RECENT POLLEN SPECTRA FROM GARHWAL HIMALAYA

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Abstract

An attempt has been made to build up pollen/vegetation relationship through the study of a set of 43 surface samples collected in transects from various communities such as Sal forest, *Acacia catechu* zone, subtropical pine forest, pine-oak woods, oak-deodar woods and spruce-fir-oak woods at different altitudes ranging from about 700-2700 m from Dehradun Division-Golatappar, Kala Gad, Sahastradhara, on way from Mussoorie to Kampti Falls and Chakrata to Devban.

The study reveals the total absence of Sal forest as well as *Acacia catechu* zone in the pollen spectra, thus depicting false picture of the surrounding vegetation. However, pine-oak woods, spruce-fir-oak woods, etc. are more or less faithfully represented. Chir-pine remains to be over-represented throughout, whereas insected pollinated spectra are either under-represented or even un-represented.

Introduction

The present paper deals with the study of pollen/vegetation relation of Dehradun Division-Golatappar, Kala Gad, Sahastradhara; on way from Mussoorie to Kampti Falls and Chakrata to Devban via Kalsi. These regions are located in the Garhwal Himalaya which constitute the central part of Western Himalaya between 30° and 31°N, 70° and 80°E. To date no work of this kind has been carried out in this region or any part of Garhwal Himalaya. However, similar work in the adjoining states of Kumaon on the West and Himachal Pradesh on the east has been done by Gupta (1977) and Sharma (1973) respectively.

Vegetation

There are quite a few publications on the flora of Garhwal (Strachey and winter bottom 1946-1849; Duthie, 1906; Rau, 1961) or references to its flora in the floras of adjoining regions (Osmaston, 1922, 1927; Kanjilal, 1928; Saxena, 1966; Malhotra, 1973; Samuel & Gaur, 1979; Awasthi & Sharma, 1980).

An attempt has been made to build up the pollen/vegetation relationship amongst various plant communities at different altitudes and samples (Table 1) collected in transects.

In Dehradun region sampling was done in the Sal forest, *Acacia-Dalbergia* zone community, subtropical pine forest, pine-oak woods, oak-deodar woods and spruce-fir-oak woods. Thus the work has been carried out from a low altitude-680 m a.s.l. to high altitude-2700 m a.s.l. with subalpine vegetation.

Method—The surface samples (soil samples as well as moss cushions) were boiled with 10 % potassium hydroxide solution for a few minutes, then sieved and the obtained filtrate was centrifuged and washed to remove alkali. After dehydration with glacial acetic acid it was acetolysed (Erdtman, 1943). In case of soil samples hydrofluoric acid treatment was given before acetylosis Slides have been prepared in 50 per cent glycerine calculated in terms of total terrestrial pollen.
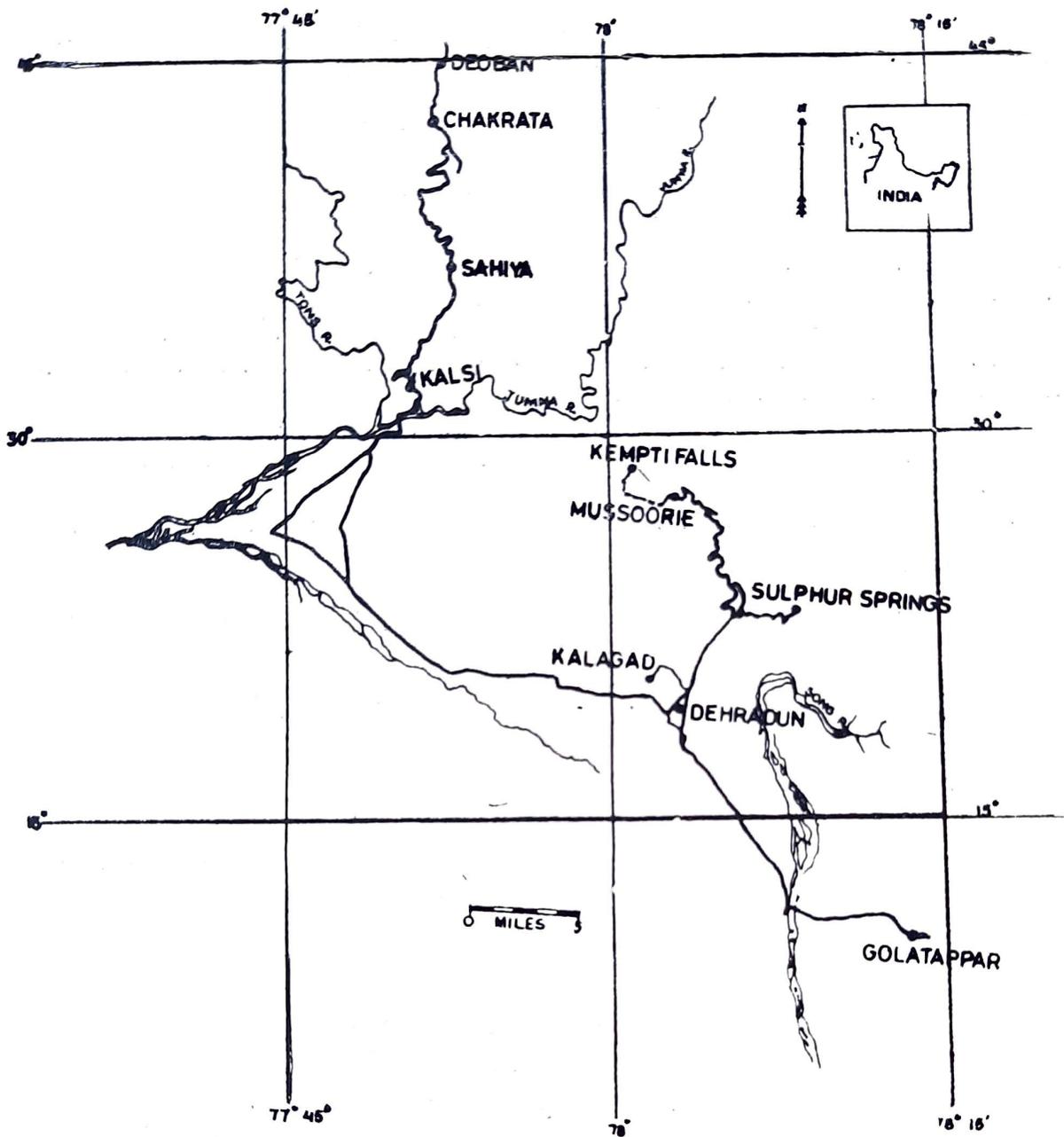
Map showing the localities.

