
Additions to the Neogene florule from near Bhikhnathoree, West Champaran District, Bihar

Nilamber Awasthi & R. N. Lakhanpal

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Eleven new species have been described from the Siwalik beds of Bhikhnathoree, West Champaran District, Bihar. These are based on leaf-impressions which show close resemblance with the leaves of modern *Urena lobata*, *Aphanamixis polystachya*, *Toona ciliata*, *Pterocarpus macrocarpus*, *Derris scandens*, *Pongamia pinnata*, *Cassia glauca*, *Syzygium bracteatum*, *Ardisia solanacea*, *Ipomoea eriocarpa* and *Phoebe lanceolata*.

Key-words—Morphology, Dicot leaf-impressions, Siwalik.

Nilamber Awasthi & R. N. Lakhanpal, Birbal Sabni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.

सारांश

पश्चिम चम्पारन जनपद (बिहार) में भिखनाथोरी के समीप से परचनूतन कालीन वनस्पतिजात में योगदान

नीलाम्बर अवस्थी एवं राजेन्द्र नाथ लखनपाल

बिहार में पश्चिम चम्पारन जनपद में भिखनाथोरी की शिवालिक संस्तरो से अशिमत पत्तियों की 11 नई जातियाँ वर्णित की गई हैं। ये सभी पत्तियों की छापें हैं तथा वर्तमान *यूरेना लोबेटा*, *एफेनामिक्सिस पोलिस्टैकिया*, *तूना सिलियेटा*, *टेरोकार्पस मेक्रोकार्पस*, *डेरिस स्कैन्डेन्स*, *पॉन्गेमिया पिननाटा*, *कैसिया ग्लाउका*, *सिज़ीग्रियम ब्रैक्टिएटम*, *आर्डिसिया सोलेनेसिया*, *आइपोमोइआ इरिओकार्पा* एवं *फ़ोयबे लेन्सिलोलेटा* की पत्तियों से घनिष्ठ समानता प्रदर्शित करती हैं।

A FEW years ago, we described some leaf-impressions from a Siwalik deposit from near Bhikhnathoree in West Champaran District, Bihar. Although this small contribution was submitted in 1979, considerable time elapsed before it was published (Lakhanpal & Awasthi, 1984). In the meantime more leaf-impressions from this locality were collected by one of us (N.A.). Although not all the specimens so far collected have been identified, there are some eleven new species which are being described in the present communication.

In our earlier paper (Lakhanpal & Awasthi, 1984) we had suggested that the age of the Siwalik beds at Bhikhnathoree might be Middle Pliocene. However, an overall examination of the presently available data warrants a more critical consideration of this important aspect. It is also felt that a fresh visit to the locality should be made to collect field observations which may throw more light on the stratigraphy of these sediments. Thus we propose to

present a more comprehensible and final account of the composition, palaeoecology and age of the Bhikhnathoree flora in our next publication.

We are thankful to the authorities of the Forest Research Institute, Dehradun for permission to consult their herbarium for identifying the fossil leaves.

SYSTEMATIC DESCRIPTION

Family—Malvaceae

Urena palaeolobata sp. nov.
Pl. 1, figs 1-4

Description—Leaves are of two kinds, small and medium-sized. *Small leaf* (only one available, Pl. 1, fig. 3) symmetrical, rounded oblate, size 1.9-2.1 cm; apex rounded; base rounded; margin entire with possible incipient indentations; texture coriaceous; petiole not preserved; venation actinodromous,

