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Fabaceous macro fossils from Siwalik foreland basin of Mandi district, Himachal Pradesh, India and their phytogeographic and climatic implications

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Abstract

A detailed investigation of the plant macrofossils (leaf impression, fruit, and seed) from the Middle Siwalik sediments of Sarkaghat, Mandi District, Himachal Pradesh, India, revealed the occurrence of four new fossil taxa comparable to *Mezoneuron hymenocarpum* W.&A. ex Prain, *Dialium indum* Linn., *Acacia caesia* W.&A. and *Entada phaseoloides* Benth. of the family Fabaceae. The fossil leaves are characterized by compound, asymmetrical elliptic to narrow elliptic shapes, entire margin, eucamptodromous venation, and the presence of inter secondary veins. The fruit is a loment type having narrow ends, and there is the occurrence of a single, small, almost circular seed in each segment. In contrast, the seed is characterised by a circular to orbicular shape with a pronounced depression at the hilum. The comparable taxa of the macrofossils (except E. phaseoloides Benth.) are presently not found to grow in and around the Sarkaghat as well as in the Himalayan foothills of Himachal Pradesh, India but are found distributed in the tropical evergreen forests of other suitable phytogeographical regions which may suggest that tropical evergreen forests under warm, humid climate with heavy rainfall were in existence during the Upper Miocene in this region in contrast to a mixed deciduous forest under the tropical climate with aridness.

Keywords: Morphotaxonomy, Macrofossils, Fabaceae, Middle Siwalik, Phytogeography, Palaeoclimate, Himachal Pradesh, India

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Introduction

The Himalayan foreland basin consists of mainly Neogene deposits known as the Siwalik Group. It extends from the Potwar Plateau in the west to Brahmaputra in the east, covering a distance of about 2400 km long and 20-25 km wide (Rao et al., 1981). The fossil flora of the Siwalik foreland basin of Himachal Pradesh has been subjected to numerous changes. Many genera and species (Dipterocarpus, *Daemonorops calycarpus*, *Cynome trapolyandra, Antidesma mortzii, Fissistigma rubiginosum, Berberis manipurana, Cratoxylon prunifolium*, etc.) which are recorded in Himachal Pradesh during the Miocene either migrated or faced extinction. The evolution of the Siwalik floras in the northern region has largely influenced the Himalayan orogeny (Singh et al., 2022). The Middle-Miocene orogeny of the Himalaya led to the proliferation of several gymnosperm groups and the appearance of several subtropical angiospermous taxa (Awasthi, 1991).

The family Fabaceae results from one of the most spectacular radiations of flowering plants. Regarding the number of species, this is the third most diverse family after Asteraceae and Orchidaceae, including about 730 genera and 19,400 species (Lewis et al., 2005), and it represents one of the most ecologically diverse groups. The Fabaceae is widely distributed worldwide, especially in tropical rainforests and dry forests. Until now, no fossils of leaves and fruits were unequivocally belonging to the Fabaceae before the Paleogene. However, from the Paleocene onwards, the family was already documented in many fossil assemblages worldwide. In North-America, legume fossils are known beginning around 65.35 mya (Lyson et al., 2019). A good amount of fabaceous fossils, including vegetative and reproductive organs, are recorded in Mexico (Miranda, 1963; Cevallos-Ferriz et al., 1994; Magallón-Puebla et al., 1994; Martínez-Cabrera et al., 2006; Poinar & Brown, 2002). This family also has a rich fossil record in the Siwalik Group of India and Nepal (Adhikari et al., 2024; Antal & Awasthi, 1993; Dwivedi et al., 2006; Khan et al., 2011; Lakhanpal & Dayal, 1966; Prakash, 1973, 1976; Prasad, 1990, 2008; Prasad & Awasthi, 1994; Prasad et al., 2019; Trivedi & Ahuja, 1978; Yadav, 1988). In the present paper, the authors described two fossil leaves and fruit and seed of the family Fabaceae from the Middle Siwalik (Upper Miocene) sediments of Sarkaghat area in the Siwalik sediments of Himachal Pradesh, India, and discussed their phytogeographic and climatic significance. This investigation revealed the occurrence of new legume macrofossils of *Mezoneuron hymenocarpum* W.&A. ex Prain, *Dialium indum* Linn., *Acacia caesia* W.&A., and *Entada phaseoloides* Benth. The Sarkaghat area, Himachal Pradesh, India, further extends our knowledge of the fossil record of the family Fabaceae.

Material and methods

Several workers contributed to the general geology and stratigraphy of the Siwalik Group both in India and Pakistan (Falconer, 1868; Lydekkar, 1883; Pilgrim, 1910, 1913; Colbert, 1935; Lewis, 1937; Opdyke et al., 1979; Azzaroli & Napoleone, 1982; Johnson et al., 1982, 1985). The dated sections of the Siwalik range are from the Middle Miocene to the Lower Pleistocene (18 Ma to 1.7 Ma). The Siwalik succession represents clastic sediments of the nature of freshwater molasses

