POLLEN MORPHOLOGY AND INTERSPECIFIC DELIMITATIONS OF INDIAN SPECIES OF THE GENUS *STYRAX* L.

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ABSTRACT

Detailed pollen morphology of all the five Indian species has been studied. General pollen morphology is rather uniform and only one main pollen type is present except for *Styrax serrulatum* Roxb. in which 4- and 5- colporate apertures are also found in addition to usual 3- colporate aperture. The palynologically significant differences exist in polar-axis, equatorial-axis, colpi breadth, apocolpium diameter, mesocolpium distance, exine thickness and the shape of ora in relation to its length and breadth. Special attention is paid to interspecific variability amongst all the five species. Various morphological trends have been tabulated and evaluated in right perspective. Collective analysis of all the numerical data suggests four groupings whereas length/breadth of ora presents a straight interspecific delimitation in all the five species.

INTRODUCTION

Styrax L. has been long considered the type genus of family Styracaceae. ENGLER (1912) considered *Styrax* as monotypic and an independent genus, whereas HOOKER (1882) grouped it with *Symplocos* Jacq. under Styracaceae. However, it has been further pointed out that *Styrax* L. with ten stamens arranged in one series could be differentiated from *Symplocos* Jacq. with many stamens arranged in many series. HUTCHINSON (1967) delimits *Styrax* L. from the rest eleven genera accounted under the family Styracaceae chiefly on the position of ovary and the number of stamens. It has a total strength of one hundred and thirty species (WILLIS, 1973) distributed all over the world except for Africa. In India, only five species occur which are chiefly confined to Eastern Himalaya extending up to 2,100 m a.s.l. The members are mostly trees or woody shrubs and constitute evergreen forest.

Detailed palynology of *Styrax* has not been worked out so far, except for feeble description of *S. officinalis* (ERDTMAN, 1952 ; HOROWITZ & BAUM, 1967 ; HADDAD, 1969), *S. suberifolium* (ERDTMAN, 1952), *S. japonicum* and *S. obassia* (IKUSE, 1956). All the five species occurring in Indian subcontinent have been palynologically investigated in order to elucidate interspecific pollen variability. It has been observed that the pollen of *Styrax* spp. investigated are of the same type. However, various other morphological trends could be worked out so as to determine variability amongst all the five species.

MATERIAL AND METHOD

The polliniferous material for present investigations was procured from herbarium of Forest Research Institute, Dehradun (DD). The method of acetolysis and terminology used here is in accordance with ERDTMAN (1952).

The pollen diagnoses were carried out under photon microscopy (Olympus microscope with a highest magnification of 100×15). The size measurements are based on random selection of 40-50 pollen grains per species.

We acknowledge our thanks to the Director, Forest Research Institute, Dehradun for according permission to collect polliniferous material from the herbarium. Thanks

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DESCRIPTION OF POLLEN GRAINS

Pollen grains in the five *Styrax* species investigated are single, isopolar, tricolporate (rarely tetra- or pentacolporate). Average size varies between 31.0×37.0—39.0×43.0 μm. Shape as defined by polar and equatorial ratio (P/E) are invariably oblate-spheroidal. Amb varies from subtriangular to triangular, and position of the aperture is mostly angular. Exine thickness varies from 2.0—3.5μm. Sexine is generally as thick as nexine but sometimes nexine thickened at the aperture, tegillate with even margins.

The ectoapertures meridionally oriented, generally long with acute apices and prominent 'margo' according to REITSMA (1970). Endoapertures situated on the equator, variably developed, and generally equatorially elongated (lalongate), sometimes dumb-bell shaped (Pl. 1, Fig. 5) and rectangular (Pl. 1, Fig. 1). Endoapertures mostly without a definite membrane, irregular in shape.

From the foregoing description of pollen grains it is evident that all the species of *Styrax* have similar type of pollen and the variability that exists is of minor importance. Hence, polar-axis, equatorial-axis, apocolpium diameter, mesocolpium, exine thickness, ectoaperture width, and endoaperture length/breadth have been taken into account for interspecific delimitations.

