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Abstract

We describe the first two Blattodea from the early Eocene Palana Formation of the Gurha opencast lignite mine, western Rajasthan, India. Although it is not possible to attribute them to a precise family, these large wings suggest a warm and humid paleoclimate for the area at that time.

Key words: Insecta, Dictyoptera, wings, Paleogene, paleoclimate, India

If Dictyoptera are rather frequent in the fossil record since the late Carboniferous, they are mainly known from Europe, North and South America, and Northern and South-Eastern Asia

(Siberia, China, Myanmar). They are clearly less frequent from the sub-continent of India, with few Permian and Mesozoic fossils (Fletcher, 1920; Rao & Shah, 1959; Verma, 1967; Dutt, 1977; Srivastava, 1988; Pinto et al., 1992; Kapoor et al., 1993; Engel & Pérez-de La Fuente, 2012; Arya et al., 2005). Indeed, fossil insects are rarely recorded from India, even if it since a long time ago (Hislop & Hunter, 1855; Hislop, 1860); but with the recent exception of those from the early Eocene Cambay amber (see Rust et al., 2010).

Here we describe the first two cockroach's wings from the early Eocene Palana Formation of the Gurha opencast lignite mine, western Rajasthan, India. Shukla et al. (2014) already indicated the presence of insects from this mine. Patel et al. (2019a) recently described an orb-weaver spider (Araneae, Araneidae) and report only insects like *Formica* sp., mayfly naiad, etc. (Patel et al., 2019b) from the same formation, otherwise known for their fossil pollen, leaves, flowers, fruits, (Shukla et al., 2014; 2018; Shukla & Mehrotra, 2019).

The sample site, also known as Gurha opencast lignite mine (72.52269°E, 27.5229°N), is located at 70 km from Bikaner (Fig. 1a). For the general geology of the subsurface Gurha lignite opencast mine (Fig. 1b). The site is comprised of multiple layers starting from the pebbly ash bed in the basement, followed by the Palana Formation. It consists of various layers with variable thicknesses, including the base of lignite (4.5 m). A (3.8 m) carbonaceous shale intercalated with a thin band of dirty maroon sandstone (12.0 cm), variegated clay (6.0 m), carbonaceous shale, (3.7 m), variegated shale (3.5 m), and maroon shale (3.0 m), respectively. The Palana Formation is overlaid by the Kolayat Formation, which consists of variegated clays or fuller's earth (9.5 m), also overlaid by yellow ferruginous sandstones with lenses of clay and sandy shales (5.5 m), gritty sandstones, lime kankar (7.5 m) of the Jogira Formation, with recent alluvium and soil at the top (3.88 m).

The sedimentological and paleontological data, with plant leaves, rare fishes, and invertebrates, support a fluvio-lacustrine environment with the influence of volcanism at the

base for the Palana Formation. The pollen assemblages indicate an early Eocene (Ypresian) age (Shukla et al., 2014).

The specimens were recovered by hand picking from the thin, laminated, carbonaceous, and maroon shale beds of the Palana Formation exposed in the Gurha opencast lignite mine Bikaner District, Rajasthan, India. They were studied using a Leica MZ-6 microscope. Photographs were taken using a Nikon D5500 DSLR camera and Olympus digital micropad 777 microscope. Specimens were at times treated with ethanol (95 %) on the surface to create greater contrast between the fossil and the surrounding matrix. The venation patterns were determined from composite line drawings of the part and counterpart, improved by using Corel draw X7 software. We follow the wing venation terminology of Snodgrass (1935) and Schubnel et al. (2020).

Wing venation terminology is abbreviated as follows:

C: costa; **Cu:** cubitus; **CuA:** cubitus anterior; **CuP:** cubitus posterior; **M:** media; **R:** radius; **RA:** radius anterior; **PCu:** postcubitus; **ScP:** subcosta posterior; **i**: forewing; **ii**: hind wing; **iii**: anal fan.

Catalogue number GU/R/B/G**:** Garhwal University/Rana/Bikaner/Gurha.

Superorder Dictyoptera

Order Blattodea Brunner von Wattenwyl, 1882

(Figs 2-3)

Material. Specimens GU/R/B/G/3009 (tegmen); GU/R/B/G/3004 (incomplete tegmen and incomplete hind wing); deposited in Department of Geology, HNB Garhwal University Srinagar Uttarakhand, India.

Horizon and Locality. Carbonaceous and maroon shale beds of the Palana Formation (early Eocene), Gurha opencast lignite mine Bikaner Rajasthan.

Descriptions.

