



## Atlas of Airborne Pollens of Bikaner City

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### ABSTRACT

Plants that depend on wind to disperse their pollen generate copious amounts of pollen, blow across great distances, and trigger allergies in humans, even if people live far from the source. To manage pollen allergy, monitoring the amount of pollen in the air is crucial. Airborne pollen is identified by comparing it with reference collections, using taxonomic features such as the quantity and distribution of apertures, as well as various patterns of exine ornamentation. These characteristics serve as the primary criteria for identifying atmospheric pollen. The present study contributes to aero palynological knowledge by documenting the airborne pollen spectrum in Bikaner, aiding in the identification of pollen grains with allergenic significance. These findings can inform public health strategies for managing pollen allergies and mitigating respiratory health risks associated with airborne pollen exposure.

**Keywords:** Pollen, Aeropalynology, Anemophilous, Pollen morphology, Allergenic.

### INTRODUCTION

Pollens are the grains origination from the male reproductive part of the flower and fertilize the female flower to propagate the plant species. The term pollen has been derived from a Greek word meaning “fine flour.” Dispersal of pollen grains to the female flower may be done by various agencies like birds (ornithophily), insects like bees, butterflies and moths (Entomophily), bats (chiropterophily), wind (Anemophily), etc., when inhaled. These pollens may cause irritation in the respiratory system and trigger allergies in people. Asthma, seasonal rhinitis, and bronchial irritation are just a few of the symptoms that can result from a broad upper respiratory tract and nasobronchial allergy caused by pollen suspended in the air.<sup>[1]</sup> Anemophilous plants that depend on wind to disperse their pollen generate a large amount. These pollens are blown away across great distances and trigger allergies in humans living far away from the source.

In India, hay fever and allergic rhinitis affect 20 to 30% of the population, and asthma affects 15% of the population.<sup>[2,3]</sup> Pollen grains are considered to be the main airborne allergens that cause allergic rhinitis, asthma, and atopic dermatitis. Therefore, it is very important to keep an eye on the amount of pollen in the air to manage pollen allergy.<sup>[4-6]</sup> Monitoring the concentrations of allergenic pollen in the air is now considered the most accurate method for assessing the health risk to those who have pollinosis globally.<sup>[7-12]</sup> The geographical location and bioclimatic conditions of an area determine the spatial variations in the airborne pollen spectra whereas, the temporal fluctuations are because of plant phenology and the local flora of that area.<sup>[13-16]</sup>

Aeropalynological sampling is the key approach to assessing the presence and abundance of airborne allergens, utilizing diverse sampling devices such as gravimetric, impaction, suction, and filtration samplers. The collected samples of airborne pollen are scanned using direct microscopy and are identified by comparing them with reference collections.<sup>[12]</sup> Taxonomic features such as the numbers and distribution of apertures and various patterns of exine ornamentation serve as the primary criteria for identifying atmospheric pollen. This study presents the characteristics of airborne pollen in Bikaner, offering valuable insights for aeropalynological research and aiding in the identification of pollen grains with allergenic significance in the local air.

### METHODOLOGY

#### Study Area

The current investigation took place in Bikaner city, located in the heart of the Thar desert. Encircling an area of 30,247.90 square kilometers, Bikaner is situated between 27°11' N and 29°03' N latitude and 71°54' E and 74°12' E longitude.<sup>[17]</sup> The predominant landscape comprises sandy plains and dunes, ranging in elevation from 61 to 305 meters above sea level. Bikaner has a hot desert climate with minimal rainfall and extreme temperatures. Summers (April to June) are intensely hot, with maximum temperatures exceeding 48°C, while winters (November to February) can see nighttime temperatures dropping below freezing point. There is a notable temperature contrast between different months of the year. Annual precipitation does not surpass 352 mm, with the majority occurring in the months of July to September during the rainy

season, coinciding with high temperatures. The region is prone to frequent sand and dust storms in the hot and dry summers, with wind velocities reaching up to 110 km/hr, reshaping the landscape by shifting sand dunes. Low relative humidity and high evaporation rates are common, contributing to periodic famine conditions in the area. The construction of canals in Rajasthan has increased vegetation along their banks, providing habitats for diverse plant species. However, it also poses risks, such as the introduction of invasive species, habitat fragmentation, and altered hydrology, which can negatively impact the region's flora.<sup>[18]</sup>

## Collection of Plants and Pollen

Fresh and fully developed flowers were collected during the anthesis stage from the natural environment. Floras were used to identify the plant species.<sup>[19-21]</sup> Slides containing pollen for examination under a light microscope were prepared using Erdtman's acetolysis method.<sup>[22]</sup> This technique, known for its two-step process of chlorination and acetylation, removes cellular content and the intine of pollen grains during chlorination. The acetylation step involves treating pollen grains with a mixture of acetic anhydride and concentrated sulphuric acid in a 9:1 ratio, resulting in a brown stain for the pollen. A pollen herbarium was also established using Erdtman's acetolysis technique, with families and their respective genera arranged in alphabetical order. The pollen terminology follows Erdtman<sup>[23]</sup> and Faegri & Iversen.<sup>[24]</sup>

## RESULTS AND DISCUSSION

### Gymnosperm

#### *Pinus spp.*

Local Name: Pine; Family: Pinaceae; Habit: A tall cone-like tree  
Flowering Period: April-July (In hills) and February-April (In plains & at lower altitudes); Mode of pollination: Anemophilous.  
Pollen Morphology (Fig. 1A): Grains saccate, 1 colporate, grains breadth 77 µm (range: 73–78 µm in unacetolysed) and 81 µm range: 78-83 µm in acetolysed); sacci 2 and 43 x 38 x 33 µm in size: colpus 50 x 48 x 49; exine 2 µm thick finely reticulate, coarsely reticulate in region of sacci.

