

STUDIES OF INDIAN POLLEN GRAINS—IV. BORAGINACEAE

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ABSTRACT

The paper describes pollen morphology of thirty one species distributed over ten genera of the family Boraginaceae.

The Indian members of Boraginaceae are characterized by 3-4-zonicolpate, zonicolporoidate and colporate types of pollen grains with psilate, obscure, granulate, retipilariate, faintly reticulate or foveolate sexine pattern. Pollen grains are either tectate or atectate. In shape, most of the pollen grains are dumb-bell-shaped and prolate-spheroidal, subprolate, prolate and perprolate shapes have been found, although not very frequent.

The taxonomy of the family is discussed in the light of pollen morphology.

INTRODUCTION

Pollen morphology of the family Boraginaceae dates back to the year 1714 when Geoffroy (see ERDTMAN, 1952) first studied the boraginaceous pollen grains. Later the palynological investigations of the family Boraginaceae were carried out by many workers such as ANDREWS (1928), ERDTMAN (1942, 1947a), CRANWELL (1942) and PEREIRA (1943). ERDTMAN (1952) finds that in pollen morphology the family Boraginaceae resembles the families like Hydrophyllaceae, Lannoaceae, Verbenaceae and Hoplestigmataceae. SELLING (1947) has recorded the smallest pollen (2.5 μ) in the genus *Myosotis*. IKUSE (1956) has reported 10-colporate, 4-porate, and 3 foraminorate aperture in *Borago officinalis* Linn., *Buglossoides zollingeri* Morris and *Lithospermum officinale* Linn. respectively. FAEGRI and IVERSEN (1964) have described pollen grains (10-12 μ) in *Cynoglossum* spp. with 6 furrows and an equatorial girdle of fused transverse furrows. SINGH (1931) made a preliminary survey of this family and described the morphology of some Indian species and genera. NAIR (1965) has given a brief account of some of the Indian genera of this family. JAIN and NANDA (1966) have reported the pollen of three species of *Heliotropium* as 3-heterocolporate.

In India the family Boraginaceae is represented by nearly one hundred and forty species distributed over thirty two genera (HOOKER, 1885, pp. 134-177). The members of this family are distributed all over the tropical India and in the temperate Western Himalayas extending upto 430 m. Some Indian species also extend to Ceylon, Malaya, Australia and Mascarena Islands.

The paper contains an account of the pollen morphology of thirty one species distributed over ten genera and discusses its bearing on the taxonomy of the family.

MATERIAL AND METHOD

The polleniferous material was procured in 1962-1963 from the Blatter Herbarium, St. Xavier's College, Bombay. The pollen slides were prepared by the method of acetolysis

ERDTMAN, 1952). The terminology used for the description of pollen is the same as followed by ERDTMAN and VISHNU-MITRE (1956-58).

DESCRIPTION OF THE POLLEN GRAINS

The aperture in the members of the family Boraginaceae studied is either 3-zonicolpate, 3-zonicolporoidate, 3-zonicolporate, 3-syncolpate, 4-zonicolporoidate or 4-zonicolporate. The colpae membrane is usually psilate and the ora generally inconspicuous. The pollen grains are mostly dumb-bell shaped but prolate spheroidal, subprolate, prolate and perprolate shapes also occur.

Sexine and nexine are hardly distinguishable with one another. Pollen may be tectate or intectate. Sexine pattern varies from psilate, obscure, granulate, faintly reticulate, retipilariate to foveolate. Punctae and spinules occur only in some species of *Cordia*.

Genus—*Cordia* Linn.

Six species have been investigated which show 3-zonicolpate, colporoidate and colporate types of aperture. Sexine stratification variable.

***C. rothii* Roem. & Schult.**

(R. R. Fernandez, No. 4045, Blatter Herbarium, Bombay)

Pollen $60.7 \times 25.1\mu$, perprolate, 3-brevicolpate. Colpae membrane psilate. Nexine slightly thicker than sexine. Sexine pattern finely reticulate and punctitegillate.

***C. wallichii* G. Don**

(Tavakar, No. 2216, Blatter Herbarium, Bombay)

Pollen exactly similar to *C. rothii* Roem. & Schult.

