

Pollen Morphology of Genus *Sedum* in Korea

Kim, Jeong Hee*

Department of Biology, Seoul National University, Seoul 151-742, Korea

Pollens of 20 species of *Sedum* were investigated with a scanning electron microscope. The pollen morphology of *Sedum* was rather variable, within particular species or even within a single inflorescence. Differences occurred in the number and shape of apertures and surface sculpture. Besides 3-colporate, various aperture types including 2-syncolporate, 3-syncolporate, 4-stephanocolporate, 5-stephanocolporate, zonate, and irregular types were found in a single specimen. Also, striate-rugulose and psilate sculpture were found in *S. viviparum*. No correlation was found between the pollen morphology and the floral formula. Pollen characters appeared to be not useful for infrageneric classification of Korean *Sedum*.

Key words : *Sedum* spp., pollen morphology, floral formula

Sedum L. is a large genus belonging to the subfamily Sedoideae (Crassulaceae), and is mainly found in temperate or subtropical zones of the Northern Hemisphere (Berger, 1930). The number of species ranges from 350 (Froderstrom, 1930-1936) to 600 (Willis, 1973). Approximately 300 species are distributed over the Asiatic region (Ohba, 1978), and 23 species belonging to 3 sections are found in Korea (Kim, 1989).

During the past two decades, pollen characteristics have contributed significantly to the systematics of various angiosperms (Erdtman, 1986; Walker, 1971; Walker and Doyle, 1975). Radulescu (1963) reported 3-colporate, 3-syncolporate, and 4-colporate pollen grains in some *Sedum* species in Rumania. Also, Hart (1974) reported that pollens of 24 European species of *Sedum* were mostly 3-colporate with the occasional, though rare, 2- or 4-colporate. From these two studies, it appears that *Sedum* species have variation in the number of apertures. However, Calie (1981) reported that only 3-colporate pollen grains, with negligible interspecific variation, were found in *Sedum* sect. *Ternata*.

In this study, the pollen morphology of 20 species was investigated to find potential new characteristics for classifying Korean species of *Sedum*.

MATERIALS AND METHODS

Materials used in this study were collected in Korea by the author (Table 1). Voucher specimens were deposited at SNU, and collection data for SEM studies are given in Table 1.

Pollen grains were acetolysed using the methods described by Erdtman (1960). For SEM, dry pollen grains were mounted on conducting tape affixed to an aluminum stub with silver paint, and coated with 25 nm gold and examined with SEM (Jeol, JSM-35) at 25 kV. Terminology proposed by Erdtman (1986) was used to describe the pollen morphology.

RESULTS

Pollen morphology from three sections of Korean *Sedum* is described below. Characteristics of pollen grains of each species are listed in Table 2.

Sedum sect. *Telephium* (Figs. 1-10).

Pollen grains usually 3-colporate, sometimes 2-syncolporate, 4-colporate, 3-syncolporate, or otherwise irregular in *S. viviparum* and *S. alboroseum*; prolate to prolate-spheroidal (polar axis: $20.4 \pm 3.2 \mu\text{m}$ to $28.0 \pm 1.0 \mu\text{m}$); striate-rugulose, or very rarely psilate were found in some grains of *S. viviparum*; endoapertures round.

*Corresponding author: Fax +82-2-872-6881

Table 1. Collection data of 20 species of Korean *Sedum* used for SEM observations of pollen grains