Styrax serrulatum Roxb. (Pl. 1, Figs. 7-9)

(K. C. Sahni, sheet no. 5061/147664, DD)

Pollen grains tricolporate, rarely 4-5 colporate, oblate-spheroidal (32.7×37.5μm), range 48.0-50.0×45.0-57.0 μm. Amb triangular. Colpi broad and long, almost running from pole to pole. Maximum colpus width about 6.0 μm and gradually tapering towards poles. Apocolpium diameter about 4.5 μm and mesocolpium about 23.0 μm. Ora lalongate (4.5×10.0 μm). Exine thickness about 3.0 μm. Sexine as thick as nexine. Sexine pattern rugulate, tegillate.

Styrax hookeri Clarke (Pl. 1, Figs. 1-2)

(M. V. Lawrie, sheet no. 85919, DD)

Pollen grains tricolporate, oblate-spheroidal (38.7×43.4 μm), range 35.0-42.0×38.0-50.0 μm. Amb triangular. Colpi broad, long, running almost from pole to pole. Maximum colpus width about 4.7 μm, gradually tapering at the poles. Apocolpium diameter about 7.6 μm and mesocolpium about 26.6 μm. Ora lalongate (6.2×12.0 μm). Exine thickness about 3.0 μm. Sexine as thick as nexine. Sexine pattern rugulate, tegillate.

Styrax rugosum Kurz (Pl. 1, Figs. 10-12)

(Parkinson, sheet no. 41198, DD)

Pollen grains tricolporate, oblate-spheroidal (38.5×41.8 μm), range 35.0-40.0×40.0×44.0 μm. Amb triangular. Colpi broad, long with acute apices. Maximum colpus width about 4.8 μm. Apocolpium diameter about 11.0 μm and mesocolpium about 28.0 μm. Ora lalongate (5.6×12.4 μm). Exine about 1.8 μm thick. Sexine as thick as nexine. Sexine pattern rugulate, tegillate.

Styrax virgatum Wall. (Pl. 1, Figs. 4-6)
(C. W. D. Kermode, sheet no. 87415, DD)

Pollen grains tricolporate, oblate-spheroidal (33.6×37.6 μm), range 30.0-38.0×34.0-40.0 μm. Amb triangular. Colpi thin, long, running almost from pole to pole. Maximum colpus width about 2.6 μm, gradually tapering at poles. Apocolpium diameter about 2.6 μm and mesocolpium about 21.0 μm. Ora lalongate (3.8×11.8 μm). Exine about 2.2 μm thick. Sexine as thick as nexine. Sexine pattern rugulate, tegillate.

Styrax polyspermum Clarke (Pl. 1, Fig. 3)
(Sukoe, sheet no. 53450, DD)

Pollen grains tricolporate, oblate-spheroidal (31.0×37.0 μm), range 30.0-32.0×36.0-38.0 μm. Amb ± triangular. Colpi thin, long, running from pole to pole. Maximum colpus width 3.3 μm, and gradually tapering at the poles. Apocolpium diameter about 6.8 μm and mesocolpium about 22.0 μm. Ora lalongate (3.0×10.0 μm). Exine thickness about 2.7 μm. Sexine almost as thick as nexine. Sexine pattern rugulate, tegillate.

EVALUATION OF NUMERICAL DATA (Table-1)

(i) *Polar axis*

The polar axis varies from 35.0-42.0 μm in *S. hookeri*, 35.0-40.0 μm in *S. rugosum*, 30.0-38.0 μm in *S. virgatum*, 30.0-36.0 μm in *S. serrulatum* and 30.0-32.0 μm in *S. polyspermum*. The maximum number of pollen grains falls in the average of 40.0 μm in *S. hookeri*, 38.0 μm in *S. rugosum*, 36.0 μm and 30.0 μm in *S. virgatum*, 32.0 μm in *S. serrulatum* and 31.0 μm in *S. polyspermum*.

As a result of polar axis values, the above species can be grouped into three types viz., *S. polyspermum* type, *S. serrulatum* and *S. virgatum* type, and *S. hookeri* and *S. rugosum* type. There is not much of appreciable difference in *S. serrulatum* and *S. virgatum* although the maximum pollen grains fall under 32.0 μm in *S. serrulatum* and 36.0 μm in *S. virgatum*. *S. hookeri* and *S. rugosum* are grouped together owing to common polar axis values.

