

**SOME FOSSIL LEAVES OF THE SALICACEÆ FROM  
NINGAL NULLAH AND LAREDURA, PIR PANJAL,  
WITH A NOTE ON THE SIGNIFICANCE OF  
TEMPERATE SPECIES IN THE PLEISTOCENE  
FLORA OF KASHMIR**

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INTRODUCTION

NEARLY eight years ago, in the summer of 1935, Dr. R. R. Stewart of the Gordon College, Rawalpindi, made a collection of about 600 plant-fossils from the Lower Karewa deposits of Kashmir exposed at Ningal Nullah (alt. 9,000 ft.; lat. 34° 4'; long. 74° 19') in the neighbourhood of Botapathri (Survey of India Map 43 J/8), a summer abode of Kashmiri shepherds on the northern slopes of the Pir Panjal Range. The fossiliferous beds, which

are assigned the Lower Pleistocene Age by De Terra and Paterson (1939) occur in the form of dome-shaped low grassy mounds stretching for over a mile from the right bank of the Ningal Nullah a perennial stream, which has its origin somewhere on the high peaks of the Pir Panjal. Numerous small rivulets, and artificial water channels have dissected their way through the clayey deposits and have furnished many plant-bearing outcrops for easy collection of fossil material. Dr. Stewart's collections were made from a few spots along two water channels.

Some years later, in 1941, the author visited this locality and discovered another fossiliferous stratum running parallel to the Ningal Nullah stream at a distance of over a furlong from its right bank. This stratum is exposed in the dried bed of a hill stream, which has cut through the beds as deep as 8-10 feet at some places. Small blocks of clay can be easily excavated for splitting, but larger blocks could not be extracted on account of the friable nature of the clay.

The plant material gathered both by Dr. Stewart and myself from this locality consists of leaf impressions embedded in a loosely-set sandy clay intermixed with small quantities of loam. The clays are very regularly bedded and split out neatly along the plane of bedding into thin layers, often as fine as a centimetre in thickness. Most of the larger leaves split out fragmentary on account of the friable nature of the clay, and small leaves being rather uncommon, the material, therefore, abounds in incomplete leaves.

The entire material is under investigation at Lucknow under the guidance of Professor B. Sahni, F.R.S., and a flora of 62 genera and 122 species distributed over 34 families of Angiosperms was reported by the author (Puri, 1942, pp. 222-24) in 1941. The present paper is devoted to the description of fossil leaves of the Salicaceæ in this material.

In addition to the Ningal Nullah material this paper also includes a description of two more leaves of *Salix* sp., collected by the author in 1940 from Laredura (alt. 6,000 ft.; 34° 7' N.; 74° 21' E.), a small village near Dangarpur (Survey of India Map 43 J/8) on the northern slopes of the Pir Panjal.

#### CONDITION OF THE MATERIAL

The fossil leaves from Ningal Nullah are impressions mostly from skeletal net works of veins; and no trace of organic matter of a leaf is preserved in any of them. Our experience in the field showed that the freshly split leaves in a dry atmosphere tend to wither away and thin layers of clay

often warp and curve up in sun thereby spoiling the impressions. Therefore, some of them were painted in field with varnish or canada balsam, which proved quite useful in preserving details of venation.

The state of the fossil material often indicates the physical conditions under which the plant parts had been deposited. Applying this principle to our material it may be deduced that the fossil leaves at Ningal Nullah had probably rotted in water for a considerable time before getting deposited in the lake bed. With a view to ascertain roughly the amount of time required for living leaves of the Karewa species to take up similar appearance in venation with the fossil leaves the author tried rotting of living leaves in the laboratory. On keeping herbarium material of living species of the Salicaceæ in a China-tray in muddy water from the garden tank at room temperatures during the month of February 1941 it was found that the leaves had become quite soft after ten days and the upper and lower epidermis layers could be easily peeled off by a gentle rubbing of the leaves between the fingers. The photographs reproduced in Pl. V, Fig. 3 and Pl. VI, Fig. 14 were taken at this stage for comparison with the fossils. Leaves of *Populus ciliata* are a bit tougher and they take a little longer time to soften. A complete rotting of leaves occurs in a month's time when all other tissues excepting the venation skeleton are dissolved out. Fresh leaves of a *Salix* sp. from the garden rotted out comparatively earlier than dried herbarium material.

Incidentally it may be useful to mention here that cuticles of living leaves can be easily prepared in this way and by immersing them in nitric acid and potassium chlorate for an hour or so they may, perhaps, be employed for comparison with fossil cuticles.

This paper has been prepared under the guidance of Professor B. Sahni, F.R.S., to whom I am greatly indebted for invaluable help and stimulating criticism.

I am also grateful to Dr. R. R. Stewart, my old teacher in Systematic Botany, for a loan of his material and for facilities extended to me for work in his Herbarium. As usual I have to thank the Vice-Chancellor, University of the Panjab and Principal Jodh Singh of the Khalsa College, Amritsar, for a research grant from that University and authorities of the Lucknow University for a Research Fellowship. I am glad to acknowledge the help my wife has given me in correcting the proofs.

## SYSTEMATIC LIST OF THE SPECIES

*Salix Wallichiana* Anders.*Salix denticulata* Anders.*Salix* sp. A*Salix* sp. B*Salix* sp. C*Populus ciliata* Wall.*Populus nigra* L.*Populus* sp. A.*Populus* sp. B

## DESCRIPTION

Order: Salicales

Family: Salicaceæ

The family Salicaceæ is represented in the Karewa flora by four well-determined species belonging to two modern genera from Laredura and Ningal Nullah. The species are based on leaves, the majority of which are fragments of various sizes.

The leaves of this family, whether living, or fossils, have some characteristic features, which are remarkably uniform and constant in the two genera and on the basis of macroscopic features such as shape and venation one can recognise and separate willows and poplars from an assemblage of living, or fossil leaves. Though the generic identification is attained with ease, it is comparatively more difficult to distinguish between the different species, some of which have very similar leaves.

In addition to four fully determined species there are three more leaves of *Salix* which could not be specifically determined on account of their fragmentary nature, and two well preserved distinct leaf fragments of *Populus* which do not seem to match any living species of the Himalayas; and hence they are incompletely determined. The family includes in all nine fossil species, five of which belong to *Salix* and four to *Populus*.

## KEY TO THE GENERA

- |  |         |                    |
|--|---------|--------------------|
| I. Leaves linear-lanceolate, or linear-oblong, secondaries |         |                    |
| 15-32 pairs  | .. .. . | <i>Salix</i> (1)   |
| II. Leaves ovate, secondaries 5-8 pairs                    | .. .. . | <i>Populus</i> (2) |

Genus *Salix* Linn.

The genus is represented by two fully determined and three half determined species. There are a few leaves which may belong to either of

the two or to both species, namely, *Salix acmophylla* Boiss. or *Salix viminalis* Linn. Three more specimens, which are nicely preserved leaf fragments, could not be referred to any living species, and are described as *Salix* sp. A, B and C.

All specimens, with the exception of one complete leaf, are fragmentary impressions showing well-preserved venation. Excepting two leaves, which come from the author's collections, all others had been previously heavily varnished by Dr. Stewart in field or laboratory as a result of which the photographs of these did not show up well the details of venation. One complete leaf is found folded on itself at about its middle.

The classification of living willows is a very difficult task, even when the flowers and fruits are present, and the determination of species from fossil leaf fragments is still more difficult, but the author having made a diligent study of the macroscopic characters of living species has been able to prepare the following key for the fossil species, described in this paper:—

KEY TO THE SPECIES

- I. Leaves large, oblong-lanceolate, fragment 3·3" × 7", secondaries 20 pairs .. .. *Salix Wallichiana* (1)
- II. Leaves much smaller .. .. *Salix* sp. A and *Salix denticulata*
  - (i) Leaves lanceolate, 4" × ·5", secondary nerves 19–20 pairs .. .. *Salix* sp. A (3)
  - (ii) Leaves oblong, leaf 1·45" × ·75", secondaries 9–10 pairs .. .. *Salix denticulata* (2)
  - (iii) leaves linear, fragment 2·6" × ·6"
    - (a) Secondaries about 26 pairs .. .. *Salix* sp. B (4)
    - (b) Seconbaries abou 14 pairs .. .. *Salix* sp. C (5)

(i) *Salix Wallichiana* Anders.

(Plate V, Figs. 1–3)

The leaf fragment, which is a little more than half of a leaf, represents only the basal portion, which measures 3·3" long by ·65 inch in its broadest part. It is oblanceolate in outline and has a uniform width for most of its length getting slightly narrowed towards its base, which bears a small, thick petiole, measuring ·25 inch in length. The leaf fragment tends to become narrowed also towards the broken apical side and it seems to have been probably acute or acuminate at its tip. The margins are probably entire.

