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Research Article

POLLEN ANALYSIS OF SPIDER WEB SAMPLES FROM KOTWA-JAMUNIPUR OF ALLAHABAD (PRAYAGRAJ) DISTRICT, UTTAR PRADESH

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ABSTRACT
Various kind of natural traps such as tree barks, soil samples, moss, lichen cushions and leaves have been used to study the modern pollen rain. In recent years, spider webs have also been proved to be a tool in the pollen analysis to study the modern pollen rain and its relationship with the local vegetation. Spider web meshes are capable to trap airborne pollen grains and can also be used to study airborne pollen flora of a geographical region. The present investigation deals with the pollen analysis of 6 spider web samples collected from Allahabad (Prayagraj) district April 2019.
Pollen analysis of 6 web samples recorded presence of 25 pollen morphotypes belonging to 21 families. Of these, 14 pollen types were from arboreal and 10 pollen types were from non arboreal taxa. In the palynoassemblage, quantitative representation of pollen grains of arboreal and non arboreal taxa was 67.48% and 29.66% respectively, rest 1.08% remained unidentified. Pollen grains of *Holoptelea integrifolia* was the most abundant pollen type recovered from all the samples followed by Poaceae, Amaranthaceae/Chenopodiaceae, *Ailanthus excelsa, Ricinus communis, Ziziphus jujuba, Acacia nilotica, Parthenium hysterophorus, Brassica campestris, Thuja occidentalis, Dalbergia sissoo, Cassia siamea, Carica papaya* and *Thuja occidentalis*.
The pollen assemblage recovered from the spider webs largely reflects the ground vegetation of the study area and also exhibits the reflection of the aeropalynoflora of Allahabad which in turn is also correlated with the airborne pollen grains of Allahabad.

Keywords: *Pollen Morphotypes, Spider Web, Prayagraj*

INTRODUCTION
Pollen analysis is the study of pollen grains, fossil as well as living. It is most widely adopted biological technique used for the reconstruction of past vegetation and climate and to understand the relationship between vegetation and modern pollen rain. For the pollen analysis various natural pollen traps viz. tree barks, surface soil /sediments, moss and lichen cushions have been used conventionally in order to study the pollen rain–vegetation relationship of a particular geographical region (Groenman-vanWaateringe, 1998; Li *et al.*, 2013; Song *et al.,* 2014 and Quamar and Bera, 2018). In addition spider webs can also be regarded as a kind of natural trap for catching airborne pollen grains.
In recent year, spider webs have emerged as potent natural pollen traps and their qualitative and quantitative pollen analysis have been proved to be a strong tool to assess the actual contribution of the local plants in the pollen rain and the overall representation of local and regional vegetation. Apart from being helpful in reconstruction of the vegetation of an area, such studies could also aid in understanding the aeropalynoflora of the area. (Ranal, 2004; Song *et al.*, 2007, 2013; Quamar and Chauhan, 2011 a,b; Li *et al.*, 2013; Quamar and Bera, 2014 a,b,c,d, 2015a,b, 2016 a,b.).
The present investigation on pollen analysis of spider web samples collected from Kotwa-Jamunipur of Allahabad district is undertaken to understand the relationship between local vegetation and pollen rain as recorded from spider webs. The pollen assemblage recovered from the analysis of spider webs has been correlated with the airborne pollen grains of Allahabad (Sahney and Chaurasia, 2008 a,b,c).

