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Aeropalynological study in Rohtak city, Haryana, India: a 2-year survey

Manisha Ahlawat · Pushpa Dahiya · Dhruva Chaudhary

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Abstract An aeropalynological survey was conducted at two different sites in Rohtak city, Haryana, at a height of 1.8 m, three times a day, for two consecutive years (July 2007–June 2009). A total of 31 pollen types were identified to the lowest taxonomical level whenever possible. The major contributor to the pollen load was *Cannabis sativa* (28.9 %) followed by Poaceae (20.65 %), Chenopodiaceae/Amaranthaceae (10.56 %), *Parthenium hysterophorus* (6.80 %), *Morus alba* (6.15 %), *Artemisia* sp. (4.03 %), *Cyperus* sp. (3.20 %) and *Eucalyptus* sp. (3.07 %). Two major pollen seasons were recognized, that is, July–October and March–April, although pollen was recorded in varying concentrations all along the year. Spatial variations were also observed, with higher pollen loads at the site surrounded by dense vegetation. The study will provide preliminary but useful data to local allergologists for effective diagnosis and treatment of respiratory allergic ailments.

Keywords Pollen · Hypersensitivity · Spatial variations · Seasonal variations

M. Ahlawat · P. Dahiya (✉)
Department of Botany, Maharshi Dayanand University, Rohtak 124001, Haryana, India
e-mail: pushpa.dahiya@hotmail.com

D. Chaudhary
Department of Pulmonary and Critical Care Medicine, University of Health Sciences, Rohtak, Haryana, India

1 Introduction

Pollen is male gametophytic generation of seed plants and acts as a vehicle for the transport of gametes to female reproductive structure (pistil). Nature employs different agencies for accomplishment of this process, the most common being wind. Due to their aerial prevalence all year round, they play a major role in the pathogenesis of respiratory allergic ailments, particularly allergic rhinitis and bronchial asthma (Kang et al. 1979; Nair et al. 1986; Belmonte et al. 1998; Leuschner et al. 2000; Singh and Kumar 2003; Garcia-Mozo et al. 2006; Shukla and Shukla 2010). These diseases are in rising phase worldwide including Asian countries (Weeke 1992; Chhabra et al. 1998; Singh and Kumar 2003; Gaur et al. 2004; Harwanegg and Hiller 2004; DÁmato et al. 2007). The rise is mainly attributed to urbanization, industrialization, environmental pollution and change in lifestyle (Hussan et al. 2002; Singh and Dahiya 2008; Sharma et al. 2009).

For effective management of these ailments, detailed information on the type and concentration of airborne pollen is prerequisite. Therefore, aeropalynological studies are important to understand the pollen spectrum of different geographical areas (Newmark 1968; Singh and Babu 1982; Solomon 1983; Lewis et al. 1984; DÁmato and Lobefalo 1989; Agashe and Alfadil 1989; Malik et al. 1991).

A lot of information is available on airborne pollen types from temperate countries, but the subject has received relatively less attention in tropical and

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subtropical countries. India not only is a subcontinent of rich biodiversity, but also has various geoclimatic zones with marked seasonal fluctuations in temperature and relative humidity. Therefore, it is imperative that investigations of aerial microflora of different geographical regions be carried out as prevalence of pollen is determined by the diversity of local flora and prevailing climatic conditions (Bush 1989; Jato et al. 2002; Gioulekas et al. 2004; Mandal et al. 2008). Moreover, spatial variations should also be assessed within the same geographical region in order to get a wider view of pollen spectrum of that area (Frenz 2000; Mandal et al. 2006).

