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Modern pollen rain deposition pattern in Lashoda Tal, Raebareli District, Uttar Pradesh, India

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ABSTRACT

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The pollen analysis of 10 surface samples from Lashoda Tal (Lake) surroundings, Raebareli District, Uttar Pradesh deals with the pollen rain–vegetation relationship. The investigation reveals the dominance of non–arboreals and relatively low frequencies of arboreals. *Acacia nilotica* (av.10%), *Holoptelea integrifolia* (av. 3.9%), *Syzygium cumini* (av. 2.2%) and *Madhuca indica* (av. 1.7%) are the major components among the trees, representing av. 18.8% pollen. The rest of the trees, viz. *Prosopis juliflora*, *Terminalia* sp., *Moringa oleifera*, *Shorea robusta*, etc. which occur commonly are meagre. The under–representation of all these taxa could be inferred to their low pollen production owing entomophilly as well as selective preservation of pollen in the sediments. In all, the trees constitute av. 24.2% fraction of the pollen rain. The representation of grasses, sedges, Cheno/Am, Caryophyllaceae, Brassicaceae, Asteraceae, etc. in the pollen rain substantiates their actual composition in the ground flora, constituting the chunk of av. 71.4%. The frequent encounter of Cerealia and culture pollen taxa depicts the proximity of cultivated land. The study also furnishes information concerning the prominent pollen/spores in the local milieu, which get deposited on the ground along with rains/dews. Their relative abundance assists in ascertaining the specific common pollen/spores in the aerospora relevant to allergic diseases.

Key–words—Pollen rain, Surface sediments, Lashoda Tal, Raebareli District, Uttar Pradesh (India).

भारत में उत्तर प्रदेश के रायबरेली जिले की लशोढ़ा ताल की आधुनिक पराग वर्षा निक्षेपण पद्धति

अंजलि त्रिवेदी, अन्जु सक्सेना एवं एम.एस. चौहान

सारांश

लशोढ़ा ताल (झील) के इर्द–गिर्द, जिला रायबरेली, उत्तर प्रदेश से प्राप्त 10 पृष्ठीय नमूनों का पराग विश्लेषण का पराग वर्षा–वनस्पति संबंधता से सरोकार है। यह गैर–वृक्षीयों की प्रभुत्वता एवं वृक्षीयों के सापेक्ष तथा अल्प आवृत्ति का अन्वेषण खुलासा करता है। औसतन 18.8% पराग निरूपित करते हुए वृक्षों में एकैसिया निलोटिका (औसतन 10%), होलोप्टेलिया इंटेग्रीफोलिया (औसतन 3.9%), सायज़ीजियम कुमिनि (औसतन 2.2%) और मधुका इंडिका (औसतन 1.7%) मुख्य घटक हैं। अन्य वृक्ष अर्थात् प्रोसेपिस जुलिफ्लोरा, टर्मिनेलिया जाति, मोरिंगा ओलीफेरा, शोरिया रोबस्ता , इत्यादि जो सामान्यतः कम होते हैं। इन समस्त टैक्सा का अल्प निरूपण कीटपरागण और अवसादों में पराग को वरणात्मक परिरक्षण के कारण उनके अल्प पराग उत्पादन में अनुमानित किया जा सकता है। सब में, वृक्ष पराग वर्षा के और 24.2% अंश संघटित करते हैं। औसतन 71.4% का विखंड संघटित करते हुए स्थल वनस्पति–जात में उनका वास्तविक संघटन पराग वर्षा में घास, प्रतृण, कोनो/एम, कैरियोफायल्लेसी, ब्रसीकेसी, एस्टेरेसी, इत्यादि का निरूपण पुष्ट करते हैं। अनाज एवं संवर्धन पराग टैक्सा का बारंबार समागम कृष्ट भूमि का सामीप्य चित्रित करता है। अध्ययन स्थानीय परिवेश में उन्नत पराग / बीजाणु संबंधी जानकारी भी प्रदान करती है, जो वर्षा/ओस के संग भूमि पर निक्षेपित हो गई। एलर्जी रोगों के सुसंगत वायु बीजाणु–जात में विशिष्ट सामान्य पराग/बीजाणु अभिनिश्चित करने में उनकी सापेक्षिक प्रचुरता मदद करती है।

सूचक शब्द—पराग वर्षा, पृष्ठीय अवसाद, लशोढ़ा ताल, जिला रायबरेली, उत्तर प्रदेश (भारत)।

EXTENSIVE information has been derived on modern pollen rain vis–à–vis vegetation relationships for the tropical evergreen and deciduous forests in south India, Sri Lanka (Bonnefille *et al.*, 1999; Anupama *et al.*, 2000; Barboni & Bonnefille, 2001), foothills of Himalaya (Sharma 1985; Gupta & Yadav, 1992), northeast India (Basumatary & Bera,