MATERIAL AND METHODS

Allahabad (Prayagraj) district lies in between 25.4358° N and 81.8463° E at an elevation of 103 meter above the sea level. The district covers an area of 5482 sq. kms in the southern part of Uttar Pradesh in Ganga plains adjoining Vindhyan plateau of India. The boundary of the district is formed by the districts of Pratapgarh and Jaunpur in the north; Bhadohi and Varanasi in the east; Mirzapur in the south east; Rewa (M.P.) in the south; Banda in the south west and Kaushambi district in the west. The district is divided into 3 physical parts (1) Trans- Ganga (Gangapar) (2) Trans- Yamuna (Yamunapar) and (3) The Doab. Allahabad district has humid subtropical climate. It has three seasons, a long hot summer, a short humid rainy season and a cool dry winter. It forms a part of the floristic sub- division of India, known as the Gangetic plain, with a grassland vegetation having plantations of trees mostly along roadsides, gardens, wastelands etc. Kotwa-Jamunipur are the villages in Bahadurpur Block in Allahabad District of Uttar Pradesh State, India. It is located 21 KM towards East from District head quarters Allahabad. Vegetation of Kotwa-Jamunipur consists of arboreal taxa viz. *Holoptelea integrifolia, Dalbergia sissoo, Azadirachta indica, Ailanthus excelsa, Acacia nilotica, Ficus religiosa, Prosopis juliflora, Bougainvillea* sp., *Ziziphus jujuba, Tectona grandis, Bombax ceiba, Carica papaya, Citrus* sp., *Ricinus communis, Tectona grandis, Bombax ceiba, Cassia siamea, Tinospora cordifolia* and *Citrus* sp. Herbaceaous taxa comprises grasses along with herbs like *Brassica campestris, Parthenium hysterophorus, Mirabilis jalapa, Phlox drummondii, Ageratum conyzoides, Adhatoda zeylanica, Alternanthera sessilis,* Amaranthaceae/ Chenopodiaceae, *Celosia cristata Coriandrum sativum* etc.

All the 6 Spider Webs were collected in April 2019. All samples were collected from the trees growing along the road sides Kotwa-Jamunipur of Allahabad district (Plate-1a, b).

All the collected web samples were placed in separate polythene bags. Field surveys were performed around the sites of collection from time to time to collect the floral material for the preparation of pollen reference slides.

Standard methods have been followed in the preparation of spider web samples (Faegri *et al.,* 1989; Bera *et al.,* 2002).

Two gram of each spider web sample was transferred to a container containing concentrated Hydrochloric acid which dissolves the meshes instantaneously and then passed through the sieve to remove the superfluous matter. The samples were washed with distilled water several times to remove the acid content by centrifugation and decantation. After centrifuging, the residue was mixed with 10 ml concentrated Hydrofluoric acid in polythene test tube and kept for 2 days to remove silica. The filtrate was washed and centrifuged thrice to remove silica particle. The residue was acetolysed using the method suggested by Erdtman (1952). From the residue four slides were prepared from each sample. Residue was mounted in saffranin glycerine jelly under the coverslip of 18×18 mm size and sealed by copal varnish and thoroughly scanned under microscope.

Identification of pollen grains recovered from spider webs and barks were made largely with the help of the reference pollen slides prepared from local ground plants and the relevant literature (Wodehouse, 1935; Erdtman, 1952; Nautiyal and Midha, 1984; Nayar, 1990; Bhattacharya *et al.,* 2006).

Photomicrographs of pollen grains have been taken with Leica DM 2500 light microscope with Leica DFC295 camera attachment (Plate-2). SEM photographs were taken with Electron Probe Micro Analyser model “JEOL JXA 8100” operated at 15KV & 10KV and 1× 10-8 A at National Centre of Experimental Mineralogy and Petrology (NCEMP), University of Allahabad. Before SEM imaging, samples were coated with 30nm thick carbon using Jeol JEE-420 vacuum evaporator (Plate-1c-i).

RESULTS

Pollen analytical data of 6 spider web samples collected from Kotwa-Jamunipur locality

