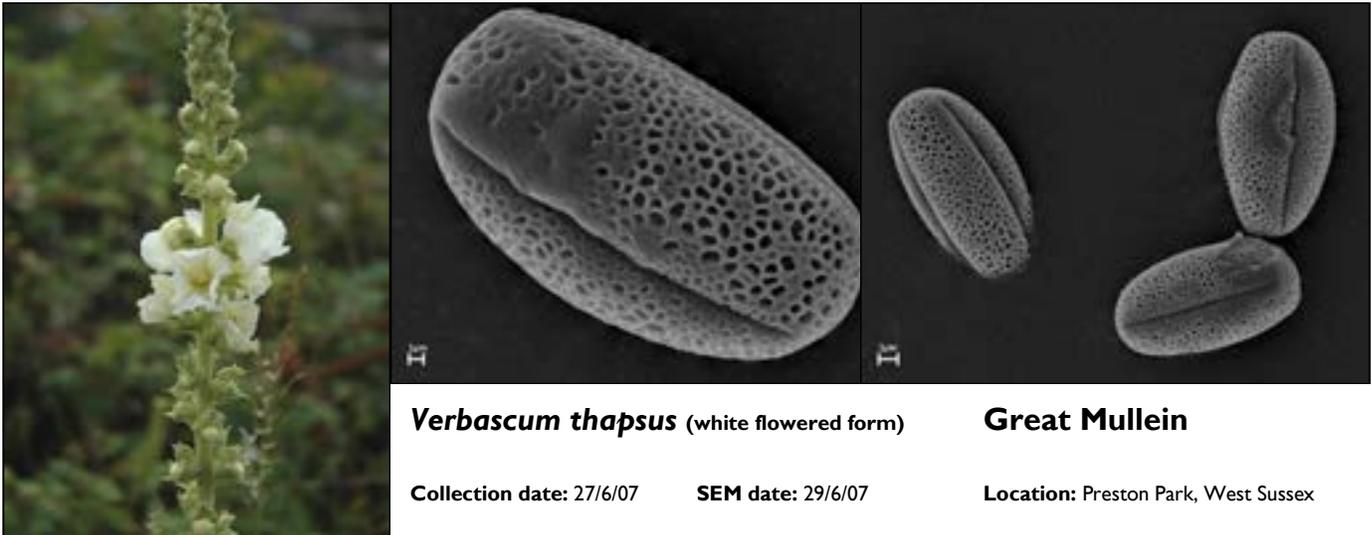
Collection date: 14/6/07

SEM date: 21/6/07

Location: Wakehurst Place Kew West Sussex

Verbascum thapsus is a trizonalcolporate, coarsely reticulate pollen grain that is elliptic to obovate with blunt poles in equatorial view. The colpi widen at the equator and terminate at the poles but are long. Colpi have psilate membranes and are slightly sinuous. Lumina decrease in size towards the inrolled colpi, this area is tectate to microreticulate. The grain shows some collapse and deterioration.

A native to lean, often gravel-like soils such as roadsides and waste ground. Height: 2m.

Family: *Scrophulariaceae****Verbascum thapsus*** (white flowered form)**Great Mullein**

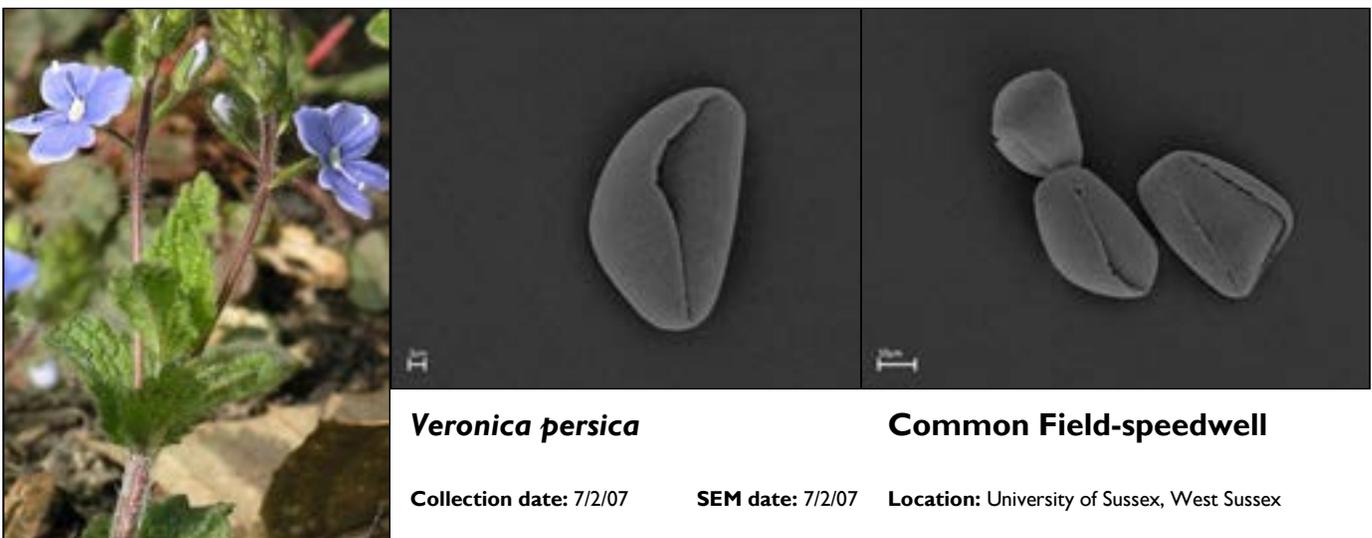
Collection date: 27/6/07

SEM date: 29/6/07

Location: Preston Park, West Sussex

Verbascum thapsus (white flowered form) is a trizonolcolporate coarsely reticulate pollen grain that is elliptic to rhombic obovate with blunt poles in equatorial view. The colpi widen at the equator and terminate at the poles but are long. Colpi have psilate membranes and are slightly sinuous. Lumina decrease in size towards the inrolled colpi, this area is tectate to microreticulate.

A native to lean, often gravel-like soils such as roadsides and waste ground. Height: 2m.

***Veronica persica*****Common Field-speedwell**

Collection date: 7/2/07

SEM date: 7/2/07

Location: University of Sussex, West Sussex

Veronica persica is a trizonolcolpate psilate to perforate grain, elliptic to lobed circular in equatorial view with a granulate colpus membrane. The surface is lightly perforate with the colpi appearing ragged along the margins and folding inwards giving the appearance of a collapsed pollen grain.

An introduced plant that has naturalized extensively throughout Britain, typical to both cultivated and waste ground. Height: 20cm.

Scropulariaceae family summary.

The two species of *Digitalis* represented, *D. grandiflora* and *D. purpurea* appear to have distinct differences in grain shape and exine sculpturing. *D. grandiflora* grains are typically elliptic in equatorial and polar views but with narrow obtuse poles while *D. purpurea* is elliptic in equatorial and polar views but without a obtuse pole. The exine of *D. grandiflora* is reticulate-perforate while the exine of *D. purpurea* appears is psillate reticulate-perforate. The colpi on many of the *D. purpurea* grains analyzed appear to widen towards the poles while the colpi on *D. grandiflora* were narrow throughout the grain sample. Further analysis and comparison to a collection of type samples needs to be undertaken to ensure the results are reliable, however initial results look promising with SEM analysis being able to distinguish between these two closely related species.