(ii) *Equatorial axis*

The equatorial axis varies from 38.0—50.0 μm in *S. hookeri*, 40.0-46.0 μm in *S. rugosum*, 36.0-40.0 μm in *S. serrulatum*, 34.0-40.0 μm in *S. virgatum* and 36.0-38.0 μm in *S. polyspermum*. The maximum number of pollen grains fall in the average of 37.0 μm in *S. polyspermum*, 38.0 μm in *S. virgatum* and *S. serrulatum*, 40.0 and 42.0 μm in *S. rugosum* and 42.0 μm in *S. hookeri*.

Evaluation of numerical data of equatorial axis amongst all the five species has enabled to differentiate *S. hookeri* and *S. rugosum* separately as they attain first and second highest maxima in range and average respectively. *S. serrulatum*, *S. virgatum* and *S. polyspermum* are not differentiated from one another as they show quite a lot of overlapping both in range and average as well.

(iii) *Colpi breadth*

The colpi breadth varies from 2.0-3.0 μm in *S. virgatum*, 4.0-5.0 μm in *S. hookeri*, 4.0-6.0 μm in *S. rugosum*, 2.4-4.0 μm in *S. polyspermum* and 4.0-8.0 μm in *S. serrulatum*.

Colpi breadth among all the five species has revealed that *S. virgatum* and *S. serrulatum* stand unique for their lowest and highest range respectively. The three species namely *S. hookeri*, *S. polyspermum* and *S. rugosum* show a close resemblance in the common range,

Table 1--Showing range and mean values in microns of various morphological features of *Styrax* spp.

	1 Polar Axis		2 Equatorial Axis		3 Apocolpium		4 Mesocolpium		5 Maximum colpus breadth		6 Exine thickness		7 OS length/ breadth	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
S. serrulatum	32—36	32.7	36—40	37.5	3—6	4.5	22—25	23	4—8	6	2.5—3.5	3	4—5× 10—12	4.5× 10
S. hookeri	35—42	38.7	38—50	43.4	5—10	7.6	24—30	26.6	4—5	4.7	2.0—3.5	3	5—8× 11—14	6.2× 12.0
S. rugosum	35—40	33.5	40—46	41.8	10—12	11	25—30	28	4—6	4.8	1.5—2	1.8	4—7× 10—18	5.6× 12.4
S. virgatum	30—38	33.6	34—40	37.6	2.5—5	3.6	18—25	21	2—3	2.6	2—2.5	2.2	3—4× 10—14	3.8× 11.8
S. polyspermum	30—32	31	36—38	37	5—8	6.8	22—25	22	2.5—4	3.3	2.0—3	2.7	2.7—4× 8.5—12	3×10

and their discrimination from each other seems rather difficult. However, *S. rugosum* can be differentiated if the two maxima of colpi breadth are considered.

(iv) *Apocolpium diameter*

The apocolpium diameter ranges from 2.5-5.0 μm in *S. virgatum*, 3.0-6.0 μm in *S. serrulatum*, 5.0-8.0 μm in *S. polyspermum*, 5.0-10.0 μm in *S. hookeri* and 10.0-12.0 μm in *S. rugosum*.

The study of apocolpium diameter suggests four groupings such as *S. rugosum*, *S. serrulatum* and *S. virgatum* as independent while *S. hookeri* and *S. polyspermum* together. However, both the species grouped together can also be differentiated from one another if the range alone is considered.

(v) *Mesocolpium*

In this case, range of mesocolpium is not distinct and the values overlap each other. The minimum value in either case is distinct. However, two groups are recognized on the basis of range and maximum values. *S. hookeri* and *S. rugosum* have a maximum of 40.0 μm whereas *S. polyspermum*, *S. virgatum* and *S. serrulatum* have maximum of 25.0 μm.

(vi) *Exine thickness*

The range of exine thickness in *S. rugosum* is from 1.5.2.0 μm with a maximum pollen in 2.0 μm, in *S. virgatum* from 2.0-2.5 μm with a maximum pollen in 2.0 μm, in *S. polyspermum* from 2.0-3.0 μm with a maximum pollen in 2.5 μm, in *S. hookeri* from 2.0-3.5 μm with a maximum pollen found in 3.0 μm and 3.5 μm in *S. serrulatum* from 2.5-3.5 μm with a maximum in 3.5 μm.