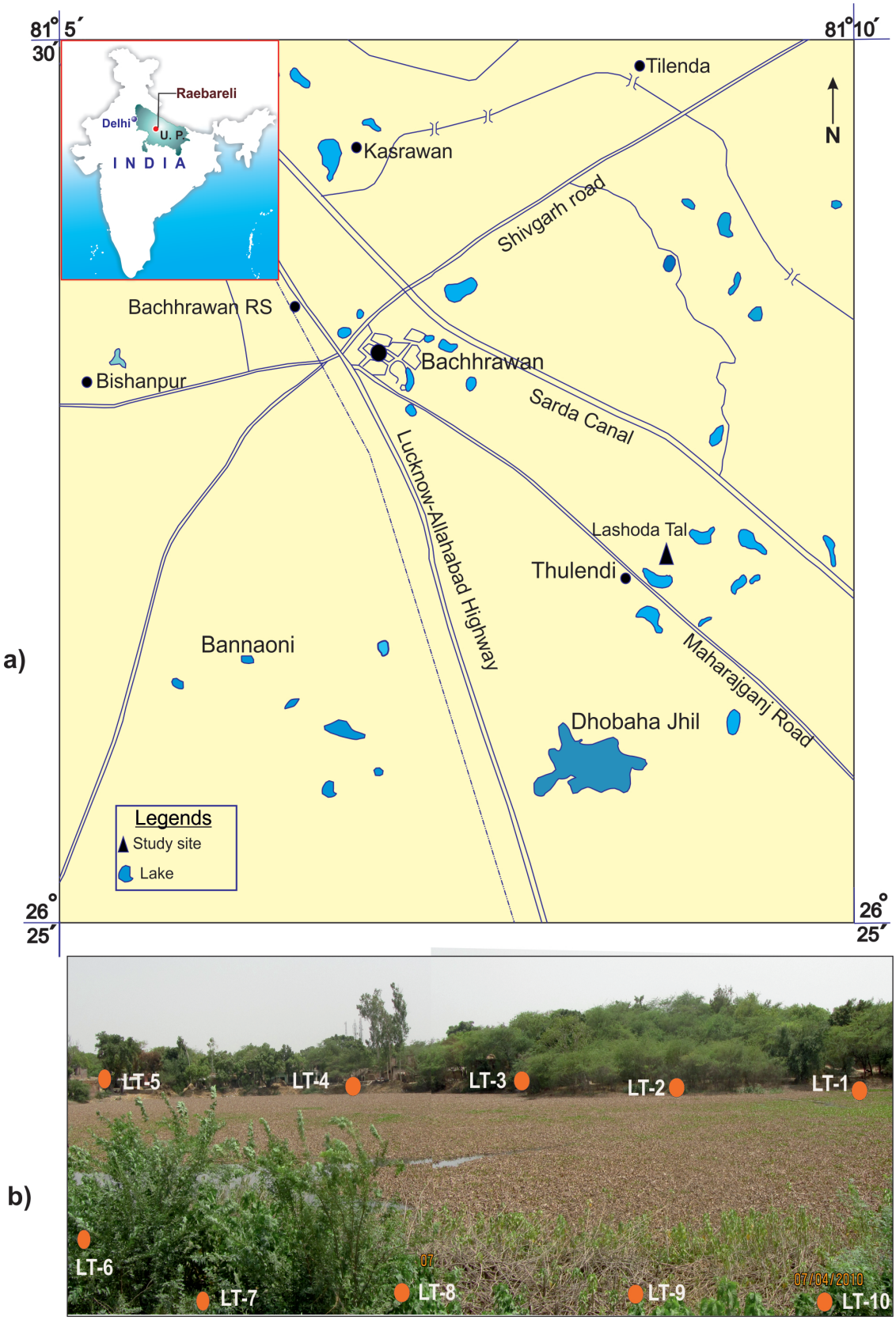

Fig. 1—(a) Map of Lashoda Tal, Raebareli District, U.P., India. (b) Panoramic view of lake showing locations of surface samples.

2007), Madhya Pradesh (Chauhan 1994, 2008; Quamar & Chauhan, 2007) and tropical deciduous scrub vegetation in northwest desert (Singh *et al.*, 1973). These studies have provided authentic comparative data–base on the pollen rain vis–a–vis extant vegetation and served as modern analogue for the factual appraisal of pollen sequences from the sediment deposits from their respective regions in terms of past vegetation succession and concurrent climate oscillations during the Quaternary Period. However, the Ganga Plain one of the potential regions of the country for the Quaternary palaeofloristic studies has so far not been given enough attention to deduce the pollen deposition pattern, which is a pre–requisite prior to the investigation of sedimentary deposits, except for some report from Jalesar area, Unnao District (Trivedi & Chauhan, 2011), Bari Tal, Lucknow District (Trivedi *et al.*, 2014), Chaudhary–Ka–Tal (Trivedi *et al.*, in press) and Kikar Tal, Raebareli District (Saxena et al., in press). Hence in the present paper an endeavour has been put forward to generate more the data–base on modern pollen rain to unravel the extent of representation of various regional and local taxa, their pollen dispersal efficiency and amplitudes from their provenance as well as assessment of possible factors affecting preservation of pollen/spores in the sediments. To resolve all these focal points, ten surface samples were pollen analysed from the vicinity of Lashoda Tal, Raebareli District in the Central Ganga Plain.

