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First discovery of the Coccoidea (Hemiptera: Sternorrhyncha) from the Siwalik sediments (Middle Miocene) of Darjeeling foothills, Eastern Himalaya, India

SUBIR BERA*, SAMIK MITRA, MANJU BANERJEE, JACEK SZWEDO**

* Department of Botany, University of Calcutta, 35, Ballygunge Circular Road, Kolkata - 700019, India; e-mail: berasubir@yahoo.co.in
** Department of Systematics and Zoogeography, Museum and Institute of Zoology, Polish Academy of Sciences, Wilcza 64, PL 00-679 Warszawa, Poland; e-mail: szwedo@miiz.waw.pl

ABSTRACT. Two females of scale insects (Hemiptera, Coccoidea) on a Moraceae leaf are recorded from the Miocene sediments of India.

KEY WORDS: Hemiptera, Sternorrhyncha, Coccoidea, Miocene, fossils, India

INTRODUCTION

Evidences of plant-insect association and interactions in the past have opened a new view in the field of evolutionary biology. Records of such interactions mostly occur as mine or bite marks (BERRY 1916, 1930, SMILEY et al. 1975, CRANE & JARZEMBOWSKI 1980, ROZEFELDS 1988, LABANDEIRA et al. 1994, KRASSILOV 2003), as foliar galls (BROOKS 1955; SRIVASTAVA & SRIVATSAVA 1998), as mite houses on leaf surface (O'DOWD et al. 1991) as well as inclusions in amber (KOTEJA 2000). The insect trace fossils as well as their meaning, content and nomenclature have been recently reviewed by ZHERIKHIN (2002, 2003). Such evidences are commonly recorded from Palaeogene and Neogene deposits of different parts of the world. The present article deals with two, compressed fossil scale insects (Hemiptera: Sternorrhyncha: Coccoidea) preserved on the median vein of a fossil dicotyledonous leaf. In addition, marks of insect — mining traces also are noted on the leaf surface. In situ, occurrence of coccoid as body fossil on fossil plant organ is rare and the present report is the first of its kind from the Indian subcontinent. Earlier records of similar kind (Fig. 11) are documented from Lower Cretaceous of Transbaikalia (KOTEJA 1988,

1989) and England (KOTEJA 1999) – representing archeococcids (Orthezioidea: Matsucoccidae and Xylococcidae), and Miocene of Sicily (PAMPALONI 1902, KOTEJA & BEN-DOV 2003) and Miocene of Germany (ZEUNER 1938, KOTEJA 2000) – representing neococcids (Coccoidea: Diaspididae).

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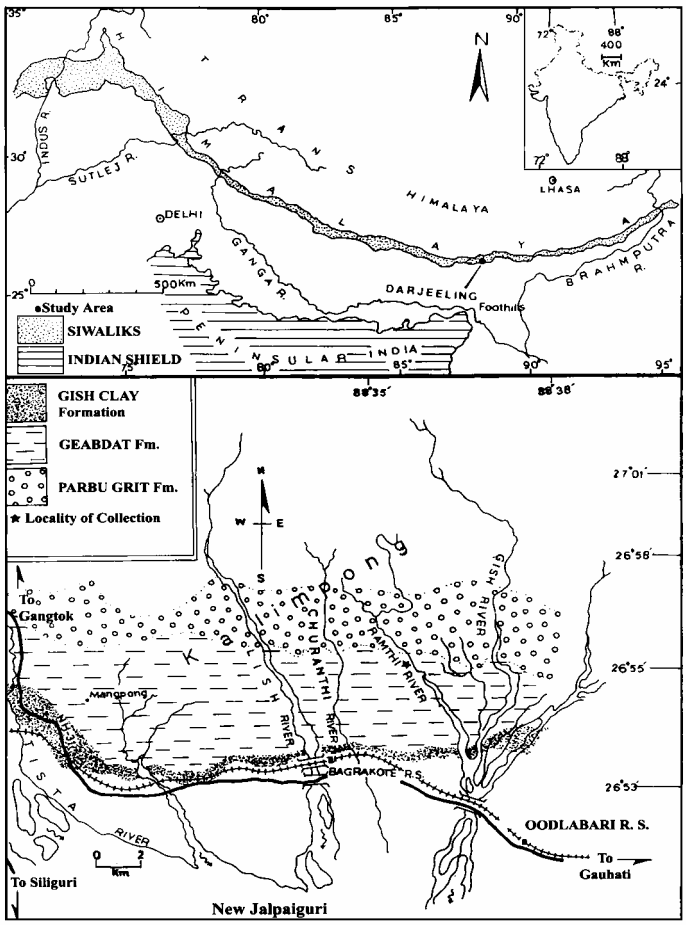


Fig. 1. Study area.

