Impact of Himalayan uplift on the Late Cenozoic flora of India*

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Stupendous upliftment of Himalayas took place in different phases. With the rise of Himalayas and recession of Tethys sea, India started acquiring its present configuration during Miocene. The continuity of land connection from western Malaysia to eastern India took place and large areas were converted into land all along Tethys upto Africa. Large scale migration and admixture of floras took place between Indian peninsula, south east Asia and Africa due to establishment of land connections. The growing continentality caused by the rise of Himalayas led to the gradual decrease in rainfall. It brought significant changes and the evergreen elements started dwindling and subsequently disappeared although few taxa survived. Recently, a very interesting fossil flora from the Chotanagpur plateau of Bihar (Mahuadanr valley, Palamu) have been described comprising impressions of leaves, flowers and fruits besides silicified woods. In the present communication impression of leaves of *Adina cordifolia, Casearia tomentosa, Drypetes assamica, Ficus microcarpa* and *Hiptage bengalensis* have further been described and the impact of Himalayan upliftment on the flora discussed.

Key-words—Himalaya, Cenozoic Flora, India.

INTRODUCTION

NEOGENE floras are widely distributed both in peninsular and extra peninsular regions of the country viz. Tipam Sandstones, Dupitila Series in the east, Tertiary of Kutch, Gujarat and Rajasthan in the west and Siwalik in the north, Cuddalore Sandstones, Neyveli Lignites and Warkalli beds in south besides Katni Formation of central India. (Guleria 1992, Awasthi 1992).

An interesting flora from the Mahuadanr valley, Palamu District, Bihar have been described comprising impressions of leaves, flowers and fruits besides silicified woods (Prakash *et al.* 1988; Bande & Srivastva 1990; Srivastava & Bande 1992; Srivastava *et al.* 1992). The geology of this area has been worked out in detail by Puri and Misra (1982). Pyroclastic sediments, conglomerate, sandstone and shale occur as the main rock types. Among the sedimentary rocks exposed in the area, the overlying shales have provided fossils of fishes, birds, leaves, flowers, fruits and insects while petrified woods have been recovered from the underlying conglomerate/sandstones (Puri & Misra 1982; Bande & Srivastava 1992; Prakash *et al.,* 1988; Srivastava & Bande 1992 & Srivastava *et al.* 1992). In the present communication leaf impressions of *Adina cordifolia, Casearia tomentosa, Drypetes assamica, Ficus microcarpa* and *Hiptage bengalensis* are being described.

SYSTEMATIC DESCRIPTION

Family-Flacourtiaceae

Casearia tomentosa Roxb.

Pl 1, fig. 1

Material - The study is based upon one leaf impression alongwith its counterpart the preservation of which is fair enough.

Description - Length of leaf 8.8 cm and width 4.5 cm; whole lamina and base symmetrical, elliptic, apex not preserved, base obtuse normal; margin entire; glands not visible but some insect holes are present; chartaceous texture; venation pinnate, craspedodromous, simple, primary vein moderate, straight, secondary vein with acute angle of divergence, further venation could bot be studied due to preservational factor.

Discussion - Elliptic shape, obtuse base, entire margin pinnate - craspedodromous venations with simple moderately thick, straight primary vein are

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the important characters of the fossil leave and it shows close resemblance with the extant leaves of *Casearia tomentose* (BSI, NC, Herbarium sheet no. 6592/10206). The genus *Casearia* comprises 160 species out of which 10 are reported to occur in India. *Casearia tomentosa* is a small tree found throughout India, especially in Sub-Himalayan tract from Indus eastward to Nepal; Oudh, Chotanagpur, Bangladesh, central western and South India. It is very rare in Sri Lanka (Santapau & Henry 1973). This coustitute the first fossil record of genus *Casearia* from India.

Family - Euphorbiaceae

***Drypetes assamica* Pax & K. Hoffm.**

(= *Cyclostemon assamicus* Hook. f.)

Pl. 1, fig. 2

Material - The study is based upon two leaf impressions (Only one figured).

Description - The length of the fossil leaves 7.2 and 9.5 cms and width 3.0 and 3.0 cms, respectively. The preservation of both the leaf impressions is fair enough; lamina and base symmetrical, elliptic, apex acute, base acute (normal); margin entire; glands not visible; texture coriaceous; petiole normal; venation pinnate, camptodromous, loop formation by the secondaries prominent at few places, primary vein stout, straight, secondary vein with acute angle of divergence, uniform, joining super adjacent secondaries at obtuse angle, venation beyond this could not be studied due to preservational factor.

