POLLEN ANALYSIS AND PALAEOBOTANY OF IMPRESSION BEARING SEDIMENTS IN THE LOWER KAREWAS*

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ABSTRACT

The paper describes a comparative account of pollen content and the megafossils in the Lower Karewa deposits at Ningle Nullah, Laredura, Dangarpur and Liddarmarg.

At Ningle Nullah pollen analysis reveals dense Oak woods although not a single leaf impression of *Quercus* has been found in the megafossils. At Liddarmarg, Dangarpur and Laredura the dominance of *Quercus* among the leaf impression is not equally reflected in the pollen spectra. Conifers absent in the megafossils are represented by low frequencies. Members of Lauraceae, Rosaceae, Papilionaceae, Cornaceae, well represented among megafossils, are absent or poorly represented in pollen record. *Trapa* abundant in megafossils is either absent or extremely rare in pollen spectra.

The paper emphasises the importance of both micro- and megafossil data in the reconstruction of past vegetation.

INTRODUCTION

THE comparative study of fossil pollen spectra with qualitative and quantitative assessement of the megafossils has been carried out at Ningle Nullah, Laredura, Dangarpur, Liddarmarg and Nichahom in the Lower Karewas (First Interglacial) of Kashmir Valley. The megafossils from these have earlier been reported by Middlemiss (1910), De Terra and Paterson (1939), Puri (1948) and reconsidered by Vishnu-Mittre (1965). We have examined the collections available at the Sahni Institute and at the Geological Survey of India and constructed the frequency charts. The fossiliferous beds comprise dark or yellow, coarse to fine clays from about 0·3 m. to 0·91 m. in thickness. In relation to the overall thickness of the Lower Karewas, the plant bearing clays constitute a fraction overlain or underlain by other lacustrine deposits devoid of leaf impressions. De Terra and Paterson assign them to Lithozone 4 but at Nichahom we have found them in Lithozone 3 also. The discrepancies found between the micro- and megafossil records are highlighted.

Pollen analysis of random samples has been carried out by the usual method (KOH, HF and acetolysis) and the pollen spectra have been constructed from the percentage of individual taxa calculated in terms of total land plants pollen.

1. NINGLE NULLAH

The site Ningle Nullah, (De Terra and Paterson 1939; Puri 1948), is at a height of 2937·5 m and the plant bearing beds are exposed here in vertical cliffs along the small streams. Table 1 gives a record of the plant remains recovered from three different exposures at this site. There are slightly over 103 leaf impressions reported from here. Impressions of leaves belonging to Salicaceae and Rosaceae dominate over the others. The Gymnosperms are absent in the megafossils. The vegetation appears to have consisted of deciduous forest comprising poplars, willows, birches and elms, with the shrubby vegetation comprising *Desmodium gangeticum* and *Cornus macrophylla* (Vishnu-Mittre 1965, 317). The absence of oak leaves at Ningle Nullah led Puri (1945, 1957) to suggest that the climate at Ningle Nullah at the time of deposition of the sediments was temperate.

Pollen analysis of 6 random samples bearing leaf impressions (Text-fig. 1) shows quite contrary to the evidence from megafossils. The dominance of Oak pollen indicates dense Oak community. Not a single megafossil of Oaks has been recovered. The dominance of Salicaceae (*Salix* and *Populus*) in the megafossils is not reflected in the pollen spectra, perhaps due to insect pollination of these species. *Acer* about 12% in the megafossils is absent from the pollen spectra. This may, again, be attributed to insect pollination. The low pollen frequency of *Betula*, *Alnus*, *Fraxinus* and *Aesculus* compares well with their low frequency in the megafossils. There is no record of Rosaceae in the pollen spectra although the family is co-dominantly present in the megafossils. Pollen of Papilionaceae and Cornaceae of which megafossils are

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1 and 3 respectively is absent in pollen spectra. Likewise, *Rhamnus* present in the megafossils and with a characteristic pollen is unrepresented in the pollen spectra. *Typha* is represented by its pollen but pollen of *Nelumbo* has not been encountered.

The low pollen frequencies of conifers and of *Ephedra* are suggestive of long distance transport and this is in accord with their absence among megafossils. The pollen record brings out evidence of the following which are absent in the megafossils, these are, Conifers, *Juglans* (up to 10%), *Engelhardtia* (up to 2%) *Corylus* (up to 10%), *Carpinus* (up to 3%), *Quercus* (up to 45%) and small frequencies each of Cyperaceae, Gramineae, *Chenopod-Amaranth* type, Caryophyllaceae, Umbelliferae, Ranunculaceae, Polypodiaceae, *Lemna*, *Potamogeton* and *Botryococcus*.

TABLE 1 — FOSSIL FLORA FROM NINGLE NULLAH

SPECIES	NATURE OF SPECIMENS	NUMBER OF SPECIMENS
HIPPOCASTANCEAE		
Aesculus indica Colebr.	lvs	3
ULMACEAE		
Ulmus laevigata Royle	lvs	4
SALICACEAE		
Salix wallichiana Anders.	—	10
Salix elegans Wallich.	1	1
Salix sp.	lvs	6
Populus ciliata wall.	lvs	10
Populus balsamifera Linn.	lvs	10
Populus sp.	lvs	3
BETULACEAE		
Betula utilis D. Don	1	5
Alnus nepalensis D. Don	lvs	3
A. sp.	lvs	4
ACERACEAE		
Acer pentapomicum Stewart.	lvs	2
A. villosum Wallich.	lvs	3
A. pictum Thunb.	lvs	6
A. sp.	1	1
CORNACEAE		
Cornus macrophylla Wall.	1	1
Marlea begoniaefolia Roxb.	lvs	2
COMPOSITAE		
Inula Cappa, D.C.	lvs	2
PAPILIONACEAE		
Desmondium gangeticum D.C.	1	1
NYMPHAEACEAE		
Nelumbo (Nelumbium) nucifer Gaertn.	lvs	4
OLEACEAE		
Fraxinus excelsior Linn.	1	1
TYPHACEAE		
Typha sp.	—	—
Sparganium sp.	—	—
ROSACEAE		
Prunus cornuta watt.	lvs	4
Prunus sp.	lvs	2
Pyrus malus Linn.	lvs	3
P. sp.	lvs	5
Cotoneaster nummularia Fisch & Mey	lvs	5
C. microphylla Wall.	lvs	3

Abbreviations used: l = leaf; lvs = leaves; fr = fruit.