perfect, basal five primary veins arising from a basal point, each primary vein stout to moderate, the middle and two upper primaries running straight to the margin, the lower lateral primaries slightly curving upward towards margin, four pairs of sub-opposite secondaries discernible, arising at an angle of about 60° in the lower pairs, moderately thick, curving upwards and branched near the margin; tertiaries branched near the margin and forming indefinable reticulum. *Medium-sized leaves* (Pl. 1, figs 1, 2) almost symmetrical, 3-lobed with shallow sinuses, median broadly acute, lateral lobes obtuse, size 3.5×3.00 to 4.5×4.7 cm; base cordate; margin entire to finely serrate; texture coriaceous; petiole not preserved, displaying a clear point of attachment; venation actinodromous, perfect, basal five primary veins arising from a basal point, middle and the upper two primaries stout, running straight towards margin and ending at the tip of each lobe, the lower lateral primaries running in a slightly curved course towards the margin and their branches merging with those of the adjacent primaries, 4-5 alternate to sub-opposite pairs of secondaries arising from the median primary at an angle of about 45° in the lower pair increasing to about 80° in those towards the apex, 6-7 pairs of secondaries arising from the two lateral primaries at an angle of $80-90^\circ$; tertiaries percurrent or forming orthogonal reticulate pattern; higher order of venation forming reticulum not easily recognisable; marginal ultimate venation looped; areoles seemingly well-developed, oriented, quadrangular to pentagonal, medium in size.

Holotype—Specimen no. BSIP 36114.

Discussion—Medium-sized three-lobed leaves with pentanerved cordate base are found in *Kydia calycina* Roxb., *Thespesia lampas* Dalz. et Gibs. and *Urena lobata* Linn. However, the leaves of *K. calycina* and *T. lampas* being about 12.5×10.0 cm are much bigger in size than our fossil leaves. In this respect leaves of *Urena lobata* measuring $2.5-5.0 \times 7-7.5$ cm are very similar. Moreover, the lobes in *Thespesia lampas* are much longer than in the fossil specimens. In *Kydia calycina* the tertiary veins are more closely spaced than in *Urena lobata*. In this character also our fossil leaves are closer to *Urena lobata*. It may further be mentioned that in addition to the normal 3-lobed leaves borne on the main axis of *Urena lobata* there are also some very small leaves borne on axillary branches. In our collection we also have a small leaf which in size and shape is very similar to the small leaves of *Urena lobata*. Considering all these characters we are assigning our fossil leaves to the genus *Urena* under a new species

named *Urena palaeolobata*, suggesting the similarity of the fossil leaves with those of *Urena lobata*.

The genus *Urena* consists of 6 species (Willis, 1973, p. 1196) distributed in tropical and subtropical regions of both the hemispheres. *Urena lobata* is a tall erect undershrub. In India, it is generally distributed in waste land over the northern parts of the country (Duthie, 1960, p. 80).

Family—Meliaceae

Aphanamixis bhikhnathoriensis sp. nov.

Pl. 1, fig. 5

Description—Leaflet almost complete, asymmetrical, ovate, size 7.6×3.0 cm; apex broken, appearing to be short acuminate; base oblique; margin entire; texture thick, chartaceous; petiole normal with longitudinal furrow; preserved length 0.6 cm; venation pinnate, eucamptodromous, mid vein stout, markedly curved; secondaries 14-15 pairs, angle of divergence $60-80^\circ$, course more straight in the wider side of the lamina and curved in the narrower side, sub-opposite, turning up before reaching the margin and meet the next higher secondaries, inter-secondaries rare, simple; tertiaries hardly discernible at places, seeming to be percurrent; finer details not preserved.

Holotype—Specimen no. BSIP 36117.

Discussion—This asymmetrical leaflet with oblique base and pinnate eucamptodromous venation indicates strong affinities with Meliaceae. On critical comparison it shows close resemblance with the leaflet of *Aphanamixis polystachya* (Wall.) Parker (previously known as *Amoora robituka* W. & A.) in all respects except the size. The fossil leaflet is smaller than those of the modern *A. polystachya*. In this regard it must be mentioned that the fossil leaves of Bhikhnathoree, in general, are smaller in size than their corresponding modern taxa. Most probably this reflects a general drier aspect of this florule.

Aphanamixis polystachya is a moderate-sized evergreen tree, occurring along the sub-Himalayan tracts in eastern Uttar Pradesh, Bihar, northern West Bengal, Assam and extending into Andaman and Nicobar Islands. Further east, it spreads from Chittagong in Bangladesh to Burma and Malay Peninsula. It is also found in the Western Ghats and adjoining hill ranges from North Kanara to Tinnevelly (Tirunelveli), extending southward to Sri Lanka (Gamble, 1972).

Toona siwalika sp. nov.

