

RECENT POLLEN SPECTRA FROM HIMACHAL PRADESH

CHHAYA SHARMA

Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

An attempt has been made to study the composition of pollen rains at different elevations through a set of nine surface samples collected from various ecological formations situated at altitudes ranging from 240—2400 m. The study has brought out the over representation of the pine irrespective of the altitude; oak pollen on the other hand is under represented. In general, the pollen spectra from the deforested as well as the forested areas reflect faithfully its vegetational composition.

INTRODUCTION

In Himachal Pradesh which is wholly mountainous, the wide range of altitudes met within the area have led to the existence of different climates and also to a variety of microclimatic situations, as a result of which the vegetation is segregated into distinct altitudinal zones (SHARMA, 1970), which in turn has affected profoundly the nature of pollen rain at different elevations.

The present study confines mainly to the surface samples from Himachal Pradesh though two samples from the adjoining plain in Punjab too have been analysed with a view to gauge the composition of the pollen rain in the deforested plain, which is presently under intensive cultivation. A set of nine samples has been collected from different localities (see map) situated at various altitudes ranging between 240—2400 m (800—8000') to study the composition of pollen rains at different elevations.

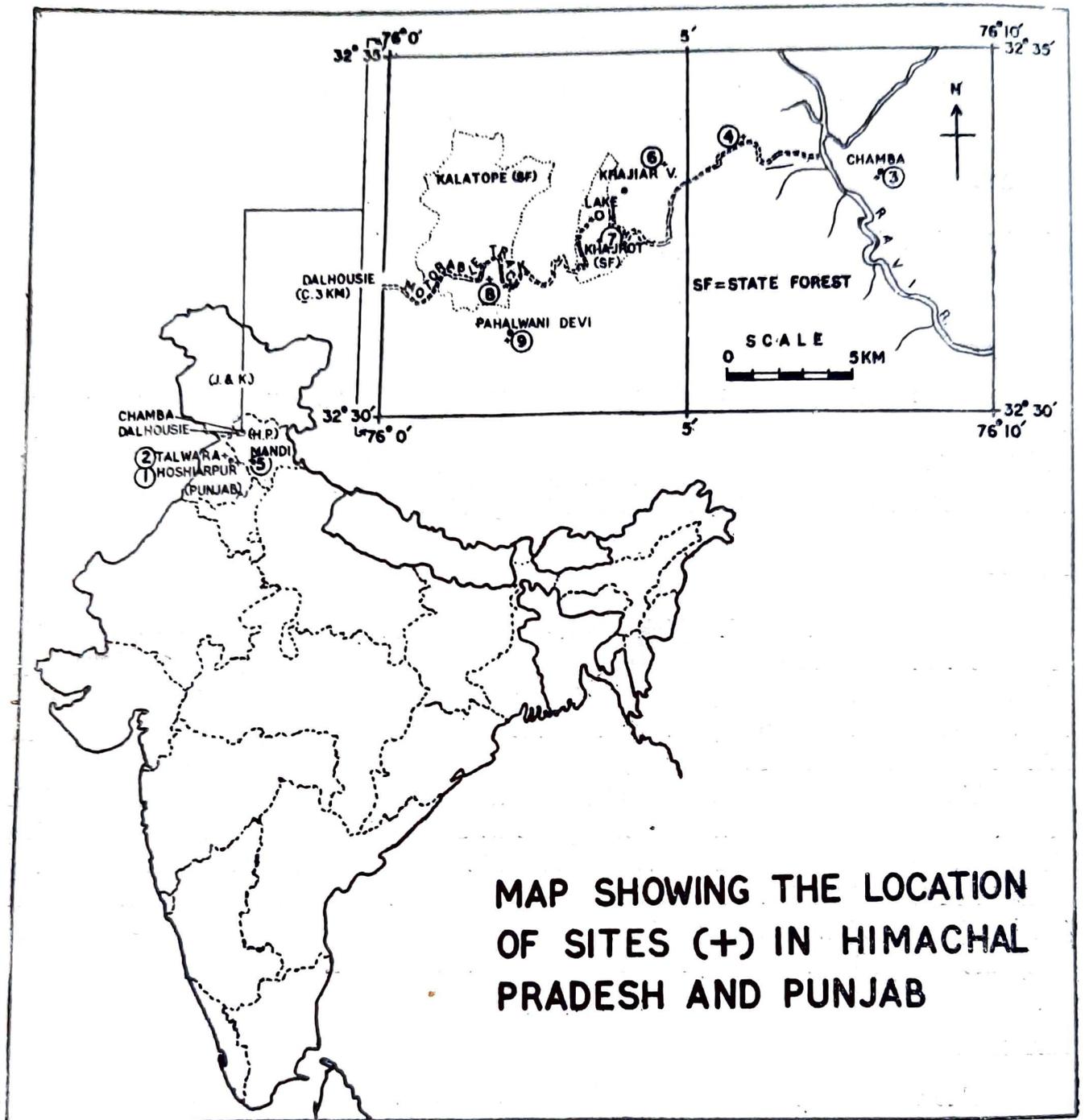
METHODS

The surface samples (moss cushions and soil samples) were boiled in 10% solution of potassium hydroxide for a few minutes, then sieved and the obtained filtrate was centrifuged and washed with water 2-3 times to remove the alkali. After dehydration with glacial acetic acid, it was acetolysed following the usual technique of ERDTMAN (1943). In case of samples containing silica the material was treated with 40 per cent hydrofluoric acid for 8-10 days before acetolysis to remove silica. The slides were prepared in 50 per cent glycerine.