Specimen (GU/R/B/G/3009) (Fig. 2). Incomplete tegmen with postero-apical part missing; original coloration not preserved; wing 24.8 mm long, about 8.2 mm wide; ScP ends on anterior margin, 8.8 mm from wing base, with weak anterior branches; R ends at wing apex, with numerous distally forked anterior branches, all parallel; area between R and anterior wing margin 2.6 mm wide; RA and RP not well differentiated; median area rather reduced, with few branches of M; CuA with numerous parallel branches covering a broad area; CuP+PCu strongly arched and concave; veins of postcubital-anal area all parallel and ending into CuP+PCu.

Specimen (GU/R/B/G/3004) (Fig. 3). Distal halves of a tegmen and a hind wing, darkened (original color); fragment of tegmen 16 mm long, about 5.5 mm wide (Fig. 3A); numerous anterior branches of R and area between R and anterior wing margin broad, ca. 2.3 mm wide (Fig. 3A); fragment of hind wing 6.7 mm long with numerous branches of main veins (Fig. 3B) and a part of anal fan (Fig. 3C), partly folded below rest of wing so that cubital branches seem not to be parallel to anal fan.

Discussion

These two fossils obviously belong to the crown group of Blattodea. The tegmen of the specimen GU/R/B/G/3009 is very similar to the *Periplaneta* Burmeister, 1838 (Blattidae) because of the part of wing between costal margin and ScP with only few weak anterior branches of ScP, numerous parallel anterior branches of R/RA, strong stem of R/RA, M clearly independent of R, numerous parallel branches of M and CuA, M rather reduced compared to CuA, and numerous branches of PCu and anal veins ending in CuP+PCu (Rehn, 1951: pl. 2, fig. 21; Li et al., 2018: fig. 2). But such characters are also present in *Epilampra* Burmeister, 1838 (Blaberidae). Therefore it is not possible to attribute it to a precise family. Blattidae and Blaberidae are quite ‘distant’ in the dictyopteran phylogeny (Legendre et al., 2015).

Sample GU/R/B/G/3004 consists of the costal part of the tegmen and the distal two-third of the hind wing of the same specimen. After the smaller width of the area between anterior margin of the forewing and R/RA, it corresponds to a taxon different from GU/R/B/G/3009. But the absence of the basal parts of wings forbids us to even tentatively compare it to any extant group.

Nevertheless, the presence of these rather large cockroaches in this outcrop is of interest because they suggest a warm and humid paleoclimate for the area during the early Eocene, in accordance to the results of Shukla et al. (2014).

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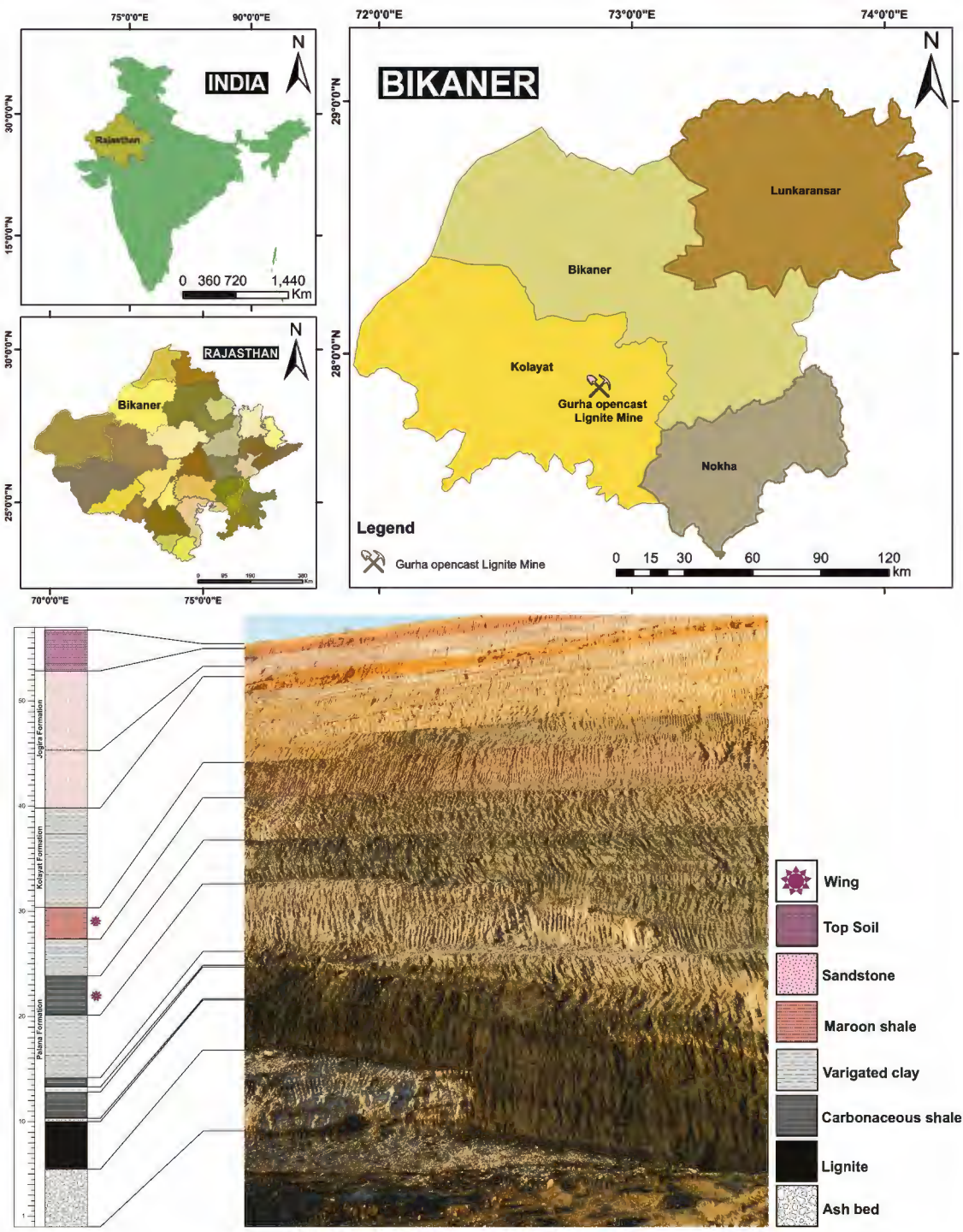
FIGURE 1. (A) Location map of Gurha opencast lignite mine near Bikaner, western Rajasthan, India; (B) Stratigraphy and lithology exposed in Gurha opencast lignite mine. Scale bar in meters.

