Commun. Fac. Sci. Univ. Ank. Series C
V. 5, pp 1-18 (1987)

A COMPARATIVE STUDY ON THE FINE STRUCTURES OF THE POLLEN WALLS AND ANNULI IN SOME TURKISH BETULACEAE, MORACEAE, CANNABACEAE, HALORAGACEAE.

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(Received: 26 February 1987)

ABSTRACT

In this electron microscopic study, the fine structure of the pollen walls and annuli of *Betula medwediewii* Regel., *Coryllus avellana* L., *Carpinus betulus* L., *Ostrya carpinifolia* Scop (Betulaceae), *Morus alba* L. (Moraceae), *Cannabis sativa* L., *Humulus lupulus* L. (Cannabaceae), *Myriophyllum spicatum* L. (Haloragaceae) has been carried out by using T.E.M.

The similarities and the differences between the thickness, the sculpture and the structure of the exine have been shown in these families. The electron micrographs representative for each taxa have been given and the measurements of annuli and exine have been expressed graphically.

INTRODUCTION

The present paper deals with a comparative investigation of fine structure of the exine and annuli of the pollen grains of *Betula medwediewii* Regel., *Coryllus avellana* L., *Carpinus betulus* L., *Ostrya carpinifolia* Scop. (Betulaceae), *Morus alba* L. (Moraceae), *Cannabis sativa* L., *Humulus lupulus* L. (Cannabaceae), *Myriophyllum spicatum* L. (Haloragaceae) by using T.E.M.

Pollen grains of these taxa show a thickening around the pore margin. However, it is difficult to decide whether this is the result of thickening of the nexine or of the sexine and to see the distinction between the nexine and sexine.

Since there is a close resemblance among these five families with respect to the structure and thickening of exine of their pollen grains, the identification of these pollen grains is usually difficult.

The identification of light microscopic study of *C. avellana, C. betulus, O. carpinifiolia* (Betulaceae) found in Turkey have appeared in a publication of Aytuğ (1971).

There is no such other paper on the morphology of pollens belonging to the five families mentioned above.

Praglowski (1962) had studied some pollen grains of the families of Betulaceae, Corylaceae etc. using light microscope. The schematic representation of annuli of some Betulaceae species had been shown in that paper.

Electron microscopic studies on some species of pollen grains of Betulacea except the species of *Betula medwediewii* were carried out by Nilsson et all (1977), Takeoka and Stix (1963), Ueno (1963). In this paper the structure of the exine and the annulus of pollen grain of *Betula medwediewii* which is found in Northeast Anatolia and West Transcaucasia (Davis, 1982) have been studied with T.E.M.

The close resemblance between the pollen grains of Cannabaceae and Moraceae often raises certain identification problems. The existence of many different characteristics between *Cannabis sativa* and *Humulus lupulus* was mentioned by Punt (1984).

Hamilton (1976) has also combined the similar poratae pollen types including *C. sativa* and *Morus* type pollen, into a single key by using light microscope and S.E.M.

The pollen grain of *M. spicatum* was investigated by using T.E.M. and S.E.M. in order to describe the pollens' morphological features in detail (Praglowski, 1970; Engel, 1978).

The purpose of this paper is to show the similarities and differences between the protruted pore and the sculpture of the exine in some poratae pollen grains of these families by using T.E.M.

Such palynological studies on these families are necessary not only to identify present day air-borne or fossil pollen but also to solve some structural problems of these families.

MATERIAL AND METHODS

All the pollen samples except those of *Betula medwediewii* were taken from dried flowers of herbarium speciments for T.E.M. The samples were softened and acetolyzed by using techique of Reitsma (1969).

The acetolyzed grains were treated with 2 % Os O_4, stained with uranyl acetate, dehydrated and embedded in eponeraldite by the method described by Skvarla (1966).

All these procedures were carried out at Hacettepe University, Botany Department. Pollen sections were cut with a LKB Ultratome using a glass knife. The second staining process was made in lead citrate for five minutes (Reynolds, 1963) and examined with a Zeiss EM-9A transmission electron microscope at Ankara University, Faculty of Veterinary, Histology Department.

The thicknesses of tectum, $nexine_1$, $nexine_2$ and annulus and the height of columella have been measured at least for four micrographs of each species. The magnifications are generally 4 500 or 9 500 on the films and 3x4 500 or 3x9 500 on the cards.

The thickness of the exine has been measured at various distances from the area near the pore to the nonapertural area by ca. 0,4 μm steps (Fig. 1).

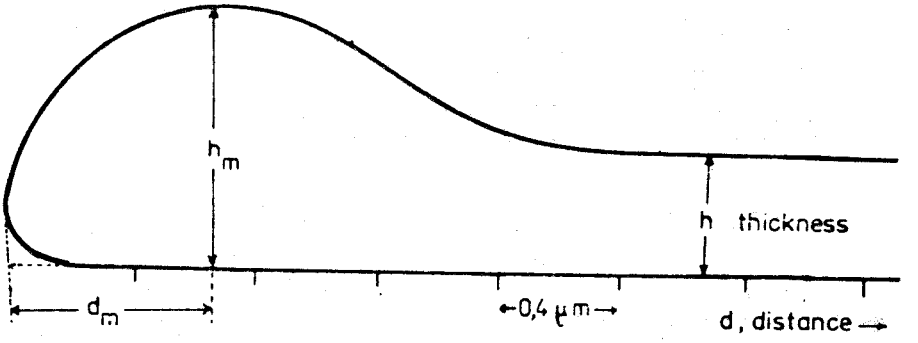

Fig. 1. Schematic representation of the thickening of the exine in annulus and nonapertural area and steps in distances upon our measurements based. h_m: The maximum of the exine thickness. d_m: The distance from annulus to the place at which the maximum thickness is observed.