1. **Sample code**- S.W.-1

Source of collection- *Holoptelea integrifolia* tree

Pollen types recovered- 13 types

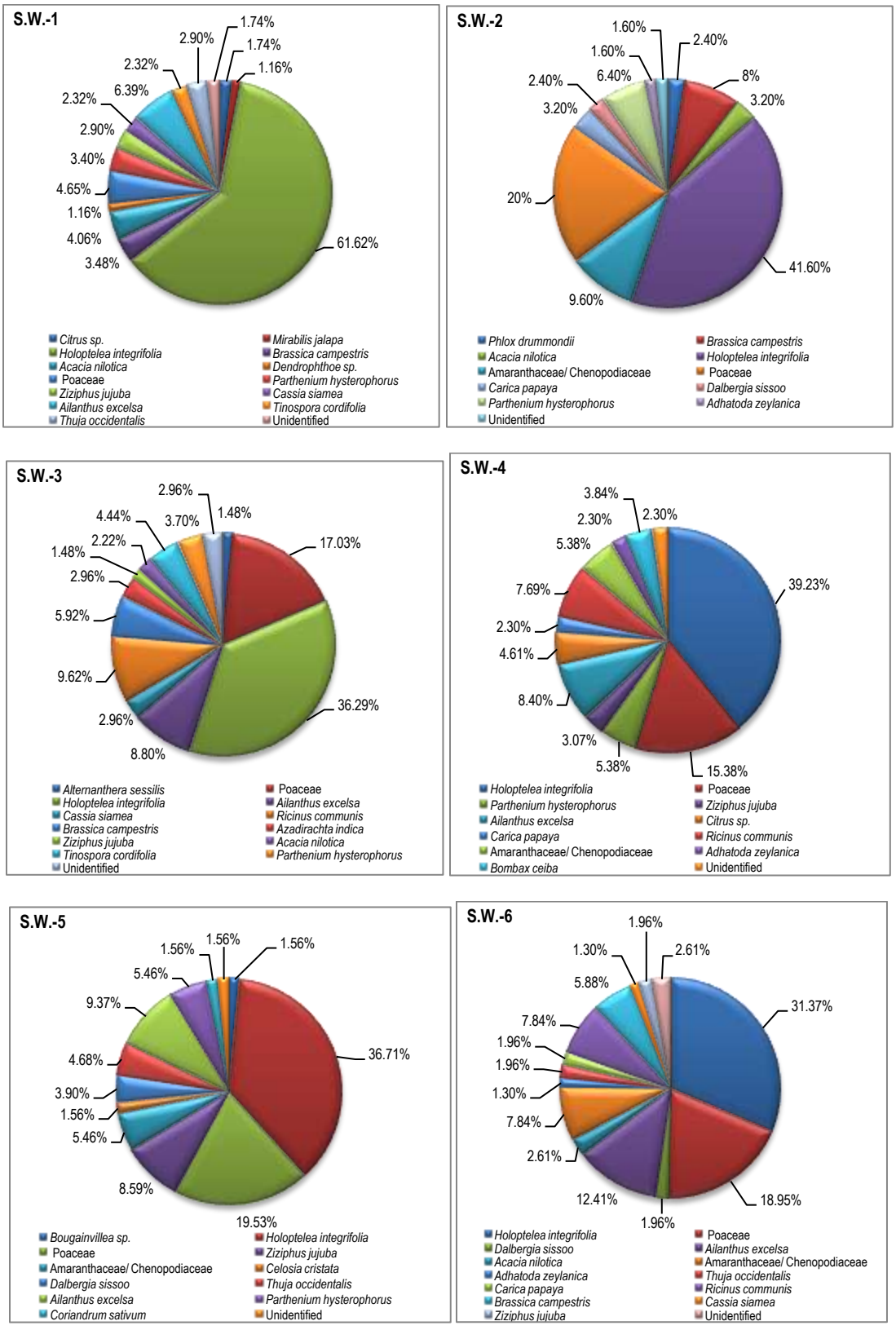

Figure 1: Pollen spectra of web samples collected from Kotwa-Jamunipur of Allahabad district

Pollen types and their percentages -
Holoptelea integrifolia [61.62%], *Ailanthus excelsa* [6.39%], Poaceae [4.65%], *Acacia nilotica* [4.06%], *Brassica campestris* [3.48%], *Parthenium hysterophorus* [3.48%], *Ziziphus jujuba* [2.90%], *Thuja occidentalis* [2.90%], *Cassia siamea* [2.32%], *Tinospora cordifolia* [2.32%], *Citrus* sp. [1.74%], *Dendrophthoe* sp. [1.16%] and *Mirabilis jalapa* [1.16%].

2. **Sample code**- S.W.2
Source of collection- *Ziziphus jujuba* tree
Pollen types recovered- 10 types
Pollen types and their percentages -
Holoptelea integrifolia [41.60%], Poaceae [20%], Amaranthaceae/ Chenopodiaceae [9.60%], *Brassica campestris* [8%], *Parthenium hysterophorus* [6.40%], *Acacia nilotica* [3.20%], *Carica papaya* [3.20%], *Dalbergia sissoo* [2.40%], *Phlox drummondii* [2.40%] and *Adhatoda zeylanica* [1.60%].