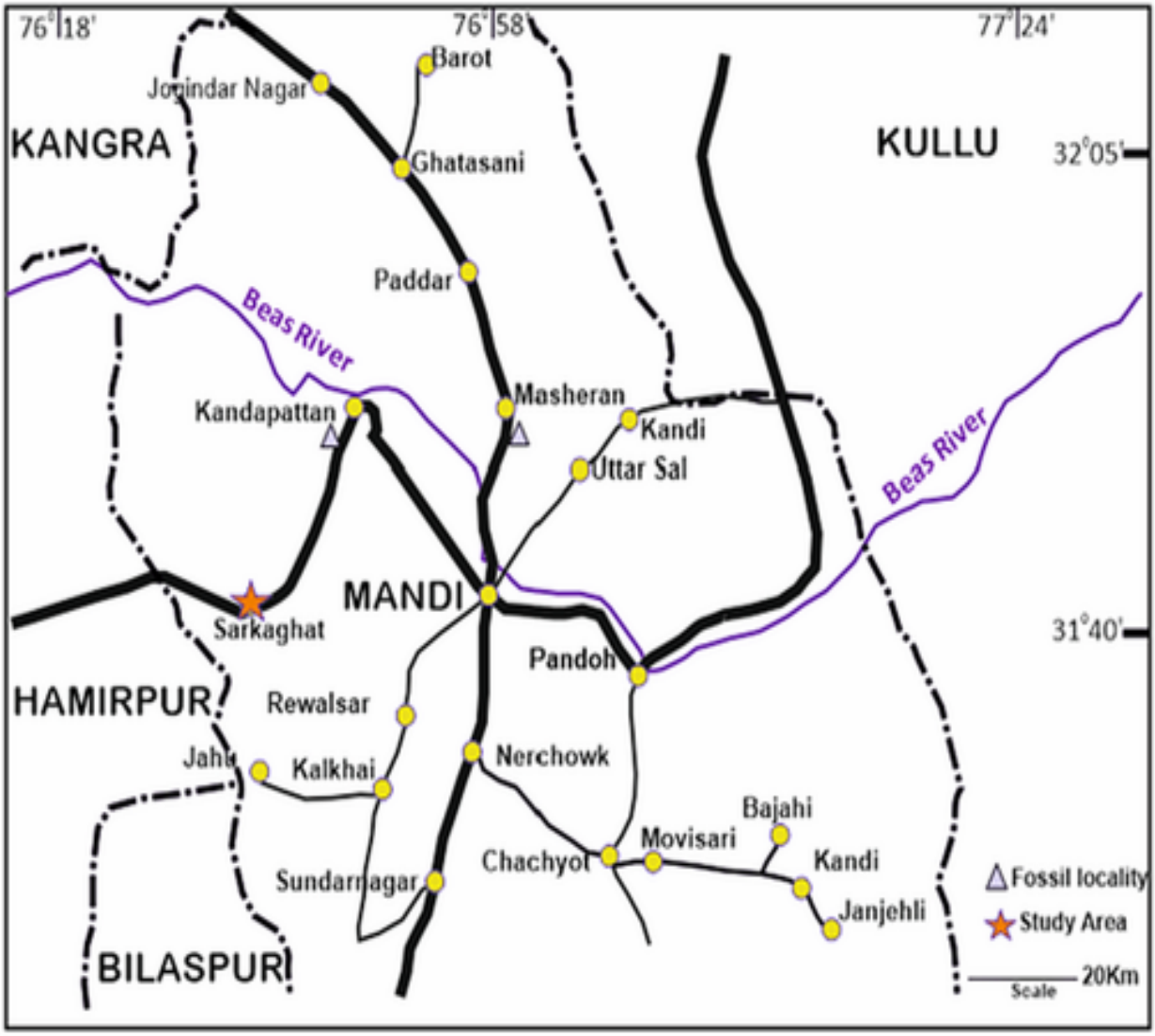

Figure 1. Study area and fossil locality

sediments such as muds, silts, sands, and gravels, which accumulated in a long, narrow foredeep formed to the south of the rising Himalaya in the third episode of uplift of the Himalaya during the Middle Miocene (Valdiya, 2002). The local stratigraphy of the Siwalik succession of the western sector has been studied by Rao et al. (1981), Gupta & Verma (1988), and Gupta (1997, 2000). Rao et al. (1981) divided the Siwalik Group into the Lower, Middle, and Upper Siwaliks.

The Sarkaghat Anticline is exposed in the northeast part of the Kangra re-entrant of the Himachal Sub-Himalaya along the northerly dipping Main Boundary Fault (MBF). Between the NNW-SSE trending Awah Devi-Lamba Graon syncline in the south and Main Boundary Fault (MBF) in the north, the NW plunging Sarkaghat Anticline is a regional structure in the Paleogene-Siwalik belt around west Sarkaghat, Mandi district, Himachal Pradesh (Cande