Linaria vulgaris and *Linaria purpurea* are both trizonolcolporate reticulate pollen grains. However differences do occur between the two grains. The shape of the grains seems to be the more obvious difference with *L. purpurea* being much more elliptic in form and with blunt poles while *L. vulgaris* is more rounded and does not have the blunt poles in equatorial view. The second distinct difference between the two is that the lumina of *L. vulgaris* appear perforate (light microscope should confirm this) while *L. purpurea* pollen grains have no perforations.

Verbascum thapsus pollen grain analysis demonstrates little variation between the normal yellow flowered species and the rare white flowered form. The main difference between the two is the condition of the pollen grains, the white flower form bearing, full, plump and unhindered grain while the yellow flowered form demonstrated sever deterioration of the grains.

Mimulus guttatus is pantocolpate pollen grain and from a morphological point of view is an odd representation of this particular family where almost all the other family members are trizonolcolporate reticulate pollen grains. Another exception to this group general grouping is *Odontites vernus* which is a trizonolcolporate grain but not elliptic in shape and with a very heavy tectum or coating revealing no sculpture.

Veronica persica is a trizonolcolpate psillate to perforate grain, elliptic to lobed circular in equatorial view with the colpi appearing ragged along the margins and folding inwards giving the appearance of a collapsed pollen grain. Since only one *Veronica* species was examined and there is no comparative data however this common genus warrants further investigation and possible candidates might include the following very common species: *V. officinalis*, *V. chamaedrys*, *V. montana*, *V. scutella*, *V. anagallis-aquatica*, *V. acinifolia*, *V. triphyllos*, *V. agrestis*, *V. polita*, *V. filiformis*, and *V. hederifolia* (Stace, 1997, pp. 603-605).

Family: Solanaceae



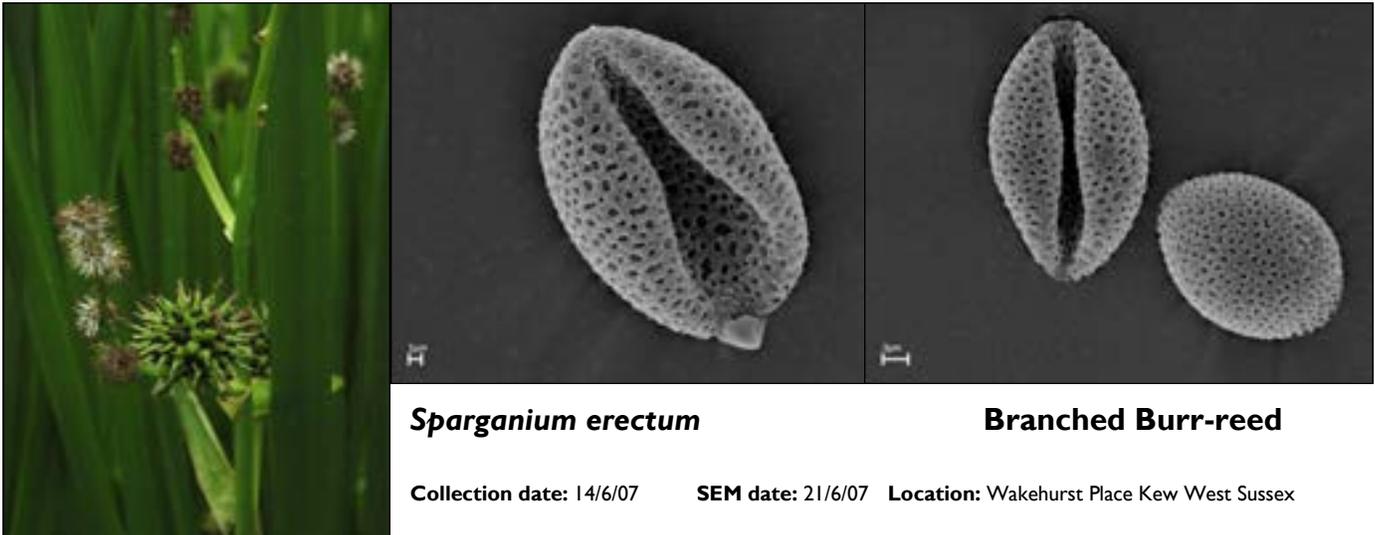
Solanum dulcamara is a small pollen grain, <math>< 16 \mu\text{m}</math> in diameter. It is elliptic in shape, trizonocolporate and psilate-scabrate. The colpus is shallow but broad and terminates obtusely in the poles.

A native plant often found in hedges and walls, along the base of hedgerows and waste land. Somewhat vine-like in growth habit it can reach a height of 3m.

***Solanaceae* family summary.**

According to Moore *et al* (1991, pp. 133) *Solanum* falls into a group of pollen grains that are often difficult to distinguish between each other because of their lack of surface sculpture including distinction in the colpi attitude, *S. nigra*, another very common species found in England distinguishes itself from *S. dulcamara* by being $2\mu\text{m}$ bigger in diameter with no difference in pollen grain sculpture.

Family: *Sparganiaceae*



Sparganium erectum

Branched Burr-reed

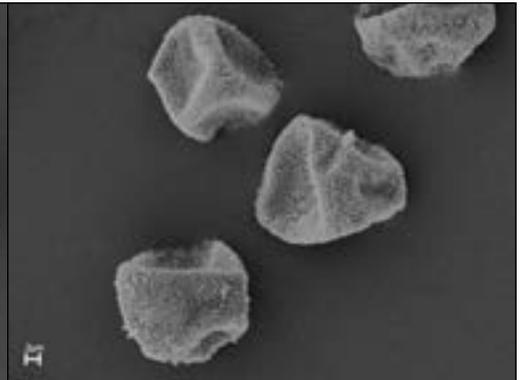
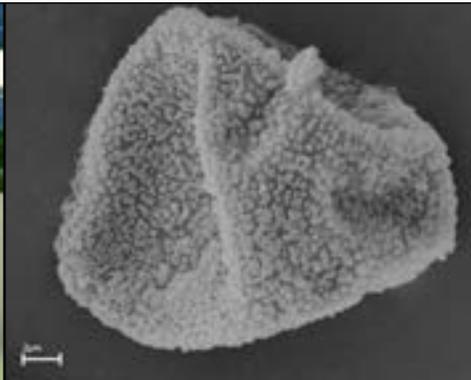
Collection date: 14/6/07 SEM date: 21/6/07 Location: Wakehurst Place Kew West Sussex

Sparganium erectum is a monocolpate pollen grain that is elliptic-obovate in shape. Surface sculpture is rugulate, coarsely so with no apparent variation towards the poles or the colpus margins. The colpus is broad, closing towards the equator and terminating in the poles. The colpi margins are in rolled, while the colpus is gaping, extremely so, with the colpus membrane carrying the same sculptural details as the exine.

A native of Britain found in swamps and along stream edges. Height: 1.5m.

