



POLLEN RAIN STUDIES IN THE ENVIRONS OF TAJMAHAL, AGRA

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ABSTRACT

Present paper attempts to evaluate the palynoflora in the environs of the Taj complex. The overall pollen assemblage depicts that the environs of Taj are charged with palynomorphs from higher as well as lower plant groups which include trees, shrubs, herbs, ferns, bryophytes, fungi, etc. However, a few recovered taxa are most probably exotic as they do not grow either in the area or in the vicinity. Pollen analysis of spider's webs in the present study has opened an important frontier in evaluating the modern pollen rain. Spider's webs are often quite rich in pollen/spores, etc., and have proved to be a reliable parameter, particularly when soil samples are either unproductive or remain poor in pollen yield.

Furthermore, comparison of recovered taxa from surface soil and web has amply demonstrated that spider's webs are as good as soil samples and sometimes even better for pollen rain studies. Retrieval of fungal spores from the walls of the main gate of the Taj complex, must be taken care of as their deposition is very likely to affect the lustre of the marble monument in the long run.

Keywords: Surface samples, spider's webs, soil samples, palynomorphs, pollen spectra, Tajmahal, Agra

INTRODUCTION

Agra (Latitude 27°N 09'; Longitude 78°E), about 225 km from Delhi, is located between Mathura and Surajpur in Uttar Pradesh. The city was founded by Badal Singh in 1475 and is now the world-famous tourist attraction for its Moghal period monument - the Taj mahal, besides many other archaeological monuments. Taj mahal stands on the west bank of river Yamuna. It is one of the most spectacular monument constructed between 1631-1653 by the Mughal emperor Shahjahan. The garden layout has a total area of $\pm 580 \times 300$ m and covers most of the Taj complex. The Charbagh gardens separated by the water courses originating from the central, raised pool, were divided into 16 flower beds, making a total of 64. There are 400 plants in each bed. All the trees, either *Cyperus* (signifying death) and fruit trees (signifying life) were planted to maintain the symmetry. A green carpet of garden, a Persian garden, also runs from the main gateway to the foot of the Taj mahal.

The present site selected for the first time for pollen analytical studies, aims at the evaluation of air-borne pollen/spores, etc. in this region and the reconstructed pollen spectra as well as Pollen deposition model from Taj gardens have provided a true picture of the extant vegetation of this area. The investigations not only summarise the results in totality but also compare the taxa retrieved from the soil samples as well as spider's webs.

VEGETATION

The present vegetation of Agra District reflects extreme degradation of natural forests attributed to excessive interference for centuries in the light of Mughal Period human activities particularly construction of many red-sandstone huge monuments in and around Agra City. Nevertheless, existing floristic composition of Agra region is not very different than what has been catalogued for the adjoining districts of Bharatpur (Prasad, 1988, 1989; Prasad *et al.*, 1991) and Delhi (Maheshwari, 1963). The bulk of permanent vegetation is xerophytic and semi-arid type, comprising mostly shrubby elements and scattered trees-the former often forming gregarious patches in open wasteland. The noteworthy arboreals are *Aca-*

cia nilotica, *A. luecophloea*, *A. sensgal*, *A. modesta*, *A. cat-echu*, *Anogeissus pendula*, *Azadirachta indica*, *Albezzia lebbeck*, *Balanites roxburghii*, *Butea monosperma*, *Cordia dichotoma*, *C. rothii*, *Crataeva nuruvata*, *Dalbergia sissoo*, *Dichrostachys cinerea*, *Ehretia laevis*, *Feronia limonia*, *Holoptelea integrifolia*, *Parkinsonia aculeata*, *Prosopis spicigera*, *Wrightia tinctoria*, *Zizyphus mauritiana*, etc.

Among the shrubs, clumps of unarmed *Adhatoda vasica* are the most commonly seen element often with its co-dominant thorny *Capparis sepiaria* and *C. decidua*. *Calotropis procera*, *Euphorbia decidua*, *Clerodendrum phlomidis* are other few common shrubby elements. The mesquites - chiefly *Prosopis juliflora* introduced in the country at the beginning of last century and now very well established- is the most commonly seen element throughout the region.

