Some more leaf-impressions from the Himalayan foot-hills of Darjeeling District, West Bengal, India

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In the present paper five well-preserved leaf-impressions collected from the Siwalik sediments of Sevok Road cutting and Ramthi River sections in Darjeeling District, West Bengal have been described. These are *Xanthophyllum mioflavescens* sp. nov., *Pterospermum siwalicum* sp. nov., *Swintonia miocenica* Awasthi & Prasad, *Millettia oodlabariensis* sp. nov., and *Glochidion* (= *Phyllanthus*) *palaeohirsutum* sp. nov. showing close resemblance with the extant taxa *Xanthophyllum flavescens* Roxb., *Pterospermum semi-sagittatum* Ham., *Swintonia floribunda* Griff., *Millettia albiflora* Prain and *Glochidion hirsutum* Muell. of the families Xanthophyllaceae, Sterculiaceae, Anacardiaceae, Fabaceae and Euphorbiaceae, respectively. The presence of these elements in the Siwalik sediments further suggests the prevalence of tropical humid climate in the region during sedimentation.

Key-words —Leaf-impressions, Morphotaxonomy, Xanthophyllaceae, Sterculiaceae, Anacardiaceae, Fabaceae, Euphorbiaceae, Lower Siwalik (India).

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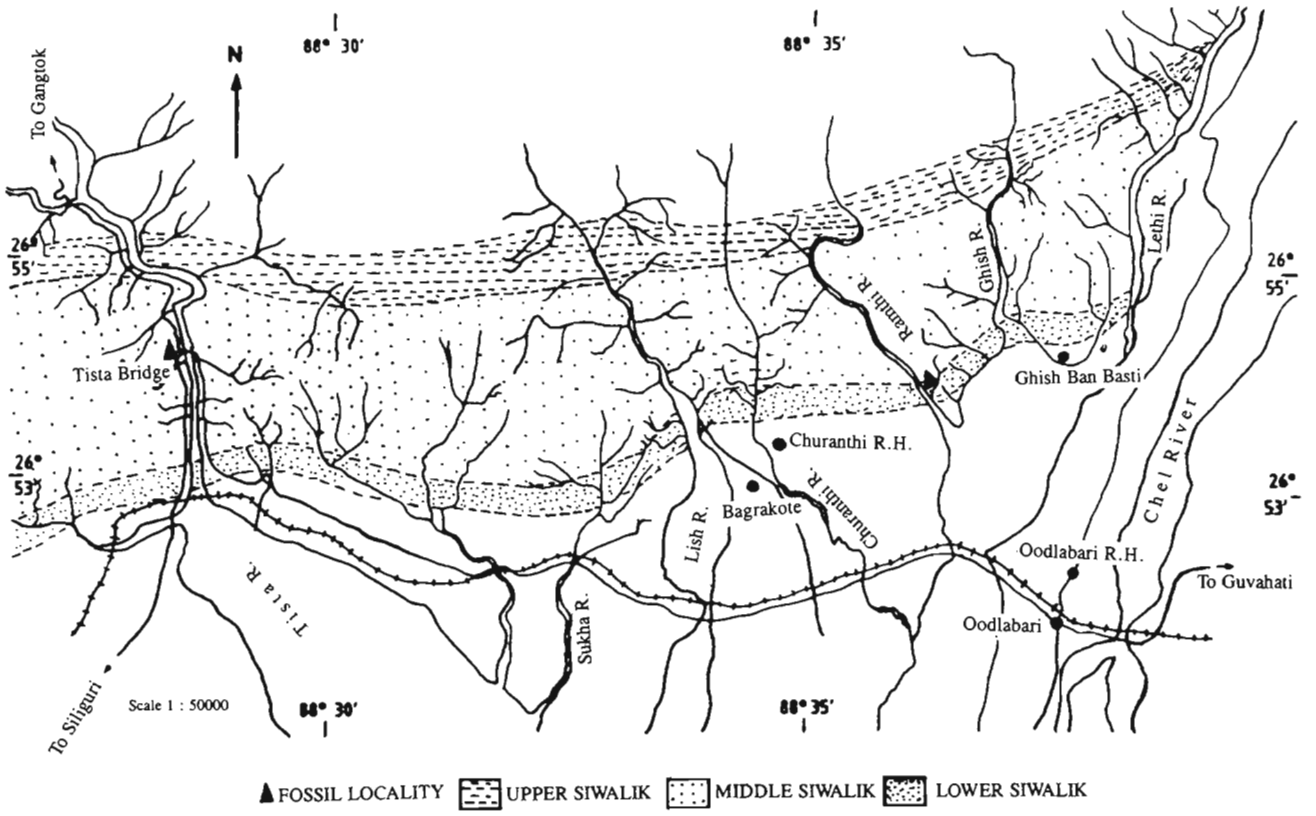
सारांश

