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LATE TERTIARY LEAF FLORA OF MAHUADANR VALLEY, JHARKHAND

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ABSTRACT

Leaf impressions from the Late Tertiary sediments of the Mahuadanr valley, Jharkhand have been studied morphotaxonomically. The qualitative and quantitative methods of comparison of morphological features between the fossil and extant taxa revealed the occurrence of some more taxa representing 12 species of 10 dicotyledonous families. On the basis of present assemblage as well as previously published data, the palaeoclimate and phytogeography of the Mahuadanr area during the late Tertiary have been deduced.The analysis of present distribution of all the modern comparable species of the fossils indicates that most of the taxa presently grow in the mixed deciduous forests of the Himalayan foothills, central India, south India and adjoining area of the Mahuadanr valley, which suggests that mixed deciduous type of forest flourished in and around the fossil locality during sedimentation. The presence of a good amount of recovered taxa growing today in the vicinity of the Mahuadanr fossil locality indicates that some flora is persisting, suggesting that there was not much climatic change in the area since the late Tertiary time.

Keywords: Plant megafossils, Leaf impressions, Angiosperms, Palaeoclimate, Phytogeography, late Tertiary, Mahuadanr, Jharkhand (India)

INTRODUCTION

The present fossil locality, Mahuadanr valley (84° 06'N: 23° 23' E), lies in the District Latehar of Jharkhand. Mahuadanr is the largest village in this area and is situated about 116 km south of Daltenganj. Rajdanda is about 4 km NNE of Mahuadanr on the side of a road connecting Mahuadanr with Daltenganj. The nearest railway station is Chhipadohar on Gomoh-Dehri-on-Sone loop line of Eastern Railway (Fig.1). The fossiliferous beds are exposed along Birha River and its tributary, Jhumari at Rajdanda village. Late Tertiary sediments of Mahuadanr valley consist of conglomerate succeeded by sandstone and clay shale. It represents an upward fining sedimentary cycle which shows the characteristic feature of basinal sedimentation. Puri (1976) for the first time collected a few fossil fish and leaf impressions. Later Puri and Mishra (1982) recorded bird, fish and plant fossils and on the basis of palynological analysis indicated an Upper Tertiary age. An extensive collection was made by Bande and Srivastava and they recorded large number of leaf impressions, flowers, fruits and silicified woods (Bande and Srivastava, 1990; Prakash *et al.*, 1988; Srivastava and Bande, 1992; Srivastava *et al.*, 1992 and Srivastava and Srivastava, 1998; Srivastava, 1998). Shukla *et al.* (2000) have recently described some insects and related organs from the resin collected from the area. Kumar *et al.* (2000) have studied the DOM types and depositional environment of this bed. A number of carbonized woods have also been collected. The impact of neotectonic activity has been reported by Ananad-Prakash *et al.* (1996); Srivastava (1998).

Recently, a large number of well-preserved leaf impressions were collected from the late Tertiary sediments of the Jhumari nala section of the Mahuadanr valley, Jharkhand. A detailed study of this collection reveals the occurrence of 12 new taxa which are described and discussed in the present communication.

GEOLOGICAL SETTING OF MAHUADANR VALLEY

The state of Jharkhand is geologically very rich in mineral resources. This has attracted the attention of a large number of geologists since 1866. Quite a good number of fossil plants have also been recorded from various coalfields of the state viz., Jharia, Bokaro, Giridih, Karanpura, Deoghar Itkori, Ramgarh, Auranga, Hutar, Daltenganj and part of Raniganj and Rajmahal hills (Roy Chowdhury *et al.*, 1974).

The Jharkhand state which extends from south of Ganga in the North to the hill ranges on the border of Orissa in the South is structurally divided into two broad tectonic divisions:

1. Gangetic plains.
2. Chotanagpur plateau region.

The Chotanagpur plateau represents a part of the Indian Peninsular Shield, a relatively stable cratonic block of the earth's crust. Tectonically, the plateau can be divided into seven domains and the structure of entire area may be described under the following heads:

1. Area to the South of Singhbhum shear zone,
2. Area to the North of Singhbhum shear zone,
3. Chotanagpur granite gneiss terrain,
4. Gaya-Rajgir-Monghyr belt,
5. Vindhyan terrain in Palamau and Shahabad Districts,
6. Gondwana Group coalfield area, and
7. Rajmahal Trap area.

The present area of investigation is in the Chotanagpur granite gneiss terrain (Roy chowdhury *et al.*, 1974). The geology of this area has been worked out in detail by Puri and Mishra (1982).

The Deccan Trap rocks extend to the south-western corner of the Palamu District and cover the high plateau around Mahuadanr and Netarhat, the top portion of which is now usually weathered and altered to laterite and bauxite.

The sedimentary formations in the area, forming an outlier within the Pre-Cambrian Chotanagpur Granite/Gneiss country, are exposed over a length of about 2.6 km and a width of 1.5 km along Birha River and its tributaries (Fig.2) between Rajdanda and Beltoli villages(84°06'40":23°23'15"). The rock types include pyroclastic sediments, conglomerates, sandstones and shales.

The stratigraphic sequence (Fig.3, Table 1) proposed by Puri and Mishra (1982) for this area is as follows:

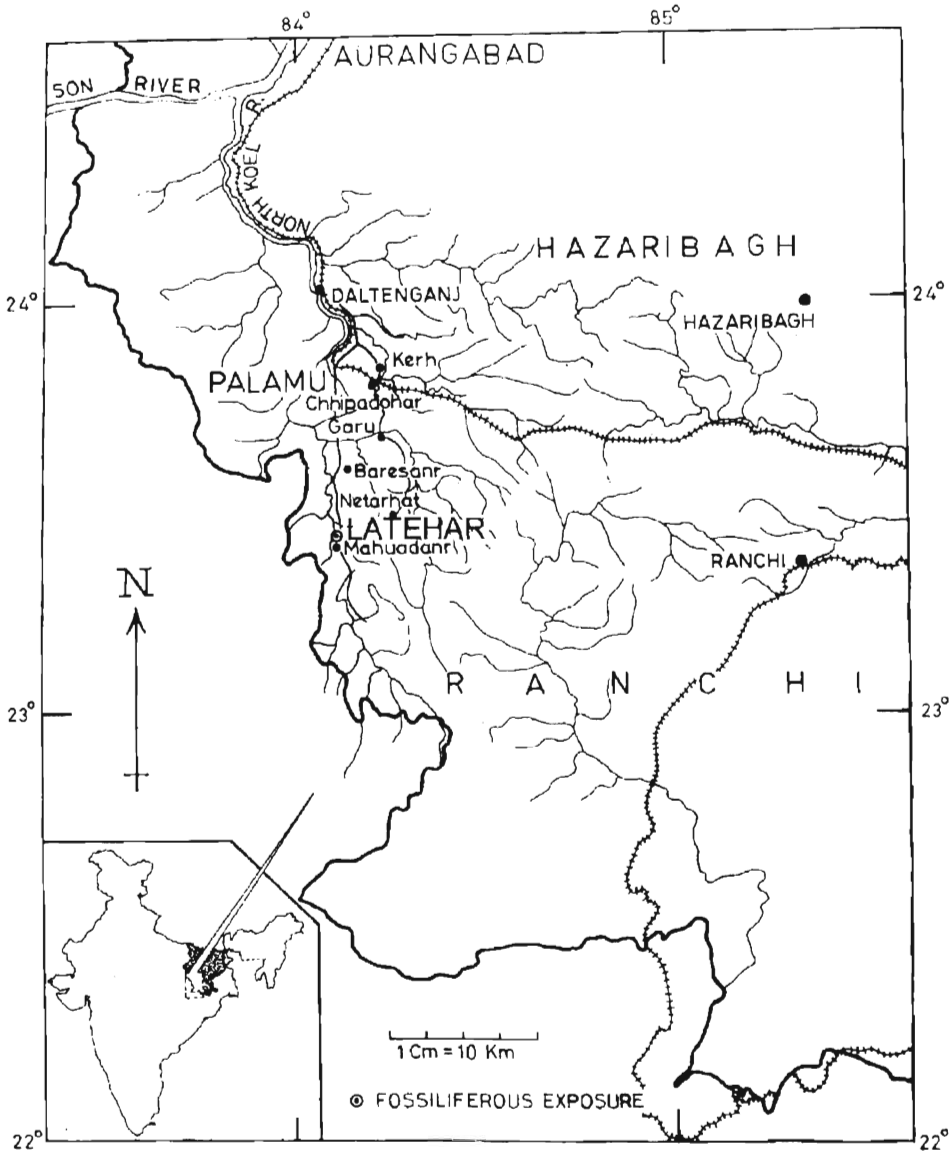


Fig. 1. Map showing the fossil locality in Mahuadanr valley, Jharkhand.

Table 1: Stratigraphic Succession in Mahuadanr area (after Puri and Misra, 1982).

Recent	Newer Alluvium	
Holocene	Older Alluvium	
----------	Unconformity ----------	
	Shale bed	3.2 m
Upper Tertiary	Sand stone bed	3.0 m
	Conglomerate bed	2.0 m
----------	Unconformity ----------	
	Pyroclastic rocks	6.0 m
----------	Unconformity ----------	
Pre-Cambrian	Chotanagpur Granite Gneiss	

Towards the northwestern and southwestern extremities of the sedimentary outlier, a small outcrop of pumiceous rhyodacite, measuring 35 x 34 m is exposed in the Jhumari nala. In the southwestern part of the area, the pyroclastic rocks are also exposed and are overlain unconformably either by conglomerates or sandstones or even shales; in the northwestern part of the area, the pyroclastic rocks (volcanic sandstones) are exposed along Birha River downstream from Road Bridge near Rajdanda and are overlain by sandstones. Here the volcanic bed is massive in appearance and contains angular fragments of gneisses, amphibolites, felspars in a medium-grained matrix. The top 15 cm of these sediments have rounded pellet-like bodies embedded in the rock matrix (Puri and Mishra, 1982).

The conglomerate unit is exposed only towards the southern and southwestern extremities of the sedimentary outlier. In the southwestern extremity, the conglomerate bed has a thickness of one meter, whereas it attains a thickness of two meters in the southeastern extremity. This unit overlies the granite gnessis in Birha River and the Rampur nala and the pyroclastic extrusives in the Jhumri nala and is overlain by sandstones. It contains 8-12 cm long, rounded to subrounded fragments of granite gneiss and is sometimes interbedded with shales and sandstones in the Rampur nala and Birha River.

