THE GENUS *QUERCUS* IN THE KAREWA DEPOSITS OF KASHMIR, WITH REMARKS ON THE OAK FORESTS OF THE KASHMIR VALLEY DURING THE PLEISTOCENE

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(With Four Plates)

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INTRODUCTION

THE Lower Karewa Series of Kashmir, which are probably the best preserved Pleistocene deposits of India, have yielded, in recent years, from more than a dozen localities a rich fossil flora comprising mainly of Dicotyledonous families; however, some Monocotyledons and other plant groups, namely, Coniferales, Filicales and fresh-water algæ are also represented (Puri, 1939). The microscopic remains have been studied in some detail and about a hundred species of diatoms have been identified by Conger (see de Terra and Paterson, 1939, pp. 120–22) and fifteen species are described by Iyengar and Subrahmanyan (1943) from the Karewa shales; in addition to these, Wodehouse (1935) has described pollen grains of a dozen

species from a few pieces of clay sent to him by Dr. H. de Terra, the leader of the two Karakoram Expeditions to India in 1932 and 1935. A large number of specimens of an alga are identified with *Botrydium*; a detailed account of this interesting form is in preparation as a joint paper with Mr. Rama Nagina Singh of the Benares Hindu University.

Dr. de Terra presented a major part of his collections of the first Expedition, made at Liddarmarg (lat. 33° 48′; long. 74° 39′; alt. 10,600 ft.), Gogajipathri (lat. 33° 51′;long. 74° 41′; alt. 8,800 ft.) and Dangarpur (lat. 34° 8′; long. 74° 20′; alt. 6,500 ft.) to the Lucknow University for investigation under Professor B. Sahni, F.R.S. Prof. Sahni had originally entrusted the material to the late Dr. S. K. Mukerji, Reader in Botany at the University, and the latter before his death in 1934 was able to identify thirteen genera of fossil leaves, which were announced by de Terra (see Wodehouse and de Terra, 1935, p. 1) and later by Prof. Sahni (1936, p. 12) in an important paper giving a short account of the Karewas.

Although the macroscopic plant remains were known to occur in the Karewa deposits some 85 years back (Godwin Austen, 1859), no attention was paid to study this interesting flora till 1910 when the late Mr. C. S. Middlemiss (1911, p. 122) with the help of I. H. Burkill reported the occurrence of five different genera including *Quercus* from his collection from Liddarmarg.

All this material, which was unsatisfactorily examined before (see Puri, Paper I, unpublished in the Thesis) was later acquired by Prof. Sahni for investigation by the author, who later on supplemented it with his own collections from Laredura, Dangarpur and Botapathri. Further material was collected by Prof. Sahni in 1934 and 1936 from Dangarpur, Botapathri and several other localities; Dr. R. R. Stewart also made another collection from Laredura in 1936; thus all the material now comprising several thousand specimens which have so far been collected from the Karewas, have been made available to the author for study.

The present paper is devoted to the description of fossil leaves of *Quercus*, which on account of its best representation in the Karewa flora, both qualitatively and quantitatively, deserves a separate paper to itself.

I am highly indebted to Professor B. Sahni, F.R.S., for his guidance and helpful criticism during the preparation of this paper. Apart from the scientific guidance I have freely received other help from him without which this paper would never have been completed, for all that I take this opportunity of expressing my deepest debt of gratitude to him.

It is a pleasure to thank Dr. R. R. Stewart of the Gordon College, Rawalpindi, to whom I owe a great deal of my knowledge of the forest flora of the N. W. Himalayas and many a tips in identification of fossil leaves of *Quercus*. I am also grateful to Dr. N. L. Bor, formerly the Forest Botanist at the Forest Research Institute, Dehra Dun, and his assistant Mr. M. B. Raizada for help and facilities during my work at the Herbarium.

For loan of Middlemiss's collection and some photographs of *Q. glauca* and *Q. incana* from this material I am thankful to the Director, Geological Survey of India.

I must thank the Vice-Chancellor of the Panjab University and Principal Jodh Singh of the Khalsa College, Amritsar, for research grants from the University and the College and the authorities of the Lucknow University for award of a Research Fellowship. I am glad to acknowledge the help my wife has given me in correcting the proofs.

Plant-bearing Outcrops

Locality L.—Laredura, near Dangarpur, seven miles from Baramulla towards Gulmarg, height about 6,000 ft. above sea-level.

Locality 1 *D.*—One furlong east of Dangarpur village, at a steep cliff, 6,300 ft. above sea-level.

Locality 2 *G.*—Gogajipathri, one and half furlong towards the north of the upper houses at the village of that name, at 8,800 ft. altitude.

Locality 3 *L.*—Liddarmarg, in the stream bed 500 ft. west of the shepherd's huts, the beds dip 6 degrees north-east and are at 10,600 ft.

Locality K 14/948.—Liddarmarg, in two stream beds near the present Gujar (herdsmen) encampment, the dip of the beds is of the usual slightly inclined character, the altitude is 10,600 ft. above sea-level.

Locality B.—Botapathri, about 5 miles South of Dangarpur; the beds are exposed in a stream bed at an altitude of 9,500 ft. on south-west of the main huts of the village (Botapathri).

Systematic List of the Species

Quercus semecarpifolia Smith.
Quercus dialatata Lindl.
Quercus Ilex L.
Quercus incana Roxb.
Quercus glauca Thunb.
Quercus sp.

