SYSTEMATICS

OF

FOSSIL ASSEMBLAGE
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LILIOPSIDA
Family: Marantaceae
Genus: Donax LOUR.

Donax ovatus (AWASTHI & PRASAD) n. comp.
Pl.1, Figs. 1-4

Material: There are four, well preserved leaf impressions devoid of cuticle.

Description: Leaves simple, slightly asymmetrical, one side of lamina is wider than the other, preserved size 4.0 x 2.5 cm, 8.0 x 4.0 cm, 7.0 x 3.0 cm, ovate to elliptic; apex acute; base seemingly acute; margin entire; texture chartaceous; petiole indistinct; venation pinnate, eucamptodromous; primary vein (1°) single straight, moderate; secondary veins (2°) numerous, angle of divergence 20°-40°, narrow acute, less than 1mm apart, opposite to alternate, uniformly curved up, lower pairs of secondary run upward along the margin to a greater length, unbranched. Tertiary veins (3°) absent.

Figured specimen: Specimen No. T-104-T-106.

Locality: Spot No. 4, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Affinities: The most characteristic features of the present fossil leaves such as slightly asymmetrical ovate to elliptic shape, entire margin, numerous, fine, very closely placed secondary with narrow acute angle of divergence suggest that these leaves belong to the genus Donax LOUR. (Clinogyne SALISB.) of the family Marantaceae. In order to find out its specific affinity the herbarium sheets
of all the available species of this genus have been examined and found that these leaves resemble closely with the modern leaves of *Donax grandis* BENTH. & HOOK. in shape, size and venation pattern.

**Fossil record and comparison:** The fossil leaves resembling the genus *Donax* (*Clinogynae*) have been described earlier under the form species *C. ovatus* AWASTHI & PRASAD (1990) from the Siwalik sediments of Surai Khola area, Nepal and *Clinogynae* cf. *C. ovatus* from Kasauli Formation, Himachal Pradesh (ARYA & AWASTHI, 1995). These leaves have been compared with the same extant species, *C. grandis* and also similar to the present fossils. ANTAL & PRASAD (1995) described another fossil leaf showing affinity with *Clinogynae dichotoma* from the Siwalik sediments of Oodlabari area in Darjeeling District, West Bengal. This fossil leaf differs in the nature and course of secondary veins which arise comparatively less angle. Two fossil leaves resembling *Donax cannaeformis* Lour. have been described from the Kasauli Formation, Himanchal Pradesh and Siwalik sediments of Koilabas Nepal respectively under a form species *D. kasauliensis* (PRASAD & DWIVEDI 2008; SRIVASTAVA & GULERIA 2002). On comparison, it has been found that both the fossil leaves of *D. kasauliensis* exhibit unmatched morphological characters as well as larger in size. In view of this the present fossil is described as *D. ovatus* (AWASTHI & PRASAD, n.comb).

**Present day distribution:** The genus *Donax* Lour. Consists of 20 species which are mostly distributed in tropical Africa (WILLIS, 1973). The extant species *Donax ovatus* BENTH. & HOOK. with which fossil shows closest affinity is a large shrub that found in savannah of Myanmar, sub-himalayan tract, Andaman Islands and Malaya peninsula (HOOKER, 1884).

**MAGNOLIOPSISIDA**

Family: Anonaceae
Genus: Anona MILLER
*Anona miocenica* sp. nov.
Pl.1, Figs.5,6,8
Material: This species consists of three, well preserved leaf impressions. The apex is broken in the entire specimen.

Description: Leaf simple, almost symmetrical, narrow elliptic, preserved size 4.8x1.9 cm and 10.5x3.5 cm; apex broken; base acute; margin entire; texture chartaceous; petiole indistinct; venation pinnate, eucamptodromous, primary vein (1st) single, prominent stout slightly curved; secondary veins (2nd) 10 pairs visible, 0.5-1.5 cm apart, alternate to subopposite, angle of divergence 60°-80°, wide acute, uniformly curved up, moderate, basal secondaries less acute, unbranched; tertiary veins (3rd) fine, angle of origin AO-RR, percurent, almost straight, branched, oblique in relation to midvein, alternate to opposite and close.

Holotype: Specimen No. T-104.
Paratype: Specimen No. T-105, T106.
Locality: Spot No. 1, near Hanuman Chatti, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Etymology: After the name of Miocene period.

Affinities: The characteristic features of the present fossils such as narrow elliptic shape, acute apex and base, entire margin, eucamptodromous venation and wide acute angle of divergence of secondary veins suggest their affinity with the modern leaves of the genus *Anona* MILLER of the family Anonaceae. In order to find out its specific affinity, a large number of herbarium sheets of different species of this genus have been examined and concluded that the leaves of *Anona reticulata* Linn. show closest similarity with the fossil leaves in shape, size and venation pattern (C.N.H. Herbarium sheet Nos. 11387, 54190, 28551, 215; Pl.1, fig.7).

Fossil Record and comparison: PRASAD et al. (1999) described a fossil leaf showing resemblance with *Anona laurifolia* LINN. under the form species, *A. koilabasensis* from the Siwalik sediments of Nepal. Although this fossil leaf shows close similarity in the nature and arrangement of tertiary veins but differs in having lorate shape with obtuse base. The course of secondary veins is also different as
compared to the present fossil leaves. In view of this the present fossils are being described here as a new species *Anona miocenica*.

**Present day description:** The genus *Anona* MILLER consists of 137 species of shrubs distributed in the tropical regions of America, Brazil, Africa (MABBERLEY, 1997). Only four introduced species are found to grow in India (WILLIS 1973). The comparable species, *Anona reticulata* LINN. is a small tree naturalized in West Bengal and elsewhere (HOOKER, 1872).

Genus: *Popowia* ENDL.

*Popowia siwalica* sp. nov.  
Pl.1, Figs 9,10

**Material:** This species is based on two well preserved leaf impressions.

**Description:** Leaf simple, symmetrical, elliptic, preserved size 3.8 x 1.9 cm and 3.5 x 2.6 cm; apex slightly broken in both specimens; base obtuse; margin entire; petiole not preserved; texture chartaceous; venation pinnate, eucamptodromous; primary vein (1°) single, slightly curved, stout; secondary veins (2°) 6-7 pairs visible, 0.5 to 0.08 cm apart, alternate to sub opposite, angle of divergence about 55°, moderately acute, uniformly curved up, secondary veins run upward to a little distance, unbranched; tertiary veins (3°) fine, angle of origin usually RR, percurrent, almost straight, rarely branched, oblique in relation to midvein, predominantly alternate and close.

Holotype: Specimen No. T-107.
Locality: Spot No.10, near Bhairav Mandir, Purniyagiri. Road section, Tanakpur Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Miocene-Pliocene.
Etymology: After the name of Siwalik Formation.

**Affinities:** The diagnostic features of the present fossil leaves are elliptic shape, obtuse base, eucamptodromous venation with secondary veins running upward for a little distance before joining their superadjacent secondary veins, RR, percurrent, predominantly alternate tertiaries. During identification it has been observed that
these features are found common in the modern leaves of the genus *Popowia* ENDL. of the family Anonaceae. The comparative study with modern leaves of all the available species of this genus suggests that the present fossil leaves show closest affinity with the leaves of *Popowia ramosissiana* BEDD. (Syn. *P. beddomeana* HOOK. F. & TH.; C.N.H. Herbarium sheet No.12559).

**Fossil record and comparison:** There is no record of fossil leaf resembling the genus *Popowia* ENDL. from the Tertiary sediments of India. This fossil leaf represents its first occurrence in the Siwalik sediments of Uttarakhand, hence it is being described as *Popowia siwalica* sp. nov.

**Present day distribution:** The genus *Popowia* ENDL. comprises 30 species distributed in the tropical regions from Asia to Australia. *Popowia ramosissiana* BEDD. with which fossils show closest affinity is a evergreen, small tree or shrub found commonly between Tinnvelli and Travancore (BRANDIS, 1971).

Genus: *Saccopetalum* BENNETT.

*Saccopetalum pretomentosum* PRASAD et. al., 2004

Pl.2, Figs 1, 3

**Material:** There is a single, well preserved leaf impression.

**Description:** Leaf simple, symmetrical, wide ovate; preserved size 6.0 x 4.0 cm; apex seemingly acute; base obtuse; margin entire; texture chartaceous; venation pinnate, encamptodromous; Primary vein (1°) single, prominent, stout; secondary veins (2°) 7-8 pairs, 0.4 to 1.5 cm apart, alternate, angle of divergence about 40°, narrow acute, branched, lower secondaries with 2-3 branches, curved up and run for a greater length towards apex; tertiary veins (3°) moderate in thickness, angle of origin usually RR, percurrent, straight to sinuous, oblique to right angle in relation to midvein, predominantly alternate and close.

Specimen: Specimen No.T-108
Locality: Spot No.10, Bhairauv Mandir, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

**Affinity:** The characteristic features of the present fossil leaf are ovate shape, acute apex, obtuse base, eucamptodromous venation, narrow acute angle of divergence of secondary veins with profusely branches, percurrent, straight to sinous tertiary veins with oblique to right angle in relation to midvein. These features are found commonly in the extant leaves of *Saccopetalum* BENNETT. of the family Anonaceae. After comparative study of all the available species of *Saccopetalum* BENNETT., it was observed that the fossil leaf shows similarity with the leaves of *S. tomentosum* HOOK. F. & TH. (C.N.H. Herbarium sheet No.14330; Pl.2, Fig.2).

**Fossil record and Comparison:** So far, two fossil leaves resembling the genus *Saccopetalum* BENNET. have been described from the Tertiary sediments of India. AWASTHI & MEHROTRA (1995) described a fossil leaf as *Saccopetalum palaeolongiflorum* from the Oligocene sediments of Makum Coalfield, Assam. The fossil leaf has larger size (18 cm in length) with wide elliptic shape as compared to ovate shape in the present fossil. Later on PRASAD et al., 2004 reported a fossils leaf, *Saccopetalum pretomentosum* from Lower Siwalik sediments of Kathgodam, Uttarakhand. The fossil shows similarity with the extant leave of *S. tomentosum* and also possesses similar morphological features as the present fossil. Hence it is being described under the same species, *S. pretomentosum* PRASAD et al.

**Present day distribution:** The genus *Saccopetalum* BENNETT. (now *Miliusa*) consists of 40 species distributed in the Indo-Malayan region and Australia (MABBERLEY, 1997). The modern comparable species *Saccopetalum tomentosum* (= *Miliusa tomentosum*) HOOK. F. & TH. is a deciduous tree and found to grow in Oudh, Nepal Terai upto Gorakhpur and Southwards throughout the peninsula (BRANDIS, 1971).
Meiogyne MIQ.

Meiogyne purniyagiriensis sp. nov.

Pl.2, Figs 4, 6

**Material:** This species is based on a single, well preserved and complete leaf impression.

**Description:** Leaf simple, symmetrical, narrow ovate; size 4 x 1.5 cm; apex sharply acute; base wide acute to nearly obtuse; slightly inequilateral; margin entire; texture chartaceous; petiole broken; venation pinnate; eucamptodromous to brochidodromous; primary veins (1°) single; prominent, weak, straight; secondary veins(2°) 9-10 pairs visible, 0.2 to 0.6 cm apart, alternate to opposite; angle of divergence 40°-70°, narrow to wide acute, uniformly curved up; secondaries of one side of lamina arise at wide acute angle towards basal region, sometimes branched, few secondaries joins each other before reaching the margin, intersecondary veins present, simple; tertiary veins (3°) fine, angle of origin usually RR, percurrent, almost straight, sometimes branched, oblique in relation to midvein, predominantly alternate and close; quaternary veins (4°) poorly preserved arising at right angle, forming triangular to polygonal meshes.

**Holotype:** Specimen No.T-109.

**Locality:** Spot No.1, near Hanuman chatti, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

**Horizon & Age:** Siwalik Formation; Mio – Pliocene.

**Etymology:** After the name of Purniyagiri Temple.

**Affinity:** The present fossil leaf is characterized by narrow ovate shape, sharply acute apex, slightly asymmetrical, nearly obtuse base, entire margin, eucamptodromous to brochidodromous venation, narrow to wide acute angle of divergence of secondary veins, RR, percurrent tertiaries having an oblique angle in relation to midvein. The nature of few basal secondaries which are joining to their superadjacent secondaries before reaching the margin is also an important character. A comparative study of the herbarium sheets of different families and genera shows that the above features are found commonly in the extant leaves of...
Meiogyne pannosa DALZ. of the family Anonaceae (C.N.H. Herbarium sheet No.11449; Pl.2, Fig. 5).

**Fossil record and comparison:** The fossil leaf resembling the genus Meiogyne MIQ. is not known so far from the Tertiary sediments of India and abroad. This is the first record of the present fossil from the Siwalik sediments of Uttarakhand and therefore, it has been described under the new specific name Meiogyne purniyagiriensis.

**Present day distribution:** The genus Meiogyne MIQ. consists of nine species distributed in the Indo-Malayan region (MABBERLEY, 1997). The modern comparable taxon, *M. pannosa* DALZ. is a shrub or small tree distributed in the evergreen forests of Western Ghat. It is more common in South and Central Sahyadri and rare in Maharashtra Sahyadri.

**Kingstonia** HOOK. F. & THOMSON

*Kingstonia palaeonervosa* sp. nov.

Pl.2, Figs 7.9

**Material:** This consists of only one, well preserved leaf impression.

**Description:** Leaf simple, symmetrical, very narrow elliptic; size 7.5 x 1.8 cm; apex seemingly acute; base acute; margin entire; texture chartaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, slightly curved, stout; secondary veins (2°) about 11 pairs visible, 0.4 cm to 0.8 cm apart, angle of divergence 60°-70°, moderately acute, uniformly curved up, seemingly unbranched; intersecondary veins present, simple; tertiary veins (3°) fine, angle of origin usually RR, rarely AO, percurrent, straight to sinuous, branched, oblique in relation to midvein, predominantly alternate and close.

**Holotype:** Specimen No. T-110.

**Locality:** Spot No.10, Bhairauv Mandir, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

**Horizon & Age:** Siwalik Formation; Mio-Pliocene.
Etymology: By adding prefix ‘Palaeo’ to the name of comparable species, *K. nervosa*.

**Affinity:** In being symmetrical, very narrow elliptic shape with an acute apex and base, eucamptodromous type of venation along with RR, percurrent, straight to sinuous tertiary veins, the present fossil shows its nearest affinity with the extant taxon, *Kingstonia nervosa* (HOOK. F. THOMSON) RAUSCHERT of the family Anonaceae (C.N.H. Herbarium sheet No. 4774; Pl., 2 Fig.8).

**Fossil records and comparison:** There is no record of fossil leaf of the genus *Kingstonia* HOOK F. TH. from the Cenozoic sediments of India and abroad. This fossil leaf represents its first occurrence and has been described as *Kingstonia palaeonervosa* sp. nov.

**Present day distribution:** The genus *Kingstonia* HOOK. F. & TH. comprises single species, *Kingstonia nervosa* (HOOK F. & TH.) RAUSCHERT (Syn. *Dendrokingstonia nervosa* RAUSCHERT) with which fossil shows close affinity is a tree and distributed in the evergreen forests of Malayan peninsula, Java, Malacca and Maingay (HOOKER, 1872).

**Family:** Polygalaceae

**Genus:** Securidaca LINN.

*Securidaca precorymbosa* sp. nov.

Pl.3, Figs 1,3

**Material:** There is a single, fairly preserved, almost complete leaf impression.

**Description:** Leaf simple, symmetrical, wide ovate; size 3.5 x 2.5 cm; apex slightly broken, seemingly acute; base obtuse, normal; margin entire; texture coriaceous; petiole broken; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, moderate, straight; secondary veins (2°) about 7 pairs visible, 0.3 to 0.7 cm apart, angle of divergence acute, about 60°, moderate, uniformly curved up, seemingly branched, upper secondaries arise more acutely;
intersecondaries arise more acutely, intersecondary veins present, frequent; tertiary veins (3°) fine, poorly preserved, angle of origin AO, percurrent, almost straight, oblique in relation to midvein, predominantly alternate and close.

Holotype: Specimen No. T-112.
Locality: Spot No.8, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Etymology: By adding prefix ‘pre’ to the name of modern comparable species, *S. corymbosa*.

**Affinity**: The fossil leaf is characterized by wide ovate shape, obtuse base, entire margin, eucamptodromous venation, moderately acute angle of divergence of secondary veins and AO, percurrent tertiary veins. These features undoubtedly indicate that the present fossil leaf closely resembles the extant leaf of *Securidaca corymbosa* TRIANA & PLANCH of the family Polygalaceae (C.N.H. Herbarium sheet No.36423; Pl.3, Fig.2).

**Fossil record and comparison**: So far, two fossil leaves resembling the extant leaves of *Securidaca inappendiculata* HASK. have been known under the form species *Securidaca miocenica* PRASAD et. al., 1997 from the Siwalik sediments of Seria Naka, Uttar Pradesh, India and Koilabas, Nepal respectively. These fossil leaves differ entirely from the present fossil leaf in having large, elliptic shape as compare to small, wide ovate shape in this fossil leaf. On account of its distinctiveness this fossil specimen has been described as a new species *Securidaca precorymbosa*.

**Present day distribution**: The genus *securidaca* LINN. comprises about 114 species of trees and scramblers. The modern comparable species *S. corymbosa* TRIANA & PLANCH is presently distributed in north-east Indian region.

**Family**: Xanthophyllaceae
**Genus**: *Xanthophyllum* ROXB.

*Xanthophyllum mioglaucum* sp nov.
Material: There are two, well preserved and complete leaf impressions.

Description: Leaf simple, symmetrical, narrow elliptic; size 7 x 2.4 cm, 7 x 2.8 cm; apex acute; base acute; margin entire; texture thick coriaceous; petiole broken; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 6-7 pairs visible, 0.8 to 2.0 cm apart, alternate, angle of divergence about 55°, moderately acute, seemingly unbranched, uniformly curved up and run for a short distance toward apex; intersecondary veins present, simple; tertiary veins (3°) fine, angle of divergence usually RR, rarely AO, percurrent, straight to sinuous, sometimes branched, oblique in relation to midvein, predominantly alternate and close.

Holotype: Specimen No. T-113.
Paratype: Specimen No. T-114.
Locality: Spot No.1, near Hanuman Chatti, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Etymology: By adding prefix 'mio' to the name of extant species, X. glaucum.

Affinity: The diagnostic features of the present fossil leaf such as symmetrical, narrow elliptic shape, acute apex and base, entire margin, eucamptodromous venation, alternate secondary with moderately acute angle of divergence, usually RR, percurrent and close tertiaries indicate that the present fossil shows resemblance with the modern leaves of the genus Xanthophyllum ROXB. of the family Xanthophyllaceae. In order to find out specific affinity, the herbarium sheets of all the available species of this genus were critically examined and it was concluded that the leaves of Xanthophyllum glaucum WALL. (C.N. H. Herbarium sheet Nos 2953, 209, 505; Pl.3, Fig.6) show close similarity with the fossil leaf in shape, size and venation pattern.

Fossil record and comparison: ANTAL & PRASAD (1996a) reported a fossil leaf resembling the genus Xanthophyllum ROXB. under a form species X.
_mioflavecens_ from the Siwalik sediments of Darjeeling District, West Bengal. This species differs from the present fossil in being larger size with few sparsely arranged secondary veins. Besides, a fossil wood resembling this genus has also been reported from the Mio-Pliocene beds of Cuddalore Series, South India (AWASTHI, 1987). As the present fossil leaf is distinct from already known fossil leaf, this has been described under a new species, _Xanthophyllum mioglaucum_.