The venation is fine and pinnate-reticulate. A fairly strong midrib starts from the base, and runs straight in the lamina gradually thinning out in the

upper (apical) part. 15 to 20 weak secondaries, which are much thinner than the midrib, arise from the latter on either side at acute angles. In between the two secondaries a single weak secondary, which is very much thinner, and much less conspicuous than the midrib, also arises from it at almost the same angle at which the stronger secondaries shoot out. These weaker secondaries do not reach the margins, but soon break up in the lamina and anastomose with tertiary ribs to form long meshes, which constitute the first framework of reticulations (Pl. V, Fig. 2). The stronger as well as the weaker secondaries do not run straight, but follow an undulating course, as a result of which the area enclosed by two secondaries is not strictly rectangular but becomes unsymmetrical (Pl. V, Fig. 2). The width of the enclosed area all along the course of the laterals, therefore, does not remain uniform. The secondaries tend to run parallel, but they arise in a very irregular manner, sometimes sub-opposite, opposite, or often alternate. At some places a weaker and a stronger secondary rib may anastomose with each other and become one. The secondaries do not as a rule end abruptly in the margin, but run along it for some distance before they get lost or immersed in it (Pl. V, Fig. 2). The meshes of the tertiary reticulations are fairly conspicuous and strong. They are seen in the form of polygonal, or angular meshes (Pl. V, Fig. 2). The finer reticulations are greatly obscured by varnish, and hence they are not brought out satisfactorily even in a five diameter enlarged photograph of a part of the lamina reproduced in Fig. 2.

The fossil leaf, apparently shows some resemblance with leaves of *Woodfordia fruticosa* (Linn.) S. Kurz., a tropical shrub of the Lythraceæ but a closer examination reveals important differences between the two in details of venation, which were pointed out by the author in a paper dealing with a description of a fossil leaf of *Woodfordia fruticosa* (see Puri, 1943, p. 127).

Our fossil leaf is identical in all respects with leaves of *Salix Wallichiana* Anders, one of which is shown in the photograph (Pl. V, Fig. 3) for comparison with the fossil.

*Number of specimens.*—Ten.

*Occurrence.*—Ningal Nullah at 9,000 ft. in the Pir Panjal Range, Kashmir.

*Collections.*—R. R. Stewart, 1935 and G. S. Puri, 1940.

*Registered No. of figured specimen.*—N. 132.

(2) *Salix elegans* Wall.

(Plate V, Figs. 6, 7 and Plate VI, Fig. 9)

The two fossil leaves belonging to this species are fairly incomplete, being broken from apex and seem to have an oblong outline of the lamina. They gradually narrow down from the middle into a cuneate base and seem to have been acute at the apex. In one specimen (see Pl. VI, Fig. 9) there is a small twig lying close to the base, and at first sight the leaf may seem to be attached to it but a closer examination shows that the twig in question is lying on a higher level than the leaf and does not have any organic connection with it. The margins of both the leaves are entire.

The venation is fine and pinnate-reticulate. A fairly thick midrib follows an almost straight course in the lamina gradually thinning out in the apical part. 9-10 secondaries, which are about one-fourth as thick as the midrib, diverge from it in an opposite, occasionally sub-opposite and rarely alternate manner at almost equal distances from one another (Pl. V, Figs. 6, 7) on either side at angles of approximately 50 to 55 degrees. They run outwards bifurcating below the margins into thin branches, which are seen in a part of the leaf (Pl. V, Fig. 6) enlarged to five diameters in Plate V, Fig. 7. These branches, at some places, are often indistinguishable from tertiary ribs, which also are of the same nature and thickness. The former tend to form close to the margin by anastomosing with branches of the lower and upper secondaries, seen on righthand side in the enlarged photograph (Pl. V, Fig. 7), a series of small semi-circular loops with their convexities facing outwards. Tertiaries arise from the secondaries at different angles and anastomose variously among themselves to form large meshes of irregular shapes and different sizes (Pl. V, Fig. 7). At some places they are obscured by a thick coat of varnish. These meshes further break up into a close network consisting of small and oval, or polygonal meshes, which constitute a finer reticulation seen clearly in the enlarged photograph (Pl. V, Fig. 7) of a part of the leaf.

Our fossil leaves are identical in all respects with living leaves of *Salix elegans* Wall. with which they are, therefore, identified.

*Number of specimens.*—Two.

*Occurrence.*—Laredura, at 6,000 ft. and Ningal Nullah, at 9,000 ft. in the Pir Panjal Rang., Kashmir.

*Collections.*—R. R. Stewart, 1935, and G. S. Puri, 1939.

*Registered Nos. of figured specimens.*—Plate V, Figs. 6, 7 = N 20; Plate VI, Fig. 9 = L 150.

(3) *Salix* sp. A

(Plate V, Figs. 4, 5)

Plate V, Fig. 4 is a natural size photograph of a complete leaf, which measures 1.64 inches long by .5 inch in the broadest part, a little above the middle, and has a lanceolate outline of the slightly oblique lamina. It narrows down abruptly into a cuneate base and also tapers upwards into an acute or somewhat acuminate apex and possesses entire margins. An irregularly applied thick coating of varnish, which appears in the photograph (Pl. V, Fig. 4) as dark patches along the margins may conceal the true extent of the margins, which are otherwise fairly well marked out in the specimen.

The venation is fine and pinnate-reticulate. A conspicuous midrib runs in the lamina gradually thinning out upwards and lies slightly displaced from its centre thereby dividing the lamina into two slightly asymmetrical halves. 19-20 weak secondaries, inconspicuous and much thinner than the midrib, shoot out at angles of approximately 40 degrees, on either side of the midrib and tend to remain equidistant and run closely in the lamina more or less parallel to one another and become slightly arcuate (Pl. V, Fig. 5) in the upper part of the leaf, where they tend to converge. They do not end directly in the margin but a little below it form a series of loops or sometimes large meshes by curving upwards and inwards and anastomosing with the superior laterals on the same side. Tertiaries are indistinct, largely obscured by the varnish, but here and there, they are visible forming large meshes of different shapes and sizes seen in the photograph (Pl. V, Fig. 5) of a part of the leaf enlarged to five diameters. Finer reticulation also is largely obscured by the varnish and consequently it is not brought out in the photograph.

Our fossil leaf does not seem to resemble any one species of *Salix* though in some features, e.g., shape, size, margins, etc., it may show some resemblance with living leaves of *Salix tetrasperma* Roxb.; but with our present state of knowledge concerning the macroscopic features of living leaves of willows it seems unsafe to specifically determine our fossil leaf with any living species of *Salix*, hence it is described here as Sp. A.

*Number of specimens.*—Five.

*Occurrence.*—Ningal Nullah, at 9,000 ft. in the Pir Panjal Range, Kashmir.

*Collection.*—R. R. Stewart, 1935.

*Registered No. of figured specimen.*—N 203.



(4) *Salix* sp. B

(Plate VI, Figs. 10, 11)

Plate VI, Fig. 10 is a natural size photograph of a fossil leaf, which is folded on itself at about the middle and is slightly broken at the apical part. It is lanceolate in outline and measures 2·6 inches long by 1·6 inch at the broadest part, and slightly narrows downwards into a more or less rounded base bearing a bit of petiole, and possesses entire margins.

The venation is fine and pinnate-reticulate. A fairly stout midrib runs straight in the lamina gradually thinning out towards the apex, and gives off on its either side at acute angles about 26–27 secondaries which are very conspicuous, even though they are not even half as thick as the midrib. The secondaries after running straight in the lamina for a short distance from the midrib soon curve upwards and follow an undulating course. Some of the secondaries are pinnate-arcuate, while others are pinnate-looped, which may be seen clearly in a part of the leaf enlarged to five diameters in a photograph represented in Pl. VI, Fig. 11. Sometimes a lower secondary anastomose near the margin with its superior on the same side or it runs along the latter for some distance and finally anastomose to form circular loops (Pl. VI, Fig. 11), which in a series seem to form a sort of marginal vein running parallel and below the margin (Pl. VI, Fig. 11). There are also one or more weaker secondaries, which arise in between the stronger secondaries and unlike the latter soon start looping or anastomosing in the lamina with tertiaries fairly down below the margins (Pl. VI, Fig. 11). Tertiaries arise either from the midrib, or from the secondaries meet halfway in the area enclosed by the two secondaries to form large angular meshes, which further break up into a well-preserved net work of smaller meshes, which constitute a finer reticulation (Pl. VI, Fig. 11).

Our fossil leaf resembles modern leaves of quite a few species of *Salix*, notably *Salix viminalis* Linn. and *Salix acmophylla* Boiss., both of which are very similar leaves but with our present state of knowledge concerning the macroscopic features of willow leaves it is not possible to specifically determine it, hence it is described here as *Salix* sp. B.

*Number of specimens.*—One.

*Occurrence.*—Laredura, at 6,000 ft. in the Pir Panjal Range, Kashmir.

*Collections.*—G. S. Puri, 1940.

*Registered No. of figured specimen.*—L 559.

(5) *Salix* sp. C

(Plate V, Fig. 8 and Plate VI, Fig. 12)

Plate V, Fig. 8 is a natural size photograph of a leaf fragment, which measures 2 inches long by .6 inch in the broadest part. It is broken both from base as well as apex, but evidently it seems to have had a lanceolate outline with an acute apex and narrowed base. The margins are entire.