A sum of 150-200 tree and shrub pollen was counted in each sample—except the surface sample from Bagewal, situated in the deforested plain of Punjab, in which only 20 tree and a shrub pollen was available for the count. All the percentages were calculated in terms of total tree and shrub pollen and the pollen spectra constructed.

POLLEN SPECTRA

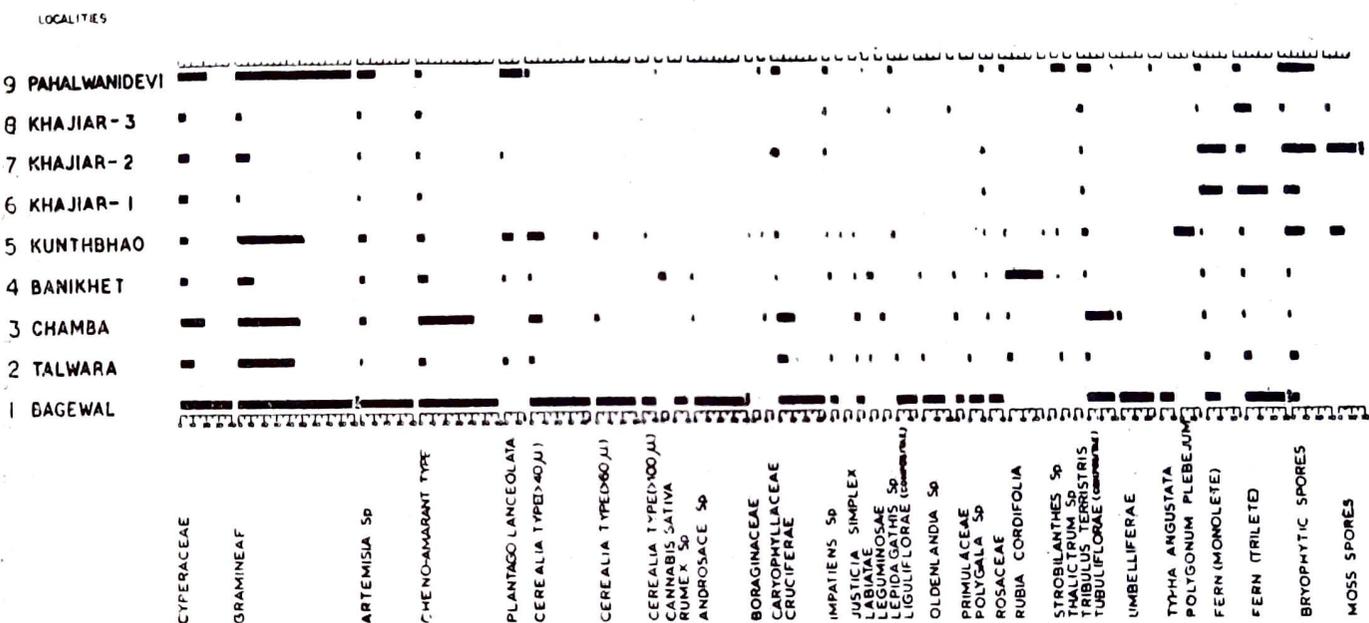
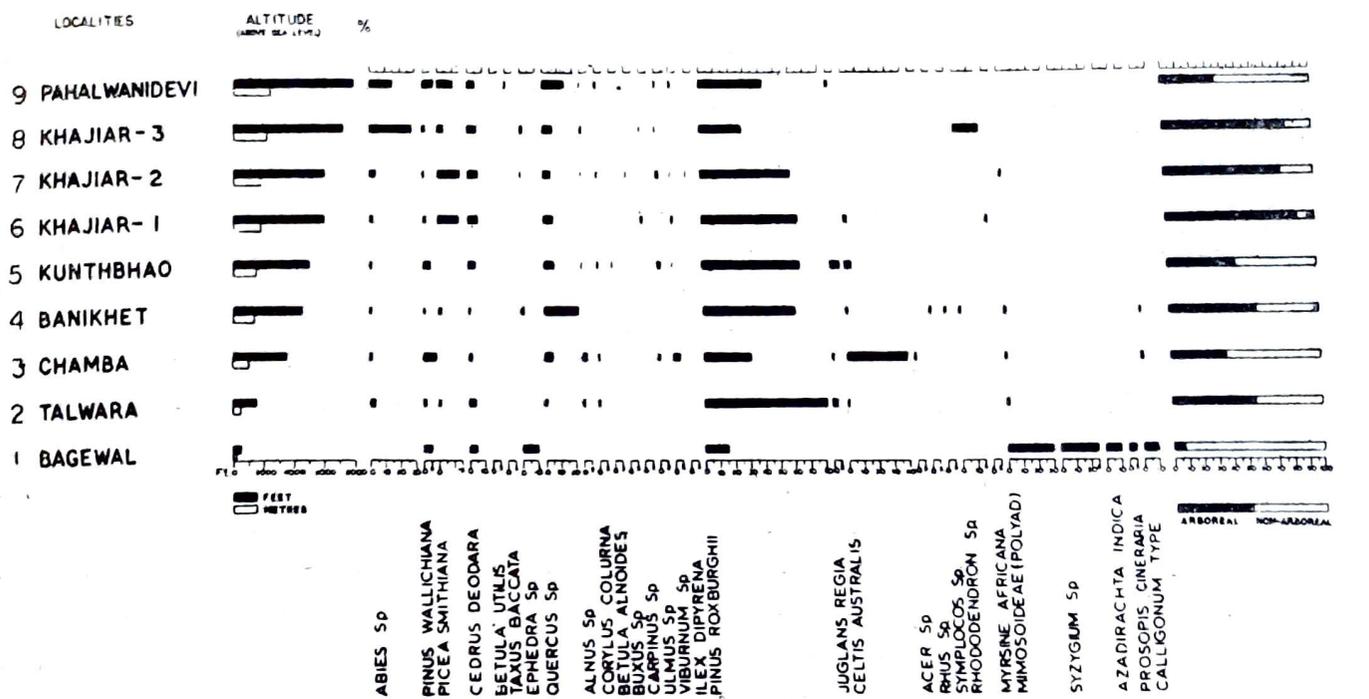
The result of pollen analyses of the nine surface samples are given below in the