### Angiosperm

#### *Aerva pseudotomentosa Blatt. & Halb.*

Local Name: Bui, Buari; Family: Amaranthaceae; Habit: Woody undershrub.  
Flowering Period: October - April; Mode of pollination: Anemophilous.

Pollen Morphology (Fig. 1B): Pantoporate, spheroidal, size 19.3 µm (range: 17.5–20.3 µm); mesoporum 3 µm; exine 2 µm, sexine thicker than nexine, reticulate.

#### *Amaranthus spinosus Linn.*

Local Name: Kantio-chandelo, Kanta-miris; Family: Amaranthaceae; Habit: Erect, armed annual herb.  
Flowering Period: July – November; Mode of pollination: Anemophilous.

Pollen Morphology (Fig. 1C): Pantoporate, spheroidal, diameter 28 µm (range: 24–32 µm); pores uniformly distributed over the surface,

pore circular, pore diameter 2.5 µm, interporal distance 3.5 µm, exine 1.5 µm granulate.

#### *Coriandrum sativum Linn.*

Local Name: Dhania; Family: Apiaceae; Habit: An annual herb.  
Flowering Period: January – May; Mode of pollination: Entomophilous  
Pollen Morphology (Fig. 1D): 3-zonocolporate, per-prolate, size 33 x 13.8 µm (range: 30–36.5 x 12.5–15 µm); endocolpium lalongate, syncolpate; exine 3.5 µm thicker than nexine, tagillate.

#### *Launaea fallax (Jaub. & Spach.) Kuntze*

Local Name: Bhagtal; Family: Asteraceae; Habit: An annual or perennial herb.  
Flowering Period: January – June; Mode of pollination: Amphiphilous.  
Pollen Morphology (Fig. 1E): 3-zonocolpoidorate, oblate-spheroidal, size 27.6 x 29 µm (range: 26–28.5 x 27–31 µm); colpi short, endocolpium lalongate, exine 8 µm, sexine much thicker than nexine echinolophate with 5 to 6 µm long echines.

#### *Parthenium hysterophorus Linn.*

Local Name: Congress ghaas, Gaazar ghaas; Family: Asteraceae.; Habit: An exotic weed.  
Flowering Period: Throughout the year; Mode of pollination: Amphiphilous.  
Pollen Morphology (Fig. 1F & 1G): 3-zonocolpate, oblate-spheroidal, size 15.5 x 17.2 µm (range: 14–16 x 16.5–18 µm); endocolpium circular, exine 6 µm much thicker than nexine, spinulate with 3 to 4 µm long spinules.

#### *Sonchus asper Hill.*

Local Name: Kali-Jibi; Family: Asteraceae; Habit: An annual herb.  
Flowering Period: November - January; Mode of pollination: Amphiphilous.  
Pollen Morphology (Fig. 1H & 1I): 3-zonocolpoidorate, spheroidal, diameter 42.6 µm (range: 40–44.5 µm); endocolpium lalongate, exine 12 µm, sexine much thicker than nexine, echinolophate with about 10 µm long echines.

