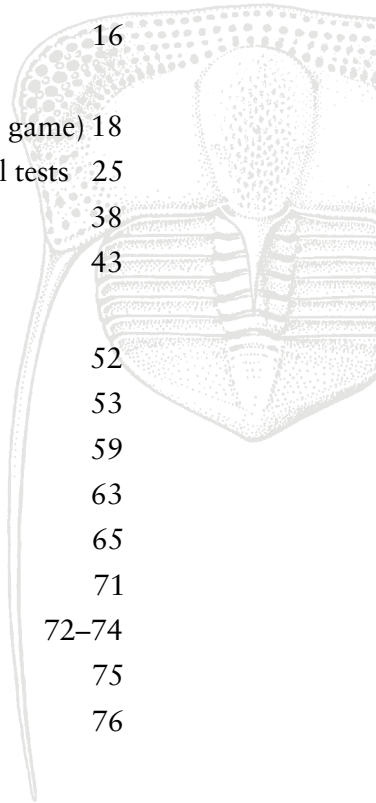


## The Palaeontology Newsletter

### Contents

Editorial	2
Association Business	3
Association Meetings	12
News	16
From our correspondents	
Down in the basement (a mug's game)	18
<i>R for palaeontologists: statistical tests</i>	25
Future meetings of other bodies	38
Meeting Reports	43
Obituary	
David James Carter DFC	52
Undergraduate Bursary reports	53
Sylvester-Bradley report	59
Yorkshire Fossil Festival	63
Book Reviews	65
Books available to review	71
<i>Palaeontology</i> vol 57 parts 5 & 6	72–74
<i>Special Papers in Palaeontology</i> 92	75
<i>Papers in Palaeontology</i>	76



---

Reminder: The deadline for copy for Issue no 88 is 10th February 2015.

---

On the Web: <<http://www.palass.org/>>

---

ISSN: 0954-9900



## Editorial

The Annual Meeting and AGM are upon us again and it is time for myself and some other Council members to step down, other members to take on new roles and we have the excitement of an election for Ordinary Members. I was unaware of the last time there was an election to Council but Tim Palmer, our 'Master of the Rolls', reported there was a vote for President in 1979. I am pleased to find out that Bill Ramsbottom, a fellow ammonoid researcher won. However, I think the power of the ammonoid bloc has waned in the intervening years. The election is an encouraging sign that people remain willing to serve the Association during an interval of 'hard times for these times', when so much emphasis is placed upon the REF, the grant rounds and other institutional pressures. Oliver Wendell Holmes Jr, a justice of the Supreme Court, stated 'I like to pay my taxes. With them I buy civilization.' I regard serving with learned societies and professional bodies of your peers as the 'taxes' one pays to enjoy the 'civilization' of scientific meetings, journals and supporting our peers. For anyone thinking of standing for Council, it should be stressed that the Association covers reasonable expenses to attend Council meetings.

My own involvement with the Newsletter goes back nearly 15 years, when I began to contribute by supplying meeting reports from North American events. At that point I also did it to keep myself writing, as writing in natural language is a discipline I had lost in the midst of doing a great deal of computer programming and statistical work. I took on Council posts partly to develop 'transferable' skills by other routes, but also out of a sense that the Association had helped me during my Ph.D. studies and I ought to give something back when I could. Above all, it seemed the right thing to do. I also have the sense that all on Council are acting as stewards, sustaining the Association to pass it onwards, which is what I am doing with the *Newsletter*. As with the other publications, we do review how the *Newsletter* is used to communicate with the members. You may notice this is a thinner Newsletter than the usual Annual Meeting edition, as the Annual Meeting section has been reduced to include only AGM papers and travel and scheduling information for the Annual Meeting; this saves on paper and postage. The full abstracts are available online, at <[http://www.palass.org/modules.php?name=annual\\_meeting](http://www.palass.org/modules.php?name=annual_meeting)>, and will be included in the delegate packs at Leeds. PDF and screen-reading have now become commonplace to the extent that the time seems right for this change.

