

## POLLEN MORPHOLOGY OF SOME PAKISTANI MEDICINAL PLANTS

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Pollen morphology of sixty-five Pakistani medicinal plants, which are used in different systems of medicine, have been studied. The pollen grains of one plant i.e. *Albizzia lebbek* occur in polyads, while in all other plants studied these occur singly. The pollen grains are of various shapes i.e. varying from spheroidal to prolate with polar or lateral germinal exits. The pollen grains of various plants also vary in thickness of their exine. The exine may be, with or without ornamentations. The different measurements of the pollen grains recorded are: equatorial diameter, apocolpium diameter, width of colpi at the equator and with the description of the end of colpi and thickness of exine with comparison of sexine and nexine

### Introduction

Considerable emphasis has been laid on the pollen morphology during recent years. Palyonology, or the study of spores and pollen grains has found application in plant taxonomy, plant geography, climatology and geology. Pollen analysis has also been tried as a means of tracing the history of the cultivated cereals.<sup>1</sup> Pollen grains and spores are used in different indigenous systems of medicines for various diseases.

The flowers of *Adhatoda vasica* are regarded as antiseptic.<sup>2</sup> Similarly the flowers of *Dianthus caryophyllus* are considered as cardiotoxic, diaphoretic, alexiteric, nervine and antiseptic in Spain and North America. Chopra *et al.*<sup>2</sup> have mentioned that *Elaeagnus umbellata* flowers are stimulant, cardiac and astringent, while the flowers of *Ocimum basilicum* are carminative, diuretic, stimulant and demulcent.

In some cases the flower drug samples are found adulterated with various other flowers which are similar in appearance, as *Viola* flowers are commonly mixed with *Impatiens* flowers. Similarly the flowers of *Coccinia glauca*, *Onosma macrocephala*, *Anchusa italica*, *Anchusa hybrida* and *Trichodesma molle* have been supplied under the same name. The flowers of *Onosma echioides* and *Macrotomia benthamii* are commonly sold under the same name in Punjab<sup>3</sup>. Against these adulterations there is no effective method of checking the purity of the drugs. Pollen grain analysis however, helps in qualitative analyses of drug powders and in the correct identification of drugs.

The plants selected in the present study are mostly those in which the flowers or pollen grains are regarded as drugs while in others the flowering shoots along with the leaves are the drugs in the indigenous systems of medicines.

### Materials and Methods

The plants, on whose stamens the pollen grain

studies have been carried out, were mainly collected from the Experimental Farm of North Regional Laboratories, P.C.S.I.R., Peshawar and its adjoining areas. Stamens of some other plants were also taken from the voucher specimens present in the herbarium.

Pollen grain preparations from the fresh as well as herbarium specimens were made as described by Erdtman.<sup>1,4</sup> The preparations were stained with safranin and mounted in glycerine. The diagrams were drawn with the help of camera lucida and the measurements were taken with an eyepiece micrometer. The measurements of about twenty pollen grains of each plant were taken and analysed statistically. The measurements mentioned in each case represent their averaged values. The uses of flowers and plants given in the text are after Chopra *et al.*<sup>2</sup> The descriptive terms used are after Erdtman<sup>1,4</sup> and Nair.<sup>5</sup>

### Description of Pollen Grains

#### (1) PLANTS IN WHICH FLOWERS ARE REGARDED AS DRUGS

*Achillea millefolium*. Linn. (*Compositae*-flowers-essential oil, azulene) Plate I, Fig. 1. Pollen 3 zonicolporate spheroidal,  $10\mu$  excluding spines, apocolpium diameter  $5\mu$ , exine  $3\mu$  thick, sexine is thicker than nexine, spinate; spines are pointed.

*Adhatoda vasica*, Nees: (*Acanthaceae*-flowers antiseptic) Plate I, Fig. 2. Pollen 2 zoniporate, prolate  $64 \times 36\mu$ , pore elliptical  $6 \times 4.2\mu$ , exine  $3\mu$  thick, sexine thicker than nexine, faintly granulate.

*Alhagi maurorum*. Baker: (*Leguminosae*-flowers used for piles) Plate III, Fig. 4. Pollen 3 zonicolporate, prolate, spherical in polar view.



*Anthemis odontostephana*. Linn: (*Compositae*—decoc-tion of flowers febrifuge, carminative) Plate I, Fig. 3. Pollen 3 zonicolporate, oblate, spheroidal,  $25 \times 20\mu$ , excluding spines. Apocolpium diameter  $10\mu$  colpi  $4\mu$  wide at the equator, tenuimarginate, ends blunt. Ora not well defined. Exine  $4\mu$  thick. Sexine thicker than nexine, spinate.

Pollen 3 zonicolporate, spheroidal, equatorial dia-meter  $21.45\mu \times 21.45\mu$ ; apocolpium diameter  $13.2\mu$ . Colpi  $3\mu$  wide at the equator, tenui-marginate, narrow, ends tapering and pointed. Exine  $3.3\mu$  thick, sexine much thicker than nexine, thin towards margin of colpi, psilate. Intine thick.