***Sparganiaceae* family summary.**

Sparganium erectum has unusual colpi margins that are in rolled, while the colpus is gaping, extremely so, with the colpus membrane carrying the same sculptural details as the exine. Further analysis is warranted since this widening of the colpus could be pollen grain deterioration. Additionally the characteristics of the grain given in the morphology section could be incorrect. The grain could in fact be orbicular in shape but the collapse has caused this constricting characteristic thus confusing the morphologic aspects of the pollen

Family: *Taxaceae****Taxus baccata*****Yew**

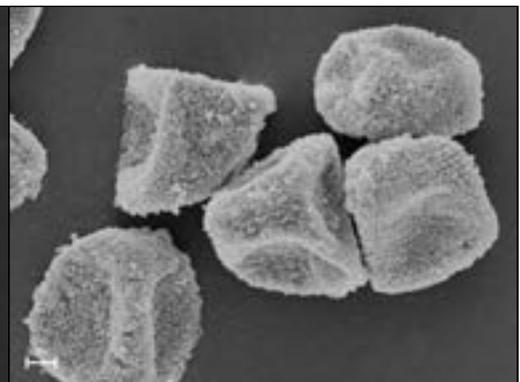
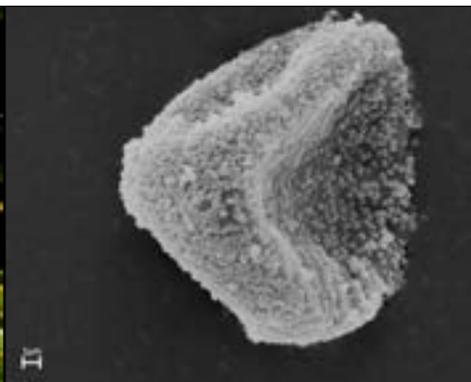
Collection date: 13/3/07

SEM date: 21/3/07

Location: Wakehurst Place, West Sussex

Taxus baccata pollen grains are without echinae, have no reticulate pattern with the sculpturing elements arranged randomly. The grain is apparently intectate with no lacunae. Sculptural elements, gemmae, microgemmae or minute granules (a mixture of the three) cover the entire grain, almost carpet-like but none long enough to be a clavae or bacula. Pollen grains are < 50µm in size. Pollen grains are obtusely angular with sculptural elements varying in size.

A native evergreen typically found on well drained limestone soils. Height: 28m.

***Taxus baccata* 'Fastigiata Aurea'****Golden Upright yew**

Collection date: 13/3/07

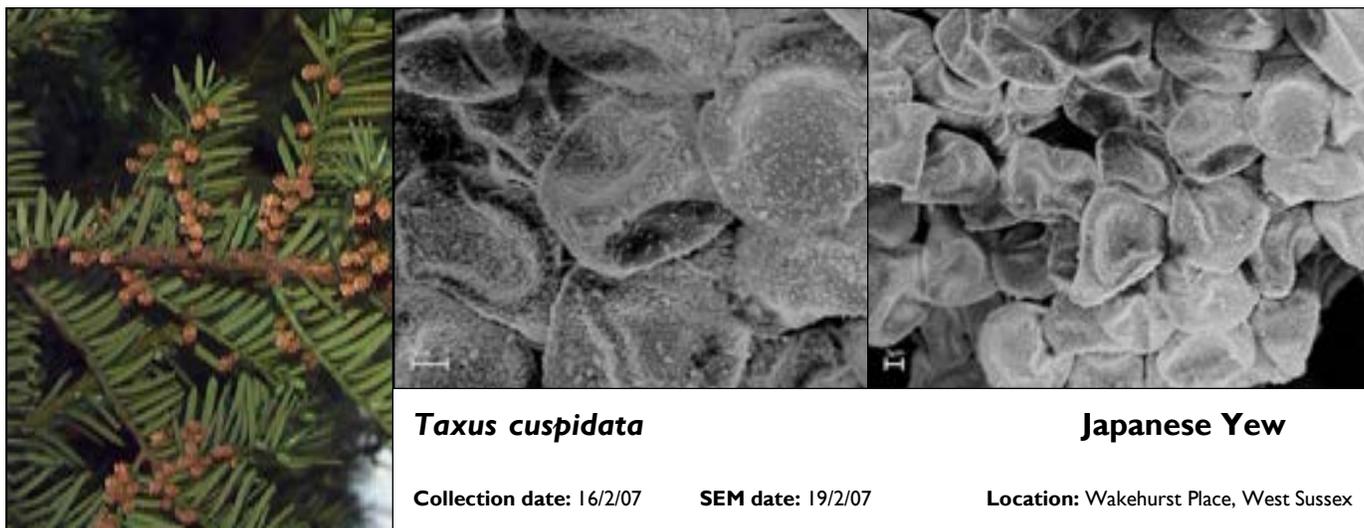
SEM date: 21/3/07

Location: Wakehurst Place, West Sussex

Taxus pollen grains are without echinae and have no reticulate pattern with the sculpturing elements arranged randomly with a broadly angular form. The pollen grain is apparently intectate with no lacunae. Sculptural elements, gemmae, microgemmae or minute granules (a mixture of the three) cover the entire grain, almost carpet-like but none long enough to be a clavae or bacula. Pollen grains are < 50µm in size. Pollen grains are obtusely angular with the sculptural elements of varying size.

A landscape cultivar that is commonly planted, found particularly in church graveyards. Height: 15m.

Family: *Taxaceae*



Taxus cuspidata

Japanese Yew

Collection date: 16/2/07

SEM date: 19/2/07

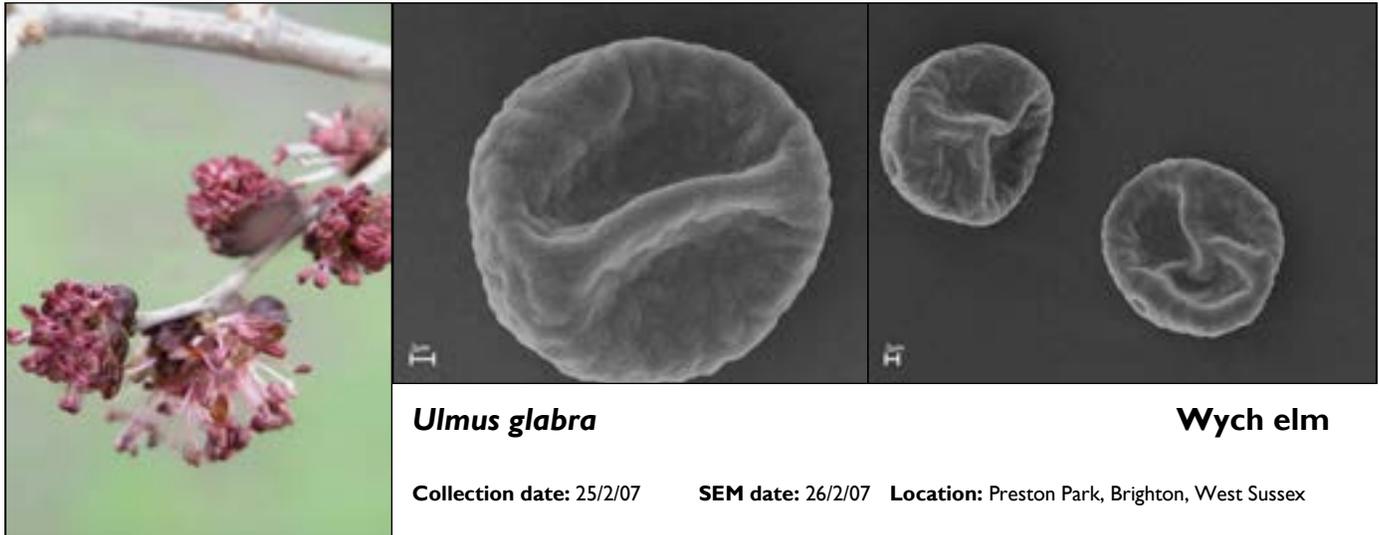
Location: Wakehurst Place, West Sussex

Taxus pollen grains are without echinae and have no reticulate pattern. The sculpturing elements are arranged randomly. The grain is apparently intectate with no lacunae. Sculptural elements, gemmae, microgemmae or minute granules (a mixture of the three) cover the entire grain, almost carpet-like but none long enough to be a clavae or bacula. Pollen grains are < 50µm in size. Grain shape is obtusely angular with sculptural elements of varying in size.