The *Newsletter* has a number of hidden helpers. Dr Vanessa Bowman has compiled the Future Meetings of Other Bodies (FMOB) during my term as Editor and Nick Stroud, who you will find acknowledged in tiny print, does a tremendous job on the production of the camera-ready material, as well as acting as a source of advice and copy-editing. Tim Palmer provides the liaison with Y Lolfa, the Welsh printing firm based in Aberystwyth that I am pleased the Association uses for the *Newsletter*. Y Lolfa provides us with an excellent service and quick turnaround. I extend my thanks to them all and know they will all ease the new Newsletter Editor into office in 2015.

**Al McGowan**

*Newsletter Editor*

<[newsletter@palass.org](mailto:newsletter@palass.org)>



# Association Business

## Annual Meeting 2014

### Notification is given of the 2014 Annual General Meeting

This will be held at the University of Leeds on 16th December 2014, following the scientific sessions.

All the information for the AGM and the Annual Meeting is included in the supplement to this Newsletter (on the coloured pages), and on the PalAss website.

### AGENDA

1. Apologies for absence
2. Minutes of the 2013 AGM, University of Zurich
3. Trustees Annual Report for 2013
4. Accounts and Balance Sheet for 2013
5. Election of Council and vote of thanks to retiring members
6. Report on Council Awards
7. Annual Address

At the AGM in December 2014, the following vacancies will occur on Council:

- Vice-President
- Newsletter Editor
- Book Review Editor
- Meetings Coordinator
- two Ordinary Members

The following nominations have been received:

Vice President: Mr David J. Ward

Newsletter Editor: Dr Jo Hellawell

Meetings Coordinator: Dr Thijs Vandenbroucke (2nd term)

Book Review Editor: Dr Tom Challands

Ordinary Members (two vacancies): Prof. Andy Gale, Dr Maria McNamara, Dr Imran Rahman\*

\* More nominations have been received for the positions of Ordinary Member than are vacant, so as stipulated in the Association's constitution a ballot will be held at the AGM. All members of the Association are eligible to vote. Provision has been made for a postal vote for those members who are unable to attend the AGM. **A voting form is included with the Newsletter.** Personal statements from the candidates are printed over the page:



**Prof. Andy Gale (Portsmouth):** I am an enthusiastic stratigrapher and palaeontologist who has concentrated his research over 45 years on the Cretaceous Period, working also on the taxonomy, phylogeny and fossil record of starfish and more recently, barnacles. I have published extensively, including a *Special Paper in Palaeontology* and in *Palaeontology*. I have taught palaeontology to BSc students in various UK university departments, and supervised a succession of PhD students. On the committee, I offer the Association the benefits of long experience of teaching, administration and research in the academic world, together with an enthusiastic commitment to palaeontology. I give numerous lectures on palaeontological topics to regional geological societies and university student societies that may be used to promote the work of the Association. For example, I am lecturing to the Sedgwick Club in Cambridge in November, which provides an excellent opportunity to remind the audience of what the Association offers to students.

**Dr Maria McNamara (Cork):** Maria is a Lecturer in Geology at University College Cork in Ireland and has been a member of the Association for the past 12 years. Over this time she has contributed numerous oral and poster presentations at the Annual Meeting and published in *Palaeontology*, and has represented the Association at public outreach events. She now wishes to stand for the position of Ordinary Member on the Association Council as she is keen to make a more active contribution to the running of the Association. She hopes to assist with various Council activities, such as the review of grant applications and preparation of the Association Newsletter. In particular, she is keen to help develop and implement new initiatives to support palaeontological research, especially by early career researchers, and to help develop and deliver outreach activities to foster an enhanced appreciation and awareness of palaeontology in Europe and further afield. In doing so she aims to encourage and support researchers from all fields of palaeontology and to raise the profile of palaeontology in the public sphere.

**Dr Imran Rahman (Bristol):** I am a research fellow at the University of Bristol working on the palaeontology and evolution of early echinoderms. I have been a member of the Palaeontological Association since 2003 and have regularly attended Annual Meetings during this period. I am a scientific editor of the Association's flagship journal, *Palaeontology*, and co-founder and commissioning editor of *Palaeontology* [online], an outreach website sponsored by the Association. I wish to stand for election as an Ordinary Member of the Council so that I can contribute to the continued success of the Association, promoting the study of palaeontology and allied sciences within the UK and abroad. In particular, I am keen to support the activities of early-career researchers, and would like to ensure that the Association plays an important role in helping to develop their careers.



