Pollensurfacepatternandits taxonomic significance of the Korean Polygonaceae pollen

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Abstract

Pollen grains of 37 species, 1 subspecies, and 2 varieties of 11 genera in the Korean Polygonaceae were investigated by using a scanning electron microscope. The result revealed that the family was divided into four pollen groups on the basis of surface scupturing: foveolate and echinate or scabrate (Aconogonum, Bistorta, Rumex, and Polygonum s.s.), foveolate or fossulate but not echinate (Pleuropterus, Rheum, Reynotria, and Fagopyrum), psilate but echinae present only at the sides of the colpus (Bilderdyokia), and reticulate (Tovara and Persicaria).

A presumed phylogenetic relationship was obtained on the basis of pollen aperture and surface sculpturing characters and some taxonomic problems were discussed.

Introduction

Pollen morphology of the Polygonaceae has been proven eurypalynous and contributed to the infrafamilial systematics (Wodehouse 1931, Hedberg 1946, Erdtman 1966, Huang and Chen 1969, Nowicke and Skvarla 1977). On the Korean Polygonaceae, some descriptive works were conducted by Lee (1979) and Chang (1979). Hong and Lee (1983) described 2 varieties, 1 subspecies, 37 species of 11 genera and presented the intergeneric phylogeny mainly on the basis of aperture character. However, in the palynological classification of this family, the sculpturing pattern seems to be significant as much as that of the aperture character. All of the pollens of Koenigia have echinae while
their aperture number shows a wide range of variation, i.e., *K. hertilis*, *K. islandica* and *K. pilosa* 12 colporate, *K. cyanandrum* 20-30, *K. filicaule* 15 (Hedberg 1946). In addition, results of many authors are discordant with each other especially in the descriptions of sculpturing pattern: Wodehouse (1931) described that the surface of *Polygonum* is alveolate and *Persicaria* exhibits a similar pattern. Doida (1962) described *Polygonum* as very conspicuously reticulate. According to Hedberg (1946), however, the genera separated from *Polygonum* s.l. show different patterns: *Polygonum* s.s. finely verrucate, *Persicaria* reticulate, and *Fagopyrum* similar to negative reticulate. Hong and Lee (1983) suggested the exine sculpturing of Korean polygonaceous pollen is generally reticulate, especially conspicuous in *Tovara* and *Persicaria*. Such discrepancies were thought to be caused by using light microscope only and would be elucidated by using a scanning electron microscope (Graham and Barker 1981). The results would be useful to resolve the taxonomic problems as well as to rearrange the generic relationship that was constructed in Hong and Lee (1983).

**Materials and Methods**

Pollen samples including 37 species, 1 subspecies and 2 variety of 11 genera were obtained primarily from the field collection (Hong and Lee 1983). For light and scanning electron microscopy, all samples were prepared by a modified acetyolysis method (Lee 1983). Samples for SEM were ion-coated with gold-palladium, examined and photographed with JEOL120EX scanning electron microscope. For light microscopy, pollen grains were mounted in glycerine jelly on microscope slides and sealed with paraffin. Observation was conducted with a LEITZ-LABORUX microscope. Terminology followed Faegri and Inversen (1964) and Erdtman (1966).

**Results**

**General pollen morphology of the Korean polygonaceae:** The equatorial shape mostly subprolate, oblate-spheroidal (*Rumex*), or spherical (*Tovara* and *Persicaria*). The polar shape circular in most genera, intersemigangular in *Bilderdykia* and intersubangular in *Pleuropterus*. The grain size range between 18.2 and 68.5 μm; the smallest *Bilderdykia* and the largest *Persicaria*. The aperture types various: tricolpate (*Aconogonum*), polyporate (*Persicaria*), polycoplate (*Tovara*), and tricolporate. Tricolporate grains subdivided into one possessing costa transversales (*Bilderdykia, Polygonum* s.s., *Reynotria*, and *Fagopyrum*) and another lacking it (*Rheum, Pleuropterus, Bistorta, Rumex* and *Persicaria nepalensis*).