All of the thicknesses have been measured from the base of spinule. Following Faegri and Iversen (1975), Moore and Webb (1978), Punt (1984) the term annulus has been chosen for the thickening of sexine around the pore for all pollen types. The other terms used were taken from Erdtman (1969).

Speciments Investigated

Betula medwediewii Regel (Syn. *Betula megrelica* D. Sosn) Trabzon: Maçka-Meryemana, *Küçük. Coryllus avellana* L. Rize: Çamlıhemşin Pokut Yaylası, *Güner* 3820 HUB. *Carpinus betulus* L. (Syn. *Carpinus caucasica* Grossh.) Artvin: Borçka Murgul Kabaca Köyü, *Güner* 4686 HUB. *Ostrya carpinifolia* Scop. (Syn. *Carpinus ostrya* L.) Maraş: Süleymanlı – Berit Dağı, *Yıldız* 1896 HUB. *Morus alba* L. (Syn. *Morus sylvestris* Forsskâl) Erzincan: Kemaliye Jırzı sandık bağı, *Yıldırımlı* 2919 HUB. *Cannabis sativa* L. Kars: Posof, *Demirkuş* 1818 HUB. *Humulus lupulus* L. İstanbul: Belgrad Ormanı, *W. Kotte.* ANK. *Myriophyllum spicatum* L. Konya: Seydişehir Suğla Gölü, *Ocakverdi* 1505 ANK.

DESCRIPTION OF POLLEN GRAINS

Betula medwediewii Regel. (Plate 1, C–D)

Pollen tectate (pertectate). Exine ca. 0,85 μm. The thickness of the exine rises to a maximum value of about 1,87 μm in annulus (in a distance of about 2 μm), then falls to a limiting value of about 0,85 μm thick (in a distance of about 4 μm, as shown in Fig. 2).

Sexine ca. 0,70 μm thick; in annulus 0,8-1,0 μm (in a distance of about 0,4–2,0 μm) (Table 1, Fig. 3). $Nexine_1$ ca. 0,14 μm, in annulus 0,18–0,42 μm. $Nexine_2$ is a finely lamelate structure around the pore 0,22–0,63 μm thick, but indistinct in nonapertural area. A cavity called vestibulum

TABLE 1

	The maximum value of the sexine thickness (μm)	The place of maximum from the near pore (μm)
Betula medwediewii	1.15	2.0
Coryllus avellana	1.85	0.8
Carpinus betulus	1.35	0.8
Ostrya carpinifolia	0.51	0.8
Morus alba	0.36	1.6
Cannabis sativa	0.72	0.8
Humulus lupulus	1.36	1.2
Myriophyllum spicatum	0.48	2.4

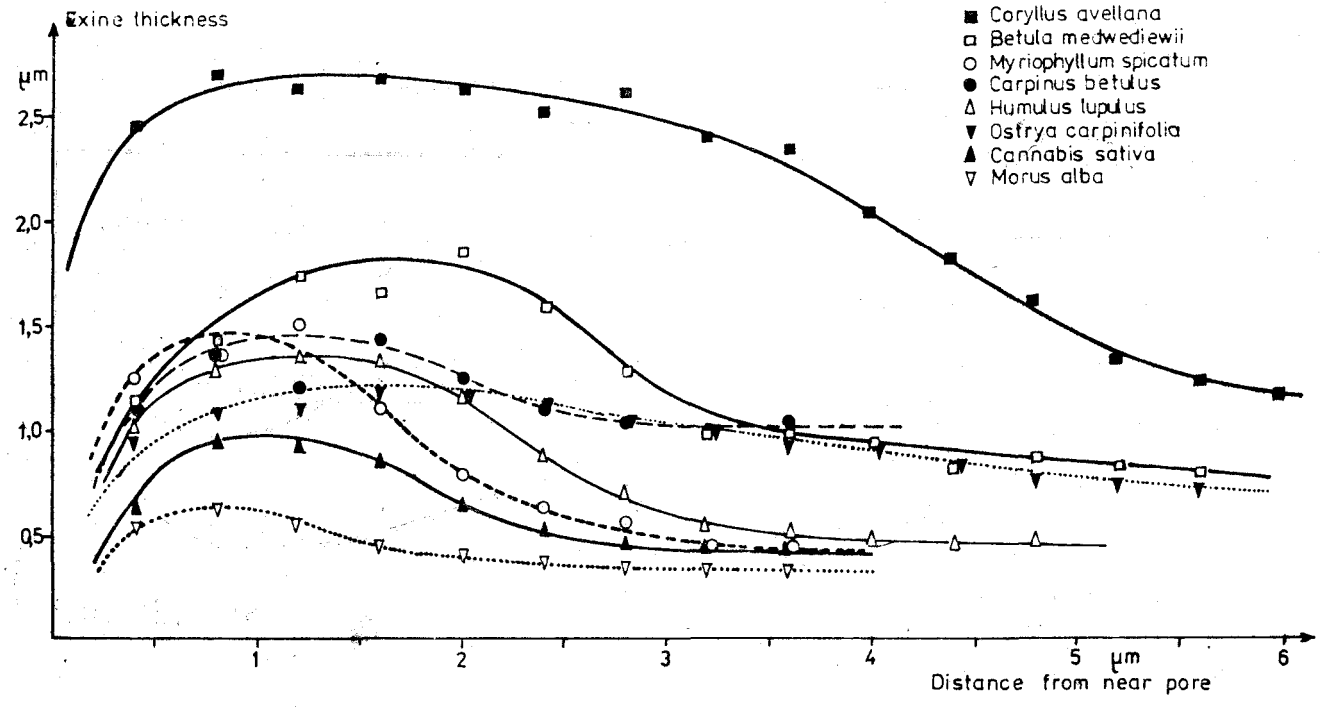

Fig. 2. The exine thickness versus the distance from the near pore in eight taxa.