Provenance of samples collected from Garhwal Himalaya for recent pollen spectra :

1. Golatappar   (i)   — Moss cushion scraped from *Diospyros* tree within the forest.

2. Golatappar   (ii)   — Moss cushion at the edge of swamp under *Diospyros* tree-within the forest.

3. Golatappar   (iii)   — Soil sample a few yard away from the above within swampy area.

4. Golatappar   (iv)   — Soil samples further away from the above.

5. Golatappar   (v)   — Moss cushion very near the above to compare the composition in soil sample and moss cushion within the same area.

6. Golatappar   (vi)   — Moss cushion scraped from a bark of *Syzygium cuminii* near swampy area within the same forest.

7.	Kala Gad	(i)	— Moss cushion from Kala Gad along the rock exposure by the side of road within Sal forest.
8.	Kala Gad	(ii)	— Moss cushion from within Sal forest, a few hundred yards away from above along the slope, across the river.
9.	Kala Gad	(iii)	— Moss cushion further away from the above within the same forest.
10.	Kala Gad	(iv)	— Moss cushion further away towards the river outside the forest.
11.	Kala Gad	(v)	— Moss cushion scraped from an exposed stone lying within the river.
12.	*Acacia catechu* formation		— Moss cushion scraped from the exposed rock on the road side.
13.	*Acacia catechu* formation		— Moss, *Riccia* away from the previous one.
14.	Sahastradhara	(i)	— Moss cushion scraped from a rock near the temple.
15.	Sahastradhara	(ii)	— Moss cushion away from the temple.
16.	Sahastradhara	(iii)	— Moss cushion further away from the temple; very near to one of the streams.
17.	Sahastradhara	(iv)	— Moss cushion further away from the above.
18.	On way from Mussoorie to Falls	(i)	— Moss cushion within oak forest.
19.	On way from Mussoorie to Falls	(ii)	— Moss cushions scraped from oak tree about 5 km away from the above within oak forest.
20.	Kampti Falls	(i)	— Moss cushion from right side of Kampti Falls (a few yards away).
21.	Kampti Falls	(ii)	— Moss cushion just near the Falls.
22.	Kampti Falls	(iii)	— Moss cushion approximately at the same distance as sample no. 20 but on left side of Falls.
23.	Kampti Falls	(iv)	— Moss cushion further away from the Falls on left side.
24.	Kampti Falls	(v)	— Moss cushion further away from the above within a small cave.
25.	Kampti Falls	(vi)	— Moss cushion further away from the Falls on left side.
26.	Kalsi	(i)	— Moss cushion from one of the Ashva Medh Yagya site from this archaeological site.
27.	Kalsi	(ii)	— Moss cushion away from the above from the same site.
28.	On way from Kalsi to Chakrata	(i)	— Moss cushion from near the Nala flowing at the roadside near Kalsi.
29.	On way from Kalsi to Chakrata	(ii)	— Moss cushion scraped from the exposed rock near Nikesi and Check-Chowki, Kalsi.
30	On way from Kalsi to Chakrata	(iii)	— Moss cushion about 4 km from Kalsi Rest House.
31.	On way from Kalsi to Chakrata	(iv)	— Moss cushion scraped from the edge of the rock near Sahiya.