MATERIAL AND METHODS

Study area

The fossils are collected from the Ramthi river traverse section of Darjeeling foothills area, eastern Himalaya (Fig. 1).

Age and geological horizon

The sediments, from which the present fossil is recovered, belong to upper part of Geabdat Sandstone Formation of Middle Siwalik (late Middle Miocene) sector.

Examination

The fossil angiosperm leaf impression is preserved on whitish gray medium grained sandstones, with poorly preserved cuticular carbon layer. Two scale insects are noted on the ventral surface of the dicotyledonous leaf along the median vein.

The morphographic features of both the leaf and the insects are thoroughly studied and photographed under stereo-microscope. One of the scales was carefully scooped out and subjected to scanning electron microscopy for detail photography.

Comparison of the fossil foliage with the extant form is made by consulting the preserved Herbarium sheets of the Central National Herbarium, Shibpur, Howrah. The specimen (Number Dar. Ramthi 10/2a) is stored in the Repository of Palaeobotany Palynology Laboratory, Department of Botany, University of Calcutta.

RESULTS

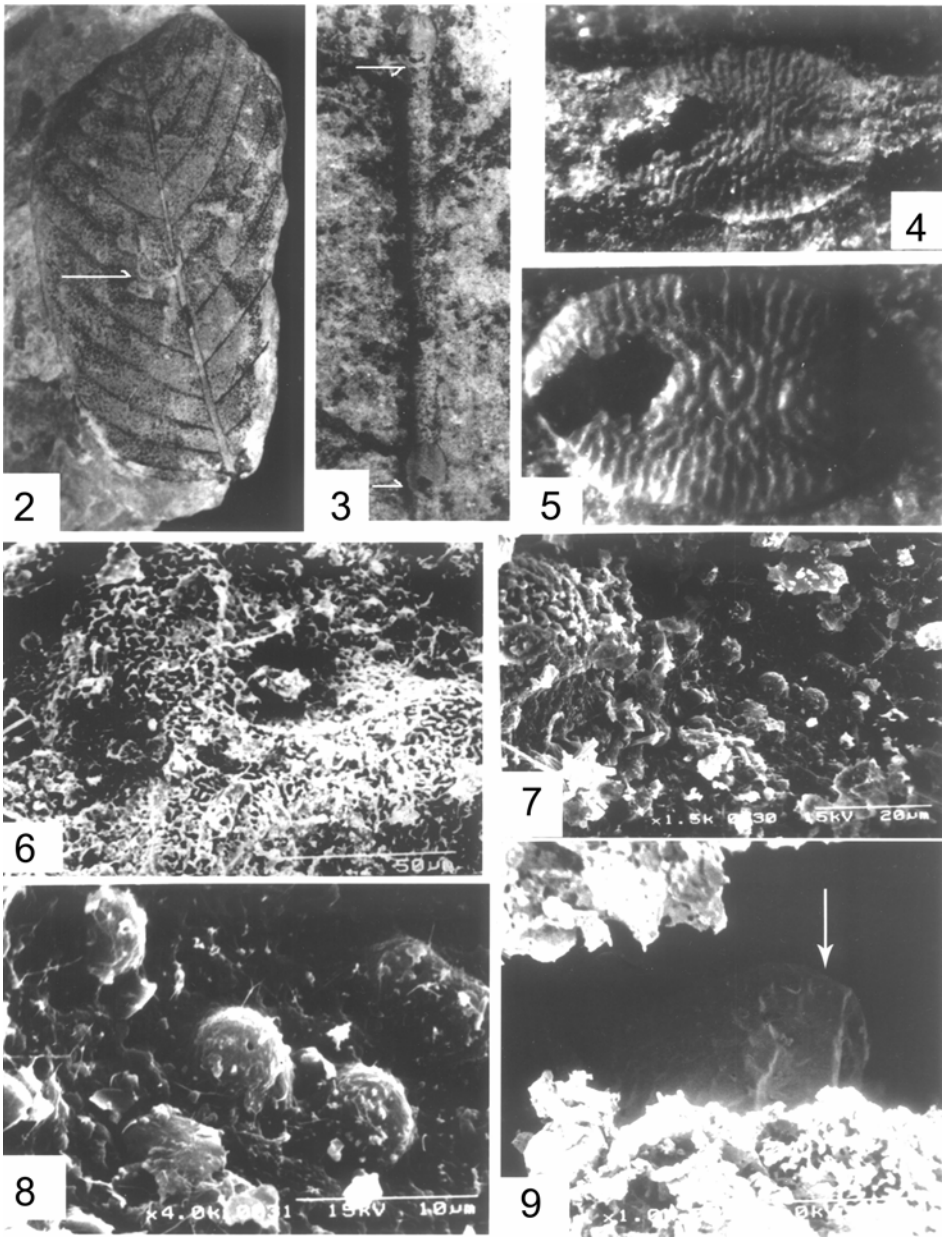
The leaf (Fig. 2)

