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Leaves of Menispermaceae and Dioscoreaceae from the Olmos Formation (Upper Cretaceous) from the state of Coahuila, Northern Mexico

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ABSTRACT

Two new species, *Menispermites olmosensis* sp. nov. (Menispermaceae) and *Dioscorites palauensis* sp. nov. (Dioscoreaceae) are described from fossil leaves collected in Coahuila state in the late 1970s by Dr. Reinhard Weber. Actinodromous palmate primary venation with craspedodromous secondary veins and the presence of a fimbrial vein, among other attributes, relate it to the extinct genus *Menispermites* Lesquereux and place *Menispermites olmosensis* sp. nov. as related to the extant genera *Abuta* and *Odontocarya* of the Menispermaceae. These same features relate it to the extinct genus *Menispermites* Lesquereux. On the other hand, campylodromous primary venation, along with the disposition and course of tertiary veins, show the similarity of *Dioscorites palauensis* sp. nov. to the Dioscoreaceae. Similar fossil records for the Late Cretaceous suggest that the vegetation distributed in North America was continuous with similar elements to those of the existing tropical rain forests. This approach supports the Boreotropical Hypothesis in the explanation of the origin of modern humid tropical rain forests.

1. Introduction

Angiosperms dominate extant terrestrial ecosystems (Friis et al., 2011; Boyce and Leslie, 2012). Their origins and rapid diversification in the Early Cretaceous (approximately 125 mya), are addressed through various approaches, such as evolution, systematics and ecology (Crepet, 2000; Barrett and Willis, 2001; Friis et al., 2003; Crepet et al., 2004; Krassilov and Golovneva, 2004; Magallón and Castillo, 2009; Smith et al., 2011; Boyce and Leslie, 2012). In such studies, the fossil record acts as direct evidence to establish the minimum time of presence for taxonomic groups of extant plants, also providing informative and corroborative characters (Martínez-Millán and Cevallos-Ferriz, 2005). Permineralized fruits and seeds from the Late Cretaceous in Coahuila, Mexico, have been related to many extant taxa like the genus *Phytolacca* (*Coahuilacarpon phytolaccoides*) (Cevallos-Ferriz et al., 2008); the families Ceratophyllaceae (*Ceratophyllum lesii*), Lythraceae (*Decodon tiffneyi*) (Estrada-Ruiz et al., 2009), Ranunculaceae (*Eocaltha zoophila*) (Rodríguez-de la Rosa et al., 1998) and Proteaceae (*Patocarpus coahuilensis*) (Vázquez, 2015); and the orders Alismatales (*Operculifructus lopezii* and *O. latomatensis*) (Estrada-Ruiz and Cevallos-Ferriz, 2007) and Zingiberales (*Striatornata sanantoides* and *Tricostatocarpon silvapinedae*) (Rodríguez-de la Rosa and Cevallos-Ferriz, 1994).

Among the taxonomic determinations based on fossil remains are *Coahuiloxylon*, with anatomical characteristics comparable to those present in the Anacardiaceae and Burseraceae; *Muzquizoxylon*, which has similarities with the family Cornaceae; *Olmosoxylon*, related to the family Lauraceae; *Wheeleroxylon*, associated with the family Malvaceae; *Sabinoxylon* and *Quercinium centenoae*, which have similar morphological characters to the family Fagaceae; *Palmoxylon*, comparable to the family Arecaceae; and *Paraphyllanthoxylon*, with affinities to the families Lauraceae, Anacardiaceae and Burseraceae (Estrada-Ruiz and Cevallos-Ferriz, 2007; Méndez-Cárdenas et al., 2013).

The determinations of fossil flowers are also remarkable, as in the case of *Coahuilanthus belindae*, with morphological characters reminding to the family Rhamnaceae (Calvillo-Canadell and Cevallos-Ferriz, 2007).

