Project Title	**The effect of the Toarcian (Early Jurassic) extreme environmental change on insects**
Host University	The Open University
Theme	Organisms & Ecosystems Dynamic Earth
Key words	Jurassic, fossils, insects, global warming, plants, palaeoenvironmental change
Supervisory team	**PI:** Angela Coe (The Open University; Angela.Coe@open.ac.uk) **Co-I:** Bryony Caswell (University of Hull; B.A.Caswell@hull.ac.uk) Karen Bacon (University of Leeds, K.Bacon@leeds.ac.uk;) Scott Hayward (University of Birmingham; S.A.Hayward@bham.ac.uk) Luke Mander (Open University; Luke.Mander@open.ac.uk)
Is the PhD suitable for part time study?	Yes

Project Highlights:

- Address fundamental questions about how the effects of extreme environmental change associated with global warming influences insect populations
- Fieldwork on Jurassic rocks in the UK and Denmark and a chance to work with museum collections of exceptionally preserved fossils
- Multi-institutional and cross DTP supervisory team providing a range of opportunities

Overview:

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 periods of global warming with high atmospheric *p*CO2 over long timescales we can increase our understanding of the nature and scale of potential future changes in insect-plant interactions.

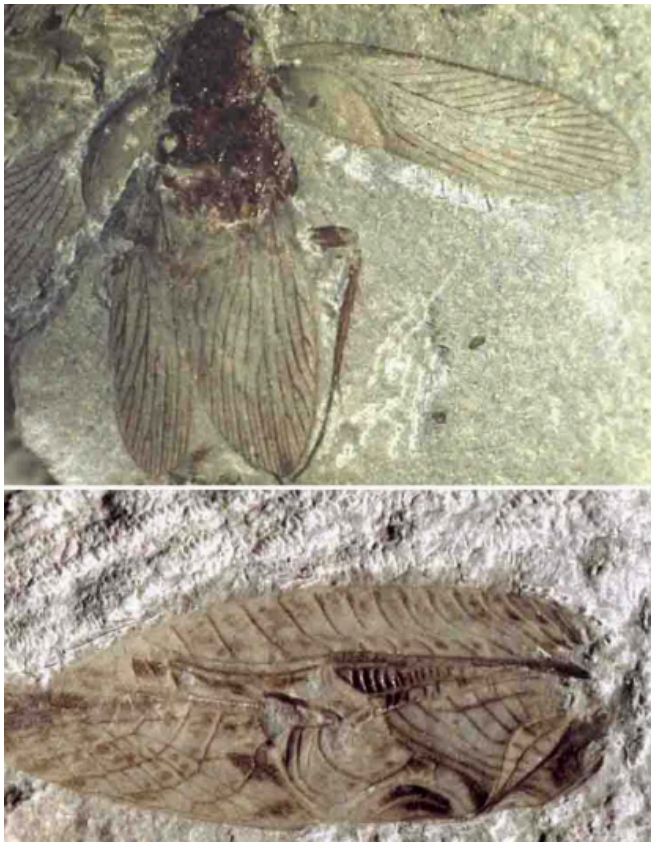

Figure 1: Examples of fossilised insects from Toarcian strata in Germany that will be the focus of this study. Each image = c.12 mm across (from Ansorge, 2003).

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 demonstrated[4].

This project will firstly make a general assessment of insect fossil distribution through both space and time in the Mesozoic. The project will then focus on the thousands of insects found throughout the UK and Europe[3] in association with the extreme environmental change event that occurred during the Toarcian (183 Ma, Early Jurassic) by documenting the changes in the insect and plant communities at this time. During the Toarcian event, global temperatures rose by approximately 7-10°C, large quantities of CO_2 were released into the ocean-atmosphere system and there was an increased hydrological cycle. 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 geochemical and macrofossil study of the Toarcian in Leicestershire which shows the event had a major impact on marine biota[8] also suggests there might be a link between the preservation of insect beds and key stages in the climatic change. Additionally, it has been suggested that Coelorrhyncha evolved during the Toarcian and their modern counterparts would indicate that this may be related to increased humidity and decomposition rates.

Methodology:

- **Establish the relationship between accumulation of fossilized insects during the Mesozoic and global temperatures and pCO_2 increases** by collating published data from insect beds and environmental proxies.

- **Assess variations in the composition of insect communities (type, abundance and diversity) for the Toarcian event** by: (a) identifying insects and assessing insect leaf damage from shallow-marine successions in Leicestershire, Gloucestershire and Bornholm, Denmark; and (b) making observations museum collections of insects and plants from this interval.
- **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 for the Bornholm section. These metrics are good indicators of plant C:N ratios (and so nutritional quality) and photosynthetic rates[5, 9].
- **Determine the relationship between changes in the insect populations and climatic changes during the Toarcian event** using published palaeoproxy records.