In India, atmospheric surveys on airborne pollen were initiated in Delhi, the capital city (Dua and Shivpuri 1962), and Jaipur (Kaliswal et al. 1959). The studies have been continued by other workers in different parts of the country from time to time (Singh and Babu 1982; Nair et al. 1986; Malik et al. 1990; Arora and Jain 2001; Singh et al. 2003; Mandal et al. 2008; Shukla and Shukla 2010). However, no such information is available from Haryana, a landlocked state in Northern India with semi-arid climatic conditions. Keeping this in view, the present study was undertaken to monitor the pollen grains in the atmosphere of Rohtak city, Haryana, for a period of 2 years (July 2007–June 2009). Since most of the people are exposed to pollen at lower height, it was considered appropriate to study the pollen load at a height of 1.8 m as an aid for diagnosis and treatment of allergic disorders of local inhabitants.

2 Materials and methods

2.1 Survey area

The present investigation was carried out in Rohtak city located in the South East of Haryana state in Northern India. The city is situated 28°50' N 76°40′ E and covers an area of 1668.47 km^2. The mean maximum and mean minimum temperatures of the city are 40.5 and 7 °C, respectively. The city receives an average annual rainfall of 592 mm. In the present study, two fixed sampling sites were selected: site I located in centre of the city surrounded by densely populated area. Flora around the site is mainly composed of shrubs like *Hibiscus rosa indica*, *Cassia occidentalis*, *Lantana camara*, *Rosa* sp. and *Calendula* sp., which are mainly cultivated for ornamental purposes. Beside these, fruit-yielding trees like *Morus alba*, *Syzygium cumini*, *Mangifera indica*, *Psidium guajava* and *Carica papaya* are predominant. Herbaceous vegetation occurs spontaneously in open areas and mainly includes plants belonging to families like Poaceae, Asteraceae, Cyperaceae, Chenopodiaceae and Amaranthaceae. Site II is located on the outskirts of the city with recent urban expansion. It is surrounded by cultivated fields with crops like *Triticum aestivum*, *Brassica campestris*, *Pennisetum americanum*, *Saccharum officinarum* and *Sorghum bicolor*. Road-side plantations include avenue trees like *Eucalyptus reglans*, *Albizzia lebbeck*, *Acacia nilotica*, *Cassia fistula* and *Delonix regia*. Luxuriant growth of weeds like *Parthenium hysterophorus*, *Cannabis sativa* and seasonal grasses also occurs in vacant places.

2.2 Sampling technique

Atmospheric survey for airborne pollen concentration in Rohtak city was carried out for two consecutive years (July 2007–June 2009) at a fixed height (1.8 m), using a personal volumetric glass slide sampler (Gautam Enterprises, New Delhi). It is portable, battery-/power-operated sampler with a flow rate of 10 L/min. It has a rectangular orifice at top for suction of air and a slit on the side to insert the glycerine-coated microslide. The sampler was operated for 20 min at weekly intervals, and samples were collected from both the sites at three times a day (08, 14, 20 h) for practical convenience. Airborne particles get deposited onto the slide in form of a rectangular streak. The exposed slides were mounted with 22 × 22 cover glass and scanned for different pollen types at 40× magnification.

2.3 Pollen identification

Identification of pollen types was done with the help of reference slides prepared directly with pollen of known taxa. Continuous observation of flowering period of the plants in the region has made possible the assessment of the major contributing sources for each pollen type appearing on the exposed slides. Beside this, published literature was also consulted (Erdtman 1952; Lewis et al. 1984; Nair et al. 1986). The pollen concentration was derived by counting pollen count

and dividing by volume of air sampled (20 min × 10 L/min × 0.001 m^3/L = 0.2 m^3).

3 Results

3.1 Pollen diversity

A total of 31 pollen types were trapped as a result of 624 samples collected during 2 year of survey period. Depending on their morphological features, they were identified up to family, genus or species level (Table 1). Pollen of grasses could not be identified up to generic level and thus were included under Poaceae. Pollen of *Chenopodium* sp. and *Amaranthus* sp. was grouped together as Cheno/Amaranth due to their stenopalynous nature. A small fraction (1.13 %) of pollen flora remained unidentified because of their distorted nature.