The venation is fine, and pinnate-reticulate. A fairly stout midrib runs in the fragment slightly thinning out in the upper part and seems to divide the lamina into unequal halves. 13–15 pairs of closely situated, thin secondaries leave the midrib at acute angles and run in an undulating manner towards the margins. There arise in between two strong secondaries one or more weaker secondaries, which do not reach the margins, but either break up into a network of large meshes, hardly distinguishable from tertiary meshes or they unite with other secondaries. Tertiaries usually arise from the midrib and also from the strong as well as weak laterals and variously anastomose to form large meshes, which further break up into a finer reticulation of smaller meshes (Pl. VI, Fig. 12).

The fossil leaf on account of its characteristic venation is identified with the genus *Salix*, but it could not be specifically determined on account of its resemblance with several species of *Salix* represented in the modern vegetation of Kashmir and neighbouring regions.

*Number of specimens.*—One.

*Occurrence.*—Ningal Nullah, at 9,000 ft. in the Pir Panjal Range, Kashmir.

*Collector.*—G. S. Puri, 1940.

*Registered No. of figured specimen.*—Loc. 1 N 10.

Genus *Populus*

The genus includes two well-determined species and two others which are distinct and do not match any modern species of the Himalayas. The specimens are impressions of leaves, most of which are imperfectly preserved but on account of their characteristic venation it has been possible to determine them by a comparison with living species of *Populus*.

## KEY TO THE SPECIES

- I. Leaves large . . . . . *Populus ciliata* and *Populus* sp. A  
 (i) Secondaries run straight at acute angles . . . . . *P. ciliata* (1)  
 (ii) Secondaries arise at almost right angles and run forward forming wide semi-circular curves in the lamina . . . . . *Populus* sp. A (3)

- II. Leaves small .. .. *Populus nigra*, *Populus* sp. B  
(i) Leaves broad, ovate, or sub-orbicular, wider than long, secondaries  
4-5 pairs, wide apart and not equidistant .. *P. nigra* (2)  
(ii) Leaf probably ovate, longer than broad, secondaries more than 7  
pairs, closer and equidistant .. .. *Populus* sp. B (4)

(i) *Populus ciliata* Wall.

(Plate VI, Fig. 14 and Plate VII, Fig. 15)

Plate VII, Fig. 15 is a natural size photograph of a leaf fragment, which measures 3.3 inches long by 2.7 inches in the broadest part. Although the leaf is too fragmentary to indicate a true nature of its shape, base, apex, margins, etc., it is very well preserved as regards venation and nature of the primary and secondary veins; and by a comparison with a living leaf of *Populus ciliata* reproduced in Pl. VI, Fig. 14, it seems that the fossil leaf had probably a broadly ovate outline with a rounded or cordate base and an acute apex.

The venation is pinnate and reticulate. A fairly prominent midrib runs in the lamina thinning out in the upper part, and gives off 4-5 laterals which are almost half as thick, on either side, in a pinnate manner at acute angles. The basal lateral on the righthand side is profusely branched and gives off as many as 5-6 branches, one of which is seen to give off a branch of the third order; the upper laterals are branched only once or twice (Pl. VII, Fig. 15). Tertiaries form large rectangular meshes or cross-ties, which are preserved at some places in the fragment. Meshes of finer reticulations are not well preserved.

Our fossil leaf is identical in all respects with modern leaves of *P. ciliata* Wall. (Pl. VI, Fig. 14), a common poplar of the Himalayas.

*Number of specimens.*—Ten.

*Occurrence.*—Ningal Nullah, at 9,000 ft. in the Pir Panjal Range, Kashmir.

*Collections.*—R. R. Stewart, 1935.

*Registered No. of figured specimen.*—N 68.

There is another leaf fragment from the same collection which shows a good deal of resemblance to living leaves of *P. ciliata*, though absolute identity with this species cannot be claimed on account of the badly preserved nature of the fragmentary material. It is also figured here. Plate VI, Fig. 13 is a natural size photograph of the fragment, which shows a midrib with two to three pairs of laterals arising from it in an alternate manner

at acute angles like modern leaves of *P. ciliata*. The basal pair of secondaries which is branching in the fossil like *P. ciliata* seems to arise at angles slightly different from those in the latter species, and this may, to some extent, be accounted for a slight variation but assuming that the fossil leaf must have completely rotted in water before fossilisation, it may not be ridiculous to suggest that the present position of the laterals in the fossil is probably due to slight displacement of these from their original position and such an assumption is supported by an actual experiment performed in the laboratory on living leaves of *P. ciliata*, which on rotting became so soft and pulpy that the laterals lost their original distended position and in some cases even got broken from the midrib. But all this in the absence of a clear positive evidence is not sufficient to warrant accuracy in assigning the fossil to the modern species.

*Number of specimens.*—One.

*Occurrence.*—Ningal Nullah, at 9,000 ft. in the Pir Panjal Range, Kashmir.

*Collector.*—R. R. Stewart, 1936.

*Registered No. of figured specimens.*—N 100.

(2) *Populus nigra* L. var. *fastigiata* Desf.

(Plate VII, Figs. 16, 18)

Plate VII, Fig. 16 is a natural size photograph of a leaf fragment, which seems to have been triangular to sub-orbicular, or broadly ovate in outline with a feebly cuneiform base. A small part of the petiole measuring about .4 inch in length is also preserved in one specimen.

The venation is pinnate and reticulate with a pseudo-palmate base. Two strong secondaries arise from basal part of the midrib a little above the base and run straight towards the margins, which are broken from the corresponding points of their ending, thus their course further ahead in the lamina cannot be ascertained. A fairly stout midrib, which slightly undulates and runs in a zigzag manner in the lamina, gives off 3-4 secondaries, thinner than itself, on either side in a sub-opposite, or alternate manner at acute angles. The laterals give off a number of branches on the outer side, and the latter tend to form indistinct loops by uniting with one another (Pl. VII, Fig. 16). Tertiaries form large meshes of various shapes and sizes, which further break up into a poorly preserved network of smaller meshes of finer reticulations.

In size, shape, margins and all details of venation our fossil leaf is identical with living leaves of *P. nigra* Linn. var. *fastigiata* Desf. one of which is reproduced in Pl. VII, Fig. 18 for a comparison.

*Number of specimens.*—Ten.

*Occurrence.*—Ningal Nullah, at 9,000 ft. in the Pir Panjal Range, Kashmir.

*Collector.*—R. R. Stewart, 1935.

*Registered No. of figured specimen.*—N 172.

There is another leaf fragment (shown in Pl. VII, Fig. 17) from the same locality, which shows sufficient similarity in shape, size, base, and apex with living leaves of *P. nigra*, but the four pairs of lateral veins in the fossil arise at acute angles in an alternate manner and seem to be closer and of a slightly different nature than what we find in living leaves of *P. nigra*, with which they seem to be closely related but not identical. Quite a few such leaves have been found in Stewart's collection.

### (3) *Populus* sp. A

(Plate VII, Figs. 19–20)

Plate III, Fig. 19 is a natural size photograph of a leaf fragment, which seems to differ from the other two species of *Populus* described in the present paper. It measures 2.2 inches long by about an inch in the middle but a greater part of one half of the leaf in breadth is entirely missing. Though base and apex are also broken, their shape can still be made out and the leaf seems to have had an ovate-oblong lamina, with rounded base, and acute apex. The margin also is greatly damaged.

The venation is pinnate reticulate with a prominent midrib, which runs in the lamina slightly thinning out in the apical part. It gives off, on either side, in an alternate manner 5–6 secondaries at acute angles. The latter are about half as thick, and run straight towards the damaged margin, a little below which it is not possible to trace their nature. The lower two laterals close to the margin distinctly give off, on their outer and lower side, one or two branches, which show a tendency to curve upwards probably to form loops. The latter are quite thin, and are slightly distinguished from tertiary ribs, which either form cross-ties, or large rectangular meshes (Pl. VII, Fig. 20). Finer reticulation is not well preserved in the fossil.

Our fossil leaf does not show much similarity to any living species of *Populus* represented in the modern flora of India; but the form of venation is highly suggestive of its having some resemblance to another fossil leaf

figured in Plate VII, Fig. 17, which again has as much similarity with living leaves of *P. nigra*.

*Number of specimens.*—One.

*Occurrence.*—Ningal Nullah, at 9,000 ft. in the Pir Panjal Range, Kashmir.

*Collector.*—R. R. Stewart, 1935.

*Registered No. of figured specimen.*—N 260.

(4) *Populus* sp. B

(Plate VIII, Figs. 21–23)

Plate IV, Figs. 21 and 22 are natural size photographs of two counterparts of a fossil leaf, which is so incomplete and fragmentary that it is not possible to give a clear and exact description of its shape, base or apex. However, the form of venation suggests that the fossil might have had an ovate lamina with a cordate or rounded base and acute apex, more or less similar to living leaves of the other two species of poplars described above. The margins, too, are probably entirely missing.