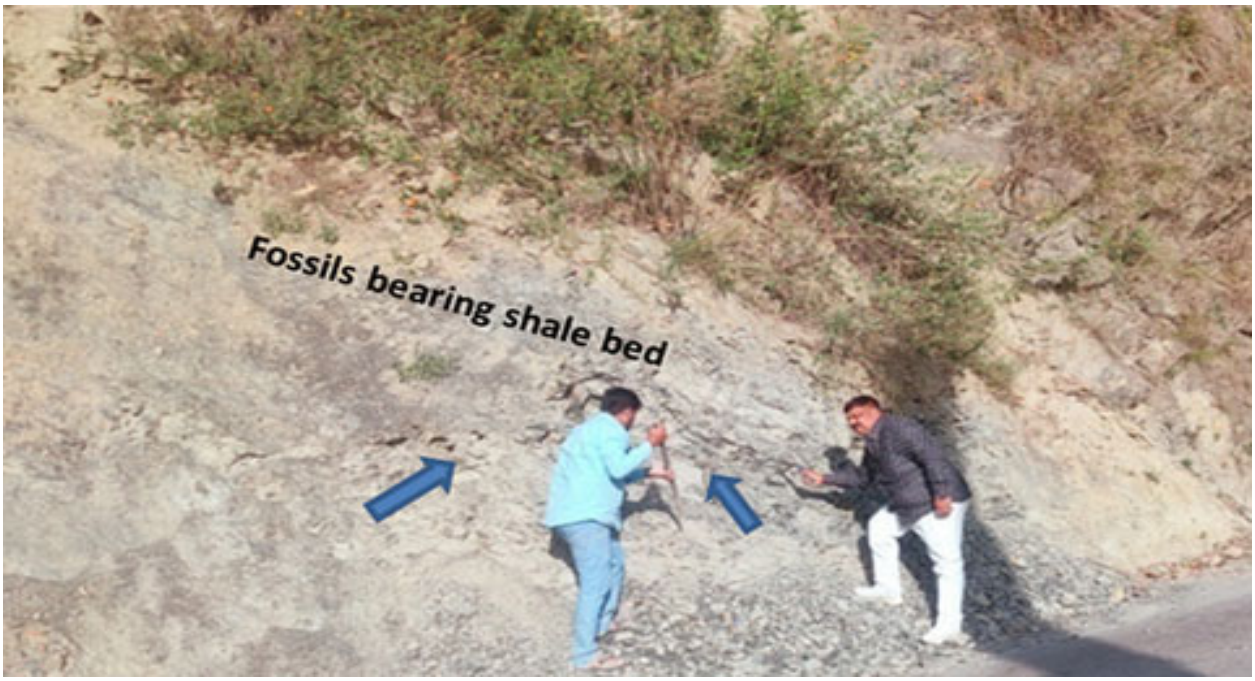

Figure 2. A Siwalik section exposed near Kandapattan on Dharampur-Joginder Nagar Road showing fossils bearing shale bed

& Kent, 1992). The fossil locality lies along the National Highway 70 very near the Sarkaghat area of Mandi District, Himachal Pradesh (N 31°44'26" E 76°43'33") (Fig. 1). The fossil leaf bearing bed is a part of middle Siwalik Sarkaghat anticline (Figs. 2, 3). It is characterized by mainly thick units of fine to coarse, dark grey indurate, multistoried sandstones with red, yellow, and brown mudstones.

More than 40 specimens of leaf and seed impressions were collected from Middle Siwalik beds exposed in a road cutting section near Kandapatten (31º48.411' N 76º46.094' E) about 4 km from Dharampur on Sarkaghat to Joginder Nagar Road (Figs. 2, 3). Several well preserved leaf and fruit impressions were also collected from a Road section exposed near Masheran (31.6918º N76.7468º E) about 8 km from Sarkaghat on Sarkaghat to Rewaslsar Road, Mandi District, Himachal Pradesh.

All the macrofossils (leaf, fruit, and seed impressions) have been studied morphologically with the help of a low power microscope. Their identification is made with the help of Herbarium sheets in the Herbaria of Central National Herbarium, Howrah, West Bengal. For the description of leaf impressions, the terminology given by Hickey (1973) and Dilcher (1974) is followed, while the fruit and seed are described as usual practices. The photographs of the leaves, fruit, and seed of the modern comparable taxa will be provided to show similarity with the fossil leaves.

Results and discussion

Systematics of macro fossils

Family: **Fabaceae** Lindley

Genus: **Mezoneuron** Desf.

Mezoneuron siwalica n. sp.

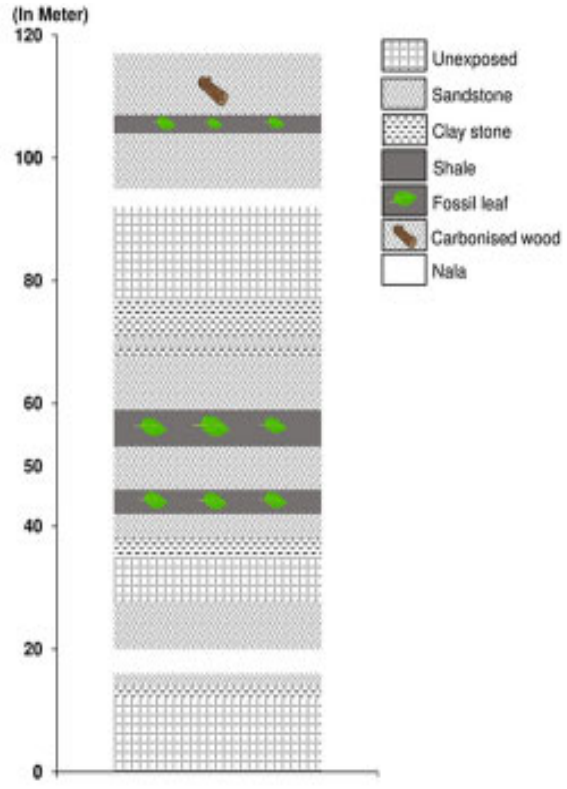

Figure 3. Lithocolumn of the exposed section near Kandapattan showing the occurrence of fossil leaves collected for the present study

(Figs.4: A, C, D)

Material: One specimen containing six leaflets on a twig. They are poorly preserved but almost complete.