Flower image: <http://www.hort.uconn.edu/plants/t/taxcus/taxcus00.jpg>

***Taxaceae* family summary.**

The three *Taxus* examples presented here cannot be identified as to species or cultivar under SEM. This is reinforced by Moore *et al* (1991, pp.96) who keys *Taxus* grains to the genus level only but warns that if the grain splits, which it frequently does, it could then resemble *Juniperus* species and be keyed out there.

Family: *Ulmaceae*

Ulmus glabra is a tetrazonoporate-pentazonoporate rugulate pollen grain that is orbicular in shape. The pori are non-vestibulate with slight thickened margins. The grain has broad rugulae or shallow, wide reticulum. The tectum undulates when viewed along a collapsed portion of the exine. All of the grains examined showed evidence of collapse.

A native tree that is commonly planted in parks and along streets. Height:30m.

***Ulmaceae* family summary.**

Since only one member of the *Ulmaceae* family was examined little can be discerned from the grain analysis. However a closely related genus, *Zelkova* according to Moore *et al* (1991, pg 105) has similar pollen characteristics and type slides need to be consulted to determine identification. *Zelkova serrata*, which has a similar growth habit to that of *Ulmus glabra* has been used as a planting substitute where Dutch elm disease has occurred and could further add to the confusion concerning the identification of both the plant and the pollen grain.

Family: *Urticaceae*



Urtica dioica

Common Nettle

Collection date: 17/5/07

SEM date: 25/5/07

Location: Clayton, West Sussex

Urtica dioica is a tetrazonoporate, scabrate pollen grain. The scabrae are unequal in size and scattered in distribution. The pori protrude slightly at the equator and appear roughly circular. Overall pollen grain shape is oblong obtuse both in polar and equatorial view.

A very common plant to wasteland, hedgerows and roadsides. To about 1m usually forming dense patches due to its rhizomatous nature.

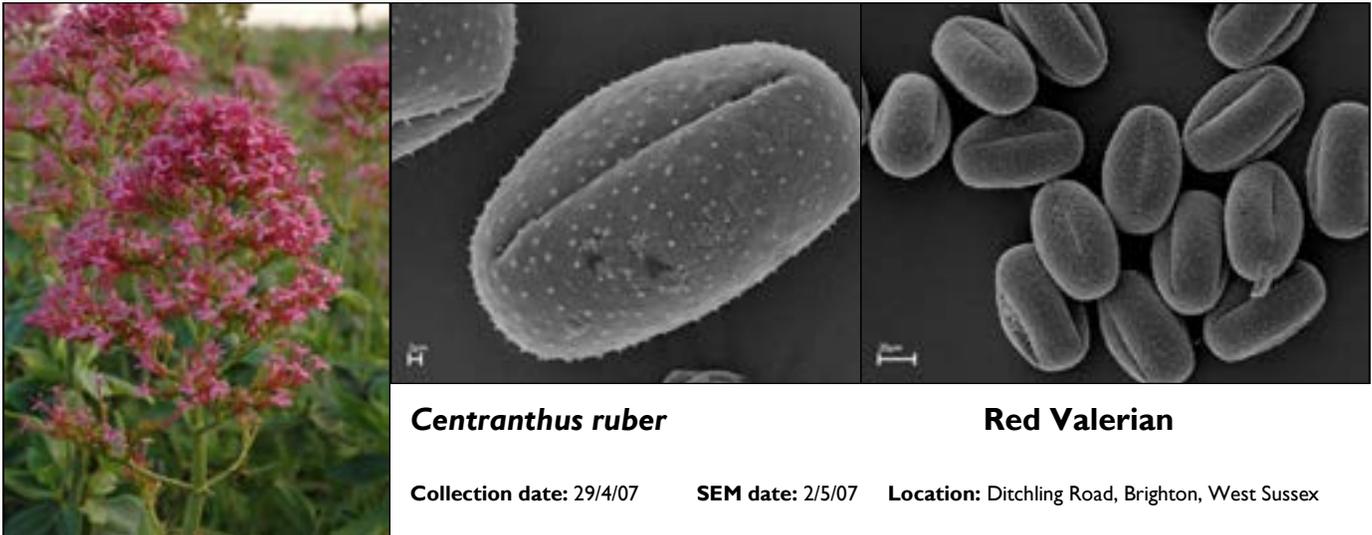
***Urticaceae* family summary.**

Stace (1997, pp.117-118) lists only three species of *Urtica*, one a subspecies of *U. dioica* and the other *U. urens* although he lists two other genera in the family *Urticaceae*, *Parietaria* and *Soleirolli soleirolii* as commonly found in Britain.

Moore *et al* (1991, pp. 102-105) does state that both *U. dioica* and *U. urens* can be keyed successfully, the primary difference being that *U. urens* scabrae are consistent in size, Moore also states that *Parietaria* can also be keyed.

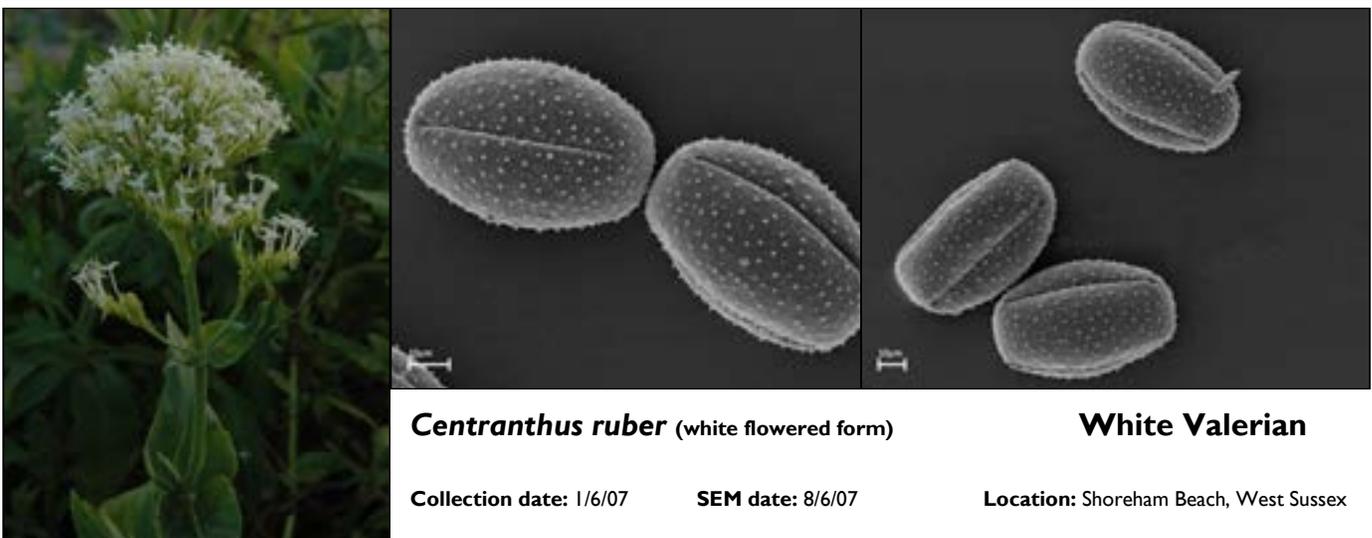
Damian *et al* (2007) has demonstrated success in classifying two species of *Urticaceae* by automatic LM image digitization, the group based at the Universidade de Vigo achieved 100% resolution in distinguishing between pollen of *U. dioica* and *Parietaria judaica* even though both pollen types lack extensive surface detail and are similar in form and size.

