Late Tertiary flora of Mahuadanr Valley, Latehar District, Jharkhand, India

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ABSTRACT

Singh S. K. & Prasad M. 2010. Late Tertiary flora of Mahuadanr Valley, Latehar District, Jharkhand, India. Geophytology 38(1-2): 45-55.

The present study on the dicot leaf impressions collected from the Late Tertiary sediments of Mahuadanr Valley reveals the occurrence of some new fossil leaves which have been identified with the extant species *Sterculia versicolor* Wall. (Sterculiaceae), *Grewia salvifolia* Heyne (Tiliaceae), *Aegle marmelos* Correa. (Rutaceae), *Desmodium cephalotus* Wall., *D. gangeticum* DC., *Millettia pubinervis* Kurz (Fabaceae) and *Lagerstroemia parviflora* Roxb. (Lythraceae). Present day distribution of modern comparable species of the fossils indicates that almost all the taxa grow in mixed deciduous forests of the Himalayan foot hills, Central India, South India as well as in the adjoining area of the Mahuadanr Valley which suggests that such type of forest was flourishing in and around the fossil locality during the sedimentation.

Key-words: Leaf impressions, dicotyledons, morphotaxonomy, Late Tertiary, Mahuadanr, forest type, Jharkhand (India).

INTRODUCTION

The fossil locality Mahuadanr Valley (84° 06′ N: 23° 23′ E) is located in the Chhotanagpur plateau region of Latehar District, Jharkhand. The Late Tertiary sediments are exposed on the bank of the Birha River between Rajdanda and Mahuadanr villages. The rocks are pyroclastics, conglomerates, sandstone and shales.

Based on fossil fishes and birds Puri and Mishra (1982) have suggested Late Tertiary age to this section and also inferred a fresh-water ponding depositional environment. A large number of fossil leaves, flowers, fruits and silicified woods were recorded from here (Prakash et al. 1988, Bande & Srivastava 1990, Srivastava & Bande 1992, Srivastava et al.1992, Srivastava & Srivastava 1998, Singh and Prasad 2007, 2008, 2009). Present investigation on the leaf impressions collected from Mahuadanr Valley reveals the occurrence of seven new taxa of dicotyledonous families.

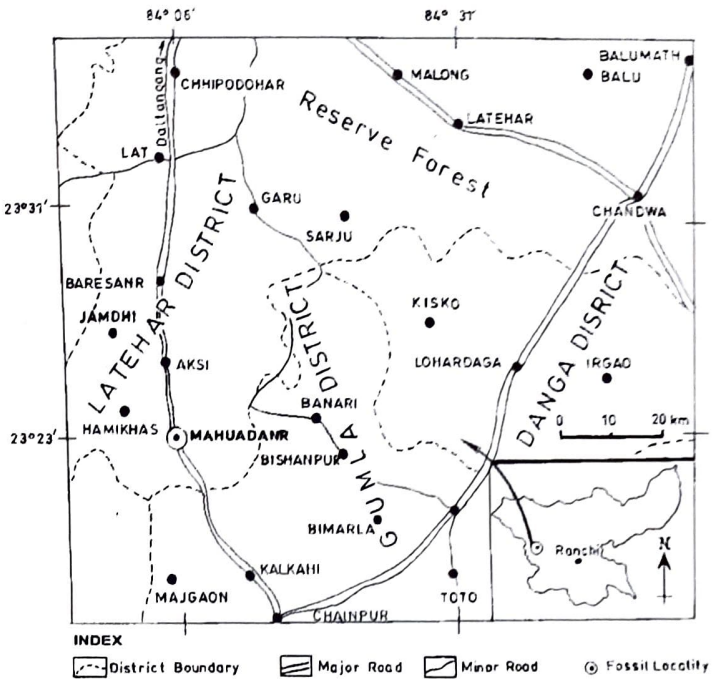
MATERIAL AND METHOD

The fossil leaf impressions were collected from the Upper Tertiary sediments exposed along the Birha River and its tributary Jhumari nala near Mahuadanr in Latehar District, Jharkhand. (Text-figure 1). The leaf impressions are well preserved on brown shales and mostly devoid of cuticles. These were studied with the help of low power microscope under reflected light. Their identification has been done through the consultation of a number of herbarium sheets of extant taxa at the Central National Herbarium, Shibpur, Howrah, West Bengal. For the description of leaf impressions, the terminology given by (Hickey 1973) and (Dilcher 1974) has been followed. All the figured specimens and their negatives are kept in the Museum, Birbal Sahni Institute of Palaeobotany, Lucknow.

SYSTEMATIC DESCRIPTION

Family: Sterculiaceae

Genus: *Sterculia* Linn.



Text-figure 1. Map showing location of the area of study.

Sterculia versicolor Wall.

Plate 1, figures 1-2, 4

Material: A single specimen with counter part.