Discussion - Elliptic shape, symmetrical lamina and base, pinnate camptodromous venation loop formation, stout and straight primary vein are the important characters of fossil leaves. It is closely comparable with the modern leaves of *Drypetes assamica* (BSI, NC, Herbarium sheet no. 2664/3596). The genus *Drypetes* comprises about 200 species out of which 15 are found in India mostly in Assam. The genus *Drypetes* includes the species of *Cyclostemon* and *Hemcyclia*. *Drypetes assamica* is a small tree found in sub- Himalayan tract from the swampy forests of Dehradun eastwards to Chotanagpur, Darjeeling Terai and Assam; Khasi Hills, hills of Circars, always in the forest undergrowth in damp places (Santapau & Henry 1973).

Family - Malpighiaceae

***Hiptage bengalensis* (L) Kurz.**

(= *Hiptage madabelota* Gaertn.)

Pl. 1, fig. 3

Material - The study is based upon a single leaf impression, the preservation of which is fair enough.

Description - Length of leaf 7.8 cm and width 3.8 cm; whole lamina and base asymmetrical, oblong, apex not preserved, base obtuse, one side cuneate; margin entire; gland not visible; texture chartaceous; petiole normal; venation pinnate, craspedodromous, primary vein stout, markedly curved, secondary veins (2°) with acute angle of divergence, thin, curved uniformly, intersecondary vein simple, further details could not be studied due to preservation.

Discussion - Oblong shape, asymmetrical base, pinnate, craspedodromous venation with stout markedly curved primary vein and presence of intersecondary veins are the important characters of the fossil leaf and it shows close resemblance with the extant leaf of *Hiptage bengalensis* (BSI, NC, Herbarium sheet no. 2177/6084). The genus *Hiptage* Gaertn. comprises about 20 species out of which 3 occur in India. *Hiptage bengalensis* is a large struggling shrub and is found throughout hotter part of India including Chotanagpur region, Myanmar and Sri Lanka. It is also grown in gardens for white and

PLATE 1 ⟶

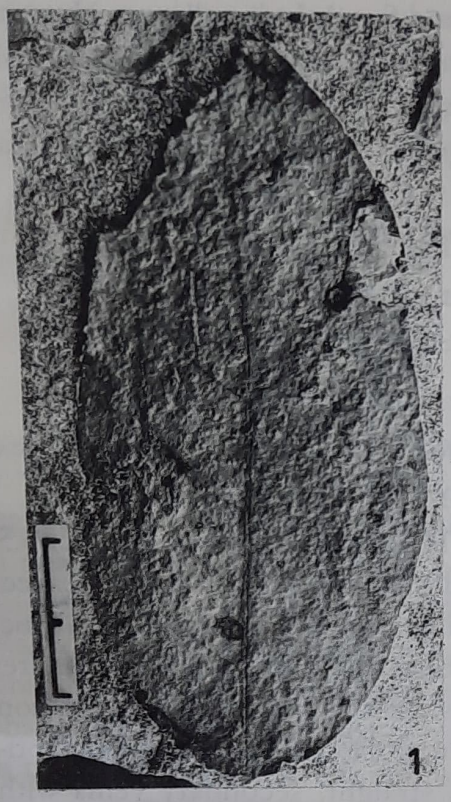
Fig. 1. Fossil leaf of *Casearia tomentosa* Roxb. (B.S.I.P. Specimen no. 37556)

2. Fossil leaf of *Drypetes assamica* Pax & K.Hoffm. (B.S.I.P. Specimen no. 37554b).

3. Fossil leaf of *Hiptage bengalensis* (L) Kurz. (B.S.I.P. Specimen no. 37557).

4. Fossil leaf of *Adina cordifolia* Hook. F (B.S.I.P. Specimen no. 37555).

5.&6. Fossil leaves of *Ficus microcarpa* Linn. (B.S.I.P. Specimen no. 37557-37558)