***C. sebestena* Forsk.**

Pl. 1, Figs. 16-17

(G. L. Shah, No. 4115, Blatter Herbarium, Bombay)

Pollen, $41.8 \times 37.8\mu$, prolate spheroidal, 3-colpate. Colpae membrane psilate. Sexine as thick as nexine. Sexine pattern retipilariate; ategillate.

***C. dichotoma* Forst.**

(N. A. Irani, No. 4883, Blatter Herbarium, Bombay)

Pollen, $47.2 \times 36.4\mu$, subprolate, 3-zonicolpate. Colpae membrane psilate with acute apices. Nexine thicker than sexine. Sexine pattern granulate; punctitegillate.

***C. domestica* Roth.**

Pl. 1, Fig. 18

(R. R. Fernandez, No. 2909, Blatter Herbarium, Bombay)

Pollen, $38.1 \times 27.2\mu$, prolate, 3-zonicolporoidate. Colpae membrane ornamented. Sexine as thick as nexine. Sexine pattern granulate, tegillate.

***C. myxa* Linn.**

(G. L. Shah, No. 1697, Blatter Herbarium, Bombay)

Pollen, 21.6×18.9 , μ subprolate, 3-zonicolporate, os inconspicuous. Colpae membrane ornamented and with acute apices. Sexine thicker than nexine. Exine pattern reticulate; tegillate.

Genus—Ehretia Linn.

The aperture in the species investigated, is either 3-syncolpate, 3-zonicolporoidate or 3-zonicolporate. The 3-zonicolporoidate aperture seems to be quite frequent whereas 3-syncolpate and 3-zonicolporate apertures are rare.

E. microphylla Lamk.

Pl. 1, Figs. 4-5

(S. K. Wagh, No. 6587, Blatter Herbarium, Bombay)

Pollen, 28.6×24.8 μ , subprolate, 3-syncolpate, colpae membrane prominently ornamented with tapering apices. Sexine and nexine \pm equithick. Sexine pattern obscure; tegillate. Tenuixinous.

E. pubescens Royle

(S. K. Wagh, No. 6745, Blatter Herbarium, Bombay)

Pollen, 25.1×19.9 , μ subprolate, 3-zonicolporoidate, colpae membrane psilate with tapering apices. Sexine slightly thicker than nexine. Sexine pattern very faintly reticulate; tegillate.

E. aspera Willd.

Pl. 1, Fig. 6

(No. 22013, Blatter Herbarium, Bombay)

Pollen, 29.1×22.4 μ , subprolate, 3-zonicolporoidate, colpae membrane ornamented and have tapering apices. Sexine and nexine almost equally thick or sometimes sexine slightly thicker than nexine. Sexine pattern retipilariate; nontegillate.

E. laevis var. **canarensis** Clarke

(S. K. Wagh, No. 8044, Blatter Herbarium, Bombay)

Pollen, 21.6×18.9 μ , subprolate, 3-zonicolporoidate, and very rarely colpate. membrane ornamented and with tapering apices. Sexine slightly thicker than nexine. pattern psilate; tegillate.

E. laevis var. **floribunda** Royle

(K. V. Shenoi, No. 2621, Blatter Herbarium, Bombay)

Pollen, 26.4×18.0 μ , prolate, 3-zonicolporate, os obscure. Colpae membrane ornamented and with acute apices. Nexine thicker than sexine. Sexine pattern very faintly reticulate; tegillate.

E. acuminata Br.

Pl. 1, Figs. 1-3

(No. 14525, Blatter Herbarium, Bombay)

Pollen, $24.3 \times 19.1 \mu$, subprolate, 3-zonicolporate, os lalongate. Colpae membrane crustate. Sexine as thick as nexine. Sexine pattern (OL) reticulate, muri heterobrochate; tegillate.

Genus—Coldenia Linn.

C. procumbens Linn.

(S. K. Wagh, No. 5256, Blatter Herbarium, Bombay).

Pollen, $27.0 \times 22.9 \mu$, subprolate, 3-brevicolporate, os not distinct. Nexine slightly thicker than sexine. Sexine pattern very finely reticulate; tegillate.