#### *Xanthium strumarium Linn.*

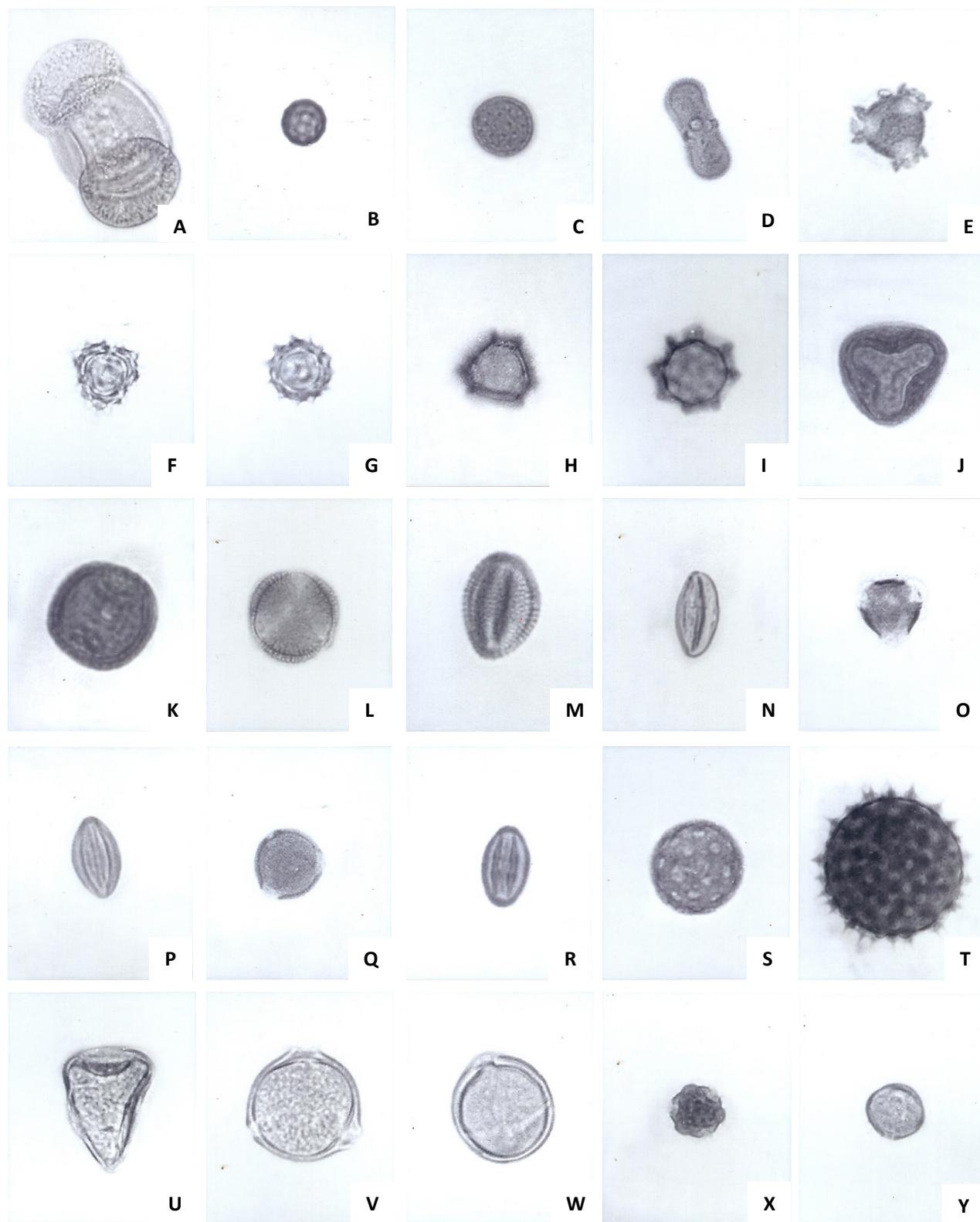
Local Name: Chota dhatura, Gokhru; Family: Asteraceae; Habit: An annual shrub.  
Flowering Period: September - December; Mode of pollination: Anemophilous.  
Pollen Morphology (Fig. 1J & 1K): 3-zonoporate, spheroidal, size 21.8 µm (range: 20–24 µm); pore diameter 3.5 µm, exine 3 µm, sexine thicker than nexine, spiniferous.

#### *Brassica campestris Linn.*

Local Name:Sarson.  
Family: Brassicaceae; Habit: A tall annual herb.  
Flowering Period: January-April; Mode of pollination: Amphiphilous.  
Pollen Morphology (Fig. 1L & 1M): 3-zonocolpate, sub-prolate, size 30.5 x 28.5 µm (range: 25–33 x 19–30 µm); exine 3 µm, sexine thicker than nexine, reticulate.

#### *Heliotropium curassavicum Linn.*

Local Name: Kali bui; Family: Boraginaceae; Habit: An annual herb.  
Flowering Period: March – December; Mode of pollination:



**Fig. 1:**Pollen grains A. *Pinus* sp.; B. *Aerva pseudotomentosa* (SV); C. *Amaranthus spinosus* (SV); D. *Coriandrum sativum* (EV); E. *Launaea fallax* (PV); F. *Parthenium hysterophorus* (PV); G. *Parthenium hysterophorus* (EV); H. *Sonchus asper* (PV); I. *Sonchus asper* (EV); J. *Xanthium strumarium* (PV); K. *Xanthium strumarium* (EV); L. *Brassica campestris* (PV); M. *Brassica campestris* (EV); N. *Heliotropium curassavicum* (EV); O. *Capparis decidua* (PV); P. *Capparis decidua* (EV); Q. *Cleome gynandra* (PV); R. *Cleome gynandra* (EV); S. *Chenopodium album* (SV);T. *Ipomoea carica* (SV);U. *Cyperus rotundus* (PV);V. *Ricinus communis* (PV);W. *Ricinus communis* (EV);X. *Lawsonia inermis* (PV);Y. *Lawsonia inermis* (EV);

Amphiphilous.

Pollen Morphology (Fig. 1N): 3-zonocolporate, prolate, size 26.1 x 17  $\mu\text{m}$  (range: 23.5–30 x 16–18.5  $\mu\text{m}$ ); endocolpium elongate, exine 2  $\mu\text{m}$ , sexine thicker than nexine, psilate.

#### *Capparis decidua* (Forsk.) Edgew.

Local Name: Ker, Kerro; Family: Capparaceae; Habit: Much branched glabrous shrub or small tree.

Flowering Period: February-April and August-October; Mode of pollination: Amphiphilous.

