
Some more leaf-impressions from the Lower Siwalik sediments of Koilabas, Nepal

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Four species of leaf-impressions are described from the Lower Siwalik sediments of Koilabas, Nepal. They are: *Dipterocarpus siwalicus* Lakhanpal & Guleria of Dipterocarpaceae and *Albizia siwalica* sp. nov., *Millettia koilabasensis* sp. nov., and *Ormosia robustoides* sp. nov. of Fabaceae.

Key-words—Leaf-impressions, *Dipterocarpus*, *Albizia*, *Millettia*, *Ormosia*, Lower Siwalik, Miocene (Nepal).

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सारांश

नेपाल में कोइलाबास के अधरि शिवालिक अवसादों से कुछ और पर्ण-छाप

महेश प्रसाद

नेपाल में कोइलाबास के अधरि शिवालिक अवसादों से पर्ण-छापों की चार जातियाँ वर्णित की गई हैं। ये डिप्टेरोकार्पेसी कुल के डिप्टेरोकार्पस शिवालिकस लखनपाल व गुलेरिया तथा फैबेसी कुल के एल्बिज़िया शिवालिक नव जाति, मिलेशिया कोइलाबासेन्सिस नव जाति एवं ओर्मोसिया रोबस्टोयडिस नव जाति नामक वर्गक हैं।

A FEW years ago, the leaf-impressions of *Dillenia palaeoindica*, *Anogeissus eosericea* and *Syzygium miocenicum* were described from the Lower Siwalik sediments of Koilabas (27°42'N : 82°20'E), Nepal (Prasad & Prakash, 1984: pp. 246-256). From the same locality four more species have been presented in this paper. The terminology used here is after Hickey (1973) and Dilcher (1974).

SYSTEMATIC DESCRIPTION

Family—Dipterocarpaceae

Genus—*Dipterocarpus* Gaertn. f.

Dipterocarpus siwalicus Lakhanpal & Guleria 1986
Pl. 1, figs 1, 3, 4

Three almost complete leaf-impressions and two fragments represent this species.

Description—Leaf simple, symmetrical ovate; lamina length 11.0 cm, maximum width 6.0 cm; apex

acute; base obtuse to cordate, normal; margin entire, slightly undulate; texture chartaceous; petiole 0.8 cm in length, venation pinnate, simple eucamptodromous; primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 16 pairs visible with angle of divergence acute, moderate (50-60°), upper ones more acute than lower, alternate to rarely sub-opposite, 0.5-1.2 cm apart, lowermost two pairs of secondaries closely placed, uniformly curved up and run almost parallel to each other, moderately thick, unbranched; tertiary veins (3°) fine with angle of origin AR-RO, pattern percurrent, simple, almost unbranched, straight, oblique in relation to midvein, alternate to opposite, close; higher order venation indistinct.

Discussion—In overall characters the fossil leaves show close resemblance with *Dipterocarpus siwalicus* Lakhanpal & Guleria 1986, a species already described from the Lower Siwalik beds near Jwalamukhi, Himachal Pradesh. Besides, the present fossil possesses a small petiole which is not preserved in *D. siwalicus* Lakhanpal & Guleria.

Because of its close similarity with *D. siwalicus* it has been assigned to the same species.

The modern species *D. tuberculatus* Roxb., with which the fossil shows closest similarity, is a large deciduous tree growing in plains and low hills in the valley of Burma. It also grows in Chochin-China and Thailand.

Figured specimens—Specimen nos. BSIP 35945-35947.

Family—Fabaceae

Genus—*Albizia* Duraz

Albizia siwalica sp. nov.

Pl. 1, figs 5, 7

The present species is based on three well-preserved and almost complete impressions.

Description—Leaflet asymmetrical, wide obovate, preserved length 3.0-4.7 cm with petiolule 0.2 cm long, lamina length 3.0-4.5 cm, maximum width 2.0-3.0 cm; apex obtuse; base obtuse, inequilateral; margin entire; texture chartaceous; venation pinnate, brochidodromous; primary vein (1°) single, prominent, moderate, straight to slightly curved; secondary veins (2°) 7 pairs visible with angle of divergence acute, moderate (about 60°), uniformly curved up joining superadjacent secondaries, alternate to opposite, 0.6-1.0 cm apart, occasionally branched; tertiary veins (3°) fine with angle of origin nearly RR, pattern percurrent, straight to sinuous, rarely branched, oblique in relation to midvein, predominantly alternate and close; quaternary veins (4°) not visible.