## AWARDS AND PRIZES

The Palaeontological Association recognises excellence in our profession by the award of medals and other prizes. The Association sees its lists of medal and award winners as a record of the very best palaeontologists worldwide, at different career stages, and offering different kinds of contributions to the field. The Association stresses the importance of nominations, and encourages all members to make nominations.

Attention is drawn to the modified rubric and new deadlines of the awards and prizes, which are detailed below.

### *Lapworth Medal*

The Lapworth Medal is the most prestigious award made by the Association. It is awarded by Council to a palaeontologist who has made a significant contribution to the science by means of a substantial body of research; it is not normally awarded on the basis of a few good papers. Council will look for some breadth as well as depth in the contributions, as well as evidence that they have made a significant impact, in choosing suitable candidates.



The medal is normally awarded each year. Candidates must be nominated by at least two members of the Association. Nominations should include a single page that summarises the candidate's career, and further supported by a brief statement from the two nominees. A list of ten principal publications should accompany the nomination. Letters of support by others may also be submitted. Council will reserve the right not to make an award in any particular year.

The career summary, statements of support and publication list should be submitted in MS Word or PDF format, ideally as a single document if possible.

Nominations should be sent to <[secretary@palass.org](mailto:secretary@palass.org)> by **31st March**.

The Lapworth Medal is presented at the Annual Meeting.

### *President's Medal*

The President's Medal is a mid-career award given by Council to a palaeontologist who has had between 15 and 25 years of full-time experience after their PhD, in recognition of outstanding contributions in his/her earlier career, coupled with an expectation that they will continue to contribute significantly to the subject in their further work.

The medal is normally awarded each year. The candidate must be nominated by at least two members of the Association. Nominations should include a single page that summarises the candidate's career, and be further supported by a brief statement from the two nominees. A list of ten principal publications should accompany the nomination. Letters of support by others may also be submitted. Council will reserve the right not to make an award in any one year. If a candidate



has taken time out from their professional career for family and other purposes, this should be highlighted.

The career summary, statements of support and publication lists should be attached in MS Word or PDF format, ideally as a single document if possible.

Nominations should be sent to <[secretary@palass.org](mailto:secretary@palass.org)> by **31st March**.

The President's Medal is presented at the Annual Meeting.

## ***Hodson Award***

The Hodson Award is conferred on a palaeontologist who has had no more than ten years of full time experience after her/his PhD, excluding periods of parental or other leave, but not excluding periods spent working in industry, and who has made a notable contribution to the science.

The candidate must be nominated by at least two members of the Association and the application must be supported by an appropriate academic case, namely a single page of details on the candidate's career, and a brief statement from each of the two nominees. A list of principal publications should accompany the nomination. Letters of support by others may also be submitted. If a candidate has taken time out from their professional career for family and other purposes, this should be highlighted.

The academic case, statements of support and publication list should be attached in MS Word or PDF format.

Nominations should be sent to <[secretary@palass.org](mailto:secretary@palass.org)> by **31st March**.

The award will comprise a fund of £1,000.

The Hodson Award is presented at the Annual Meeting.

## ***Mary Anning Award***

The award is open to all those who are not professionally employed within palaeontology but who have made an outstanding contribution to the subject. Such contributions may range from the compilation of fossil collections, and their care and conservation, to published studies in recognised journals.

The candidate must be nominated by at least one member of the Association. Nominations should comprise a short statement (up to one page of A4) outlining the candidate's principal achievements, as well as one or more letters of support. Members putting forward candidates should also be prepared, if requested, to write an illustrated profile in support of their nominee for inclusion in the *Newsletter*.

Nominations should be attached in MS Word or PDF format and should include the full contact details of the candidate.

Nominations should be sent to <[secretary@palass.org](mailto:secretary@palass.org)> by **31st March**.

The award comprises a cash prize of £200 plus a framed scroll.

The Award is presented at the Annual Meeting.



## ***Golden Trilobite Awards***

Golden Trilobite Awards are awarded at the discretion of Council for high quality websites that promote the charitable aims of the Association. Nominations for websites should consist of a link to the site and a brief supporting case from a member of the Association.



Nominations should be sent to <[secretary@palass.org](mailto:secretary@palass.org)> by **31st March**.