Pollen Morphology (Fig. 1O & 1P): 3-zonocolporoidate, sub-prolate, size 19.5 x 14.9  $\mu\text{m}$  (range: 18.3–20  $\mu\text{m}$  x 13.5–16.5  $\mu\text{m}$ ); exine 1.6 mm, sexine thicker than nexine, faintly reticulate.

#### *Cleome gynandra* Linn.

Local Name: Safed bagro; Family: Capparaceae; Habit: An erect annual herb

Flowering Period: July –December; Mode of pollination: Entomophilous.

Pollen Morphology (Fig. 1Q&1R): 3-zonocolporate, prolate, size 20 x 14.7  $\mu\text{m}$  (range: 19–20.8 x 12–17  $\mu\text{m}$ ) endocolpium lolongate; exine 1.6  $\mu\text{m}$ , sexine thicker than nexine, faintly reticulate.

#### *Chenopodium album* Linn.

Local Name: Chelaro, Bathua sag; Family: Chenopodiaceae; Habit: Small, much-branched, annual herb.

Flowering Period: September - March; Mode of pollination: Anemophilous.

Pollen Morphology (Fig. 1S): Pantoporate, spheroidal, diameter 29  $\mu\text{m}$  (range: 28–32  $\mu\text{m}$ ); pore diameter 1.8  $\mu\text{m}$ , sexine as thick as nexine.

#### *Ipomoea carica* (Linn). Sweet

Local Name: Railway creeper; Family: Convolvulaceae; Habit: A glabrous twiner.

Flowering Period: September - November; Mode of pollination: Entomophilous.

Pollen Morphology (Fig. 1T): Pantoporate, spheroidal, diameter 84.2  $\mu\text{m}$  (range: 77–93.1  $\mu\text{m}$ ); mesoporum 6  $\mu\text{m}$ ; exine 13.6  $\mu\text{m}$  (range: 12–16  $\mu\text{m}$ ), nexine thick, spinate; spines 9–12  $\mu\text{m}$  long, interspinal distance 4.5 to 6  $\mu\text{m}$ .

#### *Cyperus rotundus* Linn.

Local Name: Motha; Family: Cyperaceae; Habit: Stoloniferous sedge.

Flowering Period: July - December; Mode of pollination: Anemophilous.

Pollen Morphology (Fig. 1U): Monoporate, rudimentary aperture, spheroidal, diameter 26  $\mu\text{m}$  (range: 22–30  $\mu\text{m}$ ); exine 1  $\mu\text{m}$  thick psilate.

#### *Ricinus communis* Linn.

Local Name: Arandi, Arand; Family: Euphorbiaceae; Habit: A tall shrub.

Flowering Period: January – April; Mode of pollination: Anemophilous.

Pollen Morphology (Fig. 1V&1W): 3- zonocolporate, prolate-spheroidal, size 32 x 30.8  $\mu\text{m}$  (range: 31–34.3  $\mu\text{m}$  x 28.6–32  $\mu\text{m}$ );

colpi distinct, meeting at poles; endocolpium elongate; exine 2.5  $\mu\text{m}$  thick, sexine slightly thicker than nexine, reticulate.

#### *Lawsonia inermis* Linn.

Local Name: Mehandi; Family: Lythraceae; Habit: A shrub.

Flowering Period: June – October; Mode of pollination: Amphiphilous.

Pollen Morphology (Fig. 1X&1Y): 3-zonocolporate, sub-prolate, size 20.3 x 16.6  $\mu\text{m}$  (range: 18–21 x 14.5–1.7  $\mu\text{m}$ ); endocolpium circular; exine 2  $\mu\text{m}$ , sexine thicker than nexine, psilate or faintly granulate.

#### *Abutilon indicum* Linn.

Local Name: Tara-kanchi; Family: Malvaceae; Habit: An annual or perennial herb

Flowering Period: October -April; Mode of pollination: Entomophilous.

Pollen Morphology (Fig. 2A): 3-zonocolporate, prolate-spheroidal, size 66.8 x 63.3  $\mu\text{m}$  (range: 63.3–69.3  $\mu\text{m}$  x 53.3–6.5  $\mu\text{m}$ ) endocolpium circular; exine 3.3  $\mu\text{m}$ , sexine as thick as nexine, spinate, spines 3.5 mm long.

#### *Azadirachta indica* A. Juss.

Local Name: Neem, Neemro; Family: Meliaceae; Habit: A large evergreen tree.

Flowering Period: February - June; Mode of pollination: Amphiphilous.

Pollen Morphology (Fig. 2B&2C): 4-zonocolporate, prolate-spheroidal, size 39.5 x 35  $\mu\text{m}$  (range: 37–43  $\mu\text{m}$  x 32–39  $\mu\text{m}$ ) endocolpium slightly elongated; exine 3 mm, sexine slightly thicker than nexine, faintly striato-reticulate.

#### *Acacia nilotica* (Linn.) Del.

Local Name: Babool, Banwal; Family: Mimosaceae; Habit: A moderate or medium-sized tree.

Flowering Period: May –October; Mode of pollination: Amphiphilous.

