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Research paper

Evolutionary and paleobiological implications of Coleoptera (Insecta) from Tethyan-influenced Cretaceous ambers

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ABSTRACT

The intense study of coleopteran inclusions from Spanish (Albian in age) and French (Albian–Santonian in age) Cretaceous ambers, both of Laurasian origin, has revealed that the majority of samples belong to the Polyphaga suborder and, in contrast to the case of the compression fossils, only one family of Archostemata, one of Adephaga, and no Myxophaga suborders are represented. A total of 30 families from Spain and 16 families from France have been identified (with almost twice bioinclusions identified in Spain than in France); 13 of these families have their most ancient representatives within these ambers. A similar study had previously only been performed on Lebanese ambers (Barremian in age and Gondwanan in origin), recording 36 coleopteran families. Few lists of taxa were available for Myanmar (Burmese) amber (early Cenomanian in age and Laurasian in origin). Coleopteran families found in Cretaceous ambers share with their modern relatives mainly saproxylic and detritivorous habits in the larval or adult stages, rather than wood-boring behavior. Fifteen of the coleopteran families occur in both the Lebanese and Spanish ambers; while only five are present in both Spanish and French. Considering the paleogeographic proximity and similarity of age of the Spanish and French ambers, the small number of taxa found in common at both areas is surprising. The ancient origin for the Lebanese and Spanish ambers, the paleogeography (including some barriers for terrestrial biota) and the local paleohabitats are factors that may explain the dissimilarity with the French specimens. Wildfires are believed to be a more likely cause of resin production during the Cretaceous than infestation by beetles. Current knowledge of the beetle species found in the Cretaceous ambers is introduced.

1. Introduction

In the early Cretaceous, the Tethys Ocean occupied a vast paleogeographic area (Fig. 1a). It was flanked by passive margins to the southern side, while terrain that had started to drift away from that margin before the Cretaceous supported shallow carbonate platforms in the central zone. The northern margin was characterized by a subduction zone that consumed oceanic crust alongside Laurasia (Skelton et al., 2003). The Tethyan margins were covered by vast gymnosperm-dominated forests (Ziegler et al., 1993; Burgoyne et al., 2005; Coiffard et al., 2012; Peralta-Medina and Falcon-Lang, 2012; Zhou et al., 2012). According to the evidence of the paleoenvironment and taphonomical factors, copious amounts of resin were produced and eventually fossilized to become amber in these forests (Martínez-Delclòs et al., 2004). The modern Myanmar amber deposit corresponds to the former eastern Tethys Ocean (Cenomanian in age, Figs. 1a and 3). Thousands of bioinclusions have been found in it and, at the moment, Myanmar is the area with the highest production of Cretaceous amber (also called Burmese amber) in the world (Shi et al., 2012). In the central part of the Tethys Ocean, close to the African continent, the Lebanese amber forests developed (Barremian in age, Figs. 1b and 3). A few thousand bioinclusions have been found in it at various localities, making Lebanese amber the most ancient that has yielded an important number of insects (Azar et al., 2010).