Family: Valerianaceae



Centranthus ruber is a trizonocolpate grain, >50 μm in size, with the exine echinate. The colpi are wide and terminate at the poles. The colpus is slightly sunken. The columellae are coarse and are densely packed all over the exine. The columellae appear more distinct than the echinae. Overall grain shape is broadly elliptic to rhombic-obtuse.

An introduced plant that has now become very common, often found growing on lean dry soils, walls, banks and beach rubble. Height: 1m.



Centranthus ruber is a trizonocolpate grain, >50 μm in size, with the exine echinate. The colpi are wide and terminate at the poles. The colpus is slightly sunken. The columellae are coarse and are densely packed all over the exine. The columellae appear less distinct than the echinae. Overall grain shape is broadly elliptic to rhombic-obtuse.

An introduced plant that has now become very common, often found growing on lean dry soils, walls, banks and beach rubble. Height: 1m.

Valerianaceae family summary.

Both *Centranthus ruber* and *Centranthus ruber* (white flowered form) are found growing in association with each other suggesting than interbreeding and cross pollination of the species occurs. The red flowered form appears under casual observation to be the more dominant form with in fact the plant's species name *ruber* referring to the red flower form. Pollen grains from both collections appear identical except in one detail, the columellae appear more distinct than the echinae on the red flowered form while the opposite was observed on the white flowered form.

Family: *Violaceae****Viola arvensis***

Collection date: 28/6/07

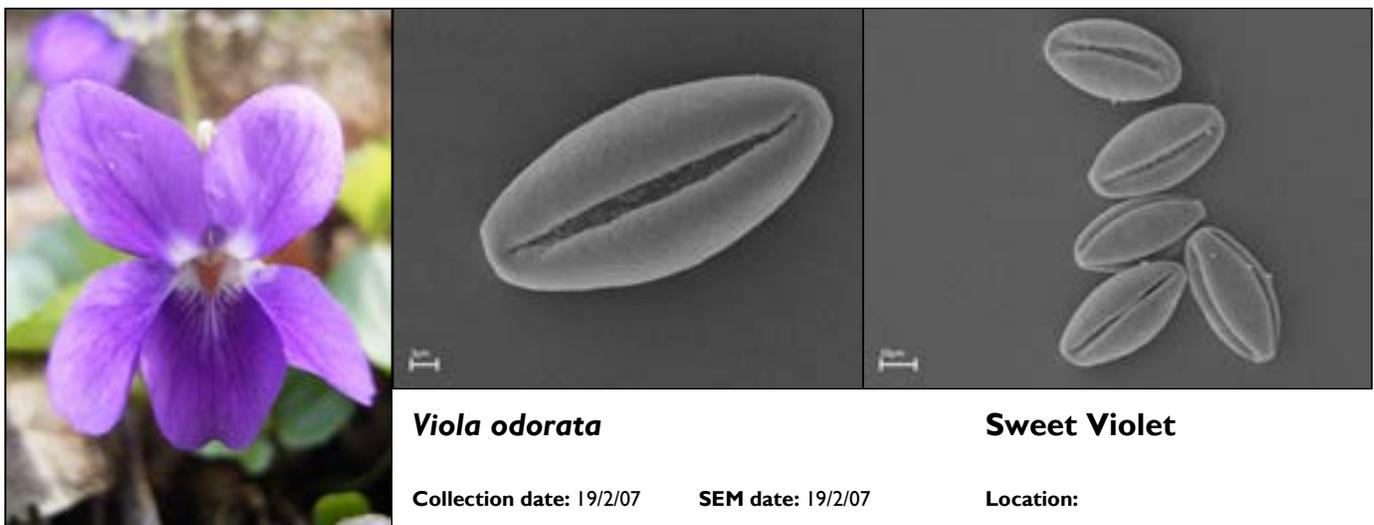
SEM date: 29/6/07

Field Pansy

Location: Clayton, West Sussex

Viola arvensis is a pentazonocolporate grain with a psillate-scabrate sculpture and with a flat or slightly concave apocolpia. The grain is pentangular in polar view with the exine projecting in the porous region at the equator. Each colpus has an equatorial bridge, constriction or rupture. The colpi are wide, obtuse ended and are purported to have granulate membranes which may be difficult to see if the colpi are rolled in as in the images above.

A native plant found both on cultivated and waste ground. Height: 50cm.

***Viola odorata***

Collection date: 19/2/07

SEM date: 19/2/07

Sweet Violet

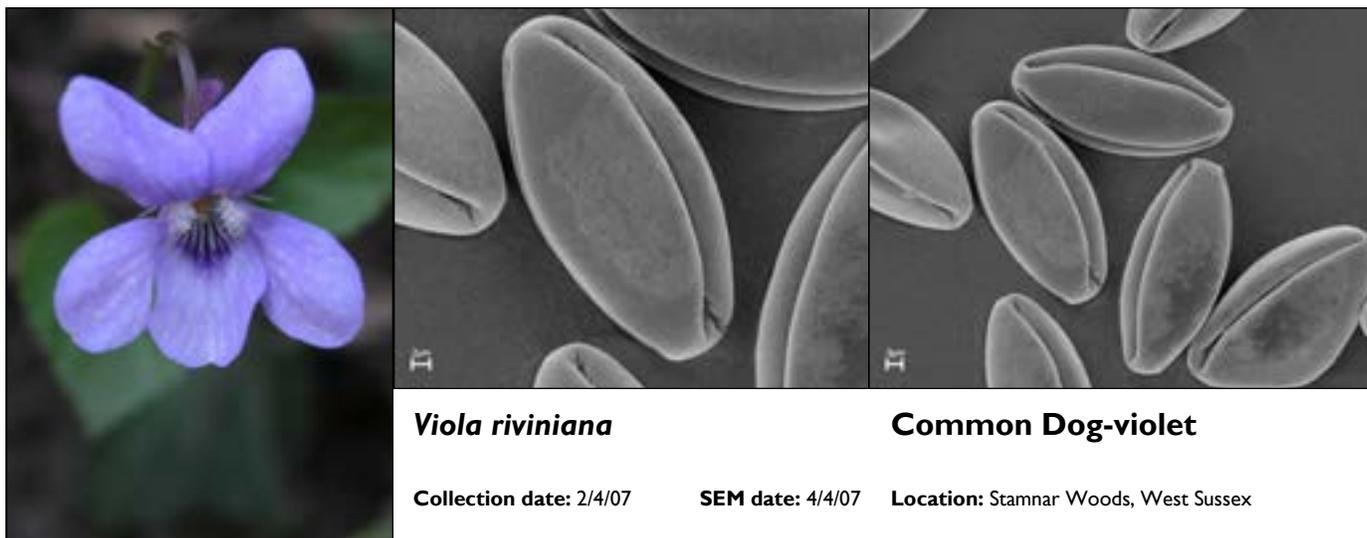
Location:

Viola odorata pollen grains are elliptic to rhombic-obtuse in equatorial view but appear elliptic in polar view. Pollen grains are tetrazonocolporate with long colpi terminating at or close the poles. The pori are not large and thus not easily seen in the magnifications above. Each colpus has a constriction rupture or equatorial bridge and is obtuse ended. The apocolpia appears flat to concave while the sculpture is psillate-scabrate. The colpus membrane is granulate.