On the basis of surface sculpturing pattern, the family divided into four groups: foveolate and either scabrate or echinate (*Aconogonum, Bistorta, Rumex* and *Polygonum*), foveolate or fossulate but neither scabrate nor echinate (*Pleuropterus, Rheum, Reynotria* and *Fagopyrum*), psilate but echinae present only at the sides of the colpus (*Bilderdykia*), reticulate and baculate protuberances present in its lumen (*Tovara* and *Persicaria*). The infrafamilial phylogeny, suggested by Hong and Lee (1983), corresponds well with this result based on the surface sculpturing pattern. Nevertheless, tricolporate pollen group is more subdivided by the character of surface sculpturing. In addition, the pollen types of *Tovara* and *Persicaria* would be considerably different in the size of lumen, and the distribution and shape
of bacula in lumen.

Based on the results, it is possible to construct a pollen key to the genera of Korean Polygonaceae.

Pollen key to the genera

A. Grain prolate to prolate-spheroidal or suboblate. Aperture tricolpate or tricolporate. Surface reticulate or not reticulate.
B. Aperture tricolpate or tricolporate. Surface echinate or scabrare.
C. Surface with foveolae.
   D. Aperture tricolpate. Scabrae globular ....................................... *Aconogonum*
   D. Aperture tricolporate. Scabrae obtuse-tipped or echinate.
   E. Foveolae not connected.
      F. Pore circular. Foveola margin sunken, surface evenly flat .......... *Bistorta*
      F. Pore equatorially elongate and fused with each other. Foveola margin not sunken, surface ± bullate .......................... *Polygonum* s.s.
   E. Foveolae connected with each other ........................................... *Rumex*.
   C. Surface without foveolae, echini present only around colpi .................. *Bilderdykea*
B. Aperture tricolporate. Surface neither echinate nor scabrare.
   G. Pore circular. Fossulae small, surface ± rugulate.
      H. Surface somewhat smooth .................................................. *Rheum*
      H. Surface irregularly grooved ........................................... *Pleuropteris*
   G. Pore elongate, transversal costae prominent. Fossulae large (+reticulate), not rugulate.
      I. Fossulae smaller, circular or elliptic ............................ *Reynotria*
      I. Fossulae larger, stellate ............................................. *Fagopyrum*
A. Grain spherical. Aperture polycolpate, tricolporate or polyporate. Surface reticulate.
   J. Aperture polycolpate ..................................................... *Tovara*
   J. Aperture tricolporate or polyporate.
   K. Aperture polyporate ....................................................... *Persicaria*
   K. Aperture tricolpate ....................................................... *P. nepalensis*

Description of the sculpturing pattern

*Aconogonum*—The surface foveolate and scabrare. Foveolae generally round, sometimes elongate to somewhat irregularly shaped, the diameter roughly 0.05-0.26 μm. Scabrae more or less globular, diameter 0.15-0.34 μm. The frequency of scabrae about 70-132 per 100 sq. μm, that of foveolae about 200-450. Interspecific variation of the pattern not significant. Figs. 3, 6, 7, 8, 10, 11.

*Rumex*—The surface foveolate and scabrare. Foveolae connected with each other by grooves. The number of connected foveolae less than 4 in *R. japonicus, R. crispus, R. aquatica*; up to 6 in *R. acetosa*
and *R. conglomeratus*; and over 7 in *R. acetocella* and *R. obtusifolius*. Scabrae minute, distribute on the ridges. The frequency of foveolae 130-250 per 100 sq. µm, that of echinae 260-530. The ratio of echinae/foveolae 1.28-1.97 variable in different species. Figs. 13, 14, 16, 17.

*Bistorta*—The surface foveolate and scabrate. Foveolae round, margin sunken; scabrae tip obtuse. The diameter of scabra 0.07-0.21 µm. Frequency of scabrae about 228-256 per 100 sq. µm., that of foveolae about 150-650. Ratio of scabra and foveola numbers seem to be different between species. Figs. 9, 12, 31, 34.

*Polygonum* s.s.—The surface foveolate and scabrate. Foveolae round to elliptic, 0.09-0.21 µm in diameter. Scabara tip blunt, about 0.17 µm in diameter. The surface not smooth but more or less bullate. Frequency of foveolae about 250 per 100 sq. µm, that of scabrae about 50. The degree of bullateness seems various among species. Figs. 15, 18, 19, 20, 22, 23.

