# FOSSIL FLORA FROM THE SIWALIK SEDIMENTS OF KOILABAS, NEPAL

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**Abstract**

An assemblage of leaf-impressions is described from the Lower Siwalik sediments of Koilabas, a village about 5 km north of Jarva (27° 37′ N : 82° 31′ E) in Nepal. It consists of 22 species belonging to 17 genera and 14 families of dicotyledons. The present distribution of the modern equivalents of the fossil taxa suggests that moist evergreen to deciduous tropical vegetation was growing in the region and the climate was more humid during Lower Siwaliks than today.

## Introduction

The Siwalik Group consists of an enormously thick succession of sediments exposed all along the Himalayas foot-hills from Brahmputra Valley on the east to the Potwar Plateau and Bannu plains on the west. Though a rich vertebrate fauna has been recorded from these sediments, the record of known plant megafossils of the Siwalik Group is rather meagre. These have been reviewed by Prakash (1975, 1979) and Awasthi (1982). Since then some fossil woods from Kalagarh and leaf-impressions from Koilabas in western Nepal and Bikhnathoree in Bihar (Awasthi & Prasad, 1987; Prakash & Prasad, 1984; Prasad, 1987, 1988, 1990; Prasad & Prakash, 1984, 1987; Lakhanpal & Awasthi, 1984) have been added to this flora.

The present investigation on the leaf-impressions from the Lower Siwalik sediments of Koilabas (27° 42′ N : 82° 20′ E) in western Nepal was undertaken to work out in detail the fossil assemblage of this region and to reconstruct the history of the past vegetation, palaeoecology and phytogeography of the region during Lower Siwalik period.

The plant fossils so far known from the Siwalik flora of Koilabas consists of only leaf remains of *Terminalia* (Tripathi & Tewari, 1983), *Dillenia*, *Syzygium*, *Anogeissus* (Prasad & Prakash, 1984), *Dipterocarpus*, *Albizia*, *Millettia* and *Ormosia* (Prasad, 1990).

The leaf-impressions are preserved on massive, grey, sandy shales exposed along the upstream of a small rivulet near the village Koilabas, Nepal, about 5 km north of Jarva, district Gonda of Uttar Pradesh (Map 1). Although the fossils are fairly well-preserved, there is no cuticle found in any of the specimens. The fossiliferous area lies in the Dang section of the Siwalik Group (also known as Churia Group) which occurs in most of the places immediately south of the Main Boundary Thrust in Nepal (Map 2). In Dang section the Lower Siwalik beds (Lower Formation) are known to occur from Koilabas Village to Darwaja, containing fine grained sandstone, calcareous sandstones, thin limestones, marls, and variegated clays with some pebbles (Sharma, 1977).

The Siwalik Group of Nepal Himalaya has been studied by a number of geologists like Medlicott (1875), Auden (1935), Lehner (1943), Hagen (1959), Bordet (1961), Glennie and Ziegler (1964), Ohta and Akiba (1973), Sharma (1977, 1980) and Chaudhri (1983). According to Hagen (1959) the Nepal Siwaliks are subdivisible into Upper, Middle and Lower Siwaliks. However, Glennie and Ziegler (1964) have suggested a simpler, two-fold lithological subdivision under (i) Conglo-

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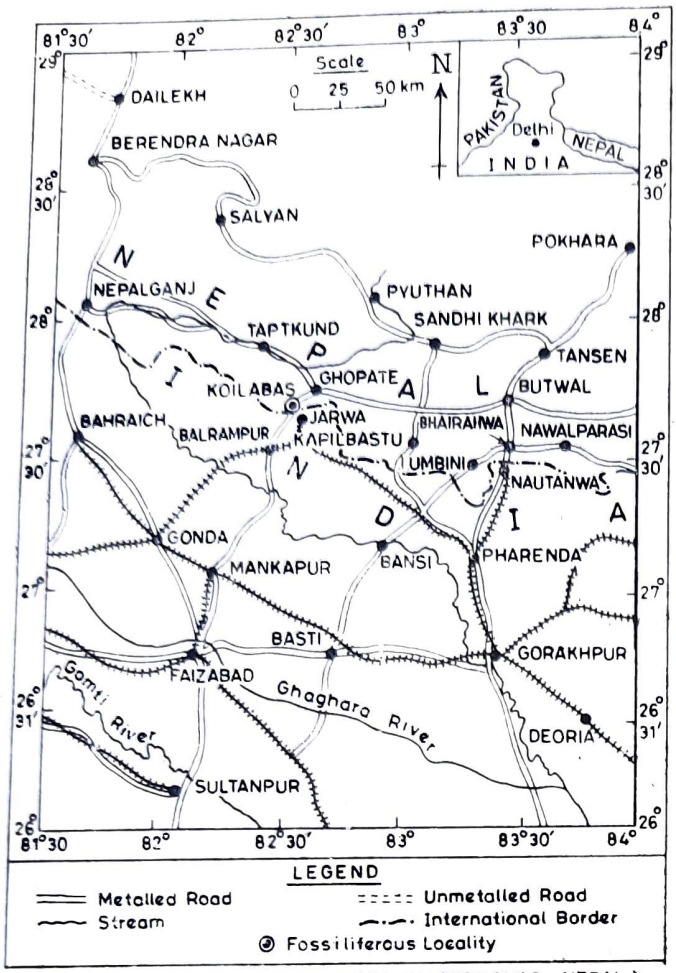
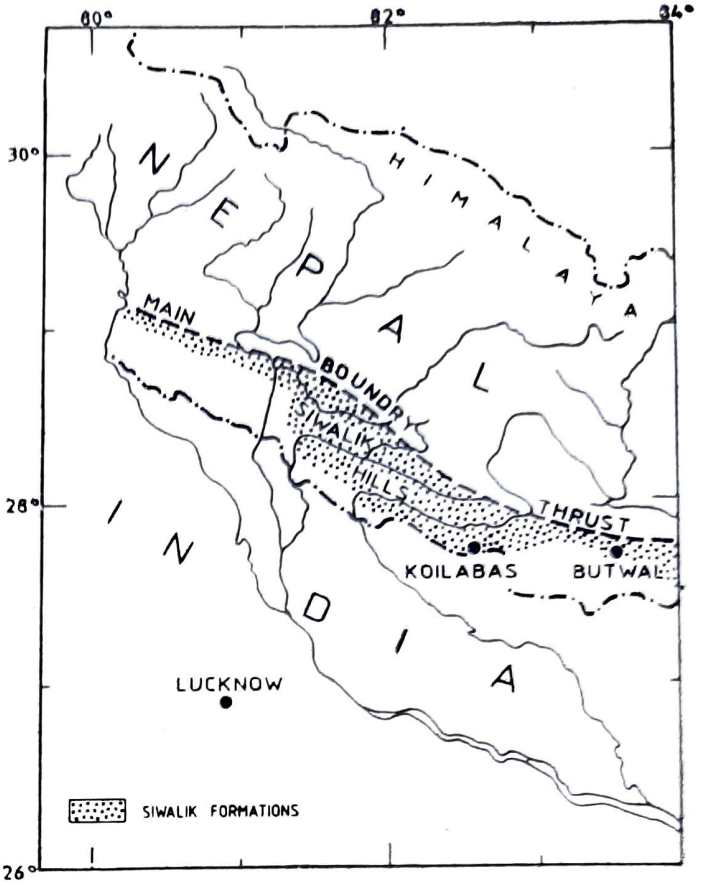



MAP-1 SHOWING FOSSILIFEROUS LOCALITY (KOILABAS, NEPAL)




Map 2

merate Facies, and (ii) Sandstone Facies. They have also been described as Churia Group by Sharma (1977) and divided into two formations, viz., Lower Churia Formation and Upper Churia Formation. Recently, Chaudhri (1983) has reverted to the three-fold division of Lower, Middle and Upper formations on the basis of sedimentological studies of the Siwalik deposits. Thus the Koilabas sediments fall in the Lower Siwaliks

## Systematic description

### Family—Flacourtiaceae

*Genus—RYPAROSA* (*Ryparia*) Blume

*Ryparosa prekunstelri* sp. nov.
Pl 1, fig. 1

The species is based on a leaf-impression and its counterpart preserved on grey shale.

*Description*—Leaf simple, appearing symmetrical, oblanceolate; preserved length with petiole 12.9 cm, lamina length 12.4 cm, maximum width 4.8 cm; apex broken; base acute, normal; margin entire; texture thick, chartaceous; petiole 0.5 cm preserved, normal; venation pinnate, brochidodromous, primary vein (1°) single, prominent, thick towards the basal region, stout, almost straight; secondary veins (2°) 5-6 pairs with angle of divergence acute, narrow, gradually increasing towards the apex (25° near the base and 45° near the apex), 1.2—3.2 cm apart, uniformly curved up, alternate, unbranched; tertiary veins (3°) fine with angle of origin nearly RR, pattern percurrent, rarely branched, straight to sinuous, perpendicular near midrib and nearly oblique towards margin, opposite to alternate, close to distant; quaternary veins (4°) indistinct.

*Affinities*—The important characters of the fossil leaf like oblanceolate shape, acute base, brochidodromous venation in the apical portion and narrow acute angle of divergence of secondaries are found commonly in the modern leaves of *Flacourtia montana* Zipp. ex Span. and *Ryparosa* Blume of the family Flacourtiaceae. However, in the

leaves of *Flacourtia montana* the margin is serrate in contrast to the entire margin in the present fossil. Obviously, the leaves of *Ryparosa* show close resemblance with the present fossil.

Among the species of *Ryparosa* the leaves of *R. hulletii* King, *R. kunstelri* King, *R. scortechinii* King and *R. wrayi* King show resemblance. However, the leaves of these species of *Ryparosa* cannot be distinguished easily on the basis of superficial morphological characters but taking into consideration the finer details the present fossil is very close to the leaves of *R. kunstelri* King (Pl. 1, fig. 2).

*Fossil records and comparison*—As far as the author knows there is no fossil record of the leaves of *Ryparosa* from India and abroad. Obviously, it is the first record of the fossil leaf of *Ryparosa* from the Siwalik beds of Nepal and is being described here as *Ryparosa prekunstelri* sp. nov., the specific epithet indicating its possible affinity with *Ryparosa kunstelri*.

The genus *Ryparosa* consists of 18 species distributed in the Andaman and Nicobar Islands, western Malaysia and North New Guinea (Willis, 1973). *Ryparosa kunstelri* King, with which the fossil shows closest resemblance, is a Malayan tree.

*Holotype*—Specimen no. BSIP 36148.

**Family—Guttiferae**

Genus—*MESUA* Linn.

*Mesua tertiara* Lakhanpal, 1964
Pl. 1, figs. 3, 5

Two leaf-impressions preserved on bluish-grey shale represent this species. They are almost complete.

The characteristic features of the fossil leaves are elliptic to lanceolate shape with bluntly acute apex and acute base, small petiole, entire margin and semicraspedodromous venation. In all the morphological details the fossils show close similarity with the modern leaves of *Mesua ferrea* Linn (Pl. 1, figs. 4, 6) of the family Guttiferae.

In 1951, Lakhanpal and Bose described four fossil leaves from the Fuller's Earth beds of Kapurdi in western Rajasthan and compared them with the modern leaves of *Mesua* of Guttiferae. Subsequently, Lakhanpal (1964) found that they show close resemblance with the modern leaves of *Mesua ferrea* Linn. and described them as *Mesua tertiara*. As the present fossils also show the same features, they are being placed under the same species.

*Mesua ferrea* Linn. with which the fossil resembles is an evergreen tree found in mountains of Bangladesh, eastern Himalaya, Chittagong, Upper Burma, Tenasserim, Eastern and Western peninsula and Andaman Islands. It is also common in western Duars and Assam, Khasi hills, western Coast from North Kanara southwards in Sri Lanka and in Malaya.

*Figured specimens*—Specimen nos. BSIP 36149 and 36150.

**Family—Meliaceae**

Genus—*CHLOROXYLON* DC.

*Chloroxylon palaeoswietenia* sp. nov.
Pl. 1, figs 7, 9; Pl. 2, fig. 1

The present species is based on three leaflet-impressions, of which one is well-preserved and almost complete.

*Description*—Leaflets simple, asymmetrical, elliptic to oblong; lamina length 2.5-4 cm, maximum width 1.4 cm; apex emarginate; base acute, inequilateral; margin entire; texture chartaceous; petiolule invisible; venation pinnate, brochidodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) about 8 pairs, uniformly curved up, branched, each branch joining their adjacent secondaries, usually alternate, 0.2-0.7 cm apart, angle of divergence acute moderate (40°-60°) with secondaries more acute towards basal region, intersecondary veins present, simple; tertiary veins (3°) fine, abundant, with angle of origin nearly RR, pattern random reticulate, branched, usually oblique, rarely nearly parallel in relation to midvein, alternate to opposite and close; quaternary veins (4°) very fine, randomly oriented forming orthogonal to polygonal meshes.

*Affinities*—The most important characters of the fossil leaflets such as, elliptic to oblong shape, asymmetrical form, emarginate apex, inequilateral base, presence of intersecondary veins and brochidodromous venation indicate their close resemblance with the modern leaflets of *Chloroxylon swietenia* DC (F. R. I. H. S. Nos. 119793 and 9334) of the family Meliaceae. (Pl. 1, figs 8, 10; Pl. 2, fig 2.

As no fossil leaflet of *Chloroxylon* DC is known so far from India and abroad, the present finding forms the first record of fossil leaflets of *Chloroxylon* DC from Nepal and is being named as *Chloroxylon palaeoswietenia*, the specific epithet indicating its being the likely forerunner of *C. swietenia*.

The genus *Chloroxylon* DC consists of only one species, *C. swietenia* DC. It is a moderate sized deciduous tree common in Satpura Range, Deccan, Konkan, Karnataka and the drier parts of the peninsula and Sri Lanka (Brandis, 1972, p. 74; Gamble, 1972, p. 161).

*Holotype*—Specimen no. BSIP 36151.

*Paratype*—Specimen no. BSIP 35152.

**Family—Fabaceae**

Genus—*CASSIA* Linn.

*Cassia nepalensis* sp. nov.
Pl. 2, fig. 3

This species is represented by a single, well preserved, almost complete leaflet-impression.

*Description*—Leaflet symmetrical, narrow ovate; lamina length 4.8 cm, maximum width 2.1 cm; apex acuminate; base obtuse; margin entire; texture chartaceous; petiolule not preserved; venation pinnate, eucamptodromous; primary vein (1°) single, thicker in lower half, stout, almost straight; secondary veins (2°) 8 to 9 pairs, 0.3-0.7 cm apart, mostly alternate, uniformly curved up, unbranched, angle of divergence acute, moderate; intersecondary veins present, thin, simple; tertiary veins (3°) poorly preserved, fine, pattern random reticulate, distant to close.

*Affinities*—The important characters of the fossil leaflet are symmetrical form, narrow ovate shape, acuminate apex, obtuse base, entire margin and eucamptodromous venation. These characters have been found common in the leaves/leaflets of *Sterculia graciliflora* Korth. of Sterculiaceae, and *Dalbergia latifolia* Roxb., *D. sissoo* Roxb. and *Cassia* Linn. of Fabaceae. Of these, *Sterculia graciliflora*, although almost similar in shape and venation can be differentiated in having acute apex as against acuminate apex in the present fossil. The leaflets of both the species of *Dalbergia*, i.e., *D. latifolia* Roxb. and *D. sissoo* Roxb. differ from the present fossil in possessing broad ovate to elliptic shape in contrast to narrow ovate shape in this fossil. A large number of species of *Cassia* have been compared with the present fossil and it was fonnd that the leaflets of *Cassia hirsuta* Linn. (F. R. I. Herbarium sheet no. 41206, (Pl. 2, fig. 4) and *C. laevigata* Willd. show close resemblance with the present fossil.

*Fossil records and comparison*—A large number of leaflets have been assigned to the genera *Cassia* Linn. and *Cassiophyllum* sp. The latter consist of only two species, i.e. *Cassiophyllum* sp. Geyler (1887) and *Cassiophyllum berenices* (Ung.) Krausel (in Givulescu, 1968). A number of species of *Cassia* have been recorded from different parts of the world such as Australia, Bolivia, Brazil, Czechoslovakia, Germany, Greenland, India, Indonesia, Italy, Japan, New Zealand, Panama, Switzerland, U. S. A. and U. S. S. R. (Unger, 1850, 1867; Ettingshausen, 1869; Schimper, 1874; Lesquereux, 1874; Gaudin, 1903; Berry, 1916, 1918, 1919, 1930, 1931, 1935, 1938, 1939, 1945; Principi, 1921, 1922; Hollick, 1924; Knowlton, 1930; Ball, 1931; Salmon, 1934; Brown, 1934; Weyland, 1938; LaMotte, 1952; Kilpper, 1969; Becker, 1969; Ishida, 1970; Guleria, 1978; Lakhanpal & Guleria, 1982).

