The Northwest European Pollen Flora, 37

UMBELLIFERAE

W. PUNT

Laboratory of Palaeobotany and Palynology, State University, Utrecht (The Netherlands)

LITERATURE

Aytuğ et al. (1971), Caturian (1948), Cauwet-Marc et al. (1978), Cerceau (1959), Cerceau-Larrival (1962, 1963, 1965, 1967a, b, 1971, 1973, 1981), Cerceau-Larrival and Carbonnier-Jarreau (1980), Cerceau-Larrival and Roland-Heydacker (1972, 1976, 1978), Cerceau-Larrival et al. (1977), Erdtman (1943, 1952), Erdtman et al. (1961, 1963), Faegri and Iversen (1975), Fereira and Purper (1972), Gruas-Cavagnetto and Cerceau-Larrival (1978, 1984), Guyot et al. (1980), Kuprianova and Alyoshina (1972), Larrival-Cerceau (1955a, b), Mandenova et al. (1978), Moore and Webb (1978), Nigaud (1977, 1978, 1980), Nilsson et al. (1977), Roland-Heydacker and Cerceau-Larrival (1978), Silvestre (1972), Tavoda (1982), Van der Pluym and Hideux (1977), Van Zeist et al. (1977), Visset (1972).

INTRODUCTION

The family Umbelliferae is a large one with 2850 species (Cerceau-Larrival, 1967b). It is well represented in Europe with some 500 taxa grouped into ca. 110 genera. Its pollen grains are usually very distinctive with their characteristic inner and outer outlines, slit-like ectocolpi and broad, band-like costae. Most important for the recognition of the very characteristic “bone” shape, however, is the inner contour which is more stable than the variable outer contour. Family characters have been mentioned by several authors in general pollen keys (Erdtman et al., 1963; Faegri and Iversen, 1975; Moore and Webb, 1978). Another source of information is the descriptions in regional pollen floras (Aytuğ et al., 1971; Kuprianova and Alyoshina, 1972).

The most important studies on pollen morphology, however, are those of Cerceau-Larrival. Since 1959 she has published a great deal on the Umbelliferae. She was the first to recognize a number of characteristics that are important for the identification of Umbelliferae pollen: P/E ratio, outline of the inner contour and outline of the outer contour, variation of the exine thickness at the poles, the shoulders and in the equatorial area, the length of the ectocolpus, features of the endoaperture, etc. (Cerceau, 1959). Using these characteristics she was able to construct a key to Umbelliferae pollen from France and North Africa (1959). Later, this key was modified and extended to include a number of other well-known umbellifers (1962). Both keys demonstrate well the variation within the family. One of these characteristics, the variation of the sexine at the poles, shoulders and equatorial area, has proved to be most valuable.

In 1962, Cerceau-Larrival introduced a classification of the Umbelliferae in which the family was divided into five groups. This classification was afterwards improved (1971) and, together with Roland-Heydacker (1976), refined with the aid of SEM and TEM studies. These groups, which have been termed "pollen types" were arranged as follows:

Pollen type I: The sub-rhomboidal type is characterized by: (a) small size ($P = 15-25 \mu\text{m}$); (b) P/E ratio = 1–1.5; (c) thin exine ($1-2 \mu\text{m}$); (d) even thickness of the exine; (e) large endoaperture; (f) long ectoaperture. An example of this most primitive type is *Bupleurum*.

Pollen type II: The subcircular type, which evolved from the sub-rhomboidal type has practically the same characteristics, but its shape is somewhat more spherical. Examples are *Actinotus* and *Xanthosia*, both genera from the Southern Hemisphere.

Pollen type III: The oval type is characterized by: (a) larger size ($P = 25-35 \mu\text{m}$); (b) P/E ratio 1.5–2; (c) thicker exine; (d) exine rather uneven in thickness; (e) large endoaperture; (f) long ectoaperture. Examples of this type are *Crithmum*, *Cicuta* and *Heracleum*.

Pollen type IV: The subrectangular type is characterized by: (a) lengthening of the pollen grains ($P = 35-45 \mu\text{m}$); (b) P/E ratio about 2; (c) exine thick; (d) increased unevenness of the exine; (e) endoaperture smaller; (f) ectoaperture shorter. The most frequent type in the family.

Pollen type V: The equatorially constricted type is characterized by: (a) large size ($P = 50-70 \mu\text{m}$); (b) P/E ratio over 2; (c) exine proportions extreme; (d) exine thickness very uneven; (e) endoapertures small; (f) ectoapertures short. Examples of this most complex pollen type are the groups Echinophorae, Tordyliinae and Caucalideae (e.g. *Orlaya*).

Despite the significance of these pollen groups for the understanding of phylogenetic lines within the family, they comprise too many taxa to be of practical use in the present Flora. In most of Cerceau's later publications much attention is given to phylogeny, but her interesting theories are beyond the scope of the present work.

Detailed comment on Cerceau's publications are made in the section on morphology (pp. 157–162) and under the relevant types.

One of the most important publications on pollen types in the Umbelliferae has appeared in the report of palynological investigations in western Iran (Van Zeist et al., 1977). Under their chapter on pollen types many from the Umbelliferae have been described. Of course, most of the Iranian species are absent from Northwest Europe, but many of the genera described also occur here. Van Zeist et al. described the following pollen types from Iran: (1) *Anisosciadium* type; (2) *Bunium* type; (3) *Bupleurum* type; (4) *Eryngium* type; (5) *Ferula* type; (6) *Malabaila* type; (7) *Pimpinella* type; (8) *Sium erectum* type; (9) *Thurgenia* type. From these types, numbers 1, 5 and 9 do not include genera represented in Western Europe. Most types are rather variable and comprise more than one genus, but they group the genera in a broad way. Van Zeist has also illustrated several fossil pollen grains; from his plates it was possible to correlate them with modern taxa. Comments on the genera and the fossil pollen grains are given under the relevant pollen types.

MORPHOLOGY

General

Pollen grains of the Umbelliferae have a number of characteristic features and most types are easily recognized by one or more obvious features. Nevertheless, identification can be difficult because all features are variable to some extent; some more so than others. Despite this, if the characteristics are used in combination, correct identification can be achieved. Variation in pollen characteristics and their suitability for use in the identification is discussed below.

Pollen class

The number of apertures is remarkably constant in the Umbelliferae. All Northwest European taxa have pollen with three compound apertures. Aberrant pollen grains with more or fewer apertures occur only rarely.

P/E ratio

In her publications, Cerceau-Larrival has recognized discrete groups of P/E ratios (such as $P/E = 1.5$, $P/E = 2.0$) but has also shown that species can be variable in this respect (e.g. $P/E = 1.5-2.0$). This variability has been confirmed in the present study; most species were found to have pollen with a large variation in their P/E ratio. Because of this I have not used P/E ratio as a differential characteristic in the main key. This is in sharp contrast to Cerceau's (1959, 1962) keys in which it is used as the principal characteristic for the identification of the pollen.

Apertures

Ectoaperture. The features of the ectoapertures show relatively limited variation within one taxon. They are always very narrow and slit-like, but they differ in length. Indeed, length is one of the most important features for differentiation and five length categories have been established in which the length of the aperture is compared with the length of the grain. The term *pd* is introduced; *pd* stands for polar distance, the vertical distance from the equator to the pole. It is equivalent to $1/2P$ and may be measured in colpus view or side view. The five categories are (Fig.1D):

colpus very long: length greater than *pd*.

colpus long: length between $3/4$ *pd* and *pd*.

colpus rather long: length between $2/3$ *pd* and $3/4$ *pd*.

colpus short: length between $1/2$ *pd* and $2/3$ *pd*.

colpus very short: length less than $1/2$ *pd*.

Sometimes the ectocolpus shows special characteristics. For example, it may have indistinct margins (e.g. *Myrrhis odorata*) or diffuse ends (*Heracleum* spp.).

(A)

(B)

(C)

(D)

(E)

Endoaperture. Cerceau-Larrival (1962) suggested that the outline of the endoaperture is of utmost importance for the identification of the pollen of the Umbelliferae. I concur with this view for a number of pollen types (e.g. *Scandix pecten-veneris* type, *Trinia glauca* type). In many other pollen types, however, the differences are small and rather difficult to circumscribe. Moreover, the variability of specimens within taxa makes it difficult to use this character with confidence in the key. Apart from the outline, some other features are of importance: its length may be elongated (e.g. *Peucedanum* spp.) or short (e.g. *Falcaria vulgaris*); its width broad (e.g. *Sium latifolium*) or narrow (e.g. *Sison amomum*). The margins are usually distinct, but may be convex or straight under the ectocolpus. The ends are either diffuse or distinct, rounded or tapering and rarely with horns (e.g. *Cicuta virosa*). Sometimes the endoapertures are protruding (*Chaerophyllum hirsutum*, *Bifora radians*), which has implications for the outline in cross-section. Both the inner contour and the outer contour near the colpus are then yoke-like. In some types the endoapertures look like pori, but this is usually the result of a complex arrangement in which part of the endoaperture is elongated and another part protrudes. This protruding part gives a porus-like impression (e.g. *Aethusa cynapium*).

The sexine near the endoaperture gives a striking, but variable, appearance. Several pollen types show a distinct raising of the sexine just above the endoaperture, as part of the harmomegathic system (Wodehouse, 1935) (e.g. *Meum athamanticum*, *Bupleurum* spp.). Normally such a raising of the sexine also implies the presence of a fastigium, but after a close examination of the endoaperture, a true splitting of the exine (see definition of the fastigium: Reitsma, 1970) is often not visible or only very small and indistinct. The nexine and sexine layers are closely associated in the endoaperture area and the nexine ends abruptly without showing any splitting. The raised sexine also influences the outline. In equatorial view at the colpus side, when the outer contour is straight or slightly convex, there are apiculate extensions (Reitsma, 1970).

Costae

Costae are always present, but they are clearer in some pollen types than in others. Most common and characteristic for the Umbelliferae are the

Fig. 1. Scheme of terms. A. Equatorial view (side views): *a* = mesocolpium side; *b* = colpus side; *c* = shoulders; *d* = equatorial area; *e* = fastigium; *f* = raised sexine; *g* = equator; *h* = protruding pore; *k* = band-like costae; *l* = undulating tectum; *m* = irregularly edged tectum; *n* = polar cap. B. Outer contours: *a* = convex apiculate; *b* = straight, slightly apiculate; *c* = convex; *d* = rhombic. C. Inner contours: *a* = concave (1 = straight, 2 = slightly curved, 3 = distinctly curved); *b* = convex. D. Colpus view — length of colpus: *pd* = polar distance; 1 = colpus very long (colpus over *pd*); 2 = colpus long (colpus 3/4 *pd*, up to *pd*); 3 = colpus rather long (colpus between 2/3 *pd* and 3/4 *pd*); 4 = colpus short (colpus ca. 1/2 *pd* up to 2/3 *pd*); 5 = colpus very short (colpus shorter than 1/2 *pd*). E. Polar view: 1 = apertures in the sides; 2 = apertures in the corners.

broad, **band-like** costae which are present all round the equator. In surface view the band is either visible as an area of darker colour which fades away towards the poles, or in cross-section at the mesocolpium side as thickening of the nexine. Here the nexine is thicker than it is at the shoulders and poles. If sometimes the costae are restricted to the endoapertures, the nexine at the mesocolpium side is no thicker than at the shoulders or the poles (e.g. *Torilis nodosa*, *Hydrocotyle vulgaris*).

Exine

The cross-section of the exine gives important clues for distinguishing the pollen types. Especially in side view (Fig. 1A), the sexine elements have a number of variable features. The **nexine/sexine ratio** is sometimes of importance. At the poles, the nexine is normally thinner than the sexine, rarely of the same thickness (e.g. *Petroselinum segetum*). Because of the costae, the nexine increases in thickness towards the equatorial area where the nexine may be either thinner than the sexine (which is also increased), but is often as thick as the sexine or even thicker.

Sexine 1 always consists of columellae, but these columellae vary in length and breadth from area to area in Umbelliferae pollen. Some taxa have pollen in which the columellae are longer at the poles than in the equatorial area (e.g. *Angelica palustris*). In other taxa the columellae are distinctly longer in the equatorial area than at the poles (e.g. *Peucedanum* spp., *Ammi majus*). However, the most remarkable feature of the columellae is that they are often longer between the shoulders than at the equator proper. This gives the pollen grains of the Umbelliferae their characteristic bone-shaped appearance (e.g. *Pimpinella major* type, *Myrrhis odorata*). In one genus (*Heracleum*) the columellae are digitate at the poles.

Sexine 2 is a tectum, usually thin or of normal thickness, but it is very thick in *Orlaya grandiflora*. When the length of the columellae in the equatorial area is variable, sexine 2 is often distinctly undulating (e.g. *Angelica* spp.). In many other taxa, the pollen is only irregularly edged at the mesocolpium side (e.g. *Laserpitium prutenicum*) or it may be smooth (e.g. *Oenanthe fistulosa* type).

Ornamentation

The ornamentation is one of those features in the Umbelliferae that gives minimal information for the identification of pollen grains. The outer surface has a continuous variation from pertectate (*Bupleurum* at poles), simply perforate (*Hydrocotyle*), irregularly rugulate to irregularly striate or sometimes cerebroid. Cerebroid is defined thus: capita of adjacent columellae imperfectly and irregularly fused; muri very short, without particular orientation (Cerceanu-Larrival, 1971; Nigaud, 1977). Moreover, these features are only visible in the SEM; with the LM the patterns are difficult to distinguish. More information can be obtained from the cross-section of the columellae.

At the poles they vary from small, uniform, circular and crowded, to coarse, variable, irregular, angular in outline and spaced. In the mesocolpium the features of the columellae are less variable. They may differ in size from the equatorial area to the poles, but their outline and arrangement are more or less uniform.

Outlines

Cerceau-Larrival (1962) introduced the two terms "contour interne" and "contour externe", translated in this study into **inner contour** and **outer contour**. These features, as Cerceau-Larrival indicated, are extremely useful for the identification of Umbelliferae pollen. In 1962 she stated that the inner contour is more constant than the outer in any one taxon, and she therefore used this particular feature to typify the overall shape of the pollen grain, e.g. "type ovale", "type subrectangulaire" and "type equatorialo-constricté". For practical, and also for technical reasons, I prefer to use the outer contour to describe the overall shape of Umbelliferae grains. This is one of the reasons that descriptions of the shape given by Cerceau-Larrival are not always similar to those in this paper.

In the Umbelliferae there are three main outlines to consider:

(1) *Colpus view*. In this position one colpus is situated in the middle of the surface, and the other two are seen behind and at the sides. In this view the pollen grains appear bi-symmetric about the polar axis. This is the position in which the "contour interne" of Cerceau is best examined.

(2) *Side view*. In this view a colpus is situated on one side (**colpus side**) and the mesocolpium is visible in cross-section on the other side (**mesocolpium side**). Especially in this side view, the inner and outer contours of the colpus side and the mesocolpium side give important information on the identification of the pollen grains.

If the outer contour is concave, the pollen type is called "bone-shaped", in other cases the grains are elliptic. The inner contour may also vary considerably. The contour from poles to shoulders is, of course, convex, but the part of the contour that lies between the shoulders of a grain can be convex, straight or concave. It may be mentioned here that a **convex** inner contour corresponds with Cerceau's subrhomboidal, subcircular and oval types; **straight** corresponds with the subrectangular type and **concave** with the equatorially constricted type (Cerceau-Larrival, 1962, 1971). In this paper, where a contour is described, the description only refers to that section that lies between the shoulders. That section can be further subdivided into a straight, shallowly curved or distinctly curved part (Fig.1C).

At the colpus side the inner contour may be distinctly **inwardly curved** (*Caropsis verticillatoinundata*), concave, straight, convex or occasionally yoke-like (*Chaerophyllum hirsutum*). This is, however, only found in pollen types with protruding endoapertures (e.g. *Bifora radians* type). The outer

contour may similarly be convex, straight or yoke-like, but it has two additional features: (a) **rhombic** where the upper and lower sides are both straight but meet at an obtuse angle (Fig.1B) (e.g. *Pleurospermum austriacum* type, *Bupleurum* spp.); (b) **apiculate** when the sexine is conspicuously raised over the endoaperture and there is a sudden extension present in the middle of the outer contour (e.g. *Meum athamanticum*).

(3) *Polar view*. Because the P/E ratio is usually erect, pollen grains of the Umbelliferae are rarely seen in polar view. Cerceau (1959, 1962), however, stressed that features of this view are characteristic and important for the differentiation of the pollen types. I agree with this and, although the features are not often used in the key, for obvious practical reasons, they are given in the descriptions. The outline of the cross-section at the shoulders varies from more or less circular (e.g. *Heracleum*) to concave, because of the greatly extended mesocolpial areas (e.g. *Pimpinella major* type, *P. anisum* type). Also the position of the apertures in the sides differs. Normally the apertures are found in the sides (e.g. *Aegopodium podagraria*, *Silaum silaus*), but in a number of pollen types these apertures are in the corners (e.g. *Pleurospermum austriacum* type).

Polar caps

In colpus view the short sides of the outline represent the polar caps and they sometimes show characteristic differences. Usually they are obtuse, but in a few pollen types these caps are **subacute** (e.g. *Angelica* spp., *Sison amomum*).

Measurements

As usual, sizes of pollen grains are most unreliable as a characteristic for their identification. Variation can occur naturally within one taxon (e.g. *Myrrhis odorata*), or be caused by different treatments (glycerine jelly, silicone oil). It is also influenced by the position of the flowers and the level of the umbel (e.g. *Eryngium maritimum*; Van der Pluym and Hideux, 1977). However, if grains are treated in the same way and the same embedding medium is used, a relative difference in size cannot be denied and may be of interest for identification in a few cases. Within the *Sium latifolium* type, for example, *Berula erecta* grains are smaller than those of *Sium latifolium*. Also the group of species to which *Trinia glauca* and *Sison amomum* belong has distinctly smaller grains than those of *Scandix pecten-veneris*, *Orlaya grandiflora*, *Astrantia major*, etc.

SPECIMENS EXAMINED

Aegopodium podagraria L. — England: Hekking 3849 (U); Germany: Zijlstra 75105 (U); The Netherlands: Cleef, Haayman and 't Hart 138 (U), Lieftinck s.n. (U); Sweden: Fresh Material Anno 1979 (PLS).

- Aethusa cynapium* L. — Ireland: Hessel, Klein and Rubers 1884; Germany: Exc. Biol. Stud. Utrecht 1961—1941 (U); The Netherlands: Arnolds 1013 (U), Oudemans 370 (U); Scotland: Walton s.n. (U); Sweden: Fresh Material Anno 1978 (PLS).
- Ammi majus* L. — Belgium: Lejeune and Courtois 344 (U); The Netherlands: Arnolds 1005 (U); Portugal: Fernando, Fernando and Sousa 4186 (U).
- Anethum graveolens* L. — Germany: Behrendsen s.n. (U); The Netherlands: Kramer 514 (U); Spain: Exc. Biol. Stud. Utrecht 1967—1961 (U), Exc. Biol. Stud. Utrecht 1962—925 (U).
- Angelica archangelica* L. — Germany: Baeyens, de Jong and Van der Ploeg s.n. (L); The Netherlands: Heyligers s.n. (U), Kok Ankersmit 19 (U), Misset s.n. (U); Sweden: Johansson s.n. (L).
- A. heterocarpa* Lloyd — France: Exc. Biol. Stud. Utrecht 1963—3712 (U), Neyraut 3407 (BM), sin. col., s.n. (BM) Anno 1878.
- A. palustris* (Besser) Hoffmann — Germany: Taubert s.n. (L), Weiss 1 (L); Czechoslovakia: Kern and Reichgelt 10.672 (L), Otruba 447 (U).
- A. sylvestris* L. — Finland: Parvela s.n. 1928 (OULU); Iceland: Ferman and Van Hille 95 (U); Ireland: Hessel, Klein and Rubers 1404 (U); The Netherlands: Van der Aa s.n. (U), Fresh Material Rem Anno 1954; Norway: Exc. Biol. Stud. Utrecht 1970—1015 (U); Sweden: Fresh Material Anno 1979; idem Anno 1981 (PLS); Switzerland: Kintschi 1073 (U).
- Anthriscus caucalis* Bieberstein — Belgium: Van der Aa s.n. (U); France: Leeuwenberg 1340 (U), Schuurman Stekhoven 101 (U); The Netherlands: Voren s.n. (U); Sweden: Lindman s.n. (S).
- A. cerefolium* (L.) Hoffmann — Belgium: Le Jeune and Courtois 854 (U); The Netherlands: Swart 2083 (U), Buysman 332 (U).
- A. nitida* (Wahlenberg) Garcke — France: Exc. Biol. Stud. Utrecht 1983—38 (U); Poland: Jasiewicz and Piekos 147 (U), Ketner 115 (U); Switzerland: Exc. Biol. Stud. Utrecht 1946—188 (U).
- A. sylvestris* (L.) Hoffmann — Belgium: Gadella, Mennega and Kliphuis 61 (U); England: Gerrans 595 (BM); France: Exc. Biol. Stud. Utrecht 1956—664 (U); Germany: Behrendsen s.n. (U); The Netherlands: De Waal and Werkhoven s.n. (U), Fresh Material Rem Anno 1954; Idem Malotaux Anno 1979; Sweden: Fresh Material Anno 1978 (PLS).
- Apium graveolens* L. — Germany: Behrendsen 1201 (U), Rutishauser 16—46 (U); The Netherlands: Florschütz s.n. (U), Fresh Material Punt Anno 1964.
- A. inundatum* (L.) Reichenbach fil. — Denmark: Exc. Biol. Stud. Utrecht 1956—62 (U); England: Watson s.n. (U); Ireland: Exc. Biol. Stud. Utrecht 1962—2664 (U).
- A. nodiflorum* (L.) Lagasca — England: Leeuwenberg 1578; France: Florschütz s.n. (U); Ireland: Hessel, Klein and Rubers 1398 (U); The Netherlands: Den Held s.n. (U).
- Astrantia major* L. — England: Butler 532 (BM); France: Exc. Biol. Stud. Utrecht 1953—479 (U), Van Heerdt and Kramer 227 (U); Spain: Exc. Biol. Stud. Utrecht 1967—2054 (U); Austria: Buysman 340 (U).
- Berula erecta* (Hudson) Coville — Austria: Kramer and Westra 3816 (U); Ireland: Hessel, Klein and Rubers 1642 (U); The Netherlands: Westhoff s.n. (U), Fresh Material Rem Anno 1952; Sweden: Fresh Material Anno 1979 (PLS).
- Bifora radians* Bieberstein — Austria: Buysman 660 (U); Bulgaria: Markova and Černeva 854 (U); The Netherlands: Arnolds 1853 (U).
- Bunium bulbocastanum* L. — France: de Jong s.n. (U); Germany: Exc. Biol. Stud. Utrecht 1976—94 (U); The Netherlands: Groet 53 (U), Jonker s.n. (U), Kooper s.n. (U), Smit s.n. (U).
- Bupleurum aristatum* Bartling = *B. baldense* Turra.
- B. baldense* Turra — France: Exc. Biol. Stud. Utrecht 1963—3815 (U); Yugoslavia: Baretta 2 (U), Willems W-328 (U).
- B. falcatum* L. — France: Berg 4 (U), Exc. Biol. Stud. Utrecht 1953—322 (U); Germany: Exc. Biol. Stud. Utrecht 1964—2139 (U); Luxembourg: Mennega s.n. (U).
- B. gerardii* Allioni — France: Exc. Biol. Stud. Utrecht 1963—3962 (U); Portugal: Matros and Marques s.n. (U), Fernandes, Matros and Santos 5743 (U).

- B. longifolium* L. — France: Quarles van Ufford s.n. (U); Germany: Wittewaal s.n. (U), Sine Col. 764 (U).
- B. tenuissimum* L. — The Netherlands: Arnolds 1438 (U), Lindeman s.n. (U); Spain: Exc. Biol. Stud. Utrecht 1964—845 (U).
- Caropsis verticillatoinundata* (Thore) Rauschert — France: Faculté des Sciences Clermont-Ferrand s.n. (U), Lambinon s.n. (L).
- Carum carvi* L. — Andorra: Exc. Biol. Stud. Utrecht 1967—1128 (U); Germany: Exc. Biol. Stud. Utrecht 1976—54 (U); The Netherlands: Arnolds 1098 (U); Fresh Material Reitsma Anno 1964; Norway: Exc. Biol. Stud. Utrecht 1970—232 (U), Exc. Biol. Stud. Utrecht 1970—320 (U); Sweden: Ragnar Ohlsen s.n. (S).
- C. verticillatum* (L.) Koch — England: Van der Meulen, Wiegers and Willems W 70-039; France: Exc. Biol. Stud. Utrecht 1963—3541 (U); The Netherlands: Oudemans 1094 (U).
- Caucalis platycarpus* L. — England: C. I. and N.Y. Sandwith 730 (U); France: Exc. Biol. Stud. Utrecht 1961—1734 (U).
- Chaerophyllum aureum* L. — Switzerland: Exc. Biol. Stud. Utrecht 1913—160 (U), Zogg 78/098 (U).
- C. bulbosum* L. — France: H. and P.J.M. Maas 63 (U); Germany: Leeuwenberg 1624 (U), Hekking s.n. (U); The Netherlands: Neyenhuis s.n. (U).
- C. hirsutum* L. — Austria: Kramer 1326 (U), Traxler s.n. (U); France: Exc. Biol. Stud. Utrecht 1960—18 (U), idem 1965—1097 (U), idem 1965—1191 (U), idem 1965—1209 (U), Janssen and Van der Burgh 1966—12 (U); Spain: Horreus de Haas 115 (U).
- C. temulentum* L. — England: Exc. Biol. Stud. Utrecht 1968—160 (U); The Netherlands: Dijkstra 378 (U), Fresh Material Punt Anno 1961, idem Voorrips Anno 1966; Portugal: Fernandes and Sousa 3191 (U); Sweden: Fresh Material Anno 1979 (PLS).
- Cicuta virosa* L. — Germany: Sine Col. 743 (U); Ireland: Hessel, Klein and Rubers 1421 (U); The Netherlands: Arnolds 1316 (U), Hekking, Lindeman, Mulder and Westra s.n. (U), Swart 462 (U), Vegter s.n. (U), Fresh Material Punt Anno 1960, idem Voorrips Anno 1966.
- Cnidium dubium* (Schkuhr) Thellung — Denmark: Sine Col. 15032—4 (L); Germany: Zimmermann s.n. (L); Sweden: Alm 1158 (L); Czechoslovakia: Fresh Material Anno 1971.
- Conium maculatum* L. — England: Hayes 42 (BM); Finland: Hiiskonen s.n. (OULU); France: Exc. Biol. Stud. Utrecht 1961—1700 (U), Leeuwenberg 1507 (U); Ireland: Hessel, Klein and Rubers 891 (U); The Netherlands: Groet 52 (U); Sweden: Fresh Material Anno 1979 (PLS).
- Conopodium majus* (Gouan) Loret — France: Van der Burgh 1963—3068 (U), Faculté des Sciences Clermont-Ferrand s.n. (U); Ireland: Exc. Biol. Stud. Utrecht 1962—2442 (U); Scotland: Exc. Biol. Stud. Utrecht 1977—74 (U); Sweden: Fresh Material Anno 1979 (PLS).
- Coriandrum sativum* L. — The Netherlands: Dijkstra 915 (U), Exc. Biol. Stud. Utrecht 1955 s.n. (U); Sweden: Blom s.n. (U).
- Crithmum maritimum* L. — England: Hessel, Klein and Rubers 1723 (U); Wales: Mennega 42 (U); Yugoslavia: Verbeek and Lambeck 156 (U).
- Cuminum cyminum* L. — The Netherlands: Buysman 40 (U), Kok Ankersmit 24 (U), Swart 1513 (U).
- Daucus carota* L. ssp. *carota* — England: Raven and Cannon 16338 (BM); France: Florschütz s.n. (U); The Netherlands: Van Dijk s.n. (U), Fresh Material Punt Anno 1960; Spain: Exc. Biol. Stud. Utrecht 1967—1954 (U).
- D. carota* L. ssp. *gummifer* J.D. Hooker — France: Exc. Biol. Stud. Utrecht 1963—3543 (U); Spain: De Smidt 77 (U).
- D. carota* L. ssp. *sativus* (Hoffmann) Arcangeli — The Netherlands: Van Heuren s.n. (L); Sweden: Kajaani s.n. (OULU).
- Eryngium alpinum* L. — France: Quarles van Ufford s.n. (U); Switzerland: Brandenburger s.n. (U).

- E. campestre* L. — Austria: Buysman 360 (U); The Netherlands: Arnolds 1067 (U), Docters van Leeuwen-Reynvaan 6454 (U), Heyligers s.n. (U); Spain: Exc. Biol. Stud. Utrecht 1967—1750 (U).
- E. maritimum* L. — England: Mennega 40 (U), Sell 67/1654 (BM); The Netherlands: Arnolds 1063 (U); Sweden: Fresh Material Anno 1978 (2 X) (PLS).
- E. viviparum* Gay — France: Baenitz 10285 (L), Schulz Cent. 11—1068 (L).
- Falcaria vulgaris* Bernhardt — Austria: Kramer and Westra 3798 (U); France: Exc. Biol. Stud. Utrecht 1953—363 (U), idem 1961—1695 (U); Germany: Behrendsen 1211 (U), Leeuwenberg 1611 (U), Wirtgen s.n. (U).
- Foeniculum vulgare* Miller ssp. *piperitum* (Ucria) Coutinho — France: De Fouw and Sloet 44 (U), Van Heerdt and Kramer 146 (U); Italy: Smit 127 (U).
- F. vulgare* Miller ssp. *vulgare* — Ireland: Hessel, Klein and Rubers 2127 (U); The Netherlands: Arnolds 1420 (U), Bakhuizen van den Brink 4991 (U).
- Heracleum mantegazzianum* Sommier et Levier — Dixer, Holm, Nielsen and Pedersen 488 (L); The Netherlands: Hortus Acad. Leiden s.n. (L).
- H. sphondylium* L. — England: Thackeray 610 (U); Ireland: Exc. Biol. Stud. Utrecht 1962—2030 (U); The Netherlands: Fresh Material Punt Anno 1963; Sweden: Fresh Material Anno 1981 (PLS).
- H. sphondylium* L. ssp. *montanum* (Schleicher et Gaudin) Briquet — France: Krüger and Bick H.J. 62 (U); Switzerland: Kintschi 1169 (U), Herb. Boom 12052 (L).
- Hydrocotyle vulgaris* L. — Iceland: Oosterveld 0.1848 (U); Ireland: Hessel, Klein and Rubers 1427 (U); The Netherlands: Den Held s.n. (U), Uittien s.n. (U), Fresh Material Florshütz Anno 1952; Scotland: Cannon and Kendrick 298 (BM).
- Laser trilobum* (L.) Borkhausen — Germany: Schultes 43 (L), Weiss 1 (L).
- Laserpitium latifolium* L. — France: Exc. Biol. Stud. Utrecht 1953—274 (U), idem 1961—1663 (U), idem 1966—2152 (U); The Netherlands: Mennega 8192 (U); Sweden: Dahlstedt s.n. (S).
- L. prutenicum* L. — France: Sin. Col., s.n. (U); Germany: Behrendsen 1318 (U); Hungary: Behrendsen s.n. (U).
- Levisticum officinale* Koch — The Netherlands: Kok Ankersmit 18 (U), Swart 1510 (U), Punt s.n. (U).
- Ligusticum scoticum* L. — England: Exc. Biol. Stud. Utrecht 1972—2049 (U); Norway: Exc. Biol. Stud. Utrecht 1965—2427 (U); Sweden: Fresh Material Anno 1978 (PLS).
- Meum athamanticum* Jacquin — Belgium: Exc. Biol. Stud. Utrecht 1978-10; France: Janssen and Van der Burgh 1966—33 (U), H. and P.J.M. Maas 69 (U); Germany: Zijlstra 75001 (U).
- Myrrhis odorata* (L.) Scopoli — Austria: Reichenbach 1022 (U); Germany: Commijs s.n. (U); The Netherlands: Kok Ankersmit 31 (U), Mennega 7708 (U), Fresh Material Punt Anno 1961.
- Oenanthe aquatica* (L.) Poirét — Finland: Lindemans s.n. (OULU); Ireland: Hessel, Klein and Rubers 1390 (U); The Netherlands: Arnolds 1534 (U), Gadella and Mennega s.n. (U), Mennega s.n. (U), Fresh Material Rem Anno 1952, idem Punt Anno 1958; Sweden: Olsson 154 (UPS).
- O. crocata* L. — England: Exc. Biol. Stud. Utrecht 1968—126 (U), Howard 1105 (U), Thackway 604 (U); France: Exc. Biol. Stud. Utrecht 1963—3177 (U).
- O. fistulosa* L. — England: Gerrans s.n. (BM); Germany: Sine Col. 766 (U); The Netherlands: Arnolds 1684 (U), Van Dijk s.n. (U), Kooper s.n. (U), Docters van Leeuwen-Reynvaan 6582 (U), Fresh Material Punt Anno 1960, idem Rem Anno 1952, idem Voorrips Anno 1964; Spain: Gorter-ter Pelkewijk G87 (U).
- O. fluviatilis* (Babington) Coleman — England: T.A. and C. Cotton s.n. (L), C.I. and N.Y. Sandwith s.n. (L).
- O. lachenalii* C.C. Gmelin — France: Lehmann Anno 1836 (U); Ireland: Exc. Biol. Stud. Utrecht 1969—195 (U); The Netherlands: Brummer-de Vries s.n. (U), Van Dijk s.n. (U), Fresh Material Punt Anno 1961.
- O. peucedanifolia* Pollich — Germany: De Beyer s.n. (L), W.G. s.n. (L); The Netherlands: Buysman 1260 (U), Van der Sande Lacoste s.n. (L).