Description: Leaf simple, narrow elliptic; preserved size 10.2 x 4.0 cm; apex broken, base acute, slightly asymmetrical, texture chartaceous, margin entire, venation pinnate, craspedodromous to eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) about 23 pairs visible, 0.2 to 0.7 cm apart, alternate to opposite, angle of divergence acute about 65°-70°, uniformly curved up, unbranched, moderate, sometimes joined to their superadjacent secondary vein, inter secondary veins present, rare, simple; tertiary veins (3°) fine, angle of origin RR, percurrent, straight to sometime sinuous, oblique in relation to midvein, predominantly alternate, close.

Affinity: Acute base, entire margin, craspedodromous to eucamptodromous venation, moderately acute angle of divergence of secondary veins, rare occurrence of intersecondary veins and RR, percurrent, straight to sinuous and close tertiary veins suggest affinity of the fossil leaf with the extant leaves of *Sterculia versicolor* Wall. of the family Sterculiaceae (C. N. H. Howrah, Herbarium sheet No. 75449; Plate1, figure 3). Five fossil leaves resembling the genus *Sterculia* Linn. have been known from the Tertiary sediments of India & Nepal. These are *S. kathgodamense* Prasad (1994a) from the Siwalik sediments of Kathgodam, Uttarakhand, *S. mioensifolia* and *S. premontana* from Siwalik sediments of Suraikhola area, Nepal (Prasad & Pandey 2008), *S. urens* Roxb. and *S. villosa* Roxb. from the Late Tertiary sediments of Mahuadanr Valley (Bande & Srivastava 1990, Singh & Prasad 2007). The above mentioned fossil leaves have been compared with the present fossil and it was found that none of them matched with it. They mostly differ in having less numbers of secondary veins as compared to the present fossil.

Present day distribution: The genus *Sterculia* Linn. includes about 150 species (Mabberley 1997). *Sterculia versicolor* Wall. is a tree found to grow in Myanmar on limestone rocks, by the bank of Irrawaddy near Segaen (Hooker,1872).

Figured specimen: 39632a, 39632b

Family: Tiliaceae

Genus: *Grewia* Linn.

Grewia salvifolia Heyne.

Plate 2, figure 8; Plate 3, figure 7

Material: Single, well preserved, somewhat incomplete leaf impression.

Description: Leaf simple, asymmetrical at basal region; narrow elliptic, preserved size 4.1 x 1.6 cm; apex broken, base obtuse, asymmetrical, margin almost entire; texture chartaceous; petiole preserved, very short, swollen, venation pinnate, seemingly eucamptodromous; primary vein (1°) single, stout, thinner towards apex, straight; secondary veins (2°) only 2 pairs visible, 3.3 cm apart, basal pairs arise at