A native woodland plant found on base rich soils. Height: 5cm.

Floral image: <http://upload.wikimedia.org/wikipedia/commons/thumb/3/33/Viola-odorata-closeup.jpg/450px-Viola-odorata-closeup.jpg>

Family: *Violaceae*



Viola riviniana

Common Dog-violet

Collection date: 2/4/07

SEM date: 4/4/07

Location: Stannar Woods, West Sussex

Viola riviniana pollen grains are elliptic to rhombic-obtuse in equatorial view but appear elliptic in polar view. *V. riviniana* pollen grains are tetrazonocolporate with long colpi terminating at or close to the poles. The pori are not large and thus not easily seen in the magnifications above. Each colpus has a constriction rupture or equatorial bridge and is obtuse ended. The apocolpia appears flat to concave while the sculpture is psillate-scabrate.

A native plant found on a wide range of wooded sites. Height: 20cm.

***Violaceae* family summary.**

Viola odorata and *Viola riviniana* pollen grains are elliptic to rhombic-obtuse in equatorial view but appear elliptic in polar view. Pollen grains are tetrazonocolporate with long colpi terminating at or close the poles. The pori are not large and thus not easily seen in the magnifications above. Each colpus has a constriction rupture or equatorial bridge and is obtuse ended. The apocolpia appears flat to concave while the sculpture is psillate-scabrate. *V. odorata* colpus membrane is granulate whereas it is not in *V. riviniana*.

Viola arvensis is a pentazonocolporate grain with a psillate-scabrate sculpture with flat or slightly concaved apocolpia. The grain is pentangular in polar view with exine projecting in the porous region at the equator. Each colpus has an equatorial bridge, constriction or rupture. The colpi are wide, obtuse ended and are purported to have granulate membranes which may be difficult to see if the colpi are rolled in as in the images above. As such it is distinct from both *V. odorata* and *V. riviniana* but similar to *Polygala* although not so that the two could be confused.

Discussion, summary and conclusions.

Discussion and Summary

In the family summary section of this paper I have encapsulated the pollen morphological characteristics for each species depicted and compared and contrasted them to other family members. In addition plants from one family may have been compared and contrasted to another family if they identical morphologic characteristics. Additionally the summary section following the family has suggested preliminary conclusions regarding the effectiveness of SEM in pollen analysis. This has resulted in what I consider to be some potentially outstanding taxonomic issues regarding pollen morphology of some plants relative to their floral attributes when subjected to scrutiny in their familial relationships. Technical problems such as heavy coatings (tectum) on some pollen types rendering detailed examination of sculptural detail difficult are also explored. Mention in also made to type collection comparison for species that show some variability within single collections but also lack detail that may distinguish them to a class in only one sampling interval. Hence, for a summary review and detailed conclusions for a specific genus, species, variety or cultivar refer to the appropriate family summary. Presented here is a summary of the results regarding the development of a SEM database, the role of SEM in plant science relationships and what the future may hold for the field of palynology.

The summary section of this research will endeavor to discuss and answer the following five questions regarding the role of SEM and its relationship to palynology:

1. Is SEM the only choice in pollen analysis?
2. What is a type collection and is it necessary?
3. Automatic counting and pollen recognition, why?
4. Is there a need for the development of further palynology resources?
5. Is a pollen key useful in identification?

It is fortunate that most genera analyzed under SEM show distinct and recognizable morphological differences thus enabling classification to the species level. There are several instances though where SEM does not resolve pollen morphological differences to a degree that is acceptable: a genus level of classification only is a common occurrence. Some pollen grains where a extensive tectum covers underlying sculptural detail the morphological characteristics of that pollen grain are hidden, not permitting the identification to possibly even the genus level let alone further refinement to the species level. Simple tools are available to easily resolve this issue, in the form of an acetolysis wash. Further details about this technique are presented in the family summary where appropriate (*Euphorbiaceae*).

However there are many genera that do not have detectable differences even when surface sculpturing is clearly visible, examples are the *Poaceae* and *Taxaceae* families, where classification based on pollen morphology stops at the genus level. Technology such as confocal microscopy and modern light microscopy need to be included here to possibly further refine and

define pollen morphology. Skvarla *et al* (2003) through transmission electron microscopy (TEM) has examined the annulus –pore of several members of the *Poaceae* family in the hope of resolving some of these outstanding classification issues and even though this approach has worked on another complex and confusing family, *Plantaginaceae*, additional detailed study is warranted to determine if such analysis could be used on all members of the family. Even then we may not be able to definitely classify all pollen grains to the species level and I suspect certainly not to the variety, subspecies, cultivar or interspecific hybrid levels.

Is SEM the only choice in pollen analysis?

Thus there is no one piece of technology or tool that will provide all the answers in understanding pollen morphology, instead we must rely upon a combination of them. The majority of the images available in databases and on the internet are LM stained slides of pollen and although these provide necessary detail about cell wall, pori circumference and sculptural thicknesses these tools still do not produce a clear 3 dimensional or easily understandable visual image of the pollen grain: SEM does. Thus the combination of the two tools, or even three, TEM, may provide a comprehensive understanding of a particular pollen grain. Again this may not always be as conclusive as we would like it to be, we only have to look once again at such families as *Poaceae* and *Taxaceae* where grains appear similar under both imaging regimes and even with TEM (*Poaceae*), morphological classification issues are still unresolved.

Science is part of a process where we focus on a specific detail or issue in relationship to a much more complex ‘picture’, This process occurs in pollen analysis, where we develop an interest in the structure of the pollen grain but may not include or relate it to the larger picture, where did it come from and how did it get here? These are questions we need to ask

ourselves especially when trying to analyze and understand pollen morphology. I believe it is important to realize that part of that 'big' picture is to understand the relationship between the pollen grain and its source; the flower. In other words, if pollen grains characteristics are similar within a given family shouldn't the pollen morphology be also? I believe the answer to that question should be yes; but a yes which requires further clarification. If we examine the *Rosaceae* family, one of the largest plant families in the world , a group that is very complex and produces many natural hybrids yet with numerous subfamily levels, we begin to understand the complexity with which we are faced; some plant taxonomy and pollen morphological characteristics do not relate to members of even the same genus (Stace, 1991) . Does this mean that we need to reclassify plants? In some cases I think we do, as we are at present and will continue to do so as new technologies and our understanding of plant familial relationships continue to grow. The International Code of Botanical Nomenclature (ICBN) is a work in progress, we only have to look at the recent re-classification of the *Aceraceae* and *Hippocastanaceae* families to the *Sapindaceae* family. These two groups of plants I learned, not so long ago were organized in their separate families (*Aceraceae* and *Hippocastanum*) and although they remain in separate subfamilies they are now in the same family. What caused this familial upheaval, was it pollen morphology? No. Was it DNA analysis? Yes, partially, but it was also a review of the morphological characteristics of the plant itself. If we examine the two types of pollen grains (*Acer* and *Hippocastanum*) f we see similarities in pollen size, shape and sculpturing elements but we can also detect characteristics that may be also common to other families.