Pollen Morphology (Fig. 2D): Polyads, 16 celled, flattened, size 28.7 x 38.3  $\mu\text{m}$  (range: 27–30 x 37–40  $\mu\text{m}$ ) considering each cell a single grain, its size is 12 x 13.5  $\mu\text{m}$ . Each cell possesses 4 defined pores with pore diameter of 12  $\mu\text{m}$  exine 1.5  $\mu\text{m}$ . Sexine in the distal walls of individual grains is thicker than nexine, faintly reticulate.

#### *Albizia lebbeck* (Linn.) Willd.

Local Name: Sares, Siris; Family: Mimosaceae; Habit: A large, deciduous tree.

Flowering Period: January –September; Mode of pollination: Amphiphilous.

Pollen Morphology (Fig. 2E): Polyad, 16-celled, spheroidal; diameter 66  $\mu\text{m}$  (range: 65–68  $\mu\text{m}$ ) considering each cell as individual, its size is 18.5 x 12  $\mu\text{m}$ ; exine 1.5  $\mu\text{m}$ , thick, sexine as thick as nexine, psilate.

#### *Prosopis cineraria* (Linn.) Druce

Local Name :Khejari; Family: Mimossaceae; Habit: A large tree.

Flowering Period: February–April; Mode of pollination: Amphiphilous.

Pollen Morphology (Fig. 2F&2G): 3-zonocolporate, sub prolate, size 31.9 x 24  $\mu\text{m}$  (range: 30–35  $\mu\text{m}$  x 22–27  $\mu\text{m}$ ) endocolpium elongate; colpi occasionally syncopate exine 3  $\mu\text{m}$ , sexine as thick as nexine, reticulate.

*Prosopis juliflora (Swartz) DC.*

Local Name: Vilayati kikkar, Angreji bavanlio; Family: Mimosaceae; Habit: A large shrub.

Flowering Period: January – May and July -November; Mode of pollination: Amphiphilous.

Pollen Morphology (Fig. 2H&2I): 3-zonocolporate, prolate, size 30 x 20  $\mu\text{m}$  (range: 29–33 x 18–22  $\mu\text{m}$ ) endocolpium elongate, colpi tips acute; exine 1.5  $\mu\text{m}$  thick, sexine thicker than nexine, pilate.

*Glinus lotoides Linn.*

Local Name: Bakada, Hata, Dholakani; Family: Molluginaceae; Habit: A prostrate herb.

Flowering Period: November – February; Mode of pollination: Anemophilous.

Pollen Morphology: 3-zonocolpate, prolate-spherodal, size 28 x 25  $\mu\text{m}$  (range: 24–33  $\mu\text{m}$  x 21–28  $\mu\text{m}$ ); exine 1.5  $\mu\text{m}$  thick, psilate.

*Morus alba Linn.*

Local Name: Shehtoot; Family: Moraceae; Habit: A small or medium sized tree.

Flowering Period: February – April; Mode of pollination: Anemophilous.

Pollen Morphology (Fig. 2J): 2-porate, spheroidal, size 19  $\mu\text{m}$  (range: 17–21  $\mu\text{m}$ ); pore diameter 3.5  $\mu\text{m}$ , interporal distance 16  $\mu\text{m}$ ; exine 1.5  $\mu\text{m}$  thick psilate.

*Eucalyptus globulus Lebill.*

Local Name: Safeda; Family: Myrtaceae; Habit: A giant tree attaining huge dimensions.

Flowering Period: January – April; Mode of pollination: Anemophilous.

Pollen Morphology (Fig. 2K&2L): 3-zonocolpate, oblate, size 11.5 x 18  $\mu\text{m}$  (range: 10–13.5 x 16.5–19  $\mu\text{m}$ ); endocolpium elongated, syncolpate; exine 1.5  $\mu\text{m}$  thick, sexine as thick as nexine, psilate.

*Boerhavia diffusa Linn.*

Local Name: Chinawari, Gandha-purva; Family: Nyctaginaceae; Habit: A perennial herb.

Flowering Period: Throughout the year; Mode of pollination: Anemophilous.

Pollen Morphology (Fig. 2M): Pantoporat, spheroidal, diameter 64.6  $\mu\text{m}$  (range: 61.8–67.1  $\mu\text{m}$ ); mesoporum 5  $\mu\text{m}$ , interporal distance 16  $\mu\text{m}$ ; exine 6  $\mu\text{m}$ , sexine as thick as nexine or slightly thicker, spinulate, spinules 3 to 4  $\mu\text{m}$  long.

*Argemone mexicana Linn.*

Local Name: Satayanashi; Family: Papaveraceae; Habit: A spiny herb

Flowering Period: November-May; Mode of pollination: Amphiphilous

Pollen Morphology (Fig. 2N&2O): 3-zonocoplante, prolate, size 36.9 x 24.3  $\mu\text{m}$  (range: 33.3–40 x 16.6–30  $\mu\text{m}$ ), sexine as thick as nexine or slightly thicker; reticulate; crassimurate, lumina almost circular.

*Crotalaria burhia Buch-Ham.*

Local Name: Shinio; Family: Papilionaceae; Habit: An undershrub

Flowering Period: August -January; Mode of pollination: Amphiphilous.