DISTRIBUTION OF THE SPECIES IN SPACE IN THE KAREWAS

Species	Laredura alt. 6.000 ft.	Dangarpur alt. 6,300 ft.	Gagajipathri alt. 8,800 ft.	Liddarmarg alt. 10,600 ft.	Botapathri alt. 9,500 ft.
Q. semecarpifolia	×	×	×		
Quercus dilatata	×	×	×		
Quercus Ilex	×	×	×		
Quercus incana				×	×
Quercus glauca				×	×
Quercus sp.				×	

DESCRIPTION

Family Fagaceæ

The family is represented in the Karewa flora by leaf impressions, which are identified with five well determined modern species of *Quercus*; in addition to leaves, there is also present one specimen of an impression from the outer flattened surface of a cupule, which also belongs to a species of *Quercus*. The Fagaceæ is one of the most important fossil families represented in the Karewa Formations. Oak leaves constitute nearly half of the entire fossil plant material from the Karewas, and they are found in great abundance at five different localities, which are not only distantly situated, but also lie at different altitudes.

It may be interesting to point out that fossil leaves of the three species—*Quercus semecarpifolia* Smith, *Quercus Ilex* L., and *Quercus dilatata* Lindl.—are found in hundreds in the beds that are exposed at Laredura (6,000 ft. to 6,500 ft. altitude), Dangarpur (6,300 ft. altitude), and Gogajipathri (8,800 ft. altitude), while the remaining two species, *viz.*, *Quercus incana* Roxb. and *Quercus glauca* Thunb. have not yet been discovered at these localities; however, they form a major part of the material which I have examined from Botapathri (9,500 ft. altitude) and Liddarmarg (10,600 ft. altitude); the first three species are not found at these two localities.

It may also be pointed out here that the five species, which during the Pleistocene times were probably growing in pure forests in this part of Kashmir, do not form a part of the present-day flora of the valley or the neighbouring hills of the Pir Panjal, but they have taken to the more favourable outer ranges, which receive heavy rains from the monsoon. This fact not only points out a contrast between the climatic conditions, that prevailed in the valley then and now but also throws considerable light on the past and present distribution of the Kashmir forests.

1. *Leaves*

Genus Quercus

Quantitatively, as well as qualitatively, *Quercus* is the best represented genus in the Karewa flora. Every other leaf in the entire material is an oak. In all the localities where it is found, it dominates over all other genera. Its representation in the Laredura beds is about 55% ; 60 to 70% of the specimens from Dangarpur and Gogajipathri belong to it, and it has the amazing percentage of 75 in the collections from the Liddarmarg clays. The only other genus which can at all compete with it in numerical strength is *Trapa*. The former is represented by leaves and the latter by fruits.

The specific determination of fossil leaves of *Quercus* is a difficult task because the living species exhibit an extreme range of variation in shape, size, nature of margins, base and apex within a species. Sometimes the variations are so bewildering that it becomes difficult to recognise normal variations within a particular species. Fortunately a large amount of well preserved fossil material was available and an intensive study of modern leaves belonging to numerous species of the genus both in the Herbarium and in the field has facilitated the identification of the fossil forms.

The fossil leaves of *Quercus semecarpifolia* Smith. and *Quercus Ilex* L. are usually not well preserved as regards details of the tertiary and finer reticulations; this may be partly due to the fact that the living leaves of these species have an indistinct and immersed venation, which is not well marked on either surface of the lamina. In the remaining three species, though the leaves are also quite thick, the venation is well marked on the lower surface and a few well preserved fossil leaves show up the venation quite clearly. The fossil leaves of *Quercus dilatata* Lindl. are usually the best preserved as regards venation and quite a few complete fossil leaves may be favourably compared to living leaves in this respect.

KEY TO THE SPECIES

I. Leaves oblong-lanceolate, regularly cuspidate serrate, venation strict-pinnate .. .. .. *Q. incana.* *Q. glauca.*

(i) Serrate to the base, laterals 12–20 pairs, generally 15–17 .. .. *Q. incana* (4)

(ii) Serrate from the middle, laterals 10–14 pairs generally 12–13 .. .. *Q. glauca* (5)

II. Leaves elliptic-oblong, ovate, oval-oblong, or ovate-lanceolate, entire or coarsely spinous-toothed, venation pinnate or pinnate-looped .. *Q. dilatata*
Q. semecarpifolia
Q. Ilex.

(iii) Venation conspicuously pinnate-looped, laterals 8–12 pairs, generally 10, thin and fine, tertiaries and finer reticulations conspicuous .. .. *Q. dilatata* (2)

(iv) Venation pinnate, laterals 4–6 pairs, upper 3 or 4 secondaries in toothed leaves form a sort of corymb, laterals intermediate in thickness between *Q. dilatata* and *Q. semecarpifolia* and tertiaries and finer reticulations somewhat conspicuous .. .. *Q. Ilex* (3)

(v) Venation faintly pinnate-looped, immersed, laterals 8–9 pairs and thickest of all species, tertiaries and finer reticulations mostly obscure .. .. .. *Q. semecarpifolia* (1)

(1) *Quercus semecarpifolia* Smith.

(The 'Karshu' Oak)

(Plate XV, Figs. 1–7 and Pl. XVI, Figs. 9, 10)

The fossil leaves figured here are of different sizes and also show a good deal of variation in shapes of the lamina, which may be elliptic-oblong, ovate, oblong-ovate or obovate in outline. Apex may be acute or rounded. Base is usually narrower, which may be tapering or rounded; in one specimen (Pl. XV, Fig. 4) it is slightly cordate. The margins are entire. (In some living leaves and a few badly preserved fossil leaves not figured here, the margins are cuspidately serrate varying from one tooth to an entirely toothed margin). A small thick petiole measuring about ·5 inch in length is preserved in one specimen (Pl. XV, Fig. 1).

