

# Interplay between pollen rain and vegetation of Tarai- Bhabar in Kumaon Division, U.P., India

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An attempt has been made to trace the forest history and regional upland vegetation of Tarai-Bhabar in Kumaon Region through pollen analysis of surface samples. The pollen spectra have exhibited the corresponding vegetation of the area. However, some components are either under represented or absent. Entomophily, poor pollen dispersion and differential preservation are some of the plausible reasons for precluding their proper representation in the pollen rain. The relationship between modern vegetation and their pollen has been worked out. Extensive farming and afforestation schemes introduced in the region have also considerably influenced the pollen spectra. The relative percentage of pollen/spores preserved in the sediment does not necessarily correspond to the factual floristic composition of the area under investigation. A certain type is either over represented or under represented in the pollen rain which may in turn lead to an essentially deceptive and distorted picture of the palaeovegetation.

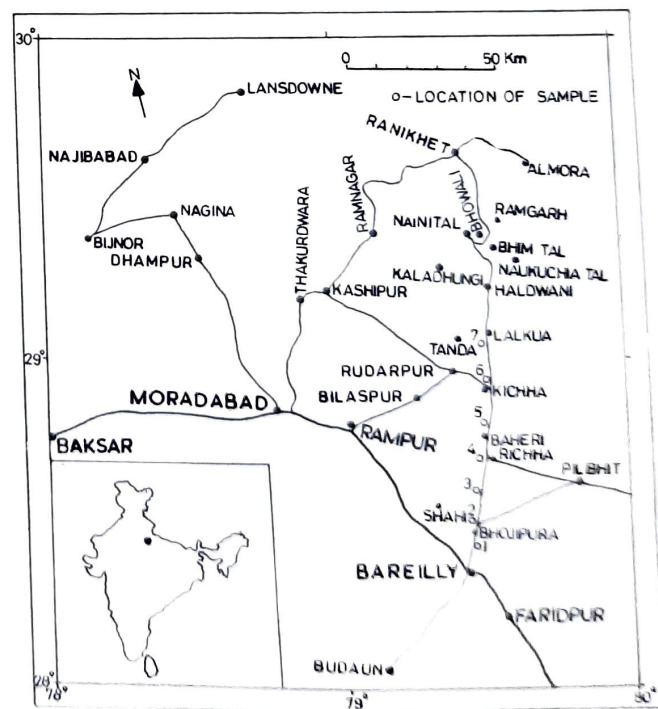
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## INTRODUCTION

To overcome the riddle of erratic representation of vegetation, an interpretative link is established between the pollen data and vegetation. Two separate pollen spectra have been reconstructed from the samples collected between Bareilly and Lalkuan (Map 1) to evaluate the forest history and upland vegetation. Efforts have been made to understand the local and regional representation of pollen taxa and their interplay.

## VEGETATION

The area in question is a part of the upper Gangetic plain of the Indian subcontinent. Topographically it is most significant and complex part of the upper Gangetic plain at the foot of the Siwaliks from west to east and consists of two parallel strips; the piedmont zone or the Bhabar, and the adjoining sloppy zone, the Tarai. The Bhabar, about 32 km wide, includes the waterless area comprising drifted deposits of boulders, gravels and silts from the Himalaya. Owing to sandy and pebbly deposits, there is high degree of



Map 1. Showing the location of samples

porosity and water scarcity which encourages the deciduous forest to thrive. Pasturage, lopping and bonfire are some of the biotic actions which adversely affect the forest and sometimes transform them into savannah. The Tarai region lies immediately south of Bhabar and is characterized by numerous springs and swamps with subsoil of sandy alluvium type.