The prominent herbaceous elements (seasonal, ephemerals and annuals) mainly belong to the families Amaranthaceae, Tiliaceae, Acanthaceae, Asteraceae, Convolvulaceae, Commelinaceae, Zygophyllaceae, Cyperaceae and Poaceae. Omnipresent species are - *Tridax procumbens*, *Achyranthus aspera*, *Andrographis paniculata*, *Anisomeles indica*, *Corchorus spp.*, *Argemone mexicana*, *Tribulus terrestris*, *Ageratum haustorianum*, *Lantana camara*, *Cassia tora*, *Peristrophe bicalculata*, *Crotalaria medicaguinea*, *Solanum surrantense*, *Triumfetta rhomboides*, *Croton bonplandianum*, *Tephrosia purpurea*, *Justicia simplex*, etc. These are the most commonly growing weeds of wasteland and *Eichornia crassiseeps* covering almost every ditch and pond.

Among the limnicolous, submerged and free-floating plant species, most commonly growing taxa are *Xanthium strumarium*, *Asteracantha longifolium*, *Polygonum barbatum*, *Typha angustata*, *Cyperus spp.*, *Echinocola crusgalli*, *Potamogeton crispus*, *P. pictinatus*, *Hydrilla verticillata*, *Vallisneria spiralis*, *Cerartophyllum demersum*, *Marsilea minuta*, *Nymphaea nouchali*, *Jussia repens*, *Ipomea reptans*, *Azolla pinnata*, *Lemna spp.*, *Utricularia spp.* etc