The venation is strict-pinnate and reticulate. A strong midrib runs in the lamina making a deep groove in some (Pl. XV, Figs. 2, 4), which are evidently impressions from the lower surfaces of leaves; in others (Pl. XV, Figs. 1, 7), which are probably impressions from the upper surface, the midrib does not leave a groove. Usually it runs straight in the lamina gradually thinning out towards the apex and in figured specimens it seems to divide the lamina into slightly asymmetrical halves. 6 to 8 secondaries, which are about half as thick as the midrib, diverge from it on either side at different angles; the latter varying from obtuse to slight obtuse and sometimes to a

little acute angle in the figured specimens. Generally the lower and the upper secondaries come off at almost the same angles but occasionally one or two upper pairs of laterals may depart at slightly acute or open angles than the lower. The secondaries may fork either near the margins or far below in the lamina (Pl. XV, Figs. 1, 3); but sometimes they may curve upwards and end in the margins without forking (Pl. XV, Fig. 4). The forking is mostly indistinct but in some laterals (see Pl. XV, Fig. 1) it is very distinct and characteristic. Tertiaries are obsolete in the fossils, which are impressions from the upper surfaces, and they are very faintly visible in those, which represent the impressions from the lower surface. They seem to be arising at right angles from the secondaries (Pl. XV, Figs. 4, 5). These anastomose to form more or less cross-ties in the area between the two laterals (Pl. XV, Fig. 4). Finer reticulations are not visible in any of the specimens.

Our fossil leaves are identical in all respects with living leaves of *Quercus semecarpifolia* Smith., a large evergreen tree of the Western Himalayas, which is known in these regions as "Karshu oak" or "Kharshu" in vernacular language.

Number of specimens—About one hundred.

Occurrence—Laredura at 6,000–6,500 ft., Dangarpur at 6,300 ft. and Gogajipathri, at 8,800 ft., in the Pir Panjal Range, Kashmir.

Collectors—H. de Terra, B. Sahni, R. R. Stewart and G. S. Puri.

Registered Nos. of figured specimens: Pl. XV, Fig. 1 = L 165;
Fig. 2 = L 562; Fig. 3 = L 590; Figs. 4, 5 = L 624/3;
Fig. 6 = L 184; Fig. 7 = Loc. 1D/26; Pl. XVI, Fig. 9 = L 521;
Fig. 10 = L 344.

(2) *Quercus dilatata* Lindl.

"The Moru Oak"

(Plate XVI, Figs. 11–17; Pl. XVII, Figs. 19, 20)

The fossil leaves belonging to this species are usually oblong, oblong-ovate or elliptic-oblong in outline. They vary a good deal in size ranging from 1·1 by ·55 inch (see Pl. XVII, Fig. 19) to 2·8 by 1·2 inches (Pl. XVI, Fig. 12). Base may be rounded, ovate or narrowed and oblique. Apex is always acute. The margins are entire, or coarsely cuspidate-serrate (Pl. XVI, Fig. 17).

In two specimens, which are counterparts, there occur on the surface a few insect galls (?), which are seen in the natural size photographs as raised dots (Pl. XVI, Fig. 15) and hollow cavities (Pl. XVI, Fig. 14) respectively.

Insect galls have been occasionally seen on living oak leaves and their occurrence in the fossil state is not very unusual.

The venation is pinnate-loped and reticulate. A fairly strong midrib runs straight in the lamina gradually thinning out towards the apex. It gives off at open angles on its either side in an alternate, opposite or sub-opposite manner 8–12 secondary ribs, which are finer than the midrib, but are fairly conspicuous. In one specimen (see Pl. XVI, Fig. 12) the laterals tend to run parallel to one another. In living leaves of this species the venation, though equally conspicuous on both surfaces, is not well marked out on either, hence it is not possible to say to which surface of the leaf the fossil impression belongs. The secondaries run straight to the margins and bifurcate beneath it into two small branches, which form semi-circular loops the convex sides of which are facing the margins. The adjoining loops tend to anastomose and form an infra-marginal vein running below and parallel to the margin. This looping is characteristic of this species, and is not found in any other oak. The tertiary ribs arise from the laterals on either side at right angles, and anastomose variously about

TABLE I

Characters	*Q. dilatata* Lind.	*Q. Ilex* L.	*Q. semecarpifolia* Sm.
1. Margins ..	Thin and not recurved	Thick and mostly recurved	Thick but very slightly recurved
2. Venation ..	Equally well marked on both surfaces and prominent in the fossils	Well marked on the lower surface only and mostly obscure in fossil leaves	Well marked on the lower surface only and obscure in fossils
3. Thickness of laterals	Thinnest	Intermediate between the three	Thickest of the three oaks
4. No. of laterals	8—12 pairs	4—6 pairs	6—8 pairs
5. Nature of laterals	They bifurcate under the margins and the branches form very distinct and characteristic loops, which join to form an infra-marginal vein, running below and parallel to the margins	Some bifurcate into thick branches, which do not form loops, but end in the margins either in the marginal teeth (if they are serrate) or in the entire margins	Rarely bifurcate into thick branches. Sometimes the laterals curve upwards to form indistinct loops relatively closer to the margins
6 Tertiaries ..	Form fine cross-ties or large rectangular meshes	Form large rectangular meshes	Form indistinct cross-ties or large meshes
7. Finer reticulations	Distinct	Slightly distinct	Mostly obscure
8. Nature of the two surfaces in living leaves	Smooth on both surfaces	Smooth on the upper surface, but thickly covered with white fluffy hairs on the lower surface. Hairs are large and stellate and they do not fall off in older leaves	Smooth on the upper surface but thinly covered with long hairs on the lower surface. Hairs fall off in older leaves

midway in the area enclosed by the two laterals to form large rectangular meshes, which are seen prominently in some specimens. Finer reticulation is also clearly seen in the enlarged photographs.

Our fossil leaves are identical in all respects with *Quercus dilatata*, the second most common Himalayan species, which occurs in a well-defined elevation zone lying intermediate with the zones of *Q. semecarpifolia* and *Q. incana*.