The mixed dry deciduous forest of open nature characterizes the Bhabar zone. The important components of the forest are *Salmalia malabarica*, *Holarrhena antidysenterica*, *Cassia fistula*, *Lannea coromandelica*, *Garuga pinnata*, *Randia longifolia*, *Terminalia bellerica*, *Adina cordifolia* and *Ziziphus xylopyrus*. Some typical shrubs of mixed dry deciduous forest are *Ziziphus mauritiana*, *Helicteres isora*, *Urena lobata* and *Sida veronicifolia*. Nevertheless, a considerable area of Bhabar is also infested by *Shorea robusta* and *Acacia catechu*. The common trees are *Holoptelea integrifolia*, *Hymenodictyon excelsum*, *Garuga pinnata* and *Lagerstroemia parviflora*. The understory is predominated by *Mallotus philippensis* and *Ziziphus mauritiana*. The river bed is colonized by *Dalbergia sissoo* and *Acacia catechu* whereas moist depressions are colonized by *Trewia nudiflora* and *Syzygium cumini*. The climbers such as *Bauhinia vahlii*, *Spathobolus roxburghii* and *Millettia auriculata* are often plentiful.

The sal forest is regarded as climax community in the successive stage from riverain to mixed dry deciduous forest. *Shorea robusta* is the dominant taxon of sal forest followed by *Clerodendrum viscosum*. The co-dominant elements are *Lagerstroemia parviflora* and *Terminalia tomentosa* constituting the top canopy with sprinkling of *Terminalia bellerica*, *Adina cordifolia* and *Ficus* sp. The second storey trees are *Mallotus philippensis*, *Syzygium cumini*, *Ougeinia oojeinensis* and *Careya arborea*. The shrubby vegetation is represented by *Holarrhena antidysenterica*, *Randia longispina*, *Clerodendrum viscosum*, *Millettia auriculata*, *Desmodium* spp. and *Pogostemon plectranthoides*. The common herbs are *Imperata cylindrica*, *Themeda gigantea* and *Vetiveria zizanioides*. The climbers are represented by *Butea parviflora*, *Millettia auriculata* and *Bauhinia vahlii*.

Although sal forest elements extend downwards into the Tarai zone but, owing to unfavourable conditions, they do not thrive well. Grasses are normally absent but there may be an abundance of ferns. The commonest shrubs are *Ardisia solanacea*, *Murraya koenigii*, *Glycosmis pentaphylla* and *Adhatoda vasica* (Osmanston, 1927; Singh, 1967; Champion & Seth, 1968).

## MATERIAL AND METHOD

Surface samples enroute from Bareilly to Lucknow were collected at an interval of about 7 km each. The samples

were processed through KOH and HF treatment. Thereafter, the usual technique of acetolysis was followed (Erdman, 1943). For pollen identification, living counterparts of modern pollen/spores lodged in the sporothek of BSIP herbarium were consulted. Efforts have been made to identify all the pollen taxa in each sample but a few pollen could not be identified and, therefore, not considered for interpretation. Pollen counting was done under X 40 magnification of binocular Olympus microscope. Two to eight hundred pollen/spores were counted to minimise the personal error. The pollen spectra in terms of arboreals and total land plants have been prepared separately. The taxa are arranged in sequence of trees, shrubs, herbs, marshy plants and followed by aquatics. Pteridophytes (trilete and monoete spores) have been put at the extreme right side of each spectrum.