order of increasing altitude. A brief account of the present vegetation cover found in each area is provided in order to interpret the pollen spectra. The frequency of the different pollen types found in these samples is shown in the accompanying diagram.

(a) **BAGEWAL:** The surface sample is collected from a swampy area, by the side of a stream near Bagewal, District Hoshiarpur, Punjab, at a height of about 240 m (800') A. S. L. The area is completely free of natural forests, the vegetation being mainly comprised of open lands grown with common agricultural crops, such as wheat, maize, *Brassica campestris*, gram, millets, etc. The tree elements, consisting of *Mangifera indica*, *Dalbergia sisso*, *Azadirachta indica*, *Melia azedarach*, *Acacia arabica*, *Ficus* spp., etc. are planted. *Pinus roxburghii*, the nearest conifer tree, grows at a distance of over 25 km from the site.

Pollen spectrum: The AP ratio of only 7%, amply reveals the overall dominance of the non-arboreal vegetation in the area. The maximum value amongst the arboreals is that of Mimosoideae (Polyad) 30%, mostly belonging to *Acacia arabica* and *Albizia lebbek*.



Percentages calculated in terms of total tree and shrub pollen.

This is followed by *Syzygium* (25%) and *Pinus roxburghii* (15%). The frequencies of *Azadirachta indica*, *Calligonum* type, and *Ephedra* are around 10% in each case, and those of *Cedrus deodara*, *Pinus wallichiana* and *Prosopis cineraria* (= *P. spicigera*) about 5% each. The pollen of *Pinus roxburghii*, *P. wallichiana* and *Cedrus deodara* is derived from the hills through long distance transport by wind. Similarly the few pollen grains of *Prosopis cineraria* (= *P. spicigera*) a desert element commonly growing in southern Punjab and Rajasthan also may have been derived in the same way from south and south-west direction.

Amongst the non-arboreal elements the pollen of *Androsace* is the most dominant with values at 705%. It is most likely that the pollen of *Androsace* is derived from a local source. The high frequencies of Gramineae (205%) reflect the open conditions of the area in which the grasses are, in fact, the most dominant. The lack of forest cover is also attested by the high frequencies of all light demanders, such as Cyperaceae, Chenoparant type, *Artemisia*, Cruciferae, Compositae and Umbelliferae. Other plants of open habitats repre-

sented are Rosaceae, *Polygala*, *Impatiens*, *Oldenlandia*, Labiatae and Primulaceae. The high value of Cerealia type of pollen together with other associated elements (culture pollen) is representative of the intensive wheat cultivation in the area. Fern spores are quite abundant (160%) and appear to have been derived from a local source, as Ferns in general do not grow in the area, except in protected places. Aquatic vegetation is represented by the pollen of *Typha angustata* with values at about 10%.

The overall picture presented by the pollen spectrum from Bagewal faithfully brings out the deforested nature of the area with a general preponderance of non-arboreal vegetation. The influence of long distance transport of pollen from outside appears to be well within the norms as the site is very close to the Himalayan belt.

(b) TALWARA: The surface sample is collected from a site near a *Dendrocalamus strictus* stand in the sparsely forested Himalayan foothills at Talwara, situated at a height of about 460 m (1,500') A.S.L. The surrounding vegetation at the site of collection, on account of its marginal situations with respect to the plains, consists of a transitional flora between the plains of the Punjab on one hand, and the montane of the Siwalik hills on the other. The common tree and shrub elements of the plains, such as *Ficus*, *Dalbergia*, *Mangifera*, *Melia*, *Azadirachta*, *Morus*, *Holoptelea*, *Acacia*, *Albizia*, *Salmalia*, *Cassia*, *Calotropis*, *Adhatoda*, etc., occur together with montane elements such as *Mallotus*, *Toona*, *Grewia*, *Rubia*, *Dendrocalamus* and *Pinus roxburghii*. The conifer forests represented by *P. roxburghii* are found at elevation of about 450 m (1,500') and occur within a distance of 6-8 km of Talwara. Openlands, largely devoid of forests, and now under intensive cultivation also occur within a short distance of the site of collection.