**Present day distribution:** The genus _Xanthophyllum_ ROXB. is chiefly an Indo-Malayan genus comprising about 93 species (MABBERLEY, 1997). _Xanthophyllum glaucum_ WALL. (_X. macrocarpum_) with which fossil leaf shows closest resemblance is a large, evergreen tree distributed in moist places of Upper and Lower Myanmar and Malayan peninsula (BRANDIS, 1971; RIDLEY, 1767).

Family: Clusiaceae
Genus: _Kayea_ WALL.

**_Kayea kalagarhensis_ PRASAD, 1993**

Pl.3, Figs 10, 11; Pl.4, Figs 1, 3

**Material:** There are three specimens of well preserved leaf impression.

**Description:** Leaf simple, symmetrical, narrow elliptic; preserved length 12.5 x 3 cm 5.5 x 1.8, 4 x 1.5 cm; apex alternate, base wide acute, normal; margin entire; texture coriaceous; petiole broken; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, massive, almost straight; secondary veins (2°) about 36 pairs visible, closely placed, less than 0.5 cm apart, angle of divergence 80° - 90°, right angle decreasing towards apex, uniformly curved up, opposite to alternate, rarely branched; intersecondary veins present, simple, frequent; tertiary veins (3°) fine, poorly preserved, angle of origin AO - RR, almost, percurrent, sometimes branched, oblique in relation to midvein, predominantly alternate and close. Further details could not be seen.

Holotype: Specimen No. T-116 to T-118.

Locality: Spot No.3, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.

Affinity: The characteristic features of the present fossil leaves are symmetrical, narrow elliptic shape, alternate apex, wide acute base, entire margin, eucamptodromous venation, closely placed secondary veins with nearly right angle of divergence and usually RR, percurrent, branched tertiary veins. A details study of the herbarium sheets of different genera and species, it was seen that the above features are found common in the modern leaves of *Alstonia scholaris* R. BR. and *Kayea floribunda* WALL. of the family Apocynaceae and Clusiaceae respectively. Of these, the leaves of *Alstonia scholaris* R. BR. differ in having intramarginal veins which are not found in the fossil. Thus, these leaf impressions show closest resemblance with the modern leaves of *Kayea floribunda* WALL. (C.N.H. Herbarium sheet No.47570, 47560; Pl.4, figs 2,4).

Fossil record and Comparison: Two fossil leaves resembling the genus *Kayea* WALL. have been described as *Kayea kalagarhensis* PRASAD from Siwalik sediments of Kalagarh Uttarakhand (PRASAD, 1993) and Koilabas, Nepal (PRASAD, 1994e). These fossil leaves have also been compared with the extant species *K. floribunda* WALL. and very similar to the present fossil leaf in almost all the morphological features. In view of this, the present fossils are being described under the same species, *Kayea kalagarhensis* PRASAD.

Present day distribution: The modern comparable taxon, *Kayea floribunda* WALL. is an evergreen, medium sized tree growing in the forests of Sikkim, Khasi Hills and Martaban Hills in Mayanmar (CHOWDHURY & GHOSH, 1958).

Genus: *Calophyllum* LINN.

*Calophyllum suraikholaensis* AWASTHI & PRASAD, 1990

Pl.3, Figs 8,9

Material: There is a single, well preserved and incomplete leaf impression.
Description: Leaf simple, symmetrical; seemingly narrow oblong; preserved size 5.5 x 3.0 cm; apex broken; base broken; margin undulated; texture chartaceous; venation pinnate, craspedodromous; primary vein (1°) single, prominent, straight, stout; secondary veins (2°) fine, numerous, very closely placed, alternate to opposite, angle of divergence right angle, uniformly curved up, unbranched, tertiary veins (3°) not seen.

Holotype: Specimen No. T-115.

Locality: Spot No. 3, Purniyagiri Road section, Tanakpur Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Affinity: The characteristic features of the present fossil leaf such as narrow oblong shape, undulated margin, closely placed, almost parallel secondary veins and craspedodromous type of venation undoubtedly indicate its resemblance with the extant leaves of *Calophyllum* sp. specially *C. polyanthum* WALL. of the family Clusiaceae.

Fossil record and comparison: Five Fossil species of the genus *Calophyllum* Linn. have been reported so far from the Tertiary sediments of India and abroad. These are *Calophyllum pliocenicum* Krasser (1903) from Ouricanga Brazil, *C. nathorstii* (Geyler) Krausel and *Calophyllum* sp. Krause (1929) from Sumatra, *Calophyllum masensis* Pons (1978) from Colombia and *C. suraikholaensis* from the Siwalik sediments of Surai Khola, Nepal (Awasthi & Prasad, 1990) Oodlabari, West Bengal (Antal & Awasthi, 1993), Kathgodam, Uttarakhand (Prasad, 1994c), Kerala coast (Awasthi & Srivastava, 1992), Palaeocene of Cherapunji (Ambwani, 1991), Oligocene of Makum Coal field, Assam (Awasthi & Mehrotra, 1995). A comparative study of the above known fossil leaves shows that the fossil leaf, *Calophyllum suraikholaensis* Awasthi & Prasad described from the Siwalik sediments of Kathogdam, Uttarakhand is almost identical to the present fossil leaf and hence it has been described under the same species.
Present day distribution: The genus *Calophyllum* LINN. comprises about 187 species of trees distributed in both the hemispheres. *C. polyanthum* WALL. with which fossil resembles closely is presently growing in the evergreen forests of Tenasserim, Andaman and Nicobar Island, Malaya peninsula and Sri Lanka (BRANDIS 1971).

Family- Dipterocarpaceae
Genus - *Dipterocarpus* F. GAERTN.

*Dipterocarpus suraikholaensis* PRASAD & PANDEY, 2008
Pl.4, Fig. 8; Pl.7, Fig.10

Material: This is consist of two, well preserved and incomplete leaf impressions.

Description: Leaf simple, symmetrical, seemingly wide elliptic; preserved size 8.0 x 5.0 cm 10.0 x 4.0 cm (one side of lamina); apex broken; base broken; margin entire; texture coriaceous; venation pinnate, craspedodromons; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) only 7-8 pairs visible, 1.4-2.0 cm apart, running straightly before joining to the margin or their superadjacent secondary, angle of divergence about 55°, moderately acute, unbranched; tertiary veins (3°) fine, angle of origin usually RR, percurrent, straight to sinuous, oblique in relation to midvein, predominantly alternate and close.

Specimen: No. T-119A, T-119 B.

Locality: Spot No. 9, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Affinity: The distinguishing characters of the present fossil leaf such as wide elliptic shape, entire margin, craspedodromous venation, moderately acute angle of divergence of secondary veins and RR, percurrent, straight to sinuous tertiary veins collectively indicate its resemblance with extant leaves of the genus *Dipterocarpus* F. GAERTN. A critical examination of herbarium sheets of all the
available species of this genus shows that the leaves of *Dipterocarpus turbinatus* GAERTN. (Syn. *D. alatus* ROXB.) have closest affinity with the present fossil leaf (C.N.H. Herbarium sheet No.52699; Pl.4, Fig.9).

**Fossil record and comparison:** Several fossil leaves showing close similarity with the genus *Dipterocarpus* GAERTN. have been recorded from the Tertiary sediments of India and abroad. They are listed as:

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<td></td>
<td>Siwalik of Surai khola, Nepal</td>
<td>Prasad &amp; Pradhan, 1998</td>
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<td>Siwalik of Kathgodam, Uttarakhand</td>
<td>Prasad &amp; Tripathi, 2000</td>
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<td>Siwalik of Suraikholka, Nepal</td>
<td>Prasad et al., 1999</td>
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<td>Siwalik of Bhutan</td>
<td>Antal &amp; Prasad, 1996b</td>
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<td><em>D. koilabasensis</em></td>
<td>Siwalik of Koilabas, Nepal</td>
<td>Prasad &amp; Pandey, 2008</td>
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<td><em>D. surai kholanensis</em></td>
<td>Siwalik of Suraikholka, Nepal</td>
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After comparison of the present fossil leaves with the above already known fossil leaves it has been observed that the fossil leaf, *Dipterocarpus surai kholaensis* PRASAD & PANDEY shows closest similarity with the present fossils and hence it has been described under the same species.
Present day distribution: The genus *Dipterocarpus* F. GAERTN. comprises about 69 species distributed in India and Malaysia (MABBERLEY, 1997). *Dipterocarpus turbinatus* GAERTN. (Syn. *D. alatus* ROXB.) with which fossils show closest resemblance is a large, evergreen tree presently distributed in the forests of Chittagong Hills, Myanmar, Andaman and Malayan peninsula (BRANDIS, 1971; HOOKER, 1872).

Genus: *Parashorea* KURZ.

*Parashorea mioplicata* sp. nov.

Pl.5, Figs 1, 2,4

**Material:** This species is based on two, well preserved leaf impressions with slightly broken apex.

**Description:** Leaf simple, almost symmetrical, elliptic; preserved size 8.5 x 3.5 cm, 6.5 x 3.0 cm; apex seemingly acute; base seemingly obtuse; margin entire; texture coriaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, slightly curved; secondary veins (2°) about 7 pairs visible, 0.8 to 2.5 cm apart, alternate, unbranched, angle of divergence 45° – 50°, narrow acute, uniformly curved up and running parallel to each other for a long distance, basal secondary arises closely, tertiary veins (3°) fine, angle of origin RR, percurrent, branched, straight to sinuous, oblique to nearly right angle in relation to midvein, predominantly alternate and close.

Holotype: Specimen No. T-122.
Paratype: Specimen No. T-123.
Locality: Spot No.3, Purniyagiri Road section, Purniyagiri, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Etymology: By adding prefix ‘mio’ to the modern comparable species, *P. plicata*.

**Affinity:** Medium size of leaves with elliptic shape, eucamptodromous venation, narrow acute angle of divergence of secondary veins, closely placed.
basal secondary veins., RR, percurrent, straight to sinuous tertiary with oblique to nearly right angle in relation to midvein are the important features of the present fossils. These features suggests that the fossil leaves belong to the extant genus *Parashorea* KURZ. of the family Dipterocarpaceae. A critical examination of the herbarium sheets of a number of species of this genus indicates that the leaves of *Parashorea plicata* BRANDIS (C.N.H. Herbarium sheet No.31779; Pl.5, Figs 3, 5) show closest resemblance with the present fossils in shape, size and venation pattern.

**Fossil record and comparison:** As far as author is aware, there is no record of fossil leaf resembling the genus *Parashorea* KURZ. The present fossil forms the first occurrence of the fossil leaves of this genus in the Siwalik sediments of Tanakpur area and has been assigned as *Parashorea mioplicata* sp. nov.

**Present day distribution:** The genus *Parashorea* KURZ. consists of about 19 species (MABBRELEY, 1997). It is reported to be a small genus and is represented over a wide area from Myanmar, Indo China, Sumatra, and Malaya Peninsula in the West to Borneo and the Philippines in the east. *Parashorea plicata* BRANDIS with which fossil leaves resemble closely is a large tree found to occur in the Philippines.

Genus: *Hopea* Roxb.

*Hopea Kathgodamensis* PRASAD 1994d

Pl.4, Figs 5, 6, 7

**Material:** There are two, fairly preserved and complete leaf impressions.

**Description:** Leaf simple, symmetrical, ovate to lanceolate, preserved size 5.2 x 2.2 cm and 3.0 x 1.5 cm; apex acuminate; base wide acute; margin entire, texture coriaceous; venation pinnate, eucamptodromous; primary veins (1°) single, prominent, stout, almost straight; secondary veins (2°) about 12 pairs visible, less than 0.5 cm apart, seemingly unbranched, usually alternate, angle of divergence 55° – 65°, acute, moderate uniformly curved up; intersecondary veins present,
simple; tertiary veins (3°) poorly preserved, fine, angle of origin RR, percurrent, straight to sinous, branched, oblique in relation to midvein, predominantly alternate and close.

Holotype: Specimen No. T-120.
Paratype: Specimen No. T-121.
Locality: Spot No.3, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.

Affinities: The characteristic features of the present fossil leaves such as symmetrical, ovate to lanceolate shape, acuminate apex, obtuse base, entire margin, eucamptodromous venation, closely placed secondary veins which arise at moderate angle and joined superadjacent secondary, presence of intersecondary veins and RR, percurrent tertiaries indicate that the present fossil leaves show close resemblance with the modern leaves of *Hopea* ROXB. of the family Dipterocarpaceae. In order to find out its specific affinity, the herbarium sheets of available species of this genus were critically examined and it was concluded that the leaves of *Hopea dryobalanoides* MIQ. (Syn. *H. borneensis* HEIM. *H. micrantha* HOOK F. KING; C.N.H. Herbarium sheet Nos51956, 511194) show closest affinity with the present fossils.

Fossil record and comparison: From Siwalik sediments, there are four fossil records of *Hopea* leaves. ANTAL & AWASTHI (1993) reported *Hopea siwalica* from the Lower Siwalik sediments of Darjeeling District, West Bengal, India, *H. mioglabra* PRASAD (1994e) from Lower Siwalik sediments of Koilabas, Nepal, *H. kathgodamensis* PRASAD (1994c) from Lower Siwalik sediments of Kathgodam, India, while *H. mioparviflora* PRASAD & PRADHAN (1998) from the Middle Siwalik sediments of Surkhet area, Nepal. On comparison of the present fossil leaves with all the above known fossils it has been observed that they resemble closely with those of *H. kathgodamensis* PRASAD in shape, size and venation pattern and has also been compared with the extant species of *Hopea micrantha* (HOOK F.) KING (= *G. dryobalanoides* MIQ.) as the present fossil.
There is a difference in the number of secondary veins which is greater in the above known fossil species.

**Present day distribution:** The genus *Hopea* ROXB. consists of about 102 species distributed in the Indo-Malayan regions. *H. dryobalanoides* MIQ. with which fossils show affinity is a tall tree and found to grow in undisturbed, mixed dipterocarps forest of Malayan peninsula, Sumatra, Borneo and Philippines.

Family: Rutaceae
Genus *Toddallia* JUSS.

*Toddallia purniyagiriensis* sp. nov.  
Pl.6. figs 1,3

**Material:** This species is based on a single, well preserved leaf impression. There are three other incomplete leaf impressions.

**Description:** Leaf asymmetrical, narrow elliptic; size 6.0 x 2.5 cm; apex seemingly acute; base acute; inequilateral; margin entire; texture chartaceous; petiole broken; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) more than 12 pairs visible, less than 0.8 cm apart, alternate to subopposite, angle of divergence about 55°, moderately acute, uniformly curved up, seemingly unbranched; intersecondary veins present, simple, frequent, 2-3 veins in between two secondaries; tertiary veins (3°) fine, poorly preserved, angle of origin AO-RR, percurent, almost straight, sometimes branched, oblique in relation to midvein, alternate to opposite close.

Holotype: Specimen No. T-124.
Localities: spot No.4, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Etymology: After the name of Purniyagiri Temple.

**Affinity:** The diagnostic features of the present fossil leaf are narrow elliptic shape, acute base and apex, entire margin, eucamptodromous venation,
closely placed secondaries with moderate angle of divergence, presence of frequent intersecondary veins and AO-RR, percurrent tertiary veins. These characters suggest the affinity of fossil leaf with those of the genus Toddallia JUSS. of the family Rutaceae. A number of extant species of the genus Toddallia JUSS. were examined and found that the present fossil leaf is closely comparable with the leaves of Toddallia asiatica LAMK. (Syn. T. aculeata PERS.; C.N.H. Herbarium sheet Nos 5669, 22798).

**Fossil record and comparison:** So far, the best information to the author, there is no record of the fossil leaf of Toddallia JUSS. from the Tertiary of India. In view of this, the present fossil leaf is being described as a new species Toddallia purniyagiriensis.

**Present day distribution:** The genus Toddallia JUSS. Includes only one species, T. asiatica LAMK. with which fossil leaf shows closest affinity. This is an evergreen shrub and distributed in Sumatra, Java, China and Philippines. (HOOKER, 1872).

Genus: *Atlantia* CORREA

*Atlantia siwalica* sp. nov.

Pl.6, Figs 9, 10, 11

**Material:** There are two, well preserved, almost complete leaf impressions.

**Description:** Leaf slightly asymmetrical, elliptic; preserved size 6.5 x 3.0 cm, 6.5 x 3.5 cm; apex broken; base obtuse, inequilateral; texture coriaceous; petiole broken; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) about 6 pairs visible, closely placed, less than 0.5 cm apart, angle of divergence 65°-75°, moderately acute, uniformly curved up; intersecondary veins present, simple; tertiary veins (3°) poorly preserved, angle of origin usually AO, rarely RR, percurrent, straight to wavy, sometimes branched, oblique in relation to midvein, alternate to opposite and close.
Holotype: Specimen No. T-125A.
Paratype: Specimen No. T-125B.
Locality: Spot No. 1, near Hanuman Chatti, Purniya Giri Road section, Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Miocene-Pliocene.
Etymology: After the name of Siwalik Formation.

Affinity: The characteristic features exhibited by the present fossil leaves such as slightly asymmetrical, elliptic shape, obtuse base, entire margin, eucamptodromous venation, closely placed secondaries with moderately acute angle of divergence, presence of intersecondary veins, usually AO angle of origin of tertiary veins indicate that the present fossil leaves show close resemblance with the modern leaves of the genus *Atlantia* CORREA (*Paramignya* WIGHT) of the family Rutaceae. In order to find out specific affinity, the herbarium sheets of all the available species of this genus were critically examined and it was concluded that the leaves of *Atlantia* (*Paramignya*) *monophylla* CORREA (Syn. *A. floribunda* WALL.) show close similarity with the present fossil leaves in shape, size and venation pattern (C.N.H. Herbarium sheet No. 76259).

Fossil records and comparison: The fossil leaves resembling the exant species *Atlantia monophylla* CORREA have been described as *A. miocenica* PRASAD (1994e) from Siwalik sediments of Koilabas, Nepal and *A. palaemonophylla* MEHROTRA (2000a) from the Tura Formation, Meghalaya. Both the above fossil leaves show their affinity with the extant species, *A. monophylla* CORREA as the present fossils but differ entirely in being smaller size with very closely placed secondary veins which arise at narrow acute angle. In light of the above facts the present fossil leaves have been described here as *Atlantia siwalica* sp. nov.

Present day distribution: The genus *Atlantia* CORREA consists of about 12 Indo-Malayan species of shrubs or small trees. *Atlantia* (*Paramignya*) *monophylla* CORREA with which fossil leaves resemble closely is a small evergreen tree presently distributed in Kanara, western district of Mysore, Nilgiris,
Hills of the northern Circars, Cedded district and Karnataka, Khasi Hills and Myanmar (BRANDIS 1971).

Genus: *Clausena* BURM. F.

*Clausena miocenica* sp. nov.

Pl.7, Figs.1,3

**Material:** This species is based on a single, well preserved and complete leaf impression.

**Description:** Leaf asymmetrical, elliptic; preserved size 7.0 x 3.0 cm; apex acute; base, acute; margin entire; texture thick chartaceous; petiole broken; venation pinnate, craspedodromous to eucamptodromous; primary vein (1°) single, prominent, stout, curved; secondary veins (2°) about 7 pairs visible, 0.6 to 1.5 cm apart, usually opposite, angle of divergence about 65°, acute, moderate, uniformly curved up, seemingly unbranched, intersecondary veins present, simple, rare; tertiary veins (3°) fine, angle of origin AO-RR, percurrent, straight to sinuous, branched, oblique in relation to midvein, predominantly alternate and close.