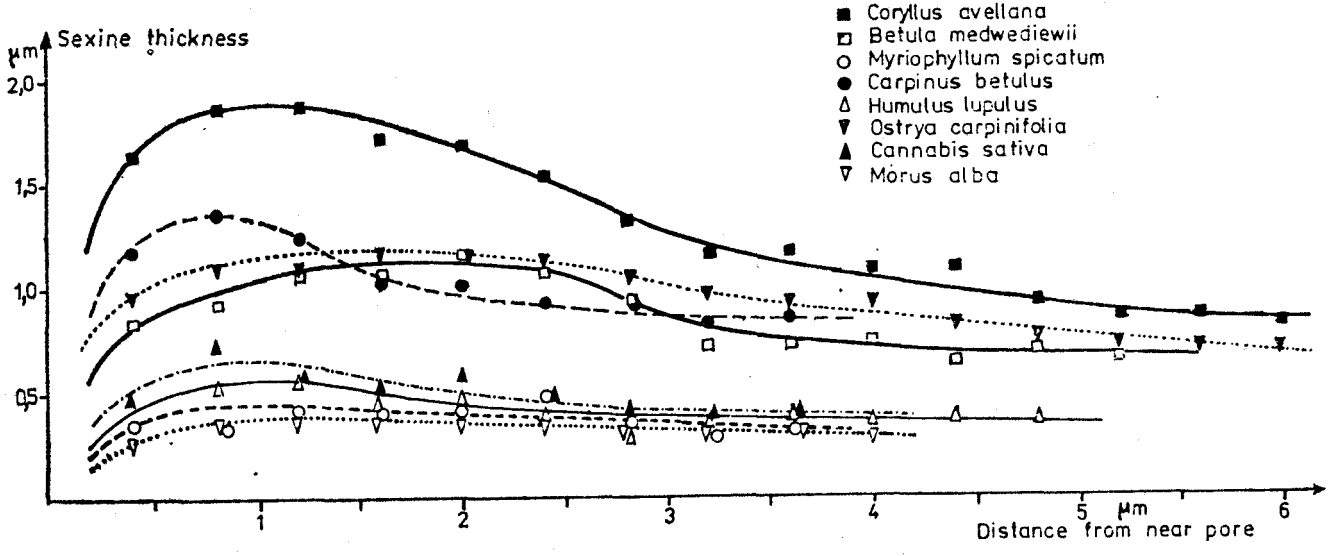

Fig. 3. The sexine thickness versus the distance from the near pore in eight taxa.

between sexine and nexine in the vicinity of aperture is found. This type of cavity is open to the pore. Beginning from the pore, $nexine_1$ is absent up to 1,6 μm, while the sexine is thicker in this interval.

Sexine (S) thicker than nexine (N). The thickness ratio of sexine to nexine (TR), TR = S: (N_1+N_2) = 2:1 near the pore and S: N_1 = 3:1 in nonapertural region.

Tectum continuous, 0,54–0,73 μm thick. Perforated by microchannels. Exine scabratae, supratectal spinule 0,12–0,15 μm height, 0,28–0,30 μm width. Operculum present, 0,29 μm width and 0,58 μm height, irregular in shape. Infratectal bacula, 0,30–0,48 μm height in annulus; 0,17–0,18 μm height in nonapertural region.

Coryllus avellana L. (Plate 1. A–B)

Pollen tectate (pertectate). Exine ca. 1 μm thick. The thicness of the exine rises to a maximum value of about 2,70 μm in annulus (in a distance of about 1,6 μm) then falls to a limiting value of about ca. 1 μm thick (in a distance of about 5,6 μm in nonapertural region) (Fig. 2).

Sexine ca. 0,73 μm thick; in annulus 1,50–1,85 μm (in a distance of about 0,8–2,4 μm) (Table 1, Fig. 3). $Nexine_1$ ca. 0,15 μm thick. It is absent while the sexine thickens to form an annulus. It begins in a distance of about 1,6 μm near the pore and then it is separated into branches in a distance of about 2,8 μm. At this separating point $nexine_1$ ca. 0,59 μm. $Nexine_2$ ca. 0,19 μm thick, but ca. 0,80 μm thick in annulus and discontinuous in nonapertural area.

Sexine thicker than nexine. TR = S: (N_1+N_2) = 2:1 near the pore, S: N_1 = 5:1 in nonapertural area.

Tectum, continuous, ca. 0,55 μm thick, but rises 0,74–0,97 μm in annulus; perforated by microchannels. Infratectal bacula 0,18–0,23 μm; in annulus 0,33–0,88 μm long. Exine scabratae, spinule ca. 0,32 μm width and 0,15 μm height. Operculum disappear.

Carpinus betulus L. (Plate 1 E, Plate 2 F.)

