

Fossil leaves and a fruit from Warkalli beds, Kerala Coast, India*

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Leaf-impressions resembling those of *Calophyllum* L. (Clusiaceae), *Gluta* L. (Anacardiaceae) and *Cinnamomum* Schaeffer (Lauraceae), and a trilocular euphorbiaceous fruit are described from the Warkalli beds, Varkala, Kerala Coast. Occurrence of carbonised woods and leaves of these genera at several places in Kerala Coast suggests their wider distribution in the region during Middle Miocene.

Key-words - Angiosperms, fossils, leaves, fruit, Warkalli beds (Middle Miocene), Kerala Coast, India.

INTRODUCTION

The Middle Miocene sediments of Kerala classified as Warkalli beds are exposed in the cliff sections and clay mines at several places along the coast, from Thiruvananthapuram District in the south to Kasargod District in the north. They are rich in carbonised woods which occur in the lignitic beds overlain by carbonaceous clays, variegated clays and sandstones. Systematic study of carbonised woods has been carried out by Awasthi and Ahuja (1982), Awasthi and Panjwani (1984), Awasthi and Srivastava (1989, 1990, 1992), who identified a fairly good number of dicotyledonous taxa from different localities. Except for carbonised woods, so far no other megafossil has been reported from the Warkalli beds. However, during field surveys to Kerala Coast in early 1971, the senior author came across a few small patches of sediments containing leaf-impressions in the sea cliffs at Papanasam, Varkala; and in Shashtankota, near the spillway of the dam, Kollam District. The material from the latter site could not be brought to the laboratory due to its highly fragile nature though a few of them collected at the site appeared very similar to *Cinnamomum*.

The material collected from Papanasam is also fragile, preserved in the thinly laminated carbonaceous sandy clays, and consists of a variety of leaves. During transportation to the laboratory, most specimens were broken into fragments. However, a few of them displaying the features of the leaves of *Calophyllum*, *Gluta* and *Cinnamomum*, and a

fruit collected from Payangadi clay mine could be studied which form the subject matter of the present communication.

SYSTEMATIC DESCRIPTION

LEAVES

Family - Clusiaceae

Genus - *Calophyllum* Linn.

Calophyllum suraikholaensis Awasthi & Prasad 1990

Pl. 1., figs 3-5

Material - There are five specimens representing this species. They are incomplete with either apical or basal part missing.

Description - Leaves simple, symmetrical, narrow elliptic to elliptic or oblong, preserved length and width of two specimens 7.2 x 3.4 cm and 5.7 x 3.2 cm respectively; apex obtuse; base acute to cuneate; margin entire; texture seemingly coriaceous; petiole preserved in one specimen, 7 mm in length; venation pinnate, simple, craspedodromous, primary veins prominent, straight, stout in the basal region, thinning out towards the apex; secondary veins numerous, very closely placed, opposite or alternate, unbranched, angle of divergence of basal secondary nearly 90° slightly acute; tertiary veins not seen.

Hypotype - Specimen nos. BSIP. 36797, 36798

Horizon & locality - Warkalli beds, Papanasam

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(Varkala), Thiruvananthapuram District, Kerala.

Affinities - In their shape, size and venation pattern the fossil specimens are comparable to the leaves of the genus *Calophyllum*. Out of a large number of the extant species of *Calophyllum* examined, leaves of *C. polyanthum*, *C. spectabile*, *C. inophyllum* etc. show resemblance with the present fossil leaves. It is not possible to suggest which of these could be the nearest modern counterpart of the fossil.

Among the known fossil leaves of *Calophyllum* from India and abroad (see Awasthi & Prasad, 1990), *Calophyllum suraikholaensis* Awasthi & Prasad (1990) described from the Siwalik sediments of Surai Khola, Nepal is very similar to our present fossil specimens. Therefore, we assign it to the same species.

Family - Anacardiaceae

Genus - *Gluta* Linn.

Gluta papanasamica sp. nov.

Pl. 1 figs 1,2

Material - This species is represented by 6 incomplete specimens.

Description - Leaves simple, symmetrical, elliptic, preserved length and width of two specimens 10 x 3.2 cm and 6.5 x 4.2 cm respectively; apex broken; base acute; margin entire; texture coriaceous; venation pinnate, eucamptodromous; primary vein prominent, stout, straight, secondary veins alternate to subopposite; angle of basal secondary veins nearly 90°, wide acute towards the apical half, running straight, turning upwards just before reaching the margin; tertiary veins not preserved.

Holotype - Specimen no. BSIP 36799

Paratype - Specimen no. BSIP 36780

Horizon & locality - Warkalli beds, Papanasam (Varkala), Thiruvananthapuram District, Kerala.