The venation is pinnate-reticulate with the upper laterals prominently arched. A thick, strong midrib, which seems to run straight in the lamina, gradually thins out in the upper part, and gives off on its either side, at almost right angles, 4–5 equally prominent secondaries, which are approximately half as thick as the midrib. They run straight for about half the way in the fragment and beyond curve upwards forming semi-circular arches with the midrib. The lower secondary, a part of which is missing, gives off on its outer and lower side 2–3 branches, which at their ends curve upwards and tend to form loops in one counterpart (brought out in the photograph Pl. VIII, Fig. 22). In between two secondaries there arises a weaker secondary, which soon breaks up and gets lost into a network of the tertiaries, which also form cross-ties clearly seen in a part of the leaf (Pl. VIII, Fig. 22) enlarged to five diameters in the photograph Pl. VIII, Fig. 23. The tertiary meshes enclose a net work of smaller meshes, which constitute a finer reticulation.

The fossil leaf fragments do not match, in all details of venation, with any modern poplar of the Himalayas, though its venation is awfully like the genus *Populus*, with which it is, therefore, generically determined. On account of the incomplete nature of the fragments in which unfortunately none of the base, apex, or margins are preserved, it seems all the more reasonable that the specific determination of this fragment should not be

attempted especially when they do not seem to match any living species of Kashmir, or the nearby regions in the Himalayas.

*Number of specimens.*—Two (counterparts).

*Occurrence.*—Ningal Nullah, at 9,000 ft. in the Pir Panjal Range, Kashmir.

*Collector.*—G. S. Puri, 1941.

*Registered Nos. of figured specimens.*—Pl. VIII, Fig. 21 = Loc. I N 51; Pl. VIII, Figs. 22-23 = Loc. I N. 52.

#### GENERAL MODERN DISTRIBUTION OF THE SALICACEÆ

The family Salicaceæ—with 180 modern species distributed in two genera *Salix* and *Populus*—is, at the present time, chiefly north temperate in its global distribution; some species flourish on high mountain regions in alpine climates, also in the Arctic zone, in very severe atmospheric conditions, as a result of which these plants are reduced to stunted bushes or prostrate shrubs. There are, however, a few tropical species also, which are fairly common in warmer parts of the world. It is best represented in Europe, also in America and occurs in Africa, Asia and spreads through Malay Archipelago into Australia.

#### GENERAL MODERN DISTRIBUTION OF *Salix*

Of the two genera, *Salix* is more widely spread, occurring in the Old as well as the New World. Its major areas of distribution in the northern hemisphere are North-West Europe, Central Europe, Southern Europe, the Mediterranean, and the Caucasus through which it seems to have spread into the Himalayas. It is equally well distributed in Pacific North America.

In India, there are as many as 26 well-determined species, besides a few doubtful ones, which are not taken into account in this paper. They are inhabiting different altitudinal zones in the Himalayas, ascending by some species to the snow-line and descending by others to as low elevations as sea-level in plains, where they are usually met with along streams or banks of fresh-water lakes. The largest number of Indian species occur in the Sikkim Himalayas. Western Himalayas and Temperate Himalayas come next as regards the number of species. A few are represented in Western Tibet. Dwarf willows are not uncommon in the Alpine Himalayas. One species is wild in the Deccan and another is found in the Khasi Hills, Assam. Burma affords a single species growing along streams. Willows and poplars are absent from Ceylon.

MODERN DISTRIBUTION OF THE FOSSIL SPECIES OF *Salix*

The Karewa species, as we shall see presently, are now mainly confined to the Western or Temperate Himalayas and do not seem to have a wider distribution at the present time. *Salix Wallichiana*, a graceful Himalayan willow, grows wild, or cultivated in the Temperate Himalayas, fairly continuously from Kashmir to Bhutan up to an altitude of 9,000 ft., and occurs also in the Punjab plains usually cultivated at water mills and along streams. Further east, it has been recorded by Gamble (1902, p. 687) at an altitude of 9,000 ft. but I could not confirm this either from literature, or Herbarium material. From Kashmir westwards, it is distributed in Afghanistan and has been recorded from the Kurram Valley (alt. 10-12,000 ft.) and has been collected by Stewart from the Kagan Valley in Hazara and Changla-Gali in the Murree Hills, where it occupies moister localities on sheltered aspects of the mountains.

The Kashmir distribution of the species, with which we are specially concerned here, is both interesting and significant. The species seems to have a much wider distribution now than in the Pleistocene time as is evidenced by its occurrence in the Karewa deposits. At the present time the species is reported to occur commonly in the Jhelum Valley (alt. 6,000 ft.), Baramulla and vicinity, and in Kamraj Division (alt. 6,500 ft.). On the Main Himalayan slopes it is abundant at Sonamarg and Gilgit and has been collected from Pahlgam in the Sindh Valley. In the valley proper it is often gregarious in moister localities and occurs commonly associated with *Populus ciliata*, *Juglans regia*, *Ulmus Wallichiana*, *Celtis alpina*, *Fraxinus excelsior*, *Parrotia Jacquemontiana*, *Populus nigra*, etc., and with *Cedrus Deodara* and *Pinus excelsa*, as its coniferous associates, up to an altitude of 7,000 ft. It may be pointed out that the prevailing climatic conditions at this altitude of the valley are temperate and a fair amount of available water and atmospheric moisture in sheltered places combine together to create at this altitude ideal conditions for the growth of willows and poplars together with other mesophytic species.

Outside Kashmir *Salix Wallichiana* occurs in Pangi, Kulu, the Simla Hills, Jaunsar, Mussoorie, etc., of course, in moister localities and according to a sheet bearing the number 13955 in the Forest Herbarium, Dehra Dun, it ascends to an elevation of 12,500 ft. in Garhwal and is recorded from Kumaon Hills and also from Bhutan.

The second Karewa species—*Salix elegans*—is usually a high-level species, met with in the Western Himalayas from Nepal to Murree Hills, between the altitudes of 6,000 and 11,000 ft.; westwards it occurs as far as Kagan and in the Kurram Valley.



In Kashmir, at the present day, it seems to be more widely spread than the former species, where it occurs both on the Main Himalayan slopes—collected from Sonamarg (alt. 10,000 ft.), Pahlgam, Sindh Valley Division and the northern slopes of the Pir Panjal Range at Khillanmarg (alt. 9–10,000 ft.). It is no less common at other places and is recorded from the Kishenganga Valley, Kishtwar, Gurez, the Jhelum Valley, Keran, Marwa Dachhan, Muzafarabad, Ramban and Udhampur. In the Kashmir Valley proper between the altitudes of 6,000 and 7 or 8,000 ft. it is rather scanty, occupying very moist places, but it is more common in the next higher zone—white birch zone—where it occurs commonly, associated with a more or less pure strand of *Betula utilis*, and *Syringa Emodi*, with *Lonicera* sp., *Rhododendron campanulatum*, *Pyrus foliolosa*, etc., at the altitudes of 10,500 ft. to 12,000 ft.

Outside Kashmir, eastwards, it is recorded from Kulu (alt. 10,700 ft.) Chamba, the Pangi, Simla Hills, Jaunsar, Deoban, Jabberkhet, Dharmsala, Tehri Garhwal, Almora District, Western Nepal, Kunawar, etc.; and also from the Niti Pass at an altitude of 11,500 ft.

#### GENERAL MODERN DISTRIBUTION OF *Populus*

The genus *Populus* is comparatively less widely distributed than *Salix*, occurring mainly in the north temperate zone of both the Old and the New World. Unlike *Salix* it does not seem to extend to the Arctic regions, nor it touches snow-line in India or elsewhere, and alpine climates are not suited to poplars. The largest number of species are represented in Eastern Asia and Atlantic North America. A few species, however, are also fairly abundant in Europe.

In India we have only 6 species—5 are indigenous to the country and one is cultivated. Of these, three are found in the North-Western Himalayas, and one in the Temperate Himalayas. The warmer climates of the Punjab plains are fairly congenial to *Populus euphratica* and a single species occurs in Bhutan. It may be interesting to observe that four out of the six Indian species extend into Western Tibet and are also distributed over geographically much wider areas, extending into some parts of Asia and Europe.

#### MODERN DISTRIBUTION OF THE FOSSIL SPECIES OF *Populus*

Of the two well-determined Karewa species—one is restricted at the present time solely to some parts of the Temperate Himalayas, while the other has a much wider distribution, occurring in a wild form in Western Asia and Central Europe. It also enjoys a fairly wide distribution in a cultivated state in some parts of the North-Western Himalayas, especially Kashmir, the Punjab plains and Western Tibet.