Pollen tectate (pertectate). Exine ca. 1 μm thick. The thickness of the exine rises to a maximum value of about 1,52 μm (in a distance of about 1,6 μm) then falls to a limiting value of ca. 1 μm (in a distance of about 2,8 μm) (Fig. 2).

Sexine 0,88–1,43 μm thick; in annulus 0,97–1,43 μm (in a distance of about 0,8–1,6 μm) (Table 1, Fig. 3). Beginning from the pore $nexine_1$

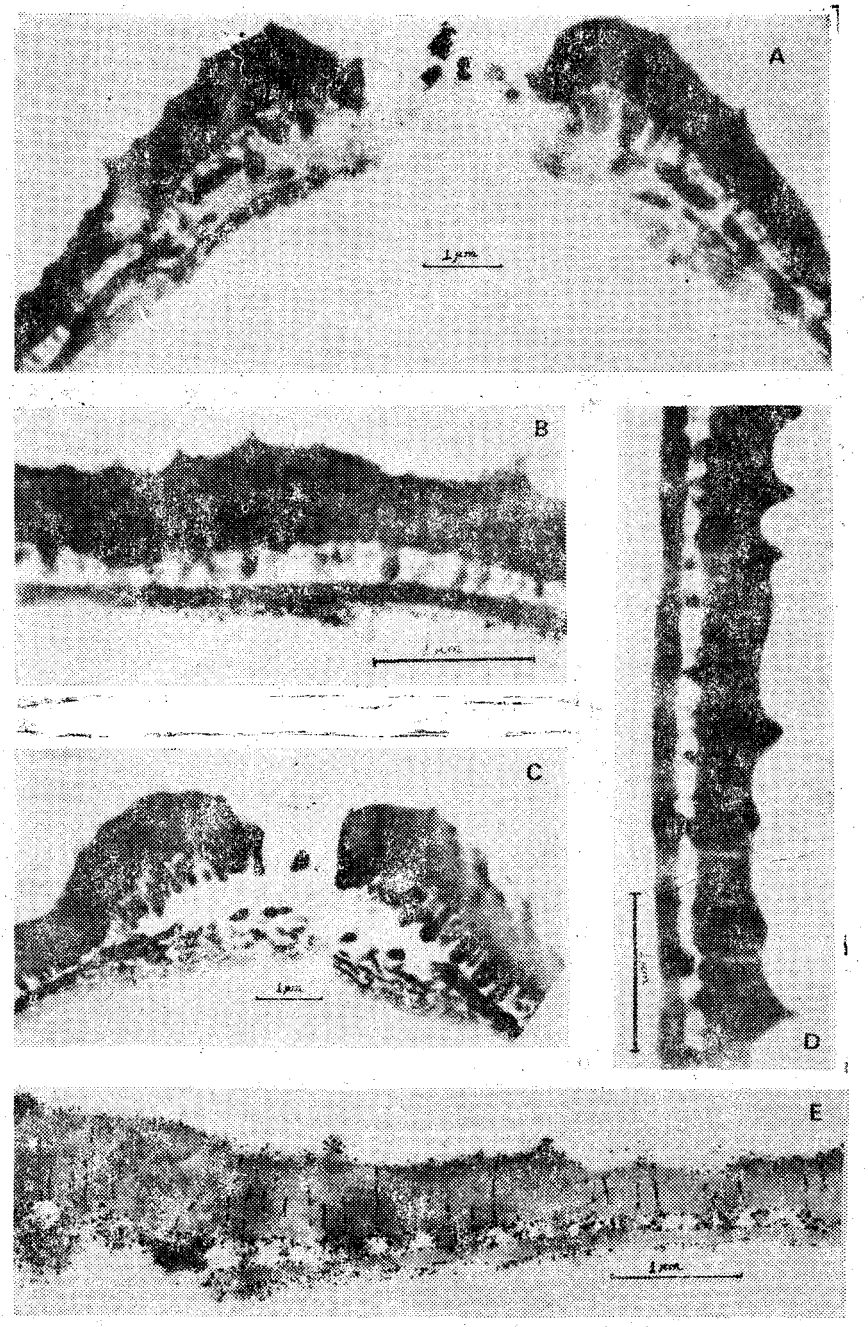

Plate 1. (A–B): *Coryllus avellana* L. (A): Vertical median section through tbe sporoderm near the margin of a pore (x13 500). (B): Vertical section through the sporoderm (x28 500). (C–D: *Betula medwediewii* Regel. (C): Vertical median section through the sporoderm near the margin of a pore (x12 000). (D): Vertical section through tbe sporoderm (x28 500). (E): *Carpinus betulus* L. Vertical section through tbe sporoderm near one of tbe apertures (x22 500).

and nexine$_2$ are absent up to 1,6 μm, while the sexine is thicker and forms an annulus in this interval. Nexine$_1$ ca. 0,14 μm thick, but increases towards the pore 0,19–0,27 μm. Nexine$_2$ ca 0,20 μm thick in annulus, indistinct in nonapertural area.

Sexine thicker than nexine. TR = S: (N_1+N_2) = 2:1 near the pore and S: N_1 = 6:1 nonapertural area. The inner surface of annulus is padded with bacular or other fused elements.

Tectum continuous, 0,55–0,78 μm thick; perforated by microchannels. Exine scabratae, supratectal spinule ca. 0,16 μm long; ca. 0,37 μm width. Infratectal bacula 0,32–0,65 μ m height; in annulus 0,50–0,65 μm height and operculum present, diameter ca. 0,68 μm width and ca. 0,68 μm height.