2. LIDDARMARG

This site is situated at a height of 3281 m to 3312 m. and the sections are exposed in the stream bed. The collections have been made from three exposures by Middlemiss, De Terra and Professor Sahni from sandy shales dipping slightly 4° to 6° north-west (Puri 1948, 115).

Table 2 gives qualitative and quantitative record of leaf impressions which are as many as 209. The collection is dominated by leaves of *Quercus* (about 50%) and the next in order of abundance are of Lauraceae (15%), Aceraceae (6%), Betulaceae (7%) and Urticaceae (4%). The other natural orders are represented by 1 to 3 specimens each except *Typha* which has ten specimens. There is no record of conifers.

Most pollen spectra (Text-fig. 2), show low percentages of pollen of conifers but higher values for *Cedrus* and *Picea* occur in the top two spectra, *Ephedra* too has small frequencies. Oak is dominant, but not as dominant as in the megafossils. Lauraceae, the next dominant group in the megafossils, is absent. *Betula* is very poorly represented than *Alnus* whereas leaves of *Betula* are twice (10) those of *Alnus* and both are high pollen producers. *Acer*, the next dominant megafossil, has 22% pollen in the lowest spectrum but does not exceed 3% in the remaining spectra. Its abnormal values in the lowest spectrum could be due to incorporation of *Acer* flowers in the sediments. The family Rosaceae, represented by megafossils belonging to 3 genera, has 2-10% pollen. Pollen grains of Papilionaceae, Cornaceae, Berberidaceae, Rubiaceae, Oleaceae, Myrsinaceae, Rhamnaceae, Pittosporaceae, Rutaceae, Buxaceae, Urticaceae and Euphorbiaceae represented by a few specimens each in the megafossils are absent. A single leaf impression of *Ulmus* is reflected

TABLE 2 — FOSSIL FLORA FROM LIDDARMARG

Species	Nature of specimens	Number of specimens
FAGACEAE		
Quercus incana Roxb. ,	lvs	65
Q. glauca Thunb.	lvs	50
Q. sp	1	1
URTICA.CEAE		
Ficus cunia Buch-Ham	lvs	4
Mallotus philippensis Mull	lvs	5
ACERACEAE		
Acer oblongum Wall.	lvs	10
A. pentapomicum Steward	lvs	2
A. sp.	fr.	1
LAURACEAE		
Litsaea lanuginosa Nees.	lvs	3
Cinnamomum tamala Nees.	lvs	—
Machilus odoratissima Nees.	lvs	25
M. duthie King.	lvs	—
Phoebe lanceolata Nees.	lvs	2
BUXACEAE		
Buxus wallichiana Baillon	lvs	2
B. papillosa Schm.	lvs	2
ULMACEAE		
Ulmus sp.	1	1
RUTACEAE		
Skimmia laureola Hook f.	—	—
Toddalia sp.	—	—
PITTOSPORACEAE		
Pittosporum eriocarpum Royle	1	1
RHAMNACEAE		
Rhamanus virgatus Roxb.	—	—
R. triquetra Wall.	—	—
Berchemia floribunda Wall.	—	—
MYRSINACEAE		
Myrsine africana Linn.	—	—
M. semiserrata Wall.	—	—
OLEACEAE		
Syringe emodi Wall.	1	1
RUBIACEAE		
Wendlandia exserta D.C.	1	1
ROSACEAE		
Pyrus communis Linn.	lvs	2
Cotoneaster bacillaris Wall.	1	1
Spiraea sp.	1	1
BETULACEAE		
Betula utilis D. Don	lvs	10
Alnus nepalensis D. Don	lvs	5
BERBERIDACEAE		
Berberis lycium Royle	lvs	2
Berberis sp.	lvs	3
CORNACEAE		
Dendrobenthamia capitata (Wall.) Hutch.	—	—
HAMAMELIDACEAE		
Parrotia jacquemontiana Dcne.	lvs	2
PAPILIONACEAE		
Desmodium podocarpum D.C.	lvs	2
D. laxiflorum D.C.	lvs	2
D. sp.	1	1

(*Continued*)

TABLE 2 — FOSSIL FLORA FROM LIDDARMARG

Species	Nature of specimens	Number of specimens
COMPOSITAE		
Inula cappa D.C.	1	1
ARACEAE		
Acorus sp.	—	—
Cyperaceae	—	—
Scirpus sp.	—	—
Cyperus sp.	—	—

by up to 10% pollen and two specimens of *Parrotia* by 2-3% pollen.