The award comprises a “Golden Trilobite” banner and links to the Association’s own website.

Awards will be announced in the *Newsletter* and on the Association website.

## ***Honorary Life Membership***

To be awarded to individuals whom Council deem to have been significant benefactors and/or supporters of the Association. Recipients will receive free membership.

Nominations should be sent to <[secretary@palass.org](mailto:secretary@palass.org)> by **31st March**.

Honorary Life memberships are announced at the Annual Meeting.

## ***Annual Meeting President’s Prize***

Awarded for the best talk at the Annual Meeting. All student members of the Palaeontological Association, and all members of the Association who are early career stage researchers within one year of the award of a higher degree (PhD or MSc), excluding periods of parental or other leave, are eligible for consideration for this award, which consists of a cash prize of £200. The prize is announced at the end of the Annual Meeting.

## ***Annual Meeting Council Poster Prize***

Awarded for the best poster at the Annual Meeting. All student members of the Palaeontological Association, and all members of the Association who are early career stage researchers, *i.e.* those within one year of the award of a higher degree (PhD or MSc), excluding periods of parental or other leave, are eligible for consideration for this award, which consists of a cash prize of £200. The prize is announced at the end of the Annual Meeting.



## GRANTS

Palaeontological Association grants are offered to encourage research, education, and outreach through different means. Undergraduates, early stage researchers, and otherwise unfunded persons are given special encouragement to apply. All of these awards and grants are core to the charitable aims of the Palaeontological Association.

A full list of the Association's grants may be found on the Association's website (<[www.palass.org](http://www.palass.org)>). Those with deadlines in the next six months are detailed below.

### *Undergraduate Research Bursary*

The Palaeontological Association Undergraduate Research Bursaries are aimed at giving undergraduate students the opportunity to acquire research skills and experience that will significantly transform their academic career. The bursaries will support projects co-designed by students and their supervisor(s) that give students registered for an undergraduate degree their first experience of undertaking a palaeontological research project. The bursaries provide a stipend for the student for up to eight weeks. The scheme is not intended to fund students to undertake routine work for the supervisor(s) and the Association expects the supervisor(s) to provide significant personal mentoring of successful student applicants.

**Available Funds:** The Association expects to fund multiple projects per year and the total fund available and number of awards made will be at Council's discretion. Successful applicants will receive funding of £200 per week, pro rata, up to a maximum of eight weeks. Funds will be disbursed as a single payment made to the department/school. The stipend is not intended as a salary and is non-transferable. No funding is available for any other costs associated with the project. Supervisor(s) are expected to fund consumables and fieldwork, for example, from other sources.

**Student eligibility:** Bursaries are non-transferable and the named student must be registered for an undergraduate degree for the duration of the proposed project. The student must not have had any previous experience of independent research in palaeontology. Candidates need not be geologists, palaeontologists or Earth scientists, but must be registered for an undergraduate science degree. No age limit applies to the awards.

**Supervisor eligibility:** The principal supervisor must be an academic member of staff in the same institution as the student, so they can give significant career advice and take ultimate responsibility for the student researcher. The principal supervisor must be a member of the Association at the time the application is received. If the principal supervisor is on a fixed-term contract, then this contract must extend beyond the proposed end-date of the project. PhD students and postdoctoral researchers in the same institution may be named as additional supervisors and share in the training and supervision of the student, thus enhancing the quality of the research experience for the student.

**Eligible areas of research:** The Association exists to promote research in palaeontology and its allied sciences, and the research must fall within this remit. The awards must not be used to support research on live animals.





**Other terms and conditions:** A maximum of one application per eligible supervisor will be accepted per round. An eligible student may only be named on one application per round. No supervisor may be named, as either principal or additional supervisor, on more than one application per round. Applications must be submitted by the supervisor, not the student, through the appropriate link on the Association's website. Applicants are responsible for checking that applications from their institution conform to these guidelines. If an individual student or supervisor is named on more than one application received per round then none of those applications will be considered further.

**Ethics:** The Palaeontological Association expects that any projects requiring ethical clearance from the hosting institution, or from other bodies responsible for overseeing relevant ethical issues, will have been granted ethical approval for the proposed work, if required. Research on live animals cannot be supported.