Affinities - In shape, size and venation pattern the fossil leaves show resemblance with those of the genus *Gluta*. Detailed comparison of the fossil leaves with the herbarium sheets of a number of species of *Gluta* and other closely allied anacardiaceous taxa was made in order to identify them upto specific level. It was found that the leaves of *Gluta usitata* (Wall.) Hou (= *Melanorrhoea usitata* Wall.) and *G. glabra* (Wall.) Hou (*M. glabra* Wall.) show close similarity with the fossil leaves. In both, the extant and fossil leaves, the primary vein is very stout and the basal secondary veins arise at 90°.

So far, there is only a single record of the fossil leaf of *Gluta*, *G. siwalika* described from the Siwalik sediments of Surai Khola, Nepal (Awasthi & Prasad, 1990). Our present fossil leaves differ from it in the size, venation pattern and the angle of divergence of secondary veins. As pointed out above, the angle of divergence of basal secondaries in our fossil leaves is almost 90° while in *Gluta siwalika* it is acute. Moreover, in size and shape *Gluta siwalika* is bigger and narrow elliptic. In view of these differences the present fossil leaves are assigned to a new species, *Gluta papanasamica*. The specific name is after the locality Papanasam from where they have been collected.

Family - Lauraceae

Genus - *Cinnamomum* Schaeffer

Cinnamomum sp.

Pl. 1, figs 6-7

Material - Two incomplete specimens, one with apical half and the other with basal half.

Description - Leaf with apical half 4.8 cm in length, 2.8 cm in width, seemingly elliptic; apex acute; margin entire; texture chartaceous; triplinerved, venation acrodromous, perfect, lateral primary veins slightly curving towards the apex. Leaf with basal half 3.00 cm. in length, base acute; margin entire; petiole present, 1 cm in length; texture chartaceous; venation acrodromous, triplinerved, veins arising from above the base, suprabasal; tertiary veins not seen.

Specimen - BSIP nos. 36781, 36782.

Horizon & locality - Warkalli beds, Papanasam (Varkala), Thiruvananthapuram District, Kerala.

Affinities - Both the fossil specimens are triplinerved, which is a characteristic feature of the leaves of *Cinnamomum* of the family Lauraceae.

As the leaves are incomplete, it is not possible to identify them precisely upto specific level. Therefore, they are being referred to the genus *Cinnamomum* Schaeffer.

FRUIT

Family - Euphorbiaceae

Genus - *Euphorbiocarpon* Mehrotra et al.

Euphorbiocarpon payangadiense sp. nov.

Pl. 1, figs 8-10

PLATE 1

(All figures are of natural size unless otherwise mentioned)

Gluta papanasamica sp. nov.

1. Fossil leaf. Holotype no. BSIP. 36799.

2. Another fossil leaf. Specimen no. BSIP. 36800.

Calophyllum suraikholaensis Awasthi & Prasad.

3. Fossil leaf. Paratype no. BSIP. 36797.

4. Another specimen showing basal part. Paratype no. BSIP 36798.

5. Fossil leaf magnified to show venation, x 3. Paratype no. BSIP 36797.

Cinnamomum sp.

6. Fossil leaf (apical part). Specimen no. BSIP 36801.

7. Fossil leaf (basal part). Specimen no. BSIP 36802

Euphorbiocarpon payangadiense sp. nov.