*Bilderdykia*—The surface psilate except for the sides of colpi where short echinae distribute densely. The width of the echinate surface beside a colpus about 0.45 µm. The degree of echina density seems different between the two studied species. Figs. 1, 2, 4, 5.

*Rheum*—The surface foveolate, foveolae sunken and two or more of them connected with each other by slightly winding, sunken lines. Number of foveolae about 130 per 100 sq. µm. Figs. 21, 24.

*Pleuropterus*—The surface foveolate, the area between foveolae more or less irregularly raised and the surface look like rugulate. Foveolae distribute along the grooves. The number of foveolae about 174 per 100 sq. µm. Figs. 25, 28.

*Reynotria*—The surface foveolate to reticulate. Foveolae irregularly round, much larger in diameter (0.18-0.26 µm) than the above genera, the margin sunken in *R. sachalinensis* (Figs. 27, 30). The diameter is even greater (0.17-0.85 µm) and the surface look like reticulate in *R. elliptica* (Figs. 26, 29).

*Fagopyrum*—The surface fossulate. Fossulae irregular-shaped, evenly distributed. The area between the fossulae are raised and the ridges surrounding each fossula form polygons. The number of fossulae about 40 per 100 sq. µm. Figs. 32, 35.

*Tovara*—The surface reticulate, lumen stellate to irregular-shaped, about 2-6 granular protuberances in lumen, average diameter 2.0 µm. Muri about 0.63 µm in width, winding. The base of columellae forming the muri extends outward and muri look bead-like. Figs. 33, 36, 37, 40.

*Persicaria*—The surface reticulate. Lumen polygonal, irregularly round, or irregular-shaped, many granular protuberances in lumen, average diamenter 0.85 µm. Muri about 2.5 µm in width, more or less straight to winding. The out-extension of columella bases more conspicuous than in *Tovara*. The surface pattern is so variable among the species. Figs. 38, 39, 41, 42.

**Palynological relationships:** As in the presumed evolutionary tree on the basis of morphological basis (Fig. 1), the most primitive aperture type was the tricolpate (*Aconogonum*), while the advanced ones were polycolpate (*Tovara*) and polypoate (*Persicaria*). Because *Tovara* and *Persicaria* pollen grains had spherical shape, many apertures spreading over the grain, and conspicuously reticulate sculpturing pattern, the two genera were closely related and well separated from the rest of the genera. The
Fig. 1. A presumed phylogenetic relationships of the Korean polygonaceous genera on the basis of pollen aperture types (from Hong and Lee, 1983) and surface sculpturing patterns. The primitive characters were regarded to be the tectate-perforate and scabrate/echinate surface and the tricolpate aperture. (1) The evolution of semitectate exine and reticulate surface. (2) The loss of scabrae and echinae and the enlargement of fossulae. (3) The appearance of tectate-imperforate exine and echinae on the surface at the sides of colpus.

intermediate aperture type was tricolporate.

Among the tricolporate genera, the surface of *Bistorta, Polygonum* and *Rumex* was foveolate and scabrate or echinate and closely related (Figs. 13, 22, 23), however, *Rumex* showed a tendency to increase the number of echinae and puncti as well as the number of aperture (Figs. 6, 17). *Fagopyrum, Reynotria, Rheum, and Pleuropterus* were foveolate but did not have echinae (Figs. 21, 24-30, 32, 35), among which *Reynotria* (Figs. 26, 27, 29,30) and *Rheum* (Figs. 21, 24) had larger puncti than those
of others. The surface of *Pleuropterus* is fossulate and irregularly grooved. The puncti of *Fagopyrum* are more differentiated than the former genera and form a stellate shape (Figs. 32, 35). Since *Bilderdykia* (Plate I, Figs. 1, 2, 4, 5) pollen is psilate and possesses echinae only at the sides of the colpus, it is well distinguished from the rest of the tricolporate groups. On the other hand, *Fagopyrum, Reynotria, Polygonum* and *Bilderdykia* have transversely elongate pores with a costa (costa transversale) and are thought to be more advanced than the others, among which *Polygonum* s.s. is the most advanced because the transversal colpi are fused to each other (costa equatoriales).

*Persicaria nepalensis* possesses the reticulate sculpturing pattern and the spherical grain shape which are typical to *Persicaria*, and a tricolporate aperture instead of the polyporate aperture. It is suggested to be the most primitive within *Persicaria* and an intermediate species between the tricolporate genera and the other *Persicaria* species.