MATERIAL AND METHODS

Location

Lashoda Tal (Lake) is located about 55 km southwest of Lucknow and 5 km east of Bachhrawan township in the close proximity of Thulendi Village on the right side of the road leading from Bachhrawan to Maharajganj in Raebareli District between Long. 81º6'37.98" & Lat. 26º28'47.34" (Fig. 1). The lake is perennial and almost circular in shape. It is very large in size, measuring approximately 500 m in length and 200 m in breadth. It is very deep and remains covered with a thick mat of *Eichornia crassipes*–a common noxious weed of aquatic ecosystem in the Ganga Plain, It is surrounded by wetland, except on the southern flank, where embankment has been raised to protect the adjoining cultivated fields from inundation during the monsoon season. The eastern and northern flanks of the lake are elevated and densely inhabited. The western and southern flanks of the lake are under cultivation of traditional crops such as *Triticum aestivum* (wheat), *Oryza sativa* (paddy), *Cicer aeretinum* (chana), *Arachis hypogea* (groundnut) and *Phaseolus* sp. for a wider extent. Presently, the lake is being used for the irrigation of cultivated land as well as a reservoir for potable water to the local populace.

Climate

The climate of the region, in general, is humid and it is greatly influenced by the southwestern monsoon (Chauhan *et al.*, 1990). Winter season from November to February is characterized by average minimum and maximum temperatures of 7.6º C and 21º C respectively. The temperature occasionally descends to 0ºC during the extreme cold months of December and January. Summer season from April to June is characterized by hot blowing winds with average minimum and maximum temperatures of 27º C and 32.5º C respectively. The temperature shoots up to 46º C in the month of June. Monsoon season arrives in the mid–June and continues till mid–September. An approximate of 75% precipitation occurs during this period. The weather gets sultry from July to September.

Vegetation

The area in the vicinity of the lake has patchy stands or groves of forest interspersed with stretches of open mixed savannah, dominated by grasses (Champion & Seth, 1968). Thus, the landscape imparts a view of open vegetation. The trees, viz. *Acacia arabica*, *Acacia nilotica*, *Holoptelea integrifolia*, *Cordia dichotoma*, *Syzygium cumini*, *Madhuca indica*, *Capparis decidua*, *Butea monosperma*, *Symplocos racemosa*, *Ailanthus excelsa*, *Melia azadirachta*, *Aegle marmelos*, *Bauhinia variegata*, *Albizia lebbek*, *Flacourtia indica*, *Terminalia*, *Dalbergia sisoo*, *Acacia catechu*, etc. together with thickets of *Ziziphus mauritiana*, *Carissa opaca*, *Adhatoda vasica*, *Indigofera* sp. and *Nyctanthes arbor–tritis* occur sparsely distributed in the scrub forests. However, in certain areas *Acacia*–scrub forests dominated by *Acacia nilotica* with scattered shrubby elements of *Ziziphus mauritiana*, *Adhatoda vasica*, *Carissa opaca*, *Ricinus communis*, *Mimosa pudica*, *Abrus precatorius*, etc. can be seen in pockets. The herbaceous vegetation of terrestrial habitat comprises *Ageratum conyzoides*, *Euphorbia hirta*, *E. thymifolia*, *Mazus japonicus*, *Sonchus oleraceus*, *Oxalis acetosella*, *Chenopodium album*, *Sida rhombifolia*, *Chenopodium album*, *Micromeria biflora*, *Luecas aspera*, *Blumea eriantha*, etc. *Cyperus rotundifolia*, *Polygonum plebeium*, *Polygala chinensis*, *Ammania baccifera*, *Rotala rotundifola*, *Hygrophilla auriculata*, *Alternanthera sessilis*, etc. occur profusely in marshy places, adjoining to the lake, whereas the aquatic vegetation includes, *Trapa natans*, *Lemna* sp., *Potamogeton* sp., *Nymphoides cristata*, *Jussieau* sp., *Nelumbo nucifera*, etc. are abundant in lakes, ponds and ditches.

In the vicinity of the Lashoda Tal, there is some local variability in the vegetation. In general, the different flanks of the lake have *Acacia*–scrub vegetation. However, they are more profuse on the northern and southern flanks.