MATERIAL AND METHODS

The fossil leaf impressions were collected from the late

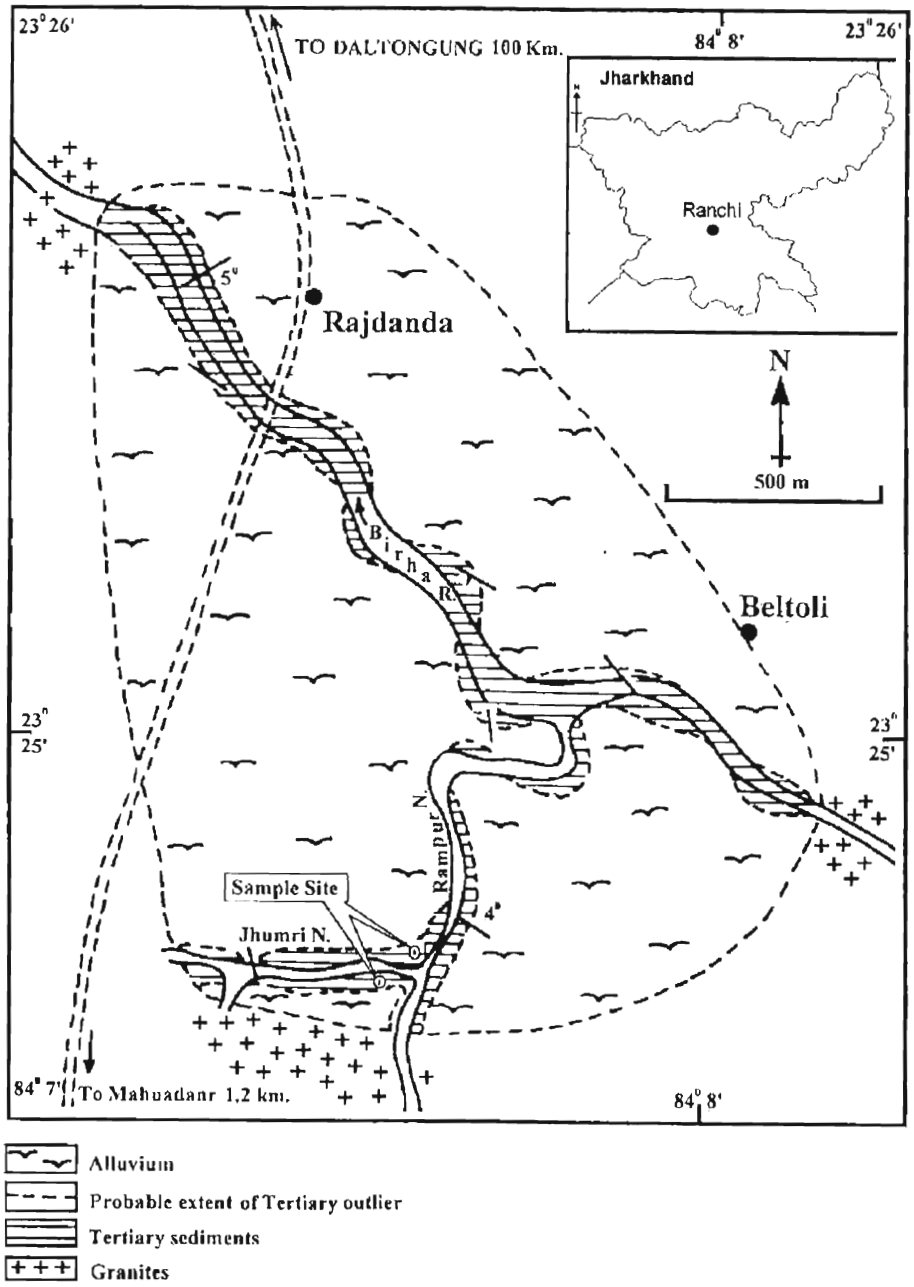


Fig. 2. Geological map of the study area.

Tertiary sediments exposed along Birha River and its tributary, the Jhumari nala. It is easily approachable by road and situated about 4 km from Mahuadanr village on a road connecting to Daltenganj. The fossil leaves are preserved as impressions in brown clay shales and are mostly devoid of cuticles. The fossils were studied morphologically with the help of low-power microscope under reflected light. Their identification involved consultation of herbarium sheets of extant taxa at the Herbarium of Central National Herbarium, Shibpur, Howrah and Botanical Survey of India, Allahabad. For the description of leaf impressions, the terminology given by Hickey (1973) and Dilcher (1974) has been followed. For the assignment of these identified leaf impressions, the name of comparable extant species has been used to avoid any taxonomical problem. The photographs of both fossil and modern comparable leaves were taken on 35mm B/W film with a Yashica SLR camera.

All the figured specimens and their photonegatives are kept in the Museum, Birbal Sahni Institute of Palaeobotany, Lucknow.

SYSTEMATIC DESCRIPTION

Family **Flacourtiaceae**

Genus ***Flacourtia*** comm.ex L' Herit

Flacourtia indica Linn.

(Pl. I, fig. 1; Pl. II, fig. 6)

Material: A single, complete and well-preserved leaf impression.

Description: Leaf simple, almost symmetrical, preserved length 6 cm, width 4 cm; shape elliptic; apex rounded; base slightly asymmetrical, obtuse; margin serrate, the axis inclined to the tangent of margin; gland not visible; texture coriaceous;

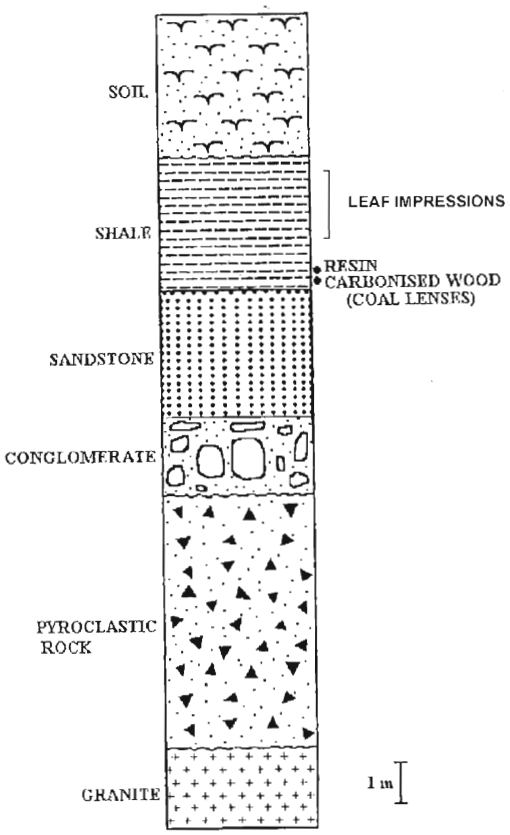


Fig. 3. Lithocolumn of the exposed section in the Mahuadanr area.

petiole not preserved; venation pinnate, eucamptodromous; primary vein (1°) moderate, more or less straight; secondary veins (2°) with acute angles of divergence, more acute at base, thickness of secondary veins is moderate, uniformly curved, intersecondary veins present simple; tertiary veins (3°) fine, angle of origin AR, ramified, transverse, percurrent, sinuous, relationship to midvein oblique, alternate and opposite, close; quaternary veins (4°) thin, forming orthogonal to polygonal meshes.

Discussion: Elliptical shape, obtuse base and serrated margin with eucamptodromous venation are the important characters of the present leaf which show near resemblance with modern leaves of *Ventilago madraspatna, Flacourtia indica*. On a comparative study of the herbarium sheets of both the above taxa, it has been found that the present fossil leaf shows closest resemblance with the leaf of *Flacourtia indica* Linn. (B.S.I.C.C Herbarium sheet no. 38253; Pl. I, Fig. 2).

Both fossil wood and leaf are known from the Tertiary beds of India and Nepal. Trivedi and Srivastava (1986) described fossil wood *Flacourtioxylon mohgaonense* from Deccan Intertrappean Series, Mohgaon Kalan, Chhindwara District, Madhya Pradesh whereas Nambudiri (1966) described fossil leaf *Flacourtiaites intertrappean* from the same bed. So far, four fossil leaves resembling the genus *Flacourtia* comm. have been described from the Siwalik sediments of Nepal. These are *Flacourtia nepalensis* Awasthi and Prasad (1990) and *Flacourtia tertiara* Prasad and Awasthi (1996) from Suraikhola sequence western Nepal. *Flacourtia seriaensis* Prasad *et. al.*, (1997) and *Flacourtia koilabasuansis* Prasad and Dwivedi (2007) from the Siwalik of the Koilabas area, western Nepal. The above fossil leaves do not show similarity with the present fossil and also none of them compared with the extant species *Flacourtia indica* Linn. as the present fossil.

Flacourtia comm. includes about 15 tropical (Mabberley, 1997) species, which are widely distributed in the old world (Hooker, 1872). *Flacourtia indica* Linn. is found in the sub-Himalayan tract, from Punjab eastward, Rajputana, Bihar, and Central India, the Deccan and the Peninsula, mostly in dry open places and on rocky hills (Brandis, 1971). It is also found in the forests of the Chotanagpur region (Wood, 1903; Haines, 1910).

Family **Malvaceae**
Genus ***Abroma*** Jacq.
Abroma augusta Linn.
(Pl. I, figs. 3, 4)

Material : A single, complete and well-preserved leaf impression.

Description: Leaf simple, symmetrical, length 14 cm, width 13.5 cm; apex acuminate; base cordate; margin entire, lobed; gland not visible; texture coriaceous; petiole not preserved; venation actinodromous, basal; primary veins (1°) seven, moderate and curved; secondary veins (2°) with acute (moderate) angle of divergence, angle uniform curved abruptly joining supradjacent at right angle, intersecondary veins not distinct; tertiary veins (3°) RR, percurrent, some time branched, oblique in relation to mid vein, predominantly, alternate and distant; quaternary veins (4°) thick, orthogonal; quinternary veins (5°) thick, orthogonal, marginal, ultimate venation looped; areole developed, random, pentagonal.

Discussion: Large size, lobed margin, acuminate apex, cordate base, actinodromous venation with 7 primaries arising from single point and joining of supradjacent secondary at right angle are the important characters of the fossil leaf. These features show near resemblance with modern leaves of *Firmiana, Pterygota, Sterculia,* and *Abroma*. However, the critical study of the leaves of above genera indicates its strong resemblance with the leaf of *Abroma augusta* Linn. (B.S.I.P. Herbarium sheet no. PT-135) in shape, size and venation pattern.

As far as the authors are aware, there is no other fossil record of *Abroma augusta* from India. The occurrence of the present fossil forms its first record from the late Tertiary sediments of the Mahuadanr valley, Jharkhand, India.

The genus *Abroma* Jacq. has 2 species distributed in tropical Asia to Australia. *Abroma augusta* Linn. is widespread throughout the hotter part of India from the northwest Province to Sikkim, (altitude 3000ft), Khasi Hills and Assam (Hooker, 1872). It is also very common in the forests of the Chotanagpur region (Wood, 1903; Haines, 1921).

Family **Sterculiaceae**
Genus ***Sterculia*** Linn.
Sterculia urens Roxb.
(Pl. II, fig. 1)

Material: A single, incomplete leaf impression with good preservation.