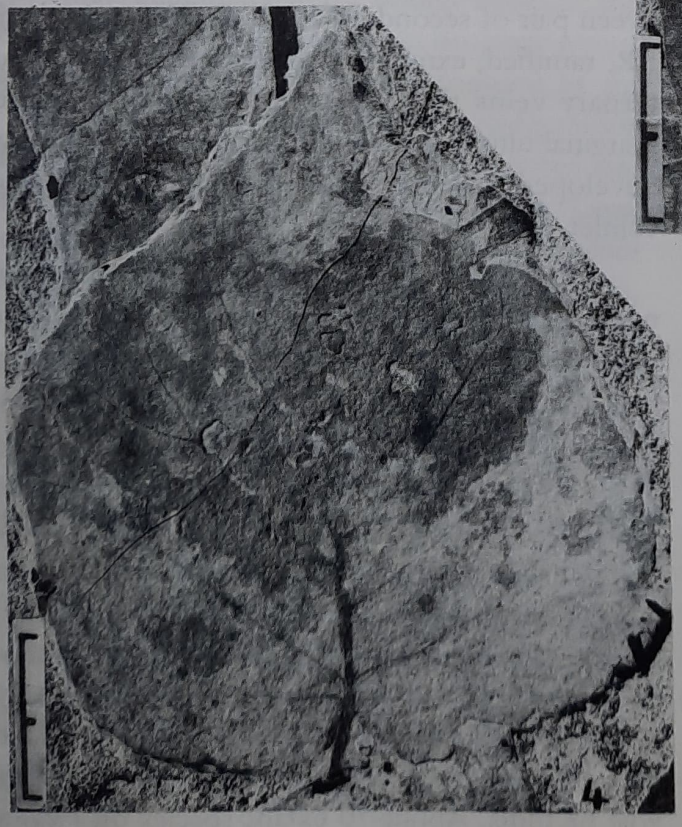


PLATE 1

yellow flowers (Santapau & Henry 1973). This constitute the first fossil record of genus *Hiptage* from Cenozoic of India.

Family - Rubiaceae

***Adina cordifolia* Hook. f.**

Pl. 1, fig. 4

Material - The study is based upon two impression of fossil leaves (only one figured).

Description - The length of these are 9 and 6.5 cm whereas the width is 8 and 6.5 cm, respectively; ovate (very wide ovate) apex acute, base cordate; margin entire; glands not visible; texture chartaceous; petiole normal; venation camptodromous (brochidodromous), primary vein moderate, curved, secondary veins with acute angle of divergence the lowest pair more obtuse, curved abruptly, joining super adjacent secondary at acute angle, thin, tertiary veins with acute angle of divergence curved abruptly to join superadjacent tertiary, this pattern is prominent in the basal part of the leaf as well as near the margin, highest vein order showing excurrent branching is 4^0, quarternary veins thin, orthogonal, quinternary veins thick orthogonal, marginal venation incomplete, areoles well developed, random, quadrangular to polygonal, medium, veinlets none.

Discussion - Ovate shape, acute apex, cordate bases, camptodromous venation, formation of loop by tertiary veins more prominent in basal part, are the important characters of the fossil leaves and show close resemblance with the extant leaves of *Adina cordifolia* (BSI, NC, Herbarium sheet no. 6121/14429). From the Tertiary of India only three genera (*Gardenia*, *Randia* and *Mitragyna* of family Rubiaceae are known (Awasthi 1992, Prasad 1990, Bande & Srivastava 1990).

The genus *Adina* comprises about 200 species confined to subtropical Asia and Africa out of which only six are known to occur from India. *Adina cordifolia* is a large tree found in deciduous forests of the greater part of India, in the sub-Himalayan tract and lower Himalaya from Yamuna eastward to Bhutan and upto 900 meters: common throughout central, western and South India, all over Myanmar in deciduous forest and dry regions of Sri Lanka (Santapau & Henry 1993). This constitutes the first fossil record of genus *Adina* from the Cenozoic of India.

Family - Moraceae

***Ficus microcarpa* Linn f.**

(= *F. retusa* Linn.)

Pl. 1, figs 5-6

Material - The study is based upon three leaf impressions (Only two figured).

Description - The length of these are 5.2, 5.5, and 6.0 cms, width 2.5, 2.4 and 3.2 cms, respectively; whole lamina and base symmetrical, elliptic, apex acuminate, base acute normal; margin entire; texture coriaceous; petiole not preserved; venation pinnate, camptodromous, (brochidodromous), primary vein stout, straight, secondary veins with acute angle of divergence, lowest pair more acute than pairs above, curved abruptly, joining superadjacent secondary at acute angle, intersecondary veins are present more than one between pair of secondary veins, simple, tertiary veins RR, ramified, exmedial, highest vein order 4^0, quaternary veins thick relatively randomly oriented, marginal ultimate venation incomplete, areoles well developed, oriented, mostly quadrangular, large, veinlet none.

Discussion - Elliptic form, brochidodromous venation, more acute angle of divergence of lowest pair of secondary veins, bifurcation of secondaries near the margin and well developed areoles are the important characters of the fossil leaves which indicate its affinity with the leaves of *Ficus microcarpa* (BSI, NC, Herbarium collection no. 43648/56599).