Pollen from herbs dominated the spectrum (79.43 %) followed by trees (16.71 %) and shrubs (3.86 %). Based on the average relative percent contribution obtained from the two sites of Rohtak city, eight predominant pollen types comprised about 83.36 % of the total pollen catch. *Cannabis sativa* pollen type with a mean concentration of 54.57 pollen/m^3 was the major contributor (28.90 %) to the total catch. Poaceae (20.65 %) and Cheno/Amaranth (10.5 %) followed the list with mean concentration of 29.78 and 14.71 pollen/m^3, respectively. *P. hysterophorus* and *M. alba* contributed 6.80 % and 6.15 %, respectively, followed by *Artemisia* sp., *Cyperus* sp. and *Eucalyptus* sp. (Table 2).

3.2 Seasonal variations

Seasonal variations of total and eight dominant pollen types encountered during the survey period are given in Figs. 1 and 2.

Two pollen seasons were recognized for Rohtak city—(1) July–October and (2) March–April—although pollen grains were recorded throughout the year. From Site I, the maximum pollen catch (3,385 pollen/m^3) was observed during the first year of investigation in the month of March 2008, whereas in the next year, the highest catch (2,405 pollen/m^3) was recorded in October 2008. From Site II also, highest pollen concentration of 7,550 pollen/m^3 was recorded during the first year of survey in September 2007. August was the month with maximum catch (6,145 pollen/m^3) in second year.

3.2.1 *Cannabis sativa*

Major season for *Cannabis* pollen comprised from May to September. The highest concentration was observed in the month of September during both years from Site II with 5,396 pollen/m^3 and 610 pollen/m^3, respectively. However, from Site I, August was the month with highest pollen catch during both the years of survey.

3.3 Poaceae

Pollen of Poaceae family exhibited peaks in February–April and August–October, although they were trapped in all months in different concentrations. From Site I, highest (665 pollen/m^3) and lowest (70 pollen/m^3) concentrations were recorded during the same year of survey (2008–2009) in March and January, respectively. However, from Site II maximum concentration (1,365 pollen/m^3) was recorded during August 2007 and minimum (55 pollen/m^3) in July 2007.

3.4 Cheno/Amaranth

The pollen of Cheno/Amaranth group was sporadically recorded throughout the year, with a peak from September to November. The highest concentration was obtained in the month of October 2007 and September 2008 from Site I and II, respectively. No pollen was trapped from Site II in the month of February 2008.

3.4.1 *Parthenium hysterophorus*

The aerial concentration of pollen revealed a peak from May to September with highest concentration of 515 pollen/m^3 and 725 pollen/m^3 from Site I and II, respectively. No pollen was recorded from December–March in the year 2007–2008 at Site II. However, from Site I, pollen was observed in all the months except for February.

3.4.2 *Morus alba*

The pollen showed a very short and distinct season from February to March. A characteristic peak was observed in the month of March 2008 with 1,290 pollen/m^3 at Site I and 3,075 pollen/m^3 at Site II. During 2008–2009, highest concentration of 240 pollen/m^3 and 290 pollen/m^3 was observed in the month of March 2009 and February 2009 at Site I and II, respectively.

Table 1 Pollen identified from the atmosphere of Rohtak city along with their season