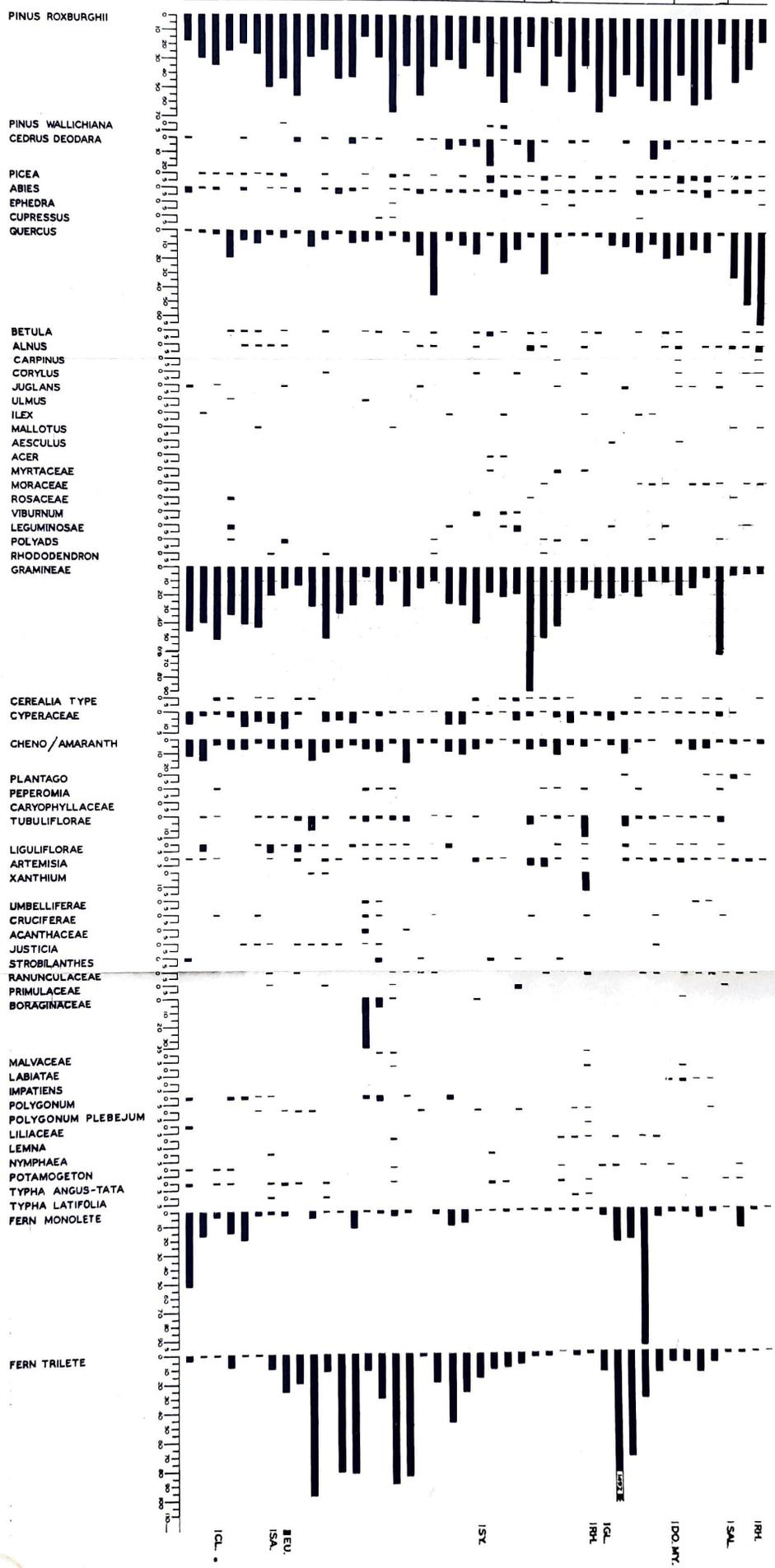|		
32.	On way from Kalsi to Chakrata (v)	— Moss cushion scraped from the exposed rock on road side within oak forest (*Quercus incana*) about 6 km from Sahiya.
33.	On way from Kalsi to Chakrata (vi)	— Moss cushion scraped from the bark of *Quercus incana* tree within the same forest.
34.	On way from Kalsi to Chakrata (vii)	— Moss cushion about a furlong away from the above within the same forests.
35.	Chakrata (i)	— Moss cushion scraped from the exposed rock just at the entrance of the oak-deodar forest.
36.	Chakrata (ii)	— Moss cushion higher up with in the same forest.
37.	On way from Chakrata to Devban (i)	— Moss cushion scraped from the exposed rock near road side in the deforested area Devban is about 5 km from this side.
38.	On way from Chakrata to Devban (ii)	— Moss cushion a few hundred yards away from the above in the opposite direction.
39.	On way from Chakrata to Devban (iii)	— Moss cushion scraped from exposed rock at a higher altitude than above, about 2 km from Devban.
40.	On way from Chakrata to Devban (iv)	— Moss cushion near Devban from the edge of the rock along the road side.
41.	Devban (i)	— Moss cushion scraped from the bark of *Quercus semecarpifolia* tree infront of Rest House within Devban forest.
42.	Devban (ii)	— Moss cushion a few yards away from the above within the same forest.
43.	Devban (iii)	— Moss cushion opposite the Rest House.