Holotype: specimen No. T-129.

Locality: Spot No 1, near Hanuman Chatti, Purniyagiri Road section, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Etymology: After the Miocene age.

**Affinity:** Asymmetrical, elliptic shape, acute apex and base, entire margin, craspedodromous to eucamptodromous venation, presence of intersecondary veins, AO-RR, percurrent and close tertiary veins are the diagnostic features which indicate that the fossil leaf belong to the genus *Clausena* BURM. F. of the family Rutaceae. An examination of the leaves of various extant species of this genus was done and it was observed that the fossil leaf resembles those of *C. anisum-olens* (BLANCO.) MERR. (C.N.H. Herbarium sheet No.2525; pl.7, Figs 2, 4) in shape, size and venation pattern.
**Fossil record and comparison:** Until now, no fossil wood or leaf of the genus *Clausena* BURM. F. are known from the Tertiary of India. To designate this new finding, a new species *Clausena miocenica* has been established.

**Present day distribution:** The genus *Clausena* BURM. F. includes about 25 species distributed in the old world, Tropical Africa and South east Asia. The comparable species, *C. anisum-olens* (BLANCO.) MERR. (Syn. *C. laxiflora* QUIS. & MERR.) is an evergreen shrub or small tree growing naturally in the rain forests. It is endemic to Philippines and Borneo.

**Family:** Zygophyllaceae

**Genus:** *Balanites* DEL.

**Balanites siwalica sp. nov.**

Pl.5, Figs 7,8,10

**Material:** It is represented by two well preserved, complete leaf impressions.

**Description:** Leaf symmetrical, narrow elliptic; preserved size 3.0 x 1.5cm and 4.0 x1.7cm; apex obtuse; base acute, slightly oblique; margin entire; texture chartaceous; petiole 0.3 cm long, normal; venation pinnate; eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 9-10 pairs visible, closely placed, less than 0.7 cm apart, alternate to opposite; angle of divergence about 55°, acute moderate, uniformly curved up, seemingly unbranched; intersecondary veins present, simple; tertiary veins (3°) fine, angle of origin usually RR, sometimes AO, percurrent, straight to sinuous, branched, oblique in relation to midvein, predominantly alternate and close.

**Holotype:** Specimen No. T-126

**Paratype:** Specimen No. T-127

**Locality:** Spot No. 10, Bharauv Mandir, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

**Horizon & Age:** Siwalik Formation; Mio-Pliocene

**Etymology:** After Siwalik Formation.
Affinity: The characteristic features of the present fossil leaves are narrow elliptic shape, obtuse apex, slightly asymmetrical, acute base, entire margin, eucamptodormous venation, closely placed secondary veins with moderate angle of divergence, usually RR, percurrent tertiaries and presence of intersecondary veins. After a detailed comparative study it has been found that these features are common in the modern leaves of *Balanites* DEL. of the family Zygophyllaceae. Among the *Balanites* species the present fossils show closest affinity with those of *Balanites roxburghii* (Syn. *B. aegyptiaca* (L.) DEL. (C.N.H. Herbarium sheet No. 2624; Pl.1, Fig.9) in almost all the morphological features.

Fossil record and comparison: The genus *Balanites* DEL. was previously not known as fossil. The present fossils form its first occurrence from the Siwalik sediments of Uttarakhand, India and described as a new species *Balanites siwalica*.

Present day distribution: The genus *Balanites* DEL. consists of about 25 species distributed in the tropics of Africa and Myanmar. *B. roxburghii* (Syn. *B. aegyptiaca* (L.) DEL. with which fossils resemble closely is a small tree or shrub growing chiefly in the drier part of India and Myanmar.

Family: Meliaceae
Genus: *Aglaia* LOUR.

*Aglaia siwalica* sp. nov.

Pl.6, Figs 5, 7

Material: There is a single, well preserved, almost complete leaf impression.

Description: Leaf asymmetrical, lanceolate; preserved size 8.0 x 2.7cm; apex slightly broken; base acute, inequilateral; margin seemingly entire; texture chartaceous; petiole 0.2cm visible, normal; venation pinnate, craspedodromous to eucamptodromous; primary vein (1°) single, stout, almost straight;
secondary veins (2°) about 10 pairs visible, 0.5 to 1.0 cm apart, angle of divergence about 60°, acute, moderate, arise straightly and curved up uniformly, seemingly unbranched, alternate to opposite; inter secondary veins present, simple; tertiary veins (3°) fine, angle of origin RR, percurrent, usually straight, sometimes branched, oblique in relation to midvein, predominantly alternate, close.

Holotype: Specimen No. T-128.

Locality: Spot No 9, near Krishnapuri Village, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Etymology: After the name of Siwalik Formation.

Affinity: The distinguishing features of the present fossil leaf are asymmetrical lanceolate shape, acute, inequilateral base, craspedodromous to eucamptodromous venation, straight curving of secondary veins, presence of intersecondary veins and RR, percurrent tertiaries. Such features are found in the modern leaves of the genus Aglaia LOUR. of the family Meliaceae. A careful examination of the leaves of more than 25 species of Aglaia LOUR. indicates that A. bicolor MERR. (C.N.H. Herbarium sheet No. 80737; Pl.6, Fig.6, 8) shows closest similarity with the present fossil.

Fossil record and comparison: So far, there is no record of fossil leaf resembling the genus Aglaia from the Tertiary of India, though a fossil wood of this genus has been reported from the Siwalik sediments of Himachal Pradesh (YADAV, 1989). In view of this the present fossil leaf is being described here as a new species, Aglaia siwalica.

Present day distribution: The genus Aglaia LOUR. comprises about 105 species distributed in the Indo-Malayan region, South east Asia and New Guinea. Aglaia bicolor MERR. with which fossil leaf shows closest affinity is a large evergreen tree presently distributed in Philippines.

Family: Icacinaceae

Genus: Gomphandra WALLICH ex LINDLEY

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Gomphandra palaeocoriacea sp. nov.
Pl.7, Figs 5, 6, 7, 9

Material: This is represented by three, fairly preserved, complete leaf impressions.

Description: Leaves simple, slightly asymmetrical, one lamina lobe is slightly greater in width, narrow elliptic; preserved size 5.5 x 1.8 cm, 5.0 x 1.8 cm and 5 x 1.6 cm; apex acute; base acute; margin entire; texture coriaceous; petiole 0.2 cm long, normal; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight, secondary veins (2°) 5-6 pairs visible, 0.8 to 1.8 cm apart, alternate. angle of divergence, 55°- 60°, acute, moderate, uniformly curved and run for a little distance and joined to their superadjacent secondary vein; unbranched; tertiary veins (3°) fine, angle of origin usually RR, percurrent, straight to sinuous, branched, oblique in relation to mid vein, predominantly alternate and close.

Holotype: Specimen No. T-130.
Paratype: Specimen Nos T-131, T-132.
Locality: Spot No. 8, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Etymology: By adding a prefix 'Palaeo' to the name of comparable species G. coriacea.

Affinity: The diagnostic features of the present fossil leaves such as slightly asymmetrical, narrow elliptic shape, acute apex and base, entire margin, eucamptodromous venation, sharp curvature of secondary veins, and RR, percurrent, branched and close tertiaries indicate that the modern leaves of extant Gomphandra coriacea WIGHT of the family Icacinaceae (C.N.H. Herbarium sheet No. 2639; Pl.7, Fig.8) have closest affinity with the present fossils.

Fossil record and comparison: So far, the fossil leaf resembling the genus Gomphandra WALLICH ex LINDLEY is not yet known though a fossil wood, Gomphandroxylon samnapurensis BANDE & KHATRI (1980) is known from the
Deccan Intertrappean beds of Madhya Pradesh, India. Thus this fossil leaf is the first report from the Siwalik sediments of Uttarakhand, India and hence described here as *Gomphandra palaeocoriacea* sp. nov.

**Present day distribution:** The genus *Gomphandra* WALLICH EX LINDLEY consists of 33 species of trees or shrubs distributed in South east Asia to Solomon Island (MABBERLEY, 1997). The modern comparable species *G. coriacea* WIGHT is a glabrous shrub presently distributed in the evergreen forests of Western Ghats from north Kanara southwards (BRANDIS, 1971).

Family: Rhamanceae

Genus: *Ventilago* GAERTN.

*Ventilago miocalyculata* sp. nov.

Pl.8, Figs 1,2,4

**Material:** This species is represented by a single well preserved, almost complete leaf impression with its counterpart.

**Description:** Leaf simple, symmetrical, ovate; preserved size 8.5 x 4.5 cm; apex slightly broken, seemingly acute; base obtuse; margin entire; texture coriaceaeous; petiole broken, venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 5 pairs visible, 0.8 to 2.5 cm apart, alternate, unbranched, sharply curved up and joined to their superadjacent secondary through a series of cross veins, angle of divergence (55°-60°), acute, moderate; tertiary veins (3°) fine, angle of origin RR, rarely AO, percurrent, branched, straight to sinuous, nearly right angle in relation to midvein, predominantly alternate, close.

Holotype: Specimen No. T-133.

Paratype: Specimen No.T-134.

Locality: Spot No. 1, near Hanuman Chatti, Purniyagiri Road section, Champawat

District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.

Etymology: By adding a prefix 'Palaeo' to the modern comparable species, *V. Calyculata*.

**Affinity:** The important diagnostic features of the present fossil leaf such as ovate shape, seemingly acute apex, obtuse base, entire margin, eucamptodromous venation, sharply curved secondary veins with moderate angle of divergence and RR, percurent, straight to sinuous tertiary veins with nearly right angle in relation to midvein strongly indicate its close affinity with the leaves of the genus *Ventilago* GAERTN. of the family Rhamaneae. After critical examination of the modern leaves of all the available species of this genus it has been found that the leaves of *Ventilago calyculata* TUL. (Syn. *V. madrasputana* GAERTN.) show closest affinity with the present fossil (C.N.H. Herbarium sheet No. 22052 ; Pl.8. Figs 3,5).

**Fossil record and comparison:** So far, two fossil leaf resembling the genus *Ventilago* GAERTN. have been reported from the Siwalik sediments. ANTAL & PRASAD (1997) described a fossil leaf as *Ventilago tistaensis* from the Lower Siwalik sediments of Darjeeling District West Bengal. Later on KONOMATSUM & AWASTHl (1999) described another fossil leaf *V. ovatus* from the Middle Siwalik sediments of Dumkibas, western Nepal. The present fossil leaf can easily be differentiated from both the above fossils in possessing only few pairs of secondaries with very sharp curvature before reaching the margin. In view of this the present fossil is designated as *Ventilago miocalyculata* sp. nov.

**Present distribution:** The genus *Ventilago* GAERTN. comprises 35 species, presently distributed in the old world, tropical Africa and Madagascar. The modern comparable taxon, *V. calyculata* TUL. (= *V. madrasputana* GAERTN.) is a small tree found to grow in the Sub-himalayan tract, Jammu eastwards, Oudh forests, Nepal, Central India and the Peninsulas, Silhet and Myanmar (BRANDIS, 1971).

Family: Sapindaceae
Genus: *Sapindus* Linn.
**Sapindus eotrifoliatus sp. nov.**

Pl.8, Figs 6,7; Pl.9, Figs 1,3,4

**Material:** Three are four specimens of leaf impression which are well preserved almost complete and also arranged on a twig.

**Description:** Leaf compound, symmetrical, very narrow elliptic; preserved size 8.5 x 3.0 cm, 6.5 x 2.2 cm 7.0 x 2.5 cm and 8.5 x 3.5 cm; apex acute; base acute; margin entire; texture coriaceous; petiole 1.0 cm long, normal; venation pinnate, eucamptodromous, primary veins (1°) single, prominent, stout, almost straight; secondary veins (2°) about 9 pairs visible, 0.3 to 2.0 cm apart, alternate to opposite, seemingly unbranched, angle of divergence 60°-70°, moderate to wide acute, uniformly curved up and joined to superadjacent secondary; intersecondary veins present, simple; tertiary veins (3°) moderate, angle of origin usually RR, percurrent, zigzag, sometimes branched, nearly right angle in relation to midvein, predominantly alternate and close..

Holotype: Specimen No. T-135.
Locality: Spot No.10, near Bhairauv Mandir, Purniyagiri Road Section, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Etymology: By adding a prefix 'Palaeo' to the modern comparable species, *S. trifoliatus*.

**Affinity:** The distinguished morphological features of the fossil leaves such as compound leaf, very narrow elliptic shape, acute apex and base, entire margin, eucamptodromous venation, wide acute angle of divergence of secondary veins, presence of intersecondary veins, percurrent, RR, zigzag tertiary veins having nearly right angle in relation to midvein strongly indicate that the fossil leaves belong to the genus *Sapindus* LINN. of the family Sapindaceae. After critical study of the modern leaves of different species of this genus it has been found that the present fossil leaves show closest affinity with the extant leaves of *Sapindus trifoliatus* LINN. (Syn. *S. emarginatus* WALL; *S. laurifolius* VAHL.) in shape, size and venation pattern (C.N.H. Herbarium sheet No.95064; Pl.9, Figs 2,5).
**Fossil record and comparison:** Two fossil leaves resembling the genus *Sapindus* LINN. have been described as Leaf type D and Leaf Type E from the Eocene of Barmer Rajasthan, India (DESHMUKH & SHARMA, 1978). These fossils show their resemblance with *Sapindus bilinicus* and *S. falcifolius* AL. respectively. On critical study of the above known fossil leaves it has been observed that these are identical (one type) and differ from present fossil leaves in having larger size (10-16 x 3.5 – 4.5cm) with more number of secondary veins which arise comparatively at narrow acute angle of divergence. In being different from above already known fossil leaves, the present fossils have been assigned to a new specific name, *Sapindus eotrifoliatus*.

**Present day distribution:** The genus *Sapindus* LINN. consists of 13 species distributed in the tropical and subtropical regions of Africa and Australia (WILLIS,1973). *Sapindus trifoliatus* LINN. with which fossil leaves show closest affinity is a large tree presently found to grow in the evergreen forests of Kokan and Canara as well as in the dry region of Sri Lanka (GAMBLE, 1972).

**Genus:** *Lepisanthes* BLUME

*Lepisanthes miocenica* sp. nov.

Pl.11, Figs 1, 2

**Material:** This species is based on single, fairly preserved and almost complete leaf impression.

**Description:** Leaf simple, symmetrical, very narrow elliptic; preserved size 11.0 x 3.0 cm; apex slightly acute to attenuate; base acute; margin entire; texture coriaceous; petiole not preserved; venation pinnate, eucamptodromous; primary vein (1*) single prominent, stout, almost straight; secondary veins (2*) about 14 pairs visible, 0.4 x 1.2 cm apart, alternate to subopposite, angle of divergence 60°-70°, wide acute, uniformly curved up, seemingly unbranched, intersecondary veins present, simple, frequent; tertiary veins (3*) fine, angle of origin usually RR, percurrent, straight to sinuous, sometimes branched, oblique in relation to midvein, predominantly alternate, close

Holotype: Specimen No. T-139.
Locality: Sukhidang near Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Etymology: After Miocene age of the sediments.

Affinity: The distinguishing features of the present fossil leaf such as very narrow elliptic shape, seemingly attenuate apex, acute base, eucamptodromous venation, moderate to wide acute angle of divergence of secondary veins, presence of inter secondary veins and RR, percurent tertiary veins collectively suggest its closest affinity with the modern leaves of Lepisanthes fruticosa (ROXB.) LEENH. (syn. Otophora fruticosa (ROXB.) BLUME, Basionym sapindus fruticosa ROXB.) of the family Sapindaceae (C.N.H. Herbarium sheet No. 95326). During its identification it has been seen that this fossil leaf also shows superficial resemblance with the modern leaves of Sapindus attenuatus WALL. of the family Sapindaceae in shape and size but it differ in the curvature and arrangement of secondary veins.

Fossil record and comparison: There is no record of fossil leaves resembling the genus Lepisanthes BLUME from the Tertiary sediments of India and abroad. This fossil leaf reports it first occurrence in the Siwalik sediment of Tanakpur area, Uttarakhand and hence it is being described as Lepisanthes miocenica sp.nov.

Present day distribution: The genus Lepisanthes BLUME comprises about 24 species of trees or shrubs. The modern comparable taxon, L. fruticosa (ROXB.) LEENH. is an evergreen tree distributed in Indochina, Myanmar, Thailand, Malaya, Java, Malacca, Sumatra and Philippines.

Genus: Lepisanthes BLUME

Lepisanthes tanakpurensis sp. nov.

Pl.12, Figs 1, 3

Material: There is a single, fairly preserved leaf impression without apex.

Description: Leaf simple, symmetrical, very narrow elliptic; preserved size 14.5 x 3.5 cm; apex broken, base attenuate; margin entire; texture coriaceous;
petiole broken; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, massive, straight; secondary veins (2°) about 12-13 pairs visible, 0.5 to 1.8 cm apart, alternate to opposite, seemingly unbranched, angle of divergence 50°-60°, moderately acute, uniformly curved up, sometimes joining superadjacent secondary vein before reaching the margin; intersecondary veins present, simple, frequent; tertiary veins (3°) fine, fairly preserved, angle of origin RR, percurrent, straight to curved, sinuous, branched, oblique to nearly right angle in relation to midvein, predominantly alternate and close.

Holotype: Specimen No. T-154.

Locality: Spot No. 6, Purniyagiri Road section, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Etymology: After the name of town, Tanakpur near the fossil localities.

Affinity: The most important morphological characters of the fossil leaf like its large size, attenuate base, entire margin, eucamptodromous venation, moderately acute angle of divergence, RR, percurrent, oblique to nearly right angle of tertiary veins in relation with medvien show that the fossil leaf belong to the genus Lepisanthes BLUME of the family Sapindaceae. In order to find out the nearest specific affinity of the present fossil, the herbarium sheets of all the available species of the genus Lepisanthes have been examined and it was concluded that the extant leaves of L. tetraphylla RADLK. show closest similarity with the fossil specimen (C.N.H. Herbarium sheet No. 5902; Pl.12, Fig.2).

Fossil record and comparison: The earlier described fossil leaf, Lepisanthes miocenica has been compared with the present fossil and found that it differs in being small size having less number of secondary veins which arise at wide acute angle of divergence as compared to moderate acute angle in the present fossil leaf. In view of these differences, the present fossil leaf is described under a new specific name, Lepisanthes tanakpurensis.

Present day distribution: The extant taxon, Lepisanthes tetraphylla RADLK. with which fossil leaf shows closest similarity is a middle sized tree, presently
distributed in Deccan and east side of the Peninsula. It is also found commonly in Kokon, Tenasserim and Pondicherry (BRANDIS, 1971).

Genus: Harpullia ROXB.

Harpullia siwalica PRASAD & AWASTHI, 1996

Pl.11, Fig 3; Pl.10, Fig 6

**Material:** There is single, well preserved leaf impression without apex.

**Description:** Leaf simple, symmetrical, narrow elliptic; preserved size 9.5 x 3.5 cm; apex broken; base broken, asymmetrical; margin entire; texture chartaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 7-8 pairs visible, 0.6 to 2.0 cm apart, alternate, to subopposite, angle of divergence 55°-60°, uniformly curved up and running parallel to the margin to a considerable distance, unbranched; inter secondary veins present simple; tertiary veins (3°) fine, angle of origin RR, rarely AO, percurrent, straight to sinuous, branched, oblique in relation to midvein, predominantly alternate and close.