Quite a good number of fossil leaves belonging to *Ficus* are known from India (Srivastava 1991). Bande and Srivastava (1990) have already described three species of *Ficus (F. foveolata, F. glaberrima & F. tomentosa)* from this bed. The present study forms the first record of *Ficus microcarpa* from the Cenozoic of India. About 70 extant species of *Ficus* are known from India (Santapau & Henry 1973). *Ficus*

microcarpa is a large evergreen usually epiphytic tree found in Sub-Himalayan tract from Kumaon eastward, Assam, Khasi Hills and Bangladesh, forest of Sunderbans, common in Myanmar, Coco and Andaman Islands, very common in Sri Lanka. It also grows in Chotanagpur region (Santapau & Henry 1973).

DISCUSSION

It is now an established fact that the Himalayas are rising due to the impact of the collision of Indian and Asian plates. This act of mountain building is the most important event of Tertiary Period in north India. The mighty rise of Himalaya took place in different phases. According to one view (Raina *et al.* 1982) there were three principal phases, while Sharma (1984) recognises at least five major phases. During the initial one or two phases ending in the Oligocene, there was progressive shallowing and narrowing of Tethys, resulting in a complete evacuation of sea water which led to the establishment of subaerial facies. The next phase known as Dharmsala by some geologists and Sirmurian orogeny by others culminated in the Middle Miocene and was the strongest of the Himalayan orogenic movements. With rise of Himalaya and recession of the sea, India started acquiring its present configuration during Miocene and large areas were converted into land all along the Tethys region upto Africa. Large scale migration and admixture of floras took place between Indian peninsula, southeast Asia and Africa due to the establishment of land connections. The presence of some temperate elements (*Quercus, Prunus, Pyrus, Rosa, Spirarea,* Cotoneaster and *Rubus,* etc.) in the Kerala beds further indicates that the northern elements came only after the land connections became possible (Lakhanpal 1970). During Neogene rich floras were flourishing in which family Dipterocarpaceae was a prominent constituent, its occurrences from east to west and north to south alongwith other elements suggest warm tropical climate throughout peninsula (Lakhanpal 1970; Guleria 1992). The growing northward movement of Indian peninsula caused aridity by the end of Neogene. It also resulted in gradual decrease in the rainfall. Post Pliocene orogeny of Himalaya brought further changes and the evergreen elements started dwindling whereas proliferation of subtropical moist deciduous to dry deciduous vegetation took place (Awasthi 1992, Guleria 1992). These are some of the broad inferences about the impact of Himalayan uplift on the Late Cenozoic flora of India in general. Further, an effort has been made to discuss the impact on the Late Cenozoic flora of Mahuadanr valley in particular.

The process of valley formation in Mahuadanr seems to have been initiated by the development of a depression in this region of Chotanagpur granite and gneisses during the Upper Tertiary. Soon the area became a site of deposition and a thin sequence of Upper Tertiary and Quaternary sediments was deposited. The development of bad lands and deeper stream channels in the otherwise flat terrain seems to be the result of another phase of rejuvenation of the area (Anand-Prakash *et al.* 1996). According to Ravi Shanker (1987, 1993) "the post depositional evolution of Gondwana basins as well as mountain ranges and plateaus in central India are demonstrated to be synchronous with Himalayan orogenic events....." He further opined that the chain of Satpura and associated mountain ranges in central India with Proterozoic and Mesozoic rock sequences with or without Deccan Intertrappean cover were uplifted to present levels only in the Tertiary-Quaternary period.

Anand-Prakash *et al.* (1996) while discussing the imprint of neotectonic activity in Mahuadanr valley have opined that the regional uplift which caused considerable erosion of soft sediments forming bad lands and sharply cut stream channels demonstrates the effect of neotectonism, though on a comparatively lesser extent even in the otherwise stable areas within the peninsular shield. Ahmed & Pratibha Devi (1965) while discussing the general geography of the region are also of the view that deeply dissected escarpement of the adjoining hills are due to the upliftment of the area.

Presence of *Sindora siamea,* the characteristic evergreen species, from the sandstone unit of these

beds is very interesting in this context. *Sindora* has so far been recorded from the Mio-Pliocene (Cuddalore Sandstone, Tipam Sandstone & Siwalik beds) of India. The retreat of *Sindora* may be due to the dry climate which was set in after the final uplift of Himalaya manifested sometime during Late Pliocence and Early Pleistocene (Ramanujam 1995). Thus there is a close relationship between structural and geomorphological evolution of central Indian mountain ranges and Himalaya which is also reflected in the fossil flora of Mahuadanr valley.

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