8. Fossil fruit. Holotype no. BSIP 36803.

9. Another view of the same specimen.

10. Transverse section of the specimen showing three locules. x 1.5.

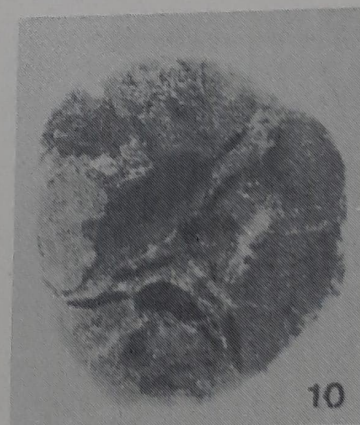
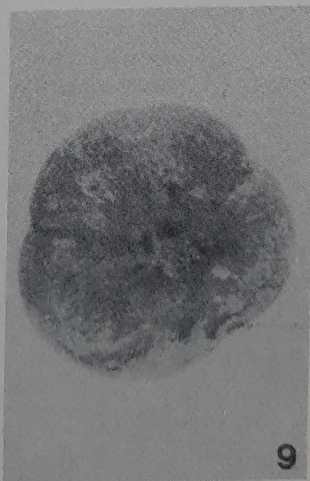
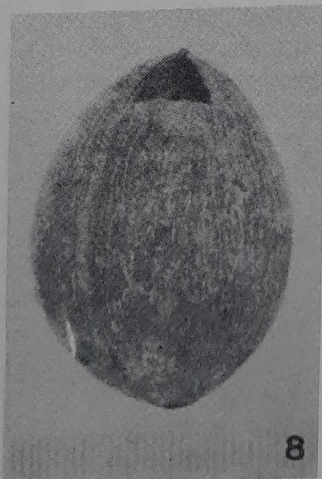
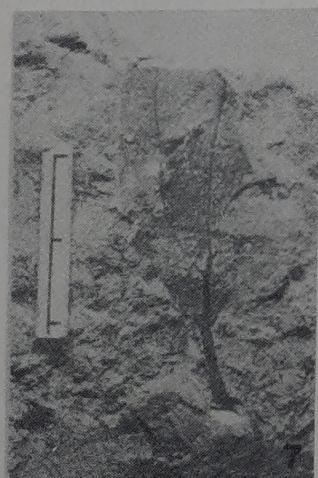
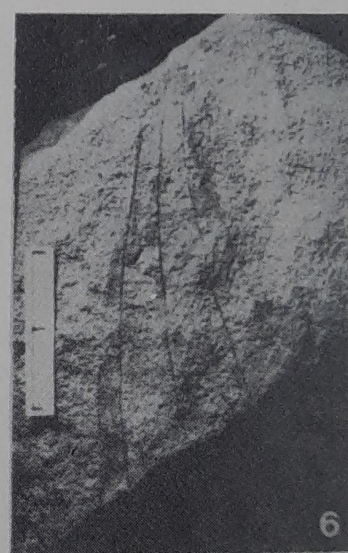
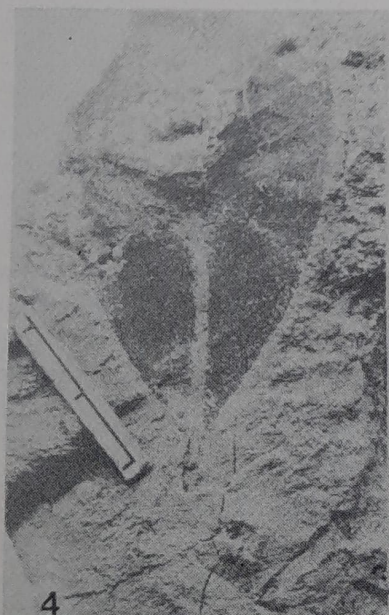
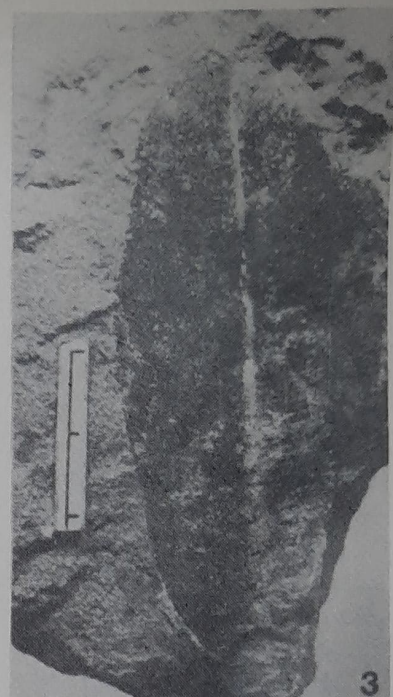
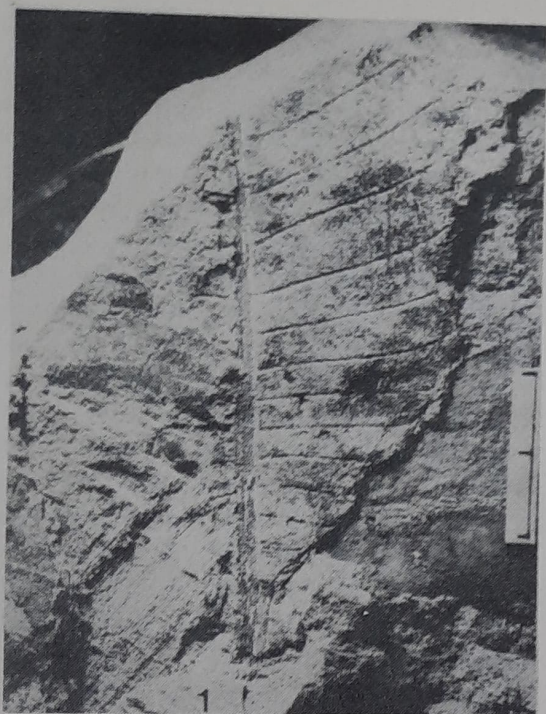


PLATE 1

Material - A single carbonised specimen.