## POLLEN SPECTRA AND THEIR COMPOSITION

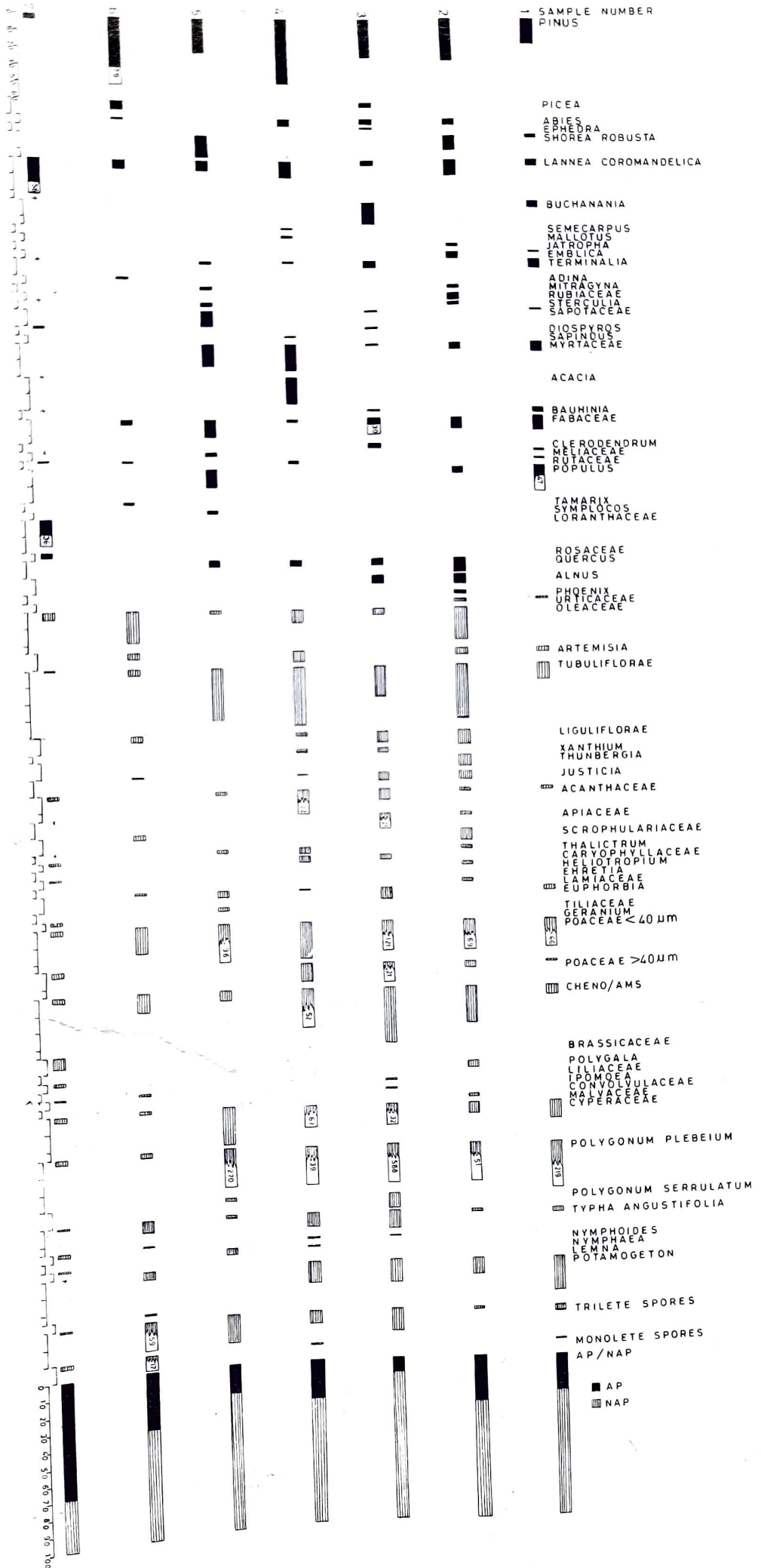
Pollen spectrum of each sample has been evaluated in terms of vegetation separately and all possible combinations and permutations are attempted in order to obtain the precision in pollen/vegetation relationship. Nevertheless, for forest history, the pollen percentages calculated in terms of total arboreal taxa (Text-fig. 1) have been taken into consideration, whereas the regional upland vegetation has been discussed on the basis of percentages calculated in terms of total land plants (Text-fig. 2).

*Surface sample 1* - The sample was collected from about 7 km north of Bareilly in Tarai region. The study has revealed the dominance of *Populus* 47% followed by *Pinus* 15%. The other arboreal elements such as Fabaceae 9%, Myrtaceae 6%, *Terminalia* 5%, *Lannea coromandelica* and *Buchanania* 4% each, *Shorea robusta* 2% and *Embllica*, Sapotaceae, Meliaceae and Rutaceae 1% each. *Bauhinia* which is the important climber in the area is represented by 3% only.