**Supporting Statement:** A referee's statement in support of the student must be included. Usually this statement should be made by the personal tutor of the student applicant. A project supervisor cannot provide the supporting statement for the student named on the application. If the personal tutor is also a supervisor, then the supporting statement may be made by another academic member of staff in the same department or school as the student.

Incomplete applications or those that fail any of the criteria listed above will be summarily rejected.

**Ranking:** Applications will be ranked on the following criteria: track record of the student candidate; quality of the proposed training and personal development opportunities offered by the project and the supervisor(s); scientific excellence of the proposed project; feasibility of the project; time that the principal supervisor is personally prepared to devote to the project; and scheduling of the research work.

The scheduling of the work is a matter for the student and supervisor to arrange by mutual agreement. The only expectation is that the work is completed within the period indicated in the application. In the event that the work is not completed within the time-frame stated in the application, the Association reserves the right to demand repayment of the funds.

**Reporting requirements and dissemination:** After completion of the work, successful candidates are required to produce a 750-word report of the findings accompanied by two to three images suitable for publication in the Palaeontological Association *Newsletter*. This report should be authored by the student and submitted to <[secretary@palass.org](mailto:secretary@palass.org)> within eight weeks of the stated end date of the project. Successful candidates are requested to prioritise the Association's meetings and publications as media for conveying the research results.

**Deadline:** Completed applications should be submitted by **24th February 2015**.

**Notification of decision:** Successful candidates will be notified by the middle of May.



## ***Grants-in-aid: meetings, workshops and short courses***

The Association is happy to receive applications for loans or grants from the organisers of scientific meetings, workshops and short courses that lie conformably with its charitable purpose, which is to promote research in palaeontology and its allied sciences. Application should be made in good time by the scientific organiser(s) of the meeting on the online application form (see the **PalAss website**). Such requests will be considered by Council at its March and October meetings each year. If the application is successful, we will require that the support of the Association is acknowledged, preferably with reproduction of the Association's logo, in the meeting/workshop/short course literature and other media. Inquiries may be made to the Secretary (<[secretary@palass.org](mailto:secretary@palass.org)>).

Applications should be made through online submission via the appropriate page on the Association's website, for which you will need the following information:

- Title of meeting/ workshop/ short course
- Date and Place proposed
- Name, position, and affiliation of the organiser(s)
- Brief description (not more than 10 lines) of the rationale behind the meeting / workshop / short course
- Anticipated number of attendees
- Amount requested (also whether request is for a loan or a grant)
- Other sources of funding applied for
- Specific use to which requested funds will be put

Note: If funds are requested to support one or more keynote speakers, then full details of their names, affiliations and titles of presentations should be included. The application will be strengthened if keynote speaker(s) agree to submit their papers as review articles for possible publication in *Palaeontology*.

The next deadline is **1st March 2015**.



# Palaeontology and Papers in Palaeontology

## Content Alerts

Find out about the latest articles and journal issues as soon as they are published by signing up for Wiley's Content Alerts. To do this, you need an account for Wiley Online Library.

1. Visit the journal homepage:

*Palaeontology*: [http://onlinelibrary.wiley.com/journal/10.1111/\(ISSN\)1475-4983](http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1475-4983)

*Papers in Palaeontology*: [http://onlinelibrary.wiley.com/journal/10.1002/\(ISSN\)2056-2802](http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)2056-2802)

2. Click on Log in/Register

The screenshot shows the Wiley Online Library interface for the journal 'Papers in Palaeontology'. At the top right, there is a 'Log in | Register' link. On the left side, under 'JOURNAL TOOLS', there is a 'Get New Content Alerts' link. A red arrow points from the 'Log in | Register' link to the 'Get New Content Alerts' link. The main content area displays the journal title, 'The Palaeontological Association', and a list of articles. One article is highlighted with a red box and a red arrow pointing to it from the 'Get New Content Alerts' link.

3. Return to the journal home page and click on Get New Content Alerts.

**Unfortunately PalAss cannot automatically register members who request online-only access to journals as part of their subscription, so please sign up for free alerts today.**



## ASSOCIATION MEETINGS



**58th Annual Meeting of the Palaeontological Association**  
University of Leeds, UK 16 – 19 December 2014

The 58th Annual Meeting of the Palaeontological Association will be held at the University of Leeds, UK, organized by Crispin Little (<[earctsl@leeds.ac.uk](mailto:earctsl@leeds.ac.uk)>), Fiona Gill (<[f.gill@leeds.ac.uk](mailto:f.gill@leeds.ac.uk)>), and colleagues from the School of Earth and Environment.