Ostrya carpinifolia Scop. (Plate 2; G – H)

Pollen tectate (pertectate). Exine of the pollen grain ca. 0,75 μm thick. The thickness of the exine rises to a maximum value of about 1,19 μm in annulus (in a distance of about 2,4 μm) then falls to a limiting value of 0,75 μm (in a distance of about 4,8 μm) (Fig. 2). Sexine 0,51–0,58 μm; in annulus 1,08–1,17 μm (in a distance of about 0,8–1,6 μm) (Table 1, Fig. 3).

Beginning from the pore, nexine$_1$ and nexine$_2$ are absent up to 2 μm; while the sexine is thicker and forms an annulus in this interval. The inner surface of annulus is padded with bacular or orther fused elements. Nexine$_1$ ca. 0,14 μm thick, but increases towards the pore 0.15-0.2 μm thick Nexine$_2$ ca. 0,17 μm thick in annulus, indistinct in nonapertural area.

Sexine thicker than nexine. TR = S: (N_1 + N_2) = 3:1 near the pore and S: (N_1 + N_2) = 4:1 in nonapertural area.

Tectum continuous, 0,42–0,54 μm thick, perforated by extremely thin microchannels (Plate: 2, G). Exine scabrate. Supratectal spinule ca. 0,1 μm height, 0,31 μm width. Infratectal bacula ca. 0,14–0,16 μm height; in annulus 0,47–0,67 μ m height. Operculum disappear.

Morus alba L. (Plate 3, M – N)

Pollen tectate (pertectate). Exine ca. 0,35 μm thick. The thickness of the exine rises to a maximum value of about 0,60 μm in annulus (in

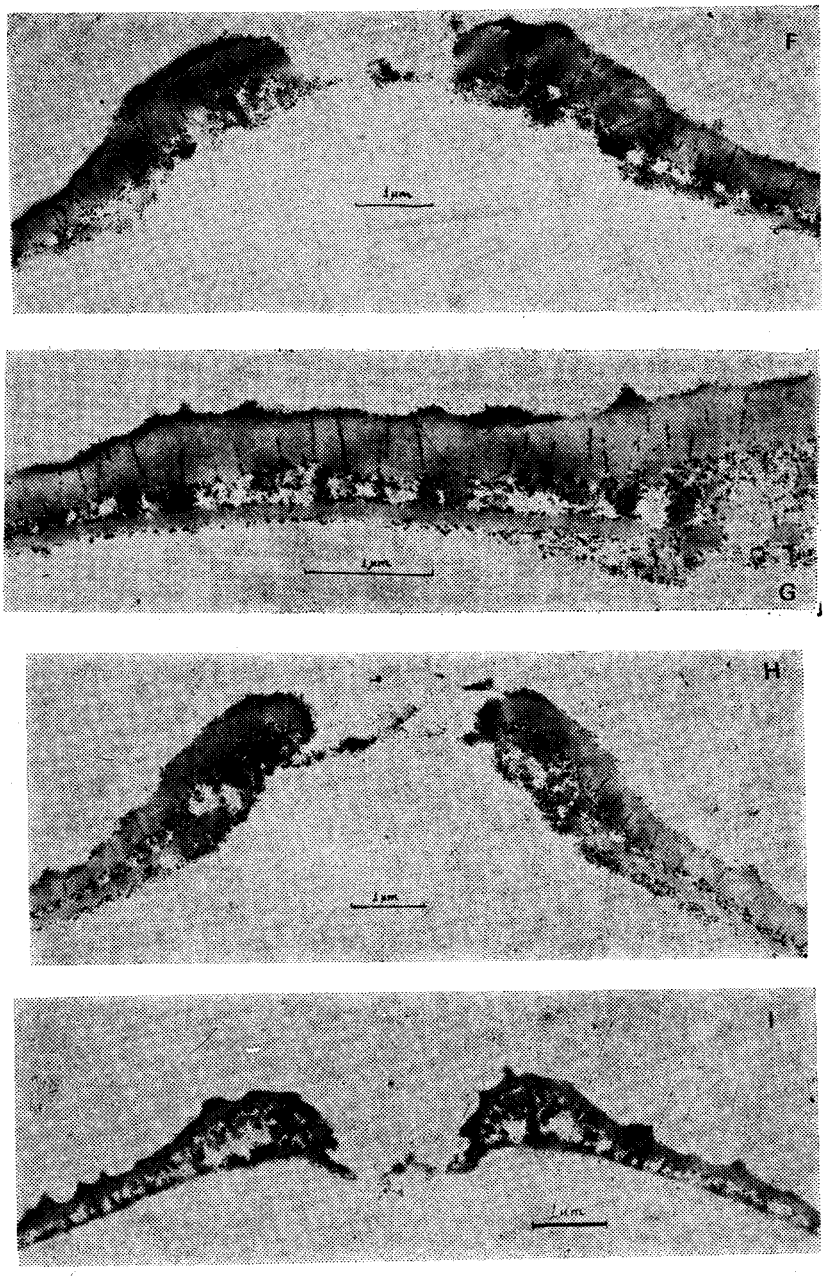

Plate 2. (F): *Carpinus betulus* L. Vertical median section through the sporoderm near the margin of a pore (x13 500). (G-H): *Ostrya carpinifolia* Scop. (G): Vertical section through the sporoderm near one of the apertures (x22 500). (H): Vertical median section through the sporoderm near the margin of a pore (x13 500). (I): *Cannabis sativa* L. Vertical median section through the sporoderm near the margin of a pore (x13 500).

a distance of about 0,8 μm), then falls to a limiting value of abuot 0,35 μm (in a distance of 2,8 μm) (Fig. 2).