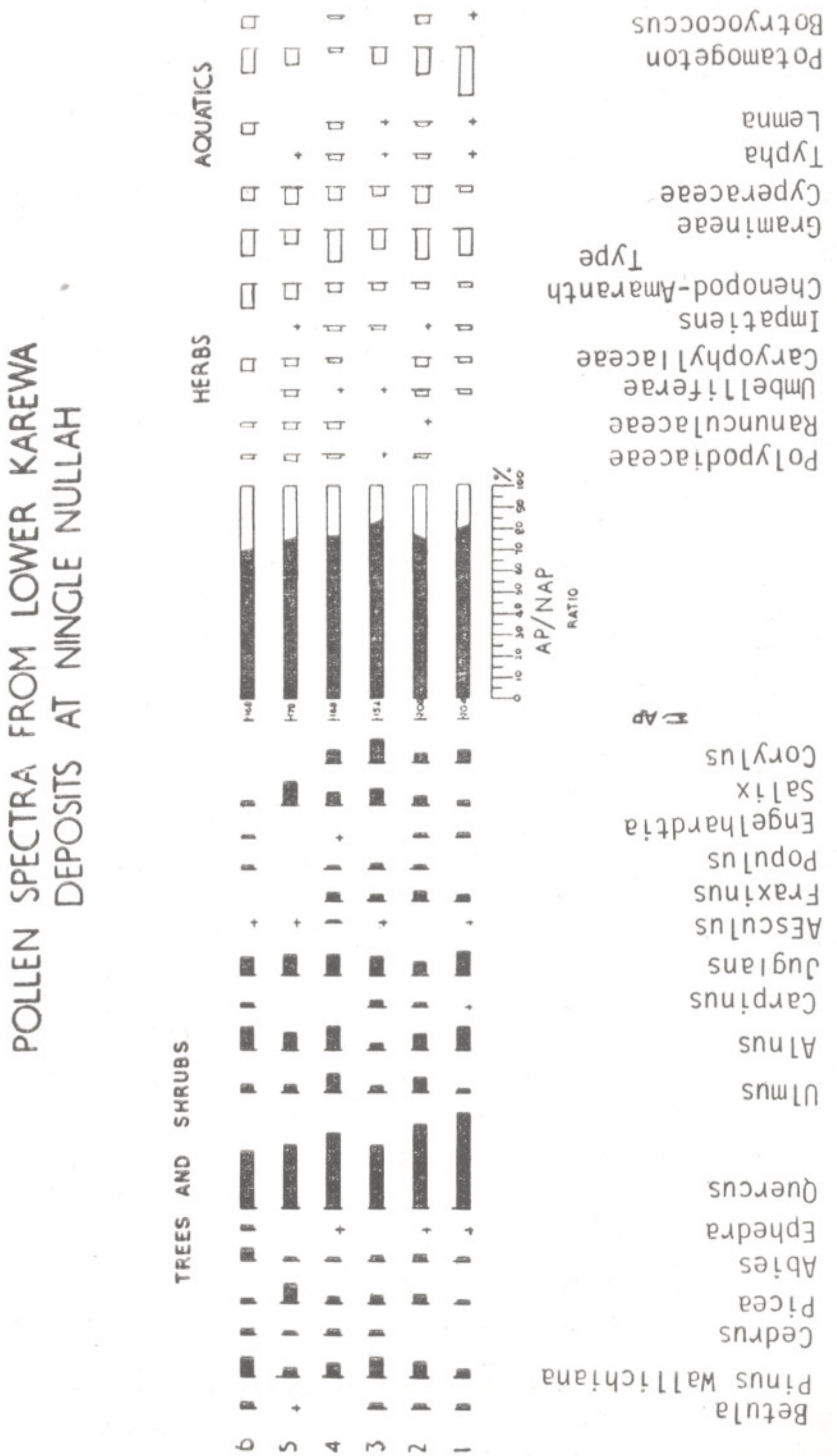
The following genera and natural orders present in the pollen spectra are unrepresented in the megafossils — Conifers, *Carpinus* (up to 3%), *Juglans* (up to 15%), *Aesculus* (up to 5%), *Rhus* (up to 2%), *Populus* (up to 2×), *Salix* (up to 10%), *Corylus* (up to 12×), *Viburnum* (up to 2%) and small frequencies of Gramineae, Chenopod-Amaranth type, *Impatiens*, Caryophyllaceae, Ranunculaceae, Polypodiaceae, *Lemna* and *Botryococcus*.

