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# Study on modern vegetation distribution in Sevan Tal area, Raebareli District, Uttar Pradesh

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## ABSTRACT

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Pollen analysis of ten surface sediment samples from Sevan Tal, Raebareli District (U.P.) reveals a good assemblage of arboreals (trees & shrubs) comprising *Holoptelea integrifolia*, *Acacia nilotica*, *Syzygium cumini*, *Madhuca indica* and *Shorea robusta*, etc. However, plant diversity in forest groves has been observed in eastern and southern fringes but are less diversified in northern and western flanks due to arable and heathland, respectively in the area. Together with av. 4% shrubs, the trees constitute av. 23.3% arboreal pollen. Even then, in general, the reduced frequencies of the trees could be ascribed to their low pollen productivity since they portray a strong tendency of entomophily. Among the non–arboreals, Poaceae with av. 35% pollen subdues the other herbaceous elements. The substantially increased frequencies of cultural taxa, viz. Cerealia, Chenopodiaceae/Amaranthaceae (Cheno/Am), *Artemisia*, *Cannabis sativa* and Brassicaceae, more particularly on the northern and western flanks, truly reflect the intensive agriculture practice in the region. The consistent presence of marshy taxa such as Cyperaceae coupled with *Polygonum plebeium*, *P. serrulatum* and Liliaceae suggests the intermittent wetlands in the proximity of the lake. In all, the representation of the non–arboreals corresponds closely with their factual occurrence in the ground flora, constituting the largest chunk of av. 75% pollen. The frequent record of *Potamogeton* together with *Lemna*, *Typha*, etc. denotes the existence of the lakes around the sampling provenance. This comparative database on pollen vis–à–vis vegetation relationship serves as modern analogue for the appropriate assessment of the pollen sequence from the sediment deposit in terms of past vegetation and climate change in the Central Ganga Plain. Moreover, the representation of the arboreals, particularly trees, in the spectra symbolizes the prevailing climatic condition in the study area.

**Key–words**—Pollen analysis, Surface soils, Pollen/spore rain, Sevan Tal, Uttar Pradesh.

## उत्तर प्रदेश में जिला रायबरेली के सेवन ताल क्षेत्र, में आधुनिक वनस्पति वितरण का अध्ययन

अंजलि त्रिवेदी, अंजु सक्सेना एवं मोहन सिंह चौहान

## सारांश

जिला रायबरेली, (उत्तर प्रदेश) के सेवन ताल क्षेत्र, से प्राप्त दस पृष्ठीय अवसाद नमूनों का पराग विश्लेषण *होलोप्टेलिया इंटेग्रिफोलिया, एकैसिया, निलोटिका, सायजीजियम कुमिनि, मधुका इंडिका, शोरिया रोबस्टा* इत्यादि सन्निहित वृक्षीयों (वृक्ष एवं झाडियां) का उत्तम समुच्चय उद्घाटित करता है। फिर भी पूर्वी एवं दक्षिणी उपांतों के वन निकुंजों में पादप विविधता प्रेक्षित की गई है परन्तु क्षेत्र में क्रमशः कृष्य एवं अजोत भूमि के कारण उत्तरी और पश्चिमी पार्श्वों में कम विविध रूपायित हैं। औसतन 4% झाडियों के साथ वृक्ष औसतन 23.3% वृक्षीय पराग गठित करते हैं। फिर भी, सामान्यतः वृक्षों की घटती आवृत्तियां अपनी अल्प पराग उत्पादकता की उत्तरदायी रही होगी क्योंकि वे कीट–परागण की दृढ़ प्रवृत्ति चित्रित करते हैं। गैर–वृक्षीयों में औसतन 35% मंद पराग के साथ पोएसी अन्य शाकीय तत्व हैं। खेती टैक्सा अर्थात् अनाज, कीनोपोडिएसी/अमरेंथेसी (कीनो/एम), *अर्टेमिसिया, कैन्नाबिस सैटाइबा* और *ब्रसीकेसी* की भरपूर वृद्धित आवृत्तियां, खासतौर पर उत्तरी व पश्चिमी पार्श्वों पर अंचल में गहन खेती यथार्थतः प्रतिबिंबित करती हैं। *पॉलीगोनम प्लेबीयम, पी. सेर्रलेटम* और लिलीएसी से युग्मित सायपेरेसी जैसी दलदली टैक्सा की अनवरत विद्यमानता झील के समीप में आंतरायिक आर्द्रभूमि व्यंजित करती है। समग्रतः गैर–वृक्षीयों का निरूपण भू–वनस्पति–जात में उनकी तथ्यपरक प्राप्ति के साथ निकटता से सुसंगत होता है, औसतन 75% पराग के विशालतम खंड संघटित कर रहा है। *लैम्ना, टायफा,* इत्यादि के साथ–साथ *पोटामोगेटन* के कदाचनिक अभिलेख नमूना–जांच उद्गम–स्थल के आस–पास झील का अस्तित्व द्योतित करता है।