Pollen/vegetation relationship

Gola Tappar—Six surface samples (moss cushions and soil samples) were collected from Golatappar. It is a preservation plot and is mainly comprised of mixed Sal deciduous forest in which Sal is the most dominant tree (70-80%). Other plants of common occurrence are *Diospyros embryopteris, Pterospermum acerifolium, Terminalia tomentosa, Syzygium cuminii, Ougenia, Flemingia, Ardisia solanacea, Callicarpa macrocarpa, Biscofia javanica, Calamus tenuis, Clerodendron viscosum, Nasturtium,* members of Asteraceae, Rosaceae, Chenopodiaceae, Amaranthaceae, Acanthaceae, Polygonaceae, grasses, sedges, Fern, etc. *Saccharum* plantation is very common. Scattered trees of *Acacia catechu* and *Dalbergia sissoo* too are seen in the area.

The pollen spectra reveal overall dominance of non-arboreals over the arboreals. The tree vegetation is represented by moderately high values of *Pinus roxburghii. Quercus* shows a fluctuating trend, i.e. low in the lower three samples and higher in upper samples. Other arboreal taxa present in low values are *Cedrus deodara, Picea, Abies, Betula, Ulmus, Juglans, Alnus,* Rosaceae, Polyads, Leguminosae (other), *Mallotus,* etc. Amongst the non-arboreals Poaceae is by far, the most dominantly represented in the spectra, Cheno/Ams and Cyperaceae are other elements comparatively well represented. Rest of the non-arboreals noticed in low values are Cerealia type, *Peperomia,* Asteraceae, Brassiaceae, Acanthaceae, *Polygonum,* etc. Ferns (monolete only) are recorded in good numbers. Aquatic vegetation is represented by low values of *Polygonum plebejum,* Liliaceae, *Potamogeton* and *Typha angustata.*

RECENT POLLEN SPECTRA FROM GARHWAL HIMALAYA.

(PERCENTAGES CALCULATED IN TERMS OF TOTAL TERRISTRIAL POLLEN.)

Column headers (top):

- GOLA TAPPAR — MOSS CUSHIONS & SOIL SAMPLES
- KALA GAD — MOSS CUSHIONS
- ACACIA CATECHU FORMATIONS — MOSS CUSHIONS
- SAHASTRADHARA — MOSS CUSHIONS
- ON WAY FROM MUSSOORIE TO FALLS — MOSS CUSHIONS 14-15
- KEMPTI FALLS — MOSS CUSHIONS
- CHAKRATA (AN ARCHAEOLOGICAL SITE) KALSI — MOSS CUSHIONS
- ON WAY FROM KALSI TO CHAKRATA — MOSS CUSHIONS
- CHAKRATA
- ON WAY FROM CHAKRATA TO DEVBAN — MOSS CUSHIONS
- DEVBAN — MOSS CUSHIONS

INDEX:

- SALMALIA .... (SAL.)
- SALIX .... (SA.)
- SYMPLOCOS .... (SY.)
- RHAMNACEAE .... (RH.)
- GLOCHIDION .... (GL.)
- MYRSINE .... (MY.)
- EUPHORBIACEAE .... (EU.)
- CLERODENDRON .... (CL.)
- DODONAEA .... (DO.)

Pollen taxa (rows):

PINUS ROXBURGHII
PINUS WALLICHIANA
CEDRUS DEODARA
PICEA
ABIES
EPHEDRA
CUPRESSUS
QUERCUS
BETULA
ALNUS
CARPINUS
CORYLUS
JUGLANS
ULMUS
ILEX
MALLOTUS
AESCULUS
ACER
MYRTACEAE
MORACEAE
ROSACEAE
VIBURNUM
LEGUMINOSAE
POLYADS
RHODODENDRON
GRAMINEAE
CEREALIA TYPE
CYPERACEAE
CHENO / AMARANTH
PLANTAGO
PEPEROMIA
CARYOPHYLLACEAE
TUBULIFLORAE
LIGULIFLORAE
ARTEMISIA
XANTHIUM
UMBELLIFERAE
CRUCIFERAE
ACANTHACEAE
JUSTICIA
STROBILANTHES
RANUNCULACEAE
PRIMULACEAE
BORAGINACEAE
MALVACEAE
LABIATAE
IMPATIENS
POLYGONUM
POLYGONUM PLEBEJUM
LILIACEAE
LEMNA
NYMPHAEA
POTAMOGETON
TYPHA ANGUS-TATA
TYPHA LATIFOLIA
FERN MONOLETE
FERN TRILETE

Bottom index abbreviations: ICL., EU./SAL., ISY., IGL./IRH., IDO./MY., ISAL., IRH.

These pollen spectra present a totally distorted picture of the surrounding vegetation. By the face value of these spectra it appears that perhaps the area was an open land without forest. Since the *Shorea robusta* is a entomophilous tree, even a single pollen was not recovered from the sample despite its 70-80% presence in the forest. There is a great impact of long transported pollen in the spectra. Dominance of Poaceae in the spectra could perhaps be due to *Saccharum* plantation in the area. Thus these pollen spectra completely fail to depict the forest vegetation.

