

原 著

スズメノテッポウの葯中における 花粉外壁とオービクル壁の装飾

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Ornamentation of the pollen exine and orbicular wall
in the *Alopecurus* anthers

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Abstract

The ornamentation of the pollen exine and orbicular wall in the *Alopecurus* anthers has been studied by scanning electron microscopy. The exine of nonapertured wall regions is reticulate and has a surface ornamentation consisting of blunt spinules. The orbicules are spheroidal structures found in the mature anthers. Their surface is covered with small spinules of the same size and shape as the blunt spinules on pollen exine. The similar form of the orbicular wall and surface of the pollen exine suggests a close correlation.

Introduction

One of the distinguishing features of the secretory tapetum is the production of orbicules (or Ubisch bodies) on the inner surface of the sporangium. There have been many detailed studies on secretory tapetum of angiosperms by the light microscope and transmission electron microscope (TEM). Orbicules are spheroidal structures that are generally only a few micrometers in diameter (Echlin, 1971), and, therefore, it is difficult to study their structural details with the light microscope. It has been appreciated since the first observation of orbicules by Rowley et al. (1959) in a TEM study of surface replicas that they occurred in close association with the tapetum and had an ornamentation similar to the pollen exine. They reported

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that in *Poa* both are covered by spinules, while in *Degeneria* both are quite smooth, and in *Cryptomeria* both are granulate. They further considered that this relationship implied that genetic control must be mediated in the same way for Ubisch body form and some aspects of exine form. Heslop-Harrison (1962) concluded from his studies on the ontogeny of pollen grains in *Silene* and *Cannabis* that the Ubisch body wall originated in the same ways as the exine.

However, except for the few studies mentioned previously, structural details of the tapetal orbicules have neither been mentioned nor illustrated. Such details can be obtained with the scanning electron microscope (SEM). The purpose of this study is to investigate the ornamentation of the pollen exine and orbicular wall in the mature anthers of *Alopecurus aequalis*, as detected by SEM.

Material and Method

Intact flowers of *Alopecurus aequalis* Sobol. var. *amurensis* Ohwi were removed from plants grown in a campus of Gunma University, and the mature anthers established by SEM examination. The anthers were split longitudinally through the connective tissue. The pollen grains from open anthers were also collected. The specimens were allowed to air dry at room temperature for about 1 hr. After air drying, specimens were attached to stubs by double-sticky tape and placed in a vacuum-evaporator with a rotating stage for coating with carbon and gold. Charging was evident immediately and increased rapidly so the micrographs were taken within as short a time as possible. The specimens were examined and photographed in a JEOL JEM-15 scanning electron microscope operated at 15 kV. Size calculations were approximate because of the variable specimen to beam angles inherent in the SEM.

Observations and Discussion

Pollen grains of *A. aequalis* are typically monoporate, being spheroidal or slightly oblate in shape ; with average diameters from 28 to 32 μm . The single germination pore (aperture) found in each pollen grain wall consists of a slightly raised collar-like annules that surrounds a central plug-like operculum (Figs. 1, 2). The exine of nonapertured wall regions is reticulate and has a surface ornamentation consisting of blunt spinules. Examination of these spinules at higher magnifications shows that they have a uniform shape and diameter of 150 nm (Fig. 3). These are densely and evenly distributed. The ornamentation of operculum differs from that found in exine (Fig. 2). In operculum, spinules vary in size and shape, the larger ones being peg-shaped or nipple ; the latter may be formed by partial fusion of a number of smaller spinules.

In the mature anthers, the tapetal membranes (or tapetal orbicular wall) of *A. aequalis* as seen by the SEM (Fig. 4) do not differ significantly from that of *Sorghum bicolor* described by Christensen and Horner (1974). In their Fig. 22 they showed the depression in tapetal orbicular wall from which a single pollen grain has been dislodged. This figure resembles Fig. 4. SEM observations suggest that even after anthesis the tapetal membranes persist and continue to outline the ghosts of tapetal cells. The external surface of tapetum displays a number of orbicules, randomly distributed. In some regions on the tapetal membranes, orbicules occur isolated (Fig. 5), while at other levels, thread-like structures laced through the orbicules are observed (Fig. 6). Each orbicule with protuberances appear to be fusing with the tapetal cell wall (Fig. 5).