पराग बनाम वनस्पति संबंधता पर यह तुलनात्मक आंकड़ा आधार मध्य गंगा के मैदान में गत वनस्पति और जलवायु परिवर्तन के संदर्भ में अवसाद निक्षेप से प्राप्त पराग अनुक्रम के उचित मूल्यांकन हेतु आधुनिक अनुरूप की भांति पर्याप्त होता है। इसके अतिरिक्त, स्पेक्ट्रा में वृक्षीयों, विशेषतया वृक्षों का निरूपण अध्ययन क्षेत्र में व्याप्त जलवायवी स्थिति का प्रतीक प्रस्तुत करता है।

**सूचक शब्द**—पराग विश्लेषण, पृष्ठीय मृदाएं, पराग/बीजाणु वर्षा, सेवन ताल, उत्तर प्रदेश।

## INTRODUCTION

POLLEN investigation is one of the utmost fruitful sources of information on Late Quaternary climate via reconstruction of past vegetation (Fraegri & Iversen, 1975). Before the analysis of sediment profile, it is essential to have the knowledge of relationship of various elements of pollen rain deposition and their preservation in relation to extant flora through the analysis of modern deposits.

Considerable data–grid has been extracted on modern pollen rain–vegetation relationships for the tropical evergreen and deciduous forests in south India and Sri Lanka (Bonnefille *et al*., 1999; Anupama *et al*., 2000; Barboni & Bonnefille, 2001), tropical deciduous forests in the foothills of Himalaya (Sharma, 1985; Gupta & Yadav, 1992), northeast India (Basumatary & Bera, 2007), Madhya Pradesh (Chauhan, 1994, 2008) and tropical deciduous scrub vegetation in northwest desert (Singh *et al*., 1973). These studies have provided ample comparative data–base on the pollen rain vis–a–vis modern vegetation, which served as the modern analog for the factual appraisal of past pollen sequences from their respective regions in terms of vegetation dynamics and coeval climatic conditions during the Quaternary Period. However, the Ganga Plain with immense potential for the