Diagnosis: Leaf compound asymmetrical; maximum length 1.8 cm and maximum width 1.3 cm; wide obovate, apex rounded; base acute in equilateral; margin entire; venation pinnate; eucamptodromous; primary vein, stout; secondary vein 8 pairs, less than 0.4 cm apart, angle of divergence (60°-65°); inter secondaries present; tertiary veins fine, angle of origin usually RR, per current, oblique about mid vein and close.

Description: Leaf compound asymmetrical; maximum length 1.8 cm and maximum width 1.3 cm; wide obovate, apex rounded; base acute in equilateral; margin entire; texture coriaceous; venation pinnate; eucamptodromous; primary vein single, straight, stout; secondary veins about 8 pairs visible, less than 0.4 cm apart, angle of divergence (60°-65°), wide acute, unbranched, uniformly curved up; inter secondaries present, simple, tertiary veins fine, angle of origin usually RR, per current, almost straight, branched, oblique about mid vein, predominantly alternate and close.

Holotype: BSIP Museum specimen no.41262.

Locality: Kandapatten (31°48.411' N76°46.094' E about 4 km from Dharampur on Sarkaghat-Joginder Nagar Road, Mandi District, Himachal Pradesh.

Horizon and age: Middle Siwalik; Upper Miocene.

Etymology: After Siwalik Group.

Remarks: The characteristic features of the present fossil leaf such as an asymmetrical, wide obovate shape, rounded apex, and acute base, eucamptodromous venation, wide acute, unbranched, uniformly curved up secondaries, presence of inter secondaries, RR, per current and close tertiaries collectively suggest its closest affinity with the modern leaves of genus Mezoneuron Desf. of the family Fabaceae. In order to find out its specific affinity, the herbarium sheets of all the available species of this genus have been critically examined, and it found that the leaves of *Mezoneuron hymenocarpum* W.&A. ex Prain show the closest affinity with the present fossil leaf (CNH herbarium sheet no. 134023; Fig. 4 B, E).

So far, fossil leaves resembling the genus Mezoneuron Desf have not been reported from India's Cenozoic sediments and abroad. This fossil leaf represents the first record of the genus Mezoneuron Desf.

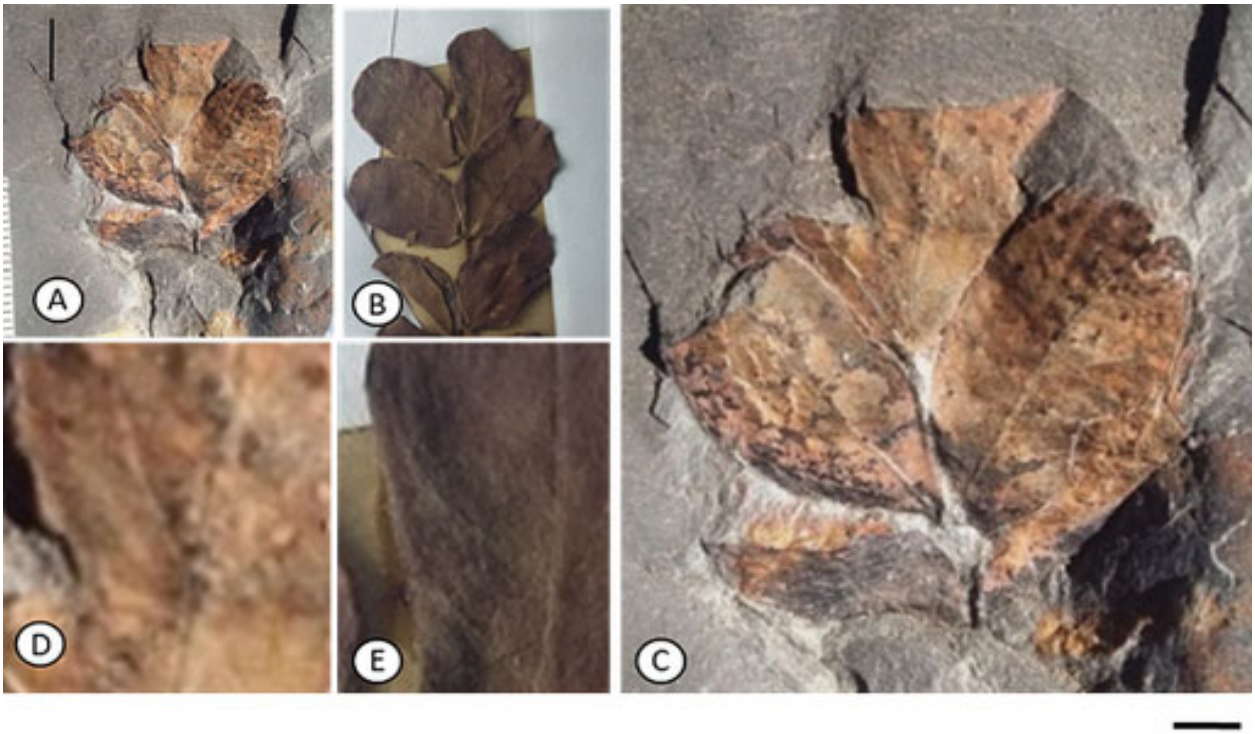

Figure 4. A - *Mezoneurum siwalica* n. sp. - Fossil leaflets in natural size showing shape, size and venation pattern. BSIP Museum specimen no. 41262; B - *Mezoneurum hymenocarpus* - modern leaflets showing similar shape, size and venation pattern; C - *Mezoneurum siwalica* n. sp. - fossil leaflets magnified to show details of morphological features. BSIP Museum specimen no. 41262; D - *Mezoneurum siwalica* n. sp. - part of fossil leaflet magnified to show details of venation. BSIP Museum specimen no. 41262; E - *Mezoneurum hymenocarpus* - part of modern leaflet magnified to show similar details of venation (Scale bar = 1 cm)

from the Siwalik sediments, and thus, it is being described as a new species, *M. siwalika*.

