STUDIES OF POLLEN CONTENT OF MOSS CUSHIONS IN RELATION TO FOREST COMPOSITION IN THE KASHMIR VALLEY

VISHNU-MITTRE AND MRS. R. D. ROBERT

Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

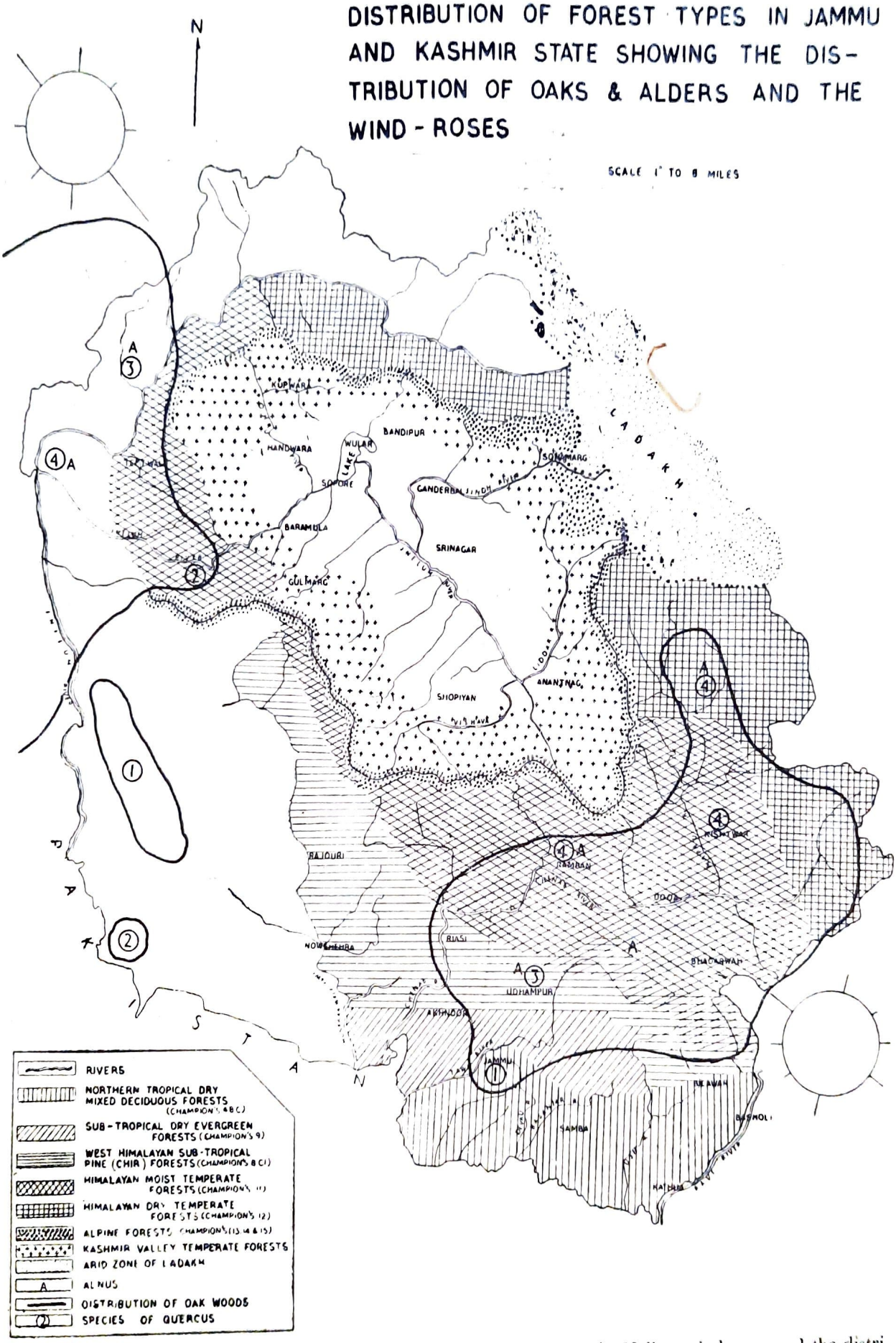
High concentration of Pine pollen in the atmosphere, insect pollination of several species and the biotic pressure on ground vegetation obtained in the Kashmir Valley vitiate the pollen spectra so that the composition of the forest is not adequately reflected by them. The paper further discusses the effect of upthermic winds, diseases and contamination from older sediments on the pollen spectra. AP/NAP ratio can hardly be used as a measure for the correct position of the forest cover. In contrast to Pine pollen which occurs in high concentrations all over the Valley, high concentrations of *Cedrus* pollen are restricted to the Deodar forest or its neighbourhood.

INTRODUCTION

The palynological investigation of moss cushions and surface samples in relation to forest composition done in the Kashmir Valley earlier (SINGH, 1963; VISHNU-MITTRE and SHARMA, 1966 and VISHNU-MITTRE, 1966) has been extended further to such parts of the valley which have not been studied so far. The moss cushions have been picked up from the Deodar forest in the Lolab valley, from the conifer mixed broad-leaved forest at Kulan, from within the Blue Pine forest at Chotipura half way between Shupian and Sedau, and from close to the Thajwas glacier. In order to assess the problem of the inference of forest composition from the pollen content of surface samples and moss cushions in the Valley, we have also drawn upon the observations published earlier.

In attempting correlation between the composition of the forest and the pollen spectra, we have considered the effect of local NAP over pollen content, the differentlial pollen preservation, the comparison of pollen content of moss cushions and surface samples, the effect of thermic and other winds on the transport of pollen, the effect of plant diseaes, the contamination of pollen content through older sediments and finally the NAP/AP ratio as a measure for the forest cover.