Description: Leaf simple, appear to be asymmetrical; preserved length 7 cm, width 11.5 cm, spherical with triangular acuminate lobe as indicated by the presence of five distinct primary veins (only two such lobes visible), base auriculate; margin entire, lobed; texture chartaceous; petiole present, normal, thick, 3.5cm long; venation actinodromous, five primaries

present; primary veins (1°) basal, perfect, marginal; secondary veins (2°) with acute angle of divergence, it first emerges from the primary vein at a very acute angle and runs parallel for a short distance and then diverges towards the margin at moderate acute angle (45°-50°), angle nearly uniform, a pair of secondary veins also emerge from the point of origin of the primary veins, thick, curved abruptly joining supradjacent secondary at right angle to form prominent loops; intersecondary veins present, simple; tertiary veins (3°) AR to RR, mostly RR, per current, convex, oblique in relation to midvein, predominantly alternate, distantly spaced; quaternary veins (4°) thin, orthogonal, marginal, areole not distinct.

Discussion: Large spherical leaf with lobes, actinodromous venation with prominent ascending loops and percurent tertiary veins are the important characters of the fossil leaf which indicate its resemblance with the leaves of *Kydia calycina, Sterculia spp., Jatropha curcus. Pterospermum acerifolium, Dombeya spp., Berrya cordifolia*. The comparative study of the morphological features of both the fossil leaf and the extant leaves indicates that the extant leaves of *Sterculia urens* Roxb. show close resemblance in shape, size and venation pattern. (C.N.H. sheet no. 57478).

Fossil wood of *Sterculia* is known from various Tertiary localities of India, viz. the Deccan Intertrappean beds, Siwalik beds, Cuddalore Sandstone, Tipam Sandstone and Namsang beds (Guleria, 1983; Lakhanpal *et al.*, 1984; Prasad, 1994). All of them were earlier described under the generic name *Sterculioxylon* Krausel (1939) but Guleria (1983) while describing fossil woods from Kachchh instituted another genus *Sterculinium* for the fossil woods of *Sterculia* and allied genera of the various species of *Sterculinium* such as *S. dattai* (Prakash and Tripathi, 1970; Guleria,1983) described from Tipam Sandstone shows close similarity with the wood of *Sterculia villosa*. Bande and Srivastava (1990) described fossil leaf of same comparable speceis *Sterculia villosa* from the Late Tertiary beds of Mahuadanr valley, Jharkhand. Three fossil leaves resembling the genus *Sterculia* Linn. have been reported from the Siwalik sediments of India and Nepal. These are *Sterculia kathgodamensis* Prasad (1994a) from the Siwalik sediments of the Kathgodam area, Nainital, Uttaranchal, *Sterculia mioensifolia* and *Sterculia premontana* Prasad and Pandey (2007) from the Siwalik sequence of the Surikhola area, western Nepal. So far, fossil leaves showing resemblance with *Sterculia urens* Roxb. have not been reported from the Tertiary sediments of India and abroad.

The genus *Sterculia* Linn. consists of about 150 species (Mabberley,1997) distributed throughout the tropics and with its best development in tropical Asia (Pearson and Brown, 1932). *Sterculia urens* Roxb. is a conspicuous element of the dry rocky hills, south of the Ganges, extending to Sambalpur, Angul and Puri, especially common in the dry hills of Chotanagpur but rarer in the Santhal Parganas, Gaya ghats and ascends to 3000 ft. at Neatarhat (Haines, 1921). It is also known from north-west India, Assam, Bihar, peninsular part, Sri Lanka (Hooker, 1972; Brandis, 1971). It is also known from the Chotanagpur region (Wood, 1903).

Family **Rhamnaceae**
Genus ***Ziziphus*** Mill.
Ziziphus mauritiana Lam.
(Pl. II, figs. 2, 3, 4)

Material: Two incomplete, fairly well-preserved leaf impressions, one with counter part, apex is broken.

Description: Leaf simple, symmetrical, leaf length 7.5 cm, width 3.4 cm, elliptic; apex not preserved; base obtuse, normal; margin entire; texture coriaceous; petiole 1.2 cm long inflated, curved; venation acrodromous, basal, imperfect; primary vein (1°) moderate and markedly curved; secondary veins (2°) angle of divergence wide acute with more or less uniform angle, loop formation present in apical side of the leaf and joining super-adjacent secondary at acute angle; intersecondary veins present, simple; tertiary veins (3°) AO to RR, percurrent, straight to sinuous, branch oblique in relation to mid vein, predominantly alternate and close, quaternary veins (4°) orthogonal, marginal; areole not visible.

Discussion: Elliptical shape, acrodromous venation, entire margin, moderate and markedly curved primary vein, inflated petiole, joinging of super-adjacent secondary at acute angle of the fossil leaves indicate resemblance with modern leaves of *Ventilago madraspatana, Flacourtia indica, Strychnos nux-vomica* and *Ziziphus* species. However, a detailed comparison of morphological features of both the fossil and modern leaves of above taxa shows their closest resemblance with those of *Ziziphus mauritiana* (B.S.I.P. Herbarium sheet no. 8618; Pl. II, fig. 5).

The fossil leaves and fruit of *Ziziphus* are known from the Tertiary sediments of India and Nepal. So far, seven fossil leaves resembling *Ziziphus* Mill. are known from the Siwalik sediments of India and Nepal. They are *Ziziphus siwalicus* Lakhanpal (1966) from Jwalamuhki in Himanchal Pradesh, *Ziziphus indicus* Singh and Prakash (1980) from Arunachal Pradesh, *Ziziphus champarensis* Lakhanpal and Awasthi (1984) from Bhikhnathoree, Bihar, *Ziziphus* cf. *Ziziphus rugosa* Prasad (1994c) from Haridwar, Uttaranchal, *Ziziphus miocenicus* Prasad (1994a) from Kathgodam, Uttaranchal, and Koilabas area, Western Nepal Prasad (1994b), *Ziziphus kathgodamensis* Prasad (1994a) from Kathgodam, Uttaranchal and *Ziziphus palaeoapetala* Antal and Prasad (1997) from Siwalik sediments of West Bengal, India. Out of these, only *Ziziphus indicus* Singh and Prakash (1980) described from the Siwalik sediments of Arunanchal Pradesh has been compared with extant species *Ziziphus mauritiana* Lam. Bande and Srivastava (1990) described fossil fruit cf. *Ziziphus xylopyrus* and *Ziziphus mauritiana* from the Mahuadanr Valley, Jharkhand.

The genus *Ziziphus* includes about 86 species (Mabberley, 1997) widely distributed in tropical America, Africa, Mediterranean, Indo-Malaya and Australia (Willis, 1973). *Ziziphus mauritiana* Lam. is a small tree and is found throughout India from northwest frontier, Sindh, base of Himalaya to Sri Lanka and Malacca. It is also found in Afghanistan, tropical Africa, the Malacca Archipelago, China and Australia (Hooker, 1872). In the forest of the Chotanagpur region, 6 species of *Ziziphus* are recorded, one of them is *Ziziphus mauritiana* Lam. (Wood, 1903)

Family **Rhamnaceae**
Genus ***Berchemia*** Neck.
Berchemia floribunda (Wall.) Brongn.
(Pl. III, figs. 1, 3)

Material: Single, almost complete and well-preserved leaf impression.

Description: Leaf simple, symmetrical, preserved length 5.3 cm, width 2.5 cm, elliptical; apex acute; base obtuse, normal; margin entire; texture coriaceous; petiole normal; vena-

tion pinnate, craspedodromous, simple; primary vein (1°) moderate, straight; secondary veins (2°) angle of divergence acute (moderate), uniform, moderate, unbranched, intersecondary veins simple; tertiary veins (3°) fine, with angle of origin RR, percurent, branched, almost straight, oblique in relation to mid vein; predominantly alternate and close. Further detail could not be observed.

Discussion: Simple craspedodromous venation, obtuse base, moderate, straight primary vein, entire margin, without loop formation of secondary veins are the important characters of the fossil leaf. These indicate near resemblance with the leaves of *Bredelia retusa* (Euphorbiaceae) and *Berchemia floribunda* (Rhamnaceae); however, a detailed comparison shows their close resemblance with those of *Berchemia floribunda* (Wall.) Brongn., (C.N.H. Howrah Herbarium sheet no. 88783; Pl. III, fig. 2)

The fossil leaf impression of *Berchemia balugoloensis* was described by Lakhanpal (1966) from the Tertiary (Lower Siwalik Formation), Balugoloa near Jawalamukhi, Kangra District, Himachal Pradesh. Later, it was also reported by Kapoor and Singh (1987) from the Kasauli Formation, Kalka-Kasauli Road, Himachal Pradesh. Recently, two more fossil leaves, viz. *Berchemia siwalica* Tripathi *et al.* (2002) and *Berchemia nepalensis* Prasad and Dwivedi (2007) were described from the Siwalik sediments. Of these, the fossil leaf *Berchemia siwalica* has been identified with the extant *Berchemia floribunda* as the present fossil.

The genus *Berchemia* Neck. consists of 12 species widely distributed from Africa to Asia. *Berchemia floribunda* (Wall.) Brongn which the fossil leaf resembles is a large shrub or small moist deciduous tree growing in the sub-Himalayan tract from Jhelum to Sikkim, ascending to 6000 ft. and the Khasi Hills of Meghalaya. (Brandis, 1971).

Family **Rhamnaceae**

Genus ***Ventilago*** Gaertn.

Ventilago madraspatana Gaertn.

(Pl. III, figs. 4, 6)

Material: A single, incomplete leaf impression with good preservation. The base is not preserved.

Description : Leaf simple, symmetrical, preserved length 6.7 cm, width 3.3 cm, narrow oblong; apex acuminate; base not preserved; margin serrate on upper side; texture chartaceous; petiole not preserved; venation pinnate, eucamptodromous; primary vein (1°) moderate, straight; secondary veins (2°) angle of divergence acute, moderate, angle uniform, thick, curved-uniformly, joining superadjacent secondary at right angle, unbrached; tertiary veins (3°) RR, percurrent, approximately at right angles to midvein, predominantly alternate and close; quaternary veins (4°), thin, orthogonal, incomplete; areoles well developed, random, rounded, veinlets none.

Discussion: Serrated margin on upper side of leaf, eucamptodromous venation, stout and straight primary vein, and RR, percurrent tertiary veins are the important characters of leaf which show near resemblance with the modern leaves of *Cinnamomum zeylanicum, Ziziphus mauritiana*, *Premna* species, *Ventilago madraspatana* Gaertn. However, a detailed comparison indicates its close resemblance with those of *Ventilago madraspatana* Gaertn. (B.S.I.P. Herbarium sheet no. 11637; Pl. III, fig. 5).

So far, two fossil leaves resembling the genus *Ventilago* Gaertn. have been known from the Siwalik sediments. One of them is *Ventilago tistaensis* Antal and Prasad (1997) from the lower Siwalik of the Oodhlabari area, West Bengal and other is *Ventilago ovatus* Konomatsu and Awasthi (1999) from the Middle Siwalik of Nepal. These fossil leaves show resemblance with the extant leaves of *Ventilago calyculata* Tul.

Genus *Ventilago* Gaertn. consists of about 35 species (Mabberley,1997) scattered in the tropics of Asia, Africa, America and the Pacific Islands. *Ventilago madraspatana* Gaertn. is found in the western peninsula from Konkan southwards, common in the hot dry places (Hooker, 1872) and is distributed throughout the central and southern area, chiefly on the edge of forest glades and along streams of Chotanagpur and Santhal Pargana, frequent in the Sambalpur and Mayurbhunj area (Haines, 1921). It is also found in the sub-Himalayan tract from Jumna eastward, Oudh forest, Nepal, Bihar, Central India and the peninsula (Brandis, 1906).