The ground vegetation in this composition is represented by exceedingly high values of *Polygonum plebeium* 51%. Poaceae is the co-dominant taxon 15%. The other nonarboreal taxa are lowly present such as Tubuliflorae and Cyperaceae 3% each, Chen/Ams 2%, *Euphorbia* and *Artemisia* 1% each. Whereas other taxa like Urticaceae, Acanthaceae and large-sized graminoid pollen are sporadic.

Amongst aquatics, *Potamogeton* and *Typha angustifolia* are represented by 4% and 1%, respectively. The pteridophytes including both trilete and monoete spores are sparingly represented.

The face value picture evolved out of the pollen spectrum does not cohere with the actual floristics of the area. The sal (*Shorea robusta*) is a predominant component of the sal forest forming top canopy, but its pollen representation is rather meagre. Likewise, several other forest taxa as mentioned in the vegetation chapter of the area, are totally



Text-figure 1. Pollen spectra from Bareilly-Lalkuan, Kumaon Division, U.P.  
(Percentage calculated in terms of arboreal pollen)

absent in the pollen assemblage. *Pinus*, though not a constituent of the forest, is represented in substantial high percentage (15%). Poplar is present in the pollen assemblage to the tune of 47% as against the total vegetation. However, poplar is an exotic plant to this area. *Populus deltoides* and large number of newly developed clones of different origin have been introduced in Tarai-Bhabar area particularly Lalkuan and adjoining areas (Mathur & Sharma, 1983). The heavy plantations have destroyed the original picture of the pollen spectrum.

The general pattern of vegetation in this spectrum has deduced the open land with a sprinkling of arboreals which is indeed, not reflected to the tune of actual modern vegetation. The most effective factor is the entomophily amongst forest trees which precludes the proper pollen representation. *Shorea robusta*, though a dominant forest tree and high pollen producer, is represented only by 2% of the total pollen assemblage. The plausible reason for this lapse could be that its pollen are not preserved owing to the enhanced pH of the soil. Total absence of sal pollen in sediments collected from sal forest of Garhwal Himalaya has been reported by Sharma (1985). The pine pollen have certainly drifted from the foothills and the subtropical zone where they even form the pure forests.

*Surface sample 2* - The sample was collected from near Bhojipura. It shows comparatively higher values of arboreal elements as compared to the preceding sample. The values of *Pinus* 35% markedly increased than before. The other arboreal elements are *Shorea robusta*, *Lannea coromandelica* and *Quercus* 9% each, Fabaceae 7%, *Alnus* 6%, *Embllica*, Myrtaceae, Rubiaceae, *Populus* and *Abies* 4% each, *Mitragyna*, *Sterculia*, *Phoenix* and *Jatropha* 2% each.

The herbaceous elements are very common and represented by Poaceae 20%, *Polygonum plebeium* 15%, Cyperaceae 12%, Tubuliflorae 10%, Chen/Ams and Oleaceae 6% each, Liguliflorae 3%, Scrophulariaceae, *Justicia* and *Thunbergia* 2% each, Malvaceae, *Heliotropium*, *Thalictrum*, Apiaceae, Acanthaceae, *Artemisia* and Urticaceae 1% each. *Typha angustifolia* 1% is almost stable. An overall improvement in the open land taxa could be noticed with the decrease in *Polygonum plebeium*. This feature could be an indicative of reduction in precipitation. *Potamogeton* 3% is relatively reduced as compared to the preceding sample. Pteridophytes are lowly represented by trilete spores.