The genus of *Mezoneuron* Desf. comprises about 10 species distributed throughout tropical Asia to the old world (Hooker, 1875). *Mezoneuron hymenocarpum* W.&A. ex Prain. with which fossils show resemblance, is a species of lianas distributed in India, Indo-China, Malaysia, and throughout Australia (Brandis, 1971).

Genus: **Dialium** Linn.

Dialium palaeoindum Prasad, 1994, 1994c (Figs. 5: A, C)

Dialium palaeoindum Prasad, p. 71, pl. 7, figs. 3, 5

Material: This consists of a single, well preserved, complete leaf specimen.

Description: Leaf asymmetrical, narrow elliptic, preserved size 5.0 x 1.9 cm; apex acute; base acute, in equilateral; margin entire: texture chartaceous; petiole not preserved; venation pinnate, eucamptodromous; primary vein single, stout, almost straight; secondary veins 10-11 pairs visible, up to 0.7 cm apart, angle of divergence wide (50°-65°), wide acute, uniformly curved up and sometimes running for a short distance and joining to the super adjacent secondaries, usually alternate; inter secondary veins present,

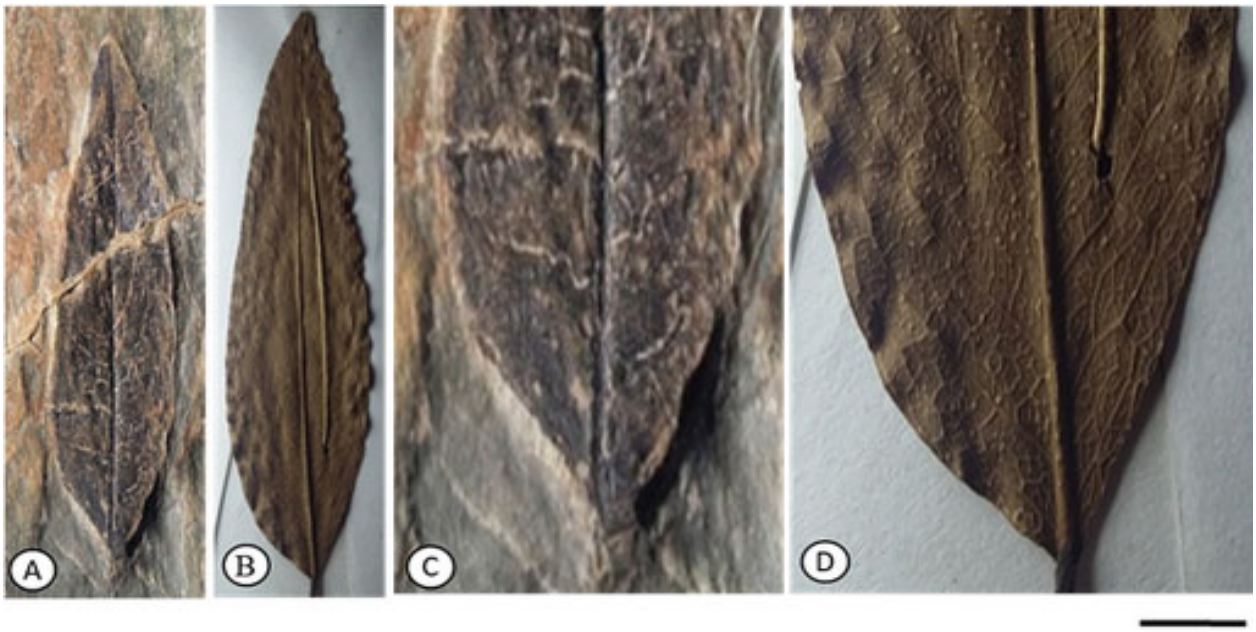

Figure 5. A - *Dialium paleoindum* Prasad 1994a - fossil leaf showing shape, size and venation pattern. BSIP Museum specimen no. 41263; B - *Dialium indum* - modern leaf showing similar shape, size and venation pattern; C - *Dialium paleoindum* Prasad 1994a - part of fossil leaf magnified to show details of venation. BSIP Museum specimen no. 41263; D - *Dialium indum* - part of modern leaf magnified to show similar details of venation (Sale bar - 1 cm)

simple, tertiary veins fine, with the angle of origin usually RR, per current, straight to sinuous, rarely branched, usually oblique to a nearly right angle (near margin) about midvein, predominantly alternate and close.

Specimen: BSIP Museum specimen no.41263.

Locality: Kandapatten (31°48.411' N 76°46.094' E), about 4 km from Dharampur on Sarkaghat- Joginder Nagar Road, Mandi District, Himachal Pradesh.

Horizon and age: Middle Siwalik; Upper Miocene.