The study of exine thickness in all the five species reveals that *S. rugosum* and *S. serrulatum* can be grouped independently owing to the minimum and maximum exine thickness respectively. The remaining three species are grouped together under one type.

(vii) *Length and breadth of ora*

Besides shape, the length and breadth of ora has been considered for making interspecific difference. The average length and breadth is 3.0×10.0 μm in *S. polyspermum*, 4.5×10.0 μm in *S. serrulatum*, 3.8×11.8 μm in *S. virgatum*, 6.2×12.0 μm in *S. hookeri* and 5.6×12.4 μm in *S. rugosum*.

The study of length/breadth values of endoaperture has revealed the independent grouping of all the five species.

DISCUSSION

Morphological evaluation of pollen grains in all the five species of the genus *Styrax* reveals close relationship within the genus. Based on NPC classification it has, however, been observed that *Styrax serrulatum* also produces 4-and 5-colporate apertures in addition to 3-colporate. If it is taken into consideration, then *S. serrulatum* may be separated from rest of the species although the rare occurrence of 4-and 5-colporate aperture is generally accounted as cytological aberration.

To understand the relationship within the genus *Styrax*, it was thought important to study the significant combination of morphological features. The numerical data such as polar-axis, equatorial-axis, colpi-breadth, length/breadth of ora, apocolpium diameter, mesocolpium distance, and exine thickness are based on the minima, maxima and averages of all the mean values of the forms included. The numerical evaluation of the morphogenetic features of the pollen grains has led the clear demarcation in some species while in others transition occur and their delimitation is to some extent arbitrary.

There is not much appreciable difference in polar axis amongst all the five species and, therefore, three groups have been suggested such as ; *S. rugosum* and *S. hookeri*, *S. serrulatum* and *S. virgatum*, and *S. polyspermum*. The equatorial axis enables to differentiate almost all the species but *S. polyspermum* and *S. virgatum* overlap at many points in averages though differ in minimum and maximum ranges. On the basis of colpi breadth, *S. virgatum* and *S. serrulatum* stand unique for their lowest and highest breadth respectively. *S. rugosum*, *S. hookeri* and *S. polyspermum* are grouped under one type owing to common features. The apocolpium diameter suggests the independent types for *S. virgatum* and *S. serrulatum* but *S. rugosum*, *S. polyspermum* and *S. hookeri* are put together because of the overlapping of apocolpium diameter. Numerical data on mesocolpium does provide two groupings, viz., *S. hookeri* and *S. rugosum* under one type for their maximum mesocolpium distance whereas, *S. polyspermum*, *S. virgatum* and *S. serrulatum* under another type for their minimum mesocolpium distance. The differences noted in exine thickness are of such magnitude that they could only suggest the separation of *S. rugosum* and *S. serrulatum* whereas, rest of the species show almost common features and hence grouped together. However, the length and breadth of ora provides a safe basis for interspecific discrimination for all the five species.

CONCLUSION

The broad morphology does not conclude the demarcation of all the five species. However, the combination of numerical data of morphological features does provide a clue to draw the interspecific delimitations. If seen in context with the individual data then only length and breadth of ora suggest the clear cut distinction amongst all the five species. The other data suggests 2-4 groups. The collective analysis of all the numerical data has suggested the grouping of *S. serrulatum*, *S. rugosum* and *S. virgatum* independently while *S. polyspermum* and *S. hookeri* together as one.

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EXPLANATION OF PLATE 1 (×1000)

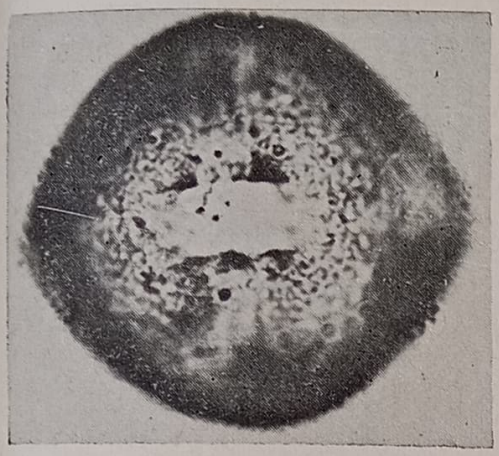
1-2 *Styrax hookeri* : 1, equatorial view showing lalongate os; 2, polar view showing rugulate pattern.

