

Leaf Impressions of *Calophyllum Siwalicus* And *Kayea Miofloribunda* (Clusiaceae) From the Siwalik Bed of Bhutan

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Abstract- *The fossil i.e. Leaves impression of Calophyllum siwalicus and Kayea miofloribunda (Clusiaceae) were collected from the Siwalik Sediments (Formation-II) near Darranga and Lakshmi river section in Bhutan for detailed systemic study. These fossil leaves have been identified with modern angiospermous taxa up to specific level. The habit, habitat and present-day distribution of the comparable extant taxa indicates the existence of tropical to sub-tropical evergreen to semi evergreen forest with humid climate in the area during the deposition of the Siwalik sediments.*

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

I. INTRODUCTION

The Siwalik foreland basin accumulated a huge pile of molasse sediments since the middle Miocene to early Pleistocene between the Lesser Himalaya in the north and the Indo-Gangetic Plain in the south (Valdiya,2002). A variety of plant megafossils including petrified woods and impressions of leaves, fruits, flowers and seeds have been recorded from Siwalik Sediments of India and Nepal (Prakash and Tripathi, 1992; Prasad and Awasthi, 1996 and Prasad *et al.*, 1999). Very little detailed work was carried out so far considering the wide extent of Siwalik Sediments in the Bhutan sub Himalaya (Prasad and Tripathi,2000). 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. The leaf features that have used mainly an aid in determining past climate, are leaf margin, drip tips, leaf size and venation density. In the the Siwalik sediments of Lakshmi and Darranga River sections area a detailed plant megafossils study is still lacking. Therefore, this research is mainly focused on the identification of plant impressions recovered from this area.

The Siwalik leaf assemblage is dominated by evergreen constituents like dipterocarps, legumes and other associated taxa in contrast to mixed deciduous constituents of the present-day floral assemblage of the regions. This is most probably due to post-Pliocene orogeny of the Himalaya which brought changes in the topography and climate and thus adversely affecting the vegetation scenario of the Himalayan foot hills.

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. Ganseer (1983) observed the classical threefold 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 threefold 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 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

1) Systematics

Family: Clusiaceae

Genus- *Calophyllum siwalicus* sp. nov. (Plate 1. Fig. 1&2)

Description: Leaf simple; lamina symmetrical, preserved lamina length 4.9 cm; maximum width 2.1 cm; oblanceolate; apex mucronate; base broken; margin entire; texture seemingly coriaceous; petiole not preserved; venation pinnate; brochidodromous; primary vein (1⁰) single, prominent, straight, shout; secondary vein (2⁰) angle of divergence moderately acute 68⁰, uniformly and slightly curved running parallel to margin; tertiary veins (3⁰) and higher order venation indistinct (Plate I Fig. 1&2).

Affinities: A detailed comparison of the present fossil leaf with the modern leaves of several species of *Calophyllum* Linn was performed at FRI, Dehradun. The compared species were *Calophyllum parkeri* Fisher; *C. inophyllum* Linn; *C. blancoi*. Pl and Tr; *C. brasiliensis* Camb; *C. costatum* F.M.Bailey; *C. kunstleri*.Wall; *C. pulcherrimum* Wall; *C. obliquinerrium* Merr; *C. spectabile* Willd; *C.*

tomentosum Wight; *C. venustum* King; *C. wallichianum* and *C. wightianum* Wall.

From this comparative study, it was found that the modern leaf of *C. parkeri* Fischer shows identical features with the present leaf impression in having from oblanceolate; entire margin; mucronate apex; coriaceous texture and moderate secondaries at angle of divergence 68⁰.

Fossil Records and Comparison: There is no fossil record of the leaf impression of *Calophyllum* from Bhutan. However, a single fossil leaf of the genus *Calophyllum* viz., *Calophyllum pliocenicum*. Therefore, the present fossil leaf is described and named as *Calophyllum siwalicus* sp. nov. The species name indicating its occurrence in the Siwalik beds of Bhutan. The species *Calophyllum parkeri* Fischer, vern *C. angustifolium* Roxb. With which the present leaf impression resembles most is found growing in Prince of Whales Island only (Hooker, 1875).