Holotype: Specimen No. T-142.

Locality: Spot No 1, near Hanuman Chatti, Purniyagiri Road section, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

**Affinity:** The present fossil leaf is characterized by symmetrical, narrow ovate shape, inequilateral base, entire margin, eucamptodromous venation, course of secondary veins and usually RR, percurrent tertiary veins. In all the above characters it shows close similarity with the modern leaves of *Harpullia arborea* (BLANCO.) RADLK. of the family Sapindaceae (C.N.H. Herbarium sheet No.61270; Pl.11. Figs 4).

**Fossil record and comparison:** PRASAD & AWASTHI (1996) reported a fossil leaf resembling the genus Harpullia ROXB. under a form species, *Harpullia siwalica* from the Siwalik sediments of Suraikhola, Nepal. On comparison with the present fossil leaf it has been observed that *H. siwalica* shows close similarity
with this fossil in almost all the morphological features and hence described here under the same species *H. siwalica* PRASAD & AWASTHI.

**Present day distribution:** The genus *Harpullia* ROXB. comprises of 37 species distributed presently in tropical Asia and Australia. The modern comparable taxon, *Harpullia arborea* (BLANCO.) RADLK. is a tall evergreen tree reported to be commonly found in the thickest and secondary forests of North-east India, Sri Lanka, Myanmar, Malaysia, Australia, Thailand and Indochina.

**Genus: Filicium THWAITES**

*Filicium koilabasensis* PRASAD, 1994e

Pl.11, Figs 5, 6; Pl.12, Fig 9

**Material:** There are two well preserved, almost complete leaflet impressions.

**Description:** Leaflet almost symmetrical, sometimes one lamina lobe is wider than other, narrow elliptic; preserved size 5.5 x 2.0 cm; apex slightly broken; seemingly acute; base acute, normal; margin entire; texture chartaceous; petiole 0.2 cm visible, normal; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) about 16 pairs visible, 0.2-0.5 cm apart, closely placed, angle of divergence about 60°, acute, moderate, alternate to opposite, branched; 'intersecondary veins present, simple, 1-2 intersecondary veins in between two secondaries; tertiary veins (3°) fine, angle of origin AO-RR, percurent, almost straight, branched, oblique in relation to mid vein, predominantly alternate, close.

Holotype: Specimen No. T 143, T 144.

Locality: Spot No.4, Purniyagiri Road section, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

**Affinity:** The important features of the present fossil leaves are slightly asymmetrical, narrow elliptic shape, acute apex and base, entire margin, chartaceous texture, very closely placed secondary veins with moderate angle, and
AO - RR, percurrent tertiaries. A critical examination of a number of herbarium sheets of different genera of dicotyledonous families indicates that the above features are found common in the modern leaflets of *Toddallia asiatica* (L.) LAM. and *T. lanceolata* of Rutaceae and *Filicium decipiens* (WIGHT & ARN.) HOOK. F. of family Sapindaceae. Of these, the leaves of *Toddallia* spp. differ from the fossil leaves in the course of secondary veins which do not join each other before the margin as in the fossils. Thus, the extant leaves of *Filicium decipiens* (WIGHT & ARN.) HOOK. F. (C.N.H. Herbarium sheet Nos. 78732, 65968; Pl. 11, Fig. 7) show closest affinity with the fossils in all the morphological features.

**Fossil record and comparison:** PRASAD (1994e) described a fossil leaf resembling the genus *Filicium* THW. ex HOOKER F. under a from species *Filicium koilabasensis* from Siwalik sediments of Koilabas area, western Nepal. On comparative study it has been observed that the present fossil leaves exhibit similar morphological features as the above known species *F. koilabasensis* PRASAD and have been described under the same species.

**Present day distribution:** The genus *Filicium* THW. ex Hook. F. comprises three species presently distributed in the tropical region of old world (MABBERLEY, 1997). *Filicium decipiens* (WIGHT & ARN.) HOOK. F. with which fossils resemble closely is a medium sized, evergreen tree occurring in the forests of Western Ghat, from the Nilgiris southwards. It also shows in Sri Lanka and tropical Africa (BRANDIS, 1971).

Family: Anacardiaceae  
Genus: *Drimycarpus* HOOK. F.  

*Drimycarpus siwalicus* sp. nov.  
Pl.10, Figs 1, 2,4  

**Material:** There is single, well preserved leaf impression with counterpart.  
**Description:** Leaf simple, almost symmetrical, narrow elliptic; to oblong; size 13.5 x 4.2 cm; apex slightly broken; base acute; margin entire; texture chartaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, massive, almost straight; secondary veins (2°) about 12 pairs visible, 0.1- 1.8 cm apart,
usually alternate, angle of divergence varies randomly, 60° - 85°, uniformly curved up, curvature is more pronounced near the margin, unbranched; intersecondary veins present, simple, rare; tertiary veins (3°) fine, angle of origin usually RR, percurrent, mostly sinuous or zigzag, sometimes branched oblique in relation to midvein, predominantly alternate and close.

Holotype: Specimen No. T 140.
Paratype: Specimen No. T 141.
Locality: Spot No. 1, near Hanuman Chatti, Purniyagiri Road section, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Etymology: after Siwalik Formation.
Affinity: The important morphological characters of the fossil leaf like, its narrow elliptic to oblong shape, seemingly acute apex and base, entire margin, eucampodromous venation, variation in the angle of divergence of secondary veins which have pronounce curvature near the margin, RR, percurrent, mostly sinuous or zigzag tertiary veins collectively indicate that the present fossil leaf resembles very closely with the extant leaves of Drimycarpus racemosus HOOK. F. (C.N.H. Herbarium sheet No. 99552; Pl. 10, Figs 3,5) of the family Anacardiaceae.

Fossil record and comparison: So far, there is no record of fossil leaves of the genus Drimycarpus HOOK. F. from the Tertiary sediments of India. Thus, the present fossil leaf from the first record from the Siwalik sediments of Uttarnchal and has been described here as Drimycarpus siwalicus sp. nov.

Present day distribution: The genus Drimycarpus HOOK. F. consists of more than two species of trees and distributed in the Indo-Malayan region. The extant axon, D. racemosus HOOK. F. with which the fossil shows resemblance, is an evergreen tree growing in north - east India, Bangladesh and Bhutan (BRANDIS, 1971).

Genus: Bouea MEISSN.

Bouea premacrophylla ANTAL & AWASTHI, 1993
Material: There is single fossil leaf representing apical portion.

Description: Almost symmetrical, preserved size 8.0 x 4.5 cm; apex acuminate; margin entire; texture chartaceous; venation pinnate, craspedodromous to eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) about 9-10 pairs visible, 0.7-1.5 cm apart, angle of divergence 75° - 80°, wide acute, seemingly alternate, uniformly curved up, unbranched; intersecondary veins present, simple; tertiary veins (3°) fine, angle of origin usually AO - RR, percurrent, usually straight, oblique in relation to midvein, predominantly alternate and close.

Paratype: Specimen No. T 147.

Locality: Spot No. 1, near Hanuman Chatti, Purniyagiri Road section, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Affinity: The fossil leaf is incomplete but its characteristic morphological features like, acuminate apex, wide acute angle of divergence of secondary veins, craspedodromous to eucamptodromous venation, nature and arrangement of secondary and tertiary veins undoubtedly indicate its affinity with the modern leaves of Bouea macrophylla GRIFTH. (C.N.H. Herbarium sheet No. 99041; Pl. 11, Fig. 9) of the family Anacardiaceae.

Fossil record and comparison: So far, two fossil leaves resembling the extant taxon, Bouea macrophylla GRIFTH. have been described under a form species B. premacrophylla from Siwalik sediments of Darjeeling District, West Bengal (ANTAL & AWASTHI, 1993) and Seria Naka, western Nepal. A comparison of present fossil leaf with above known fossils suggests that the present fossil leaf shows close similarity with the known species. Therefore, it has been described under the same species B. premacrophylla ANTAL & AWASTHI.

Present day distribution: The genus Bouea MEISSN. consists of 3 species (MABBERLEY, 1997) distributed in Indo-Malayan region. The modern comparable taxon, B. macrophylla GRIFTH. is a large evergreen tree presently
found to grow in Myanmar, Andaman, Sunderbans and Malaya peninsula (DESCH, 1957).

Family: Sabiaceae
Genus: Sabia COLEBR.

*Sabia eopaniculata* PRASAD, 1994e

Pl.12, Figs 4, 5

**Material:** Single, well preserved and complete leaf impression.

**Description:** Leaf simple, Symmetrical, narrow elliptic; preserved size 9.5 x 2.4 cm; apex acute to attenuate; base broken; margin entire; texture chartaceous; petiole 0.5 cm visible. normal; venation eucamptodromous to brochidodromons; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 6-7 pairs visible, 0.8-2.0 cm apart, seemingly alternate, branched, angle of divergence about 65° - 75°, wide acute, uniformly curved up, and running parallel to the margin for a little distance and joined to the super adjacent secondary veins; intersecondary veins present, simple, arising from midvein at wide acute angle and joined to their upper secondary veins; tertiary veins (3°) fine, angle of origin RR, percurrent, almost straight, branched, right to nearly oblique angle in relation to midvein, predominantly alternate and close.

Holotype: Specimen No. T 146.

Locality: Spot No 2, Purniyagiri Road section, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

**Affinity:** Symmetrical, narrow elliptic shape, acute to attenuate apex, acute base, entire margin, eucamptodromous to brochidodromous venation, closely placed upper and lower secondaries, wide acute angle of divergence of secondary veins which running parallel to the margin and joined to superadjacent secondary vein and forming the loop, RR, percurrent tertiary veins at usually nearly right in relation to midvein collectively indicate that the fossil leaf closely resembles the modern leaves of *Sabia paniculata* SEEM. of the family Sabiaceae (C.N.H. Herbarium sheet No. 97520).
Fossil record and comparison: So far, only one fossil leaf resembling the genus *Sabia* COLEBR. described from the Siwalik sediments of Koilabas area, Nepal as *S. eopaniculata* PRASAD 1994e. This fossil leaf has also been resembles with the extant species *S. paniculata* SEEM. and possesses more or less similar morphological characters as the present fossil. Therefore, the present fossil leaf is being described under the same species *S. eopaniculata* PRASAD.

Present day distribution: The genus *Sabia* COLEBR. consists of 19 species distributed in south east Asian region. *Sabia paniculata* SEEM. is a large shrub presently distributed throughout himalayan foot hills, Myanmar and Malayan region. (BRANDIS 1971).

Family: Conuraceae
Genus: *Gnestis* JUSS.

*Gnestis purniyagiriensis* sp. nov.

Pl.12, Figs, 6, 8

Material: This species is based on single, well preserved and complete leaf impression.

Description: Leaf symmetrical, narrow oblong; preserved size 5.5 x 1.2 cm; apex acute; base seemingly obtuse; margin entire; texture chartaceous; petiole broken, venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) more than 12 pairs visible, less than 0.5cm apart, closely placed, alternate, to opposite, seemingly unbranched, angle of divergence acute, about 55°, narrow acute, uniformly curved up; intersecondary veins present, simple; tertiary veins (3°) fine, poorly preserved, angle of origin RR, percurrent, straight to sinuous, branched, oblique in relation to midvein, predominantly alternate and close.

Holotype: Specimen No. T 148.

Locality: Spot No 2, near Krishnapuri village, Purniyagiri Road section, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Etymology: After the name of Purniyagiri Temple.
Affinity: The distinguishing features of the present fossil leaf are symmetrical, narrow oblong shape, chartaceous texture, obtuse apex and base, entire margin, closely placed secondary veins arising at narrow acute angle, presence of intersecondary veins and RR, percurrent, straight to sinuous tertiary veins. Such features are found common in the extant leaves of the genus Gnestis JUSS. of the family Connaraceae. A careful examination of the leaves of all the available species of this genus indicates that G. ramiflora Griffith. (= G. platantha Griffith.) shows closest affinity with the present fossil leaf (C.N.H. Herbarium sheet No. 101091; Pl.12 Fig.7).

Fossil record and comparison: So far, there is no fossil record of the genus Gnestis JUSS. from India and other places. Thus, it is recorded for the first time from Siwalik of Uttarakhand and described here as Gnestis purniyagiriensis sp. nov.

Present day distribution: The genus Gnestis JUSS. consists of about 13 species distributed presently in the Indo-Malayan regions and Tropical Africa. (MABBERLEY, 1997). The modern comparable taxon, G. ramiflora Griffith is a shrub or small tree found to grow in the evergreen forests of lower Myanmar and Andaman.

Family: Fabaceae
Genus: Bauhinia LINN.

Bauhinia nepalensis AWASTHI & PRASAD, 1990
Pl.13, Figs 1, 2

Material: There are two specimens of well preserved leaf impression, one is with open lobe and other with closed lobe.

Description: Leaf symmetrical, bilobed, each lobe elliptic; lamina size 6.0 x 6.0 cm (open biloved specimen) and 4.5 x 3.4 cm (close lobed specimen); apex obtuse to rounded, base auriculate, equilateral; margin entire; texture coriaceous; petiole preserved, 1.6 cm long, normal; venation pinnate, actinodromous; perfect, basal; primary vein (1°) 5, given off to each lobe from the base, prominent, moderate, curving upward; secondary veins 5-6 pairs, arising from one or both side
of the primary veins, usually alternate, angle of divergence 60° - 65°, moderately acute, curving up and joined to their super adjacent secondary veins, 0.7 - 1.8 cm apart, seemingly unbranched; tertiary veins (3°) with angle of origin nearly RR, percurrent, rarely branched, nearly right angle in relation to primary veins, predominantly alternate and close.

Holotype: Specimen No. T 149, T 150.

Locality: Spot No. 4, Purniyagiri Road section, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

**Affinity:** The diagnostic features of the present fossil leaf such as bilobed, wide elliptic shape, obtusely emarginate apex (in open lobed specimen), auriculate base, entire margin, basal, actinodromous venation, wide acute angle of divergence of secondary veins, RR, percurrent tertiaries which are nearly right angle in relation to primary veins undoubtedly suggest their affinity with the extant leaves of the genus *Bauhinia* Linn. of the family Fabaceae. From a critical examination of the herbarium sheets of all the available species of this genus, it was found that the fossil leaves are similar to those of *Bauhinia malabarica* Roxb. and *B. variegata* Linn.

**Fossil record and comparison:** Fossil leaves resembling the genus *Bauhinia* Linn. are reported under two generic name *Bauhinia*, Linn. and *Bauhinites* SEWARD & CONWAY. The latter consist of a single species *Bauhinites greenlandica* from Tertiary sediments of greenland (SEWARED & CONWAY, 1935). However, the genus *Bauhinia* Linn. comprises about 20 species reported from Tertiary sediments of all over the world (India, Australia, Bolivia, Czechoslovakia, Equador, West Germany, Greece, Greenland and North Vietnam, (BERRY, 1916, 1919, 1945; NEWBERRY, 1886,1895; UNGER, 1850, 1867; MULLER-STOLL, 1934; HEER 1859; KNOWLTON, 1919; CHANEY & SANBORN, 1933; BROWN, 1962; LAKHANPAL & AWASTHI, 1984; LAKANPAL AND GULRIA, 1982; ANTAL & AWASTHI, 1993; AWASTHI & PRASAD, 1990). Out of these, only three species have been reported from the Siwalik sediments of India and Nepal. They are *Bauhinia siwalika* from Upper
Siwalik sediments of Bhikhnathoree, Bihar, India (LAKHANPAL & AWASTHI, 1984) and from Middle Siwalik sediments of Dumkibas, Nepal (KONOMATUS & AWASTHI, 1999), Bauhinia nepalensis from Middle Siwalik sediments of Suraikhola area, western Nepal. (AWASTHI & PRASAD,1990) and Bauhinia ramthiensis from the Lower-Middle Siwalik sediments of Darjeeling District, West Bengal, India (ANTAL & AWASTHI, 1993). A critical comparison of the present fossil leaves with those of known fossil leaves indicates that the fossil leaf, Bauhinia nepalensis AWASTHI & PRASAD is very similar to the present fossils in almost all the morphological features and hence, these are being described under the same species, Bauhinia nepalensis AWASTHI & PRASAD.

Present day distribution: The genus Bauhinia LINN. consists of about 300 species of pan tropical. They are often lianas with flattened stem. The modern comparable species, B. malabarica ROXB. and B. variegata LINN. are moderate sized trees growing in Sub - Himalayan tract. These also occur in dry to moist deciduous forests of central and south India, and Myanmar (RAMESH RAO & PURKAYASTHA,1972; GAMBLE,1972).

Genus: Bauhinia LINN.

Bauhinia purniyagiriensis sp. nov.

Pl. 13, Fig.3; Pl. 14, Fig. 9

Material: There are three specimens of leaf impression, Apex and base are slightly broken in all of them.

Description: leaves symmetrical, elliptic to oblong; preserved size 10 x 4.5 cm; apex and base slightly broken; margin entire, texture coriaceous; venation acrodromous, basal, perfect; primary veins (1°) 5 pairs (one mid and two lateral) arising from the base and running upward towards the apex, mid primary almost straight, lateral primaries curved, secondary veins numerous, closely placed, sometimes branched, angle of origin varies from wide acute to nearly right angle, (60-80°), curved up and joined to their adjacent primary veins at acute to right angle; tertiary veins (3°) poorly preserved, arising from secondary veins at usually
right angle, percurrent, almost straight, nearly parallel to oblique in relation to midvein, predominately alternate and close.

Holotype: Specimen No. T 151.
Locality: Spot No. 1, near Hanuman Chatti, Purniyagiri Road section, Champawat District, Uttarakhand.
Horizon: Siwalik Formation; Mio-Pliocene.
Etymology: After purniyagiri temple.

Affinity: The Characteristic features of the present fossil leaves are: symmetrical elliptic to oblong shape, entire margin, coriaceous texture, basal, perfect, acrodromous type of venation, presence of five primary veins and numerous secondary veins arising at acute to nearly right angle from the primaries and usually RR, percurrent tertiaries having oblique to nearly parallel in relation to primaries. An extensive survey of the herbarium sheets of a number of genera and species of the dicotyledonous families indicates that such features are found more or less common in the extant leaves of Cinnamomum spp. (Lauraceae), Astronia gitingensis, Marumia nemorosa and Melastoma malabaricum, (Melastomaceae), Anisophyllea apiata (Anisophylleaceae), Allomorphia axiqua, Celtis philippinensis (Urticaceae) and Bauhinia finlaysoniana (BENTH.) BAKER (Fabaceae). After critical examination of the herbarium sheets of all the above taxa it has been concluded that the extant leaves of Bauhinia finlaysoniana (BENTH.) BAKER (C.N.H.. Herbarium sheets No. 3589; Pl. 13, Fig. 4; Pl.14, Fig.10) of the family Fabaceae show closest affinity with the present fossil leaves. The leaves of remaining taxa differ from present fossils either in having only 3 primary veins or in the nature and arrangement of the primary and secondary veins.

Fossils record and comparison: So far, about 20 fossil species of the genus Bauhinia LINN. based on leaf impression have been reported from the Tertiary sediments of India and abroad. (AWASTHI & PRASAD, 1990; ANTAL & AWASTHI, 1993; KONOMATSU AND AWASTHI,1999). A comparative study of the present fossils with all the known fossil leaves has been carried out and found that they differ from the present fossil leaves mainly in the shape, size,
number and arrangement of primary and secondary veins. Thus in being different, the present fossil has been assigned to a new species, *Bauhinia purniyagiriensis*.