These fossil leaves have been compared with the present fossil and it found that they are different from this Siwalik leaflet. Hence, it has been described as *Cassia nepalensis* sp. nov.

The genus *Cassia* comprises 500-600 species of herbs, shrubs and trees which grow in tropical and warm temperate (excluding Europe) regions of the world (Willis, 1973, p. 211). Brandis (1971) enumerated 12 species of *Cassia* from India. *Cassia hirsuta* now grows wild with both in plains and hills of the district Mysore, Deccan Ramandrug, Bellary in Karnataka and near Madras (Rao & Razi, 1981; p. 445; Gamble, 1957, p. 284). The other comparable species, *C. laevigata* grows in hill regions especially on the Nilgiris and in Khasi Hills (Gamble, 1972, p. 271).

*Holotype*—Specimen no, BSIP 36153.

Genus—*DALBERGIA* Linn. f.

*Dalbergia miosericea* sp. nov.
Pl. 2, fig. 5

This species is based on a single-well preserved leaflet-impression.

*Description*—Leaflet simple, slightly asymmetrical, elliptic; total preserved length 4.0 cm, lamina length 3.6 cm, maximum width 2.0 cm; apex emarginate; base acute; margin entire; texture chartaceous; petiolule 0.4 cm in length, normal; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, moderate, straight; secondary veins (2°) about 10 pairs visible with angle of divergence acute, moderate (about 50-55°), usually alternate, 0.2-0.5 cm apart, uniformly curved up, rarely branched; intersecondary veins present, simple; tertiary veins (3°) fine, angle of origin nearly RR, percurrent unbranched, almost straight, oblique in relation to midvein, alternate to opposite, close.

*Affinities*—The most important characters of the present fossil leaflet are slightly asymmetrical shape, elliptic form, emarginate apex, acute base, entire margin, chartaceous texture, small petiolule, intersecondary veins and eucamptodromous venation. These features are found commonly in the modern leaves/leaflets of *Atlantia monophylla* Corr. of Rutaceae, *Combretum nanum* Ham. of Combretaceae, and *Dalbergia* Linn. f., *Pterocarpus santalinus* Linn. f. and *Tephrosia tinctoria* Grah. of Leguminosae. Of these, the leaves of *Atlantia monophylla* Corr. can be differentiated in possessing narrow acute (cuneate) base as against normal acute base in the present fossil leaflet. In *Combretum nanum* Ham. and *Pterocarpus santalinus* Linn. f., the apical portion of the leaf is wider than the fossil leaflet. Similarly the leaves of *Tephrosia tinctoria* Grah. also differ in their smaller size and in possessing more than 20 pairs of secondaries in comparison to about 10 pairs of secondaries in the present fossil leaflet. Thus it is only with the leaflet of *Dalbergia* that the present fossil is really comparable. An extensive survey of the modern leaflets of a large number of species (about 60) of *Dalbergia* Linn. f., indicates that this Siwalik fossil shows closest resemblance with the leaflets of *Dalbergia sericea* Boj. (F. R. I. Herbarium sheet no. 2836); Pl. 2, fig. 6).

*Fossil records and comparison*—The fossil leaflets showing close resemblance with the leaflets of *Dalbergia* Linn. f. have been assigned to genera *Dalbergia* Linn. f. and *Dalbergites* Berry. So far 45 species of *Dalbergia* Linn. f. and 3 species of *Dalbergites* have been recorded (Ettingshausen, 1869; Schimper, 1874; Geyler, 1875; Berry, 1909, 1916, 1939; Knowlton, 1917; Principi, 1921; Hollick, 1924; Ball, 1931; Salmon-Calvi, 1934; Mac Ginitie, 1937, 1941; LaMotte, 1952; Heer, 1959; Knobloch, 1961; Lakhanpal & Awasthi, 1984). Besides, there is one more leaflet resembling that of *Dalbergia* described under the form genus *Phyllites* by Tanai (1972) from the Tertiary of Japan. These species have been reported from Africa, Australia, France, Germany, Greenland, Japan, Sumatra, U.S.A., West Indies and India. Thus, the genus *Dalbergia* was cosmopolitan in distribution during the geological past.

The occurrence of *Dalbergia* in the Siwilik of India is know by fruit resembling *D. sissoo* (Lakhanpal & Dayal, 1966).

The present Siwalik leaflet from Nepal is quite different from those of the known species of *Dalbergia*, being described here under a new species, *D. miosericea* the specific epithet indicating its resemblance with the modern leaflets of *Dalbergia sericea*.

The genus *Dalbergia* Linn. f. consists of 120 species of trees or climbling shrubs, distributed in tropical regions of the World (Willis, 1973, p. 355; Hooker, 1879, p.230). About 36 species are reported to occur in India (Gamble, 1972, p. 246). *Dalbergia sericea* Boj. with which the fossil leaf shows close resemblance is distributed in Madagascar and in sub-Himalayan tracts from Jammu to Sikkim (Brandis, 1971).

*Holotype*—Specimen no. B.S.I.P. 36154.

Genus—*MILLETTIA* W. & A.

*Millettia siwalica* sp. nov.
Pl. 2, figs 7, 9, 11

The present species is based on eight impressions of leaflets of which two are with their counter-parts. Most of them are almost complete and well-preserved on bluish-grey shale. One leaflet-impression with its counter part is very small.

*Description*—Leaflets symmetrical, ovate to wide ovate; lamina length 1.3-3.1 cm, maximum width 0.9-2.0 cm; apex bluntly acute; base nearly obtuse; margin entire; texture chartaceous; petiolule preserved only in smallest leaflet measuring about 0.2 cm, normal; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, moderate, almost straight; secondary veins (2°) 9 pairs, 0.2-0.6 cm apart with angle of divergence acute, moderate (about

50°-55°), uniformly curved up, alternate, rarely branched near the margin; intrasecondary veins present, rare, usually simple; tertiary veins (3°) fine, angle of origin AR to RO, pattern usually percurrent, branched, oblique in relation to midvein, predominantly alternate, close; quaternary veins (4°) very fine, branched, forming orthogonal to polygonal meshes.

*Affinities*—The important characters exhibited by the present fossils are symmetrical shape, bluntly acute apex, small petiolule, entire margin and eucamptodromous venation. These characters can be seen in the leaves/leaflets of *Sapium baccatum* Roxb. of Euphorbiaceae, *Dalbergia sissoo* Roxb., *D. latifolia* Roxb. and *Mellittia* W. & A. of the family Leguminosae. However, the leaves of *Sapium baccatum*, although similar in shape and size, differ in having secondaries arising at greater angle of divergence than in the present fossils. The leaflets of both the species of *Dalbergia* are usually broad, elliptic with acuminate apex, whereas the present fossils are ovate to wide ovate with bluntly acute apex. After a detailed comparison with a large number of species of *Millettia* it has been found that the leaflets of *Millettia ovalifolia* Kurz, (F.R.I. Herbarium sheet No. 80919) show closest resemblance with the present fossils in shape, size and venation pattern (Pl 2, figs 8, 10, 12.

*Fossil records and comparison*—Six species of fossil leaves resembling *Millettia* are known which have already been listed earlier by Prarad, 1990. Of these, *Millettia notoensis* Ishida 1970 can be dtfferrentiated in having few (4-5) secondary veins arising at an angle of 50°-60° in contrast to more secondary veins (9 pairs) with angle of divergence 50°-55° in the present fossils. *Millettia* sp. Huzioka & Takahasi 1970 also differs from the present fossils in having lanceolate shape instead of ovate to wide ovate in these fossils. *M. asymmetrica* Lakhanpal & Guleria 1982 is distinct in its asymmetrical form at the base as against symmetrical form in the present fossils, *M. miocenica* Lakhanpal & Guleria 1982 can also be differentiated in having oblong shape with acute apex in contrast to the ovate to wide ovate shape with nearly obtuse base in the present Siwalik fossils. Lastly, the leaf of *M. koilabasensis* Prasad 1990 also differs markedly from the present fossils in possessing narrow, obovate shape, acute base and mixed craspedodromous venation. Thus, the present fossils are entirely different from already known species of *Millettia*. Therefore, a new name *Millettia siwalica* is assigned to them.

The genus *Millettia* W. & A. consists of 80 species (Willis, 1973, p. 746) of trees, shrubs and woody climbers, distributed in the warmer regions of Africa, Asia and Australia. About 30 species are reported to occur in the Indian region, half of which are trees and the other half are large climbing shrubs and are mostly distributed in West Bengal and Burma. *Millettia ovalifolia* with which the Siwalik fossils closely resemble, is a common tree in Lower Burma and also Minbu District of Upper Burma (Gamble, 1972, p. 232; Brandis, 1971, p. 706).

*Holotype*—Specimen no. BSIP 36155.

*Paraty*—Specimen no. BSIP 36157.

**Family—Combretaceae**

Genus—*TERMINALIA* Linn.

*Terminalia koilabasensis* sp. nov.
Pl. 3, figs. 1, 2

This species is represented by a single, well-preserved, almost complete leaf impression.

*Description*—Leaf simple, symmetrical, narrow elliptic; lamina length 7.0 cm, maximum width 1.6 cm; apex acute; base acute, cuneate, margin entire; texture chartaceous; petiole not preserved venation pinnate, eucamptodromous; primary vein (1°) prominent, thicker in lower half, stout, almost straight; secondary veins (2°) 11 pairs, 0.6 to 1 cm apart, nearly alternate, angle of divergence acute, moderate to wide (about 65°-70)°, more acute on one side than other, uniformly curved up, unbranched; tertiary veins (3°) fine, angle of origin AR-RO, percurrent, rarely branched, almost straight, oblique to right angle in relation to midvein, predominantly alternate, close.

*Affinities*—The characteristic features of the present fossil leaf are narrow elliptic shape, acute apex, cuneate base, entire margin, chartaceous texture and eucamptodromous venation. After a detailed comparison it was found that the fossil leaf shows similarity with the leaves of *Doodonia viscosa* Linn. of Sapindaceae, *Tabernaemontana coronaria* Willd. of Apocynaceae and *Terminalia* Linn. of the family Combretaceae. Of these,

*Doodonia viscosa* can easily be differentiated from the present fossil leaf in possessing secondaries arising more closely than that in the fossil. The leaves of *Tabernaemontana coronaria* although with similar type of venation, differ from the present fossil in having normal acute base as against cuneate in the Siwalik fossil.

Modern leaves of a number of species of *Terminalia*, viz., *T. alata* Heyn. ex Roxb., *T. angustifolia* Jack., *T. australis* Cambess., *T. bellerica* Roxb., *T. benzoin* Linn., *T. catappa* Linn., *T. chebula* Retz., *T. citrina* Roxb., *T. coriacia* Roxb., *T. myriocarpa* H. & M., *T. nigronulosa* Pierre., *T. paniculata* Roth., *T. procera* Roxb., *T. pyrifolia* Kz. and *T. tomentosa* W & A have been compared in order to find out the closest resemblance with the present fossil. After a critical examination of herbarium sheets of the above mentioned species it was found that the leaves of *Terminalia angustifolia* (F.R.I. Herbarium sheet No. 10060) resemble closely the present fossil leaf (Pl. 3, fig. 3).

*Fossil records and comparison*—The fossil leaves resembling *Terminalia* are represented by three generic names, viz., *Terminalia* Linn., *Terminaliphyllum* Velenovsky and *Terminaliophyllum* Geyler, while the last one consists of three species, viz., *Terminaliophyllum* sp. Geyler (1887) from the Eocene of Borneo and *T. keayi* and *T. faggei* (Puri, 1966) from the post Eocene of Nigeria, the genus *Terminaliphyllum* is represented by a single species, i.e., *Terminaliphyllum rectinerve* Velenovsky (1884, 1889) from the Upper Cretaceous of Bohemia. *Terminalia* Linn. on the other hand consists of a large number of species recorded mostly from outside the Indian subcontinent. They are *Terminalia* cf. *T. catappa* Linn. (in Nemejc, 1975), *T. claibornensis* Berry (in Ball, 1931), *T. elegans* Heer (in Schimper, 1874), *T. estimina* MacGinitie (1941), *T. europea* (Web.) Weyland (1942), *T. fenzliana* Unger (in Nemejc, 1975), *T. gypsorum* Saporta (in Schimper, 1874), *T. indicola* Ball (1931), *T. italica* Principi (in Principi, 1915), *T. lauriana* Krasser (1903), *T. lesleyana* (Lesq.) Berry (1916), *T. Panandhroensis* Lakhanpal & Guleria (1981), *T. phaeocarpoides* Berry (1914), *T. radobojana* Unger (1867). *T. nottensis* Weyland (1942) *T. tallyana* Ettingshausen (in Schimper, 1874) *T. trinitense* Berry (in LaMotte, 1952), *T. ungeri* Ettingshausen (in Nemejc, 1975), *Terminalia* sp. Hollick (1936), *Terminalia* sp. Matsuo (1970) and *Terminalia* sp. Tripathi and Tiwari (1983).

After a detailed comparison of the above fossil species with this Siwalik leaf it has been found that it differs mostly from them in the shape and size. *Terminalia claibornensis* Berry and *T. indicola* Ball from the Eocene of Taxas, U.S.A., *T. europea* (Web.) Weyland, *T. nottensis* Weyland and *T. miocenica* Unger from the Tertiary of Germany and *T. lauriana* Krasser from the Tertiary of Brazil have ovate shape in comparison to narrow elliptic shape of the present fossil. Further, *T. estimina* MacGinitie from the Middle Eocene of Central Sierra, Nevada, U.S.A., *T. lesleyana* (Lesq.) Berry from the Lower Eocene of Southeastern North America, *T. maxima* Berry from the Tertiary of Brazil and *T. phaeocarpoides* Berry from the Eocene of South Carolina, U.S.A. differ in having obovate shape and *Terminalia*, sp. Matsuo from the Palaeogene of Japan *Terminalia* sp. Tripathi and Tiwari from the Lower Siwalik beds of Koilabas, Nepal, and *T. panandhroensis* Lakhanpal and Guleria from the Eocene of Kachchh, western India also differ in possessing wide ellipitic shape in contrast to narrow elliptic shape of the present fossil leaf. *Terminalia panonica* Unger from the Tertiary of South Guistina, although similar in venation pattern differs in having obtuse base as against cuneate base in this present fossil. A leaf impression resembling *Terminalia* has also been reported by Lakhanpal (1970) from the Siwalik beds of India. As this is not accompanied by description and photograph it is not possible to compare it with the present fossil. As the present fossil differs from the known *Terminalia* from India and abroad a new name *Terminalia koilabasensis* is given to it. The specific name indicates that the fossil belongs to the locality Koilabas.

The genus *Terminalia* Linn. now consists of 250 species (Willis, 1973, p. 1136). They are large trees and widely distributed in the tropics of the World. Gamble (1972) enumerated 16 species of *Terminalia* from India. *T. angustifolia* Jacq. with which the fossil leaf closely resembles is a Malayan species growing in Central Malaya Island (Hooker, 1879, p. 444; Brandis, 1971, p. 308).

*Terminalia* was cosmopolitan in distribution during the geological past. The fossil leaves have been reported from various countries such as Bolivia, Brazil, Czechoslo-

vakia, France, Greece, Indonesia, Italy, Japan, Nigeria, Spain and U.S.A. The earliest record of *Terminalia* leaf, i.e., *Terminaliphyllum* goes back to the Upper Cretaceous (Cenomanian) of Bohemia (Velenovsky, 1884, 1889). Thus it is obvious that the genus *Terminalia* has continued from the Upper Cretaceous to the present day and was more widely spread during the Tertiary period.

*Holotype*—Specimen no. BSIP 36158.

*Terminalia siwalica* sp. nov.
Pl. 3, fig. 4

The present species is based on a single almost complete leaf-impression.

*Description*—Leaf simple, asymmetrical at base only, narrow obovate; total preserved length 8.9 cm, lamina length 8.6 cm, maximum width 4 cm; apex acute; base acute, inequilateral; margin entire; texture coriaceous; petiole 0.3 cm long, normal; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 7-8 pairs with angle of divergence acute, moderate (about 50°), uniformly curved up, 0.8-1.2 cm apart, alternate, unbranched; tertiary veins (3°) fine, poorly preserved, angle of origin usually AO, percurrent, rarely branched, almost straight, nearly right angle in relation to midvein, alternate to opposite, close; quaternary veins (4°) indistinct.