3. DANGARPUR

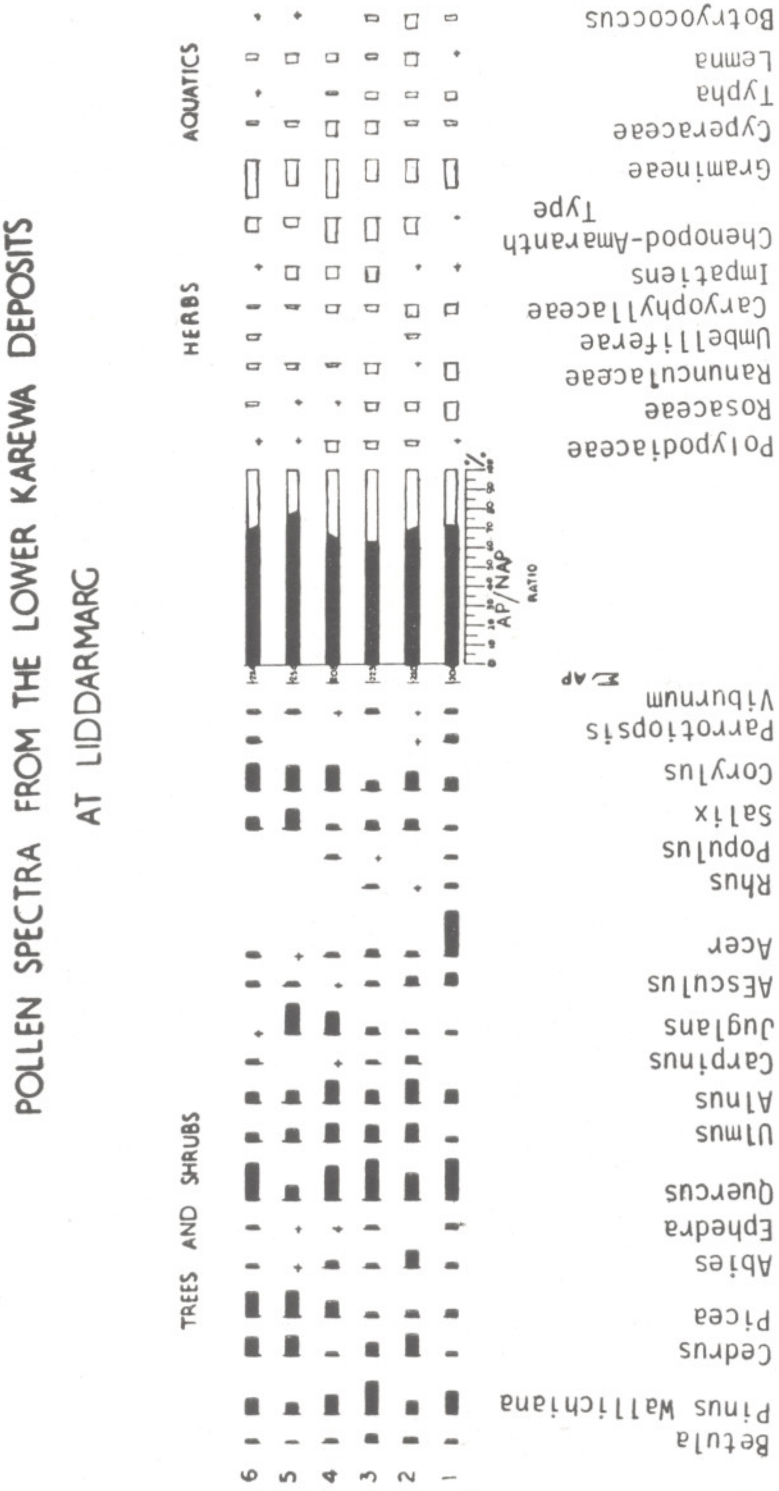
At Dangarpur, 2031·2 m above sea level, the fossiliferous sediments largely comprise dark and light grey clays and the exposures occur at several spots dipping 20° to 30° north with EW strike. Some of the beds abound in fruits of *Trapa* and the others in leaf impressions.

The megafossils of land plants are about 120 (Table 3). *Quercus* is predominant and Lauraceae, the next abundant, has 5 specimens only. *Trapa* is abundant. Conifers are absent. Deodar in the pollen spectrum (Text-fig. 3) is dominant along with Spruce, Fir and Pine. *Ephedra* has up to 2% pollen. *Quercus*, dominant in the megafossils, has 2-5% pollen and Lauraceae is absent. There is no pollen of *Trapa* contrary to its abundance in megafossils.

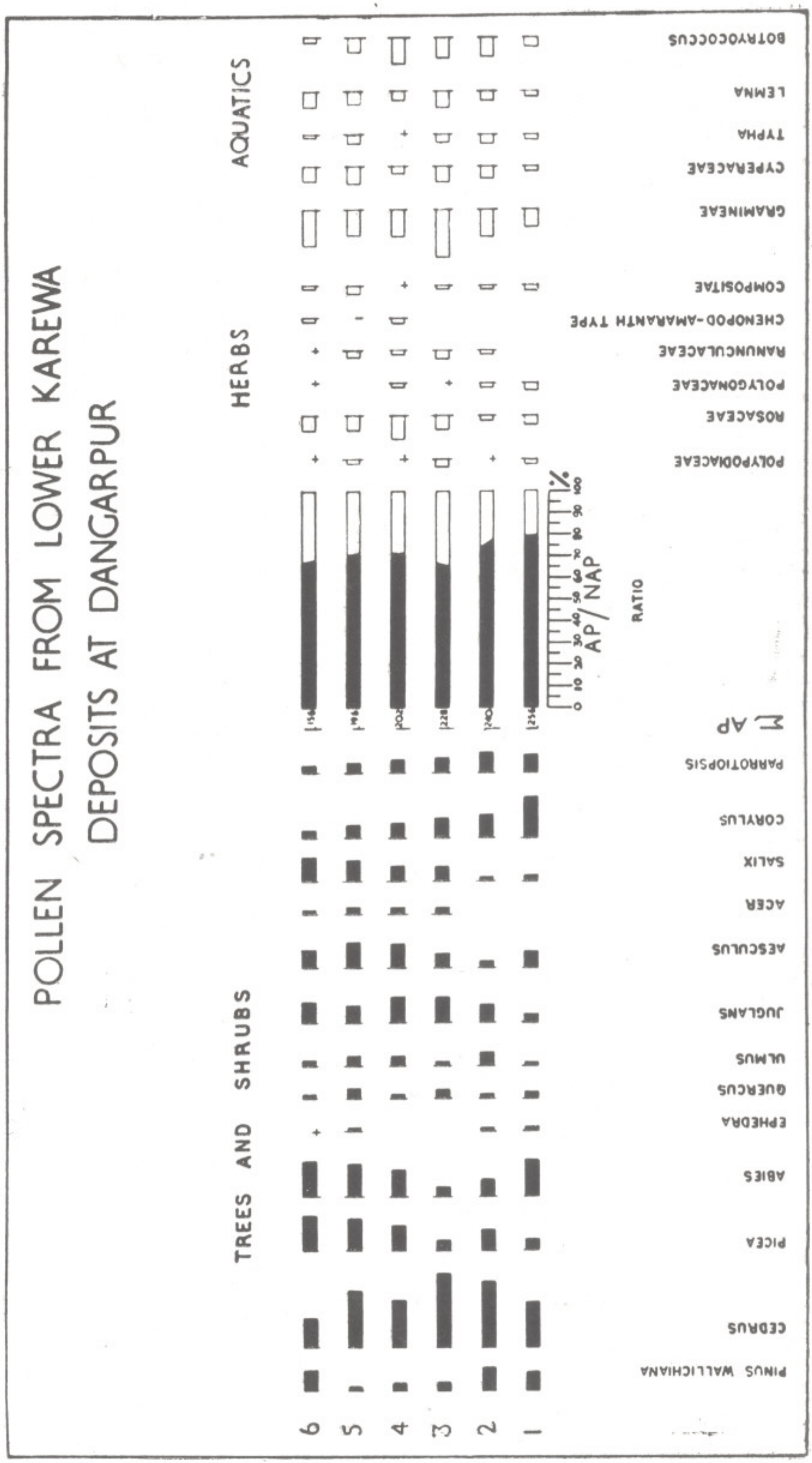
The following taxa and natural orders are absent from the megafossils — Conifers, *Ulmus* (up to 5 %), *Juglans* (up to 12%), *Aesculus* (up to 12%), *Acer* (up to 3%), *Salix* (up to 2-10%), *Corylus* (up to 3-14%), *Parrotia* (up to 3 to 8%), and small