- O. pimpinelloides* L. — England: Exc. Biol. Stud. Utrecht 1968—145 (U); France: Sipman 78 (U); The Netherlands: Henrard s.n. (L); Portugal: Rainha 2376 (U).
- O. silaifolia* Bieberstein — England: N.Y. Sandwith 5796 (L); Germany: Graf 1194 (L); Greece: Mennega and Driehuis 131 (U).
- Orlaya grandiflora* (L.) Hoffmann — Bulgaria: Fresh Material Anno 1973; France: Exc. Biol. Stud. Utrecht 1954—277 (U); Germany: Behrendsen s.n. (U); Italy: Exc. Biol. Stud. Utrecht 1955—406/408 (U); Yugoslavia: Exc. Biol. Stud. Utrecht 1960—383 (U); Switzerland: Exc. Biol. Stud. Utrecht 1946—209 (U).
- Pastinaca sativa* L. var. *sativa* — England: Leeuwenberg 1572 (U); The Netherlands: Van der Linde-Bruynooze s.n. (U), Fresh Material Punt Anno 1961; Sweden: Fresh Material 1981 (PLS).
- P. sativa* L. var. *sylvestris* (Miller) Rouy et Camus — Spain: Cabellero s.n. (U).
- Petroselinum crispum* (Miller) Hill — England: Richards s.n. (U); The Netherlands: Dijkstra 261 (U), Dijkstra 758 (U).
- P. segetum* (L.) Koch — France: De Visser s.n. (L); The Netherlands: Sloff, Kruseman and Jansen s.n. (L).
- Peucedanum alsaticum* L. — Austria: Kramer and Westra 3965 (U); France: Exc. Biol. Stud. Utrecht 1953—358 (U), idem 1961—1714; Czechoslovakia: Švestka 1348 (U), Weber s.n. (U); Switzerland: Mennega s.n. (U).
- P. austriacum* (Jacquin) Koch — France: Barbezat 5583 (L); Greece: Mirick s.n. (L).
- P. carvifolia* Villars — Germany: Exc. Biol. Stud. Utrecht 1973—44 (U); The Netherlands: Blaauw s.n. (U), Hekking s.n. (U), De Smidt s.n. (U), Uittien s.n. (U).
- P. cervaria* (L.) Lapeyrouse — Austria: Buysman 768 (U); France: Exc. Biol. Stud. Utrecht 1953—823 (U); Czechoslovakia: Fresh Material Anno 1972.
- P. gallicum* Latourette — France: Baenitz (L); Sin. Col., s.n. Anno 1908 (L); Italy: Exc. Biol. Stud. Utrecht 1955—374 (U).
- P. lancifolium* Lange — France: Merino s.n. (U), Thiébaud 2080 (L); Portugal: Da Silva 846 (L).
- P. officinale* L. — Italy: Exc. Biol. Stud. Utrecht 1955—463 (U); Yugoslavia: Rutten-Pekelharing 310 (U).
- P. oreoselinum* (L.) Moench — France: Van Heerdt and Kramer 057 (U), Van Loon v.L. 461 (U); Germany: Zijlstra s.n. (U); Switzerland: Kramer 1536 (U).
- P. palustre* (L.) Moench — England: Herb. Redgrove s.n. (BM); Finland: Smit 212 (U); France: Exc. Biol. Stud. Utrecht 1953—780 (U); The Netherlands: Uittien s.n. (U), Fresh Material Rem Anno 1952; Sweden: Fresh Material Anno 1978 (PLS).
- Physospermum cornubiensis* (L.) De Candolle — Jackson and Thurston (L); Spain: De Smidt Sp 20 (U).
- Pimpinella anisum* L. — Germany: Jansen and Wachter s.n. (L), Koch s.n. (L); The Netherlands: Henraard s.n. (L).
- P. major* (L.) Hudson — France: Exc. Biol. Stud. Utrecht 1949—462 (U); Germany: Exc. Biol. Stud. Utrecht 1976—46 (U); The Netherlands: Van Royen 674 (U), Swart 1616 (U); Sweden: Fresh Material Anno 1978 (PLS).
- P. saxifraga* (L.) Hudson — England: Sipman 509 (U); Finland: Oinonen s.n. (OULU); France: Florschütz s.n. (U); Germany: Punt s.n. (U); Ireland: Hessel, Klein and Rubers 1608 (U); The Netherlands: Arnolds 1617 (U).
- Pleurospermum austriacum* (L.) Hoffmann — Andorra: Exc. Biol. Stud. Utrecht 1967—884 (U); Germany: Behrendsen s.n. (U); Sweden: Andersson s.n. (L), Fresh Material Anno 1976 (PLS).
- Ptychotis saxifraga* (L.) Loret et Barrandon — France: Barbezat 6088 (L), Manganotti s.n. (U); Spain: Exc. Biol. Stud. Utrecht 1962—107 (U).
- Sanicula europaea* L. — England: Dandy 843 (BM), Wilson 14 (U); The Netherlands: Stafleu s.n. (U), Fresh Material Janssen Anno 1960, idem Punt Anno 1964; Sweden: Fresh Material Anno 1976 (PLS).
- Scandix pecten-veneris* L. — Germany: Swart 1547 (U); The Netherlands: Punt s.n. (U), Hortus Utrecht 365 (U), Fresh Material Punt Anno 1960; Sweden: Magnussen s.n. (U), Fresh Material Anno 1978 (PLS).

- Selinum carvifolia* (L.) L. — Finland: Marklund s.n. (U); Germany: Exc. Biol. Stud. Utrecht 1965—814 (U); Sweden: Fresh Material Anno 1979 (PLS); Switzerland: Kramer 1470 (U).
- S. pyrenaicum* (L.) Gouan — France: Exc. Biol. Stud. Utrecht 1953—456 (U), idem 1976—111 (U), Krüger and Bick H.J.10 (U); Spain: Rutten-Pekelharing 45 (U), Bordère s.n. (U).
- Seseli annuum* L. — France: Bergen s.n. (L); Germany: Dietr 330 (U), Kirschmeyer s.n. (L); Poland: Jasiewicz and Sychowa 247 (U); Switzerland: Flütsch 1166 (U).
- S. hippomarathrum* Jacquin — Germany: Exc. Biol. Stud. Utrecht 1964—2433 (U); Czechoslovakia: Deyl s.n. (U).
- S. libanotis* (L.) Koch — Austria: Kramer and Westra 3759 (U); France: Exc. Biol. Stud. Utrecht 1953—824, Van der Knaap and Van Leeuwen PIM-100 (U); Germany: Exc. Stud. Biol. Utrecht 1964—2146 (U); Sweden: Fresh Material Anno 1976 (PLS).
- S. montanum* L. — France: Dieleman Di 20 (U), Den Held and Sikking HS 1181 (U).
- Silaum silaus* (L.) Schinz et Thellung — Austria: Kramer and Westra 3956 (U); England: Balfour 1838 (U); Germany: Exc. Biol. Stud. Utrecht 1973—48 (U), Wittewaal s.n. (U); The Netherlands: Weeda s.n. (L); Spain: De Smidt SP 106 (U); Sweden: Fresh Material Anno 1976 (PLS).
- Sison amomum* L. — England: Gerrans 1437 (L), Howard 266 (U), Hutchinson 188 (U).
- Sium latifolium* L. — The Netherlands: Mennega s.n. (U), Fresh Material Voorrips Anno 1963; Sweden: Hylander s.n. (U).
- Smyrnium olusatrum* L. — England: Hessel, Klein and Rubers 806 (U), Thackeray 601 (U); France: Lanjouw, Pfälzer and Van Raalte 187 (U); Spain: Exc. Biol. Stud. Utrecht 1951—1067 (U).
- Thorella verticillatinundata* (Thore) Briquet = *Caropsis verticillatoinundata* (Thore) Rauschert.
- Torilis arvensis* (Hudson) Link — France: Exc. Biol. Stud. Utrecht 1953—328 (U), Sipman 160 (U); The Netherlands: Oudemans 1208 (U), Fresh Material Mennega Anno 1963.
- T. japonica* (Houttuyn) De Candolle — The Netherlands: Kramer s.n. (U), Meyer s.n. (U), Fresh Material Punt Anno 1961; Sweden: Willems W-289 (U), Fresh Material Anno 1979 (PLS).
- T. nodosa* (L.) Gaertner — England: Howard 796 (U); France: Leeuwenberg 1505 (U); The Netherlands: Oudemans 29 (U); Spain: Borja s.n. (U).
- Trinia glauca* (L.) Dumortier — Austria: Kramer and Westra 4103 (U); France: Exc. Biol. Stud. Utrecht 1965—1045 (U), Hekking 588 (U); Germany: Behrendsen 1204 (U).

INTRODUCTION TO THE KEY TO THE POLLEN TYPES

(1) All characteristics used for the identification of the pollen types in the main key are distinguishable with the use of a 40 × objective and 10 × eyepiece. In the secondary keys under the pollen types the use of a 100 × oil-objective is recommended.

(2) Variation of the features is considerable so several pollen types appear more than once in the main key. If a characteristic is difficult to classify, the pollen type often keys out several times.

(3) I have tried to give more than one feature in many of the leads. The first mentioned characteristic is, however, always the most important, the remaining features represent an extra check on the first characteristic. If the first characteristic is difficult to distinguish, the remaining features may also be used for identification.

(4) The main key is separated into two large parts based on the equatorial view of the pollen grain; i.e. elliptic and bone-shaped. In many examples the

distinction is difficult to make, but here again most of the doubtful pollen grains key out at least twice.

(5) When the term **inner contour** is used in the key, it refers only to that section of the inner contour on the mesocolpium side that lies between the shoulders.

KEY TO THE POLLEN TYPES

1. a. In side view outer contour of mesocolpium side straight or convex. . . 2
 b. In side view outer contour of mesocolpium side concave, sometimes only slightly so 51
2. a. In side view outer contour of colpus side rhombic or distinctly convex-rhombic; apertures in polar view situated in the corners 3
 b. In side view outer contour of colpus side concave, straight or more or less convex, sometimes yoke-like; in polar view apertures situated in the sides 10
3. a. Grains suberect; costae narrow; columellae at the poles distinctly longer than those at the equator *Hydrocotyle vulgaris* type
 b. Grains at least semi-erect; costae narrow or broad; columellae at poles longer or shorter than those at the equator 4
4. a. Colpi very long, up to or over pd 6
 b. Colpi shorter, 1/2 to 3/4 pd 5
5. a. Columellae at poles distinctly longer than those at the shoulders; tectum undulating in equatorial area; colpi short, about 1/2 pd or a little longer *Anthriscus caucalis* type
 b. Columellae at the poles shorter than those at the shoulders and equator; tectum not or only slightly undulating; colpi up to 3/4 pd
 Torilis nodosa type
6. a. Endoaperture rectangular, distinctly protruding; in side view at colpus side distinctly rhombic *Pleurospermum austriacum* type
 b. Endoaperture an elongated porus with obtuse ends; in side view at colpus side convex-rhombic or apiculate-convex 7
7. a. In side view at mesocolpium side outer contour distinctly convex . . 8
 b. In side view at mesocolpium side outer contour straight or only slightly convex; at colpus side apiculate-convex. *Meum athamanticum* type
8. a. In colpus view outer contour distinctly rhombic
 Bupleurum falcatum type
 b. In colpus view outer contour elliptic 9
9. a. Columellae at poles short and indistinct; endoaperture very narrow and small; grains rather small ($P < 25 \mu\text{m}$) *Sison amomum* type
 b. Columellae at poles long and distinct; endoaperture elongated and rather large; grain size medium ($P > 27 \mu\text{m}$) . *Carum verticillatum* type
10. a. In side view inner contour of mesocolpium side distinctly convex; costae often relatively narrow, not always forming a band around the equator 11

- b. In side view inner contour of mesocolpium side straight, concave or curved, sometimes only slightly so; costae usually broad, forming a band round the equator.16
- 11. a. At colpus side inner contour somewhat yoke-like or convex; endoaperture slightly protruding; colpi rather long, up to 3/4 pd; polar caps obtuse.*Torilis nodosa* type
- b. At colpus side inner contour straight or concave; endoaperture not protruding; colpi long or very long up to or exceeding pd, sometimes slightly shorter; polar caps often subacute.12
- 12. a. Endocolpus large and broad, not distinctly tapering at the ends . . .13
- b. Endocolpus small and narrow, or elliptic with tapering ends.14
- 13. a. Inner contour of mesocolpium side distinctly convex; costae relatively narrow, present only around the endoaperture . . *Sium latifolium* type
- b. Inner contour of mesocolpium side slightly concave, straight or only slightly convex; costae forming a broad band around the equator.*Carum verticillatum* type
- 14. a. Columellae in equatorial area shorter or about as long as those at the poles, sometimes a little longer; tectum not undulating in the equatorial area15
- b. Columellae in equatorial area much longer than those at the poles and shoulders; tectum distinctly undulating in equatorial area.*Sison amomum* type
- 15. a. Endoaperture distinct, elliptic, rather broad, with tapering or rounded ends; distinct costae present*Apium inundatum* type
- b. Endoaperture very narrow, with indistinct ends; costae narrow, indistinct*Trinia glauca* type
- 16. a. Inner contour of mesocolpium side curved, for a short section in the equatorial area; grains large ($P > 40 \mu\text{m}$); colpi very long; endoaperture broad, elliptic with diffuse ends*Astrantia major* type
- b. Inner contour of mesocolpium side curved, or straight, not curved in the equatorial area; grains usually smaller, lacking the above combination of features17
- 17. a. Colpi very long, up to or exceeding pd in side view.18
- b. Colpi less long, rarely approaching pd29
- 18. a. Fastigium distinctly present; sexine prominently raised above endoaperture.19
- b. Fastigium small or absent; sexine only slightly raised above endoaperture.20
- 19. a. Outer contour at colpus side more or less apiculate; in colpus view endoaperture porus-like, broad and a little constricted*Meum athamanticum* type
- b. Outer contour at colpus side a little protruding, but not apiculate; in colpus view endoaperture a colpus, not constricted.*Angelica palustris* type
- 20. a. Inner contour of mesocolpium side distinctly curved21
- b. Inner contour of mesocolpium side straight or only slightly curved24

31. a. Columellae at equator longer than at poles; tectum distinctly undulating in equatorial area. *Aethusa cynapium* type
 b. Columellae at equator shorter than at poles; tectum not or very slightly undulating in equatorial area. *Chaerophyllum hirsutum* type
32. a. Columellae long at equator and/or between shoulders and equator; sexine in that position twice as thick as nexine or more33
 b. Columella length less than twice nexine thickness at equator and/or between shoulders and equator37
33. a. Columellae longest at equator, outer contour of mesocolpium side convex; sexine not raised above endoaperture; inner contour distinctly curved *Ammi majus* type
 b. Columellae in equatorial area all of about the same size or longer towards the shoulders, outer contour of mesocolpium side straight or concave, often undulating; sexine raised or not raised above endoaperture; inner contour of mesocolpium side straight or curved.34
34. a. Inner contour of colpus side distinctly concave, usually inwardly curved; sexine not raised above endoaperture
 Conium maculatum type
 b. Inner contour of colpus side straight or slightly concave; sexine somewhat raised above endoaperture35
35. a. Columellae between equator and shoulders distinctly or sometimes slightly longer than those at equator; inner contour of mesocolpium side straight; endoaperture short, but relatively broad.
 Pimpinella major type
 b. Columellae in equatorial area irregular in length, but no higher between shoulders and equator; inner contour of mesocolpium side often more or less curved, sometimes straight; endoaperture short or elongated .36
36. a. Endoaperture narrow and small with more or less convex sides; colpi short to rather long, up to $2/3$ pd *Falcaria vulgaris* type
 b. Endoaperture elongated, usually with straight margins; colpi longer, $2/3$ to $3/4$ pd or sometimes longer . . *Peucedanum palustre* type (p.p.)
37. a. Columellae at poles distinct and relatively long, longer or as long as those at equator, but tectum at poles may be thicker38
 b. Columellae at poles distinctly shorter than those at equator41
38. a. Endoaperture broadly rectangular, often porus-like, in colpus view constricted in the middle; sexine distinctly raised above endoaperture; columellae in equatorial area distinctly shorter than those at poles. . . .
 Chaerophyllum hirsutum type
 b. Endoaperture an elongated colpus; sexine may be raised above endoaperture, columellae in equatorial area as long as or slightly shorter than those at poles39
39. a. Sexine not or very slightly raised above endoaperture; inner contour of mesocolpium side usually distinctly, but rather narrowly curved; columellae at poles higher than those at shoulders, about as long as those at equator *Anthriscus sylvestris* type
 b. Sexine distinctly raised above endoaperture; inner contour of mesocolpium side straight or very shallowly curved; columellae at poles longer, as long or slightly shorter than those at equator40

40. a. Columellae in equatorial area shorter than at poles; pollen usually erect, sometimes pererect *Levisticum officinale* type
 b. Columellae at poles distinctly higher than those at shoulders, but shorter than most columellae in equatorial area; usually pererect, sometimes erect. *Carum carvi* type
41. a. Columellae at poles very short, thin and indistinct; nexine at poles about as thick as sexine or often thicker; endoapertures small with diffuse margins *Petroselinum segetum* type
 b. Columellae at poles long or sometimes short, but always distinct; nexine at poles usually thinner than sexine; endoapertures small or large, with distinct margins 42
42. a. Colpi short to rather short, usually $1/2$ to $2/3$ pd 43
 b. Colpi longer, $2/3$ to $3/4$ pd or longer; inner contour of mesocolpium side concave, straight or curved. 47
43. a. Inner contour of mesocolpium side straight 44
 b. Inner contour of mesocolpium side curved 46
44. a. Tectum in equatorial area thick and smooth, not undulating; $P > 50 \mu\text{m}$ *Orlaya grandiflora* type
 b. Tectum in equatorial area thin and undulating; $P < 40 \mu\text{m}$ 45
45. a. Columellae between equatorial area and shoulders no longer than at equator; colpus length about $1/2$ pd
 Foeniculum vulgare ssp. *vulgare* (= *Peucedanum palustre* type)
 b. Columellae slightly longer at equator than towards shoulders; colpus $1/2$ to $2/3$ pd. *Pimpinella major* type
46. a. Columellae in mesocolpium distinct in cross-section, little coarser towards poles; in equatorial view of mesocolpium side columellae distinctly longer than those at poles; margins of endoaperture usually slightly convex *Pastinaca sativa* type
 b. Columellae in mesocolpium fine and small in cross-section, distinctly coarser towards poles; in equatorial view of mesocolpium side columellae slightly longer than those at poles; margins of endoaperture straight *Anthriscus sylvestris* type
47. a. Sexine not raised; inner contour of mesocolpium side distinctly curved; inner contour of colpus side concave, usually distinctly inwardly curved *Conium maculatum* type
 b. Sexine more or less raised above endoaperture; inner contour of mesocolpium side straight or slightly concave; inner contour of colpus side usually straight 48
48. a. In colpus view inner contours straight; nexine not, or only slightly, thicker in equatorial area than at poles *Seseli libanotis* type
 b. In colpus view inner contours more or less distinctly bone-shaped; nexine usually somewhat thicker in equatorial area than at poles . . 49
49. a. Tectum in equatorial area distinctly thicker than at poles, not or only slightly irregular; columellae at shoulders often slightly shorter than at poles *Carum carvi* type

- b. Tectum in equatorial area not or only slightly thicker than at poles, usually distinctly undulating, or irregularly edged; columellae at shoulders not shorter than at poles50
- 50. a. Columellae between equator and shoulders somewhat longer than those at equator; in colpus view polar caps often subacute*Angelica archangelica* type
- b. Columellae between equator and shoulders no higher than at equator; in colpus view polar caps obtuse*Peucedanum palustre* type
- 51. a. Outer contour of colpus side rhombic to distinctly convex; grains large ($P > 30 \mu\text{m}$); columellae very short, at equator as short or even shorter than at poles*Eryngium campestre* type
- b. Not that combination of features52
- 52. a. Endoapertures much elongated laterally, fused into an endocingulum or nearly so; colpi about $1/2$ pd; grains large ($P > 35 \mu\text{m}$).*Scandix pecten-veneris* type
- b. Endoaperture less elongated and not that combination of features. .53
- 53. a. On mesocolpium side outer contour at the equator only slightly concave; inner contour solely curved in the equatorial area; colpi up to or over pd; grains large ($P > 40 \mu\text{m}$)*Astrantia major* type
- b. Inner contour not solely curved in the equatorial area and not that combination of features54
- 54. a. Colpi short or rather short with diffuse ends; columellae very coarse and distinctly visible all over grain except around the colpus ends; columellae at poles branched; grains large ($P > 40 \mu\text{m}$).*Heracleum sphondylium* type
- b. Colpi short or long, but ends distinct and not that combination of characteristics55
- 55. a. In side view on mesocolpium side columellae at shoulders very long, much less high at equator, thus forming two "humps"; in mesocolpium view two mesocolpial "islands" of distinct columellae are separated by an equatorial "canal" without distinct columellae.*Pimpinella anisum* type
- b. Pollen without that combination of characteristics56
- 56. a. Endoapertures protruding; inner contour of colpus side more or less yoke-like57
- b. Endoapertures not protruding; inner contour of colpus side concave, straight or convex, not yoke-like.63
- 57. a. Columellae at poles distinctly longer than those at equator, those between equator and shoulders may be longer58
- b. Columellae at poles shorter than those at equator or equally long. .59
- 58. a. Colpi shorter than $1/2$ pd, rather indistinct; tectum at equatorial area undulating or very irregular.*Anthriscus cerefolium* type
- b. Colpi $1/2$ to $2/3$ pd, distinct; tectum in equatorial area smooth or a little irregular*Chaerophyllum hirsutum* type
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DESCRIPTION OF THE POLLEN TYPES

Aegopodium podagraria type (Plate 1)

Pollen class: 3-Zonocolporate.

P/E ratio: Pererect.

Apertures: Ectoaperture — colpus, rather long, about $1/2$ to $2/3$ pd, narrow, slit-like, often widened above the endoaperture, sunken; margins distinct; ends distinct, acute; fastigium small or absent; sexine slightly raised above endoaperture; costae extending nearly to end of colpus. Endoaperture — colpus, outline broadly elongate, elliptic; margins distinct, straight; ends distinct or diffuse, rounded; costae very broad, band-like.

Exine: Nexine thinner than sexine at poles, distinctly thicker in equatorial area. Sexine 1 of columellae, short but distinct at poles, in equatorial area distinctly longer, uniform in length or sometimes slightly longer towards shoulders. Sexine 2 a tectum, not or slightly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate-striate in SEM. Columellae in cross-section at poles small, regular in outline and size, about circular, crowded; in mesocolpium smaller, indistinct, size not increasing towards shoulders or poles.

Outlines: Equatorial view — bone-shaped. In side view inner contour of mesocolpium side straight, outer contour concave; at colpus side inner contour straight or slightly concave, outer contour straight. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides slightly concave at shoulders.

Measurements: Glycerine jelly — P 30—(34.5)—41 μm ; E 14—(16.0)—19 μm ; P/E ratio 2.02—(2.14)—2.24. Exine thickness at poles about 2 μm , at equator about 3 μm . Silicone oil — P 29—(32.5)—37 μm ; E 13—(15.0)—17 μm ; P/E ratio 2.10—(2.21)—2.41.

Species: *Aegopodium podagraria*.

Comments

The *Aegopodium podagraria* type has no features exclusive to itself; it belongs to a group of the Umbelliferae with a number of pollen characteristics in common, differentiated only by the combination of those characteristics. Pollen of *A. podagraria* is characterized by its rather short colpus, broadly elongated endoaperture, straight to slightly concave inner contour of the mesocolpium side and its not undulating, only slightly irregularly edged tectum on the mesocolpium side. It resembles pollen in the *Peucedanum palustre* type, *Conopodium majus* type, *Conium maculatum* type, etc.

Aethusa cynapium type (Plate 2)

Pollen class: 3-Zonocolporate.

P/E ratio: Erect or occasionally pererect.

Apertures: Ectoaperture — colpus, rather long, from 1/2 to 2/3 pd, narrow, slit-like, not widened above endoaperture, sunken; margins distinct, wavy; ends rather indistinct, acute; fastigium if present, very small, but sexine distinctly raised above endoaperture; costae not apparent. Endoaperture — protruding colpus, small and narrow, outline elliptic or slightly rectangular; margins slightly convex or straight; ends rounded; costae indistinct, only visible around the endoapertures, probably broad.

Exine: Nexine thinner than sexine at poles, of equal thickness in mesocolpium and only slightly thicker around endoapertures. Sexine 1 of columellae, short, but distinct at poles, higher in equatorial area, sometimes slightly shorter at equator than towards shoulders. Sexine 2 a tectum, distinctly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate in SEM. Columellae in cross-section at poles small, but rather irregular in outline, spaced; in mesocolpium more or less uniform in size and outline, smaller than at poles, about circular.

Outlines: Equatorial view — elliptic or slightly bone-shaped. In side view inner contour of mesocolpium side straight, outer contour straight or a little

concave; inner and outer contour of colpus side slightly to distinctly yoke-like. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides straight at shoulders.

Measurements: Glycerine jelly — P 23—(27.5)—32 μm ; E 12—(13.5)—18 μm ; P/E ratio 1.55—(2.02)—2.36. Exine thickness at poles ca. 1.5 μm , at equator ca. 2 μm . Silicone oil — P 21—(24.5)—28 μm ; E 11—(12.5)—14 μm ; P/E ratio 1.69—(1.98)—2.28.

Species: *Aethusa cynapium*.

Comments

Aethusa cynapium pollen is characterized by its protruding endoaperture which is a small, elliptic colpus with diffuse ends. Other pollen types with protruding endoapertures, such as the *Bifora radians* type, have rectangular endopori so *A. cynapium* is easy to recognize. The type has also some resemblance to the *Chaerophyllum hirsutum* type from which it differs mainly in its columellae which are distinctly higher in the equatorial area than at the poles. The *Torilis japonica* type differs from *A. cynapium* in its costae and the inner contour of the mesocolpium side.

Ammi majus type (Plate 3)

Pollen class: 3-Zonocolporate.

P/E ratio: Usually pererect, sometimes erect.

Apertures: Ectoaperture — colpus, short, about 1/2 pd, slit-like, not or slightly widened at equator, slightly sunken; margins distinct, wavy; ends distinct, acute; fastigium absent or small; sexine slightly raised above endoaperture; costae colpi long, extending nearly to colpus ends. Endoaperture — colpus, not protruding, elliptic in outline; margins straight or a little convex; ends distinct, rounded; costae broad, band-like around equator.

Exine: Nexine thinner than sexine at poles, slightly thickened in the equatorial area, but much thinner there than the sexine. Sexine 1 of columellae, short and distinct at poles, much higher at equator. Sexine 2 a tectum, undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate-striate in mesocolpium, more or less striate at poles in SEM. Columellae in cross-section at poles relatively small and uniform in size, more or less circular, crowded. Columellae in mesocolpium distinct and larger in cross-section than those at poles.

Outlines: Equatorial view — elliptic. In side view inner contour of mesocolpium side concave, distinctly curved, outer contour distinctly convex with very long columellae; inner contour of colpus side concave or straight, outer contour straight to a little convex. Polar caps obtuse. Polar view — triangular; in cross-section at shoulders, sides straight or a little concave; apertures in the sides.

Measurements: Glycerine jelly — P 30—(33)—39 μm ; E 15—(16)—18 μm ; P/E ratio 1.88—(2.03)—2.16. Exine thickness at poles ca. 2.5 μm , at equator up

to 6.0 μm . Silicone oil — P 26—(28)—31 μm ; E 11—(13)—15 μm ; P/E ratio 1.95—(2.17)—2.36.

Species: Ammi majus.

Comments

Pollen of *Ammi majus* is characterized by its very long columellae at the equator, the distinctly curved inner contour of the mesocolpium side and the short colpus. Some other pollen types also have long columellae in the equatorial area (e.g. *Anethum graveolens*), but these types are less distinctly elliptic in equatorial view.

Angelica archangelica type (Plate 4)

Pollen class: 3-Zonocolporate.

P/E ratio: Usually pererect, sometimes erect.

Apertures: Ectoaperture — colpus, long, about $3/4$ pd, narrow, slit-like, not or slightly widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent, sexine slightly but distinctly raised above endoaperture; costae present for half colpus length. Endoaperture — colpus, elliptic in outline, large, broadly elongated; margins straight to slightly convex; ends distinct or diffuse, rounded; costae broad, band-like.

Exine: Nexine thinner than sexine at poles, distinctly thicker in equatorial area. Sexine 1 of columellae, short and distinct at poles, slightly longer at equator, in equatorial area towards shoulders slightly longer than at poles, more or less twice as thick as nexine. Sexine 2 a thin but distinct tectum, distinctly undulating in the equatorial area.

Ornamentation: Psilate, irregularly rugulate ("cerebroid") in SEM. Columellae at poles coarse, irregular in size and outline, angular, spaced; in mesocolpium distinct, but more circular, increasing in size from equator to shoulders and poles.

Outlines: Equatorial view — usually bone-shaped, sometimes elliptic. In side view inner contour of mesocolpium side concave, slightly curved, outer contour usually slightly concave, sometimes straight; on colpus side inner contour straight to slightly concave, outer contour straight to slightly concave. Polar caps obtuse to slightly subacute. Polar view — triangular with apertures in sides; sides slightly concave at shoulders.

Measurements: Glycerine jelly — P 31—(32.5)—36 μm ; E 12—(14.5)—16 μm ; P/E ratio 2.09—(2.25)—2.55. Exine thickness at poles ca. 2.5 μm , at equator ca. 3 μm . Silicone oil — P 27—(30.5)—33 μm ; E 12—(14.0)—16 μm ; P/E ratio 1.93—(2.20)—2.53.

Species: Angelica archangelica.

Comments

Angelica archangelica pollen most resembles that of *A. heterocarpa* and *A. sylvestris*, but these latter taxa are united with the *Peucedanum palustre* type because at the equator their columellae are not noticeably shorter than

they are towards the shoulders. *Angelica palustris* pollen differs in having the columellae at the equator distinctly shorter than those at the poles.

A few pollen features are characteristic for most *Angelica* species; viz. the subacute polar caps and the distinctly undulating tectum in the equatorial area.

Van Zeist et al. (1977) figured a fossil pollen grain under their *Bunium*-type (fig.18, 16) which undoubtedly belongs to one of the *Angelica* pollen types. From the illustration it most resembles the *Angelica archangelica* type because of its subacute polar caps, long colpi, distinctly undulating tectum in the equatorial area and longer columellae towards the shoulders.

Angelica palustris type (Plate 5)

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, very long, up to or exceeding pd, narrow, slit-like, not widened at equator, sunken; margins distinct, but wavy; ends distinct, acute; small fastigium present, sometimes indistinct; sexine distinctly raised above endoaperture. Endoaperture — colpus, elliptic in outline, large and broadly elongated; margins distinct, straight; ends distinct, subacute or rounded; costae broad, band-like.

Exine: Nexine thinner than sexine at poles, but equally thick or even thicker at equator. Sexine 1 of columellae, short but distinct at poles, equally short at shoulders, but distinctly thinner and shorter at equator. Sexine 2 a tectum, irregularly edged in equatorial area.

Ornamentation: Psilate, irregularly rugulate in SEM. Columellae in cross-section at poles relatively small, uniform in size and outline, more or less circular, crowded; in mesocolpium columellae smaller in size.