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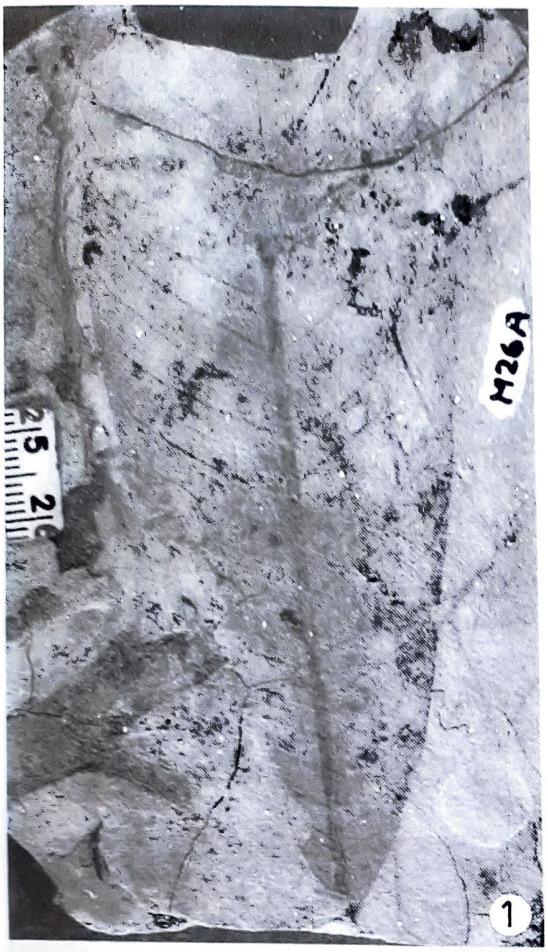
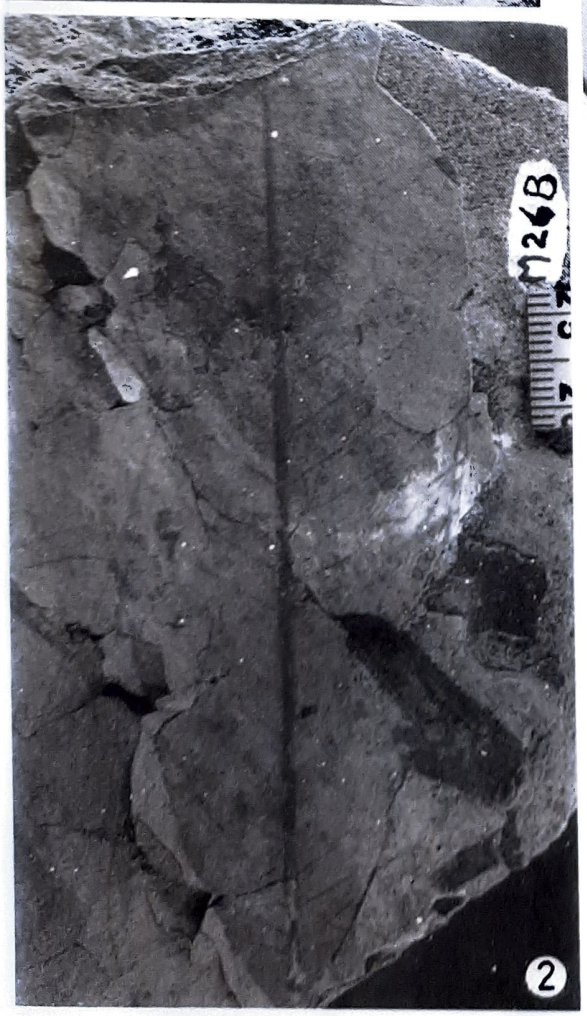
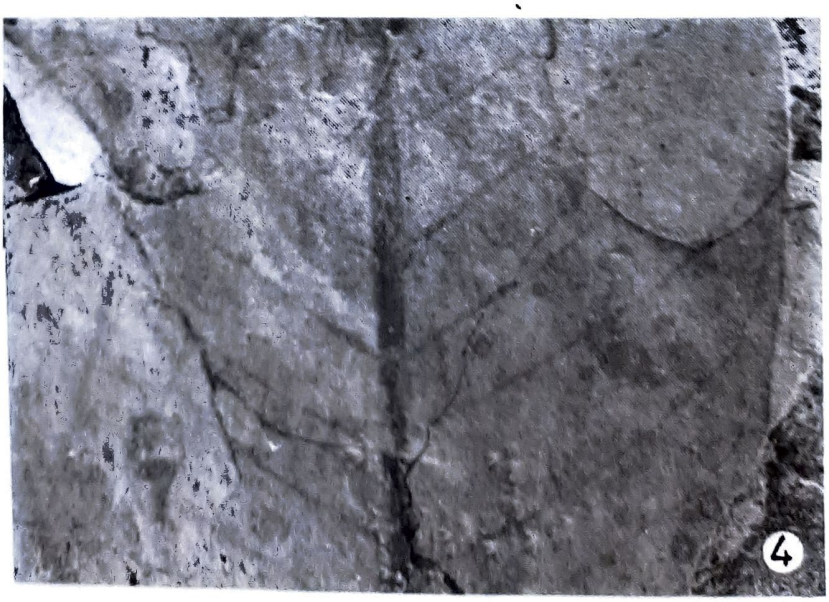
Plate 1

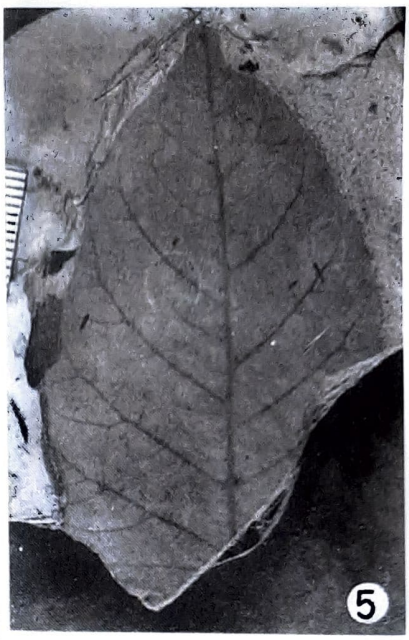
All figures are of natural size, unless otherwise mentioned.

1-4. *Sterculia versicolor* Wall. 1. Fossil leaf, BSIP specimen no. 39632a. 2. Counterpart of the same specimen, BSIP specimen no. 39632b. 3. Modern leaf. 4. Venation details of fossil leaf, x2. 5-6. *Desmodium cephalotus* Wall. 5. Fossil leaf, BSIP specimen no. 39633. 6. Modern leaf.









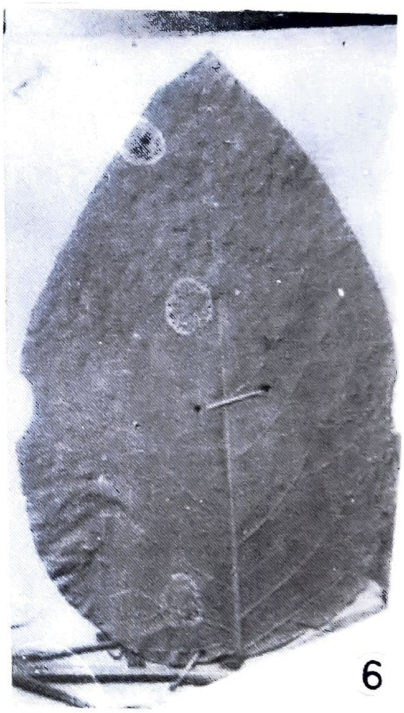


Plate 1

base and run upwards to the apical part of leaf. Basal secondary branched towards margin at about 80°; tertiary veins (3°) fine, poorly preserved, prominent, RR, percurrent, almost straight, seemingly unbranched, alternate, close to distant, right angle in relation to midvein, predominantly alternate. Further details could not be seen.