Pollen Morphology (Fig. 2P): 3-zonocolporate, sub- prolate, size 20

x 17  $\mu\text{m}$  (range: 16–24 x 14–20  $\mu\text{m}$ ) endocolpium elongated, exine faintly reticulate.

*Dalbergia sissoo Roxb.*

Local Name: Shisham; Family: Papilionaceae; Habit: Medium sized tree.

Flowering Period: February - May; Mode of pollination: Amphiphilous.

Pollen Morphology: 3-zonocolporate, sub- prolate, size 26 x 22  $\mu\text{m}$  (range: 24–27 x 21–24  $\mu\text{m}$ ) endocolpium lalongate; exine 1.5  $\mu\text{m}$  thick, psilate.

*Indigofera cordifolia Hyne ex Roth.*

Local Name: Bakerio, Bekar; Family: Papilionaceae; Habit: A prostrate, annual herb.

Flowering Period: August – November; Mode of pollination: Amphiphilous.

Pollen Morphology: 3-zonocolpate, sub- prolate, size 34 x 28  $\mu\text{m}$  (range: 30–38 x 25–32  $\mu\text{m}$ ); exine 2.5  $\mu\text{m}$  thick, granulate.

*Cynodon dactylon Linn.*

Local Name: Doob; Family: Poaceae; Habit: It is a creeping, perennial grass.

Flowering Period: Throughout the year; Mode of pollination: Anemophilous.

Pollen Morphology (Fig. 2Q): Monoporate, spheroidal, diameter 25  $\mu\text{m}$  (range: 24–28  $\mu\text{m}$ ); pore diameter 3  $\mu\text{m}$ ; exine 1.5  $\mu\text{m}$  thick, sexine slightly thicker than nexine, psilate.

*Pennisetum typhoides (Burm. F.) Stapf & Hubb*

Local Name: Bajra; Family: Poaceae; Habit: A annual herb.

Flowering Period: July - October; Mode of pollination: Anemophilous.

Pollen Morphology (Fig. 2R): Monoporate, spheroidal, diameter 40  $\mu\text{m}$  (range: 36–42  $\mu\text{m}$ ); exine 1.5  $\mu\text{m}$  thick, sexine as thick as nexine, psilate.

*Ziziphus nummularia (Burm. F.) Wt. & Am.*

Local Name: Borti, Bordi; Family: Rhamnaceae; Habit: A straggling shrub.

Flowering Period: August - November; Mode of pollination: Entomophilous.

Pollen Morphology (Fig. 2S&2T): 3-zonocolporate, prolate-spheroidal, size 20.2 x 18.5  $\mu\text{m}$  (range: 18.5–22 x 16.5–19.839  $\mu\text{m}$ ) endocolpium elongate; exine 2  $\mu\text{m}$ , sexine is as thick as nexine, fovelolate.

*Salvadora persica Linn.*

Local Name: Pilu, Mitha Jal; Family: Salvadoraceae; Habit: A small evergreen tree.

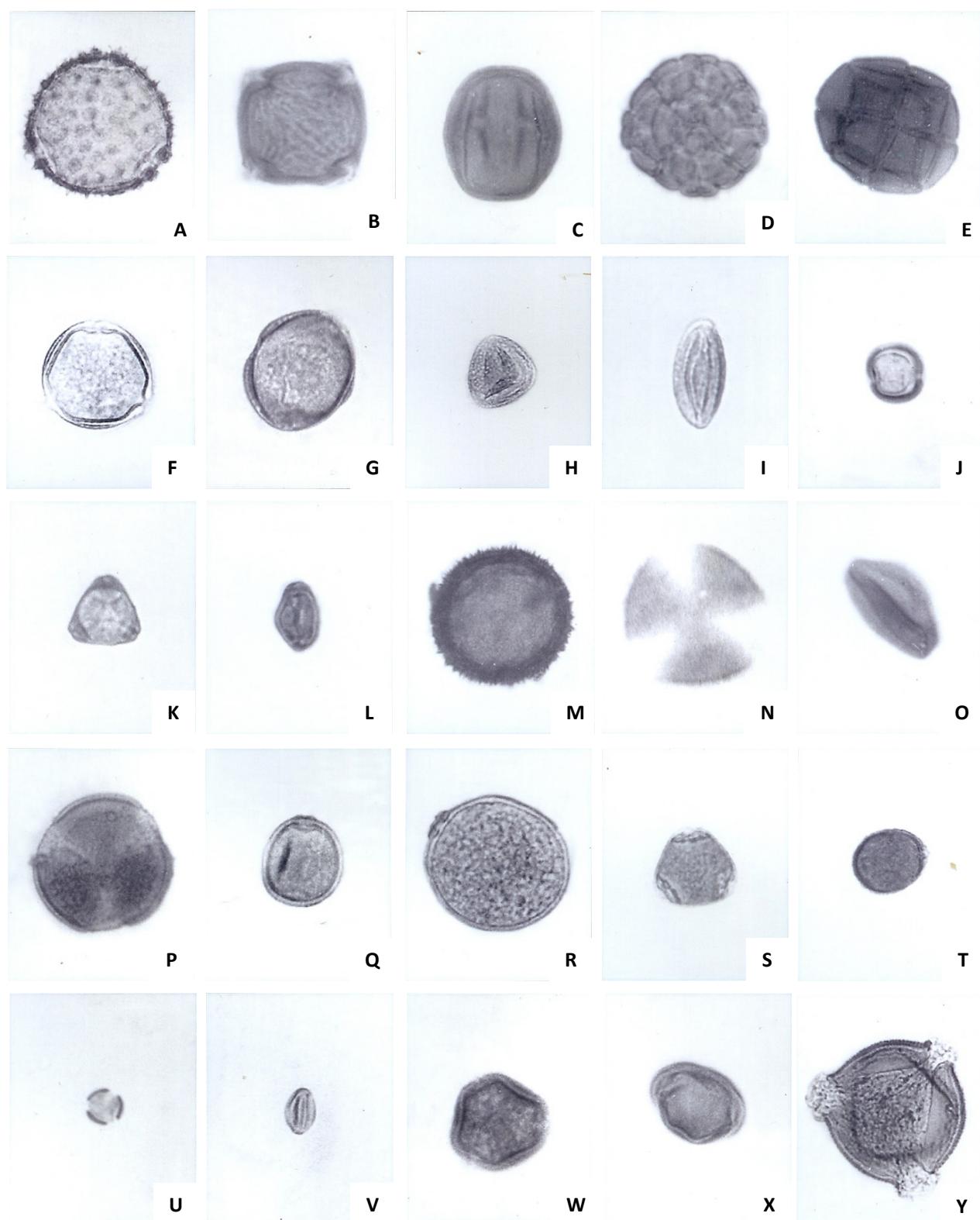
Flowering Period: February - April; Mode of pollination: Amphiphilous.