3 *S. polyspermum* : equatorial view showing rugulate pattern.

4-6 *S. virgatum* : 4, polar view showing rugulate pattern; 5, equatorial view showing lalongate os; 6, polar view showing sexine/nexine.

7-9 *S. serrulatum* : 7, polar view showing rugulate pattern; 8, equatorial view showing lalongate os; 9, equatorial view showing sexine/nexine.

10-12 *S. rugosum* : 10, polar view showing regulate pattern ; 11 & 12, equatorial views showing lalongate os and sexine and nexine.



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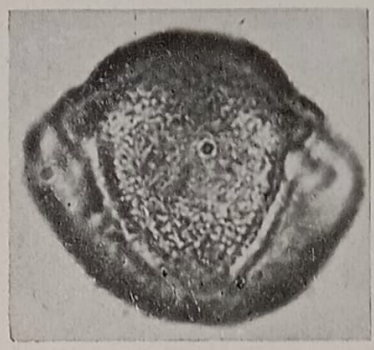

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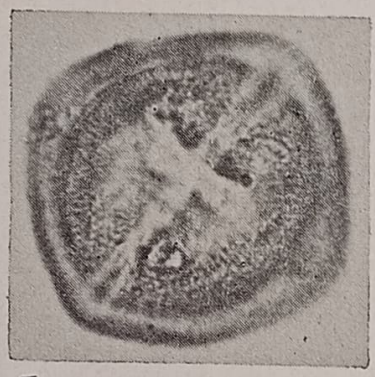

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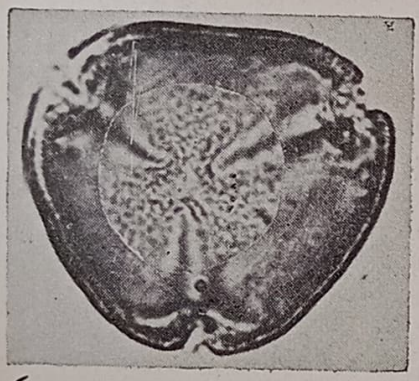

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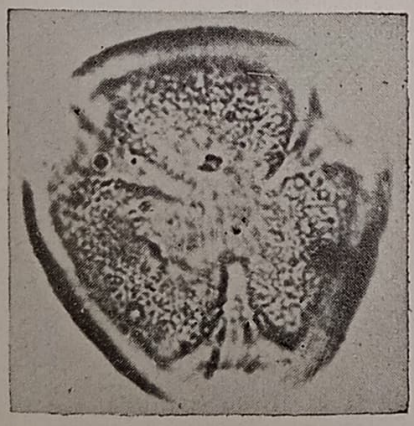

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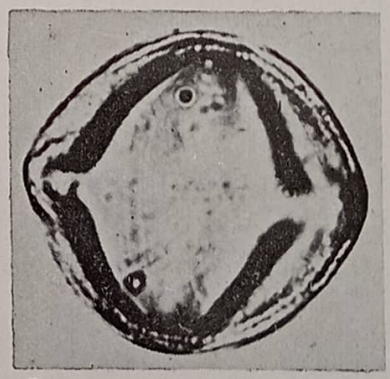

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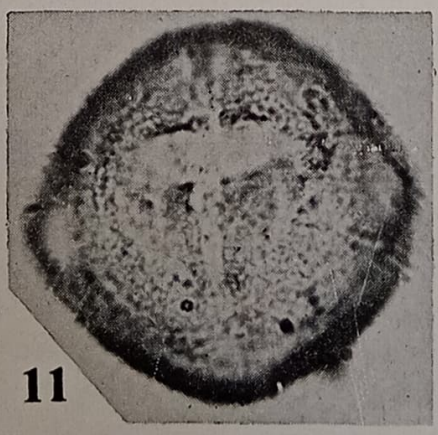

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