*Populus ciliata* grows at the present time in Temperate Himalayan regions, from Kashmir to Bhutan at altitudes ranging from 4,000 to 10,000 ft., though it is best represented above 7,000 ft. In the Western Himalayas according to Gamble (1902, p. 690) it is fairly abundant in mixed forests of *Quercus Ilex*, *Quercus dilatata*, *Cedrus Deodara* and *Pinus excelsa*, but its conifer associate in the Kagan Valley as reported by Parker (1918, p. 510) is *Abies Webbiana*. In the Kashmir Valley, it is best represented to-day at an elevation of about 7,000 ft. above the level of sea and grows in the association of *Salix Wallichiana*, the latter occupying more moister places, and *Morus serrata*, *Morus alba*, *Celtis alpina*, *Fraxinus excelsior*, *Ulmus Wallichiana*, *Platanus orientalis*, *Parrotia Jacquemontiana*, *Populus nigra*, *Cedrus Deodara*, *Pinus excelsa*, etc., in sheltered places or under mesophytic conditions.

From Kashmir westwards, it extends in the Kagan Valley in Hazara and flourishes in the neighbouring regions in the Murree Hills occurring at Dunga-Gali in association with *Aesculus indica*, *Prunus cornuta*, *Juglans regia*, etc., in the mixed coniferous forests of *Pinus excelsa* and *Taxus baccata*.

Its Kashmir distribution, in which we are specially interested here, is fairly wide; in addition to the valley proper the species is recorded both from the southern slopes of the Main Himalayas and the northern slopes of the Pir Panjal at various places including Gurez, the Jhelum Valley, Kamraj, Keran, Kishtwar, Marwa Daccha, Ramban, Muzaffarabad, the Sindh Valley, Udbampur, Sonamarg, etc.

*Populus ciliata* is fairly gregarious outside Kashmir, too, and its occurrence as taken from authentic sheets in the herbaria may be mentioned eastwards from Kashmir in Monali and Nagni in the Kulu Valley, Kalatop at Dalhousie, Matiyana and Nagkanda in the Simla Hills, Bashahr, Mussoorie and Dharmsala; and also in gregarious patches on the China slope at an altitude of 7,000 ft. in Naini Tal.

The second well-determined Karewa species, *Populus nigra* var. *fastigiata* popularly known as "the Lombardy poplar", is not indigenous to our country and affords an excellent example of how a foreign plant has become completely naturalized to our climates. It is believed to have been introduced into India from somewhere in Western Asia where it grows wild. It also grows in Central Europe, at the present time.

In India it is cultivated in the North-Western Himalayas from Simla westwards and grows equally well in plain country at Rawalpindi. It is very common in Kashmir growing profusely here and there and occurs everywhere in the valley as a roadside tree, or often hewn down in hedges; on the surrounding mountains it occurs on the Kashmir slopes of both the

Main Himalayas and the Pir Panjal Range ascending there to the altitude of 10,000 ft. It extends well into Western Tibet, where again it is abundantly cultivated up to an altitude of 12,500 ft.

From Kashmir westwards, it is cultivated in the Kagan Valley, Hazara, Abbottabad, the Muree Hills, etc., and occurs in Baluchistan; in Afghanistan. J. L. Stewart (1874, p. 472) states that Griffith observed *P. nigra* growing in a wild state at Shekhabad near Kabul at an altitude of 7,500 ft.—a fact of great importance, which may throw some light on the origin of this species in Kashmir. The relative ease and rapidity with which the Lombardy poplar seems to have acclimatised itself to Kashmir conditions is amazing; one often finds in spring old completely cut off stumps of many trees sprouting into shoots, and sprouting of dried branches lying here and there or half buried in soil for purposes of tying cattle is not an unusual sight for those familiar with the country.

Its common associates in the Kashmir Valley are *Salix Wallichiana*, *Populus ciliata*, *Morus serrata*, *Morus alba*, *Juglans regia*, *Pyrus communis* *Prunus cornuta*, etc., etc.

Outside Kashmir, eastwards it is recorded from Pangi, Chamba and Bashahr as a cultivated tree.

The unmistakable occurrence of a good many fossil leaves of *Populus nigra* var. *fastigiata* in the fossiliferous beds of the Pleistocene Age at Ningal Nullah and the fact that this species at the present time grows so profusely in Kashmir may force one to cast a little doubt on the belief of some botanists that the species is of a recent introduction to Kashmir. If the testimony of fossil plants be accepted as trustworthy towards the solution of this question then it is clear that the theory of a recent introduction of this species to Kashmir does not hold good in the face of the above-said facts and one may tentatively suggest that the existence of this species in Kashmir, at least near Ningal Nullah, is as old as the Pleistocene times.

May be that *Populus nigra* var. *fastigiata* had become extinct in Kashmir at the close of Pleistocene times and it had now spread all over the valley like a wild fire in a few years time after its recent introduction to this region on account of the fact that it had found most congenial conditions for its rapid growth; but this statement is as difficult to prove as to disprove at the present time and we may have to wait till we get further evidence to prove our contention. It may be worth while to mention that the Lombardy poplar has not flowered in Kashmir and is propagated solely by vegetative methods.\*

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\* Since this was written the author (1945) has sent a paper to *Indian Forrester* in which he has proved that the Lombardy poplar is indigenous to the Kashmir Valley.

## GENERAL FOSSIL DISTRIBUTION OF THE SALICACEÆ

A good many fossil species of the Salicaceæ based mostly on leaves, or catkins, closely allied to, or identical with modern species, have been discovered from the Northern Hemisphere. They occur in great abundance, among the rocks ranging in age from the Pleistocene to the Cretaceous. We find innumerable references to the fossil Salicaceæ in the treatises dealing with the Tertiary Floras of America and Europe, also in Asia, though the Tertiary Floras of this vast continent are still very imperfectly known. A detailed account of the fossil history of the Salicaceæ, which deserves a separate paper to itself, is outside the scope of the present work and may be reserved for a later occasion.

In spite of the availability of a vast literature dealing with the Salicaceæ, the question of its palæogeographic distribution and its original home still remains undecided because there exists a great confusion on the validity of certain fossil species. The earlier students of Tertiary Floras being unaware of the ecological methods in plant determinations either wrongly identified fossil species, or gave widely unrelated generic names to undoubtedly Salicaceous leaves. Such unfortunate examples of erroneous interpretations are by no means confined to the Salicaceæ. Similar mistakes have been made in other Dicotyledenous families included in the Tertiary Floras of America and Europe. To repeat with Graham (1939, p. 124), "Much of the published information regarding the geographic and temporal distribution of the various plant groups in past ages is unquestionably incorrect, and many evolutionary trends have been obscured by these same faulty records".

Although the palæogeographical distribution of the Salicaceæ is still imperfectly known there is evidence to show, as Rendle (1938, p. 9) believes, that the family had a wider distribution in Tertiary times than it has to-day. Fossil remains of *Salix*, mostly leaves and catkins, have been discovered in Tertiary localities within the Arctic Zone and most northern regions of America and Europe, showing that the family once extended, probably, to more northerly regions in the past than it does at present. Similarly, fossil leaves belonging to *Populus* also have been discovered in the same formations in the Arctic Zone, although poplars are unknown in these regions at the present time.

The Karewa species (excepting *Salix* sp. A and *Salix* sp. C) were discovered at the Ningal Nullah locality, the fossil flora of which is remarkably different from that of the other fossiliferous localities in having an assemblage of purely temperate species.

## DISCUSSION

The fossil occurrence at Ningal Nullah of a few well-determined species of the Salicaceæ, which are fairly abundant in the modern flora of the Kashmir Valley to-day, may indicate that this part of the valley, at least, had at one time in the past enjoyed a cooler climate essentially similar to what we find at the present time along the northern slopes of the Pir Panjal Range and the south-eastern end of the Kashmir Valley at an altitude of about 7,000 ft. above sea-level. This conclusion, which in this paper is primarily based on the evidence of fossil Salicaceæ, is nevertheless supported by the discovery, at the same locality, of several other species. A comparison between the past and present distribution of these species, whether considered individually, or collectively, as a whole, seems to indicate in unmistakable terms that cooler climates had once existed in Ningal Nullah in the past also, and that the climate of this part of the valley has probably remained unchanged since the Pleistocene.

To mention a few of the other species collected from Ningal Nullah we find that *Juglans regia*, *Acer Cæsium*, *Pyrus Malus*, *Aesculus indica*, *Rhamnus purpurea*, *Prunus cornuta*, etc., are the past as well as the present associates of the fossil Salicaceæ in the forest flora of Kashmir. A flora composed of these fossil species, at the present time, grows along the northern slopes of the Pir Panjal Range and flourishes between the altitudes of 7,000 and 8,000 ft., though some of the species may extend to even higher altitudes of 10,000 ft. or more. The fossil species have been discovered from the beds, which are now lying at an elevation of 9,000 ft. Comparing the past and present altitudinal ranges of the flora we find that there is hardly a significant difference between the two. One might very well infer from the terrestrial element alone that the fossil flora was probably deposited at the same altitudes at which it is now discovered. But the occurrence in the same beds in an heterogenous mixture with terrestrial plants of a leaf fragment of *Nelumbo nucifera* (Puri, 1944) and a few parallel-veined bits of plants comparable to living leaves of more than one species of *Sparganium* and *Typha* (see Puri, 1941, pp. 7-8) alters the evidence considerably. We have to take into account the modern distribution of these species, which are common aquatic plants of the Kashmir lakes and have never been seen growing in this region at altitudes higher than 5,200 ft.—the present elevation of the valley.