Another conspicuous feature of orbicules is its occurrence in fused aggregates. Clusters of two or more orbicules are shown in Fig. 6. Varying degrees of fusion between doublets are observed. Banerjee (1967) acetolyzed the tapetum of several grass species, spread the tapetal membranes on grids, and examined them with a TEM. His single stage replicas reveal a complex system of membranes, each consisting of an outer fenestrated layer, an irregular network of beaded strands forming a webbing about the orbicules, and an outer layer of microrods. The tapetal membranes of *A. aequalis* appears basically similar to his tapetal membranes. The orbicules are spheroidal and average 700 nm in diameter, without spinules (Figs. 5, 6). Their surface is covered uniformly with small spinules of the same size and shape as the blunt spinules on the pollen exine. Thus, it is concluded that the orbicules in *A. aequalis* have the same ornamentation as the pollen exine. These results are similar to those described by us (Yamada et al., 1980) in the case of *Cryptomeria japonica* anther.

In summary, this preliminary investigation has confirmed previous observations on morphological similarity between the orbicular wall and pollen exine and has shown SEM is a suitable tool for research in a complex system of tapetal membranes. Both the orbicular and pollen walls share many morphological characteristics.

References

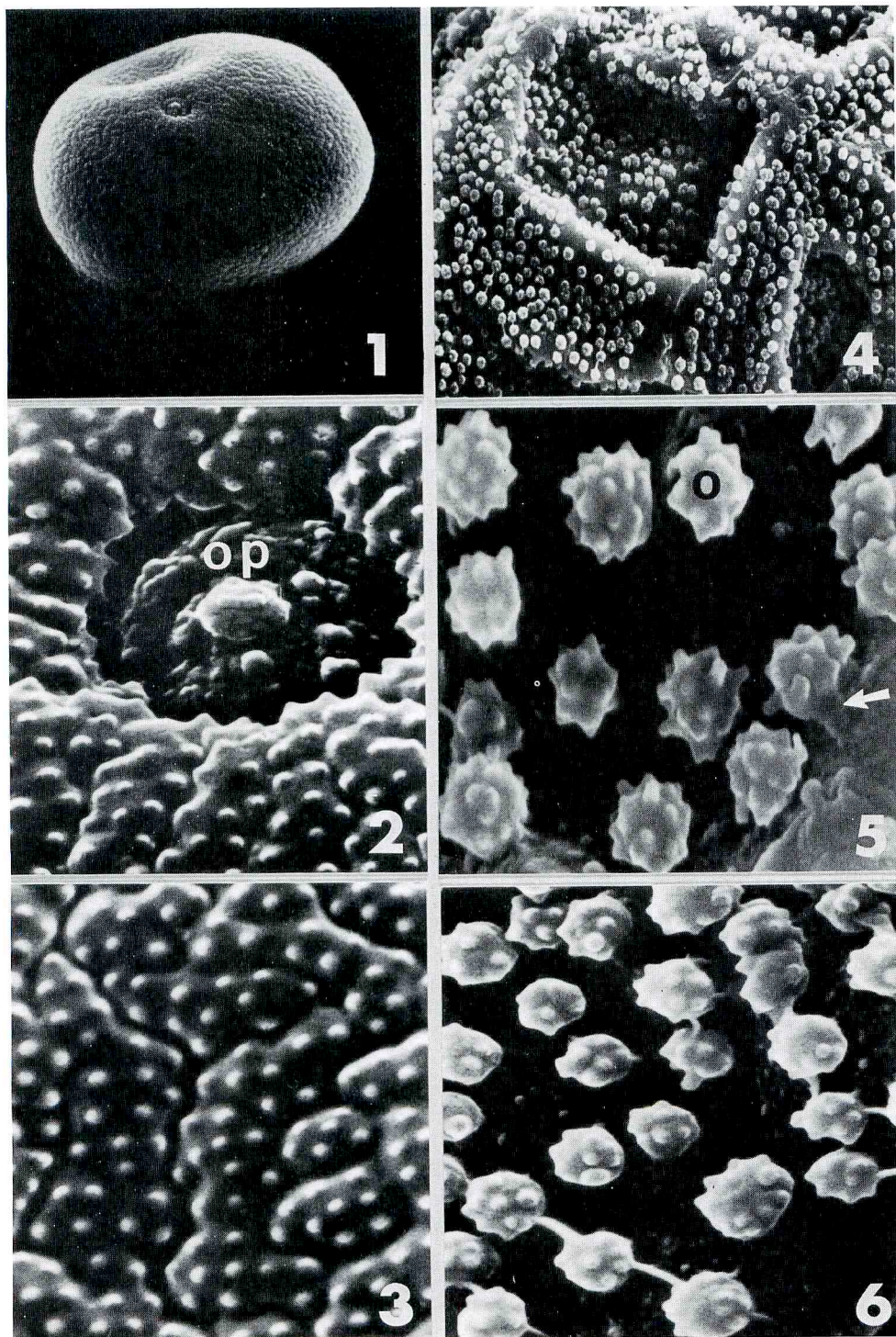
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要 約