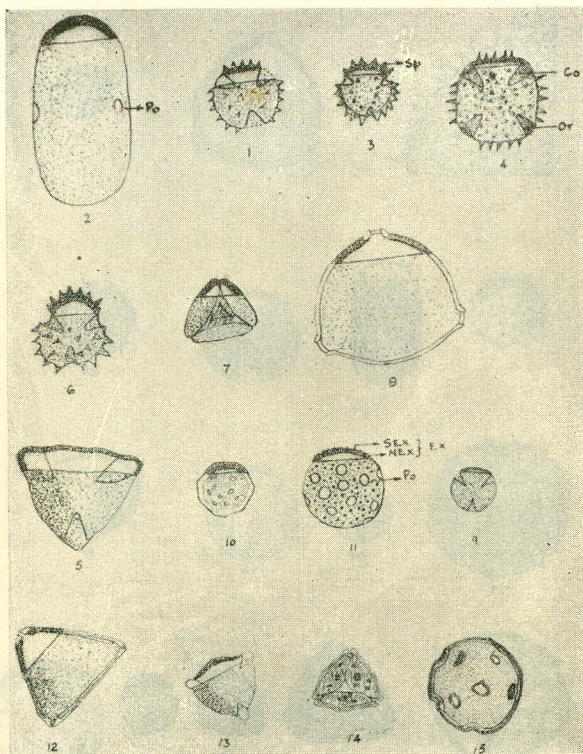


Plate 1.—Pollen grains of some Pakistani medicinal plants. 1, *Achillea millefolium*; 2, *Adhatoda vasica*; 3, *Anthemis odontostephana*; 4, *Calendula arvensis*; 5, *Cassia glauca*; 6, *Chrysanthemum cinerariaefolium*; 7, *Corydalis diphylla*; 8, *Datura stramonium*; 9, *Descurainia sophia*; 10, *Dianthus caryophyllus*; 11, *Digera arvensis*; 12, *Elaeagnus umbellata*; 13, *Eriobotrya japonica*; 14, *Eucalyptus sp.*; 15, *Fumaria indica*.

(Co, Colpus; Ex, Exine; Nx, Nexine; Or, Ora; Po, Pore; Sx, Sexine; Mag.  $\times 500$ )

*Artemisia laciniata*. Willd: (*Compositae*—uses similar to next species) Plate III, Fig. 5. Pollen 3 zonicolporate, spheroidal, equatorial diameter  $19.8\mu \times 19.8\mu$ ; apocolpium diameter  $13.2\mu$ . Colpi  $4.95\mu$  wide at the equator, tenui-marginate ends acute. Exine  $3.3\mu$  thick, sexine thicker than nexine, thinner towards margin of colpi, psilate. Intine thick.

*Artemisia scoparia*. Waldst & Kit: (*Compositae*—flower heads essential oil, plant used for earache infusion purgative) Plate III, Fig. 6.

*Calendula arvensis*. Linn: (*Compositae*—flowers—stimulant, antiseptic and emmenagogue) Plate I, Fig. 4. Pollen 4 zonicolporate (Nair P.K.K. reported as, pollen 3 zonicolporate, oblate spheroidal).<sup>5</sup> Prolate spheroidal,  $36 \times 32\mu$  excluding spines. Apocolpium diameter  $14\mu$ , colpi  $6\mu$  wide at the equator, tenuimarginate, ends acute. Ora lalongate,  $9 \times 5\mu$ . Exine  $3\mu$  thick, excluding spines, sexine spinate, spines  $4\mu$  long, pointed.

*Chrysanthemum cinerariaefolium*. Vis: (*Compositae*—flowers toxic, insecticidal) Plate I, Fig. 6. Pollen 3 zonicolporate, oblate spheroidal,  $32 \times 28\mu$ , apocolpium diameter  $12\mu$ , colpi  $4\mu$  wide at the equator, rounded at the end, ora circular, diameter  $5\mu$ , pointed.

*Datura stramonium*. Linn: (*Solanaceae*—juice of flowers for earache) Plate I, Fig. 8. Pollen 3 zonicolporate sub-oblate,  $60 \times 54\mu$ , Pore  $5\mu$  wide, annulus  $8\mu$  wide. Exine  $6\mu$  thick. Sexine thicker than nexine, smooth.

*Dianthus caryophyllus*. Linn: (*Carvophyllaceae*—flowers cardiotoxic, diaphoretic alexiteric, nervine and antiseptic) Plate I, Fig. 10. Pollen panporate, Penta to heptagonal  $23\mu$ . Pores elliptical,  $3 \times 2\mu$ , adjacent distanc of pores  $7\mu$ . Exine  $4\mu$  thick. Sexine thicker than nexine, reticulate.

*Digera arvensis*. Forsk: (*Amarantaceae*—flowers given for urinary discharge) Plate I, Fig. 11. Pollen panporate, spheroidal,  $34\mu$ . Pore circular, diameter  $4\mu$ , adjacent distance of pores  $6\mu$ . Exine  $2\mu$  thick. Sexine as thick as nexine, granulate.

*Elaeagnus umbellata*. Thumb: (*Elaeagnaceae*—flowers stimulant, cardiac and Astringent) Plate I, Fig. 12. Pollen triangular, one pore at each angle,  $44 \times 36\mu$ . Pore diameter  $2\mu$ , annulus  $3.5\mu$  wide. Exine  $1.5\mu$  thick. Sexine thicker than nexine, psilate.

*Eriobotrya japonica*. Lindl: (*Rosacea*—flowers expectorant) Plate I, Fig. 13. Pollen 3 zonicolporate, oblate,  $26\mu \times 24\mu$ , colpi tenui-marginate, ends pointed,  $4\mu$  wide at the equator. Exine  $2\mu$  thick,



thinner towards colpi margins, sexine almost as thick as nexine, faintly granulated.

