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Cecidomyiid leaf galls in Palaeocene leaves from north-eastern India

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ABSTRACT. Distinct galls have been observed on fossil leaves from the Upper Palaeocene aged flora of the Tura Formation, north-eastern India. The leaves are described under *Eomangiferophyllum damalgiriensis* Mehr. an analogue of the modern genus, *Mangifera* Linn. Galls are comparable with modern cecidomyiid galls of *Amaradiplosis echinogalliperda* Mani found on extant leaves of *Mangifera indica* L. The report for the first time demonstrates the host-plant relationship with gall forming insects in the Tertiary flora of India.

KEY WORDS: insect gall, angiospermous leaf, Upper Palaeocene North-east India

INTRODUCTION

Fossil leaves of *Mangifera* L. described under *Eomangiferophyllum damalgiriensis* by Mehrotra et al. (1998; vide fig. 2 A-E) apparently show the presence of small to large size protuberances all over the surface of lamina. The structures on detailed examination have been found to be comparable with insect galls belonging to the family of cecidomyiid of the order of Diptera.

Insect galls are poorly recorded in the fossil floras of India. Galls of unknown affinity are described in *Glossopteris* leaves of the Late Palaeozoic age (Srivastava 1988, 1996 Pant & Srivastava 1996), however, their records are entirely absent during the Mesozoic. Recent report of unidentified insesct galls in the fossil leaf *Sophora benthamii* Sterm is the only known specimen from the Tertiary flora of India (Srivastava & Srivastava 1998). In comparison insect galls are well known in contemporaneous floras of Europe and America and have been documented by many previous workers (Straus 1977, Boucot 1990, Larew 1992, Scott et al. 1994). The non availability of such specimens in the Indian floras does not signify their absence, rather, it shows the lack of initiative to examine the fossil floras in relation to insects and their activities. The present record of fossil galls having resemblance with Cecidomyiid galls of *Amradiplosis echinogalliperda* Mani found on modern leaves of *Mangifera indica* L. is firm evidence of insect-plant interaction in the angiospermous flora of India.

SAMPLE COLLECTION AND FOSSIL SITE

Palaeobotanical investigations of the north-eastern part of India in Meghalaya State have yielded well preserved plant fossil assemblages near the village Damalgiri (25° 32'N: 90° 07'E) situtated about 16 km south west of main town Tura (Fig. 1).

Plant fossils known from Tura and nearby areas belong to the taxa *Nelumbium* (Lakhanpal 1955a), *Trema*, *Neolitsea*, *Bombacites* (Lakhanpal 1955b), *Nypa*, *Nelumbo*, *Litsea*, *Phoebe*, *Artocarpus*, *Triumfetta*, *Heteropanax*, *Osmansthus*, *Ligustrum* and *Leguminocarpon* (Bhattacharyya 1983, 1985).

The samples belong to an Upper Palaeocene sequence of the Tura Formation (Saxena et al. 1996) and the following geological successions

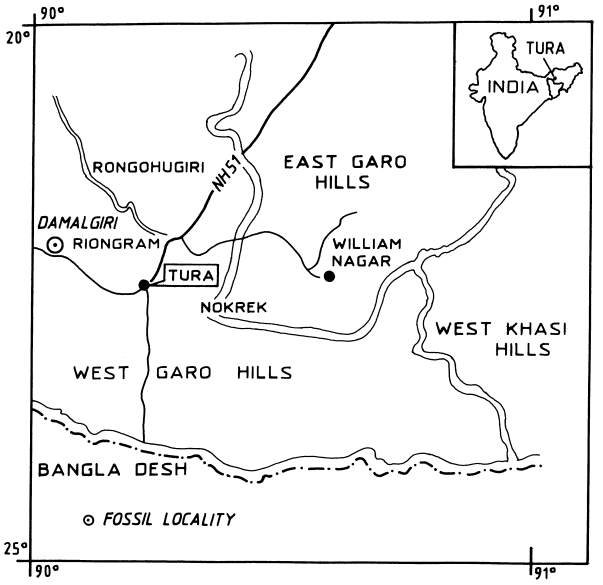

Fig. 1. Map of the area indicating fossil site, inset map of India shows location of the area

Table 1. Lithostratigraphic sequence near Tura

Age	Group	Lithology (m)
Oligocene	Jaintia	Simsang Formation: 1000
		Kopili Formation: 450–500
Eocene -Palaeocene		Siju Lime-stone: 100–160
		Tura Formation 180–250
Upper Cretaceous		Coarse grained sandstone and conglomerate 60
Pre-cambrian	Unconformity	Coarse grained granite, granodiorites banded geniss and quartzite

are proposed by Raja Rao (1981) in this area (Tab. 1).