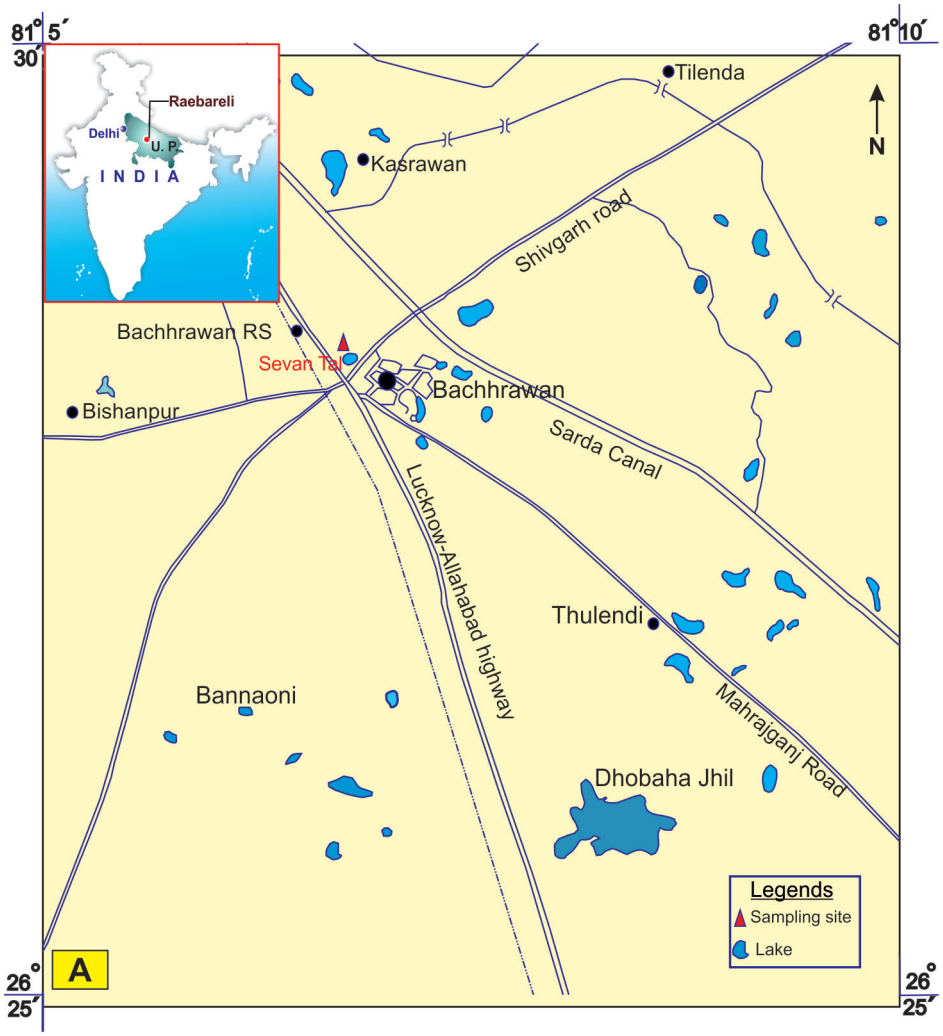


Fig. 1—A, B and C. Map of Sevan Tal, Raebareli District (U.P.) showing site of surface samples.

Quaternary palaeofloristic studies has not received much attention in understanding the pollen deposition pattern of different plant taxa/plant groups, which is of utmost need prior to the investigation of sedimentary deposits from this region. On this aspect so far a earliest study has been executed from Jalesar Lake, Unnao District, Bari Tal, Lucknow District, Lashodha Tal, Chaudhari Ka Tal and Kikar Tal, Raebareli District, in the Central Ganga Plain (Trivedi & Chauhan, 2011; Trivedi *et al.*, 2014, 2015, 2016; Saxena & Trivedi, 2017). In the current study, an effort has been made to produce additional data in order to estimate the degree of representation of different regional and local taxa in the modern pollen rain and to comprehend their pollen distribution efficacy as well as to disentangle the probable dynamics disturbing preservation of pollen/spores in the deposits through the pollen analysis of modern soil samples of the Sevan Tal, Raebareli District, Uttar Pradesh.

## PHYSIOGRAPHY

Sevan Tal (Fig. 1) is situated about 50 km southwest of Lucknow and 1 km east of Bachhrawan, Raebareli District (Long. 81º6'37.98'' & Lat. 26º28'47.34'') in the close proximity of the Bachhrawan Village. However, the lake is ephemeral and fed by rain water and remains almost dried during the summer, except little water at the centre. It is almost circular in outline with gentle slope margin. The lake is used by the local folks for fish cultivation as well as potable water. The northern and western parts adjoining to the lake are under intensive agricultural practice, whereas the eastern and southern parts possess some forest groves and *Acacia*–scrub as well as other wasteland thickets such as *Ziziphus mauritiana*, *Lantana camara*, *Calotropis procera* and other herbaceous weeds. Most of the area encircling the lake is under the cultivation of the conventional crops,


viz. *Triticum aestivum* (wheat), *Oryza sativa* (paddy), *Cicer aeretinum* (chana), *Phaseolus mungo* (moong) and *Sacchhrum offinarum* (sugarcane).

## CLIMATE

The region, in general, is humid and lies on the track by southwest monsoon (Chauhan *et al*., 1990; Farooqui & Sekhar, 2011). High seasonality is visible, i.e. winters season from November to February is characterized by average minimum and maximum temperatures of 7.6ºC and 21ºC respectively. The temperature seldom goes down to 0ºC during the extreme cold months of December and January. Summer season from March to June is marked by hot blowing winds with average minimum and maximum temperatures of 27ºC and 32.5ºC respectively. The temperature rises up to 46ºC in June. Monsoon season initiates in the mid–June and continues till mid–September. The weather becomes humid during July to September.

## MATERIALS AND METHODS

Ten surface soil samples were collected adjacent to Sevan Tal from where a trench profile is also being analyzed to reconstruct past vegetation and climate change. The samples collected at 100 m interval each as it has been observed that a major fraction of pollen gets deposited within a short distance of 100 m after their discharge from the parent plants (Luna *et al*., 2002). The sample collection was made during the June for the factual evaluation of the pollen rain vis–à–vis the land floristic could be achieved.

Ten grams of samples were boiled with 10% aqueous KOH and 40% HF in order to remove humus and silica present in the surface sediments respectively. Thereafter, the standard procedure of acetolysis (Erdtman, 1943) using acetolysis mixture (9: 1 ratio of acetic anhydride and concentrated sulphuric acid) was followed. Finally, the samples were preserved in 50% glycerin solution for microscopic examination.