*Hibiscus cannabinus*. Linn: (*Malvaceae*—juice of flowers in biliousness with acidity) Plate II, Fig. 16. Pollen panporate, spheroidal,  $120\mu$  excluding spines, pore circular, diameter  $4\mu$ . Exine  $6\mu$  thick excluding spines. Sexine thicker than nexine. Spinose, spine  $6-20\mu$  long, ends blunt. Interspinous area reticulate.

*Impatiens edgeworthii*. HKf: (*Balsaminaceae*—*impatiens balsamina* flowers are cooling, tonic) Plate II, Fig. 18. Pollen 4 zonicolpate, mostly lying in polar view, rectangular, in polar view  $44 \times 24\mu$ . Apocolpium diameter  $21 \times 7\mu$ , colpi not well developed. Exine  $2\mu$  thick. Sexine as thick as nexine, reticulate.

*Jasminum officinale*. Linn: (*Oleaceae*—flowers in skin diseases, headache, weak eyes, scorpion sting; essential oil) Plate IV, Fig. 19. Pollen 3-(4) zonicolporate, spheroidal, equatorial diameter  $33.0\mu \times 33.0\mu$ , apocolpium diameter  $23.1\mu$ . Colpi  $6.6\mu$  wide at the equator, tenuimarginate, ends pointed. Ora circular, membrane slightly sunken, smooth. Exine  $3.3\mu$  thick, sexine much thicker than nexine, reticulate, meshes varying in size. Intine thin.

*Jasminum pubescens*. Willd: (*Oleaceae*—flowers emetic) Plate II, Fig. 21. Pollen 3-4 zonicolporate, oblate spheroidal,  $44 \times 40\mu$ . Apocolpium diameter  $20\mu$ , colpi  $5\mu$  wide at the equator. Exine  $4\mu$  thick. Sexine much thicker than nexine, reticulate.

*Lathyrus aphaca*. Linn: (*Leguminosae*—flowers resolvent) Plate II, Fig. 22. Pollen 3 zoniporate, sub-oblate,  $28 \times 25\mu$ . Pore diameter  $2\mu$ . Annulus  $4\mu$  wide, faint operculum. Exine  $2\mu$  thick. Sexine and nexine are almost of same thickness, psilate.

*Malvastrum coro-mandelianum*. Carcke: (*Malvaceae*—flower as pectoral, diaphoretic) Plate IV, Fig. 22. Pollen 3 zonicolporate, oblate spheroidal, equatorial diameter  $26.4 \times 26\mu$ , apocolpium  $19.8\mu$ . Colpi  $6.6\mu$  wide at the equator, tenuimarginate, ends acute. Ora slightly longate, membrane smooth and very slightly protruding. Exine  $3.96\mu$  thick, sexine as thick as nexine, faintly granular. Intine thin.

*Ocimum basilicum*. Linn: (*Labiatae*—flowers carminative, diuretic, stimulant and demulcent) Plate II, Fig. 23. Pollen in oblique polar view 6 zonicolpate, spheroidal,  $60\mu$ , apocolpium diameter  $25\mu$ , colpi tenuimarginate, ends blunt. Exine  $3\mu$  thick. Sexine thicker than nexine, reticulate.

*Papaver dubium*. Linn: (*Papaveraceae*—petals sudorific) Plate IV, Fig. 26. Pollen 3 zonicolporate, prolate spheroidal, equatorial diameter  $29.7 \times 29.7\mu$ ; apocolpium diameter  $14\mu$ . Colpi  $9.9\mu$  wide at the equator, aperture membrane densely granular, ends acute. Exine  $2.64\mu$  thick, sexine as thick as nexine, reticulate. Intine thick.

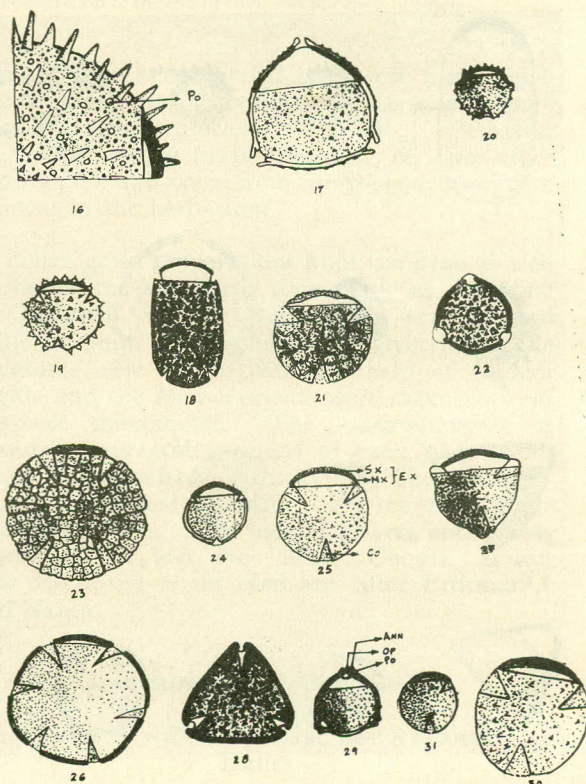


Plate 2.—Pollen grains of some Pakistani medicinal plants. (16, *Hibiscus cannabinus*; 17, *Hyoscyamus niger*; 18, *Impatiens edgeworthii*; 19, *Inula grandifolia*; 20, *Inula vestita*; 21, *Jasminum pubescens*; 22, *Lathyrus aphaca*; 23, *Ocimum basilicum*; 24, *Papaver pavonicum*; 25, *Papaver somniferum*; 26, *Rosmarinus officinalis*; 27, *Rosa indica*; 28, *Ruta graveolens*; 29, *Solanum xanthocarpum*; 30, *Valeriana wallichii*; 31, *Vitex negundo*).