*Affinities*—The most important features of the fossil leaf such as narrow obovate shape, acute apex, inequilateral base, entire margin, coriaceous texture and eucamptodromous venation are seen in the modern leaves of *Terminalia* Linn. of Combretaceae, where it shows a closest affinity with the modern leaves of *Terminalia pyrifolia* Kurz (F.R.I. Herbarium sheet no. 5219; Pl. 3, fig. 5).

*Fossil records and comparison*—It has been found that the present fossil is entirely different from them. It also differs from *Terminalia koilabasensis* described here from Koilabas in its shape, type of base and in the arrangement of tertiary veins. The shape of *T. koilabasensis* is narrow elliptic with equilateral base as against narrow obovate shape with inequilateral base in the present fossil leaf. However, the tertiaries in *T. koilabasensis* are oblique in relation to midvein whereas they are nearly right angle in the present fossil. Thus, the present fossil is also distinct from *Terminalia koilabasensis* and is being described here as *Terminalia siwalica* sp. nov.

*Terminalia pyrifolia* Kurz with which the fossil shows close resemblance is a large tree growing in the mixed forests of Burma. It is common in Pegu and Tenasserim (Brandis, 1971 p. 310).

*Holotype*—Speimen no. BSIP 36159.

Genus—*CALYCOPTERIS* Linn.

*Calycopteris floribundoides* sp. nov.
Pl. 3, fig. 6

This species consists of a single well preserved leaf-impression.

*Description*—Leaflet simple, symmetrical, narrow ovate; lamina length 5.2 cm, maximum width 2.4 cm; apex acute; base obtuse, normal, margin entire; texture coriaceous; petiolule not preserved; venation pinnate, simple craspedodromous; primary vein (1°) single, prominent stout, almost straight; secondary veins (2°) 6-7 pairs visible, 0.3-0.6 cm apart, uniformly curved up, usually alternate, unbranched, angle of divergence acute moderate (about 50°); tertiary veins (3°) fine, poorly preserved with angle of origin usually AO, percurrent, unbranched, straight, oblique in relation to midvein, predominantly alternate and close; quaternary vein (4°) invisible.

*Affinities*—The characteristic features of the fossil leaflet are narrow ovate shape, acute apex, obtuse base, entire margin, coriaceous texture and craspedodromous veration. These characters tend to indicate its affinity with the genus *Calycopteris* Lam. of the family Combretaceae and shows nearest resemblance with *Calycopteris floribunda* Lam. (F.R.I. Herbarium sheet no. 20680; B.S.I.P. H. sheet no. 10139; Pl. 3, fig. 7). The fossil leaf also bears superficial similarity with modern leaves of *Aeschynanthus ramosissima* Wall. of Gesneraceae, *Bignonia chamberlaynii* Sims. of Bignoniaceae, *Quisqualis indica* Blanco of Combretaceae and *Salvadora persica* Linn. of Salvadoracea in their shape, size, base and apex, but entirely differ in venation pattern especially in nature and arrangement of secondary and tertiary veins.

As far as the authors are aware there is no report of fossil leaflet of *Calycopteris* Lam. Thus, the present finding forms the first record of a fossil leaf of *Calycopteris* from the Siwalik beds of Nepal and is described here as *Calycopteris floribundoides*, the specific name

indicates its resemblance with the leaves of *Calycopteris floribunda*.

*Calycopteris* Lam. is a monotypic genus represented by *Calycopteris floribunda* Lam. which is a large scandant shrub growing in deciduous forests of western peninsula, Assam, Chittagong and Upper and Lower Burma (Brandis, 1971, p. 314). It is also found in central and southern India especially in deciduous forests along water courses in the Circars, Deccan and Bangla Desh (Gamble, 1972, p. 345).

*Holotype*—Specimen no. BSIP 36160.

**Family—Caprifoliaceae**

Genus—*LONICERA* Linn.

*Lonicera mioquinquelocularis* sp. nov.
Pl. 3, figs. 8, 10; Pl. 4, fig. 1

The present species is based on two fairly well-preserved leaflet impressions of which one is almost complete.

*Description*—Leaflets simple, symmetrical, ovate to wide ovate ; lamina length 2.3-3.5 cm, maximum width 2.2 cm; apex appears to be acute; base obtuse; margin entire: texture chartaceous; venation pinnate, brochidodromous; primary vein (1°) single ; prominent, moderate, straight; secondary veins (2°) 5-6 pairs visible with angle of divergence acute, moderate (about 50°60°), basal pair of secondary vein less acute, uniformly curved up, alternate to almost opposite, 0.3-0.7 cm. apart rarely branched ; tertiary veins (3°) fine, abundant with angle of origin AR-RO, percurrent, almost straight, oblique in relation to midvein, predominantly alternate and close; quaternary veins (4°) very fine, randomly oriented forming orthogonal meshes.

*Affinities*—The important characters of the fossils such as symmetrical form, ovate to wide ovate shape, acute apex, obtuse base, entire margin and brochidodromous type of venation are found in the modern leaflets of *Dalbergia latifolia* Roxb., *D. sissoo* Roxb. of Leguminosae and *Lonicera* Linn. of the family Caprifoliaceae. However, the leaflets of both the species of *Dalbergia*, i.e., *D. latifolia* Roxb. and *D. sissoo* Roxb. differ in having intersecondaries which are absent in the present fossils. The modern leaflets of large number of *Lonicera* species (about 85) have been examined and found that the leaflets of *Lonicera leschenaultii* Wall., *L. orientalis* Lam. and *L. quinquelocularis* Hardw. show near resemblance with present fossils. Out of these, leaflets of *L. leschenaultii* Wall. differ in secondary veins which arise from midrib more acutely and run parallel to the margin for a greater distance than ir the present fossil leaflets. Similarly, leaflets of *L. orientalis* Lam. can easily be differentiated in possessing acute base instead of obtuse base as seen in the present fossils. Leaflets of *L. quinquelocularis* Hardw. (F.R.I. Herbarium sheet nos. 86203 and 1205) show closest affinity with the present fossil leaflets. (Pl. 3, figs. 9, 11).

*Fossil records and comparison*—Four species of fossil leaflets of *Lonicera* Linn. have so far been recorded only from outside the Indian subcontinent. These are *Lonicera deperdita* Heer from the Tertiary of Switzerland (in Schimper, 1970-72), *L. periclymenum* Linn. (Syn. *L. zylosteum* Linn.) Krausel and Weyland (1942) from the Quaternary of Eifel, Germany and *L. mulpensis* and *Lonicera* sp. (Akhmetiev, 1973) from the Miocene of Medjuda, U.S.S.R. It has been found that the present fossils are entirely different from the fossils known so far. Thus, *Lonicera deperdita* Heer differs in having obtuse apex as against acute apex in these fossils. *Lonicera* sp. Akhmetiev and *L. periclymenum* Krausel can easily be differentiated in possessing acute base instead of obtuse base in the present fossils. Moreover, the shape of leaves in the above two species is obovate and narrow elliptic respectively, whereas it is ovate to wide ovate in the present fossil leaves. Further, *L. mulpensis* Akhmetiev possesses narrow ovate to lanceolate shape with secondaries arising more acutely.

As the present fossils are entirely different from already known speeies of *Lonicera* Linn. it is being assigned to a new species *Lonicera mioquinquelocularis* sp. nov. The specific name indicates its close resemblance with the modern leaves of *Lonicera quinquelocularis* Hardw. The present finding is the first record of a fossil leaflets of *Lonicera* from the Indian subcontinent.

The genus *Lonicera* Linn. consists of 200 species distributed in North Hemisphere. Gamble (1972) enumerated 40 species in India, many of which are small shurbs or climbers growing in very high regions in Himalaya. *Lonicera quinquelocularis* Hardw. with which the fossils show closest affinity is a large deciduous tree growing in Baluchistan, Suliman Range and Safed Koh. It is common in Northwest Himalaya from

Kashmir to Nepal (Gamble, 1972, p. 396; Brandis, 1962, p. 255; Purkayastha, 1982, p. 63).

*Holotype*—Specimen no. BSIP 36161.

*Paratype*—Specimen no. BSIP 36162.

**Family—Rubiaceae**

Genus—*RANDIA* Linn.

*Randia miowallichii* sp. nov.
Pl. 4, figs. 2, 3, 5

Three leaf-impressions of which one is small and complete preserved on bluish-grey shale.

*Description*—Leaves simple, symmetrical, oblanceolate; total preserved length 3.5—6.0 cm, lamina length 3.1—5.5 cm, maximum width 1.4—2.3 cm; apex acute; base acute, cuneate; margin entire, slightly undulated; texture chartaceous; petiole 0.4—0.5 cm. long, normal; venation pinnate, craspedodromous; primary vein (1°) prominent, thicker in lower half, stout, straight; secondary veins (2°) 10 pairs with angle of divergence acute, moderate (50°—60°) lower secondaries arising more acutely than the upper, alternate, uniformly curved up, moderately thick, unbranched; tertiary veins (3°) fine with angle of origin usually RR, percurrent, unbranched, predominantly alternate and close; quaternary veins indistinct.

*Affinities*—The most important characters, of the fossil leaves are oblanceolate shape, acute apex, cuneate base, entire margin, simple craspedodromous venation and acute angle of divergence of secondary veins. After a critical examination of large number of modern leaves, it has been found that such characters are present in *Rauwolfia serpentina* Benth. of Apocynaceae and *Randia* Linn. of family Rubiaceae. However, the leaves of *Rauwolfia serpentina* can be differentiated from the fossils in having secondaries arising more acutely than in the fossil leaves. Besides, the margin is smooth as compared to slightly undulated margin in the present fossils. Thus it is with *Randia* Linn. that these fossils show closest resemblance. The study of the modern leaves of about 50 species of *Randia* Linn. indicates that the fossils show nearest affinity with *Randia wallichii* Hook. f. (F.R.I. Herbarium sheet no. 53923; Pl. 4, fig. 4).

*Fossil records and comparison*—The fossil leaves showing close resemblance with the modern leaves of *Randia* Linn. have been described under *Randia* Linn. Three species of fossil leaves of *Randia* have so for been recorded. These are *Randia prodroma* Ung. from the Miocene of Sarmat, Salzhansen in Germany (in Salomon Calvi, 1934), *R. gossferiana* Kschun from the Tertiary of Kamrungebietes, Germany (in Menzel, 1920) and *R. Mohavensis* Axelrod (1950) from the Miocene of Kinnick Techachapi, North America (in La Motte, 1952).

As the present Siwalik leaves are different from all these known species of *Randia* Linn. and because they show closest affinity with the modern leaves of *Randia wallichii*, they have been assigned to *Randia miowallichii* sp. nov., the specific name indicate their resemblance with the species *Randia wallichii*. This is the first record of a fossil leaf of *Randia* from the Indian subcontinent.

*Randia* Linn. is a large genus comprising 200-300 species of shrubs and trees distributed throughout tropical and subtropical regions of the world. About a dozen species of shurbs and small trees are reported to occur in India (Pearson & Brown, 1932, pp. 639-940; Purkayastha, 1982). *Randia wallichii* Hook. with which the fossils show nearest affinity is a tree found in the forests of the east Himalaya, Sikkim, the Khasi Hills, Sylhet, Chittagong and in Kachar Hills (Gamble, 1972, pp. 411-412). It also grows in Andamans, Pegu, Tenasserim, Bangladesh and Burma (Brandis 1971, p. 384; Purkayastha, 1982).

*Holotype*—Specimen no. BSIP 36163.

*Paratype*—Specimen nos. BSIP 36164 and 36165.

**Family—Ebenaceae**

Genus—*DIOSPYROS* Linn.

*Diospyros koilabasensis* sp. nov.
Pl. 4. figs. 6, 8; Pl. 5, fig. 1

The present species is represented by three well preserved leaflet impressions of which one is smaller than the other. The leaflets are preserved on bluish-grey shale.

*Description*—Leaflets almost symmetrical, lanceolate to ovate; lamina length 3.5—5.0 cm, maximum width 1.4—1.8 cm.; apex slightly broken, seemingly acute; base cordate; margin entire; texture chartaceous;

venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 6 pairs, 0.6—1.5 cm apart, alternate, uniformly curved up and running along the margin for a short distance, branched, angle of divergence moderate acute (about 45°); tertitary veins (3°) fine, angle of origin usually RR, pattern mostly percurrent, branched, oblique to nearly right angle in relation to midvein, predominantly alternate, close; quaternary veins (4°) very fine, randomly oriented forming orthogonal or polygonal meshes.

*Affinities*—The most characteristic features of the present fossils such as lanceolate to ovate shape, seemingly acute apex, cordate base, entire margin and eucamtodromous venation undoubtedly indicate their resemblance with the leaflets of *Diospyros* Linn. of the family Ebenaceae. In order to find out its nearest modern equivalent about 54 species of *Diospyros* Linn. were examined critically and it was found that the present fossil leaflets show closest affinity with leaflets of *Diospyros montana* Roxb. (syn. *D. cordifolia* Roxb.) (F.R.I. Herbarium sheet Nos. 1257 and 5342B) (Pl. 4, figs. 7, 9; Pl. 5, fig. 2).

*Fosil records and comparison*—The fossil leaves resembling *Diospyros* have been described under two generic names, i.e. *Diospyros* Linn. and *Diospyrophyllum* Velenovsky, the latter consisting of only one species *Diospyrophyllum provectum* Velenovsky (1889) from the Upper Cretaceous of Bohemia. However, *Diospyros* Linn. includes a large number of species reported from different parts of the world viz., Africa, Bohemia, Canada. Europe, England, Greek, Greenland, Japan, Panama, Switzerland and U.S.A. (Schimper, 1874; Heer, 1874; Lesquereux, 1878, 1891-92; Probost, 1884; Berry, 1916, 1918, 1919, 1930; Principi, 1921; Gotham, 1933; Salomon Calvi, 1934; Hollick, 1936; McGinitie, 1937, 1941; LaMotte, 1952; Jahnichen, 1958; Chaney & Axelrod, 1959; Kilpper, 1969; Huzioka & Uemura, 1973; Tanai, 1976). Thus, the genus *Diospyros* was cosmopolitan in distribution during the geological past. From the geological distribution of fossil *Diospyros* it is evident that its earliest record *Diospyrophyllum provectum* goes back to the Upper Cretaceous of Bohemia (Velenovsky, 1884). Because no fossil leaves of *Diospyros* have been described from Indian subcontinent and the present fossil is distinct from all of them it has been assigned to a new species, *Diospyros koilabasensis*, the specific name indicating the locality Koilabas in Nepal from where the fossils were collected.

The genus *Diospyros* Linn. consists of about 500 species of trees or rarely shurbs, distributed in tropical and mild temperate regions of the world, a few in South Africa and North America (Hooker, 1882; Purkayastha, 1982). About 40 species are found in the Indian region. *D. montana* Roxb. (syn. *D. cordifolia* Roxb.) (Brandis 1971) with which the fossil resembles closely is a small or moderate sized tree growing throughout most of India and Burma from the Ravi eastward along the Himalaya, in central, western and south India (Gamble, 1972).

*Holotype*—Specimen no. BSIP 36166.

*Paratype*—Specimen no. BSIP 36167.

*Diospyros pretoposia* sp. nov.

Pl. 5, fig. 3; Pl. 6, fig. 1

This species is based on a single, well-preserved, almost complete leaf impression.

*Description*—Leaf simple, symmetrical, narrow oblong; total preserved length 19.5 cm, lamina length 18 cm, maximum width 6 cm; apex slightly broken; base obtuse, normal; margin entire; texture seemingly coriaceous; petiole 1.5 cm long, normal, thick; venation pinnate, brochidodromous; primary vein (1°) single, prominent, straight, thicker towards basal region; secondary veins (2°) about 12 pairs visible with angle of divergence acute, moderate (about 60°) uniformly curved up, secondaries on one side of the midrib run parallel to the margin for a greater distance, 0.8-2.2 cm apart, mostly alternate, branched; intersecondary veins present, simple, frequent and branched; tertiary veins (3°) fine with angle of origin AR-RO, pattern percurrent, straight, branched, oblique in relation to midvein near the midrib and nearly right angle towards margin, alternate to opposite, close.

