

Fossil Leaf Impressions from Siwalik Bed of Bhutan

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Abstract- *The present study on fossil plants comprising well preserved leaf impressions from the Siwalik Sediments (Formation - II) exposed near Darranga and Lakshmi river section in Bhutan is the first detailed and systemic work. The floral assemblage, recorded from the sediments is impoverished both in quality and quantity as constituted by 17 species belonging to 15 genera and 11 dicotyledonous families of Angiosperm. In the present assemblage a majority of taxa possess conspicuous drip tip. In some specimens the tips either got broken or indistinct due to bad preservation. Thus it shows that prevalence of tropical humid climate around Bhutan during Siwalik period.*

Indexed Terms- *Fossils, Leaf impression, Siwalik period,*

I. INTRODUCTION

The Siwalik sediments are made up of rock materials resulting from denudation of slopes of the Himalayan mountains and deposited on the flood plains of the foreland basins over a span of time (-20 Ma). Pilgrim (1913) proposed a threefold stratigraphic division of the Siwalik Group, i.e. Lower, Middle and Upper Siwalik and ranges in age from Middle Miocene to Middle Pleistocene.

The Siwalik sediments are characterized by the alternate presence of sandstone and mudstone facies, the later very often containing abundant angiospermous fossils belonging to both monocot and dicot families. During last three decades several workers have recovered enormous amount of plant megafossils including petrified woods and leaf, fruit, seed and flowers impressions from the Siwalik foreland basins of India and Nepal (Prakash and Tripathi, 1992; Prasad et al., 1999; Prasad and Tripathi, 2000). Very little detailed work was carried out so far considering the wide extent of Siwalik bed in the Bhutan sub Himalaya (Banerjee and Dasgupta,

1984) described a few leaf impressions from the Siwalik sediments of Lakshmi and Darranga River sections under some artificial genera such as, *Siwalikiphyllum*, *Dilcheria*, *Ghosia*, *Pseudopaxillatophyllum* and *Darrangiophyllum*. Unfortunately, these artificial genera could not be compared with any extant taxa. They have discussed the palaeoenvironmental and palaeoecology of the area only on the basis of morphological features of fossil leaves, In the Siwalik Sediments (Formation - II) exposed near Darranga and Lakshmi river section in Bhutan area a detailed plant megafossils study is still lacking. Therefore, this research is mainly focused on the identification of plant leaf impressions recovered from this area.

II. GEOLOGY OF THE STUDY AREA

The various Siwalik outcrops along the Himalayan foot hills of eastern Bhutan have more or less steep northerly dip and include well exposed Derrathang Section which seems mainly to belong to the Middle and Upper Siwaliks. The youngest outcrops occur near the Main Boundary Thrust and the oldest along the southern margin. Mallet (1875) also described the Middle and Upper Siwaliks from western and eastern Bhutan. Ganseer (1983) observed the classical three fold division in this region but mentioned that the distinction between the Lower and Middle sub division is not easily recognizable. Jangpangi (1974) followed them and suggested three fold division for south-eastern Bhutan in addition to the locally Diklai boulder beds.

III. MATERIAL AND METHODS

Material i.e. leaf impressions for present study were collected from the Siwalik sediment of the Lakshmi river Section in the south eastern part of Bhutan. The leaf impression are found preserved on both grey as well as brown calcareous shale. The specimens were cleared with the help of chisel and hammer. The leaf impressions were studied with the help of either hand

lens or low power microscope under reflected light. In order to identify the leaf impression, a number of herbarium sheets of extant taxa were examined at NBRI, Lucknow, Forest Research Institute, Dehradun and Central National Herbarium Shibpur, Hawrah, West Bengal. The leaf impressions showing various morphological characters were photographed in natural light and have been described following the terminology given by Hickey (1973) and Dilcher (1974). The photographs of leaf impressions showing various morphological characters were taken under the natural low angled light using a Canon digital camera. The study of structural features of fossil angiospermous leaves such as size, venation, density, texture, margin, shape and nature of leaf tip etc was done by foliar physiognomy method as this method is independent of the systemic relationship of the species and error in the interpretation of palaeoclimate are

minimized as compared to the nearest living relative method.

IV. RESULTS AND DISCUSSION

In the present study the fossil consists of a wide variety of mostly woody plants. Total 17 plant species leaf impressions belonging to 15 genera and 11 dicotyledonous families of Angiosperm in fossil forms were found in the Siwalik sedimentations. All the 17 leaf impression showed entire margin, indistinct petole nature, simple leaf organization and distinct venation pattern. Except *Diplodochus tertiarum* all leaf impression showed drip tips. The physiognomic characters of the fossil flora recovered from the Siwalik sediments of Bhutan were listed in table.