**Discussion**

According to the system of Engler (1964) and Bentham and Hooker (1962), Korean polygonaceous genera belong to two tribes: Rumiceae (*Rumex, Rheum*, and *Oxyria*) and Eupolygoneae (the rest of the genera). Whereas both *Rumex* and *Rheum* possess a tricolporate aperture, the former is well distinguished from the latter by having echinae. Thus the present result does not support the conventional system. The present result mainly based on the sculpturing pattern of the surface, well agrees with the presumed phylogeny constructed by apertural characters (Hong and Lee 1983).

The separation of *Bilderdykia* from the other tricolporate genera is obvious, i.e. in this genus, the surface is characteristically psilate except for the sides of the colpi as well as not punctate. This is well supported by the vegetative morphology of the genus: climbing habit, cordate leaf, achene with the oboval wings. *Rheum, Fagopyrum, Pleuropterus*, and *Reynotria* are grouped together because of the punctate and not-echinate surface pattern. Their close affinity is concorded with their similar fruit morphology except for *Fagopyrum* in which achene is winged and leaf shape is triangular. Genera represented by having foveolate and scabrate or echinate surface include *Polygonum* s.s., *Aconogonum, Rumex,* and *Bistorta*. Their reproductive and vegetative morphology is quite various and does not match the palynological result. *Tovara* and *Persicaria* are closely related on the morphology of flower, inflorescence, and vegetative organ. The principal difference between the genera is the stigma shape, i.e. hooked in *Tovara* and straight in *Persicaria*. Pollen morphology well demonstrates this relationship, i.e. both exhibit the spherical grain shape and reticulate surface as well as many aperture. But they are well separated and show different evolutionary lines, i.e. polycolate in the former and polyporate in the latter.

The primitive position of *Aconogonum* (Hong and Lee 1983) is also supported on the basis of surface characters. Walker and Doyle (1975) described the most primitive exine structure as a tectate-imperforate pollen, from which tectate-perforate and then semitectate natures were derived. *Aconogonum* exhibits the tectate-perforate exine and implies its primitive position among the genera. Exceptionally, however, *Bilderdykia* exine is tectate-imperforate. Two possible explanations are (1) *Bilderdykia* was independently originated from other ancestor than *Aconogonum* and (2) an evolu
tionary reversal from tectate-perforate to tectate-imperforate was involved.

A wide range of sculpturing variation was demonstrated in some genera. Palynological reports are under preparation on *Rumex* and *Persicaria*. The present study proved the usefulness of palynological characters especially by using the scanning electron microscope in the elucidation of the intergeneric relationship. Moreover, discrepancies of the sculpturing patterns indicated above were well resolved. It was manifested that many of the descriptions of the polygonaceous pollen were erroneous, e.g. the alveolate or conspicuously reticulate pattern in *Polygonum* (Wodehouse 1931, Doida 1962) was proven to be foveolate and with scabrate, the negative reticulate in *Fagopyrum* (Hedberg 1946) to be fossulate to reticulate, etc. Further study which covers a wide range of taxa would be necessary.

**摘要**

 한국의 마디풀과 11 屬 37 種 1 亞種 2 變種의 花粉를 走査電子顯微鏡으로 觀察하였다。韓國의 마디풀과 花粉은 表面 무늬에 의해 4 개의 群으로 나누었다。

(1) 有孔型이며 微粒狀 또는 刺狀突起가 있는群(성어屬, 벌의고리屬, 마디풀屬) (2) 有孔型
인미 微粒狀 또는 刺狀突起가 있는群(나도하수属, 대창屬, 호성근屬, 麓属) (3) 平滑狀인
而 溝口兩側에만 刺狀突起가 있는群(담의당궁屬) (4) 網狀인群(이사여귀屬, 여귀屬) 發芽口와
表面무늬의 特徵을 토대로 系統樹を 만들고 分類學의 問題點을 論議하였다。

**Literature Cited**


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Hedberg, O. 1946. Pollen morphology in the genus *Polygonum* L. s. lat. and its taxonomical significance.


Plate I-IV. Scanning electron microphotographs of polygonaceous pollen grains.