Pollen type	Family	Season
Achyranthes sp.	Amaranthaceae	February–April
Aerva sp.	Amaranthaceae	October–April
Ageratum sp.	Asteraceae	Throughout the year
Albizzia sp.	Mimosaceae	January–September
Argemone sp.	Papaveraceae	November–May
Artemisia sp.	Asteraceae	September–October
Azardirachta sp.	Meliaceae	February–June
Bauhinia sp.	Caesalpiniaceae	February–March
Brassica sp.	Brassicaceae	January–April
Callistemon sp.	Myrtaceae	February–March
		October–November
C. sativa	Cannabinaceae	March–September
Cassia sp.	Caesalpiniaceae	April–June
Cheno/Amaranth	Chenopodiaceae/Amaranthaceae	July–November
Citrus sp.	Rutaceae	February–March
Croton sp.	Euphorbiaceae	July–October
Cyperus sp.	Cyperaceae	July–December
Dalbergia sp.	Papilionaceae	February–March
Emblica sp.	Euphorbiaceae	March–April
Eucalyptus sp.	Myrtaceae	January–April
Gomphrena sp.	Amaranthaceae	July–September
Ipomeae sp.	Convolvulaceae	September–November
Mangifera indica	Anacardiaceae	January–April
M. alba	Moraceae	February–April
Parthenium hysterophorus	Asteraceae	Throughout the year
Poaceae		Throughout the year
Polyalthia sp.	Annonaceae	April–mid-May
Pongamia sp.	Papilionaceae	March–April
Prosopis sp.	Fabaceae	January–May and July–November
Ricinus communis	Euphorbiaceae	January–April
Salvadora sp.	Salvadoraceae	March–April and November–December
Xanthium sp.	Asteraceae	September–December

3.4.3 Artemisia sp.

A pollen season from September to November was recorded with additional small peak in February (Site II) and January/March (Site I). The highest concentrations for both years were recorded in the month of October with 685 pollen/m^3 in 2007 and 1,010 pollen/m^3 in 2008.

3.4.4 Cyperus sp.

The peak season recorded was from June to September. Among the two sites, maximum concentration was obtained from Site I during both years of investigation in the month of July 2007 (160 pollen/m^3) and September 2008 (405 pollen/m^3). Low pollen catch was recorded from October to April from both the sites.

3.4.5 Eucalyptus sp.

The pollen exhibited a high concentration from January to April with maximum catch of 485 pollen/m^3 in March 2008 and 205 pollen/m^3 in February 2009 from Site I. No pollen was encountered from May to October during the survey period.

Table 2 Average percent contribution, percent during peak season and pollen concentration of dominant pollen (June 2007–July 2009) from both the sites

Pollen types*	Average percent contribution	Percent during peak pollen season	Total no. of pollen in 624 samples	Mean no. of pollen/sample	Mean pollen concentration/m^3 air
Cannnabis sativa	28.9	87.4	6,287	10.07	50.37
Poaceae	20.65	63.22	3,431	5.49	27.49
Cheno/Amaranth	10.56	53.96	1,695	2.71	13.58
P. hysterophorus	6.80	78.24	1,086	1.74	8.70
M. alba	6.15	98.9	1,057	1.69	8.46
Artemisia sp.	4.03	95.9	693	1.11	5.55
Cyperus sp.	3.20	89.5	557	0.89	4.46
Eucalyptus sp.	3.07	83.0	481	0.77	3.85

* Types other than these contributed less than 3 %

Percentage of individual pollen was calculated against total pollen counted

Total pollen concentration = 84,495/m^3

3.5 Distinct patterns within a day

Average pollen catch of total pollen types was higher in the morning from both the sites. When individual pollen types were analysed, *C. sativa* showed a morning pattern. Pollen of Poaceae family and Cheno/Amaranth group exhibited high catch in the morning and afternoon when compared with evening time. However, a distinct afternoon pattern was reflected by *M. alba* pollen (Fig. 3).

4 Discussion

As a result of aeropalynological investigation carried out, 31 pollen types were identified. Of these, all the eight dominant pollen types analysed are reported aeroallergens from different geographical areas of India (Tilak and Vishwanathan 1980; Singh and Kumar 2003; Mandal et al. 2008). The present study exhibited dominance of pollen from herbaceous vegetation. Predominance of these pollen types was also reported by workers from different geographical regions in India (Singh and Babu 1980b; Sudha and Agashe 1996; Mishra et al. 2002; Singh et al. 2003, Sahney and Chaurasia 2008). Low contribution of pollen from trees and shrubs could be due to their low frequency of occurrence and short flowering season of some plants belonging to these groups. The height at which sampling was carried out might also be responsible for low pollen catch from tree species (Malik et al. 1991).