**Present day distribution:** The extant taxon, *Bauhinia finlaysoniana* (BENTH.) BAKER (Syn. *B. Cordifolia* ROXB.) with which fossils resemble closely is a perennial evergreen shrub presently distributed in Indonesia, Java, Malaysia, Moluccas, Philippines and Sumatra.

**Genus: Millettia W. & A.**

*Millettia mioinermis* sp. nov.

Pl.13, Figs 5,6

**Material:** This species is based on a single, fairly preserved leaf impression.

**Description:** Leaf almost symmetrical, obovate; preserved size 5.0 x 2.8 cm; apex slightly broken; base attenuate, slightly asymmetrical; margin entire; texture coriaceous; petiole broken; venation pinnate, eucamptodromons; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 8-9 pairs visible, 0.6-1.0 cm apart, alternate to sub-opposite, angle of divergence 55°-60°, moderate, uniformly curved up and joined to superadjacent secondary vein, sometimes forming loop; intersecondary veins present, tertiary veins (3°) fine, angle of origin usually AO, percurrent, almost straight, rarely branched, oblique in relation to midvein, predominantly alternate and close.

**Holotype:** Specimen No. T 152.

**Locality:** Spot No. 5, Purniyagiri Road section, Champawat District, Uttarakhand.

**Etymology:** By adding a prefix 'mio' to the name of modern comparable species, *M. inermis*.

**Affinity:** The characteristic features of the present fossil leaf are almost symmetrical, obovate shape, attenuate base, entire margin, eucamptodromous venation, moderate angle of divergence of secondary veins, usually AO,
percurent, almost straight tertiary veins and presence of intersecondary veins. On going through the herbarium sheets of different genera and species of dicotyledonous families, it has been observed that the present fossil resembles closely with the extant leaves of *Millettia inermis* (=*Andira inermis*) (WRIGHT) DC. of the family Fabaceae (C.N.H. Herbarium Sheet No. 112713).

**Fossil record and comparison:** About 30 fossil leaves resembling the genus *Millettia* W. & A. have been reported from the Tertiary sediments of India and abroad. They are listed herewith:

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<td>Menzel, 1920</td>
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<tr>
<td><em>M. notoensis</em></td>
<td>Middle Miocene of Central Japan</td>
<td>Ishida, 1970</td>
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<tr>
<td><em>Millettia sp.</em></td>
<td>Eocene of SW Honshu, Japan</td>
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<td></td>
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<td>Siwalik of Koilabas, Nepal</td>
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<td><em>M. miobrandisiana</em></td>
<td>Siwalik of Koilabas, Nepal</td>
<td>Prasad, 1994 e</td>
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<tr>
<td><em>M. imilbasensis</em></td>
<td>Siwalik of Koilabas, Nepal</td>
<td>Prasad et al., 1999</td>
</tr>
<tr>
<td><em>M. churiensis</em></td>
<td>Siwalik of Suraikhola, Nepal</td>
<td>Prasad &amp; Awasthi, 1996</td>
</tr>
<tr>
<td></td>
<td>Miocene of Neyveli lignite</td>
<td>Agarwal, 2002</td>
</tr>
<tr>
<td><em>M. oudlabariensis</em></td>
<td>Siwalik of Darjeeling of West Bengal</td>
<td>Antal &amp; Prasad 1996 a</td>
</tr>
<tr>
<td><em>M. kathgodamensis</em></td>
<td>Siwalik of Kathgodam, Uttarakhand</td>
<td>Prasad et al., 2004</td>
</tr>
<tr>
<td><em>M. palaeopachycarpa</em></td>
<td>Miocene of Neyveli lignite</td>
<td>Agarwal, 2002</td>
</tr>
<tr>
<td><em>M. palaeocubithi</em></td>
<td>Siwalik of Suraikhola, Nepal</td>
<td>Awasthi &amp; Prasad, 1990</td>
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<td><em>M. ovatus</em></td>
<td>Siwalik of Koilabas, Nepal</td>
<td>Tripathi et al., 2002</td>
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<tr>
<td><em>M. purniyagiriensis</em></td>
<td>Siwalik of Tanakpur, Uttarakhand</td>
<td>Shashi et al., 2006</td>
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<tr>
<td><em>M. prakashi</em></td>
<td>Siwalik of Tanakpur, Uttarakhand</td>
<td>Shashi et al., 2008</td>
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<td><em>M. palaeomanii</em></td>
<td>Siwalik of Koilabas, Nepal</td>
<td>Dwivedi et al., 2006b</td>
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<td><em>M. bilaspurensis</em></td>
<td>Siwalik of Bilaspur, H.P.</td>
<td>Prasad, 2006</td>
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<tr>
<td><em>M. auriculata</em></td>
<td>Late Cenozoic of Mahuadanr, Jharkhand</td>
<td>Bande &amp; Srivastava, 1990</td>
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<tr>
<td><em>M. indakabalensis</em></td>
<td>Neogene of Rajasthan</td>
<td>Mathur &amp; Mathur, 1998</td>
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The present fossil leaf has been compared with all the above known species and it was found that none of them show similarity with the present fossil leaf. They differ mainly either in shape, size or in the nature and orientation of secondary veins. Thus the present fossil has been described under a new specific name, *Millettia mioinermis*.

**Present day distribution:** The genus *MILLETTIA* W. & A. consists of about 90 species of trees, shrubs and climbers distributed in tropical regions of Africa, Asia and Australia (MABBERLEY, 1997). The modern comparable species, *M. inermis* (Wright) D C. is a tall evergreen tree distributed in West Africa, West Indies and tropical America.

**Genus:** *Millettia* W. & A.

*Millettia siwalica* PRASAD, 1990a

Pl. 13, Figs 7,9,10,11,13

**Material:** There are several leaf impressions of different shape and size with fair preservation.

**Description:** Leaf symmetrical to asymmetrical, ovate to elliptic, preserved size 4.8 x 2.7cm, 3.0 x 1.8 cm., 3.0 x 2.0 cm. and 3.0 x 1.8 cm; apex acute to obtuse; base acute to obtuse, sometimes inequilateral; texture coriaceous; venation eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) about 9 pairs visible, 0.3 to 0.6cm apart, alternate to opposite, angle of divergence 55 ° - 65 °, acute, moderate, uniformly curved; intersecondary veins present, rare; tertiary veins (3°) fine, angle of origin usually AO, percurrent, almost straight, branched, oblique in relation to midvein, predominantly alternate and close.

**Specimen:** Specimen No. T 153 - T 156.

**Locality:** Spot No.5, Purniyagiri Road section, Champawat District, Uttarakhand.
Horizon and Age: Siwalik Formation, Mio-Pliocene.

**Affinity:** The most important features of the present fossil leaves such as symmetrical to asymmetrical, elliptic to ovate shape, acute to obtuse apex and base, entire margin, eucamptodromous venation, presence of intersecondary veins, AO, percurrent tertiary veins collectively suggest that the present fossil leaves show closest affinity with the extant leaves of *Millettia ovalifolia* KURZ. of the family Fabaceae (C.N.H. Herbarium sheets No.112378, 112379, Pl.13, Fig. 8, 12).

**Fossils record and comparison:** So far, about 30 fossil leaves resembling the genus *Millettia* W. & A. have been recorded from the Tertiary sediments of India and abroad (listed earlier in this text). After a detailed comparative study of all the known fossil leaves of *Millettia* W. & A. it has been concluded that *M. siwalica* PRASAD, 1990a shows closest similarity with the present fossil leaves in almost all the morphological features and hence they have been described under the same species, *M. siwalica* PRASAD.

**Present day distribution:** The modern comparable species, *M. ovalifolia* KURZ. is an evergreen tree distributed in the lower and upper Myanmar.(GAMBLE, 1972).

**Genus:** Humboldtia VAHL.

*Humboldtia miocenica* sp. nov.

Pl. 14, Fig. 1

**Material:** This species is based on a single, well preserved and complete fruit impression.

**Description:** Pod flat, thin; 10 cm. long, 3.2 cm, wide; oblong; apex rounded; base rounded; one side margin curved in middle portion, distinct venation on surface.

**Holotype:** Specimen No.T 157.

**Locality:** Sukhidang, near Tanakpur, Champawat District. Uttarakhand.

**Horizon & Age:** Siwalik Formation; Mio - Pliocene.

**Etymology:** After Miocene Period.
Affinity: Narrow oblong shape, obtuse apex and base, nature of margin and venation pattern on the surface collectively indicate its resemblance with the genus *Humboldtia* VAHL. of the family Fabaceae. In order to find out specific affinity the herbarium sheets containing fruits of all the available species of this genus have been critically examined and found that the fruits of *Humboldtia Vahliana* WIGHT (C.N.H. Herbarium sheets No. 76598; Pl.14, Fig. 2) show close affinity with the present fossil fruit in shape, size and venation pattern.

**Fossil record and comparison:** There is no fossil record of the fruit of the genus *Humboldtia* VAHL. from Tertiary sediments of India and Nepal. The present fossil fruit shows the first occurrence in the Siwalik sediments of Uttarakhand and therefore, has been described as *Humboldtia miocenica*.

**Present day distribution.** The genus *Humboldtia* VAHL. comprises 352 species of trees and shrubs. Out of which 14 species are found in India and Sri Lanka. *H. Vahliana* WIGHT. with which fruit resembles is a small, evergreen tree found to grow along the stream in swamp around low elevation in the evergreen forests of Western Ghats, Nilgiris to Travancore up to 2000 ft.

Genus: *Wagatea* DELZ.

*Wagatea miospicata* sp. nov.

Pl.14, Fig 3

**Material:** There is a single, well preserved almost complete fruit impression.

**Description:** Pod flat, thin, elliptical to obliquely oblong; size 6.4 x 2.0 cm. apex acute, pointed, base acute, seed chamber slightly distinct, margin entire, slightly broken; venation distinct on surface.

**Affinity:** The shape size and the nature of apex; base and venation pattern of the surface suggest its affinity with the fruit of the genus *Wagatea* DELZ. of the family Fabaceae. The herbarium sheets containing fruits of all the available species of *Wagatea* DELZ. were thoroughly examined and it was found that the fruits of *Wagatea spicata* DELZ. show closest affinity with the present fossil fruit (C.N.H. Herbarium sheet No. 134789; Pl.14, Fig 4).
Holotype: Specimen No. T 158.
Locality: Spot No. 4, Purniyagiri Road section, Champawat District, Uttarakhand.
Horizon and Age: Siwalik Formation, Mio-Pliocene.
Etymology: By adding a prefix ‘mio’ in the modern comparable species, *W. spicata*.

**Fossil record and comparison:** As there is no record of fossil fruit of the genus *Wagatea* DELZ. from Tertiary sediments of India and abroad. Thus, the present fossil fruit forms the first record from the Siwalik sediments of Uttarakhand, India and has been described here as *Wagatea miocenica* sp. nov.

**Present day distribution:** The genus *Wagatea* DELZ. consists of 11 species, one of them is found in south India. The modern comparable species, *W. spicata* DELZ. is a woody climber presently distributed in dry and moist forests of west side of peninsula (BRANDIS, 1971).

Genus: *Dalbergia* LINN. F.

*Dalbergia tanakpurensis* sp. nov.

Pl. 14, Fig. 5

**Material:** This species is consisting of a single, well preserved and complete fruit impression.

**Description:** Pod flat, thin, narrow oblong; size 5.7 x 1.8 cm; apex rounded; base obtuse, venation faint; margin entire, slightly thick; variation in width at some places; 3-4 seed chambers distinct, rounded.

Holotype: Specimen No. T 159.
Locality: Spot No. 4, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation, Mio-Pliocene.
Etymology: After fossils locality, Tanakpur.

**Affinity:** The Characteristic features of the present fossil fruit such as narrow oblong shape, rounded apex, obtuse base, nature of venation and distinct
seed chambers strongly suggest that the present fossil fruit shows resemblance with the extant fruit of *Dalbergia* LNN. of the family Fabaceae. In orders to find out the specific affinity, the herbarium sheets containing fruits of all the available species of *Dalbergia* LNN. F. have been critically examined and found that the fruits of *Dalbergia indana* show closest affinity with the present fossil fruit in shape, size and other morphological feature.

**Fossil record and comparison:** As far as author awares there are four records of fossil fruit resembling the genus *Dalbergia* LNN. F. from Tertiary sediments of India and abroad. Two fossil fruits, *D. derrisocarpoides* KOLAKOVSKY and *D. primaeva* known from outside of Indian subcontinents (SHAKRYL, 1992). The other fossil fruits resembling *Dalbergia sissoo* have been reported from Siwalik sediments of Balugoloa, Himachal Pradesh (LAKHANPAL & DAYAL, 1966) and from Late Tertiary sediments of Mahuadanr valley, Jharkhand, India. These above known fossil fruits have been compared with the present fruit and found that they differ mainly from present fossil in being wider and having different nature of apex and base. In view of this, the present fossil fruit has been designated as *Dalbergia tankpurensis* sp. nov.

**Present day distribution:** The genus *Dalbergia* LNN. F. consists of 100 species of trees, shrubs and lianas distributed in tropical to subtropical regions of world (WILLIS, 1973). The modern comparable taxon, *D. indana* presently distributed in south - east Asian region.

Genus: *Derris* LOUR.

*Derris prakasii* PRASAD et al., 2004

Pl.14, Figs.7,11

**Material:** There is a single, well preserved and complete fruit impression.

**Description:** Fruit flattened, wide elliptic to oval, ends decurved, margin thick, distinctly veined; size 2.5x1.5cm, wings absent.

Specimen: Specimen No. T-166.
Locality: Spot No.4, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Affinity: The morphological features such as wide elliptic to oval shape, thick margin and nature of striation on surface of the fruit suggest its affinity with the extant fruits of *Derris trifoliatus* LOUR. (C.N.H. Herbarium sheets Nos 210140, 210141; Pl.14, Fig.8) of the family Fabaceae.

**Fossil record and comparison:** PRASAD et al., 2004 reported a fossil fruits, *Derris prakashii* resembling the same extant species *Derris trifoliatus* LOUR. from the Siwalik sediments of Kathgodam, Uttarakhand. Later on MITRA & BANERGEE (2004) described an other fossil fruit, *Derrisocarpus miocenicum* from Siwalik of West Bengal. Both the above fossil fruits possess similar morphological features as the present fossil fruit hence, it has been described under the same species, *Derris prakashii* PRASAD et al., 2004.

**Present day distribution:** The genus *Derris* LOUR. comprises about 40 species of mostly climbers distributed in South east Asia, North Australia, and East Africa. *Derris trifoliatus* LOUR. (*D. uliginosa* BENTH.) with which fossil fruit shows closest affinity is a glabrous evergreen climbers presently distributed in the tidal forest of both Peninsula and Andamans. It is also found in the coast of Sri Lanka, eastern Africa and in Western Polynesia (BRANDIS, 1971).

**Genus:** *Derris* LOUR.

**Derris mioascandens** sp. nov.

Pl.15, Figs.7,9

**Material:** This consists of single, fairly preserved and complete leaf impression.

**Description:** Leaf symmetrical, narrow elliptic; preserved size 4.4x1.2cm; apex acute, base mainly obtuse; margin entire, texture thick chartaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost
straight; secondary veins (2°) about 12 pairs visible, 0.3 to 0.6 cm apart, closely placed, angle of divergence about 60°, acute moderate, uniformly curved up, seemingly unbranched; intersecondary veins present, simple, frequent; tertiary veins (3°) fine, poorly preserved, angle of origin usually AO, percurrent, straight to sinuous, branched, oblique in relation to midvein, alternate to opposite and close.

Specimen: specimen No. T-161.

Locality: Spot No. 10, near Bhairaur Mandir, Purniyagiri Road section, Tanakpur Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Affinity: The diagnostic features of the present fossil leaf such as almost symmetrical, narrow elliptic shape, nearly obtuse base, eucamptodromous venation, closely placed secondary veins with moderate angle of divergence, presence of intersecondary veins and AO, percurrent tertiaries collectively indicate that the present fossil leaf resembles closely with the extant leaves of *Derris scandens* BENTH. (C.N.H. Herbarium sheet No. 10016; Pl.15, Fig.8) of the family Fabaceae.

**Fossil record and comparison:** So far, two fossil leaf resembling the genus *Derris* LOUR., have been known from the Siwalik sediments of India. These are *Derris champarensis* from Upper Siwalik sediments of Bhikhnathoree, Bihar (AWASTHI & LAKHANPAL, 1990) and *Derrisophyllum siwalicum* from Lower Siwalik sediments of West Bengal (MITRA & BANNERJEE, 2004). Both the above known fossil leaves differ from present fossil leaf mainly in the nature and arrangement of secondary veins.

**Present day distribution:** The modern comparable taxon, *Derris scandens* BENTH. is a large climber presently distributed in central, western and southern India extending north to the forest of Oudh and north east to eastern Bengal, Chittagong, throughout Myanmar and Andaman Islands (BRANDIS, 1971).

Genus: *Pongamia* VENT.

*Pongamia siwalika* AWASTHI & LAKHANPAL, 1990

Pl.15, Figs1,3
Material: There is a single, well preserved, almost complete leaf impression.

Description: Leaf symmetrical, obovate to elliptic; preserved size 4.5x2.8 cm; apex slightly broken; base nearly attenuate; margin entire; texture coriaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, straight; secondary veins (2°) 6 pairs visible, 0.4 to 1.0 cm apart, lowest secondary closely placed; alternate to subopposite, unbranched, angle of divergence about 55°, acute, uniformly curved up; intersecondary veins present, simple; tertiary veins (3°) fine, angle of origin AO, percurrent, straight to sinuous, branched, oblique in relation to midvein, predominantly alternate, and close.

Specimen: Specimen No. T-162.

Locality: Spot No.1, near Hanuman Chatti, Purniya gri Road section, Tanakpur, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Affinity: The distinguishing characters of the present fossil leaf are symmetrical obovate to elliptic shape, nearly attenuate base; entire margin; eucamptodromous venation; presence of intersecondary veins, AO, percurrent, straight to sinuous tertiary veins. An extensive survey of herbarium sheets of different genera and species of dicotyledonous families suggests that the extant leaves of *Pongamia pinnata* (L.) PIERRE (Syn. *Derris indica* BENNET.) of the family Fabaceae (C.N.H. Herbarium sheet No. 50061; Pl.15, Figs 2,4) show closest affinity with the present fossil leaf.

Fossil record and comparison: Three fossil leaves resembling the extant species *Pongamia pinnata* (L.) PIERRE (= *P. glabra* VENT.) have been known from Siwalik sediment of India. AWASTHI & LAKHANPAL (1990) described a fossil leaf, *Pongamia siwalika* from the Upper Siwalik sediments of Bhikhnathoree, Bihar. ANTAL & AWASTHI (1993) reported the same species from Lower-Middle Siwalik of West Bengal. Later on PRASAD (1994d) described another fossil leaf, *Pongamia* cf. *P. glabra* VENT. from the Middle Siwalik of Haridwar, India. All the above known fossil leaves are almost identical.
They differ slightly in shape and size. The present fossil leaf has been compared with those of known fossil leaves and found that the fossil leaf *P. siwalika* described from West Bengal exhibits similar morphological features as the present fossil leaf and therefore, described under the same species, *P. siwalika* ANTAL & AWASTHI.