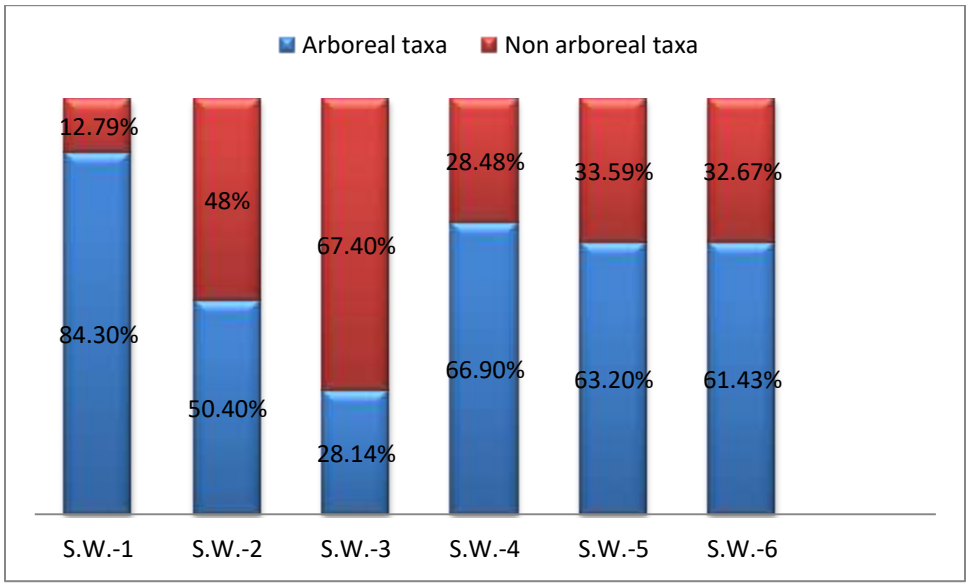

Figure 2: Pollen representation of arboreal and non arboreal taxa in the spider web samples of Kotwa-Jamunipur of Allahabad district

3. **Sample code**- S.W.-3
Source of collection- *Ziziphus jujuba* tree
Pollen types recovered- 12 types
Pollen types and their percentages -
Holoptelea integrifolia [36.29%], Poaceae [17.03%], *Ricinus communis* [9.62%], *Ailanthus excelsa* [8.80%], *Brassica campestris* [5.92%], *Tinospora cordifolia* [4.44%], *Parthenium hysterophorus* [3.70%], *Cassia siamea* [2.96%], *Azadirachta indica* [2.96%], *Acacia nilotica* [2.22%], *Alternanthera sessilis* [1.48%] and *Ziziphus jujuba* [1.48%].

4. **Sample code**- S.W.-4
Source of collection- *Ziziphus jujuba* tree
Pollen types recovered- 11 types
Pollen types and their percentages-
Holoptelea integrifolia [39.23%], Poaceae [15.38%], *Ailanthus excelsa* [8.40%], *Ricinus communis* [7.69%], *Parthenium hysterophorus* [5.38%], *Citrus* sp. [4.61%], Amaranthaceae/ Chenopodiaceae