CLIMATE

Agra enjoys subtropical climate - typical to the north In-

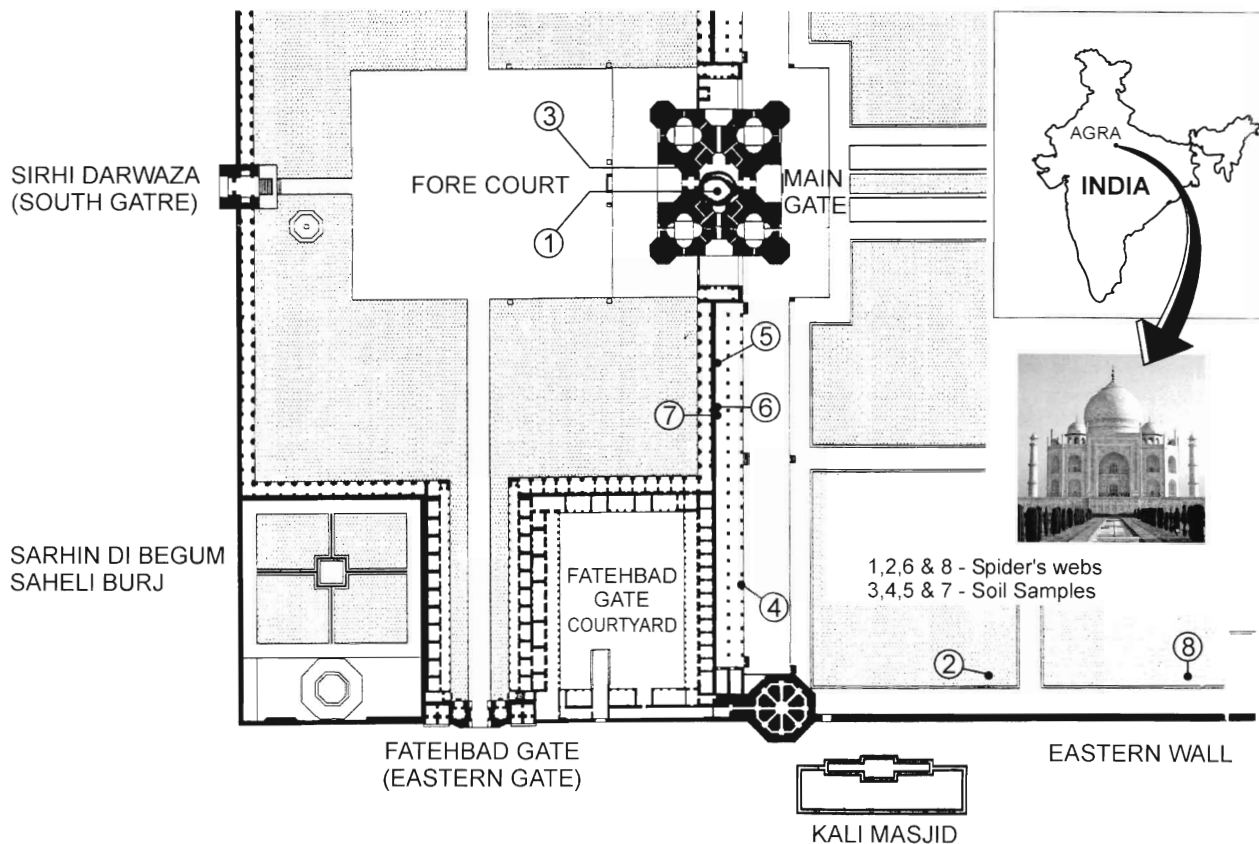


Fig. 1. Taj Complex

Sampling sites

1. Spider's webs collected from the inner side of the main gate.
2. Spider's webs collected from the bush growing in charbagh garden near Kali Masjid.
3. Mud collected from the corner wall of the main gate.
4. Mud collected from one of the pillars of the varandah near main gate.
5. Mud collected from the walls of the varandah.
6. Spider's webs collected from the walls of the varandah.
7. Mud collected from the walls of the varandah.
8. Spider's webs collected from the bush in charbagh garden.

dian gangetic plains. Summer temperatures reach 45°C and sometimes even higher, making it one of the hottest city of Uttar Pradesh. Winters are very cold and often foggy. Heavy rains and high humidity mark the monsoon season.

MATERIAL AND METHODS

Eight samples - 4 soil sediments and 4 spider's webs - were collected (Fig. 1) from different areas of Taj Mahal complex during the winter season (December 2002). Spider's webs are easily collected by rolling it at the end of the stick. The gathered webs are from the corners of the walls of the main gate, old varandah as well as from the bushes seen growing in front of Kali Masjid situated in the Charbagh garden adjoining the main gate of Taj complex. Soil samples were scrapped from the old walls of the main gate and the pillars of the old varandah. Both types of these unusual habitat samples in fact come from a small area and were stored carefully in suitable plastic bags.

Soil samples were first treated with 10% KOH solution to deflocculate the matrix, then washed several times with dis-

tilled water and sieved with 150 mesh. The filtrate was transferred in polythene jars and treated with 40% HF - keeping in this acid for 6-7 days to dissolve silica. After decanting HF, the material was repeatedly washed with distilled water until free from acid. Thereafter, the residue was acetolysed by standard acetolysis method (Erdtman, 1943, 1969) using acetolysis mixture (9:1, acetic anhydride and conc. sulphuric acid). Finally, each processed sample was stored in 50% glycerine with added few phenol drops to avoid any microbial contamination.

In case of spider's webs, samples were first treated with conc. HCl which dissolved the meshes instantaneously and then passed through the sieve (150 mesh) to remove the superfluous matters i.e. small twigs, fruits, leaves, etc. After washing the filtrate several times with distilled water, the residue was treated with HF in polythene test tubes only for two days to dissolve the dust particles, if any. Rest of the procedure was same as done for soil samples.