Scientific name	Korean name	Locality	Collection	Figure
Sect. <i>Telephium</i>				
<i>S. alboroseum</i> Baker	평의비름	Mt. Taedun	66,686	9, 10
<i>S. duckbongii</i> Chung et Kim, nom. nov.	둥근잎평의비름	Mt. Chuwang	66,668	4
<i>S. spectabile</i> Boreau	큰평의비름	Bugu	66,651	1, 2
<i>S. taquetii</i> Prager	한라평의비름	Mt. Halla	66,672	3
<i>S. verticillatum</i> Linnaeus	세잎평의비름	Mt. Odae	66,670	5
<i>S. viridescens</i> Nakai	섬평의비름	Mt. Jiri	66,671	6
<i>S. viviparum</i> Maximowicz	새끼평의비름	Inje-gun	66,675	7, 8
Sect. <i>Aizoon</i>				
<i>S. aizoon</i> Linnaeus	가는기린초	Bugu	66,692	11, 12
<i>S. ellacombianum</i> Praeger	해안기린초	Haegumgang	66,782	20
<i>S. kamtschaticum</i> Fischer	기린초	Mt. Jiri	66,747	15, 16
<i>S. sikokianum</i> Maximowicz	각시기린초	Mt. Taeam	66,790	18, 19
<i>S. takesimense</i> Nakai	섬기린초	Ulung Isl.	66,707	13, 14
<i>S. zokuriense</i> Nakai	속리기린초	Mt. Songni	66,786	17
Sect. <i>Seda-genuina</i>				
<i>S. bulbiferum</i> Makino	말뚝비름	Mt. Kwanak	66,809	25
<i>S. coreense</i> Nakai	바위돌나물아제비	Mt. Baegyang	66,833	23
<i>S. japonicum</i> Siebold	암채송화	Sasu Isl.	66,848	22
<i>S. lepidopodium</i> Nakai	갯돌나물	Kwanmae Isl.	66,843	21
<i>S. oryzifolium</i> Makino	땅채송화	Haegumgang	66,850	
<i>S. polytrichoides</i> Hemsley	바위채송화	Mt. Taeam	66,815	26
<i>S. sarmentosum</i> Bunge	돌나물	Mt. Gum	66,795	24

Sedum* sect. *Aizoon (Figs. 11-20).

Pollen grains 3- to 5-colporate, 2-syncolporate, 3-syncolporate, zonate, or irregular; prolate to spherical (polar axis: $23.5 \pm 0.5 \mu\text{m}$ to $20.0 \pm 0.0 \mu\text{m}$); semi-circular, striate-rugulose; endoapertures round.

Sedum* sect. *Seda-genuina (Figs. 21-26).

Pollen grains usually 3-colporate, 4-colporate, zonate, or irregular; prolate to prolate-spheroidal (polar axis: $17.9 \pm 0.1 \mu\text{m}$ to $23.5 \pm 0.5 \mu\text{m}$); semi-circular; striate-rugulose; endoapertures round to cross.

DISCUSSION

Pollen morphology of 10 of the 20 species examined showed considerable variation within species, within a single inflorescence, and even within a flower.

In sect. *Telephium*, variation in aperture number and shape were found in two of the seven species examined. In addition to 3-colporate, 3-syncolporate

and irregular apertures were found in *S. alboroseum*. Also, zonate (Fig. 7), 2-syncolporate (Fig. 8), and 4-stephanocolporate grains were found in *S. viviparum*. Furthermore, variation in size (polar axis: $20.4 \pm 3.2 \mu\text{m}$) and shape (prolate to spheroidal-prolate) was found in *S. alboroseum*. An equatorial view of *S. alboroseum* showed prolate-spheroidal shapes in the pollens with irregular apertures, and prolate in those with 3-colporate and 3-syncolporate apertures. In addition to striate-rugulose, psilate surface sculpture was found in *S. viviparum* (Fig. 7).

In sect. *Aizoon*, aperture variation was found in all six species. Zonate and irregular apertures, which are primitive types (Doyle, 1969), were found in *S. aizoon*, *S. kamtschaticum* (Fig. 15), *S. takesimense* (Fig. 14), and *S. ellacombianum* (Fig. 20). Three-syncolporate, 4-colporate and even 5-colporate apertures, which are advanced types (Doyle, 1969), were found in *S. aizoon* (Fig. 11), *S. kamtschaticum*, *S. ellacombianum*, and *S. sikokianum* (Figs. 18, 19).

In sect. *Seda-genuina*, aperture variation was found in only two of seven species. Zonate and irregular apertures were found in only *S. sarmentosum* (Fig.