Kala Gad—Five moss cushions were collected from near the bridge Kala Gad, 7 km from Dehradun town on way to Mussoorie within *Shorea robusta* forest at an altitude of about 2400 feet. Other common plants recorded from the area are *Woodfordia floribunda*, *Hamiltonia suaveolens*, *Cassia*, *Ficus*, *Phyllanthus*, *Alysicarpus rugosus*, *Euphorbia royleana*, members of Acanthaceae, Ranunculaceae, Asteraceae (Compositae), Chenopodiaceae, Amaranthaceae, Poaceae, Cyperaceae, etc. Luxuriant growth of ferns was noticed within the forest.

Pollen spectra depict high values of *Pinus roxburghii* (55%) in lower three samples and decline in the upper two samples in contrast to the values of oaks which show an increase in the upper samples. Other arboreal taxa such as *Pinus wallichiana*, *Cedrus deodara*, *Picea*, *Abies*, *Betula*, *Alnus*, etc. are sporadic and transported from long distances.

Herbage is dominated by Poaceae but their values are much higher in upper two samples than the lower three. Other non-arboreal constituents represented in variable frequencies are *Cerealia* (2%), Cyperaceae (up to 8%), Cheno/Ams (up to 10%), Tubuliflorae (up to 10%), Liguliflorae (up to 5%), *Artemisia* (up to 3%), *Xanthium* (1%), *Justicia* (1%), Ranunculaceae (1%), and *Polygonum* (1%), aquatic vegetation is represented by low values of *Nymphea*, *Typha latifolia*, *T. angustata*, *Polygonum plebejum*. Ferns (monolete as well as trilete) are abundantly present.

The pollen spectra fail to depict the occurrence of *Shorea robusta* forest perhaps due to insect pollinated nature of the tree. Other arboreal taxa too are not recorded from the moss cushions. Local vegetation is a partially recorded. *Pinus roxbrughii* and other gymnospermous taxa appear to have been derived through long distance transport. The values of the Poaceae and other non-arboreal elements are comparatively more in the above two spectra (4 & 5) which have been collected from outside the forest.

Acacia catechu Zone—Two moss cushions were collected from subtropical broad-leaved forest at about 2500 feet, where *Acacia catechu* and *Bauhinia retusa* are dominant. Other common trees growing in the area are *Debregeasia*, *Hamiltonia suaveolens* with shrubby growth of *Strobilanthes*, *Woodfordia fruticosa*, etc. Ground cover includes members of Acanthaceae, Ranunculaceae, Chenopodiaceae, Amaranthaceae, Asteraceae, Poaceae and Cyperaceae, etc. Ferns were growing in abundance within the forest. Scattered trees of *Pinus roxburghii* are noticed in the surrounding hills at slightly higher altitudes.

Pollen spectra reveal the highest values of *Pinus roxburghii*. Other arboreal taxa such as *Quercus*, *Pinus wallichiana*, *Abies* are presented in low values. The non-arboreal vegetation is dominated by Poaceae, followed by Cyperaceae and Cheno/Ams. Tubuliflorae, Liguliflorae and Acanthaceae are reported in sporadic numbers. Fern spores both monolete as well as trilete are recovered in maximum values (80%).

Moss cushions fail to depict *Acacia catechu* zone as most of the tree genera remain unrepresented. However, local ground vegetation including ferns are more or less faithfully represented. The pollen of *Pinus roxburghii* which is by far the most dominant amongst the tree pollen has obviously been derived from surrounding hills. Similarly

the pollen of *Cedrus, Abies* and *Quercus* are transported from near hills from higher altitudes.

Sahastradhara—It is about 15 km from Dehradun on way from Dehradun to Mussoorie and is a tourist spot. The vegetation in the area is dominated by *Sapium insigne, Cassia tora, Nyctanthes arbortristis, Sida cordata. Bauhinia retusa, Carissa, Ageratum conyzoides, Acacia catechu, Murraya koenigii, Colebrookia oppositifolia, Woodfordia fruticosa, Triumfetta rhombodiea, Cocculus laurifolius, Toona ciliata. Phoenix, Ficus, Berberis, Xanthium strumarium*, members of Polygonaceae. Acanthaceae, Boraginaceae, Poaceae. Cyperaceae, Chenopodiaceae, Amaranthaceae, etc.

The pollen spectra reveal high pollen frequency for *Pinus roxburghii* ranging from 15-70%, wheras *Quercus* is lowly represented (up to 7%), stray occurrence of *Pinus wallichiana, Picea, Abies, Cupressus, Ephedra, Betula, Ulmus, Mallotus* is also recorded. Herbaceous vegetation is represented by Poaceae (up to 30%), Boraginaceae (up to 30%) and Cheno/Ams (up to 20%). Other non-arboreal constituents with values ranging from.5-5% are Cyperaceae, *Peperomia*, Asteraceae, Apiaceae, Brassiaceae, Acanthaceae, Ranunculaceae, Malvaceae, Lamiaceae, *Polygonum*, etc. Aquatic vegetation as represented by low values of *Lemna, Nymphaea, Potamogeton* and *Typha angustata*. Fern spores (triletes) are abundant.