Leaf specimens with insect galls are preserved as compression on white to greyish white and buff coloured claystone. It is not possible to examine the cellular details as very brittle and fragile pieces of cuticles are obtained after chemical treatment of the cellular pulls. The observation is based on two leaf specimens among them one (Figs 2, 3) was described by Mehrotra et al. (1998, vide figure 2A-E). Figured specimens are preserved in the Museum of Birbal Sahni Institute of Palaeobotany, Lucknow.

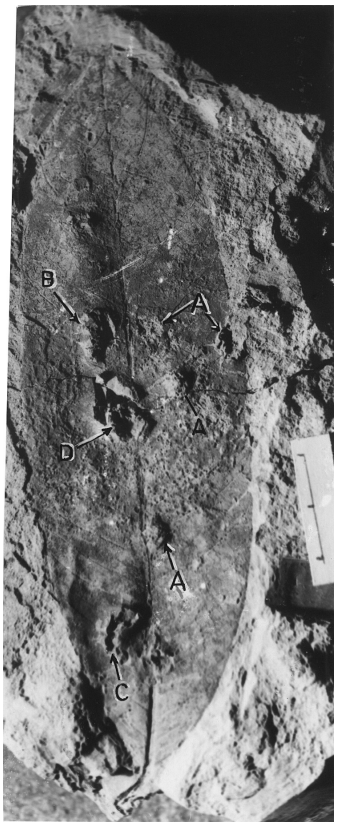

Fig. 2. Fossil leaf possessing insect gall. **A** indicates concavity and convexity; **B** shows fused gall; **C** indicates fractured galls; **D** shows pit/plaque – like structure over gall. Leaf natural size (BSIP No. 37771)

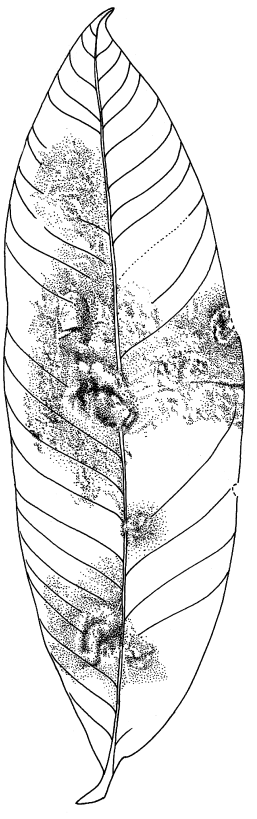

Fig. 3. Line drawing of fossil leaf showing insect gall, × 1.5

MORPHOLOGICAL FEATURES OF GALL FORMING LEAVES

Family Anacardiaceae

Genus ***Eomangiferophyllum*** Mehrotra et al. 1998 (=*Mangifera* L.)

Eomangiferophyllum damalgiriensis Mehrotra et al. 1998.

(Figs 2, 3)

Description. Leaf symmetrical, narrow elliptic; preserved lamina length 15.5 cm; maximum width 5 cm; apex acute; base symmetrical, obtuse, normal; margin entire; venation eucamptodromous; primary vein stout, straight; secondary veins alternate, angle of divergence moderately acute to right (especially at base); inter secondary veins present, simple; tertiary veins percurrent; areoles well developed.

Figured specimen. Specimen Nos. BSIP 37771 and 38097.

Horizon and Locality. Tura Formation; Damalgiri near Tura, West Garo Hills, Meghalaya, India.

Age. Upper Palaeocene

The leaves are comparable with modern leaves of *Mangifera* and their detailed description, comparison and discussion are provided by Mehrotra et al. (1998).

DESCRIPTION OF INSECT GALL

(Figs 2–6)

Insect galls preserved in concave and convex relief are distributed all over the surface of a leaf. Circular, ovoid, rough surface, globose shape galls measure 3–8 mm in diameter and often appear as raised disc (Fig. 2, arrow A). Sometimes 2–3 galls agglomerate and fuse to form a cluster (Fig. 2, arrow B). There is no specific position of the galls as they occur at any place close to the margin, veins or midrib or away from these places on general surfaces in apical and basal portions of leaf. 20 to 22 galls are present in one complete leaf specimen. Leaves contain different stages of galls with apical portions showing flat, circular small undehisced gall whereas the middle portions posseses large size open galls. Galls situated in between the midrib and margin point