The important aspects of the geography and the botany of the Kashmir Valley have been discussed earlier by SINGH (1963) and VISHNU-MITTRE (1966). Text-fig. 1 shows the distribution of forest types in the Jammu and Kashmir State. The two wind-roses in the figure show the trend of the wind currents which largely enter through the east and the west into this boat-shaped valley, bounded by lofty hill ranges all along the north and south. Wind also enters the valley through passes in the high hill ranges. Text-figure 1 also shows modern distribution of *Quercus* and *Alnus* in the Jammu and Kashmir State. Of these *Alnus* is absent from the valley proper but the occurrence of *Quercus*, also long held to be absent from the valley, has been proved by the discovery of stands of two indigenous species viz., *Q. semecarpifolia* and *Q. dilatata* (VISHNU-MITTRE, 1963). These have not been shown in the map, since their historical status is still unknown. Exotic oaks have however been recently in-



Text-Fig. 1. Map showing the distribution of forest types in the Kashmir Valley, wind roses and the distribution of *Quercus* and *Alnus* in the Jammu and Kashmir State.

troduced (VISHNU-MITTRE, 1966). The evidence of the former occurrence of both *Alnus* and *Quercus* in the valley has been discovered through pollen analyses (SINGH, 1963; VISHNU-MITTRE and SHARMA, 1966; VISHNU-MITTRE, 1966).

Severe dust storms in the valley arise semi-annually before the southeast monsoon during the spring and early fall before the winter rains, usually beginning in April and lasting until the end of May. Besides the pollen grains, a large amount of silt from the top soil is disseminated and redeposited by these storms. In the valley proper the diurnal winds pick up top soil from alluvial deposits and terraces and travel far north into the mountains. It is believed (DE TERRA and PATERSON, 1938) that this agency of wind operated more strongly in the past as evidenced by the deep burial of ancient ruined sites in thick deposits of loessic soil such as the Neolithic site at Burzahom. The storms and local air currents must have influenced considerably the dissemination of pollen in the valley in the past.

The moss cushions were boiled in pyrex glass beaker with 10% dilute KOH for a few minutes. Thereafter the mixture was sieved. The solution was passed through the strainer, centrifuged and washed free of the alkali. After dehydration with glacial acetic acid, it was acetolysed. Slides were prepared in 50% Glycerine. Pollen sum comprises AP only.

POLLEN ANALYSIS OF MOSS CUSHIONS

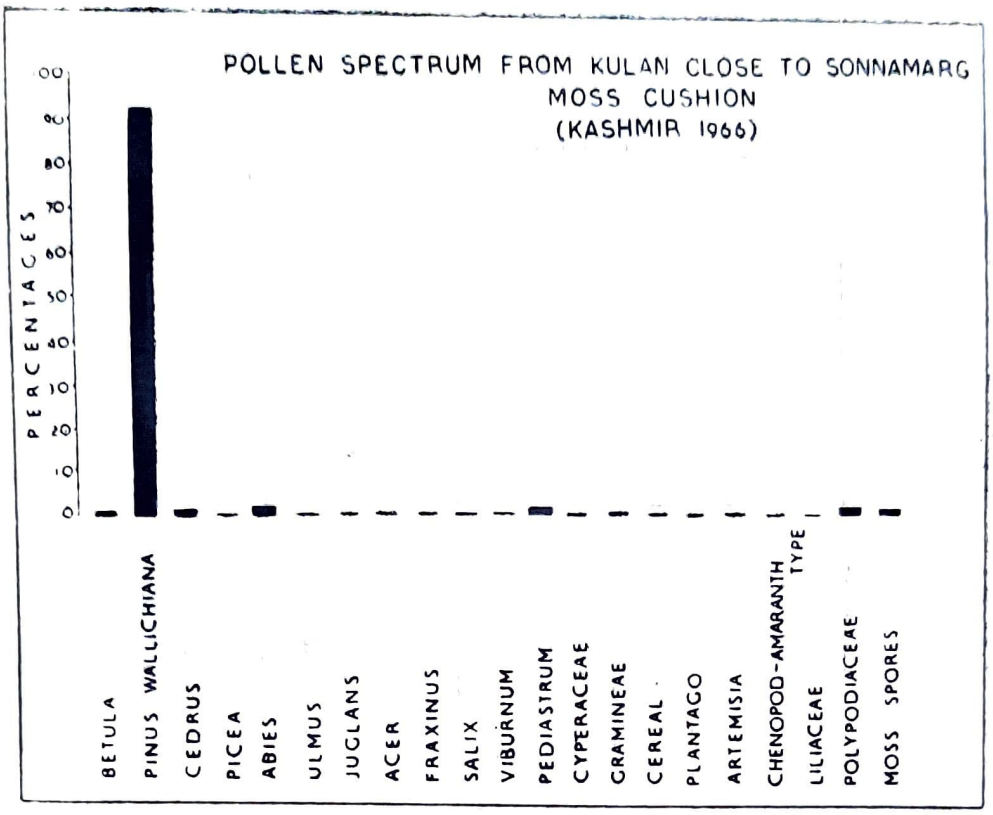
Moss cushions from Kulan in the vicinity of Sonamarg

Kulan about 2665 m. is half way between Gund and Sonamarg in the Sind Valley. Vegetation in the vicinity between Gund and Sonamarg is not only interesting but also unusual. Below Gund, the broad-leaved forest comprising Elm, Walnut, Horse Chestnut, Ash, etc. forms the lowermost belt. It is succeeded by a conifer belt on the top. But, beyond Gund, the broad-leaved forest is seen ascending higher even approaching the peaks of mountains thus invading into the conifer belt. The disturbed conifer belt is variously affected and is distributed haphazardly. In such situations the broad-leaved forest is found occurring in depressions between the folds of the mountains through which it ascends to the peaks while the conifers, mostly Blue Pine (*Pinus wallichiana*), occupy the ridges. In normal zonation of vegetation in the Himalaya, *Acer* and Birch usually ascend to the higher peaks and *Acer*, here, is also very frequent.

At Kulan, a distinct Blue Pine-Birch mixed community is seen along the left bank of the river Sind with both Spruce and Fir and some members of the broad-leaved community like Walnut, *Fraxinus*, *Acer* and Elm. The Alpine Birch (*Betula utilis*) here descends to the lowest level in the entire Kashmir Valley. Opposite this forested face of the hill and bordering the road and the right bank of the river, the mountains are largely bare bearing some trees of Blue Pine and scattered herbs and shrubs. A moss cushion was picked up from an exposed boulder in a pool at the foot of this bare hill.