In general, two peaks for airborne pollen of Rohtak city were observed: first in March–April and the second in July–October. The first peak was dominated by pollen of trees, whereas in the second peak, pollen from grasses and weeds was predominant. Maximum number of plants produce flowers during these periods, releasing huge amount of pollen in the atmosphere due to their anemophilous nature. This contributed to their high aerial prevalence. June was the month with least pollen catch at both the sites due to poor vegetation and scanty pollination during this time. Our results are in concordance with earlier reports from Delhi (Dua and Shivpuri 1962; Malik et al. 1991). Sharma and Dharke (1995) also reported March to April to be the flowering period for trees and October for herbs from Agra city.

Cannabis sativa contributed more than one-fourth to the average percent contribution, of which 87.4 % are found during peak season. Luxuriant growth of this weed in vacant places and along road sides together with its high pollen production contributed to its dominance in the atmosphere. High concentration of *C. sativa* pollen at human height from Delhi was also reported by Singh et al. 1993. Pollen belonging to Poaceae family and Cheno/Amaranth group also contributed substantially to the pollen spectrum. Wider distribution of grasses along with their long pollination period and strictly anemophilous nature was responsible for their high representation. Poaceae pollen has been reported among the dominant types by workers from different parts of India (Dua and

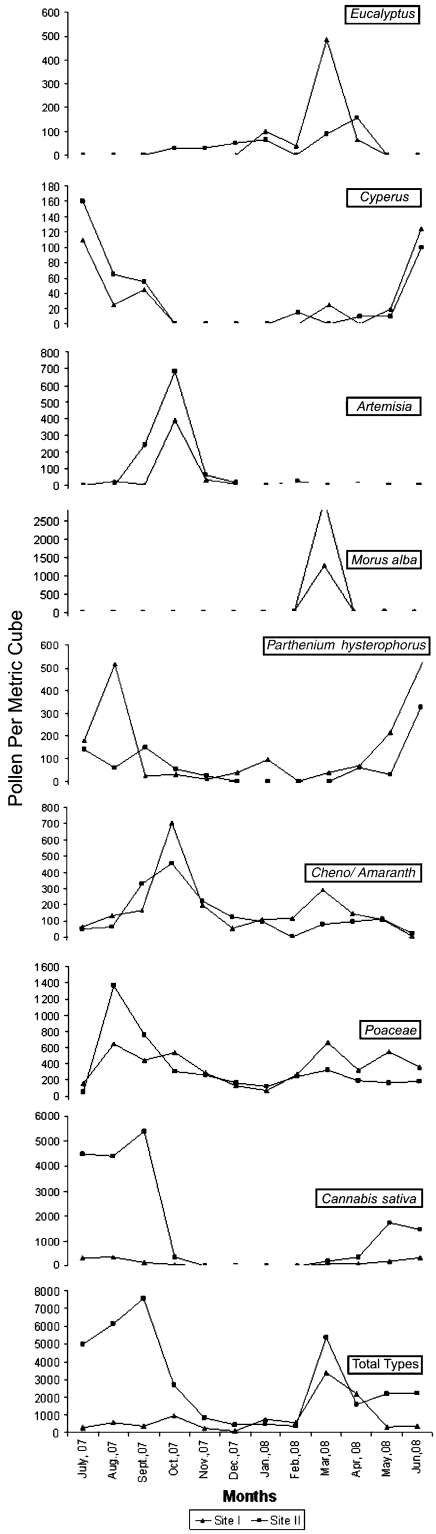


Fig. 1 Seasonal Variations of total pollen and eight dominant types (July 07–June 08)