FIGURE 2. (A) GU/R/B/G/3009; (B) features mark in GU/R/B/G/3009; (C) line diagram of GU/R/B/G/3009. Scale bars = 2 mm.

FIGURE 3. (A) GU/R/B/G/3004, part of tegmen; (B) GU/R/B/G/3004, part of hind wing; (C) GU/R/B/G/3004, part of hind wing; (D) tegmen and hind wing of modern *Periplaneta banksi* Hanitsch, 1931.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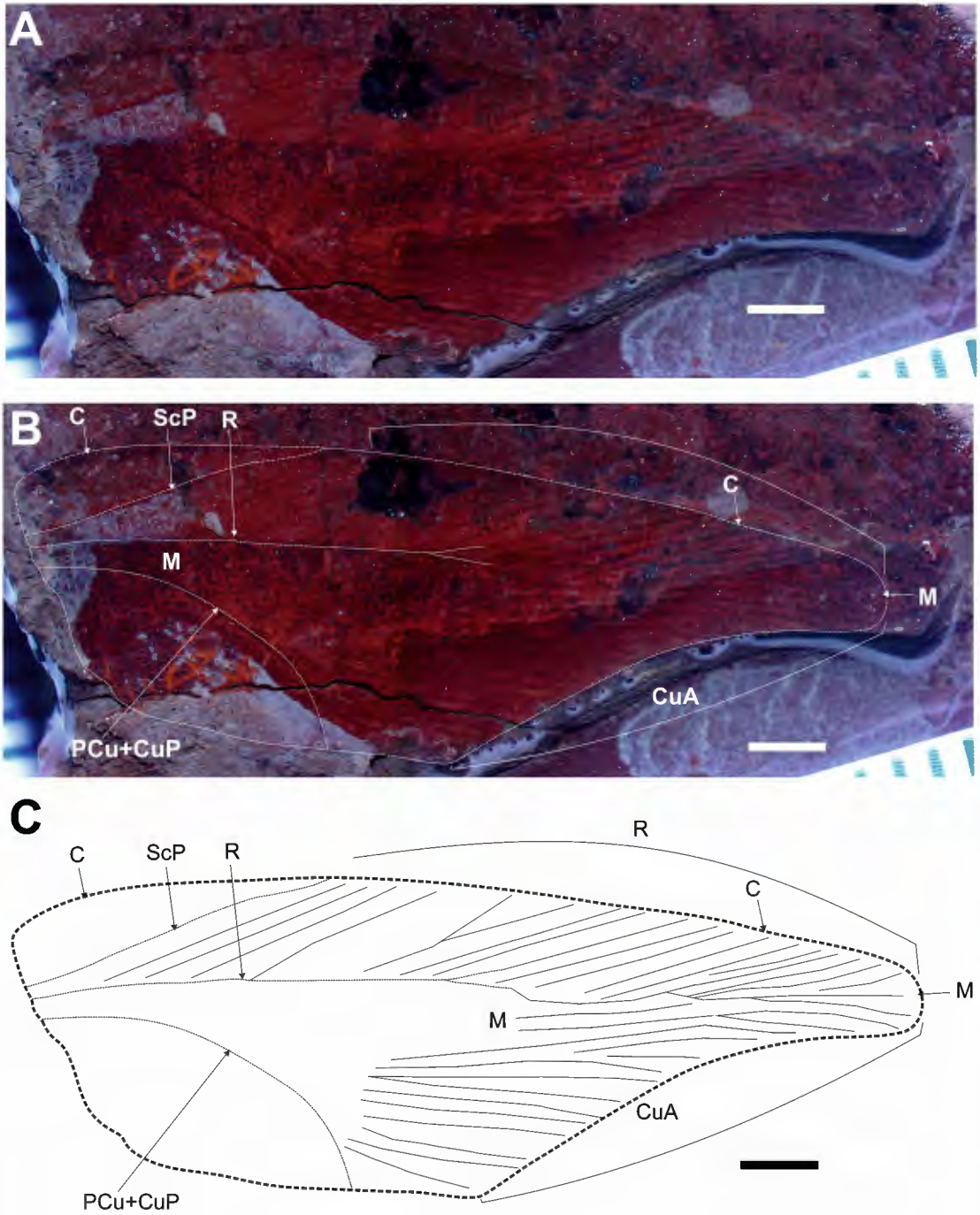
Kolayat Formation
Palana Formation
Wing
Top Soil
Sandstone
Maroon shale
Varigated clay
Carbonaceous shale
Lignite
Ash bed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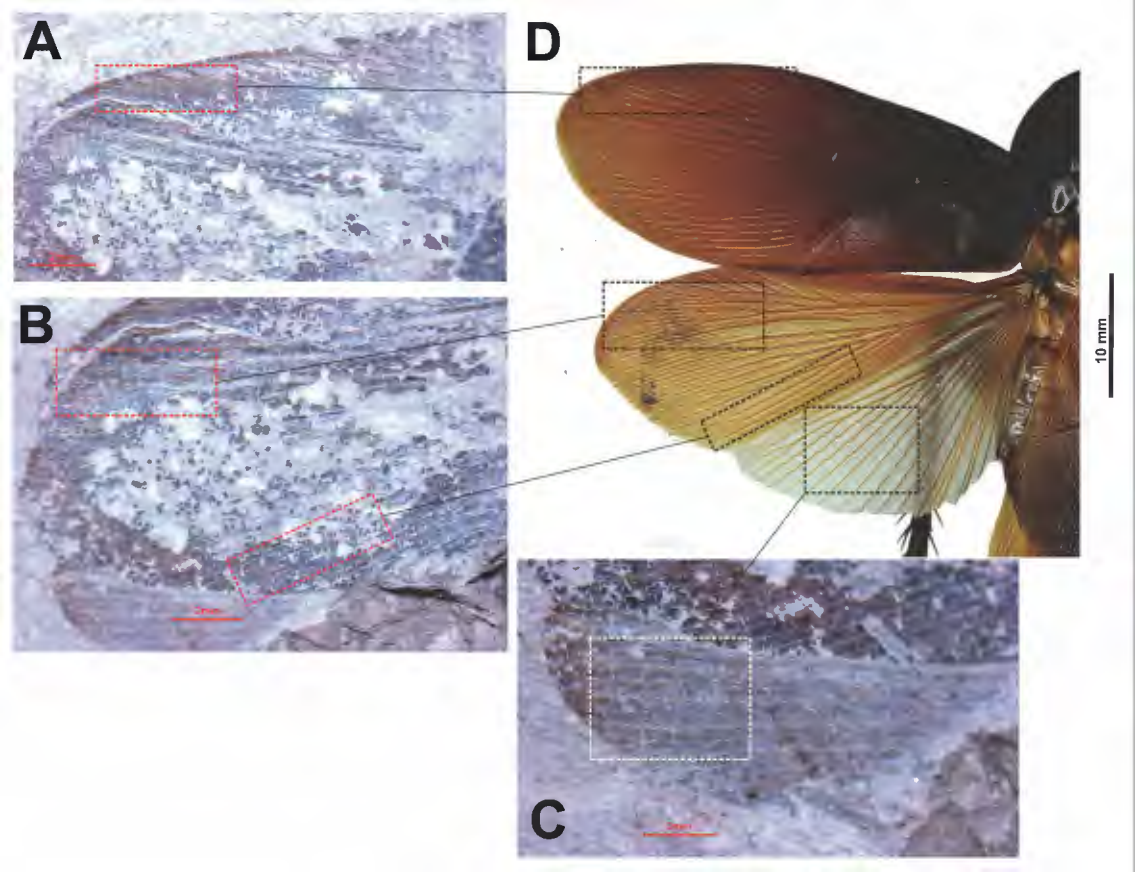
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