Some of the fossil leaves, which are not well preserved are likely to be confused with leaves of either *Q. Ilex* or *Q. semecarpifolia*, therefore, striking features of these three species are given in Table I in a tabular form.

Number of specimens.—About one hundred.

Occurrence.—Laredura at 6,000–6,500 ft., Dangarpur at 6,300 ft., Gogajipathri at 8,800 ft., in the Pir Panjal Range, Kashmir.

Collectors.—H. de Terra, B. Sahni, R. R. Stewart and G. S. Puri.

Registered Nos. of figured specimens.—Pl. XVI, Fig. 11 = L416, Figs. 12, 13 = L168, Fig. 14 = L253*a*, Fig. 15 = L253*b*, Fig. 16 = L523, Fig. 17 = L692; Pl. XVII, Fig. 19 = L492, Fig. 20 = L453.

(3) *Quercus Ilex* L.

"The Holly Oak"

(Plate XV, Fig. 8, Pl. XVI, Fig. 18 and Pl. XVII, Figs. 21–25)

The fossil leaves of this oak like other species of *Quercus* also vary a good deal in shape, size and nature of margins. The shape of leaf lamina is usually oblong, however, slight variations from the type are not infrequently met with. The size varies from $\cdot 8 \times \cdot 6$ inch (Pl. XVI, Fig. 18) to $2 \cdot 6 \times 1 \cdot 5$ inches and even larger leaves are also found. Apex may be acute or broad and somewhat obtuse bearing a sharp pointed marginal tooth. Base is mostly broad, often rounded or subcordate. The margins are very variable, they may be entire, half serrate or coarsely spinous—toothed almost to the base. The teeth may be long, sharply pointed or small and blunt.

The venation is strict-pinnate and reticulate. Midrib is usually stout and thick and it has left a fairly deep groove in some leaves (Pl. XVII, Fig. 25). which seem to be impressions from the lower surface of the leaf. Plate XVII, Fig. 21 is an impression from the upper surface of a leaf. The midrib mostly runs straight in the lamina, but it may follow a zigzag course (Pl. XVII, Fig. 21). Four to six secondaries, which are about half as thick as the midrib, arise from it on either side at acute angles. The angle of origin of

the upper and the lower pairs of laterals in the same specimen may be slightly different. The lower secondaries diverge at open angles but the upper two or three pairs may arise at acuter angles. The laterals usually run straight to the margins and end in the marginal teeth in serrate leaves, but in non-serrate leaves they end in the entire margins. Some laterals, usually the upper one or two pairs, fork once or twice at different distances from the midrib. Tertiary ribs are generally not well preserved except in one specimen (Pl. XVII, Fig. 21), a part of which is enlarged to five diameters in the photograph (Pl. XVII, Fig. 22). They arise from the laterals at straight angles and anastomose among themselves variously to form large rectangular meshes. The tertiaries enclose a fine network of rectangular or pentangular meshes, which constitutes the finer reticulations.

Living or fossil leaves of *Quercus Ilex* L. have cuspidate serrate margins like *Ilex dipyrena* Wall. and *Acanthus ilicifolius* Linn. and they may be confused with these species. But a closer examination reveals important differences, which are brought out in the following table:—

Characters	*Q. Ilex* L.	*Ilex dipyrena* Wall.	*Acanthus ilicifolius* L.
1. Shape ..	Oblong or elliptic oblong	Lanceolate	Lanceolate
2. Venation ..	Fairly prominent	Rather obscure	Comparatively quite obscure
3. Midrib ..	Thick	Comparatively much thicker	Comparatively much thicker
4. Laterals-their nature and angle of divergence	Prominent and mostly forking ; acute	Less prominent and not forking ; obtuse, almost right angle	Least prominent and not forking ; obtuse like *Ilex*
5. Finer reticulations	Clear in the form of a uniform net-work of small-oval or rectangular meshes	Comparatively much less clear, consisting of wide irregular meshes	Obsolete

Our fossil leaves are identical in all respects with *Quercus Ilex*, an evergreen Himalayan shrub popularly known as "holly oak" on account of its spinous toothed leaves, which superficially resemble *Ilex* (see the above table).

Number of specimens.—About a hundred.

Occurrence.—Laredura at 6,000–6,500 ft., Dangarpur at 6,300 ft. and Gogajipathri at 8,800 ft.

Collectors.—H. de Terra, B. Sahni, R. R. Stewart and G. S. Puri.

Registered Nos. of figured specimens.—Pl. XVI, Fig. 18=L407; Pl. XVII, Figs. 21, 22=L517, Fig. 23 = L2, Fig. 24=L605, Fig. 25 = L700.

(4) *Quercus incana* Roxb.

"The Ban Oak"

(Plate XVII, Fig. 26 and Pl. XVIII, Figs. 33–34)

The fossil leaves described under this species are generally lanceolate or ovate-lanceolate in outline but like other oaks their shape and size may vary to a slight extent; the margins are invariably regularly closely cuspidate serrate. The marginal teeth, which vary in number from 11 to 14 on either side of the margin, are usually long and sharp with their sharp edges always directed upwards.

The venation is strict-pinnate and reticulate. A thick and prominent midrib, which arises from the base of the leaf, follows a slightly curved course and divides the lamina into unequal halves. 15–17 secondaries, which are almost half as thick as the midrib, diverge from it on either side at angles of 115 to 120 degrees in a sub-opposite, opposite or alternate manner. The lower 3 or 4 pairs of secondaries generally depart at somewhat obtuse, or less acute angles than the upper pairs which arise at sharply acute angles. The secondaries are equidistant; they run parallel to one another and ultimately end in the marginal teeth. In the basal part of the leaf, where there are no teeth they end in the entire margins; the number of the secondaries corresponds to the number of teeth in the serrate part of the leaf. Tertiaries are not well preserved in the figured specimens but in some unfigured fragmentary leaves they form cross-ties in the area between the two secondaries. Finer reticulation is not well preserved in any of the figured specimens.