Pollen spectrum: The pollen spectrum reveals only a marginal dominance of the arboreal elements over the non-arboreal. An overwhelming majority of the arboreal pollen is actually contributed by *P. roxburghii* (81%). The pollen of other tree elements represented is that of *Abies*, *Cedrus deodara*, *Pinus wallichiana*, *Juglans regia* and Mimosoideae (Polyad), whose values in each case, however, do not exceed 2-4%. Amongst these the pollen of Mimosoideae alone, can be considered to represent the surrounding vegetation, while the pollen of other elements appears to have been derived through long distance transport from comparatively higher altitudes. The low pollen frequencies of elements such as *Picea*, *Quercus*, *Corylus*, *Alnus* and *Celtis* can also be through the same source.

Amongst the non-arboreal elements, Gramineae is by far the most dominant with values reaching to about 43%. The presence of grass pollen in such abundance is consistent with the occurrence of bamboo forests in the area, and also with the location of open land conditions at close distance of the site of collection. Other non-arboreal elements represented are Cyperaceae (10%), Cruciferae (7%), Chen-Amarant type (5%), Cerealia type (3%), *Plantago lanceolata* (3%), *Rubia cordifolia* (3%) and Compositae (Tubuliflorae) 2%. Stray pollen of *Artemisia*, Leguminosae, *Polygala*, *Thalictrum*, Labiatae, *Oldenlandia* and *Impatiens* is also met with in low values. Fern (monolete and trilete) and bryophytic spores are represented in low frequencies.

The high value of Gramineae, together with the overall dominance of arboreal pollen, is indicative of the transitional character of the local flora, with open-lands and forests existing side by side. The local forest tree elements, especially those belonging to the broad-leaved species, are not represented in the pollen spectrum, while a great majority of the arboreal pollen appear to have been derived by way of long distance transport by wind from higher altitudes. *Pinus roxburghii* though not found locally at Talwara is a part of the flora, in general, at similar elevations within a radius of 6-8 km. The presence of culture pollen, such as those of Cerealia type, *Plantago lanceolata*, Chen-Amarant type and

Artemisia, in the pollen spectrum is indicative of the prevailing farming activity in the area.

(c) CHAMBA: The surface sample is collected from a site near Chamba, at a height of about 1,070 m (3,500') A. S. L. *Pinus roxburghii*, though sparsely represented at the site of collection, occurs profusely in the surrounding hills within a distance of 1-3 km. The tree and shrub vegetation, in general, besides *P. roxburghii* consists of *Celtis australis*, *Toona ciliata*, *Salmalia malabarica*, *Pyrus*, *Rubus*, *Colebrookia*, *Juglans*, *Acer*, *Salix*, *Ficus*, *Grewia*, *Albizia*, *Euphorbia royleana*, *Boehmeria*, *Dodonaea*, *Lycium*, *Berberis*, *Rhus*, *Lantana*, etc. At higher elevations above 1,210 m (4,000'), conifer mixed-oak forests occur in great abundance and lie within a distance of 6-8 km from the site of collection. Adjoining the site, more or less open-land conditions prevail, and the area is at present under terrace cultivation.

Pollen spectrum: The pollen spectrum reveals a high pollen frequency for both *Celtis* and *Pinus roxburghii* reaching about 41% and 31% respectively. Other constituents with values ranging from 0.5—8% are *Pinus wallichiana* (8%), *Quercus* (5%), *Viburnum* (4%), *Alnus* (3%), *Cedrus* (2%), *Calligonum* type (2%), Mimosoideae (polyad), *Juglans*, *Acer*, *Abies*, *Corylus* and *Ulmus*. Amongst these, the pollen of *Pinus*, *Celtis*, Mimosoideae, *Juglans* and *Acer* can be considered to represent the surrounding vegetation while the pollen of the rest of the elements appears to have been derived from higher altitudes.

The non-arboreal vegetation is represented by high percentages of Gramineae (47%) and Chen-Amarant type (42%). Next in order are Compositae (Tubuliflorae) (21%) Cyperaceae (18%) Cruciferae (13%) and Cerealia type (13%). Other non-arboreal elements represented in low frequencies are *Artemisia* (4%), Labiatae (3%), Umbelliferae (2%), Primulaceae (2%) and *Lepidagathis* (2%). The pollen grains of *Rubia*, *Androsace*, Rosaceae and Caryophyllaceae, are also met with in small numbers together with Fern and bryophytic spores.

The pollen spectrum reveals the overall dominance of non-arboreal elements over the arboreal. The presence of high values of Gramineae and Chen-Amarant type is indicative of open-land conditions. The presence of culture pollen, such as Cerealia type, *Artemisia*, Chen-Amarant type etc., indicates the prevailing agricultural activity in the area. *Celtis* is, however, over-represented.