Pollen extraction methods

In all, 10 surface samples (LT–1 to LT–10) were collected for the present investigation from the *Acacia*–scrub forest area (L–1 to L–10) and the vicinity of Lashoda Lake to study the modern pollen–vegetation relationship, from where a trench profile is also being analyzed to reconstruct past vegetation and climate change. The sampling was executed at 100 m intervals each as it is assumed that the major chunk of pollen gets deposited within 100 m distance or so in open land conditions or cultivated area after getting discharged from the source plants (Luna *et al.*, 2002). The sampling strategy was planned in linear transect to understand the average representation of the prominent forest constituents/plant groups of the regional vegetation in the pollen rain.

Samples were treated with 10% aqueous KOH and 40% HF in order to remove humus and silica present in the sediments respectively. Thereafter, the conventional procedure of acetolysis (Erdtman, 1943) was followed to extract the pollen/spores from the sediments. Finally, the samples for microscopic examination were prepared in 50% glycerin solution.

All the samples analyzed were rich in pollen/spore content. The pollen sums range from 145 to 310, depending upon pollen yield of the samples. Percentage frequencies of retrieved taxa have been calculated in terms of total terrestrial plant pollen. Pollen of aquatic plants and spores of ferns and other lower cryptogams (algal remains) have been debarred from the pollen sums because of their origin from the local sources. The identification of retrieved pollen taxa has been executed by consulting the reference pollen reference slides present in the Herbarium of BSIP, Lucknow (Pl. 1). The plant taxa classified as trees, shrubs, herbs, ferns and algal remains and are arranged in the same sequence in the pollen spectra (Fig. 2).

RESULTS

Pollen rain compositions

Out of 10 surface samples analysed, LT–1, LT–2 & LT–3 are from the southern flank; LT–4 & LT–5 are from eastern flank, LT–6, LT–7 & LT–8 are from northern flank and LT–9 & LT–10 are from western flank of the lake. The pollen rain compositions (Fig. 2) of the samples from different flanks are described as below:

Pollen spectra (LT–I, LT–2 & LT–3) from the southern flank of the lake to village with luxuriant *Acacia*–scrub vegetation and frequent presence of other trees reveal the dominance of non–arboreal and relatively reduced frequencies of arboreals (trees and shrubs). The tree taxa, *Holoptelea integrifolia* (3.1–4.4%), *Madhuca indica* (1.5–2.6%), *Acacia nilotica* (3.1–14.2–3%), Moraceae (1.8–9.1%) *Syzygium cumini* (1.8–6%) and Tiliaceae (1.8–2%) are constantly

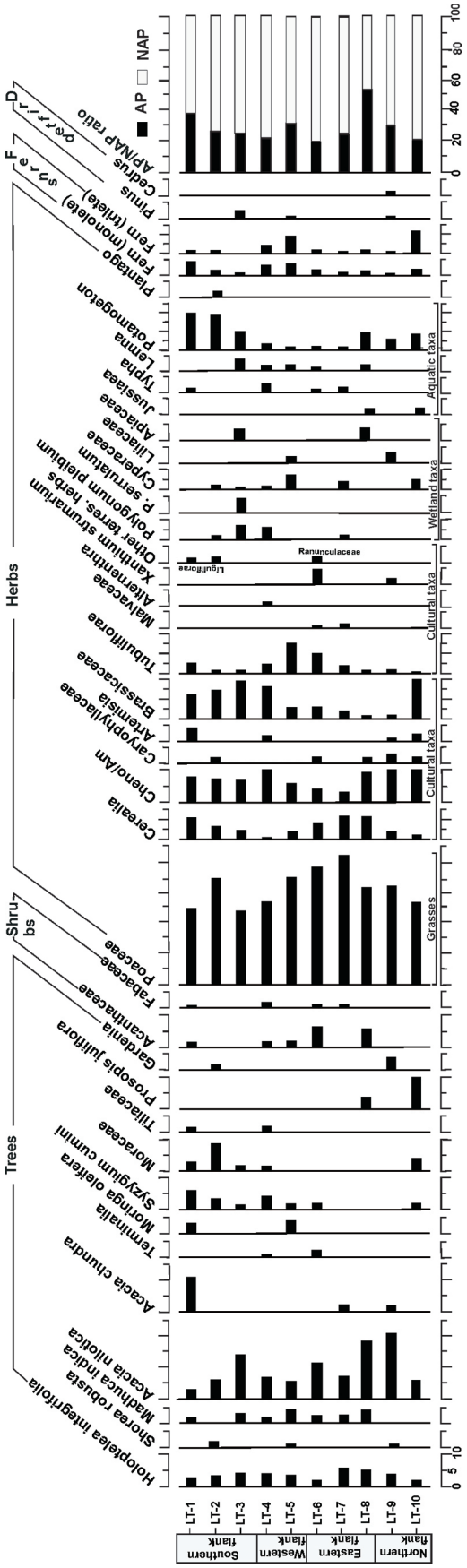

Fig. 2—Pollen spectra from Lashoda Tal, Raebareli District, U.P., India.

recorded in moderate frequencies. *Acacia chundra* (10.8%) is present in high value, though in one sample only. *Shorea robusta* (1.8%), *Gardenia* (1.8%) and *Moringa oleifera* (1.5%) are recorded at moderate to low values, though sporadically. Acanthaceae (1.5%) and Fabaceae (0.7%) are the representatives of shrubby vegetation.