[Ann, Annulus; Co, Colpus; Ex, Exine; Op, Operculum; Po, Pore; Sx, Sexine; Mag.  $\times 500$ ].

*Rosa indica*. Linn: (*Rosaceae*—Petals laxative) Plate II, Fig. 27. Pollen 3 zonicolporate sub-oblate,  $36 \times 32\mu$ , colpi  $8-6\mu$  wide at the equator, tenuimarginate, acute, exine  $2\mu$  thick, thinner towards colpi margins, sexine as thick as nexine, faintly granulate.

*Sida veronicifolia*. Lamk: (*Malvaceae*—flowers and unripe fruit for burning sensation in micturition) Plate IV, Fig. 27. Pollen panporate, spheroidal, equatorial diameter  $26.44\mu \times 26.44\mu$ . Pores circular,  $3.3\mu$  in diameter, distance between adjacent pores  $13.2\mu$ , membrane smooth. Exine



3.3 $\mu$  thick, (excluding spines) sexine as thick as nexine, spinate, spines 6.6 $\mu$  long, 3.96 $\mu$  broad at the base, 4.95 $\mu$  apart, interspinal area densely granulated. Intine thin.

*Solanum xanthocarpum*. Schrad and Wendl: (*Solanaceae*—flowers bitter, carminative, bud and flowers for watery eyes) Plate II, Fig. 29. Pollen 3 zoniporate sub-oblate 26 $\times$ 23 $\mu$ . Pore diameter 3 $\mu$ , annulus 4 $\mu$  wide, operculum 2 $\mu$ . Exine 2 $\mu$  thick. Sexine as thick as nexine, psilate.

*Viola serpens*. Wall: (*Violaceae*—flowers emollient, demulcent, used in biliousness and lung troubles, petals for infantile disorders) Plate IV, Fig. 32. Pollen 3 zonicolporate, spheroidal, equatorial diameter 26.4 $\mu$  $\times$ 28.05 $\mu$ , apocolpium diameter 19.8 $\mu$ . Colpi 6.6 $\mu$  wide at the equator, tenuimarginate, ends pointed. Ora circular, membrane smooth. Exine 1.65 $\mu$  thick, sexine as thick as nexine, psilate. Intine thick.

(2) PLANTS IN WHICH FLOWERING SHOOTS AND LEAVES ARE REGARDED AS DRUGS

*Atropa acuminata*. Røyle ex Lindley: (*Solanaceae*—leaves narcotic, sedative, diuretic, mydriatic, anodyne) Plate III, Fig. 7. Pollen 3 zonicolporate, spheroidal to prolate, equatorial diameter 39.6 $\mu$  $\times$ 39.6 $\mu$ ; apocolpium diameter 29.7 $\mu$ . Colpi 13.2 $\mu$  wide at the equator, tenuimarginate, membrane granular, ends blunt or round. Ora circular, membrane protruding smooth. Exine 2.64 $\mu$  thick; sexine as thick as nexine; striated. Intine thin.

*Capparis aphylla*. Roth: (*Capparidaceae*—top shoot and leaves as a plaster for boils and swellings, toothache, as antidote to poison) Plate III, Fig. 8. Pollen 3 zonicolporate, spheroidal, equatorial diameter 19.8 $\mu$  $\times$ 19.8 $\mu$ , apocolpium diameter 16.5 $\mu$ . Colpi 6.6 $\mu$  wide at the equator, crassimarginate, ends acute. Ora circular, membrane slightly protruding, smooth. Exine 3.3 $\mu$  thick, sexine as thick as nexine, faintly reticulate. Intine thin.

*Elsholtzia cristata*. Willd: (*Labiatae*—flowering tops given as diuretic) Plate III, Fig. 14. Pollen 6 zonicolporate, prolate, equatorial diameter 23.1 $\mu$ , apocolpium diameter 9.9 $\mu$ . Colpi 3.3 $\mu$  wide at the equator, very narrow, crassimarginate, ends pointed. Exine 1.65 $\mu$  thick, sexine is thick as nexine, faintly reticulate. Intine thick.

*Hyoscyamus muticus*. Linn: (*Solanaceae*—used as intoxicant) Plate II, Fig 17. Pollen 3-4 zoniporate, sub-oblate to prolate, spheroidal. 40 $\times$ 35 $\mu$ . Pores 8 $\mu$  wide. Sexine 3 $\mu$  thick. Sexine thicker than nexine, smooth.

*Hyoscyamus niger*. Linn: (*Solanaceae*—leaves-sedative, narcotic, anodyne antiseptic) Plate II, Fig. 17. Pollen 3-4 zoniporate, sub-oblate to prolate spheroidal, 44 $\times$ 40 $\mu$ , pore 8 $\mu$  wide, exine 2 $\mu$  thick. Sexine as thick as nexine, faintly granulate.