*Affinities*—The most important characters of the present fossil are narrow oblong shape, symmetrical form, obtuse base, entire margin coriaceous texture, thick petiole, brochidodromous venation and the presence of intersecondary veins. All these characters are commonly seen in the modern leaves of *Diospyros* Linn. of the family Ebenaceae. A critical examination of a large

number of leaves of *Diospyros* species indicates that the present fossil shows resemblance with the modern leaves of *D. hoyleana* F. White and *D. toposia* Ham. Of these, *Diospyros hoyleana* can be distinguished from the fossil leaf in possessing many secondaries which run straight upto near the margin and join the super adjacent veins whereas in the present fossil the secondaries are comparatively few and are uniformly curved up running parallel to the margin for greater distance. Thus, the leaves of *Diospyros toposia* Ham (F.R.I. Herbarium sheet No. 4873) show nearest affinity with the present fossil (Pl. 5, fig. 4; Pl. 6, fig. 2).

*Fossil records and comparison*—The fossil leaves resembling *Diospyros* have been described under two genera, viz., *Diospyrophyllum* Velenovsky and *Diospyros* Linn. The former consists of a single species *Diospyrophyllum provectum* Velenovsky (1889) from the Upper Cretaceous of Bohemia. However, *Diospyros* Linn. comprises large number of species which have been indicated earlier. After comparison with the already known available species of *Diospyros* Linn. and *Diospyrophyllum* Velenovsky, it has been found that the present fossil is entirely distinct from them. It also differs from the earlier described species *Diospyros koilabasensis* in possessing oblong shape with obtuse base as against with cordate base in *D. koilabasensis*. Further in *D. koilabasensis* the intersecondary veins are absent. As the present fossil leaf shows closest resemblance with the modern leaves of *Diospyros toposia* Ham, it is being described here as *Diospyros pretoposia* sp. nov.

About 40 species of *Diospyros* including those formerly placed under *Maba* J.R. & G. Forst have been reported to occur in the Indian region (Purkayastha, 1982, p. 122). *Diospyros toposia* Ham. (syn. *D. racemosa* Roxb.) (Brandis, 1971, p. 432) with which the fossil shows close affinity is an evergreen, middle sized tree growing in Khasi Hills, Cachar, Chittagong, Tinnevelli Hills and in the moist regions of Sri Lanka (Brandis, 1971).

*Holotype*—Specimen no. BSIP 36168.

**Family—Apocynaceae**

Genus—*Tabernaemontana* Linn.

*Tabernaemontana precoronaria* sp. nov.
Pl. 7, fig. 1

This species is represented by two well preserved, almost complete leaf impressions.

*Description*—Leaves simple, symmetrical, lanceolate, total preserved length 7.2 cm, lamina length 6.6 cm, maximum width 2.1 cm; apex acuminate; base cuneate; margin entire; texture chartaceous; petiole 0.6 cm long, normal; venation pinnate, mixed craspedodromous; primary vein (1°) prominent, stout, almost straight, secondary veins (2°) 12 pairs with angle of divergence acute, moderate, (about 55°), mostly alternate, sometimes opposite, 0.4-0.9 cm apart, uniformly curved up, moderately thick, unbranched; tertiary veins (3°) fine with angle of origin AR-RO, pattern percurrent, unbranched, straight, oblique in relation to midvien, predominantly alternate and close.

*Affinities*—The characteristic features of the fossil leaves such as lanceolate shape, acuminate apex, cuneate base, entire margin, mixed craspedodromous venation and percurrent tertiaries strongly indicate its affinity with the modern leaves of *Tabernaemontana* Linn of the family Apocynaceae. A critical examination of the herbarium sheets of large number of species of *Tabernaemontana* Linn., viz., *Tabernaemontana arborea* Rose ex. Smith, *T. bovina* Lour., *T. citrifolia* Linn., *T. coronaria* Willd., *T. crispa* Roxb., *T. dichotoma* Roxb., *T. divaricata* R. Br., *T. donnellasmithii* Rose ex. Smith, T. (*Ervatamia*) *graciliflora* Wall., *T. heyneana* Wall., *T. mucronata* Merrill, *T. ophiorrhizoides* Kurz, *T. pandocaqui* Poir, *T. penduncularis* Wall., *T. recurva* Roxb. *T. schippii* Roxb.. *T. schippii*, Standley, *T. subglobosa* Merrill, indicates that the fossil leaves show closest resemblance with the leaves of *Tabernaemontana coronaria* Willd. (Syn. *Ervatamia coronaria*) (F.R.I. Herbarium sheet no. 75334 ; Pl. 7, fig. 2).

*Fossil records and comparison*—Fossil leaves showing resemblance with the modern leaves of *Tabernaemontana* have been described from different parts of the world. These are *Tabernaemontana bohemica* Ett. and *T. radobojana* Ett. from the Tertiary of Bohemia and Radboj in Czechoslovakia respectively (in Schimper, 1874), *T. prisca* Mass, from the oligocene of West Indies (in Mengel, 1920; Principi, 1921), *T. intermedia* Potburry 1935 from the Eocene of California, *T. chrysophylloides* (Lesq.) MacGinitie 1941 from Gentral Sierra, Nevada, U.S.A., and *T. teleaginensis* Avako 1979 from the Miocene of Medjuda, U.S.S.R. Geyler 1875

has also described a leaf fragment as *Phyllites (Tabernaemontana)* from the Tertiary of Borneo and recorded another leaf fragment as *Tabernaemontanophyllum* sp. from the Eocene of Borneo.

All these species are entirely different from the present fossil leaves. *Tabernaemontana bohemica* Ett. differs from the present fossil leaves in possessing oblong shape and obtuse base in contrast to lanceolate shape and cuneate base in the present fossil. *T. radobojana* Ett. also differs in possessing elliptic shape mixed crasp edodromous type of venation found in present fossil. *T. intermedia* Potburry can easily be differentiated in lamina width and in the nature of secondaries. The lamina width in *T. intermedia* is more wide than in the present fossil and the secondaries arise nearly at right angle in contrast to acute angle in the present fossil leaves. *T. chrysophylloides* (Lesq.) MacGinitie is distinct from the present fossil in the nature of secondaries which arise less acutly and the lamina width is greater than that of the present fossil. *T. teleagiensis* Avako can also be differentiated in having ovate shape with secondaries arising nearly at right angle in contrast to lanceolate shape with secondaries arising at acute angle in the present fossil. Moreover, *Phyllites (Tabernaemontana)* Geyler is a small fragment which is more wide (5 cm in width) than the present fossil leaves.

As the present fossil is different from all the known fossils of *Tabernaemontana* leaf, it has been described here as a new species *Tabernaemontana precoronaria* sp. nov. indicating its resemblance with *T. coronaria*.

The genus *Tabernaemontana* Linn. consists of 110 species of shrubs or small trees distributed in all the tropical regions of the World (Hooker, 1882, pp. 645-646). About 10 species are reported to occur in India. *Tabernaemontana coronaria* Willd. with which the fossil leaves show closest affinity is an evergreen shrub growing in subhimalayan tracts from Dehradun eastward, very common in lower Darjelling Hills and Upper Burma, Gamble, 1972, pp. 485-486; Brandis, 1971, p. 460).

*Holotype*—Specimen no. BSIP 36169.

*Paratype*—Specimen no. BSIP 36170.

**Family—Loganiaceae**

Genus—*GAERTNERA* Lamk.

*Gaertnera siwalica* sp. nov.
Pl. 7, figs. 3, 5, 6

The present species is based on two, well preserved leaf impressions of which one is almost complete.

*Description*—Leaves simple, symmetrical, elliptic, lamina length 4.7-5.0 cm, maximum width 2.4 cm; apex acute; base slightly broken, seemingly acute; margin entire; texture chartaceous; petiole broken; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 7 pairs visible with angle of divergence acute, moderate (about 50°), uniformly curved up, alternate to nearly opposite, 0.8-1.6 cm apart, rarely branched; intersecondary veins present, simple and few; tertiary veins (3°) fine, abundant, angle of origin RR, pattern percurrent, straight to sinuous, occasionally branched, right angle in relation to midvein, alternate to opposite and close.

*Affinities*—The important characters of the present fossil leaves such as elliptic shape, acute apex and base, entire margin, presence of intersecondary veins and eucamptodromous type of venation are commonly found in the modern leaves of *Gelobium glomerulatum* Hask. of Euphorbiaceae and *Gaertnera* Lamk. of the family Loganiaceae. However, the leaves of *Gelobium glomerulatum* Hask. although similar in shape, size and in venation pattern, can be differentiated in possessing tertiary veins which are oblique in relation to midvein in contrast to right angle in the present fossil. After a detailed comparison with the modern leaves of available species of *Gaertnera* Lamk. viz., *G. bieleri* (De Willd). E. Petit, *G. koenigii* Wight, *G. longevaginalis* (Schweinf. ex Hiern.) E. Petit, *G. turniculata* Benth., *G. walkori* Wight and *G. vaginans* Merr., it has been found thatthe leaves of *G. bieleri* (De Willd.) E. Petit (F.R.I.Herbarium sheet No. 3743/141218) show closest affiinity with the present fossil leaves. (Pl. 7, figs. 47).

*Fossil records and comparison*—As so far there is no fossil record of *Gaertnera* Lamk., a new name *Gaertnera siwalica* is assigned to the present fossil leaves. Thus, it is the first record of a fossil leaf of *Gaertnera* Lamk. from the Indian subcontinent and abroad.

The genus *Gaertnera* Lamk. consists of 25 species distributed in tropical Asia and Africa (Hooker, 1885, p. 91. Only four species are reported to occur in India. However *G. bieleri* (De Willd) E. Petit with

which the Siwalik fossil resembles grows in Congo. However, according to the geographic locale, the nearest Indian species *Gaertnera racemosa* grows in the sub-himalayan tracts from Indus eastwards, common in moist places throughout Central India, the western peninsula and Burma (Brandis, 1971, P. 108).

*Holotype*—Specimen no. BSIP 36171.
*Paratype*—Specimen no. BSIP 36172.

**Family—Solanaceae**

Genus—*DATURA* Linn.

*Datura miocenica* sp. nov.
Pl. 7, fig. 8 ; Pl. 8, fig. 1.

The present species is based on two, well preserved leaf impressions of which one is almost complete.

*Description*—Leaves simple, almost symmetrical, wide ovate ; total preserved length 4.3-8 cm, lamina length 4-7.4 cm, maximum width 5.5 cm, apex acuminate; base acute, normal; margin smooth, lobed; texture appearing chartaceous ; petiole 0.3-0.6 cm visible, normal; venation pinnate, simple craspedodromous ; primary vein (1°) single, prominent, moderate, almost straight ; secondary veins (2°) 5-6 pairs with angle of divergence acute, moderate about 50°), uniformly curved up, 0.6-1 cm apart, branched; tertiary veins (3°) fine, with angle of origin AR-RO, percurrent, rarely branched, alternate to opposite, oblique in relation to midvein, close ; quaternary veins (4°) very fine, randomly oriented, forming orthogonal to polygonal meshes.

*Affinities*—The important characters exhibited by the present fossils such as wide ovate shape, acuminate apex, lobed margin and craspedodromous venation are commonly seen in the modern leaves of *Erythrina suberosa* Roxb. of *Leguminosae*, *Kydia calycina* Roxb., *Sida humilis* Willd. and *Urena lobata* Linn. of Malvaceae and *Datura* Linn. of the family Solanaceae. Of these, *Erythrina suberosa* Roxb. differs from the present fossils in the nature and arrangement of secondary and tertiary veins. The leaves of *Kydia calycina* Roxb. can easily be differentiated in the nature of secondary veins. In this species four secondaries arise at the base and run at greater length towards the apex. *Urena lobata* Linn. is distinct from present fossils in the absence of intersecondary veins. *Sida humlis* Willd. also differs in having serrately lobed margin in contrast to smoothly lobed margin in the present fossils. It is only with the leaves of *Datura* Linn. that these Siwalik fossils show close resemblance. An extensive survey of the modern leaves of *Datura* viz., *Datura alba* Nees, *D. fastuosa* Linn. *D. leichhardtii* F. Muel., *D. metel* Linn., *D. meteloides* DC ex Dun, *D. quercifolia* H. B. & K., *D. sangunia* R. & P., *D. speciosa* Salisb., *D. stramonium* Linn., *D. suaveolens* Humb. and *D. tatula* Linn. indicates that the present fossils show nearest affinity with the leaves of *Datura fastuosa* Linn. (F.R.I. Herbarium sheet no. 61057) (Pl. 8, figs. 2).

*Fossil records and comparison*—The author is not aware of any fossil record of the leaf of *Datura* from the Indian subcontinent as well as abroad. Obviously, this is first record of a fossil leaf of *Datura* which is being described under the name *Datura miocenica* sp. nov. The specific epithet indicates the age of the locality Koilabas in Nepal from where the fossil specimens were collected.

The genus *Datura* Linn. consists of 10 species distributed in tropical and warm temperate regions of the world, especially in tropical America and Australia (Willis, 1973). *Datura fastuosa* Linn. with which the fossil resembles closely is a shrub found throughout India usually in waste places, Malaya, in tropical Africa and America (Hooker, 1885).

*Holotype*—Specimen no. BSIP 35711.
*Paratype*—Specimen no. BSIP 36173.

**Family—Verbenaceae**

Genus—*VITEX* Linn.

*Vitex prenegundo* sp. nov.
Pl. 8, figs. 3, 5 ; Pl. 9, fig. 1

This species consists of three leaf impressions of which one is fairly well preserved and almost complete.

*Description*—Leaves simple, symmetrical, lanceolate ; total preserved length 10.2 cm, lamina length 9.5 cm, maximum width 2.2 cm, ; apex seems to be attenuate ; base acute, equilateral ; margin entire ; texture chartaceous ; petiole 0.7 cm, long, normal ; venation pinnate, brochidodromous ; primary vein (1°) single, prominent, stout, almost straight ; secondaries (2°) about 20 pairs with angle of divergence acute,

moderate (about 60°), uniformly curved up and joining superadjacent secondaries at obtuse angle, alternate to opposite, 0.3-0.8 cm apart, unbranched ; tertiary veins (3°) fine, abundant with angle of origin AR-RO, pattern percurrent, almost straight, rarely branched, oblique in relation to midvein alternate to opposite and close.

*Affinities*—The characteristic features of the fossil leaves are lanceolate shape, symmetrical form, attenuate apex, acute base, entire margin, chartaceous texture and brochidodromous type of venation. After examining large number of herbarium sheets at the Forest Research Institute, Dehradun and National Botanical Research Institute, Lucknow it was found that the modern leaves of *Gymnanthera fragulariana* Blume of Asclepiadaceae, *Ficus nemoralis* Wall. of Moraceae, *Myristica gibbosa* Hook f. & Thomas of Myristicaceae, *Polyalthia, longifolia* Benth. and Hook. of Anonaceae, *Woodfordia floribunda* Salisb. of Lythraceae and *Vitex* Linn. of family Verbenaceae show resemblance with the present fossils. Of these, *Gymnanthera fragulariana* Blume differs in possessing comparatively fewer secondaries which are widely arranged than in the present fossils. The leaves of *Ficus nemoralis* Wall. and *Myristica gibbosa* Hook. f. & Thomas also differ in the presence of intersecondary veins which are absent in the fossil leaves. Moreover, in *Myristica gibbosa* Hook. f. & Thomas, the secondaries are branched. *Woodfordia floribunda* Salisb. can easily be differentiated in having attenuate base in contrast to acute base in the present fossils. Similarly leaves of *Polyalthia longifolia* Benth. & Hook. differ slightly in possessing undulated margin instead of smooth margin in the fossil leaves. The modern leaves of large number of species of *Vitex* Linn. (about 35 species) have been studied and found that the leaves of *Vitex negundo* Linn., *V. peduncularis* Wall., *V. simplicifolia* Clarke and *V. leucoxylon* Linn. show resemblance with the present fossils. Since the leaves of *V. leucoxylon* Linn. and *V. peduncularis* Wall. differ minutely in possessing attenuate base in comparison to acute base in the present fossils and those of *V. simplicifolia* Clarke possess secondaries which are comparatively fever and spacely arranged, it is only with the leaves of *V. negundo* Linn. (F.R.I. Herbarium sheet No. 115448) that the present fossils show closest affinity (Pl. 8, fig. 4; Pl. 11, fig. 5).