What is a type collection and is it necessary?

This research has made repeated reference to type collections. Moore *et al* (1991) in the book *Pollen analysis, second edition* which is primarily concerned with quaternary palynology recommends the establishment of a type slide collection as a matter of common procedure. Since Moore's work relies primarily on LM images and was written before the rapid advancement of digital technology such a collection the importance of such a resource could be understood. However the primary disadvantage of holding a static collection of slides is that it would not have been readily accessible unless of course one visited Oxford. Referring to a type collection in this research it should be assumed that it refers to a database of images. It is agreed that both LM and SEM and possibly TEM images are tools that should be employed in pollen analysis and hence images from all technologies should be included in such a database. Through the process of this research readily accessible images that could be compared to current SEM images developed at the University of Sussex have been difficult if not, in many cases impossible to find. The simple summary of internet searches for SEM pollen images on page reinforce the lack of material accessible. Additionally the forensic exercise on page 25 where one pollen grain is shown that has no comparative data is yet another example of a dearth of reference material available; although this issue is easily resolvable through a site visit and interviews with the onsite researchers such resources may not always be so readily accessible.

Throughout this research efforts have been made to collect pollen at source, from verifiable plant populations so that reliable SEM images are developed. However, flower character and pollen morphological relationships should not be ignored, the *Brassicaceae* family is an example of pollen/flower morphology relationships since the pollen is identical to its relatives as is

the flower structure. *Mentha aquatica* shares the attributes of the *Brassicaceae* family even though it resides in the *Lamiaceae* family: should this plants familial relationship be questioned based on both flower and pollen morphology?

Automatic counting and pollen recognition, why?

Developing a map of past vegetative patterns, assessing climate change and plant interactions and predicting pollen counts and potential sources of allergens requires both an intricate knowledge of pollen morphology but additionally massive amounts of information to support the conclusions of such research: the greater the pollen numbers analyzed the sharper the picture realized. Quaternary palynology must look at thousands of pollen grains to build an accurate picture of a small area. Lacourse and Gajewski viewed over 5000 pollen samples that had to be manually identified before they could begin to understand the past plant species range around Sulphur Lake in the southwest Yukon Territory, Canada. In 35 core sample of lake sediment over 50 pollen grains per sample were observed under SEM in the analysis of the Lake Cristol area in the French Alps in an attempt to understand and map the range of *Pinus* species and compare it to present day ranges (Nakagawa *et al*, 2000).

Thus we can see that the argument for automatic recognition and counting of pollen samples would play a significant role not only in this one field of palynology but others. Consider aeropalynology; subject collected samples from wind traps (page 6) analyzing with SEM and an automatic recognition tool and waiting for the results. We could conceivable build a very accurate if not daily picture of pollen rain and the species producing it producing accurate regional warning and alerts.

Automatic pollen grain recognition is not a new tool, it has been successful in a number of cases already. Rodriguez *et al* (2003) has use it successfully on members of the Urticaceae family, with over 80% accuracy. Jato *et al* (1999) has used automatic recognition and counting in aeropalynology studies looking at allergens in Japan, their research attributes an 84.43% success rate in grouping pollen to five genera.

Automatic pollen grain recognition needs a model or a set of models that the compute can map and produce the 'blueprint' that is required in automatic recognition. To be as accurate as possible pollen types need to mapped that are cover all of the potential (or as many as are known) variables for a specific genus or species of plant; thus a source of information is required. The development of a database of information could be that source, a source not only using the University of Sussex's library of pollen images but might also include individual researches work or other institutions work. Such institutions might include; The Royal Botanic gardens, Kew, The Royal Botanic Gardens, Edinburgh and Dublin Botanic Gardens to name a few.

Is there a need for the development of further palynology resources?

There are as previously stated few resources available on the internet that deal will pollen imaging in any credible way, however there is also a significant lack in printed resources dealing in a more general nature with pollen analysis. What little there is deals principally with quaternary palynology and not with current pollen imaging and floral relations and the modern world of pollen. Both the University of Sussex and the Royal Botanic Gardens, Kew and Wakehurst have very limited printed resources available. The principal sources relate primarily to quater-

nary palynology and include the primary reference work by Moore *et al* (1991) entitled *Pollen analysis: second edition, Textbook of pollen analysis* (Fageri and Iversen, 1989) and the rather slim pictorial book *Atlas of airborne pollen grains and spores in Northern Europe* (Nilsson, *et al*, 1977).

New and fresh resources are needed, the *Atlas of airborne pollen grains and spores in Northern Europe* is a good pictorial resource although limited in scope but even though it contains photography that is outdated it is one of the few texts to compare and analyze pollen grains through both SEM and LM. *Pollen analysis: second edition*, seems to be today, the main reference book on pollen, frequently cited in palynology papers and websites. It has an excellent key (although directed towards fossilized pollen) and a limited but useful section of LM and SEM images. Its limitation is that it is based primarily in quaternary analysis. A fresh approach I believe is needed, a combination of the two, new and more comprehensive images of SEM and LM are required, include an analysis of flower morphology and pollen relationships, a revised key that is simple to use and a discussion on current issues and their relationship to palynology such as climate change, plant evolution relationships, aeropalynology and allergens. Of course this will all depend upon the intention and audience who would use such a resource!

Is a pollen key useful in identification?

A comprehensive pollen key is a critical tool in the field of palynology. The pollen key in *Pollen analysis: second edition* by Moore *et al* (1991) has been indispensable during the course of this research and although a key is included in *Textbook of pollen analysis* (Fageri and Iversen, 1989) the key in *Pollen analysis: second edition* is simple to use and provides much more descriptive detail on pollen grain morphology. That said however, it took almost a week of repeated use

to even begin to fully comprehend the complex terminology involved. It is understood that such terminology must exist to provide clear and concise relationships between itself and the pollen morphological characteristic it is depicting however for the casual "lay person" I believe such terminology would be overwhelming and discouraging.

A pollen key is essential but however I believe at times overly complex and needs to be adapted from user to user. If for example a lawyer called an expert witness to describe incriminating pollen evidence in a criminal prosecution and used the terminology common to palynology (see glossary) in describing pollen evidence to a jury I am sure they would be confused at best if not overwhelmed. This is confirmed by Horrocks and Walsh (1996) who state that "the court is assisted by having the scientist assess the evidence and present it in a manner which is more readily understood by lay people".

Conclusion

From clouds of pollen produced by anemophilous trees, to the traditional zoogamous route where these tiny projectiles are carried on the backs of 'beasts' to the incestuous, miserly, autogamous self pollinators it is in the quiet woods, on the chalk downs, or along the rivers edge that the world becomes a botanical battlefield for self-preservation and acquisition of new territory.

It is in the garden trenches of nature that pollen, deposited, transported or preserved produces a botanical fingerprint that can yield so much knowledge both now and of lives lived. Pollen has aided our understanding of plant evolution, the work of bees, solved crimes, caused allergies, told us what people ate and where they traveled thousands of years ago, predicted wind currents, traveled across oceans and assists us in understanding and predicting the effects of climate change.