Pollen count for each sample in both cases ranged be-

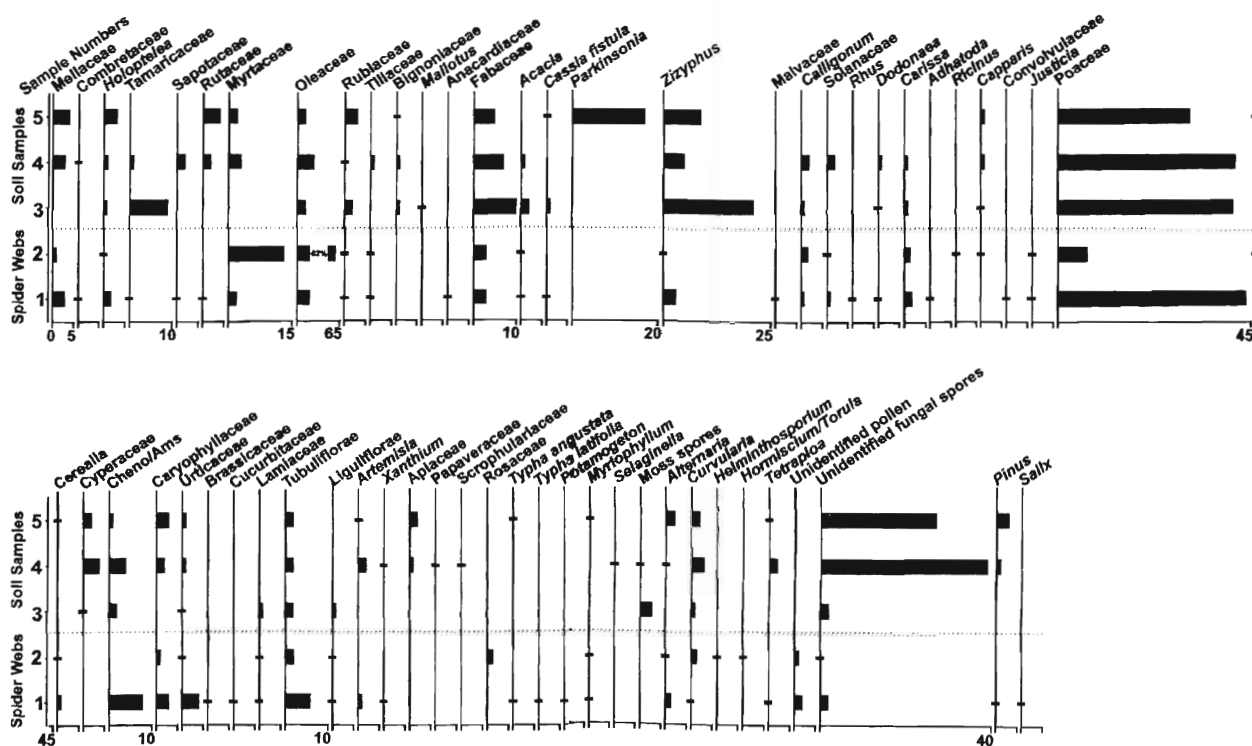


Fig. 2. Pollen Spectra from Tajmahal, Agra (Percentages calculated in terms of total terrestrial pollen).

tween 150-250, depending upon the productivity of the samples. Pollen sum is based on the total terrestrial pollen, both for soil as well as spider-web samples. The encountered pollen/spores have been arranged in sequence viz., trees, shrubs, herbs, aquatics, lower plants, unidentified, and the exotics.

POLLEN SPECTRA

The reconstructed pollen spectra (Fig. 2) are based on the plant taxa retrieved from surface sediments as well as webs collected from the premises of the Taj. The analysed samples reveal that the environs of Taj area is quite rich in pollen and spores depicting the extant vegetation (Sharma and Dhakre, 1995) comprising arboreals, non-arboreals, aquatics, lower plants and some exotics (Table 1). The preliminary palynological investigations have portrayed the relationship between the liberated pollen of different taxa retrieved from the soil samples as well as spider's webs vis-à-vis the existing vegetation in and around the Taj.

SPIDER'S WEBS

(Sample numbers 1 & 2)

Arboreals dominate over non-arboreals. Among the arboreals, Oleaceae show the maximum abundance (62%). Remaining tree taxa include Myrtaceae (13%), Zizyphus, Meliaceae, Fabaceae (3% each), and Holoptelea (2%). Meagerly recovered taxa are Acacia, Cassia fistula, Combretaceae, Tamaricaceae, Sapotaceae, Rutaceae, Rubiaceae, Tiliaceae, Anacardiaceae, etc. Shrubby elements include Malvaceae (8%), Carissa (2%), Calligonum (1.5%), Solanaceae (1%), and stray presence of Rhus, Dodonaea, and Adhatoda. Among

the non-arboreals, grasses are predominant (44%) along with Tubuliflorae (6%), Urticaceae (5%), Caryophyllaceae (3%), Rosaceae (1.5%), Cerealia and Artemisia (1% each). Aquatic taxa such as Typha angustata, T. latifolia, Potamogeton and Myriophyllum are also represented though in very low values. Among the lower plants, fungal spores - Alternaria, Curvularia (1.5% each), Helminthosporium, Homomiscium/Torula and Tetraploa are present but in very low frequencies. Unidentified taxa include pollen as well as fungal spores (2% each). Pinus and Salix pollen is most probably exotic in the environs of the region.