All the soil samples analyzed were potential in pollen/spore content. The pollen sums vary from 100–150, Percentage frequencies of the recovered pollen 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 excluded from the pollen sums because of their source from the local provenances. The plant taxa (Pollen Plate) classified as arboreals (trees and shrubs) trees, nonarboreals (terrestrial herbs and marshy) and fungal remains and are arranged in the same sequence in the pollen spectra and cumulative diagram (Figs 2 & 3).

## POLLEN RAIN COMPOSITION

Out of 10 surface soil samples analyzed, ST–1, ST–2 & ST–3 are from the southern flank; ST–4 & ST–5 are from the eastern flank, ST–6, ST–7 & ST–8 are from the northern flank and ST–9 & ST—10 are from the western flank of the Sevan (Lake) Tal. The pollen rain compositions of the samples from diverse borders are elucidated as below:

Pollen Spectra (ST–1, ST–2 & ST–3) from southern flank of the lake divulges the supremacy of non–arboreal and relatively good values of arboreals (trees and shrubs). The tree taxa, *Holoptelea integrifolia* (7.6–3.7%), *Syzygium cumini* (4.7–7.5%), *Shorea robusta* (3.8–1.5%), *Madhuca indica* (13–2.6%), *Acacia nilotica* (4.1–11.6%), are constantly recorded in adequate frequencies. *Terminalia* sp. (1–2.6%), *Acacia chundra* (1.5–2.8%), *Eucalyptus* sp. (1.4–4.2%), Moraceae (2–3.7%), *Moringa oleifera* (2%), Tiliaceae (1.8–2.0%) and *Gardenia* sp. (1.8%) are recorded in moderate to low values. The shrubby vegetation are represented by Acanthaceae (2%), *Gardenia* (1.8%) and Fabaceae (1%).

The herbaceous vegetation is characterized by the high frequencies and consistent presence of Poaceae (23.9–34.5%), Cerealia (4.4–11%), Chenopodiaceae/Amaranthaceae (7.1–8.3%), Brassicaceae (13–19.5%) and Tubuliflorae (1.8–6%), whereas Caryophyllaceae (1.8%), *Artemisia* (4%), *Xanthium* (0.5%), Liguliflorae (2%), Apiaceae (3.5%), *Plantago* (1.8%) are infrequent with modest values. The swampy elements, *Polygonum plebeium* (1.8–7.1%), *P. serrulatum* (1.5–4.4%), and Cyperaceae (2.87–3.5%) are retrieved in moderate to high frequencies. Liliaceae (1–2.5%), *Typha* (1.55%) and *Potamogeton* (1.8–7.50%) represent the aquatic flora and show an appreciable number in contrast to other flanks. Fern trilete spores (1.02%) are recovered in one sample only. The Himalayan elements, *Pinus* (1%) and *Cedrus* (0.45%) are also met with occasionally.

Pollen Spectra (ST–4 & ST–5) from the eastern flank of the lake also exhibit relatively high frequencies of arboreals as compared to the non–arboreals. The trees taxa such as *Holoptelea* (3.9–7.4%), *Acacia nilotica* (5.8–7%), *Syzygium* (1.94–3.4%), *Madhuca indica* (1.8–3.9%) and Meliaceae (0.38–1.5% each) are steadily recorded, though in low values. The rest of the trees, viz. *Terminalia* (2.9%) *Moringa oleifera* (1.94%), *Embelica officinalis* (1.20%), *Shorea robusta* (1%),

**PLATE 1**
(Scale bar = 10 μm)

1. *Madhuca indica*, 2. *Acacia nilotica*, 3. Rutaceae, 4. Rubiaceae 5. *Holoptelea integrifolia*, 6. Myrtaceae, 7. Anacardiaceae, 8. *Terminalia*, 9. *Syzygium cumini*, 10. *Prosopis juliflora*, 11. *Ficus* sp., 12. Acanthaceae 13. Brassicaceae, 14. Chenopodiaceae/Amaranthaceae, 15. *Rumex*, 16. Caryophyllaceae, 17. *Alternanthera*, 18. *Artemisia*, 19. Cerealia, 20. Poaceae, 21. Liguliflorae, 22. Tubuliflorae, 23. Malvaceae, 24. *Xanthium strumarium*, 25. Cyperaceae, 26. Apiaceae, 27. *Polygonum plebium*, 28. *Potamogeton*, 28. *Typha*, 30. Fern trilete, 31. Fern monolete, 32. *Pinus,* 33. *Nigrospora,* 34. *Alternaria,* 35. *Glomus.*