Pl. 1, fig. 6

Description—Leaflet almost complete,

asymmetrical, narrow-elliptic, preserved size 11.0 × 3.5 cm; apex acuminate; base oblique; margin entire; texture chartaceous; petiole not preserved, venation pinnate, eucamptodromous, midvein stout, curved; secondaries 10-12 pairs, alternate to sub-opposite, angle of divergence nearly uniform, 65-70°, moderate to fine, curving up near the margin to meet the next higher secondaries; tertiaries random reticulate; veinlets branched, areoles well-developed, oriented, quadrangular to pentagonal, small.

Holotype—Specimen no. BSIP 36118.

Discussion—In being asymmetrical with oblique base this fossil leaflet also shows affinities with the family Meliaceae. However, in its structural details it is distinct from the leaflet of *Aphanamixis bhikhnathoriensis* of Meliaceae. The texture of this leaflet is not as thick as that of *A. bhikhnathoriensis* as apparent from the details of finer venation discernible in the present fossil. The angle of divergence of secondaries is more in *Aphanamixis* than in *Toona*. Moreover, the course of secondaries is comparatively straight in *Aphanamixis* while more curved in *Toona*.

This fossil leaflet closely resembles those of *Toona ciliata* Roxb., hence it has been placed under the genus *Toona* and assigned to a new species *T. siwalika*.

Toona ciliata Roxb. is a large deciduous tree distributed up to about 1,200 m along the sub-Himalayan tracts from Indus eastward to Bengal and Burma. It also occurs at low elevations in South India and extends to Java and Australia (Duthie, 1960, p. 144).

Family—Fabaceae

Pterocarpus ovatus sp. nov.

Pl. 1, fig. 7

Description—Leaflet complete, symmetrical, narrow ovate, size 4.6 × 2.3 cm; apex acute, tending to be acuminate; base obtuse; margin entire; texture stiff chartaceous; petiolule short, smooth pulvinus; venation eucamptodromous; midvein moderate in

thickness; solid, course straight; secondaries very faint, 8-10 pairs, alternate to sub-opposite, angle of divergence 40-50°, tertiaries not visible.

Holotype—Specimen no. BSIP 36119.

Discussion—The presence of pulvinus at the base strongly indicates its affinity with the family Leguminosae. Amongst various comparable leguminous taxa, the leaflets of *Pterocarpus macrocarpus* match with the fossil leaflet closely. The similarity between the two is noticeable in their shape, apex, base, margin and midvein. However, the fossil is smaller in size than the living counterparts. As far as we are aware there is no previous record of fossil leaves assignable to *Pterocarpus*. Therefore, this Siwalik leaflet is being described as a new species, *Pterocarpus ovatus*, the specific epithet indicating the shape of the lamina.

The comparable modern species *Pterocarpus macrocarpus* is a deciduous tree found in the upper mixed forest of Burma.

Derris champarensis sp. nov.

Pl. 1, fig. 8

Description—Leaflet complete, symmetrical, elliptic-lanceolate, size 4.0 × 1.5 cm; apex broadly acute to retuse; base obtuse, almost rounded; margin entire; texture thinly coriaceous; petiole not preserved; venation pinnate, eucamptodromous; midvein stiff, moderate, straight; secondaries faint, 10 pairs arising at an angle of about 50°, curving up towards the margin, intersecondaries discernible; tertiaries not very clear, probably random reticulate.

Holotype—Specimen no. BSIP 36120.

Discussion—General features of the leaflet are obviously suggestive of the family Fabaceae. On critical examination, the most favourable comparison is noticeable of the leaflets of *Derris scandens* specially in shape, size, texture and venation pattern. The leaflets of *Millettia brandisiana* are also comparable, but differ in texture and venation pattern.

As far as we are aware there is no known fossil record of *Derris* leaves. The specific name of the

PLATE 1



(All figures are of natural size except otherwise mentioned)

1-4. *Urena palaeolobata* sp. nov.

5. *Aphanamixis bhikhnathoriensis* sp. nov.

6. *Toona siwalika* sp. nov.

7. *Pterocarpus ovatus* sp. nov.

8. *Derris champarensis* sp. nov.