**Present day distribution:** The genus *Pongamia* VENT. comprises single species *P. pinnata* (L.) PIERRE with which fossil resembles closely is a moderate sized evergreen tree distributed in the tidal and beach forests and along river banks and water course throughout the country. It is also found in Sri Lanka and Myanmar (GAMBLE, 1972).

**Genus: Cynometra Linn.**

*Cynometra palaeoripa* PRASAD et. al., 1999

Pl.15, Fig.5

**Material:** There are two, fairly preserved and complete leaf impressions.

**Description:** Leaf asymmetrical, elliptic; preserved size 4.7x2.0 cm; apex, bluntly acute; base acute; inequilateral; margin entire; texture chartaceous; petiole less than .02 cm visible, normal; venation pinnate, eucamptodromous to brochidodromous; primary vein (1°) single, prominent, straight, stout; secondary veins (2°) poorly preserved, about 12 pairs visible, less than 0.6 cm apart, alternate to opposite, angle of divergence about 50°, acute, moderate, uniformly curved up and joined to their superadjacent secondaries, sometimes forming loop; tertiary veins (3°) fine, angle of origin RR-AO, percurrent, straight to sinuous, oblique in relation to midvein, predominantly alternate and close.

Specimen: Specimen No. T-163.

Locality: Spot No. 10, near Bhairauv Mandir, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

**Affinity:** The diagnostic features of the present fossil leaf are asymmetrical, elliptic shape, bluntly acute apex, acute base, entire margin, eucamptodromous to
brochidodromous venation, acute angle of divergence of secondary veins which joining the superadjacent secondary and making a loop and AO-RR, percurrent tertiary veins. Such features are found common in the modern leaves of *Cynometra LINN.* of the family Fabaceae. A critical examination of the herbarium sheets of all the available species of this genus suggests that the extant leaves of *Cynometra iripa* KOTEL show closest affinity with the present fossil leaf in all the morphological features (C.N.H. Herbarium sheet No. 1387 45; Pl.15, Fig.6).

**Fossil record and comparison:** The fossil leaves resembling the genus *Cynometra LINN.* have been described under three specific names from Siwalik sediments of India and Nepal. These are *Cynometra siwalika* from Middle Siwalik sediments of Suraikhola, Nepal (AWASTHI & PRASAD, 1990), *Cynometra tertiara* from Lower- Middle Siwalik of Oodlabari, Darjeeling District, West Bengal and *C. palaeoiripa* from Siwalik sediments of Koilabas area, western Nepal (PRASAD et al., 1999) and Lower Siwalik sediments of Kathgodam, Uttarakhand (PRASAD et al., 2004). A comparative study shows that *C. palaeoiripa.* PRASAD et al. has the nearest affinity with the present fossil in possessing asymmetrical, elliptic shape with similar course of secondary and tertiary veins. In view of this, the present fossil has been assigned to the same species, *C. palaeoiripa* PRASAD et al.

**Present day distribution:** The genus *Cynometra LINN.* comprises about 70 tropical species. Of which five are found in India. The modern comparable species *C. iripa* KOTEL is presently distributed in Indo - Malayan region.

Family: Combretaceae
Genus: *Terminalia* LINN.

*Terminalia bhairauvensis* sp. nov.
Pl. 15, Figs 10,11; Pl. 16, Fig. 5

**Material:** This species is represented by three, well preserved leaf impressions.
Description: Leaf simple, symmetrical, narrow elliptic; preserved size 8.0 x 3.0 cm; apex wide acute; base wide acute to nearly obtuse; slightly asymmetrical; margin entire; texture chartaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 8-9 pairs, 0.4-1.4 cm apart, usually alternate, angle of divergence, 60°-65°, acute, moderate, uniformly curved up, unbranched; tertiary veins (3°) fine, angle of origin usually RR, percurrent, almost straight, alternate and close; quaternary veins (4°) very fine, arising at nearly right angle, branched to form polygonal meshes.

Holotype: Specimen Nos. T-164, T-165.

Locality: Spot No. 10, near Bhairauv Mandir, Purniyagiri Road sections, Tanakpur, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Etymology: After the name of Bhairauv Mandir situated just near the fossil spot.

Affinity: The present fossil leaves are characterized by narrow elliptic shape, wide acute apex, slightly asymmetrical, nearly obtuse base, entire margin, eucamptodromous venation, moderately acute angle of divergence of secondary veins, and RR, percurrent, straight to sinuous tertiaries. The closely placed basal secondary vein is also an important character of the fossil leaf. A comparative study of the herbarium sheets of different families shows that the above features are found common in the modern leaves of the genus *Terminalia* LINN. of the family Combretaceae. A critical examination of the modern leaves of all the available species of this genus revealed that these fossil leaves show their closest affinity with the leaves of *Terminalia argyrophylla* KING & PRAIN (C.N.H. Herbarium sheet No. 63675; Pl.16, Fig.6) in shape, size and venation pattern.

Fossil record and comparison: Fossil leaves resembling the genus *Terminalia* LINN. have been reported under three generic names viz., *Terminalia* LINN. *Terminaliphyllum* Velenovsky and *Terminaliophyllum* Geyler from Tertiary - Cretaceous sediments of India and abroad. These are listed as below:
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<th>Locality/Period</th>
<th>Reference</th>
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<td>Weyland, 1942</td>
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<td><em>Unger</em></td>
<td>Tertiary of Czechoslovakia</td>
<td>Nemejc, 1975</td>
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<td>Berry, 1919</td>
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<td>&amp; Awasthi, 1984</td>
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<td><em>T. panandhroensis</em></td>
<td>Tertiary of Kachchh, India, Siwalik of</td>
<td>Lakhanpal &amp; Guleria,</td>
</tr>
<tr>
<td></td>
<td>Koilabas, Nepal</td>
<td>&amp; Prasad, 1994</td>
</tr>
<tr>
<td><em>T. panonica</em></td>
<td>Tertiary of South Guistine</td>
<td>Unger, 1867</td>
</tr>
<tr>
<td><em>Unger</em></td>
<td></td>
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<tr>
<td><em>T. phaeocarpoides</em></td>
<td>Eocene of South Carolina, USA</td>
<td>Berry, 1914</td>
</tr>
<tr>
<td><em>Principi</em></td>
<td></td>
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<tr>
<td><em>T. radobojana</em></td>
<td>Tertiary of Kumi, Euboea</td>
<td>Unger, 1867</td>
</tr>
<tr>
<td>Specie</td>
<td>Geographical Location</td>
<td>Author(s)</td>
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<tr>
<td><em>T. nottensis</em></td>
<td>Tertiary of Germany</td>
<td>Weyland, 1942</td>
</tr>
<tr>
<td><em>T. tallyana</em></td>
<td></td>
<td>Schimper, 1874</td>
</tr>
<tr>
<td><em>T. trinitense</em></td>
<td>Cenozoic of North America</td>
<td>LaMotte, 1952</td>
</tr>
<tr>
<td><em>T. ungeri</em></td>
<td>Tertiary of Czechoslovakia</td>
<td>Nemejc, 1975</td>
</tr>
<tr>
<td><em>Terminalia sp.</em></td>
<td>Tertiary of Alaska</td>
<td>Hollick, 1936</td>
</tr>
<tr>
<td><em>Terminalia sp.</em></td>
<td>Palaeogene of Japan</td>
<td>Matsuo, 1970</td>
</tr>
<tr>
<td><em>Terminalia sp.</em></td>
<td>Siwalik of Koilasbas, Nepal</td>
<td>Tripathi &amp; Tiwari,</td>
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<td><em>T koilabasensis</em></td>
<td>Siwalik of Koilabas, Nepal</td>
<td>Prasad, 1990a</td>
</tr>
<tr>
<td><em>T. siwalica</em></td>
<td>Siwalik of Koilabas, Nepal</td>
<td>Prasad, 1990a</td>
</tr>
<tr>
<td><em>T. palaeochebula</em></td>
<td>Siwalik of Suraikhola, Nepal</td>
<td>Awasthi &amp; Prasad,</td>
</tr>
<tr>
<td><em>T. chebula</em></td>
<td>Late Tertiary of Mahuadanr, Jharkhand</td>
<td>Singh &amp; Prasad,</td>
</tr>
<tr>
<td><em>T. tomentosa</em></td>
<td>Late Tertiary of Mahuadanr, Jharkhand</td>
<td>Bande &amp; Srivastava,</td>
</tr>
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<td><em>T. paniculata</em></td>
<td>Miocene of Neyveli Lignite, South India</td>
<td>Agarwal, 2002</td>
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<tr>
<td><em>T. palaeochebula</em></td>
<td>Miocene of Neyveli Lignite, South India</td>
<td>Agarwal, 2002</td>
</tr>
<tr>
<td><em>T. miobelerica</em></td>
<td>Miocene of Neyveli Lignite, South India</td>
<td>Agarwal, 2002</td>
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<tr>
<td><em>T. neyvelensis</em></td>
<td>Miocene of Neyveli Lignite, South India</td>
<td>Agarwal, 2002</td>
</tr>
<tr>
<td><em>T. mulleri</em></td>
<td>Siwalik of Ranibagh, Uttarakhand</td>
<td>Trivedi &amp; Srivastava,</td>
</tr>
<tr>
<td><em>T. balugoloensis</em></td>
<td>Siwalik of Balugola, H. P.</td>
<td>Lakhanpal &amp;</td>
</tr>
<tr>
<td><em>T. miobelerica</em></td>
<td>Siwalik of Kathgodam, Uttarakhand</td>
<td>Prasad, 1994c,</td>
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<tr>
<td><em>T. obovata</em></td>
<td>Oligocene of Makum Coalfield, Assam</td>
<td>Awasthi &amp; Mehrotra,</td>
</tr>
<tr>
<td><em>T. palaeocatapa</em></td>
<td>Oligocene of Makum Coalfield, Assam</td>
<td>Awasthi &amp; Mehrotra,</td>
</tr>
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</table>
Thus the genus *Terminalia* was cosmopolitan in distribution during geological past. The fossil leaves and woods of this genus have been reported from all over the world. The earliest record of *Terminalia* leaf i.e. *Terminaliphyllum* goes back to the Upper Cretaceous of Bohemia. 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.

The present fossil leaves have been compared with all the known available species of *Terminalia* Linn. and found that the present fossil leaves do not match any of them. These differ either in the nature of apex and base or in the course and arrangement of secondary and tertiary veins. In view of this the present fossil leaves have been assigned to new species, *Terminalia bhairauvensis*.

**Present day distribution:** the genus *Terminalia* Linn. now consists of 150 species of large tree and widely distributed in the tropics of the world (MABBERELY, 1997) *Terminalia argyrophylla* KING & PRAIN with which fossil leaves closely resemble is a large tree presently found to grow in the forests of Upper Myanmar. (BRANDIS, 1971).

**Genus: Combreutum** LOEFL.

*Combreutum purniyagiriensis* sp. nov.

Pl. 16, Figs 1, 3

**Material:** This species is based on a single, fairly preserved and almost complete leaf impression.

**Description:** Leaf simple, symmetrical, wide elliptic; preserved size 8.5x 6.0cm; apex slightly indistinct, seemingly acute; base broken; margin entire;
texture chartaceous; venation pinnate, eucamptodromous to brochidodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 7 pairs, 0.8 - 2.0 cm apart, unbranched, alternate, angle of divergence 65°, acute, moderate, uniformly curved up and joining superadjacent secondary veins near the margin by making a loop, unbranched; intersecondary veins present, simple; tertiary veins (3°) moderate, angle of origin usually RR, percurrent, straight to sinuous, sometimes branched, oblique in relation to midvein, predominantly alternate and distant to close.

Holotype: Specimen No. T-166.
Locality: Spot No. 6, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Etymology: After Purniyagiri Temple.

Affinity: The important morphological characters of the fossil leaf like its wide elliptic shape, acute apex, entire margin, eucamptodromous to brochidodromous venation, wide acute angle of divergence of secondary veins, formation of loop near the margin by joining the secondary veins, presence of intersecondary veins and RR, percurrent, distant to close tertiary veins show that the fossil leaf belongs to the genus *Combretum* LOEFL. of the family Combretaceae. In order to find out the nearest affinity of the present fossil leaf, the herbarium sheets of all the available species of this genus have been examined and it was concluded that the extant leaves of *Combretum sundiacum* MIQUEL show closest similarity with the fossil leaf. (C.N.H. Herbarium sheet No. 65030; Pl.16, Figs.2,4).

Fossil record and comparison: So far, there are five fossil records of *Combretum* LOEFL. leaves from the Tertiary of India and abroad. These are *C. europium* WEB. from Oligocene of Chivone Salcedo (PRINCIPI, 1926), *C. sarothrosatachyoides* MASS. from Pliocene of Saromaziana (PRINCIPI, 1926), *Combretum decandrum* ROXB. from Late Tertiary of Mahuadanr, Jharkhand, *C. sahni* from Lower - Middle Siwalik of Darjeeling District, West Bengal (ANTAL
& AWASTHI, 1993) from Kasauli Formation, H.P., from Lower Siwalik of Koilabas area, Nepal (PRASAD, 1994e) and C. miocenicum from Lower Siwalik of Bhutan (PRASAD & TRIPATHI, 2000). On comparison of the present fossil leaf with all the above known fossils, it has been observed that only C. miocenicum PRASAD & TRIPATHI shows near resemblance in the nature and arrangement of tertiary veins but differs from present fossil leaf in being narrow elliptic shape having different course of secondary veins. The secondary veins arise at more acute angle and run upward for a long distance in comparison to the present fossil leaf. The present fossil is therefore, described here as a new species, Combretum purniyagiriensis.

**Present day distribution:** The genus *Combretum* LOEFL. comprises 370 species of tree and shrubs. Of them, 300 species are native of tropical Africa and Asia. *Combretum sundiacum* MIQUEL with which fossil shows affinity is a shrub and growing presently in the Indo-Malayan region.

Family: Melastomaceae

Genus: Medinilla GAUDICH.

**Medinilla siwalica sp. nov.**

Pl.16, Figs 7,9

**Material:** This species is represented by a single specimen of leaf impression which is complete and well preserved.

**Description:** Leaf simple, slightly asymmetrical; small; narrow elliptic; preserved size 3.2x0.7 cm; apex sharply attenuate; base slightly indistinct, seemingly acute; margin entire; texture charataceous; venation pinnate, acrodromous, supra basal, perfect; primary veins (1°) three (one mid and two lateral), lateral primary veins arising from above the base, running upward toward the apex, mid primary almost straight and lateral primary veins curved toward mid primary; secondary veins (2°) several, arising at acute angle from lateral primary while it is nearly right angle when arising from mid primary, closely placed seemingly unbranched, the secondaries arising from mid vein joined to their lateral
primary veins while the secondaries of lateral primaries joined to the margin; tertiary veins (3°) indistinct.

Holotype: Specimen No. T-167.

Locality: Spot No. 8, Purniyagiri Road section; Tanakpur, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Etymology: After Siwalik Formation.

Affinity: The diagnostic features of the present fossil leaf are: slightly asymmetrical, small, narrow elliptic shape, attenuate apex, acute base, entire margin, supra basal, perfect, acrodromous venation and peculiar nature and course of secondary veins. After a detail survey of the herbarium sheets of a large number of genera and species of dicotyledonous families, it has been observed that the above features are found common in the extant leaves of Medinilla ramiflora MERR. (C.N.H. Herbarium sheets Nos 174010, 174035; Pl. 16, Figs. 8, 10) of the family Melastomaceae.

Fossil record and comparison: As far as the author is aware, there is no record of fossil leaf resembling the genus Medinilla GAUDICH. The occurrence of this characteristic fossil leaf in the Siwalik sediments of Tanakpur area, Uttarakhand represents its first record and is hence described as Medinilla siwalica sp. nov.

Present day distribution: The genus Medinilla GANDICH. consists of 400 species distributed mainly in Southeast Asia and Africa. The modern comparable taxon, M. ramiflora MERR. is presently distributed in the evergreen forests of Philippines, Madagascar and Malaya.

Family: Lythraceae

Genus: Lagerstroemia LINN.

Lagerstroemia prakashii sp. nov.

Pl.17, Fig.1; Pl.18, Figs 1,3

Material: There are two, well preserved and complete leaf impressions.
**Description:** Leaf simple, symmetrical; very narrow elliptic to oblong; preserved size 18.2x5.8cm and 12.4x4.7cm; apex acute; base wide acute, asymmetrical; margin entire; texture coriaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, massive, almost straight; secondary veins (2°) about 14 pairs visible, 0.7 to 1.8 cm apart, alternate to subopposite, sometimes branched, angle of divergence 55°-70°, narrow to wide acute, few pairs of basal secondaries arise more acutely, uniformly curved up and joined to the superadjacent secondaries; intersecondary veins present, simple, frequent; tertiary veins (3°) fine, angle of origin AO-RR, percurrent, straight to sinuous, branched, oblique in relation to midvein, predominantly alternate and close to slightly distant.

**Holotype:** Specimen No. T-168.

**Paratype:** Specimen No. T-169.

**Locality:** Spot No.1, near Hanuman Chatti, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

**Horizon & Age:** Siwalik Formation; Mio-Pliocene.

**Etymology:** Named in the honour of Dr. Uttam Prakash, an eminent scientist of Birbal Sahni Institute of Palaeobotany Lucknow who has done remarkable work on Tertiary plant megafossils.

**Affinity:** The most important features exhibited by the present fossil leaves are: very narrow elliptic to oblong shape, acute apex, asymmetrical, wide acute base, entire margin, eucamptodromous venation, narrow to wide acute angle of divergence of secondary veins which joined to their superadjacent secondary, presence of frequent inter secondary veins and AO-RR, percurrent tertiaries. These features are found common in the extant leaves of the genus *Lagerstroemia* LINN. of the family Lythraceae. A critical observation of a number of herbarium sheets of different species of this genus indicates that the present fossil leaves show closest affinity with the extant leaves of *Lagerstroemia flosreginae* RETZ., (Syn. *L. speciosa*; C.N.H. Herbarium sheet No. 590190; Pl.17, Fig.2; Pl.18, Fig.2).

**Fossil record and comparison:** So far, five authentic fossil leaves resembling the genus *Lagerstroemia* LINN. have been described from the Tertiary
sediments of India. They are *Lagerstroemia patelii* from the Eocene of Kachchh, Gujarat (LAKHANPAL & GULERIA, 1981), from Siwalik sediments of Darjeeling District, West Bengal (ANTAL & AWASTHI, 1993), and from Kathgodam, Uttarakhand, India (PRASAD, 1994c). *L. siwalica* from Siwalik sediments of Koilabas, Nepal (PRASAD, 1994e) and Miocene of Neyveli lignite deposits, Tamil Nadu (AGARWAL, 2002). *L. jamraniensis* from Lower Siwalik sediments of Jamrani, Kathgodam, Uttarakhand (PRASAD et al., 2004), *L. mioparviflora* and *L. eomicrocarpa* from Siwalik sediments of Koilabas area, western Nepal, (DWIVEDI, et al., 2006b). On comparison of the present fossil leaves with the above known species, it has been observed that the only fossil species, *L. jamraniensis* PRASAD et al. shows some what similarity in shape and size but differs in nature of base and arrangement of tertiary veins. This species possesses symmetrical base and close tertiary veins as compared to asymmetrical base and distant tertiaries in the present fossil leaves. The rest fossil species can be easily differentiated in being smaller size with different course of secondary and tertiary veins. Thus, in being different from already know species of *Lagerstroemia* LINN., the present fossils have been assigned to a new species, *Lagerstroemia prakashii*.