2) Systematics

Family: Clusiaceae

Genus- *Kayea miofloribunda*

Description: Leaf simple; lamina symmetrical; lorate (6:1); preserved lamina length 10.6 cm; maximum preserved width 2.8 cm; base broken; margin entire; apex acute; texture chartaceous; petiole not preserved; venation pinnate simple craspedodromous; primary vein (1⁰) shout (3.8%), single straight, unbranched; secondary veins (2⁰) moderate, angle of divergence 48⁰; uniformly curved unbranched, relative thickness moderate, tertiary veins (3⁰) admedial percurrent, relationship to mid vein approximately at right angle, arrangement predominating opposite; the higher order of venation indistinct (Plate I Fig. 3&4).

Affinities: The characteristic features, of the present fossil leaf impression are its lorate shape; chartaceous texture; craspedodromous venation; acute apex and uniformly curved secondaries with angle of divergence 48⁰. Such features are observed in the modern leaves of the genus *Kayea* Wall, of the family Guttiferae.

Fossil Records and Comparison: The first fossil record of *Kayea miofloribunda* sp. nov. is known from tertiary of Bhutan. However fossil leaf of *Kayea*

miofloribunda showing nearest resemblance with modern leaves *Kayea floribunda* Wall with which the fossil leaf resembles most is found growing in dense tropical forests of the Eastern Himalaya, in Sikkim, and the Kharia mountain, ascending to 3000 ft (Hooker, 1875).

V. DISCUSSION

The genus *Calophyllum* Linn includes about 100 species (Willis, 1966) of trees widely distributed in the tropics of both Hemispheres. Most of the species occurs in tropical Asia and East Indies but none in Africa except in the Island of Madagascar of nearly a dozen species indigenous of the Indian region (India, Burma, Bangladesh, Ceylon and the Andaman), five species are found in India proper distributed in Eastern and southern parts of the country (Chaudhury and Ghosh, 1946; Pearson and Brown, 1932). The present specimen was compared with the modern leaves of several species of this genus at FRI Dehradun, e.g. *Kayea assamica* Prain; *K. elegans* King; *K. floribunda* Wall; *K. grandis* King; *K. paniculata* Merr; *K. racemosa* Planch; *K. triana* Planch; *K. nervosa* T. and *K. kunstleri* King. From this study it was found that the present fossil leaf and the modern leaf of *K. floribunda* Wall. Thus, it can be concluded that the fossil leaves *Calophyllum siwalicus* and *Kayea miofloribunda* resemble the modern leaves of *C. parkeri* Fischer and *K. floribunda* Wall., respectively.

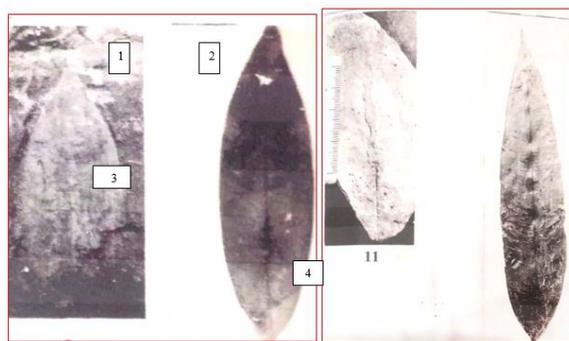


PLATE-I

Fig.1. Fossil leaf of *Calophyllum siwalicus* magnified to show details of venation.

Fig.2. Modern leaf of *Calophyllum parkeri* in natural size showing similar shape, size and venation pattern.

Fig.3. Fossil leaf of *Kayea miofloribunda* - magnified to show details of venation.

Fig.4. Modern leaf of *Kayea odorata* in natural size showing similar shape, size and venation.

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