Genus—Heliotropium Linn.

Eight species studied. The pollen grains are 3-zonicolpate, colporoidate, colporate, 4-colporoidate and 4-zonicolporate. Colporate aperture is a frequent character.

H. zeylanicum Lamt.

(N. A. Irani, No. 5223, Blatter Herbarium, Bombay)

Pollen, $32.9 \times 21.8 \mu$, prolate, 3-zonicolpate. Colpae membrane psilate with tapering apices. Sexine as thick as nexine. Sexine pattern psilate; tegillate.

H. supinum Linn.

Pl. 1, Figs. 14-15.

(G. L. Shah, No. 6810, Blatter Herbarium, Bombay).

Pollen, $45.6 \times 27.3 \mu$, prolate, 4-5 zonicolporoidate, occasionally colporate. Colpae membrane psilate and has pointed apices. Sexine as thick as nexine. Sexine pattern psilate; tegillate.

H. subulatum Hochst.

(S. K. Wagh, No. 6234, Blatter Herbarium, Bombay)

Pollen, $30.0 \times 22.9 \mu$, subprolate, 3-zonicolpate, occasionally colporoidate. Colpae membrane psilate and has tapering apices. Sexine slightly thicker than nexine but difficult to differentiate from each other. Sexine pattern psilate; tegillate.

H. curassivicum Linn.

(S. K. Wagh, No. 6671, Blatter Herbarium, Bombay)

Pollen, $24.3 \times 18.9 \mu$, subprolate, 3-zonicolpate. Colpae membrane psilate and has tapering apices. Sexine as thick as nexine. Sexine pattern psilate; tegillate. Tenuimarginate.

H. indicum Linn.

(S. C. Tavakar, No. 245, Blatter Herbarium, Bombay)

Pollen, $42.3 \times 32.9 \mu$, subprolate, 3-zonicolporate. Os lalongate, larger than colpae. Colpae membrane psilate. Sexine and Nexine \pm equithick except the nexine which is fairly thicker at the poles. Sexine pattern finely reticulate at the poles and obscure at the equator, muri homobrochate; tegillate.

H. ovalifolium Forsk.

Pl. 1, Fig. 11

(H. Santapau, No. 4201, Blatter Herbarium, Bombay)

Pollen, $29.7 \times 18.9 \mu$, prolate, 3-4 zonicolporate, os lalongate and usually synorate.

Colpae membrane ornamented and has obtuse apices. Sexine as thick as nexine. Sexine pattern vaguely reticulate; tegillate.

H. bracteatum Br.

Pl. 1, Figs. 12-13

(S. K. Wagh, No. 7633, Blatter Herbarium, Bombay)

Pollen, 44.8μ , perprolate, 4-zonicolporate, os lalongate. Colpae membrane psilate and has tapering apices. Sexine as thick as nexine. Sexine pattern psilate; tegillate.

H. scabrum Retz.

Pl. 1, Figs. 9-10.

(S. K. Wagh, No. 6439, Blatter Herbarium, Bombay)

Pollen, $24.3 \times 16.6 \mu$, subprolate, 4-zonicolporate, os lalongate but the os membrane is not conspicuous. Colpae membrane psilate. Sexine 2-3 times as thick as nexine. Sexine pattern psilate; tegillate.

Genus—Paracaryum Boiss

Two species investigated have more or less similar dumb-bell-shaped pollen grains.

P. lambertranum Clarke

(Blatter Herbarium, Bombay)

Pollen, $9.1 \times 4.1 \mu$, dumb-bell-shaped, 3-zonicolporate. Colpae streak-like and the os inconspicuous. Sexine and nexine not clearly distinguishable but often of equal thickness. Sexine pattern psilate; tegillate.

P. coelestinum Benth.

(H. Santapau, No. 21956, Blatter Herbarium, Bombay)

Pollen, $8.2 \times 4.1 \mu$, dumb-bell-shaped. Other characters as in *P. lambertranum*.

Genus—Cynoglossum Linn.

The three species investigated have similar pollen grains as in *Paracaryum*.