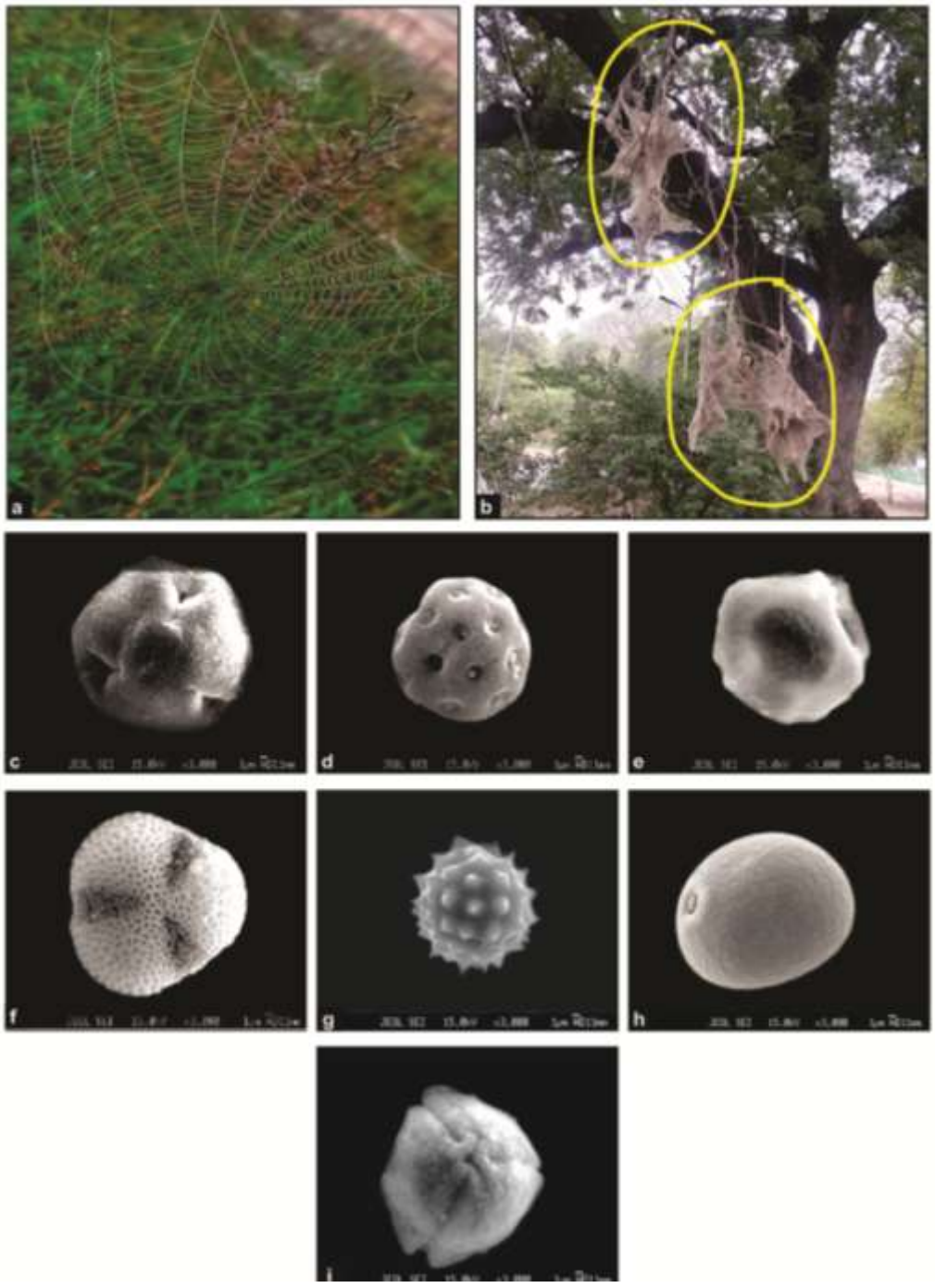

Plate 1: *a & b- Spider webs*
c-i- SEM images of some pollen types recovered from spider web samples
(c) Ailanthus excelsa (d) Amaranthaceae/Chenopodiaceae (e) Holoptelea integrifolia (f) Brassica campestris (g) Parthenium hysterophorus (h) Poaceae (i) Ricinus communis

[5.38%], *Bombax ceiba* [3.84%], *Ziziphus jujuba* [3.07%], *Carica papaya* [2.30%] and *Adhatoda zeylanica* [2.30%].

Plate 2: Pollen types recovered from spider web samples
(a) Acacia nilotica (b) *Adhatoda zeylanica* (c) *Ailanthus excelsa* (d) *Alternanthera sessilis* (e) Amaranthaceae/Chenopodiaceae (f) *Azadirachta indica* (g) *Brassica campestris* (h) *Bombax ceiba* (i) *Bougainvillea* sp (j) *Carica papaya* (k) *Cassia siamea* (l) *Celosia cristata* (m) *Citrus* sp. (n) *Coriandrum sativum* (o) *Dalbergia sissoo* (p) *Dendrophthoe* sp. (q) *Holoptelea integrifolia* (r) *Mirabilis jalaba* (s) *Parthenium hysterophorus* (t) *Phlox drummondii* (u) Poaceae (v) *Ricinus communis* (w) *Thuja occidentalis* (x) *Tinospora cordifolia* (y) *Ziziphus jujuba*
Scale Bars: 10µm

5. **Sample code**- S.W.-5
Source of collection- *Acacia nilotica* tree
Pollen types recovered- 11 types
Pollen types and their percentages-
Holoptelea integrifolia [36.71%], Poaceae [19.53%], *Ailanthus excelsa* [9.37%], *Ziziphus jujuba* [8.59%], Amaranthaceae/ Chenopodiaceae [5.46%], *Parthenium hysterophorus* [5.46%], *Thuja occidentalis* [4.68%], *Dalbergia sissoo* [3.90%], *Bougainvillea* sp. [1.56%], *Celosia cristata* [1.56%] and *Coriandrum sativum* [1.56%].
6. **Sample code**- S.W.-6
Source of collection- *Acacia nilotica* tree
Pollen types recovered- 13 types
Pollen types and their percentages-
Holoptelea integrifolia [31.37%], Poaceae [18.95%], *Ailanthus excelsa* [12.41%], Amaranthaceae/ Chenopodiaceae [7.84%], *Ricinus communis* [7.84%], *Brassica* [5.88%], *Acacia nilotica* [2.61%], *Dalbergia sissoo* [1.96%], *Thuja occidentalis* [1.96%], *Carica papaya* [1.96%], *Ziziphus jujuba* [1.96%], *Adhatoda* [1.30%], and *Cassia siamea* [1.30%].