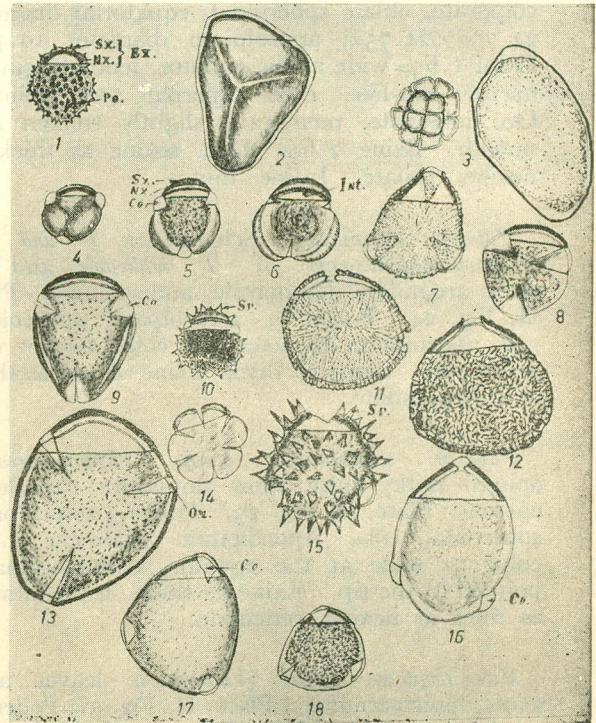


Plate 3.—Pollen grains of some Pakistani medicinal plants. (1. *Abutilon molle*; 2. *Adiantum capillus-veneris*; 3. *Albizzia lebbek*; 4. *Alhagi navororum*; 5. *Artemisia laciniata*; 6. *Artemisia scoparia*; 7. *Atropa acuminata*; 8. *Capparis aphylla*; 9. *Casia fistula*; 10. *Cotula hemispherica*; 11. *Datura alba*; 12. *Datura meteloides*; 13. *Duranta plumieri*; 14. *Elsholtzia cristata*; 15. *Helianthus annuus*; 16. *Heliotropium undulatum*; 17. *Indigofera gerardiana*; 18. *Indigofera hebeptala*).

*Indigofera gerardiana*. Wall: (*Leguminosae*—in *I. aspalathoides*—leaves, flowers and shoots-cooling, demulcent, leprosy and cancerous affection) Plate III, Fig. 17. Pollen 3 zonicolporate, subspheroidal, somewhat triangular in polar view, equatorial diameter 26.4 $\mu$ ; apocolpium diameter 16.5 $\mu$ . Colpi 6.6 $\mu$  wide at the equator, tenuimarginate, ends pointed. Ora lalongate, membrane smooth. Exine 1.65 $\mu$  thick, sexine as thick as nexine, faintly reticulate. Intine thin.

*Indigofera hebeptala*. Benth: (*Leguminosae*—uses similar to previous species) Plate III, Fig. 18. Pollen 3 zonicolporate, oblate, equatorial diameter 26.4 $\times$ 29.7 $\mu$ , apocolpium diameter 23.1 $\mu$ . Colpi 9.9 $\mu$  wide at the equator, tenuimarginate,



ends pointed. Ora not well distinct, membrane smooth. Exine  $1.65\mu$  thick, sexine as thick as nexine, psilate. Intine thin.

*Nepeta cataria* Linn: (*Labiatae*—flowering tops and leaves aromatic, carminative, tonic, diaphoretic, refrigerant, emmenagogue, antiseptic and stimulant) Plate IV, Fig. 24: Pollen 6 zonicolporate, oblate spheroidal, equatorial diameter  $24.75\mu \times 24.75\mu$ ; apocolpium diameter  $10.75\mu$ . Colpi  $1.65\mu$  wide at the equator, tenuimarginate, narrow slit-like, ends tapering and pointed. Ora longate, membrane slightly sunken and smooth. Exine  $2.64\mu$  thick, sexine as thick as nexine, psilate. Intine thin.

*Papaver pavonicum*. Schrenk ex F and M: (*Papaveraceae*—flowers of *P. nudicaule* and *P. rhoeas* are mildly diaphoretic, and sedative) Plate II, Fig. 24. Pollen 3 zonicolpate, spheroidal,  $32\mu$ , apocolpium diameter  $12\mu$ , colpi are not well developed. Exine  $2\mu$  thick, sexine almost as thick as nexine, psilate.

*Papaver somniferum*. Linn: (*Papaveraceae*—opium—milky juice from immature capsules—narcotic) Plate II, Fig. 25. Pollen 3 zonicolpate, spheroidal,  $28\mu$ . Apocolpium diameter  $7.8\mu$ , colpi  $5\mu$  wide at the equator, tenuimarginate, pointed at the tip. Exine  $2\mu$  thick, sexine almost as thick as nexine, reticulate.

*Vitex negundo*. Linn: (*Verbenaceae*—leaves aromatic, tonic vermifuge) Plate II, Fig. 31. Pollen 3 zonicolpate, spheroidal,  $26\mu$ . Apocolpium diameter  $10\mu$ , colpi  $6\mu$  wide at the equator, tenuimarginate, pointed at the end. Exine  $2\mu$  thick, sexine thicker than nexine, smooth.

### (3) PLANTS IN WHICH WHOLE HERBS OR OTHER PLANT PARTS ARE REGARDED AS DRUGS

*Abutilon molle*. Sweet: (*Malvaceae*—leaves seeds-demulcent, laxative). Plate III, Fig. 1. Pollen panporate, spheroidal, equatorial diameter  $72.6\mu \times 72.6\mu$ . Pores circular, distance between adjacent pores  $13\mu$ , membrane smooth. Exine  $3\mu$  thick (excluding spines), sexine thicker than nexine, spinate, spines  $3.3\mu$  long (excluding base), base  $3.3\mu$  long and  $6.6\mu$  broad; interspinal area densely granulated. Intine thin.