Outlines: Equatorial view — side view usually bone-shaped, sometimes elliptic. In side view inner contour of mesocolpium side slightly concave or straight, outer contour concave or straight; on colpus side inner contour straight or slightly concave, outer contour straight with a small but distinct raising of the exine above endoaperture, apiculate. Polar caps obtuse to subacute. Polar view — triangular with apertures in the sides, in cross-section at shoulders concave.

Measurements: Glycerine jelly — P 32—(37.0)—42 μm ; E 15—(17.5)—21 μm ; P/E ratio 1.78—(2.08)—2.26. Exine thickness at poles ca. 2 μm (nexine <1 μm), at equator exine ca. 2.5 μm (nexine >1.5 μm). Silicone oil — P 28—(32.0)—36 μm ; E 15—(16.5)—18 μm ; P/E ratio 1.79—(1.92)—2.13.

Species: *Angelica palustris*.

Comments

Pollen of this type resembles *Meum athamanticum* pollen in many characteristics. In particular, the outline in side view is remarkably similar. *Angelica palustris* pollen is sometimes a little bone-shaped and the sexine on the colpus side is somewhat less raised above the endoaperture. The very long

colpi and columellae, which are distinctly shorter at the equator than at the poles, are features shared by both types. Differentiating characteristics for *A. palustris* are: (a) in polar view the apertures are in the sides; (b) in colpus view the endocolpus margins are not constricted; (c) the ends of the endoaperture are more or less distinct, subacute to rounded.

Van Zeist et al. (1977) illustrate a fossil pollen grain under their *Ferula* type (fig.19, 7, 8, 9) which shows the features of the *Angelica palustris* type. The subacute polar caps, so characteristic for all *Angelica* pollen, are combined with a distinctly raised sexine above the endoaperture and columellae which are distinctly shorter at the equator than at the poles.

Anthriscus caucalis type (Plate 6)

Pollen class: 3-Zonocolporate.

P/E ratio: Erect.

Apertures: Ectoaperture — colpus, short to rather long, about 1/2 pd or a little longer, sometimes up to 2/3 pd, slit-like, not widened above endoaperture, not sunken; margins rather indistinct, wavy; ends distinct, acute; fastigium, if present, very small; sexine slightly raised above endoaperture; costae colpi absent. Endoaperture — short colpus or elongated porus, more or less rectangular in outline; margins distinct; ends distinct, rounded or truncate; costae narrow.

Exine: Nexine at poles distinctly thinner than sexine, at equator about as thick as sexine or slightly thicker. Sexine 1 of columellae, distinctly longer at poles than at equator, shorter at shoulders and irregular in length in equatorial area. Sexine 2 a thin tectum, distinctly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate-striate in SEM. Columellae in cross-section at poles irregular in size and outline, the smaller more or less circular, the larger angular, rather coarse, spaced; in mesocolpial area small, indistinct, crowded.

Outlines: Equatorial view — elliptic or slightly rhombic. In side view inner and outer contours of mesocolpium side convex; on colpus side inner contour slightly convex or straight, outer contour slightly convex to slightly rhombic. Polar caps obtuse. Polar area — cross-section at equator circular or slightly triangular with apertures in the sides.

Measurements: Glycerine jelly — P 20—(23.0)—28 μm ; E 13—(14.5)—18 μm ; P/E ratio 1.41—(1.59)—1.74. Exine thickness at poles ca. 2 μm , at shoulders ca. 1 μm , at equator ca. 1.5 μm . Silicone oil — P 18—(20.0)—22 μm ; E 12—(12.5)—15 μm ; P/E ratio 1.39—(1.57)—1.76.

Species: *Anthriscus caucalis*.

Comments

Pollen of *Anthriscus caucalis* is distinctly elliptic to slightly rhombic and, most remarkably, the colpi are not sunken. As in the two other species of *Anthriscus*, *A. cerefolium* and *A. sylvestris*, the columellae at the poles are longer than those at the shoulders. *A. caucalis* differs in its distinctly elliptic

outline and also its size. It has some features in common with other pollen types that have a clearly elliptic outline, such as the *Sison amomum* type and the *Trinia glauca* type, but these types have much longer colpi.

***Anthriscus cerefolium* type (Plate 7)**

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, short or very short, about 1/2 pd or less, slit-like, rather indistinct, not widened at equator; margins wavy; ends distinct, acute. Fastigium small; sexine distinctly raised above endoaperture; costae as long as colpus. Endoaperture — colpus, usually a little protruding; outline broadly elliptic at low focus, at higher focus rectangular with truncate ends; at low focus ends obtuse; costae broad, band-like.

Exine: Nexine thinner than sexine at poles, distinctly thicker at equator (costae). Sexine 1 of columellae, distinct and long at poles, clearly shorter at equator; longer between shoulders and equator than at them. Sexine 2 a tectum, of constant thickness, undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate-striate, and more striate towards poles, in SEM. Columellae in cross-section at poles coarse, irregular, angular in outline, spaced. In mesocolpium columellae small and indistinct at equator, but more distinct toward the poles and very distinct at poles.

Outlines: Equatorial view — a little bone-shaped. In side view inner contour of mesocolpium side concave, outer contour concave; on colpus side inner contour somewhat yoke-like because of protruding endoaperture; outer contour somewhat apiculate. Polar caps obtuse. Polar view — triangular, cross-section at shoulders with straight to slightly convex sides and apertures in the sides; at equator triangular with acute angles because of protruding apertures.

Measurements: Glycerine jelly — P 28—(32.0)—35 μm ; E 14—(16.0)—18 μm ; P/E ratio 1.88—(2.01)—2.18. Exine thickness at poles ca. 4 μm ; at equator ca. 4 μm because of thick nexine; at shoulders 3 μm . Silicone oil — P 24—(27.5)—29 μm ; E 11—(13.0)—15 μm ; P/E ratio 1.70—(2.09)—2.41.

Species: *Anthriscus cerefolium*.

Comments

Anthriscus cerefolium pollen is characterized by its very short colpi and its columellae which are distinctly shorter at the equator than the poles. Also characteristic are the slightly protruding endoapertures, but this feature is variable and not always clearly visible. *A. caucalis* differs from it in its distinctly elliptic outline, while *A. sylvestris* pollen has more uniform columellae in the equatorial area and its sexine is less raised above the endoaperture.

Pollen of *A. cerefolium* resembles closely that of the *Chaerophyllum hirsutum* type. It differs in its very short colpi and undulating or very irregular tectum in the equatorial area.

Anthriscus sylvestris type (Plates 8, 9)

Pollen class: 3-Zonocolporate.

P/E ratio: Usually pererect, sometimes erect.

Apertures: Ectoaperture — colpus, short to rather long, ca. 1/2 to 2/3 pd, slightly sunken, narrow, slit-like, not widened above endoaperture; margins distinct, wavy; ends distinct or obscure; fastigium absent; sexine not or slightly raised above endoaperture; costae colpi broad, up to half length of colpus. Endoaperture — elliptic, narrowly elongated in outline; margins distinct, straight; ends distinct, obtuse; costae thick and broad, band-like.

Exine: Nexine thinner than sexine at poles, distinctly thickened at equator, sometimes thicker than sexine. Sexine 1 of columellae, at poles often longer than those at shoulders; those at equator equally long or slightly longer. Sexine 2 a tectum, sometimes thicker at equator, not undulating in equatorial area, but slightly irregularly edged.

Ornamentation: Psilate, irregularly rugulate-striate in SEM. Columellae in cross-section at poles coarse, irregular in size and outline, more or less spaced; in mesocolpium distinct, but smaller in size and circular in outline.

Outlines: Equatorial view — elliptic. In side view inner contour of mesocolpium side distinctly curved over a short section of the equatorial area or shallowly curved, outer contour straight or a little convex; on colpus side inner contour concave, sometimes straight, outer contour not or a little convex. Polar caps obtuse. Polar view — triangular with apertures in the straight sides.

Measurements: Glycerine jelly — P 28–36 μm ; E 13–19 μm ; P/E ratio 1.71–(2.07)–2.27. Exine thickness at poles ca. 2 μm , at equator ca. 3 μm , because of the thick costae. Silicone oil — P 24–33 μm ; E 11–16 μm ; P/E ratio 1.85–(2.05)–2.30.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Anthriscus nitida</i>	28–(30.0)–32	14–(14.5)–16	2.04–(2.06)–2.17
<i>A. sylvestris</i>	28–(31.5)–36	13–(15.0)–19	1.71–(2.07)–2.27
	Silicone oil		
<i>A. nitida</i>	27–(29.0)–32	13–(14.0)–15	1.93–(2.05)–2.20
<i>A. sylvestris</i>	24–(29.0)–33	11–(14.0)–16	1.85–(2.05)–2.30

Species: *Anthriscus nitida*, *A. sylvestris*.

Comments

Pollen of the *Anthriscus sylvestris* type is rather variable and the type appears in several parts of the key. The most reliable feature for recognition is the curved inner contour of the mesocolpium side, which is distinctly or shallowly curved. Another useful character is the length of the columellae. Often the columellae are longer at the poles than at the shoulders and about

as long at the equator, but this characteristic is not consistent. More consistent is the absence of a fastigium and the sexine, which is not, or only slightly, raised above the endoaperture. The endoaperture itself is also of importance for the characterization of the pollen type; it is an elongated, rather narrow colpus with distinct, obtuse ends and more or less straight sides. Pollen of this type is very variable, but the combination of characteristics makes it distinct from other types in the Umbelliferae.

Pollen of *Anthriscus sylvestris* and *A. nitida* cannot be separated by pollen morphology.

The *A. sylvestris* type differs from *A. caucalis* in its larger size and less elliptical outline, and from *A. cerefolium* by its more uniform size, the length of its columellae in the equatorial area and the absence of a raised sexine.

If its columellae at the poles are not longer than those at the shoulders, which occasionally occurs, pollen of the *A. sylvestris* type is difficult to separate from the *Pastinaca sativa* type and *Conium maculatum* type. The latter, however, has longer colpi and the columellae in the equatorial area are distinctly longer than those at the poles. The *Pastinaca sativa* type differs mainly in its distinctly longer columellae at the equator and the convex margins of its endoaperture. The *Carum carvi* type also has some resemblance to the *A. sylvestris* type, but it can be differentiated by the more shallowly and longly curved inner contour of the mesocolpium side. Its sexine is, moreover, distinctly raised above the endoaperture.

Van Zeist et al. (1977) illustrate a fossil pollen grain under their *Bunium* type (fig.18, 17) which probably belongs to the *Anthriscus sylvestris* pollen type. The differentiating characteristics of short colpus, long polar columellae, distinctly curved inner contour of the mesocolpium side and indistinctly raised sexine above the endoaperture place this fossil pollen grain in the *Anthriscus sylvestris* type, but the single micrograph is not sufficient to be sure.

***Apium inundatum* type (Plates 10–12)**

Pollen class: 3-Zonocolporate.

P/E ratio: Erect.

Apertures: Ectoaperture — very long, usually over pd, slit-like, not or rarely slightly widened at equator, sunken; margins distinct, wavy; ends acute, distinct; fastigium absent; sexine not or only slightly raised above endoaperture; costae absent. Endoaperture — colpus, elliptic, narrow, usually tapering towards the ends; margins distinct, convex; ends acute; costae distinct, but relatively narrow, nor forming a band around the equator.

Exine: Nexine thinner than sexine at poles and equator. Sexine 1 of columellae, sometimes a little longer at poles, usually a little longer at equator, sometimes equally long at poles as at equator. Sexine 2 a tectum not undulating in equatorial area, smooth or slightly irregularly edged.

Ornamentation: Psilate, rugulate-striate in SEM. Columellae in cross-section small, uniform in size and outline, more or less circular, crowded.

Outlines: Equatorial view elliptic. In side view inner and outer contours of mesocolpium side convex. On colpus side inner contour straight or curved; outer contour straight or a little convex. Polar caps subacute. Polar view — triangular with apertures in the sides. In cross-section at shoulders sides straight to slightly concave.

Measurements: Glycerine jelly — P 22–33 μm ; E 14–18 μm ; P/E ratio 1.38–1.93. Exine thickness ca. 2 μm at poles, ca. 2.5 μm at equator. Silicone oil — P 19–26 μm ; E 10–16 μm ; P/E ratio 1.42–1.90.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Apium graveolens</i>	22–(23.5)–26	14–(15.0)–16	1.43–(1.54)–1.77
<i>A. inundatum</i>	23–(24.0)–26	15–(16.0)–17.5	1.38–(1.55)–1.79
<i>A. nodiflorum</i>	23–(28.0)–33	14–(15.0)–18	1.70–(1.81)–1.93
	Silicone oil		
<i>A. graveolens</i>	19–(23.0)–25	11–(12.0)–14	1.45–(1.72)–1.90
<i>A. inundatum</i>	22–(24.0)–25	14–(15.0)–16	1.42–(1.56)–1.75
<i>A. nodiflorum</i>	20–(22.0)–26	10–(13.0)–15	1.62–(1.73)–1.89

Species: *Apium graveolens*, *A. inundatum*, *A. nodiflorum*.

Key to the species

1. a. Outer contour of mesocolpium side usually straight or only slightly convex; columellae in equatorial area distinctly longer than those at poles; colpi very long, penetrating well into the polar area *Apium graveolens*
- b. Outer contour of mesocolpium side usually more or less convex; columellae in equatorial area not or only slightly raised in a small part of the area; colpi long, but not penetrating deeply into the polar area. . . . 2
2. a. Columellae in equatorial area only raised over a small area near the equator; sexine not raised above endoaperture *Apium inundatum*
- b. Columellae in equatorial area not or gradually increasing from shoulders to equator; sexine often slightly raised above endoaperture *Apium nodiflorum*

Comments

The pollen of the three *Apium* species in Western Europe can be separated only with difficulty and there are many transitions between them.

Pollen of the *Apium inundatum* type is characteristic in its size and shape, but these features are shared with the *Trinia glauca* and the *Sison amomum* types. Differences are mainly found in the distinct endoaperture and the thick costae.

Cerceau (1959) and Cerceau-Larrival (1962) treated the species *Apium inundatum* and *A. nodiflorum* under the genus *Helosciadium*. These aquatic *Apium* species do indeed have pollen grains which are somewhat different

from the true *Apium* species *A. graveolens*, but the differential characters are rather hard to distinguish and the overall resemblance is so evident that a taxonomic separation on the base of pollen morphology is not supported by the present study.

***Astrantia major* type (Plates 13–15)**

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, very long, up to or over pd; narrow, slit-like, not or slightly widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium, if present, small; sexine only slightly raised above endoaperture; costae absent. Endoaperture — colpus; margins distinct, straight; ends diffuse, sometimes with horns; costae distinct, but narrow and not in a band.

Exine: Nexine thinner than sexine except at equator (costae). Sexine 1 of columellae, short but distinct, at poles usually longer than at equator, or of about the same length. Sexine 2 a tectum, not undulating in equatorial area, sometimes a little thicker at poles.

Ornamentation: Psilate, irregularly rugulate (“cerebroid”) in SEM. Columellae in cross-section at poles relatively small, irregular in size, more or less circular, crowded; in mesocolpium columellae regular in size and outline.

Outline: Equatorial view — usually bone-shaped, sometimes elliptic. In side view inner contour of mesocolpium side concave, the equatorial section short, either shallowly or distinctly curved; outer contour slightly concave or slightly convex. On colpus side inner contour straight or slightly concave; outer contour straight or slightly convex. Polar ends subacute. Polar view — triangular apertures in the sides; sides at shoulders concave.

Measurements: Glycerine jelly — P 43–57 μm ; E 20–28 μm ; P/E ratio 1.73–2.27. Exine thickness at poles and equator ca. 2–3 μm . Silicone oil — P 41–53 μm ; E 18–27 μm ; P/E ratio 1.70–2.31.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Astrantia major</i>	46–(51.0)–57	20–(25.0)–28	1.73–(2.03)–2.36
<i>Sanicula europaea</i>	43–(46.0)–50	20–(22.0)–24	1.98–(2.07)–2.27
	Silicone oil		
<i>Astrantia major</i>	45–(48.5)–53	22–(24.5)–27	1.87–(2.01)–2.13
<i>Sanicula europaea</i>	41–(43.5)–46	18–(21.5)–26	1.70–(2.01)–2.31

Species: *Astrantia major*, *Sanicula europaea*.

Key to the species

1. a. Inner contour of mesocolpium side only shallowly curved; exine at poles usually thicker than at equator. *Sanicula europaea*

- b. Inner contour of mesocolpium side distinctly curved over a short section of the equatorial area; exine at poles not noticeably thicker than at equator *Astrantia major*

Comments

The *Astrantia major* type is characterized by its very long colpi, its inner contour of the mesocolpium side which is distinctly curved for a short section, its subacute polar caps and large size. It has some resemblance to the *Scandix pecten-veneris* type, but it differs in its long colpi and subacute polar caps.

The two genera belonging to the *A. major* type are remarkably similar in the main features of their pollen morphology. The best feature to differentiate between them is the inner contour of the mesocolpium side. The horns which are often present at the ends of the endoapertures of *Sanicula* pollen are noteworthy but not conclusive for identification.

Pollen of the *Astrantia major* type resembles that of the *Eryngium campestre* type in many features. Both types have large-sized pollen, very long colpi and broadly elongated endoapertures with diffuse ends. The outlines, however, are very different. In side view pollen of the *Eryngium campestre* type is distinctly convex or rhombic on the colpus side and shortly concave to more or less constricted on the mesocolpium side, whereas that of the *Astrantia major* type is less pronounced in its curves and more or less straight.

Bifora radians type (Plates 16, 17)

Pollen class: 3-Zonocolporate.

P/E ratio: Pererect.

Apertures: Ectoaperture — colpus, narrow, slit-like, short, about 1/2 pd or shorter, not widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent, but sexine distinctly raised above endoaperture; costae distinct, extending to ends of colpus, broad, band-like. Endoaperture — protruding, porus-like or short colpus, outline elliptic; margins straight, ends diffuse or distinct, obtuse, rounded; costae distinct, broad, band-like.

Exine: Nexine thinner than sexine at poles, distinctly thickened in the equatorial area (costae). Sexine 1 of columellae, short, but distinct at poles, about the same length or longer at equator, distinctly longer towards shoulders in equatorial area and there more than twice as thick as nexine. Sexine 2 a tectum, undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate ("cerebroid") in SEM. Columellae in cross-section at poles coarse, irregular in size and outline, more or less angular, sometimes the smaller ones circular, spaced; in mesocolpium columellae in cross-section smaller than at poles, circular, distinctly increasing in size towards poles.

Outlines: Equatorial view — bone-shaped. In side view, inner contour of mesocolpium side distinctly concave, straight; outer contour concave; on

colpus side inner and outer contour more or less yoke-like. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides at shoulders straight or a little concave, slightly concave at equator with distinctly bulging apertures.

Measurements: Glycerine jelly — P 31–38 μm ; E 13–16 μm ; P/E ratio 2.09–2.67. Exine thickness varying from 1.5 to 2 μm at poles and 2 to 3.5 μm in equatorial area towards shoulders. Silicone oil — P 29–33 μm ; E 12–14 μm ; P/E ratio 2.10–2.69.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Bifora radians</i>	31–(33.0)–35	13–(15.0)–16	2.09–(2.24)–2.41
<i>Coriandrum sativum</i>	32–(35.5)–38	13–(14.5)–16	2.28–(2.49)–2.67
	Silicone oil		
<i>B. radians</i>	29–(29.5)–32	12–(13.0)–14	2.10–(2.27)–2.38
<i>C. sativum</i>	31–(32.0)–33	12–(13.0)–14	2.27–(2.50)–2.69

Species: *Coriandrum sativum*, *Bifora radians*.

Comments

Like *Cuminum cyminum*, *Coriandrum sativum* is a well-known spice, which is often cultivated and occurs as a garden escape in Northwest Europe. *Bifora radians* is also not a native of Western Europe, but is casually naturalized (Tutin et al., 1968).

Pollen of the *Bifora radians* type is easily recognized by its protruding endoapertures, pererect P/E ratio and long columellae towards the shoulders. The endoaperture is often porus-like but variation in its length is considerable so elliptic endoapertures are also common.

Bifora radians and *Coriandrum sativum* are much alike and show many taxonomic features in common (Hegi, 1925–1926). Their pollen is also much alike and cannot be separated on morphological features. There is a tendency of *Coriandrum* pollen to have a higher P/E ratio and to have columellae which are longer at the shoulders, but the overlap is too large to be a reliable means of separating them.

***Bupleurum falcatum* type** (Plates 18–20)

Pollen class: 3-Zonocolporate.

P/E ratio: Semi-erect to erect.

Apertures: Ectoaperture — colpus, long to very long, usually up to or over pd, rarely slightly shorter (*B. baldense*), narrow, slit-like, sunken; margins distinct, wavy, not widened at equator; ends distinct, acute; fastigium usually distinctly present, sometimes small; sexine distinctly or sometimes slightly raised above endoaperture; costae colpi extending half way to the poles. Endoaperture — colpus, broadly rectangular; margins straight, ends diffuse,

truncate with rounded angles; costae, if visible, broad, band-like but thin, therefore often indistinguishable in surface view and only visible as a thickening of the colpus margin in cross-section.

Exine: Nexine thinner than sexine at poles, not or only slightly thickened in equatorial area. Sexine 1 of columellae, slightly or distinctly longer at poles than at equator, sometimes of about the same length. Sexine 2 a tectum, not undulating in equatorial area, smooth or at most slightly irregularly edged.

Ornamentation: Psilate, irregularly rugulate in SEM, but pertectate at poles. In cross-section columellae at poles distinct, uniform in size and outline, circular, crowded; in mesocolpium less distinct, and smaller.

Outlines: Equatorial view — usually distinctly rhombic, sometimes elliptic-rhombic. In side view inner and outer contour on mesocolpium side convex; on colpus side inner contour convex, outer contour more or less distinctly rhombic. Polar caps obtuse. Polar view — triangular with apertures in the angles; in cross-section at shoulders, sides straight or slightly convex.

Measurements: Glycerine jelly — P 19–30 μm ; E 14–22 μm ; P/E ratio 1.17–1.66. Exine thickness varying from 1.5 to 2.5 μm . Silicone oil — P 17–26 μm ; E 13–18 μm ; P/E ratio 1.22–1.63.

	P (μm)	E (μm)	P/E
Glycerine jelly			
<i>Bupleurum baldense</i>	21–(22.5)–25	14–(15.0)–17	1.27–(1.47)–1.66
<i>B. falcatum</i>	19–(23.5)–26	15–(16.0)–17	1.17–(1.47)–1.66
<i>B. gerardii</i>	19–(21.0)–25	14–(16.0)–18	1.27–(1.33)–1.42
<i>B. longifolium</i>	26–(28.0)–30	17–(19.0)–22	1.24–(1.49)–1.65
<i>B. rotundifolium</i>	20–(20.5)–22	15–(15.5)–17	1.28–(1.32)–1.38
<i>B. tenuissimum</i>	20–(21.5)–24	15–(16.0)–18	1.17–(1.34)–1.51
Silicone oil			
<i>B. baldense</i>	18–(21.0)–23	13–(14.0)–15	1.39–(1.48)–1.61
<i>B. falcatum</i>	22–(22.5)–25	14–(15.0)–16	1.41–(1.48)–1.58
<i>B. gerardii</i>	20–(23.0)–26	14–(15.5)–18	1.29–(1.45)–1.63
<i>B. longifolium</i>	23–(24.5)–26	16–(17.0)–18	1.34–(1.43)–1.50
<i>B. rotundifolium</i>	17–(18.0)–19	13–(14.0)–15	1.25–(1.29)–1.33
<i>B. tenuissimum</i>	18–(19.5)–21	14–(15.5)–17	1.22–(1.27)–1.33

Species: *Bupleurum baldense*, *B. falcatum*, *B. gerardii*, *B. longifolium*, *B. rotundifolium*, *B. tenuissimum*.

Key to the species and groups

1. a. In colpus view colpi not reaching pd, but ending just below the exine; columellae at poles about as long as those at equator or only slightly longer *B. baldense*
- b. In colpus view, colpi reaching or exceeding pd; columellae at poles longer than those at equator 2
2. a. Outline of colpus side convex-rhombic; grains relatively large (P > 26 μm) *B. longifolium*

- b. Outline of colpus side distinctly rhombic; grains relatively small ($P < 27 \mu\text{m}$) *B. falcatum* group
 . . (Species: *B. falcatum*, *B. gerardii*, *B. rotundifolium*, *B. tenuissimum*)

Comments

Pollen of *Bupleurum* species is easily distinguished by its distinctly rhombic outline in colpus view, its columellae which are longer at the poles than at the equator, its broad, often rectangular endoaperture and its small size.

The *Hydrocotyle vulgaris* type resembles this type most closely but differs in its P/E ratio which is suberect, and its narrow costae.

The *Apium inundatum* type also resembles the *Bupleurum falcatum* type in some characteristics, but it is very different in its elliptic outline and narrow endoaperture.

Van Zeist et al. (1977) illustrated under their *Bupleurum* type pollen of several recent species and they all belong to the *Bupleurum falcatum* type. In the text they also included the genera *Smyrnum* and *Physospermum*, two taxa which in this study have been combined with *Pleurospermum* in the *Pleurospermum austriacum* type (p. 228). The fossil pollen grain figured (fig. 18, 12) probably belongs to the genus *Physospermum*.

In Cerceau's key (1959) a number of *Bupleurum* species have been identified based on the measurements of their endoapertures and their size. I have not followed this method of identification because in my opinion size and measurements vary too much to give reliable results.

Caropsis verticillatoinundata type (Plate 21)

Pollen class: 3-Zonocolporate.

P/E ratio: Erect.

Apertures: Ectoaperture — colpus, long, usually over or sometimes up to pd, narrow, slit-like, not widened at equator, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent; sexine not raised above endoaperture; costae extending for a short distance along colpus. Endoaperture — colpus, elliptic, hardly elongated; margins distinct, slightly convex; ends distinct, acute; costae thick, but relatively narrow, in a narrow band around equator, broader around endoapertures.

Exine: Nexine thinner than sexine at poles, distinctly thickened at equator. Sexine 1 of columellae, short, but distinct at poles and shoulders, slightly longer at equator. Sexine 2 a tectum, not undulating in equatorial area, but irregularly edged.

Ornamentation: Psilate, irregularly rugulate-striate in SEM. Columellae in cross-section at poles small, uniform in size and outline, more or less circular, crowded; in mesocolpium also small and circular, not decreasing in size towards poles.

Outline: Equatorial view — elliptic. In side view inner contour of mesocolpium side slightly to distinctly curved, outer contour straight; on colpus side inner contour concave, outer contour straight or a little convex. Polar caps subacute.

Polar view — triangular with apertures in the sides. In cross-section at shoulders sides slightly concave.

Measurements: Glycerine jelly — P 24—(26.0)—29 μm ; E 13—(14.5)—16 μm ; P/E ratio 1.64—(1.79)—2.07. Exine thickness ca. 2 μm at poles, ca. 2.5 μm at equator. Silicone oil — P 21—(25.0)—28 μm ; E 11—(14.5)—17 μm ; P/E ratio 1.53—(1.71)—1.98.

Species: *Caropsis verticillatoinundata*.

Comments

Pollen of this type is easily recognized by its elliptic outline, the curved inner contour of the mesocolpium side, the absence of a fastigium and distinctly inwardly curved inner contour of the colpus side.

Carum carvi type (Plate 22)

Pollen class: 3-Zonocolporate.

P/E ratio: Usually pererect, sometimes erect.

Apertures: Ectoaperture — colpus, rather long, ca. 2/3 to 3/4 pd, narrow, slit-like, sunken, not widened above endoaperture; margins distinct, wavy; ends distinct, acute; fastigium small; sexine slightly, but distinctly raised above endoaperture; costae extending to half colpus length. Endoaperture — colpus, elliptic in outline, broadly elongated; margins distinct, straight, or slightly convex; ends obtuse, usually distinct; costae broad, band-like.

Exine: Nexine distinctly thinner than sexine at poles, slightly thickened in equatorial area. Sexine 1 of columellae, usually longer at poles than those at shoulders, but sometimes of equal length, columellae at equator equal in length to those at poles or a little longer. Sexine 2 a tectum, slightly undulating at equatorial area, distinctly thicker there than at poles.

Ornamentation: Psilate, irregularly rugulate in SEM. Columellae in cross-section at poles small, uniform in size and outline, circular, more or less spaced; in mesocolpium smaller, uniform in size.

Outlines: Equatorial view — usually bone-shaped, sometimes elliptic. In side view inner contour of mesocolpium side straight, or slightly curved, outer contour usually concave, sometimes straight; on colpus side inner contour straight or slightly concave, outer contour more or less straight. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides distinctly concave at shoulders.

Measurements: Glycerine jelly — P 29—(31.5)—34 μm ; E 12—(14.0)—16 μm ; P/E ratio 1.84—(2.25)—2.59. Exine thickness at poles 1.5–2.0 μm , at equator ca. 2.5 μm . Silicone oil — P 27—(30.5)—34 μm ; E 12—(14.0)—16 μm ; P/E ratio 1.84—(2.16)—2.39.

Species: *Carum carvi*.

Comments

Pollen grains of *Carum carvi* are rather variable in their features so this type appears in several parts of the key. The columellae are often longer at

the poles than at the shoulders but not invariably so. Therefore, this valuable characteristic, which is usually constant in other types in the Umbelliferae, is less useful in the identification of this type. The inner contour of the mesocolpium side also varies. It is usually more or less curved, however, not distinct, but shortly curved as it is in *Anthriscus sylvestris*. Differentiating characteristics, although occurring in many other types in the family, are the distinctly raised sexine above the endoaperture, the length of the colpus, the outline of the endoaperture, and the tectum which undulates only slightly in the equatorial area. These features, together with one or both of the characteristics mentioned above are sufficient to distinguish the *C. carvi* type from others in Northwest Europe.

Carum verticillatum type (Plate 23)

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, very long, exceeding pd, narrow, slit-like, sunken, not widened at equator; margins distinct, wavy; ends distinct, acute; fastigium absent; sexine not or only slightly raised above endoaperture; costae colpi present, but thin, up to 1/3 colpus length. Endoaperture — colpus, outline broadly elliptic, much elongated; margins distinct, straight, sometimes tapering; ends acute or subacute; costae broad, band-like but rather thin.

Exine: Nexine thin, distinctly thinner than sexine at poles, gradually thickened in the equatorial area (costae). Sexine 1 of columellae, short but distinct at poles, only slightly longer at equator. Sexine 2 a tectum, slightly thicker in equatorial area, not undulating, edges smooth.

Ornamentation: Psilate, irregularly rugulate in SEM. Columellae in cross-section at poles distinct, small in size, and more or less regularly circular in outline, crowded; throughout mesocolpium slightly larger, circular, and more spaced.

Outlines: Equatorial view — elliptic. In side view both outer contours convex, or sometimes straight on colpus side; inner contour of mesocolpium side slightly convex, straight or a little concave, but not strongly curved; inner contour of colpus side straight or slightly concave. Polar caps obtuse or subacute. Polar view — triangular; apertures in sides; sides in cross-section at shoulders concave.

Measurements: Glycerine jelly — P 27—(31.5)—37 μ m; E 14—(15.5)—17 μ m; P/E ratio 1.68—(2.00)—2.22. Exine thickness at poles ca. 2 μ m, at equator ca. 2.5 μ m. Silicone oil — P 28—(30.0)—33 μ m; E 15—(16.5)—18 μ m; P/E ratio 1.67—(1.85)—2.00.

Species: *Carum verticillatum*.

Comments

Pollen of *Carum verticillatum* resembles that of the *Oenanthe fistulosa* type and *Cicuta virosa* type. It differs from those types in having distinctly convex

outer contours and an inner contour on the mesocolpium side which is straight. Moreover, the columellae in the equatorial area are not, or only slightly, longer than those at the poles. The outer contour of the grains is smooth.

Pollen of *Carum carvi* is surprisingly different in having much shorter colpi and a usually bone-shaped outline in equatorial view.

***Chaerophyllum aureum* type (Plate 24)**

Pollen class: 3-Zonocolporate.

P/E ratio: Pererect.

Apertures: Ectoaperture — colpus, rather long, about $2/3$ pd, narrow, slit-like, not widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent but sexine raised above endoaperture; costae colpi extending nearly to colpus end. Endoaperture — short, elongated colpus (alongate), not protruding; outline elliptic, margins distinct, sides more or less straight; ends distinct, obtuse; costae distinct, very broad, band-like.