Affinity: The diagnostic features of the present fossil leaf, such as elliptic shape, obtuse base, swollen petiole, eucamptodromous venation, stout primary vein, and percurrent, RR and close to distant tertiary veins indicate that the present fossil leaf shows close resemblance with the modern leaves of the genus *Grewia* Linn. of the family Tiliaceae. In order to find out its specific affinity, the herbarium sheets of all the available species of this genus were critically examined and it was concluded that the leaves of *Grewia salvifolia* Heyen (C. N. H. Howrah, Herbarium sheet No. 2042; Plate 3, figure 8) show close similarity with the fossil leaf in shape, size and venation pattern.

So far, seven fossil leaves showing close resemblance with the genus *Grewia* Linn. are known from Tertiary sediments of India and Nepal. These are listed in Table 1. These fossil leaves have been compared with the present fossil leaf and found that all of them are comparatively bigger than the present fossil leaf. The number of secondary veins are also less in the present fossil leaf as compared to known fossil leaves.

Present day distribution: The genus *Grewia* Linn. comprises about 150 species. (Mabberley 1997). *Grewia salvifolia* Heyne with which the present fossil shows affinity is a small tree found to grow in dry and arid region of north - west India and the Deccan (Brandis 1971). It is also common in Punjab, Sind, Rajasthan, Meghalaya and central and southern India (Gamble 1972).

Figured specimen: 39638.

Table 1. Fossil leaves of the genus *Grewia* Linn. from the Tertiary sediments of India and Nepal.

Species	Fossil locality and horizon age	References
Grewia ghishia	Siwalik sediments of Ghish River, West Bengal	Antal & Awasthi 1994
G. tistaensis	Siwalik sediments Sevok Road, West Bengal	Antal & Prasad 1999
G. tiliaefolia	Late Tertiary sediments of Mahuadanr Valley, Jharkhand	Srivastava et. al. 1992
G. mallotophylla	Siwalik sediments of Arungkhola, West Nepal	Konomatsu & Awasthi 1999
G. sahnii	Tura Formation, Meghalaya	Mehrotra 2000
G. garoensis	Tura Formation Meghalaya	Mehrotra 2000
G. kathodamensis	Siwalik sediments of Kathgodam, Uttarakhand	Prasad et al. 2004

Family: Rutaceae

Genus: *Aegle* Correa

Aegle marmelos Correa

Plate 3, figures 4, 6

Material: This is represented by a single, well preserved leaf impression without its basal part.

Description: Leaf simple, slightly asymmetrical due to unequal lobes; wide elliptic, preserved size 7.5 x 3.7 cm; apex attenuate, base broken, margin entire as well as slightly crenulate; texture thick chartaceous; venations pinnate, eucamptodromous to brochidodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) about 9 pairs visible, 0.5 - 1.1 cm apart, alternate to sub opposite, angle of divergence 55° - 60°, acute, uniformly curved up and joined to the superadjacent secondary at acute angle; intersecondry veins present, simple; tertiary veins (3°) poorly preserved, angle of origin RR - AO, percurrent, branched, almost straight, oblique in relation to midvein, alternate to opposite, close to distant.

Affinity: The main diagnostic features of present fossil leaf such as elliptic shape, attenuate apex, slightly crenulate margin, thick chartaceous texture, eucamptodromous to brochidodromous venation, acute angle of divergence of secondary veins, presence of