Family **Anacardiaceae**

Genus ***Semecarpus*** Linn.f.

Semecarpus anacardium Linn. f.

(Pl. III, fig. 7)

Material: One, incomplete and fairly preserved leaf impression.

Description: Leaf simple, preserved length 10.5 cm, width 5.5cm, elliptic; apex and base not preserved; margin entire; petiole not preserved; texture coriaceous; venation pinnate, eucamptodromous to brochidodromous; primary vein (1°) stout, straight; secondary veins (2°) angle of divergence acute, moderate, angle of divergence in apical part is more acute than lower, moderately thick, secondary upturned and gradually diminishing inside the margin, connected to the superadjacent secondary by a series of cross-veins without forming prominent loop; tertiary veins (3°) with angle of origin usually RR percurent, branched, oblique in relation to midvein, predominantly alternate and close to slightly distant, quaternary veins (4°), thin, orthogonal, marginal ultimate venation looped; areoles well developed, random, pentagonal.

Discussion: Eucamptodromous to brochidodromous venation, acute angle of divergence of secondary veins, with upper more acute than lower, upturned and gradually diminishing inside margin are prominent characters which show resemblance to the modern leaves of *Terminalia* species, *Dipterocarpus tuberculatus, Semecarpus anacardium, Anthocephalus cadamba.* However, it shows the maximum resemblance with the leaf of *Semecarpus anacardium* (B.S.I C.C. Herbarium sheet no. 22958; Pl.III, fig. 8).

A fossil leaf resembling the genus *Semecarpus* Linn. f. has been described by Srivastava and Guleria (2002) from the

EXPLANATION OF PLATE I

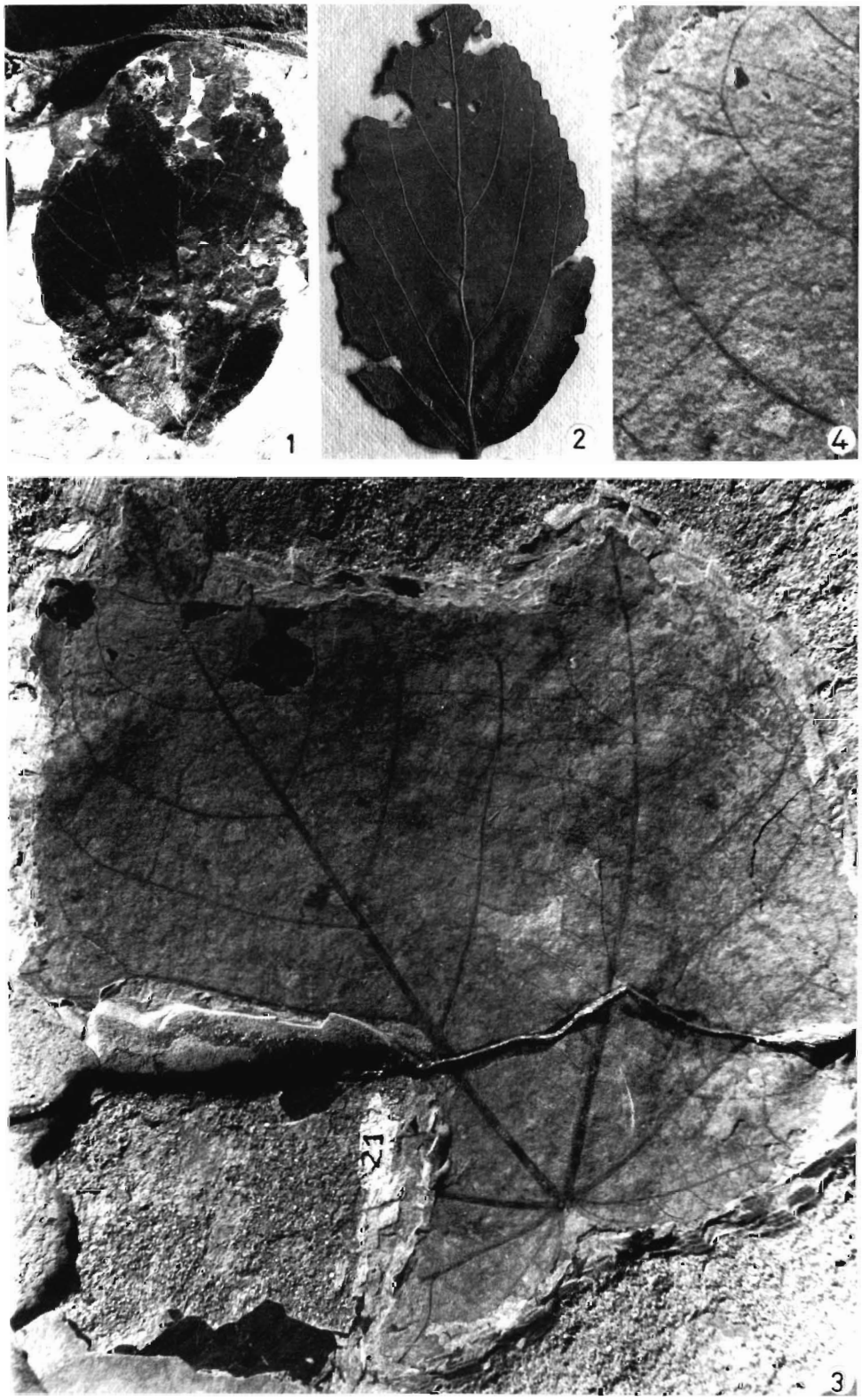
1-2. ***Flacourtia indica*** Linn.

1. Fossil leaf in natural size; BSIP specimen no.39297.
2. Modern leaf in natural size.

3-4. ***Abroma augusta*** Linn.

3. Fossil leaf in natural size; BSIP specimen no. 39298.
4. Venation pattern of fossil leaf near the margin, x 2.

Plate I



Kasauli Formation (lower Miocene) of Himanchal Pradesh under the form species *Semecarpus palaeoanacardium*. Like the present fossil, this fossil leaf has also been compared with the exant leaves of *Semecarpus anacardium* Linn. f., however, fossil of *Gluta, Melanorrhoea, Mangifera, Swintonia, Lannea, Dracantomelum* and *Holigrana* of Anacardiaceae are known from various Tertiary localities of India and Nepal (Awasthi, 1982; Bande and Prakash, 1984; Guleria, 1984, Prasad *et. al.*, 1999).

The genus *Semecarpus* Linn. f. consists of about 60 species (Mabberley; 1997), which are found in tropical Asia and Australia. *Semecarpus anacardium* Linn. f. is found in tropical outer Himalayas, from Sirmore to Sikkim, ascending to 3500 ft. and through the hotter part of India (Hooker, 1872). It is distributed throughout the whole area, chiefly in the hilly districts, from the Someshwar hills southwards and in the sub Himalayan tract from the Bias eastwards, ascending in the outer hills, Assam, Khasi Hills, Chittagong, Central India and western peninsula (Haines, 1910; Brandis, 1971).

Family **Fabaceae**

Genus ***Crotolaria*** Linn.

Crotolaria retusa Linn.

(Pl. V, figs. 2, 4)

Material: A single, almost complete leaflet impression with its counter part.

Description: Leaflet symmetrical, preserved length 5.5 cm, width 2.2 cm, obovate; apex mucronate; base acute, margin entire; petiole indistinct; venation pinnate, eucamptodromous; primary vein (1°) stout, straight; secondary veins (2°) narrow acute angle of divergence, angle of divergence is uniform, straight, unbranched; tertiary veins (3°) not visible.

Discussion: Mucronate apex and acute base and eucamptodromous venation with fine secondary veins are the prominent characters which indicate similarity with the leaves leaflets of *Ochna squammosa, Crotolaria retusa, Cassia alata* and *Crotalaria striata*. However, on detailed study of the leaf and leaflets of above taxa, it seems close to the leaf of *Crotolaria retusa* (B.S.I. C.C. Herbarium sheet no. 24 91; Pl. V, fig. 3).

As far as the authors are aware, there is no prior report of fossil leaflets of the genus *Crotolaria*. Chanda and Mukherjee (1969) reported the only fossil pollen of *Crotolaria* from the late Quaternary deposits of Calcutta, West Bengal.

Crotalaria Linn. consists of 600 Species (Mabberley,1997). It spreads everywhere in tropical and subtropical regions. *Crotolaria retusa* Linn. is distributed from tropical region to Himalayas, Sri Lanka and Malacca (Hooker, 1872). It is also very common in the forests of the Chotanagpur region (Wood, 1903; Haines, 1910).

Family ***Combretaceae***

Genus ***Terminalia*** Linn.

Terminalia chebula Retz.

(Pl. IV, fig. 1)

Material: A single and complete leaf impression.

Description: Leaf simple, symmetrical, length 21 cm, width 10.7cm, elliptic; apex acute; base rounded; margin entire; texture thick chartaceous; petiole long, normal; venation pinnate, eucamptodromous to brochidodromous; primary vein (1°) massive, straight; secondary veins (2°) angle of divergence wide acute, angle of divergence is uniform, relative thickness of secondary vein moderate, uniformly curved; joining superadjacent secondary; tertiary veins (3°) fine, poorly preserved, angle of origin usually AO, percurent, straight to sinuous, branched, oblique in relation to midvein, predominantly alternate and close. Further observation could not be made due to poor preservation.

