The effect of extreme climatic change on insect-plant interactions during the Jurassic

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The increases in atmospheric concentrations of CO_2 (pCO_2), that are associated with climate change, cause decreases in the nutritional value of plants to the herbivorous insects that feed upon them[1, 2]. In turn these changes in plant quality are a key determinant in the reproduction and survival of herbivorous insects at both the individual and the population scale. By investigating past geologic periods of global warming with high atmospheric *p*CO2 we can determine the nature and scale of future changes in insect-plant interactions.

The geological record contains a number of well-documented fossilized insect beds, but the reasons for their distribution through geological time have not yet been examined. Although a relationship between fossil insect accumulations—changes in plants—and changes in atmospheric composition have been suggested they have never been shown[5,6]. This project will firstly make a general assessment of insect fossil distribution through both space and time in the Mesozoic, and will then focus on the insect and plant fossil beds found throughout the UK and Europe[3] during the Early Jurassic. Therefore, we will consider changes in the insect and plant communities before, during and after the early Toarcian (186 million years ago) period extreme environmental change. For instance, during the Toarcian average global temperatures rose by approximately 10°C and large quantities of CO_2 were released into the ocean-atmosphere system. The scale of the changes during the Toarcian event are comparable with the IPCC climate predictions for 2099 under the high emissions scenarios[7]. A recent high-resolution geochemical study of the Toarcian in Leicestershire[4] suggests there might be a link between the preservation of insect beds and key stages during the climatic change. Additionally, it has been suggested that Coelorrhyncha (true bugs) evolved during the Toarcian and their modern counterparts would indicate that this may be related to increased humidity and decomposition rates. The main objectives of this project are to:

1. ***Test the hypothesis that there is a link between the accumulation of fossilized insects and large increases in global temperatures and*** **p*CO_2*** by collating data from insect beds and comparing these to the record of climate change from published geochemical and environmental proxies.
2. ***Assess any variations in the composition of insect communities (type, abundance and diversity) before, during and after the Toarcian event***. Firstly, by (a) collecting and identifying insects and assessing insect leaf damage from known insect and leaf bearing successions in Leicestershire, Gloucestershire and Bornholm, Denmark. High-resolution graphic logging, biostratigraphy, elemental abundances and carbon isotope stratigraphy will be produced for these sections as needed. (b) Making observations from significant insect and plant collections from the same field sites now held in museum collections.
3. ***Determine whether the nutritional quality of plants changed during the Toarcian event*** by measuring the leaf mass per area and leaf economic traits of plant matter associated with the insect beds and adjacent strata. These metrics are good indicators of plant C:N ratios (and so nutritional quality) and photosynthetic rates[8, 9]. In particular, the Pliensbachian to Toarcian section at Bornholm is suitable for these analyses.
4. ***Explore the relationship between changes and/or adaptations in the insect populations and the published records documenting the climatic changes during the Toarcian event*** (e.g. increased *p*CO2, an enhanced hydrological cycle, and increased global temperature).

The project will provide training in: (i) geological fieldwork, (ii) stratigraphy, (iii) fossil collection and preparation, (iv) fossil plant and insect identification, (v) plant functional trait analysis, (vi) geochemistry (elemental abundances and carbon isotopes analyses), (vii) ecological theory, (viii) statistics and analytical skills. The student will be based in the School of Environmental Sciences at the University of Hull working under the supervision of Dr Bryony Caswell (https://scholar.google.co.uk/citations?user=MPZyfvwAAAAJ&hl=en&oi=ao), Dr Angela Coe (http://www.open.ac.uk/people/alc8) and Dr Karen Bacon (https://www.geog.leeds.ac.uk/people/k.bacon). The University of Hull has a thriving postgraduate community and the postgraduate training programme provides a full range of courses covering: research techniques, scientific methods, information technology, scientific writing and statistical analyses which are tailored to the needs of each student. Supervision will involve regular meetings between all supervisors and further support of a research support group.

References: [1] Awmack & Leather 2002 Ann. Rev. Ent. [2] Currano et al. 2008. Proc. Nat. Aca. Sci. ; [3] Ansorge 2003 Act. Zoo. Cracov. [4]. Caswell,BA & Coe,AL 2012, Palaeogeoraphy, Palaeoclimatology, Palaeocology,365-366:124-135; [5] Retallack,GJ 2011. Paleogeography, Paleoclimatology, Paleoecology, 307:59-74; [6] Bacon,KL et al. 2016. Palaeogeography, Palaeoclimatology and Palaeoecology, 464: 51-64; [7] IPCC (2013) Climate change 2013. IPCC, New York; [8] Royer,DL et al. 2007. Paleobiology,33:574-589.