The herbs are characterized by the high frequencies and consistent presence of Poaceae (23.8–34.5%), Cerealia (4.4–10.8%), Brassicaceae (12–19.4%), Chenopodiaceae/ Amaranthaceae (7–7.48%) and Tubuliflorae (1.7–5.4%), whereas Caryophyllaceae (1.8%), *Artemisia* (3.8%), Liguliflorae (1.5%)) are sporadic with moderate values. The wetland taxa, Cyperaceae (1.7–3.6%) and *Polygonum plebeium* (1.8–7%) are retrieved in moderate to high frequencies. Apiaceae (3.5%) and *P. serrulatum* (4.4) are sporadic. The aquatic element, *Potamogeton* (9.7–19.4%) is very frequent and has the highest value in Sample LT–1, whereas *Lemna* (3.5%), *Plantago* (1.8%) and *Typha* (1.5%) are low and sporadic.

Fern spores, monolete (0.9–4.7%) and trilete (1.7–1.8%) are recovered with low to moderate values.

Pollen spectra (LT–4 & LT–5) from the eastern flank also with *Acacia* scrubs and other relatively fewer trees in contrast to southern flank of the lake also exhibit relatively much reduced frequency of arboreals as compared to the non–arboreal. The tree taxa such as *Holoptelea integrifolia* (3.6–4.3%), *Acacia nilotica* (5.8–7%), *Madhuca indica* (1.7–3.9%) and *Syzygium cumini* (1.9–4.3%) are steadily recorded, with good frequencies. The rest of the trees, viz. *Shorea robusta* (1%), *Moringa oleifera* (1.9%) and *Terminalia* (0.9%) are sporadic. In all, the arboreal constitutes *ca*. 5.23% fraction of the total pollen rain. The shrubby vegetation is represented by Acanthaceae (1.7–1.9%) and Fabaceae (1.7%) only.

The non–arboreals as usual are characterized by the high frequencies of Poaceae (27–35%) followed by Cheno/ Am (5.8–10.4%), Tubuliflorae (15.5–5.2%) and Brassicaceae (5.8–16.5%) in appreciable frequencies. Cerealia (0.9–3.9%) and *Artemisia* (1.7%) are recorded sporadically. Tubuliflorae (5.2–15.5%), the only heathland element is steadily recorded. The marshy vegetation is marked by high values of Cyperaceae (3.5–11.5%) is represented by the high frequencies noticed so far, whereas *Polygonum plebeium* (6%) and Liliaceae (1.9%) are scarce. The aquatic elements, *Potamogeton* (1.4–3.9%) and *Lemna* (1.7–1.9%) are steadily recorded, though in low to moderate frequencies.

Fern spores (monolete (3.5–3.9% & trilete 4.3–4.7%) show good values. Drifted pollen of *Pinus* (1%) are noticed in one sample only.

Pollen spectra (LT–6, LT–7 & LT–8) from the northern flank of the lake with gregarious *Acacia*–scrub and frequent presence of other trees demonstrate av. 7.67% of arboreal pollen, which is also lower than the non–arboreals. *Acacia nilotica* (7.3–18.5%) is the principal tree components followed by *Madhuca indica* (2–3.7%) and *Holoptelea integrifolia* (2–6.3%) are recorded consistently. *Prosopis juliflora* (3.7%), *Acacia chundra* (2.1%), *Terminalia* and *Syzygium cumini* (2% each) are encountered sporadically in low values. Acanthaceae (5.5–6.1%) has much enhanced values than Fabaceae (1%), which are retrieved in low values.

Among the non–arboreals, Poaceae (31–42 %) has the highest frequency in contrast to witnessed on the other flanks. The culture pollen taxa, viz. Cerealia (8.2–11.5%), Brassicaceae (1.8–6.1%) and Cheno/Am (3.1–9.2%) are encountered consistently in appreciable frequencies Caryophyllaceae (1.8–2%) is infrequent. Tubuliflorae (1.8–10.3%) includes the most prominent heathland taxa, while Malvaceae (1–2.1%), *Xanthium strumarium* (5.2%) and Ranunculaceae (2.1%) are sporadic. The marshy elements, Cyperaceae (6.3%), Apiaceae (3.7%) and *Polygonum plebeium* (2.1%) are low to moderate values in one sample each. The aquatic element *Potamogeton* (2–10%) is constantly encountered with moderate to high values. *Lemna* (1–1.8%), *Typha* (3%) and *Jussiaea* (1.8%) are sporadic with moderate frequencies.