In addition, impressions of fossil leaves have been used to suggest the presence of families Araceae, Arecaceae, Magnoliaceae, Lauraceae, Moraceae, Betulaceae and Rhamnaceae, among others (Weber, 1972; Estrada-Ruiz et al., 2013; Villanueva-Amadoz et al., 2014), based on impressions of fossil leaves. Determinations based on fossil leaves are often challenged by the lack of reproductive structures to support them; however, advances in the study of leaf architecture and the importance of leaf characters as a source of information, (Hickey, 1973; Hickey and

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Wolfe, 1975; Hickey and Doyle, 1977) have given more confidence to taxonomic assignments for these types of fossils and strengthened diverse phylogenetic hypotheses (Ramírez et al., 2000; Calvillo-Canadell and Cevallos-Ferriz, 2005; Martínez-Millán and Cevallos-Ferriz, 2005; Doria et al., 2008).

Impressions of solitary leaves are often the most common macrofossils in fossiliferous deposits, but usually, the lack of reproductive structures in organic connection and the type of fossilization, hinder taxonomic determination and material handling. Still, in many cases these characters can provide information about the environmental conditions in which the plants grew, and especially for determining their taxonomic position. The wealth and abundance of fossil remains of angiosperms, especially impressions of leaves, which are well preserved, characterize the Olmos Formation. In early studies of this fossil material 60 different types of angiosperms were recognized in the form of wood, leaves, fruits and flowers (Weber, 1972). Subsequently, the presence of more than 100 types of plants has been proposed, mainly based on remains of leaves, of which it is estimated that 70% has an entire margin and an acuminate apex, features that suggest the development of a hot and humid climate (Estrada-Ruiz et al., 2013), contrasting with the current warm-dry climate of the region. In this study, two new fossil species of angiosperms *Menispermites olmosensis* nov. sp. (Menispermaceae) and *Dioscorites palauensis* nov. sp. (Dioscoraceae) from the Olmos Formation are described based on carbonaceous compressions of leaves and their comparison with extant taxa. Taxonomic placement of these fossil specimens greatly contributes to the reconstruction of the Late Cretaceous flora (80 to 70 mya), which helps us to understand the origin and composition of the recent flora, especially in Mexico, and the evolution of these angiosperms families.

2. Material and methods

The fossil material comes from three outcrops of the Olmos Formation in Coahuila State, Northern Mexico (Fig. 1): Tajo Palaú (1065), Barroterán (1070) and Mina Rosita # 6 (1074). This material was collected in the late seventies by Dr. Reinhard Weber. Since then it has been protected in the Colección Nacional de Paleontología at the Instituto de Geología of the UNAM.

The formation is from the Upper Cretaceous, based on the presence of ammonites, dinoflagellate cysts and acritarchs. Specifically, a Maastrichtian age has been proposed (72.1 ± 0.2 mya). On the other hand, the presence of other ammonite types suggests a Campanian age (83.6 ± 0.2 mya) (Corona-Esquivel et al., 2006; González-Sánchez et al., 2007; Villanueva-Amadoz et al., 2014.). Stratigraphically, the Olmos Formation underlies the Escondido Formation and overlies the San Miguel Formation; these formations are part of the Navarro Group. As for its sediments, the formation is mainly composed of carbonaceous and calcareous shales with interbedded marl, limestone, siltstone and coal, plus fine to thick sandstones (Corona-Esquivel et al., 2006; Villanueva-Amadoz et al., 2014). The paleoenvironmental reconstruction of the Olmos Formation suggests the presence of a body of water such as a pond, a swamp, or even a deltaic system (Estrada-Ruiz et al., 2013).