Sexine 0,26–0,30 μm; in annulus 0,34–0,36 μm (in a distance of about 0,8–1,6 μm) (Table 1, Fig. 3). Nexine$_1$ thin, 0,04–0,06 μm thick, but in annulus 0,28–0,30 μm and has a finely lamellate structure around the pore, nexine$_2$ indistinct.

Sexine thicker than nexine$_1$ and TR = S: N_1 = 7:1 in nonapertural area, in annulus TR = S: N_1 = 1: 1

Tectum continuous, 0,17–0,20 μm thick (in annulus ca. 0,20 μm thick). Infratectal bacular layer is irregular in shape and metamorphose into ovoid or globular elements and 0,14–0,17 μm long. The height of bacular layer is more or less the same in annulus. Exine scabrate, irregularly distributed, 0,30–0,35 μm width, 0,15–0,28 μm height.

Pollen grain has a long operculum with spinule which consists of tectum, bacula and nexine$_1$. Tectum, ca. 0,21 μm thick; bacula ca. 0,12 μm long, nexine$_1$ ca. 0,24 μm thick. The length of operculum ca. 1,5 μm long.

Cannabis sativa L. (Plate 2, I, Plate 3 J)

Pollen tectate (pertectate). Exine, ca. 0,50 μm thick. The thickness of the exine rises to a maximum value of about 0,95 μm in annulus (in a distance of 0,8 μm), then falls to a limiting value of 0,50 μm in nonapertural area (in a distance of about 2 μm) (Fig. 2).

Sexine 0,37–0,40 μm; in annulus 0,59–0,72 μm thick (in a distance of about 0,8–2,0 μm) (Table 1, Fig. 3). Nexine$_1$ thin, 0,04–0,06 μm and indistinct nexine$_2$,

Sexine thicker than nexine$_1$. TR = S: N_1 = 12:1 in annulus and S: N_1 = 8:1 in nonapertural area.

There is a cavity closed to the pore between sexine and nexine. The thickness of the cavity rises to a maximum of about 0,32 μm (in a distance of about 1,2 μm). The cavity occured as a result of separation of the bacula from the base parts which brings about a convex shape between sexine and nexine.

Tectum continuous; 0,19–0,27 μm thick. The thickness of tectum is more or less the same towards the pore margin.