(d) BANIKHET: The surface sample is collected from underneath a *Quercus incana* formation on the northern slope, overlooking *Pinus roxburghii* formation on the opposite slope at a height of about 1,370 m (4,500') A. S. L. Other common plants growing in the vicinity are *Celtis*, *Ficus*, *Juglans*, *Ulmus*, *Symplocos*, *Salmalia*, *Berberis*, *Rhus* and scattered trees of *Acer* and *Rhododendron*. The forest vegetation, in general, does not represent a closed formation as a number of small openings are seen here and there in the valleys.

Pollen spectrum: The pollen spectrum reveals a high value for *Pinus roxburghii* (61%), together with a moderately high frequency for *Quercus* (22%). Other arboreal elements, such as *Picea* and *Celtis*, show values around 2% and *Abies*, *Cedrus*, *Pinus wallichiana*, Mimosoideae (polyad), *Symplocos*, *Rhus*, *Ephedra*, *Calligonum* type and *Rhododendron* occur in low frequencies of not more than 1%, in each case. The pollen of *Picea*, *Abies*, *Cedrus* and *Pinus wallichiana* appears to have been derived from comparatively higher altitudes. Most of the broad-leaved elements represented occur in the vicinity of the area.

Amongst the non-arboreal elements, all except *Rubia cordifolia* which is 28%, show lower frequencies. Those represented in moderate values are Gramineae (11%), Chen-Amarant type (7%) *Cannabis* (5%), Cyperaceae (5%), Leguminosae (4%), *Artemisia* (3%), Cerealia type (2%), *Impatiens* (2%), and *Plantago lanceolata* (2%). The pollen of Primulaceae, Labiatae, Compositae (Tubuliflorae), *Thalictrum*, *Oldenlandia*, Cruciferae,

Umbelliferae, Rosaceae, also occurs in low values, together with Fern and bryophytic spores.

The pollen spectrum faithfully brings out the composition of the conifer-mixed-oak forest. The low values of non-arboreal types are indicative of the small openings in the forest. The pollen transported from higher altitudes, shows comparatively much lower frequencies than the less forested areas at lower altitudes.

(e) KUNTH BHAO: The surface sample is collected from a lake site, namely Kunth Bhao, situated near Rewalsar at about 1,520 m (5,000') A. S. L. The tree vegetation in the vicinity of the lake, in view of its being under heavy lopping, is on the whole open, and is presently under terrace cultivation. A few hundred yards away from the lake, however, plantations of *Pinus roxburghii* cover the hill slopes together with some *Cedrus deodora*. Oak trees are seen here and there, in small patches, but in view of the persistent human interference they usually remain stunted. Other common trees and shrubs, growing in a more or less scattered condition, are *Celtis*, *Ulmus*, *Juglans*, *Acer*, *Toona ciliata*, *Salix*, *Alnus*, *Betula alnoides*, *Pyrus*, *Rhododendron*, *Rosa*, *Berberis*, *Rhus*, *Ilex* etc.

Pollen spectrum: The pollen spectrum reveals the highest pollen frequency for *Pinus roxburghii*, at about 65%. Other constituents in comparatively low values are *Juglans* (6%), *Quercus* (6%), *Cedrus* (5%), *Pinus wallichiana* (5%) and *Celtis* (4%). The pollen of *Ulmus*, *Corylus*, *Alnus*, *Betula*, *Viburnum*, *Abies* and *Picea* occurs only in low values. Most of the elements represented in the spectrum occur in the vicinity of the area, except for *Abies*, *Picea*, *Pinus wallichiana* and *Corylus*, whose pollen appears to have come from comparatively higher altitudes through long distance transport.

Amongst the non-arboreal elements, Gramineae is by far the most dominant, with its values at about 52%, which is indicative of open-land conditions, near the area of collection. Other non-arboreal elements represented, are Cerealia type 15%, *Plantago lanceolata* 8%, Cyperaceae 6%, Compositae, *Artemisia* and Chen-Amarant type 5% each, and low frequencies of Cruciferae and *Thalictrum*. The pollen of Rosaceae, Caryophyllaceae, Boraginaceae, *Justicia simplex*, *Strobilanthes*, Labiatae, *Rubia cordifolia* and *Impatiens* occurs in low values. *Polygonum plebejum*, is represented with a moderately high value (15%), together with bryophytic spores, and a low frequency of Fern spores.

The pollen spectrum reflects the overall dominance of non-arboreal elements over the arboreal. The high value of Gramineae together with other non-arboreal species, indicates the occurrence of open-land conditions in the area. The presence of pollen grains, of cultivated plants and weeds, such as those of Cerealia type, Compositae, etc., testify to the present-day farming activity in the area. *Pinus roxburghii*, even though present at a short distance from the site of collection is over represented by its pollen.