Exine: Nexine slightly thinner than sexine at poles, but distinctly thickened in equatorial area and there about as thick as sexine. Sexine 1 of columellae, short but distinct at poles, increasing in length towards shoulders and equator, but decreasing in width. Sexine 2 a tectum, slightly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate in SEM. Columellae in cross-section at poles coarse, irregular in size and outline, angular, spaced; in mesocolpium uniform in size and outline, small, circular and less distinct.

Outlines: Equatorial view — distinctly bone-shaped. In side view inner contour of mesocolpium side straight or a little curved, outer contour distinctly concave; on colpus side inner contour concave, not yoke-like, outer contour concave with a small apiculation formed by the raised sexine. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides at shoulders straight to a little concave.

Measurements: Glycerine jelly — P 25—(26.5)—29 μm ; E 10—(11.0)—13 μm ; P/E ratio 2.27—(2.45)—2.58. Exine thickness at poles ca. 2 μm , at equator ca. 3 μm . Silicone oil — P 23—(25.5)—28 μm ; E 9—(10.5)—12 μm ; P/E ratio 2.23—(2.46)—2.61.

Species: *Chaerophyllum aureum*.

Comments

Pollen of *Chaerophyllum aureum* most closely resembles that of *C. bulbosum* but *C. aureum* has a small elliptic endocolpus, whereas that in *C. bulbosum* is much more elongated. The columellae at the equator are also different; in *C. aureum* the columellae are about the same length throughout the equatorial area, whereas in *C. bulbosum* the columellae at the equator are distinctly shorter than those towards the shoulders. Pollen of *C. hirsutum* and *C. temulentum* differ in having columellae which are longer at the poles than at the equator.

Chaerophyllum bulbosum type (Plate 25)

Pollen class: 3-Zonocolporate.

P/E ratio: Pererect.

Apertures: Ectoaperture — colpus, short to rather long, ca. 1/2 to 2/3 pd, narrow, slit-like, not widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium small, sexine distinctly raised above endoaperture; costae extending to end of colpus, or a little shorter. Endoaperture — short colpus, sometimes porus-like, outline elliptic; margins slightly convex; ends distinct, rounded; costae broad, band-like.

Exine: Nexine thinner than sexine at poles, distinctly thickened in equatorial area, but because of increase in sexine thickness, still thinner than sexine. Sexine 1 of columellae, short at poles, not particularly distinct, distinctly increasing in length in equatorial area; columellae between shoulders and equator distinctly longer than those at equator; sexine there twice as thick as nexine or more. Sexine 2 a tectum, thin, distinctly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate ("cerebroid") in SEM. Columellae at poles in cross-section coarse, irregular in size, varying in outline from circular to angular, spaced; in mesocolpium very small, indistinct in outline, circular, distinctly increasing in size towards poles.

Outlines: Equatorial view — bone-shaped. In side view inner contour of mesocolpium side distinctly concave, but with straight central section, outer contour slightly to distinctly concave; inner contour of colpus side straight to concave, the outer also concave. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides slightly concave at shoulders.

Measurements: Glycerine jelly — P 23—(28.0)—33 μm ; E 10—(11.5)—14 μm ; P/E ratio 2.15—(2.42)—2.71. Exine thickness at poles ca. 2 μm , at equator 2.5 μm and at shoulders ca. 3.5 μm . Silicone oil — P 22—(25.5)—29 μm ; E 10—(11.5)—14 μm ; P/E ratio 2.01—(2.23)—2.51.

Species: *Chaerophyllum bulbosum*.

Comments

The *Chaerophyllum bulbosum* type is not particularly close in its pollen morphology to any other type in the Umbelliferae from Northwest Europe. It shows the characteristic bone-shaped outline, but is relatively small. It has most in common with the taxonomically related *Chaerophyllum aureum*, from which it mainly differs in the length of the columellae in the equatorial area and more elongated endoaperture. Pollen of *Chaerophyllum hirsutum* and *C. temulentum* differ from *C. bulbosum* in a range of features, but especially in the very low columellae at the equator.

Chaerophyllum hirsutum type (Plates 26, 27)

Pollen class: 3-Zonocolporate.

P/E ratio: Pererect, rarely erect.

Apertures: Ectoaperture — colpus, short to rather long, ca. 1/2 to 2/3 pd, narrow, slit-like, not widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium small, but distinct; sexine prominently raised above endoaperture; costae colpi long, extending nearly to colpus ends. Endoaperture — short, broad colpus or elongated porus, lalongate, sometimes slightly protruding; outline elliptic or rectangular, margins distinct, straight, often constricted in middle; ends very obtuse to truncate; costae distinct, very broad, band-like.

Exine: Nexine thinner than sexine at poles, as thick as sexine or thickened in equatorial area (costae). Sexine 1 of columellae, short, but distinct at poles, shorter and less distinct in equatorial area. Sexine 2 a tectum, not or slightly undulating in equatorial area, but a little irregular.

Ornamentation: Psilate, irregularly rugulate ("cerebroid") in SEM. Columellae in cross-section at poles rather coarse, regular in size and outline, more or less spaced. In mesocolpium much smaller, more or less circular in outline, less distinct, increasing in size towards poles.

Outlines: Equatorial view — usually bone-shaped, sometimes elliptic. In side view inner contour of mesocolpium side concave, or straight; outer contour usually concave, sometimes straight; on colpus side inner contour slightly concave, straight or yoke-like, outer contour concave with a distinct sexine extension above the endoaperture, often also yoke-like. Polar caps obtuse. Polar view — triangular with apertures in the sides; cross-section at shoulders straight or slightly concave, at equator distinctly concave.

Measurements: Glycerine jelly — P 24–41 μm ; E 11–18 μm ; P/E ratio 2.09–2.50. Exine thickness at poles ca. 2 μm , at equator ca. 1.5 μm . Silicone oil — P 22–34 μm ; E 11–16 μm ; P/E ratio 1.94–2.39.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Chaerophyllum hirsutum</i>	31–(35.5)–41	14–(15.5)–18	2.09–(2.28)–2.50
<i>C. temulentum</i>	24–(28.5)–34	11–(13.0)–16	2.00–(2.16)–2.39
	Silicone oil		
<i>C. hirsutum</i>	28–(31.0)–34	12–(14.0)–16	2.04–(2.23)–2.39
<i>C. temulentum</i>	22–(25.5)–28	11–(12.5)–15	1.94–(2.10)–2.34

Species: *Chaerophyllum hirsutum*, *C. temulentum*.

Key to the species

1. a. Columellae in equatorial area varying in size, longer towards shoulders than at equator; grains small ($P < 34 \mu\text{m}$) *C. temulentum*
- b. Columellae in equatorial area all of about the same size; grains larger ($P > 28 \mu\text{m}$) *C. hirsutum*

Comments

The *Chaerophyllum hirsutum* type resembles the *Aethusa cynapium* type in its commonly protruding endoaperture and yoke-like inner contour, but it

is easily recognized by its columellae which are distinctly shorter in the equatorial area than at the poles.

C. aureum differs in having columellae about the same length as both poles and equator, whereas *C. bulbosum* has columellae which are distinctly longer at the equator than at the poles.

The most obvious distinction between the pollen of the two species in this type is in the size of the grains; pollen of *C. temulentum* is distinctly smaller than that of *C. hirsutum*. There is also a tendency in *C. temulentum* for the columellae in the equatorial area to increase in length towards the shoulders, but this feature is never striking and may be lacking.

Cicuta virosa type (Plate 28)

Pollen class: 3-Zonocolporate.

P/E ratio: Pererect to erect.

Apertures: Ectoaperture — colpus, very long, exceeding pd, narrow, slit-like, not or a little widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; small fastigium present; sexine distinctly raised above endoaperture; costae colpi faint but present, rather narrow and short. Endoaperture — colpus, broadly elliptic, elongated (lalongate); margins straight; ends diffuse or faintly visible, more or less obtuse to truncate, sometimes with horns; costae broad, band-like.

Exine: Nexine distinctly thinner than sexine at poles, about as thick as sexine at equator. Sexine 1 of columellae, short, but distinct at poles, only slightly longer in equatorial area. Sexine 2 a tectum, slightly thicker in equatorial area, irregularly edged, but not particularly undulating.

Ornamentation: Psilate, irregularly rugulate. Columellae in cross-section at poles small, uniform in size and outline, circular, crowded; in mesocolpium slightly larger, not decreasing towards poles.

Outlines: Equatorial view — elliptic. In side view inner contour of mesocolpium side straight to shallowly curved, outer contour straight to slightly convex; on colpus side inner contour concave or straight, outer contour straight or slightly convex, not apiculate. Polar caps subacute. Polar view — triangular with apertures in the sides; in cross-section at shoulders sides concave; apocolpium small.

Measurements: Glycerine jelly — P 32—(36.0)—40 μm ; E 15—(17.0)—20 μm ; P/E ratio 1.74—(2.11)—2.38. Exine thickness at poles ca. 2 μm , at equator 2.5—3 μm . Silicone oil — P 29—(32.0)—35 μm ; E 14—(16.0)—18 μm ; P/E ratio 1.84—(2.03)—2.31.

Species: *Cicuta virosa*.

Comments

Pollen of the *Cicuta virosa* type resembles that of the *Oenanthe fistulosa* type and the *Carum verticillatum* type. It differs from the *Carum verticillatum* type in having more or less straight outer contours in side view, a slightly curved inner contour, a distinctly raised sexine above the endoaperture and

an irregularly edged outer contour in the equatorial area. Differential characters with the *Oenanthe fistulosa* type are less obvious but may be found in the only slightly curved, more straight inner contour, the subacute polar caps and the irregular edge of the outer contour of the mesocolpium side.

***Conium maculatum* type (Plate 29)**

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, long, up to pd, narrow, slit-like, not or slightly widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent; sexine not raised above endoaperture. Endoaperture — colpus, elliptic in outline, elongated; margins straight or slightly convex; ends distinct, obtuse; costae band-like, but relatively narrow. **Exine:** Nexine distinctly thinner than sexine, but thickened in equatorial area (costae). Sexine 1 of columellae, distinct at poles, usually shorter at shoulders and distinctly longer at equator. Sexine 2 a tectum, slightly undulating in equatorial area.

Ornamentation: Psilate, rugulate in SEM. Columellae in cross-section at poles distinct, rather coarse, but of about the same size and outline, spaced; in mesocolpium smaller but all of the same size.

Outlines: Equatorial view — elliptic or rarely very slightly bone-shaped. In side view inner contour of mesocolpium side usually distinctly curved, rarely shallowly curved; outer contour straight or rarely very slightly concave. On colpus side inner contour usually distinctly inwardly curved; outer contour straight. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides slightly concave at shoulders.

Measurements: Glycerine jelly — P 24—(27.5)—30 μm ; E 13—(14.0)—15 μm ; P/E ratio 1.85—(1.97)—2.18. Exine thickness at poles ca. 2 μm , at equator ca. 4 μm . Silicone oil — P 26—(28.0)—31 μm ; E 11—(13.5)—15 μm ; P/E ratio 1.80—(2.06)—2.28.

Species: *Conium maculatum*.

Comments

The *Conium maculatum* type is characterized by its elliptic outline, distinctly curved inner contour of both sides, the long colpus (up to pd) and its sexine which is not raised. The type resembles the pollen of *Bunium bulbocastanum* very closely, but differs from it by the complete lack of raising of the sexine, the longer colpus and distinctly curved inner contour of the colpus side.

***Conopodium majus* type (Plate 30)**

Pollen class: 3-Zonocolporate.

P/E ratio: Usually pererect, less frequently erect.

Apertures: Ectoaperture — colpus, short to rather long, slightly more than 1/2 to 2/3 pd, narrow, slit-like, not widened above endoaperture, sunken;

margins distinct, wavy; ends distinct, acute; fastigium very small or absent; sexine slightly raised above endoaperture; costae extending nearly to end of colpus. Endoaperture — colpus, broadly elliptic in outline, elongated; margins straight; ends distinct, rounded; costae distinct, very broad, band-like.

Exine: Nexine thinner than sexine at poles, thickened in equatorial area. Sexine 1 of columellae, short but distinct at poles, of about the same length or longer at equator and distinctly longer towards shoulders, up to twice as thick as nexine. Sexine 2 a tectum, unvarying in thickness, distinctly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate ("cerebroid") in SEM. Columellae in cross-section at poles coarse, irregular in size and outline, angular, not spaced; in mesocolpium smaller, more or less circular in outline, all of similar size.

Outlines: Equatorial view — bone-shaped. In side view inner contour of mesocolpium side concave, outer contour usually concave; on colpus side inner contour concave, outer contour straight to concave. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides straight at shoulders.

Measurements: Glycerine jelly — P 28—(33.0)—38 μm ; E 13—(14.0)—16 μm ; P/E ratio 2.05—(2.35)—2.65. Exine thickness at poles ca. 2 μm , at equator 3.5 μm . Silicone oil — P 26—(30.5)—36 μm ; E 12—(14.0)—16 μm ; P/E ratio 1.93—(2.19)—2.17.

Species: *Conopodium majus*.

Comments

Pollen of the *Conopodium majus* type is characterized by its bone-shaped outline, distinctly higher columellae towards the shoulders and rather short colpi. It belongs to a group of pollen types that closely resemble one another and include the *Aegopodium podagraria* type, *Peucedanum palustre* type, *Pimpinella major* type, etc.

Specimens of *Conopodium majus* are often misidentified as *Bunium bulbocastanum*, as both taxa have subterranean tubers. Their pollen differ, however, in a number of features and can easily be separated. *Bunium bulbocastanum* has longer colpi (2/3 to 3/4 pd), shows a distinctly curved inner contour of the mesocolpium side, a P/E ratio which is usually erect and, most important of all, the columellae at the equator are usually not shorter than those towards the shoulders.

Crithmum maritimum type (Plate 31)

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, very long, exceeding pd, narrow, slit-like, not widened at equator, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent; sexine not or only slightly raised above endoaperture; costae extending for half colpus length. Endoaperture — colpus, elongated, rather small and narrow, elliptic with more or less straight margins; ends indistinct and if visible obtuse; costae broad, band-like.

Exine: Nexine about as thick as sexine at poles; slightly thickened in equatorial area, but sexine also slightly thicker than at poles. Sexine 1 of columellae, short and indistinct at poles, slightly longer at equator. Sexine 2 a tectum, not or slightly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate, the muri beset with scabrae in SEM. Columellae in cross-section at poles small, uniform in size and outline, more or less circular, crowded. Columellae in mesocolpium in cross-section smaller in outline, but more distinct, decreasing in size and distinctness towards shoulders.

Outlines: Equatorial view — elliptic. In side view, inner and outer contour of mesocolpium side straight, inner contour sometimes slightly concave; on colpus side inner contour straight and outer contour straight or slightly convex. Polar caps usually obtuse, sometimes somewhat subacute. Polar view — triangular with apertures in the sides; cross-section at shoulders a little concave.

Measurements: Glycerine jelly — P 23—(25.0)—29 μm ; E 11—(12.5)—18 μm ; P/E ratio 1.94—(2.02)—2.13. Exine thickness at poles ca. 1 μm , at equator ca. 1.5 μm . Silicone oil — P 22—(23.5)—28 μm ; E 11—(13.0)—15 μm ; P/E ratio 1.63—(1.82)—2.09.

Species: *Crithmum maritimum*.

Comments

The *Crithmum maritimum* type belongs to a group of pollen types that also includes the *Apium inundatum* type, *Trinia glauca* type, *Sison amomum* type and the *Seseli libanotis* type. They are characterized by rather small, elliptic grains with, usually, very long colpi. Differential characters are difficult to define although the pollen grains are easily recognizable with experience.

The most important features of the type are those of the endoaperture (elongated and without a raised sexine) combined with the relatively short columellae in the equatorial area.

Cuminum cyminum type (Plate 32)

Pollen class: 3-Zonocolporate.

P/E ratio: Erect, rarely pererect.

Apertures: Ectoaperture — colpus, long, about 3/4 pd or up to pd, slit-like, sunken, not widened above endoaperture; margins rather indistinct, wavy; ends distinct, acute; fastigium small, sexine distinctly raised above endoaperture; costae extending to 2/3 colpus length. Endoaperture — elongated porus, lalongate, outline rectangular or obtusely elliptic, protruding; margins distinct, straight; ends distinct or diffuse, obtuse or truncate; costae very broad, band-like, distinct.

Exine: Nexine thinner than sexine at poles, distinctly thickened in equatorial area, about as thick as sexine at equator. Sexine 1 of columellae, short but distinct at poles, and of the same length or slightly longer at equator, but

distinctly longer between equator and shoulders. Sexine 2 a tectum, distinctly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate in SEM. Columellae in cross-section at poles and mesocolpium small, uniform in size and outline, circular, crowded.

Outlines: Equatorial view — distinctly bone-shaped. In side view inner contour of mesocolpium side concave, the mesocolpial section straight, outer contour concave; on colpus side inner contour yoke-like, outer contour also yoke-like, with a small, but distinct apiculation above endoaperture. Polar view — triangular. Polar caps obtuse to subacute. Apertures in sides; cross-section at shoulders concave.

Measurements: Glycerine jelly — P 28—(30.5)—32 μm ; E 13—(16.0)—17 μm ; P/E ratio 1.68—(1.90)—2.05. Exine thickness at poles ca. 2 μm , at equator ca. 3 μm , towards shoulders ca. 4 μm . Silicone oil — P 26—(28.0)—31 μm ; E 14—(16.0)—17 μm ; P/E ratio 1.54—(1.74)—1.91.

Species: *Cuminum cyminum*.

Comments

Cuminum is not a European taxon, it occurs from North Africa to South Asia. It is, however, well known in Western Europe, frequently cultivated and often found as an escape from gardens.

The pollen grains are recognized by their more or less rectangular, protruding, porus-like endoaperture, long colpi, and columellae which are distinctly longer between the equator and shoulders.

Daucus carota type (Plate 33)

Pollen class: 3-Zonocolporate.

P/E ratio: Usually erect, sometimes pererect.

Apertures: Ectoaperture — colpus, short or rather long, ca. 1/2 pd or a little longer, narrow, slit-like, not widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium present, small, sexine distinctly raised above endoaperture; costae indistinct, extending to colpus ends. Endoaperture — small, porus-like or short colpus, narrow, often protruding; margins straight; ends distinct, obtusely rounded or truncate; costae very broad, band-like.

Exine: Nexine at poles thinner than sexine, distinctly thickened in equatorial area (costae) but not thicker than sexine. Sexine 1 of columellae, distinct at poles, but short; distinctly longer in equatorial area (often twice nexine thickness) but decreasing again towards equator. Sexine 2 a tectum, distinctly or only slightly undulating.

Ornamentation: Psilate, irregularly rugulate-striate in SEM. Columellae in cross-section at poles coarse, irregular in size and outline, more or less spaced. In mesocolpium more or less uniform in size, circular, smaller than those at poles.

Outlines: Equatorial view — bone-shaped. In side view inner contour of mesocolpium side distinctly curved, outer contour concave, especially at

equator; on colpus side inner contour often yoke-like, sometimes straight, outer contour straight with an apiculation at equator where aperture protrudes. Polar caps obtuse to slightly subacute. Polar view — triangular with apertures in the sides; sides in cross-section at shoulders straight.

Measurements: Glycerine jelly — P 27–36 μm ; E 13–18 μm ; P/E ratio 1.79–2.21. Exine thickness at poles ca. 2 μm , at equator ca. 3 μm . Silicone oil — P 25–31 μm ; E 12–15 μm ; P/E ratio 1.89–2.24.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>D.c. ssp. carota</i>	29–(31.5)–36	14–(16.0)–18	1.79–(1.98)–2.13
<i>D.c. ssp. gummifer</i>	27–(29.5)–33	13–(14.5)–16	1.92–(2.03)–2.21
<i>D.c. ssp. sativa</i>	30–(32.5)–36	14–(15.5)–18	1.97–(2.08)–2.16
	Silicone oil		
<i>D.c. ssp. carota</i>	26–(28.5)–31	12–(14.0)–15	1.89–(2.05)–2.24
<i>D.c. ssp. gummifer</i>	25–(27.0)–29	12–(13.5)–15	1.93–(2.01)–2.14
<i>D.c. ssp. sativa</i>	27–(28.0)–29	13–(14.0)–15	1.89–(1.98)–2.02

Species: *Daucus carota* ssp. *carota*, *D. carota* ssp. *gummifer*, *D. carota* ssp. *sativa*.

Comments

Pollen of *Daucus carota* is characterized by the small, more or less protruding endoaperture which is porus-like or may be a short colpus. The grains of *D. carota* ssp. *gummifer* have a particular tendency for their endoapertures to protrude. This is less pronounced in the other subspecies, but even there the endoapertures tend to bulge from the surface. The columellae in the mesocolpium are longer towards the shoulders than at the equator. This characteristic is, however, present in many other pollen types such as the *Chaerophyllum hirsutum* type, *Pimpinella major* type, *Bifora radians* type, etc. The type also has some resemblance to the *Aethusa cynapium* type, except that the latter type is distinctly elliptic and has indistinct costae.

Grains of the three subspecies differ only slightly in size. Those of ssp. *gummifer* are smallest, and those of *sativa* largest; ssp. *carota* is rather variable in size, but it is usually larger than ssp. *gummifer*.

Van Zeist et al. (1977) studied pollen of *Daucus persica* and identified it as belonging to their *Pimpinella* type, which is characterized by pronounced ridges in the "interzone" (zone between the equatorial and polar zones). *Daucus carota* pollen is different in having a distinctly curved inner contour on the mesocolpium side and columellae which are all of about the same length in the mesocolpium area.

Eryngium campestre type (Plates 34–37)

Pollen class: 3-Zonocolporate.

P/E ratio: Usually erect, less frequently pererect.

Apertures: Ectoaperture — colpus, rather long, long or very long, varying from ca. $\frac{1}{2}$ pd to over pd, narrow, slit-like, nor or slightly widened above endoaperture, sunken; margins usually distinct, sometimes rather vague, wavy; ends distinct or diffuse, acute; distinct fastigium present; sexine distinctly raised above endoaperture; costae colpi absent. Endoaperture — colpus or porus, usually distinctly protruding; margins straight, ends diffuse; costae broad or narrow, usually not forming a band.

Exine: Nexine slightly thinner than sexine at poles or of equal thickness, not thickened at equator. Sexine 1 of very short, rather indistinct columellae at poles, equally long or shorter at equator. Sexine 2 a tectum, often slightly thicker at shoulders, not undulating in equatorial area.

Ornamentation: Psilate, in SEM irregularly rugulate. Columellae in cross-section at poles fine, regular in outline and size, circular, crowded; in mesocolpium also small and circular.

Outlines: Equatorial view — bone-shaped. In side view inner contour of mesocolpium side concave, straight or shallowly curved, outer contour concave; on colpus side inner contour convex, outer contour rhombic to distinctly convex, apertures usually protruding, margin apiculate. Polar caps obtuse to subacute. Polar view — triangular. Cross-section at shoulders with apertures in slightly concave sides, but at equator, cross-section shows colpi in obtuse angles and sides straight.

Measurements: Glycerine jelly — P 34–54 μm ; E 19–28 μm ; P/E ratio 1.64–2.18. Exine thickness at poles and equator 1.5–2.5 μm . Silicone oil — P 30–50 μm ; E 16–27 μm ; P/E ratio 1.58–2.15.

	P (μm)	E (μm)	P/E ratio
Glycerine jelly			
<i>Eryngium alpinum</i>	48–(49.5)–51	23–(25.0)–27	1.88–(1.98)–2.08
<i>E. campestre</i>	36–(44.0)–49	20–(23.0)–26	1.83–(1.93)–2.11
<i>E. maritimum</i>	43–(50.5)–54	23–(26.0)–28	1.64–(1.96)–2.18
<i>E. viviparum</i>	34–(37.0)–39	19–(20.0)–22	1.70–(1.84)–1.97
Silicone oil			
<i>E. alpinum</i>	35–(40.5)–46	17–(22.5)–27	1.69–(1.80)–2.10
<i>E. campestre</i>	34–(38.5)–44	18–(20.5)–23	1.58–(1.88)–2.15
<i>E. maritimum</i>	41–(44.5)–50	23–(24.0)–25	1.70–(1.85)–2.13
<i>E. viviparum</i>	30–(33.0)–36	16–(18.0)–20	1.62–(1.81)–2.05

Species: *Eryngium alpinum*, *E. campestre*, *E. maritimum*, *E. viviparum*.

Key to the species

1. a. Endocolpi distinctly elongated, sometimes fused into an endocingulum; ectocolpus long, up to but not exceeding pd; costae broad *E. maritimum*
- b. Endoaperture a porus or broad, short colpus; ectocolpus short to very long, costae broad or narrow. 2
2. a. Ectocolpus rather long or short, not exceeding $2/3$ pd; endoporus with broad costae *E. alpinum*

- b. Ectocolpus longer than $3/4$ pd; endoaperture with broad or narrow costae3
- 3. a. In side view on colpus side endoaperture usually not protruding, not or only slightly raised from the margin (not apiculate); ectocolpus very long, usually well over pd; costae broad *E. campestre*
- b. In side view on colpus side endoaperture distinctly protruding from the margin (apiculate); ectocolpus long, approaching but not exceeding pd; costae narrow *E. viviparum*

Comments

The *Eryngium campestre* type is easily recognized by its peculiar outline in side view; one side rhombic-convex, the other distinctly concave, thus giving the pollen grains an asymmetric appearance. Moreover, the short columellae, the thin equatorial area, the size and the features of the endoaperture provide characteristics to differentiate pollen of *Eryngium* from all other pollen types in the Umbelliferae of Northwest Europe.

All the species in this type look very much alike but the Northwest European members of the genus differ from each other in rather constant characteristics and their identification on pollen morphology is therefore fairly reliable.

Van Zeist et al. (1977) published an *Eryngium* type in which they included *Sanicula europaea*. Although there is some resemblance, the outlines of grains in the two types are different. All species of *Eryngium* have a distinctly convex or even rhombic outer contour on the colpus side combined with a more or less constricted outer contour on the mesocolpium side. *Sanicula europaea* pollen has a straight or slightly convex outer contour on the colpus side and a shallowly concave outer contour on the mesocolpium side.

Beautiful LM plates of *E. maritimum* have been published by Van der Pluym and Hideux (1977) showing the distinctly elongated, nearly fused endoapertures and the very long colpi, characteristic of this taxon.

Falcaria vulgaris type (Plates 38–41)

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpi short or rather long, ca. $1/2$ to $2/3$ pd, narrow, slit-like, not widened at equator, slightly sunken; margins distinct, wavy; ends distinct, acute; fastigium absent or very small, but sexine usually slightly raised above endoaperture; costae colpi extending nearly to end of colpus. Endoaperture — usually an elliptic colpus, sometimes a small, elongate porus; margins distinct, usually more or less convex, sometimes straight; ends distinct, rounded; costae broad, band-like.

Exine: Nexine thinner than sexine at poles or equally thick, at equator slightly or distinctly thickened (costae) on mesocolpium side. Sexine 1 of columellae, very short and not always visible at poles, far longer in equatorial area, usually at least twice as thick as nexine, sometimes less; more or less

Comments

Pollen of the *Falcaria vulgaris* type most closely resembles that of *Foeniculum vulgare*. It differs mainly in its shorter colpus (up to ca. $2/3$ pd) and smaller, less elongated endopores which usually have more or less convex sides. In addition, pollen of the *Falcaria vulgaris* type is often bone-shaped in equatorial view, whereas that of the *Foeniculum vulgare* type is usually elliptic in outline.

Pollen of all four species in the type is characterized by the colpus length (up to ca. $2/3$ P), much longer columellae in the equatorial area than at the poles which lengthen rather abruptly just outside the polar caps. Usually these columellae are uniform in length throughout the equatorial area. Also the rather small, elliptic endocolpus with usually more or less convex sides is characteristic for this type. The species are difficult to separate from each other and the overlap of the differential features is considerable. *Anethum graveolens* pollen has the longest columellae and is smallest in size; its endocolpus is also slightly different as it sometimes has straight sides and is narrowly elongated.

Torilis arvensis usually has distinctly pererect grains, and its columellae in the equatorial area are often less than twice as long as the nexine thickness, which is, in addition, often not much thicker at the equator (i.e. the costae are thin).

The last two species have pollen which are extremely similar; they are best separated from the other two species by their curved inner contour of the mesocolpium side. Both have grains which are erect or occasionally pererect, whereas the other two are more decidedly pererect.

Van Zeist et al. (1977) combined *Falcaria vulgaris* in a large pollen type with *Pimpinella* species and several other genera (e.g. *Seseli* and *Daucus*) which have long columellae between the equator and the shoulders. In the *Falcaria vulgaris* type, however, these long columellae are not particularly pronounced between the equator and the polar zone.

Heracleum sphondylium type (Plates 42–44)

Pollen class: 3-Zonocolporate, rarely irregularly shaped.

P/E ratio: Usually pererect, sometimes erect.

Apertures: Ectoaperture — colpus, short or rather long, ca. $1/2$ to $2/3$ pd, narrow, slit-like, usually a little widened above endoaperture, sunken; margins distinct in the middle part, indistinct towards poles; ends diffuse, ending in an area with few, indistinct columellae; fastigium absent, sexine not or slightly raised; costae nearly as long as colpi. Endoaperture — colpus, elliptic; margins distinct, slightly convex; ends distinct, obtuse; costae broad, band-like, thick.

Exine: Nexine thinner than sexine. Sexine 1 of columellae, distinct and long at poles, often branched, more or less decreasing in length towards shoulders and increasing again towards equator. Sexine 2 a tectum, not or slightly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate to "cerebroid" in SEM. In cross-section columellae at poles very coarse, irregular in size, varying from circular to slightly angular, spaced; in mesocolpium smaller, more uniform in size, circular; area around the ends of the colpi without, or with only a few columellae.

Outlines: Equatorial view — usually a little bone-shaped, sometimes elliptic, with straight sides. In side view inner contour of mesocolpium side curved, often distinctly so, outer contour straight or a little concave; on colpus side inner contour usually distinctly inwardly curved, outer contour straight or slightly convex, especially at the equator. Polar caps obtuse. Polar view — triangular; apertures in the sides; sides at shoulders straight or slightly concave.

Measurements: Glycerine jelly — P 42–65 μm ; E 19–30 μm ; P/E ratio 1.93–2.35. Columellae at poles 3.0–4.5 μm , at equator 4.0–5.0 μm . Silicone oil — P 36–60 μm ; E 17–27 μm ; P/E ratio 1.68–2.31.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Heracleum sphondylium</i>	42–(47.5)–52	19–(21.0)–26	1.93–(2.11)–2.24
<i>H. mantegazzianum</i>	56–(59.0)–65	25–(27.0)–30	2.09–(2.18)–2.35
	Silicone oil		
<i>H. sphondylium</i>	36–(41.5)–45	17–(20.5)–26	1.68–(2.0)–2.25
<i>H. mantegazzianum</i>	48–(53.0)–60	21–(24.5)–27	2.05–(2.17)–2.31

Species: *Heracleum mantegazzianum*, *H. sphondylium* ssp. *sphondylium*, *H. sphondylium* ssp. *montanum*.

Key to the species

1. a. Columellae at poles distinctly longer than those at shoulders and usually longer than those at equator; columellae in mesocolpium in cross-section more or less circular; margins of endoaperture distinct; P usually $< 48 \mu\text{m}$ *Heracleum sphondylium*
- b. Columellae at poles slightly longer or no longer than at shoulders, often shorter than at equator; columellae in mesocolpium in cross-section more or less angular; margins of endoaperture less distinct, ends more or less diffuse; P usually $> 48 \mu\text{m}$ *Heracleum mantegazzianum*

Comments

Heracleum mantegazzianum is a Caucasian species which was introduced into European gardens at the end of the nineteenth century. It escaped easily and is now widely naturalized.

Pollen of *Heracleum* species is easily recognized by a combination of features of which the most important are: (1) very coarse columellae throughout the grain; (2) a small area around the ends of the colpi without, or with only a few columellae; and (3) the branched columellae at the poles. Its pollen is similar to that of the *Pastinaca sativa* type but *Heracleum* pollen is larger and has thicker columellae which are branched and longer at the poles.

The two subspecies of *H. sphondylium* (*sphondylium* and *montanum*) are identical in pollen-morphology. On the other hand, pollen of *H. mantegazzianum* can be distinguished from that of *H. sphondylium* because its polar columellae are shorter, or at least no longer, than those at the equator. In addition, in *H. mantegazzianum* the columellae are coarser and less regular at both poles and mesocolpium, the grains are slightly longer and there is a small difference in P/E ratio (see table above).