SOIL SAMPLES

(Sample numbers 3-5)

In soil samples too, arboreals dominate over non-arboreals. Pollen of Zizyphus (21%) and Parkinsonia (17%) predominate over Fabaceae (10%); Tamaricaceae (9%), Meliaceae, Rutaceae, Oleaceae (4% each); Myrtaceae, Rubiaceae, Holoptelea (3% each); Sapotaceae, Acacia (2% each); Tiliaceae, Bignoniaceae, Cassia fistula (1% each). Malotus and Combretaceae pollen are encountered meagrely. Shrubs though represented but rarely, include Calligonum, Solanaceae (2% each); Dodonaea and Carissa (1% each). Among the non-arboreals, grasses (41.5%) predominate over Cyperaceae (4%) besides Chenop/Ams (4% each); Caryophyllaceae (3%); Apiaceae, Tubuliflorae, Artemisia (2% each); Urticaceae, Lamiaceae, Liguliflorae, Capparis (1% each). Cerealia, Xanthium, Papaveraceae and Scrophulariaceae are sporadically present. Among the aquatics, only Typha angustata and Myriophyllum pollen are recovered and that too in low frequencies. Spores of lower plants viz., Selaginella (<1%), mosses (3%), fungi such as Curvularia

Table 1: Showing recovered palynomorphs.

Samples Numbers	Percentage Values (+) = <1%, (-) = absent)				
	Spider's webs			Soil Samples	
	1	2	3	4	5
Retrieved taxa	Main Gate	Bush near Main Gate	Main Gate	Varandah	Varandah
ARBOREALS					
<i>Acacia</i>	+	+	2	1	-
<i>Adhatoda</i>	+	-	-	-	-
Anacardiaceae	+	-	-	-	-
Bignoniaceae	-	-	1	1	+
<i>Calligonum</i>	1	1.5	1	2	-
<i>Carissa</i>	2	1.5	1	1	-
<i>Cassia fistula</i>	+	-	1	-	+
Combrctaceae	+	-	-	+	-
<i>Dodonaea</i>	+	-	-	+	1
Fabaceae	3	3	10	7	5
<i>Holoptelea</i>	2	+	1	1	3
<i>Mallotus</i>	-	-	+	-	-
Malvaceae	+	-	-	-	-
Meliaceae	3	1	-	3	4
Myrtaceae	2	13	-	3	2
Olcaceae	3	62	2	4	2
<i>Parkinsonia</i>	-	-	-	-	17
<i>Rhus</i>	+	-	-	-	-
<i>Ricinus</i>	-	+	-	-	-
Rubiaceae	+	+	2	+	3
Rutaceae	+	-	-	2	4
Sapotaceae	+	-	-	2	-
Solanaceae	1	+	-	2	-
Tamaricaceae	+	-	9	1	-
Tiliaceae	+	+	-	1	-
<i>Zizyphus</i>	3	+	21	5	9
NON-ARBOREALS					
Apiaceae	-	-	-	1	2
<i>Artemisia</i>	1	-	-	2	+
Brassicaceae	+	-	-	-	-
<i>Capparis</i>	-	+	+	1	1
Caryophyllaceae	3	1	-	2	3
Cercalia	1	+	-	-	+
Cheno/Ams	8	-	2	4	1
Convolvulaceae	+	-	-	-	-
Cucurbitaceae	+	-	-	-	-
Cyperaceae	-	-	+	4	2
<i>Justicia</i>	+	+	-	-	-
Lamiaceae	+	+	1	-	-
Liguliflorae	+	+	1	-	-
Papaveraceae	-	-	-	+	-
Poaceae	44	7	41	41.5	31
Rosaceae	-	1.5	-	-	-