The moss cushions fail to reflect the surrounding vegetation of the area. Sahastradhra is a Pine and Oak free zone. There is a great influence of pollen coming from long distance transport. However, the local ground vegetation is more or less faithfully represented.

On way from Mussoorie to Kampti Falls—Two moss cushions were picked up on way from Mussoorie to Kempti Falls at a distance of 5 km each. First sample is from Oak forest mixed with *Pyrus pashia* and undergrowth of *Rubus, Coriaria nepaliensis, Berberis, Boenninghousenia* (very common), *Indigofera, Zanthoxylum alatum*, members of Ranunculaceae, Rhamnaceae, Poaceae, Cyperaceae, Chenopodiaceae, Amaranthaceae, Asteraceae, Acanthaceae, etc. The ferns are poor here.

Second Moss cushion on the other hand is picked up from Oak zone on northern aspect on limestone formation. The undergrowth is of *Hypericum, Rosa, Artemisia, Eriophorum, Wendlandia, Anaphalis, Coriaria nepalensis, Pyrus pashia*, etc. Ground cover is more or less the same as mentioned above. Ferns, however, are abundantly present.

Pollen spectra show the dominance of *Pinus roxburghii* and co-dominance of *Quercus*. Values of *Quercus* is much more in the second sample in comparison to previous one. Other arboreal genera such as *Pinus wallichiana, Picea, Abies, Betula, Alnus, Juglans*, Fabaceae. Leguminosae are present sporadically. Non-arboreal vegetation on the whole is poorly represented. Poaceae attains 15% and 10% respectively. Other non-arboreal taxa such as Cyperaceae, Cheno/Ams, Asteraceae, Acanthaceae, Ranunculaceae, *Polygonum* are present sporadically. Ferns spores (Trilete) are recovered in good number but in one sample only.

The pollen spectra faithfully reflect the closed nature of the forest with the overall dominance of arboreal vegetation over the non-arboreal. The high values of oaks are indicative of dominance of oaks in the forest but the *Pinus roxburghii* remains to be over represented. The values of other tree elements are either distorted or remain unrepresented. Fern spores have also depicted about their occurrence in the area.

Kampti Falls—Six moss cushions were collected from the Kampti Falls situated at an altitude of about 4000 feet. It is about 20 km from Mussoorie. The common plants around are *Gerardiana heterophylla, Debregeasia, Rhus, Machilus, Litsea, Cedrela toona, Salix,*

Hamiltonia suaveolens, Rubus, Colebrookia oppositifolia, Berberis, Strobilanthes, Artemisia, Xanthium strumarium. Thymus. Other members are of Lamiaceae, Asteraceae, Rosaceae, Polygonaceae, Poaceae, Cyperaceae, Chenopodiaceae, Amaranthaceae, etc. Plantations of *Pinus roxburghii* occur within a distance of about a kilometer from the site of collection in the surrounding hills. *Cedrus* too is planted at a higher elevations. Coniferous vegetation on the whole is almost negligible. *Quercus incana* trees are noticed in patches at a higher altitudes and most of them were found in lopped condition.

The pollen spectra reveal the dominance of *Pinus roxburghii* followed by *Quercus* and *Cedrus-Abies* is recovered in low but consistent values. Other arboreal taxa such as *Pinus wallichiana, Betula, Alnus, Corylus, Ilex, Acer,* Myrtaceae, Leguminosae, *Viburnum,* etc. are reported in sporadic values. Non-arboreal vegetation is represented by high values of Poaceae, low values of Cerealia type, Cheno/Ams, Cyperaceae, Asteraceae, Acanthaceae, Boraginaceae, Polygonaceae. Aquatic vegetation is represented by stray occurrence of *Nymphaea, Typha angustata* and *Polygonum plebejeum.* Fern spores both monolete as well as trilete are recorded in variable frequencies.

These moss cushions, though did not depict the plants growing around have, however faithfully bring out the nearby occurrence of *Pinus roxburghii, Cedrus* and *Quercus.* Local ground vegetation is more or less faithfully represented.

Kalsi—This is an archaeological site, about 35 km from Dehradun on way to Chakrata. Most of the area is barren and under paddy and sugarcane cultivation. Ground vegetation is mainly comprised of grasses, members of Asteraceae, Leguminosae, Lamiaceae, Euphorbiaceae, etc. This site was excavated during 1952-1954. Out of the four Ashwamedh Yagyas performed by Sheel Burman in 3 century A. D., remains of three have been recovered from this site.