C. furcatum Wall.

Pl. 1, Fig. 7

(P. F. Fysin, No. 32784, Blatter Herbarium, Bombay)

Pollen, $8.5 \times 5.0 \mu$, dumb-bell-shaped, \pm like *P. lambertranum* Clarke.

C. denticulatum var. **zeylancium** Wight.

(S. K. Wagh, No. 5555, Blatter Harbarium, Bombay)

Pollen, $8.5 \times 5.0 \mu$, dumb-bell-shaped, almost as in *P. lambertranum* Clarke.

C. glochidiatum Wall.

(N. A. Irani, No. 2098, Blatter Herbarium, Bombay)

Pollen, $12.1 \times 8.1 \mu$, dumb-bell-shaped, almost as in *P. lambertranum* Clarke.

GENUS—**Lindelofia** Lehm.

L. angustifolia A. Brand

(M. J. Hackney, No. 165, Blatter Herbarium, Bombay)

Pollen, $11.3 \times 7.5 \mu$, dumb-bell-shaped, Similar to *P. lambertranum* in almost all characters.

Genus—**Eritrichium** Sehrader.

E. rupestre Bunge

(N. L. Bor, No. 8660, Blatter Herbarium, Bombay)

Pollen, $11.5 \times 6.6 \mu$, dumb-bell-shaped. Pollen almost similar to *P. lambertranum* Clarke.

Genus—**Mertensia** Roth.

M. echioides Benth.

(L. D. Kapur, Blatter Herbarium, Bombay)

Pollen, $10.0 \times 5.0 \mu$, dumb-bell-shaped, almost as in *P. lambertranum* Clarke.

Genus—**Macrotomia** DC.

M. benthami DC.

Pl. 1, Fig. 8

(M. J. Hackney, Blatter Herbarium, Bombay)

Pollen, $25.3 \times 10.5 \mu$, dumb-bell-shaped, 3-zonicolpate. Colpae membrane psilate and have obtuse apices. Sexine and nexine indistinguishable. Exine pattern psilate; tegillate. Tegillum uneven at the notches.

M. enchroma Royle

(N. L. Bor, No. 8661, Blatter Herbarium, Bombay)

Pollen, $21.6 \times 10.8 \mu$, almost as in *M. benthami*.

DISCUSSION AND TAXONOMICAL CONSIDERATION

The taxonomical arrangement of Indian representatives of the family Boraginaceae followed here is that as given in the Flora of British India (HOOKER, 1885). HOOKER (1885) divided the family Boraginaceae into four tribes, viz., Cordieae, Ehretieae, Heliotropiceae and Borageae

CORDIEAE—(*Cordia*)

This tribe represented by only one genus, is characterised by the terminal style on the entire ovary and 4-1 seeded drupes. The genus *Cordia* comprises nearly fifteen species of which only six species have been studied. The pollen grains vary greatly as regards to their apertures and ornamentation (Apertural types—3-zonicolpate, 3-zonicolporoidate or

3-zonicolporate; ornamentation forms—psilate, obscure retipilariate, faintly reticulate or foveolate sexine pattern).

EHRETIEAE—(*Ehretia*, *Coldenia* and *Rhabdia*)

This tribe is differentiated from Cordieae by the presence of two styles and 2-celled drupe in its members. It is represented by three genera of which two genera, viz., *Ehretia* and *Coldenia* have been investigated. Genus *Ehretia* (six species) produces 3-syncolpate, 3-zonicolpoidate and 3-zonicolporate types of pollen with either psilate, obscure, retipilariate, faintly reticulate or foveolate sexine pattern. The single species of *Coldenia* (*C. procumbens*) studied produces 3-brevicolpate and reticulate pollen.

HELIOTROPIEAE—(*Tournefortia* and *Heliotropium*)

The plants of this tribe are similar to Ehretieae in almost all the characters except the style which is depressed and conical at the apex or with a horizontal ring below the stigma. This tribe comprises two genera. The genus *Heliotropium* (eight species investigated) is eurypalynous in nature since pollen grains are either 3-zonicolpate, colporoidate, colporate, 4-zonicolpate, colporoidate or colporate. The colporate type is quite frequent. The sexine pattern is either psilate or faintly reticulate.