Fern spores monolete (1.1–2.1%) & trilete (0.54%) are present in low value. Drifted pollen of *Pinus* (1%) are showing increased frequencies.

Pollen spectra (LT–9 & LT–10) from western flank adjacent to widely spread agricultural land is marked by the presence of *Acacia* and *Prosopis* scrub and few other trees. The pollen assemblage is characterized by the relatively lowest diversity of both arboreals and non–arboreals compared to other flanks. Amongst the tree taxa, *Acacia nilotica* (6.2–21%) is consistently recorded with highest frequencies. *Prosopis juliflora* (10.3%) together with *Holoptelea integrifolia* (2.1–4%) and Moraceae (4.1% each) in moderate frequencies, though sporadic. *Gardenia* (4%), *Syzygium cumini* (2.1%), *Acacia chundra* (2%) and *Shorea robusta* (1%) are intermittently present in low values.

Among the terrestrial herbs, the herbaceous vegetation is characterized by the high frequencies and consistent presence of Poaceae (26.8–32.1%) retains its dominance over others. The culture pollen taxa such as Brassicaceae (2–20.6%) and Cheno/Am (10.3–16%) have much higher frequencies compared to Cerealia (2–4%) and Caryophyllaceae (2–3%), *Artemisia* (1–2.1%), which are also marked by their steady presence. Tubuliflorae (1–2%) have constantly moderate frequencies together with *Xanthium strumarium* (2% in one sample only) are the only representatives of heathland vegetation. The wetland elements, Cyperaceae (8.2%) and Liliaceae (3%) are in good values in one sample each. The aquatic element, *Potamogeton* (6–8.2%) is met with substantially increased values, whereas *Typha* (1–2%), *Lemna* and *Jussiaea* (1.8% each) are infrequent. Fern spores (monolete & trilete 1–2% each) are recovered in reduced frequencies. Pollen of the Himalayan elements such as *Pinus* (1%) and *Picea* (2%) are intermittent.

DISCUSSION

The study of pollen rain vis–a–vis vegetation is inevitable prior to investigation of sedimentary deposits since it furnishes the comparative database, which is used for appropriate evaluation of shifting vegetation scenarios and contemporary climate variability of the past. Therefore, to generate the required data on this aspect in order to decipher the pollen deposition pattern of various regional and local plant taxa/plant groups, the investigation of surface sediments was pursued from Lashoda Tal in the Central Ganga Plain, from where the investigation of sediment profile for the reconstruction of past vegetation and climate change has been undertaken. The pollen rain study conducted on 10 surface samples collected from different flanks of Lashoda Tal, Raebareli District (Fig. 2) has portrayed the dominance of non–arboreals (herbs) and relatively low number and frequencies of arboreals (trees & shrubs). Amongst the trees, the relatively much higher frequencies of *Acacia* (av. 10%) is recorded in all the flanks. However, it attains the highest value of 21% in the densely inhabited northern flank, truly reflecting the gregarious occurrence of *Acacia*–scrubs in this part adjoining to the lake. Among the other trees, *Holoptelea integrifolia* (av. 3.9%), *Syzygium cumini* (av. 2.2%) and *Madhuca indica* (av. 1.76%), pollen are in fairly good frequencies, probably due to its local abundance as they are conserved by the local populace for their multifaceted uses. Collectively, these taxa constitute a fraction of av. 7.86% of the total arboreal pollen. The rest of the trees such as *Shorea robusta, Acacia chundra, Terminalia*, *Moringa oleifera*, Moraceae, Tiliaceae, *Prosopis juliflora*, Meliaceae, *Gardenia*, etc. are recorded sporadically in low frequencies, despite being common in the region. However, the spurt of *Prosopis juliflora* (10%) in Sample LT–10 from northern flank only could be surmised to its locally profuse occurrence. The erratic representation of these taxa in the pollen rain could be attributed to their low pollen productivity since most of the tropical trees exhibit a strong tendency of entomophilly (Chauhan, 2008). In all, they constitute 16.3% pollen out of 24.2% arboreal pollen retrieves in the pollen rain. Similar observations have also been made concerning the ambiguous behaviour of most of the tropical trees in the pollen rain from Jalesar in Unnao District (Trivedi & Chauhan, 2011), Bari Tal, Lucknow (Trivedi *et al.*, 2014), Chaudhary–Ka–Tal (Trivedi *et al.*, in press) and Madhya Pradesh (Chauhan, 1994, 2008) as well as from the tropical forests of western Uganda (Vincens *et al.*, 1997). Selective preservation of their pollen and microbial degradation cannot be denied as a good number of fungal spores, viz. *Nigrospora*, *Tetraploa*, *Glomus,* etc. have also been recovered in the sediments during the course of investigation. The poor shrubby vegetation in the area is faithfully depicted by the infrequent pollen of Acanthaceae and Fabaceae.