Most of the arboreal elements in this spectrum, except for *Pinus*, *Abies*, *Quercus* and *Alnus*, are important constituents of Tarai-Bhabar sal and mixed dry deciduous forests. *Jatropha* and *Sterculia* are the important distinguishing taxa of mixed dry deciduous forest. *Phoenix*, although represented in low values, is important constituent of sal forest, mixed dry deciduous forest and chirpine forest (especially in sandy ravines). Poplar pollen are largely derived from the plantations of different clones of *Populus*

*deltoides* in the surroundings. *Pinus*, *Abies*, *Quercus* and *Alnus* are the extra-regional elements and have travelled right from the vegetation of outer Himalaya.

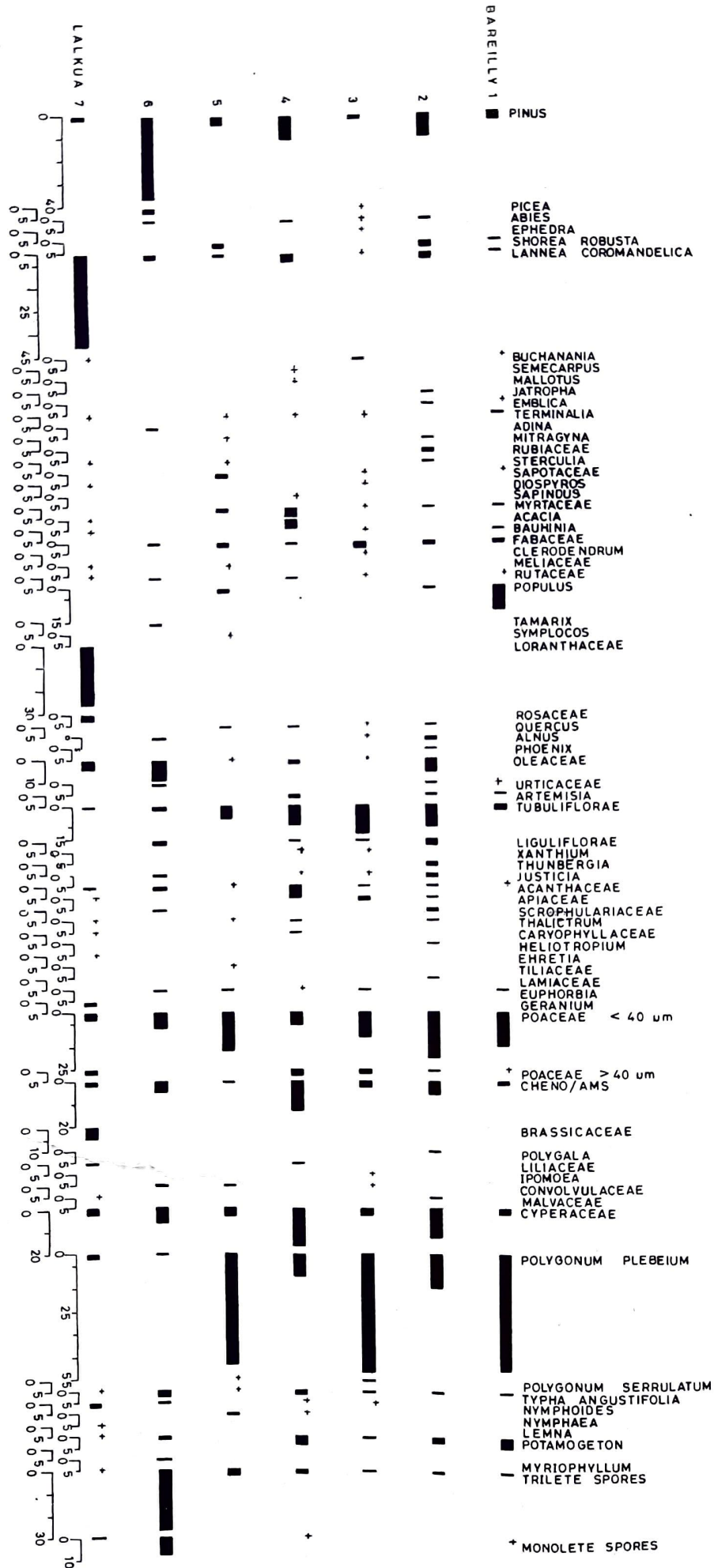
*Surface sample 3* - The sample collected from between Bhojipura and Richha shows remarkable decrease in the value of arboreals as compared to the preceding spectrum. The important constituents are Fabaceae 30%, *Pinus* 23%, *Buchanania* 14%, *Terminalia* and *Quercus* 4% each, *Lannea coromandelica*, *Clerodendrum*, *Picea* and *Abies* 3% each, Sapotaceae, Myrtaceae, *Diospyros* and *Ephedra* 1% each. *Alnus* is represented by 5%. *Bauhinia* 1% is the sole representative liana in this sample.