पश्चिम बंगाल (भारत) में दार्जिलिंग जनपद के हिमालयी गिरि-पादों से कुछ पर्ण-छाप

जसवन्तसिंह अन्तल एवं महेश प्रसाद

प्रस्तुत शोध-पत्र में पश्चिम बंगाल के दार्जिलिंग जनपद में सिवक रोड़ कटान एवं रामठी नदी के खंडों के शिवालिक अवसादों से प्राप्त पाँच सुपरिरक्षित पर्ण-छापों का वर्णन किया गया है। इन्हें *जैन्थोफिल्लम् मायोफ्लेवेसेन्स* नव जाति, *टेरोस्पर्मम शिवालिकम्* नव जाति, *स्विन्टोनिआ मायोसेनिका* अवस्थी व प्रसाद, *मिलेशिआ ऊदलाबाड़ीयेन्सिस* नव जाति तथा *ग्लोकीडिऑन (फिल्लेन्थस) पेलियोहिर्सुटम्* नव जाति से नामाँकित किया गया है जो वर्तमान *जैन्थोफिल्लम् फ्लेवेसेन्स* राक्स., *टेरोस्पर्मम् सेमीसेजीटेटम* हेम., *स्विन्टोनिआ फ्लोरिबंडा* ग्रिफ., *मिलेशिआ एल्बिफ्लोरा* प्रेन एवं *ग्लोकिडिआन हिर्सुटम्* मुएॅल. से घनिष्ठता प्रदर्शित करती हैं तथा क्रमशः जैन्थोफिल्लेसी, स्टरकुलिएसी, एनाकार्डिएसी, फैबेसी एवं यूफोर्बिएसी नामक कुलों से सम्बद्ध हैं। शिवालिक अवसादों में इन वर्गकों की उपस्थिति से इस क्षेत्र में अवसादन के समय उष्णकटिबन्धीय नम जलवायु का होना इंगित होता है।

THE Siwalik sediments exposed along Sevok Road cutting and on the banks of Ramthi River, a tributory of Tista River in Darjeeling District, West Bengal are rich in angiospermous plant megafossils comprising fossil woods, leaf-impressions, fruits, seeds, etc. So far, a number of leaf-impressions resembling the extant genera *Polyalthia* (Anonaceae), *Shorea* (Dipterocarpaceae), *Bouea* and *Nothopegia* (Anacardiaceae), *Millettia*, *Pongamia* and *Bauhinia* (Fabaceae), *Combretum* (Combretaceae), *Randia* (Rubiaceae) and *Cinnamomum* (Lauraceae) are known from Ramthi River sections (Antal & Awasthi, 1993; Antal & Prasad, 1996; Antal *et al.*, 1996). The present study on the leaf-impressions collected recently from the Lower Siwalik localities (Map 1) reveals the occurrence of some new elements, viz., *Xanthophyllum mioflavescens* sp. nov., *Pterospermum siwalicum* sp. nov., *Swintonia miocenica* Awasthi & Prasad 1990, *Millettia oodlabariensis* sp. nov. and *Glochidion palaeohirsutum* sp. nov. They have been described and discussed in this communication.



Map 1—Geological map of the area (after Misra, 1984).

All the specimens have been deposited in the Museum of Birbal Sahni Institute of Palaeobotany, Lucknow

SYSTEMATIC DESCRIPTION

Family — Xanthophyllaceae

Genus — *Xanthophyllum* Roxb.

Xanthophyllum mioflavescens sp. nov.

Pl. 2, fig. 3; Pl. 3, fig. 6

This species is based on a single specimen.

Description—Leaf simple, symmetrical, narrow elliptic, preserved size 6.2 x 3.4 cm; apex broken; base acute, equilateral; margin entire; texture semi-coriaceous; venation pinnate, eucamptodromous; primary vein single, moderate, almost straight, prominent; secondary vein four pairs visible, basal secondaries closely placed, rising upward along the margin for some distance, angle of divergence 45° to 50°, moderate, uniformly curved up and joining superadjacent secondaries, alternate, 0.3 to 2.8 cm apart, seemingly unbranched; intersecondary veins present, simple to composite; tertiary veins fine, angle of origin usually RR, pattern percurrent, straight to sinuous, branched, oblique to right angle in relation to midvein, predominantly alternate, usually close.