Pollen does so much, it does what it is supposed to do; fertilize plants resulting in the continuation of life on earth, but unknowingly it does much, much more. However, our understanding of pollen morphology and its use in modern science is still very limited and in its infancy, few well developed, accessible databases exist and even fewer books; we need to know more and we are ready to learn, hence towards a national pollen database.

Glossary of palynology related terms.

Apocolpium: The area at the end of a zonocolpate pollen grain delineated by the terminus of the colpus

Aeropalynology: The study of pollen and spores in the air (often relating to allergies)

Anemophilous: A plant that produces massive amounts of pollen and is wind pollinated.

Autogamous: Plants that are self pollinating and as such produce little pollen.

Baculum: A sculptural element that is longer than broad and always higher than $1\ \mu\text{m}$: Bacula, singular. Baculate-to have.

Clavae: A series of projections on a pollen grain which is higher than it its broad and narrower at its base than its terminus: Clava-singular, Clavate-to have.

Colpate: More than one colpi.

Colpus: A furrow or groove that traverses the pollen grain, the length must be \Rightarrow than 2 X width: Colpi-singular.

Columellae: Small rod like elements that are attached to the tectum at the top and at the bottom to the nexine.

Columellate: With columellae.

Costa: A collar or thickening, maybe ridge-like around an aperture.

Dizonocolpate: In equatorial view having two colpi.

Echinae: Pointed or conical elements around the outside of the grain.

Echinate: Having echinae.

Endoaperture: Aperture in nexine.

Endocracks: Fissures, cracks or gaps in the nexine.

Endoporus: An endoaperture that may be faintly circular or elliptic: length/width ration <2 .

Equatorial Bridge: An interruption of the colpus at the equator where the mesocolpia joins together over the colpus.

Glossary of palynology related terms continued.

Equatorial Girdle: A circular Endoaperture circumventing the equator of a zonocolporate pollen grain.

Eureticulate: The tectum is partially dissolved with the arrangement of the columellae often corresponding to that of the muri.

Foveolae: Large perforations in the tectum, but narrower than the area between each Perforation: Foveolate-to have.

Gemma: A sculptural element that is has a width the same as the height but is narrows at its base.

Heterocolpate: Colpi may be apertures while other apertures are colpi and pori.

Hexangular: The shape of a six sided polygon, referring to pollen grain shape.

Hexapantocolpate: Scattered over the surface in no apparent arrangement are six colpi.

Hexapocolporate: Scattered over the surface in no apparent arrangement are six colpi with a porus to each colpi.

Hexapantoporate: Scattered over the surface in no apparent arrangement are six pori.

Hexazonocolpate: Six colpi arranged in the equatorial zone.

Hexazonolcolporate: Six colpi arranged in the equatorial zone with each having a pori.

Hexazonoporate: Six pori arranged in the equatorial zone.

Infratectal bacula: Slim rods which traverse the bases of the echinae and the thickness of the tectum.

Intectate: No tectum is present, the sculptural elements are free, i.e.: *Geranium* pollen grains.

Lacuna: In echinolophate pollen grains it is a large gap, or tall ridge.

Lumen: The gap between the walls of a structure of a reticulate, striate or rugulate grain: Lumina-plural.

Melissopalynology: The study of pollen in honey often relating to unifloral honey certification

Meridional: the features of a grain that run from the distal to the proximal pole.

Glossary of palynology related terms continued.

Mesocolpium: The surface area between two adjacent colpi.

Microechinate: Echinae less than 1 μm in height.

Microreticulate: With lumina less than 1 μm in diameter.

Microrugulate: With rugulae less than 1 μm in diameter.

Monocolpate: Having one colpus.

Monoporate: having one pori.

Muri: A wall or ridge separating lumina of a reticulate, striate or rugulate grain.

Nexine: An unsculptured portion of the inner exine.

Operculum: A thick membrane over the porus of colpus, often forming a ridge: Operculate-
to have.

Pentapantocolpate: Scattered over the surface in no apparent arrangement are five colpi.

Pentapantocolporate: Scattered over the surface in no apparent arrangement are five colpi
with a porus to each colpi.

Pentapantocolporate: Scattered over the surface in no apparent arrangement are five pori.

Pentazonalcolpate: Five colpi arranged in the equatorial zone.

Pentazonocolporate: Five colpi arranged in the equatorial zone each with a pori.

Pentazonoporate: Five pori arranged in the equatorial zone.

Perforate: Small holes, less than 1 μm in diameter piercing the tectum.

Pila: A rod like element with a swollen end, i.e.: Ilex: Pilate-to have.

Pollinosis: An allergic medical condition prevalent in some individuals caused by a reaction
to pollen grains in the air.

Pollen rain: Pollen grains that are found in the air and can be carried great distances by air
currents.

Glossary of palynology related terms continued.

Polyantocolpate: Scattered over the surface in no apparent arrangement are more than six colpi.

Polyantocolporate: Scattered over the surface in no apparent arrangement are more than six pori.

Polyzonocolpate: More than six colpi arranged in the equatorial zone.

Polyzonalcolporate: More than six colpi arranged in the equatorial zone each with a pori.

Porus: An aperture with a length/breadth ratio less than 2: Porate-to have.

Porus membrane: A thin layer of exine covering the pori.

Psilate: Smooth, lacking sculpture.

Rectangular-obtuse: An oblong pollen grain with rounded corners.

Reticulum: Mesh like sculptural elements.

Rugulate: Sculpturing elements with the length/breadth ratio of 2 or greater.

Sacci: Sack like elements i.e.: *Pinus* sp.: Saccate-to have.

Scabrae: Sculptural elements less than 1 μ m high: Scabrate-to have.

Semitectate: Partially absent tectum.

Sexine: The outer part of the exine that is sculptured.

Simplicolumellate: Columellae in one row under each murus.

Striate: Pattern of parallel muri and lumina, more or less running in rows.

Suprareticulate: Sculpturing that is independent of columellae, reticulum on top of the tectum.

Syncolpate: Two or more colpi fused at their ends.

Tectum: As tectate but forming the outer layer of the sexine: Tectate-to have.

Tetrad: Four pollen grains joined as a group.

Glossary of palynology related terms continued.

Tetrapantocolpate: Scattered over the surface in no apparent arrangement are four colpi.

Tetrazonocolpate: Four colpi arranged in the equatorial zone.

Tetrazonocolporate: Four colpi arranged in the equatorial zone, with each colpi having a porus in its centre.

Tetrazonoporate: Four pori arranged in the equatorial zone.

Trizonocolpate: Three colpi arranged in the equatorial zone.

Trizonocolporate: Three colpi arranged in the equatorial zone, with each colpi having a porus in its centre.

Trizonoporate: Three pori arranged in the equatorial zone.

Unifloral: Originating from one species of plant, often relating to the content on honey derived from the nectar of one plant.

Verrucae: Nodules or wart-like elements, broader than height: Verrucate-to have.

Vestibulum: A small chamber, in the vicinity of the porus, where the sexine and nexine have split: Vestibulate-to have.

Zonoaperture: Either pori or colpi running in a band around the equator.

Zonoaporate: Pori running in a band around the equator.

Zonocolpate: Colpi running in a band around the equator.

Zonocolporate: Colpi running in a band around the equator, with each colpus having a porus in its centre.

Zoogamous: Plants that produce moderate amounts of pollen and depend on pollinators (animals, birds, insects and beetles) for pollination.

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