Table 2. Comparison of some representative pollen characters of 20 species of Korean *Sedum*

Taxa	Character	Polar length (μm)	Equatorial length (μm)	P/E	Equatorial view	Polar view	Sculpture	Porate shape	Aperture type
Sect. <i>Telephium</i>									
<i>S. spectabile</i>		21.5 \pm 0.5	16.5 \pm 1.5	1.20-1.40	subprolate, prolate	lobate-circular	striate-rugulose	round	3-colporate
<i>S. duckbongii</i>		23.5 \pm 0.5	1.59 \pm 0.1	1.45-1.50	prolate	lobate-circular	striate-rugulose	round	3-colporate
<i>S. verticillatum</i>		28.0 \pm 1.0	20.5 \pm 1.0	1.30-1.45	prolate	lobate-circular	striate-rugulose	round	3-colporate
<i>S. viridescens</i>		25.0 \pm 1.2	17.3 \pm 1.0	1.35-1.40	prolate	lobate-circular	striate-rugulose	round	3-colporate
<i>S. taquetii</i>		23.0 \pm 1.0	15.5 \pm 0.5	1.40-1.60	prolate	lobate-circular	striate-rugulose	round	3-colporate
<i>S. viviparum</i>		22.9 \pm 0.2	17.9 \pm 0.1	1.34-1.36	prolate	semi-circular	striate-rugulose, psilate	round	3-colporate, zonate, 2-syncolporate, 4-stephanocolporate
<i>S. alboroseum</i>		20.4 \pm 3.2	15.8 \pm 1.1	1.13-1.54	prolate-spheroidal, prolate	semi-circular	striate-rugulose	round	3-syncolporate, irregular, 3-colporate
Sect. <i>Aizoon</i>									
<i>S. aizoon</i>		23.5 \pm 0.5	20.5 \pm 0.5	1.15-1.20	subprolate	semi-circular	striate-rugulose	round	zonate, 3-syncolporate, 3-colporate, 4-stephanocolporate
<i>S. takesimense</i>		22.5 \pm 1.3	18.0 \pm 1.2	1.20-1.35	subprolate, prolate	semi-circular	striate-rugulose	round	3-colporate, zonate, irregular
<i>S. ellacombianum</i>		20.0 \pm 0.0	18.0 \pm 2.0	1.00-1.25	spherical, subprolate	semi-circular	striate-rugulose	round	3-colporate, zonate, 3-syncolporate
<i>S. zokuriense</i>		20.5 \pm 1.5	16.0 \pm 2.0	1.15-1.46	subprolate, prolate	semi-circular	striate-rugulose	round	3-colporate, 2-syncolporate,
<i>S. sikokianum</i>		22.0 \pm 2.0	17.5 \pm 2.5	1.20-1.33	subprolate,	semi-circular	striate-rugulose	round	3-colporate, 4-stephanocolporate
<i>S. kamschaticum</i>		22.5 \pm 1.5	18.0 \pm 2.0	1.18-1.38	subprolate, prolate	semi-circular	striate-rugulose	round	3-colporate, irregular, 4-stephanocolporate, 3-syncolporate
Sect. <i>Seda-genuina</i>									
<i>S. sarmentosum</i>		20.9 \pm 0.1	19.9 \pm 0.1	1.05	prolate-spheroidal	semi-circular	striate-rugulose	round	3-colporate, irregular, zonate
<i>S. bulbiferum</i>		17.9 \pm 0.1	15.5 \pm 1.5	1.06-1.29	prolate-spheroidal, subprolate	semi-circular	striate-rugulose	round	3-colporate, 4-stephanocolporate
<i>S. coreense</i>		23.5 \pm 0.5	17.5 \pm 0.5	1.28-1.41	subprolate, prolate	semi-circular	striate-rugulose	cross	3-colporate
<i>S. polytrichoides</i>		21.0 \pm 2.1	17.5 \pm 1.2	1.06-1.21	prolate-spheroidal, subprolate	semi-circular	striate-rugulose	cross	3-colporate
<i>S. lepidopodium</i>		20.0 \pm 0.4	18.0 \pm 0.1	1.1	prolate-spheroidal,	semi-circular	striate-rugulose	round	3-colporate
<i>S. oryzifolium</i>		20.0 \pm 0.2	18.0 \pm 0.1	1.1	prolate-spheroidal,	semi-circular	striate-rugulose	round	3-colporate
<i>S. japonicum</i>		20.3 \pm 0.1	18.2 \pm 0.1	1.1	prolate-spheroidal,	semi-circular	striate-rugulose		3-colporate

24), and 4-colporate grains were found in *S. bulbiferum* (Fig. 25). Also, endoaperture variation was found in taxa belonging to sect. *Seda-genuina*. The endoaperture was cross-shaped in *S. coreense* (Fig. 23) and *S. polytrichoides* (Fig. 26), and round in *S. sarmentosum* (Fig. 24), *S. bulbiferum* (Fig. 25), *S. japonicum* (Fig. 22), *S. oryzifolium*, and *S. lepidopodium* (Fig. 21).