Training and skills:

In addition to a wide range of generic training from CENTA2 and the Open University, the student will be trained in a number of subject specific skills. These include high-resolution graphic logging, advanced field note taking, sample collection and preparation, stratigraphy, ecology, statistics and analytical skills. There will be the opportunity to work in museums. The successful candidate will be encouraged and supported in applying for an internship of a month or more and to take part in career-enhancing opportunities such as teaching, science communication and understanding policy.

Students will be awarded CENTA2 Training Credits (CTCs) for participation in CENTA2-provided and 'free choice' external training. One CTC equates to 1⁄2 day session and students must accrue 100 CTCs across the three years of their PhD.

Partners and collaboration (including CASE):

The project will involve working with museum curators, these will be identified when the collections to be studied have been prioritised, and they will then become project partners. The project will also provide the opportunity to be part of the PANORAMA DTP through the supervision of Drs Bryony Caswell and Karen Bacon from Hull University and Leeds University respectively.

A potential CASE partner interested in the affect of climate change on present-day insect populations is currently being explored. This, together with the supervision from Dr Hayward who is involved with looking at the impact of high pCO2 on insects using BiFOR, is designed with the specific idea of ensuring that the results from this project are integrated with present day plant-insect interactions and the possible impacts of future climate change.

Possible timeline:

Year 1: Construct database of insect accumulations during the Mesozoic and compare this to environmental proxies, visit museum collections. Conduct fieldwork in Denmark including detailed fieldwork training with supervisors.

Year 2: Analyse data from fieldwork in Denmark, visit sites in UK. Undertake additional geochemical analyses as required to supplement existing data. Complete further work with museum collection. Write manuscript on changes in insect populations during the Mesozoic.

Year 3: Finish interpretation, prepare thesis and further manuscripts. Possibly suspend PhD studies for several months to complete internship.

Further reading:

[1] Awmack, C. S. & Leather, S. R. (2002) 'Host plant quality and fecundity in herbivorous insects', *Annual Review Entomology*, 47, pp. 817-844.

[2] Currano, E. et al. (2008) 'Sharply increased insect herbivory during the Palaeocene-Eocene Thermal Maximum', *Proceedings of the National Academy of Sciences*, 105, pp. 1960-1964.

[3] Coviella, C. E. and Trumble, J. T. (1999) 'Effects of elevated atmospheric carbon dioxide on insect-plant interactions', *Conservation Biology*, 13, pp. 700-712.

[4] Retallack, G. J. (2011) 'Exceptional fossil preservation during CO2 crises?', *Paleogeography, Paleoclimatology, Paleoecology*, 307, pp. 59-74.

[5] Bacon, K. L. et al. (2016) 'Can atmospheric composition influence plant fossil preservation potential via changes in leaf mass per area? A new hypothesis based on simulated palaeoatmospheric experiments', *Palaeogeography, Palaeoclimatology and Palaeoecology*, 464, pp. 51-64.

[6] Ansorge, J. (2003) 'Insects from the Lower Toarcian of Middle Europe and England', *Acta zoologica cracoviensia*, 46, pp. 291-310.

[7] IPCC. (2013) 'Climate change 2013', *IPCC*, New York.

[8] Caswell, B. A. and Coe, A. L. (2012) 'A high-resolution shallow- marine record of the Toarcian (Early Jurassic) Oceanic Anoxic Event from the East Midlands Shelf, UK', *Palaeogeography, Palaeoclimatology, Palaeocology*, 365-366, pp. 124-135.

[9] Royer, D. L. et al. (2007) 'Fossil leaf economics quantified; calibration, Eocene case study and implications', *Paleobiology*, 33, pp. 574-589.

Further details:

Applicants should have a strong background in, and enthusiasm for field geology and fossils including the ability to work independently in the field after initial training. The student will join a well-established team researching palaeoenvironmental change at the Open University (http://www.open.ac.uk/science/environment-earth-ecosystems/research/palaeoenvironmental-change). If you would like to apply or require further information please contact **Angela Coe** at the Open University (Angela.Coe@open.ac.uk).

Applications must include:

- a cover letter outlining why the project is of interest and how your skills are well suited to the project
- an academic CV containing contact details of three academic references
- a CENTA application form, downloadable from: http://www.centa.org.uk/media/1202/centa-studentship-application-form.docx
- and an Open University application form, downloadable from: https://tinyurl.com/y73hrfou

Applications should be sent to **STEM-EEES-PhD-Student-Recruitment@open.ac.uk** **by 12pm (noon) on 21st January 2019**