The herbaceous vegetation is marked by the constantly high frequencies of grasses (Poaceae) with av. 31.5% pollen with maximum value of 42% at the eastern flank. However, the encounter of Cerealia and other associated crop land weeds, viz. Cheno/Am, Brassicaceae, Caryophyllaceae and *Alternanthera* with av. 26.7 % infers that most of the area in the vicinity of the lake is under intensive agrarian practice as well as some other sort of human activities. Besides, the heathland elements, viz. Asteraceae (Tubuliflorae & Liguliflorae), Ranunculaceae, Malvaceae, etc. are infrequent and recorded with av. 6.25% pollen. The fluctuating moderate to high frequencies of wetland taxa, viz. sedges (Cyperaceae), *Polygonum plebeium* and Apiaceae with av. 6.85% pollen demonstrates the intermittent marshes condition along the lake margin and the adjoining areas. In general, the representation of non–arboreals corresponds closely with the actual presence of ground flora in the region, as manifested by the largest fraction of av. 71.4% pollen. Furthermore, the record of the aquatic elements, viz. *Potamogeton*, *Jussiaea* and *Typha* in a deviating manner depicts the proximity of lake and other water–bodies, wherefrom their pollen get trapped in the surface sediments after emission from the parent plants.

The sporadic encounter of *Pinus* and *Cedrus* pollen in the sediment implies their transportation by watercourse as well as by winds from the temperate and subtropical belts of the Himalaya, where these taxa grow in pure formation. Their presence also suggests the Himalayan connection of wind circulation pattern with the Ganga Plain.

PLATE 1 →

(all scales in 2μm)

1. *Acacia nilotica*
2. *A. chundra*
3. *Madhuca indica*
4. *Holoptelea integrifolia*
5. Meliaceae
6. *Shorea robusta*
7. *Terminalia*
8. *Moringa oleifera*
9. *Syzygium cumini*
10. *Prosopis juliflora*
11. Acanthaceae
12. Poaceae
13. Cerealia
14. Caryophyllaceae
15. Cheno/Am
16. Brassicaceae
17. *Artemisia*
18. *Alternanthera*
19. Tubuliflorae
20. Liguliflorae
21. Malvaceae
22. *Xanthium strumarium*
23. Cyperaceae
24. Apiaceae
25. *Potamogeton*
26. *Polygonum plebeium*
27. *Lemna*
28. *Typha*
29. Fern trilete spore Type–I
30. Fern trilete spore Type–II

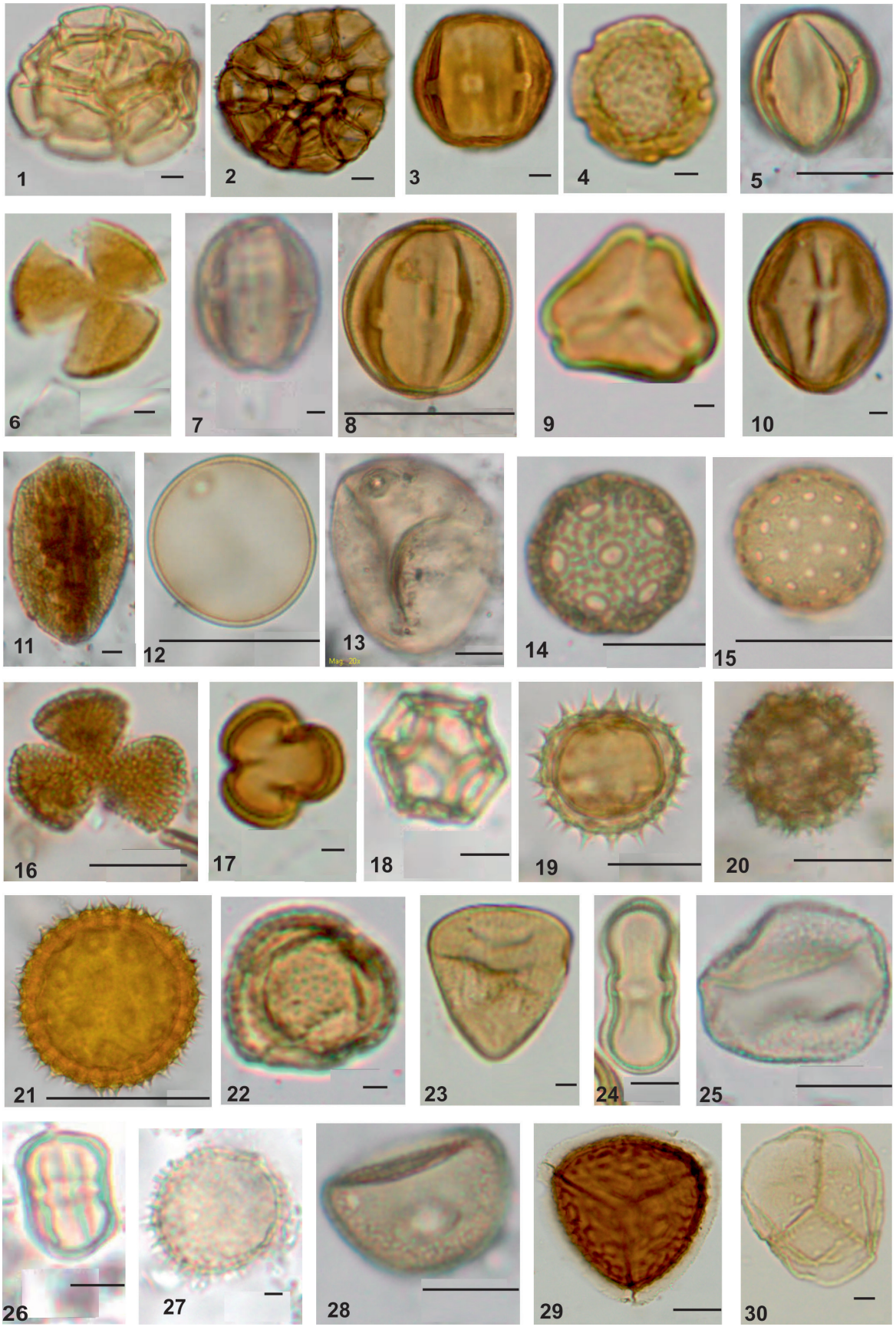
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PLATE 1