**The information required for the Annual Meeting is provided in the supplement on the coloured pages in this Newsletter and on the PalAss website. The abstracts for the talks and posters are available on the PalAss website and will be included in the Conference pack at the Meeting.**

Please address all queries to <[annualmeeting@palass.org](mailto:annualmeeting@palass.org)>.

We look forward to seeing you in Leeds in December!

The organisers of the Annual Meeting gratefully acknowledge the support of the sponsors:

# WILEY



**SSP**  
SIRI SCIENTIFIC PRESS



## Abstract of Annual Address

### Understanding Ancient Earth Climates and Environments using Models and Data

**Professor Alan M. Haywood**

*School of Earth & Environment, Woodhouse Lane, University of Leeds, Leeds LS2 9JT, UK.  
<eamh@leeds.ac.uk>*

Geology and palaeontology have demonstrated that climate is not stable. We know that climate change occurs over a variety of timescales (*e.g.* tectonic, orbital, millennial, centennial, decadal, sub-decadal). The fossil record and advanced numerical models of climate, and increasingly the Earth system, are gradually lifting the veil on the mysteries of Earth's climatic and environmental evolution and variability. Studies have focused on understanding the drivers for changes in mean climate state as well as the causes and consequences of climatic transitions and rapid climate change. In this talk we will explore how models and data have been used successfully together to better understand three distinctly different intervals in Earth history, each presenting its own unique challenges, scientific questions and benefits.

The first case study is focused on the relative role of climate and environmental change versus human influence on the extinction of Late Quaternary megafauna. Despite decades of research, the roles of climate and humans in driving the dramatic extinctions of large-bodied mammals during the Late Quaternary period remain contentious. Models and data have shown that climate has been a major driver of population change over the past 50,000 years. However, species respond differently to the effects of climatic shifts, habitat redistribution and human encroachment. Although climate change alone can explain the extinction of some species, such as Eurasian musk ox and woolly rhinoceros, a combination of climatic and anthropogenic effects appears to be responsible for the extinction of others.

The second case study focuses on quantifying the equilibrium response of global temperatures to an increase in atmospheric carbon dioxide concentrations, which is one of the cornerstones of climate research. Components of the Earth's climate system that vary over long timescales, such as ice sheets and vegetation, have an important effect on this temperature sensitivity, but are normally neglected. Climate models, using geological derived boundary conditions (vegetation and ice cover), have been used to simulate the climate of the mid-Pliocene warm period, and to analyse the forcing and feedbacks that contributed to the relatively warm temperatures. Estimates suggest that the response of the Earth system to elevated atmospheric carbon dioxide concentrations is 30% to 50% greater than the response based on those fast-adjusting components of the climate system that are used traditionally to estimate climate sensitivity. This suggests that targets for the long-term stabilization of atmospheric greenhouse-gas concentrations aimed at preventing a dangerous human interference with the climate system should take into account this higher sensitivity of the Earth system.

The final case study focuses on the Eocene to Oligocene transition and the shift between a greenhouse and ice house state ~33 million years ago. The development of the Antarctic Circumpolar Current (ACC) has been linked to the thermal isolation and growth of the Antarctic Ice Sheet at the time, yet the development of the ACC during the Cenozoic is controversial in terms of timing and its role in major climate transitions. Climate model results show that a coherent ACC was not possible during the Oligocene due to Australasian palaeogeography, despite deep water connections through the Drake Passage and Tasman Gateway and the initiation of Antarctic glaciation. These simulations of ocean currents compare well to marine proxy records relating to the physical oceanography of the Oligocene, and provide a framework for understanding apparently contradictory dating of the initiation of the ACC.



**Lyell Meeting 2015: 'Mud, glorious mud, and why it is important for the fossil record'**

The Geological Society, Burlington House, London 11 March 2015

A contribution from the Joint Committee for Palaeontology to the Geological Society 'Year of Mud'.