The pollen analysis of two moss cushions collected from this site reveal tremendously high values of Poaceae. *Pinus roxburghii* and *Quercus* are recovered in fairly high values in one of the samples. Other arboreal constituents represented are *Cedrus* (up to 15%), *Picea* and *Abies* (3% each), *Ephedra* (5%), *Betula* (2%), *Alnus* (3%), Moraceae (.5%), *Rhododendron* (.5%) and Polyad (.5%), Herbage, apart from Poaceae is recorded by Cheno/Ams (7%), Asteraceae (5%), *Cerealia* (5%), Cyperaceae (3%), *Peperomia* (5%), Caryophyllaceae (.5%), Brassicaceae (1%), Ranunculaceae (1%), aquatic vegetation remains unrepresented. Ferns too are poorly recorded.

The spectra faithfully bring out the deforested nature of the area depicting overall dominance of grasses. Pine is over represented and *Cedrus* and *Picea* behave abnormally. This together with some other taxa in all probability have been transported from a long distance as these taxa do not grow anywhere in the surroundings.

On way from Kalsi-Chakrata—Three moss cushions were collected from on way from Kalsi to Sahiya at a distance of about 2 km each. First sample was picked up from the Nalla flowing at the road side just at the entrance of the forest. The site is surrounded by *Eucalyptus* plantations and free of *Pinus.* Second sample was collected near the Nikasi and Check Chawki, Kalsi, surrounded by *Mangifera* and *Salmalia* trees. The third one was picked up about 4 km from Kalsi Rest House on way to Chakrata. The vegetation here is almost the same except for absence of *Eucalyptus. Tectona grandis* plantation is common. This area is again a *Pinus roxburghii* free zone. Ground vegetation is dominated by grasses, sedges, members of Acanthaceae, Asteraceae, Polygonaceae, Brassicaceae, etc. Mountains here are not as rich in vegetation as the ones at Mussoorie.

The pollen spectra reveal the dominance of *Pinus roxburghii* amongst the arboreals. *Quercus* is very poorly represented. Scattered occurrence of *Cedrus, Picea, Abies, Ephedra,*

Pollen spectra show the dominance of *Pinus roxburghii* and co-dominance of *Quercus* and *Cedrus*. Other arboreal taxa such as *Picea, Abies, Betula, Alnus*, Leguminosae, Polyad are recorded in very low values. Non-arboreal vegetation is very poorly represented by Poaceae (10%), Cerealia (.5%), Cyperaceae (0.5%), Cheno/Ams (0.5%), Asteraceae (0.5-2%), *Impatiens* (1%), Ranunculaceae (1%), *Justicia* (0.5%), Brassicaceae (0.5%), and *Impatiens*. Aquatics are very poorly recorded by *Lemna* (1%) and *Potamogeton* (0.5%).

While pollen spectra do reflect the closed nature of the forest but *Pinus roxburghii* again is over represented whereas oak-deodar are comparatively poorly represented. The pine pollen has evidently been derived from the lower slopes by upthermic winds as its frequencies do not match with rather sparse occurrence of this in oak-deodar forest.

On way from Chakrata to Devban—Four moss cushions were collected from on way from Chakrata to Devban at an interval of 2-3 km each. First two samples were picked up from deforested areas about 6 km from Devban, whereas third just at the beginning of the forest about 2 km from Devban and the last near the Devban. In the deforested area vegetation was mainly comprised of Asteraceae, Labiatae, Ranunculaceae, etc. *Cotoneaster microphylla* was very dominant and was forming a beautiful carpet. The forested region was mainly dominated by *Picea, Abies* and *Quercus semecarpifolia*. Pines are rare.

Pollen spectra (forested as well as unforested region) are dominated by high values of *Pinus roxburghii* followed by *Quercus, Picea* and *Abies. Pinus wallichiana, Betula, Alnus, Carpinus, Corylus, Juglans, Aesculus*, Moraceae, Polyad etc. are recorded in very low frequencies. Herbage is poorly represented. Value of Poaceae is between 10-20% except for one sample in which exceptionally high values (63%) have been recorded and of Cheno/Ams up to 7%. Other non-arboreal constituents such as *Cerealia* type, Cyperaceae, *Plantago, Peperomia*, members of Asteraceae, Apiaceae, Brassicaceae, Ranunculaceae, Primulaceae, Boraginaceae, Lamiaceae and *Impatiens* are sporadically represented. Aquatic vegetation is almost negligible except for stray occurrence of *Typha angustata*. Fern spores are moderately encountered.

Pollen spectra faithfully bring out the forested nature of the area, but give entirely distorted picture of the unforested region as there was no difference in the constituents recovered in the samples from deforested as well as forested regions. *Pinus roxburghii* continues to be over represented both in forested as well as unforested regions. Similarly other trees too falls to differentiate between forested and unforested areas and thus depicting a false picture of the surrounding vegetation.

Devban—Three moss cushions were collected from Devban—two from two sides of the Rest House and the third a few yards away from the Rest House within the forest. It is situated at an altitude of 9,230 feet. The forest is mainly comprised of *Picea, Quercus semecarpifolia* and *Abies*. Other common plants in the area are *Taxus, Acer, Salix, Ilex, Rhamnus purpureus, Piptanthus nepalensis, Symplocus, Lonicera, Viburnum, Berberis, Strobilanthes, Asparagus*, etc. Ground cover is poor and is represented by members of Ranunculaceae, Acanthaceae, Asteraceae, grasses, sedges, Chenopodiaceae, Amaranthaceae etc. *Pinus wallichiana* is rare whereas *Pinus roxburghii* is common in the lower slopes.