Discussion—A survey of modern plants indicates that similar leaflets are found in *Swietenia mahagoni* Jacq. of Meliaceae, *Pterospermum blumeianum* Korth. of Sterculiaceae and *Albizia* Duraz. of the family Fabaceae. Of these, the leaflets of *Swietenia mahagoni* Jacq. and *Pterospermum blumeianum* Korth. resemble the fossil leaflets in possessing similar shape, size and the type of venation but

differ distinctly in nature and arrangement of tertiary veins which are random reticulate in contrast to percurrent in the present fossil impressions. Thus the fossil specimens compare closely with the modern leaflets of the genus *Albizia* Duraz. Detailed study of about 30 species of the modern leaflets of *Albizia* was done and it has been observed that the leaflets of *Albizia gamblei* Prain (F.R.I. Herbarium sheet no. 46739) show similarity with the fossil leaflets in possessing similar shape, size and venation pattern.

Fossil records and comparison—So far only two fossil leaflets resembling those of *Albizia* have been described from abroad. They are *Albizia miokalkora* (Hu & Chaney) Ishida 1970 from the Miocene of central Japan and *Leguminosites* (*Albizia* sp.) Geyler 1875 from the Tertiary of Borneo. Of these, the latter is a fragment only in which the venation is not visible. However, *Albizia miokalkora* differs in being much smaller in size (about 1.1-1.8 cm in length) and with oblong shape as against larger size (about 3-4.7 cm in length) and obovate shape of the present fossil leaflets. Since the fossil leaflet is entirely different from the known fossil species of *Albizia*, it is being described here as *Albizia siwalica* sp. nov. Though this is the first record of a leaflet impression of *Albizia* from India, petrified wood of *Albizia* is already known from the Lower Siwalik beds of Nalagarh in Himachal Pradesh (Prakash, 1975). This wood also shows closest resemblance with the modern *Albizia lebbek* (now known as *A. gamblei*) confirming again the occurrence of this taxon during the Lower Siwalik in India.

The genus *Albizia* Duraz. consists of 150 species which are distributed in tropical and subtropical regions of the Old World (Willis, 1973). In India, its 14 species are reported to occur. *A. gamblei* Prain (Syn. *A. lebbek* Gamble), with which *A. siwalica* shows closest resemblance, is a deciduous tree attaining about 16 m hills of Burma (Brandis, 1971, p. 270, Gamble, 1972, p. 302).

Holotype—Specimen no. BSIP 35948.

PLATE 1

1. *Dipterocarpus siwalicus* Lakhanpal & Guleria—Fossil leaf in natural size, specimen no. BSIP 35945.
2. *Dipterocarpus tuberculatus*—Modern leaf in natural size showing similar shape, size and venation.
3. *Dipterocarpus siwalicus* Lakhanpal & Guleria—Another fossil leaf in natural size showing nature of petiole, specimen no. BSIP 35946.
4. *D. siwalicus* Lakhanpal & Guleria—Basal part of another fossil leaf showing cordate base, specimen no. BSIP 35947.
5. *Albizia siwalica* sp. nov.—Fossil leaflet in natural size, specimen no. BSIP 35948.
6. *Albizia gamblei*—A modern leaflet in natural size showing similar shape, size and venation.
7. *Albizia siwalica* sp. nov.—Another fossil leaflet in natural size showing variation in shape, specimen no. BSIP 35949.
8. *Albizia gamblei*—Another modern leaflet in natural size showing close similarity with fig. 7