TEXT-FIG 1 — Pollen spectra from impression bearing sediments at Ningle Nullah, Kashmir Valley.



TEXT-FIG. 2 — Pollen spectra from impression bearing sediments at Liddarmarg, Kashmir Valley.



TEXT-FIG. 3 — Pollen spectra from impression bearing sediments at Dangarpur, Kashmir Valley.

frequencies of Gramineae, Cyperaceae, Compositae, Chenopod-Amaranth type, Ranunculaceae, Polygonaceae, Rosaceae, Polypodiaceae, *Lemna* and *Botryococcus*.

TABLE 3 — FOSSIL FLORA FROM DANGARPUR

Species	Nature of specimens	Number of specimens
FAGACEAE		
Quercus semecarpifolia Smith.	lvs	33
Q. dilatata Lindl.	lvs	33
Q. ilex Linn.	lvs	33
ARALIACEAE		
Hedera nepalensis K. Koch.	fr.	1
LAURACEAE		
Litsaea elongata Wall.	lvs	4
L. sp.	l	1
HYDROCARYACEAE		
Trapa natans Linn.	fr.	abundant
T. bispinosa Roxb.	fr.	,,
TYPHACEAE		
Typha sp. or *Sparganium* sp.	lvs	10
CERATOPHYLLACEAE		
Ceratophyllum sp.	lvs	5
HALORAGACEAE		
Myriophyllum sp	lvs	—
CYPERACEAE		
Scirpus sp.	—	—
Cyperus sp.	—	—

TABLE 4 — FOSSIL FLORA FROM LAREDURA

Species	Nature of specimens	Number of specimens
URTICACEAE		
Mallotus philippinensis Muell.	lvs	5
HIPPOCASTANACEAE		
Aesculus indica Colebr.	lvs	2
MYRSINACEAE		
Myrsine sp.	—	—
OLEACEAE		
Olea grandulifera Wall.	l	1
Fraxinus sp.	fr.	4
ULMACEAE		
Ulmus wallichiana Planch.	lvs	10
U. laevigate Royle	lvs	8
Ulmus campestris Linn.	l	1
Ulmus sp.	l	1

(*Contd.*)

TABLE 4 — FOSSIL FLORA FROM LAREDURA

Species	Nature of specimens	Number of specimens
JUGLANDACEAE		
Engelhardtia colebrookiana Lindl.	l	1
SALICACEAE		
Woodfordia fruticansa Linn.	l	1
Salix elegans Wall.	l	1
S. sp.	l	1
FAGACEAE		
Quercus semecarpifolia	lvs	31
Q. dilatata Lindl.	lvs	33
Q. ilex Linn.	lvs	33
BETULACEAE		
Betula utilis D. Don	Bark	1
B. utilis D. Don	lvs	6
B. alnoides Buch-Ham	l	1
B. sp.	lvs	4
Alnus nitida Endl.	lvs	2
Corylus ferox Wall.	l	1
ACERACEAE		
Acer villosum Wall.	lvs	3
A. caesium Wall.	l	1
A. caesium Wall.	fr.	1
A. sp.	fr.	1
A. sp.	lvs	4
BERBERDIACEAE		
Berberis lycium Royle	lvs	2
ARALIACEAE		
Hedera nepalensis K. Koch	lvs	4
PAPILIONACEAE		
Desmodium nutans Wall.	l	1
D. latifolium D.C.	l	1
D. tiliaefolium G. Don	l	1
Indigofera hebepetala Benth	l	1
I. sp.	l	1
ANACARDIACEAE		
Rhus punjabensis Stewart	l	1
R. succedania Linn.	l	1
Odina wodier Roxb.	l	1
ROSACEAE		
Prunus cerasoides D. Don	l	1
P. sp.	fr.	1
Pyrus pashia Buch-Ham	l	1
Rosa webbiana Wall.	lvs	1
R. macrophylla Lindl.	lvs	2
R. sp.	l	1
Spiraea sp.	l	1
Cotoneaster bacillaris Wall.	l	1
Rubus fruticosus Linn.	lvs	2
R. spp.	lvs	2
RANUNCULACEAE		
Ranunculus sp.	fr.	1
Clematis sp.	fr.	1
HYDROCARYACEAE		
Trapa natans Linn.	fr.	abundant
Trapa bispinosa Roxb.	fr.	abundant
CERATOPHYLLACEAE		
Ceratophyllum spp.	l	5
HALORAGACEAE		
Myriophyllum spp.	l	—

4. LAREDURA

Situated at an altitude of 1875 m, the fossiliferous beds at Laredura are exposed at five different locations. The other outcrops occur towards north-east of Laredura. Exposures along a narrow stream, close to the village, have yielded thousands of fruits of *Trapa* (Puri, op.cit.). We collected several fruits of *Trapa, Euryale ferox* and *Nymphaea* from an exposure about 2 km away from the village.