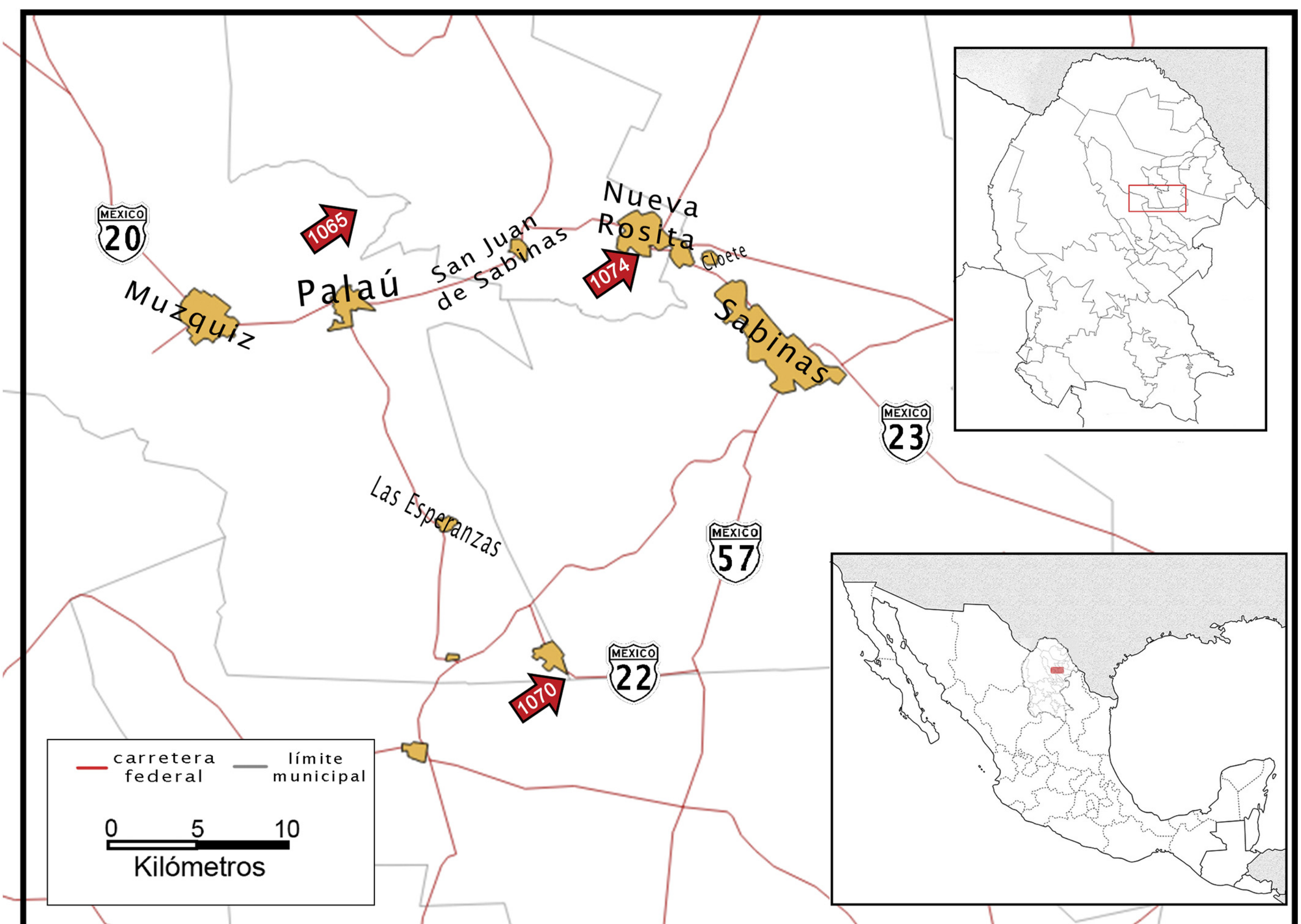

Fig. 1. Three localities where the Olmos Formation outcrops. Locality 1065, Tajo Palaú, lat. 27°55′40″ long. 101°25′50″. Locality 1070, Barroterán, Mina 3, lat. 27°38′47″ long. 101°17′0″. Locality 1074, Mina Nueva Rosita # 6, lat. 27°55′42″ long. 101°13′54″.