According to Cerceau's keys (1959, 1962) *H. mantegazzianum* pollen belongs in the group of pollen with a P/E ratio of exactly 1.5. My observations, which were carried out on two samples, suggest that pollen of this taxon has a P/E ratio in excess of 2.0 (pererect).

Hydrocotyle vulgaris type (Plate 45)

Pollen class: 3-Zonocolporate.

P/E ratio: Usually suberect, less frequently semi-erect.

Apertures: Ectoaperture — colpus, long or very long, up to or over pd, slit-like, not widened at equator, not or slightly sunken; margins distinct, but wavy; ends distinct, acute; fastigium present, small; sexine distinctly raised above endoaperture; costae colpi absent. Endoaperture — short colpus or elongated porus, protruding, more or less rectangular in outline; margins distinct, straight; ends diffuse; costae narrow.

Exine: Nexine thinner than sexine at poles, but about as thick as sexine at equator. Sexine 1 of columellae, distinct at poles, but indistinct and much shorter at equator. Sexine 2 a tectum, slightly thicker at poles, not undulating in equatorial area.

Ornamentation: Psilate — simpliperforate, an irregular pattern of small elements in SEM. Columellae in cross-section in mesocolpial area small and indistinct, more distinct at poles, uniformly small in size, more or less circular in outline, crowded.

Outlines: Equatorial view — in colpus view rhombic in outline; in side view, inner and outer contours of mesocolpium side convex; on colpus side inner and outer contours rhombic; polar caps obtuse. Polar view — triangular, colpi in the corners; sides at shoulders a little convex. Mesocolpial sides sunken.

Measurements: Glycerine jelly — P 23—(23.5)—25 μm ; E 19—(20.0)—22 μm ; P/E ratio 1.04—(1.15)—1.21. Exine thickness varying from ca. 2 μm at poles to 1.5 μm at equator. Silicone oil — P 21—(23.0)—27 μm ; E 19—(19.5)—21 μm ; P/E ratio 1.08—(1.17)—1.26.

Species: *Hydrocotyle vulgaris*.

Comments

Pollen of *Hydrocotyle* is easily recognized by a number of features and cannot be confused with any other pollen type of the Umbelliferae in North-west Europe. Its pollen grains are rhombic in outline, usually suberect or semi-erect, and the mesocolpial areas are sunken. Some other important features are the long columellae at the poles, the narrow costae endocolpi and the long to very long colpi.

Its pollen is regularly found in Quaternary deposits, and has frequently been identified. For comments and data on distribution in Quaternary deposits see Godwin (1975).

***Laser trilobum* type (Plate 46)**

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, long, up to pd or nearly so, narrow, slit-like, sunken; margins distinct, wavy; not widened above endoaperture; ends distinct, acute; fastigium small, sexine distinctly raised above endoaperture; costae extending to half length of colpus. Endoaperture — colpus, or elongated porus (alongate), more or less rectangular, elliptic; margins straight; ends distinct, obtuse or rounded; costae broad, band-like.

Exine: Nexine thinner than sexine at poles, slightly thickened in equatorial area, about as thick as sexine at equator, thinner than sexine towards shoulders. Sexine 1 of columellae, short and distinct at poles, of similar length at equator, but distinctly longer towards shoulders. Sexine 2 a tectum, irregularly edged in equatorial area, not or weakly undulating.

Ornamentation: Psilate, irregularly rugulate in SEM. Columellae in cross-section at poles relatively small, uniform in size, circular, crowded; in mesocolpium of about the same size or slightly smaller.

Outlines: Equatorial view — bone-shaped. In side view, inner contour of mesocolpium side straight, or only shallowly curved, outer contour distinctly concave; on colpus side inner contour straight to a little concave, outer contour straight or a little yoke-like because of raised sexine (apiculate). Polar caps obtuse. Polar view — triangular with apertures in the sides; sides in cross-section at shoulders concave.

Measurements: Glycerine jelly — P 31—(33.5)—37 μm ; E 15—(16.0)—18 μm ; P/E ratio 1.90—(2.12)—2.39. Exine thickness at poles ca. 2 μm , at equator ca. 2.5 μm , towards shoulders ca. 3 μm . Silicone oil — P 27—(29.0)—32 μm ; E 15—(15.5)—17 μm ; P/E ratio 1.66—(1.87)—2.08.

Species: *Laser trilobum*.

Comments

The *Laser trilobum* type is characterized by its long colpi, bone-shaped outline, relatively short columellae at the equator and irregularly edged tectum in the equatorial area. It resembles the *Oenanthe fistulosa* type to some extent, but this latter type is usually more elliptic, has longer columellae at the equator and has a tectum which is less irregularly edged.

Pollen of *L. trilobum* resembles that of *Silaum silaus* very closely. Although some of the features overlap (see *Silaum silaus* type, p. 233) the overall appearance, e.g. the larger size, smaller P/E ratio and, especially, the combination of differential features are sufficiently distinct for two separate types to be maintained.

***Laserpitium latifolium* type (Plate 47)**

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, rather long to long, about 3/4 pd, narrow, slit-like, sunken, not widened above endoaperture; margins distinct, wavy; ends distinct, acute; small fastigium present, sexine conspicuously raised above endoaperture; costae extending nearly to end of colpus. Endoaperture — short colpus or porus-like, elliptic in outline, broad; margins distinct, straight; ends distinct, obtuse to subacute; costae broad, band-like, distinct.

Exine: Nexine thinner than sexine at poles, thicker than sexine at equator. Sexine 1 of columellae, short but distinct at poles, distinctly shorter in equatorial area, at shoulders as long as those at poles or slightly longer. Sexine 2 a tectum, smooth in equatorial area or somewhat irregularly edged.

Ornamentation: Psilate, irregularly rugulate in SEM. Columellae in cross-section at poles rather coarse, more or less uniform in size, but outlines irregular, more or less angular, spaced; in mesocolpium cross-section of columellae very small, indistinct, increasing in size towards poles.

Outlines: Equatorial view — bone-shaped. In side view inner contour of mesocolpium side straight, not curved, outer contour slightly concave; on colpus side inner contour straight, outer contour slightly yoke-like because of prominently raised sexine, obtusely apiculate. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides slightly concave in cross-section at shoulders.

Measurements: Glycerine jelly — P 34—(38.5)—42 μm ; E 15—(18.0)—20 μm ; P/E ratio 1.83—(2.17)—2.57. Exine thickness at poles ca. 2.5 μm , at equator ca. 2.0 μm . Silicone oil — P 31—(32.5)—34 μm ; E 14—(17.5)—19 μm ; P/E ratio 1.73—(1.88)—2.16.

Species: *Laserpitium latifolium*.

Comments

The pollen grains of *L. latifolium* are characterized by the short columellae in the equatorial area and the prominently raised sexine above the endoaperture. The endoaperture is short, but broadly elliptic in outline. In many features they resemble the *Levisticum officinale* type. This latter is, however, usually elliptic in outline and its endoapertures are narrower.

The *Chaerophyllum hirsutum* type is also very similar with regard to endoaperture features and the short columellae at the equator. *L. latifolium* pollen, however, lacks the longer columellae at, or near, the shoulders which are so characteristic of the *Chaerophyllum hirsutum* type. Also the P/E ratio differs in being higher in the *C. hirsutum* type.

***Laserpitium prutenicum* type (Plate 48)**

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, narrow, rather long to long, about $3/4$ pd or slightly less, slit-like, not widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium small, sexine slightly raised above endoaperture; costae extending nearly to colpus ends. Endoaperture — colpus, elliptic in outline, broadly elongated; margins distinct, straight; ends less distinct, obtuse; costae very broad, band-like, distinct.

Exine: Nexine thinner than sexine at poles but slightly thickened in equatorial area and there about equal in thickness to sexine. Sexine 1 of columellae, short and distinct at poles, slightly longer at shoulders and of about equal length in equatorial area to those at poles. Sexine 2 a tectum, a little irregularly edged in equatorial area.

Ornamentation: Psilate to irregularly rugulate ("cerebroid") in SEM. Columellae in cross-section at poles rather coarse, more or less uniform in size, but outlines irregular and more or less angular, spaced; in mesocolpium cross-section of columellae smaller, regular in outline, more or less circular, distinct and in mesocolpium area not obviously increasing in size towards poles.

Outlines: Equatorial view — bone-shaped. In side view, inner contour of mesocolpium side straight to shallowly curved; outer contour slightly concave; on colpus side inner contour straight, outer contour straight with a little apiculation at endoaperture. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides slightly concave in cross-section at shoulders.

Measurements: Glycerine jelly — P 29—(32.0)—34 μm ; E 12—(14.5)—16 μm ; P/E ratio 2.01—(2.19)—2.37. Exine thickness at poles and equator ca. 2.5 μm . Silicone oil — P 25—(26)—27 μm ; E 12—(13)—15 μm ; P/E ratio 1.84—(2.03)—2.18.

Species: *Laserpitium prutenicum*.

Comments

Laserpitium prutenicum pollen is characterized by the columellae which are of the same length at the poles as at the equator; those at the shoulders are a little longer. It differs from *L. latifolium* pollen in this characteristic but also in the more elongated endoaperture, the more distinct columellae in the mesocolpium area and, especially, in the less prominently raised sexine above the endoaperture.

Some other pollen types, such as the *Carum carvi* and *Peucedanum palustre* types, differ mainly because they have distinctly higher columellae in the equatorial area than at the poles.

Levisticum officinale type (Plate 49)

Pollen class: 3-Zonocolporate.

P/E ratio: Usually erect, sometimes pererect.

Apertures: Ectoaperture — colpus, rather long, ca. $2/3$ to $3/4$ pd, narrow, slit-like, not widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium small; sexine distinctly raised above endoaperture; costae extending nearly to colpus ends. Endoaperture — colpus, elliptic in

outline, in colpus view often constricted; margins straight; ends obtuse, rounded; costae broad, band-like, but thin.

Exine: Nexine thinner than sexine at poles and equator, but slightly thickened at equator (costae). Sexine 1 of columellae, short, but distinct at poles, shorter in equatorial area. Sexine 2 a tectum, not undulating, sometimes slightly irregularly edged.

Ornamentation: Psilate; irregularly rugulate in SEM. Columellae in cross-section at poles rather small, about uniform in size and outline, circular, more or less spaced; in mesocolpium smaller.

Outlines: Equatorial view — side view often elliptic, sometimes a little bone-shaped. In side view inner contour of mesocolpium side straight or very shallowly curved, outer contour straight or very slightly concave. On colpus side inner contour straight or slightly concave, outer contour straight or slightly convex. Polar caps obtuse. Polar view — triangular, in cross-section at shoulders a little concave, apertures in the sides.

Measurements: Glycerine jelly — P 22—(31.5)—36 μm ; E 13—(16.5)—19 μm ; P/E ratio 1.78—(1.92)—2.15. Exine thickness at poles and equator ca. 2 μm . Silicone oil — P 23—(27.0)—30 μm ; E 12—(14.0)—15 μm ; P/E ratio 1.67—(1.92)—2.14.

Species: *Levisticum officinale*.

Comments

Levisticum officinale pollen is characterized by the following features: the columellae at the equator are shorter than those at the poles; the outline is elliptic and endocolpus is distinctly elliptic with straight margins. It resembles both the *Chaerophyllum hirsutum* type and *Laserpitium latifolium* type to some extent, but differs in its endoaperture and its straighter inner and outer contours on the colpus side. The *Carum carvi* type also has some resemblance to *Levisticum officinale*, the latter, however, has distinctly shorter columellae in the equatorial area, whereas in the former the equatorial columellae are a little longer than the polar ones, or of about the same length. Only those at the shoulders are distinctly shorter than those at the poles.

Meum athamanticum type (Plates 50, 51)

Pollen class: 3-Zonocolporate.

P/E ratio: Usually erect, rarely pererect.

Apertures: Ectoaperture — colpus, very long, up to or exceeding pd, slit-like, not widened above endoaperture, sunken; margins distinct, but wavy; ends distinct, acute; fastigium distinct, sexine prominently raised above endoaperture; costae present along colpus border. Endoaperture — colpus, broadly elliptic in outline, or a broad lalongate porus; margins straight, distinct beneath colpus, less distinct towards ends, constricted in the middle; ends rounded; costae broad, band-like.

Exine: Nexine thinner than sexine at poles, not or only slightly thickened in equatorial area. Sexine 1 of columellae, distinct at poles and shoulders,

usually shorter at equator, sometimes equally long. Sexine 2 a tectum, thin, not undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate ("cerebroid") in SEM. Columellae in cross-section at poles small, uniform in size, more or less circular, more or less crowded; in mesocolpium small, rather indistinct, increasing in size towards poles.

Outlines: Equatorial view — elliptic to slightly bone-shaped. In side view, inner contour of mesocolpium side usually straight, sometimes a little concave or a little convex; outer contour straight, a little convex or slightly concave. In colpus view inner contour usually more or less straight; outer contour straight or a little convex, apiculate because of prominently raised sexine. Polar view — triangular with apertures in the corners; in cross-section at shoulders sides slightly concave. Polar caps obtuse.

Measurements: Glycerine jelly — P 26–36 μm ; E 16–22 μm ; P/E ratio 1.38–2.00. Exine thickness 2.0–2.5 μm at poles, 1.5–2.0 μm at equator. Silicone oil — P 25–33 μm ; E 14–25 μm ; P/E ratio 1.13–1.96.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Ligusticum scoticum</i>	29–(33.0)–36	17–(19.0)–22	1.61–(1.73)–1.83
<i>Meum athamanticum</i>	26–(29.5)–33	16–(18.0)–22	1.38–(1.66)–2.00
	Silicone oil		
<i>Ligusticum scoticum</i>	26–(29.0)–33	15–(17.0)–19	1.61–(1.72)–1.96
<i>Meum athamanticum</i>	25–(28.0)–31	16–(18.0)–23	1.13–(1.52)–1.81

Species: *Ligusticum scoticum*, *Meum athamanticum*.

Key to the species

1. a. Endoaperture with diffuse, more or less truncate ends. Columellae in cross-section in equatorial area visible, only slightly increasing in size towards poles *Ligusticum scoticum*
- b. Endoaperture with rather distinct, rounded ends; columellae in cross-section in equatorial area indistinct, but increasing considerably in size towards polar caps. *Meum athamanticum*

Comments

The pollen grains of this type are characterized by their obtuse polar caps and the straight outer contours with an apiculation on the colpus side. This latter feature is the result of the prominently raised sexine above the endoaperture.

The linking of these two taxa in a single pollen type is not as unexpected as it might seem since the genera *Meum* and *Ligusticum* are closely related. Indeed, *M. athamanticum* was formerly included in the genus *Ligusticum* (as *L. meum*). *Meum* is monotypic, whereas *Ligusticum* has several representatives in Southern Europe (Hegi, 1925–1926).

The combination of features in this type is distinct for both species but has some resemblance to the *Angelica palustris* type. Both types share the following characters: very long colpi and equatorial columellae shorter than those at the poles. *Meum anthamanticum* pollen differs slightly in the more elliptic outline in equatorial view (straight sides) and the more protruding sexine above the endoaperture (apiculate). Other differentiating features are: (a) apertures in the corners in polar view; (b) endocolpus broader, more porus-like and with distinct central constriction; (c) endoaperture ends less distinct, often truncate to slightly rounded.

Myrrhis odorata type (Plate 52)

Pollen class: 3-Zonocolporate.

P/E ratio: Pererect.

Apertures: Ectocolpus — colpus, short, about 1/2 pd or less, not or slightly widened above endoaperture, sunken; margins rather indistinct, wavy; ends indistinct; fastigium small or absent, but sexine distinctly raised above endoaperture; costae indistinct. Endoaperture — broad colpus or elongated porus, not protruding, often rectangular in outline; margins straight, often slightly curved at ends; ends diffuse; costae broad, band-like.

Exine: Nexine thinner than sexine at poles; at equator a little thickened (costae). Sexine 1 of columellae, shorter at poles than at equator, distinctly longer between shoulders and equator and there more than twice nexine thickness. Sexine 2 a tectum, distinctly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate ("cerebroid") in SEM. In cross-section columellae at poles coarse, irregular in size and outline, more or less spaced; in mesocolpium varying in size and outline, those at equator uniformly small, circular, increasing in size towards poles, and also more irregular in outline, angular.

Outlines: Equatorial view — bone-shaped. In side view, inner and outer contour on mesocolpium side straight or curved; on colpus side inner contour distinctly concave, outer contour straight to slightly concave, with a small apiculation in the middle. Polar caps obtuse. Polar view — triangular, apertures in concave sides.

Measurements: Glycerine jelly — P 39—(44.0)—48 μm , E 16—(18.0)—19 μm ; P/E ratio 2.21—(2.44)—2.73. Exine thickness at poles 2–3 μm , in equatorial area up to 4–6 μm . Silicone oil — P 33—(34.0)—37 μm ; E 12—(15.0)—17 μm , P/E ratio 2.01—(2.27)—2.65.

Species: *Myrrhis odorata*.

Comments

Pollen grains of *Myrrhis odorata* are easily recognized by their short colpi and distinctly longer columellae towards the shoulders. The endoaperture is variable, but usually more or less rectangular. However the size, although rather large for most Northwest European specimens, is probably not constant and is therefore unreliable as a distinguishing feature. Specimens from

Western Europe, according to Hegi (1925–1926), are of cultivated origin; those that grow outside gardens are escapes. One specimen, raised from seed of Russian origin (Mennega 7708) and probably of wild stock, has pollen grains with a mean size considerably smaller than the West European specimens (glycerine jelly $P = 35 \mu\text{m}$, silicone oil $P = 31.0 \mu\text{m}$). These measurements have not been included with the others.

Oenanthe fistulosa type (Plates 53–59)

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, long to very long, from pd to distinctly exceeding pd, narrow, slit-like, sometimes a little widened at equator, sunken; margins distinct, wavy; ends distinct, acute; fastigium small or absent, sexine usually more or less distinctly raised above endoaperture, rarely not raised; costae absent. Endoaperture — colpus, elliptic in outline; margins straight or convex; ends usually diffuse, sometimes visible, rarely with horns; costae distinct and thick, but relatively narrow, band-like.

Exine: Nexine about as thick as sexine or thinner at poles, because of costae distinctly thickened in equatorial area. Sexine 1 of columellae, usually distinct at poles, short or rather long, distinctly longer at equator. Sexine 2 a tectum, not or very slightly irregular in equatorial area.

Ornamentation: Psilate, rugulate-striate in SEM. Columellae in cross-section at poles distinct, uniform in size and outline, more or less circular, crowded; in mesocolpium a little smaller, not decreasing towards poles.

Outlines: Equatorial view — elliptic, sometimes a little bone-shaped. In side view, inner contour of mesocolpium side usually distinctly curved, sometimes only shallowly so; outer contour usually straight, sometimes slightly concave or convex. On colpus side inner contour straight or slightly inwardly curved, outer contour straight or slightly convex. Polar view — triangular with apertures in the sides. Sides in cross-section at shoulders concave. Colpi often penetrating deeply into apocolpium; apocolpium index small or large. Polar caps obtuse or slightly subacute.

Measurements: Glycerine jelly — P 32–44 μm ; E 16–25 μm ; P/E ratio 1.63–2.46. Exine thickness 1.5–3 μm . Silicone oil — P 26–38 μm ; E 13–23 μm ; P/E ratio 1.58–2.32.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Oenanthe aquatica</i>	32–(35.5)–40	16–(17.0)–21	1.77–(2.07)–2.25
<i>O. crocata</i>	32–(35.5)–40	16–(17.5)–19	1.91–(2.05)–2.43
<i>O. fistulosa</i>	35–(39.5)–44	19–(21.5)–25	1.63–(1.84)–2.07
<i>O. fluvialis</i>	33–(36.5)–38	16–(16.5)–17	2.10–(2.21)–2.28
<i>O. lachenalii</i>	32–(34.5)–38	16–(17.0)–19	1.90–(2.06)–2.46
<i>O. peucedanifolia</i>	32–(35.5)–41	16–(17.5)–19	1.84–(2.06)–2.21
<i>O. pimpinelloides</i>	33–(36.5)–41	16–(18.0)–19	1.84–(2.01)–2.18
<i>O. silaifolia</i>	33–(38.0)–44	16–(2.16)–19	1.92–(2.16)–2.31

The *O. fistulosa* type belongs to a group of three types which are characterized by very long colpi, an elliptic outline and large, broad colpi. The *Carum verticillatum* type is best distinguished by its distinctly convex outer contours on both sides of the equatorial view and the convex inner contour of the mesocolpium side. This last characteristic is in contrast to the characteristically curved inner contour of the *O. fistulosa* type and also to the more or less straight outer contour. A second type, the *Cicuta virosa* type, resembles the *Oenanthe fistulosa* type even more closely but its polar caps are more subacute and the edge of the outer contour of the mesocolpium side is distinctly irregular.

***Orlaya grandiflora* type (Plate 60)**

Pollen class: 3-Zonocolporate.

P/E ratio: Pererect.

Apertures: Ectoaperture — colpus, short to rather long, about 1/2 pd or slightly more, narrow, slit-like, slightly widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium very small or absent, sexine slightly, but distinctly raised above endoaperture; costae faint, extending to colpus ends. Endoaperture — colpus, elliptic in outline; margins distinct, straight to slightly convex; ends distinct, rounded; costae very broad, band-like, rather faint.

Exine: Nexine about as thick as sexine or slightly thinner at poles, distinctly thickened in equatorial area. Sexine 1 of columellae, short, but distinct at poles, in equatorial area slightly longer than at poles, but uniform in length. Sexine 2 a distinct tectum, considerably thickened in equatorial area, where it is about as thick as sexine 1, smooth, not or only slightly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate in SEM. Columellae in cross-section at poles small, more or less regular in size, but irregular in outline, angular, crowded; in mesocolpium of about the same size throughout, but less crowded at equator.

Outlines: Equatorial view — rectangular, elliptic or slightly bone-shaped. In side view, inner contour of mesocolpium side straight or shallowly curved, outer contour straight or slightly concave; on colpus side inner contour concave or straight, outer contour straight. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides straight or slightly convex at shoulders.

Measurements: Glycerine jelly — P 52—(58.0)—63 μm ; E 24—(25.5)—29 μm ; P/E ratio 2.08—(2.27)—2.50. Exine thickness at poles ca. 3 μm , at equator ca. 4 μm . Silicone oil — P 48—(51.5)—54 μm ; E 20—(23.5)—27 μm ; P/E ratio 2.00—(2.20)—2.37.

Species: *Orlaya grandiflora*.

Comments

Pollen of the *Orlaya grandiflora* type is easily recognized by its smooth, very thick tectum in the equatorial area, its large size and short colpi. It is dissimilar from all other pollen types in the Umbelliferae in Western Europe.

Pollen of the related taxon *Caucalis platycarpus* has some resemblance to this type in the size of its grains, but it differs clearly in its more bone-shaped outline and thinner, distinctly undulating tectum.

Van Zeist et al. (1977) included pollen of *Orlaya grandiflora* in their *Malabaila* type. This type also comprises several species of *Heracleum*, which are indeed very similar to *Malabaila* pollen. *Orlaya* pollen, however, differs in many features such as the short, distinct colpuses, the thick, smooth tectum and the less coarse columellae.

Pastinaca sativa type (Plate 61)

Pollen class: 3-Zonocolporate.

P/E ratio: Usually pererect, sometimes erect.

Apertures: Ectoaperture — colpus, short to rather long, up to 1/2 pd or slightly longer, narrow, sometimes a little widened above endoaperture, slightly sunken; margins distinct, wavy; ends distinct, acute; fastigium absent; sexine not raised above endoaperture; costae extending nearly to colpus ends. Endoaperture — colpus, elliptic in outline; margins distinct, a little convex; ends distinct, obtuse; costae very broad, band-like, thick.

Exine: Nexine distinctly thinner than sexine, distinctly thickened in equatorial area. Sexine 1 of columellae, at poles about as long as at shoulders, but distinctly shorter than at equator. Sexine 2 a tectum, slightly or not undulating in equatorial area, irregularly edged.

Ornamentation: Psilate, irregularly rugulate ("cerebroid") in SEM. Columellae in cross-section at poles coarse, irregular in size, more or less angular in outline, spaced; in mesocolpium columellae distinctly visible, thinner, smaller and more uniform in size, distinctly thicker towards poles.

Outlines: Equatorial view — usually elliptic, sometimes a little bone-shaped. In side view, inner contour of mesocolpium side curved, outer contour straight or a little concave; on colpus side inner contour distinctly inwardly curved, outer contour straight or a little convex. Polar caps very obtuse. Polar view — triangular with apertures in the sides; sides more or less straight or a little concave at shoulders.

Measurements: Glycerine jelly — P 34—(37.5)—41 μm ; E 17—(18.5)—19 μm ; P/E ratio 1.90—(2.05)—2.25. Exine thickness at poles ca. 2 μm , at equator 3—4 μm . Silicone oil — P 29—(32.0)—35 μm ; E 13—(16.0)—18 μm ; P/E ratio 1.80—(2.01)—2.15.

Species: *Pastinaca sativa*.

Comments

Pollen of this type is more or less comparable with that of the *Heracleum sphondylium* type; the length of the colpus, the features of the endoaperture

and the rather coarse columellae are similar in both types. *Pastinaca sativa* differs, however, because of its distinct colpus ends without an area of less distinct columellae, its simple, non-branched columellae at the poles, its longer columellae at the equator and its smaller size.

***Petroselinum segetum* type (Plate 62)**

Pollen class: 3-Zonocolporate.

P/E ratio: Erect.

Apertures: Ectoaperture — colpus, long, up to pd, narrow, slit-like, not widened at equator, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent; sexine not or only slightly raised above endoaperture; costae up to 1/3 colpus length. Endoaperture — colpus, elliptic, narrowly elongated; margins straight, ends rounded; costae broad, band-like.

Exine: Nexine at poles about as thick as, or thicker than sexine, slightly thickened in equatorial area, but there sexine distinctly thicker. Sexine 1 of columellae, very short, and indistinct at poles, distinctly longer at equator, often shortest at shoulders. Sexine 2 a tectum, not or only slightly undulating in equatorial area, but irregularly edged.

Ornamentation: Psilate, irregularly rugulate in SEM. Columellae in cross-section at poles small, uniform in size and outline, more or less circular, crowded; in mesocolpium columellae more distinct, slightly smaller, distinctly decreasing in visibility towards poles.

Outlines: Equatorial view — elliptic. In side view, inner contour of mesocolpium side straight or slightly concave, outer contour straight to slightly concave; on colpus side inner contour straight to slightly concave, outer contour straight to slightly convex. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides at shoulders slightly concave.

Measurements: Glycerine jelly — P 23—(24.5)—26 μm ; E 13—(14.0)—15 μm ; P/E ratio 1.64—(1.77)—1.94. Exine thickness at poles ca. 2 μm , at equator ca. 2.5 μm . Silicone oil — P 21—(23.0)—25 μm ; E 12—(13.0)—14 μm ; P/E ratio 1.64—(1.74)—1.95.

Species: *Petroselinum segetum*.

Comments

The *Petroselinum segetum* type belongs to a group of pollen types with small, elliptic grains and long colpi. This type is characterized by its thick nexine, very short and indistinct columellae, and colpi just reaching pd. Other differential characters are the elongated endoaperture and the smooth or only slightly undulating tectum.

Pollen of *Petroselinum crispum* (*Peucedanum palustre* type) differs in the length of its columellae at the equator and its distinctly undulating tectum. In addition, its pollen is much larger.

***Peucedanum palustre* type (Plates 63–75)**

Pollen class: 3-Zonocolporate.

P/E ratio: Usually pererect, sometimes erect.

Apertures: Ectoaperture — colpus, rather long to long, slightly over 1/2 pd to pd, narrow, slit-like, not widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent or small, but sexine always more or less raised above endoaperture; costae extending to half colpus length. Endoaperture — colpus, lalongate, elliptic; margins distinct, usually straight, sometimes slightly convex; ends rounded, subacute to sub-obtuse or obtuse; costae broad, band-like.

Exine: Nexine thinner than sexine at poles, slightly or distinctly thickened in equatorial area (costae). Sexine 1 of columellae, short, but distinct at poles, longer at shoulders and in equatorial area, but usually less than twice nexine thickness. Sexine 2 a tectum, thin at poles, slightly thicker and slightly to distinctly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate-striate to “cerebroid” in SEM. Columellae in cross-section at poles rather regular in outline, more or less circular, usually medium-sized but variable; in mesocolpium smaller, either uniformly sized throughout mesocolpium, or smaller at shoulders.

Outlines: Equatorial view — usually elliptic, sometimes slightly bone-shaped. In side view, inner contour of mesocolpium side straight, concave, rarely (probably as an aberrant feature) slightly shallowly curved; outer contour usually straight, sometimes slightly concave; on colpus side inner contour straight; outer contour more or less straight. Polar caps obtuse or subobtuse. Polar view — triangular with apertures in the sides; sides slightly concave at shoulders.

Measurements: Glycerine jelly — P 26–43 μm ; E 12–19 μm ; P/E ratio 1.69–2.55. Exine thickness 2–3 μm at poles, 3–3.5 μm at equator. Silicone oil — P 21–37 μm ; E 11–18 μm ; P/E ratio 1.75–2.54.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Angelica heterocarpa</i>	29–(33.5)–37	13–(14.0)–16	2.07–(2.39)–2.53
<i>A. sylvestris</i>	30–(33.0)–43	12–(15.0)–19	2.00–(2.33)–2.54
<i>Bunium bulbocastanum</i>	26–(29.0)–33	14–(15.0)–17	1.69–(1.91)–2.03
<i>Foeniculum vulgare</i>			
ssp. <i>vulgare</i>	27–(29.5)–33	13–(14.5)–17	1.83–(2.01)–2.15
ssp. <i>piperitum</i>	26–(29.0)–31	12–(12.5)–13	2.21–(2.31)–2.36
<i>Petroselinum crispum</i>	29–(31.0)–34	12–(14.0)–15	2.05–(2.23)–2.36
<i>Peucedanum alsaticum</i>	26–(28.5)–31	12–(14.0)–16	1.78–(2.03)–2.16
<i>P. austriacum</i>	34–(35.5)–37	14–(15.0)–17	2.19–(2.34)–2.55
<i>P. carvifolia</i>	28–(32.0)–35	13–(14.5)–16	2.09–(2.21)–2.41
<i>P. cervaria</i>	28–(32.0)–38	12–(14.5)–18	2.03–(2.18)–2.35
<i>P. gallicum</i>	29–(30.5)–32	13–(14.0)–16	2.02–(2.20)–2.44
<i>P. lancifolium</i>	28–(31.5)–35	12–(13.5)–15	2.21–(2.29)–2.47
<i>P. officinale</i>	31–(33.5)–37	14–(16.0)–18	2.00–(2.11)–2.23

5. a. Columellae between shoulders and equator often slightly longer than those at equator; cross-section of columellae at equator finer than in rest of mesocolpial area. *Selinum carvifolium* group
(*S. carvifolium*, *S. pyrenaicum*)
- b. Columellae between shoulders and equator no longer than those at equator; cross-section of columellae of uniform size throughout mesocolpium. *Petroselinum crispum*
6. a. Inner contour of mesocolpium side more or less curved 7
- b. Inner contour of mesocolpium side straight 8
7. a. On mesocolpium side columellae at poles usually longer than those at shoulders, or equally long; columellae increase in length below shoulders; endoaperture broadly elongated; margins straight; inner contour of mesocolpium side usually distinctly curved; erect or pererect.
. *Bunium bulbocastanum*
- b. On mesocolpium side columellae at poles usually shorter than those at shoulders; columellae increase in length from poles downwards; endoaperture small and narrow, usually with convex margins; inner contour of mesocolpium side shallowly curved; distinctly pererect
. *Foeniculum vulgare* ssp. *piperitum*
8. a. Columellae at equator about as long as nexine thickness or only slightly longer; sexine distinctly raised above endoaperture; grains relatively small *Peucedanum palustre* group
(*P. gallicum*, *P. palustre*)
- b. Columellae at equator distinctly longer than nexine thickness (about $1\frac{1}{2}$ times); sexine usually only slightly raised above endoaperture; endoaperture usually broadly elliptic 9
9. a. Colpi short, about $1/2$ pd *Foeniculum vulgare* ssp. *vulgare*
- b. Colpi distinctly longer, up to $2/3$ pd *Peucedanum carvifolia* group
(*P. austriacum*, *P. carvifolia*, *P. cervaria*, *P. lancifolium*,
P. oreoselinum, *P. officinale*)

Comments

Pollen of this large type is, for pollen-morphologists, the characteristic Umbelliferae pollen. The grains are usually pererect, less frequently on the upper limits of the erect category, and have a bone-shaped outline. This phenomenon is, however, not due to the outer, but the inner contour of the grains. In fact, the overall outline is usually elliptic or subrectangular, and only occasionally are the long sides a little concave at the equator. The inner contours, on the other hand, are distinctly concave (central section may be straight or curved), thus giving the pollen its characteristic bone-shaped appearance.