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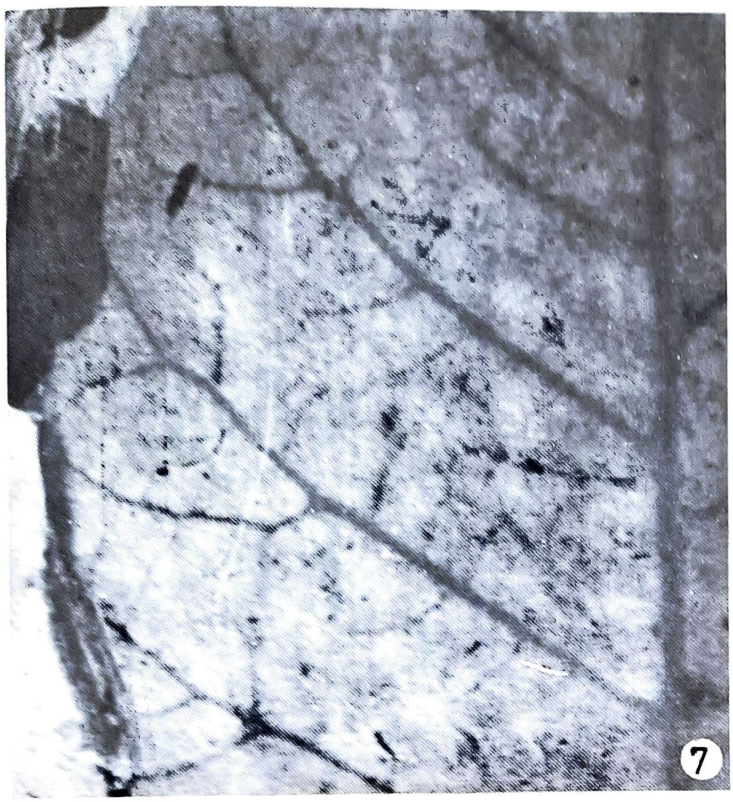
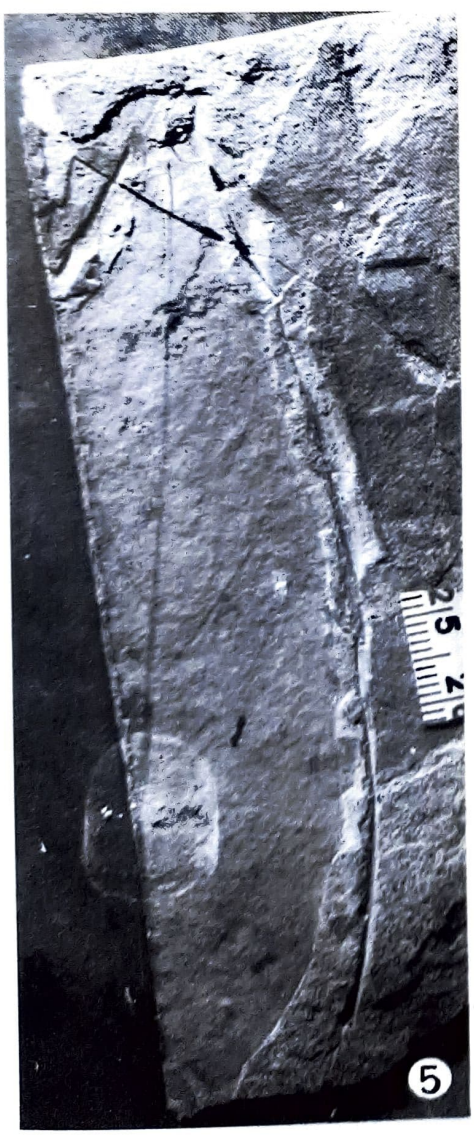
Plate 2

All figures are of natural size, unless otherwise mentioned.

1-2. *Millettia pubinervis* Kurz. 1. Fossil leaf, BSIP specimen no. 39634. 2. Modern leaf. 3-6. *Desmodium gangeticum* DC. 3. Fossil leaf, BSIP specimen no. 39635a. 4. Modern leaf. 5. Fossil leaf, BSIP specimen no. 39635b. 6. Modern leaf. 7. *Desmodium cephalotus* Wall. Venation details of fossil leaf, x3. 8. *Grewia salvifolia* Heyne. Venation details of fossil leaf near margin, x2.





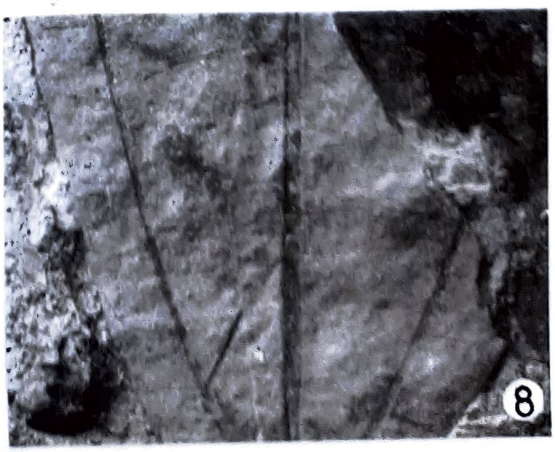


Plate 2

frequent intersecondary veins and RR – AO, percurrent, close to distant tertiaries indicate that the fossil leaf shows its affinity with the extant leaflets of genus *Aegle* of family Rutaceae. For its specific affinity all the available species of this genus were examined and it was found that the leaves of *Aegle marmelos* (C. N. H. Howrah, Herbarium sheet No. 7252; Plate 3, figure 5) come closest to present fossil leaf.

As far as the authors are aware, there is no record of fossil leaf of the genus *Aegle marmelos* from Tertiary sediments of India and abroad. The present specimen forms its first fossil record from the Mahuadanr Valley, Jharkhand.

Present day distribution: *Aegle marmelos* Correa is a small tree with thorny branches. It is found in sub-Himalayan forest from the Jhelum eastwards, central, south and western India. In Myanmar it grows in dry forest (Gamble 1972).