Pollen Morphology (Fig. 2U&2V): 3-zonocolpate, prolate, size 14 x 9.3  $\mu\text{m}$  (range: 13–15.5 x 7.6–11  $\mu\text{m}$ ); colpi membrane thin, endocolpium indistinct; exine 1.5  $\mu\text{m}$ , psilate.

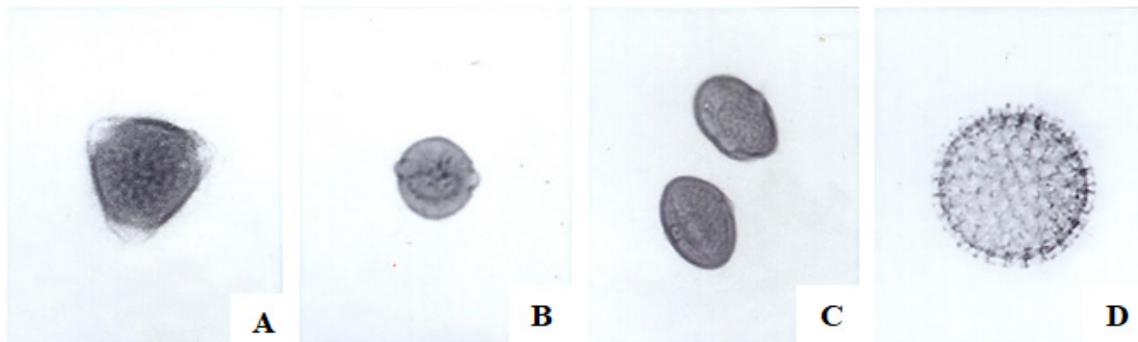
*Ailanthus excelsa Roxb.*

Local Name: Motio-Aduso; Family: Simaroubaceae; Habit: A large tree.

Flowering Period: December -March; Mode of pollination: Amphiphilous.



**Fig. 2:**Pollen grains A. *Abutilon indicum* (PV); B. *Azadirachta indica* (PV); C. *Azadirachta indica* (EV); D. *Acacia nilotica* (SV); E. *Albizia lebbeck* (SV); F. *Prosopis cineraria* (PV); G. *Prosopis cineraria* (EV); H. *Prosopis juliflora* (PV); I. *Prosopis juliflora* (EV); J. *Moraceae* (PV); K. *Eucalyptus globulus* (PV); L. *Eucalyptus globulus* (EV); M. *Boerhavia diffusa* (SV); N. *Argemone mexicana* (PV); O. *Argemone mexicana* (EV); P. *Crotalaria burhia* (PV); Q. *Cynodon dactylon* (PV); R. *Pennisetum typhoides* (PV); S. *Ziziphus nummularia* (PV); T. *Ziziphus nummularia* (EV); U. *Salvadora persica* (PV); V. *Salvadora persica* (EV); W. *Ailanthus excelsa* (PV); X. *Ailanthus excelsa* (EV); Y. *Datura innoxia* (EV).



**Figure 3:** Pollen grains A. *Solanum surattense* (PV); B. *Solanum surattense* (EV); C. *Corchorus tridens* (EV); D. *Tribulus terrestris* (SV).

## Key to airborne Pollen Grains

### I. Pollen grains winged

:*Pinus spp.*

### II. Pollen grains simple

:Cyperaceae

1. Grains with rudimentary aperture and pyriform in shape

:A

2. Grains porate

:B

A1. Grains 1-porate

:Poaceae (Cult.)