9. *Pongamia siwalika* sp. nov., × 1.25.

10. *Cassia antiqua* sp. nov.

11. *Syzygium palaeobracteatum* sp. nov.

12. *Ardisia antiqua* sp. nov.

13. *Ipomoea eriocarpoides* sp. nov.

14. *Phoebe champarensis* sp. nov.

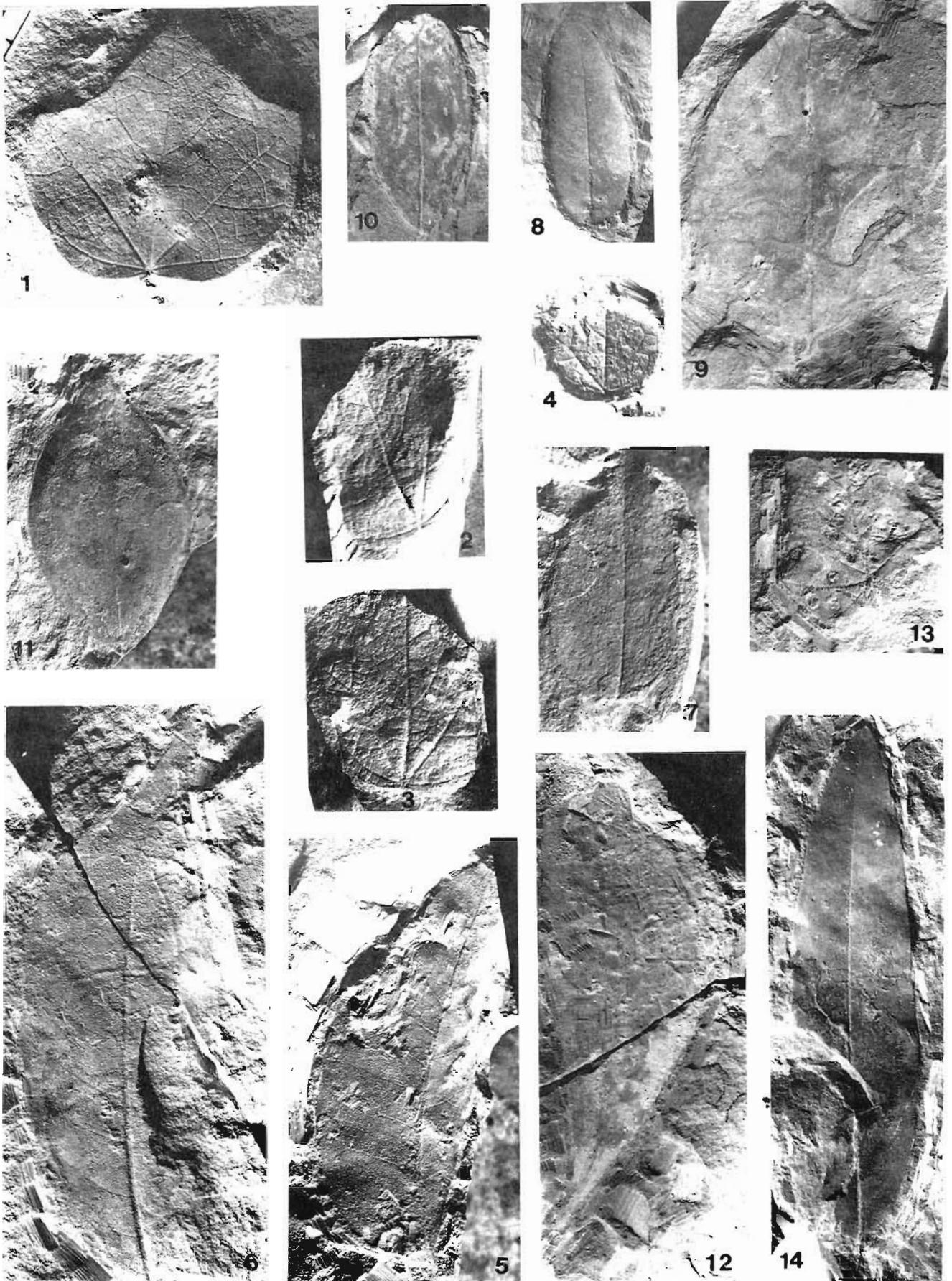


PLATE 1

new fossil, *Derris champarensis* is after Champaran District, from where it has been collected.