Excluding *Trapa* fruits which occur abundantly, the megafossils of land plants (Table 4) are about 193. *Quercus* is dominant among these. Rosaceae and Ulmaceae the next abundant have more than 13 specimens each, followed by Aceraceae by 10 specimens. The other natural orders have 1 to 5 specimens each. Conifers are absent.

The Pollen spectra (Text-fig. 4) show overall high frequencies of pollen of conifers; each genus has up to 15% pollen. Ephedra has about 2% in some spectra. *Quercus* has comparatively more pollen than the others (up to 22%) but it certainly not so dominant as in the megafossils. Rosaceae represented by thirteen specimens has (up to 4%) pollen; Ulmaceae, a codominant with Rosaceae, has only 2-7% pollen. *Acer*, represented by 10 specimens, has (up to 4%) pollen; *Aesculus* 1-3% pollen; *Salix* up to 10% pollen (15% in spectrum No.6); birch 3 to 10% pollen; *Rhus* stray to 1-3% pollen and Ranunculaceae up to 3% (6% in pollen spectrum No.8). Abundance of *Trapa* is reflected by stray to 1% pollen only.

No pollen grains of Papilionaceae, Oleaceae, Myrsinaceae, Euphorbiaceae, Lythraceae and Haloragaceae of which up to 5 leaf impressions occur have been found. The pollen spectra bring out the presence of Conifers, *Ephedra, Juglans* (3-19%), *Carpinus* (up to 4%), *Fraxinus* (traces of pollen), *Populus* (1-3%), *Corylus* (3-12%), *Viburnum* (1-3%) and small frequencies of Gramineae, Cyperaceae, Compositae, Chenopod-Amaranth type, *Impatiens*, Caryophyllaceae, Umbelliferae, Polygonaceae, Polypodiaceae, *Typha*, *Lemna* and *Potamogeton*, of which there is no trace in the megafossils.

5. NICHAHOM

There are quite a few exposures of silty and sandy clays bearing plant impressions at Nichahom. They are associated with bands of lignite. Fruits of aquatics have been found in one of the lignitic exposures. The plant bearing sediments are from 0·3 m to 0·6 m thick. Although rich in megafossils, pollen in sufficient quantity has been recovered only in some of them.

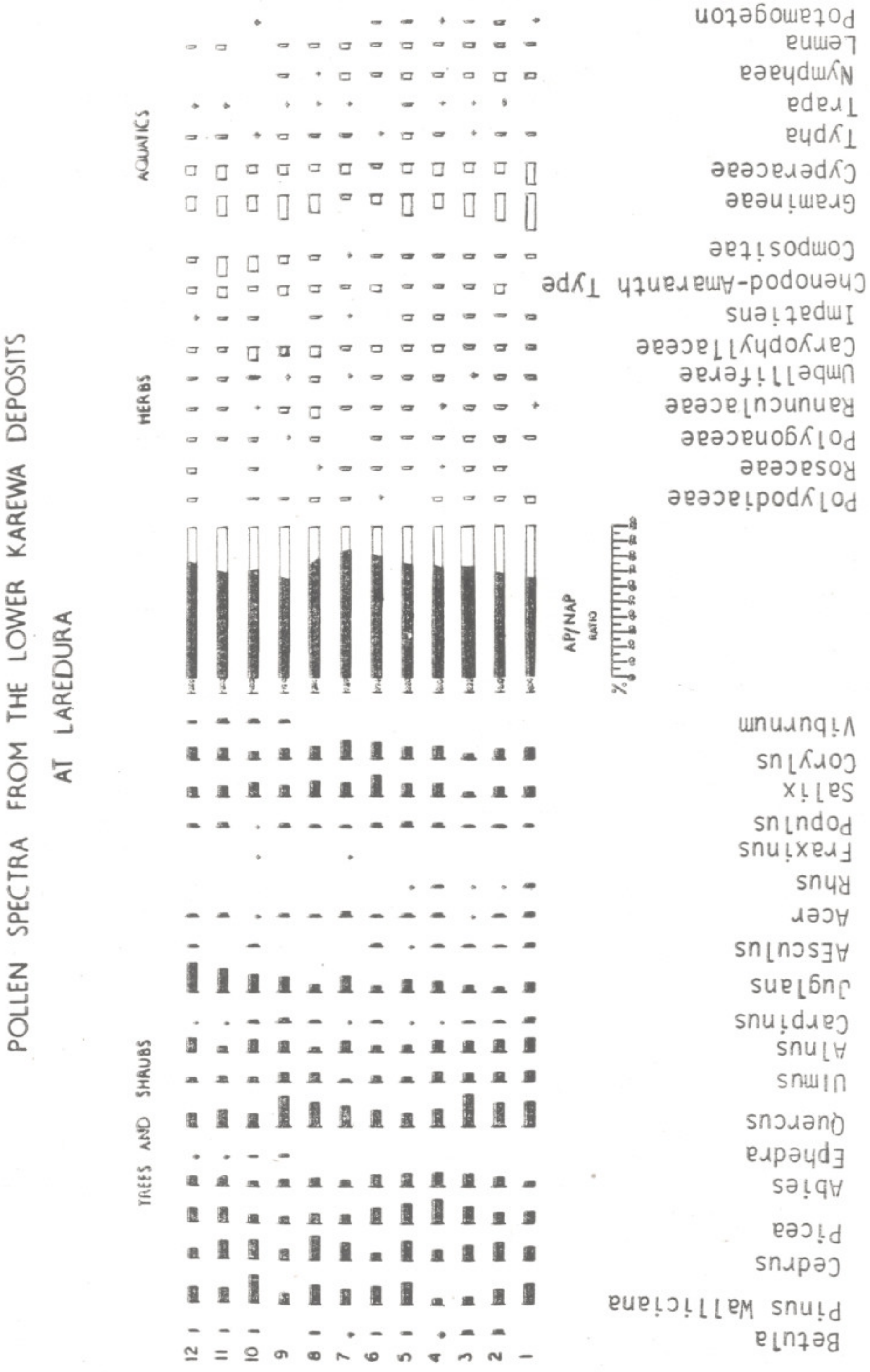
Exposure 1 — Consists of about 0·3 m thick grey silty clay along the slope and slightly above the cemented conglumerate of fluvial origin. The clay is underlain and overlain by a thick deposit of brown sand.