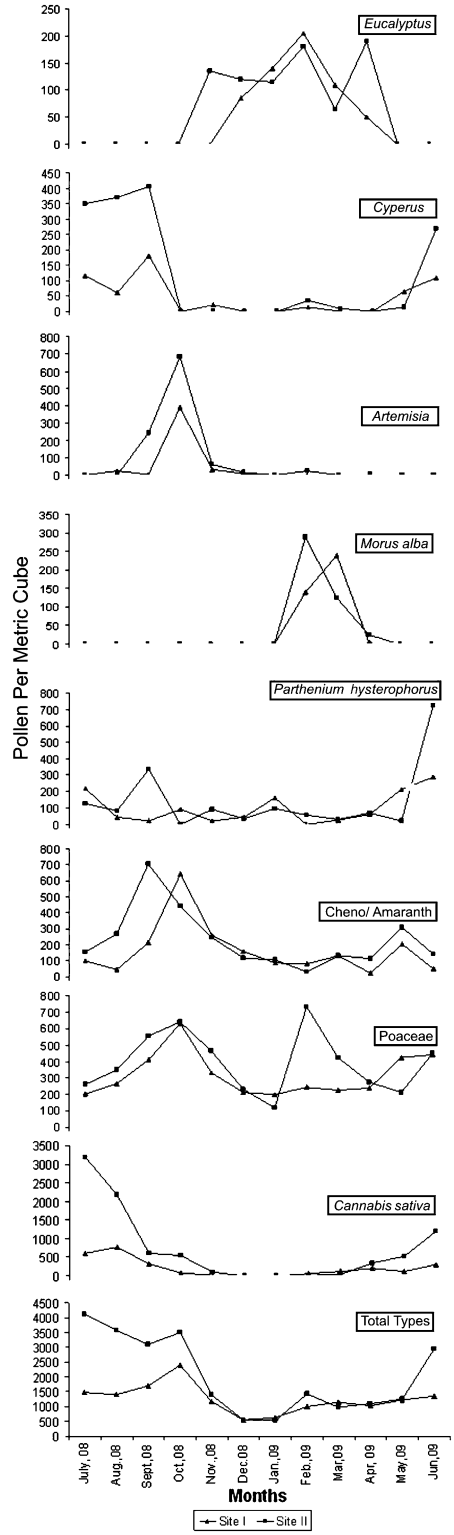


Fig. 2 Seasonal Variations of total pollen and eight dominant types (July 08–June 09)

Shivpuri 1962; Singh and Babu 1980a, 1982; Malik et al. 1990; Singh et al. 2003; Mandal et al. 2008). From Saudi Arabia, Alwadie (2008) reported pollen from Poaceae family as major contributor within a day to total pollen load. The dominance of this pollen in the atmosphere of Rohtak city is of great interest as it is reported to induce pollinosis, particularly in summer/winter (Singh and Kumar 2003; Mandal et al. 2008).

The high prevalence of pollen from Cheno/Amaranth group might be due to widespread occurrence of these weeds in the proximity of the sampling sites, especially along road sides and vacant lots. Short and precise pollen season of *M. alba* was responsible for its characteristic peak in March. This is in consensus with the observations made by earlier workers (Malik et al. 1991; Singh et al. 2003).

Parthenium hysterophorus, an exotic weed and aggressive colonizer, has occupied practically every part of the city and grows almost throughout the year. The vigorous nature of this weed and aerial abundance of its pollen have also been reported from different geographical zones of India (Tilak and Vishwanathan 1980; Agashe et al. 1983; Malik et al. 1990; Shukla and Shukla 2010). High aerial prevalence of *P. hysterophorus* pollen is of great significance to the survey area as it has been reported to be an important aeroallergen from different parts of the country (Subbarao et al. 1985; Singh and Kumar 2003; Mandal et al. 2006). *Artemisia* sp. and *Cyperus* sp. pollen also dominated the pollen spectrum as semi-arid areas like the one under study favours the growth of these species. Pollen season for *Artemisia* sp. comprised from August to November, which is slightly variable from earlier reports (Singh et al. 1993, 2003). Extensive plantation of *Eucalyptus* sp. as urban tree in public avenues accounts for a high prevalence of its pollen in the air. Although *Eucalyptus* is mostly entomophilous in nature, its pollen is released in the atmosphere in large amounts during high breeze.