*Fossil records and comparison*—The fossil leaves resembling modern leaves of *Vitex* have been described under the genus *Vitex* Linn. Only two fossil species of *Vitex* are so far known from outside India. These are *Vitex cuneata* Schun. & Thonn. from the Tertiary of Jonji, Africa (in Menzel, 1920) *V. lobkowitzii* Ett. from valley of Schichov (in : Schimper, 1970-71). Besides, a fruit of *Vitex* has also been described as *Vitex rotundifolia* Linn. from the Tertiary of Kyshu, Japan, (Miki & Kokawa, 1962). Of these *Vitex lobkowitzii* differs in being ovate with only 4-5 pairs of secondaries as against lanceolate shape with about 20 pairs of secondaries in the present fossils.

This is the first record of fossil leaves of *Vitex* from the Indian subcontinent and as these are distinct from the known fossil leaves of *Vitex* they are being described under a new species, *Vitex prenegundo* sp. nov., the specific name indicating their affinity with *V. negundo* Linn.

The genus *Vitex* Linn. consists of 150 species of trees or shrubs and is widely distributed in tropical and warm temperate regions of both the hemispheres. At least 15 species are included in the Indian flora (Pearson & Brown, 1932, p. 803). *Vitex negundo* Linn., with which the fossils show close affinity, is a large shrub or small tree common every where in the plains and lower hills in India ascending to 5000 ft. in the west Himalaya, extending west to Peshawar and Sind. It is also common near the streams in Sri Lanka and China (Pearson & Brown, 1932, p. 803; Brandis, 1971, p. 503, 504).

*Holotype*—Specimen no. BSIP 36174.
*Paratype*—Specimen no. BSIP 36175.

Genus—*VITEX* Linn.

*Vitex siwalicus* sp. nov.
Pl. 9, fig. 2

This species is based on a single, poorly preserved, almost complete leaf-impression.

*Description*—Leaf simple, symmetrical, narrow elliptic; preserved lamina length 9.0 cm, maximum width 3 5 cm; apex slightly broken; base broken; margin entire; texture chartaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) about 11 pairs visible with narrow acute angle of divergence (about 40°), uniformly curved up, alternate to opposite,

0.5-0.8 cm apart, unbranched; tertiary veins (3°) fine with angle of origin nearly RR, percurrent, almost straight, rarely branched, oblique in relation to midvein, predominantly alternate and close; quaternary veins (4°) indistinct.

*Affinities*—The most important characters of the present fossil leaf such as narrow elliptic shape, entire margin, chartaceous texture and eucamptodromous venation with narrow acute angle of divergence of secondary veins are seen in the modern leaves of *Terminalia tripteroides* Heyne ex Wall. of Combretaceae and *Vitex* Linn. of the family Verbenaceae. Of these *T. tripteroides*, although similar in shape and size differ in having secondaries which are comparatively fewer and widely spaced than in the present fossil leaf. In order to find out the nearest equivalent of the fossil leaf, the modern leaves of a large number of species of *Vitex* have been studied and it was found that the leaves of *Vitex pubescens* Vahl. (F.R.I. Herbarium sheet No. 2003/112290) show nearest affinity with the fossil leaf (Pl. 9, fig 3).

*Fossil records and comparison*—Only three fossil leaves of *Vitex* has so far been recorded; two from outside India. These are *Vitex lobkowitzii* Ett. from the Valley of Schichov, (in Schimper, 1970-72) and *V. cuneata* Schun, et. Thonn. from the Tertiary of Jonje, Africa (in Menzel, 1920). *V. prenegundo* sp. nov. has been described here from the Siwalik beds of Nepal. However, *Vitex lobkowitzii* Ett. differs in possessing ovate shape with few (4-5) pairs of secondaries. This fossil leaf can also be differentiated from *Vitex prenegundo* earlier in having elliptic shape with less number of secondaries (about 11 pairs) as against lanceolate shape with about 20 pairs of secondaries in *V. prenegundo* sp. nov.

As the present fossil is different from already known fossil leaves of *Vitex*, it is being assigned to a new species *Vitex siwalicus* sp. nov.

*Vitex pubescens* Vahl. (syn. *V. arborea* Roxb.) with which the present fossil shows closest resemblance is a large evergreen tree growing in western peninsula. It is common on the east coast from Orissa and on the west from Nilgiris to southwards. It also grows in Sylhet, Lower Burma and Andaman Islands (Brandis, 1971, p. 504),

*Holotype*—Specimen no. B.S.I.P. 36176.

**Family—Lauraceae**

Genus—*CINNAMOMUM* Schaeffer

*Cinnamomum mioinuctum* sp. nov.
Pl. 9, figs 4, 6; Pl. 10, fig. 1

The present species is based on well preserved leaf-impression with its counter part.

*Description*—Leaf simple, symmetrical, narrow obovate ; total preserved length 4 cm, lamina length 3.6 cm, maximum width 1.8 cm ; apex obtuse; base nearly cuneate; margin entire ; texture thick chartaceous ; petiole 0.4 cm long, normal ; venation pinnate, eucamptodromous ; primary vein (1°) single, prominent, stout, almost straight ; secondary veins (2°) about 4 pairs with angle of divergence narrow acute (about 35°), alternate, 0.8-1.2 cm apart, uniformly curved up, branched ; tertiary veins (3°) fine, angle of origin nearly RR, percurrent, branched, straight to sinuous, nearly right angle in relation to midvein, predominantly alternate, close.

*Affinities*—The most important characters of the present fossil leaf are symmetrical form, narrow ovate shape, obtuse apex, nearly cuneate base, entire margin, eucamptodromous venation with tertiaries running at right angles to midvein.

The leaves of *Plecospermum spinosum* Trec. of Urticaceae, *Ehretia obtusifolia* Hochst. of Boraginaceae, *Vitex doniana* Sweet of Verbinaceae, *Cassia tora* Linn. of Leguminosae, *Cinnamomum* Schaeffer and *Dehaasia cuneata* Bl. of the family Lauraceae are nearly similar to the fossil leaf. Of these, the leaves of *Plecospermum spinosum* Trec., *Ehretia obtusifolia* Hochst., *Vitex doniana* Sweet, *Cassia tora* Linn. and *Dehaasia cuneata* Bl. although resembling in shape and size, differ in having many secondaries which are comparatively closely placed than in the fossil. Thus it is only with the leaves of *Cinnamomum* Schaeffer that the fossil resembles closely. The modern leaves of a large number of species (about 50) of *Cinnamomum* have been compared with the present fossil leaf and it was found that the leaves of *C. inuctum* Meissn. (F.R.I. Herbarium sheet No. 63559) show closest affinity with the fossil leave (Pl. 9, figs. 5, 7).

*Fossil records and comparison*—The fossil leaves resembling the modern leaves of *Cinnamomum* Schaeffer have been assigned to the following four genera namely *Cinnamomum* Schaeffer, *Cinnamomiphyllum* Nathorst 1888, *Cinnamomophyllum* Krausel & Weyland 1950 and *Cinnamomoides*

Seward 1925. Eighty six species of *Cinnamomum* Schaeffer, one species of *Cinnamomiphyllum* Nathorst, nine species of *Cinnamomophyllum* Krausel & Weyland and five species of *Cinnamomoides* have so far been recorded from India and abroad.

After a critical study of already known fossil leaves of *Cinnamomum* it has been found that most of them possess acrodromous type of venation in comparison to pinnate eucamptodromous type of venation in the present fossil leaf. However, only few species of *Cinnamomum* have pinnate type of venation as found in this fossil. These species are *Cinnamomum affine* Lesq. from Laramine Formation of Marshall, U.S.A. (in Knowlton, 1916), *C. dilleri* Potburry (1935) from the Eocene of California, U.S.A., *C. polymorphum* Heer from the Oligocene of France (in Principi, 1916), *C. rotundifolium* Principi (1916) from Tertiary of France, *C. praevirens* Dean (1923) from the Tertiary of Morwell, Australia, *C. wonnacotti* Bandulska (1928) from the Eocene of Bournmouth, England, *C. scheuchzeri* Heer from the Tertiary of Chivan, Africa (in Knobloch, 1961 ; Menzel, 1920), *C. spectabile* Heer from the Miocene of Rockenburg, Africa and *C. transversum* Heer from the Tertiary of Monod, Africa (in Schimper, 1874).

A detailed comparison has been made with these above species and it has been found that the present fossil is quite different from them. Thus, the leaves of *Cinnamomum affine* Lesq., *C. spectabile* Heer and *C. transversum* Heer differ from the present fossil in possessing elliptic shape in contrast to narrow obovate shape in the fossil leaf. Moreover, the base in the leaf of *C. spectabile* Heer is obtuse which is cuneate in Siwalik fossil. *C. scheuchzeri* Heer, *C. praevirens* Dean and *C. wonnacotti* Bandulska can easily be differentiated in having acute apex in comparison to obtuse apex in the fossil. Besides, in *C. praevirens* and *C. wonnacotti* the secondaries are more than 6 pairs as against about 4 pairs of secondaries in the present fossil. However, the leaves of *C. rotundifolium* Principi and *C. polymorphum* Heer differ in possessing ovate shape. Moreover, the apex in *C. polymorphum* Heer is acuminate which is obtuse in the fossil leaf. The tertiaries in *C. rotundifolium* Principi are comparatively more spacely arranged. Similarly, *C. dilleri* Potburry also differs in venation pattern where the lowest pairs of secondaries arise just near the base showing imperfect acrodromous venation whereas in the present fossil the lowest pairs of secondary veins arise at a greater distance from the base.

Only three species of *Cinnamomum* are known from India. The first, *Cinnamomum* sp. cf. *C. tamala* Nees has been described by Pathak (1969) from the Upper Tertiary (Middle Siwalik) of Mahanadi River section, Darjeeling, West Bengal. The second, *C. palaeotamala* (Lakhanpal & Awasthi, 1984) is known from the Siwalik beds of Bihar-Nepal boundary, while the last one *C. eokachchhensis* Lakhanpal and Guleria (1981) has been recorded from the Eocene of Kachchh, western India. All the three species of *Cinnamomum* can be easily differentiated from the present fossil in possing acrodromous type of venation in comparison to pinnate, eucamptodromous type of venation in these Siwalik fossil leaf. Thus, the present fossil, differs from all the known leaf remains of *Cinnamomum* and is being given a new specific name *Cinnamomum mioinuctum*. The specific epithet indicates resemblance with the modern leaves of *C. inuctum* Meissn.

The genus *Cinnamomum* Schaeffer consists of 250 species (Willis, 1973, p. 255) of evergreen trees and shrubs and is found in the tropical and sub-tropical regions of East Asia and Indo-Malaya. Gamble (1972) enumerated 24 species from India. *C. inuctum* Meissn. with which the fossil shows closest resemblance is a tree distributed in Tovoy, Malacca, South Tennesserim and Malaya peninsula (Hooker, 1885, p. 135, Brandis, 1971, p. 532).

*Holotype*—Specimen no. BSIP 36177.
*Paratype*—Specimen no. BSIP 36178.

**Family—Moraceae**

Genus—*FICUS* Linn.

*Ficus retusoides* sp. nov.
Pl. 10, figs. 2, 4, 5

The present species is based on two well preserved leaf impressions; of which one is almost complete.

*Description*—Leaves simple, slightly asymetrical, elliptic, total preserved length 4.5-5.8 cm, lamina length 4.5-5.4 cm, maximum width about 2.6 cm, apex acute; base acute, normal, equilateral; margin entire; texture seemingly chartaceous;

petiole 0.4 cm long, normal; venation pinnate, brochidodromous; primary vein (1°) single, prominent, moderate, almost straight secondary veins (2°) more than 20 pairs, with angle of divergence acute, moderate, (about 60), 0.3-0.6 cm apart opposite to alternate, uniformly curved up, branched and join to form intramarginal veins running parallel to both the margins; intersecondary veins present, simple; tertiary veins (3°) fine, abundant, with angle of origin AR-RO, pattern usually percurrent, sometimes branched, almost straight, oblique in relation to midvein, predominantly alternate and close.

*Affinities*—The most important characters of the fossil leaves are elliptic shape and closely placed secondary veins along with intersecondary and intra-marginal veins. A critical examination of the modern leaves from a large number of herbarium sheets at the Forest Research Institute Dehradun, reveals that these features are found in the modern leaves of *Mesua ferrea* Linn., *Calophyllum inophyllum* Linn., *C. decipiens* Wt., *C. apetalum* Willd., *C. tomentosa* Wt., *Garcinia gambogia* Derr., *G. malabarica* Derr. of Guttiferae, *Syzygium* Gaertn. of Myrtaceae and *Ficus* Linn. of the family Moraceae. Of these, *Mesua ferrea* can be easily differentiated from the present fossils in its small size and narrow elliptic shape in contrast to comparatively large size and broad elliptic shape of the present fossils. The leaves of all the above mentioned species of *Calophyllum* differ from the present fossils in the angle of divergence of secondaries and in the leaf texture which is coriaceous and the secondaries which arise at a greater successive distance. Further, the leaves of *Syzygium*, although showing somewhat near resemblance with the present fossils, also differ in their venation pattern as the interval between the two successive secondaries is lesser than in the present fossils. Besides, the intersecondary veins are more common in *Syzygium* and areoles are smaller in size. However, it is only with the leaves of *Ficus* Linn. that the present fossils show closest affinity. A detailed study of the modern leaves of a large number of species of *Ficus* (about 80 species) indicates that the present fossils show nearest affinity with the leaves of *Ficus retusa* Linn. (F.R.I. Herbarium sheet No. 8890); Pl. 10, figs. 3, 6).

*Fossil records and comparison*—There are abundant and wide spread records of fossil leaves resembling *Ficus*. These have been described under four genera, viz., *Ficus* Linn. *Ficonium* Ett., *Ficophyllum* Fontaine emend. Edwards and *Protoficus* Saporta. About three hundred and seventy five species of *Ficus*, two species of *Ficonium*, seven species of *Ficophyllum* and six species of *Protoficus* are so far known from different parts of the world, viz., North America, South America, Africa (Ethiopia), Europe, (Belgium, Czechoslovakia, France, Germany, Greenland, Hungary, Italy, Rumania, Yugoslavia, etc.), Asia (Burma, China, Egypt, India, Indonesia, Japan, USSR) and Australia and New Zealand). The earliest record of *Ficus*-like leaf is known from the Lower Cretaceous of Maryland described by Fontaine (1889) under the generic name *Ficophyllum*. From distribution point of view *Ficus* was well represented in North America and Europe during the tertiary and it has continued its existence from the Cretaceous till today.

A number of fossil leaves belonging to *Ficus* are known from India. Puri (1947, 1948) described two fossil leaves resembling *Ficus cunia* Buch-Ham. and *F. nemoralis* Wall. from the Karewas of Kashmir. In 1968, Lakhanpal described *Ficus precunia* from the Siwalik beds of Jawalamukhi and Gupta and Jiwan (1972) reported *Ficus cunia* from Dharmshala beds of Bilaspur, H. P. Later on *F. arnottiana* Miq. and *F. glomerata* Roxb. were described from the Quaternary deposits of Maharashtra by Mahajan and Mahabale (1973). Recently, Lakhanpal and Guleria (1981) also described *Ficus kachchhensis* from the Eocene and *F. khariensis* (1982) from the Mioene of Kachchh, western India. Lately, one more species *F. champarensis* has been described by Lakhanpal and Awasthi (1984) from the Siwalik beds near Bhikhnathoree in west Champaran District, Bihar. All these above fossil species of *Ficus* are different from the present fossils. Thus *Ficus precunia* Lakhanpal (1968), *F. champarensis* Lakhanpal and Awasthi (1984) and *Ficus cunia* described by Puri (1947) and Gupta and Jiwan (1972) differ from the present fossil in shape, size and type of venation. In addition, the above fossils also possess inequilateral, lobed base as compared to equilateral, acute base in the persent fossils. Further, the remaining fossil species of *Ficus* can also be differentiated in possessing few secondaries which do

not form intramarginal veins as found in the present fossils. Thus, the present fossils differ from all earlier known Indian species of *Ficus*. Therefore, a new species *Ficus retusoides* is assigned to these Siwalik fossil leaves, the specific name indicating their closest resemblance with *Ficus retusa* Linn.

The genus *Ficus* Linn. consisting of about 800 species (Willis, 1973, p. 458) is widely distributed throughout the tropics of both hemispheres, but most abundant in the islands of Indian Archipelago and the Pacific Oceon. A few species are extended beyond the tropics into southern Florida (U.S.A.), Mexico, Argentina, southern Japan and China, the Canary Islands and South Africa. About 80 species are reported to occur in India (Pearson & Brown, 1932). *Ficus retusa* Linn. with which the fossils show close similarity is an evergreen tree growing in sub-Himalayan tracts from Kumaon eastwards, Khasi, Hills, Bihar, Chhota Nagpur, Bundelkhand, central provinces, parts of Sunderbans, Deccan Peninsula and Andamans. It is also common in Sri Lanka, Bangladesh, Burma and Malaya, (Hooker, 1885, p. 511; Gamble, 1972, pp. 643-644; Brandis 1971, p. 603).