S.N.	Fossil Taxa	Family	Average leaf size sq.cm	Leaf texture	Leaf base shape
1	<i>Mycelia bhutanensis</i>	Magnoliaceae	28.35	Chartaceous	Indistict
2	<i>Gynocardia mio-odorata</i>	Flacourtiaceae	47.04	Chartaceous	Indistict
3	<i>Calaphyllum bhutanensis</i>	Clusicaceae	27.3	Chartaceous	Acute
4	<i>C. Siwalicus</i>	Clusicaceae	10.29	Coriaceous	Indistict
5	<i>Kayea miofloibunda</i>	Clusicaceae	29.68	Chartaceous	Indistict
6	<i>Vateria palaeocanaliculata</i>	Dipterocarpaceae	8.97	Chartaceous	Indistict
7	<i>Sterculia miocenica</i>	Sterculiaceae	14.00	Chartaceous	Acute
8	<i>Diplodochus tertiarum</i>	Tiliaceae	21.39	Chartaceous	Acute
9	<i>Trioma tertiarum</i>	Burseraceae	22.94	Chartaceous	Indistict
10	<i>Zizyphus sabnii</i>	Rhamnaceae	3.0	Chartaceous	Indistict
11	<i>Z.bhutanensis</i>	Rhamnaceae	7.39	Chartaceous	Curdate
12	<i>Erioglossum mio-edule</i>	Sapindaceae	15.84	-	Acute
13	<i>Harpullia tertiarum</i>	Sapindaceae	22.25	Coriaceous	Acute
14	<i>Hemigyrosa miocenica</i>	Sapindaceae	14.95	Chartaceous	Acute
15	<i>Buchanania teriarum</i>	Anacardiaceae	45.51	Chartaceous	Obtuse
16	<i>Gluta sahnii</i>	Anacardiaceae	28.52	Chartaceous	Indistict
17	<i>Butea siwalicus</i>	Fabaceae	45.12	Coriaceous	Obtuse

The leaf margin and leaf size are the best indicator of climate. The typical entire margined leaves of the woody families like Anonaceae, Clusiaceae, Sapotaceae and Dipterocarpaceae etc. are practically absent from mesophytic cold temperate regions. On the contrary, nonentire leaved families as Betulaceae, Aceraceae, Platanaceae, etc are absent from low land tropical areas. Nevertheless, the families like Malvaceae, Rosaceae, Ulmaceae, Fagaceae, Tilaceae, Flacourtiaceae, Anacardiaceae and fabaceae bear both

types of leaf margins(Table).According to Bailey and Sinnott (1916) the woody plants of tropical low lands posses entire margins, while in temperate they possess non-entire margins. Similarly Srivastava (2006) concluded that the tropical rain forests have the highest percentage of entire margined species. The percentage decreases with decreasing temperature either with increasing altitude to the Submontane and montane rain forest or with increasing latitude to the warm temperate forest. This criterain, when applied to

the Siwalik Flora of the Bhutan, reveals that all species have entire margin indicating warm tropical climate. According Webb (1959) the leaf size may be measured typically by 5 size classes, Viz; leptophyll (upto 0.258sqcm), nanophyll (0.25-2.25sq.cm), microphyll (2.25-20.0sq.cm), mesophyll (20.0-182.0 sq.cm) and macrophyll (182-1640 sq.cm). According to this classification the floral elements obtained from middle Siwalik area of Bhutan area possess mainly microphyll and mesophyll types of leaves. Application of the above criterion to the present assemblage in which most of the taxa possess optimal sized leaves again indicates that a tropical humid climate prevailed in the area during Mio-Pliocene. The 'Dip tip', an extended leaf tip, is also another important physiognomic feature of angiospermous leaves and is generally seen in wet tropical forest elements (Srivastava, 2006). The function of drip tip is to hasten the run off of water from the leaf. Richards (1952) pointed out that it facilitates them to retard the growth of epiphytes. The deciduous leaves generally lack drip tip because of their short life span. In the present assemblage a majority of taxa possess conspicuous drip tip. In some specimens the tips either got broken or indistinct due to bad preservation. Thus it also shows that prevalence of tropical humid climate around Bhutan during Siwalik period.

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