*Adiantum capillus-veneris*. Linn: (*Potypodiaceae*—plant demulcent, expectorant, diuretic, emmenagogue, tonic, febrifuge) Plate III, Fig. 2. Pollen nonaperturate, trilet, equatorial diameter  $29.7\mu \times 33.0\mu$ . Exine  $1.32\mu$  thick, sexine slightly thicker than nexine, psilate. Intine thin.

*Albizzia lebbek* Benth: (*Leguminosae*—plant for snakebite and scorpion sting) Plate III, Fig. 3. Pollen in polyads, composed of 16 cells, 8 cells form central cubical block, 8 outer cells encircle the block. Grains flattened, round,  $85.8\mu \times 85\mu$  in diameter; central cells cubical; peripheral cells square faced on outside, slightly tapering towards inner face to fit into the ring. Exine  $3.3\mu$  thick, sexine as thick as nexine, slightly thicker on the peripheral cells than the central cells, psilate. Intine thin, thick at the corners of peripheral cells.

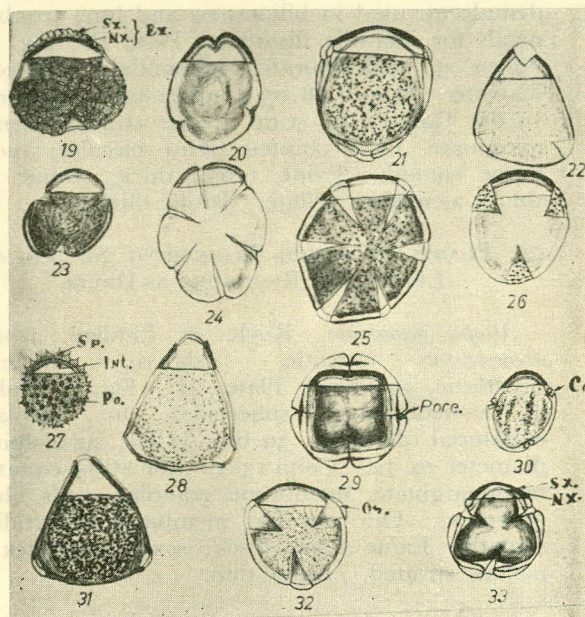


Plate 4.—Pollen grains of some Pakistani medicinal plants. (19, *Jasminum officinale*; 20, *Lantana indica*; 21, *Lippia nodiflora*; 22, *Malvastrum coromandelianum*; 23, *Marrubium vulgare*; 24, *Nepeta cataria*; 25, *Origanum vulgare*; 26, *Papaver dubium*; 27, *Sida veronicaefolia*; 28, *Solanum nigrum*; 29, *Tabernaemontana coronaria*; 30, *Thevetia nerifolia*; 31, *Verbena officinalis*; 32, *Viola serpens*; 33, *Withania somnifera*).

[Sx, Sexine; Nx, Nexine; Ex, Exine; Int, Intine; Co, Colpus; Po, Pore; Sp, Spine; Or, Ora].

*Cassia fistula*. Linn: (*Leguminosae*—seeds and leaves laxative) Plate III, Fig. 9: Pollen 3 zonicolpate, prolate, equatorial diameter  $26.4\mu \times 28.05\mu$ , apocolpium diameter  $23.1\mu$ . Colpi  $1.65\mu$  wide at the equator, long, narrow slit, tenuimarginate, ends pointed, surrounded by considerably thin wall area. (Exine thinnest at margin of colpi). Intine thin.

*Cassia glauca*. Linn: (*Leguminosae*—bark and leaves in diabetes and gonorrhoea) Plate I, Fig. 5. Pollen 3 zonicolpate triangular,  $44 \times 40\mu$ . Colpi  $12\mu$  wide at the equator. Exine  $2\mu$  thick, sexine thicker than nexine, psilate.



*Corydalis diphylla*. Wall: (*Fumariaceae*—in eye diseases) Plate I, Fig. 7. Pollen 3 zoniporate, flattened with triangular outline,  $32 \times 28 \mu$ . Pore one at each angle, each crossed by nexinous pore. Exine  $3 \mu$  thick. Sexine thicker than nexine, smooth.

*Cotula hemispherica*. Wall: (*Compositae*—plant applied externally in rheumatism, eye wash and colds) Plate III, Fig. 10: Pollen 3 zonicolporate, spheroidal, equatorial diameter  $26.4 \mu \times 26.4 \mu$ ; apocolpium diameter  $16.5 \mu$ . Colpi  $4.95 \mu$  wide at the equator, tenuimarginate, ends acute. Ora circular, membrane protruding, smooth. Exine  $4 \mu$  thick (excluding spines), sexine much thicker than nexine, spinate, spines  $4 \mu$  apart;  $3.3 \mu$  long,  $2.31 \mu$  broad at the base; interspinal area densely granulated. Intine thick.

*Datura alba*. Nees: (*Solanaceae*—leaves and seeds in insanity, cerebral complications, diarrhoea, fever with catarrhal, skin diseases, and antispasmodic) Plate III, Fig. 11. Pollen 3 zoniporate, spheroidal, equatorial diameter  $66.0 \mu \times 66.0 \mu$ . Pores circular or elliptical,  $3.3 \mu$  in diameter, membrane sunken and smooth. Exine  $2.97 \mu$  thick, sexine slightly thicker than nexine, distinctly striated. Intine thick.