The *Peucedanum palustre* type comprises pollen of many taxa, most belonging to the genus *Peucedanum*. Except for the typical outer and inner contours, the type is characterized by rather long or long colpi and the columellae on the mesocolpium side which are always higher in the equatorial area than at the poles.

Most of the characteristics of this type are somewhat variable. The colpus length varies between taxa from $1/2$ pd to pd, but sometimes this range of variation is also found among the different specimens of one taxon. The columellae at the equator vary in length; they are at least as thick as the nexine but may be up to $2\frac{1}{2}$ times as thick in *Peucedanum alsaticum*. The inner contour on the mesocolpium side is also variable. Most species of *Peucedanum* have straight inner contours, but exceptionally, shallowly curved inner contours can occur. On the other hand, most taxa apart from *Peucedanum* have more or less curved inner contours but, again, in most taxa pollen grains can occur with straight sides.

So the key to the pollen groups and species has to be used with care. The characters given are all variable to a certain extent and it is therefore sometimes difficult to be certain of a correct identification. In particular, immature pollen grains have not developed all the features to the full extent. Nevertheless, a combination of a number of features often leads to a good result. For that reason I have attempted to characterize the differential characters in short descriptions of some taxa and groups as follows.

Angelica sylvestris group (*Angelica heterocarpa* and *A. sylvestris*). Inner contour shallowly curved or straight; colpus length long to very long, between $3/4$ pd and pd; length of columellae at equator about $1\frac{1}{2}$ times nexine thickness or less; endoaperture elongated, margins straight; P/E ratio pererect. Special characteristics: (a) tectum distinctly undulating; (b) polar caps in colpus view subobtusate; (c) in colpus view, outline of long sides distinctly concave, constricted at the equator. Ornamentation in SEM "cerebroid".

Bunium bulbocastanum. Inner contour on mesocolpium side usually distinctly curved, colpus usually rather long ($2/3$ – $3/4$ pd); length of columellae at equator usually up to twice as long as nexine thickness, but sometimes shorter; P/E ratio usually erect or pererect. Special characteristics: columellae at the poles often longer than those at the shoulders. Ornamentation in SEM rugulate-striate.

Foeniculum vulgare. Pollen grains are very variable and the two subspecies tend to differ in their pollen morphology as follows:

	Colpus length	Columellae length at equator	Inner contour on mesocolpium side	P/E ratio
<i>ssp. vulgare</i>	ca. $1/2$ pd	$1\frac{1}{2}$ – $2 \times$ nexine	straight	erect or sometimes pererect
<i>ssp. piperitum</i>	$2/3$ – $3/4$ pd	1 – $1/2 \times$ nexine	shallowly curved	pererect

F. vulgare *ssp. vulgare* is best recognized by its combination of a short colpus ($1/2$ pd), long columellae at equator ($1\frac{1}{2}$ – $2 \times$ nexine) and straight inner

contour on mesocolpium side. Pollen of ssp. *piperitum* most closely resembles the group of *Peucedanum* species recognized as the *Peucedanum carvifolium* group. Differentiating features are the small endoapertures with convex margins and the usually shallowly curved inner contour on the mesocolpium side. In the SEM the ornamentation is striate-rugulate.

Petroselinum crispum. Inner contour usually shallowly curved; colpus long (about $3/4$ pd); length of columellae at equator $1\frac{1}{2}$ –2 times as thick as nexine; P/E ratio pererect; endoaperture prominently elongated, margins often slightly convex. No special differentiating characteristics.

Peucedanum alsaticum. Pollen of this species is uncharacteristic of the genus *Peucedanum* and does not resemble that of any other Northwest European species of the genus. The differentiating characteristics are: inner contour on mesocolpium side straight; colpus long (up to pd); length of columellae at equator high, up to $2\frac{1}{2}$ times as thick as nexine; P/E ratio often erect; endoaperture narrowly elongated; margins straight. Special characteristics: columellae at equator usually higher than in any other species of this pollen type; outer contour of mesocolpium side straight to slightly convex; pollen relatively small (see table).

Peucedanum palustre group. This group consists of two *Peucedanum* species, which, in many characters, resembles the *P. carvifolia* group. All the differentiating characters are more or less relative and it is again the combination of features which results in the suggested separation of species. Differentiating characteristics are: inner contour of mesocolpium side straight; colpus long ($2/3$ – $3/4$ pd); columellae at equator short, equal to columellae at poles or only slightly longer; P/E ratio usually pererect; endoaperture rather small, elongated with straight margins. Special characteristic: sexine distinctly raised above the endoaperture.

Peucedanum carvifolia group. This group comprises most of the *Peucedanum* species and shows the basic features of the pollen type best: P/E ratio distinctly pererect, bone-shaped appearance; columellae at equator distinctly longer than those at poles, but no longer than twice nexine thickness. Its differentiating characteristics are: inner contour of mesocolpium side straight; colpus long ($2/3$ – $3/4$ pd); length of columellae at equator ca. $1\frac{1}{2}$ times nexine thickness; P/E ratio usually pererect; endoaperture elongated, margins straight. Special characteristic: sexine usually only slightly raised above the endoaperture.

Selinum carvifolia group. This group, comprising the two Northwest European *Selinum* species, resembles the pollen of the *Peucedanum* species very closely. It differs mainly in two characteristics: the very long colpi (over $3/4$ pd) and the more or less curved inner contour of the mesocolpium side. The differentiating characteristics are: inner contour of the mesocolpium side more or

less curved, sometimes straight; colpus length long ($3/4-1$ pd); length of columellae at equator rather short, $1-1\frac{1}{2}$ times nexine thickness; P/E ratio usually distinctly pererect; endoaperture broadly elongated, margins straight. No special characteristic.

According to Cerceau-Larrival (1962) *Peucedanum cervaria* should be transferred from the genus *Peucedanum* either to the genus *Imperatoria*, which includes the species *Peucedanum ostruthium* (not studied here), or to a new genus because of its subrectangular pollen. The present observations do not support this suggestion as subrectangular pollen also occurs in other *Peucedanum* species of the *P. carvifolia* group, including *P. officinale*.

Nigaud (1977), using SEM information, suggested four groups based on surface ornamentation within the French *Peucedanum* species: (1) cerebroid — *P. palustre*, *P. officinale*, *P. venetum*; (2) rugulate — *P. austriacum*, *P. carvifolia*, *P. cervaria*, *P. gallicum*, *P. lancifolium*; (3) striato-rugulate — *P. paniculatum*; and (4) striate — *P. schottii*. However, intermediates exist from one ornamentation to another, e.g. cerebro-rugulate (*P. oreoselinum*) and cerebro-perforate (*P. alsaticum*). As these features are only visible with the aid of the SEM I have not used Nigaud's results in the key to the species.

The *Bunium* type of van Zeist et al. (1977) is rather variable and probably comprises a number of pollen types described here. The illustrations of modern pollen of *Bunium rectangulum*, a species that does not occur in Western Europe, do not fit in the *Peucedanum palustre* type to which *Bunium bulbocastanum* belongs. From the illustrations it is clear that its sexine is prominently raised above the endoaperture, that the broadly elongated endoaperture is slightly protruding and that the columellae at the equator are distinctly shorter than those of *B. bulbocastanum*. Because of the more or less distinctly longer columellae towards the shoulders, the pollen grains might be placed in the *Pimpinella major* type.

The fossil examples differ from *Bunium rectangulum* and even more from the *Peucedanum palustre* type. For fig.18, 16 of Van Zeist et al. (1977) compare the *Angelica archangelica* type and for fig.18, 17 see the *Anthriscus sylvestris* type.

Pimpinella anisum type (Plate 76)

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, short, about $1/2$ pd, very narrow, slit-like, rather indistinct, sunken; margins present but indistinct, wavy; ends more or less visible, acute; fastigium present; sexine distinctly raised above endoaperture; costae about as long as colpi. Endoaperture — porus, rectangular to quadrangular, sometimes slightly protruding; margins distinct, straight; ends distinct, angles acute; costae broad, band-like.

Exine: Nexine thinner than sexine at poles, thickened in equatorial area (costae). Sexine 1 of columellae, very variable in length; at poles distinct,

increasing in length towards shoulders and ends of equatorial area, decreasing in length towards equator where columellae are about as long as those at poles; length of columellae at shoulders and ends of equatorial area about 4 times nexine thickness, branched. Sexine 2 a tectum, not particularly undulating in equatorial area. Because of extremely long columellae on either side of equator, mesocolpial area is characterized by two high "humps". *Ornamentation*: Psilate, irregularly rugulate ("cerebroid") in SEM. Columellae in cross-section at poles relatively small, uniform in size and circular in outline, crowded to spaced; in mesocolpium, columellae between poles and equator distinct and larger in size than at poles or equator, thus forming "islands" on either side of equator, separated by a "channel".

Outlines: Equatorial view — bone-shaped. In side view inner contour of mesocolpium side straight or a little concave, outer contour distinctly concave with two "humps"; on colpus side, inner contour straight or a little yoke-like, outer contour straight to a little convex to yoke-like. Polar caps obtuse. Polar view — triangular, cross-section at shoulders slightly concave, at equator sides prominently constricted, because of extremely long columellae.

Measurements: Glycerine jelly — P 31—(34.0)—35 μm ; E 15—(16.5)—18 μm ; P/E ratio 1.89—(2.06)—2.32. Exine thickness at poles 2 μm , at shoulders in equatorial area up to 4.5 μm . Silicone oil — P 26—(29.5)—33 μm ; E 14—(16.5)—18 μm ; P/E ratio 1.54—(1.78)—2.01.

Species: *Pimpinella anisum*.

Comments

The type is mainly characterized by its very long columellae between the shoulders and the equator. These columellae are often branched. They give rise to "islands" in the mesocolpium which are separated by a "channel" at the equator. A few other differentiating characters are the short ectocolpus and the protruding endoporus. This pollen type is unlike any other in the Umbelliferae.

Van Zeist et al. (1977) included in their *Pimpinella* type several Northwest European genera, e.g. *Daucus*, *Falcaria*, *Seseli*, and a few others that do not occur in Western Europe. The pronounced ridges in the interzone are particularly characteristic but there are other differential characteristics in the fairly short colpi and the rectangular endoporus. From the micrographs, it is clear that *Pimpinella barbata* and *P. orinitum* belong to the *P. anisum* type. Also, the micrograph of the fossil pollen grain (fig.20, 4) belongs to this type.

However, the three other genera mentioned above may be separated on special characters. *Daucus* pollen has a distinctly curved inner contour on the mesocolpium side, and the columellae in the mesocolpium area are all of about the same length and size, or only slightly longer towards the shoulders. *Falcaria vulgaris* pollen probably fits most closely in the *Pimpinella* type, but its columellae in the mesocolpium area are shorter and there are no pronounced ridges in the interzone ("islands"). *Seseli libanotis* pollen resembles the other examples less closely, even according to the description of the

Pimpinella type given by Van Zeist et al. Its pollen is more or less elliptic and the columellae at the equator are longer than those towards the shoulders. Its pollen has no pronounced ridges.

***Pimpinella major* type (Plates 77, 78)**

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, rather long ($1/2$ – $2/3$ pd), narrow, slit-like, not widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium small or absent, but sexine distinctly raised above endoaperture; costae indistinct, faint, extending almost to colpus end. Endoaperture — lalongate porus or short, relatively broad colpus, not protruding, elliptic or rectangular in outline; margins straight; ends distinct, often truncate with rounded corners, less frequently rounded; costae broad, band-like. **Exine:** Nexine thinner than sexine at poles, only slightly thickened in equatorial area. Sexine 1 of columellae, short and rather indistinct at poles, usually distinctly increasing towards shoulders, decreasing again towards equator, occasionally columellae at shoulders and equatorial area all of same length or only slightly longer towards shoulders, columellae on mesocolpium side often at least twice as long as nexine thickness. Sexine 2 a tectum, distinctly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate in SEM. In cross-section columellae at poles irregular in size and outline, angular, more or less spaced. In mesocolpium, fine and small at equator (but visible), usually distinctly longer towards poles and at shoulders.

Outlines: Equatorial view — usually distinctly bone-shaped, rarely elliptic (*Pimpinella saxifraga*). In side view, inner contour of mesocolpium side straight, but not curved, outer contour usually concave, rarely straight; on colpus side inner contour concave or straight, outer contour straight with a slight apiculation at endoaperture. Polar caps obtuse. Polar view — triangular, sides at shoulders slightly concave.

Measurements: Glycerine jelly — P 27–36 μm ; E 13–17 μm ; P/E ratio 1.81–2.47. Exine thickness ca. 1.5 μm at poles, up to 3 μm in equatorial area. Silicone oil — P 24–33 μm ; E 12–18 μm ; P/E ratio 1.61–2.30.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Pimpinella major</i>	27–(33.0)–36	13–(15.5)–17	1.86–(2.13)–2.47
<i>P. saxifraga</i>	27–(30.0)–34	14–(15.0)–17	1.81–(2.00)–2.21
	Silicone oil		
<i>P. major</i>	27–(31.0)–33	12–(15.5)–18	1.61–(2.01)–2.30
<i>P. saxifraga</i>	24–(27.5)–30	13–(14.0)–17	1.79–(1.97)–2.17

Species: *Pimpinella major*, *P. saxifraga*.

Comments

The *Pimpinella major* type is rather variable in the features of its sexine on the mesocolpium side. Generally, the columellae at the shoulders are somewhat longer than those at the equator proper but, especially in specimens of *P. saxifraga*, they are equal in length. The sexine/nexine ratio also differs. Usually the sexine is at least twice as thick as the nexine between the equator and the shoulders, but not in all pollen grains. Grains that do not have these two characteristic features are not easy to differentiate from the *Peucedanum palustre* type. The thicker tectum in the equatorial area and the indistinct undulation which may even be absent are, however, two additional features which might differentiate the least characteristic grains.

Pollen grains of both species in the type are so much alike that they cannot be separated.

Pleurospermum austriacum type (Plates 79–81)

Pollen class: 3-Zonocolporate.

P/E ratio: Erect, rarely semi-erect or pererect.

Apertures: Ectoaperture — colpus, very long, over pd, slit-like, not widened at equator, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent, but sexine distinctly raised above endoaperture; costae indistinct, extending only for a short distance along colpus. Endoaperture — porus, distinctly protruding; outline rectangular or quadrangular; margins straight; ends diffuse or distinct; costae indistinct, narrow, restricted to porus borders. **Exine:** Nexine thinner than sexine, not thickened in equatorial area. Sexine 1 of columellae, short but distinct at poles, shorter towards equator. Sexine 2 a tectum, thin, not undulating in equatorial area, smooth, or a little irregularly edged.

Ornamentation: Psilate, irregularly rugulate to cerebroid in SEM. In cross-section columellae at poles uniform in size, circular, crowded; in mesocolpium columellae less distinct, smaller.

Outlines: Equatorial view — colpus side distinctly rhombic. In side view, inner contour of mesocolpium side slightly convex, straight or curved, outer contour convex; on colpus side inner contour convex to irregular because of protruding aperture, outer contour rhombic, angular or apiculate in the middle. Polar caps obtuse. Polar view — triangular; sides straight to a little convex; apertures in the angles.

Measurements: Glycerine jelly — P 27–40 μm ; E 19–25 μm ; P/E ratio 1.29–2.06. Exine thickness at poles ca. 2.0 μm , sometimes somewhat less. Silicone oil — P 26–35 μm ; E 15–25 μm ; P/E ratio 1.21–1.98.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Physospermum cornubiense</i>	27–(32.0)–36	19–(22.0)–25	1.32–(1.45)–1.58
<i>Pleurospermum austriacum</i>	29–(31.5)–34	21–(22.5)–25	1.29–(1.40)–1.50
<i>Smyrnum olusatrum</i>	33–(36.0)–40	19–(20.5)–25	1.67–(1.77)–2.06

	P (μm)	E (μm)	P/E ratio
	Silicone oil		
<i>Physospermum cornubiense</i>	26—(29.5)—33	18—(22.0)—25	1.21—(1.36)—1.51
<i>Pleurospermum austriacum</i>	26—(27.5)—30	19—(21.0)—23	1.25—(1.31)—1.43
<i>Smyrniium olusatrum</i>	25—(30.0)—35	15—(18.0)—21	1.42—(1.66)—1.98

Species: Physospermum cornubiense, Pleurospermum austriacum, Smyrniium olusatrum.

Key to the species

1. a. Pollen erect, or pererect, P/E ratio over 1.60; columellae at poles distinctly longer than those at equator; in mesocolpium, columellae in cross-section distinctly thinner than those towards poles; sexine 1 at poles thicker than nexine *Smyrniium olusatrum*
- b. Pollen erect, sometimes semi-erect, P/E ratio less than 1.60; columellae at poles about the same length as at equator or only slightly longer; in mesocolpium and towards poles columellae in cross-section all of about the same size; at poles sexine 1 no thicker than nexine 2
2. a. In equatorial view, outer contour of colpus side gradually merging into the much raised aperture and sexine; outer contour angular, not apiculate *Pleurospermum austriacum*
- b. In equatorial view, outer contour of colpus side abruptly merging into the much raised aperture and sexine; outer contour apiculate.
. *Physospermum cornubiense*

Comments

The *Pleurospermum austriacum* type includes three genera, each of which has a single species in Northwest Europe but many more representatives outside the area. *Smyrniium* has ca. seven species in the Mediterranean and Asia Minor, *Physospermum* has ca. four species in the Mediterranean and the Caucasus and the largest genus, *Pleurospermum*, reaches from southern England to the Amur area of Siberia.

Pollen of this type is very characteristic and easily recognized by its rhombic outline and very long colpi. All three genera fall easily into the type and are distinctly different from all other Umbelliferae pollen types in the area. Nevertheless small differences exist between the taxa. In particular, *Smyrniium olusatrum* can be differentiated by its elongated appearance (P/E ratio >1.60) and distinct, long columellae at the poles. The two other taxa are much alike and can only be differentiated when perfectly mature pollen grains are available. A gradual transition of the side into the raised sexine above the endoaperture is more characteristic of *Pleurospermum austriacum*, whereas an abrupt (apiculate) raising of the sexine from the surface seems to be a differential character of *Physospermum cornubiense*. These differences are, however, not consistent in all grains.

Van Zeist et al. (1977) illustrated a fossil pollen grain (fig.18, 12) belonging to their *Bupleurum* type, which is probably a *Physospermum* grain.

Smyrnum has erect pollen and distinctly longer columellae at the poles than at the equator. The figured pollen grain lacks these features and since the sexine is slightly apiculate, it is probably a *Physospermum* species.

***Scandix pecten-veneris* type (Plates 82–84)**

Pollen class: 3-Zonocolporate.

P/E ratio: Pererect.

Apertures: Ectoaperture — colpus, short (ca. 1/2 pd or shorter), narrow, but widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium distinctly present or absent; sexine distinctly to slightly raised above endoaperture or not raised. Endoaperture — colpus, large, broadly elongated or endocingulum; margins distinct, usually straight or slightly convex towards the ends; ends diffuse, a little tapering. Costae rather broad, band-like.

Exine: Nexine thinner than sexine at poles, thickened in equatorial area and there about as thick as sexine or thicker. Sexine 1 of columellae, distinctly visible at poles, sometimes longer than those at shoulders (*Scandix pecten-veneris*), usually shorter than those at shoulders and equator. Tectum slightly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate in SEM. In cross-section columellae at poles either coarse and irregular or uniform in size, circular, crowded; at mesocolpium either irregular in outline and coarser (*Caucalis platycarpus*) or uniform in outline and size (*Candix pecten-veneris*).

Outlines: Equatorial view — distinctly bone-shaped. In side view, inner contour of mesocolpium side distinctly curved, outer contour distinctly concave; on colpus side inner contour concave, more or less inwardly curved, outer contour straight, sometimes a little apiculate (*Scandix pecten-veneris*). Polar caps very obtuse. Polar view — triangular, sides at shoulders straight with apertures centrally in sides and deeply concave at equator.

Measurements: Glycerine jelly — P 39–55 μm ; E 19–26 μm ; P/E ratio 2.06–2.64. Exine thickness at poles 2–3.5 μm , at equator 4–6 μm . Silicone oil — P 38–49 μm ; E 17–24 μm ; P/E ratio 1.84–2.30.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Caucalis platycarpus</i>	45–(50.5)–55	19–(21.5)–26	2.12–(2.35)–2.64
<i>Scandix pecten-veneris</i>	39–(45.0)–49	19–(20.5)–23	2.06–(2.17)–2.33
	Silicone oil		
<i>Caucalis platycarpus</i>	38–(41.5)–44	17–(19.0)–21	2.10–(2.17)–2.24
<i>Scandix pecten-veneris</i>	40–(43.5)–49	18–(21.0)–24	1.84–(2.09)–2.30

Species: *Caucalis platycarpus*, *Scandix pecten-veneris*.

Key to the species

1. a. Sexine distinctly raised above endoaperture, outer contour on colpus side slightly apiculate; columellae in cross-section at mesocolpium uniform in size and outline and of the same size as those at equator. *Scandix pecten-veneris*
 b. Sexine not or only slightly raised above endoaperture, outer contour on colpus side not apiculate; in cross-section columellae in mesocolpium variable in size and outline, more or less angular and distinctly coarser than those at poles *Caucalis platycarpus*

Comments

This pollen type is easily recognized because of its distinctly bone-shaped outline, short colpi, very obtuse polar caps and large size. It has some resemblance to the *Astrantia major* and *Orlaya grandiflora* types. *Orlaya* pollen differs in its much thicker tectum which does not undulate, and its less obvious bone-shape. The *Astrantia major* type has pollen with much longer colpi and a peculiar constriction of the outer and inner contours at the equator.

Pollen of *Caucalis* and *Scandix*, although very similar to their main characters, can easily be separated by the presence of a much raised sexine in *Scandix* pollen, a characteristic which *Caucalis* lacks. Another, but less clear differentiating character is found in the cross-section of the columellae in the mesocolpium. In *Caucalis* these columellae are much coarser in the equatorial area than near the poles and they are also more irregular in outline and size, whereas in *Scandix* pollen all these columellae are more uniform in both outline and size.

***Seseli libanotis* type (Plates 85–88)**

Pollen class: 3-Zonocolporate.

P/E ratio: Erect to pererect.

Apertures: Ectoaperture — colpus, rather long to very long ($2/3$ pd to pd or exceeding pd, usually ca. $3/4$ pd), slit-like, not widened above equator, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent; sexine usually raised above endoaperture, sometimes not or only slightly raised; costae colpi gradually decreasing in thickness from equator towards poles, usually extending to half colpus length. Endoaperture — colpus, elliptic in outline, often with straight margins, sometimes convex; ends usually distinct, less frequently diffuse; costae broad, band-like.

Exine: Nexine thinner than sexine at poles or about equally thick, always thinner than sexine in equatorial area, but slightly thicker there than at poles. Sexine 1 of columellae, short, distinct or indistinct at poles, longer and distinct at equator, sometimes shortest at shoulders. Sexine 2 a tectum, usually more or less undulating, or irregularly edged in equatorial area.

Outlines: Equatorial view — elliptic. In side view, inner contour of mesocolpium side straight or slightly convex, outer contour straight; on colpus side

Comments

The *Seseli libanotis* type comprises the genera *Seseli* and *Cnidium*. Pollen of *Cnidium dubium* is usually distinguished by its rather short colpus from that of *Seseli* with its long colpi. Otherwise *Cnidium* cannot be separated from *Seseli* on its pollen-morphology. It might be suggested that the two genera could be separated in different pollen types, but I have chosen to amalgamate them because too many grains have colpi which are intermediate in length.

The *Seseli libanotis* type resembles the *Apium inundatum* type in several characteristics such as the elliptic equatorial outline, the thin exine at the poles, the rather small size, etc. Characteristics that separate the two types are the very long colpus, the convex inner contour of the mesocolpium side, and the polar caps which are often subacute in the *Apium inundatum* type.

Pollen of the different *Seseli* species is not easily separated and the key to the species given here carries no guarantees for determination, since most of the features given vary in their expression. Features of the endoaperture are rather constant, but the length of the colpi is less reliable.

Van Zeist et al. (1977) mentioned *Seseli libanotis* pollen under their *Pimpinella* type, which has all the characteristics of the present *P. anisum* type. *Seseli* pollen differs, however, by its elliptic outline and longer columellae at the equator than towards the shoulders, a very characteristic feature of all *Pimpinella* pollen.

Cerceau-Larrival (1962) suggested that the genus *Seseli* should be split into three genera based on pollen-morphology, mainly P/E ratio characteristics. *Seseli montana* should be considered a true *Seseli*, but *S. libanotis* was suggested for transfer to the genus *Libanotis* and *S. hippomarathrum* to an unnamed new genus (together with *S. gracile* and *S. tortuosum*, two species not studied in this paper). The pollen observations reported in this paper confirm that pollen of *S. montana* is slightly different, but not so exceptional as to suggest a split from the other two species. *S. hippomarathrum* and *S. libanotis* pollen are much alike, and differ only a little in the length of their colpi, and I did not observe a special differentiation in the P/E characteristics. For that reason I would prefer to retain all three taxa in the genus *Seseli*.

Silaum silaus type (Plate 89)

Pollen class: 3-Zonocolporate.

P/E ratio: Usually pererect.

Apertures: Ectoaperture — colpus, long, up to or nearly up to pd, narrow, slit-like; not widened above endoaperture; margins distinct, wavy; ends distinct, acute; fastigium, if present, very small, sexine not or only slightly raised above endoaperture; costae rather indistinct, up to 1/3 colpus length. Endoaperture — colpus, outline broadly elliptic, elongated; margins straight to slightly convex; ends distinct, obtuse; costae broad, band-like.

Exine: Nexine thinner than sexine at poles and equator, slightly thickened in equatorial area. Sexine 1 of columellae, short, but distinct at poles, of about

the same length or shorter at equator, about the same length or longer towards shoulders, but only slightly so. Sexine 2 a tectum, not undulating, but irregularly edged in equatorial area.

Ornamentation: Psilate, irregularly rugulate-striate in SEM. Columellae in cross-section at poles coarse, but regular in size, circular or a little angular in outline, more or less spaced; in mesocolpium smaller in outline, circular, all of about the same size.

Outlines: Equatorial view — bone-shaped. In side view, inner contour of mesocolpium side straight, outer contour more or less concave; on colpus side inner contour straight, outer contour a little yoke-like or straight. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides in cross-section at shoulders concave.

Measurements: Glycerine jelly — P 27—(32.0)—35 μm ; E 12—(14.5)—17 μm ; P/E ratio 2.05—(2.20)—2.67. Exine thickness at poles and equator ca. 2 μm . Silicone oil — P 25—(28.5)—35 μm ; E 12—(13.5)—16 μm ; P/E ratio 1.90—(2.11)—2.26.

Species: *Silaum silaus*.

Comments

Pollen of *Silaum silaus* is rather variable and has no particularly characteristic features. The best features for recognition of its pollen are the long colpi, which are up to pd in length but do not exactly reach the border, and its columellae in the equatorial area, which are as long as those at the poles or a little longer. Other valuable differential characteristics are the more or less straight, not curved inner contour of the mesocolpium side, the irregularly edged, but not undulating tectum in the equatorial area, and the not, or only slightly raised sexine.

Pollen of the *Silaum silaus* type resembles that of the *Laser trilobium* type very closely. Because of the variability of the differential characters, a small overlap occurs; e.g. some pollen grains (in one specimen) of *L. trilobium* do not have higher columellae at the shoulders, and in *S. silaus* the sexine is sometimes a little raised above the endoaperture. Nevertheless, the combination of features and also the overall appearance is too divergent to combine the pollen of the two taxa into a single pollen type.

Sison amomum type (Plate 90)

Pollen class: 3-Zonocolporate.

P/E ratio: Usually erect, rarely pererect.

Apertures: Ectoaperture — colpus, long to very long (up to or over pd), narrow, not widened at equator, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent; sexine not raised above endoaperture; costae absent. Endoaperture — colpus, very narrow, rather small, elliptic, sides convex, a little tapering; margins distinct; ends subacute, distinct; costae narrow, rather indistinct, not forming a band around equator.

Exine: Nexine thinner than sexine, not thickened at equator on mesocolpium side. Sexine 1 of columellae, short, thin and indistinct at poles, much higher

and more distinct at equator, columellae gradually increasing from shoulders to equator. Sexine 2 a tectum, usually more or less undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate ("cerebroid") in SEM. Columellae in cross-section at poles small, uniform in size, circular, crowded; in mesocolpium more distinct, but still uniform in size, circular.

Outlines: Equatorial view — elliptic or slightly rhombic. In side view, inner contour of mesocolpium side convex, outer contour more convex; on colpus side inner contour straight to a little concave, outer contour convex to slightly rhombic. Polar caps obtuse. Polar view — triangular with apertures in the sides; cross-section at shoulders with concave sides.

Measurements: Glycerine jelly — P 19.5–(21.5)–25 μm ; E 12–(12.0)–14 μm ; P/E ratio 1.61–(1.80)–2.12. Exine thickness at poles 1.0–1.5 μm , at equator 1.5–2.5 μm . Silicone oil — P 17–(19)–21 μm ; E 11–(12)–13 μm ; P/E ratio 1.29–(1.58)–1.74.

Species: *Sison amomum*.

Comments

In its size and shape, pollen of *Sison amomum* resembles that of *Trinia glauca* and the *Apium inundatum* type very closely. The best differential characteristics are found in the combination of distinct, long columellae at the equator, a more or less undulating tectum, a very narrow endoaperture and thin costae around the endocolpus. The latter two features are also characteristic of *Trinia glauca* pollen, but in that species the pollen lacks the high columellae and undulating tectum. The *Apium inundatum* type differs mainly in the features of its endoaperture. Pollen grains of the *Sium latifolium* type are also rather similar but differ mainly in their broadly elliptic endoapertures.

Sium latifolium type (Plates 91, 92)

Pollen class: 3-Zonocolporate.

P/E ratio: Erect, rarely semi-erect.

Apertures: Ectoaperture — colpus, long or very long (up to or over pd), slit-like, but sometimes a little wider above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent; sexine not, slightly or distinctly raised above endoaperture; costae colpi absent. Endoaperture — colpus, broadly elliptic in outline; margins distinct, straight or convex; ends distinct or diffuse, tapering, acute or subacute; costae distinct but relatively narrow, not forming a band around the equator.

Exine: Nexine thinner than sexine at poles, not thickened in equatorial area. Sexine 1 of columellae, thin and rather distinct at poles, not or slightly thicker at equator. Sexine 2 a tectum, not or slightly thickened in equatorial area, not undulating, but slightly irregularly edged.

Ornamentation: Psilate, irregularly rugulate ("cerebroid") in SEM. At poles columellae in cross-section small, uniform in size, more or less circular, crowded. In mesocolpium columellae in cross-section small, circular.

Outlines: Equatorial view — distinctly elliptic. In side view, inner and outer contours of mesocolpium side distinctly convex; on colpus side inner contour straight or inwardly curved, outer contour convex. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides slightly concave at shoulders and equator.

Measurements: Glycerine jelly — P 21–37 μm ; E 14–21 μm ; P/E ratio 1.34–1.99. Exine thickness 1.5–2 μm at poles, 1.5–2.5 μm at equator. Silicone oil — P 20–33 μm ; E 13–19 μm ; P/E ratio 1.30–1.80.

	P (μm)	E (μm)	P/E ratio
	Glycerine jelly		
<i>Berula erecta</i>	21–(23.5)–25	14–(15.5)–16.5	1.34–(1.51)–1.74
<i>Sium latifolium</i>	28–(33.5)–37	17–(19.5)–21	1.53–(1.70)–1.99
	Silicone oil		
<i>Berula erecta</i>	20–(24.0)–27	13–(16.0)–18.5	1.30–(1.47)–1.75
<i>Sium latifolium</i>	27–(28.5)–33	15–(17.0)–19	1.54–(1.68)–1.80

Species: *Berula erecta*, *Sium latifolium*.