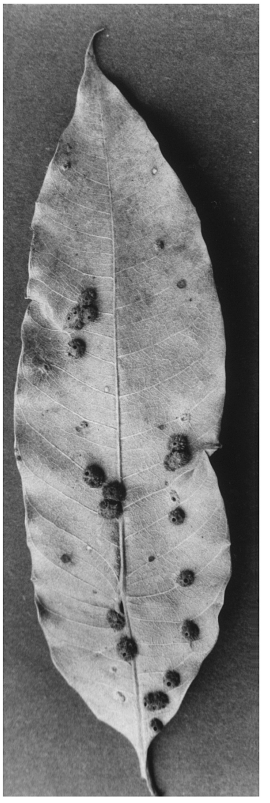

Fig. 4. Modern leaf of *Mangifera indica* L. with insect gall of *Amradiplosis echinogalliperda* Mani. Natural size

Fig. 5. A portion of fossil leaf enlarged to show the details of insect gall, × 1.5

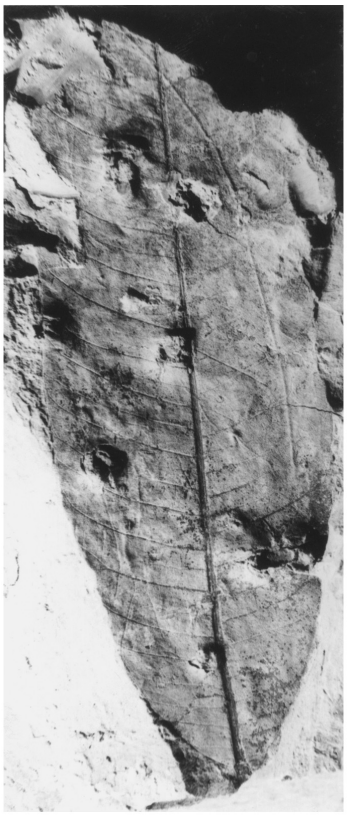

Fig. 6. Another specimen showing incomplete leaf with insect gall. Natural size (BSIP No. 38097)

out convexity (Fig. 2, arrow A). Some of the preserved galls are fractured (Fig. 2, arrow C) as if they are laterally compressed.

The appearance is attributed to the preservation of compression-type of plant material. Bulged, globose galls scattered over and above the normal surface of lamina as recorded in living leaves of *Mangifera indica* are anticipated to have similar structures in the fossilized condition, probably due to infiltration of rock matrix as discussed by Rex & Chaloner (1983) in case of leaf cushion's preservation of *Lepidodendron*-axes. The occurrence of pit/ plague like structures (Fig. 2, arrow D) probably represents empty galls where adults have escaped from the gall.

COMPARISON AND DISCUSSION

The galls discovered over the surface of fossil leaf resembling *Mangifera* have been compared with the number of galls produced by different types of insects in extant leaf of *Mangifera*(Sundar-Raman 1924, Mani 1935, 1947, 1948, 1952, 1959, Agrawal 1969, Singh 1969). The investigation indicates that midge galls or Cecidomyiid galls of the Diptera group of insects commonly affect the leaves of *Mangifera*. So far 15 types of the midge galls are reported in the flora. Amongst them Cecidomyiid galls of *Indodiplosis mangiferae* Felt, *Amradiplosis allahabadensis* Grover, *Indodiplosis mangifoliae* Grover, *Allasomyia tenuispashta* Kieffer and *Amradiplosis echinogalliperda* Mani are dominant in India. Galls of *Amradiplosis echinogalliperda* Mani and *Indodiplosis mangiferae* Felt are known in the flora growing in and around the fossil site (Mani 1948). The structure and nature of fossil galls are quite distinct and characteristic and as such it is difficult to compare them with the known galls of *Mangifera*. However, size, shape and organization are closely comparable with Cecidomyiid galls of *Amradiplosis echinogalliperda* Mani (Mani 1947, fig. 20). Figure 4 shows the modern leaf with galls of *Amradiplosis echinogalliperda* Mani alongwith the fossil leaves possessing galls. The concave-convex nature of fossil galls and their irregular shape, rough surface and raised margin indicate thick and bulged behaviour of the galls. In all probability the absence of echinate nature of galls is the result of the fossilization process.

Cecidomyiid galls of *Indodiplosis mangiferae* and *Amradiplosis allahabadensis* also compare with present day leaf galls but they differ significantly in their smaller size (1–3 mm in diameter) and in producing large number of galls (approximately 2–10 galls per sq.cm area) to cover the entire surface of leaf (Singh 1969).

The earliest occurrence of *Mangifera* leaves with galls in the Upper Palaeocene shows one of the oldest association of Cecidomyiid insects in Tertiary floras. The discoveries of advanced forms of Cecidomyiid insects and its activities in the Tertiary ranging in age from Palaeocene to Pliocene (Gagne 1973, 1979, Straus 1977, Boucot 1990, Harris 1994) suggest the diversification and establishment of Cecidomyiid insects with living counterparts of the Tertiary flora.