In this community *Pinus wallichiana* forms about 50 to 60% of the forest and Fir is the next abundant conifer. *Picea* is rare and so is *Cedrus*. Birch is comparatively more than the other broad-leaved trees and *Acer* is next in abundance.

Pollen spectrun (Text-fig. 2) reveals predominant Blue Pine community with 91.4% *Pinus*. Fir the next dominant conifer has only 2% pollen. *Cedrus* is 1.3% and *Picea* is rare. Birch, dominant among the broad-leaved constituents, is represented by about 1% pollen whereas the others are under 1%. *Acer* a significant number of the vegetation is 0.7%. The non-arboreals are under 0.4%. *Polypodium* and spores of mosses (of local origin) are upto 1.3%.



Text-Fig. 2. Pollen spectrum from Kulan.

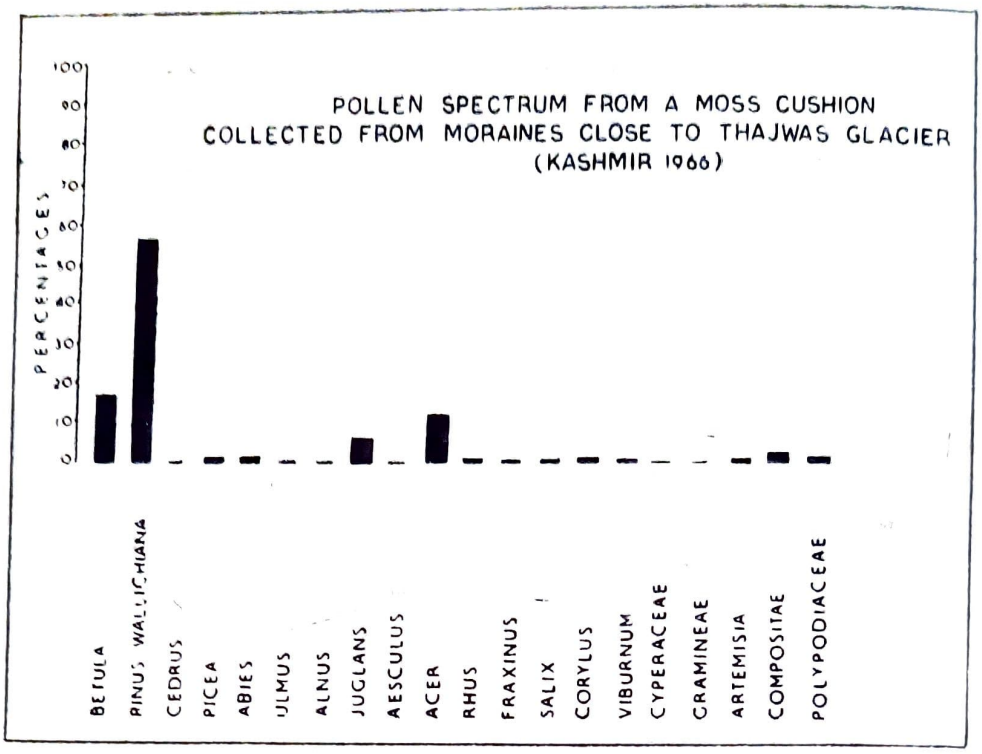
The pollen spectrum fails to depict the exact composition of the community although it indicates a dense Blue Pine forest with traces of broad-leaved and non-arboreal constituents. This may largely be due to high pollen production of Pine and low pollen production of Fir and insect-pollination of *Acer*.

Traces of cereal pollen in this spectrum are in accord with agriculture being practised in the vicinity. The occurrence of (1.98%) colonies of *Pediastrum* in the pollen content suggests that the Moss Cushion bearing boulder in the pool must have been submerged sometime.

Moss Cushion from the Valley of Thajwas Glacier

This Moss cushion was collected from one of the boulders in the glacial moraines, probably belonging to the Vth or VIth Glaciation in the valley of Thajwas Glacier. The tops of the mountains in this valley are mostly snow-bound. The vegetation on the north-east face consists of broad-leaved forest comprising *Acer caecium*, *Prunus cornuta* and *Betula utilis*. Fir, Birch and *Acer* are in abundance and Birch along with *Acer* ascends to the snow line. On the south-west aspect of the hills, more or less similar vegetation is seen but the blanks are colonised by *Pinus wallichiana*. *Sambucus ebulus* and *Lonicera* are the most prominent shrubs. The tree line at high peaks is colonised by *Salix tetrasperma* and *Juniperus recurva* with rarely occurring *Rhododendron*.

Pollen spectrum (Text-fig. 3) brings out about 60% Blue Pine and extremely low frequencies of Fir (1.44%) and Spruce (1.3%). *Cedrus* is extremely rare. Birch is 16.5%, *Acer* 11.1% and *Juglans* 5.8%. *Rhus*, *Aesculus*, *Fraxinus* and *Ulmus* are very poorly represented and so is *Salix* which forms an important constituent of vegetational belt between snow line and Birch. *Corylus* is 1%. Compositae are 2% and Polypodiaceae 1.50% and the rest are under 1%. Comparatively more open conditions obtained at the site and the presence of a large meadow in the valley are not reflected in the pollen spectrum.



Text-Fig. 3, Pollen spectrum from Thajwas glacier.