Key to the species

1. a. Inner contour of colpus side distinctly inwardly curved; pollen rather small (P usually < 27 μm) *Berula erecta*
- b. Inner contour of colpus side straight to slightly concave or convex; pollen larger (P usually > 27 μm) *Sium latifolium*

Comments

The *Sium latifolium* type is easily recognized by its distinctly elliptic outline in equatorial view, the columellae which are not or only slightly longer in the equatorial area, and the distinct, broadly elliptic endoapertures. Elliptic pollen grains are not rare in the Umbelliferae, but either they have longer columellae at the equator than at the poles, or the endoapertures are small.

The type comprises two species which can be separated by the characteristics given in the key. Whereas it is not difficult to separate these taxa on these differences, the features that the species have in common are so obvious that I decided to keep them in a single pollen type.

The genus *Berula* had already been separated from *Sium* by Koch in the nineteenth century, but this separation was not followed by most European taxonomists. The differential characteristics of *Sium* are mainly based on differences in the fruit and the stylopodium. Pollen-morphology does not support the separation of the two genera as has been done in Flora Europaea (Tutin et al., 1968).

Van Zeist et al. (1977) described a *Sium erectum* type and gave it a rather wide circumscription. I would have maintained the name of this type in the present study but, since *Sium erectum* has been transferred to the genus *Berula* in Flora Europaea, I decided to change the name of the type to the

Sium latifolium type. Moreover, Van Zeist et al. also included in their pollen type *Sison amomum* and *Trinia glauca*, two taxa with several pollen features in common, such as very long colpi, elliptic outline and narrow costae. Pollen of the *Sium latifolium* type, however, has large, broadly-elliptic endoapertures, whereas *Sison* and *Trinia* pollen grains have small, narrow endoapertures.

Torilis japonica type (Plate 93)

Pollen class: 3-Zonocolporate.

P/E ratio: Pererect to erect.

Apertures: Ectoaperture — colpus, short to rather long (ca. 1/2–2/3 pd), narrow, slit-like, not widened above endoaperture, sunken; margins distinct, wavy; ends distinct, acute; small fastigium present, sexine distinctly raised above endoaperture; costae faint, extending to colpus ends. Endoaperture — colpus, small and narrow, often somewhat protruding, outline elliptic; margins straight to slightly convex; ends distinctly rounded to slightly subacute; costae broad, band-like, rather thin.

Exine: Nexine thinner than sexine at poles and in equatorial area. Sexine 1 of columellae, short, but distinct at poles, distinctly longer in equatorial area, not noticeably longer towards shoulders. Sexine 2 a tectum, thin, distinctly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate in SEM. Columellae at poles in cross-section relatively small, uniform in size, circular, crowded; in mesocolpium relatively coarse, decreasing distinctly in size towards shoulders, circular.

Outlines: Equatorial view — bone-shaped. In side view, inner contour of mesocolpium side straight, outer contour concave; on colpus side inner contour concave or slightly yoke-like, outer contour concave, somewhat obtusely apiculate. Polar caps obtuse. Polar view — triangular with apertures in the sides; sides straight in cross-section at shoulders.

Measurements: Glycerine jelly — P 27—(30.5)—35 μm ; E 11—(13.5)—16 μm ; P/E ratio 2.05—(2.24)—2.43. Exine thickness at poles ca. 2 μm , at equator ca. 3 μm . Silicone oil — P 21—(25.0)—30 μm ; E 10—(12.0)—15 μm ; P/E ratio 1.73—(2.08)—2.34.

Species: *Torilis japonica*.

Comments

Pollen of *Torilis japonica* is characterized by its short colpi, small, elliptic endoapertures and distinctly undulating tectum in the equatorial area. The columellae are very variable in this area, but those towards the shoulders are not noticeably longer and their length is not as much as twice the nexine thickness anywhere in the area. Its pollen resembles a number of other pollen types such as the *Aethusa cynapium* type, the *Bifora radians* type, the *Chaerophyllum bulbosum* type, etc. These latter types, however, each differ in one or more essential features.

T. japonica pollen also differs from that of other *Torilis* species. *Torilis nodosa* is distinctly elliptic, and also shows many other different features. *T.*

arvensis pollen is much more similar, especially in its small, elliptic endoaperture, but the columellae in the equatorial area are much longer and are at least twice as thick as the sexine.

***Torilis nodosa* type (Plate 94)**

Pollen class: 3-Zonocolporate.

P/E ratio: Erect, rarely pererect.

Apertures: Ectoaperture — colpus, long (ca. $3/4$ pd or sometimes a little less), narrow, slit-like, not widened above equator, sunken; margins distinct, wavy; ends acute, distinct; fastigium absent, but sexine more or less distinctly raised above endoaperture; costae colpi absent. Endoaperture — a small, broadly elliptic colpus or elongated porus, somewhat protruding; margins distinct, straight; ends distinct, rounded; costae narrow, present only around endoaperture, not forming a band.

Exine: Nexine thinner than sexine at poles, not thickened on mesocolpium side. Sexine 1 of columellae, short at poles, somewhat longer in equatorial area, equally long at shoulders. Sexine 2 a tectum, slightly undulating in equatorial area.

Ornamentation: Psilate, irregularly rugulate ("cerebroid") in SEM. Columellae at poles in cross-section rather indistinct, small, regular in outline, crowded; in mesocolpium slightly more distinct.

Outlines: Equatorial view — elliptic. In side view, inner and outer contours of mesocolpium side a little convex; on colpus side inner contour convex or slightly yoke-like, outer contour slightly convex. Polar caps very obtuse, sometimes truncate. Polar view — triangular; apertures in the sunken sides. Sides in cross-section at shoulders straight or slightly concave.

Measurements: Glycerine jelly — P 21—(30.0)—36 μm ; E 13—(16.5)—20 μm ; P/E ratio 1.57—(1.78)—2.05. Exine thickness at poles ca. 2 μm , at equator ca. 2.5 μm . Silicone oil — P 20—(24.5)—29 μm ; E 11—(14.5)—17 μm ; P/E ratio 1.47—(1.68)—2.01.

Species: *Torilis nodosa*.

Comments

This pollen type is easily recognized by a combination of characters: (a) the convex outline with remarkably obtuse, nearly truncate polar caps; (b) the narrow costae around the endoapertures, which are not elongated into a band around the equator; (c) the slightly protruding apertures.

Pollen of *T. nodosa* is very different from that of other *Torilis* species in Northwest Europe (*T. arvensis*, *T. japonica*) and, indeed, from any other pollen type in the area.

***Trinia glauca* type (Plate 95)**

Pollen class: 3-Zonocolporate.

P/E ratio: Usually erect, rarely pererect.

Apertures: Ectoaperture — colpus, long (up to or exceeding pd), narrow, slightly or not widened at equator, sunken; margins distinct, wavy; ends distinct, acute; fastigium absent; sexine not raised above endoaperture; costae absent. Endoaperture — colpus, elongated, not protruding, outline not clear, but often more or less elliptic, very narrow; margins straight; ends diffuse or rounded; costae indistinct, narrow, not forming a band around the equator. **Exine:** Nexine thinner than sexine at poles and in equatorial area. Sexine 1 of columellae, indistinct and very short, at equator sometimes a little longer than at poles, but more often of equal length. Sexine 2 a tectum, not undulating at equator, smooth.

Ornamentation: Psilate, irregularly rugulate-striate in SEM. Columellae in cross-section at poles small and indistinct, crowded; at mesocolpium slightly more distinct, circular in outline.

Outlines: Equatorial view — elliptic. In side view, inner and outer contours of mesocolpium side convex; on colpus side inner contour straight or a little convex, outer contour convex. Polar caps obtuse. Polar view — triangular with apertures in the sides, not or only slightly sunken; in cross-section at shoulders sides straight.

Measurements: Glycerine jelly — P 22—(23.5)—28 μm ; E 11—(13.5)—15 μm ; P/E ratio 1.57—(1.78)—1.95. Exine thickness at poles 1—1.5 μm , at equator up to 2 μm . Silicone oil — P 19—(21.5)—24 μm ; E 11—(13.0)—15 μm ; P/E ratio 1.45—(1.65)—1.91.

Species: *Trinia glauca*.

Comments

Trinia glauca pollen resembles that of the *Apium graveolens* type very closely. It is also distinctly elliptic and has very thin, indistinct columellae at the poles. The best differential character is found in the endoaperture which in *Trinia* is a much elongated, narrow colpus with diffuse ends, not very obvious margins and indistinct costae. In *Apium graveolens* pollen the endocolpus has distinctly rounded ends and also the margins are clearly visible; moreover, the costae are distinct and surround the endoaperture which is not very narrow.

The *Trinia glauca* type also resembles the *Sison amomum* type in its size, shape and narrow endoaperture, but it differs from it in its short columellae at the equator and its tectum which is not undulating. Also, pollen of the *Sium latifolium* type is rather similar but differs in its large, broadly elliptic endoapertures.

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Plate descriptions (all plates $\times 2000$, except where otherwise stated)

PLATE 1 (p. 244)

Aegopodium podagraria L. (figs.1—2, Lieftinck s.n.; figs.3—10, Zijlstra 75105)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium straight, sexine slightly raised above endoaperture.
4. Equatorial view; cross-section, columellae uniform in length in the equatorial area.
5. Short colpus slightly widened above the endoaperture.
6. Broadly elongated endocolpus, elliptic in outline with straight margins.
7. Polar view; columellae at high focus.
8. Polar view, columellae at low focus, regular in outline, circular, small, crowded.
9. Polar view; cross-section at shoulders.
10. Polar view; cross-section at equator.

PLATE 2 (p. 245)

Aethusa cynapium L. (figs.1—10, Exc. Biol. Stud. Utrecht, Germany 1961-1941).

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; inner contour of mesocolpium straight, protruding endoporus.
4. Endoporus at high focus.
5. Short colpus and elongated endoaperture at low focus.
6. Ornamentation in mesocolpium.
7. Polar view; cross-section at equator.
8. Polar view; cross-section at shoulders.
9. Polar view, columellae at low focus, small, regular in size, irregular in outline, spaced.
10. Polar view, columellae at high focus.

PLATE 3 (p. 246)

Ammi majus L. (figs.1—2, Lejeune and Courtois 344; figs.3—10, Fernando et al. 4186).

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, outer contour of mesocolpium distinctly convex, columellae in equatorial area much higher than the nexine thickness.
4. Colpus view; cross-section.
5. Short colpus and elliptic endocolpus with straight margins and distinct ends.
6. Ornamentation in mesocolpium.
7. Polar view; columellae at high focus.
8. Polar view; columellae at low focus, small, uniform in size, more or less circular, crowded.
9. Polar view; cross-section at shoulders.
10. Polar view; cross-section at equator.

PLATE 1 (*Aegopodium podagraria* type: *A. podagraria*)

PLATE 2 (*Aethusa cynapium* type: *A. cynapium*)

PLATE 3 (*Ammi majus* type: *A. majus*)

PLATE 4 (p. 248)

Angelica archangelica L. (fig.1, Misset s.n.; 2—9, Heyligers s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section inner contour of mesocolpium distinctly curved, polar caps subacute.
4. Equatorial view; outline distinctly bone-shaped.
5. Polar view; columellae at low focus, coarse, irregular in size, angular, spaced.
6. Polar view; columellae at high focus.
7. Equatorial view; broadly elongated endocolpus with straight margins and distinct ends.
8. Short colpus.
9. Ornamentation in mesocolpium.

PLATE 5 (p. 249)

Angelica palustris (Besser) Hoffmann (figs.1—2, Kern and Reichgelt 10.672; figs.3—7, Otruba 447)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, columellae at the equator distinctly shorter than the poles, sexine distinctly raised above the endoaperture.
4. Very long colpus and broadly elongated endocolpus with straight margins and subacute ends.
5. Polar view; cross-section at equator.
6. Polar view; columellae at low focus, small, uniform in size, circular or a little angular, crowded.
7. Polar view; cross-section at shoulders

PLATE 6 (p. 250)

Anthriscus caucalis Bieberstein (figs.1—2, Leeuwenberg 1340; figs.3—8, Van der Aa s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, outer contour of colpus side a little rhombic, columellae of mesocolpium side irregular in length.
4. Equatorial view; cross-section, sexine raised above the endoaperture.
5. Polar view; cross-section at equator, outline more or less circular.
6. Polar view; columellae at low focus, small, regular in size, irregular in outline, crowded.
7. Polar view; columellae at high focus.
8. Short colpus and short endocolpus with straight margins and distinct ends.

PLATE 7 (p. 251)

Anthriscus cerefolium (L.) Hoffmann (figs.1—9, Buysman 332)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, protruding porus, inner contour of colpus side yoke-like, columellae at equator distinctly shorter than those at poles, increasing towards shoulders.
4. Endoporus at high focus, rectangular in outline.
5. Short colpus and endoporus at low focus.
6. Polar view; columellae at high focus.
7. Polar view; columellae at low focus, coarse, irregular in size and outline, angular, spaced.
8. Polar view; cross-section at shoulders.
9. Polar view; cross-section at equator.

PLATE 4 (*Angelica archangelica* type: *A. archangelica*)

PLATE 5 (*Angelica palustris* type: *A. palustris*)

PLATE 6 (*Anthriscus caucalis* type: *A. caucalis*)

PLATE 7 (*Anthriscus cerefolium* type: *A. cerefolium*)

PLATE 8 (p. 253)

Anthriscus nitida (Wahlenberg) Garcke (figs.1- 2, Ketner 115; figs.3- 8, Exc. Biol. Stud. Utrecht, France 1983-88)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, columellae at poles longer than at shoulders.
4. Rather long colpus and narrow, elongated endocolpus with straight margins and distinct ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders, very short columellae.
8. Polar view; columellae at low focus, small, irregular in size and outline, crowded.

PLATE 9 (p. 254)

Anthriscus sylvestris (L.) Hoffmann (fig.1, Gadella et al. 61; figs.2- 8, Malotau s.n.)

1. SEM micrograph; ornamentation ($\times 10\ 000$).
2. Equatorial view; cross-section, inner contour of mesocolpium curved, columellae at poles longer than at shoulders.
3. Ornamentation in mesocolpium.
4. Elongated, rather narrow endocolpus with straight sides and tapering ends.
5. Rather long colpus.
6. Polar view; cross-section at equator, columellae short.
7. Polar view; columellae at low focus, rather coarse, more or less irregular in size and outline, spaced.
8. Polar view; columellae at high focus.

PLATE 10 (p. 255)

Apium inundatum (L.) Reichenbach fil. (figs.1-5, Watson s.n.)

1. SEM micrograph; equatorial view ($\times 5000$).
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner- and outer contour of mesocolpium side distinctly convex.
4. Colpus view; cross-section; outline distinctly elliptic.
5. Very long colpus and elliptic endocolpus with convex margins and tapering ends.

PLATE 11 (p. 256)

Apium graveolens L. (figs.1-2, Rutishauser 16-46; figs.4-8, Behrendsen 1201)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, outer contour of mesocolpium only slightly convex; columellae in equatorial area distinctly longer than those at poles.
4. Very long colpus and elongated endocolpus with straight margins and acute ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator, columellae as long as nexine thickness.
7. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
8. Polar view; columellae at high focus.

PLATE 8 (*Anthriscus sylvestris* type: *A. nitida*)

PLATE 9 (*Anthriscus sylvestris* type: *A. sylvestris*)

PLATE 10 (*Apium inundatum* type: *A. inundatum*)

PLATE 11 (*Apium inundatum* type: *A. graveolens*)

PLATE 12 (p. 258)

Apium nodiflorum (L.) Lagasca (figs.1—2, Hessel et al. 1398; figs.3—8, Leeuwenberg 1578)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, columellae uniform in length, sexine slightly raised above the endoaperture.
4. Equatorial view; cross-section, columellae gradually increasing from shoulders to equator.
5. Very long colpus and narrow endocolpus with convex margins and acute ends.
6. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
7. Polar view; cross-section at shoulders, columellae very short.
8. Polar view; cross-section at equator, columellae somewhat longer.

PLATE 13 (p. 259)

Astrantia major L. (figs.1—4, Exc. Biol. Stud. Utrecht, France 1953—479)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side distinctly curved over a short section of the equatorial area.
4. Very long colpus and broad, elongate endocolpus with straight margins and the truncate ends with horns.

PLATE 14 (p. 260)

Astrantia major L. (figs.2—4, Exc. Biol. Stud. Utrecht, France 1953—479)

2. Polar view; columellae at high focus.
3. Polar view; columellae at low focus, relatively small, irregular in size, more or less circular, crowded.
4. Polar view; cross-section.

Sanicula europaea L. (figs.1, 5, Wilson 14)

1. SEM micrograph; equatorial view.
5. Equatorial view; cross-section, inner contour of mesocolpium side only shallowly curved over a short section of the equatorial area.

PLATE 15 (p. 261)

Sanicula europaea L. (fig.1, Stafleu s.n.; figs.2—5, Wilson 14)

1. SEM micrograph; equatorial view with colpus.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Polar view; columellae at high focus, relatively small, uniform in size, circular, crowded.
4. Endocolpus broad, with straight margins, ends without horns.
5. Very long colpus.

PLATE 12 (*Apium inundatum* type: *A. nodiflorum*)

PLATE 13 (*Astrantia major* type: *A. major*)

PLATE 14 (*Astrantia major* type: *A. major*, 2–4; *Sanicula europaea*, 1, 5)

PLATE 15 (*Astrantia major* type: *Sanicula europaea*)

PLATE 16 (p. 263)

Bifora radians Bieberstein (figs.1—8, Buysman 660)

1. SEM micrograph; equatorial view.
2. SEM micrograph; polar view ($\times 5000$).
3. Equatorial view; cross-section, distinctly protruding endoporus, inner contour of colpus side yoke-like, columellae towards the shoulders distinctly longer in equatorial area and there more than twice as thick as nexine.
4. Endoporus at high focus, rectangular in outline.
5. Endoporus at low focus, a short colpus or elongate porus.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, coarse, irregular in size and outline, spaced.

PLATE 17 (p. 264)

Coriandrum sativum L. (figs.1—8, Blom s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of colpus side slightly yoke-like; columellae towards the shoulders longer in equatorial area.
4. Endoporus at high focus, rectangular in outline.
5. Short colpus and rectangular endoporus with straight margins.
6. Polar view; cross-section at shoulders.
7. Polar view; columellae at low focus, coarse, irregular in size and outline, spaced.
8. Polar view; columellae at high focus.

PLATE 18 (p. 265)

Bupleurum falcatum L. (figs.1—6, Exc. Biol. Stud. Utrecht, France, 1953-322)

1. SEM micrograph; equatorial view with colpus ($\times 5000$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, outer contour of colpus side rhombic, columellae longer at poles than at equator.
4. Colpus view; cross-section, outer contours distinctly rhombic.
5. Very long colpus and broad endocolpus with straight margins and truncate, diffuse ends.
6. Polar view; cross-section, apertures in the corners.

PLATE 19 (p. 266)

Bupleurum baldense Turra (figs.1—6, Baretta 2)

1. Equatorial view; cross-section, columellae at poles about as long as those at equator.
2. Colpus view; cross-section, outer contours distinctly rhombic.
3. Long colpus not over pd and broad endocolpus with straight margins and diffuse ends.
4. Polar view; cross-section at equator, apertures in corners.
5. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
6. Polar view; columellae at high focus.

Bupleurum gerardii Allioni (figs.7—12, Willems 63-3962)

7. Equatorial view; cross-section, inner contour of colpus side rhombic, columellae at poles longer than those at equator.
8. Polar view; cross-section at equator, apertures in the corners.
9. Very long colpus and rectangular endocolpus with diffuse ends.
10. Polar view; colpus ends.
11. Polar view; columellae at high focus.
12. Polar view; columellae at low focus, small, regular in size, circular, crowded.

PLATE 16 (*Bifora radians* type: *B. radians*)

PLATE 17 (*Bifora radians* type: *Coriandrum sativum*)

PLATE 18 (*Bupleurum falcatum* type: *B. falcatum*)

PLATE 19 (*Bupleurum falcatum* type: *B. baldense*, 1–6; *B. gerardii*, 7–12)

Bupleurum tenuissimum L. (figs.1—2, Exc. Biol. Stud. Utrecht, Spain 1964-845; figs.3—6, Lindeman s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Ornamentation in mesocolpium.
4. Equatorial view; cross-section, columellae at poles slightly longer than those at equator, inner contour of colpus side distinctly rhombic.
5. Polar view; cross-section at equator, apertures in the corners.
6. Polar view; columellae at low focus, small, regular in size, circular, crowded.

Bupleurum longifolium L. (figs.7—9, s.c., s.n. no. 764)

7. Equatorial view; cross-section, inner contour of colpus side rhombic.
8. Colpus view; cross-section, outer contours distinctly rhombic.
9. Very long colpus and rectangular endoporus with straight margins and diffuse ends.

PLATE 21 (p. 269)

Caropsis verticillatoinundata (Thore) Rauschert (figs.1—2, Herb. Gén., Fac. des Sciences Clermont-Ferrand s.n.; figs.3—6, Lambinon s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side distinctly curved, of colpus side inward curved.
4. Polar view; cross-section at equator.
5. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
6. Very long colpus and elliptic endocolpus with slightly convex margins and acute, distinct ends.

PLATE 22 (p. 270)

Carum carvi L. (figs.1—2, Exc. Biol. Stud. Utrecht, Andorra 1967-1128; figs.3—9, Exc. Biol. Stud. Utrecht, Germany 1976-54)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side slightly curved, columellae at poles longer than those at shoulders.
4. Rather long colpus.
5. Broadly elongated endocolpus with straight margins and distinct, obtuse ends.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, small, regular in size, circular, crowded.
9. Polar view; columellae at high focus.

PLATE 23 (p. 271)

Carum verticillatum (L.) Koch (figs.1—9, Exc. Biol. Stud. Utrecht, France 1963-3541)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side slightly convex, columellae more or less uniform in length.
4. Long colpus and broad, much elongated endocolpus with straight margins and acute ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, small, regular in size, circular, crowded.
9. Polar view; columellae at high focus.

PLATE 20 (*Bupleurum falcatum* type: *B. tenuissimum*, 1–6; *B. longifolium*, 7–9)

PLATE 21 (*Caropsis verticillatoinundata* type: *C. verticillatoinundata*)

PLATE 22 (*Carum carvi* type: *C. carvi*)

PLATE 23 (*Carum verticillatum* type: *C. verticillatum*)

PLATE 24 (p. 273)

Chaerophyllum aureum L. (figs.1—9; Exc. Biol. Stud. Utrecht, Switzerland 1913-160)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, outer contour of mesocolpium side distinctly concave, columellae in the equatorial area all of about the same length.
4. Colpus view; rather long colpus and porus-like endoaperture, outline distinctly bone-shaped.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, coarse, irregular in size and outline, spaced.
9. Polar view; columellae at high focus.

PLATE 25 (p. 274)

Chaerophyllum bulbosum L. (fig.1, H. and P.J. Maas 63; fig.2, Leeuwenberg 1624; figs.3—8, Neyenhuis s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, length of columellae in equatorial area longer near the shoulders than at equator.
4. Short colpus and porus-like endoaperture with slightly convex margins.
5. Polar view; columellae at high focus.
6. Polar view; columellae at low focus, coarse, very irregular in size and outline spaced.
7. Polar view; cross-section at shoulders.
8. Polar view; cross-section at equator.

PLATE 26 (p. 275)

Chaerophyllum hirsutum L. (figs.1—4, Horreus de Haas 115; figs.6—9, Exc. Biol. Stud. Biol. Utrecht, France 1960-18)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, columellae at poles distinctly higher than those at equator, endoaperture slightly protruding, inner contour of colpus side slightly yoke-like.
4. Endoaperture at high focus porus-like, short colpus.
5. Endoaperture at low focus, colpus-like with straight, a little constricted margins, ends obtuse.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, rather coarse, irregular in size, more or less regular in outline, more or less spaced.
9. Polar view; columellae at high focus.

PLATE 24 (*Chaerophyllum aureum* type: *C. aureum*)

PLATE 25 (*Chaerophyllum bulbosum* type: *C. bulbosum*)

PLATE 26 (*Chaerophyllum hirsutum* type: *C. hirsutum*)

PLATE 27 (p. 277)

Chaerophyllum temulentum L. (figs.1—2, Exc. Biol. Stud. Utrecht, England 1968-160; figs.3—9, Dijkstra 378)

1. SEM micrograph; equatorial view.
2. Equatorial view; cross-section, inner contour of mesocolpium side straight, endoaperture distinctly protruding, inner contour of colpus side yoke-like.
3. Short colpus and porus-like endoaperture.
4. Ornamentation in mesocolpium.
5. Equatorial view; cross-section, columellae at equator distinctly shorter than those at poles.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, small, regular in size and outline, more or less spaced.
9. Polar view; columellae at high focus.

PLATE 28 (p. 278)

Cicuta virosa L. (figs.1—2, Hessel et al. 1421; figs.3—9, Swart 462)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Ornamentation in mesocolpium.
4. Equatorial view; cross-section; inner contour of mesocolpium side only slightly curved, outer contour of mesocolpium side straight, polar caps subacute.
5. Broad, elongate endocolpus with straight margins and truncate ends with horns.
6. Very long colpus a little widened above the endoaperture.
7. Polar view; cross-section at equator.
8. Polar view; cross-section at shoulders.
9. Polar view; columellae at low focus, small, uniform in size, circular, crowded.

PLATE 29 (p. 279)

Conium maculatum L. (figs.1—2, Leeuwenberg 1507; figs.3—9, Exc. Biol. Stud. Utrecht, 1961-1700)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side curved, sexine not raised above the endoaperture.
4. Rather narrow, elongate endocolpus with straight margins and obtuse ends.
5. Long colpus, slightly widened above the endoaperture.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, rather coarse, of about the same size, circular, spaced.
9. Polar view; columellae at high focus.

PLATE 27 (*Chaerophyllum hirsutum* type: *C. temulentum*)

PLATE 28 (*Cicuta virosa* type: *C. virosa*)

PLATE 29 (*Conium maculatum* type: *C. maculatum*)

PLATE 30 (p. 281)

Conopodium majus (Gouan) Loret (figs.1—8, Van der Burgh 1963-3068)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium straight, columellae in equatorial area longer than those at poles, sexine raised above the endoaperture.
4. Short colpus.
5. Broad, elliptic endocolpus with straight margins and distinct ends.
6. Polar view; cross-section at equator.
7. Polar view; columellae at low focus, coarse, irregular in size and outline, crowded.
8. Polar view; columellae at high focus.

PLATE 31 (p. 282)

Crithmum maritimum L. (figs.1—7, Verbeek and Lambeck 156)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium straight, outer contour elliptic, columellae at equator longer than those at poles.
4. Polar view; cross-section at equator.
5. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
6. Very long colpus and rather narrow, elongate endocolpus with straight margins and distinct ends.
7. Ornamentation in mesocolpium.

PLATE 32 (p. 283)

Cuminum cyminum L. (figs.1—3, Kok Ankersmit 24; figs.4—9, Swart 1513)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side straight, columellae distinctly longer between shoulders and equator, sexine distinctly raised above the endoaperture.
4. Long colpus and protruding endoaperture at high focus, rectangular in outline.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
9. Polar view; columellae at high focus.

PLATE 33 (p. 284)

Daucus carota L. ssp. *gummifer* J.D. Hooker (figs.1—2, Exc. Biol. Stud. Utrecht, France 1963-3543)

1. SEM micrograph; equatorial view, distinctly protruding endoaperture.
2. SEM micrograph; ornamentation ($\times 10\ 000$).

Daucus carota L. ssp. *carota* (figs.3—9, Florschütz s.n.)

3. Equatorial view; cross-section, inner contour of colpus side yoke-like, columellae distinctly longer between shoulders and equator.
4. Short colpus and porus-like endoaperture with straight margins and distinct ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section just above the equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, coarse, irregular in size and outline, more or less spaced.
9. Polar view; columellae at high focus.

PLATE 30 (*Conopodium majus* type: *C. majus*)

PLATE 31 (*Crithmum maritimum* type: *C. maritimum*)

PLATE 32 (*Cuminum cyminum* type: *C. cyminum*)

PLATE 33 (*Daucus carota* type: *D. carota* ssp. *gummifer*, 1–2; *D. carota* ssp. *carota*, 3–9)

PLATE 34 (p. 286)

Eryngium campestre L. (figs.1—5, Heyligers s.n.)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, outer contour of colpus side convex-rhombic and that of mesocolpium side concave, columellae short.
4. Endoporus rectangular with broad costae.
5. Very long colpi.

PLATE 35 (p. 287)

Eryngium maritimum L. (figs.1—2, Arnolds 1063; figs.3—4, Mennega 40)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, outer contour of colpus side distinctly convex and that of mesocolpium slightly concave, inner contour of mesocolpium side slightly curved.
4. Long colpus and very long endocolpus with broad costae, straight margins and diffuse ends.

PLATE 36 (p. 288)

Eryngium alpinum L. (figs.1—4, Brandenburger s.n.)

1. Equatorial view; cross-section, outer contour of colpus side rhombic, inner contour of mesocolpium side distinctly curved over a short section of the equatorial area.
2. Short colpus and rectangular endocolpus with broad costae.
3. Polar view; cross-section at equator.
4. Polar view; columellae at low focus, small, more or less circular, crowded.

PLATE 37 (p. 289)

Eryngium viviparum Gay (figs.1—6, Baenitz 10285)

1. Equatorial view; cross-section, outer contour of colpus side rhombic with distinct apiculation (protruding endoaperture), columellae at poles distinctly longer than those at equator.
2. Long colpus and rectangular endoaperture with narrow costae.
3. Polar view; columellae at high focus.
4. Polar view; columellae at low focus, small, regular in size, circular, crowded.
5. Polar view; cross-section at equator.
6. Polar view; cross-section at shoulders.
7. Ornamentation in mesocolpium.

PLATE 34 (*Eryngium campestre* type: *E. campestre*)

PLATE 35 (*Eryngium campestre* type: *E. maritimum*)

PLATE 36 (*Eryngium campestre* type: *E. alpinum*)

PLATE 37 (*Eryngium campestre* type: *E. viviparum*, 1–6; *E. alpinum*, 7)

PLATE 38 (p. 291)

Falcaria vulgaris Bernhardt (figs.1—2, Exc. Biol. Stud. Utrecht, France 1961-1695; figs.3—10, Wirtgen s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side curved, columellae at equator very long, more than twice as nexine thickness.
4. Rather long colpus.
5. Small, relatively narrow endocolpus with straight margins and distinct ends.
6. Ornamentation in mesocolpium.
7. Polar view; cross-section at equator.
8. Polar view; cross-section at shoulders.
9. Polar view; columellae at high focus.
10. Polar view; columellae at low focus, small, uniform in size, circular, crowded.

PLATE 39 (p. 292)

Anethum graveolens L. (figs.1—2, Exc. Biol. Stud. Utrecht, Spain 1967-1961; figs.3—9, Exc. Biol. Stud. Utrecht, Spain 1962-925)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium straight, columellae at equator very long, more than twice as nexine thickness.
4. Rather long colpus and small, narrow endocolpus with straight margins and distinct ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae coarse, irregular in size and outline, spaced.
9. Polar view; columellae at high focus.

PLATE 40 (p. 293)

Ptychotis saxifraga (L.) Loret et Barrandon (figs.1—2, 6—9. Mangenotti s.n.; Barbezat 6088)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium straight, columellae at equator very long, more than twice as nexine thickness.
4. Short colpus.
5. Small, elliptic endocolpus with convex margins and distinct ends.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, small, uniform in size, circular, spaced.
9. Polar view; columellae at high focus.

PLATE 38 (*Falcaria vulgaris* type: *F. vulgaris*)

PLATE 39 (*Falcaria vulgaris* type: *Anethum graveolens*)

PLATE 40 (*Falcaria vulgaris* type: *Ptychotis saxifraga*)

PLATE 41 (p. 295)

Torilis arvensis (Hudson) Link (figs.1—2, Exc. Biol. Stud. Utrecht, France 1953-328; figs.3—9, Sipman 160)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side straight, columellae at equator very long, more than twice as nexine thickness.
4. Rather long colpus and small, narrow endocolpus with slightly convex margins and distinct ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus of medium size, regular in size, circular, crowded.
9. Polar view; columellae at high focus.

PLATE 42 (p. 296)

Heracleum sphondylium L. (figs.1—4, Thackeray 610)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side distinctly curved, columellae at poles longer than those at equator, branched.
4. Endocolpus, elliptic with convex margins and distinct ends.