Derris scandens (Roxb.) Benth. is a large evergreen climbing shrub distributed in the sub-Himalayan tract from Uttar Pradesh eastward to Assam, Chittagong, Burma, Andamans, south India, Sri Lanka, Malay Peninsula and China.

Pongamia siwalika sp. nov.

Pl. 1, fig. 9

Description—Leaflet complete, symmetrical, ovate, size 4.8 × 3.5 cm; apex shortly acuminate; base obtuse; margin entire; texture chartaceous to thinly coriaceous; petiolule short, 2 mm in length, slightly curved; venation eucamptodromous; midvein thick, thinning out toward apex; course almost straight; secondaries about 6 pairs, alternate, arising at about 45°, running curved up to the margin, further details of venation not discernible.

Holotype—Specimen no. BSIP 36121.

Discussion—In its shape, apex, base, margin and the number and course of secondaries this fossil leaflet resembles the smaller leaflets of *Pongamia*. Therefore, it is being described as a new species, *P. siwalika*, indicating its occurrence in Siwaliks.

Pongamia pinnata is a moderate-sized tree growing near banks of streams and water course in peninsular and extra-peninsular India ascending to an elevation about 650 to 1,000 m. It is also common in tidal and beach forests of Sri Lanka, Malaysia, extending to the coast of South China, Fiji and tropical Australia.

Cassia antiqua sp. nov.

Pl. 1, fig. 10

Description—Leaflet complete, symmetrical, elliptic, 4.0 × 2.0 cm in size, obtuse; base acute; margin entire; texture chartaceous; petiole not preserved; venation pinnate, eucamptodromous; midvein stout; secondaries 11 pairs, angle of divergence about 45-55°, fine, curving upward along the margin, higher order of venation not discernible.

Holotype—Specimen no. BSIP 36122.

Discussion—General shape and size of the leaflet suggest that it belongs to the family Fabaceae. On closer comparison with the leaflets of various modern legumes it was found that in shape, size, apex, base, margin and general venation the fossil leaflet resembles those of *Cassia glauca* L.

Leaves of *Cassia* have so far not been reported from India. However, about a dozen species of this genus have been described by Berry (1916) from the Lower Eocene of south-eastern North America. A few

other reports from the Tertiary of United States have been made by Brown (1929, 1934) and Becker (1969). The shape, size and venation pattern of these fossil cassias of America are distinct from the present fossil leaflet. Therefore, it is being described as a new species *Cassia antiqua*, suggesting its antiquity in India.

Cassia glauca (Roxb.) O. Ktze is a shrub or small tree growing wild in the forest of western south India, Burma and Malaysia.

Family—Myrtaceae

Syzygium palaeobracteatum sp. nov.

Pl. 1, fig. 11

Description—Leaf symmetrical, complete, wide elliptic, size 0.5 × 3.0 cm; apex shortly acuminate; base acute; margin entire; texture smooth, coriaceous; petiole not preserved; venation pinnate, hyphodromous, only a faint and straight midvein discernible, other details not preserved due to thick texture.

Holotype—Specimen no. BSIP 36123.

Discussion—In shape, size, apex, margin, base and coriaceous texture this leaf-impression shows a close resemblance with the leaves of *Syzygium bracteatum*. In this comparable modern species the secondary and tertiary veins are very faint which due to thick texture of leaf could hardly be preserved in fossil state. Due to the marked similarity with *S. bracteatum* this Siwalik leaf is being described as *Syzygium palaeobracteatum* sp. nov.

Syzygium bracteatum is a shrub or small tree found in the peninsula as well as in Assam and Khasi Hills. In the peninsula, on the east side it occurs as semi-evergreen scrub as far north as Orissa. On the west side it grows in evergreen forests ascending to about 1,600 m (Brandis, 1906, p. 325).

Family—Myrsinaceae

Ardisia antiqua sp. nov.