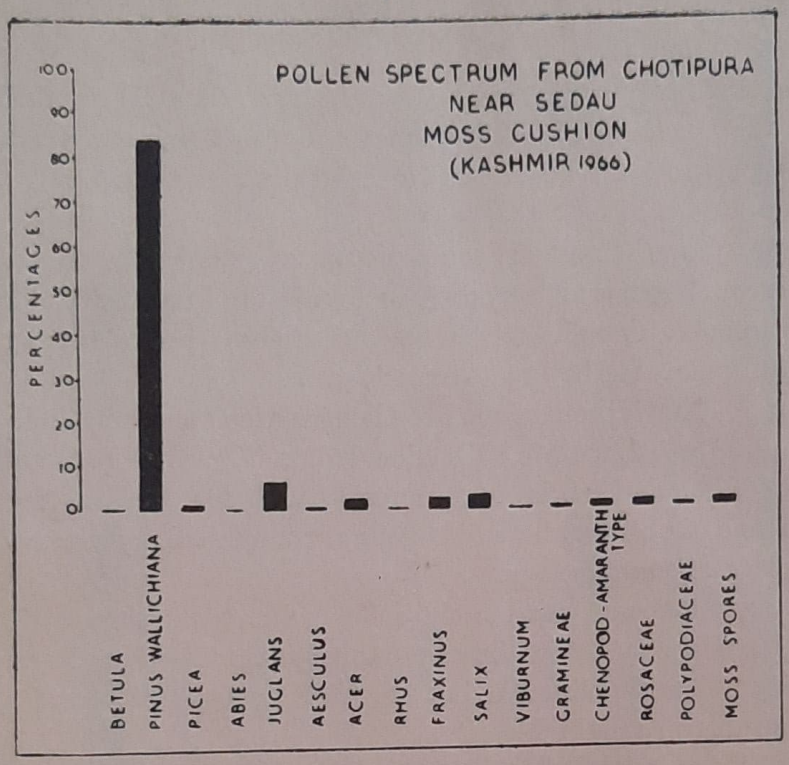
The occurrence of traces (0.18%) of *Alnus* pollen in the spectrum is obviously due to long distance transport either from the Kishenganga valley towards the west or from valleys towards the south-east of this region as shown in Text-fig. 1. Pollen of *Cedrus*, *Juglans*, *Rhus*, *Aesculus*, *Fraxinus*, and *Ulmus* have been transported by the thermic winds from lower altitudes.

Moss Cushion from Chotipura

Chotipura is on the way to Sedau and Shupiyan. The moss cushion was collected from within a dense stand of Blue-pine forest. *Sambucus ebulus* and *Stipa sibirica* were the prominent shrubs and herbs growing in the forest. The region around the Blue pine stand was under extensive maize crop at the time of our visit. Besides orchards of Apples and Pear *Juglans* is frequently planted. Not far from the site, a swamp was seen colonised by *Sparganium*. The hillocks surrounding the plateaux on the north and south bear Pine forest. There is no broad-leaved forest around but for occasional trees of *Acer*, *Rhus* and *Aesculus*. *Salix* is planted. On the whole, the area under cultivation far exceeds the area under forest.

Pollen spectrum (Text-fig. 4) shows Blue-Pine over 80% and *Picea* 1.48%. *Abies* is extremely rare. *Juglans* although under 10% dominates over the other broad-leaved constituents. *Salix* is 2.9% and both *Acer* and *Fraxinus* 2.5% each. Pollen of Rosaceae is 1.86% and may be attributed to the planted trees in the orchards. Chenopod—Amarnath type is represented by 1.52%.

On the whole, the Pollen Spectrum does reflect a dense Pine stand and the high values of *Juglans* indicate plantation of Walnut. Pollen of Birch, absent in the vicinity, has been transported from higher attitudes not very far from this site. The pollen spectrum does not reflect open conditions obtained here pherhaps it is due to the sample being from within the forest. The open areas comprise cultivated fields and the weeds are mostly insect-pollinated. The graminaceous weeds are under heavy pressure of grazing. Despite wide cultivation, no cereal pollen has been encountered. Orchards of Apple and Pear are under-represented, because their pollen is insect-pollinated.



Text-Fig. 4. Pollen spectrum from Chotipura.

Moss Cushions from Chandigam

The Lolab valley in the north-west of the Kashmir Province is famous for the oldest and dense Deodar (*Cedrus deodara*) forests. Deodar is almost absent on the Pir Panjal except at Yarwan close to Chahar Sherif where a sizeable patch of Deodar occurs on shales and hard rocks. The Deodar forest in the Lolab valley has been the least disturbed even during the prehistorical periods, since no evidence to that effect has been found here so far. Moss cushions were collected from Forest Compartment no. 22S, from the base of the hill to about 360 m. at an interval of about 30 to 50 m., in order to see how far the composition of the pollen spectra reflects the composition of the forest. The pollen spectra are collectively shown in Text-fig. 5.

Moss Cushion I was collected at the fringe of the forest from an Ash tree from within an Ash community at the slope of this hill. The composition of the forest is given below:

Deodar	70-80%
Blud Pine	10%
Ash, Juglans and *Acer*	4.5% each
Aesculus	upto 2%
Celtis	0.5%

The undergrowth consists of abundant *Viburnum*, *Parrotiopsis* and *Cotoneaster* and the ground vegetation comprises grass, composites, *Artemisia*, members of Labiatae, Liliaceae and mosses.

In the pollen spectrum *Cedrus* is 65.7% and *Pinus* 6.6% thus reflecting more or less their exact composition in the forest, although slightly under-represented. *Acer* and *Fraxinus* are under-represented whereas *Aesculus* and *Celtis* are over-represented. *Rhus*, absent in community at this level, is 2.6% in the pollen spectrum. *Parrotiopsis* has roughly twice the percentage of *Viburnum* although *Viburnum* is dominan tin the shrub layer. Herbs are very poorly represented

and *Artemisia* (3.25%) has the highest frequency amongst them all followed by Chenopod-Amarnath type and Compositae.

Moss Cushion 2 was collected from an *Aesculus* tree about 60 m. above Moss Cushion No. 1. At this site there is an increased frequency of *Cedrus* which is undergoing considerable regeneration. Blue Pine and the broad-leaved constituents are comparatively less here than at the previous site.

Pollen spectrum shows almost the same picture as revealed by the composition of the forest described above. There is an overall reduction in the frequencies of Blue Pine and the broad-leaved constituents although *Aesculus* has the highest pollen frequency amongst the broad-leaved constituents. Herbs are extremely rare.

Moss Cushion 3 –This sample comprising lichens growing on the bole of a Deodar tree was collected about 30 m. above Moss Cushion No. 2. The plant community here may be described as *Cedrus deodara—Parrotiopsis* community with few trees of *Aesculus*. *Cedrus* trees are widely-spaced and the spaces between them are inhabited by plants of *Artemisia*, Labiatae, Scrophulariaceae and grasses.