Although aperture variation in Korean *Sedum* species shows similar trends as of other European and Rumanian species, it appears to be more extensive in Korean taxa.

Variation in floral formula, 4- to 6-merous or heteromerous, occurred within a single species, and even within the same inflorescence in Korean *Sedum* (Kim, 1989). But the degree of aperture variation and variation in floral formula is not correlated. Variation in pollen grains as well as floral formula appeared to be more extensive in sect. *Aizoon* than in sect. *Telephium* and sect. *Seda-genuina*. In conclusion, the pollen morphology of Korean *Sedum* species has very limited taxonomic value.

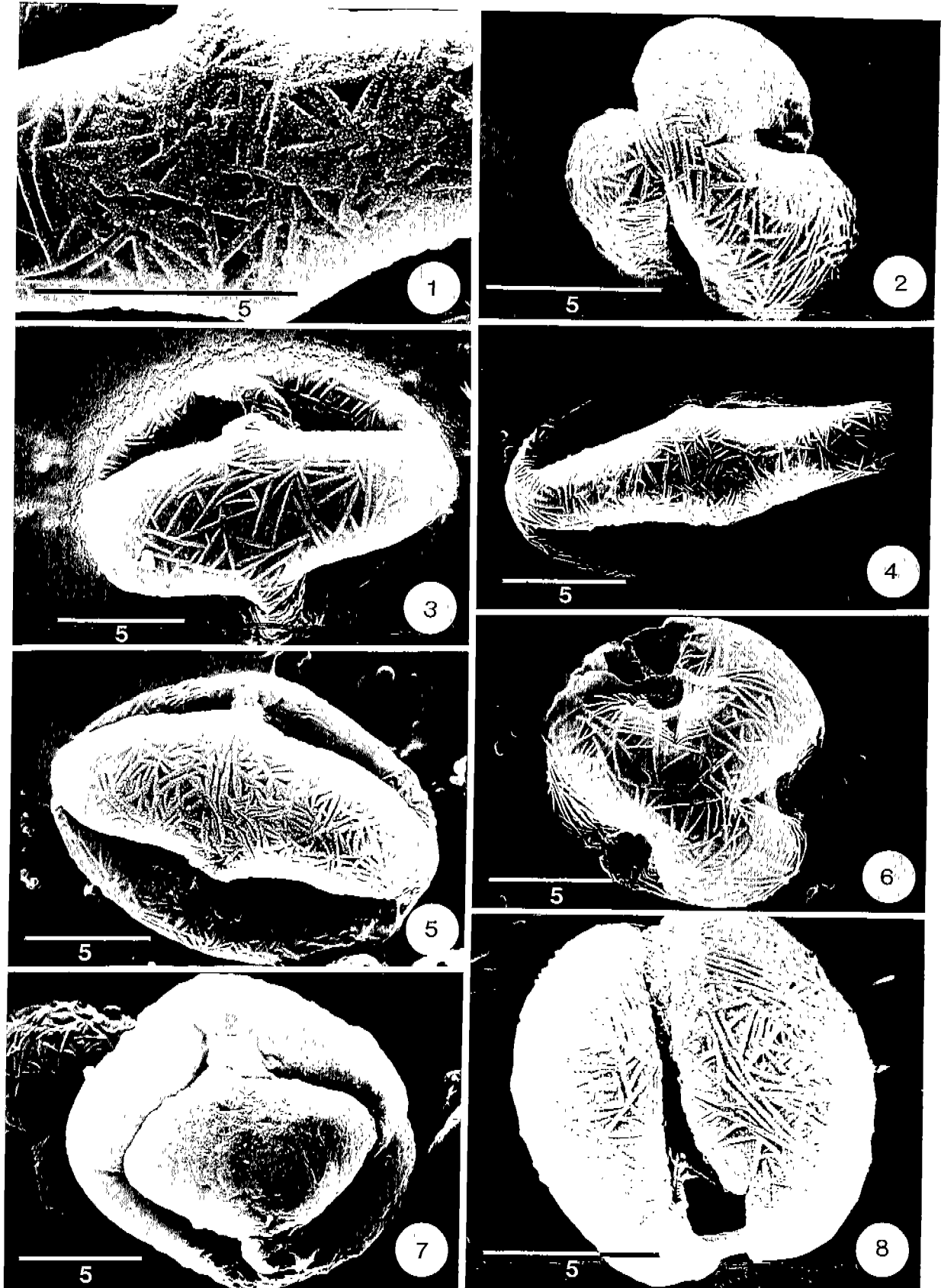
LITERATURE CITED

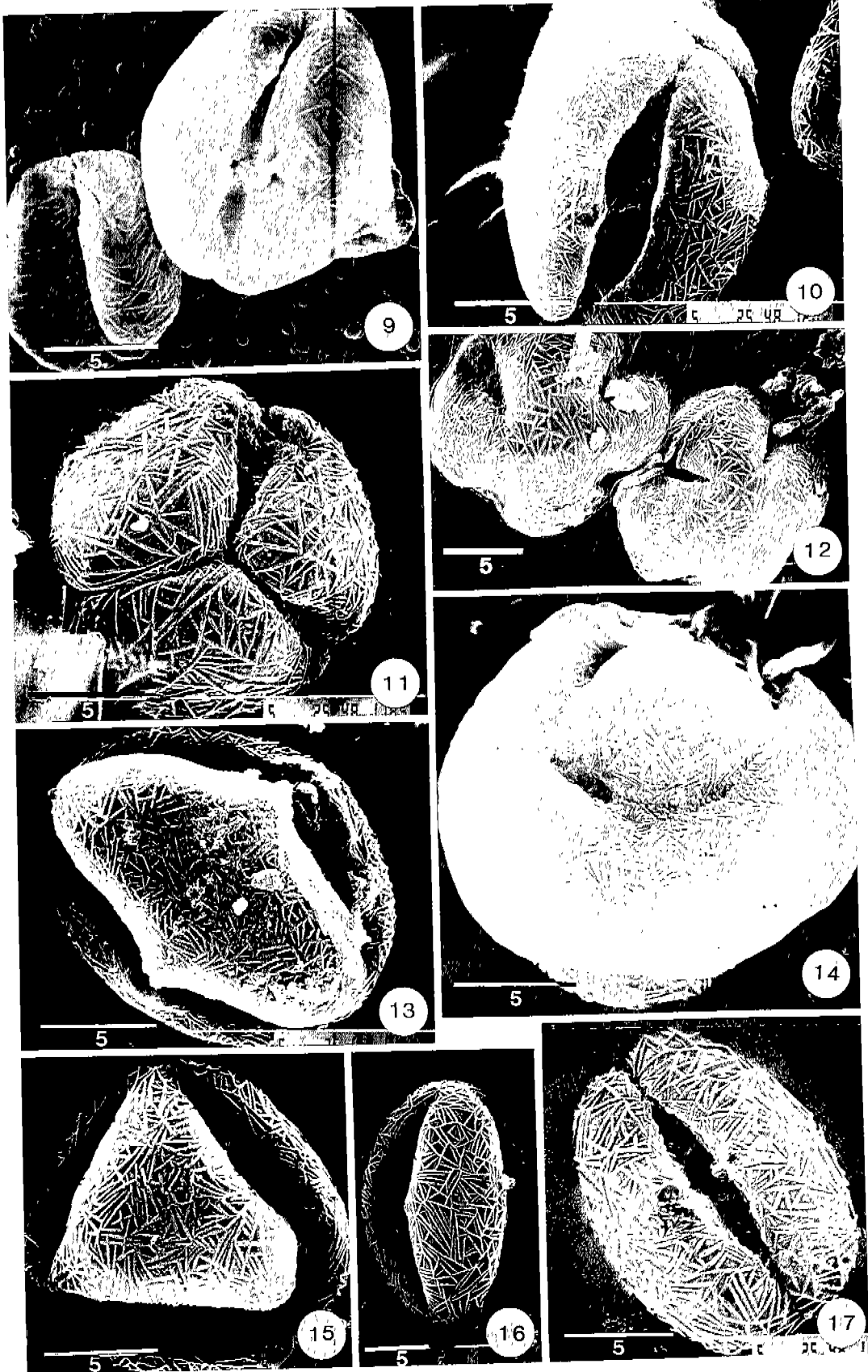
- Berger, A. 1930. Crassulaceae. In, Die Natürlichen Pflanzenfamilien, A. Engler and K. Prantl (ed.), 2nd ed. 18a, Wilhelm Engelmann, Leipzig. pp. 436-465.
- Calie, P.J. 1981. Systematic studies in *Sedum* section *Ternata* (Crassulaceae). *Brittonia* 33: 498-507.
- Doyle, J.A. 1969. Cretaceous angiosperm pollen and the Atlantic Coastal plain and its evolutionary significance. *J. Arnold Arbor.* 50: 1-35.
- Erdtman, G. 1960. The acetolysis method. *Svensk. Bot. Tidsskr.* 39: 561-564.