*Datura meteloides*. Dunal: (*Solanaceae*—leaves and seeds antispasmodic, anodyne, narcotic) Plate III, Fig. 12. Pollen 3 zoniporate, oblate spheroidal, equatorial diameter  $66.0 \mu \times 62.7 \mu$ . Pores circular,  $3.63 \mu$  in diameter, membrane smooth. Exine  $2.64 \mu$  thick, sexine as thick as nexine, striato-reticulate. Intine thin.

*Descurainia sophia*. Linn: (Webb); (*Cruciferae*—Astringent, antiscorbulic) Plate I, Fig. 9. Pollen 3 zonicolporate, spheroidal,  $16 \mu$ . Apocolpium diameter  $6 \mu$ . Colpi  $3 \mu$  wide at the equator, ends pointed. Exine  $1.5 \mu$  thick. Sexine almost as thick as nexine, smooth.

*Duranta plumieri*. Jacq: (*Berberaceae*—plant poisonous, leaves contain saponin and fruit an alkaloid) Plate III, Fig. 13. Pollen 3 zonicolporate, oblate spheroidal, equatorial diameter  $36.3 \mu \times 36.0 \mu$  apocolpium diameter  $30.36 \mu$ . Colpi  $3.63 \mu$  wide at the equator; crassimarginate, ends tapering and pointed. Ora circular membrane slightly protruding, smooth. Exine  $3.3 \mu$  thick, sexine as thick as nexine, or slightly thicker; nexine thickened at the margins of colpi, psilate. Intine thick.

*Eucalyptus sp*: (*Myrtaceae*—oil from leaves is antiseptic, root purgative) Plate I, Fig. 14. Pollen 3 zoniporate, flattened with triangular outline.  $24 \mu \times 20 \mu$ . Pore diameter  $2 \mu$ , annulus  $4 \mu$  wide. Exine  $2 \mu$  thick, sexine as thick as nexine, psilate.

*Fumaria indica*. Pugsley: (*Fumariaceae*—plant diuretic diarrhoea and aperient) Plate I, Fig. 15. Pollen panporate, spheroidal,  $36 \mu$ , pore elliptical,  $4 \mu$ , adjacent distance of pore  $8 \mu$ . Exine  $3 \mu$  thick. Sexine thicker than nexine, psilate.

*Helianthus annuus*. Linn: (*Compositae*—Seeds diuretic; expectorant, in bronchial, laryngeal and pulmonary affections; coughs and colds in scorpion sting) Plate III, Fig. 15. Pollen 3 zonicolporate spheroidal, equatorial diameter  $33.0 \mu \times 29.7 \mu$ , apocolpium diameter  $23.1 \mu$ . Colpi  $9.9 \mu$  wide at the equator, tenuimarginate, ends acute. Ora circular, membrane protruding, smooth. Exine  $3 \mu$  thick (excluding spines) sexine thicker than nexine, spinate, spines  $6 \mu$  long,  $3 \mu$  broad at the base,  $4.95 \mu$  apart. Intine thin.

*Heliotropium undulatum*. Vahl: (*Boraginaceae*—plant in scorpion bite, venomous reptiles, and camel's bad eyes) Plate III, Fig. 16. Pollen 3 zonicolporate, 3 pseudocolpi in immature grain, spheroidal, equatorial diameter  $33.0 \mu \times 33.0 \mu$ , apocolpium diameter  $23.1 \mu$ . Colpi  $5.25 \mu$  wide at the equator, crassimarginate, narrow, abruptly ending round the pore; ora circular, membrane protruding, smooth. Exine  $1.98 \mu$  thick, sexine as thick as nexine, psilate. Intine thick.

*Inula grandiflora*. Willd: (*Compositae*—*Inula helinium* plants are used in chronic bronchitis) Plate II, Fig. 19. Pollen 3 zonicolporate, oblate spheroidal,  $24 \mu \times 18 \mu$  excluding spines. Apocolpium diameter  $10 \mu$ , colpi  $5 \mu$  wide at the equator, tenuimarginate, pointed ora circular, diameter  $5 \mu$ . Exine  $2 \mu$  thick, sexine thicker than nexine, spinate, spines  $1.5 \mu$  long.

*Inula vestita*. Wall: (*Compositae*) Plate II, Fig. 20. Pollen 3 zonicolporate, oblate spheroidal,  $20 \mu \times 15 \mu$  excluding spines apocolpium diameter  $5 \mu$  colpi  $3 \mu$  wide at the equator tenuimarginate, Ora not well defined. Exine  $4 \mu$  thick. Sexine thicker than nexine, spinate, spines  $1.5 \mu$  long.

*Lantana indica*. Roxb: (*Verbenaceae*—leaves in snake-bite) Plate IV, Fig. 20. Pollen 3-4 zonicolporate sub-oblate to spheroidal, equatorial diameter  $26.4 \mu \times 23.1 \mu$ ; apocolpium diameter  $19.8 \mu$ . Colpi  $1.32 \mu$  wide at the equator, crassimarginate ends pointed. Exine  $3.3 \mu$  thick, sexine as thick as nexine psilate. Intine thick.