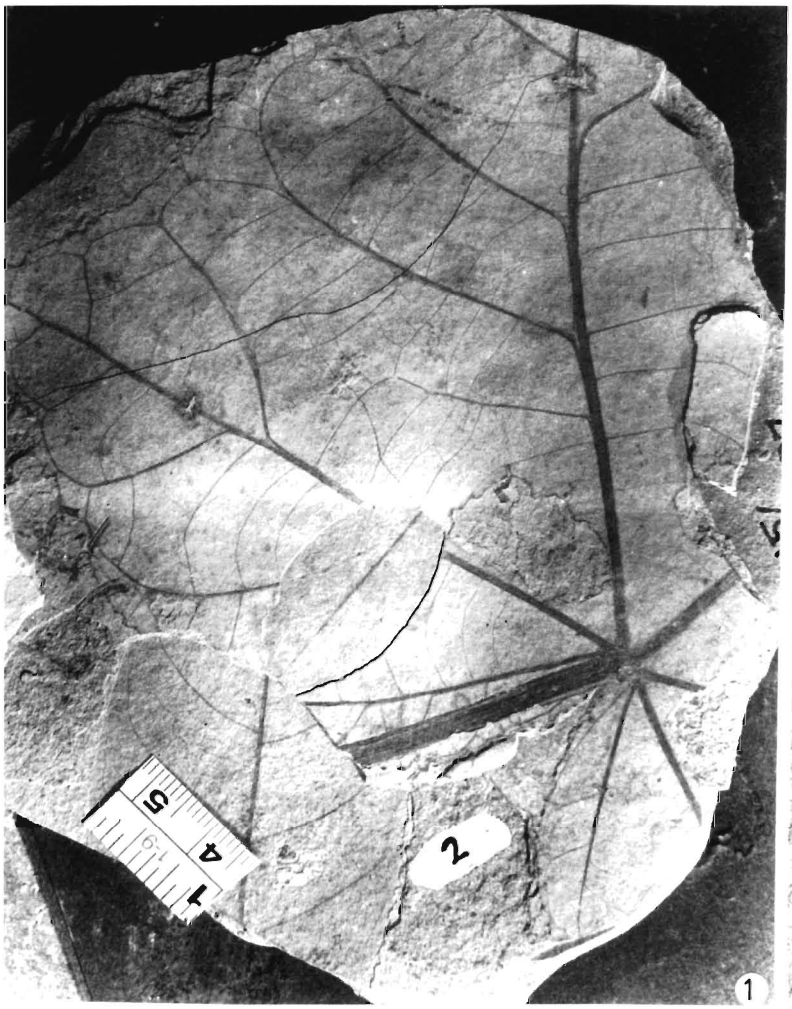
Discussion: Rounded base, chartaceous texture, entire margin with eucamptodromous to brochidodromous venation and uniformly curved secondary veins are the important characters of the fossil leaf which suggest its resemblance with the modern leaves of *Terminalia* sp., *Anthocephalus cadamba and Artocarpus chaplasa*. However, a detailed examination of both fossil and living leaves reveals its close resemblance with the modern leaves of *Terminalia chebula* Retz in almost all characters (B.S.I.C.C. Herbarium sheet no 24987; Pl. V, fig. 1).The leaves of *Anthocephalus cadamba* differ from the present fossil leaf in their wide, ovate basal part with greater angle of divergence of secondary veins; however, the leaves of *Artocarpus chaplasa* differ in being ovate and in having relatively a less angle of divergence of secondary veins.

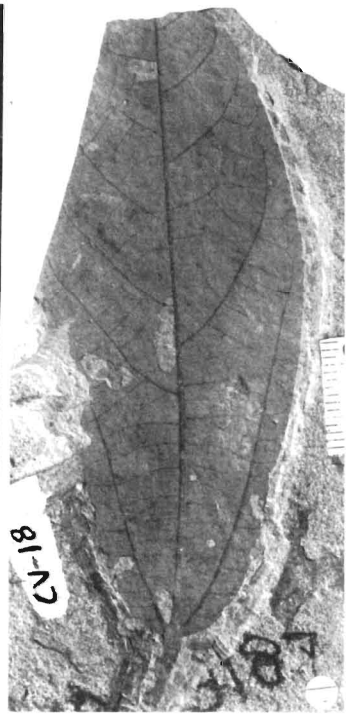
Both fossil wood and leaf-impression of *Terminalia* Linn. are known from various Tertiary localities of India and Nepal. Fossil leaves of *Terminalia* have been described under the modern generic name. Lakhanpal (1970) has reported a leaf-impression resembling *Terminalia* from the Siwalik beds of Himachal Pradesh. Lakhanpal and Guleria (1981) and Lakhanpal *et al.* (1984) have described 2 species, viz. *Terminalia panandhroensis* (comparable to *T. crenulata*) and *T. kachchhensis* (comparable to *T. chebula*) from the Tertiary of Kachchh. Tripathi and Tiwari (1983) have described a leaf-impression cf. *T. arjuna* from the Siwalik beds of Koilabas. Prasad (1990) has also described *T. koilabasensis* (comparable to *T. angustifolia* Jacb.) and *T. siwalica* (comparable to *T. pyrifolia* from the Siwalik beds of Koilabas, Nepal. Awasthi and Prasad (1990) described a fossil leaf *Terminalia palaeochebula* (comparable to *Terminalia chebula* Retz from the Siwalik sequence of Suraikhola, Nepal. Bande and Srivastava (1990) and Bande and Srivastava (1992) have described the fossil wood and leaf impression of *Terminalia tomentosa* from the late Tertiary sediments of Mahuadaur, Jharkhand. Most of the fossil woods have been described under the generic name *Terminalioxylon* Schonfeld, of which 16 species are known from different Indian Cenozoic horizons, viz. Cuddalore Sandstones, Tipam Sandstones, Dupitila Series

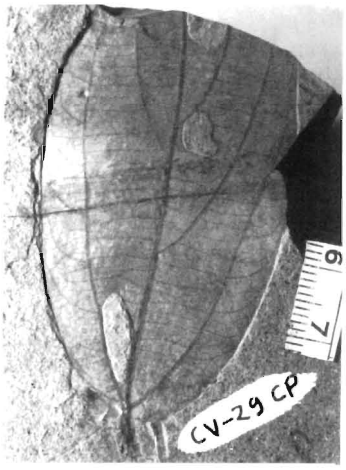
EXPLANATION OF PLATE II

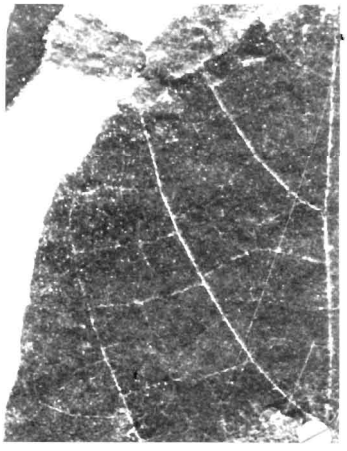
1. ***Sterculia urens*** Roxb.
   Fossil leaf in natural size; BSIP museum specimen no. 39299.
2-5. ***Ziziphus mauritiana*** Lam.
   2. Fossil leaf in natural size; BSIP museum specimen no. 39300A.
   3. Counterpart of fig.2. 39300B.
   4. Another Fossil leaf in natural size; BSIP museum specimen no. 39301.
   5. Modern leaf in natural size.
6. ***Flacourtia indica*** Linn.
   Venation pattern of fossil leaf near margin, x 3.

Plate II









of Arunachal Pradesh, Siwalik beds, Tertiary beds of West Bengal, Andhra Pradesh, Gujarat and Kerala (Mahabale and Deshpande, 1965; Prakash, 1966; Ramanujam, 1966; Awasthi, 1982; Guleria, 1983; Bande and Prakash, 1984 ; Lakhanpal *et al.*, 1984).

The genus *Terminalia* Linn. comprises about 150 species (Mabberley,1997) which are large trees destributed widely in the tropics of the world. In India, 12 species are known to occur (Santapau and Henry, 1973). The extant species, *T. chebula Retz.* grow wild in the Chotanagpur region and it is abundant in Northern India from Kumaon to Bengal and southward to the Sri Lanka (Hooker, 1872). It is also found in sub-Himalayan tract from Sutlej eastwards, ascending to 5,000 ft., common in the deciduous forests of both peninsulas (Brandis, 1906).

Family **Rubiaceae**
Genus ***Gardenia*** Ellis.
Gardenia resinifera Roth. (*G. lucida* Roxb.)
(Pl. VI, figs. 3, 5)

Material: Single leaf-impression, base and apex not preserved. Preservation is fair and enough to reveal the finer details of leaf.

Description: Leaf simple, symmetrical, preserved leaf length 6.8 cm, width 4 cm, maximum width on one side of midrib is 2.5 cm; apex and base are not preserved; margin entire; texture chartaceous; petiole not preserved; venation pinnate, eucamptodromous; primary vein (1°) moderate, straight; secondary veins (2°) angle of divergence acute, wide, upper more acute than lower, moderate uniformly curved up and joined super-adjacent secondary, unbranched; tertiary veins (3°) angle of origin AO, percurrent, almost straight, branched, oblique in relation to midvein, predominantly alternate and closed. quaternary veins (4°) thin, orthogonal; areoles well developed, veinlet none.

Discussion: Eucamptodromous venation with AO-RR, percurrent tertiary veins are the important features of the fossil leaf. Such characters are found in the leaves of *Teliacora acuminata* and *Gardenia resinifera*. However, in the details of leaf architecture they show close resemblance with the modern leaves of *Gardenia resinifera* (*B.S.I.C.C.* Herbarium sheet no. 4 027; Pl. VI, fig. 4).

Two fossil leaves resembling the genus *Gardenia* Ellis are known from the Siwalik sediments of India. Lakhanpal and Awasthi (1984) reported *Gardenia palaeoturgida* (comparable to *Gardenia turgida)* from the Siwalik sediments of the Bhikhnathoree, Bihar. Later, Prasad (1994a) described another fossil leaf *Gardenia nainitalensis* comparable to *Gardenia scandense* from Siwalik sediments of the Kathgodam area, Nainital District, Uttaranchal. Other fossil leaves resembling the genera of the family Rubiaceae such as, *Randia, Canthium, Mitragyne Anthocephalus, Diplospora* and *Morinda* are also known from the Tertiary sediments of India and Nepal (Prasad *et. al.*, 1999; Prasad and Dwivedi, 2007; Prasad and Awasthi, 1996; Prasad, 1994b; Bande and Srivastava, 1990)

Gardenia Ellis. comprises about 60 species (Mabberley, 1997). They are distributed widely in tropical and subtropical regions of the world. *Gardenia resinifera* Roth is distributed in the western peninsula, common from the Konkan southwards, Sambalpur, Boropahar range and in Nakti Chapatar forest (Hooker, 1872; Haines, 1910). It is also very common in the forest of the Chotanagpur region (Wood, 1903).

Family **Verbenaceae**
Genus ***Premna*** Linn.
Premna latifolia Roxb.
(Pl. VI, fig. 1)

Material: Two leaf-impressions, one with apex and other with base. preservation is excellent.

Description: Leaf simple, almost symmetrical, preserved length 5.6 cm, width 3.1 cm; apex acuminate; base acute, decurrent; margin entire; texture chartaceous; petiole not preserved; venation pinnate, eucamptodromous; primary vein (1°) moderate, markedly curved; secondary veins (2°) angle of divergence acute, moderate, angle of divergence in upper side more acute than lower; moderate, uniformly curved, unbranched; inter-secondary veins simple; tertiary veins (3°) angle of origin, AO-RR, percurrent, branched, almost straight, oblique, in relation to midvein, predominantly alternate and close, quaternary veins (4°) thin, randomly oriented; areoles well developed, orthogonal-pentagonal, veinlet none.

Discussion: Acuminate apex, eucamptodromous venation with percurrent, AO- RR tertiary vein, are the prominent characters of the fossil leaf. Critical examination of both the fossils and living leaves of a number of taxa suggests that the present fossil show their close resemblance with the modern leaves of *Premna latifolia* Roxb. (B.S.I.C.C. Herbarium sheet no. 5841; Pl. VI, fig. 2).

As far as the authors are aware, there is no fossil record of the genus *Premna* Linn. from India and Nepal. However, fossil wood and leaf-impressions of family Verbenaceae are known from the Deccan Intertrappean beds, the Siwalik Group, Tipam Sandstone (Bande, 1987; Biradar and Bonde, 1984; Ingle, 1972; Prakash and Tripathi, 1974; Srivastava, 1998; Antal and Awasthi, 1993; Prasad, 1990).