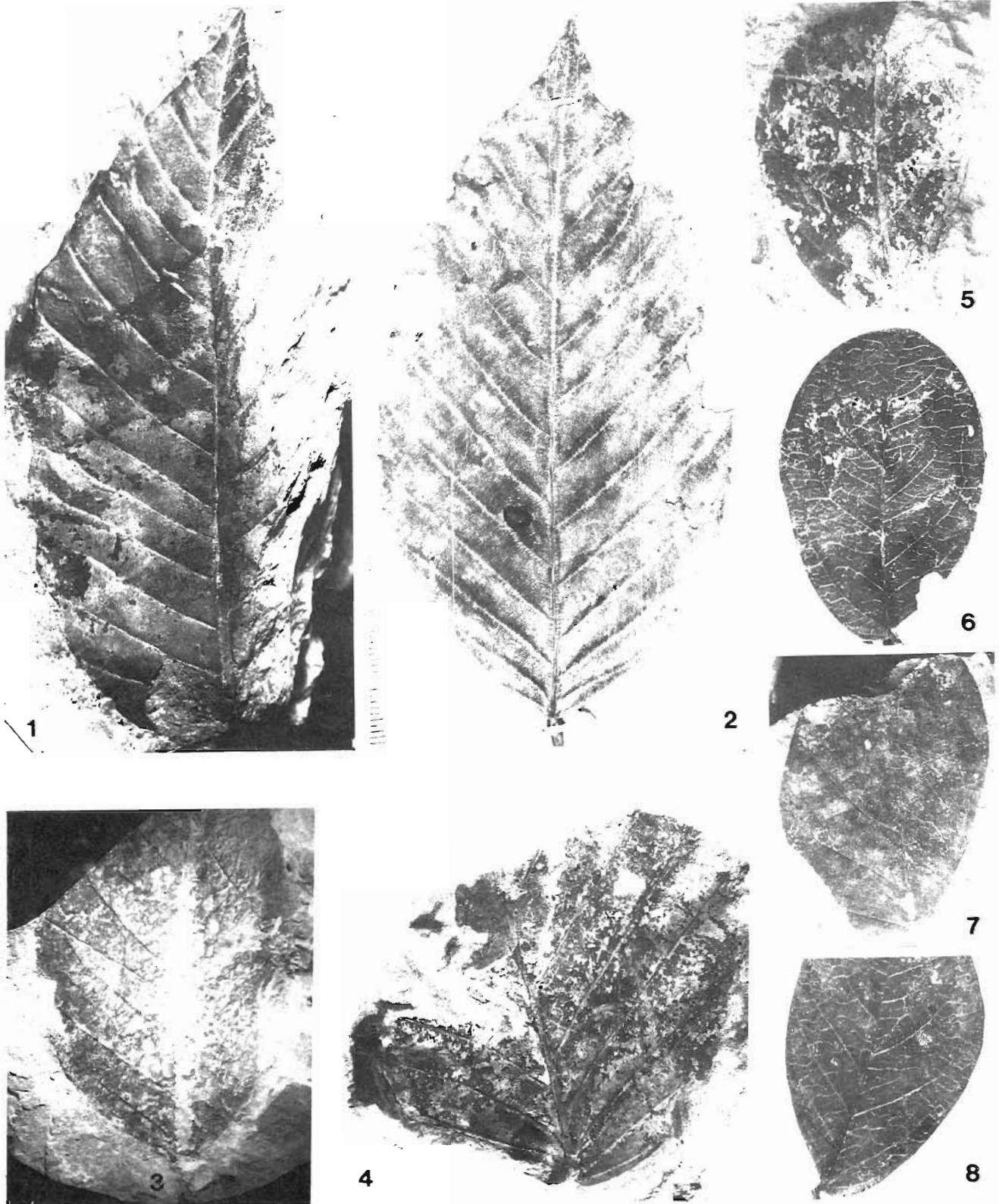


PLATE 1

Genus—*Millettia* W. & A.

Millettia koilabasensis sp. nov.
Pl. 2, fig. 1

The present species consists of a single well-preserved impression of a leaflet.

Description—Leaflet symmetrical, narrow obovate; lamina length 8.0 cm, maximum width 3.5 cm; apex acute; base somewhat acute; margin entire; texture chartaceous; petiolule not preserved; venation pinnate, eucamptodromous; primary vein (1°) single, prominent, stout, straight; secondary veins (2°) 8 pairs visible with angle of divergence acute, moderate (about 50°), alternate, 1.0-1.4 cm apart, uniformly curved, unbranched; intersecondary veins present, simple, rare; tertiary veins (3°) fine with angle of origin AR-RO, pattern percurrent, sometimes branched, straight to sinuous, oblique in relation to midvein, alternate to opposite, close to distant; quaternary veins (4°) indistinct.