Total number of plant remains recovered are 60 (Table 5). The dominant genus is *Quercus* and the next in order of abundance are *Acer, Ulmus, Alnus* and Rosaceae respectively. The conifers or aquatics are absent.

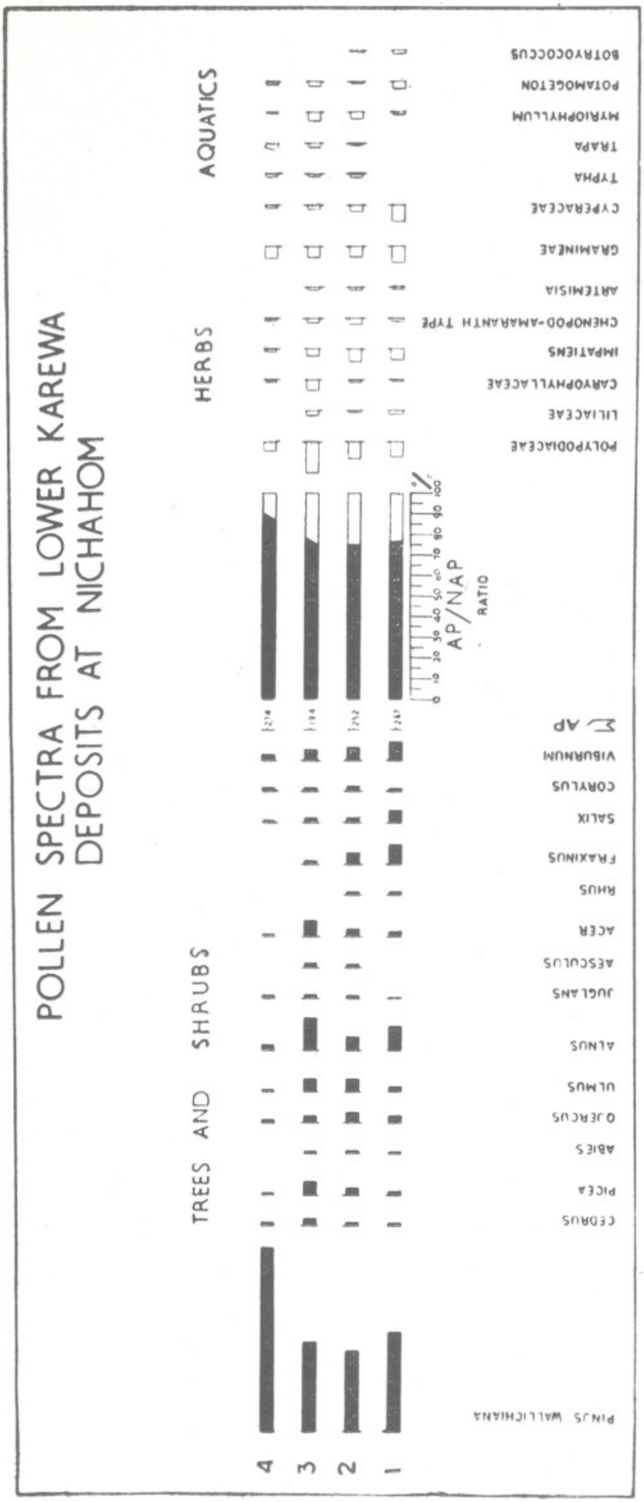
TABLE 5 — FOSSIL FLORA FROM NICHAHOM

SPECIES	NATURE OF SPECIMENS	NUMBER OF SPECIMENS
NICHAHOM-1		
ULMACEAE		
Ulmus sp.	lvs	10
FAGACEAE		
Quercus dilatata Lindl.	lvs	6
Q. ilex Linn.	lvs	6
Q. sp.	lvs	16
BETULACEAE		
Alnus nepalensis D. Don	lvs	6
ACERACEAE		
Acer sp.	fr.	2
A. sp.	lvs	10
ROSACEAE		
Rosa sp.	lvs	4
NICHAHOM-4		
ULMACEAE		
Ulmus sp.	lvs	15
FAGACEAE		
Quercus sp.	lvs	24
BETULACEAE		
Alnus sp.	lvs	12
Alnus sp.	fr.	4

The pollen spectra (Text-fig. 5) reveal Blue pine as a dominant conifer with average frequencies about 50% (90% in spectrum number 4). *Cedrus*, Spruce and Fir are extremely lowly present. *Quercus*, dominant among the megafossils has 2 to 5% pollen; *Acer* the next dominant only 2 to 3%



TEXT-FIG. 4 — Pollen spectra from impression bearing sediments at Laredura, Kashmir Valley.



TEXT-FIG. 5 — Pollen spectra from impression bearing sediments at Nichahom, Kashmir Valley.

(8% in spectrum 3); *Ulmus* 2 to 5% and *Alnus*, the fourth dominant, 3 to 15% (higher values in spectra 1 and 3) There is no record of Rosaceae.