Remarks: The most important features of the present fossil leaf are a narrow elliptic shape, acute apex, equilateral base, the wide, acute angle of divergence of secondary veins, presence of abundant inter secondary veins and RR, per current tertiaries with oblique to a nearly right angle about midvein indicate that it shows close affinity with the modern leaves of Dialiumindum Linn. of the family Fabaceae (CNH herbarium sheet no. 136541; Figs.: 5 B, D).

So far, only one fossil species, *Dialium palaeoindum* Prasad, is resembling the genus *Dialium* Linn. and has been reported from the Siwalik sediments of the Kathgodam area (Prasad, 1994). As the present fossil leaf closely resembles the above known fossil leaf, it has been kept under the same species.

The genus *Dialum* Linn. includes 40 species distributed from the tropical Americas to sub-Saharan Africa, Madagascar, India, Indochina, and western Malesia (Mabberley, 1997). The modern comparable species, *Dialium*

indum Linn.is a tree distributed throughout the evergreen forest of Peninsular Thailand, Peninsular Malaysia, Borneo, the Sunda Islands, Sumatra, and Java (Lim, 2012).

Genus: **Acacia** Adans.

Acacia miocenica n.sp.

(Figs. 6: A, B, D, F)

Material: This species is based on two well preserved and almost complete fruit impressions.

Diagnosis: Pod 12 x 3.0 cm; oblong; apex indistinct; base acute; one side margin curved in the middle portion, about 7 segments are seen; in some segments, the impression of seed is distinct, veins on the surface present.

Description: Pod flat, thin; 12 cm long, 3.0 cm wide; oblong; apex indistinct; base acute; margin moderately thick, one side margin curved in the middle portion, segmented, about 7 segments are seen, the segments are of the almost same size, in some segments the impression of seed is distinct, distinct venation seen on the surface, veins arise from one of the margins and run up to the other side, the distance between two veins is not equal, few thin veins also seen in between them with irregular branching.

Holotype: BSIP Museum specimen no: 41264-41265.

Locality: Near Masheran (31.6918º N 76.7468º E), about 8km from Sarkaghat on Sarkaghat – Rewaslsar Road, Mandi district, Himachal Pradesh, India.

Horizon and age: Middle Siwalik; Upper Miocene.

Etymology: The specific epithet is after the 'Miocene' epoch.

Remarks: Narrow oblong shape, acute base, oblique septa, presence of 7 segments along with the impression of a seed, nature of margin, and venation pattern on the surface collectively indicate its resemblance with the genus *Acacia* Adans. of the family Fabaceae. In order to find out specific affinity, the herbarium sheets containing fruits of all the available species of this genus, such as *A. sericata, A. osanoldii, A. longifolia, A. auriculata, A. cochlocarpa, A. glaucscense*, and *A. australis*, etc. have been critically examined and found that the fruits of Acacia caesia W.&A. (CNH herbarium sheet no. 573887; Fig. 6: C, E) show a close affinity with the present fossil fruit in shape, size, and other morphological features.

There is a single fossil record of the fruit of the genus *Acacia* Adans. from Siwalik sediments in Arunachal Pradesh, India, as *Acacia miocatchuoides* (Khan et al., 2014). This fossil fruit shows affinity with the extant species *Acacia catechu* Willd. This differs from the present fruit due to the elliptic shape and smaller size (2.4 x 0.5 cm) in contrast to the narrow oblong shape and larger size. Given these facts, the present fruit has been described as a new species, *Acacia miocenica*. The genus of *Acacia* Adans. is also known in the fossil record in the form of petrified woods (Navale, 1962; Awasthi, 1973) and leaf impressions (Prasad, 1994a).

The genus of *Acacia* Adans. It comprises about 1200 species of trees and shrubs native to Africa and Australia (Mabberley, 1997). *A. caesia* W&A., with which fossil fruit resembles, is a climbing shrub distributed in India, Sri Lanka, Thailand, and Malaysia (Brandis, 1971).

Genus: **Entada** Adans.

Entada palaeoscandens Awasthi & Prasad (1989)

(Figs. 7: A- C) 1990 Entada palaeoscandens Awasthi & Prasad, p. 309, pl. 5, fig. 4. 1993 Entada palaeoscandens (Awasthi & Prasad) Antal & Awasthi, p. 53, pl. 19, fig. 7. 1994 Entada