### **Introduction**

Mudrocks provide an unrivalled medium for the preservation of fossils. This exceptional preservation has, in turn, enabled significant scientific advances in the functional morphology and evolution of biota throughout life history, and a high-resolution record of the ways in which biota adapt and evolve during environmental change.

It has long been observed that mudrocks yield abundant, diverse and well-preserved micro- and macro-fossils. Almost all of the strata yielding fossils with soft parts preserved are also from mud-grade deposits. More recent studies have discovered that the seawater chemistry at the time of deposition remains largely unaltered in shells preserved in mudrocks. This enables these fossils to be used as proxies for important Earth surface parameters such as water temperature, salinity, ice volume, rate of chemical weathering and pH. The role of mudrocks in providing an ideal medium for understanding life throughout geological time also applies to lake deposits where terrestrial palynomorphs provide us with records of vegetation change in response to climatic fluctuations. The relative stratigraphical completeness of most mudrock successions makes them ideal for high-resolution studies and hence for understanding the rock record on biological timescales.

The meeting will be of interest to those interested in understanding Earth surface processes, particularly periods of extreme environmental change, as well as those interested in the exceptional preservation of fossils.

Speakers will include:

- Professor Derek Briggs (Yale)
- Professor Nick McCave (Cambridge)
- Professor Hugh Torrens (Keele)
- Dr Volke Wilde (Senckenberg)
- Dr David Martill (Portsmouth)
- Professor Paul Pearson (Cardiff)
- Dr William Gosling (University of Amsterdam)

### **Convenors**

- Angela Coe (Open University)
- Alan Lord (Senckenberg)

### **Call for Poster Abstracts**

We welcome poster contributions for this meeting, particularly from students. If you would like us to consider your research for a poster please send an abstract of no more than 400 words to <[naomi.newbold@geolsoc.org.uk](mailto:naomi.newbold@geolsoc.org.uk)> by 9th January 2015.

There will be a linked public lecture on the evening of the 10th March by Euan Clarkson (University of Edinburgh) entitled 'The Cambrian Alum Shales of Scandinavia and their remarkable trilobites'.

Full details of the Lyell Meeting are provided at <<http://www.geolsoc.org.uk/lyell-2015>>.



Palaeobiology  
University of Bristol



# **Progressive Palaeontology 2015**

University of Bristol

14th and 15th May

Organizer: Joseph Keating

Abstract submission opens  
after the Annual Meeting in  
Leeds

[http://palass.org/  
modules.php?name=propal](http://palass.org/modules.php?name=propal)



news



## *Online polls for palaeontology*

Palaeontology features in two online polls. The Geological Society of London's 100 Top Geosites (<<http://www.geolsoc.org.uk/100geosites>>) included many sites with palaeontological interest, especially in the Educational Category. The release of the results of the poll, during Earth Science Week, attracted considerable media interest and the event was well-publicized and managed.

The Rotunda Museum in Scarborough, hub of the recent Yorkshire Fossil Festival, won in the Educational Category (<<http://www.geolsoc.org.uk/Education-and-Careers/100-Great-Geosites/4-Educational/The-Rotunda-Museum>>).

In the Coastal category, Hunstanton Cliffs topped the poll, partly for the fossils that can be collected there (<<http://www.geolsoc.org.uk/Education-and-Careers/100-Great-Geosites/7-Coastal/Hunstanton-Cliffs>>).

Beyond the sites that had the most votes, there are also awards for spectacular scenery and geotourism, so the honours were spread around within each category.

The development of an interactive map (<<http://www.geolsoc.org.uk/Education-and-Careers/100-Great-Geosites/Interactive-Map>>) that allows people to locate sites close to where they are is an excellent idea as well. Think geo, go local!

Meanwhile, the Scottish Geodiversity Forum launched a Fossil Five Poll, which will be open until Spring 2015. The idea was inspired by a previous poll by Scottish Natural Heritage (SNH) to find Scotland's 'Big Five' extant taxa. Although this generated considerable interest, the winners were the usual charismatic megafauna with fur and feathers. The Fossil Five Poll was designed to embrace a broader range of organisms, ranging from microbes to dinosaurs. Please cast your vote and encourage others to do so. The full list of candidates can be found at <<http://www.scottishgeology.com/poll/>>. Take the time to browse the rest of the redesigned website as well.