In the light of the above facts it seems there is a little room for doubt in concluding that the fossil plants discovered from Ningal Nullah were deposited at lower elevations—about 5,200 ft. above sea-level—and that the

beds had since been uplifted and elevated to these higher altitudes by the Pleistocene Himalayan uplift, which affected the whole of the Karewa Series. The occurrence in the fossil beds of some of the terrestrial plants represented among the fossil flora, which are now growing at the altitude of 8,000 ft., or higher, may be explained by assuming that they must probably have been washed down by streams flowing through the forest into the Karewa Lake.

#### THE SIGNIFICANCE OF TEMPERATE SPECIES IN THE FOSSIL FLORA

The Karewa floras hitherto discovered at other localities are principally composed of such fossil species, which, at the present time, are common trees of sub-tropical or tropical rain forests of the outer Himalayan ranges. The occurrence at Ningal Nullah of the Salicaceæ and other fossil species (in a more or less pure assemblage), which are now inhabiting cooler and moister aspects of the Kashmir Valley, is highly significant. As already stated, it indicates that this part of the valley during the Pleistocene times had probably experienced a temperate climate not very different from those that now prevail near the fossiliferous outcrops.

It is interesting to find that at Laredura (another outcrop at a distance of about five miles from Ningal Nullah) at an altitude of 6,000 ft. above sea-level there occurs a different type of flora composed mainly of three dominant species of oaks, namely, *Quercus semecarpifolia*, *Q. dilatata*, and *Q. Ilex* and many other less important species, e.g., *Carpinus viminea*, *C. faginea*, *Fraxinus xanthoxyloides*, *Olea glandulifera*, *Engelhardtia Colebrookeana*, etc. These species are unrepresented in the modern flora of the Kashmir Valley or the northern slopes of the Pir Panjal Range; but they instead, form an important floristic formation in tropical montane forests. While the dominant species of this flora are conspicuous by their absence from the Kashmir Valley to-day, there are quite a few other fossil species, namely, *Aesculus indica*, *Rosa Webbiana*, *Ulmus Wallichiana*, *U. laevigata*, *Betula utilis*, *Desmodium tiliæfolium*, etc., which are still growing in these regions. This flora, as we shall see presently, is intermediate between the Ningal Nullah and Liddarmarg floras.

The fossil flora discovered from a third locality (Liddarmarg) is still more different in species from that of Ningal Nullah and indicates a climate of a pronounced sub-tropical nature. Here among the dominant plants of *Quercus incana*, *Q. glauca* and some members of the Lauraceæ, namely, *Machilus Duthiei*, *M. odoratissima*, *Litsea lanuginosa*, we find other less common species, e.g., *Buxus papillosa*, *B. Wallichiana*, *Acer oblongum*, *Ficus Cunia*, *Phoebe lanceolata*, etc. All these species are absent from the

valley at the present time but on the other hand they constitute an important element of the sub-tropical rain forests of the outer Himalayas.

It is interesting to note that the three fossiliferous localities, which have yielded three different fossil floras—the first indicating a cooler climate and the other two seemingly tropical and sub-tropical in their climatic aspects—are assigned the same geological age by De Terra (see De Terra and Paterson, 1939, pl. 55), who also stated that the floras preserved at these localities were deposited during the First Interglacial Period in the Himalayas.

With a view to understand the past climatic conditions of these regions let us reconstruct some of the important topographical features of the valley during the Pleistocene. The fossil plants provide ample evidence to show that the Pir Panjal Range, which now extends along the southern border of the valley, forming a formidable barrier to summer monsoon winds, was, at a time when oak forests were flourishing in these regions represented by a low ridge, over which the tropical and sub-tropical elements present in the fossil floras had extended into those parts from where they are absent to-day. The subsequent uplift of this range brought about important changes in the climate and vegetation of the valley, which was now cut off from the water-laden monsoon winds and thus furnished congenial conditions for the growth of temperate species in place of tropical plants, most of which became extinct from the northern slopes of the Pir Panjal Range and are, therefore, unrepresented in the modern flora of this region (Puri, 1943, pp. 128-31).

The discovery of temperate species among the deposits of the same age exposed at Ningal Nullah which indicates a cooler climate, is really interesting and it may raise a pertinent question to explain how during the same phase of the Pleistocene, the three fossil floras, discovered from three different localities (now situated within a radius of about 30 to 35 miles), were growing on the northern slopes of the Pir Panjal Range contemporaneously at adjacent places? If we presume that the three floras belong to the same Interglacial Period the difference in the specific composition of the three floras may be attributed to other causes, some of which may be local variations in topography, soil, proximity of the lake, climate, etc. But it may also be possible to suggest that they were growing in different Interglacial Periods.

In view of the fact that a part of the work on this collection is still to be completed it may seem premature to offer comments in favour of any probability at this stage, therefore, a detailed discussion of this question is reserved for a later occasion.

## SUMMARY

1. Nine fossil species of the Salicaceæ are described from leaf impressions among the material collected partly by R. R. Stewart in 1936 and partly by the author in 1940 from a few spots from the Ningal Nullah locality lying near Botapathri at an elevation of 9,000 ft. above sea-level ; the strata are exposed on a wide grassy meadow on the right bank of Ningal Nullah stream. The fossiliferous beds belong to the Lower Karewa Series and are Pleistocene in Age.

2. Of the nine species described in this paper there are four, namely, *Salix Wallichiana*, *S. denticulata*, *Populus ciliata* and *P. nigra* var. *fastigiata* which are fully determined, the remaining five incompletely determined species include three belonging to *Salix*, which could not be identified specifically on account of the fragmentary nature of the plant material; and two distinct species of *Populus*, that do not seem to resemble any modern Himalayan species.

3. All the fully determined species are represented in the modern flora of the Kashmir Valley, and *Salix Wallichiana* occurs at the present time in temperate parts of the Himalayas from Kurram Valley (alt. 10-12,000 ft.) through Kashmir to as far east as Garhwal (alt. 12,500 ft.), Nepal and Bhutan. It also occurs in moist places in the inner dry valleys of Pangi and Kagan. *Salix denticulata* is commonly found in the north-western Himalayas extending eastwards also like the first species, from the Kurram Valley to Western Nepal. *Populus ciliata*, the common Himalayan poplar, also grows in temperate regions between the altitudes of 4,000 and 10,000 ft., from the Kagan Valley through Kashmir to Bhutan. *Populus nigra*, var. *fastigiata* which is wild in Kabul is believed to be cultivated at the present time in the Western Himalayas up to the altitude of 12,500 ft.

4. A comparison of the past and present distribution of the well determined fossil species, which are still growing in the Kashmir Valley near the fossiliferous region at the present time indicates that this part of the valley, at least, at one time during the Pleistocene had probably enjoyed a temperate climate essentially similar to modern climate of the valley, and this would have allowed the growth of temperate species like *Juglans regia*, *Rhamnus purpurea*, *Prunus cornuta*, *Pyrus Malus*, *Acer Cæsium*, etc., all of which are the present as well as the past associates of the Salicaceæ.

5. Though the terrestrial element of this flora as a whole does not indicate in clear terms that the uplift of the fossiliferous beds had taken place after their deposition, the presence among them of an aquatic element represented by a leaf fragment of *Nelumbo nucifera*, and some parallel-veined



leaf fragments comparable to modern species of *Sparganium* and *Typha*, shows beyond doubt that the beds had been uplifted by the Pleistocene Himalayan Orogenies.

6. While discussing the significance of temperate species in this flora it is pointed out that the other two floras discovered at Laredura and Liddarmarg indicate a prevalence in the valley, during the Pleistocene, of tropical or sub-tropical climate opposed to a cooler climate indicated by the Ningal Nullah species.

7. The causes of the occurrence during the Pleistocene of three different floras on the northern slopes of the Pir Panjal Range of that time contemporaneously at three localities are also hinted at but a fuller discussion of this question is reserved for a later occasion.

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## EXPLANATION OF PLATES

The figures are from untouched photographs and specimens are preserved in the Botany Museum, University of Lucknow. They are of natural size where otherwise stated.

PLATE V. *Salix Wallichiana* Anders.

- Fig. 1. Fossil leaf impression. R. R. Stewart collection, 1935, Registered No. N 132, Ningal Nullah (alt. 9,000 ft.), Pir Panjal Range, Kashmir Valley, *Karewa Series (Pleistocene)*.  
 Fig. 2. A part of the leaf enlarged to show details of venation.  $\times$  Ca. 5.  
 Fig. 3. Living leaf for comparison with the fossil.

*Salix* sp. A

- Fig. 4. Fossil leaf impression. R. R. Stewart collection, 1935, Registered No. N 203, Ningal Nullah.  
 Fig. 5. A part of the leaf (Fig. 4) enlarged to show details of venation.  $\times$  Ca. 5.

*Salix elegans* Wall.