The herbaceous elements are represented by *Polygonum plebeium* 52%, Tubuliflorae 12%, and grasses 11%. The other elements are Chen/Ams and sedges 3% each, large-sized graminoid pollen, *Artemisia* and Apiaceae 2% each, Liguliflorae, Acanthaceae, *Euphorbia*, *Polygonum serrulatum* 1% each, Oleaceae, *Xanthium*, *Justicia*, *Ipomoea* and Convolvulaceae less than 1% each. Aquatics are sporadically represented by *Typha angustifolia* and *Potamogeton* 1% each and *Nymphoides* less than 1%. Pteridophytes are sporadic.

Pollen spectrum depicts that *Buchanania*, being abundant in Tarai-Bhabar sal forest, is well represented. The sal pollen, generally not favoured in preservational processes, either due to low sporopollenin content or any other unknown factor, is absent from this spectrum. The absence of sal pollen may also indicate the predominance of mixed dry deciduous forest in the area. The exotic tree elements are pine, spruce, fir, *Ephedra* and oak which are obviously wind transported from long distance. The high values of chirpine encountered in this spectrum may be accounted as due to the nearness of its provenance or their local plantations. In areas, directly exposed to sun or on dry rocky plains, the chirpines generally cross their lower limits and encroach into the sal forest. This feature also helps to account for high value of pine pollen. Fabaceae is recorded in high frequencies in this spectrum. *Dalbergia sissoo* forest occurs in the river beds. The high values of Fabaceae tips towards the existence of *Dalbergia sissoo* forest.

The pollen spectrum is influenced by the local and extra-local upland herbaceous plant community. The occurrence of large-sized graminoid pollen belonging to cerealia and *Xanthium* - a weed of crop field, suggested that the agricultural practices might have reasonably influenced the pollen spectrum.

*Surface sample 4* - The sample was collected from near Richha which shows notable increase in the values of arboreals than in the preceding sample. The arboreals are represented by *Pinus* 39%, Myrtaceae and *Acacia* 16% each, *Lannea coromandelica* 10%, *Abies* and *Quercus* 4% each, Fabaceae and Rutaceae 2% each, *Semecarpus*, *Mallotus*, *Sapindus* and *Terminalia* 1% each. The herbage is dotted by increased values of Acanthaceae 5%, Chen/Ams



13%, sedges 16% and reduced values of *Polygonum plebeium* 10%, Tubuliflorae 9%, and grasses 6%. The other elements are large-sized graminoid pollen, *Artemisia* and Oleaceae 2% each, Liliaceae, Caryophyllaceae, *Thalictrum* and Liguliflorae 1% each; *Justicia* and *Xanthium* less than 1% each.

The aquatics are represented by *Potamogeton* 4%, *Typha angustifolia* 2%, *Nymphoides* and *Nymphaea* less than 1% each. Pteridophytes have slightly improved than before.

The pollen spectrum is reflected by the dominance of mixed dry deciduous forest elements except for *Pinus*, *Abies* and *Quercus*, which are derived from extra-regional zone. The high values of *Acacia* and Myrtaceae were observed for the first time in this sample. *Acacia catechu* occupying a large area in the river beds is faithfully reflected by its high values in this spectrum. Likewise, *Syzygium cumini* occupies the moist depression. *Eucalyptus* hybrids have also been planted in large areas which were previously under cover of tall grasses and bushes. The high values of Myrtaceae may be referred due to both *Syzygium cumini* as well as *Eucalyptus* hybrids. The pollen spectrum is also influenced by the agricultural practices in the area as exemplified by the presence of large-sized graminoid pollen which may belong to cerealia.