On comparison the leaf shows close resemblance to the extant Moraceae leaf *Artocarpus lakoocha* ROXB. (C.N.H. sheets No. 256 - S.S.R. BENET Collection from Chengail, Howrah).

The extant *A. lakoocha* is a predominantly tropical–subtropical plant distributed in the sub-Himalayan tracts from Kumaon to Assam, Myanmar and Andaman – Nikobar Islands.

Mine marks on leaf surface (Fig. 2)

Activities of miners at the middle of the leaf nearer to the midvein are observed; mines “O” and “&” shaped, 0.8 mm – 1.0 mm in diameter, originating from lateral and mid vein. The nature and characteristics indicate activity of possible Lepidoptera or Diptera larvae.



Figs 2–9. 2 - Fossil leaf cf. *Artocarpus lakoocha* ROXB. with traces of mining (shown by arrow). 3 - Positions of two fossil insects on the median vein of the fossil leaf (shown by arrow), 4–5 - Enlarged view of one of the fossil insects, 6 - SEM photograph showing structural details of the body surface of an isolated insect, 7 - Microstructures enlarged, 8 - Enlarged view of bead like structures with terminal pores, 9 - Eggshell with thin laminar folds inside the posterior part of the body cavity.

Scale insect (Figs 3–10)

The insects are dorsally oriented, elongated-oval in shape, margin wavy, length 1–1.2 mm, width 0.7–0.8 mm. Anal cleft on the proximal part, about $^{1}/_{5}$–$^{1}/_{6}$ of the body length (250–260 µm); oral region oval, 300 × 250 µm in dimension (Figs 3–5). A closer view of the dorsal surface under SEM photography reveals wavy, alternating ridges and furrows lying almost parallel to each other; ridges 24–27 and furrows as many as ridges; ridges are coarser at the central part of the body, mostly simple, sometimes branched, branching open dichotomous, 25–30 µm in breadth. Ridges are ornamented with incomplete reticulations (Figs 6, 7) and furrows with circular bead like structures; each of the beads shows an opening at their tips, which appears to be either the points of attachment of bristle like structures or device for aeration (Figs 7, 8). However, post mortal shriveling of the body may cause this transverse body rippling.

Further closer view towards the anal region of the insect has revealed occurrence of eggshell (Fig. 9) within the anal cleft of one of the insects; eggshell oval with many laminar folds on the surface, 35 × 20 µm in dimension. Presence of eggshell confirms that these scale insects were females.

The insects are grouped under the superfamily Coccoidea of the Hemiptera: Sternorrhyncha on the basis of overall characters revealed through macro- and micromorphic studies. Farther closer observations reveal closer resemblances of the present specimen with several features of extant Coccoidea (neococcids) but any definite comparable form could not be ascertained. Unfortunately some salient features, i.e. the anal plates are not preserved, so the more detailed placement of the insect remains obscure.