The following present in the pollen spectra are absent among the megafossils, conifers. *Juglans*, *Aesculus*, *Rhus*, *Fraxinus*, *Salix*, *Corylus*, *Viburnum*, *Typha*, *Myriophyllum*, *Potamogeton*, *Trapa*, Polypodiaceae, Liliaceae, Caryophyllaceae, *Impatiens*, Chenopod-Amarnath Type, *Artemisia*, Gramineae and Cyperaceae.

Exposure 2 occurs towards top of the plateau much above Exposure 1. It consists of carbonaceous clay about 2·8 m thick overlain by 0·8 m thick brown sand which is again overlain by 2 m of carbonaceous clay with about 0·3 m thick band of grey clay passing through it. But for a few small woody fragments, only fruits of *Trapa* occur in abundance together with a small number of *Nymphaea* fruits. Pollen grains are absent.

Exposure 3 is exposed in the quarry. In the upper grey silty clay, overlying the band of lignite, leaf impressions of *Quercus*, *Salix*, Leguminosae and Maple fruit are found. The material did not yield any pollen grains. *Exposure* 4 comprising a small bed of fine silty clay, about 0·15 m thick, underlain and overlain by brown sand, occurs in a small ditch close to the quarry below the lignitic band.

Leaves of *Quercus* are dominant and the next in order of abundance are *Alnus* and *Ulmus* (Table 5) The samples yielded a few blue pine pollen grains only.

Exposure 5 occurs at the foot of the plateau, and consists of a weathered lignite band, about 0·3 m to 0·6 m thick, overlain and underlain by silty carbonaceous clay. Abundant fruits of *Trapa*, *Nymphaea* and *Euryale ferox* were noted in the lignite bed. Owing to the highly weathered nature of the deposits, samples for pollen analysis were not collected.

CONCLUSION

The combined study of the leaf impressions and pollen content from the leaf bearing sediments at Ningle Nullah, Laredura, Dangarpur, Liddarmarg and Nichahom has brought out information of considerable interest which can be employed in the correct interpretation of the pollen diagrams from the Kashmir Valley in particular and the western Himalaya in general.

At the outset, this study enhances the importance of both the micro- and megafossils in the reconstruction of the former vegetation, and sounds a note of caution to singular reliance on any of these data for inference of past vegetation and climate. The absence of Oaks in leaf impressions at Ningle Nullah so impressed Puri (1957) that he interpreted a different climate and, vegetation at this site. The pollen spectra however, suggest the dominance of Oaks here. The pollen grains of members of Rosaceae, Lauraceae, Ericaceae, Leguminosae, etc., of which megafossils occur are absent in the pollen spectra. This can however be explained away palynologically, but it becomes difficult to infer their presence from a pollen diagram prepared from sediments devoid of any megafossils. The same may be said of some members of Euphorbiaceae, Rutaceae, Myrsinaceae, Rubiaceae, Pittosporaceae and Rhamnaceae associated with our oak woods.

The megafossils substantiate the pollen record but the latter gives much larger information than megafossils. For instance, several genera such as *Carpinus*, *Juglans*, *Aesculus*, *Corylus*, *Viburnum* and a large proportion of the herbaceous elements such as Gramineae, Cyperaceae, Chenopodiaceae, Amaranthaceae, *Impatiens*, Caryophyllaceae, and some of the aquatics and algae comprise contribution of palynology to our knowledge of former vegetation.

The pollen record as compared to megafossils gives a picture of vegetation in the region besides that of local plant communities. The pollen of conifers is an outstanding example of their presence in the region, of which the megafossils have not been found except those listed by Stewart (De Terra and Paterson 1939, 119) and a compressed conifer cone discovered in 1964 from Alapathri by Dr. B. D. Sharma and the senior author. It is very likely that the conifers had occurred at an altitude higher than occupied by the broadleaved communities that is why their megafossils have been found very rarely. The overall pollen frequency of the conifers is suggestive of their occurrence at a distance.

There may be dangers inherent in a comparative study of microfossils and megafossils, especially, when both are considered quantitatively. For instance, pollen frequency of a genus usually reflects its frequency in the forest barring exceptions and the insect-pollinated species. The frequency of a megafossil, howsoever, statistically determined, cannot be relied upon for its factual quantity in the forest. This investigation has shown how the dominance of Salicaceae in the megafossils at Ningle Nullah and the dominance of *Quercus* at other sites is not reflected in the same way in the pollen spectra. Similarly, the quantity of megafossils of *Betula* and *Alnus* at Liddarmarg does not match with their pollen frequencies. Likewise, the abundance of *Trapa* fruits at Dangarpur is not represented by even a single pollen.

In spite of the discrepancies involved in correlation of micro- and megafossils, it can hardly be denied that the megafossils are of indispensable importance in pollen-analytical studies. Although frequency of megafossils may not be a very reliable indicator of their factual presence, the occurrence of a megafossil alone, is additional information of considerable value, of which the pollen evidence may be lacking. Furthermore the megafossils provide evidence of species, whereas the specific identification from the pollen grains is often not possible.

It has already been discussed above that the conifers, as suggested by their pollen record and a few megafossils, had existed far away from the sites of preservation, and in such situations where any means for the transport of their needles, shoots, cones etc., were largely non-existent. From ecological viewpoint, the enormous quantities of megafossils mostly belonging to the broad-leaved forest at all these sites can be explained by the occurrence of the broad-leaved forest in depressions and mountainous folds through which water channels usually pass. Depending upon altitude and aspect, sometimes conifers like Fir, *Cedrus deodara*, etc. may also occur there. The situation seen at Ningle Nullah seems anomalous. One can, however, conjecture about it. Perhaps, locally the shores of the lake at this site were surrounded by a deciduous plant community so that their megafossils could find their way into the lake but the overwhelming majority of the Oaks in the region continued to contribute pollen to the pollen rain as reflected by pollen analysis of the sediments from this site.

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