Pollen spectrum does not adequately reflect the composition of the community. *Parrotiopsis*, an important member of the community, is extremely under-represented chiefly because the species is insect-pollinated but the higher values of *Aesculus*, another insect-pollinated species, are unexplainable.

Moss Cushion 4 was collected from an *Aesculus* tree about 60 m. above the previous sample. The frequency of *Cedrus* at this site has increased further, and there is an increase in *Parrotiopsis*, Walnut, *Ash* and *Aesculus*. Spaces between the trees are colonised by numerous herbaceous elements of which *Artemisia* is more common.

Pollen spectrum shows dominance of Deodar although its values are comparatively reduced. *Fraxinus*, *Aesculus*, *Parrotiopsis* increased and *Juglans* fluctuates high over its values in the previous samples. There is increase in the pollen of *Artemisia*, Liliaceae and Rosaceae which were comparatively less represented in the previous pollen spectrum.

Moss Cushion 5 was collected about 60 m. above the Moss Cushion No.4. Here Deodar has much increased concentration with some trees of Blue Pine. Broad-leaved trees and shrubs are extremely rare and *Parrotiopsis* is a dominant shrub.

Pollen spectrum brings out an almost factual picture of the composition of the forest but for *Parrotiopsis* whose values are reduced further perhaps its pollen production is affected being in a closed forest.

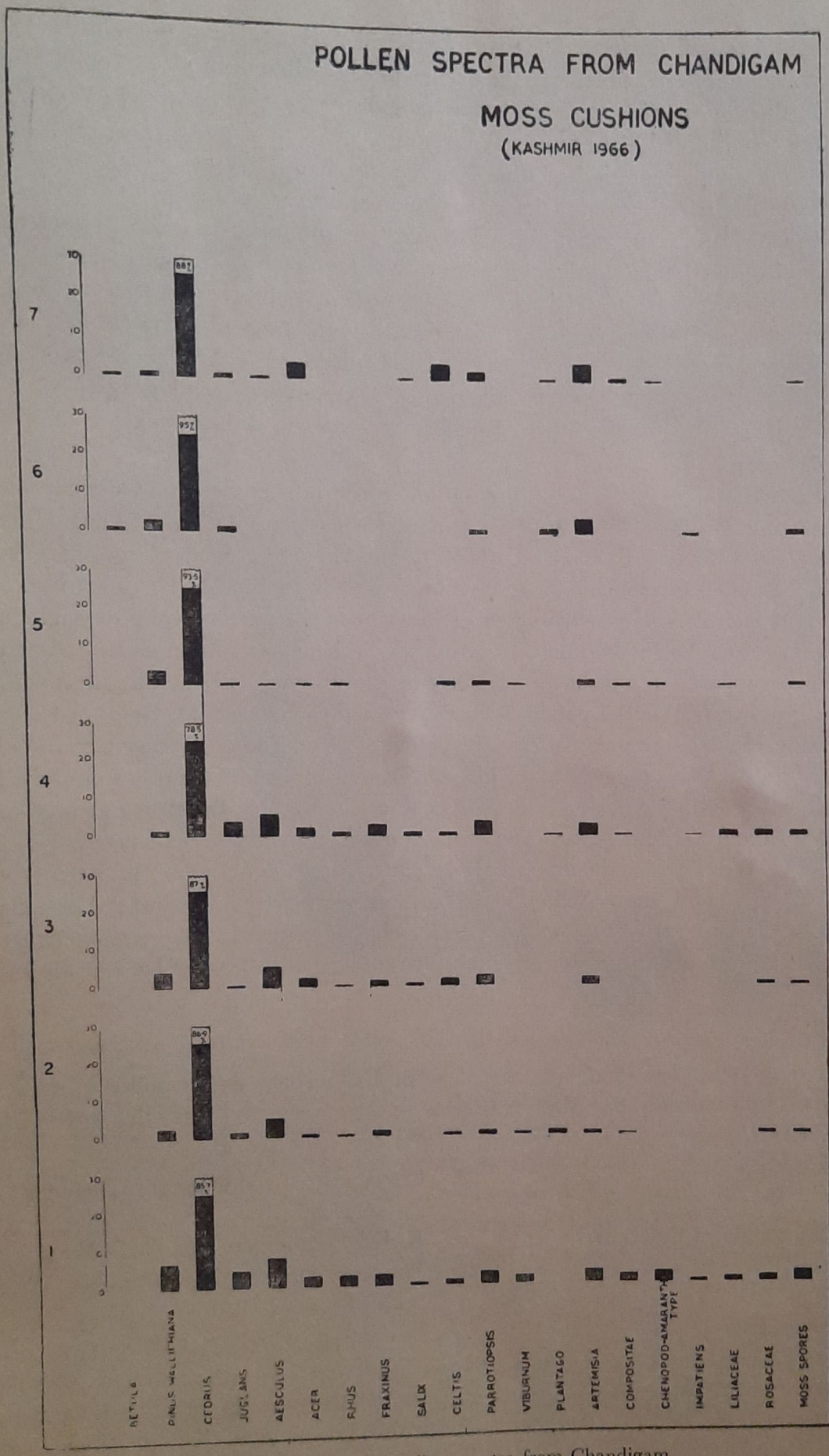
Moss Cushion 6 was collected about 60 m. above the previous one from a pure Deodar forest. Pollen spectrum shows 94.5% of Deodar with little of Blue Pine. *Juglans* is 1.2%, *Parrotiopsis* 0.6% and the pollen of Birch, extremely rare in the community, is first met with here. Pollen of *Artemisia* has increased to 3.6%.

Moss Cushion 7 was collected about 60 m. above Moss Cushion No. 6. Deodar is dominant with a few trees of *Acer* and *Celtis*. *Parrotiopsis* and *Artemisia* are also present.

Pollen spectrum shows dominance of Deodar although its values are comparatively reduced from that of the previous sample. *Artemisia* and *Parrotiopsis* show higher values and same is the case with *Celtis* and *Acer*. 0.5% of Birch pollen is also present.