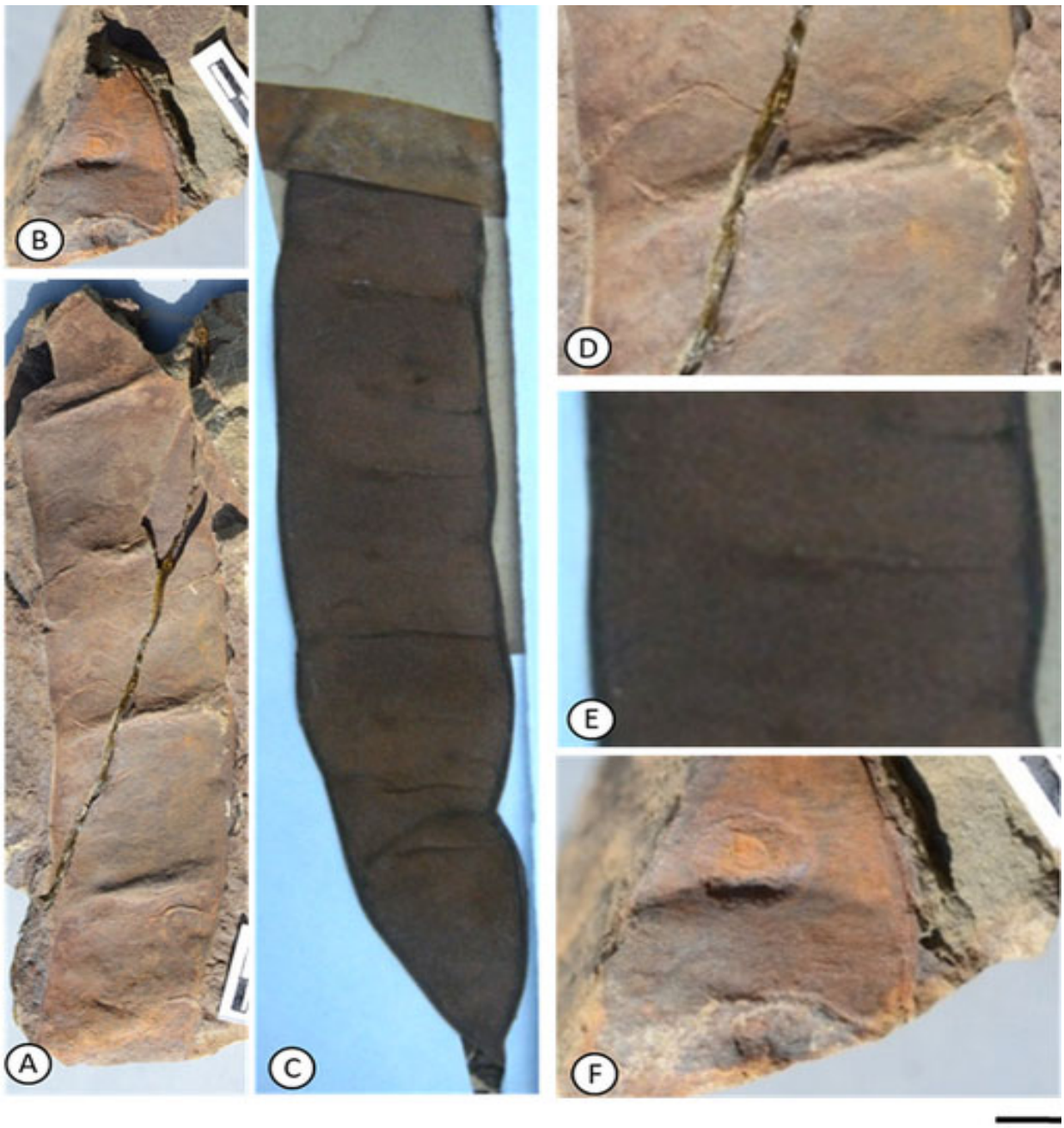

Figure 6. A - *Accasia miocaesia* n. sp. - fossil fruit showing shape, size and other details. BSIP Museum specimen no. 41264; B - *Accasia miocaesia* n. sp. - another fossil fruit showing nature of apical part. BSIP Museum specimen no. 41265; C - *Accasia caesia* W.&A. - modern fruit showing similar shape, size and venation pattern; D - *Accasia miocaesia* n. sp. - a part of fruit magnified to show the nature of faint striation on the fruit surface. BSIP Museum specimen no. 41264; E - *Accasia caesia* W.&A. - a part of modern fruit to show the similar faint striation on the fruit surface; F - *Accasia miocaesia* n. sp. - a part of fossil fruit magnified to show the occurrence of small rounded seeds. BSIP Museum specimen no. 41265. (Scale bar = 1 cm)

Figure 7. A, B - *Entada palaeoscandens* Awasthi & Prasad - fossil seeds showing shape, size and depression on the hilum. BSIP Museum specimen no. 41265; C - *Entada palaeoscandens* Awasthi & Prasad - a part of fossil seed showing the nature of seed surface. BSIP Museum specimen no. 41265; D - *Entada phaseoloides* Benth. - modern seed showing similarity with the fossil seeds (Scale bar = 1 cm)

palaeoscandens (*Awasthi & Prasad*) *Prasad, p. 145, pl. 7, fig. 9. 1995 Entada palaeoscandens* (*Awasthi & Prasad*) *Awasthi & Mehrotra, p. 170, pl.* 6, fig. 5. 2003 *Entada palaeoscandens* (Awasthi & Prasad) Agarwal, p. 136, fig. 3A, B.

Material: There are two slightly broken specimens of fossil fruit.

Description: Seed large in size, about 3.0 x 3.8 cm in diameter, slightly flattened, circular to orbicular, cordate or reniform with a pronounced sinus at the hilum. The

seed surface is almost smooth.
Specimen: BSIP Museum specimen no.41265A, 41265B.
Locality: Kandapatten (31°48.411' N 76°46.094' E), about 4 km from Dharampur on Sarkaghat- Joginder Nagar Road, Mandi District, Himachal Pradesh.
Horizon and age: Middle Siwalik; Upper Miocene.
Remarks: The diagnostic features exhibited by the fossil seed, such as its large size with circular to an orbicular shape having a distinct sinus at the hilum, undoubtedly suggest that the present seed resembles the seed of extant *Entada phaseoloides* Benth. (syn. *E. scandens* (L.) Benth, *E. pursaetha* DC., *Mimosa entada*Linn., *E. rheedei* Spreng.) of the family Fabaceae (Fig. 7 D).