DISCUSSION

25 pollen types representing 21 families were retrieved from the analysis of 6 web samples collected from Kotwa-Jamunipur locality during April 2019. Of these, 14 pollen types were from arboreal and 10 pollen types were from non arboreal taxa (Plate-2). In the palynoassemblage, quantitative representation of pollen grains of arboreal and non arboreal taxa was 67.48% and 29.66% respectively, rest 1.08% remained unidentified. In one sample pollen grains of an epiphyte-*Dendrophthoe* sp. (1.54%) were also recovered.

Out of 6 web samples, pollen spectrum of 5 web samples (S.W.-1, S.W.-3, S.W.-4, S.W.-5 and S.W.-6) demonstrated dominance of arboreal taxa over non arboreal taxa while pollen spectrum of S.W.-2 demonstrated dominance of non arboreal taxa over arboreal taxa (Fig-2). Qualitatively pollen diversity in web samples ranged from 10 (S.W.-2) to 13 (S.W.-1 and S.W.-6) per sample while quantitatively pollen counts ranged from 125 (S.W.-2) to 172 (S.W.-1) per sample (Fig-1).

Among the arboreal taxa, pollen grains of *Holoptelea integrifolia* was the most abundant pollen type recovered from all the samples (6 samples) contributing 3.96% to 63.12%. The next abundant pollen type was *Ailanthus excelsa* recorded in 5 samples contributing 6.39% to 12.41%, followed by *Ricinus communis* (7.69% to 9.62%), *Ziziphus jujuba* (1.48% to 8.59%), *Acacia nilotica* (2.22% to 4.06), *Thuja occidentalis* (1.96% to 4.68%), *Dalbergia sissoo* (1.96% to 3.90%), *Cassia siamea* (1.30% to 2.96%), *Carica papaya* (1.96% to 3.2%). Pollen grains of *Thuja occidentalis* were recorded in 3 samples despite being absent in local vegetation. *Thuja occidentalis* which is a common ornamental plant grown in the gardens. Being anemophilous their pollen grains can be carried far away by wind. On the other hand, some of the taxa viz. *Bombax ceiba* and *Dalbergia sissoo* have sparse representation in the pollen assemblage of spider web despite being the common trees of Allahabad. Both the taxa are entomophilous in nature and the under-representation of their pollen grains may be due to their low dispersal efficiency.

Intermittent presence of pollen grains of tree taxa in web samples like those of *Azadirachta indica*, *Carica papaya*, *Cassia siamea* and *Citrus* sp. corresponds to the presence of the source plant only around the sites of collection.

Pollen grains of *Tectona grandis* have not been encountered at all in the pollen assemblage of web samples despite fair presence of trees of *Tectona grandis* around the collection site which may be due to low pollen dispersal efficiency and poor pollen preservation as ascribed by Quamar and Bera (2016a, b). It must be mentioned here that *Tectona grandis* has been reported to be a high pollen producer by Bhattacharya *et al.*, (1999).

Absence of pollen grains of various species of *Ficus* like *Ficus religiosa, Ficus racemosa, Ficus virens* and *Ficus benghalensis* have been recorded in the pollen spectra of spider webs, despite being fairly present around the sampling sites. *Ficus* spp. have hypanthodium inflorescence thus there is no discharge of pollen in air resulting their altogether absence in the pollen assemblage.

Among 10 non-arboreal taxa, pollen grains of Poaceae were most abundant encountered in all the web samples (6) contributing 1.91% to 24.24% followed by those of Amaranthaceae/Chenopodiaceae (4) contributing 5.38% % to 9.6%, *Brassica campestris* (4) contributing 3.48% to 8%, *Parthenium hysterophorus* (4) contributing 3.4% to 6.4%.