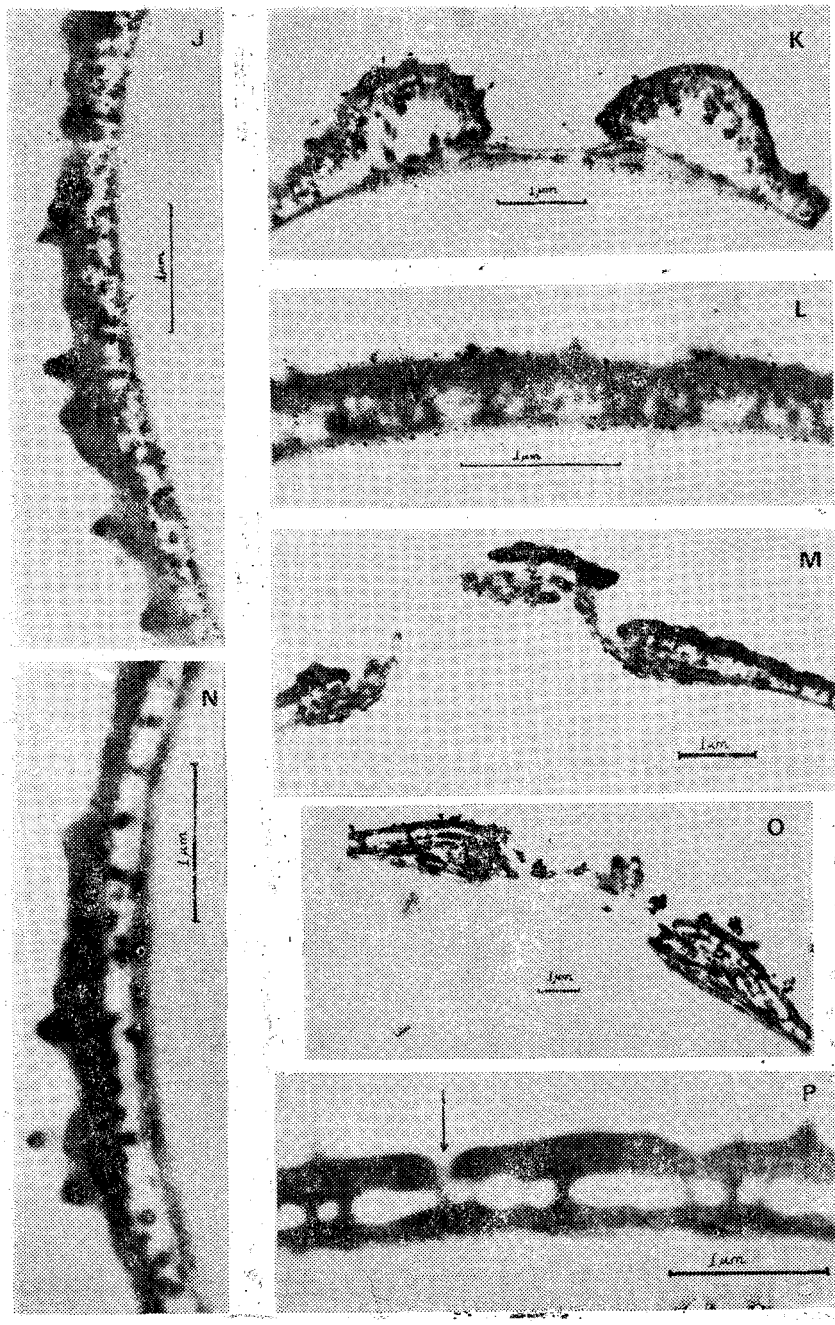

Plate 3. (J): *Cannabis sativa* L. Vertical section through the sporoderm (x22 500). (K–L): *Humulus lupulus* L.(K): Vertical median section through the sporoderm near the margin of a pore (x15 500). (L): Vertical section through the sporoderm (x28 500). (M–N): *Morus alba* L. (M): Vertical median section through the sporoderm near the margin of a pore with operculum (x13 500). (N): Vertical section through the sporoderm (x28 500). (O–P): *Myriophyllum spicatum* L. (O): Vertical median section through the sporoderm near the margin (x7 425). (P): Vertical section through the sporoderm (x28 500).

Infratectal bacula, ca. 0,19 μm long, but in annulus ca. 0,40 μm long, irregularly distributed, thickened at the base and with anastomosis of some thickened parts in annulus.

Exine scabratae, spinules, 0,09–0,16 μm height and 0,21–0,44 μm width. Operculum present; 0,30 μm height, 0,67 μm width.

Humulus lupulus L. (Plate 3, K – L)

Pollen tectate (pertectate). Exine, ca. 0,45 μm thick. The thickness of the exine sharply rises to a maximum value of about 1,36 μm in annulus (in a distance of about 1,2 μm) and then falls to a limiting value of 0,45 μm in a distance of about 3,6 μm (Fig. 2).

Sexine 0,28–0,35 μm; in annulus 0,40–0,55 μm thick (in a distance of about 0,4–2,0 μm) (Table 1, Fig. 3). $Nexine_1$ thin, 0,04–0,07 μm thick $Nexine_2$ very thin ca. 0,07 μm or indistinct, but in annulus ca. 0,3 μm thick, as a granular in appearance.

Sexine thicker than nexine and TR = S: $(N_1 + N_2) = 2:1$ in annulus, S: $N_1 = 8:1$ in nonapertural region.

There is a cavity closed to the pore between sexine and nexine. The tickness of the cavity rises to a maximum of about 0,62 μm (in a distance of about 1,2 μm).

Tectum continuous, 0,14–0,18 μm thick, the thickness of the tectum is more or less the same towards the pore margin, ca. 0,14 μm. Infratectal bacula, ca. 0,19 μm long, but in annulus ca. 0,4 μm long. The structure of bacula is the same as *Cannabis sativa*.

Exine scabratae, supratectal spinules small, 0,14–0,20 μm width, 0,07–0,14 μm height. Operculum disappear.

Myriophyllum spicatum L. (Plate 3. O–P)

Pollen tectate (pertectate). Exine, ca. 0,58 μm thick. The thickness of the exine rises to a maximum value of about 1,5 μm in annulus (in a distance of about 1,2 μm), then falls to a limiting value of 0,58 μm (in a distance of 4 μm) (Fig. 2).

Sexine 0,28–0,40 μm; in annulus 0,41–0,48 μm (in a distance of about 1,2–2,4 μm) (Table 1, Fig. 3). $Nexine_1$ 0,10–0,14 μm thick, but in annulus 0,65–1,00 μm thick. $Nexine_2$ visible in all area, 0,05–0,07 μm thick.

Sexine thicker than nexine, but in annulus TR = S: (N_1+N_2) = 0,4:1, S: (N_1 + N_2) = 2:1 in nonapertural area. Annulus formed by Nexine$_1$ outgrowth.

Tectum discontinuous, 0,17 μm – 0,22 μm thick. It is disrupted by 0,04–0,09 μm width, short scattered furrows all throughout the tectum. Infratectal bacula are extremely fine; 0,18–0,32 μm height. Unbranched bacula seem to be slightly thinner midway and irregularly distributed. Operculum disappear. Exine scabratae, spinule ca. 0,28 μm width and 0,14 μm height.

The maximum value of the thickness of sexines and the distances where the maximum apperars from near the pore are given at Table 1 for eight taxa studied.

RESULT AND DISCUSSION

The pollen structure of eight taxa studied in this paper is tectate (pertectate) according to their electron micrographs. There is a thickening of exine around the pore margin (annulus) in these taxa (Fig. 2, Fig. 3). The sexine consists of tectum and infratectal bacula. The tectum is continuous in all taxa except in *Myriophyllum spicatum.*

The tectum of pollen grains in *Coryllus avellana, Betula medwediewii, Ostrya carpinifolia, Carpinus betulus* is perforated by extremely thin channels. In *Coryllus avellana, Carpinus betulus* and in some *Betula* species except *Betula medwediewii* microchannels were described by Takeoka and Stix (1963) and Nilsson (1977), but in the studies on Japanese Betulaceae microchannels were not described (Ueno, 1963).

The tectum of *M. spicatum* is disrupted by short, scattered furrows all throughout the tectum (Plate 3, P). The structure of furrows were not explained by Engel (1978) and Praglowski (1970).