*Holotype*—Specimen no. BSIP 36179.

*Ficus precunia* Lakhanpal, 1968
Pl. 10, figs. 7, 8

The present species consists of three leaf impressions of which one is with a counter part. Two of them are almost complete. The leaf impressions are preserved on blackish grey shales.

*Affinities*—The important diagnostic characters of the fossil leaf such as ovate shape, seemingly acute base, auriculate, inequilateral lobed base and brochidodromous venation strongly indicate its affinity with the modern leaves of *Ficus* Linn. of the family Moraceae in which they show closest resemblance with the leaves of *Ficus cunia* Buch-Ham. Fossil leaves resembling *Ficus cunia* are already known from India. Puri (1947) described the fossil leaves of *Ficus cunia* from the Karewas of Kashmir, while Lakhanpal (1968) recorded *Ficus precunia* from the Siwalik beds near Jawalamukhi, Himachal Pradesh. A leaf of *Ficus cunia* has also been reported by Gupta and Jiwan (1972) from Dharmshala beds of Himachal Pradesh. As the impression from the Siwalik beds of Koilabas are comparable to the leaves of *Ficus cunia*, they are being described here under *Ficus precunia* Lakhanpal 1968. However, the leaf from the Siwalik beds of Jawalamukhi slightly differs in having comparatively larger size than the present fossil.

*Ficus cunia* Buch-Ham. is a moderate-sized tree growingi n sub-Himalayan tracts from Chenab eastwards ascending up to 4000 ft in Khasi Hills, eastern Satpura Hills, Chhota Nagpur, Bengal, Orissa, Manipur, Chittagong and Lower and Upper Burma. It grows usually on the banks of streams or in ravines (Gamble, 1972, p. 648; Brandis, 1971, p. 606).

*Figured specimen*—Specimen nos. BSIP 36180 and 36181.

*Ficus nepalensis* sp. nov.
Pl. 11, figs. 1, 3

This species is represented by a single well preserved incomplete leaf impression. The impression in devoid of cuticle.

*Description*—Leaf simple; symmetrical; elliptic; preserved lamina length 7.0 cm, Maximum width 4.0 cm, apex broken; base indistinct, appearing nearly obtuse; margin entire; texture coriaceous; petiole not preserved; venation pinnate, brochidodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 5 pairs visible with angle of divergence acute, moderate (about 55°), 1.2-2.0 cm apart, opposite to alternate, uniformly curved up; intersecondary veins present, simple; tertiary veins (3°) fine abundant, with angle of origin more or less RR, pattern percurrent sometimes branched, straight to sinuous, oblique in relation to midvein, predominantly alternate; quaternary veins (4°) very fine, randomly oriented, forming orthogonal to polygonal meshes.

*Affinities*—The important features exhibited by the fossil leaf are elliptic shape, entire margin seemingly obtuse base, presence of intersecondary veins and pinnate, brochidodromous type of venation. These characters indicate that the fossil leaf belongs to the genus *Ficus* Linn. of the family Moraceae. A large number of herbarium specimens of *Ficus* have been studied and it was found that the present fossil shows close similarity with the leaves of *F. glaberrima* Blume (F.R.I. Herbarium sheet nos.

5835 and 63755; Pl. 11, figs. 2, 4).

*Fossil records and comparison*—Among the Indian fossil leaves which have been enumerated earlier, only *Ficus khariensis* Lakhanpal & Guleria 1982 described from the Miocene of Kachchh, western India shows some similarity with the present fossil. However it can also be differentiated in the nature of secondary veins which arise at an angle of 60°-75° in contrast to angle of about 55° in the present fossil. Besides there are no intersecondary veins which are present in the Siwalik fossil leaf. As the present fossil leaf differs from already known species of *Ficus*, it is being described here as a new species, *Ficus nepalensis*, the specific name indicates its occurrence in the tertiary of Nepal.

*Ficus glaberrima* Blume with which the present fossil leaf resembles closely is an evergreen tree growing in the tropical Himalaya from Kumaon to Bhutan and Burma. It also grows in the Garhwal, Central India, Andaman Islands, Malaya Peninsula, Khasi Hills and Chittagong (Hook, 1885, p. 506; Gamble, 1972, p. 640; Brandis, 1971, p. 600).

*Holotype*—Specimen no. BSIP 36182.

## Discussion

The present study of the leaf-impressions from Koilabas in western Nepal has added considerably to our knowledge of the angiospermic flora of Lower Siwalik beds. The Koilabas flora consists of a great variety of mostly woody plants represented by leaf-impressions belonging to 30 species distributed among 23 genera of 17 families as listed below :

Dilleniaceae
- *Dillenia palaeoindica* Prasad & Prakash 1984

Flacourtiaceae
- *Ryparosa prekunstelri* sp. nov.

Guttiferae
- *Mesua tertiara* Lakhanpal 1964

Dipterocarpaceae
- *Dipterocarpus siwalicus* Lakhanpal & Guleria; Prasad 1990

Meliaceae
- *Chloroxylon palaeoswietenia* sp. nov.

Fabaceae
- *Albizia siwalica* Prasad 1990
- *Cassia nepalensis* sp. nov.
- *Dalbergia miosericea* sp. nov.
- *Millettia siwalica* sp. nov.
- *M. koilabasensis* Prasad 1990
- *Ormosia robustoides* Prasad 1990

Combretaceae
- *Anogeissus eosericea* Prasad & Prakash 1984
- *Calycopteris floribundoides* sp. nov.
- *Terminalia koilabasensis* sp. nov.
- *T. siwalica* sp. nov.
- *Terminalia* sp. Tripathi & Tiwari 1983

Myrtaceae
- *Syzygium miocenicum* Prasad & Prakash 1984

Caprifoliaceae
- *Lonicera mioquinquelocularis* sp. nov.

Rubiaceae
- *Randia miowallichii* sp. nov.

Ebenaceae
- *Diospyros koilabasensis* sp. nov.
- *D. pretoposia* sp. nov.

Apocynaceae
- *Tabernaemontana precoronaria* sp. nov.

Loganiaceae
- *Gaertnera siwalica* sp. nov.

Solanaceae
- *Datura miocenica* sp. nov.

Verbenaceae
- *Vitex prenegundo* sp. nov.
- *V. siwalicus* sp. nov.

Lauraceae
- *Cinnamomum mioinuctum* sp. nov.

Moraceae
- *Ficus precunia* Lakhanpal 1968
- *F. retusoides* sp. nov.
- *F. nepalensis* sp. nov.

*Palaeoecology*—Because the plant megafossils of the Siwalik Group are very similar to a considerable number of modern taxa, it would be desirable to comment upon the general climate setting and the type of forest complex around Koilabas during the Lower Siwalik period based mainly on our own findings as well as on those reported by others. In this connection reference may be made to the modern species to which the Lower Siwalik plant megafossils from Koilabas have been assigned leaving out the doubtful forms (Table 2). The modern comparable species of the Lower Siwalik taxa from this area are *Dillenia indica*, *Ryparosa kunstelri*, *Mesua ferrea*, *Dipterocarpus tuberculatus*, *Chloroxylon swietenia*, *Albizia lebbek*, *Dalbergia sericea*, *Millettia ovalifolia*, *M. macrostachya*, *Cassia laevigata* ; *C. hirsuta*, *Ormosia robusta*, *Anogeis-*

**Table 1—Detailed distribution of the modern equivalents of fossil taxa from the Lower Siwalik Beds of Koilabas.**

| Fossil taxa | Modern equivalents | Present day distribution |
|---|---|---|
| *Dicotyledons* | | |
| Dilleniaceae | | |
| *Dillenia palaeoindica* Prasad & Prakash | *Dillenia indica* Linn. | Moist evergreen forests of subhimalayan tracts from Nepal eastwards extending to Burma, Madhya Pradesh, Andhra Pradesh, Tamil Nadu and also Southeast Asia |
| Flacourtiaceae | | |
| *Ryparosa prekunstelri* sp. nov. | *Ryparosa kunstelri* King | Malaya |
| Guttiferae | | |
| *Mesua tertiara*, Lakhanpal | *Mesua ferrea* Linn. | Evergreen forests of eastern Bengal, eastern Himalaya, Chittagong, Upper Burma, Tennasserim, Andmans, Assam, Khasi, Hills, western Coast from North Kanara, Sri Lanka |
| Dipterocarpaceae | | |
| *Dipterocarpus siwalicus* Lakhanpal & Guleria; Prasad | *Dipterocarpus tuberculatus* (Syn. D. grandiflora Wall.) | Moist deciduous forests of plains and low hills in the valley of Burma |
| Meliaceae | | |
| *Chloroxylon palaeoswietenia* sp. nov. | *Chloroxylon swietenia* DC. | Deciduous forests of Satpura range, Deccan Konkan, Karnataka and Sri Lanka |
| Fabaceae | | |
| *Albizia siwalica* Prasad | *Albizia gamblei* (Syn. *A. lebbek* (L.) Willd) | Moist deciduous forest of Sikkim, Lower Hills and Terai and Naga hills in Nagaland |
| *Cassia nepalensis* sp. nov. | *Cassia hirsuta* Linn. | Both plains and hills of district Deccan, Ramandrug Bellary and Karnataka |
| | *C. laevigata* Gamble | Hill region especially on Nilgiris and Khasi Hills |
| *Dalbergia miosericea* sp. nov. | *Dalbergia sericea* Boj. | Madagascar and in sub-himalayan tracts |
| *Millettia siwalica* sp. nov. | *Millettia ovalifolia* Kurz. | Common in Lower Burma and from Jammu to Sikkim and in Minbu District of Upper Burma |
| *Millettia koilabasensis* Prasad | *Millettia macrostachya* Coll. & Hensl. | Shan Hills of Upper Burma |
| *Ormosia robustoides* Prasad | *Ormosia robusta* Wight | Wild in Arunachal Pradesh and Cachar District of Assam, Sylhet and Chittagong in Bangladesh and Burma |

**Table 1**—(*Contd.*)

| Fossil taxa | Modern equipments | Present day distribution |
|---|---|---|
| Combretaceae | | |
| *Anogeissus eosericea* Prasad & Prakash | *Anogeissus sericea* Brandis | Common on Panchmarhi Hills in Jabalpur District near Nerbuda river, Garhakota in Sagar District and Panchmahal and Gujarat |
| *Calycopteris floribundoides* sp. nov. | *Calycopteris floribunda* Lam. | Deciduous forest of Western peninsula, Assam, Chittagong and Burma |
| *Terminalia koilabasensis* sp. nov. | *T. angustifolia* Jack | Central Malaya Island |
| *Terminalia siwalica* sp. nov. | *T. pyrifolia* Kurz. | Mixed forests of Burma, common in Pyinmana and Western Metktila District |
| *Terminalia* sp. Tripathi & Tiwari | *T. arjuna* Bedd. | Common throughout the peninsula, Gujarat, North circars, Deccan scarce in Karnataka on the Western Coast |
| Rubiaceae | | |
| *Randia miowallichii* sp. nov. | *Randia wallichii* Hook. f. | East Himalaya, Sikkim, Khasi Hills, Sylhet, Chittagong and in Kachin Hlls, Andmans, Bangladesh and Burma |
| Ebenaceae | | |
| *Diospyros koilabasensis* sp. nov. | *Diospyros montana* Roxb. syn. *D. cordifolia* Roxb.) | Throughout most of India and Burma from the Ravi eastward along the Himalaya |
| *Diopyros pretoposia* sp. nov. | *Diospyros toposia* Ham. | Evergreen forests, growing in Khasi hills, Cachar, Chittagong, Tinnevelli Hills and in the moist regions of Sri Lanka |
| Apocynaceae | | |
| *Tabernaemontana precoronaria* sp. nov. | *Tabernaemontana coronaria* Willd. | Evergreen forests, growing in Subhimalayan tracts from Dehradun eastward, Darjeeling Hills and Upper Burma and Sri Lanka |
| Solanaceae | | |
| *Datura miocenica* sp. nov. | *Datura fastuosa* Linn. | Found throughout India, usually in Waste places, Malaya, in tropical Africa and America |
| Verbenaceae | | |
| *Vitex prenegundo* sp. nov. | *Vitex negundo* Linn. | Common every where in the plains and lower hills of India ascending to 5000ft. in the West Himalaya, extending west of Peshawar and Sind, Also common near the streams in Sri Lanka |
| *Vitex siwalicus* sp. nov. | *Vitex pubescens* Vahl. (Syn—*V. arborea* Roxb.) | Evergreen forests growing in Western peninsula, Orissa, Nilgiris, Sylhet, Burma and Andman Islands |

**Table 1**—(*Contd.*)

| Fossil taxa | Modern equipments | Present day distribution |
|---|---|---|
| Lauraceae | | |
| *Cinnamomum mioinuctum* sp. nov. | *Cinnamomum inuctum* Meissn. | Distributed in Tovoy, Malacaa, South Tennesserim and Malaya peninsula |
| Moraceae | | |
| *Ficus precunia* Lakhanpal | *Ficus cunia* Ham. | Sub-himalayan tracts, Chenab to Bhutan, Central India, Assam, Chittagong and Burma Ascends upto 1200 m. |
| *Ficus retusoides* sp. nov. | *Ficus retusa* Linn. | Evergreen forests growing in Sub-himalayan tracts from Kumaon eastwards, Khasi Hills, Bihar, Chota Nagpur Bundelkhand, Bengal Deccan peninsula and Andmans also common in Burma and Malaya |
| *Ficus nepalensis* sp. nov. | *Ficus glaberrima* Blume | Evergreen forest, Srilanka, in tropical Himalaya from Kumaon to Bhuttan and Burma, Andman Islands, Chittagong and Malaya peninsula |

*sus sericea, Calycopteris floribunda, Terminalia angustifolia, T. arjuna, T. pyrifolia, Syzygium claviflorum, Lonicera quinqueloculari*s, *Randia wallichii, Diospyros montana, D. toposia, Tabernaemontana coronaria, Datura fastuosa, Vitex negundo, V. pubescens, Cinnamomum inuctum, Ficus cunia, F. retusa* and *F. glaberrima.* Their present day distribution as shown in Table 1 indicates that tropical to sub-tropical vegetation of warm humid climate was prevalent around Koilabas during the Lower Siwalik period.

The Lower Siwalik deposits are also provided with red beds. According to Krynine (1949) majority of reds beds develop under acidic conditions where annual rainfall was more than 40 inches and the mean annual temperature exceeds 60° F. This temperature-rainfall condition is suggestive of warm humid climate.

*Phytogeography*—The study of the habit and habitat of the above comparable taxa indicates that the forms like *Dillenia indica, Ryparosa kunstelri, Mesua ferrea, Dipterocarpus tuberculatus, Albizia lebbek, Dalbergia sericea, Millettia ovalifolia, M. macrostachya, Ormosia robusta, Terminalia angustifolia, T. pyrifolia, Randia wallichii, Diospyros toposia Tabernaemontana coronaria, Vitex pubescens, Cinnamomum inuctum, Ficus retusa* and *Ficus glaberrima* are evergreen to semi-evergreen or moist deciduous and grow generally near water reservoirs while the taxa namely *Chloroxylon swietenia, Cassia hirsuta, Anogeissus sericea, Calycopteris floribunda, Diospyros montana, Datura fastuosa, Vitex negundo* and *Ficus cunia* are deciduous. Most of them (evergreen and semi-evergreen taxa) could not survive in Koilabas area due to climatic changes but continued to grow in north eastern part of the Indian subcontinent and adjoining regions of Bangladesh, Burma, etc. where climate is humid and more favourable for their survival. However, the deciduous taxa still continue to flourish near Koilabas area (Table 1).