The above series of Moss Cushions do, however, bring out the occurrence of predominant Deodar community but the representation of other constituents especially that of the broad-leaved genera is variable within the same forest. *Parrotiopsis* and certain other important constituents being insect-pollinated are poorly represented.

This may be attributed partly to differential pollen preservation in moss cushions and lichens. Surprisingly *Aesculus* and *Celtis* tend to be slightly over-represented while within the



Text-Fig. 5. Collective disposition of pollen spectra from Chandigam.

forest than *Acer* and *Fraxinus*. Pollen of *Rhus* and *Salix* are from outside the community. Two instances of interest noted are the occurrence of pollen of Birch in the top samples and the high values of *Artemisia* recorded in the top and bottom samples. Both are of local origin. First Birch tree is noted higher up in the transact.

The under-representation of Blue Pine is due to the damage being caused by *Fomes* and *Arceuthobium minutissimum*, a loranthaceous parasite, resulting in the death of several pine trees which are being replaced by Deodar. The minor fluctuations in the frequency of Deodar pollen may be due to the pollen from the broad-leaved elements which occur in the depressions irrespective of the altitude. *Prunus* is present and its rare pollen is included in the small percentage of Rosaceae pollen. The ground flora comprising Compositae, *Polygonum*, *Viburnum*, *Rumex*, *Cannabis sativa*, *Urtica dioica*, Umbellifers, *Potentilla*, *Fragaria*, species of *Ranunculus*, *Plantago*, *Oxalis*, etc., is very poorly represented by pollen. Some of the above are insect-pollinated, but the others probably produce less pollen owing to their existence within the forest.

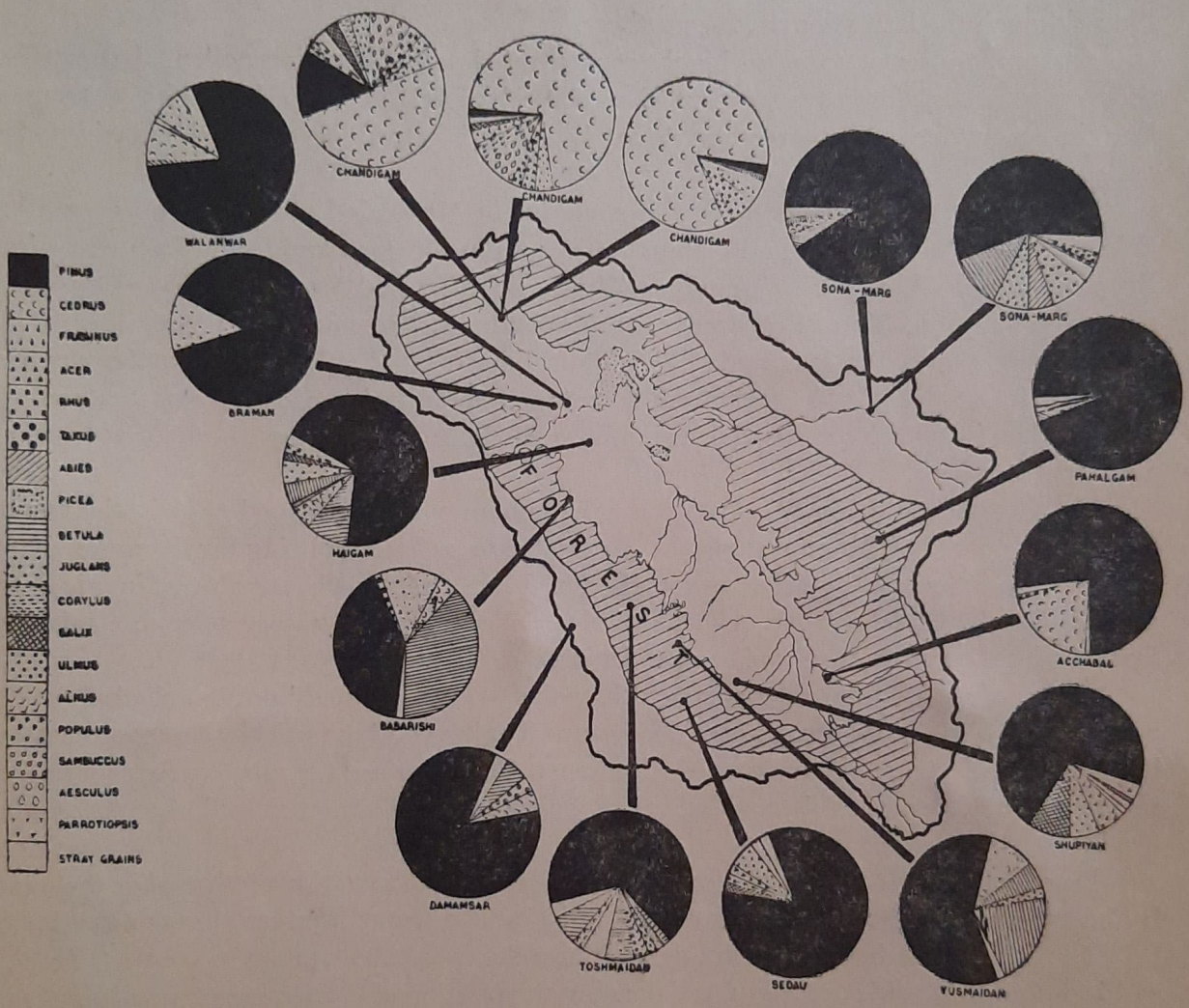
The moss cushions in the dense, tall, Deodar forest at Chandigam are all collected from a height ranging from 3m—360m from the ground. Poor representation of pollen of herbs may be due to their pollination by insects as well as due to low pollen production. Absence of grass pollen in the pollen spectra should be attributed to the latter cause. There are indications of vertical and lateral transport of pollen of local trees within the forest through the wind currents active at a height of 3m—360m from which the moss cushions have been collected. Further experimentation is however necessary to establish if the abundance of Deodar pollen is derived from vertical fall of pollen of local trees or the wind currents from the surrounding hills bearing Deodar forest are laden with pollen of Deodar and of other trees. Within the altitude of 360 m. above the base of the hill, the Deodar in the forest shows a gradual increase in its frequency till it becomes pre-dominant towards the top. Pollen percentage of *Cedrus* upto 120 m. above the base of the forest remains more or less the same (samples 1-3: 85-7%, 86.9%, 87%). It declines at 180 m. (sample 4:78.5%), but rises between 240-300 m. (samples, 5, 6:93.5%, 95%) and again declines at 360 m. (sample 7:88%). Vertical fall of pollen does not seem to explain this. At the same time it cannot be excluded. A large part of this pollen may be due to transport of pollen from the surrounding hills bearing Deodar forest.