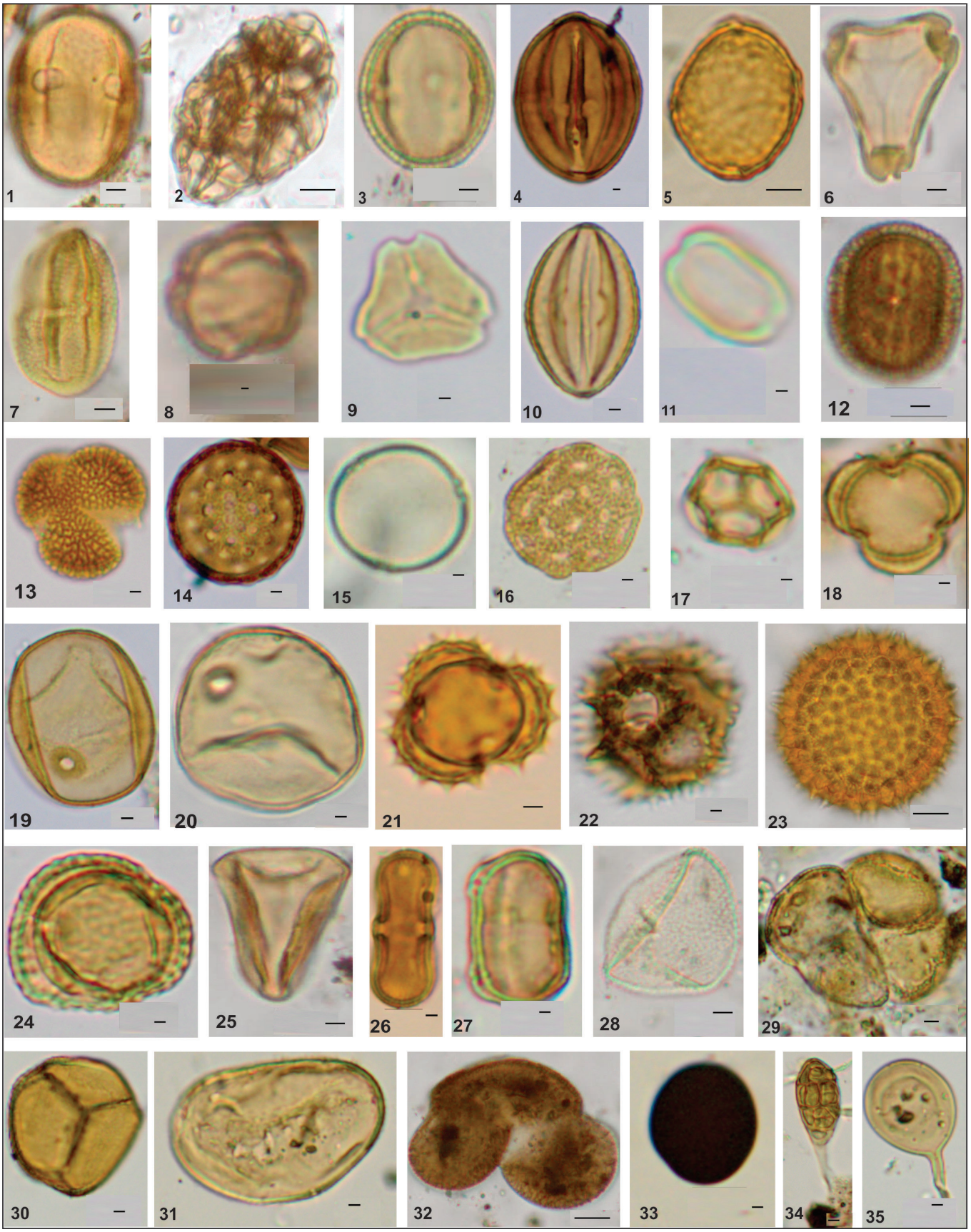
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**PLATE 1**

and Moraceae (2.7%) are sporadic. The shrubby elements are represented by Acanthaceae (1.8–2%), followed by *Mimosa* and Fabaceae (1.2% &1.74% respectively).