(f) KHAJIAR-1: This surface sample comprised of forest soil, is collected from underneath a broad-leaved forest, consisting of mainly *Quercus* associated with *Celtis*, *Cotoneaster*, *Rhododendron arboreum*, *Acer*, *Viburnum cotinifolium*, *Myrsine africana*, etc., at a height of about 1,670 m (5,500') A. S. L. in the northeast of Khajiar, District Chamba. Plantations of *Cedrus* occur within a distance of about one kilometre from the site of collection. The other common trees and shrubs growing at comparatively lower altitudes in the area are *Pinus roxburghii*, *Toona ciliata*, *Sarcococca*, *Berberis*, etc. Undergrowth of various Ferns and Bryophytes occurs at various altitudes on the forested slopes.

Pollen spectrum: The pollen spectrum reveals the highest pollen frequency for *Pinus roxburghii* at about 64%. Other constituents represented in comparatively lower frequencies, are *Picea* 14%, *Cedrus*, 7%, *Quercus* 6%, *Celtis* 2%, *Abies* 2% and *Pinus wallichiana* 2%. The pollen of *Viburnum*, *Myrsine* and *Carpinus* occurs only in low values. The pollen of elements,

such as *Picea*, *Abies*, *Pinus wallichiana* appears to have come from comparatively higher altitudes. Of these *Pinus wallichiana*, in fact, does not grow in the Khajiar area, but is known to grow in small numbers a few kilometres away from Khajiar, in the Kalatope forest.

Non-arboreal elements, are represented in very low frequencies. The maximum frequency of 6% is reached by Cyperaceae, while other elements such as Gramineae, Cheno-Amarant type, *Artemisia*, Compositae (Tubuliflorae) and Rosaceae, are represented in only low values. Fern and bryophytic spores are, however, met with in the pollen spectrum in high values.

While the pollen-spectrum does reflect the closed nature of the forest, it fails to bring out the character of the local forest community, which is largely represented by broad-leaved mixed oak forest. The *Pinus roxburghii* pollen has evidently been derived from lower slopes as its high frequencies do not match with the rather sparse occurrence of this species in the broad-leaved forest. Of all the elements, the frequencies of oak are by far the least indicative of the actual proportion of the oak trees in the forest community.

(g) KHAJIAR-2: The surface sample consisting of a moss cushion, is collected from a height of about 1,980 m (6,500') A. S. L. inside the Khajrot forest, from a place situated to the southwest of the Khajiar village. The forest is chiefly comprised of *Picea* and *Abies* which occur to the extent of about 40% each. These are followed by *Cedrus* 10%, and oak which is seen only sporadically. To the east of the Khajrot forest, lies the Jhuru forest, which is comprised of mainly *Abies* and *Picea*, while the open meadow of Khajiar is situated to the northeast. Plantations of *Cedrus*, are seen in the east-north-east direction, while mixed conifer-broad-leaved forests occur towards the north. The few broad-leaved elements seen in the Khajrot forest are *Aesculus*, *Juglans*, *Acer*, *Ulmus*, *Populus*, *Buxus*, *Ilex*, *Rhododendron arboreum*, *Skimmia*, *Viburnum*, *Berberis*, *Sarcococca*, etc. A variety of Ferns and Bryophytes are seen as undergrowth throughout the forests.

Pollen spectrum: The pollen spectrum is representative of the closed forest but it once again reveals the highest value for *Pinus roxburghii*, even though the species grows at least 610 m (2,000') lower down in this area. On the other hand, both *Picea* (15%) and *Abies* (4%), are under-represented by a wide margin. Other arboreal constituents represented are *Cedrus* 7%, and *Quercus* 5%. The pollen of *Pinus wallichiana*, *Corylus*, *Ulmus*, Mimosoideae (polyad), *Buxus*, *Ephedra*, *Ilex*, *Viburnum*, *Alnus*, *Rhus*, and *Acer* occurs only in low values. Of all these elements, only the pollen of *Pinus roxburghii* and *Pinus wallichiana* appears to have been derived from long distance.

Amongst the non-arboreal species represented in the pollen spectrum, Graminea attains the maximum value at about 10%. Other elements represented are Cyperaceae 7%, Cruciferae 3% and Cheno-Amarant type 2%. The pollen of *Artemisia*, *Plantago lanceolata*, Compositae (Tubuliflorae), Rosaceae and *Impatiens* is seen in low values. Fern and bryophytic spores are, however, represented in high values. Moss spores, attain frequencies up to 455%.

(h) KHAJIAR-3: The surface sample, consisting of a moss cushion, is collected from Kala Pahar, a hill top midway between Khajiar and Dalhousie at about 2,130 m (7,000') A. S. L. The forest is comprised of chiefly *Abies* and *Picea*, of which *Abies* is dominant. *Cedrus* occurs, but only as a minor element. *Pinus wallichiana* is also known to occur in this forest. The few broad-leaved trees seen scattered are *Quercus*, *Acer*, *Aesculus*, *Carpinus*, *Juglans*, *Ulmus*, *Alnus*, *Populus*, *Rhododendron arboreum*, etc. *Viburnum* and *Skimmia* mainly constitute the undergrowth. A variety of Ferns and Bryophytes are seen throughout the forests.