Scrophulariaceae	-	-	-	+	-
Tubuliflorae	6	2	2	2	2
Urticaceae	5	+	+	1	1
<i>Xanthium</i>	+	-	-	+	-
AQUATICS					
<i>Myriophyllum</i>	+	+	-	-	+
<i>Potamogeton</i>	+	-	-	-	-
<i>Typha angusta</i>	+	-	-	-	+
<i>Typha latifolia</i>	+	-	-	-	-
LOWER PLANTS					
Moss spores	-	-	3	+	-
<i>Selaginella</i>	-	-	-	+	-
FUNGAL SPORES					
<i>Alternaria</i>	1.5	+	-	+	2
<i>Curvularia</i>	+	1.5	1	3	2
<i>Helminthosporium</i>	-	+	-	-	-
<i>Hormiscium/Torula</i>	-	+	-	-	-
<i>Tetraploa</i>	+	-	-	2	+
UNIDENTIFIED					
Unidentified pollen	2	1	-	-	-
Unidentified fungal spores	2	+	2	39	27
EXOTICS					
<i>Pinus</i>	+	-	-	1	3
<i>Salix</i>	+	-	-	-	-

(3%), *Alternaria*, *Tetraploa* (2% each) are encountered in very low frequencies. Unidentified elements include fungal spores in high frequencies (39%). *Pinus* (3%) alone is the exotic represented in the soil samples.

DISCUSSION AND CONCLUSION

Pollen analysis of 8 soil and web samples collected from the premises of Taj mahal has revealed the deposited or suspended pollen and spores of different plant taxa, originating mostly from the extant vegetation in the region. Reconstructed pollen spectra clearly depict the dominance of Oleaceae (62%) among the arboreals and Poaceae (44%) among the non-arboreals. Though grass pollen dominate in almost all the analysed samples yet retrieved, Oleaceae pollen predominates the overall extant vegetal taxa of the region. Comparative account of the pollen recovered from both types of samples has convincingly demonstrated that spider's webs are better pollen/spore catcher than the soil samples (Bera *et al.*, 2002 ; Sharma and Budhraj, 2003). Presence of aquatic taxa in the spider's webs can be attributed to their distant transport through the insects evidenced by their recovered body parts. Spores of lower plants are most likely of *in situ* origin preferring humid conditions in the soil substratum. As regards the exotics, their pollen are transported to the site from the high altitudes but it cannot be ruled out that a few trees of *Pinus* as well as *Salix* might be growing as planted trees in the vicinity of Taj. The comparative assessment of palynoflora through

the analysis of the two entirely different nature of substrata, i.e. surface soil and web samples, has provided more dependable scenario of Taj environs. Today, this white-marble monument is purportedly under the virtual siege of "suspended particle matter" from all sides as pollutants. The preliminary investigation has clearly demonstrated that there is a scope to take up further palynological investigations to unravel the vegetation scenario around this monument and the environmental changes that this region has witnessed during the recent past. These studies can also throw much light on the density of suspended pollutant particles in the environs around Taj mahal so that the appropriate preventive measures could be taken to safeguard the vanishing lustre of this wonderful monument.

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EXPLANATION OF PLATE I

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|--|--|
| <p>1. Cerealia, 2. Poaceae, 3. <i>Acacia</i>, 4 & 5. Caesalpiniaceae, 6. <i>Cassia</i>, 7. Urticaceae, 8 & 9. Chen/Ams, 10. Caryophyllaceae, 11. Solanaceae, 12. <i>Artemisia</i>, 13. Meliaceae, 14. Sapotaceae, 15. Tubuliflorae, 16. <i>Typha</i></p> | <p><i>angustata</i>, 17. <i>T. latifolia</i>, 18. Unidentified fungal hypae, 19. <i>Alternaria</i>, 20. <i>Curvularia</i>, 21. Aquatic fungal spore, 22-23. Unidentified fungal spores (x 1000).</p> |
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