Our fossil leaves are identical in all respects with *Quercus incana,* a moderate sized evergreen oak, which is one of the commonest trees of the Western Himalayan temperate forests.

Number of specimens.—About fifty.

Occurrence.—Liddarmarg at 10,600 ft., and Botapathri at 9,500 ft., in the Pir Panjal Range, Kashmir.

Collectors.—C. S. Middlemiss, H. de Terra, B. Sahni and G. S. Puri.

Registered Nos. of figured specimens.–Pl. XVII, Fig 26=B.1 Pl. XVIII, Fig. 34=B.2. Pl. XVIII. Fig. 33=K14/948 B.

(5) *Quercus glauca* Thunb.

(Plate XVIII, Figs. 28–32)

The leaves described below are oblong-lanceolate in shape with a narrowed base and acute apex. Leaf lamina, which is broadest in the middle,

becomes gradually narrowed towards base and apex. The margins are cuspidate serrate from the middle of the leaf, the lower part being entire. The marginal teeth, which are somewhat conical in shape, are small and blunt and their number on either side of the margin varies from 7–8.

The venation is strict-pinnate and reticulate. A strong midrib, which has left a fairly deep groove in some specimens (see Pl. XVIII, Fig. 31) that are evidently impressions from the lower surface of the leaves, runs in the lamina thinning out towards the apex. 11–12 secondaries which are about half as thick as the midrib, diverge from it on either side at angles of about 115–20 degrees. They arise from the midrib in an alternate manner and run straight in the lamina parallel to one another. These, too, like the midrib, have left deep grooves in the impressions. They end in the marginal teeth in the upper part of the leaf, but in the lower portion, where there is no tooth corresponding to a lateral, they end directly in the entire margins. Tertiary ribs are well marked and run conspicuously in the area enclosed by the two laterals. They arise from the laterals at right angles and meet about midway to form cross-ties, or large rectangular meshes (Pl. XVIII, Fig. 30). The finer reticulation is not well preserved in any specimen, but it seems to consist of a network of small meshes, which are oval or pentangular in shape.

Our fossil leaves are identical in all respects with *Quercus glauca* Thunb., a graceful Western Himalayan evergreen tree of the outer ranges.

Living and fossil leaves of *Quercus glauca* and *Quercus incana* being very similar in size, shape, venation, etc., are likely to be confused with each other. The following table is intended to give the differences by which the two species can be separated:—

Characters	*Quercus glauca* Thunb.	*Q. incana* Roxb.
I. *Living leaves*—		
(1) Size	4–7 by 1–3 inches.	Comparatively smaller 3–6 by 1·2 inches.
(2) Colour of the lower surface	Young leaves are covered on the lower surface by a few small silky hairs which fall off in older leaves. The hairs are simple and T-shaped.	White tomentose on the lower surface and thickly covered with long setllate hairs, which occur in roseltes. As many as 6-8 hairs may radiate from one hair base.
(3) Margins ..	Serrate from the middle, the lower part is entire.	Serrate almost to the base.
(4) Number of the laterals	10–14 pairs, generally, 12–13	12–20 pairs, generally 15
II. *Fossil leaves*	Of the above-mentioned characters it is clear that the first two cannot be made use of in the fossil impressions especially when the latter occur as fragments. The number of laterals also cannot be fully ascertained unless there is a complete leaf. So, the only reliable character which can help in identification of fossil leaves is the nature of the margins ; and small fragments, provided their basal part is preserved can also be identified on the character of the margins.	

Number of specimens.—About fifty.

Occurrence.—Liddarmarg at 10,600 ft. in the Pir Panjal Range, Kashmir.

Collectors.—C. S. Middlemiss, G. S. Puri and H. de Terra.

Registered Nos. of figured specimens.—Pl. IV, Fig. 28 = K14/948.*a*26. Figs. 29–30 = Loc.3L73, Fig. 31 = K14/948.*a*8. Fig. 32 = K/4/948*a*.

Cupule:

Quercus sp.

(Plate XVIII, Fig. 35)

Pl. XVIII, Fig. 35 is a natural size photograph of an impression from the outer surface of the basal cup of an oak cupule, which has become flattened during fossilisation to assume a circular shape. A spherical dot in the middle of the specimen is the impression of the basal point with which the nut must have been attached to the branch. The scaly pattern seen in the photograph is impression from the outer surface markings of the cup.

Our specimen shows a striking resemblance to a cupule of *Quercus* but its specific determination cannot be attained due to the imperfectly preserved nature of the specimen.

Number of specimen.—One.

Occurrence.—Liddarmarg at 10,600 ft., in the Pir Panjal Range, Kashmir.

Collector.—C. S. Middlemiss, 1910.

Registered No. of figured specimen.—K14/948.

General Modern Distribution of the Genus *Quercus*

The genus *Quercus*, which contains about 300 modern species, is chiefly distributed at the present time in the north temperate regions and in tropical parts of mountainous Asia; in the tropics it extends from North America through the Mediterranean countries, namely, Southern Europe, the Caucasus, etc., into Asia and thence into the Malaya Archipelago. It is conspicuous by its absense from Central and South Africa and Australasia. Quite a few species are common in Afghanistan from whence they seem to have extended into the Himalayas. The Himalayan oaks are mostly hill species; a few are sometimes found in the plains, mostly as cultivated trees.