Pollen spectrum: The pollen spectrum reveals a high value for *Abies*, at about 28%,

together with an equally high frequency for *Pinus roxburghii* (28%). Other tree and shrub species represented are *Rhododendron* 17%, *Quercus* 7%, *Cedrus* 6%, *Picea* 4%, *Pinus wallichiana* 2% and *Ephedra* 2%. The pollen of *Alnus*, *Ulmus* and *Carpinus* occurs only in low values. The high value of *Pinus roxburghii* has obviously resulted from the pollen derived from comparatively lower slopes as the species does not grow in the area at similar elevations.

Non-arboreal vegetation as a whole, is represented in very low frequency (18%). The maximum frequency of 5% is attained by Cyperaceae. Other non-arboreal elements represented in the pollen spectrum are Gramineae (4%), Chen-Amarant type (3%), and *Artemisia* (2%). The pollen of Primulaceae, Compositae and *Impatiens* is seen only in very low values.

The pollen spectrum reflects the almost closed nature of the forest with the overall dominance of arboreal vegetation over the non-arboreal. The high values of *Abies* are indicative of the dominance of *Abies* in the forest, but the sub-dominant position of *Picea* is not correctly represented. The existence of most of broad-leaved elements occurring in the forest, is faithfully brought out. The non-arboreal component of the pollen spectrum is indicative of the small clearings in the otherwise closed forest.

(i) PAHALWANI DEVI: The surface sample is collected from a site, namely Pahalwani Devi, situated above Khajjar, overlooking the Khajrot forest, at about 2,440 m (8,000') A. S. L. The site lies above the tree line, and is thus comprised of an open meadow. The meadow remains under heavy grazing by sheep and goat for most part of the year. The area is covered with plants of open habitat, such as *Plantago*, *Artemisia*, Chenopodiaceae, Compositae, Cruciferae, etc. A variety of Ferns and Bryophytes are also seen in the vicinity of the area. The dense forest of *Picea* and *Abies*, together with scattered *Cedrus*, *Quercus* and some other broad-leaved elements, occurs about 150 m below the site of the collection. The broad-leaved elements consist of mainly *Aesculus*, *Juglans*, *Acer*, *Ulmus*, *Populus*, *Rhododendron arboreum*, *Viburnum*, *Berberis* etc.

Pollen spectrum: The pollen spectrum depicts the overall dominance of the non-arboreal vegetation (64%) over the arboreal (36%). Amongst the trees, the highest frequency of 42% is reached by *Pinus roxburghii*. Other tree species represented, are *Abies* 14%, *Quercus* 14%, *Picea* 10%, *Cedrus* 7% and *Pinus wallichiana* 7%. The pollen of *Juglans*, *Alnus*, *Corylus*, *Ulmus*, *Taxus* and *Viburnum* occurs in low numbers.

Amongst the non-arboreal elements, Gramineae is by far the most dominant with its value at about 90%, indicating the open grassland conditions prevailing in the area of collection. Other non-arboreal elements represented, are Cyperaceae 21%, *Plantago lanceolata* 17%, *Artemisia* 13%, Compositae 12%, Cruciferae 6%, Chen-Amarant type 4%, Cerealia type 3%, *Rubia cordifolia* 3%, *Impatiens* 3% and *Rosaceae* 2%. The pollen grains of Caryophyllaceae, Umbelliferae, Leguminosae, *Tribulus*, Labiatae, *Cannabis* and *Thalictrum*, together with Fern and bryophytic spores, are also met with in very low values. The aquatic vegetation is represented by the pollen of *Typha angustata*, which occurs to the extent of 1.5%.

The pollen spectrum faithfully brings out the open-land conditions of the area, but the near proximity of the forested slopes to the area of collection has a profound effect on the nature of the pollen rain. The pollen of *Pinus roxburghii*, which is by far the most dominant amongst the tree pollen, has obviously been derived from lower altitudes ascending at least 1,000 m from the mother source. Similarly the values of other tree elements are also distorted. Thus, the frequencies of *Quercus*, *Picea*, *Abies* and *Cedrus*, are not representative of the actual presence of these species at the site of collection. Nevertheless, taking the Khajjar-Chamba area as a whole, encompassing a territory within a radius of 15 Km,

the pollen spectrum from Pahalwani Devi gives a representative idea of the overall composition of the tree vegetation occurring at different altitudes, and the diversity of the ecological habitats found in the area. The non-arboreal fraction of the pollen spectrum on the other hand is highly diagnostic of the prevailing local conditions.

DISCUSSION

The studies on surface samples in the western Himalayas (SINGH, 1963; VISHNU-MITRE & SHARMA, 1966; VISHNU-MITRE, 1966; VISHNU-MITRE & ROBERT, 1971) together with the present evidence, reveal that the Indian oaks are, on the whole, low pollen producers and their pollen is not carried to very long distances. Under the present studies, the absence of long distance transport of oak pollen is amply brought out by the surface sample from Bagewal—a locality in plains, situated adjacent to the Himalayan range. The pollen spectra from Talwara in the foothills and Pahalwani Devi situated above the timber line near Khajiar, however show that oak pollen is not immune to being carried over short distances. On the whole, oak pollen tends to be under-represented in pure oak forests.