Average pollen concentration of total and few individual types obtained from two sites revealed spatial variations. Site II encountered higher pollen load since in close vicinity vacant lands inhabited by annual and perennial weeds are found. Moreover, surrounding cultivated fields might have also contributed to higher pollen catch. Lower counts recorded from Site I could be due to its location in the city centre, which corresponds to poor vegetation cover. Similar correlation between pollen concentration and surrounding vegetation has also been reported by other works (Romano 1988; Mandal et al. 2006). Spatial variability in the airborne pollen types has also been reported by Frenz (2000), showing that nearby vegetation has profound local influence on airborne pollen.

Average pollen catch obtained from both the sites was higher in the morning as pollen types such as *C. sativa*, *M. alba*, *Artemisia* sp. and *Eucalyptus* sp. were prevalent during this time. Pollen of Poaceae family was encountered in high concentrations both in the morning and in the afternoon. Morning patterns for this pollen were also reported by Singh and Babu (1980b), whereas Malik et al. (1991) observed high

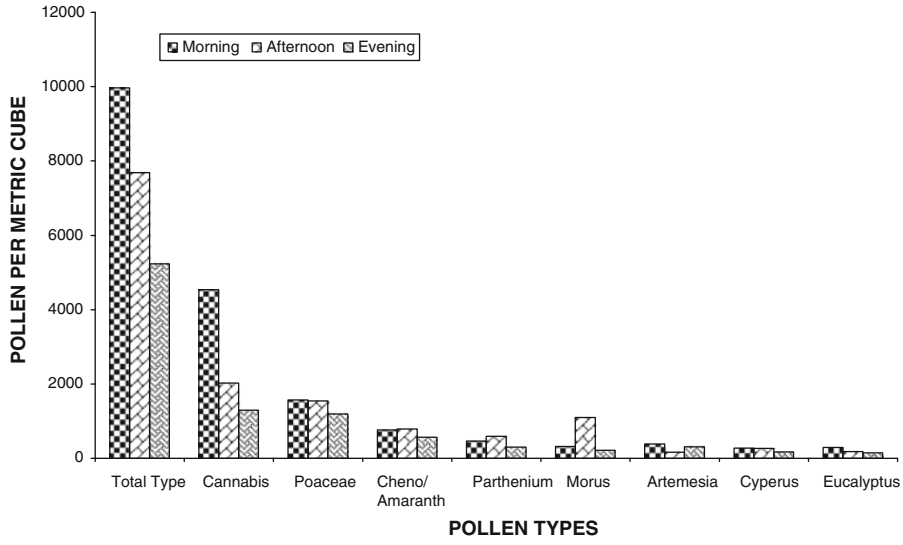


Fig. 3 Distinct patterns within a day of total and dominant pollen types

catch in the afternoon from different zones of Delhi. It is important to note that pollen of *P. hysterophorus* was high in the afternoon, as also reported by Malik et al. (1991).

5 Conclusion

The uniqueness of the present study is that it presents the first results of airborne pollen monitoring undertaken at Rohtak city, Haryana. The pollen spectrum showed seasonal variability with well-defined peak in autumn and spring. Pollen grains of *C. sativa* and Poaceae family were the major contributors to the total pollen load. Pollen from herbaceous plants was more abundant. Of the two sites selected, Site II encountered high pollen load due to its close vicinity to vacant lands and cultivated fields.

As the many of the pollen types encountered during the study are reported allergens, the data collected will be useful to the clinicians in identifying the potential allergy risk seasons and thus managing respiratory allergies of local inhabitants. Such studies should be carried out on a long-term basis with more number of sampling stations in order to develop predictive models of airborne pollen concentrations in the city. The present work is being continued for studying long trends of seasonal and annual variations of airborne pollen.

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