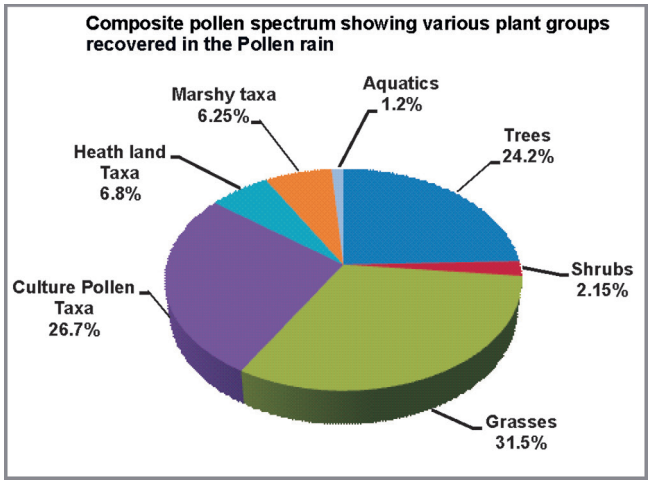

Fig. 3—Composite pollen spectrum from Lashoda Tal, Raebareli District, U.P., India.

In all, trees constitute av. 24.2% fraction of the pollen rain. Together with av. 2.5% shrubs they form av. 26.7% arboreal pollen. The non–arboreals constitute the major chunk of av. 71.4% pollen of the total pollen rain.

CONCLUSIONS

The comparative assessment of AP and NAP ratio from open scrub vegetation at Lashoda Tal unravels only av. 26.7% arboreal (trees & shrubs) pollen out of total pollen influx with *Acacia* av. 10%, *Holoptelea integrifolia* av. 3.9% and *Madhuca indica* av. 1.7% being the major ingredients. The rest of the trees are represented by av. 5.5% pollen only (Fig. 3). The extremely poor depiction of other trees in the pollen rain could be attributed to their low pollen productivity as well as their sparse presence in the area. Further, the arboreal pollen diversity is relatively better on the southern flank as the area adjoining to this part support good groves of trees and shrubs. Among the non–arboreals, grasses (Poaceae) are recorded with av. 31.5% of pollen, whereas Cerealia, culture pollen taxa and heathland taxa collectively form av. 33% fraction of the total pollen rain. On the whole the terrestrial herbs constitute the largest fraction of av. 64.2% pollen. On the other hand marshy comprising sedges and others are encountered with av. 6.8% pollen. Collectively, the non–arboreals with average pollen frequency of 71.4%, encompassing terrestrial and marshy herbs, largely portrays the presence of open vegetation in the region. Therefore, it is deduced that this comparative database on pollen rain vis–à–vis vegetation is to be taken as a modern analogue for the scrupulous evaluation of vegetation dynamics of the past while interpreting the pollen sequences from the Central Ganga Plain and other region with similar extant floristic composition. The pollen rain data–grid also signifies the prevailing present climatic condition in the study area. The physiognomic aspects of the trees whether they are dry, moist or evergreen can be determined from the available information by seeing the climatic requirements of the retrieved plant taxa in the pollen assemblage as well as empirical climatic data for the region.

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