Holotype—Museum no. BSIP 37558.

Locality—Right bank of the upstream (about 2 km) of Ramthi River near Oodlabari, Darjeeling District, West Bengal.

PLATE 1

All figures are of natural size unless otherwise mentioned.

1-3. *Pterospermum siwalicum* sp. nov. — Fossil leaves showing shape, size and venation pattern.

4. *Pterospermum semi-sagittatum* — Modern leaf with similar shape, size and venation pattern.

PLATE 1

Horizon—Lower Siwalik.

Affinities—The characteristic features of the fossil leaf are narrow elliptic shape, eucamptodromous venation, closely placed basal secondaries, distantly placed middle secondaries and percurrent tertiary veins. A survey of modern plants indicates that similar leaves are found in the genus *Xanthophyllum* Roxb. of the family Xanthophyllaceae. In order to find out the nearest resembling species, leaves of about 13 modern species of this genus were examined. Amongst them, the leaves of *X. flavescens* Roxb. (F.R.I. Herbarium sheet no. 77114; Pl. 2, fig. 4) show closest affinity with the present fossil leaf.

Awasthi (1987) has described a fossil wood of *Xanthophyllum* resembling the same species, *X. flavescens* from the Cuddalore Sandstone near Pondicherry, which obviously shows its wider distribution in India during Tertiary Period.

So far, there is no record of fossil leaves of *Xanthophyllum* Roxb. from the Tertiary sediments of India and Nepal. Therefore, it has been described as *X. mioflavescens* sp. nov.

Xanthophyllum flavescens Roxb., with which the fossil leaf shows closest resemblance, is a large evergreen tree found to grow in the evergreen forests of eastern Bengal, Myanmar, south India, Sri Lanka up to 1,300 m, Sumatra and Java (Gamble, 1972; Hooker, 1872).

Family — Sterculiaceae

Genus — *Pterospermum* Schreb.

Pterospermum siwalicum sp. nov.
Pl. 1, figs 1-3

It consists of four specimens but all are incomplete.

Description—Leaf simple, symmetrical, seemingly lanceolate, preserved size 11 x 4.8 cm, 7 x 4.8 cm, 9 x 4.5 cm, 8 x 4.3 cm; apex acute; base broken; margin entire; texture coriaceous; venation pinnate; eucamptodromous; primary vein single, prominent, stout, almost straight; secondary veins five pairs visible, opposite to alternate, 2 to 3.5 cm apart, uniformly curved up joining to superadjacent secondaries, angle of divergence 40°-60°, upper secondaries arise with more angle of divergence, seemingly unbranched, intersecondaries not seen; tertiary veins fine with angle of origin RR, pattern percurrent, usually simple sometimes nearly curved to sinuous, branched, oblique to right angle in relation to midvein, close to distant; quaternary veins very fine arising usually at right angle forming rectangular to polygonal meshes.

Holotype—Specimen no. BSIP 37559.

Paratypes—Specimen nos. BSIP 37560-37562.

Locality—Right bank of the upstream (about 2 km) of Ramthi River near Oodlabari, Darjeeling District, West Bengal.

Horizon—Lower Siwalik.

Affinities—Shape, size and venation pattern of the present fossil leaves indicate its close resemblance with the modern leaves of *Pterospermum semi-sagittatum* Ham. (F.R.I. Herbarium sheet no. 39A, Pl. 1, fig. 4) of the family Sterculiaceae. Unfortunately, the basal part of the leaf could not be recovered.

As far as the authors are aware, there is only one record of the fossil leaf, *P. palaeoheyneanum* Antal & Awasthi 1993, from Ghish River Section near Oodlabari, Darjeeling District, West Bengal. The present fossil leaves differ from the above known species both in shape and venation pattern and therefore has been described as *P. siwalicum* sp. nov. However, a fossil wood of *Pterospermum* is also known from the Pliocene beds of Mothala in Kutch District, western India (Awasthi *et al.*, 1980). This obviously indicates the existence of this genus during the Tertiary Period.