In India we have over 50 species of *Quercus*, some of them are of great importance in Indian forestry. Of these about 24 are confined mostly to Burma, though several of these extend into the neighbouring mountains

of Assam, Chittagong and also into Manipur. Some of the Burmese species are found in the Eastern Himalayas also and out of the ten species of *Quercus* known from this region the following four—*Q. lamellosa, Q. pachyphylla, Q. lineata* and *Q. spicata*—are the most important forest trees. In the Western Himalayas we have fives pecies, of which *Q. incana, Q. dilatata* and *Q. semecarpifolia* are by far the commonest and widely distributed forest tress; the other two species are *Q. Ilex* and *Q. glauca.* The Indian oaks, with an exception of one or two Burmese species, *e.g., Q. velutina* and *Q. semiserrata,* which are found at lower elevations, are all forest trees of the Himalayan regions and a few of these ascend to very high elevations and often merge into alpine forests or reach the upper limit of tree growth. A large number of the oaks are gregarious in their occurrence and usually form pure or mixed forests—either in association with conifers, or broad-leaved trees. Several species are well characterised in their altitudinal range and succeed one another regularly at different elevations in the Himalayas. The elevation zones are well defined in the case of the three North-Western Himalayan species, namely, *Quercus incana, Q. dilatata* and *Q. semecarpifolia,* which succeed one another from the lower to the higher altitudes in the above order.

The altitudinal zones of oaks generally coincide with those of the coniferous species, which also form characteristic belts both in the Western and Eastern Himalayas. The relation between the oak and coniferous forests in the Western and Eastern Himalayas is well brought out by the following table compiled by Champion (1936, p. 230).

Western Himalayas		Eastern Himalayas	
Broad-leaved forest	Coniferous forest	Coniferous forest	Broad-leaved fores:
1. *Rhododendron campanulatum* *Betula utilis*	*Abies Webbiana*	..	*Rhododendron* spp. *Betula utilis*
2. *Q. semecarpifolia*	*Abies Pindrow*	*Abies densa*	*Q. pachyphylla*
3. *Q. dilatata*	*Abies Pindrow* *Picea Morinda* *Cedrus Deodara*	*Picea spinulosa* *Tsuga brunoniana*	*Q. pachyphylla* *Q. lamellosa*
4. *Q. incana*	*Cedrus Deodara*	*Tsuga brunoniana*	*Q. lamellosa* *Q. lineata*
5. Sub-tropical	*Pinus longifolia*	..	..

Modern Distribution of the Fossil Species

Our fossil species are the most common forest trees of the Western Himalayas; they aremainly confined to these regions, but some of them have

a much wider distribution. The areas of their detailed distribution are given below:—

(i) *Quercus semecarpifolia.*—This species, at the present time, grows throughout the outer and moister ranges of the Temperate Himalayas from Bhutan westwards between the altitudes of 8,000 and 12,000 ft. It is particularly abundant on southern aspects; in the Kurram Valley it occurs at 9,000–11,000 ft; it also extends eastwards and occurs in K. & J. Hills (Assam) at 4,200 ft., Burma–Manipur frontier at 8,000–10,000 ft., and in China. Although it is a high level species, which usually occurs in regions of high snowfall and moderate monsoon rainfall, it may often descend to 6,500 ft., and at some places it grows abundantly below 8,000 ft. Towards the top of its altitudinal range it reaches the upper limit of tree growth and touches the treeless alpine meadows either directly or merges into the alpine forests of *Betula utilis* and *Rhododendron* sp. In the dry and arid valleys of the inner Himalayas it is unknown. It forms pure forests in its well characterised zone and also occurs abundantly in the coniferous forests of *Picea Morinda, Abies Webbiana, Taxus baccata* or even *Pinus excelsa.* It also forms large forests in association with deciduous dicotyledonous trees and occurs plentifully in the broad-leaved forests composed of *Pyrus lanata, Prunus Padus, Acer Cæsium, Juglans regia,* etc., towards the lower limit of its zone; at higher elevations it is associated with *Betula utilis, Rhododendron* sp. and *Abies Webbiana.*

A rich shrubby undergrowth composed of *Rosa macrophylla, Rubus niveus, Salix elegans, Viburnum stellulatum, V. cotinifolium, V. fœtens, Lonicera quinqueloculari*s, *Strobilanthes Wallichii,* etc., usually occurs in the forest of *Quercus semecarpifolia.*

Its distribution in the north-west and central Himalayas is not a continuous one and available data from the authentic sheets of the Herbaria show that it grows in the Kurram Valley, Hazara, Bashahr, Deoban, Jaunsar, Kulu, Chamba, Dharmsala, Naini Tal, Almora District and in K. & J. Hills (Assam).

The Kashmir distribution of the species with which we are specially concerned here is confined to the outer ranges; it grows in the Kishenganga Valley at 9,000 ft., also in Keran and Ramban. It is interesting to note that it has never been seen growing in the Kashmir Valley, the northern slopes of the Pir Panjal Range and the southern slopes of the Main Himalayas.

In the "western temperate broad-leaved forests" it forms pure forests locally but is mostly associated with other broad-leaved trees, *e.g.*, at Dhakuri

in the Central Almora division at an altitude of 9,500 ft., it occurs with *Betula alnoides, Pyrus lanata, Quercus dilatata, Acer Cæsium, Abies Pindrow, Meliosma dilleniæfolia, Pyrus foliolosus, Rhododendron arboreum, Betula utilis, Rosa macrophylla, Salix elegans, Viburnum fœtens,* etc. (Champion, 1936, p. 236). At another place at an altitude of 11,000 ft., in the Garhwal Himalayas the common associates of *Q. semecarpifolia* are *Abies Pindrow, Rhododendron arboreum, Prunus Padus, Ilex dipyrena, Taxus baccata, Acer* spp., *Rosa serica, Rosa macrophylla, Cotoneaster acuminata, Salix elegans, Viburnum cotinifolium, V. stellulatum, V. fœtens,* etc. (Champion, *loc. cit.*, p. 236).