*Lippia nodiflora*. Mich: (*Verbenaceae*—plant febrifuge diuretic maturant for boils) Plate IV, Fig. 21: Pollen 3 zoniporate, spheroidal, triangular in polar view, equatorial diameter  $33.0 \mu \times 36.3 \mu$ . Pores at angles, circular, membrane slightly protruding,  $3.63 \mu$  in diameter, membrane



smooth. Exine  $3\mu$  thick, sexine slightly thicker than nexine, swollen at margin of pores, psilate. Intine thick.

*Marrubium vulgare* Linn: (*Labiatae*—herb bitter tonic, expectorant, diuretic carminative, pectoral, in colds and coughs and pulmonary affections) Plate IV, Fig. 23. Pollen 3 zonicolporate, oblate, equatorial diameter  $23.1\mu \times 24.75\mu$ ; apocolpium diameter  $16.5\mu$ . Colpi  $6\mu$  wide at the equator, tenuimarginate, ends acute. Ora lalongate (not well defined) membrane smooth. Exine  $3\mu$  thick, sexine as thick as nexine, faintly reticulate. Intine thick.

*Origanum vulgare* Linn: (*Labiatae*—volatile oil, aromatic, stimulant, tonic diaphoretic, in colic and hysteria, rheumatism, tooth ache and earache) Plate IV, Fig. 25. Pollen 6 zonicolporate, oblate, equatorial diameter  $29.7\mu \times 32.01\mu$ , apocolpium diameter  $13.2\mu$ . Colpi  $3.63\mu$  wide at the equator, narrow, ends pointed. Ora lalongate (not well-defined) membrane smooth. Exine  $2.64\mu$  thick, sexine as thick as nexine, faintly granular. Intine thin.

*Rosmarinus officinalis* Linn: (*Labiatae* oil—carminative and stimulant) Plate II, Fig. 26. Pollen 6 zonicolporate in oblique polar view. Spheroidal,  $52\mu$ . Apocolpium diameter  $8\mu$ , colpi  $6\mu$  wide at the equator, tenuimarginate, pointed at the end. Exine  $3\mu$ , sexine almost as thick as nexine, reticulate.

*Ruta graveolens* Linn: (*Rutaceae*—plant antiseptic, stimulant leaves are used in rheumatic pain) Plate II, Fig. 28. Pollen 3 zoniporate, sub-oblate,  $52 \times 40\mu$ , pore diameter  $4\mu$ . Exine  $2\mu$ , sexine thicker than nexine, faintly reticulate.

*Solanum nigrum*. Linn: (*Solanaceae*—plant juice hydragogue, blood spitting, piles, dysentery. Berries in fever, diaphoretic, hydrophobia) Plate IV, Fig. 28. Pollen 3-4 zoniporate, sub-oblate to prolate equatorial diameter  $23.1\mu \times 23.1\mu$ ; slightly triangular in polar view. Pores at angles, circular,  $6.6\mu$  in diameter. Exine  $3.3\mu$  thick, sexine almost as thick as nexine, faintly granular. Intine thin.

*Tabernaemontana coronaria* Willd: (*Apocynaceae*—used for diseases of eye) Plate IV, Fig. 29. Pollen 3-4 zonicolporate, oblate, equatorial diameter  $33.0\mu \times 28.05\mu$ , apocolpium diameter  $19.8\mu$ . Colpi  $3.3\mu$  wide at the equator, very narrow slit, crassimarginate, ends tapering and pointed. Ora lalongate, narrow, zonorate, membrane sunken, smooth. Exine  $5\mu$  thick, sexine thicker than nexine, nexine forms a rectangular outline, sexine

thickened at the middle of rectangular sides to form spheroidal shape in polar view, psilate. Intine thick.

*Thevetia nerifolia*. Juss: (*Apocynaceae*—highly poisonous, glucoside thevetin is reported) Plate IV, Fig. 30. Pollen 3-4 zonicolporate, oblate spheroidal, equatorial diameter  $75.9\mu \times 77.22\mu$ , apocolpium diameter  $66.0\mu$ . Colpi  $3.3\mu$  wide at the equator, crassimarginate, narrow, ends pointed. Ora elliptical, membrane sunken and smooth. Exine  $5\mu$  thick, sexine thicker than nexine, psilate. Intine thick.

*Valeriana wallichii*. D.C.: (*Valerianaceae*—root stimulant, carminative, antiseptic) Plate II, Fig. 30. Pollen 3 zonicolporate, spheroidal  $56\mu$ . Apocolpium diameter  $23\mu$ , colpi  $10\mu$  wide at the equator. Exine  $3\mu$ . Sexine thicker than nexine, spinulate.

*Verbena officinalis*. Linn: (*Verbenaceae*—plant-febrifuge, tonic, useful in nerve complaints) Plate IV, Fig. 31. Pollen 3 zoniporate, spheroidal, equatorial diameter  $33.0\mu \times 33.0\mu$ . Pores circular, diameter  $6\mu$ , membrane protruding, smooth. Exine  $1.32\mu$  thick, sexine as thick as nexine, psilate. Intine thick.

*Withania somnifera*. Dunal: (*Solanaceae*—leaves bitter, given in infusion in fever) Plate IV, Fig. 33. Pollen 3 zonicolporate, oblate, triangular in polar view, equatorial diameter  $26.4\mu \times 28.71\mu$ , apocolpium diameter  $19.8\mu$ . Colpi  $5\mu$  wide at the equator, crassimarginate, ends pointed. Ora circular, membrane smooth. Exine  $2.97\mu$  thick, sexine thicker than nexine, psilate, Intine thick.

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