The genus *Premna* Linn. comprises about 50 tropical species (Mabberley,1997). *Premna latifolia* Roxb. is distributed in the lower hills of the Coromandel Coast and Bengal, from Rajmahal to the southern Circars. It is also found in sub-Himalayan tract from the Chenab eastwards, ascending to 2,000 ft., Oudh forest, Bengal plain, Western Peninsula, Upper and Lower

EXPLANATION OF PLATE III

1-3 ***Berchemia floribunda*** (Wall) Brongn.
1. Fossil leaf in natural size; BSIP museum specimen no. 39302.
2. Modern leaf in natural size.
3. Venation details of fossil leaf (Fig.1) showing venation pattern near margin, x 4.

4-6 ***Ventilago madraspatana*** Gaertn.
4. Fossil leaf in natural size; BSIP museum specimen no. 39303.
5. Modern leaf in natural size.
6. Venation details of fossil leaf (Fig.6) showing venation pattern near margin, x 4.

7-8. ***Semecarpus anacardium*** Linn.
7. Fossil leaf in natural size; BSIP museum specimen no. 39304.
8. Modern leaf in natural size.

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Plate III

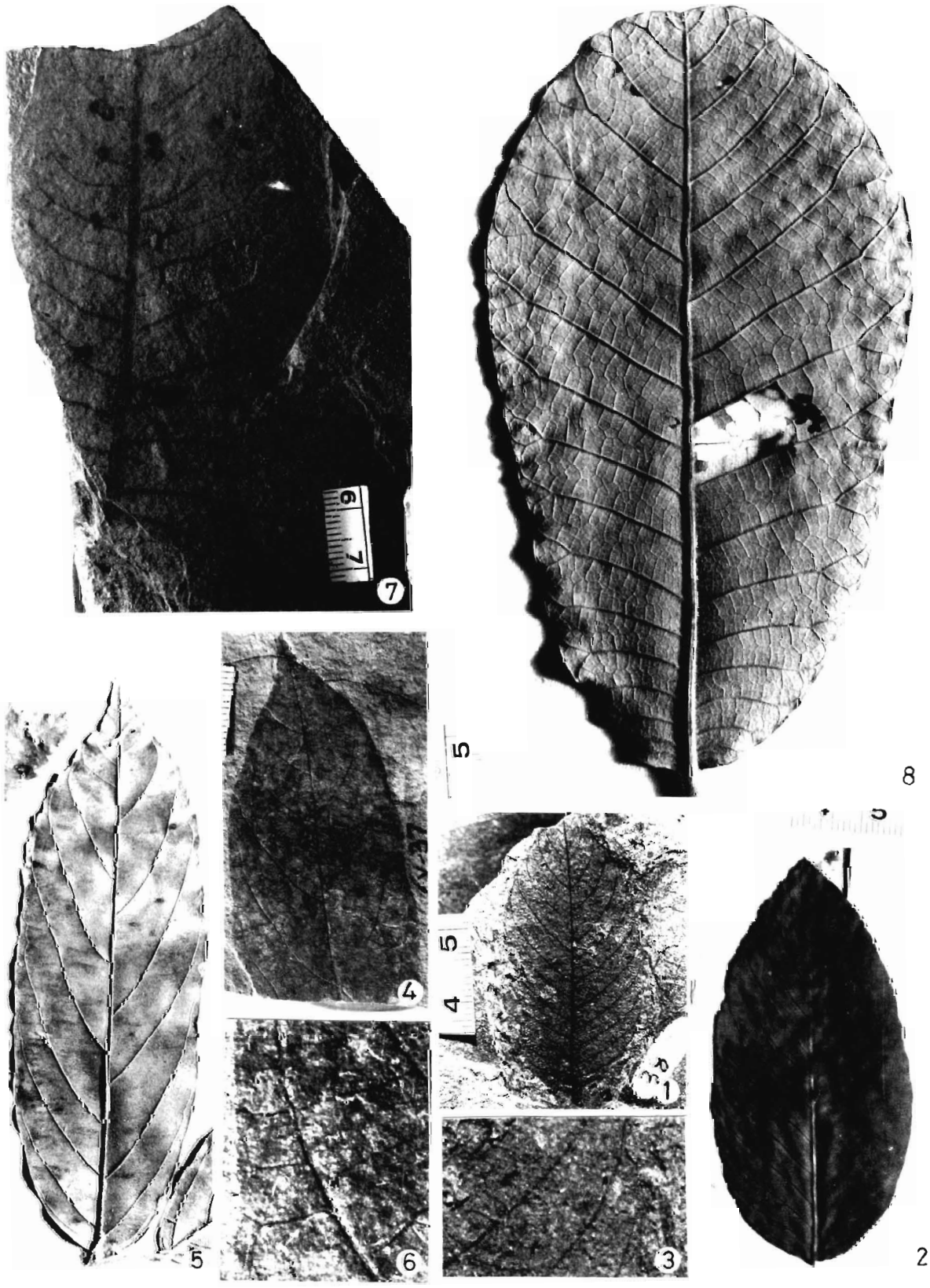


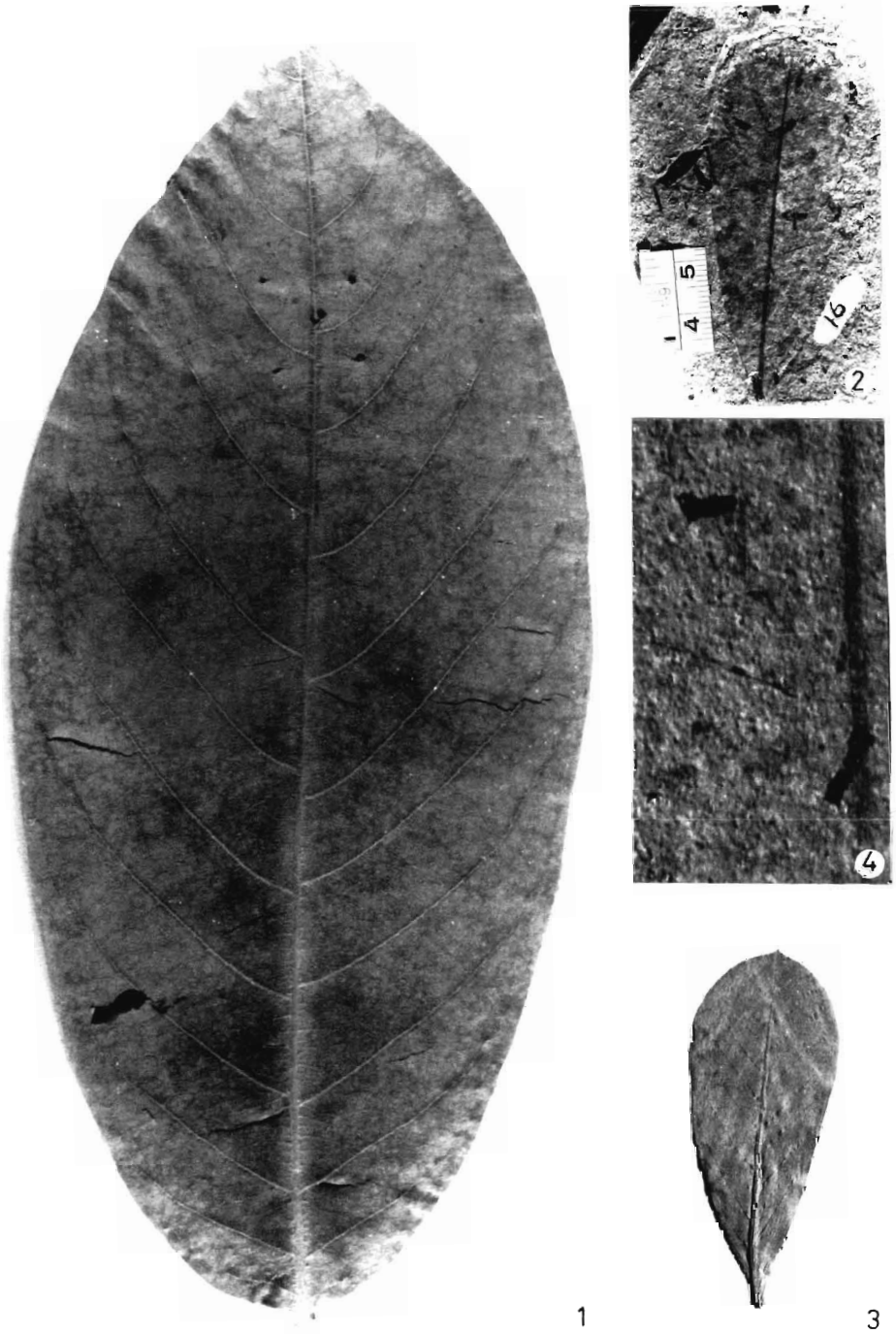
Plate IV

SINGH AND PRASAD

EXPLANATION OF PLATE IV

1. ***Terminalia chebula*** Retz.
   Fossil leaf in natural size; BSIP museum specimen no. 39305.