- Erdtman, G. 1986. Pollen Morphology and Plant Taxonomy (Angiosperms). E.J. Brill, Leiden. 553 pp.
- Froderstrom, H. 1930-1936. The Genus *Sedum* L. A Systematic Essay, Part 1-4. *Acta Hort. Gothob.* 5, app.: 1-75; *ibid.* 6, app.: 1-111; *ibid.* 7, app.: 1-25; *ibid.* 10, app.: 1-262.
- Hart, H.'t. 1974. The pollen morphology of 24 European species of the genus *Sedum*. *Pollen et Spore* 16: 373-387.
- Kim, J.H. 1989. A taxonomic study of genus *Sedum* in Korea. Ph.D. thesis. Seoul National Univ., Seoul. 237 pp.
- Ohba, A. 1978. Generic and infrageneric classification of the old world Sedoideae. *J. Fac. Sci., Univ. Tokyo* 12: 139-198.
- Radulescu, D. 1963. Palynological research on indigenous species of Crassulaceae of the People's Republic of Rumania. *Acta Bot. Horti Bucurestiensis* 1961/1962: 423-433.
- Walker, J.W. 1971. Pollen morphology, phytogeography and phylogeny of the Annonaceae. *Contr. Gray Herb.* 202: 1-130.
- Walker, J.W. and J.A. Doyle. 1975. The basis of angiosperm phylogeny: palynology. *Ann. MO. Bot. Gard.* 62: 664-723.
- Willis, J.C. 1973. A Dictionary of the Flowering Plants and Ferns. 8th ed., revised by H.K. Airy-Shaw. Cambridge Univ. Press, Cambridge. pp. 1-66.