The Ground vegetation is honestly portrayed in the pollen assemblage of spider webs. Poaceae, Amaranthaceae and Chenopodiaceae are stenopalynous families and their representation in the spider webs is the collective contribution of pollen grains belonging to various taxa of the families. Availability of *Brassica campestris* around most of the collection sites may be accounted for its good representation in the pollen assemblage while *Parthenium hysterophorus* is a common rapid spreading weeds growing around the sampling sites and they bloom for greater part of the year.

It may be mentioned here that pollen of Poaceae and *Holoptelea integrifolia* are also major component of airborne pollen spectrum of Allahabad. Among other types recorded from the web samples Amaranthaceae/Chenopodiaceae, *Brassica campestris, Parthenium hysterophorus, Thuja occidentalis, Ailanthus excelsa, Ricinus communis, Aegle marmelos, Ziziphus jujuba, Dalbergia sissoo, Acacia nilotica, Cassia siamea, Carica papaya, Tinospora cordifolia* and *Citrus* sp. are also common components of aeropalynoflora of Allahabad (Sahney and Chaurasia, 2008b,c). The pollen assemblage recovered from the spider webs largely reflects the ground vegetation of the study area and also exhibits the reflection of the aeropalynoflora of Allahabad which in turn is also correlated with the ground vegetation.

Airborne pollen grains are known to be one of the causative agents concerned with inhalant allergy in human being like hay fever, asthma etc. Among the pollen grains recovered in dominant number from the pollen analysis of spider webs *Holoptelea integrifolia, Ricinus communis*, Amaranthaceae/Chenopodiaceae, *Brassica campestris, Cassia siamea, Ailanthus excelsa,* Poaceae, *Tinospora cordifolia* and *Parthenium hysterophorus* are reported as allergenic pollen (Sahney and Chaurasia, 2008a,c; Sahney *et al.,* 2017; Agrawal *et al.,* 2008; Seetharam *et al.,* 2015; Seetharam *et al.,* 2016; Quamar and Bera, 2016b).

The present study proves that spider webs are capable natural substrate for catching airborne pollen grains. It can be used as an alternative method to trap airborne pollen grains of an area. However, analysis of pollen content recovered by spider web samples indicates that the spider webs are potent and efficient because of sticky nature of spider webs. The fine sticky strands of the web can capture pollen grains in the air currents. Similar observation was also made by Song *et al.,* 2013.

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REFERENCES

Agrawal *et al.,* (2008). Identification of common allergens by skin prick test associated with united airway disease in Allahabad, Uttar Pradesh, India. *Indian Journal of Allergy Asthma Immunology,* **22**(1) 7-13.

Bera SK, Trivedi A and Sharma C (2002). Trapped pollen and spores from spider webs of Lucknow environments. *Current Science,* **83** 1580-1585.

Bhattacharya A, Mondal S & Mandal S (1999). Entomophilous pollen incidence with reference to atmospheric dispersal in eastern India. *Aerobiologia,* **15** 311–315.

Bhattacharya K, Majumdar MR and Bhattacharya SG (2006). *A text book of Palynology*, New Central book agency (P) Ltd. Kolkata.

Erdtman G (1952). Pollen Morphology and plant Taxonomy. Angiosperm. Almquist & Wicksell, Stockholm. USA.

Faegri K, Iversion J, Kaland PE and Krzywinski K (1989). Textbook of Pollen Analysis. Chichester: Wiley.

Groenman-van Waateringe W (1998). Bark as a natural pollen trap. *Review of Palaeobotany and Palynology,* **103** 289–294.

Li SP, Hu,YQ, Ferguson DK, Yao JX and Li CS (2013). Pollen dispersal in a mountainous area based on pollen analysis of four natural trap types from Lugu Lake, southwest China. *Journal of Systematics and Evolution,* **51**: 413–425. doi:10.1111/jse.12004.,

Nautiyal DD and Midha M (1984). Aerobiology of Allahabad (1973- 1979). *Phyta Monograph,* **2** 1-100.

Nayar TS (1990). Pollen flora of Maharashtra State, India. Today & Tomorrow's printers and publishers, New Delhi, 157 and 67 plates.

Quamar MF and Chauhan MS (2011a). Pollen analysis of spider webs from Khedla village, Betul District, Madhya Pradesh. *Current Science*, **101**(12) 1586-1592

Quamar MF Chauhan MS (2011b). Modern pollen spectra from Hoshangabad District, southwestern Madhya Pradesh, India. *Geophytology*, **41**: 55–60.