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## Explanation of Plates

### Plate 1

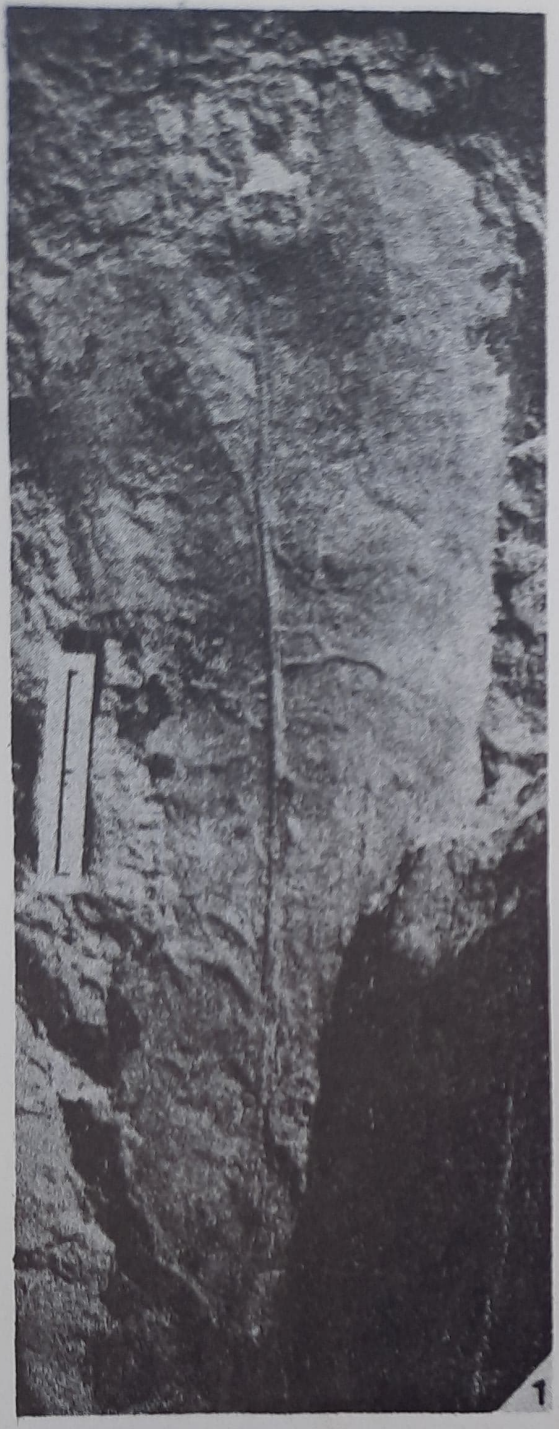
1. *Ryparosa prekunstelri* sp. nov.—fossil leaf in natural size.
2. *Ryparosa kunstelri*—Modern leaf in natural size showing similar shape, size and venation pattern.
3. *Mesua tertiara* Lakhanpal—fossil leaf in natural size.
4. *Mesua ferrea*—Modern leaf in natural size showing similar shape and size.
5. *Mesua tertiara* Lakhanpal—Another fossil leaf in natural size showing variation in shape and size.
6. *Mesua ferrea*—Another modern leaf in natural size showing close similarity with the fossil leaf shown in fig. 5.
7. *Chloroxylon palaeoswietenia* sp. nov.—Fossil leaf in natural size.
8. *Chloroxylon swietenia*—Modern leaf in natural size showing similar shape and size.
9. *Chloroxylon palaeoswetenia* sp. nov.—Another fossil leaf in natural size showing variation in shape and size.
10. *Chloroxylon swietenia*—Another modern leaf in natural size showing similar shape, size and venation pattern as shown in fig. 9.

### Plate 2

1. *Chloroxylon palaeoswietenia* sp. nov.—Fossil leaf magnified to show details of venation. X 6.
2. *Chloroxylon swietenia*—Modern leaf magnified to show similar details of venation. X 6.
3. *Cassia nepalensis* sp. nov.—Fossil leaf in natural size.
4. *Cassia hirsuta*—Modern leaf in natural size showing similar shape, size and venation pattern.
5. *Dallergia miosericea* sp. nov.—Fossil leaf in natural size.
6. *Dalbergia sericea*—Modern leaf in natural size showing similar, shape, size and venation pattern.
7. *Millettia siwalica* sp. nov.—A fossil leaf in natural size showing variation in shape and size.
8. *Millettia ovalifolia*—Modern leaf in natural size showing similar shape and size.
9. *Millettia ovalifolia*—Modern leaf in natural size showing similar shape and size.
10. *Millettia ovalifolia*—Modern leaf in natural size showing close similarity with the fossil leaf shown in fig. 9.
11. *Millettia siwalica* sp. nov.—Fossil leaf (fig. 7) magnified to show details of venation. X 5.
12. *Millettia ovalifolia*—Modern leaf (Fig. 8) magnified to show similar details of venation. X5.

### Plate 3

1. *Terminalia koilabasensis* sp. nov.—Fossil leaf in natural size.
2. *Terminalia koilabasensis* sp. nov.—Apical portion of fossil leaf showing nature of apex. X 1.
3. *Terminalia angustifolia*—Modern leaf in natural size showing similar shape, size and venation.
4. *Terminalia siwalica* sp. nov.—Fossil leaf in natural size.
5. *Terminalia pyrifolia*—Modern leaf in natural size showing similar shape, size and venation.
6. *Calycopteris floribunda* sp. nov.—Fossil leaf in natural size.
7. *Calycopteris floribunda*—Modern leaf in natural size showing similar shape, size and venation pattern.
8. *Lonicera mioquinquelocularis* sp. nov.—Fossil leaf in natural size.
9. *Lonicera quinquelocularis*—Modern leaf in natural size.
10. *Lonicera miquinquelocularis* sp. nov.—Another fossil leaf in natural size.
11. *Lonicera quinquelocularis*—Another modern leaf in natural size showing close similarity with fossil leaf (Fig. 10).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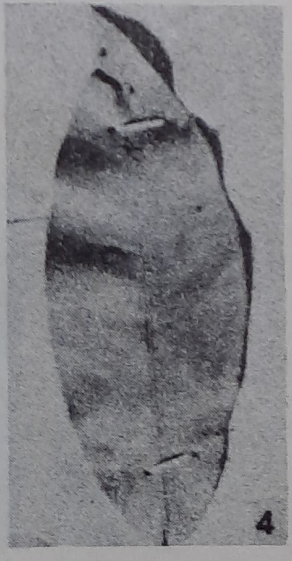
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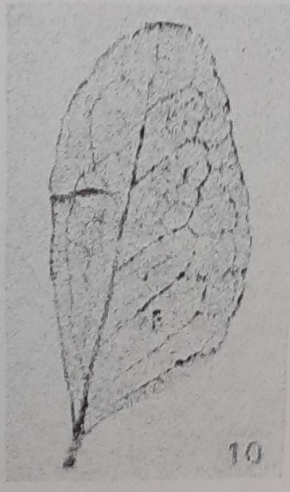
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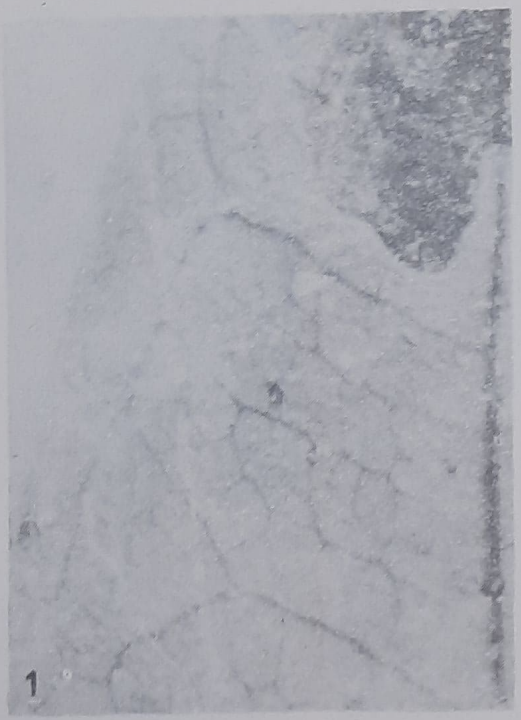
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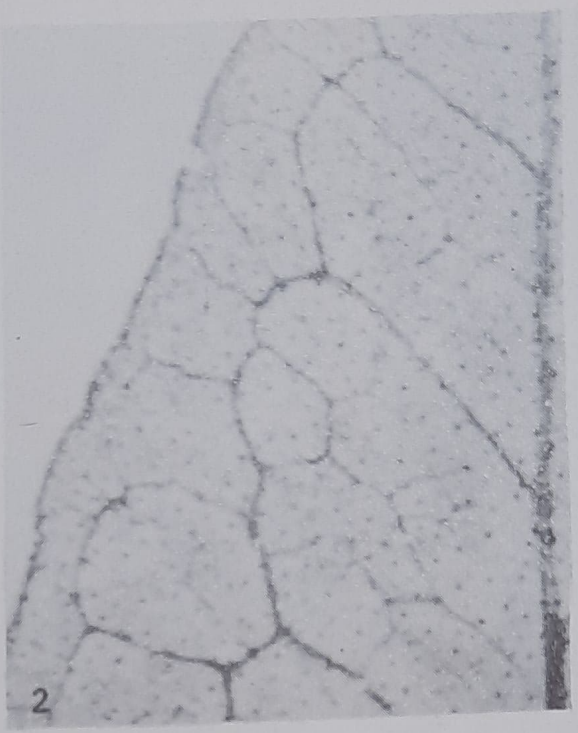
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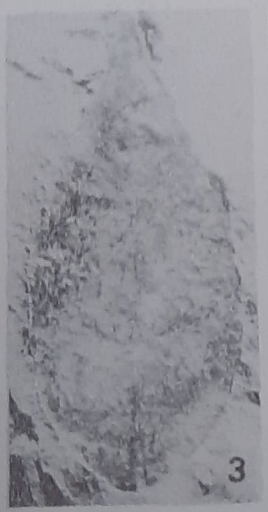
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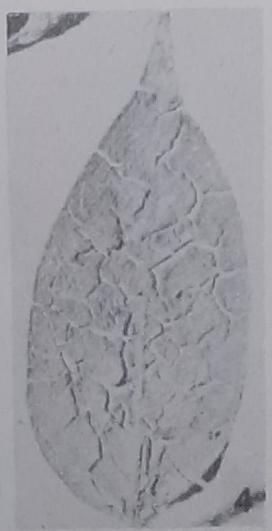


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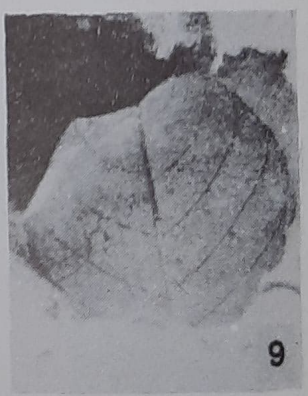
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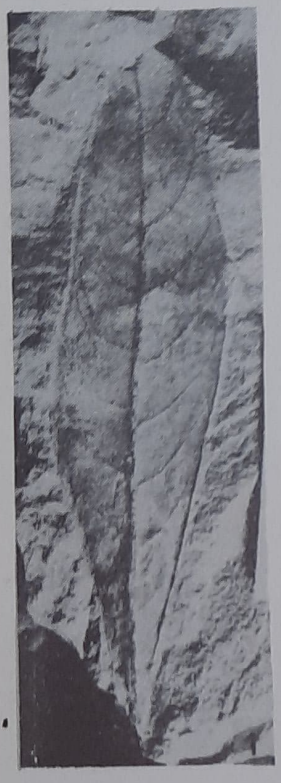
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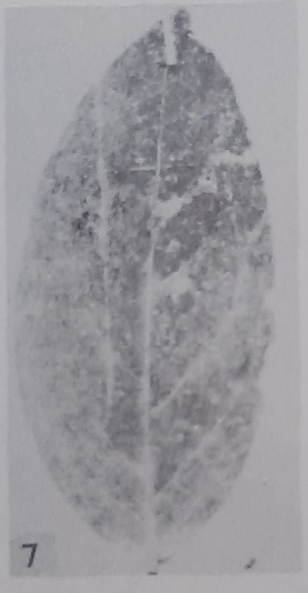
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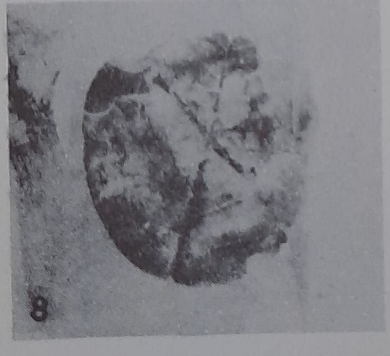
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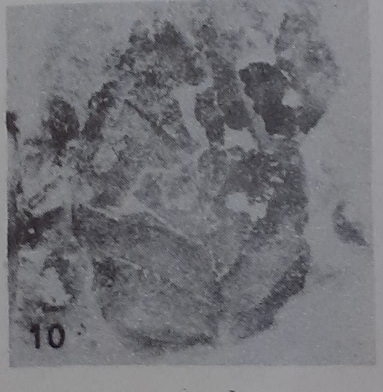
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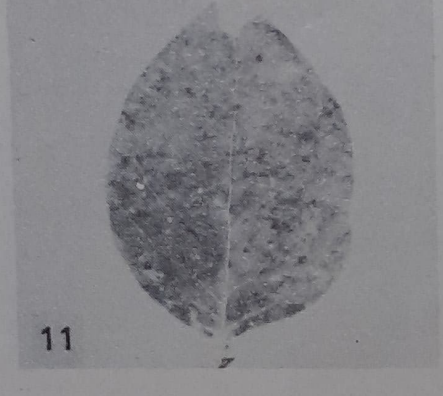
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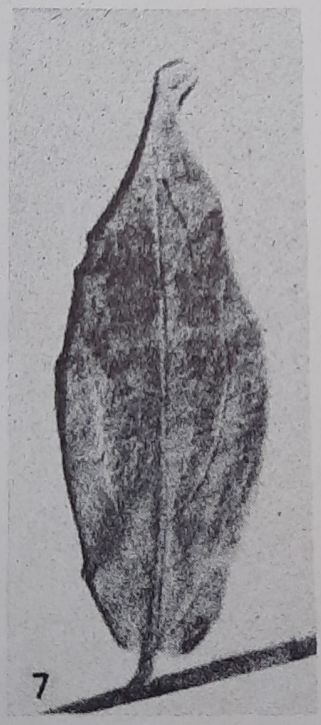
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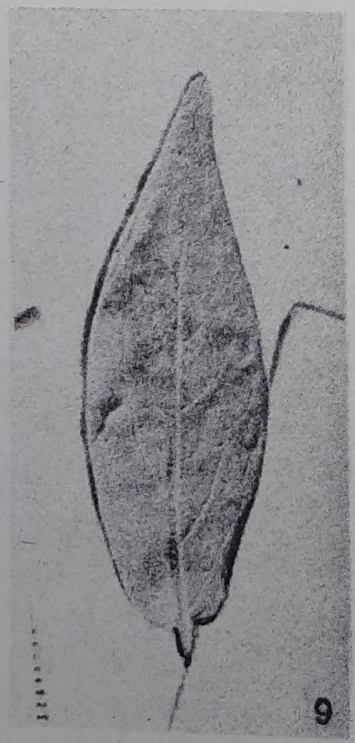
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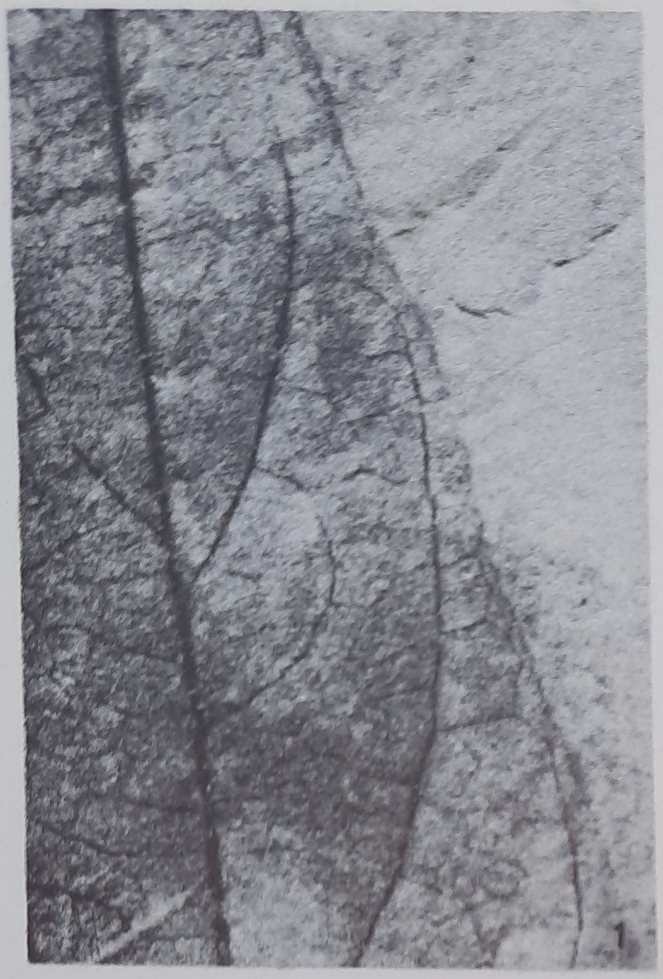