Description - Fruit tricarpeal, trilocular, seemingly indehiscent drupe, oval in shape, 3.4 cm in length, 2.2 cm in diameter; longitudinal ridges present on the surface. In transverse section triradiate mark like septa present separating the locules, one locule is bigger having a well developed seed, the second seed is less developed and the third one is seemingly abortive.

Holotype - Specimen no. BSIP 36783

Horizon & locality - Warkalli beds, Payangadi Super Clay Mine, Kannur District, Kerala.

Affinities - In its external features the carbonised fruit shows similarity with those of Arecaceae and Euphorbiaceae. However, fibrovascular bundles, with a well developed sclerenchymatous sheath, a characteristic feature of palm fruits, is not seen in the present fruit when examined under SEM. So the possibility of its being a palm fruit is ruled out.

In the family Euphorbiaceae there are two genera *Elaeophorbia* Stapf and *Drypetes* Vahl which have three seeded drupaceous fruits, but they are round and smaller than the present fossil. In shape and size it resembles the fruits of *Jatropha*. However, the fruits of *Jatropha* are dehiscent capsule having entirely different morphological character, while the present fossil fruit appears to be indehiscent with hard and tough surface.

Due to non-availability of fruits of other genera for detailed comparison, it is not possible at present to assign the fossil fruit to any extant genus of Euphorbiaceae. Therefore, it is placed under the genus *Euphorbiocarpon* Mehrotra *et al.* This genus was created to designate the trilocular indehiscent drupaceous fossil fruits of Euphorbiaceae. The present carbonised fruit differs from the only known species *Euphorbiocarpon drypeteoides* Mehrotra *et al.* in shape, size and other features. Hence, it is named as *Euphorbiocarpon payangadiense*, after the locality Payangadi.

DISCUSSION

Occurrence of the leaves of *Gluta*, *Calophyllum* and *Cinnamomum* in the Warkalli beds provides further evidence of their wider distribution in the region during Middle Miocene-Pliocene. The genus *Gluta* is well known for its fossil woods reported from the Neogene sediments of northeast India, Himalayan foot-hills of U.P., Bengal, Pondicherry, Neyveli, Kerala, Gujarat (Awasthi, 1966; also see Srivastava, 1991). The leaf of this genus has been described recently from the Siwalik sediments of Nepal (Awasthi & Prasad, 1990).

Similarly, the genus *Calophyllum*, whose fossil wood is already reported from Warkalli beds (Awasthi & Ahuja,

1982), is another important taxon of the tropical evergreen forest. It is known from the Neogene sediments of Pondicherry (Lakhanpal & Awasthi, 1965), northeast India, Bengal (see Srivastava, 1991) and Nepal (Awasthi & Prasad, 1990). The genus *Cinnamomum* too is of common occurrence in the Indian Tertiary rocks and has a long geological history in India, its earliest record so far being from the Lower Eocene deposits of Kutch (Lakhanpal & Guleria, 1982). Of these, *Calophyllum* and *Cinnamomum* continued to grow in the wet evergreen to moist deciduous forests which are now restricted to Western Ghats and northeastern India. In India, the genus *Gluta* is represented by a single species, *G. travancorica*. It occurs in the evergreen forest of south Travancore and Tirunelveli (Tinnevely) and has now totally disappeared from other parts of the country as indicated by its fossil record. However, most of them are distributed in Myanmar and Malaysian region in the tropical evergreen to moist deciduous forests (Hou, 1978).

Besides, occurrence of other taxa, viz., *Hydnocarpus*, *Dryobalanops*, *Shorea*, *Fagara* (= *Zanthoxylum*), *Canarium*, *Swintonia*, *Cynometra*, *Cassia*, *Carallia*, *Anisophyllea*, *Careya*, *Payena*, *Diospyros*, *Leea* and *Gonystylus* in the Warkalli beds (Awasthi & Ahuja, 1982; Awasthi & Panjwani, 1984; Awasthi & Srivastava, 1989, 1990, 1992) indicates prevalence of very warm and humid conditions with heavy rainfall all along Kerala Coast during Middle Miocene-Pliocene. Most of these evergreen taxa, e.g., *Dryobalanops*, *Anisoptera*, *Shorea*, *Swintonia*, *Gonystylus* and some species of *Gluta*, *Hydnocarpus*, *Canarium* no more exist in Kerala and other parts of the Indian sub-continent. It is envisaged that gradual desiccation over its greater part in the post Pliocene time caused extinction of most of such evergreen taxa.

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