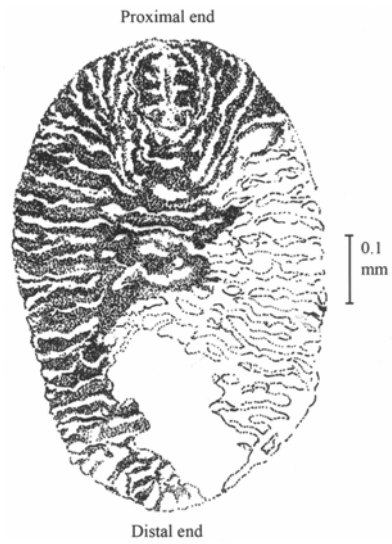


Fig. 10. Outline drawing of fossil Coccoidea.

DISCUSSION

The first fossil record of scale insect associated with its host cf. *Artocarpus lakoocha* (Moraceae) suggests that such insects were present in warm-humid tropical forests. Presence of eggshell confirms that the insect was the female. It is to be noted that extant species of Coccoidea are frequently found on the leaf surfaces of *Artocarpus* species including *A. lakoocha*. It may thus be presumed that Moraceae members must have served as hosts of the present day coccoids at least since Neogene time in the eastern part of Indian subcontinent.

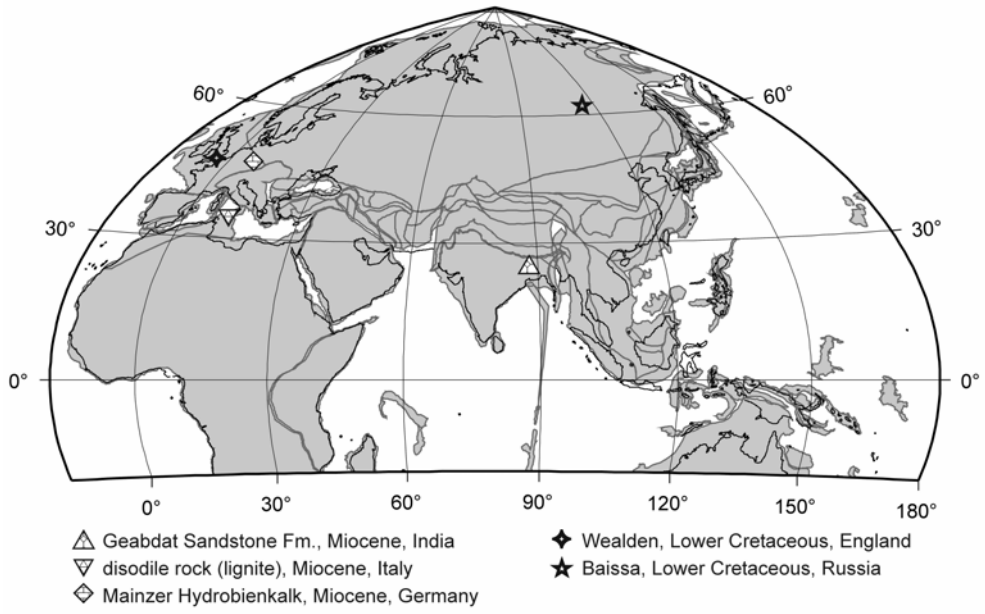


Fig. 11. Impression fossils of scale insects, drawn on the Miocene palaeogeographic map, Hammer projection, 11.5 Ma. Recent shoreline outlined in black, plate fragments outlined in dark grey.

The scarcity of scale insects impression fossils is still a puzzle, but number of species representing both archeococcids (Orthezioidea) and neococcids (Coccoidea), are known from fossil resins (KOTEJA 2000a, b, 2001). The oldest neococcids are known from the Lower Cretaceous Lebanese amber, and in the Palaeogene have represented a diverse group. It is interesting to know on which host plants ancestral and fossil scale insects fed in various periods of geological times, with which types of vegetation and climatic conditions they were associated. The scale insects appeared as an abundant and diversified group in Early Cretaceous, but their roots are unknown from fossil record, even if supposed time of their origin is Triassic (KOTEJA 2001). It is believed that the most recent periods of scale insects diversification is related to the evolution of two other groups of organisms intimately associated with coccids: angiosperm plants and ants (GRIMALDI & ENGEL 2005). To

test hypotheses about scale insect phylogeny and relationships data on their biology, host-parasite relationships, origins of gall induction, biogeography, evolution of chromosome systems and molecular characteristics (COOK et al. 2002), as well as morphology based palaeontological and neontological research and correlation of radiation events are necessary (KOTEJA 2000a). The fossils described above gives another piece of information for the eco-evolutionary scenario of coccoids.

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