The pine pollen, both *Pinus roxburghii* and *P. wallichiana*, in the western Himalayas is much over-represented and is carried over to fairly long distances and thus, it is in line with the evidence from various parts of the world (FAEGRI & IVERSEN, 1964; HESMER, 1933, VARESCHI, 1935; LUDI, 1937; ERDTMAN, 1943; CARROLL, 1943; POTZGER *et al.* 1957; SINGH, 1963; VISHNU-MITRE & SHARMA, 1966; VISHNU-MITRE & ROBERT, 1971). Recent studies carried out in the Rajasthan Desert, and north-west India in general by SINGH (1970), have also shown the presence of pine pollen in small numbers in the surface samples. In Himachal Pradesh, pine pollen is by far the most abundant of the tree elements in the surface samples, irrespective of altitude. On the whole, the overall picture presented by all the nine surface samples faithfully brings out the deforested as well as the forested nature of the areas from which the sample is collected. The pollen spectrum from Bagewal depicts deforested nature of the area with a general preponderance of non-arboreal vegetation. The high value of Gramineae (non-arboreal) together with the overall dominance of arboreal pollen from the Talwara surface sample is indicative of the transitional character of local flora, with open-lands and forests occurring side by side.

The pollen spectrum from Chamba reveals the overall dominance of non-arboreal elements over the arboreal, indicating the open-land conditions existing side by side with forested conditions. In all the above three surface samples prevailing farming activity is represented by the dominance of culture pollen.

The pollen spectrum from Banikhet brings out the composition of the Conifer-mixed-oak forest. The surface sample from Kuth-Bhao presents the picture of open-land conditions and the presence of pollen grains of cultivated plants and weeds, such as those of Cerealia type, *Plantago*, Chenop/Amarant type, *Artemisia*, Compositae, etc. indicates the prevailing agricultural activity in the area.

The pollen spectra from Khajiar (670—2130 m) reflect the closed nature of the forest. The spectrum from Khajiar no. 1 however, fails to bring out the character of local forest community, which is largely represented by broad-leaved-mixed-oak forest, so also Khajiar no. 3 in which the sub-dominant position of *Picea* is not correctly represented. The non-arboreal components of the pollen spectra are indicative of the small clearings in the otherwise closed forest.

The pollen spectrum from Pahalwani Devi brings out the open-land conditions

of the area, but the near proximity of the forested slopes to the area of collection has a profound effect on the nature of pollen grain. Thus, the frequencies of *Quercus*, *Picea*, *Abies* and *Cedrus* are all distorted and do not represent the true picture of the area. The non-arboreal elements, on the other hand do reflect the prevailing local conditions.

In Himachal Pradesh, but for the anomalous representation of pine pollen derived through long distance transport, the pollen spectra from deforested or forested areas are seen to reflect faithfully the vegetational conditions of the areas studied so far in this region.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the guidance of Dr. Gurdip Singh during the course of this work. She is thankful to Dr. Vishnu-Mittre for kindly going through the manuscript and valuable suggestions.

REFERENCES

- CARROLL, G. (1943). The use of bryophytic polsters and mats in the study of recent pollen deposition. *Am. J. Bot.* **30**: 361-366.
- ERDTMAN, G. (1943). *An Introduction to Pollen-Analysis*. Waltham, Mass.
- FAEGRI, K. & IVERSEN, J. (1964). *Text-book of Pollen Analysis*. Munksgaard, Copenhagen.
- HESMER, H. (1933). Die naturliche Bestockung und die Waldentwicklung auf verschiedenartigen markischen Stabdorten. *Z. Forest-u. Jagdw.* **65**: 505-540, 569-606, 631-651.
- LUDI, W. (1937). Die pollensedimentation im Davoser Hochtale. *Ber geobot. Forsch. Inst. Rubel.* **1936**: 365-470.
- POTZGER, J. E., COURTEMANCHE, A., SYLVIO, B. M. & HUEBER, F. M. (1957). Pollen from moss polsters on the mat of Lac Shawbog, Quebec, correlated with a forest survey. *Butler Univ. bot. stud.* **13**(1956): 24-35.
- SHARMA, C. (1970). Studies in the Late Quaternary vegetational history in Himachal Pradesh. *Ph. D. Thesis Lucknow. Univ.*
- SINGH, G. (1963). A preliminary survey of the Post-glacial vegetational history of the Kashmir Valley. *Palaeobotanist.* **12**(1): 73-108.
- SINGH, G. (1970). History of Post-glacial vegetation and climate of the Rajasthan desert. *Scheme Report* (Unpublished).
- VARESCHI, V. (1935). Pollenanalysen aus Gletschereis. *Ber geobot. Forsch. Inst. Rübél Z.* **1934**: 81-99.
- VISHNU-MITRE (1966). Some aspects concerning pollen-analytical investigations in the Kashmir Valley. *Palaeobotanist.* **15**(1-2): 157-175.
- VISHNU MITTRE & SHARMA, B. D. (1966). Studies of Post-glacial vegetational history from the Kashmir Valley—1. Haigam Lake. *Palaeobotanist.* **15** (1-2): 185-212.
- VISHNU-MITRE & ROBERT, R. D. (1971). Studies in the pollen content of moss cushions in relation to forest composition in the Kashmir Valley. *Geophytology.* **1**(1): 84-96.