**Present day distribution:** The genus *Lagerstroemia* LINN. comprises about 53 species distributed in the tropical Africa, Asia, Polynesia and pacific region. *L. flos-regiane* RETZ. with which fossil leaves show resemblance is a large deciduous tree presently found in Assam valley, Bangladesh, Chhotanagpur and the Circars. It is also found in the western Coast from South Konkan, Myanmar and Srilanka (GAMBLE, 1972).

Genus: *Lagerstroemia* LINN.

*Lagerstroemia mioparviflora* DWIVEDI et al., 2006b

Pl.18, Figs 4,5,6,8,9,11

**Material:** There are four specimens of leaf impression. Two are complete and well preserved.
**Description:** Leaf simple, symmetrical, ovate to narrow elliptic; preserved size 4.2x2.3cm, 4.0x2.0cm, 6.0x1.5cm and 5.0x1.4cm; apex acute; base nearly obtuse; margin entire; texture chartaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 6-9 pairs visible, 0.5 to 1.3cm apart; alternate, seemingly unbranched, angle of divergence 50°-60°, acute, moderate uniformly curved up; intersecondary veins present, simple; tertiary veins (3°) fine, angle of origin usually RR, percurrent, straight to sinuous, branched, oblique to nearly right angle in relation to midvein, predominantly alternate, close to nearly distant.

**Specimen:** Specimen No. T-170 - T-174.

**Locality:** Spot No. 10, near Bhairav Mandir, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

**Horizon & Age:** Siwalik Formation; Mio-Pliocene.

**Affinity:** The most important characters exhibited by the present fossil leaves such as ovate to narrow elliptic shape, acute apex, nearly obtuse base, eucamptodromous venation, moderately acute angle of divergence of secondary veins, presence of intersecondary veins and RR, percurrent tertiary veins which are oblique to nearly right angle in relation to midvein collectively indicate their resemblance with the extant leaves of *Lagerstroemia parviflora* ROXB. (C.N.H. Herbarium sheet Nos 74096, 9745; Pl. 18, Figs 7,10) of the family Lythraceae. During identification, it has been observed that there is much variation in shape and size of the leaves of *Lagerstroemia parviflora* ROXB.

**Fossil record and comparison:** All the fossil leaves resembling the genus *Lagerstroemia* LINN. (mentioned earlier in this text) have been compared with the present fossil leaves and concluded that the fossil leaf, *Lagerstroemia mioparviflora* DWIVEDI et al., 2006b shows closest similarity with the fossil leaves and thus these have been described under the same species *L. mioparviflora* DWIVEDI et al.

**Present day distribution:** The genus *Lagerstroemia* LINN. comprises about 53 species and presently distributed in tropical region of the old world. The modern comparable species *L. parviflora* ROXB. is a large tree found to occur in
the sub-Himalayan tract from Jammu eastward ascending to 3000 ft. It also occurs in Assam, West Bengal and Myanmar (BRANDIS, 1971).

Family: Rubiaceae
Genus: *Ixora* LINN.

*Ixora purniyagiriensis* sp. nov.  
Pl.19, Figs1,3,4,5,6; Pl.20, Fig.1

**Material:** This species is represented by more than 10 specimens of well preserved leaf impressions.

**Description:** Leaf simple, symmetrical, lanceolate to very narrow elliptic; preserved size 14.0 x 3.5cm, 8.5x 4.0cm and 7.5 x 3.5 cm; apex attenuate; base acute, cuneate; margin entire; texture chartaceous; venation pinnate, eucamptodromous, primary vein (1°) single, prominent, massive, straight to curved; secondary veins (2°) about 26 pairs visible, 0.3 to 0.8 cm apart, closely placed, alternate to opposite, seemingly unbranched, angle of divergence 60°-80°, upper secondary veins more acute, moderate to right angle, uniformly curved up and joined to superadjacent secondary veins; intersecondary veins present, simple, abundant; tertiary veins (3°) fine, angle of origin usually RR, percurrent, almost straight, oblique in relation to midvein, predominantly alternate and close.

**Holotype:** Specimen No. T-175.

**Paratype:** Specimen Nos T-176 - T-179.

**Locality:** Spot No. 5, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

**Horizon & Age:** Siwalik Formation; Mio-Pliocene.

**Etymology:** After Purniyagiri Mata temple.

**Affinity:** The most important features of the present fossil leaves are lanceolate to narrow elliptic shape, attenuate apex, cuneate base, entire margin, eucamptodromous venation, closely placed secondary, presence of intersecondary veins and RR, percurrent, almost straight tertiary veins. These features are found
common in the modern leaves of *Terminalia myriocarpa* of the family Combretaceae, *Kayea floribunda* WALL. of the family Clusiaceae and *Ixora lobbii* LOUDON of the family Rubiaceae. On critical examination of the herbarium sheets of above taxa, it has been observed that the leaves of *Terminalia myriocarpa* differ from fossils in being absence of intersecondary veins and the basal secondary veins are closely placed than the secondaries in apical and middle portion. The leaves of *Kayea floribunda* WALL. can be differentiated by its nature and arrangement of secondaries which are fine, more in number and very closely placed. Thus, the leaves of *Ixora lobbii* LOUDON (C.N.H. Herbarium Sheet Nos 210140, 210141; Pl.19, Figs 2,7; Pl.20, Fig.2) are only with which the present fossil leaves show closest affinity in shape, size and venation pattern.

**Fossil record and comparison:** So far, there is no record of any fossil leaf resembling the genus *Ixora* LINN. from the Tertiary sediments of Indian subcontinents. The present fossil leaves represent its first record from the Siwalik sediments of Tanakpur area, Uttarakhand and is being described herewith as *Ixora purniyagiriensis* sp. nov.

**Present day distribution:** The genus *Ixora* LINN. consists of 300 tropical species of shrubs or trees. About 30 species are found in tropical Africa. The modern comparable species *Ixora lobbii* LOUDON is an evergreen tree presently distributed in Indo-China, Malaya Islands, Java and Borneo.

**Genus:** *Randia* LINN.

**Randia tanakpurensis** sp. nov.

Pl.20, Figs3,5

**Material:** This species is based on three well preserved leaf impression.

**Description:** Leaf simple, symmetrical ob lanceolate; preserved size 7.6x3.0cm; apex obtuse base cuneate; margin entire; texture coriaceous; venation pinnate, eucamptodromous; primary vein (1°) single; prominent, stout, almost straight; secondary veins (2°) 7 pairs visible, 0.6 to 1.3 cm apart, alternate, seemingly unbranched, angle of divergence 45°-60°, acute, narrow to moderate,
uniformly curved up, running upward for a short distance; intersecondary veins present, simple; tertiary veins (3°) fine, angle of origin AO-RR, percurrent, almost straight, branched, oblique in relation to midvein predominantly alternate and close to distant.

Holotype: Specimen No. T-180.
Locality: Spot No.3, Purniyagiri Road section, Tanakpur, Champawat District, Uttamchal.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Etymology: After the name of fossil locality, Tanakpur.

Affinity: The diagnostic features of the present fossil leaf such as symmetrical, oblancoolate shape, obtuse apex, cuneate base; entire margin, eucamptodromous venation nature and course of secondary veins, AO-RR, percurrent, close to distant tertiary veins collectively suggest its affinity with the modern leaves of Randia floribunda (= R. dumentorum LAM.) of the family Rubiaceae (C.N.H. Herbarium Sheet No. 205345; Pl.20, Fig.4) in shape, size and venation pattern.

Fossil record and comparison: So far, seven fossil species resembling the genus Randia LINN. have been reported from India and abroad (PRASAD AND DWIVEDI, 2007). Of these four species are described from the Siwalik sediments of India and Nepal. These are Randia miowallichii PRASAD (1990a) from Siwalik sediments of Koilabas, western Nepal and from Oodlabari, Derjeeling District, West Bengal, India. (ANTAL & AWASTHI 1993), R. siwalica and R. palaeofasciculata from Siwalik sediments of Suraikhola, western Nepal (PRASAD & AWASTHI, 1996) and R. miuncaria PRASAD & DWIVEDI (2007) from the Siwalik sediments of Serianaka, Koilabas area, western Nepal. On comparison, it has been observed that none of these known species show similarity with the present fossil leaves. They differ mostly either in shape, size or in the nature and course of secondary veins. R. miowallichii PRASAD differs in having craspedodromous type of venation pattern as compared to eucamptodromous in the present fossils. R. palaeofasciculata PRASAD & AWASTHI can be differentiated in being smaller size (3.4x1.4 cm) as compared to 7.6x3.0 cm in the present
fossils. Similarly, the fossil leaf, *R. siwalica* PRASAD & AWASTHI differs in being its larger size (18.5x5.8 cm) with narrow elliptic shape. Though, the leaf of *R. miouncauria* PRASAD & DWIVEDI shows similarity in shape and size but differ in the number and course of the secondary veins. The secondary veins are less in number and spacely placed i.e. 0.8 to 2.4 cm apart. In being different from already known species the present fossil leaves have been assigned to a new specific name, *Randia tanakpurensis*.

**Present day distribution:** The genus *Randia* LINN. consist of 300 species (including *Basanantha* Hook. F.) distributed throughout the tropical to subtropical regions of the world. *Randia floribunda* (= *R. dumentorum* LAM.) with which fossils show resemblance is a shrub or small tree presently found throughout India extending north to the Beas, Myanmar and Sri Lanka (BRANDIS, 1971).

Family: Sapotaceae  
Genus: *Plaquium* BLANCO.  

*Plaquium palaeograndis* sp. nov.  
Pl.20, Fig.6; Pl.21, Fig.8; Pl.22, Fig.1.

**Material:** There are two, well preserved leaf impressions without apex.  
**Description:** Leaf simple, symmetrical, ob lanceolate, preserved size 11x4.8cm and 9.0x5.0 cm, apex broken, base acute to cuneate; margin entire, texture chartaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, straight; secondary veins (2°) about 9-10 pairs visible, 0.6 to 1.8 cm apart, alternate to opposite, seemingly unbranched, angle of divergence 60°-70°, wide acute; uniformly curved up and joined to superadjacent secondary veins, curvature is more pronounced near the margin; intersecondary veins present, simple, rare; tertiary veins (3°) angle of origin usually AO rarely RR, percurrent, sometimes branched, oblique in relation to midvein, predominantly alternate, close to nearly distant.  
Holotype: Specimen No. T-181.  
Paratype: Specimen No. T-182.
Locality: Spot No. 1, near Hanuman Chatti, Purniyagiri Road section, Tanakpur, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Etymology: By adding a prefix 'palaeo' to the name of modern comparable species, *P. grandis*.

**Affinity:** The characteristic features of the present fossil leaves such as symmetrical, oblongate shape, acute to cuneate base, entire margin, eucamptodromous venation, wide acute angle of secondary veins having a pronounced curvature near the margin, presence of inter secondary veins, usually AO, percurrent, close to nearly distant tertiary veins strongly indicate their resemblance with the modern leaves of the genus *Plaquium* BLANCO. of the family Sapotaceae. A critical study of the herbarium sheets of this genus shows that the leaves of *Plaquium grandis* (THWAITES) ENGL. (Syn. *Dichopsis grandis* (THWAITES) C. B. CLARKE in shape, size and venation pattern (C.N.H. Herbarium sheets No. 280694; Pl.22, Figs 2, 3).

**Fossil record & Comparison:** As far as author aware there is no record of fossil leaves resembling the genus *Plaquium* BLANCO. As the present fossil form the first occurrence of the fossil leaves of this genus in the Siwalik sediments of Tanakpur, Uttarakhand and have been assigned as *Plaquium palaeograndis* sp. nov.

**Present day distribution:** The genus *Plaquium* BLANCO. Comprises about 60 species mainly confined to Indo-Malayan region and Islands of Samoa (Pearson & Brown, 1932) *Plaquium grandis* (THWAITES) ENGL. with which fossils resemble closely is an evergreen tree distributed presently in the Indo-Malayan region.

Genus: *Chrysophyllum* LINN.

**Chrysophyllum bhairavensis** sp. nov.

Pl.21, Figs 3, 5

**Material:** There is a single, well preserved leaf impression.
**Description:** Leaf simple, symmetrical, narrow elliptic; preserved size 5.7x2.2 cm; apex acute; base obtuse; margin entire; texture chartaceous; venation pinnate, craspedodromous to eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) about 28 pairs visible, less than 0.3 cm apart, closely placed, alternate to opposite, unbranched, angle of divergence 70°-85°, acute to right angle, upper secondary more acute, uniformly curved up; inter secondary veins present, simple, frequent, 2-4 intersecondary veins present in between two secondary veins; tertiary veins (3°) fine, angle of origin AO-RR; percurrent, usually straight, sometimes branched, oblique in relation to midvein, alternate to opposite, close.

**Holotype:** Specimen No. T 183.

**Locality:** Spot No. 10, near Bhairauv Mandir, Purniyagiri Road section, Champawat District, Uttarakhand.

**Horizon & Age:** Siwalik Formation; Mio-Pliocene.

**Etymology:** After the name of Bhairauv Mandir situated just near the fossil spot.

**Affinity:** The diagnostic features of the present fossil leaf such as narrow elliptic shape, acute apex, obtuse base, craspedoromous to eucamptodromous venation, closely placed secondaries with acute to right angle of divergence, presence of 2-4 intersecondary veins and AO-RR, percurrent tertiary veins collectively suggest that the present fossil shows closest affinity with the leaves of the genus *Chrysophyllum* LINN. of the family Sapotaceae. An examination of the leaves of various extant species of this genus revealed that the fossil leaf resembles those of *Chrysophyllum viridifolium* WOOD & FRANKS (C.N.H. Herbarium sheet No. 279994; Pl.21, Figs.4,6).

**Fossil record and comparison:** MEHROTRA (2000a) described a fossil leaf showing resemblance with the genus *Chrysophyllum* LINN under form species, *C. tertiarum* from Tura Formation of Garo Hills, Meghalaya, India. Later on PRASAD (2007) reported another fossil leaf, *C. churiensis* from Lower Churia Formation of Arjun Khola, western Nepal. On comparison of the present fossil with both the known fossil leaves it has been observed that none of them show...
similarity with the present fossil leaf. *C. tertiarum* MEHROTRA differs in being elliptic shape with fewer number of distantly placed (0.5-0.6cm) secondary veins as compared to about 28 pairs of closely placed secondary veins in the present fossil leaf. Similarly, the fossil leaf, *C. churiensis* PRASAD differs in its larger size having more number (50) of secondary veins. As the present fossil leaf is different from both the known species, it has been described as a new species, *Chrysophyllum bhairauvensis*, the specific name indicates its occurrence near the Bhairauv Mandir in Purniyagiri Road section.

**Present day distribution:** The genus *Chrysophyllum* LINN. consists of about 43 species distributed in Tropical America, Africa, Madagascar and Australia. Few species are also found in the Indo-Malayan region. The comparable species *C. viridifolium* WOOD & FRANKS is an evergreen tree distributed in South-east Africa to South-east Asian region.

Family: Lauraceae

Genus: *Cinnamomum* SHAEFFER

*Cinnamomum palaeotamala* LAKHANPAL & AWASTHI, 1984

Pl. 23, Figs 3,4; Pl.25, Fig.8

**Material:** This is consisting of single, well preserved leaf impression with its counterpart.

**Description:** Leaf simple, symmetrical, narrow elliptic; preserved size 13.0x4.0cm; apex broken; base acute; margin entire; texture coriaceous; petiole 0.5 cm visible, normal; venation nearly basal acrodromons, perfect; primary vein (1°) three, stout, one mid and two lateral primary veins, mid primary almost straight, and lateral primary veins slightly curved, unbranched; secondary veins (2°) fine numerous, arising from both mid and lateral primaries, the secondary veins arising from primary veins at acute to nearly right angle, few secondary veins arising from outer side of lateral primary veins are more acute and run upward and joined the superadjacent secondaries near the margin while the secondaries of mid primary
veins are joined to their lateral primaries at nearly right angle, sometimes branched.

Specimen: Specimen No. T184, T185.
Locality: Spot No.1, near Hanuman Chatti, Purniyagiri Road section, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.

Affinity: The diagnostic features of the present fossil leaf such as symmetrical, narrow elliptic shape, acute base, entire margin, basal, perfect acrodromous venation and nature and orientation of primary and secondary veins indicate that the present fossil leaf shows close resemblance with the modern leaves of *Cinnamomum* SCHAEFFER of the family Lauraceae. In order to find out its specific affinity, the herbarium sheets of available species of this genus were thoroughly examined and it was concluded that the leaves of *Cinnamomum tamala* NEES show closest affinity with the present fossil leaf.

Fossil record and comparison: Several fossil leaves resembling the genus *Cinnamomum* SHAEFFER have been reported from India and aboard under four generic names i.e. *Cinnamomum* SHAEFFER, *Cinnamomiphylllum* NATHORST, *Cinnamomoides* SEWARD and *Cinnamomophylllum* KRAUSEL & WEYLAND (PRASAD & PANDAY, 2008). So far, six fossil leaves were reported from the Siwalik sediments of India and Nepal. PATHAK (1969) reported a fossil leaf resembling *Cinnamomum tamala* from the Middle Siwalik of Mahanadi River Section, West Bengal, India. *Cinnamomum* sp. has been described by ANTAL & AWASTHI (1993) from Lower-Middle Siwalik of Oodlabari area, West Bengal, India. *C. mioinuctum* PRASAD (1990a) and *C. nepalensis* PRASAD & PANDAY (2008) described from the Siwalik sediments of Koilabas and Surai Khola, Nepal respectively. *C. palaeotamala* LAKHANPAL & AWASTHI (1984) has been described from Upper Siwalik sediments of Bhikhnathoree Bihar, India. Lastly *C. miotavoyanum* (SHASID et al., 2008) reported from the Lower Siwalik sediments of Tanakpur area Uttarakhand. A comparative study of the present fossil with all the above known fossil has been suggested that *C. palaeotamala* LAKHANPAL & AWASTHI show closest similarity with the present fossil, hence it has been
described herewith under the same species, *C. palaeotamala* LAKHANPAL & AWASTHI.

**Present day distribution:** The genus *Cinnamomum* SCHAEFFER consists of 350 species (including *Phoebe*) of evergreen trees and shrubs distributed mainly in tropical and sub-tropical regions of East and South-east Asia to Australia. About 24 species of this genus occur in the Indian region (GAMBLE, 1972). *Cinnamomum tamala* NEES with which fossil shows affinity is a moderate sized, evergreen tree occurring in Sub-himalayan tract and outer ranges ascending to 2000 ft. from Jammu eastward chiefly in dam ravines, Khasi Hills, Sylhet and Myanmar (BRANDIS, 1971).

Family: Myristicaceae  
Genus: *Myristica* LINN.  
*Myristica siwalica* sp. nov.  
Pl.21, Figs1,7; Pl.22, Fig. 9

**Material:** There are three specimens, one almost complete and other two representing basal and apical part respectively.

**Description:** Leaf simple, symmetrical, narrow elliptic to oblcong; preserved size 13.5x5.8 cm, 6.0x5.0 cm and 4.0x2.8 cm; apex acute; base wide acute; margin entire; texture coriaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 14 pairs visible 0.7 to 1.7 cm apart, seemingly unbranched, alternate to opposite, angle of divergence 70°-80°, wide acute, basal secondaries with more angle of divergence, uniformly curved up and joined to their superadjacent secondaries; inter secondary veins present, simple; tertiary veins (3°) fine, angle of origin AO-RR, percurrent, straight to sinuous, sometimes branched, oblique in relation to midvein, predominantly alternate and close.