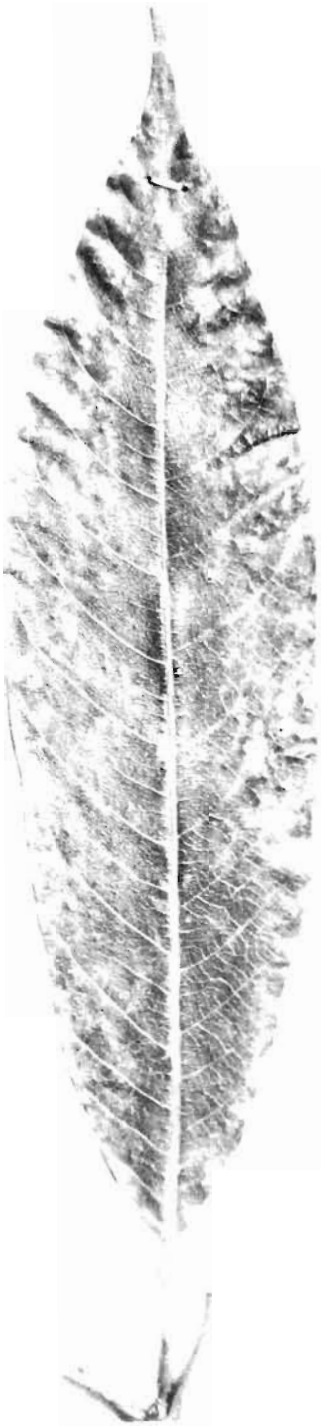
The modern comparable species *P. semi-sagittatum* Ham. is a large handsome deciduous tree growing in the forest of Chittagong hill tracts and

PLATE 2 →

All figures are of natural size unless otherwise mentioned.

1. *Swintonia miocenica* Awasthi & Prasad — Fossil leaf showing shape, size and venation pattern.
2. *Swintonia floribunda* — Modern leaf with similar shape, size and venation pattern.
3. *Xanthophyllum mioflavescens* sp. nov. — Fossil leaf showing shape, size and venation pattern.
4. *Xanthophyllum flavescens* — Modern leaf with similar shape, size and venation pattern.
5. *Swintonia miocenica* Awasthi & Prasad — A part of fossil leaf (fig. 1) magnified to show details of venation x 2.

1



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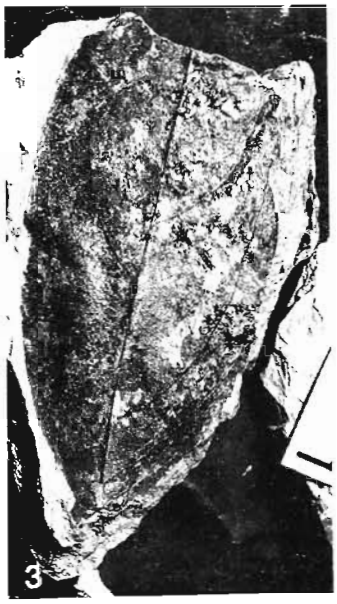

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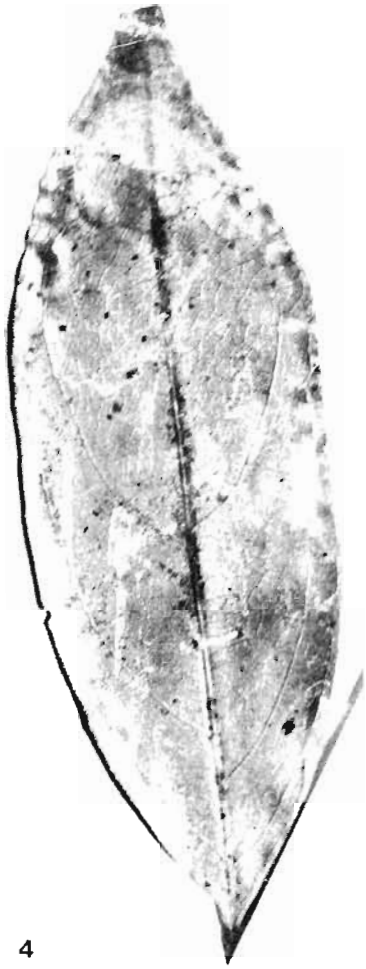

4

5

PLATE 2

Upper and Lower Myanmar, sometimes planted in other parts of India (Gamble, 1972; Brandis, 1971).

Family — Anacardiaceae

Genus — *Swintonia* Griff.

Swintonia miocenica Awasthi & Prasad 1990
Pl. 2, figs 1, 5

This species is based on two almost complete and well preserved specimens, of which one is with counter part.