Discussion—The characteristic features of the present fossil, such as obovate shape, acute base, chartaceous texture, presence of intersecondary veins and eucamptodromous type of venation are common in the modern leaves/leaflets of *Alphonsea lucida* King of Anonaceae, *Claoxylon purpureum* Merr. of Euphorbiaceae, *Combretum decandrum* Roxb. of Combretaceae, *Saprosma ternatum* Benth. & Hook. of Rubiaceae and *Millettia* W. & A. of the family Fabaceae. Out of these, the leaves of *Alphonsea lucida* King differ from the present fossil leaflet in having only 6 pairs of widely spaced (about 2.5 cm apart) secondaries as against more than 8 pairs of secondaries which are comparatively closely placed (1.0-1.4 cm apart). Similarly the leaves of *Combretum decandrum* Roxb., although similar in shape and size, differ from the fossil leaflet in the arrangement of closely placed tertiary veins as well as in the nature of apex. These leaves possess acuminate apex as against acute apex in the fossil. The leaf of *Claoxylon purpureum* Merr. is also close to the fossil leaflet but slightly differs from it in having serrate margin while the present leaflet

impression has entire margin. In the leaves of *Saprosma ternatum* Benth. & Hook. all the secondaries arising from the midrib join the superadjacent secondaries and form prominent loops, whereas in the fossil only a few pairs of secondaries towards apex seem to form loops.

A large number of leaflets of the genus *Millettia* were compared with the present fossil and it was found that the modern leaflets of *M. tetraptera* Kurz. and *M. macrostachya* Call. & Hemsl. show resemblance with the fossil. However, *M. tetraptera* Kurz. slightly differs from the fossil in possessing lamina with comparatively more width towards apex. Thus, the fossil leaflets shows closest resemblance with the modern leaflets of *M. macrostachya* Call. & Hemsl. (F.R.I. Herbarium specimen no. 53602; Pl. 2, fig. 12).

Fossil records and comparison—The impressions showing resemblance with the modern leaflets of *Millettia* have been described under the genus *Millettia* W. & A. So far, there are only five species of *Millettia* known from India and abroad. These are *Millettia impressa* (Harms) Mengel 1920 from Kamerum, West Africa (?Cenozoic), *M. notoensis* Ishida 1970 from the Mid-Miocene of central Japan, *Millettia* sp. Huzioka & Takahasi 1970 from the late Eocene of Southeast Honshu, Japan and *M. asymmetrica* and *M. miocenica* (Lakhanpal & Guleria, 1982) from the Miocene of Kachchh, western India. Since *M. impressa* is unaccompanied by any description or photograph, it is not possible to compare it with the present fossil. However, *M. notoensis* differs in its shape and number of secondaries. The shape of *M. notoensis* is ovate whereas it is obovate in the present fossil and there are only 4-5 pairs of secondaries in contrast to more than 8 pairs of secondaries in the present fossil specimen. *Millettia* sp. from Japan can easily be differentiated in being lanceolate in shape with inequilateral obtuse base in contrast to obovate shape with acute base in the present fossil. Further, *M. asymmetrica* differs from the present fossil leaflet in its elliptic shape. Similarly, *M. miocenica* is also distinct in having oblong shape without inter-

PLATE 2

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1. *Millettia koilabasensis* sp. nov.—Fossil leaflet in natural size, specimen no. BSIP 35951.
2. *Millettia macrostachya*—Modern leaflet in natural size showing similar shape, size and venation.
3. *Ormosia robustoides* sp. nov.—Fossil leaflet in natural size, specimen no. BSIP 35952.
4. *Ormosia robusta*—Modern leaflet in natural size showing similar shape, size and venation.
5. *Ormosia robustoides* sp. nov.—Another fossil leaflet showing variation in shape and size, × 1, specimen no. BSIP 35953.
6. *Ormosia robusta*—Another modern leaflet showing similar variation in shape and size, × 1.
7. *O. robustoides* sp. nov.—A fossil leaflet (fig. 5) magnified to show details of venation, × 4; specimen no. BSIP 35952.
8. *Ormosia robusta*—Modern leaflet (fig. 6) magnified to show similar details of venation, × 4.