In the " western mixed coniferous forests" it grows according to Champion (*loc. cit.*, p. 242), in Deoban, Chakrata at an altitude of 8,000 ft., in association with *Abies Pindrow, Picea Morinda, Euonymus lacerus, Rhamnus purpurea, Meliosma dilleniæfolia, Rosa macrophylla, Lonicera angustifolia, Viburnum stellulatum, V. cotinifolium, Hedera, Vitis himalayana,* etc., etc. It also grows in the spruce deodar belt of the Sutlej Valley; here its associates are *Picea, Cedrus, Abies Pindrow, Pinus excelsa, Q. dilatata, Q. incana, Acer acuminatum, A. Cæsium, A. pictum, Euonymus lacerus, Taxus baccata, Betula alnoides, Viburnum nervosum,* etc., etc. (Champion, *loc. cit.*, p. 242).

In the "western oak-fir forest", which is represented at Deoban in the Chakrata division, Jaunsar, it occurs with *Abies Pindrow, Picea Morinda, Q. dilatata, Acer Cæsium, Ilex dipyrena, Rosa macrophylla, Rubus niveus, Lonicera angustifolia, Viburnum fœtens, Salix elegans, Rhamnus purpurea,* etc., etc. (Champion, *loc. cit.*, p. 245). At Pulga in the Parbatti Valley (Kulu) it occurs at an atitude of 8,500–9,000 ft. with *Abies Pindrow, Pinus excelsa, Picea Morinda, Acer* sp., *Taxus baccata, Corylus colurna, Pyrus lanata, Rosa macrophylla, Viburnum fœtens, Berberis* sp., *Indigofera gerardiana,* etc., etc. (Champion, *loc. cit.*, pp. 246–47).

Quercus semecarpifolia reaches the upper limit of tree growth and is freely met within the Alpine forests, *e.g.*, in the "Alpine fir-birch forests" of the North Garhwal it occurs with *Abies Webbiana, Betula utilis, Pyrus foliolosa, Rhododendron campanulatum, Cotoneaster acuminatum, Rosa serica, Lonicera* spp., *Rubus niveus,* etc., etc. (Champion, *loc. cit.*, p. 270).

(ii) *Quercus dilatata* Lindl.—This species called "Moru" in the vernacular, is perhaps the largest of the Western Himalayan oaks and occurs from Nepal westwards at the altitude of 7,000 to 9,000 ft. Although it grows gregariously in all situations it seems to prefer cool and moist localities and is by far the commonest on northerly aspects; temperate conditions comprising a heavy winter snowfall and a good rainfall are congenial for

its growth. In cooler places it often descends as low as 5,000 ft., but far west in the Kurram Valley on Safedkoh and in Afghanistan it commonly ascends to 10,000 ft. It grows in the Kagan Valley and is a common tree in the Murree Hills, mostly occupying northern slopes. In Chitral it occurs in cooler places at 8,900 ft.

In Kashmir, though it is common in the Kishenganga Valley, the Lower Jhelum Valley, Keran, Kishtwar, Marwa Dachhan, Muzaffarabad, Ramban and Udhampur, it has never been found in the Valley proper, the southern slopes of the Main Himalayas or the northern slopes of the Pir Panjal Range.

It occurs in the outer ranges from Jaunsar to Kulu, at Kangra, Mussoorie, Naini Tal and Tehri Garhwal.

The Moru oak forms a well-defined zone, which is intermediate in altitude between the elevation zones of *Quercus semecarpifolia* and *Q. incana.* It occurs gregariously in pure patches or forms mixed forests with conifers in the Western Himalayas and with broad-leaved trees in the Central Himalayas. The commonest conifer occurring with it is *Picea Morinda,* though *Pinus excelsa, Cedrus Deodara* and *Abies Pindrow* are also frequently associated with it; it is often accompanied by *Taxus baccata.* Amongst the commonest broad-leaved trees occurring in the *Q. dilatata* forests we have several species of *Acer—Acer Cæsium* and *A. pictum* being the most common – *Ulmus Wallichiana, Prunus Padus, Cornus macrophylla, C. capitata, Euonymus pendulus, E. tingens, Juglans regia, Corylus colurna, Betula alnoides,* and *Populus ciliata*; shrubby plants of *Viburnum, Lonicera, Rubus, Rosa, Indigofera, Desmodium,* etc., are also present as an undergrowth.

Although the altitudinal range of the "Moru" oak is fairly well defined, *Quercus semecarpifolia* and *Q. incana* frequently merge into its zone and the three are often found growing together. Such an association is described by Champion (*loc. cit.*, p. 235) from Garhwal, where the associated flora includes *Betula alnoides, Carpinus viminea, Acer Cæsium, Machilus Duthiei, Euonymus pendulus, Ilex dipyrena, Rhamnus purpurea, Eurya acuminata, Buxus Sempervirens, Litsæa umbrosa, Pieris ovalifolia, Staphylea Emodi,* etc., etc.

Quercus dilatata occurs commonly in the "western temperate broad-leaved forests" and often forms pure patches usually growing with one or more species of *Acer.* In the "*Q. dilatata—Acer* forests", which are represented at Bhatkot in the Central Almora division, it occurs with *Q. incana, Abies Pindrow, Taxus baccata, Euonymus pendulus, Ilex dipyrena, Rhamnus purpurea, Eurya acuminata, Rhododendron arboreum, Meliosma dilleniæfolia, Cedrella serrata, Pyrus lanata, Pieris ovalifolia, Machilus*

Duthiei, Fraxinus micrantha, Betula alnoides, Rosa macrophylla, Myrsine semiserrata, Berberis aristata, Hedera Helix, etc., etc. (Champion, *loc. cit.*, p. 234).