B1. Grain size more than 35µm

:Poaceae (wild)

B2. Grain size less than 35 µm

:Moraceae

A2. Grains 2-zonoporate

:*Xanthium strumarium*

A3. Grains 3-zonoporate

:B

A4. Grains pantoporate

:C

B1. Grain size more than 45µm

:*Tribulus terrestris*

C1. In Iumina of each brochus a pore is present

:D

C2. Distribution of pore is not as above

D1. Exine surface spinate

:*Ipomoea cariaca*

D2. Exine surface spinulate

:*Boerhavia diffusa*

B2. Grain size less than 45 µm

:Amaranthaceae

:Chenopodiaceae

3. Grains 3-zonocolpate

:A

A1. Exine psilate

:B

B1. Grain prolate

:*Salvadora persica*

B2. Grain prolate-spheroidal

:*Glinus lotoides*

A2. Exine granulate

:*Indigofera cordifolia*

A3. Exine reticulate

:B

B1. Grain size more than 30 µm

:*Argemone Mexicana*

B2. Grain size less than 30 µm

:Brassicaceae

4. Grains colporate

:A

A1. Grains 3-zonocolporate

:B

B1. Exine surface psilte or faintly granulate

:C

C1. Grains prolate

:*Heliotropium curassavicum*

C2. Grains subprolate

:D

D1. Endocolpium circular

:*Lawsonia inermis*

D2. Endocolpium lalongate

:*Dalbergia sissoo*

C3. Grains oblate-spheroidal

:*Solanum surattense*

C4. Grains oblate

:*Eucalyptus globulus*

B2. Exine surface granulate

:*Corchorus tridens*

B3. Exine surface foveolate

:*Ziziphus nummularia*

B4. Exine surface faintly reticulate

:C

C1. Grains prolate

:*Cleome gynandra*

C2. Grains subprolate

:*Crotalaria burhia*

C3. Grains oblate-spheroidal

:*Ailanthus excelsa*

B5.	Exine surface clearly reticulate	:C
C1.	Grains subprolate	: <i>Prosopis cineraria</i>
C2.	Grains prolate-spheroidal	: <i>Ricinus communis</i>
B6.	Exine surface striato-reticulate	: <i>Datura innoxia</i>
B7.	Exine surface pilate	: <i>Prosopis juliflora</i>
B8.	Exine surface tagillate	: <i>Apiaceae</i>
B9.	Exine surface spinate	:C
C1.	Grain size 65 µm	: <i>Abutilon indicum</i>
C2.	Grains size less than 35 µm	: <i>Asteraceae</i>
A2.	Grains 4-zonocolporate	: <i>Meliaceae</i>
5.	Grains 3-zonocolporoidate with exine surface faintly reticulate	: <i>Capparis decidua</i>
6.	Grains 3-zonocolpoidate with echinolophate exine surface	: <i>Launaea fallax</i>
		: <i>Sonchus asper</i>
		: <i>Acacia nilotica</i>
		: <i>Albizia lebbeck</i>

### III. Pollen grains in polyad

1. Polyad size 40 µm
2. Polyad size 65 µm

Pollen Morphology (Fig. 2W&2X): 3-zonocolporate, oblate-spheroidal, size 22.1 x 27.3 µm (range: 21–24.5 µm x 26–29.5 µm) endocolpium circular; exine 3.3 µm, sexine is as thick as nexine, faintly reticulate.

*Datura innoxia* Mill.

Local Name: Dhatura; Family: Solanaceae; Habit: Annual herbs. Flowering Period: September - March; Mode of pollination: Entomophilous.

Pollen Morphology (Fig. 2Y): 3-zonocolporate, oblate-spheroidal, size 43.1 x 46.7 µm (range: 38.5–53.3 x 40–56.6 µm); endocolpium elongate, exine 2 µm, sexine thicker than nexine, striato-reticulate.

*Solanum surattense* Burm. F.

Local Name: Bhur hingani, Ringani, Adkuntali; Family: Solanaceae; Habit: A very prickly, perennial herb.

Flowering Period: Almost throughout the year; Mode of pollination: Entomophilous

Pollen Morphology (Fig. 3A&3B): 3-zonocolporate, oblate-spheroidal, size 18.3 x 19.8 µm (range: 16.5–19 µm x 17–20 µm); endocolpium elongate, exine 1.5 µm, sexine thicker than nexine, psilate.

*Corchorus tridens* Linn.

Local Name: Kagnasha; Family: Tiliaceae; Habit: An annual herb. Flowering Period: August - December; Mode of pollination: Anemophilous

Pollen Morphology (Fig. 3C): 3-zonocolporate, prolate, size 25.9 x 63.3 µm (range: 23.3–26.6 µm x 16.6–18.36.5 µm) endocolpium lolongate; exine 2 µm, sexine as thick as nexine, granulate.

*Tribulus terrestris* Linn.

Local Name: Kanti; Family: Zygophyllaceae; Habit: A prostrate herb. Flowering Period: August - December; Mode of pollination: Anemophilous

Pollen Morphology (Fig. 3D): Grain pantoporate, spheroidal, diameter 45.7 µm (range: 43–50 µm); exine 6.5 µm, reticulate, sexine as thick as nexine, reticulate; in lumina of each brochus a pore is present with pore diameter 4 µm.

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