- Fig. 6. Fossil leaf impression. R. R. Stewart collection, 1935, Registered No. N 20, Ningal Nullah.  
 Fig. 7. A part of the leaf (Fig. 6) enlarged to show details of venation.  $\times$  Ca. 5.

*Salix* sp. C

- Fig. 8. Fossil leaf impression. G. S. Puri collection, 1940, Registered No. Loc. 1 N 10, Ningal Nullah.

PLATE VI. *Salix elegans* Wall.

- Fig. 9. Fossil leaf impression. G. S. Puri collection, 1939, Registered No. L 150, Laredura (The piece of twig lying near the base of the leaf does not seem to belong to it).

*Salix* sp. B

- Fig. 10. Fossil leaf impression folded on itself at the middle. G. S. Puri collection, 1939, Registered No. L 600, Laredura (alt. 6,000 ft., Pir Panjal Range), Kashmir Valley, *Karewa Series (Pleistocene)*.  
 Fig. 11. A part of the leaf (Fig. 10) enlarged to show details of venation.  $\times$  Ca. 5.  
 Fig. 12. A part of the leaf (Pl. V, Fig. 8) enlarged to show details of venation.  $\times$  Ca. 5.

*Populus ciliata* (?)

- Fig. 13. Fossil leaf impression. R. R. Stewart collection, 1935, Registered No. N 100, Ningal Nullah.

*Populus ciliata* Wall.

- Fig. 14. Modern leaf partly rotted in water for comparison with the fossil leaves (Pl. VI, Fig. 13 and Pl. VI, Fig. 15).

PLATE VII. *Populus ciliata* Wall.

- Fig. 15. Fossil leaf impression. G. S. Puri collection, 1941, Registered No. Loc. I N 15, Ningal Nullah.

*Populus nigra* Linn. var. *fastigiata* Desf.

- Fig. 16. Fossil leaf impression. R. R. Stewart collection, 1935, Registered No. N 172, Ningal Nullah.  
 Fig. 17. Fossil leaf impression. R. R. Stewart collection, 1935, Registered No. N 50, Ningal Nullah.  
 Fig. 18. Modern leaf partly rotted for comparison with the fossils (Figs. 16, 17).

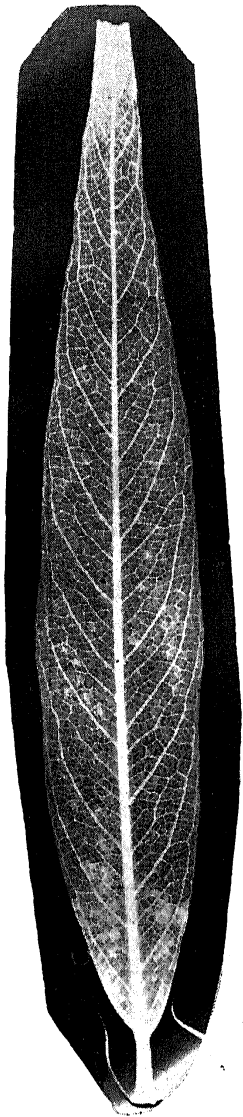
*Populus* sp. A

- Fig. 19. Fossil leaf impression. G. S. Puri collection, 1941, Registered No. Loc. I N 45, Ningal Nullah.  
 Fig. 20. A part of the fossil leaf (Fig. 19) enlarged to show details of venation.  $\times$  Ca. 5.

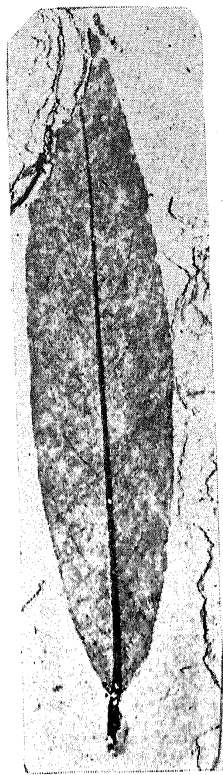
PLATE VIII. *Populus* sp. B

- Fig. 21. Fossil leaf impression. R. R. Stewart collection, 1935, Registered No. N 150, Ningal Nullah.  
 Fig. 22. Counter-part of fossil leaf (Fig. 21) broken and slightly smaller than N 150.  
 Fig. 23. A part of the leaf (Fig. 22) enlarged to show details of venation.  $\times$  Ca. 5.

2×Ca. 5



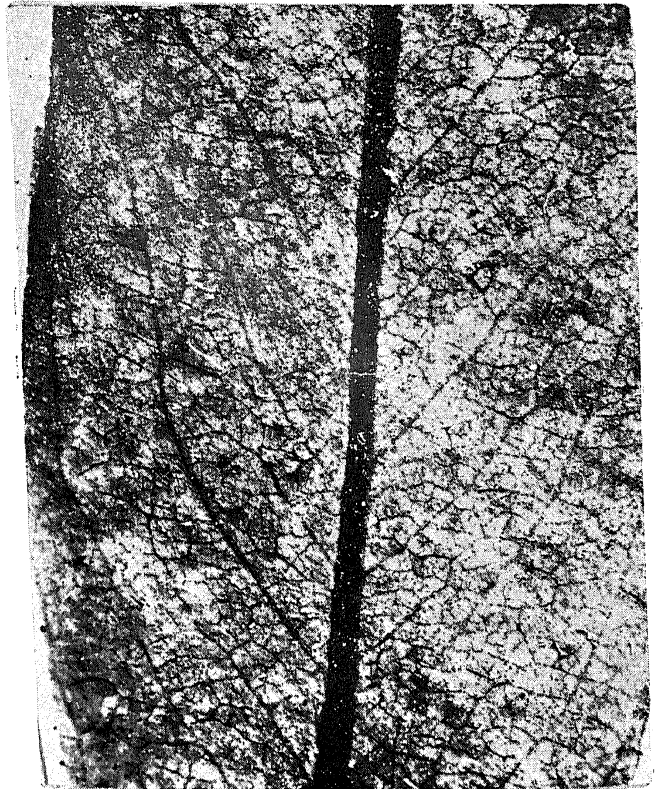
3



1



4



6



8

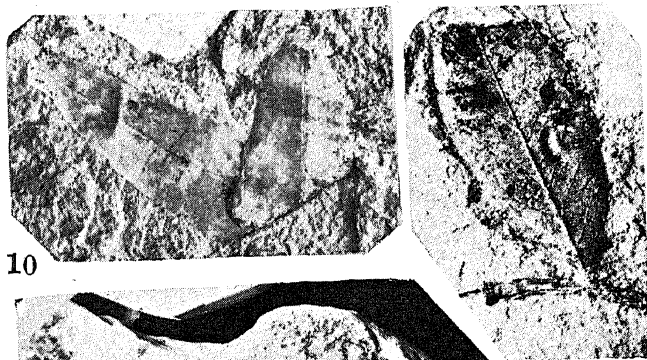


7×Ca. 5



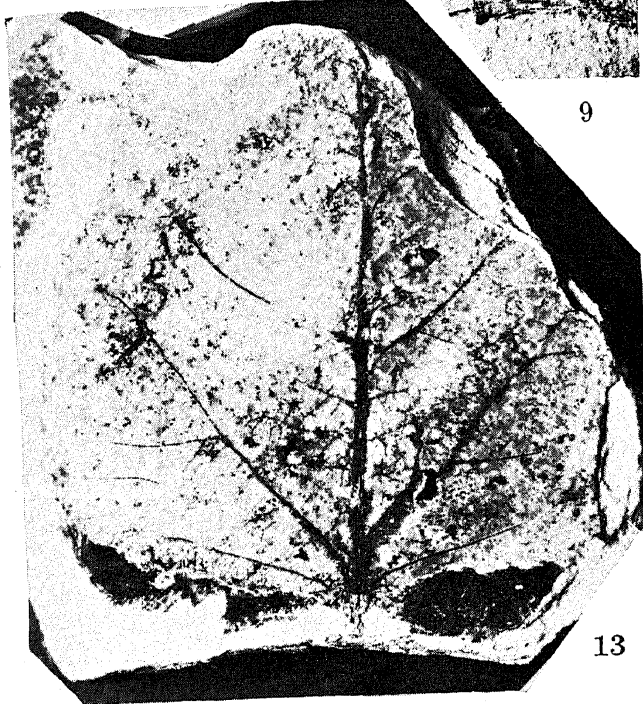
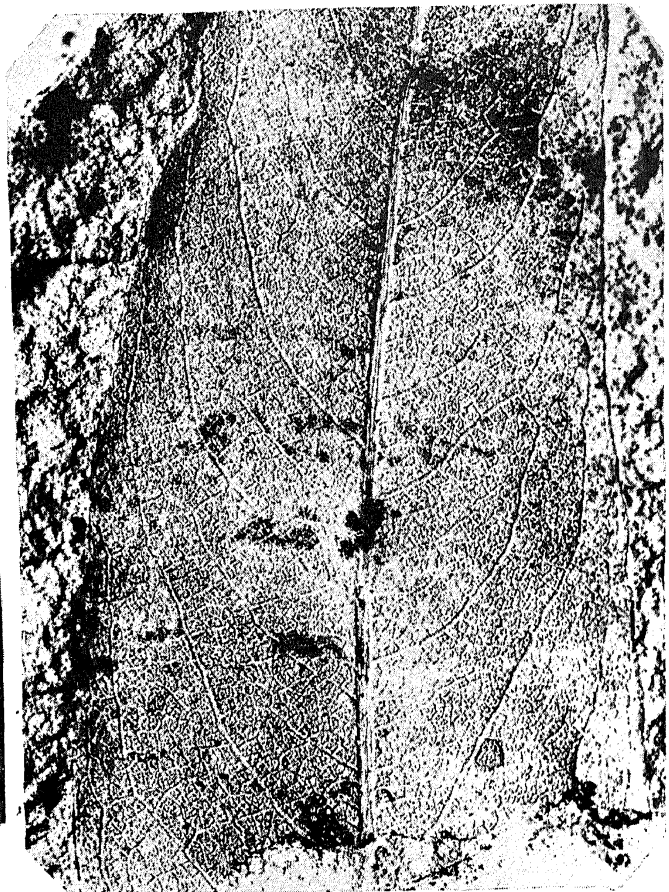
5×Ca. 5