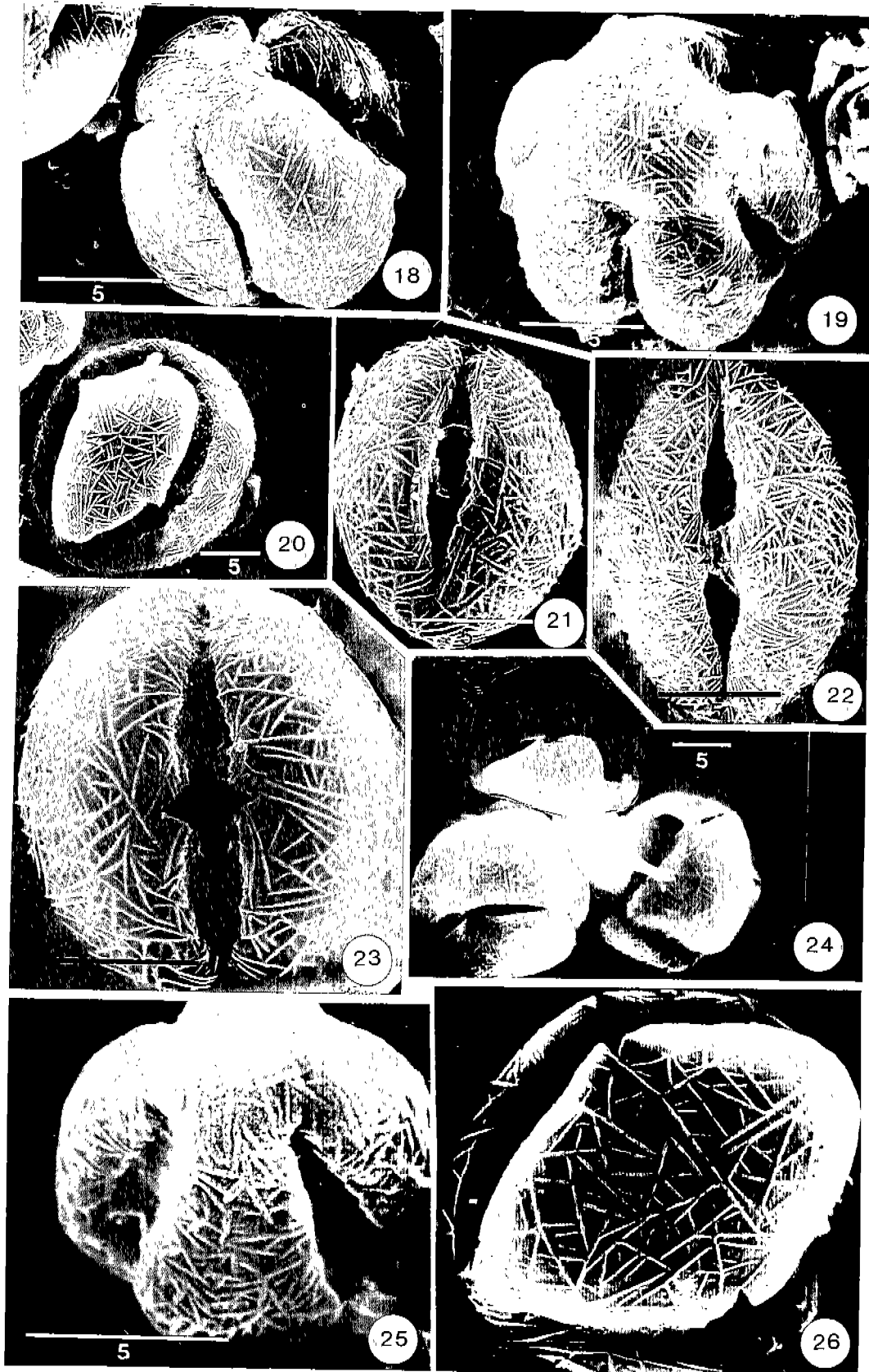
(Received December 3, 1993)