*Surface sample 5* - The sample was collected from between Richha and Kichha area. The overall values for arboreals have slightly decreased in this pollen spectrum as compared to preceding spectrum. The arboreals are represented by *Pinus* 21%, Myrtaceae 13%, *Shorea robusta* 12%, Fabaceae and *Populus* 11% each and Sapotaceae 9%. The other elements are *Lannea coromandelica* 6%, *Quercus* 4%, *Terminalia*, *Mitragyna*, *Sterculia*, Meliaceae and *Symplocos* 2% each.

Grasses increased and Chen/Ams decreased markedly. The other herbaceous elements are *Polygonum plebeium* 49%, Tubuliflorae 6%, Cyperaceae 4%, Convolvulaceae, and *Euphorbia* 1% each, Tiliaceae, *Thalictrum*, Acanthaceae and Oleaceae less than 1% each. The aquatics, like *Nymphaea* and *Typha angustifolia*, are represented by 1% and less than 1%, respectively. Pteridophytes represented by trilete spores 3%, increased slightly over the preceding samples.

The high values of sal, accompanied by other associates as discussed above, match with the existence of Bhabar sal forest in the area. However, high values of chirpine and banj-oak in the pollen assemblage could be defined as due to the telescopically nearness of the chirpine-oak woods. Similarly poplar pollen are also derived from plantations.

*Surface sample 6* - The sample collected from near Kichha shows considerable improvement in the values of arboreals over the preceding sample. Amongst the arboreals, *Pinus* spurted sharply forming a summit of 79%. The other arboreal elements are *Lannea coromandelica* and *Picea* 5% each, Fabaceae 3%, *Adina*, *Abies*, Rutaceae and

*Tamarix* 1% each. Oleaceae improved to 9%, Tubuliflorae declined to 2% and *Polygonum plebeium* 1% than in the preceding samples. The other herbaceous elements are grasses and sedges 7% each, Chen/Ams 5%, Liguliflorae and Acanthaceae 2% each, Urticaceae, *Justicia*, Scrophulariaceae, *Euphorbia* and Convolvulaceae 1% each.

There is overall decline in the values of aquatic community corresponding to the high values of pteridophytes.

The spectrum is characterised by very high values of pine pollen. The chirpine, besides being high pollen producer, is also favoured by high buoyancy to cover long distances. The exceedingly high values of pine as compared to other pollen indicates that most of its pollen might have drifted from the adjoining homeland of pines in the near vicinity. Spruce and silver fir pollen are also exotic elements but in low values as they have to travel a long way. The arboreal elements constituting the Bhabar sal forest are very poorly represented whereas *Shorea robusta* is altogether absent, pollen-wise. The pteridophytes having common occurrence in the moist shady places are equally high in the pollen/spore assemblage. The decrease in grass pollen and increase in pteridophytes is reflected by the flora of the area.

*Surface sample 7* - The sample collected from near Lalkuan shows very high values of arboreals than in the preceding samples. The dominant constituents are *Lannea coromandelica* 56% and Loranthaceae 36%, of which the later appeared for the first time in this sample. The values of pine pollen suddenly dwindled down to the tune of 3% indicating almost pine free zone. The other arboreal elements are Rosaceae 4%, *Diospyros* and Rutaceae 1% each, *Terminalia*, *Sterculia*, *Buchanania*, *Acacia*, *Bauhinia* and Meliaceae less than 1% each.