11×Ca. 5

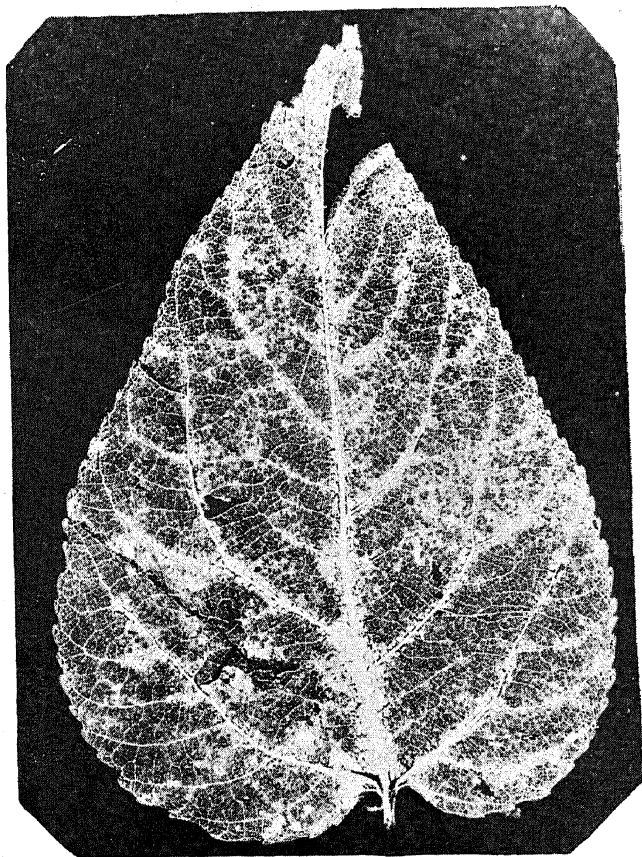


10

9



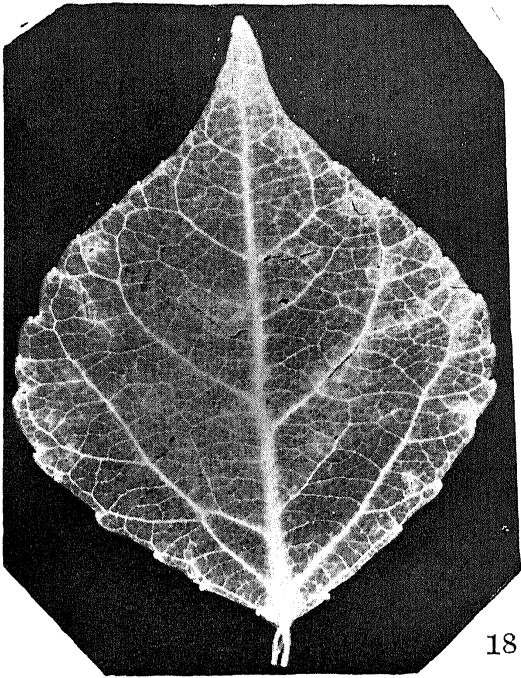
13



14



12×Ca. 5



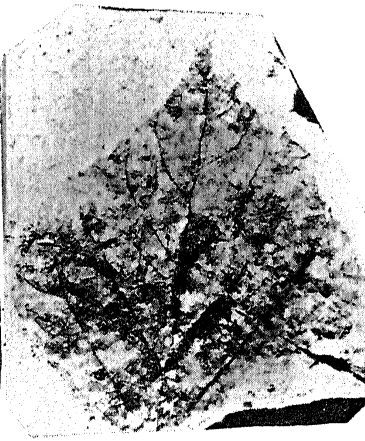
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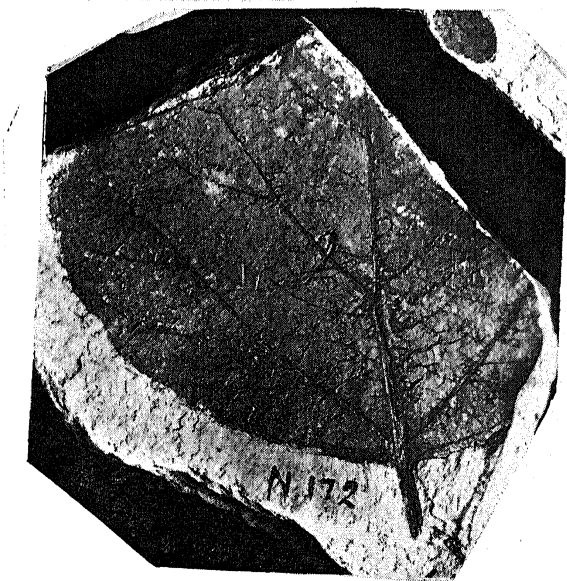
15



19



17



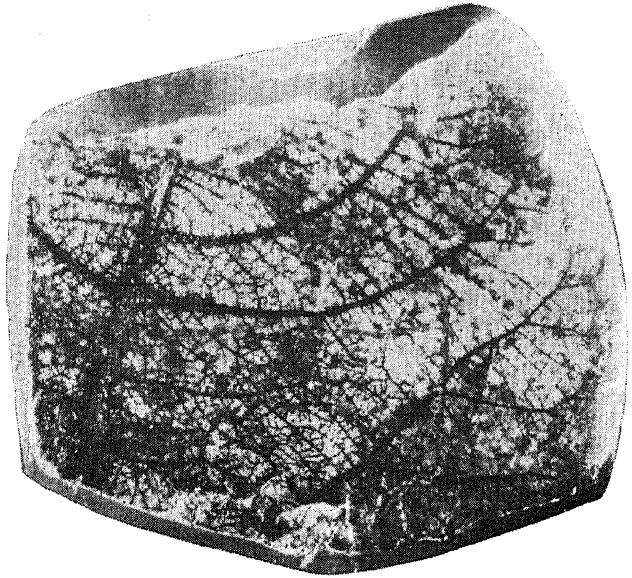
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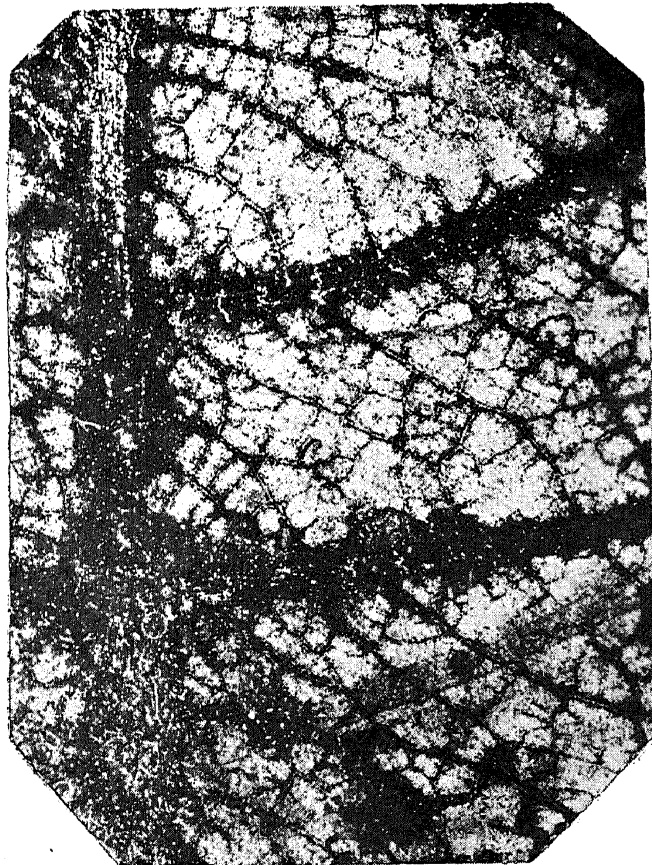
20 × Ca. 5



21



22



23 × Ca. 5