DISCUSSION

Including those described here there are in all fourteen recent pollen spectra (Text-fig. 6) from the following four distinct regions so far constructed from the valley (Vishnu-Mittre, 1966).

1. The forest region .. .. Chotipura, Chandigam, Achchabal and Babarishi.
2. The margin of the forest .. Kulan, Pahalgam and Toshmaidan.
3. Partly forested and partly open areas Thajwas glacier, Yus-Maidan, Walanwar and Braman.
4. Open areas .. .. Damamsar, Haigam and Shupian.

These pollen spectra come from varying altitudes such as, from between 1600-1800 m. above sea level (Achchabal, Shupian, Haigam, Walanwar, Braman and Chandigam); from between 1800-2800 m. (Pahalgam, Babarishi, Yus-maidan, Kulan, Thajwas glacier, Chotipura) and from between 3000-35000 m. (Toshmaidan and Damamsar). Thus, the pollen spectra investigated and considered here come from the wide botanical and geographical areas.



Text-Fig. 6. Geographical distribution of pollen spectra from moss cushions in the Kashmir Valley.

Under the prevalence of dry temperate climate, impact of biotic factor, the predominance of conifers and lack of oaks and alders (barring stray occurrences of oaks: Vishnu-Mittre 1963), the vegetation types recognised in the Kashmir Valley are few. *Parratiopsis* forest in fact represents a retrogressive seral stage progressing towards Blue Pine or Deodar forest. *Deodar-Parratiopsis* forms a compact and close community in the Lolab Valley. *Parratiopsis* being insect-pollinated, pollen spectrum indicates more or less pure Deodar community. The mixed conifer forest is dominated by *Abies* and *Picea* though *Pinus* and *Cedrus* are also represented in fair proportions. Owing to low pollen production of *Abies* and *Picea*, predominance of Blue Pine is indicated by the pollen spectrum. Position is more or less the same in pure *Abies* forest as at Yus Maidan and Baba Rishi because of the presence of good amount of Blue Pine in it. The dry temperate broad-leaved forest occurring in particular microclimatic and edaphic situations along streams, most depressions and in sheltered ravines and constituting the lower belt of the conifer forest forms so thin and narrow strips that a pollen spectrum can hardly reflect its identity. Blue Pine is again dominant. The pollen spectra from high and low level *Abies* forest produce more or less identical results. The high

level Blue Pine—*Abies*—Birch community is reflected in a moss cushion by Blue Pine—Birch—*Abies* in the order of abundance.

No samples have so far been examined from *Abies*—Birch, Birch—*Rhododendron* associations; Birch is expected to dominate here and perhaps Blue Pine also over *Abies*. The samples from alpine scrub are expected to show dominance of *Juniperus* together with Blue Pine although the latter does not occur there.

Atmosphere seems to be so highly concentrated with Blue Pine pollen, that it affects pollen spectra of all forest types except that of Deodar forest. It wo'nt be unfair to comment that the present forest types are not adequately and satisfactorily represented by their modern pollen spectra.

In regard to individual genera this study in the Kashmir Valley is equally revealing. Pollen of Blue Pine occurs equally abundantly both in the open and in the forested regions. Even in the Fir—Blue Pine community (Vishnu-Mittre and Sharma, 1966) where Fir is of high proportion, Blue Pine records its abundance perhaps owing to comparatively low pollen production of Fir. It is obvious that Pine pollen is unreliable for its factual occurrence and this fact should not be overlooked during the interpretation of subfossil pollen spectra. High pollen frequencies of Deodar are only restricted to the regions where Deodar occurs abundantly.

The broad-leaved constituents are usually much under-represented even in the regions where they occur in high proportion. It may be due to pollen rain being highly concentrated with conifer pollen. But under-representation of Birch, a high pollen producer, in one of the samples is quite amazing. As much as 11% *Acer* pollen at the Thajwas glacier site is derived from the local occurrence of *Acer caesium*, an insect-pollinated species.

Among shrubs, the picture presented by pollen spectrum should not be relied upon, for instance, the abundant occurrence of *Sambucus* at Thajwas finds practically no representation in the pollen spectrum. Abundance of *Viburnum* at Chandigam is not adequately represented in the pollen spectrum. This may be due to their insect-pollination as well as to low pollen production.

Extremely low percentage of non-arboreals, even in moss cushions collected in the open, is illustrative of the fact that the ground flora is under a heavy pressure of grazing animals.

The position of *Artemisia*, a prolific pollen producer, is also equally interesting. As may as 16 species of *Artemisia* occur in the Valley but the position of the genus in the pollen spectra is also follows: hardly any pollen in the open, extremely rare in the glaciated region and a very small percentage in the Deodar forest. The absence of *Artemisia* in the open is probably due to the biotic factor controlling its distribution in the valley (Vishnu-Mittre, 1966). It is, therefore, that one rarely comes across a plant of *Artemisia* excepting in the *Parrotiopsis—Artemisia* community or within the forest.

Some of the problems mentioned earlier are discussed below in the light of hitherto investigated pollen spectra.