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REFERENCES

AGRAWAL B.D.1969. Studies on the galls of *Indodiplosis mangifoliae* Grover (Cecidomyiidae: Diptera) on the leaves of *Mangifera indica* Linn. Cecidologia indica, 4(1): 7–12.

BHATTACHARYYA B. 1983. Fossil plants from the Tura Formation (Eocene) in the Garo Hills, Meghalaya. Indian Journal of Earth Sciences, 10(1): 1–10.

BHATTACHARYYA B. 1985. Leguminous fruits from the Eocene of Garo Hills, Meghalaya. The Quarterly Journal of the Geological Mining and Metallurgical Society of India, 57: 215–225.

BOUCOT A.J. 1990. Evolutionary palaeobiology of behaviour and Coevolution. Elsevier, Amsterdam.

GAGNE R.J. 1973. Cecidomyiid from Mexican Tertiary amber (Diptera). Proceedings of the Entomological Society of Washington, 75: 169–171.

GAGNE R.J. 1979. Cecidomyiid (Diptera) from Canadian amber, Proceedings of the Entomological Society of Washington, 79: 57–62.

HARRIS K.M. 1994. Gall midges (Cecidomyiid) classification and biology. In: Williams M.A.J. (ed.). Plant Galls. Systematic Association, Special Volume No. 49: 201–211.

LAKHANPAL R.N. 1955a. Recognizable species of Tertiary plants from Damalgiri in the Garo Hills, Assam. The Palaeobotanist, 3: 27–31.

LAKHANPAL R.N. 1955b. On the occurrence of *Nelumbium* in the Tertiary of Assam. The Journal of the Indian Botanical Society, 34: 222–224.

LAREW H.G. 1992. Fossil Galls: 51–59. In: Shorthouse J.P. & Rohfritsch O. (eds.), Biology of insect indused galls. Oxford University Press, Oxford.

MANI M.S. 1935. Studies on Indian Itonididae (Cecidomyiid: Diptera) II. Descriptions of new midges and galls. Record Indian Museum, 37: 425–454.

MANI M.S. 1947. Some new and imperfectly known gall midges (Itonididae: Diptera) from India. Bulletin Entomological Research, 38: 39–448.

MANI M.S. 1948. Cecidozoa and Zoocecidia from India. Journal of the Royal Asiatic Society Bengal Science, 14: 27–195.

MANI M.S. 1952. Some gall midges associated with *Mangifera indica* Linn. in India and their galls. Agra University Journal of Research, 1: 47–54.

MANI M.S. 1959. *Cecidotheca indica*. Agra University Journal of Research, 8: 91–180.

MEHROTRA R.C., DILCHER D.L. & AWASTHI N. 1998. A Palaeocene *Mangifera*-like leaf from India. Phytomorphology, 48: 91–100.

PANT D.D. & SRIVASTAVA P.C. 1996. Lower Gondwana insect remains and evidence of insect-plant interaction. Proceedings International Conference on Global Environment and Diversification of Plant through Geological Time: 317–326. Allahabad.

RAJA RAO C.S. 1981. Coalfield of North Eastern India I. Bulletin Geological Survey of India, 45: 1–76.

REX G.M. & CHALONER W.G. 1983. The experimesntal formation of plant compression fossils. Palaeontology, 20: 231–252.

SAXENA R.K., TRIPATHI S.K.M. & PRASAD V. 1996. Palynoflora investigation of the Tura Formation (Palaeocene) in Nongwal Bibra area, East Garo Hills, Meghalaya. Geophytology, 26: 19–31.

SCOTT A.C., STEPHENSON J. & COLLINSON M.E. 1994. The fossil record of leaves with galls. In: Williams M.A.J. (ed). Plant galls. Systematic Association, Special Volume No. 49: 447–470.

SINGH S. 1969 Biology of *Amradiplosis allahabadensis* Grover. Cecidologia indica, 4: 15–22.

SRIVASTAVA A.K. 1988. Lower Barakar flora of Raniganj coalfield and insect/plant relationship. The Palaeobotanist, 36: 138–142.

SRIVASTAVA A.K. 1996. Plant/animal relationship in the Lower Gondwanas of India. Gondwana Nine, 1: 549–555.

SRIVASTAVA A.K. & SRIVASTAVA G.P. 1998. Insect gall impression on fossil angiosperm leaf. Geophytology, 26: 95–97.

STRAUS A. 1977. Gallen, Minen und andere Frasspuren in Pliozän von Willershausen am Harz. Verhandlungen des Botanischen Vereins der Provinz Bradenburg, 113: 43–80.

SUNDAR-RAMAN A.H. 1924. A contribution to the study of Indian Zoocecidia. The Journal of the Indian Botanical Society, 4: 35–49.