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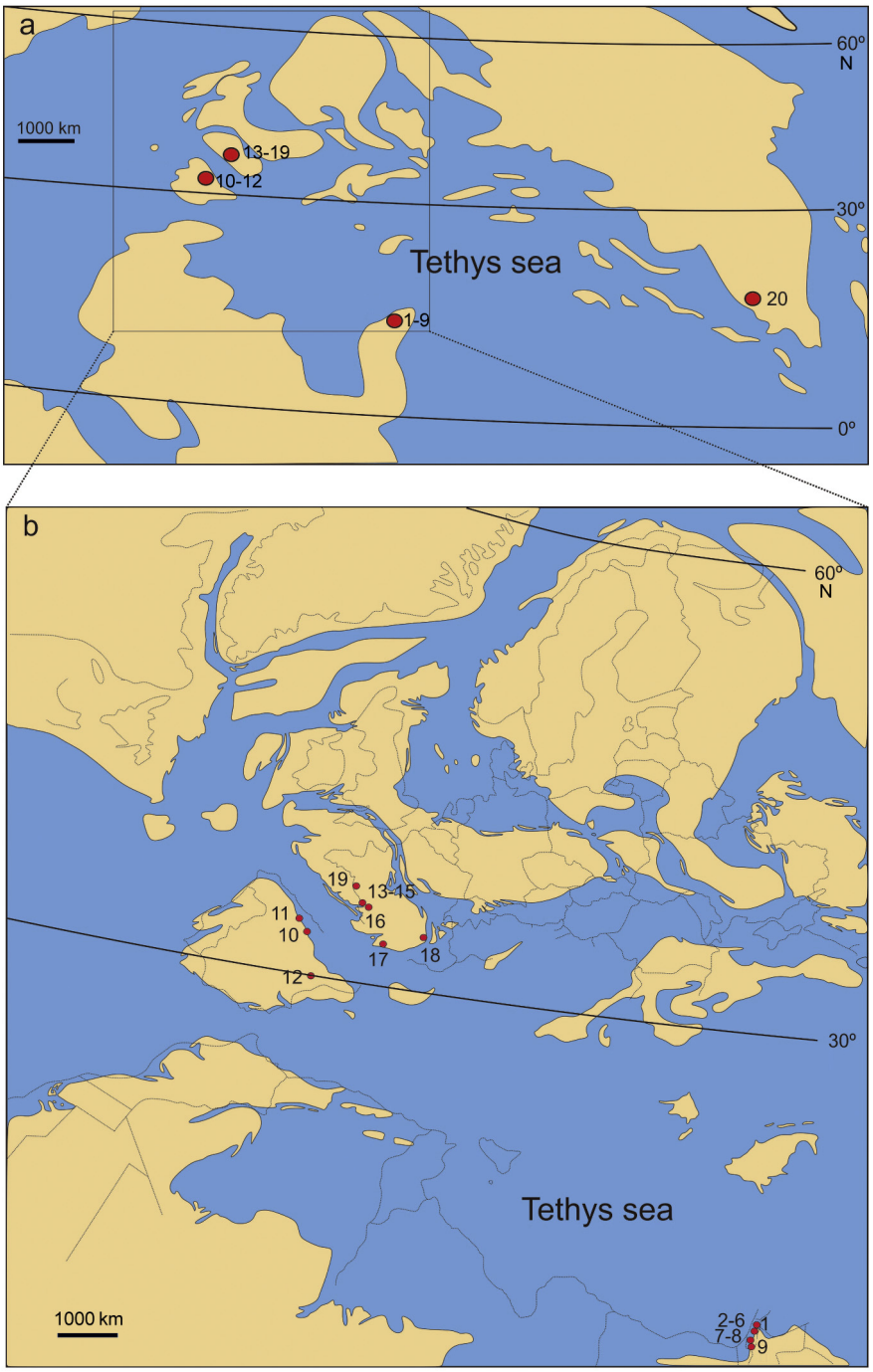

Figure 1. Main Cretaceous sites with beetles embedded in amber from the Lebanon, Spain, France, and Myanmar. They are indicated by circles and numbered. The deposits in Lebanon are: (1) Nabaa Es-Sukkar-Brissa; (2) Hammana-Mdeyrij; (3) Bouarij; (4) Ain Dara; (5) Kfar Selouane; (6) Falougha; (7) Bkassine; (8) Roum-Aazour-Homsiyyeh; and (9) Rihane. The deposits in Spain are: (10) Peñacerrada I; (11) El Soplao; and (12) San Just. The deposits in France are: (13) Archingeay-Les Nouillers; (14) Cadeuil; (15) Fouras/Bois-Vert; (16) La Buzinie; (17) Fourtou; (18) Salignac; and (19) La Garnache. Finally, the deposits in Myanmar are found near Tanai in the Hukawng Valley (20). (a) World paleogeographical map that corresponds to the Aptian (125 Ma) for the Lebanese sites and the Albian (100 Ma) for the rest. (b) Detail of the western margins of the Tethys Ocean showing the deposits in the Lebanon, Spain and France. Modified from Blakey (2011).

Finally, along the western margin of the Tethys Ocean, in the proto-Atlantic, forests dominated by conifers developed and they gave rise to the Spanish (Albian in age) and French ambers (Albian–Santonian in age, Figs. 1b and 3) (Peñalver and Delclòs, 2010; Perrichot et al., 2010; Perrichot and Néraudeau, 2014).

Coleoptera (commonly known as beetles) is the most species-rich order of animals on Earth, with no less than 386,500 species described (Grimaldi and Engel, 2005; Ślipiński et al., 2011). Coleoptera is divided into four suborders: Archostemata, Adephaga, Myxophaga, and Polyphaga. Polyphaga contains the largest number of species (almost 90% of the whole Coleoptera order), characterized by extremely diverse feeding habits.

Beetles inhabit almost all available niches and exploit a huge variety of food. However, the major ecological contribution of coleopterans comes from their role in the decomposition of plant and animal debris and the formation of organic soil (Crowson, 1981).