The non–arboreals as usual are characterized by the high frequencies of Poaceae (21–27.8%) followed by Brassicaceae (5–16.5%), Tubuliflorae (10.5–5%), Cheno/Am (5.8–6.4%), *Xanthium* (3.4%), Cerealia (0.8–7.88%) and *Artemisia* (1.7–3.1%) in appreciable frequencies. Malvaceae (1.8%) are also retrieved sporadically. The marshy vegetation is marked by high values of Cyperaceae (5.5–8%) and *Polygonum plebeium* (4%). The aquatic element, represented by only *Potamogeton* (3.8–4%). Drifted pollen of *Pinus* (1%) are noticed intermittently. Marsy taxa fern monolete (4.8–5.8%) and trilete (4.4–10.7%) representing peak of the pollen spectrum

Pollen Spectra (ST–6, ST–7 & ST–8) from the northern flank of lake demonstrate that low diversification and values of arboreal. *Acacia nilotica* (3.3 to 3.4%) and *Madhuca indica* (1.7–2.6%) are the principal tree components followed by *Syzygium* (2–2.1%) and *Holoptelea* (1.3–2.6%). *Eucalyptus* (0.5%) encountered sporadically in moderate inadequate values shrubby vegetation is represented by Acanthaceae (5.56%) and Fabaceae (1%) only.

Among the terrestrial herbs, Poaceae (30–35%) has the highest frequency, in contrast, to witness on the other flanks. Cerealia (8.25–11%), Cheno/Am (4.1–10.3%), Brassicaceae (6.9–8.5%) and *Xanthium* (4.5–5.3%) are the most prominent herbaceous taxa. Others, viz. Caryophyllaceae (1.85–2.1%), *Artemisia* (5%), Tubuliflorae (1.9–9.5), Apiaceae (1.5–3.6%) Malvaceae, Liguliflorae (1–2.1% each) and Ranunculaceae (1.5–2%) are consistently recovered in moderate frequencies. Urticaceae (2%), are encountered only in one sample. The marshy element, Cyperaceae (5.5–6.3%) is represented by the high values so far, whereas, *Polygonum plebeium* (2.1–3.8%) has low to moderate values and *P. serrulatum* (2.5%), *Jussua* (0.5%), Liliaceae (2.7%) are noticed in one sample only. Fern monolete (1–1.8%) & trilete (1–5%) are in good value. Algal remains *Potamogeton* (2.1–4%) present in good amount but *Typha* (3.1%) present in one sample only. Drifted pollen of *Pinus* (1%) have shown no change.

Pollen Spectra (ST–9 & B–10) from western flank are portrayed by the moderately low variety of both arboreals and non–arboreals compared to seen so far. The woody taxa, *Acacia nilotica* (6.5–5%) is constantly recorded with raise values tracked by *Holoptelea* (1.5–2 %) and *Syzygium* sp. (1–3%) are in modest percentages. *Sclechera* sp. (2.5%) and *Acacia chundra* (2%) are somewhat good portrayed in compare to *Shorea robusta, Eucalyptus,* Moraceae and *Emblica officinalis* (1% each), which are infrequent. *Mimosa pudica* (1.2%) is the only representative of shrubby element, is met with spasmodically.

The non–arboreals, Poaceae (32–30.8%), Cheno/Am (10%), *Xanthium* (2–9%) show high values. *Artemisia* (3–5%), Cerealia (2.0–4.9%), Caryophyllaceae (2–3%)