Holotype: Specimen No. T 186.  
Paratype: Specimen No. T 187, T 188.
Locality: Spot No.3, Purniyagiri Road section, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Etymology: After Siwalik Formation.

Affinity: The most important features of the present fossil leaves namely large elliptic to oblong shape, acute apex, wide acute base, eucamptodromous venation, wide acute angle of divergence of secondary veins, AO-RR, percurrent tertiaries suggest that the fossil leaf belong to the genus *Myristica* LINN of the family Myristicaceae. Critical survey of herbarium sheet of 25 extant species of *Myristica* LINN. indicate that *M. crassa* King (C.N.H. Herbarium sheet Nos. 10088, 381869; Pl. 21, Fig.2) shows closest affinity with the present fossils.

Fossil record and comparison: So far, Nine fossil leaves resembling the genus *Myristica* (*Knema*) LINN. have been known from India and abroad. These are *Myristicophyllum minus* and *M. majus* from the Tertiary of Labuan (GEYLER, 1887). *M. panamense* from Gubbra Formation, Panama (BERRY, 1918), *Myristica apocynophyloides* from the Tertiary of Uricanga, Germany (KRASSER, 1903), *Myristica* sp., and *Knema* sp., from Kushtaka Formation, Alaska (WOLFE, 1977), *Myristica* (*Knema*) *teriata* from the Tertiary of Germany (ETTINGSHAUSEN, 1869), *M. mioglomerata* from Siwalik sediments of Surai Khola, Nepal (AWASTHI & PRASAD, 1990) and *M. lorata* from Oligocene of Makum Coalfield, Assam (AWASTHI & MEHROTRA, 1995). The present fossil leaves have been compared with all the above known species of *Myristica* LINN. and *Myristicophyllum* GEYLER and concluded that the present fossil leaves are different from all of them. They differ mostly in the number and orientation of the secondary veins. Moreover, the fossil leaf *M. mioglomerata* AWASTHI & PRASAD further differ in possessing obtuse to notched apex as compared to acute apex in the present fossils. Thus, in being different the present fossils have been designated as a new species, *Myristica siwalica*.

Present day distribution: The genus *Myristica* (*Knema*) LINN. consists of 72 species distributed in tropical Asia to Australia (MABBERLEY, 1997).
Myristica crassa KING (Syn. M. suavis KING) with which fossils resemble is an evergreen tree found to grow in Indonesia, Sumatra, and Malaysia.

Family: Euphorbiaceae
Genus: Mallotus LOUR.

*Mallotus prejaponicus* sp. nov.

Pl.22, Fig. 7; Pl. 23, Fig1; Pl.24, Fig. 7

**Material:** This species is based on single, well preserved, almost complete leaf impression with counter part.

**Description:** Leaf simple, symmetrical, ovate, preserved size 8.0x5.8 cm; apex acute to nearly attenuate; base obtuse; margin slightly lobed; texture thick chartaceous; petiole 1.0cm long, normal; venation pinnate, basal acrodromous, imperfect, primary vein (1°) three, one mid and two lateral primaries arise at the base. Mid primary stout, almost straight, lateral primaries curved upward and give off secondary veins towards the margin; secondary veins (2°) arise from both mid and lateral primaries at moderately acute angle of divergence, seemingly unbranched, alternate, uniformly curved up; Tertiary veins (3°) fine, angle of origin usually RR, percurrent, straight to sinuous, branched, oblique to right angle in relation to midvein, predominantly alternate, close to nearly distant.

Holotype: Specimen No. T 190.
Paratype: Specimen No. T 189.
Locality: Thuligad, near Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation, Mio-Pliocene.
Etymology: By adding a prefix ‘Pre’ to the name of modern comparable species, *M. japonicus*.

**Affinity:** The diagnostic features of the present fossil are symmetrical, ovate shape, acute to nearly attenuate apex, obtuse base, nearly lobed margin, basal, imperfect acrodromous venation, the nature and orientation of secondary veins and usually RR, percurrent tertiaries which are close to nearly distant and oblique to right angle in relation to midvein. The comparative study of the herbarium sheets of a number of genera and species of the dicotyledonous families.
suggests that these features are found common in the extant leaves of the genus *Mallotus* LOUR. of the family Euphorbiaceae. The critical examination of all the available species of this genus indicate that the extant leaves of *M. japonicus* SPRENG (C.N.H. Herbarium sheet Nos 415512, 72717; Pl.22 Fig.8; Pl.23, Fig.2) shows closest affinity with the present fossil leaf in shape, size and venation pattern.

**Fossil record and comparison:** So far, two authentic fossil leaves of the genus *Mallotus* LOUR. have been reported from the Siwalik sediments of India and Nepal. *M. kalimpongensis* ANTAL & AWASTHI is from Lower - Middle Siwalik of Darjeeling District, West Bengal, India (ANTAL & AWASTHI, 1993) and from Middle Siwalik of Surai Khola, western Nepal (PRASAD & PANDAY, 2008), *M. venkatachalai* PRASAD (1994c) from Lower Siwalik sediments of Kathgodam, Uttarakhand, India. On comparison it has been found that both the fossil species possesses basal acrodromous venation but differ from the present fossil in shape as well as orientation of primary and secondary veins. In view of these differences, the present fossil leaf is described under a new specific name, *Mallotus prejaponicus*.

**Present day distribution:** The genus *Mallotus* LOUR. consists of about 140 species distributed from Africa to East and south-east Asia, Indo-Malaya, New Calodenia, Fiji, North and East Australia (WILLIS, 1973). *Mallotus japonicus* SPRENG with which fossil shows closest affinity is a woody shrub distributed in East Asia and Philippines.

Genus: *Mallotus* LOUR.

*Mallotus kalimpongensis* ANTAL & AWASTHI, 1993

Pl. 22, Figs 4,5

**Material:** This species is represented by two well preserved leaf impressions which are without apex.

**Description:** Leaf simple, symmetrical, narrow elliptic, preserved size 6.5x2.5cm and 5.1x2.4 cm; apex broken; base wide acute to nearly obtuse; margin
entire; texture chartaceous; petiole broken; venation pinnate, acrodromous, basal, imperfect; primary vein (1°) three (one mid primary and two lateral primary veins), mid primary vein almost straight while lateral primaries curved upward to one half of the leaf length; secondary veins (2°) arising form both mid primary and lateral primary veins, angle of divergence 50°-55°, acute, moderate, slightly curved, alternate, the lateral primaries give off secondary veins toward the margin; tertiary veins (3°) fine, angle of origin RR, percurrent, straight, sinuous, sometimes branched, right angle in relation to midvein, predominantly alternate and close.

Specimen: Specimen Nos. T 191, T 192
Locality: Spot no.1, near Hauman Chatti, Purniyagiri Road section, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.

Affinity: Symmetrical, narrow elliptic shape, nearly obtuse base, entire margin, basal, imperfect, acrodromous venation, nature of primary and secondary veins, moderately acute angle of divergence of secondary veins, and RR, percurrent tertiary veins which are right angle in relation to mid vein undoubtedly suggest that the present fossil leaves show closest affinity with the extant leaves of *Mallotus philippinensis* MUELL-ARG. (C.N.H. Herbarium sheet No. 1131; Pl. 22, Fig. 5) of the family Euphorbiaceae.

Fossil record and comparison: Fossil leaf resembling the genus *Mallotus* LOUR (mentioned earlier in this text) have been compared and found that the leaf, *M. kalimpongensis* ANTAL & AWASTHI (1993) described from the Lower-Middle Siwalik of Darjeeling District shows closest similarity with the present fossil leaf in shape, size and venation pattern. Hence, the present fossil leaf has been described under the same species, *Mallotus kalimpongensis*.

Present day distribution: The modern comparable taxon, *Mallotus philippinensis* MULL-ARG. is a large shrub or small tree growing in the deciduous to evergreen forests of Sub-himalayan tract eastward from Punjab ascending to 1,500 m. It is also found common in western, central and southern India, Andamans, Myanmar and Sri Lanka (GAMBLE 1972; BRANDIS, 1971).
Genus: *Baccaurea* LOUR.

*Baccaurea miocenica* sp. nov.

Pl. 23, Fig. 5; Pl.24, Fig.1

**Material**: There is single, well preserved leaf impression with slightly broken apex.

**Description**: Leaf simple, symmetrical, oblanceolate; preserved size 9.7x3.5 cm; apex broken; base acute, cuneate; margin entire; texture chartaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, slightly curved; secondary veins (2°) 6 pairs visible, 0.5 to 2.0 cm apart, alternate, unbranched, angle of divergence varies from 55°-70°, moderate to wide acute, uniformly curved up and running for a long distance and joined to supradjacent secondaries; inter secondary veins present, simple, rare; tertiary vein (3°) fine, angle of origin, RR, percurrent, straight to sinuous, oblique to nearly right angle in relation to midvein, predominantly alternate, close to distance.

**Holotype**: Specimen No. 193.

**Locality**: Spot No.1, near Hanuman Chatti, Purniyagiri Road Section, Tanakpur, Champawat District, Uttarakhand.

**Horizon & Age**: Siwalik Formation, Mio-Pliocene.

**Etymology**: After Miocene period.

**Affinity**: The most characteristic features of the present fossil leaf are symmetrical, oblanceolate shape, cuneate base, entire margin, eucamptodromous venation; moderate to wide acute angle of divergence of secondary veins, presence of inter secondary veins, RR, percurrent, close to distant tertiaries with oblique to right angle in relation to midvein. These collectively indicate its resemblance with the extant leaves of *Baccaurea* LOUR. of the family Euphorbiaceae. In order to find out its specific affinity, a large number of herbarium sheets of all the available species of this genus were examined and it was concluded that the leaves of *Baccaurea tetrandra* LOUR. (C.N.H. Herbarium sheet No. 2399; Pl.24, Fig.2; Pl.23, Fig.6) shows closest affinity with the present fossil leaf.
Fossil record and comparison: There is no record of fossil leaf resembling the genus *Baccaurea* LOUR. from the Tertiary sediments of India and abroad. The present fossil represents its first record from the Siwalik sediments of Tanakpur area, Uttarakhand, India and is being described herewith as *Baccaurea miocenica* sp. nov.

Present day distribution: The genus *Baccaurea* LOUR. comprises about 80 species presently distributed in India, south-east Asia and pacific region. *Baccaurea tetrandra* LOUR. (Syn. *B. cauliflora*) with which fossil resembles closely is an evergreen tree found to grow in North-east India, Myanmar, Vietnam, Thailand and Malaya.

Genus: *Bridelia* Willd.

*Bridelia hanumanchattensis* sp. nov.

Pl.25, figs 1, 3

Material: This species is consisting of single, well preserved leaf impression with broken base.

Description: Leaf simple, symmetrical, elliptic; preserved size 6.0x3.2 cm; apex bluntly acute, base slightly broken; margin entire; texture coriaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent stout; secondary veins (2°) about 9 pairs visible, 0.4-0.8 cm apart, alternate to opposite, unbranched, angle of divergence 60°-65°, acute, moderate, uniformly curved up, joined to their superadjacent secondary; inter secondary veins present, simple; tertiary veins (3°) poorly preserved, fine, angle of origin usually RR, percurrent, straight to sinuous, oblique in relation to midvein, alternate to opposite, close.

Holotype: Specimen No. T 194.

Locality: Spot No.1, near Hanuman Chatti, Purniyagiri Road Section, Tanakpur, Champawat District, Uttarakhand.

Horizon & Age: Siwalik Formation; Mio-Pliocene.

Etymology: After the name of famous place, Hanuman Chatti on Thuligad-Purniyagiri Road from where fossil was collected.
Affinity: The present fossil leaf is characterized by its elliptic shape, bluntly acute apex, entire margin, eucamptodromous type of venation, closely placed, upper secondaries, moderately acute angle of divergence of secondary veins, presence of intersecondary veins, RR, percurrent tertiary veins. Such features are found common in the extant leaves of Securidaca inappendiculata HASK. (Polygalaceae), Diospyros pruriens DELZ. (Ebenaceae), Paramignya monophylla WIGHT (Rutaceae) and Bridelia ovata KURZ. (Euphorbiaceae). On critical examination of a number of herbarium sheets of the above taxa, it has been found that the extant leaves of Securidaca inappendiculata HASK. and Paramignya monophylla WIGHT differ from present fossil leaf in having comparatively more angle of divergence of secondary veins than the present fossil leaf. Though, the leaves of Diospyros pruriens DELZ. is similar to the present fossil leaf in shape, size and type of venation but differ in number and nature of intersecondary veins which are very rare in the Diospyros pruriens. Thus, the leaf of Bridelia ovata KURZ is only with which fossil shows close resemblance (C.N.H. Herbarium sheet No. 400503; Pl.25, Figs 2,4).

Fossil record and comparison: So far, five fossil leaves resembling the genus Bridelia WILLD., have been known from Tertiary sediments of India and Nepal. PATHAK (1969) described two fossil leaves having affinity with the extant taxa B. stipularis BL. and B. verrucosa HAINES respectively from Middle Siwalik sediments of Mahanadi River Section, West Bengal. AWASTHI AND MEHROTRA (1995) reported another fossil leaf of this genus under the form species Bridelia oligocenica from the Oligocene of the Makum Coalfield, Assam India. Later on PRASAD AND PANDEY (2008) described two fossil leaves, B. mioretusA and B. siwalica from the Middle Siwalik sediments of Surai Khola area, Western Nepal. These fossil leaves have been compared with the present fossil leaf and it was found that none of them show resemblance with the present fossil. Both the fossil leaves described by PATHAK (1969) are fragmentary in nature and possesses different venation pattern. The fossil leaf B. oligocenica AWASTHI & MEHROTRA can easily be differentiated by its narrow size (2.5 cm in width) of the leaf with narrow acute angle of divergence of secondary veins. Similarly, B.
mioretusa PRASAD & PANDEY is a large leaf (12.3x7.2 cm) with more acute angle of divergence of secondary veins which run straightly to upward and the lasty B. siwalica PRASAD & PANDEY differs from present fossil in having oblique base with less acute (80°) angle of divergence of secondary veins. In view of these differences, the present fossil leaf is described under a new specific name, Bridelia hanumanchattensis.

Present day distribution: The genus Bridelia WILLD. comprises about 60 species of trees, shrubs and straggling climbers distributed presently in the tropical regions of old world. Bridelia ovata KURZ with which fossil shows closest affinity is a climbing shrub of Andamans, (BRANDIS, 1971).

Family: Urticaceae
Genus: Ficus LINN.

Ficus precunea LAKHANPAL, 1968
Pl.25, Figs 5,7

Material: There is a single, well preserved and incomplete leaf impression.

Description: Leaf simple, asymmetrical, small, elliptic, preserved size 3.5x2.0 cm; apex broken, base cordate; margin entire; texture coriaceous; petiole indistinct; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout; secondary veins (2°) 5-6 pairs visible, less then 0.5 cm apart, alternate, unbranched, angle of divergence about 55°, acute, moderate, running upward for a short distance. The basal secondary turned downwards into the lobe and branched, intersecondary veins not distinct; tertiary veins (3°) fine, angle of origin RR, percurrent, branched, oblique to nearly right angle in relation to midvein, predominantly alternate, close to distant.

Specimen: Specimen No. T 195.
Locality: Spot No. 4, Purniyagiri Road Section, Tanakpur, Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Affinity: The morphological features exhibited by the present fossil leaf like, small, elliptic shape, cordate base, entire margin, eucamptodramous venation, curvature of basal secondary veins towards downwards into the lobes and its branching, RR, percurrent, close to distant tertiaries collectively suggest its affinity with the extant leaves of *Ficus cunea* HAM. (Syn. *F. semicordata* BUCH-HAM; C.N.H. Herbarium sheet Nos. 37290, 22916; Pl.25, Fig.6) of the family Urticaceae.

**Fossil record and comparison:** about 18 fossil leaves resembling the genus *Ficus* LINN. have been described from Cenozoic sediments of India (PRASAD et al., 2004). Out of them, three fossil leaves resembling the same taxon, *Ficus cunea* HAM. have been described under the form species, *Ficus precunea* LAKHANPAL from Siwalik sediments of Balugoloa, H.P. (LAKHANPAL, 1968) from Koilbas, Nepal (PRASAD, 1990a) and Kathgodam, Uttarakhand, India (PRASAD et al., 2004) and show closest similarity with the present fossil leaf. Hence, this fossil leaf has been described under the same species *Ficus cunea* LAKHANPAL.

**Present day distribution:** The genus *Ficus* LINN. comprises 750 species of trees, shrubs or root clinging lianas, widely distributed throughout the tropics of both Hemispheres especially Indo-Malaya to Australia. The modern comparable species, *F. cunea* HAM. is a small tree distributed in the Sub-Himalayan tract, Assam and Myanmar (BRANDIS, 1971).

**Genus:** *Sarcochlamys* GAUDICH.

*Sarcochlamys miopulcherima* sp. nov.

Pl.24, Figs 3,5

**Material:** This species is represented by a single specimen of leaf impression which is without apex.

**Description:** Leaf, symmetrical, lanceolate; preserved size 8.5x2.4cm; apex slightly broken, seemingly alternate; base obtuse; margin slightly non-entire; texture coriaceous; venation pinnate, basal, perfect, acrodromous; primary vein (1°) three (one mid primary and two lateral primary), lateral primary veins slightly curved; stout; secondary veins (2°) several, arising from both mid and lateral
primaries mainly at right angle. Secondaries arising from lateral primaries towards margin joined with intra marginal veins and arising from mid primary vein joined with lateral primaries at nearly right angle; fine, intramarginal veins present on both side of the margin; tertiary veins (3°) indistinct.

Holotype: Specimen No. T 196.
Locality: Spot No. 10, Bhairauv mandir, Purniyagiri Road section, Tanakpur Champawat District, Uttarakhand.
Horizon & Age: Siwalik Formation; Mio-Pliocene.
Etymology: By adding the prefix 'mio' to the Modern comparable species, S. pulcherima.

Affinity: The characteristic features of the present fossil leaf such as symmetrical, lanceolate shape, obtuse base, slightly non-entire margin, basal, perfect acrodromous venation, right angle of secondary veins and presence of intramarginal veins undoubtly suggest that the fossil leaf belongs to the genus Sarcochlamys GAUDICH. of the family Euphorbiaceae. A critical examination of herbarium sheets of all the available species of this genus suggests its affinity with Sarcochlamys pulcherima GAUDICH (C.N.H. Herbarium sheet No. 879, 434945; Pl.24, Figs 4,6).

Fossil record and comparison: As far as author awares there is no record of any fossil leaf resembling the genus Sarcochlamys GAUDICH. from the Tertiary sediments of India and abroad. The present fossil forms its first record from the Swialik sediments of Tanakpur area, Uttarakhand, India and is being described here as Sarcochlamys miopulcherima sp. nov.

Present day distribution: The genus Sarcochlamys GAUDICH. comprises only one species S. pulcherima GAUDICH. with which present fossil shows affinity. It is an evergreen shrubs or small tree distributed into Indo-Malayan region. It grows mainly in the evergreen forests of Assam, Khasi Hills, West Bengal, Bangladesh, Myanmar and Sumatra (BRANDIS, 1971).