Description—Leaf simple, symmetrical, narrow elliptic, preserved size 16.5 x 5.4 cm; apex slightly broken; base acute, normal; margin entire; texture thick, chartaceous; petiole not visible; venation pinnate, eucamptodromous; primary vein single, prominent, stout, slightly curved; secondary veins 15 pairs visible, angle of divergence about 60°, 0.6 to 1.8 cm apart, alternate to sub-opposite, uniformly curved up, unbranched, intersecondary veins present, frequent, simple to composite; tertiary veins fine with angle of origin AR-RO, percurrent, branched, oblique in relation to midvein, alternate to opposite and close.

Specimen—Museum nos. BSIP 37563 and 37563A.

Locality—Sevok road section on the left bank of Tista River (near Tista Bridge), Darjeeling District, West Bengal.

Horizon—Lower Siwalik.

Affinities—The important diagnostic features of the present fossil leaf such as narrow elliptic shape, entire margin, eucamptodromous venation, presence of frequent intersecondaries and course of secondaries and tertiaries strongly indicate its close affinity with the leaves of extant genus *Swintonia* Griff. of the family Anacardiaceae. After critical examination of various modern species of *Swintonia*, it has been found that the leaves of *Swintonia floribunda* Griff. (F.R.I. Herbarium sheet no. 5595; Pl. 2, fig. 2) show closest similarity with the present fossil leaf in all morphological features.

Awasthi and Prasad (1990) have described a fossil leaf — *Swintonia miocenica* from the Siwalik sediments of Surai Khola beds, western Nepal showing its close resemblance with *S. floribunda*. The present fossil leaf is also similar to the specimen of Awasthi and Prasad (1990) and hence has been placed under the same species.

The extant taxon *Swintonia floribunda* Griff., with which the fossil shows close resemblance, is a lofty and glabrous tree growing in the evergreen forests of Chittagong Hills, Pegu Yoma, Martaban and Tenasserim. It is common near the coasts but also inland, common on the hills east of Toungoo at about 650 m (Brandis, 1971).

Family — Fabaceae

Genus — *Millettia* Wt.

Millettia oodlabariensis sp. nov.
Pl. 3, fig. 1

This species is represented by a single specimen.

Description—Leaf simple, symmetrical, narrow elliptic to lanceolate, preserved size 14.3 x 3.5 cm; apex slightly broken; base wide acute, slightly inequilateral; margin entire; texture coriaceous; petiole not preserved; venation pinnate, eucamptodromous to brochido-dromous; primary vein single, prominent, stout, slightly curved in apical portion; secondary veins 11 pairs visible, less than 0.3 to 1.7 cm apart, angle of divergence 60° to 75°, moderate to wide acute, uniformly curved up, secondaries in apical portion join to superadjacent secondaries forming loops, mostly alternate but sometime opposite to subopposite, seemingly unbranched, intersecondary veins present; tertiary veins fine, angle of origin usually RR, percurrent, sometimes curved, branched oblique in relation to midvein, predominantly alternate and close, further details could not be seen.

PLATE 3 →

All figures are of natural size unless otherwise mentioned.

1. *Millettia oodlabariensis* sp. nov. — Fossil leaf showing shape, size and venation pattern.
2. *Millettia albiflora* — Modern leaf with similar shape, size and venation pattern.
3. *Glochidion palaeohirsutum* sp. nov. — Fossil leaf showing shape, size and venation pattern.
4. *Glochidion hirsutum* — Modern leaf with similar shape, size and venation pattern.
5. *Glochidion palaeohirsutum* sp. nov. — A part of fossil leaf magnified to show details of venation x 2.3.
6. *Xanthophyllum mioflavescens* sp. nov. — A part of fossil leaf magnified to show details of venation x 3.

PLATE 3

Holotype—Specimen no. BSIP 37564.

Locality—Sevok road cutting section on the left bank of Tista River (near Tista Bridge), Darjeeling District, West Bengal.

Horizon—Lower Siwalik.

Affinities—The important distinguishing features of the fossil leaf are narrow elliptic shape, wide acute, slightly inequilateral base, eucamptodromous to brochidodromous venation, presence of intersecondary veins and percurrent tertiaries. These features collectively indicate that the present fossil leaf shows its affinity with the leaves of extant genus *Millettia* of the family Fabaceae. A critical examination of the modern leaves of about 14 species of the genus was done and found that the modern leaf of *M. albiflora* Prain (F.R.I. Herbarium Sheet no. 66114; Pl. 3, fig. 2) shows closest resemblance with the present fossil leaf.

