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Editorial: A fossil view of insect evolution: integrating paleontological evidence to explore the origins of insect biodiversity

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Editorial on the Research Topic
A fossil view of insect evolution: integrating paleontological evidence to explore the origins of insect biodiversity

Introduction

In 2025, 180 years will have elapsed since the publication of the first treatise on fossil insects, the *History of the Fossil Insects in the Secondary Rocks of England* published by the English rector Peter Bellinger Brodie in 1845. To celebrate the rich history of palaeoentomological research—from its accidental and unexpected beginnings to the present era—*Frontiers in Earth Science* and *Frontiers in Ecology and Evolution* are inviting a collection of contributions to capture the state of the art of fossil insect research today.

Reverend Brodie belonged to a defunct intellectual milieu. During the height of the Industrial Revolution, before the consolidation of modern academia, an extraordinary proportion of the breakthroughs in our understanding of Nature have been elaborated by members of the English clergy and affluent amateurs—men spared of debilitating manual labour, with a comfortable house and a steady supply of tea. The freedom to tinker and pursue the unlikely are what initially lead to the foundation of palaeoentomology. Along with an earthquake, a mass extinction 201 million years before that, and a good measure of luck.

Rumours were circulating along the course of the River Severn in western England regarding the presence of strange creatures embedded in rocks. On 27th May 1773, a powerful earthquake followed by a landslide occurred between Buildwas and Coalbrookdale in Shropshire. The river spilled out of its banks and eighteen acres of land were carried down the valley, opening up large chasms and exposing rocky slopes. John Fletcher, Vicar of Madeley, travelled to the scene of destruction and later recalled: "A great many fossils were

found bearing the impression of a flying insect, not unlike the butterfly into which silkworms are changed" (Fletcher, 1833). At this time, palaeontology as a discipline did not yet exist–it would take half a century for that term to be coined and 70 years for the first dinosaurs to be recognised. For then, not much could be said about the strange insects engulfed in rocks.

Reverend Brodies' fascination with fossils dated back to his childhood spent in London and his later theological studies in Cambridge. Upon his first professional appointment in the parish of Wylye in Wiltshire, Brodie set out to investigate the claims. Over the succeeding 53 years, Brodie would discover and study some of the most famous classical localities yielding Triassic and Jurassic insects in England—including Aust Cliff, Dumbleton, Wainlode Cliff and Westbury in Gloucestershire—and amass a collection of some 25 thousand specimens, principally from the Rhaetian and Hettangian.

Anyone admiring insects in flight, visiting flowers, or pacing along footpaths in a forest would be excused to doubt how these fragile creatures could possibly preserve in the geological record. Brodie's key insight was that the fossilisation of insects was not just possible; under certain condition, fossil insects were abundant. He recognised that many of the fragmentary specimens he excavated in the Vale of Gloucestershire were not seeds or plant leaves but the disarticulated remains of ancient insects. Much of Brodie's fossils came from what he called the "Insect limestone," an unassuming about 30 cm thick blue-grey rock found at various exposures along southern-western England. A large part is associated with the so-called "Cotham marble," a massive stromatolite that sprawled over much of present-day England in waters vacated in the aftermath of the end-Triassic mass extinction that probably provided suitable conditions for the preservation of fragile insects. Unbeknown to Brodie. stromatolites indeed provide one widespread mechanism by which insects can become preserved in the fossil record and formed the perfect preconditions for him to make his discoveries, over 200 million years later.

Indeed, Brodie was not the first to describe fossil insects; Ernst Friedrich Germar, a German entomologist, had described fossil insects from the Solnhofen Limestone before him. However, Brodie's significant contribution came through his 1845 monograph and over a hundred shorter papers published during his lifetime, which provided the first coherent treatments of palaeoentomology, establishing the foundation for the discipline for decades to come. Among them were the then oldest record of mosquitos, dragonflies, and abundant beetles that inspired the imagination of his contemporaries of what ancient ecosystems must have looked like.

Palaeoentomology has come a long way since Brodie's initial exploratory work in Triassic and Jurassic of England. In the words of the mathematician Stanislaw Ulam, the hallmark of a *bona fide* scientific discipline is that it not only yields results that are correct and verifiable, but also non-trivial. In other words, for every right answer there should also be a surprise, a bang, a *something extra* that we had no idea about at all—that which has the potential to shock, fascinate and excite. This collection of papers is about that *something extra*. For palaeoentomology is no longer merely a cataloguing of the millions of insects that have been extirpated over the past 400 million years, but also has the power to bring insights into what we would have had no way of knowing otherwise, had it not been for the fossils.

Perspectives

In this Research Topic, Zhang et al., Du et al., and Zhang et al. present morphological data for Cretaceous velvety shore bugs, burrowing bugs, and assassin bugs, respectively. These studies contribute to our understanding of the evolution of key morphological characters and specialized behaviors in these insect groups. Li et al. describe rare tiny aquatic sphaeriusid beetles preserved in mid-Cretaceous Burmese amber, showcasing the effectiveness of confocal microscopy in studying dark bioinclusions within amber. Li et al. focus on psocid fossils and the insights they offer into insect phylogeny, particularly with respect to missing fossil links. Li et al. and Li et al. utilize advanced photography and phylogenetic analytical methods to shed light on the systematic positions of Cretaceous beetles in the Coleoptera Tree of Life. Additionally, they demonstrate how fossils bridge the morphological gaps between extinct and extant forms. Fossil insects play a crucial role in reconstructing the biogeography of ancient ecosystems, as Ma et al. illustrate through their visually captivating study of stream lacewings. Lastly, Li et al. show how detailed studies of both compression fossils and amber bioinclusions can enhance our understanding of the relationships among living taxa.

We look forward to welcoming many more contributions on new, fascinating aspects of palaeoentomology.

Author contributions

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