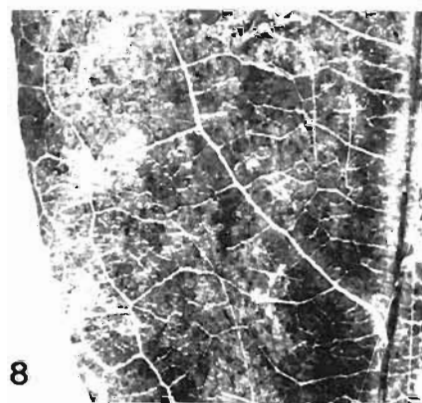
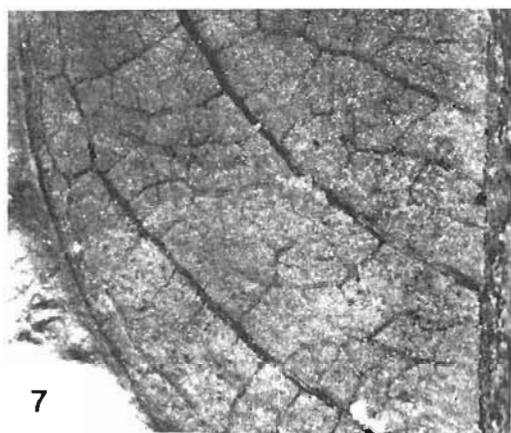


PLATE 2

secondary veins which are present in the present fossil leaflet.

Thus, the present fossil is quite different from the already known fossil species of *Millettia* and is being assigned to a new species, *Millettia koilabasensis*. Its specific name is after the locality from which the material was collected.

The genus *Millettia* W & A. consists of 180 species (Willis, 1973, p. 746) of trees, shrubs and woody climbers distributed in the warmer region of Africa, Asia and Australia. About 30 species are reported to occur in India and Burma. *Millettia macrostachya* Call & Hemsl with which the present leaflet-impression resembles closely, is a tree of Shan Hills of Upper Burma (Gamble, 1972, p. 232).

Holotype—Specimen no. BSIP 35951.

Genus—*Ormosia* Jack

Ormosia robustoides sp. nov.

Pl. 2, figs 3, 5, 7

This species is based on two well-preserved, almost complete impressions of leaflets.

Description—Leaflets symmetrical, lanceolate; lamina length 9-10 cm, maximum width 2.7-3.5 cm; apex acute; base obtuse; margin entire; texture chartaceous; petiolule broken; venation pinnate, eucamptodromous, primary vein (1°) single, prominent, stout, almost straight; secondary veins (2°) 12 pairs visible with angle of divergence acute, moderate to wide (60°-70°), alternate to opposite, 0.3 to 2.0 cm apart, uniformly curved up and running parallel to margin for a short distance, moderately thick, rarely branched; intersecondary veins present, simple, abundant and branched; tertiary veins (3°) fine with angle of origin AR-RR, pattern percurrent, branched, almost straight, oblique in relation to midvein, predominantly alternate and close; quaternary veins (4°) very fine, abundant, usually forming orthogonal meshes.

Discussion—The most important characters exhibited by the present fossil leaflets are lanceolate shape, acute apex, obtuse base, margin entire, chartaceous texture, eucamptodromous venation and the presence of intersecondary veins. These characters are found in the modern leaves/leaflets of *Evodia meliaefolia* Benth., *Glycosmis cymosa* Zipp. ex Span and *Tetradium fraxinifolium* Wall. ex Royle of Rutaceae, *Rhus punjabensis* Stew. ex Brandis and *Pistacia integerrima* Stew. of Anacardiaceae, *Heritiera formis* Buch. of Sterculiaceae, *Heynea trijuga* Roxb. of Meliaceae, *Cananga odorata* Hook. of Anonaceae and *Dialium indicum* Linn. and *Ormosia* Jack of Fabaceae. Of these, the leaflets of *Evodia meliaefolia* Benth., although similar in shape