Explanation of Figures

Figs. 1-26. Scanning electron micrographs of the pollen grains of *Sedum*. 1, 2. *S. spectabile*; 3. *S. taquetii*; 4. *S. duckbongii*; 5. *S. verticillatum*; 6. *S. viridescens*; 7, 8. *S. viviparum*; 9, 10. *S. alboroseum*; 11, 12. *S. aizoon*; 13, 14. *S. takesimense*; 15, 16. *S. kamtschaticum*; 17. *S. zokuriense*; 18, 19. *S. sikokianum*; 20. *S. ellacombianum*; 21. *S. lepidopodium*; 22. *S. japonicum*; 23. *S. coreense*; 24. *S. sarmentosum*; 25. *S. bulbiferum*; 26. *S. polytrichoides*. (Bars represent 5 μ m)







韓國產 돌나물屬 植物의 花粉形態

金貞姬*

서울대학교 自然科學大學 生物學科

적 요

돌나물속 20종의 화분을 주사전자현미경으로 관찰하였다. 돌나물속 식물의 화분은 종내에서 그리고 한 화서내에서도 발아구의 수와 형태, 표면무늬상의 변이가 나타났다. 발아구는 3공구형 외에도 합2공구형, 합3공구형, 4공구형, 5공구형, 환형, 불규칙형이 관찰되었다. *Sedum viviparum*의 화분 표면무늬는 유선돌기가 나선상으로 배열된 형과 평활상인 것이 관찰되었다. 화분의 형태적인 변이와 화식의 변이간에 직접적인 관련성을 입증할 수 없었다. 한국산 돌나물속 식물의 중간 구분에 화분형질은 유용하지 못하다.

주요어: 돌나물속, 화분형태, 화식

*교신저자: Fax (02) 872-6881