Towards the upper limit of its range it merges into the zone of *Quercus semecarpifolia* and occurs in the "Kharshu" oak forest of Dhakuri in Central Almora division (Kumaon) at an altitude of 9,500 ft.

In the moist Deodar forests, which are a part of the western temperate coniferous forests, it occurs in the Kagan Valley (Hazara) with *Cedrus Deodara, Pinus excelsa, Parrotia jacquemontiana, Viburnum nervosum,* etc. (Champion, *loc. cit.*, p. 240).

In the "western oak-fir forest" of Deoban, Chakrata, it occurs with *Q. semecarpifolia, Acer Cæsium, Euonymus lacerus, Ilex dipyrena, Rosa macrophylla, Rubus niveus, Lonicera angustifolia, Abies Pindrow, Picea Morinda,* etc. (Champion, *loc. cit.*, p. 245).

(iii) *Quercus Ilex* L., which in India is mainly confined to the inner dry tracts of the Himalayas, is an evergreen shrub of a wide distribution occurring in the Mediterranean region from southern France and Spain eastwards through Italy, Morocco, Algeria, Tunis, and extends into India through Greece and Afghanistan; the arid aspects of the hills and drier localities provide most congenial habitats for its growth.

In India it occurs in dry temperate mixed evergreen forests, which are represented in the inner dry valleys of the Himalayas above the altitude of 5,000 ft. It ascends to various elevations in different places, thus on the Sulaman range it grows at 5,000–6,000 ft., in the Kurram Valley at 6,500-9,000 ft., in Chitral at 6,000–8,500 ft., in the upper dry valleys of the Jhelum, Chenab, Ravi and Sutlej at 4,400–8,500 ft., and in the Kagan Valley at 4,500–6,000 ft. It often descends to lower altitudes and occurs at 3,500 ft., in the hills lying north of the Peshawar Valley.

In Kashmir the species is common in the lower part of the Kishenganga Valley at the altitude of 3,500–7,000 ft., and also occurs in Keran, Kishtwar, Marwa Dachhan, Muzaffarabad and Ramban; it always occupies hotter aspects.

The common associates of this oak in the Kagan Valley, where it is gregarious, are *Fraxinus xanthoxyloides, Daphne oleoides,* and *Cedrus Deodara,* but in drier regions *Pinus gerardiana* is more frequent; it mostly occurs with *Cedrus Deodara* but in Chitral *Pinus excelsa* is associated with it.

In the "dry temperate mixed evergreen forests" of Kilba, upper Bashahr division, *Quercus Ilex* occurs in association with *Pinus gerardiana, Cedrus*

Deodara, Acer pentapomicum, Celtis australis, Fraxinus xanthoxyloides, Rhus succedanea, Parrotia jacquemontiana, Olea cuspidata, Zanthoxylon alatum, Daphne oleoides, Rosa Webbiana, Lonicera angustifolia, etc., etc. (Champion, *loc. cit.*, p. 254).

In upper Kagan Valley, Hazara, it grows with *Juniperus macropoda, Fraxinus xanthoxyloides, Daphne oleoides, Rosa Webbiana, Ribes grossularia,* etc., etc.

(iv) *Quercus incana* Roxb.—The "Ban" oak grows gregariously often forming pure forests, chiefly in the outer ranges of the Western Himalayas westwards from Nepal at an altitude of 4,000–8,000 ft; in moist ravines and other cooler aspects it descends to lower elevations and grows in the Mothronwala Swamp (Dehra Dun) at 1,900 ft. It occurs at 2,300 ft., in the Kangra Valley, and has been seen growing in the Lower Beas Valley in Kulu at 3,000 ft. Towards the upper limit of its altitudinal range it is freely mixed with *Quercus dilatata,* but at lower elevations in moist ravines it is found with *Q. glauca.* Although the "ban" oak grows on all aspects it usually prefers cool and moist ravines. When it grows with other temperate species, the oak takes drier and warmer situations. A temperate climate with a good monsoon rainfall and moderate snowfall is favourable for its growth though it often ascends to regions of heavy snowfall.

Forests of *Quercus incana* are fairly common in the Western Himalayas and here the oak is usually associated with broad-leaved trees which may be *Rhododendron arboreum, Pieris ovalifolia, Populus ciliata, Ilex dipyrena, Cornus macrophylla, C. oblongum, C. capitata, Pyrus Pashia, Acer oblongum, A. pictum, Ulmus Wallichiana, Ficus nemoralis, Carpinus viminea, Alnus nepalensis, Betula alnoides*; in moist ravines there may occur *Machilus Duthiei, M. odoratissima, Phœbe lanceolata, Litsæa umbrosa,* etc., etc. At other places the "ban" oak occurs with the conifers, namely, *Cedrus Deodara* and *Pinus excelsa*; at lower elevations it also occurs with *Pinus longifolia.* The drier aspects of the "ban" oak forests are usually occupied by shrubby plants of *Berberis, Indigofera, Desmodium,* etc., but at other places we may have *Viburnum cotinifolium, V. stellulatum, Berberis nepalensis, Lonicera quinquelocularis, Myrsine semiserrata, M. africana, Desmodium tiliæfolium,* etc., etc.

In the " western temperate broad-leaved forests" *Quercus incana* is the chief broad-leaved tree and according to Champion (1936, pp. 232, 233) it grows at Binsar in the W. Almora division, at an altitude of 6,500 ft. in association with *Carpinus viminea, Cedrela serrata, Rhododendron arboreum, Pieris ovalifolia, Ilex dipyrena, Betula alnoides, Viburnum cotinifolium,*