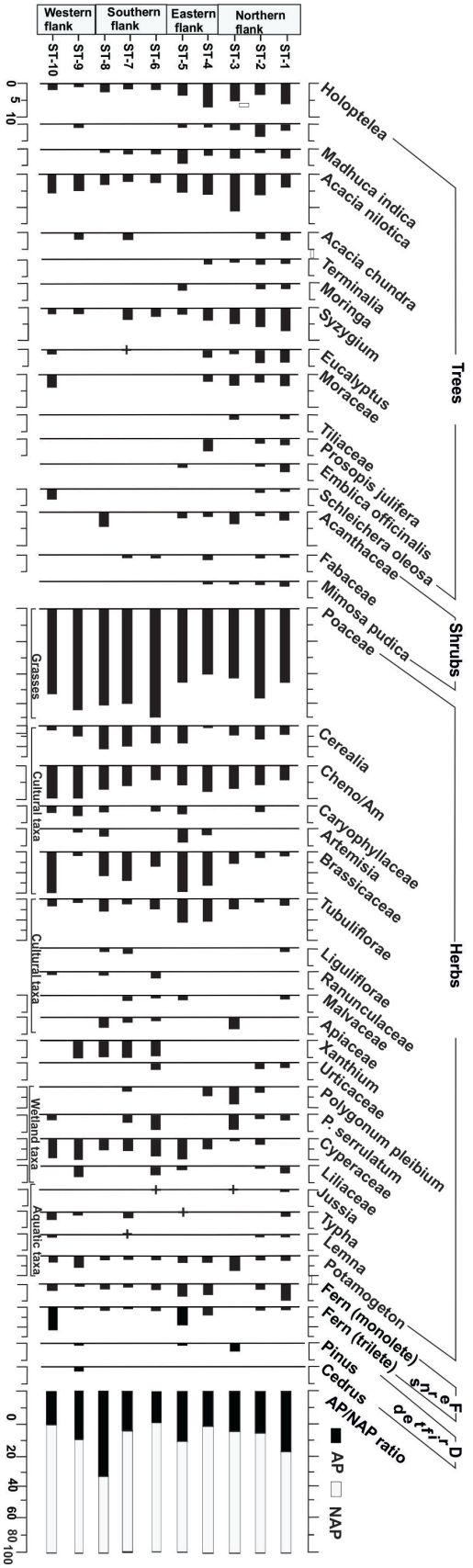


Fig. 2—Pollen spectra from Sevan Tal, Raebareli District (U.P.).

and Tubuliflorae (1–2.8%) have moderate frequencies. Brassicaceae (10–20%) exhibits the highest value noticed so far in pollen spectrum ST–10. Others, such as Liliaceae (2.9%), Urticaceae (1.5%), Ranunculaceae, Malvaceae (1% each) and Liguliflorae (0.5%), are registered inadequately. Cyperaceaeae (7.5–10.5%) attains the highest values so far, whereas *Polygonum serrulatum* (1.9%) and *P. plebeium* (1%) has low to moderate values. The extra regional taxa *Pinus* (1%) and *Cedrus* (2%) present in good number. Aquatics, *Potamogeton* (3.2–6%) and *Typha* (2.5–1%) recovered in good values whereas *Lemna* (1.2%) also present meagrely. Fern spores, trilete (1.4–10%) and monolete (1–2%) are recovered in improved value.

## DISCUSSION AND CONCLUSIONS

The relative valuation of AP and NAP proportion from Sevan Tal divulges average 27.3% arboreal (23.3% trees & 4% shrubs) pollen out of the overall pollen inflow. Chiefly *Holoptelea integrifolia, Acacia nilotica* and *Syzygium* average 12.7% being the key ingredients and the trees actually growing there.

The respite of the trees is signifying by average 10.6% pollen only. Their enormously deprived representation of other trees in the pollen shower could be accredited to their little pollen efficiency as well as meagre attendance in the area. The arboreal pollen diversity is moderately better on eastern and southern fringes as they are conserved as the forest grove by the local people. The microbial activity during the preservation cannot ruled out. The shrubs, viz. Acanthaceae, *Mimosa* and Fabaceae among middling 3.1% pollen are low in appearance. The low presence of tree taxa would also support the assumption of the Clark *et al.* (1995) that the absence of vegetation in some areas are directly related to the human activity rather than the result of inauspicious microsites.

Amongst the non–arboreals, the steady lofty predominance of the grass pollen average 35% corresponds with their truthful attendance in the land vegetation.

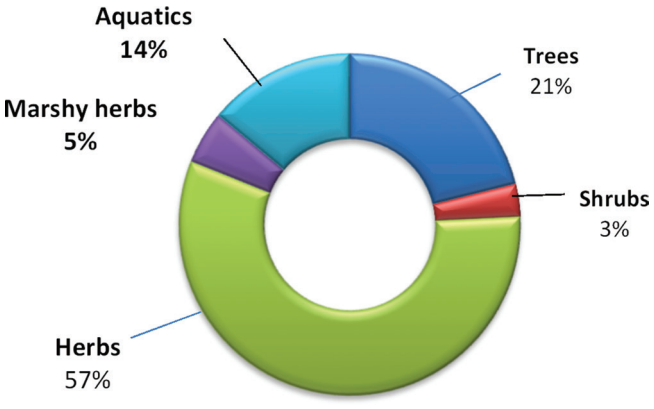


Fig. 3—Composite Diagram of the pollen taxa recovered in surface soil sediments of Sevan Tal (U.P.).

Furthermore, the Poaceae are one of the tremendous pollen producers, which also attributes to their higher occurrence in pollen shower. While, Cerealia, culture pollen taxa and heathland taxa collectively form average 33.4% proportion of the total pollen rain. The regular existence of Cerealia along with Cheno/Am, Caryophyllaceae, Brassicaceae, with *Artemisia* and Tubuliflorae suggest the prevalence of strong agricultural and pastoral activity in the vicinity of lakes. The constituent and notable occurrence of heathland taxa, i.e. Tubuliflorae with Liguliflorae suggest the occurrence of pastoral activities in the area, as the pollen of Asteraceae are unpalatable to livestock, thereby leaving them in the soils which ultimately resulted from high pollen occurrence in the spectra. On the whole, the terrestrial herbs constitute the largest fraction average 65% pollen. In total, the land and marshy herbs (non–arboreals) covering with the principal portion of average 75% pollen, encircling endorse the presence of open grassland vegetation in the area.