The fossil leaflets and fruit/seeds resembling the genus *Entada* Adans. are reported from Cenozoic sediments of Austria (Unger, 1862), Japan (Tanai, 1955; Ishida, 1970; Huzioka, 1972; Takahasi, 1954), USA. (MacGinitie, 1969), Venezuela, South America (Berry, 1921), Nepal (Awasthi & Prasad, 1989; Prasad, 1993), and India (Awasthi & Mehrotra, 1995; Agarwal, 2003). Awasthi & Prasad (1989) described the fossil leaflet and seed resembling the extant taxa *Entadapha seoloides* Benth. from the Middle Siwalik sediments of the SuraiKhola area, western Nepal, under the form species *E. palaeoscandens*. Later on, three more fossil seeds comparable to the genus *Entada* Adans. are reported under the same specific name from Lower Siwalik sediments of the Koilabas area, western Nepal (Prasad, 1993), Oligocene sediments of Makum Coalfield, Northeast India (Awasthi & Mehrotra, 1995) and Miocene sediments of Kalviwadi, Sindhurg District, Maharashtra (Agarwal, 2003). A comparative study of the present seed has been carried out with the above known fossil seeds of *Entada* Adans. and concluded the Sarkaghat fossil seed resembles the fossil seed described from the Koilabas area, Nepal, in shape, size, and other morphological. Thus, it has been kept under the same form species, *E. palaeoscandens* Awasthi & Prasad (1989).

Entada Adans. is a genus of flowering plants in the subfamily Caesalpinioideae and family Fabaceae. It consists of about 40 species of trees, shrubs, and tropical lianas. About 21 species are known from Africa, six from Asia, two from the Tropical American, and one from the pantropical distribution. *E. phaseoloides* Benth. with which fossil seed shows resemblance is a large woody climber distributed in the sub-Himalayan tract from Nepal eastwards. It is common in Sylhet, Manipur, Western Ghats, Andaman, and Malaysia (Brandis, 1971; Nelsen, 1992).

The family Fabaceae, which dominates the plant fossil assemblage of the Siwalik Group, is an economically important family of flowering plants, including the species of trees, shrubs, and herbs distributed in temperate and tropical regions of the world. The fossil records from all the Siwalik localities of India and Nepal showed the dominance of fabaceous taxa (Prasad, 2008). About 110 species based on plant megafossils, mainly fossil woods and leaves, are recorded from the Siwalik Group of India, Nepal, and Bhutan. These belong to the genera *Acacia, Acrocarpus, Adenanthera, Albizia, Bauhinia, Butea, Caesalpinia, Canavalia, Cassia, Dalbergia, Derris, Dialium, Entada, Humboldtia, Indigofera, Koompassia, Millettia, Mucuna, Ormosia, Pahudia, Pongamia, Pterocarpus, Samanea, Saraca, Sindora, Spatholobus and, Wagatea* and *Xylia*. The fossil assemblage of the Sarkaghat area

comprises only six taxa viz., *Acacia miocenica* n. sp., *Entada palaeoscandens* Awasthi & Prasad (1990), *Cynometra siwalika* Prasad et al. (2013). *Dialium palaeoindum* Prasad (1994), *Mezoneuron siwalica* n. sp., and *Millettia bilaspurensis* Prasad et al. (2013), and these fabaceous taxa of the Siwalik foreland basin have not been recorded from Paleocene-Eocene sediments of Indian subcontinents, which suggest a late entry of these taxa into the Indian sub-continent, probably prior to the Miocene, after the development of land connections of the Indian and Eurasian plates (Smith & Briden, 1979) that allowed free movement of elements from regions where they were flourishing most probably southeast Indian regions. Early Miocene was the appropriate time for southeast Asian fabaceous elements to enter the Indian sub-continent through its northeast corner during early Miocene (Agarwal et al., 2006). After the Early Miocene, the fabaceous taxa spread throughout India, becoming a major part of angiospermous flora (Guleria, 1991; Prasad, 2008). Various fossils (fossil woods, fruits, flowers, leaflets, and pollen) belonging to the family Fabaceae have been recorded from different localities in India and abroad from the Upper Cretaceous onwards. This fossil record shows that the oldest record of this family is a fruit reported from the Late Cretaceous of northern Mexico (Centeno-González et al., 2021).

Conclusions

The present study on macrofossils from the Siwalik Group (Upper Miocene) of the Sarkaghat area, Himachal Pradesh, India, revealed the occurrence of four new fossil taxa, *Mezoneuron siwalica* n. sp., *Dialiumpalaeo indum Prasad, Acacia miocenica n. sp., and Entada palaeoscandens* Awasthi & Prasad of the family Fabaceae. The modern comparable taxa of the above fossils suggest that a tropical evergreen forest existed in Sarkaghat and nearby areas during the Upper Miocene instead of the mixed deciduous forest today. The present-day distribution of the extant taxa of the recorded fossils from the Upper Miocene of Sarkaghat, *e.g., Mezoneuron hymenocarpum W.&A. ex Prain.* and *Dialium indum* Linn. are presently not found to grow in and around the Sarkaghat area as well as in the whole Himalayan foothills of Himachal Pradesh, India, but are found distributed in other suitable phytogeographical regions of India, Malaysia, and Australia, etc., which suggesting a climatic change after Upper Miocene period. There is a diverse fabaceous fossil record documented in different localities of India and abroad from the Upper Cretaceous to the Pliocene, and the oldest record of this family is represented by fruit from the Late Cretaceous of Mexico.

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