Plate V

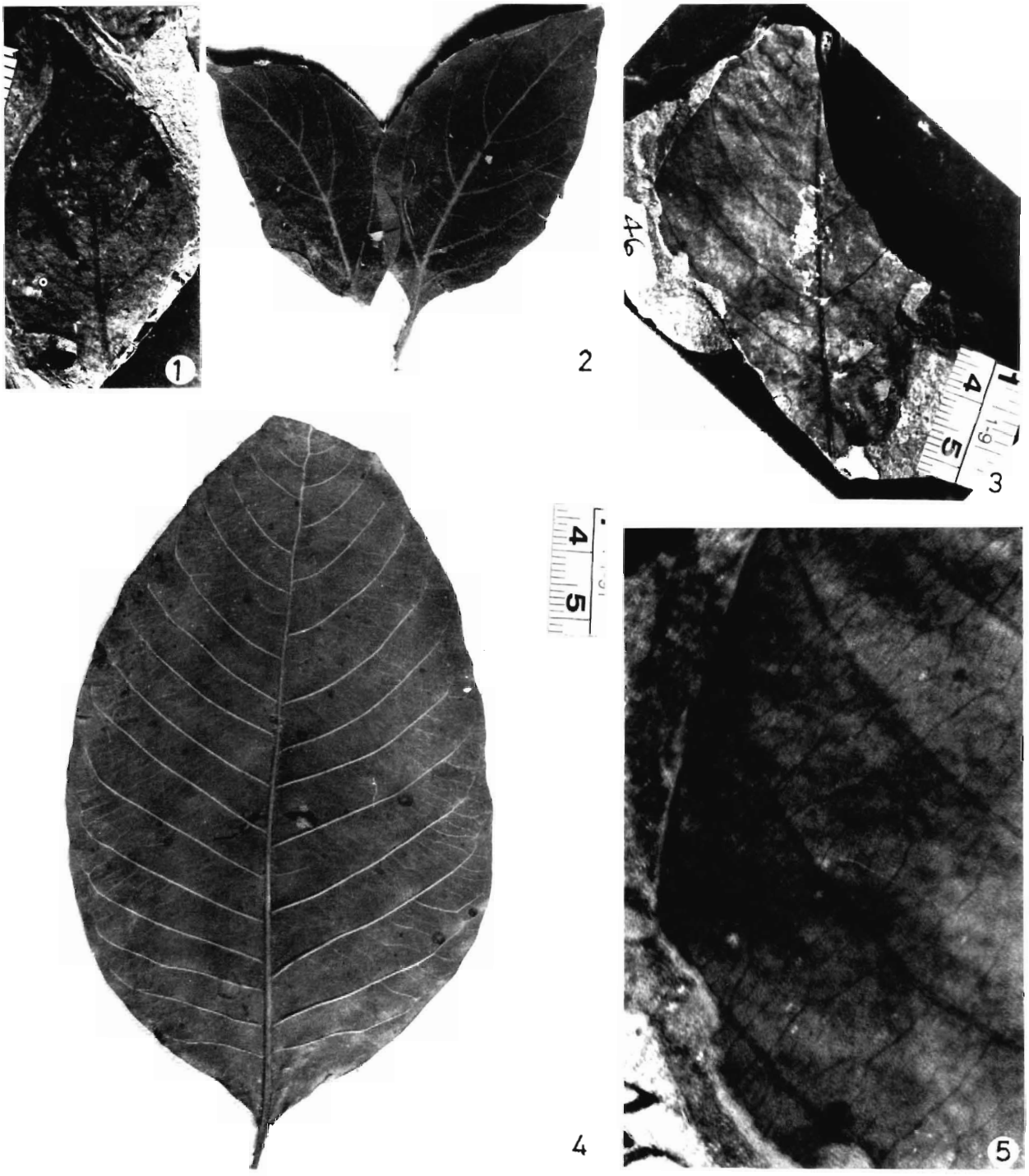


SINGH AND PRASAD

EXPLANATION OF PLATE V

1. ***Terminalia chebula*** Retz.
   1. Modern leaf in natural size.

2-4. ***Crotolaria retusa*** Linn.
   2. Fossil leaf in natural size; BSIP museum specimen no. 39306.
   3. Modern leaf in natural size.
   4. Fossil leaf (Fig.2) further enlarged to show details of venation. x 4.



SINGH AND PRASAD

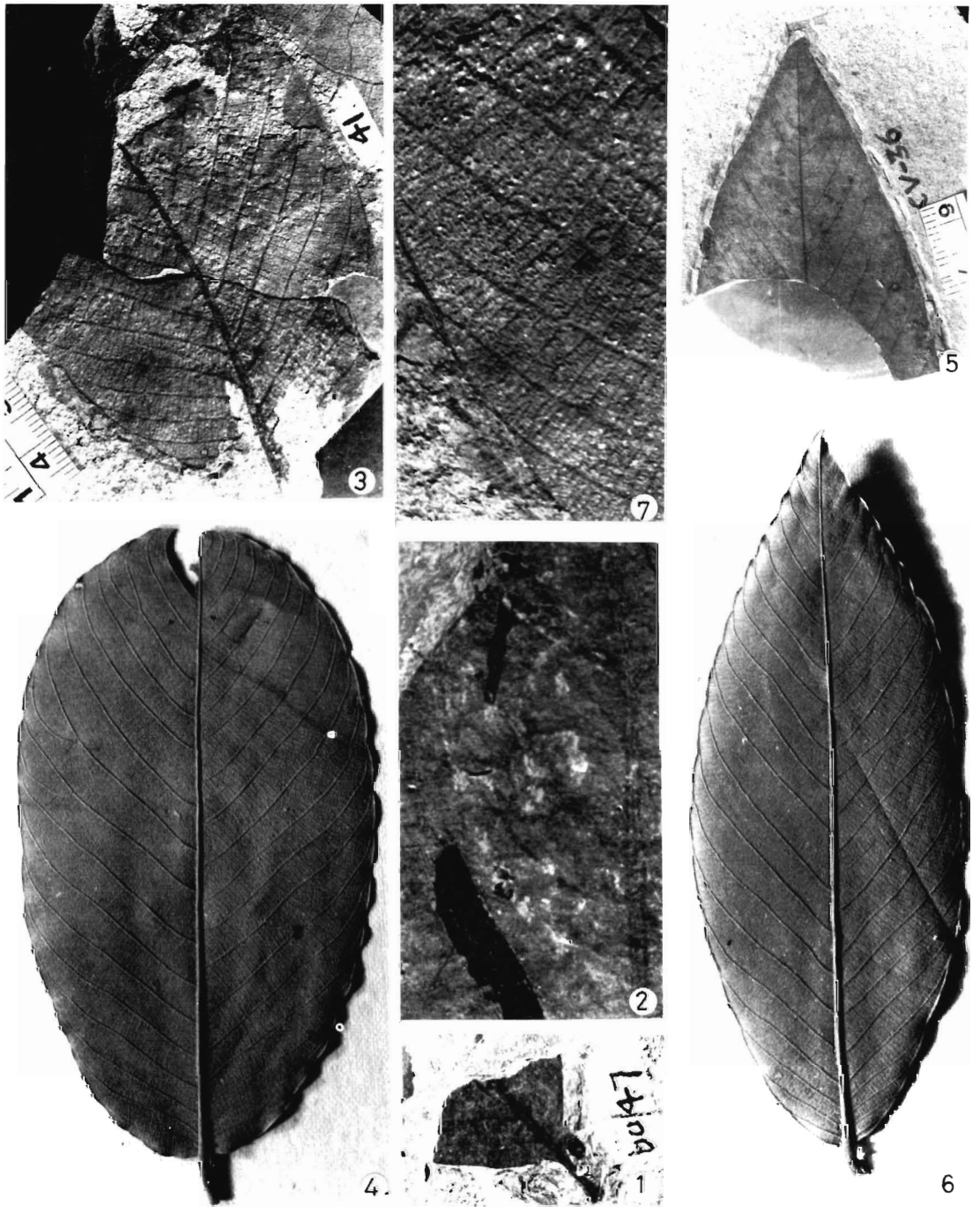
EXPLANATION OF PLATE VI

1-2. ***Premna latifolia*** Roxb.

1. Fossil leaf in natural size; BSIP museum specimen no. 39307.
2. Modern leaf in natural size.

3-5. ***Gardenia resinifera*** Roth.

3. Fossil leaf in natural size; BSIP museum specimen no. 39308.
4. Modern leaf in natural size.
5. Details of venation of fossil near margin, x 4.



SINGH AND PRASAD

EXPLANATION OF PLATE VII

1-2. ***Premna latifolia*** Roxb.

1. Another fossil leaf base in natural size; BSIP museum specimen no. 39309.
2. Details of venation (fig. 1) near margin, x 4.

3-7. ***Bridelia retusa*** Spreng

3. Fossil leaf in natural size; BSIP museum specimen no. 39310.
4. Modern leaf in natural size.
5. Another fossil leaf in natural size; BSIP museum specimen no. 39311.
6. Another modern leaf in natural size.
7. Details of venation of fossil leaf (fig. 3) near midrib, x 4.

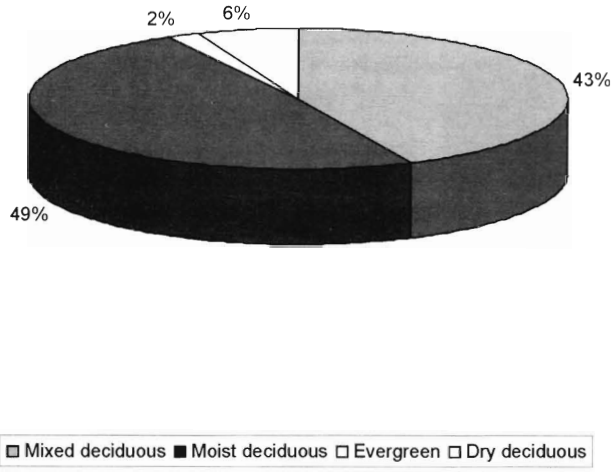


Fig. 4. Diagrammatic representation of different types of forest elements of the late Tertiary flora of Mahuadanr Valley.

Myanmar (Hooker, 1872; Brandis, 1906). It is common in the forests of the Chotanagpur region (Wood, 1903; Haines, 1910).

Family **Euphorbiaceae**

Genus ***Bridelia*** Willd.

Bridelia retusa Spreng.

(Pl. VII, figs. 3, 5, 7)

Material: Two-leaf impressions, one with base and other with apex, preservation is fair.

Description: Leaf simple, symmetrical, preserved size 8.4 x 6.2 cm and 6.0 x 3.1 cm; apex acute; base rounded; margin entire; texture chartaceous; petiole 0.4 cm visible, normal; venation pinnate, simple craspedodromous; primary vein (1°) stout, straight; secondary veins (2°) angle of divergence acute, moderate, uniformly, thick, uniformly curved, unbranched; tertiary veins (3°) angle of origin RR, percurrent, almost straight, branched, oblique in relation to midvein, opposite to alternate, close; quaternary veins (4°) fine, orthogonal; areoles well developed, random, pentagonal.

Discussion: Simple craspedodromous venation, acute angle of divergence of secondary veins, RR, percurrent tertiary veins and well developed areoles are important characters of fossil leaves which indicate its affinity with the modern leaves of *Mitragyna parvifolia, Millettia auriculata, Shorea robusta, Bridelia retusa* and *Psychortia truncata*. However, a comparative study of a large number of herbarium sheets of above taxa suggests their close resemblance with the modern leaves of *Bridelia retusa* Spreng. (B.S.I.C.C. Herbarium sheet no. 26394, 26391; Pl. VII, figs.4, 6).

The genus *Bridelia* is fairly well known from various Tertiary localities of India both in the form of fossil woods and leaf-impressions, e.g. *Bridelia stipularis* Blume, and *Bridelia verrucosa* Haines. (Pathak, 1969) from the Mahanadi River section, Darjeeling, West Bengal. *Bridelia* sp. (Medlicot and Oldham, 1893) from the Late Quaternary, Fort William, Calcutta, West Bengal. Awasthi and Mehrotra (1995) have reported another fossil leaf of this genus under as *Bridelia oligocenica* from the Oligocene of the Makum coal field, Assam, India. Recently, Prasad and Pandey (2007) described two more fossil leaves, viz. *Bridelia mioretusa* and *Bridelia siwalica* from the Siwalik sequences of the Suraikhola area, Western Nepal. Like the present fossil from, the two already known fossil leaves viz. *Bridelia oligocenica* and *Bridelia mioretusa* show their resemblance with the extant leaf of *Bridelia retuse* spreng. Fossil wood *Bridelioxylon cuddalorense* is also known from the Cuddalore Sandstone (Ramanujam, 1956).

Bridelia Willd. consists of about 60 species (Mabberley, 1997) distributed in tropical Africa, Asia and Australia. *Bridelia retusa* Spreng. found throughout the hotter parts of India, along the foot hills of the Himalayas from Kashmir to Mishmi, ascending to 3500 ft., Malacca, Travancore and Sri Lanka (Hooker, 1872). It is also found throughout the sub himalayan tract from Chenab eastwards. It is common in the Oudh forest, Sikkim, Rajputana, central provinces, Chotanagpur Bihar, Western peninsula and Myanmar, (Haines, 1910; Wood,1903).