Figured specimen: 39637.

Family: Fabaceae

Genus: *Desmodium* Desv.

***Desmodium cephalotus* Wall.**

Plate 1, figure 5, Plate 2, figure 7

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

Description: Leaflet ovate, almost symmetrical, preserved size 6.6 x 3.7 cm; apex bluntly acute; base broken; margin entire; texture thick chartaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, straight; secondary veins (2°) 7-8 pairs visible, 0.7 to 1 cm apart, alternate to sub opposite, angle of divergence about 60°, moderate, uniformly curved up, branched, lower pairs of secondary veins give rise to 3-4 branches towards the margin, intersecondary veins present, common, simple; tertiary veins (3°) fine, fairly preserved, angle of origin AO, percurrent, straight to sinuous, oblique in relation to midvein, predominantly alternate, close to distant.

Affinity: The important distinguishing features of the present fossil leaflets are ovate, symmetrical shape, bluntly acute apex, entire margin, eucamptodromous venation, alternate to subopposite secondary veins with moderate angle of divergence, AO, percument tertiaries with oblique in relation to midvein. These features collectively indicate that the present fossil leaf shows its affinity with the leaves of extant genus *Desmodium* Desv.of the family Fabaceae. A critical examination of the modern leaflets of more than 50 species of this genus was carried out and it was concluded that the modern leaflets of *Desmodium cephalotus* (C. N. H. Howrah, Herbarium sheet No. 603; Plate 1, figure 6) show closest affinity with the present fossil.

There is only one record of fossil leaf showing close resemblance with the *Desmodium luxiflorum* Desv. from the same locality (Singh & Prasad 2009). This fossil leaf is entirely different from the present fossil leaf as it has many closely placed secondary veins.

Present day distribution: The genus *Desmodium* Desv. consists of about 450 tropical species (Mabberley 1997). *Desmodium cephalotus* Wall. is a large shrub which is found in sub-Himalanyan tract from Dehradun eastward, common in both peninsulas, (Brandis 1971). It is common in eastern Himalaya from Nepal to Assam, dry mixed forest of Myanmar, also in Savannah and north to the Kachin hills, in the teak forest of south India, (Gamble 1972).

Figured specimen: 39633.

***Desmodium gangeticum* DC.**

Plate 2, figures 3, 5

Material: This species is represented by two well preserved leaflets.

Description: Almost symmetrical, narrow elliptic; preserved size 10.8 x 4.0 cm, and 4.7 x 2.0 cm; apex acute; base slightly broken; margin entire; texture coriaceous; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost

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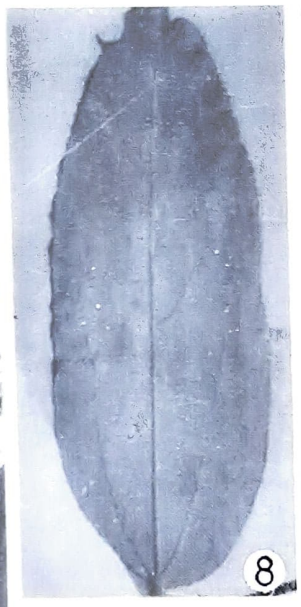
Plate 3

All figures are of natural size, unless otherwise mentioned.

1-3. *Lagerstroemia parviflora* Roxb. 1. Fossil leaf, BSIP specimen no. 39636. 2. Modern leaf. 3. Venation details of fossil leaf near margin, x3. 4-6. *Aegle marmelos* Correa. 4. Fossil leaf, BSIP specimen no. 39637. 5. Modern leaf. 6. Venation details of fossil leaf near margin, x3. 7-8. *Grewia salvifolia* Heyne. 7. Fossil leaf, BSIP specimen no. 39638. 8. Modern leaf. 9. *Desmodium gangeticum* DC. Venation details of fossil leaf, x2.