Quamar MF and Bera SK (2016a). Pollen analysis of modern tree bark samples from the Manendragarh Forest Range of the Koriya district, Chhattisgarh, India. *Grana,* **56**(2) 137-146.

Quamar MF and Bera SK (2016b). Pollen analysis of spider web samples from Korba district, Chhattisgarh (central India): an aerobiologiacal aspect. *Aerobiologia,* **32**(4) 645-655.

Quamar MF and Bera SK (2018). Aerobiological implications of the extracted palynomorphs from the modern tree barks of the Korba District, Chhattisgarh, central India. *Palynology*, **43**(1) 34-42.

Quamar MF and Bera SK (2014a). Vegetation and climate change during mid and late Holocene in northern Chhattisgarh (central India) inferred from pollen records. *Quaternary International,* **349** 357-366.

Quamar MF and Bera SK (2014b). Pollen production and depositional behavior of teak (*Tectona grandis* Linn. F.) and sal (*Shorea robusta* Gaertn. F.): an overview. *Quaternary International,* **325** 111-115.

Quamar MF and Bera SK (2014c). Surface pollen and its relationship with modern vegetation in tropical deciduous forests of southwestern Madhya Pradesh, India: A review. *Palynology,* **38**(1) 147-161.

Quamar MF and Bera SK (2014d). Evidence of low pollen dispersal efficiency of sal (Shorea robusta Gaertn. F.): Modern pollen-rain study from Manendragarh area of Koriya District, Chhattisgarh (India). *Journal of Applied Bioscience,* **42** (2) 92-97.

Quamar MF and Bera SK (2015a). Modern pollen-vegetation relationships in the tropical mixed deciduous forests of Koriya District in Chhattisgarh, India. *Grana,* **54** (1) 45-52.

Quamar MF and Bera SK (2015b). Studies on Modern Pollen Assemblages: a Reliable Measure to Interpret Palaeoclimate in the Tropical Deciduous Forests of Koriya District. Gondwana Geological Magazine, Chhattisgarh, India. *Grana,* **54** (1) 45-52.

Ranal MA (2004). Bark spore bank of ferns in a gallery forest of the Ecological station of Panga, Uberlândia–MG, Brazil. *American Fern Journal*, 94 57–69.

Sahney M, Jaiswal R, Rahi S and Kumar A (2017). Pollen analysis of spider webs from Allahabad District, Uttar Pradesh. *Indian Journal of Aerobiology,* **30** (1 & 2) 61-69

Sahney M and Chaurasia S (2008a). Qualitative survey of airborne pollen grains at Allahabad. *Indian Journal of Aerobiology*, **21**(1) 1-12.

Sahney M and Chaurasia S (2008b). Incidence of grass pollen in the atmosphere of Allahabad during 2002-2004. *Proceeding of the National Academy of Sciences, India*, Sect. B, Vol.78 Pt.IV.

Sahney M and Chaurasia S (2008c). Seasonal variation of airborne pollen in Allahabad, India. *Annals of Agriculture and Environmental Medicine*, **15** 287-293.

Seetharam DS, Ramakrishna H, Ganga Kailash J and Prabhakar R (2015). Allergenic aerospora from the spider webs of Sanjeevaiah Park in Hyderabad city, Telangana state. *Pollution Research*, **34**(4) 109-119.

Seetharam DS, Ramakrishna H, Prabhakar R and Ganga KJ (2016). Aerobiological study from the Spider webs of Pakhal wildlife Sanctuary, Warangal district, Telangana state, India. *The Bioscan*, **11**(2) 851-856.

Song XY, Bera S, Yao YF, Blackmore S and Li CS (2013). Natural traps of spores and pollen grains from the region surrounding Wenbi Reservoir, Yunnan, China. *Chinese Science Bulletin*, **58** 162–168.

Song XY, Bera S, Yao YF, Ferguson DK and Li C (2014). Tree barks as a natural trap for airborne spores and pollen grains from China. *Chinese Science Bulletin*, **59**(19) 2331-2339.

Song XY, Blackmor S, Bera S and Li CS (2007). Pollen analysis of spider webs from Yunnan, China. *Review of Palaeobotany and Palynology*, **145** 325–333.

Wodehouse RP (1935). Pollen Grains. Their structure, identification and significance in science and medicine. *Mc. Graw Hill Book Company, Inc. New York and London.*