PLATE 43 (p. 297)

Heracleum sphondylium L. (figs.1, 3—5, Thackeray 610)

1. Rather long colpus, margins indistinct towards the ends, columellae in cross-section more or less circular.
3. Polar view; columellae at high focus.
4. Polar view; columellae at low focus, coarse, irregular in size, but more or less circular in outline, spaced.
5. Polar view; cross-section at equator.

Heracleum mantegazzianum Sommier et Levier (fig.2, Dixen et al. 488)

2. Short colpus widened above the endoaperture with indistinct ends, columellae in cross-section angular.

PLATE 44 (p. 298)

Heracleum mantegazzianum Sommier et Levier (figs.1—4, Dixen et al. 488)

1. Equatorial view; cross-section, columellae at pole only slightly longer than those at shoulders, sexine slightly raised above endoaperture.
2. Rather long colpus with indistinct ends and endocolpus with diffuse ends, columellae in cross-section angular.
3. Polar view; columellae at high focus.
4. Polar view; columellae at low focus, very coarse, irregular in size, distinctly angular, spaced.

PLATE 41 (*Falcaria vulgaris* type: *Torilis arvensis*)

PLATE 42 (*Heracleum sphondylium* type: *H. sphondylium*)

PLATE 43 (*Heracleum sphondylium* type: *H. sphondylium*, 1, 3–5; *H. mantegazzianum*, 2)

PLATE 44 (*Heracleum sphondylium* type: *H. mantegazzianum*)

PLATE 45 (p. 300)

Hydrocotyle vulgaris L. (figs.1—3, 5, Hessel et al. 1427; figs.4, 6—7, Den Held s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side convex, outer contour of colpus side rhombic, columellae at poles longer than those at equator.
4. Polar view; cross-section, apertures in the corners.
5. Very long colpus and short endocolpus with diffuse ends and narrow costae.
6. Polar view; columellae at high focus.
7. Polar view; columellae at low focus, small, uniform in size, circular, crowded.

PLATE 46 (p. 301)

Laser trilobum (L.) Borkhausen (figs.1—3, Weiss 1; figs.4—8, Schultes 43)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side shallowly curved, columellae in between shoulders end equator distinctly longer than those at equator.
4. Broad, elliptic endocolpus with straight margins and distinct ends.
5. Long colpus.
6. Polar view; cross-section at equator.
7. Polar view; columellae at high focus.
8. Polar view; columellae at low focus, small, uniform in size, circular, crowded.

PLATE 47 (p. 302)

Laserpitium latifolium L. (figs.1, 3, Mennega 8192; figs.2, 4—7, Exc. Biol. Stud. Utrecht, France 1953-274)

1. SEM micrograph; ornamentation ($\times 10\,000$).
2. Equatorial view; cross-section, columellae in equatorial area shorter than those at poles, sexine distinctly raised above the endoaperture, outer contour of colpus side apiculate.
3. Rather long colpus and broad endocolpus with straight margins and obtuse ends.
4. Polar view; cross-section at equator.
5. Polar view; cross-section at shoulders.
6. Polar view; columellae at high focus.
7. Polar view; columellae at low focus, coarse, more or less uniform in size, angular in outline, spaced.

PLATE 48 (p. 303)

Laserpitium prutenicum L. (figs.1—2, 5—10, Behrendsen s.n.; figs.3—4, s.c., s.n. France)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section columellae at poles of the same length as those at equator, those at the shoulders a little longer.
4. Broad, elongate endocolpus with straight margins and distinct, obtuse ends.
5. Rather long colpus.
6. Ornamentation in mesocolpium.
7. Polar view; cross-section at equator.
8. Polar view; cross-section at shoulders.
9. Polar view; columellae at low focus, rather coarse, uniform in size, but angular in outline, spaced.
10. Polar view; columellae at high focus.

PLATE 45 (*Hydrocotyle vulgaris* type: *H. vulgaris*)

PLATE 46 (*Laser trilobum* type: *L. trilobum*)

PLATE 47 (*Laserpitium latifolium* type: *L. latifolium*)

PLATE 48 (*Laserpitium prutenicum* type: *L. prutenicum*)

PLATE 49 (p. 305)

Levisticum officinale Koch (figs.1—8, Punt s.n.)

1. SEM micrograph, equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, columellae at equator shorter than those at poles, inner face of mesocolpium side straight.
4. Broad, elongate colpus with straight margins and distinct obtuse ends.
5. Polar view; columellae at high focus.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, rather small, uniform in size, circular, more or less spaced.

PLATE 50 (p. 306)

Meum athamanticum Jacquin (figs.1—2, H. and P.J. Maas 69; figs.3—8, Exc. Biol. Stud. Utrecht, France 1978-10)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, outer contour of colpus side distinctly apiculate, columellae at equator indistinct, distinctly shorter than those at poles.
4. Polar view; cross-section at equator.
5. Very long colpus and broad, elongate endocolpus with straight margins and distinct, rounded ends.
6. Polar view; cross-section at shoulders.
7. Polar view; columellae at high focus.
8. Polar view, columellae at low focus, small, uniform in size, circular, more or less crowded.

PLATE 51 (p. 307)

Ligusticum scoticum L. (figs.1—2, Exc. Biol. Stud. Utrecht, Norway 1965-2427; figs.3—8, Exc. Biol. Stud. Utrecht, England 1972-2049)

1. SEM micrograph; equatorial view with colpus and apiculation.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, outer contour of colpus side distinctly apiculate, columellae in equatorial area visible, only slightly increasing in length towards the poles.
4. Very long colpus and broad, elongate endocolpus with straight margins and diffuse, more or less truncate ends.
5. Polar view; cross-section at equator.
6. Polar view; cross-section at shoulders.
7. Polar view; columellae at high focus.
8. Polar view; columellae at low focus, small, uniform in size, circular, more or less crowded.

PLATE 49 (*Levisticum officinale* type: *L. officinale*)

PLATE 50 (*Meum athamanticum* type: *M. athamanticum*)

PLATE 51 (*Meum athamanticum* type: *Ligusticum scoticum*)

PLATE 52 (p. 309)

Myrrhis odorata (L.) Scopoli (figs.1–2, Commijs s.n.; figs.3–4, Kok Ankersmit 31; figs.5–7, Reichenbach 1022)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Polar view; columellae at high focus.
4. Polar view; columellae at low focus, coarse, irregular in size and outline, spaced.
5. Equatorial view; cross-section, inner contour of mesocolpium side straight, columellae in equatorial area distinctly shorter at equator than towards the shoulders.
6. Broad, elongate endocolpus with straight margins and diffuse ends.
7. Short colpus, slightly widened above the endoaperture.

PLATE 53 (p. 310)

Oenanthe fistulosa L. (figs.1–3, 5, 7–8, Kooper s.n.; fig.4, Arnolds 1684, fig.6, Van Leeuwen-Reynvaan 6582)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of mesocolpium shallowly curved, outer contour straight.
4. Very long colpus and broad, elongate endocolpus with convex margins and acute ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
8. Polar view; columellae at high focus.

PLATE 54 (p. 311)

Oenanthe aquatica (L.) Poiret (figs.1–3, 6–8, Arnolds 1534, figs.4–5, Gadella and Mennega s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, nexine distinctly thinner than sexine at poles, sexine distinctly raised above the endoaperture, outer contour of colpus side straight with distinct apiculation.
4. Very long colpus and broad, elongate endocolpus with straight margins and diffuse ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at shoulders.
7. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
8. Polar view; columellae at high focus.

PLATE 55 (p. 312)

Oenanthe crocata L. (figs.1–2, 5, 7–10, Exc. Biol. Stud. Utrecht, France 1963-3177; figs.3–4, Exc. Biol. Stud. Utrecht, England 1968-126)

1. SEM micrograph; equatorial view ($\times 1500$).
2. Ornamentation in mesocolpium.
3. Broad, elongate endocolpus with straight margins and diffuse ends.
4. Equatorial view; cross-section, nexine about as thick as sexine at the poles, inner contour of mesocolpium side slightly curved.
5. Polar view; cross-section at equator.
6. Very long colpus.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
9. Polar view; columellae at high focus.

PLATE 52 (*Myrrhis odorata* type: *M. odorata*)

PLATE 53 (*Oenanthe fistulosa* type: *O. fistulosa*)

PLATE 54 (*Oenanthe fistulosa* type: *O. aquatica*)

PLATE 55 (*Oenanthe fistulosa* type: *O. crocata*)

PLATE 56 (p. 314)

Oenanthe fluviatilis (Babington) Coleman (figs.1–4, T.A. and C. Cotton s.n.)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, nexine distinctly thinner than sexine at poles, inner contour of mesocolpium distinctly curved.
4. Very long colpus and broad, elongate endocolpus with straight margins and diffuse ends.

Oenanthe lachenalii C.C. Gmelin (fig.5, Van Dijk s.n.; figs.6–7, Exc. Biol. Stud. Utrecht, Ireland 1969-195; fig.8, Brummer-de Vries s.n.)

5. SEM micrograph; ornamentation ($\times 10\,000$).
6. Equatorial view; cross-section, nexine distinctly thinner than sexine at poles, inner contour of mesocolpium distinctly curved.
7. Very long colpus and broad, elongate endocolpus with diffuse ends.
8. Ornamentation in mesocolpium.

PLATE 57 (p. 315)

Oenanthe peucedanifolia Pollich (figs.1–8, Van Sanden Lacoste s.n.)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. SEM micrograph; section of exine, nexine about as thick as sexine.
4. Equatorial view; cross-section, inner contour of mesocolpium distinctly curved, outer contour straight.
5. Very long colpus and relatively narrow endocolpus with straight margins and diffuse ends.
6. Polar view; cross-section at equator.
7. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
8. Polar view; columellae at high focus.

PLATE 58 (p. 316)

Oenanthe pimpinelloides L. (figs.1–2, Henrard s.n.; figs.3–5, Rainha 2376)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, nexine about as thick as sexine at poles, inner contour of mesocolpium distinctly curved.
4. Relatively narrow, elongate endocolpus with convex margins.
5. Long colpus.

PLATE 59 (p. 317)

Oenanthe silaifolia Bieberstein (figs.1–2, Graf 1194; figs.3–8, Mennega and Driehuis 131)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of mesocolpium rather shallowly curved.
4. Very long colpus and relatively broad, elongate endocolpus with straight margins and diffuse ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
8. Polar view; columellae at high focus.

PLATE 56 (*Oenanthe fistulosa* type: *O. fluviatilis*, 1–4; *O. lachenalii*, 5–8)

PLATE 57 (*Oenanthe fistulosa* type: *O. peucedanifolia*)

PLATE 58 (*Oenanthe fistulosa* type: *O. pimpinelloides*)

PLATE 59 (*Oenanthe fistulosa* type: *O. silaifolia*)

PLATE 60 (p. 319)

Orlaya grandiflora (L.) Hoffmann (figs.1—2, Behrendsen s.n.; figs.3—7, Exc. Biol. Stud. Utrecht, France 1954-277)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Polar view; columellae at low focus, small, more or less uniform in size, irregular in outline, angular, crowded.
4. Polar view; columellae at high focus.
5. Short colpus and elliptic endocolpus with convex margins and distinct ends.
6. Equatorial view; cross-section, tectum in equatorial area considerably thickened, inner contour of mesocolpium straight.
7. Polar view; cross-section at equator.

PLATE 61 (p. 320)

Pastinaca sativa L. var. *sylvestris* (Miller) Rouy et Camus (fig.1, Cabellero s.n.)

1. SEM micrograph; equatorial view.

Pastinaca sativa L. var. *sativa* (figs.2, 6—8, Van der Linde-Bruynooze; figs.3—5, Leeuwenberg 1572)

2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side distinctly curved, sexine not raised above the endoaperture, columellae at equator distinctly longer than those at poles.
4. Elliptic endocolpus with convex margins and distinct ends.
5. Short colpus a little widened above the endoaperture.
6. Polar view; cross-section at equator.
7. Polar view; columellae at low focus, coarse, irregular in size, angular in outline, spaced.
8. Polar view; columellae at high focus.

PLATE 62 (p. 321)

Petroselinum segetum (L.) Koch (figs.1—2, De Visser s.n.; figs.3—10, Sloff et al. s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, nexine thicker than sexine at poles, columellae at equator longer than those at poles.
4. Narrowly elongated, elliptic endocolpus with convex margins and diffuse ends.
5. Long colpus.
6. Ornamentation in mesocolpium.
7. Polar view; cross-section at equator.
8. Polar view; cross-section at shoulders.
9. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
10. Polar view; columellae at high focus.

PLATE 60 (*Orlaya grandiflora* type: *O. grandiflora*)

PLATE 61 (*Pastinaca sativa* type: *P. sativa* var. *sylvestris*, 1; *P. sativa* var. *sativa*, 2–8)

PLATE 62 (*Petroselinum segetum* type: *P. segetum*)

PLATE 63 (p. 323)

Peucedanum palustre (L.) Moench (figs.1–2, Uttien s.n.; figs.3–10, Redgrove s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side straight, columellae in equatorial area longer than those at the poles.
4. Rather long colpus, sexine distinctly raised above the endoaperture.
5. Rather narrow, elliptic endocolpus with straight margins and distinct ends.
6. Ornamentation in mesocolpium.
7. Polar view; cross-section at equator.
8. Polar view; cross-section at shoulders.
9. Polar view; columellae at low focus, rather regular in size, more or less circular, crowded.
10. Polar view; columellae at high focus.

PLATE 64 (p. 324)

Peucedanum alsaticum L. (figs.1–2, 6–9, Mennega s.n.; figs.3–5, Kramer and Westra 3965)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side straight, columellae in equatorial area distinctly longer than those at the poles.
4. Rather long colpus and rather narrow, elliptic endocolpus with straight margins and distinct ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, small, rather regular in size and outline, crowded.
9. Polar view; columellae at high focus.

PLATE 65 (p. 325)

Peucedanum austriacum (Jacquin) Koch (fig.1, Barbezat 5583; figs.2–4, Mirick s.)

1. SEM micrograph; ornamentation ($\times 10\ 000$).
2. Endocolpus with straight margins and distinct ends.
3. Equatorial view; cross-section, columellae at equator longer than those at poles, sexine slightly raised above endoaperture.
4. Colpus length in between $1/2$ and $2/3$ pd.

Peucedanum cervaria (L.) Lapeyrouse (figs.5–8, Buysman 768)

5. Equatorial view; cross-section.
6. Polar view; columellae at high focus.
7. Polar view; columellae at low focus, medium-sized, regular in size, circular, more or less spaced.
8. Rather long colpus, length about $2/3$ pd, endocolpus rather narrow with convex margins and distinct ends.

PLATE 63 (*Peucedanum palustre* type: *P. palustre*)

PLATE 64 (*Peucedanum palustre* type: *P. alsaticum*)

PLATE 65 (*Peucedanum palustre* type: *P. austriacum*, 1–4; *P. cervaria*, 5–8)

PLATE 66 (p. 327)

Peucedanum lancifolium Lange (figs.1—3, Da Silva 846)

1. SEM micrograph; equatorial view.
2. Equatorial view; cross-section.
3. Long colpus and endocolpus.

Peucedanum carvifolia Villars (figs.4—5, Blauw s.n.)

4. Equatorial view; cross-section.
5. Rather long colpus and endocolpus.

Peucedanum officinale L. (figs.6—7, Rutten-Pekelharing 310)

6. Equatorial view; cross-section.
7. Rather long colpus and endocolpus.

Peucedanum gallicum Latourette (figs.8—9, s.c., s.n., Anno 1908)

8. Rather long colpus and endocolpus.
9. Equatorial view; cross-section.

PLATE 67 (p. 328)

Peucedanum oreoselinum (L.) Moench (figs.1—2, Zijlstra s.n.; figs.3—8, Kramer 1536)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section.
4. Polar view; cross-section at equator.
5. Rather long colpus and elliptic endocolpus with straight margins and distinct ends.
6. Polar view; cross-section at shoulders.
7. Polar view; columellae at high focus.
8. Polar view; columellae at low focus, rather coarse, irregular in size, more or less circular in outline, more or less spaced.

PLATE 68 (p. 329)

Angelica heterocarpa Lloyd (figs.1—8, Neyraut 3407)

1. SEM micrograph; equatorial view ($\times 1000$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, polar caps subobtuse, tectum distinctly undulating in equatorial area, inner contour of mesocolpium side curved, columellae at equator longer than those at the poles.
4. Colpus and elliptic endoaperture with straight margins and distinct ends.
5. Polar view; cross-section at equator.
6. Polar view; cross-section at shoulders.
7. Polar view; columellae at low focus, very coarse, irregular in size, angular spaced.
8. Polar view; columellae at high focus.

PLATE 69 (p. 330)

Angelica sylvestris L. (figs.1—6, Kintschi 1073)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Ornamentation in mesocolpium.
4. Equatorial view; cross-section, tectum in equatorial area distinctly undulating, inner contour of mesocolpium side curved, columellae at equator longer than those at the poles.
5. Colpus view; cross-section, polar caps subobtuse.
6. Rather long colpus, narrow, elongate endocolpus with straight margins and distinct ends.

PLATE 66 (*Peucedanum palustre* type: *P. lancifolium*, 1–3; *P. carvifolia*, 4–5; *P. officinale*, 6–7; *P. gallicum*, 8–9)

PLATE 67 (*Peucedanum palustre* type; *P. oreoselinum*)

PLATE 68 (*Peucedanum palustre* type: *Angelica heterocarpa*)

PLATE 69 (*Peucedanum palustre* type: *Angelica sylvestris*)

PLATE 70 (p. 332)

Bunium bulbocastanum L. (figs. 1–8, De Jong s.n.)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side slightly curved, length of columellae at equator twice as long as the nexine thickness, columellae at poles longer than those at shoulders.
4. Broad, elongate endocolpus with straight margins and distinct ends.
5. Rather long colpus.
6. Ornamentation in mesocolpium.
7. Polar view; ornamentation at low focus, rather small, regular in size, circular, crowded.
8. Polar view; columellae at high focus.

PLATE 71 (p. 333)

Foeniculum vulgare Miller ssp. *piperitum* (Ucria) Coutinho (figs. 1–2, Van Heerdt and Kramer 146; figs. 3–10, Smit 127)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, columellae at equator $1-1\frac{1}{2}$ longer than nexine thickness, inner contour of mesocolpium sides shallowly curved, P/E ratio pererect.
4. Narrow, elongate endocolpus with straight margins and distinct ends.
5. Rather long to long colpus.
6. Ornamentation in mesocolpium.
7. Polar view; cross-section at equator.
8. Polar view; cross-section at shoulders.
9. Polar view; columellae at low focus, coarse, more or less regular in size and outline, spaced.
10. Polar view; columellae at high focus.

PLATE 72 (p. 334)

Foeniculum vulgare Miller ssp. *vulgare* (figs. 1–9, Bakhuizen van den Brink 4991)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, columellae at equator $1\frac{1}{2}-2$ times longer than nexine thickness, inner contour of mesocolpium side straight, P/E ratio more or less erect.
4. Short colpus.
5. Narrow, elongate endocolpus with straight to slightly convex margins and distinct ends.
6. Ornamentation in mesocolpium.
7. Polar view; cross-section at equator.
8. Polar view; columellae at low focus, small, irregular in size, more or less circular, more or less spaced.
9. Polar view; columellae at high focus.

PLATE 70 (*Peucedanum palustre* type: *Bunium bubocastanum*)

PLATE 71 (*Peucedanum palustre* type: *Foeniculum vulgare* ssp. *piperitum*)

PLATE 72 (*Peucedanum palustre* type: *Foeniculum vulgare* ssp. *vulgare*)

PLATE 73 (p. 336)

Petroselinum crispum (Miller) A.W. Hill (figs.1—2, Richards s.n.; figs.3—8, Dijkstra 758)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side shallowly curved, columellae at equator $1\frac{1}{4}$ —2 times thicker than nexine thickness.
4. Broad, prominently elongated endocolpus with slightly convex margins and distinct ends.
5. Rather long colpus.
6. Polar view; cross-section at shoulders.
7. Polar view; columellae at low focus, small, regular in size, circular, crowded.
8. Polar view; columellae at high focus.

PLATE 74 (p. 337)

Selinum carvifolia (L.) L. (figs.1—2, Marklund s.n.; figs.3—4, Exc. Biol. Stud. Utrecht, Germany 1965-814; figs.5—9, Kramer 1470)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side slightly curved, columellae at equator rather short, $1-1\frac{1}{4}$ times nexine thickness, P/E ratio pererect.
4. Long colpus and broad, elongate endocolpus with straight margins.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, small, uniform in size, circular, crowded.

PLATE 75 (p. 338)

Selinum pyrenaicum (L.) Gouan (figs.1—5, Bordère s.n.; figs.6—9, Krüger and Bick H.J.10)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side shallowly curved, length of columellae at equator rather short, $1-1\frac{1}{4}$ times nexine thickness, P/E ratio pererect.
4. Long colpus.
5. Broad, elongate endocolpus with straight margins and distinct ends.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, small, uniform in size, circular, crowded.
9. Polar view; columellae at high focus.

PLATE 76 (p. 339)

Pimpinella anisum L. (figs. 1—2, Koch s.n.; Figs.3—8, Jansen and Wachter s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, columellae between equator and the shoulders extremely long, often branched.
4. Polar view; columellae at high focus.
5. Polar view; columellae at low focus, small, uniform in size, circular, more or less crowded.
6. Polar view; cross-section at equator.
7. Short colpus and rectangular endoporus.
8. Mesocolpium with two "islands" separated by a "channel".

PLATE 73 (*Peucedanum palustre* type: *Petroselinum crispum*)

PLATE 74 (*Peucedanum palustre* type: *Selinum carvifolia*)

PLATE 75 (*Peucedanum palustre* type: *Selinum pyrenaeum*)

PLATE 76 (*Pimpinella anisum* type: *P. anisum*)

PLATE 77 (p. 341)

Pimpinella major (L.) Hudson (figs.1–7, Exc. Biol. Stud. Utrecht, Germany 1976-46)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, columellae between shoulders and equator distinctly longer than at equator, sexine distinctly raised above the endoaperture.
4. Rather long colpus and short endocolpus with straight margins and truncate ends.
5. Polar view; cross-section at equator.
6. Polar view; columellae at low focus, medium-sized, irregular in outline, more or less spaced.
7. Polar view; columellae at high focus.

PLATE 78 (p. 342)

Pimpinella saxifraga (L.) Hudson (figs.1–2, Arnolds 1617; figs.3–9, Punt s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, columellae between shoulders and equator only slightly longer than those at equator, sexine distinctly raised above the endoaperture.
4. Rather long colpus and short endocolpus with straight margins and diffuse ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, small, rather irregular in size, more or less circular, crowded.
9. Polar view; columellae at high focus.

PLATE 79 (p. 343)

Pleurospermum austriacum (L.) Hoffmann (figs.1–2, Behrendsen s.n.; figs.3–8, Andersson s.n.)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, outer contour of mesocolpium side gradually merging into the much raised aperture and sexine, not apiculate.
4. Ornamentation in mesocolpium.
5. Rectangular endoporus.
6. Polar view; cross-section at equator.
7. Polar view; columellae at low focus, small, very regular in size, circular, crowded.
8. Polar view; columellae at high focus.

PLATE 80 (p. 344)

Physospermum cornubiensis (L.) Decandolle (figs.1–10, De Smidt, Sp. 20)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section of colpus view, outer contour abruptly merging into the much raised aperture and sexine.
4. Equatorial view; cross-section, columellae at poles slightly longer than those at equator.
5. Rectangular endoporus.
6. Ornamentation in mesocolpium.
7. Polar view; cross-section, because of much raised endoapertures, sides more or less concave.
8. Polar view; cross-section at shoulders.
9. Polar view; columellae at low focus, small, regular in size, circular, crowded.
10. Polar view; columellae at high focus.

PLATE 77 (*Pimpinella major* type: *P. major*)

PLATE 78 (*Pimpinella major* type: *P. saxifraga*)

PLATE 79 (*Pleurospermum austriacum* type: *P. austriacum*)

PLATE 80 (*Pleurospermum austriacum* type: *Physospermum cornubiensis*)

PLATE 81 (p. 346)

Smyrnum olusatrum L. (figs.1, 4, 6—7, Hessel et al. 806; figs. 2, 3, 5, Thackeray 601)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, P/E ratio perirect, columellae at poles distinctly longer than those at equator, sexine distinctly raised over endoaperture, outer contour of colpus side apiculate.
4. Ornamentation in mesocolpium.
5. Rectangular endoporus.
6. Polar view; cross-section at equator.
7. Polar view; columellae at low focus, small, regular in size, circular, crowded.
8. Polar view; cross-section at high focus.

PLATE 82 (p. 347)

Scandix pecten-veneris L. (figs.1—5, Punt s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Short colpus and large, broad, endocingulum with straight margins.
4. Ornamentation in mesocolpium.
5. Colpus view; cross-section, endocingulum.

PLATE 83 (p. 348)

Scandix pecten-veneris L. (figs.1—5, Punt s.n.)

1. Equatorial view; cross-section, sexine distinctly raised above the endoaperture, outer contour of colpus side slightly apiculate.
2. Polar view; cross-section at equator.
3. Polar view; cross-section at shoulders.
4. Polar view; columellae at low focus, coarse, irregular in size, angular, spaced.
5. Polar view; columellae at high focus.

PLATE 84 (p. 349)

Caucalis platycarpus L. (figs.1—5, Exc. Biol. Stud. Utrecht, France 1961-1734)

1. SEM micrograph; equatorial view, sexine not raised above the endoaperture.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, endocingulum with convex sides.
4. Polar view; columellae at low focus, small, regular in size, circular, more or less spaced.
5. Very short colpus, columellae coarse and spaced.

PLATE 85 (p. 350)

Seseli libanotis (L.) Koch (figs.1—9, Exc. Biol. Stud. Utrecht, Germany 1964-2146)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Long colpus, but not over pd.
4. Equatorial view; cross-section, columellae in equatorial area gradually increasing from the poles towards the equator.
5. Rather narrow, elongate endocolpus with convex margins and diffuse ends.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at high focus.
9. Polar view; columellae at low focus, small, regular in size, circular, crowded.

PLATE 81 (*Pleurospermum austriacum* type: *Smyrniolum olusatrum*)

PLATE 82 (*Scandix pecten-veneris* type: *S. pecten-veneris*)

PLATE 83 (*Scandix pecten-veneris* type: *S. pecten-veneris*)

PLATE 84 (*Scandix pecten-veneris* type: *Caucalis platycarpus*)

PLATE 85 (*Seseli libanotis* type: *S. libanotis*)

PLATE 86 (p. 352)

Cnidium dubium (Schkuhr) Thellung (fig.1, s.c., s.n., Anno 1957; figs.2—7, Alm 1158)

1. SEM micrograph, equatorial view ($\times 5000$).
2. Equatorial view; cross-section, inner contour of mesocolpium side straight, columellae in equatorial area longer than those at equator.
3. Short colpus and relatively broad endocolpus with straight margins and diffuse ends.
4. Polar view; columellae at high focus.
5. Polar view; columellae at low focus, small, rather irregular, circular, more or less spaced.
6. Polar view; cross-section at shoulders.
7. Polar view; cross-section at equator.

PLATE 87 (p. 353)

Seseli annuum L. (figs.1—2, Bergen s.n.; figs.3—4, Jasiewicz et al. 247)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, columellae at poles indistinct, sexine distinctly raised above the endoaperture.
4. Narrowly elongated endocolpus more than three times longer than broad, margins straight, ends distinct.

Seseli montanum L. (figs.5—10, Dieleman Di-20)

5. Equatorial view; cross-section, sexine not raised above the endoaperture, columellae at poles distinct, decreasing in length from shoulders towards the equator.
6. Ornamentation in mesocolpium.
7. Elliptic endocolpus with convex margins and diffuse ends.
8. Very long colpus.
9. Polar view; columellae at high focus.
10. Polar view; columellae at low focus, small, more or less regular in size, circular, crowded.

PLATE 88 (p. 354)

Seseli hippomarathrum Jacquin (figs.1—2, Deyl s.n.; figs.3—9, Exc. Biol. Stud. Utrecht, Germany 1964-2433)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\,000$).
3. Equatorial view; cross-section, sexine only slightly raised above the endoaperture, columellae gradually increasing from poles to the equator.
4. Long colpus and rather small, elliptic endocolpus with straight margins and distinct ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, small, regular in size, circular, crowded.
9. Polar view; columellae at high focus.

PLATE 86 (*Seseli libanotis* type: *Cnidium dubium*)

PLATE 87 (*Seseli libanotis* type: *S. annum*, 1–4; *S. montanum*, 5–10)

PLATE 88 (*Seseli libanotis* type: *S. hippomarathrum*)

PLATE 89 (p. 356)

Silaum silaus (L.) Schinz et Thellung (figs.1—2, Wittewaal s.n.; figs.3—8, Exc. Biol. Stud. Utrecht, Germany 1973-48)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, columellae at equator as long as those at poles, inner contour of mesocolpium side straight, sexine raised above the endoaperture.
4. Broad, elongate endocolpus with straight margins and distinct, obtuse ends.
5. Polar view; cross-section at equator.
6. Polar view; cross-section at shoulders.
7. Polar view; columellae at high focus.
8. Polar view; columellae at low focus, coarse, but rather regular in size, a little angular, more or less spaced.

PLATE 90 (p. 357)

Sison amomum L. (figs.1—2, Hutchinson 188; figs.3—8, Gerrans 1437)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side convex, outer contour convex.
4. Very long colpus and very narrow, elongate endocolpus with straight margins and diffuse ends.
5. Equatorial view; cross-section, outer contour of both sides rhombic.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at high and low focus, small, regular in size, circular, crowded.

PLATE 91 (p. 358)

Sium latifolium L. (figs.1—4, Mennega s.n.; figs.5—7, Hylander s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side distinctly convex, inner contour of colpus side more or less straight.
4. Broadly elliptic, elongate, endocolpus with straight margins and diffuse ends.
5. Polar view; cross-section at shoulders.
6. Polar view; columellae at high focus.
7. Polar view; columellae at low focus, small, regular in size, circular, crowded.

PLATE 92 (p. 359)

Berula erecta (Hudson) Coville (figs.1—3, 5, 5—9; Westhoff s.n.; fig.4, Kramer and Westra 3816)

1. SEM micrograph; equatorial view ($\times 1500$).
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side distinctly convex, inner contour of colpus side inwardly curved.
4. Long colpus and broad, elongate endocolpus with straight margins and diffuse ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; columellae at low focus, small, regular in size, circular, crowded.
8. Polar view; columellae at high focus.
9. SEM micrograph; polar view.

PLATE 89 (*Silaum silaus* type: *S. silaus*)

PLATE 90 (*Sison amomum* type: *S. amomum*)

PLATE 91 (*Sium latifolium* type: *S. latifolium*)

PLATE 92 (*Sium latifolium* type: *Berula erecta*)

PLATE 93 (p. 361)

Torilis japonica (Houttuyn) Decandolle (figs.1—2, Kramer s.n.; figs.3—7, Meyer s.n.)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Polar view; columellae at high focus.
4. Polar view; columellae at low focus, small, regular in size, circular, crowded.
5. Equatorial view; cross-section, tectum distinctly undulating in equatorial area, columellae variable in length but notably longer towards the shoulders.
6. Short colpus and small, narrow endocolpus with straight margins and distinct obtuse ends.
7. Equatorial view; cross-section, sexine distinctly raised above the endoaperture.

PLATE 94 (p. 362)

Torilis nodosa (L.) Gaertner (figs.1—2, Oudemans 29; figs.3—4, Borja s.n.; figs.5—8, Howard 796)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, obtuse, nearly truncate polar caps, distinctly raised sexine above the endoaperture.
4. Long colpus and small, narrow, elongate endocolpus with straight margins and distinct ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; columellae at high focus.
8. Polar view; columellae at low focus, small, regular in size, circular, crowded.

PLATE 95 (p. 363)

Trinia glauca (L.) Dumortier (figs.1—2, Kramer and Westra 4103; figs.3—8, Exc. Biol. Stud. Utrecht, France 1965-1045)

1. SEM micrograph; equatorial view.
2. SEM micrograph; ornamentation ($\times 10\ 000$).
3. Equatorial view; cross-section, inner contour of mesocolpium side convex, columellae at poles very short, indistinct.
4. Very narrow, much elongated endocolpus with straight margins and acute ends.
5. Ornamentation in mesocolpium.
6. Polar view; cross-section at equator.
7. Polar view; cross-section at shoulders.
8. Polar view; columellae at low focus, very small, indistinct, crowded.

PLATE 93 (*Torilis japonica* type: *T. japonica*)

PLATE 94 (*Torilis nodosa* type: *T. nodosa*)

PLATE 95 (*Trinia glauca* type: *T. glauca*)