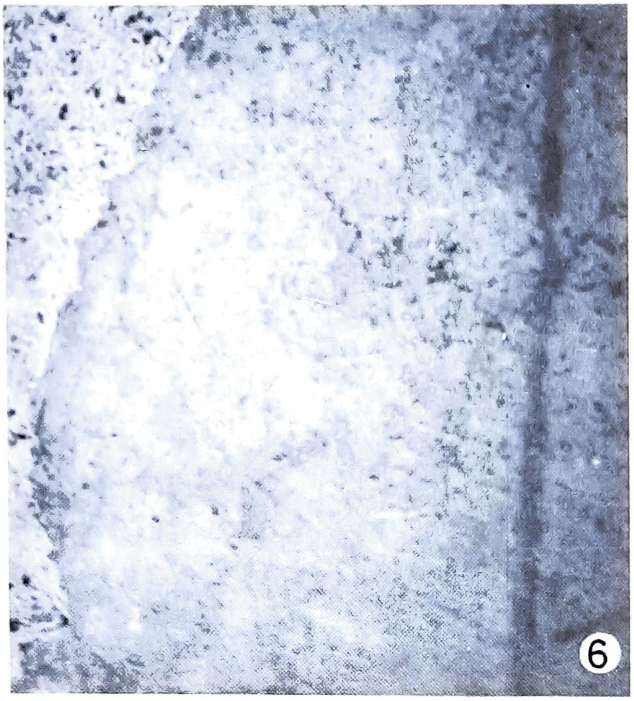


Plate 3

straight; secondary veins (2°) about 6 pairs, 0.3 to 1.4 cm apart, alternate to opposite, angle of divergence 60°-65°, moderate, uniformly curved up, seemingly unbranched; intersecondary veins not visible; tertiary veins (3°) fine, poorly preserved, angle of origin usually RR, percurrent, straight to slightly sinuous, branched, oblique in relation to midvein, predominantly alternate and close.

Affinity: The characteristic features of the present fossil leaflet are symmetrical, elliptic shape, acute apex, entire margin, coriaceous texture, eucamptodromous venation, moderate angle of divergence of secondary vein, RR, percurrent, straight to slightly sinuous tertiary veins. These features are commonly found in the extant leaflets of the genus *Desmodium* Desv. of the family Fabaceae. A number of extant species of this genus were examined and it was concluded that our fossil closely resembles *Desmodium gangeticum* DC. (C. N. H. Howrah, Herbarium sheet No. 14946; Plate 2, figures 4, 6).

The earlier known fossil *D. luxiflorum* described from the same locality (Singh & Prasad 2009) differs from the present fossil in possessing closely placed secondary veins. The other fossil leaf described in this text, *D. cephalotus* Wall., also differs from present fossil leaf in having ovate shape with frequently branched secondary veins.

Present day distribution: The modern comparable taxa *Desmodium gangeticum* DC. is found in Sub-Himalayan tract from the Jummu eastward, both Peninsulas, Sri Lanka, Java, Sumatra, Borneo and Philippines (Brandis 1971). It is also common in the forest of Chotanagpur region (Wood 1903).

Figured specimen: 39635a, 39635b.

Genus: *Millettia* W. & A.

***Millettia pubinervis* Kurz**

Plate 2, figure 1

Material: Single, complete leaf impression.

Description: Leaf symmetrical, oblanceolate; preserved size 7.2 x3.0 cm; apex acuminate; base acute; texture thick chartaceous; margin entire; petiole not preserved; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 7-8 pairs, 0.5-1.1 cm apart, alternate to sub opposite, uniformly curved up, angle of divergence 65°-70°, seemingly unbranched, moderate; inter secondary veins present, simple; tertiary veins (3°) fine, angle of origin usually RR, percurrent, straight to sinuous, oblique in relation to midvein, predominantly alternate, close.

Affinity: The diagnostic features of the present fossil leaf are oblanceolate shape, acuminate apex, chartaceous texture, eucamptodromous venation, moderate secondary veins and RR, percurrent tertiary veins. These features commonly occur in the extant leaves of the genus *Millettia* of the family Fabaceae. After critical examination of the herbarium sheets of all the available species of this genus, it has been found that the present fossil leaf shows closest similarity with the extant leaves of *Millettia pubinervis* in shape, size and venation pattern. (C. N. H. Howrah, Herbarium sheet No. 112242; Plate 2, figure 2).

About 30 fossil leaves resembling genus *Millettia* Wight & Arn. have been reported from the Tertiary sediments of India and abroad. They are listed in Table 2. The present fossil leaf has been compared with all the above known species and it has been noticed that the fossil leaf *M. ovatus* Tripathi et al. described from Siwalik sediments of Jarva near Koilabas is also compared with the same extant species, *M. pubinervis* as the present fossil but differs from present fossil leaf in being smaller size (3.5 x 2.5 cm). The other fossil leaves differ mainly either in shape, size or in the nature and orientation of secondary veins.

Present day distribution: The genus *Millettia* Wight & Arn. 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 *Millettia pubinervis* Kurz. is found growing in Upper Myanmar generally in deciduous forest on the edge of streams and hills of east Toungoo (Brandis 1971).

Figured specimen: 39634.

Family: Lythraceae

Genus: *Lagerstroemia* Linn.

***Lagerstroemia parviflora* Roxb.**

Plate 3, figures 1, 3

Table 2. Fossil leaves of the genus *Millettia* W. & A. from the Tertiary sediments of India and abroad.