Infrabacular layer in some pollen grains of *C. avellana* and in some species of *Betula* was explained as a granular-columellar stratum between tectum and foot layer by Nilsson (1977) and also was confirmed by Ueno (1963).

The infrabacular layer is irregularly distributed and the upper parts of some bacula are separated from the base parts in all species except *M. spicatum.* In this species the bacula become slightly thinner in the middle and there is no a granular layer.

In all species the sexine is thicker than the nexine except *M. spicatum* in which sexine is thinner than nexine. The sexine is equal to the nexine in *Morus alba*.

The maximum values of the thicknesses of sexines of eight taxa vary from 0,4 μm (for the *M. alba*) to 3 μm (for the *C. avellana*). Distances at which the maximum in the thickness of sexine appears vary from 0,8 μm (*C. avellana, C. sativa*) to 2 μm (*B. medwediewii*) (Table 1, Fig. 2, Fig. 3).

All of the taxa studied have nexine$_1$. Nexine$_2$, which has a granular apperance, is distinct towards the annulus but becoming indistinct or discontinuous in nonapertural area in all of the taxa except *M. spicatum*. Nexine$_2$ is continuous and distinct from the area near to the pore to the nonapertural area in this species.

The term granular appearance has been used by many authors without any explanation (Takeoka, 1963; Ueno, 1963; İnceoğlu, 1982) for nexine$_2$. The granular appearance of nexine$_2$ occurs in the T.E.M. methods especially when osmium tetroxide is used for fixation. This substance changes the nexine$_2$ into a granular appearance by dissolving. Glutaraldehyde-osmium tetroxide also gives the same result. However, nexine$_2$ has not a granular appearance, if it is treated with potasium permanganat in T.E.M. method. A detailed study supporting this interpretation of this subject had been made by Roland and Roland (1968). The nexine of *M. spicatum* has an outgrowth from which annulus is formed (Plate 3.O). This structure was called "aspis channel" by Engel (1978).

Nexine$_1$ and nexine$_2$ are absent while the sexine thickens to form an annulus near the pore in *O. carpinifolia* and *C. betulus*, but only nexine$_1$ is absent in *B. medwediewii* and *C. avellana*.

The cavity called vestibulum is open to the pore in *B. medwediewii*. There is no cavity in *C. avellana, O. carpinifolia, C. betulus*.

In this paper it is also shown that both *Cannabis sativa* and *Humulus lupulus* have a convex shaped cavity which is not open to the pore. It was mentioned that this cavity was in the shape of "U" in *Cannabis* type (Moore, 1978). The surface of exine is scabrate in these taxa.

Punt (1984) mentioned a number of differences in characteristics among *H. lupulus, C. sativa, M. alba* in two families (Urticales) using

S.E.M. According to Punt margin of the pore having an operculum appears as a rim between pore and annulus in *C. sativa*, but this rim and operculum are absent in *H. lupulus*. The surface of *H. lupulus* is more or less verrucate while in *C. sativa* and M. *alba* scabratae.

It is shown that *C. sativa* and *H. lupulus* has cavity, but in *M. alba* it is absent (Plate 3. M). *Morus alba* has a long operculum which consists of tectum, bacula and nexine$_1$ (Plate 3. M). The existence and structure of operculum and the thickness and width of annulus have not been mentioned for the type of North west European *M. alba* (Punt, 1984). Operculum is present in *C. sativa* but disappear in *H. lupulus*.

The exine is scabratae in these three species. Praglowski (1970) mentioned that the detailed study of pollen of the Haloragoideae (included *M. spicatum*) seemed worth-while to compare them with the pollen of Betulaceae, because among these species belonging to these families the similar pollen grains were encountered in Haloragoideae. But in this paper differences can be clearly seen among the *M. spicatum* and *C. avellana and Betula* and other species.

The pollen morphology on Betulaceae have been studied by Praglowski (1962) in C. *betulus*, *C. avellana*, *O. carpinifolia* and some *Betula* species using light microscope, Takeoka (1963) ir *C. avellana*, *C. betulus* using electron microscope and in *C. betulus*, *C. avellana* by Nilson (1977) using electron microscope. The thickness of exine and sexine is more or less the same in these taxa studied in this paper.

The thickness of exine has been measured ca. 1,5 μ m in East African *C. sativa* (Hamilton, 1970) and ca. 0,45 μ m in *Cannabis* type in Britain (Moore, 1978). I found that the thickness of exine corresponding to nonapertural area is the same as in *Cannabis* type of Britain.

The literatures cited above did not explain whether the measurements belong to annulus or nonapertural region except *M. spicatum*. The thickness of the exine of *M. spicatum* is thinner than that of 1–3,5 μ m (in annulus), 1–2 μ m (in nonapertural region) which were found by Engel (1978).

The measurements of annuli and exine have been given as a diagrammatic representation for each taxa in this paper.

This and other pallinological T.E.M. studies serves to understand especially the structures of sporoderm and apertures in detail.

ACKNOWLEDGEMENTS

I am very indebted to Prof. Dr. Burhan AYTUĞ and Prof. Dr. Özden İNCEOĞLU who kindly read and criticized this manuscript. I am very grateful to the director and members of the Histological Department of Veterinary Faculty of Ankara University for their help in sectioning and electron microscopical work. I also thank Mr. Siyami KARAKÜLLAH of Botanic Department of Hacettepe University for the preparation of the slides.

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