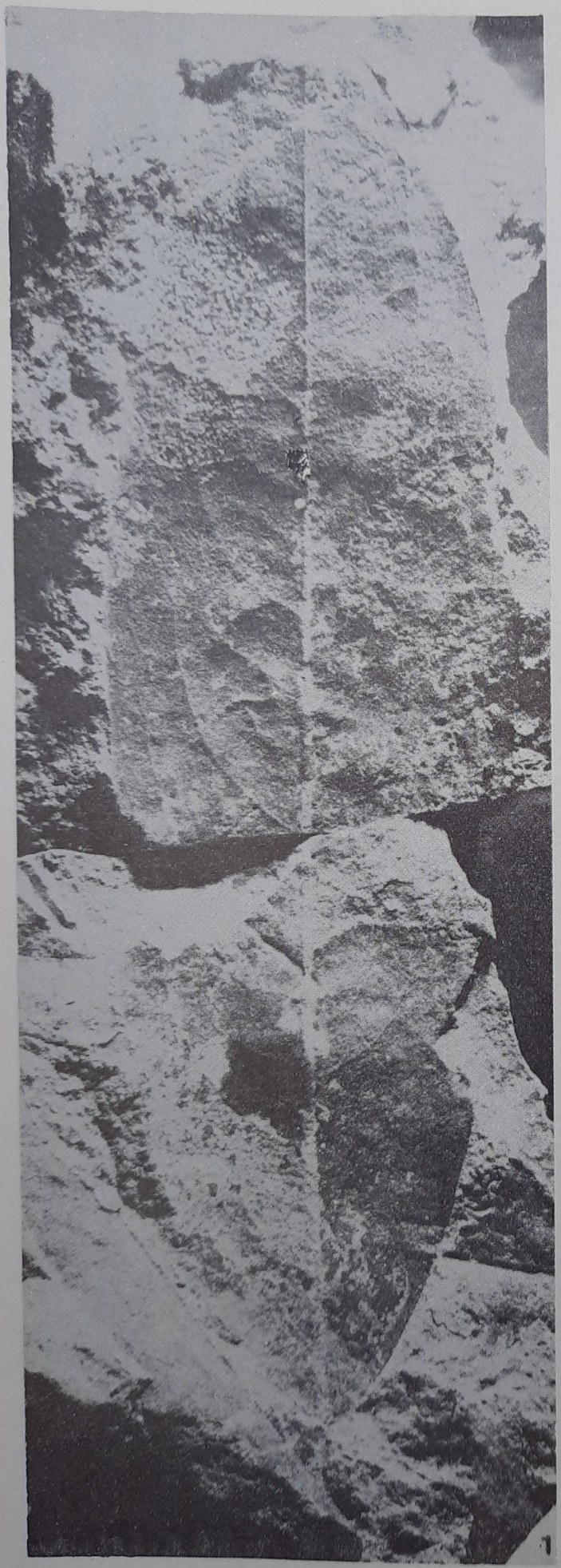

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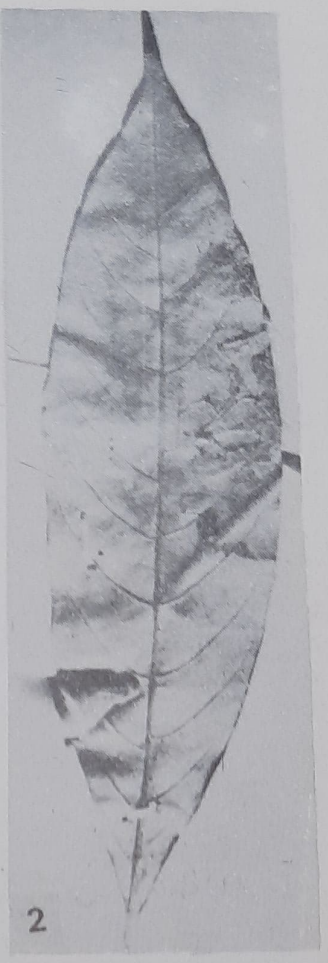
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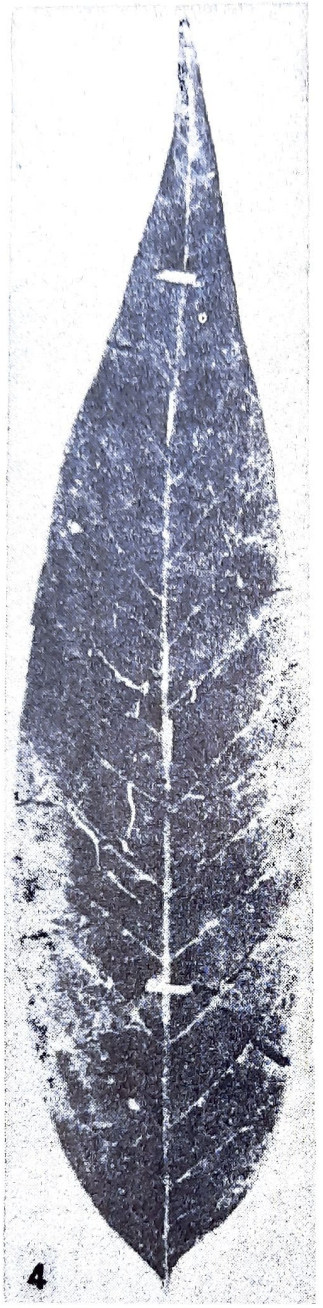


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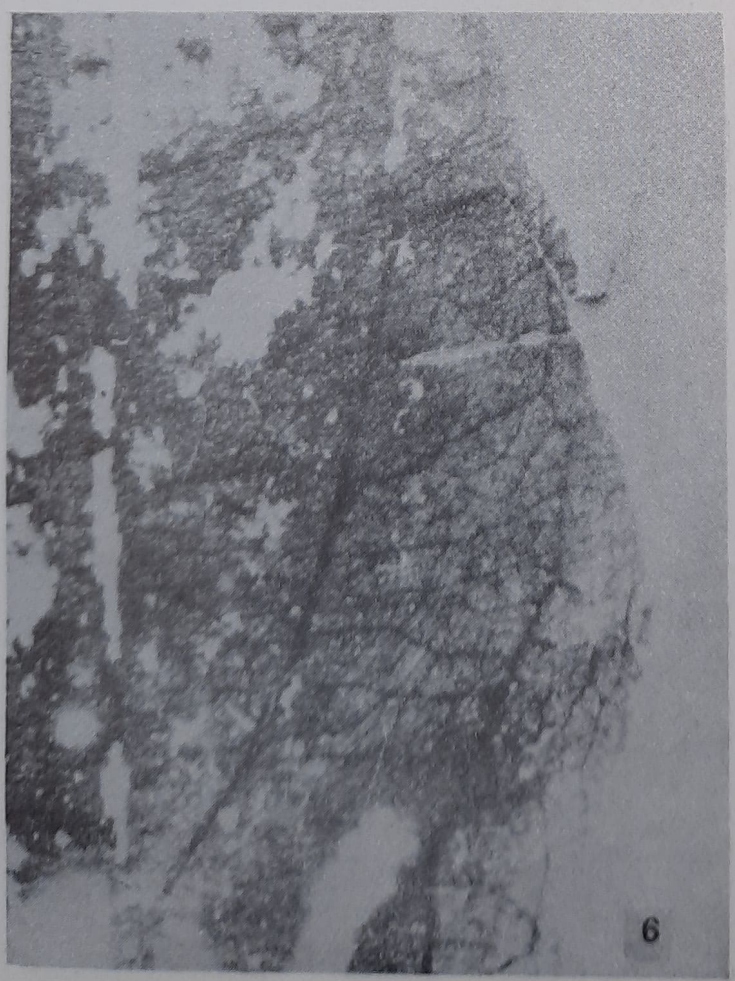
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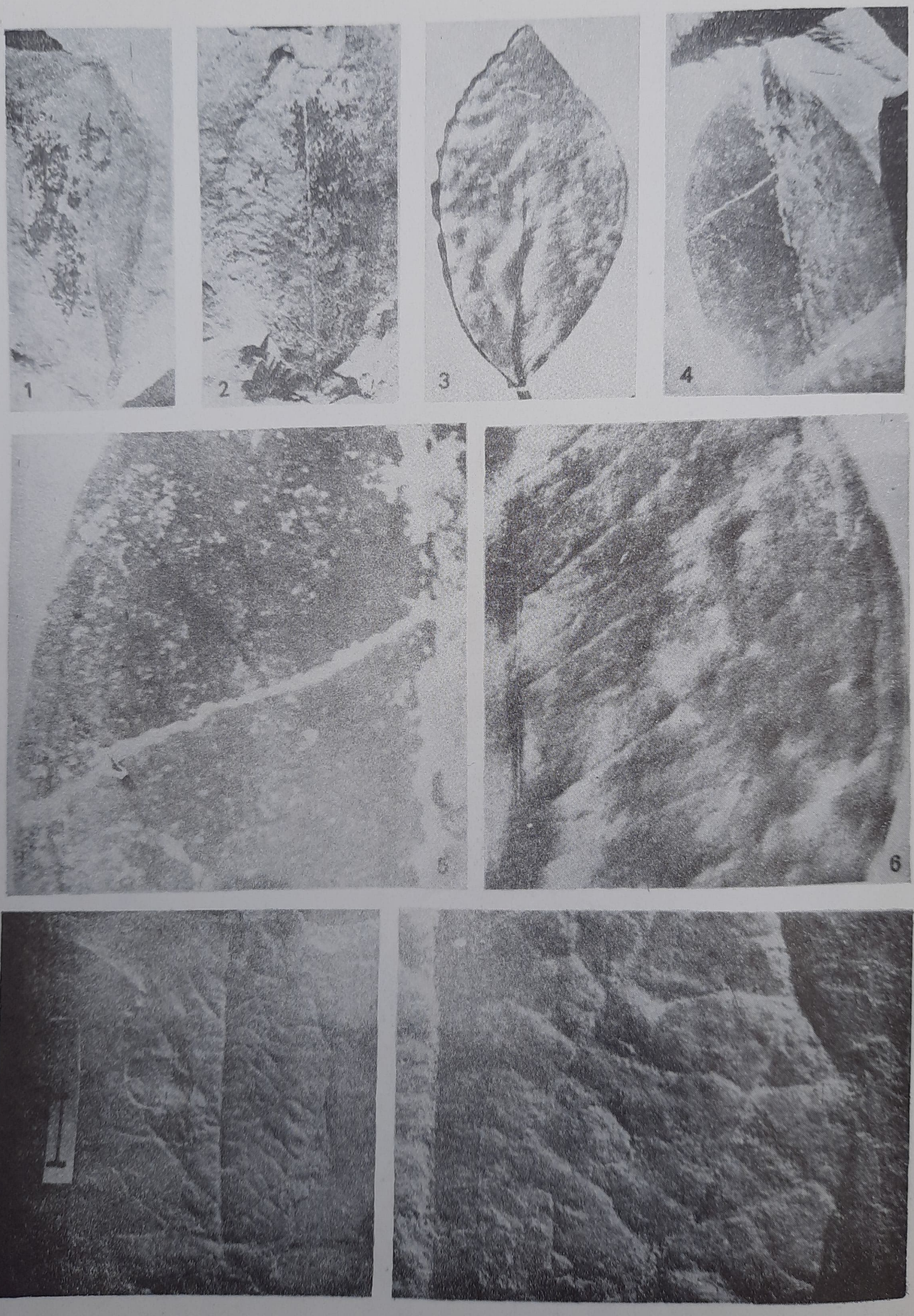
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## Plate 4

1. *Lonicera mioquinquelocularis* sp. nov.—Fossil leaf (fig. 8) magnified to show details of venation X 4.
2. *Randia miowallichii* sp. nov.—Fossil leaf in natural size.
3. *Randia miowallichii* sp. nov.—Fossil leaf in natural size showing the apex.
4. *Randia wallichii*—Modern leaf in natural size showing similar shape, size and venation.
5. *Randia miowallichii* sp. nov.—Another fossil leaf in natural size showing variation in size.
6. *Diospyros koilabasensis* sp. nov.—Fossil leaf in natural size.
7. *Diospyros montana*—Modern leaf in natural size.
8. *Diospyros koilabasensis* sp. nov.—Another fossil leaf in natural size showing variation in shape and size.
9. *Diospyros montana*—Another modern leaf in natural size showing close similarity with fossil leaf (Fig. 8).
10. *Diospyros koilabasensis*—Another fossil leaf in natural size.

## Plate 5

1. *Diospyros koilabasensis* sp. nov.—Fossil leaf (Fig. 8) magnified to show details of venation. X 4.
2. *Diospyros montana*—Modern leaf (fig. 9) magnified to show similar details of venation. X4.
3. *Diospyros pretoposia* sp. nov.—Fossil leaf magnified to show similar details of venation X 2.
4. *Diospyros toposia*—Modern leaf magnified to show similar details of venation. X2.

## Plate 6

1. *Diospyros pretoposia* sp. nov.—Fossil leaf in natural size.
2. *Diospyros toposia*—Modern leaf in natural size showing similar shape and size.

## Plate 7

1. *Tabernaemontana precoronaria*—Fossil leaf in natural size.
2. *Tabernaemontana precoronaria*—another fossil leaf in natural size.
3. *Gaertnera siwalica* sp. nov.—Fossil leaf in natural size.
4. *Gaertnera bieleri*—Modern leaf in natural size showing similar shape and size.
5. *Gaertnera siwalica* sp. nov.—Another fossil leaf in natural size showing nature of apex.
6. *Gaertnera siwalica* sp. nov.—Fossil leaf (Fig. 3) magnified to show details of venation. X 4.
7. *Gaertnera bieleri*—Modern leaf magnified to show similar details of venation. X 4.
8. *Datura miocenica* sp. nov.—Fossil leaf in natural size showing basal part.

## Plate 8

1. *Datura miocenica* sp. nov.—Fossil leaf in natural size.
2. *Datura fastuosa*—Modern leaf in natural size showing similar shape and size.
3. *Vitex prenegundo* sp. nov.—Fossil leaf in natural size.
4. *Vitex negundo*—Modern leaf in natural size showing similar shape and size.
5. *Vitex prenegundo* sp. nov.—Fossil leaf (Fig. 3) magnified to show details of venation. X 4.

## Plate 9

1. *Vitex prenegundo* sp. nov.—Another fossil leaf in natural size.
2. *Vitex siwalicus* sp. nov.—Fossil leaf in natural size.
3. *Vitex pubescens*—Modern leaf in natural size showing similar shape, size and venation pattern.
4. *Cinnamomum mioinuctum* sp. nov.—Fossil leaf in natural size.
5. *Cinnamomum inuctum*—Modern leaf in natural size showing similar shape and size.
6. *Cinnamomum mioinuctum* sp. nov.—Fossil leaf magnified to show simillar details of venation. X 4.5.
7. *Cinnamomum inuctum*—Modern leaf magnified to show similar details of venation. X 4.5.

## Plate 10

1. *Cinnamomum mioinuctum* sp. nov.—Counter part of (Fig. 4).
2. *Ficus retusoides* sp. nov.—Fossil leaf in natural size.
3. *Ficus retusa*—Modern leaf in natural size showing similar shape and size.
4. *Ficus retusoides* sp. nov.—Another fossil leaf in natural size.
5. *Ficus retusoides* sp. nov.—Fossil leaf (fig. 4) magnified to show details of venation X 4.
6. *Ficus retusa*—Modern leaf magnified to show similar details of venation. X 4.
7. *Ficus precunia* Lakhanpal—Fossil leaf in natural size.
8. *Ficus precunia* Lakhanpal—Fossil leaf magnified to show details of venation. X 3.

## Plate 11

1. *Ficus nepalensis* sp. nov.—Fossil leaf in natural size.
2. *Ficus glaberrima*—Modern leaf in natural size.
3. *Ficus nepalensis* sp. nov.—Fossil leaf magnified to show details of venation. X 3.
4. *Ficus glaberrima*—Modern leaf magnified to show similar details of venation. X 3.
5. *Vitex negundo*—Modern leaf magnified to show similar details of venation. X 4.