CONCLUSION

The present study of fossil plants comprising well-preserved leaf impressions from the late Tertiary sediments of Mahuadanr Valley in Latehar District of Jharkhand reveals the occurrence of 12 taxa belonging to ten families of dicotyledons. With the addition of these taxa, the late Tertiary floral assemblage of this area now constitutes 49 species and 43 genera of 23 dicotyledonous families. The present fossil flora is based mainly on leaf impressions, plus a few fossil woods and fruit and seeds. The floral assemblage is dominated by small to large trees. The remaining species are small shrubs and climbers. Fabaceous taxa dominated the flora with 8 species. Other well-represented families include Urticaceae, Rhamnaceae, Anacardiaceae, Sterculiaceae, Combretaceae and Rubiaceae in descending sequence of their numerical abundance in the fossil assemblage.

The nearest living relatives of the Mahuadanr fossils indicate that there were 3 types of elements in this area during sedimentation (1) moist deciduous (2) mixed deciduous (3) dry deciduous (Fig. 4). In Mahuadanr assemblage 43% taxa are mixed deciduous viz. *Dillenia* sp., *Flacourtia indica, Shorea robusta, Hiptage bengalensis, Garuga pinnata, Ziziphus mauritiana, Ziziphus xylopyrus, Schleichera oleosa, Spondias pinnata, Bauhinia purpurea, Dalbergia sissoo, Terminalia tomentosa, Gardenia resinifera, Adina cordifolia, Mitragyna parvifolia, Madhuca indica, Cryptolepis buchanani, Premna latifolia, Mallotus philippinensis* and *Ficus tomentosa*.

The 49 % taxa are moist deciduous, viz *Casearia tomentosa, Abroma augusta, Sterculia urens, Sterculia villosa, Pterygota alata, Grewia tiliaefolia, Evodia meliaefolia, Murraya paniculata, Berchemia floribonda, Ventilago madraspatana, Semecarpus anacardium, Mangifera indica, crotolaria retusa, Millettia auriculata, Ougenia oojeinensis, Sophora acuminata, Terminalia chebula, Lagerstroemia parviflora, Alstonia scholaris, Bredelia retusa, Ficus foveolata, Ficus glaberrima* and *Ficus microcarpa*.

The 6 % taxa are dry deciduous, viz *Erythrina suberosa, Diospyros montana, Vitex negundo*. Thus, the moist deciduous elements dominate the fossil flora of the Mahuadanr Valley (Table 2) during late Tertiary period.

Tertiary plant fossils are supposed to be reliable indicators of the past climate, especially those that are referable to modern taxa and the accuracy of interpretation based on them is inversely proportional to the geological ages of the sediments from which fossils are collected. The plant fossils of the present study collected from the late Tertiary (Pliocene-Pleistocene) sediments are comparable with the taxa still existing in the

Table 2: Present day distribution and forest types of taxa comparable to those of the fossil assemblage recovered from Late Tertiary sediments of Mahaudanr Valley, Jharkhand, India.

Taxon	Forest type	Habit & Habitat	Present Day Distribution
Dilleniaceae			
Dillenia sp.	Mixed deciduous	Small tree	India, Myanmar, Chotanagpur region.
Flacourtiaceae			
Flacourtia indica Linn	Mixed deciduous	Small tree	Sub-Himalayan tract, Central India, Chotanagpur region.
Casearia tomentosa Roxb.	Moist deciduous	Small tree	Sub-Himalayan tract, South & Central India, Bangladesh, Sri Lanka.
Dipterocarpaceae			
Shorea robusta Gaertn. f.	Mixed deciduous	Large tree	Sub-Himalayan tract, Central & South India, Chotanagpur region.
Malvaceae			
Abroma augusta Linn.	Moist deciduous	Small tree	Sub-Himalayan tract, Khasi Hills, Assam, Sikkim, Chotanagpur region.
Sterculiaceae			
Sterculia urens Roxb.	Moist deciduous	Tree	South & Central India, Assam , Chotanagpur region.
Sterculia villosa, Roxb.	Moist deciduous	Medium sized tree	Sub-Himalayan tract, Central Provinces, Assam, Andaman, Myanmar.
Pterygota alata, (Roxb.)R. Br.	Moist deciduous	Large tree	North east India, Western Ghats Bangladesh, Myanmar & Andaman Chotanagpur region.
Tiliaceae			
Grewia tiliaefolia Vahl.	Moist deciduous	Medium sized tree	Sub-Himalayan tract, Central & South India, Chotanagpur region.
Malpighiaceae			
Hiptage bengalensis (L) Kurz.	Mixed deciduous	Large struggling shrubs	India, Myanmar, Sri Lanka, Chotanagpur region.
Rutaceae			
Evodia meliaefolia Benth	Moist deciduous	Large tree	Chotanagpur region, Assam, Cachar Hills, China.
Murraya paniculata (Linn.) Jack.	Moist deciduous	Small tree	Sub-Himalayan tract, Myanmar, Andaman & Australia, Chotanagpur region.
Burseraceae			
Garuga pinnata Roxb.	Mixed deciduous	Medium sized tree	Sub-Himalayan tract, India, Bangladesh, Myanmar, Chotanagpur region.
Rhamnaceae			
Ziziphus mauritiana Lam.	Mixed deciduous	Small tree	India, Sri Lanka, Africa, Malaya, Malacca, Chotanagpur region.
Ziziphus xylopyrus Willd.	Mixed deciduous	Large struggling shrubs to small tree	North-West Himalaya, Western Peninsula, Chotanagpur region.
Berchemia floribonda (Wall)Brongn.	Moist deciduous	Shrubs or small tree	Sub- Himalayan tract, Khasi Hills, Assam.
Ventilago madraspatana Gaertn.	Moist deciduous	Tree	Sub-Himalayan tract, South & Central India, Western Peninsula Chotanagpur region
Sapindaceae			
Schleichera oleosa (Lour.) Oken.	Mixed deciduous	Large tree	Sub-Himalayan tract, Central India, Myanmar, Chotanagpur region
Anacardiaceae			
Semecarpus anacardium Linn.	Moist deciduous	Tree	Sub-Himalayan tract, Central India, Khasi Hills, Bangladesh , Chotanagpur region
Spondias pinnata Kurz.	Mixed deciduous	Large tree	Sub-Himalayan tract ,Western Peninsula, Myanmar, Sri Lanka, Chotanagpur region
Mangifera indica Linn.	Moist deciduous	Tree	Throughout India, Myanmar.
Fabaceae			
Crotolaria retusa Linn.	Moist deciduous	Shrub	Sub-Himalayan tract , Sri Lanka , Malacca, Chotanagpur region.
Erythrina suberosa Roxb.	Dry deciduous	Medium sized tree	Sub-Himalayan tract, Myanmar, Chotanagpur region.
Millettia auriculata Baker ex Brandis	Moist deciduous	Woody climber	Sub-Himalayan tract, Central & South India, Chotanagpur region.
Ougenia oojeinensis (Roxb.)	Moist deciduous	Tree	Sub-Himalayan tract, South & Central Provinces, Chotanagpur region
Sophora acuminata Benth.	Moist deciduous	Shrub or small tree	Nepal, Assam, Myanmar, Khasi Hills.
Bauhinia purpurea Linn.	Mixed deciduous	Medium sized tree	Sub-Himalayan tract, Assam, Bangladesh, Myanmar Central & South India, Chotanagpur region
Dalbergia sissoo Roxb.	Mixed deciduous	Large tree	Sub-Himalayan tract, Assam, Central province all along the River banks
Sindora siamea Teysm.	Evergreen	Tree	Malaya Peninsula, Wallich , Myanmar.

Combretaceae			
Terminalia chebula Retz.	Moist deciduous	Tree	Sub-Himalayan tract, Sri Lanka, India and Nepal, Chotanagpur region.
Terminalia tomentosa Wight & Arn.	Mixed deciduous	Large tree	Sub-Himalayan tract, Throughout India, Myanmar, Chotanagpur region.
Combretum decandrum Roxb.	Mixed deciduous	Climber	Sub-Himalayan tract, Assam, Central province, Myanmar, Bangladesh, Chotanagpur region.
Lythyraceae			
Lagerstroemia parviflora Roxb.	Moist deciduous	Large tree	N E India, Myanmar
Rubiaceae			
Gardenia resinifera Roth.	Mixed deciduous	Shrubs	Common in South India from Kokan Southwards, Chotanagpur region
Adina cordifolia Hook.f.	Mixed deciduous	Large tree	Throughout India, Myanmar, Sri Lanka.
Mitragyna parvifolia (Roxb.)Korth.	Mixed deciduous	Large tree	Thoughout India.
Sapotaceae			
Madhuca indica J.F. Gamel	Mixed deciduous	Tree	Throughout Indian Foot hills of Himalaya
Ebenaceae			
Diosppyros montana Roxb.	Dry deciduous	Small tree	Throughout India, Myanmar, Sub- Himalayan region.
Apocynaceae			
*Alstonia scholaris*Brown.	Moist deciduous	Large tree	Moist part of Indian region, Myanmar, Philippines, Malaya, Chotanagpur region.
Asclepediaceae			
Cryptolepis buchanani Roem. & Schult.	Mixed deciduous	Climber	Throughout India common in Sub -Himalayan tracts, Chotanagpur region.
Verbenaceae			
Premna latifolia Roxb.	Mixed deciduous	Tree	Sub-Himalayan tract, Western Peninsula, Myanmar, Chotanagpur region
Vitex negundo Linn.	Dry deciduous	Large shrub or small tree	Throughout India.
Euphorbiaceae			
Bredelia retusa Spreng.	Moist deciduous	Tree	Himalayan foot hills, Myanmar, South and Central India. Sri Lanka.
Mallotus philippinensis Muell-Arg.	Mixed deciduous	Large shrub	Sub-Himalayan tract, Both Peninsula, Chotanagpur region.
Drypetes assamica Pax & K.Hoffm.	Moist deciduous	Small tree	Sub-Himalayan tract, Khasi hills Assam, Central province Myanmar, Bangladesh, Chotanagpur region.
Urticaceae			
Ficus foveolata Wall. Ex Miq.	Moist deciduous	Climber	Eastern foot hills, khasi hills, Bangladesh, Myanmar, China, and Japan Chotanagpur.
Ficus glaberrima Blum.	Moist deciduous	Large tree	Sub-Himalayan tract, Central Province, Western Peninsula, Myanmar, Bangladesh, Assam, Andamans, Malaya.
Ficus tomentosa Roxb.	Mixed deciduous	Large tree	Central province Western Peninsula Chotanagpur region.
Ficus microcarpa Linn.f.	Moist deciduous	Tree	Sub-Himalayan tract, Assam, Khasi hills Bangladesh, Myanmar, Sri Lanka, Andaman

forests. The habit and habitat of the recorded taxa show that most of them grow in the mixed deciduous forests of the Himalayan foothills, Central India and the adjoining area of Mahuadanr Valley. This indicates that same flora is still persisting today and that the climate has not changed markedly in the area since the late Tertiary time.

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