Species	Fossil locality and horizon / age	References
Millettia impressa	Tertiary sediments of West Africa	Menzel 1920
M. notoensis	Middle Miocene sediments of Central Japan	Ishida 1970
Millettia sp.	Eocene of South-West Honshu, Japan	Huzioka & Takahashi 1970
M. asymmetrica	Miocene sediments of Kutch, Gujarat	Lakhanpal & Guleria 1982
M. miocenica	Miocene sediments of Kutch, Gujarat	Lakhanpal & Guleria 1982
M. koilabasensis	Siwalik sediments of Bhutan and Koilabas and Suraikhola, Nepal, Dafla Formation, Arunachal Pradesh	Prasad 1990b, Prasad & Tripathi 2000, Prasad & Pandey 2008, Srivastava & Mehrotra 2009
M. palaeoracemosa	Siwalik sediments of Suraikhola, Nepal and Kathgodam, Uttarakhand	Awasthi & Prasad 1990, Prasad 1994a
M. siwalika	Siwalik sediments of Koilabas, Nepal and Kathgodam, Uttarakhand	Prasad 1990a, Prasad 1994b
M. miobrandisiana	Siwalik sediments of Koilabas, Nepal	Prasad 1994c
M. imlibasensis	Siwalik sediments of Koilabas, Nepal	Prasad et al. 1999
M. churiensis	Siwalik sediments of Suraikhola, Nepal and Neyveli lignite (Miocene), Tamil Nadu	Prasad & Awasthi 1996, Agarwal 2002
M. oodlabariensis	Siwalik sediments of Darjeeling, West Bengal	Antal & Prasad 1996
M. kathgodamensis	Siwalik sediments of Kathgodam, Uttarakhand	Prasad et al. 2004
M. palaeopachycarpa	Neyveli lignite (Miocene), Tamil Nadu	Agarwal 2002
M. palaeocubithi	Siwalik sediments of Suraikhola, Nepal	Awasthi & Prasad 1990
M. ovatus	Siwalik sediments of Koilabas, Nepal	Tripathi et al. 2002
M. purniyagiriensis	Siwalik sediments of Tanakpur, Uttarakhand	Shashi et al. 2006
M. prakashii	Siwalik sediments of Tanakpur, Uttarakhand	Shashi et al. 2009
M. palaeomanii	Siwalik sediments of Koilabas, Nepal	Dwivedi et al. 2006
M. bilaspurensis	Siwalik sediments of Bilaspur, Himachal Pradesh	Prasad 2006
M. auriculata	Late Cenozoic sediments of Mahuadanr, Jharkhand	Bande & Srivastava 1990
M. indakabalaensis	Neogene sediments of Rajasthan	Mathur & Mathur 1998
M. singhii	Kasauli Formation, Himachal Pradesh	Mathur et al. 1996
Millettia sp.	Kasauli Formation, Himachal Pradesh	Mathur et al. 1996

Material: Single, well preserved leaf impression without its basal part.

Description: Leaf simple, symmetrical, narrow elliptic, preserved size 9.5 x3.0 cm; apex and base broken, seemingly acute; margin entire; texture chartaceous; venation pinnate, eucamptodromous; primary vein (1°) single, stout, almost straight; secondary veins (2°) 11-12 pairs visible, 0.6 to 1.2 cm apart, usually alternate; angle of divergence 65° -70°, wide acute to nearly right angle, uniformly curved up, unbranched; inter secondary veins present, frequent; tertiary veins (3°) moderate, angle of origin RR, percurrent, straight to sinuous, oblique to right angle in relation to midvein, predominantly alternate, close to nearly distant.

Affinity: Symmetrical, narrow-elliptic shape, entire margin, eucamptodromous venation, stout, straight, primary vein, alternate with wide acute angle of divergence of secondary vein, RR, percurrent, straight to sinuous tertiaries with right angle in relation to midvein indicate the resemblance of the fossil with the genus *Lagerstroemia* of the family Lythraceae. After detailed examination of the extant species of this genus it has been found that the present fossil leaf closely resembles the leaves of *Lagerstroemia parviflora* (C. N. H. Howrah, Herbarium sheet No. 554935; Plate 3, figure 2).

So far, five authentic fossil leaves resembling the genus *Lagerstroemia* Linn. have been described from the Tertiary sediments of India and Nepal. They are *Lagerstroemia patelii* from the Eocene of Kutch, Gujarat (Lakhanpal & Guleria 1982), Siwalik sediments of Darjeeling District, West Bengal, (Antal & Awasthi 1994), and Kathgodam, Uttarakhand (Prasad 1994a). *L. siwalica* from Siwalik sediments of Koilabas, Nepal (Prasad 1994c) 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. 2006).

Present day distribution: The genus

Lagerstroemia Linn. comprises about 53 species presently distributed in tropical regions 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).

Figured specimen: 39636.

CONCLUSION

The present investigation on the fossil leaf assemblage recovered from the Late Tertiary sediments of Mahuadanr Valley revealed the occurrence of seven angiospermous taxa, i.e. *Sterculia versicolor* Wall., *Grewia salvifolia* Heyne, *Aegle marmelos* Correa, *Desmodium cephalotus* Wall., *D. gangeticum* DC., *Millettia pubinervis* Kurz, *Lagerstroemia parviflora* Roxb. belonging to 5 dicotyledonous families. They are presently distributed in the tropical mixed deciduous forests of Himalayan foot hills and South India as well as adjoining area of Mahuadanr valley, Jharkhand. This indicates that there was an existence of tropical deciduous forest during Late Tertiary period in the region of low elevation.

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