As far as the authors are aware, there are 10 records of the fossil leaves resembling the genus *Millettia* from all over the world (Prasad, 1994, p. 75). Of them, *M. koilabasensis* Prasad 1990a, *M. siwalica* Prasad 1990b and *M. miobrandisiana* Prasad 1994 are known from Nepal Siwaliks, while *M. palaeoracemosa* Awasthi & Prasad 1990 is known from both Nepal Siwaliks and the Siwalik sediments of Nainital, India. The present fossil leaf was compared with all above known species and found different from them. Hence, it has been reported under a new specific name *M. oodlabariensis* sp. nov.

Millettia albiflora Prain with which the fossil shows closest resemblance is a tall evergreen tree distributed in Petaling, Kalanghats, Mallucca, Maingay, Perak, Selangor, etc. in the Malayan region (Ridley, 1967).

Family — Euphorbiaceae

Genus — *Glochidion* Forst.

Glochidion palaeohirsutum sp. nov.
Pl. 3, fig. 3

This species is represented by only one specimen.

Description—Leaf simple, asymmetrical, narrow ovate to elliptic, preserved size 9 x 3.8 cm; apex seemingly wide acute; base slightly broken, seemingly obtuse; margin entire, slightly undulate; texture chartaceous; petiole not preserved; venation pinnate, eucampto-dromous to brochidodromous; primary vein single, prominent, stout, slightly curved; secondary veins 8 pairs visible, angle of divergence 60°-75°, wide acute, 0.6 to 2 cm apart, uniformly curving up and joining to their superadjacent secondaries, alternate to subopposite, in apical portion form prominent loops, unbranched; tertiary veins fine with angle of origin RR, pattern percurrent, straight to sinuous, sometimes curved, rarely branched, oblique to right angle in relation to midvein, alternate to opposite, close to nearly distant; quaternary veins still fine, arising at right angle from the tertiary veins forming usually rectangular meshes.

Holotype—Specimen no. BSIP 37565.

Locality—Right bank of the upstream (about 2 km) of Ramthi River near Oodlabari, Darjeeling District, West Bengal.

Horizon—Lower Siwalik.

Affinity—Asymmetric, narrow ovate to elliptic shape, slightly undulate margin, wide acute apex, obtuse base and the orientation of secondary and tertiary veins suggest that the present fossil leaf resembles the modern leaf of the genus *Glochidion* Forst. of the family Euphorbiaceae.

In order to find out the nearest comparable species, herbarium sheets of 22 modern species of the genus were consulted and it has been found that the present leaf shows closest resemblance with *Glochidion* (=*Phyllanthus*) *hirsutum* Muell. (F.R.I. Herbarium sheet no. 16686; Pl. 3, fig. 4).

So far, a fossil leaf resembling the genus *Glochidion* has been described as *G. miocenica* Prasad 1994 from the Siwalik sediments of Kathgodam, Nainital District, Uttar Pradesh. On comparison it has been found different from the above species and hence is being described as *G. palaeohirsutum* sp. nov.

Dalvi and Kulkarni (1983) reported a leaf cuticle of *Glochidion malabaricum* Bedd. from the lignite beds of Ratnagiri, Maharashtra.

The modern comparable species *G. hirsutum* Muell. is a middle sized evergreen tree growing in the sub-Himalayan tract from Sikkim eastwards, Assam, Khasi Hills, Cachar, Chittagong, Andamans and Malaya Peninsula.

DISCUSSION

The fossil taxa recorded here from the foot-hills of Darjeeling District, West Bengal show their close resemblance with the extant taxa *Xanthophyllum flavescens* (Xanthophyllaceae), *Pterospermum semi-sagittatum* (Sterculiaceae), *Swintonia floribunda* (Anacardiaceae), *Millettia albiflora* (Fabaceae) and *Glochidion hirsutum* (Euphorbiaceae). These taxa occur now-a-days in the tropical evergreen to moist deciduous forests of north-east India, Myanmar and Malayan regions (Brandis, 1971; Hooker, 1872, 1878, 1885; Ridley, 1967) indicating the prevalence of warm and humid conditions during the deposition of these sediments in the area. Of these five taxa, three, viz., *Xanthophyllum flavescens*, *Millettia albiflora* and *Glochidion hirsutum* are found to grow both in north-east India (Bengal, Assam, Manipur), Myanmar and Malayan region. The remaining two taxa—*Pterospermum semi-sagittatum* and *Swintonia floribunda* are presently distributed in north-east India, Myanmar and Bangla Desh. This obviously suggests the exchange of floral elements between India and Malaya Peninsula through Myanmar during Miocene.

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