Pl. 1, fig. 12

Description—Leaf incomplete, about 1/4 apical part missing, oblanceolate, preserved length 9.5 cm, width 3.4 cm; apex missing; base cuneate; margin entire; texture coriaceous; petiole normal, preserved length about 7.5 mm, width 1.5 mm; venation pinnate, hyphodromous, midvein massive, slightly curved in the lower portion; secondaries not discernible.

Holotype—Specimen no. BSIP 36124.

Discussion—The oblanceolate shape, cuneate

base, coriaceous texture and massive midvein are the characteristic features of this leaf which strongly indicate its resemblance with the leaves of *Ardisia*. Amongst the various species of this genus the closest resemblance is exhibited by the leaves of *A. solanacea* Roxb. (syn. *A. humulis* Vahl).

Geyler (1887) described some leaf fragments from the Eocene of Borneo as *Ardisiophyllum* sp. Obviously, the details preserved in those fragments were not sufficient for establishing a definite species. Unfortunately, Geyler's publication is not available to us for proper comparison. The present fossil is far remote from the *Ardisiophyllum* belonging to the Eocene of Borneo in space as well as time. Therefore, it is being described under a new taxon, *Ardisia antiqua*.

The extant *Ardisia solanacea* Roxb. is a shrub found throughout eastwards to Assam, central India, Konkan, Kanara and south India. It also extends into Bangladesh, Burma and Sri Lanka. It occurs in the forest undergrowths in moist places along streams.

Family—Convolvulaceae

Ipomoea eriocarpoides sp. nov.

Pl. 1, fig. 13.

Description—Leaf symmetrical, incomplete, only about half (basal) leaf preserved, cordate ovate, preserved length 2.4 cm from the base of the lobe, width 3.0 cm; apex missing; base cordate; margin entire; texture membranaceous; petiole not preserved; venation actinodromous, 7 primaries (1 median and 3 pairs of lateral) arising from the base of the lamina, median primary running towards apex, 2 upper pairs of lateral primaries running towards the margin and the third into the lobe, thickness stiff; 2 pairs of secondaries preserved, arising from the median primary at an angle of about 50°; tertiaries coming out at an angle of 70°-80°; further details of venation not visible.

Holotype—Specimen no. BSIP 36125.

Discussion—Such characteristic features as a cordate base, 7 primaries, entire margin and membranaceous texture indicate the affinity of the fossil leaf with the leaves of *Ipomoea* of the family Convolvulaceae. On critical examination its closest resemblance is found with the leaves of *I. eriocarpa* R. Br. Therefore, the fossil is described as *Ipomoea eriocarpoides* sp. nov.

Ipomoea eriocarpa is a climbing shrub widely distributed in India growing up to an altitude 1,200 m. It is also common in the adjoining parts of Sri Lanka and Afghanistan.

Family—Lauraceae

Phoebe champarensis sp. nov.

Pl. 1, fig. 14

Description—Leaf symmetrical, complete, lanceolate, size 10.0 × 2.5 cm; apex shortly acuminate; base broadly acute; margin entire; texture coriaceous; petiole preserved, 3 mm in length; venation eucamptodromous, curving towards apex; secondaries slender, hardly 7 pairs discernible, angle of divergence 50°-60°, curving up towards margin; higher order of venation not visible

Holotype—Specimen no. BSIP 36126.

Discussion—In its shape, size, apex, base, margin and texture the fossil leaf shows favourable comparison with those of Lauraceae. However, in Lauraceae there are two types of leaves: (i) those having triplinerved base, and (ii) having common alternate type of secondaries. The present leaf-impression obviously belongs to the second type of venation. Among the modern genera of Lauraceae the fossil leaf shows closest resemblance with those of *Phoebe lanceolata* Nees. This fossil leaf, collected from Champaran District, is being named as *Phoebe champarensis* sp. nov.

Phoebe lanceolata Nees, the comparable modern species, is a medium-sized evergreen tree growing in the sub-Himalayan tract and outer ranges from Beas eastward up to Khasi Hills, Bangladesh and Upper Burma. In south India, it is distributed in Annamalai, Tirunelveli and Kerala.

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