The herbaceous elements show general decrease in their values than in the preceding samples. Brassicaceae 4%, *Geranium* 2% and *Ehretia* less than 1% appeared for the first time in this sample. The other elements, viz., Oleaceae 4%, Poaceae and Cyperaceae 3% each, Chen/Ams, *Polygonum plebeium*, large-sized graminoid pollen 2% each, Tubuliflorae, Acanthaceae and Liliaceae 1% each, Apiaceae, *Thalictrum*, Caryophyllaceae and Malvaceae less than 1% each.

The aquatics are in low values and are represented by *Potamogeton*, *Lemna*, *Nymphoides* and *Typha angustifolia*. Pteridophytes declined to sporadic values.

The very high pollen values of *Lannea coromandelica* correspond to its being an important constituent of the forest. Other elements of the forest are poorly represented. Loranthaceae members, viz., *Loranthus pulverulentus* being parasite on *Mallotus philippensis*, *Butea frondosa* and *Dalbergia sissoo*, are important constituents of the sal forest of Bhabar region. The pollen grains of Loranthaceae are quite frequent although the host pollen are not even

recorded in the sample. The occurrence of Loranthaceae pollen in high frequencies does not preclude the existence of their host plants as defined above, rather their presence could be recorded while reconstructing the palaeofloristics on the basis of pollen alone.

### CONCLUSION

Pollen analyses of surface samples from Bareilly to Lalkuan show that the pollen/spore deposition does not wholly match with the actual floristics of the area. However, a part of its vegetation is reflected in the pollen assemblage. Herbaceous taxa, mostly local and extra local in origin, are dominant. Thus, the pollen spectra are greatly influenced by the local pollen/spores. The over-representation of local herbs is a much discussed problem and it has been realised by various workers. In pollen spectra, the pollen grains of grasses, sedges and *Polygonum plebeium* generally predominate except for sixth spectrum where pteridophytic spores are in abundance.

Amongst the Tarai-Bhabar forest elements, *Lannea coromandelica* and *Terminalia* are well represented. The sal is not adequately represented in pollen assemblage to the extent as they are expected owing to its preponderance in the present day forest composition. The poor representation of sal may be due to several unknown factors. However, absence or poor occurrence of sporopollenin in pollen walls, entomophily and lack of contrivances, high pH of the soil are some of the pronounced controlling factors. One or all factors might have been responsible to prevent the proper representation of the sal pollen in the assemblage in spite of its being high pollen producer. Similar behaviour has been noticed in Garhwal Himalaya, where surface samples investigated from Kala Gad and Golaiappar, festooned with sal forest, are almost devoid of sal pollen (Sharma, 1985). Pollen grains of Loranthaceae which is represented by various species of *Loranthus* are high in sample, *Loranthus pulverulentus* is parasite on *Mallotus philippensis*, *Butea frondosa* and *Dalbergia sissoo*, and *Loranthus ligustrinus* on *Mallotus philippensis* which are important constituents

of the sal forest in Tarai-Bhabar area. Although the host plants are not recorded through pollen grains in this sample, the presence of the host plants in the vicinity could not be ignored. The good dispersal and preservation is another possible factor for over representation of the Loranthaceae pollen. Some of the arboreal elements of the Tarai-Bhabar forest are either absent or not represented adequately. This could be because of the low pollen production, dispersal and/or differential pollen preservation. The common elements of the Tarai-Bhabar area, viz., *Clerodendrum viscosum*, *Mallotus philippensis*, *Adina cordifolia* and *Randia longifolia* are represented sporadically.

The pollen grains of herbaceous plants are mostly local and extralocal in origin whereas the trees are regarded as the regional constituents. Few pollen types, viz., pine, fir, spruce, oak, alder and *Ephedra* are the extra-regional elements, derived from subtropical zone of Himalaya.

Effect of human pressure on the pollen spectra is realised by the presence of cerealia and *Xanthium* pollen in some samples. The forest department of the State Government is running various afforestation schemes to protect the deteriorating environment in Tarai-Bhabar area. Poplar, *Acacia*, *Eucalyptus* and pine are some of the preferred trees for plantation in this area and their pollen are accordingly quite frequent in some of the samples.

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