(1) *Correlation of pollen spectrum with forest composition and effect of local NAP over pollen content*

Owing to high concentration of atmosphere with Pine pollen, preponderance of insect-pollinated species and the ground vegetation being under heavy biotic pressure more particularly grazing, investigations show that an adequate composition of the forest is rarely revealed by pollen spectra from moss cushions or surface samples unless they come from within a dense stand of a conifer forest. The samples collected from the margin of the forest or from the open rarely reveal the true picture of vegetation, and the dominant genera in the vicinity are usually over-represented in the pollen spectra. For example, the moss cushion

collected from the margin of the forest at Pahalgam clearly brings out the abundance of Blue Pine in the forest. Its over-representation here is due to its high pollen production. Fir, Spruce, Deodar, *Betula*, *Salix* and *Celtis* are absent in the forest but present in the spectrum in low frequencies. The open conditions at the site are under-represented. The moss cushion at Shupiyan collected from the open brings out scattered plantations of *Juglans and Salix* at the site and the non-arboreals are found in very low frequencies. Low frequencies of other conifers and the high percentage of Blue Pine and the low percentage of broad-leaved constituents are explainable but 7% pollen of *Alnus*, absent from the valley, is quite interesting. Likewise, in moss cushions from Kulan collected from the margin of the forest, the NAP is negligible. More or less similar picture is revealed by the moss cushion from the Thajwas glacier.

The negligible NAP in the pollen spectra even in moss cushions collected from the open may be due to the heavy pressure of grazing on the ground flora, and also the prevalence of insect-pollinated species. Thus, the composition of a forest as revealed by a pollen content of a moss cushion collected from the open is much distorted owing to the negligible NAP.

(2) *Differential Pollen preservation and comparison between the pollen content from moss cushions and surface samples*

Out of several pollen spectra studied here, a few can be considered from the viewpoint of differential pollen preservation in moss cushions. Perhaps it would have proved more fruitful if the moss cushions and surface samples were studied from the same site. Nevertheless, it is possible to bring out some facts in this regard. As regards Blue Pine, it is abundantly present in most pollen spectra whether the moss cushions or surface samples come from the open or forested areas. The low frequencies of Fir pollen in moss cushions at Kulan, its rarity in that from Thajwas and its high values in the pollen spectra from the surface sediments at Yusmaidan and Baba Rishi are perhaps suggestive of differential preservation, but then there may be, however, other factors to explain that. Likewise, the effect of differential preservation on the pollen of other genera can be picked up in moss cushions and a detailed study may eventually reveal interaction of several factors responsible for the preservation of pollen in moss cushions and sediments.

(3) *Effect of thermic winds on the transport of pollen*

Pollen of *Rhus*, *Aesculus*, *Fraxinus* and *Ulmus* at the Thajwas Glacier have been carried up by the thermic winds from the Valley below.

(4) *Effect of diseases on pollen production*

The onset of disease may not only affect the morphology of pollen eventually but also destroy the forest thus affecting pollen production of affected trees. Of the two types of Pine pollen recovered in some moss cushions at Yus Maidan, Baba Rishi and Haigam, the Pine pollen type may perhaps belong to the diseased trees (Vishnu-Mittre and Sharma, 1966), At Chandigam, Blue pine is under-represented owing to the occurrence of several diseased trees some of which have already scumbed to the disease.

(5) *Contamination from older sediments*

Pollen of *Alnus* at Thajwas as well as at Shupiyan might have come either from the Pleistocene sediments or wind-transported from outside the valley. A few pollen grains being

eroded suggests their derivation from older sediments (the Pleistocene Karewa deposits). Erosion of older sediments is a common feature in the Valley. River transport of the sediments into the lakes and swamps becomes clear from the Post-glacial pollen diagram from Haigam where pollen grains upto 15% of *Quercus* are found in the sandy clay towards the extreme top of the diagram after the decline and almost virtual annihilation of oak woods during stages 'f' and 'g' (VISHNU-MITTRE and SHARMA, 1966). This unusual rise of Oak pollen, much less suggestive of re-establishment of Oaks, is a clear case of contamination from older sediments. None of the moss cushions has revealed, so far, the occurence of Oak pollen in their pollen contents. The continuity of Oak pollen in the Toshmaidan pollen diagram (SINGH, 1963), upto the extreme top reveals a continuous though low influx of Oak pollen from outside the valley or a regular contamination from the wind-blown dust carried upwards from the valley. This, however, needs further substantiation.

(6) *AP/NAP Ratio as a measure for forest cover*

Pollen content from moss cushions, surface and sub-surface samples, if considered in complete ignorance of the Botany of the Kashmir Valley would reveal that the Valley is densely wooded and is devoid of open areas. But this is contrary to what is obtained there. It is, therefore, very significant that real significance of the AP/NAP ratio should be assessed not only very intelligently but also in accordance with a thorough knowledge of the botany of the area. It has already been pointed out above that the open vegetation is under a heavy pressure of grazing and chiefly owing to that the AP/NAP ratio becomes misleading. The AP/NAP ratios as shown by some of the post-glacial diagrams from the valley (SINGH, loc. cit., VISHNU-MITTRE and SHARMA, loc. cit.) especially after the decline of Oaks, do not seem to present the factual picture of the vegetation. The topmost pollen spectra in these diagrams are very seriously vitiated by high Blue Pine pollen, although the valley proper is devoid of pine forest which occurs on the slopes and higher up along the flanks of the valley.

Our Thanks are Due to the Forest Department of Jammu and Kashmir State, particularly to Mr. A. N. Fotidar, Censervator of Forest, for all the help towards the studies of Forest communities and collection of samples.

REFERENCES

DE TERRA, H. and PATERSON, T. T. (1939). Studies on the Ice age in India and associated human cultures. *Publs Carnegie Instn.* **493:** 1-354.

SINGH, G. (1963). A preliminary survey of the Post-glacial vegetational history of the Kashmir Valley. *Palaeobotanist.* **12**(1): 73-108.

VISHNU-MITTRE (1963). Oaks in the Kashmir Valley with remarks on their history. *Grana Palynol.* **4**(2): 306-312.

VISHNU-MITTRE (1966). Some aspects concerning pollen analytical investigations in the Kashmir Valley. *Palaeobotanist.* **15**(1-2): 157-175.

VISHNU-MITTRE and SHARMA, B. D. (1963). Pollen morphology of Indian spp. of *Alnus*. *Grana Palynol.* **4**(2): 302-305.

VISHNU-MITTRE and SHARMA, B. D. (1966). Studies of Post-glacial history from the Kashmir Valley, 1. Haigam Lake. *Palaeobotanist.* **15**(1:2): 185-12.