Additionally, the expression of marshy taxa as Cyperaceae and Polygonaceae and aquatics collectively 21.9% is evocative of the boggy and wringing wet environment of the region. Among the aquatics, the steady presence of *Potamogeton* along with *Typha latifolia* and *Lemna*, in irregular frequency further reinforce the vicinity of the pond close to the sampling location.

Therefore, the recent pollen–vegetation relationship has significantly supported to understand the picture of present vegetation pattern in the pollen record, which would be helpful in predicting the past vegetational changes vis–à–vis climatic fluctuations adjacent to the Sevan Tal area.

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## REFERENCES

Anupama K, Ramesh BR & Bonnefille R 2000. Modern pollen rain from the Biligirirangan–Melagiri hills of Southern Eastern Ghats, India. Review of Palaeobotany and Palynology 108: 175–196.

Barboni D & Bonnefille R 2001. Precipitation signal in pollen rain from tropical forests, South India. Review of Palaeobotany and Palynology 114: 239–258.

Basumatary SK & Bera SK 2007. Modern pollen–spore assemblage from sediment of tropical moist deciduous forest, East Garo Hills Meghalaya. Journal of Palynology 43: 111–118.

Bonnefille R, Anupama K, Barboni D, Pascal JP, Prasad S & Sutra JP 1999. Modern pollen spectra from tropical South India and Sri Lanka, altitudinal distribution. Journal of Biogeography 26: 1255–1280.

Chauhan MS, Khandelwal A, Bera SK & Gupta HP 1990. Palynology of Kathauta Tal, Chinhat, Lucknow. Geophytology 21: 191–194.

Chauhan MS 1994. Modern pollen/vegetation relationship in the tropical deciduous sal (*Shorea robusta*) forests in District Sidhi, Madhya Pradesh. Journal of Palynology 30: 165–175.

Chauhan MS 2008. Pollen deposition pattern in the tropical deciduous sal (*Shorea robusta*) forests in northeastern Madhya Pradesh. Geophytology 37: 119–125.

Clark DA, Clark DB, Sandoval R & Castro MV 1995. Edaphic and human

effects on landscape–scale distributions of tropical rain forest palms. Ecology 76: 2581–2594.

Erdtman G 1943. An Introduction to Pollen Analysis. Chronica Botanica, Waltham, Mass., USA.

Farooqui A & Sekhar B 2011. Climate change and vegetation succession in Lalitpur area, Uttar Pradesh (India) during late Holocene. Tropical Ecology 52 (1): 69–77.

Fraegri K & Iverson J 1975. Oxford: Blackwell Scientific Publications. Textbook of Pollen Analysis, 3rd edn.

Gupta HP & Yadav RR 1992. Interplay between pollen rain and vegetation of Tarai–Bhabar in Kumaon Division, U.P., India. Geophytology 21: 183–189.

Luna SV, Figueroa J, Balthazar M, Gomez R, Townsend LR & Schoper JB 2002. Maize pollen longevity and distance isolation requirements for effective pollen control on the coastal plain of Nayarit, Mexico. Crop Science 41: 1551–1557.

Sharma C 1985. Recent pollen spectra from Garhwal Himalaya. Geophytology 13 (1): 87–97.

Saxena A & Trivedi A 2017. Pollen based vegetation and climate change records deduced from the lacustrine sediments of Kikar Tal (Lake), Central Ganga Plain, India. Palaeobotanist 66(1): 37–46.

Singh G, Chopra SK & Singh AB 1973. Pollen–rain from the vegetation of northwest India. New Phytology 72: 191–206.

Trivedi A & Chauhan MS 2011. Modern pollen rain–vegetation relationship study in Jalesar, Unnao District, Uttar Pradesh. Journal of Palynology 47: 11–21.

Trivedi A, Chauhan MS & Farooqui A 2014**.** Studies on pollen rain vis–a–vis vegetation relationship and thecamoebian diversity in Bari Tal area, Lucknow District, Uttar Pradesh. Biological Forum–An International journal 6 (1): 68–78.

Trivedi A, Saxena A & Chauhan MS 2015. Modern pollen rain deposition pattern in Lashoda Tal, Raebareli District, Uttar Pradesh, India. The Palaeobotanist 64 : 105–112.

Trivedi A, Saxena A & Chauhan MS 2016. Studies on pollen rain vis–a–vis vegetation relationship in Chaudhari–Ka–Tal, Raebareli District, Uttar Pradesh. Journal of the Palaeontological Society of India 61(1): 85–90.