The pollen spectra for the first time reveal the dominance of *Quercus* and co-dominance of *Pinus roxburghii. Picea* and *Abies* are comparatively poorly recovered. Other arboreal constituents recorded in low frequencies are *Alnus* (up to 5%), *Betula* (0.5%), *Mallotus* (0.5%), *Corylus* (0.5%), *Juglans* (0.5%), *Carpinus* (0.5%), Moraceae (1%), Rosaceae (0.5%), Leguminosae (0.5%) etc. Non-arboreal vegetation is on the whole very

poorly represented. Poaceae attains the values up to 6%, Cheno/Ams up to 4% and *Peperomia* 4%. Rest of non-arboreals are poorly represented and their values varies 0.5-2% (Cerealia type, Cyperaceae, Asteraceae, Brassicaceae, Ranunculaceae). Aquatic vegetation is represented by the pollen each of *Typha angustata* and *T. latifolia*. Ferns too are poorly recorded in these spectra.

Moss cushions faithfully depict the forested nature of the area and frequencies of oaks are truly represented. *Abies* and *Picea* are, however, under represented. The closed nature of forest is testified by overall low values of non-arboreals.

Discussion and conclusion

The study of a set of 43 surface samples (moss cushions as well as soil samples) collected from various communities and at various elevations ranging from about 700-7200 m depict that :

(1) *Shorea robusta*—a very important constituent of Sal forest at Golatappar and Kala Gad remains unrepresented in the pollen spectra. No precise data is so far available about its nature of pollen production and nature of pollination, hence the reason of its total absence in the spectra remains unexplained. Thus the pollen spectra from Golatappar and Kala Gad depict totally distorted picture of the surrounding vegetation.

(2) Pollen spectra constructed from *Acacia catechu* zone again do not correspond with the surrounding vegetation except for ground cover which is more or less faithfully represented. Chir-pine alongwith deodar, fir, oak, etc. are transported from surrounding hills.

(3) The moss cushions studied from Sahastradhara do not match with the surrounding vegetation. It is a oak and pine free zone, but pine is the most dominant component encountered in the pollen spectra-obviously transported from long distances. Nevertheless ground vegetation is more or less depicting the surrounding vegetation.

(4) Pollen spectra constructed on way from Mussoorie to Kampti Falls depict overall dominance of arboreals over non-arboreals, thus truly representing the closed nature of the forest. Chir-pine, however, remains to be over represented.

(5) The vegetation of Kampti Falls is not represented in the pollen spectra, but however, reveals the nearby occurrence of oak and pine. Herbage is more or less fathfully represented.

(6) The pollen spectra from Kalsi, a deforested area, reflect open conditions by an overall dominance of non-arboreals over arboreals. Some of the taxa such as deodar, oak, etc. have, however, been transported from long distances.

(7) The moss cushions analysed from on way from Kalsi to Chakrata depict to some extent the surrounding vegetation. Insect pollinated species such as *Mangifera*, *Eucalyptus*, *Salmalia*, etc. are either totally absent or under represented. *Pinus* as usual are over-represented. Pollen spectra constructed from Sahiya to Chakrata, however, faithfully bring out composition of conifer mixed-oak forest.

(8) Pollen spectra constructed from Chakrata reflect the closed nature of the forest but Chir-pine remains to be over represented, whereas oak-deodar are comparatively poorly recovered. Chir-pine pollen has evidently been derived from the lower slopes by upthermic winds as its frequencies do not match with its sparse occurrence in oak-deodar forest.

(9) Pollen spectra of the moss cushions, collected on way from Chakrata to Devban, truly depict closed forest as arboreal taxa are overall much higher than non-arboreals. However, the samples analysed from deforested give entirely distorted picture of

deforested region. There is hardly any marked difference in the pollen spectra constructed from deforested as well as forested regions owing to the nearness of forests. Chir-pine continues to be over-represented.

(10) The dominance of oak was observed for the first time in the pollen spectra constructed from Devban. Pollen spectra more or less faithfully represent the closed forest. *Picea* and *Abies* are, however, under represented. Herbage is very poorly noticed as the area is thickly populated with dense forest.

Thus in Garhwal Himalaya for the anomalous representation of Chir-pine and total absence of Sal forest and *Acacia catechu* formation in general the pollen spectra do correspond with the surrounding vegetation. One of the deforested areas was also truly reflected in the spectra. However, there are a few spectra which deviate from the actual floristic composition perhaps owing to insect pollinated nature of most of the taxa growing in the respective areas high pollen production to long distances, transport by many taxa as a result of that they are either unrepresented or under represented or even over represented. Hence it is suggested that great caution should be used in correlation and interpretation of fossil pollen diagrams on the basis of modern pollen rain studies.

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