and size, differs in having secondaries which do not run parallel to the margin forming distinct loops. In the leaflets of *Glycosmis cymosa* Zipp. ex Span the secondaries arise straight from the midrib with comparatively more acute angle of divergence. *Tetradium fraxinifolium* Wall. ex Royle can easily be differentiated in having serrate margin as against entire margin in the fossil leaflets. The modern leaflets of *Rhus punjabensis* Stew. ex Brandis and *Pistacia integerrima* Stew. both differ in having very few intersecondaries in comparison to abundant intersecondaries in the present fossil. Besides, in *Pistacia integerrima* Stew., the secondaries are comparatively more in number (about 18 pairs) and more closely placed too. The leaves of *Heritiera formis* Buch. are similar in venation pattern but differ in its shape and size. Here the shape is narrow elliptic with greater width in the middle part of the lamina, whereas the present fossil leaflets are lanceolate in shape with almost uniform lamina width. The leaflets of *Heynea trijuga* Roxb., although almost similar in shape and size, can also be differentiated in possessing narrow sharply acute apex in comparison to bluntly acute apex in the fossil leaflets. Moreover, the tertiary veins are comparatively wide in the leaves of *Heynea trijuga* Roxb. The modern leaves of *Cananga odorata* Hook. possess only 8 pairs of secondaries in comparison to more than 12 pairs of secondaries in the present fossil. *Dialium indicum* Linn. also differs from the present fossil in having tertiaries which are randomly oriented forming reticulum; these are not percurrent as seen in the fossil leaves. Thus, it is only the modern leaflets of *Ormosia* Jack with which the fossil leaflet-impressions show close resemblance. However, in order to find out the nearest modern equivalent of the fossil leaflets, the modern leaflets of a large number of species of *Ormosia* Jack have been studied. Out of them, four species of *Ormosia*, viz., *O. robusta* Wight, *O. fordiana* Olive., *O. calavensis* Azaola, and *O. watsonii* show near resemblance with the present leaflet-impressions. Latter three species of *Ormosia* can easily be differentiated on the basis of gross features. The leaflets of *O. fordiana* Oliv. differ in having only 7-8 pairs of secondaries which are comparatively widely spaced. The leaflets of *O. calavensis* Azaola possess narrow acute apex instead of bluntly acute apex in the present fossil. Besides, the intersecondaries are comparatively few in the modern leaflets than in the present fossil leaflets. Similarly the leaflets of *O. watsonii* also differ in possessing ovate to wide-ovate shape as against lanceolate shape of the present fossils. Thus the leaflets of *Ormosia robusta* Wight (Pl. 2, figs 4, 6, 9)

show closest resemblance with the fossil impression.

Fossil records and comparison—As there is no record of the fossil leaflets of *Ormosia* from India and abroad the present finding from the Lower Siwalik beds of Koilabas in western Nepal forms its first record. The fossil woods resembling *Ormosia robusta* Wight have already been described from the Tertiary of Bengal (Bande & Prakash, 1981) and the Siwalik beds of Nalagarh and Kalagarh in Himachal Pradesh and Uttar Pradesh respectively (Prasad, 1988; Ratan, 1989).

As the fossil leaflets closely resemble those of modern *Ormosia robusta*, it has been described here as *Ormosia robustoides* sp. nov.

The genus *Ormosia* Jack consists of about 50 species found in tropical Asia and America. Out of these, eight species are recorded from India and Burma. *Ormosia robusta* Wight, with which the fossil impressions show close resemblance, is a large tree up to 30 m in height growing in Arunachal Pradesh, Sibsagar and Cachar districts of Assam, Sylhet and Chittagong in Bangladesh and Burma (Ramesh Rao & Purkayastha, 1972, pp. 118-119).

Holotype—Specimen no. BSIP 35952.

CONCLUSION

The modern equivalents of the four leaf impressions, viz., *Dipterocarpus tuberculatus* of Dipterocarpaceae and *Albizia gamblei*, *Millettia macrostachya* and *Ormosia robusta* of Fabaceae (Leguminosae) described here from the Lower Siwalik sediments now grow in the moist evergreen forest of Burma. Prasad and Prakash (1984) described three more fossil taxa resembling *Dillenia indica* of Dilleniaceae, *Anogeisus sericea* of Combretaceae and *Syzygium claviflorum* of Myrtaceae from the same sediments, which also show the presence of evergreen to moist deciduous forest during the deposition of the sediments. Thus the present distribution of their modern equivalent taxa collectively indicate the prevalence of evergreen to moist deciduous tropical vegetation around Koilabas during Lower Siwaliks.

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