スズメノテッポウの成熟した葯中における、花粉外壁とオービクル壁の装飾を走査電子顕微鏡を用いて観察した。花粉の型はイネ科特有の単口粒である。発芽口以外の花粉外壁は、不規則な細網状構造を示し、その表面には、径約 150 nm、高さ約 100 nm の鈍頭短刺状突起が密に分布している。一方、タペート組織には、崩壊した窓枠状のタペート細胞の外廓がよく認められ、その表層には無数のオービクルが

付着し、いわゆるタペート膜系を形成している。成熟したオービクルの平均的大きさは径約 700 nm である。各オービクルの表面には鈍頭短刺状突起が散在しているが、これらの突起の形状や大きさは、花粉外壁のものと同様であった。以上のことから、スズメノテッポウでは、花粉外壁とオービクル壁の装飾との間には著しい相似性があることが認められた。

木原 均博士の米寿記念号に、この小論を捧げる。



Explanation of Figures

SEM views of pollen grain and portion of tapetum of *Alopecurus aequalis*.

- Fig. 1. View of mature pollen grain. Single germination pore is apparent in sculptured wall. x 1,400.
- Fig. 2. Enlarged view of the germination pore of Fig. 1. Note the nipple-like protuberance in the center of operculum (OP). x 14,000.
- Fig. 3. Ornamentation of pollen exine showing blunt spinules in profile. x 14,000.
- Fig. 4. Face view of tapetal membranes, oriented towards anther locules, covered with orbicules. Tapetal cell outlines are seen under the persistent walls. x 2,100.
- Fig. 5. A part of the enlargement of Fig. 4. Fusion of orbicules (O) with the wall of a tapetal cell : arrow points to protuberance. Note that pattern of surface of orbicules is similar to nonapertured wall. Compare with pollen exine in Fig. 3. x 14,000.
- Fig. 6. A part of the enlargement of the same tapetum as in Fig. 5. Each orbicule is somewhat irregular in size and shape. Note the thread-like structures laced through the orbicules. Also note aggregate of partially fused orbicules. x 14,000.

☆ 会員・伊藤 洋博士の叙勲

日本花粉学会会員で東京教育大学名誉教授の伊藤博士は昭和 55 年 11 月 3 日の秋の叙勲で勲三等旭日中綬章を受章されました。博士はシダ分類学の専門家で、多くの学者を育てられました。とくにシダ類の胞子については川崎次男（故人）・倉本嗣王の諸氏が活躍されました。ここに心から御祝を申し上げ、今後ますます御元気に過され、私達を御指導下さるよう to 御願ひします（上野）。