BORAGEAE

This tribe is further divided into four subtribes, i.e., Cynoglosseae, Eritrichieae, Anchuseae and Lithospermeae, of which only three have been completely or partially investigated.

(i) Cynoglosseae—(*Trichodesma*, *Actinocarya*, *Omphalodes*, *Cynoglossum*, *Lindelofia*, *Solenanthus*, *Paracaryum* and *Echinosperrum*)

Only three genera *Cynoglossum*, *Lindelofia* and *Paracaryum* have been investigated. This tribe is stenopalynous with smaller size (10-12 μ), dumb-bell-shaped pollen. The nature of the aperture is colporate of which colpae are marked by faint streaks with inconspicuous os. Sexine pattern is often psilate and sexine and nexine are not distinguishable from each other.

(ii) Eritrichieae—(*Eritrichium*, *Rochelia*, *Asperugo*, *Microula*, *Bothriospermum* and *Gastrocotyle*)

The subtribe comprises 6 genera of which only one species of the genus *Eritrichium* studied. Pollen is as in subtribe Cynoglosseae.

(iii) Lithospermeae—(*Mertensia*, *Moltkia*, *Trigonotis*, *Myosotis*, *Lithospermum*, *Sericostoma*, *Arnebia*, *Macrotomia* and *Onosma*)

The subtribe comprises 9 genera of which only two genera i.e., *Mertensia* and *Macrotomia* have been investigated. Pollen in *Mertensia* is similar to that of Cynoglosseae whereas *Macrotomia* produces 3-zonicolpate, dumb-bell shaped pollen with psilate sexine pattern.

RELATIONSHIPS

ENGLER (1912) placed the Boraginaceae alongwith Hydrophyllaceae under the suborder Boraginineae of the order Tubifloreae. HUTCHINSON (1959) referred it to a separate order Boraginales. LAURENCE (1951) and RENDLE (1952) have kept the family Boraginaceae along with Hydrophyllaceae under the suborder Boragineae of the order Tubiflorae.

As far as pollen morphology is concerned, the family Boraginaceae is largely characterized by a 3-zonicolporoidate type of pollen grains, together with 3-zonicolpate, colporate and 4-zonicolpate, colporoidate or colporate types. Taking into consideration the over-

whelming majority with dumb-bell shaped pollen, the genera *Paracaryum*, *Lindelofia*, *Mertensia*, *Eritrichium*, *Cynoglossum* and *Macrotomia* seem to be closely related. HOOKER (1885) has kept the above mentioned genera under three subtribes, i.e., Cynoglosseae, Eritrichiae and Lithospermeae of the tribe Borageae but the pollen morphology supports the retention of all the above genera under a single subtribe, i.e., Cynoglosseae. The systematic position assigned to the genus *Cordia* by HOOKER (1885) is also corroborated by the pollen morphology. The genera *Ehretia* and *Coldenia* have been put together under a separate tribe Ehretiae (HOOKER, 1885) but their systematic position is dubious since *Ehretia* has the heterogeneous assemblage of pollen grains. Since only one species of the genus *Coldenia* (*C. procumbens*) is investigated, much information cannot be attached to its taxonomical status. *Heliotropium* is an eury-palynous genus and its pollen morphology can be used effectively for further taxonomical work in the genus.

The occurrence of more or less similar pollen grains in Ehretiae and Hydrophyllaceae (ERDTMAN, 1952, p. 80) supports the retention of Boraginaceae alongwith Hydrophyllaceae under the suborder Boraginineae (ENGLER, 1912).

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EXPLANATION OF THE PLATE I

- 1-3. *Ehretia accuminata*; 4-5. *E. microphylla*; 6. *E. aspera*; 7. *Cynoglossum furcatum*; 8. *Macrotomia benthami*; 9-10. *Heliotropium scabrum*; 11. *H. ovalifolium*; 12-13. *H. bracteatum*; 14-15. *H. supium*; 16-17. *Cordia sebestena*; 18. *C. domestica*. (All $\times 1000$).