On the subject of geodiversity, the English Geodiversity Forum successfully launched the English Geodiversity Charter and has already run a briefing event for MPs (<<https://www.gov.uk/government/news/geodiversity-charter-for-england-launched>>). The Palaeontological Association is proud to support both the Scottish and English Geodiversity Charters.

news





## *Jurassic Coast fossils online*

Almost 1,000 fossils from Dorset and East Devon's museums are now accessible to everyone thanks to a new online database.

The **Jurassic Coast Fossil Finder** showcases the fossils held by museums along the Dorset and East Devon Coast World Heritage Site. Each fossil has been professionally photographed, including some images that can be rotated through 360°. They are presented with a description and fact file of scientific details. It is possible to search in a variety of ways and to display the results in geological order which gives a very visual representation of the nature of the fossil record in this part of the World.

Richard Edmonds, Jurassic Coast Earth Science Manager, and consultant on the project, said: "This is a fantastic resource, not just locally but globally. The Jurassic Coast has a wealth of fossils, and our aim was to make these specimens accessible to everyone. We were careful to write the text so that there is something for everyone – from fun and accessible facts for children and beginners, to more in-depth information for specialists and geology students."

The collection includes fossils commonly found by visitors, such as ammonoids and belemnites, but also rarities such as the giant pliosaur skull and recently-discovered ancient reptile footprints, and even insects. Although the first phase of the project is completed, the database will be amended and updated as new information or new specimens come to light.

"Many specimens came to the museums with little or no information, while, as the science has moved on, so has some of that information, so we welcome any input that helps us enhance or improve the content," said Richard.

The project was run by the Jurassic Coast Museums Partnership, and supported by Arts Council England, Natural England and Dorset County Council. It is one of several exciting initiatives to enhance the appeal of the museums.

The participating museums are Dorset County Museum (Dorchester), Lyme Regis Museum, Bridport Museum, Sidmouth Museum, Fairlynch Museum (Budleigh Salterton), Allhallows Museum (Honiton), Beaminster Museum, Portland Museum, Swanage Museum and Wareham Museum.

"We hope the Fossil Finder will capture people's imaginations and inspire them to go and see the fossils for real in the museums," Richard added.

See <<http://jurassiccoast.org/fossilfinder>>.





## Down in the basement

... *or* ...

### A mug's game

Edgar Sterling Cobbold, in his Herculean labours on the Comley Limestone and kindred strata, used to drink 26 cups of tea a day. It's a sentence and fact – of dubious veracity, naturally – that has stuck in my head from one of my very first lectures as a callow undergraduate of Sheffield University's Geology Department, now deceased<sup>1</sup>, some few<sup>2</sup> decades ago. It's the kind of memory that is testament to the value of a university education.

The lecture was given by Leslie Moore, the resident prof, who would stride out from his inner sanctum to give the occasional setpiece lecture to awe – successfully – the new resident inmates with the sheer scale of the study that they were embarking on. Leslie Moore was something of a Herculean figure himself, a man of imposing stature. The rumour was that he had once been trialled for the centre-forward position with Bristol Rovers, but that may be as fictitious (or not?) as Cobbold's tea-drinking prowess. His mystique was only enhanced by the ubiquitous trench coat that he wore – not so much a famous blue raincoat as a notorious grey one – and by smoking a pipe of profound antiquity, the bowl twisted and blackened into a shape that would have drawn a shrill cry of admiration from Salvador Dali. Of Moore's fame as a founding father of Carboniferous palynology we were, of course, entirely unaware.

Those 26 cups of tea, now ... a fact, an exaggeration, a mere average with considerable standard deviation, a myth, finally crystallized at the end of a chain of Chinese whispers? Or just a figment of memory? – those several decades, remember. Who knows? Nevertheless, it seems to encapsulate a character with the patience, fortitude and persistence of the old-time field geologist. For Cobbold was certainly that. By profession an engineer<sup>3</sup>, after retirement, he threw himself into the geology of Shropshire. He worked mainly in the first quarter of the 20th century, that is, a generation or two after the titans – Murchison, Sedgwick, Lyell, Lapworth *et alii* – who had put together the framework of geology. He was hence part of the generation that hammered – literally – that first sketch of Earth history into the most intricate of crowded tapestries.

He seems to have been an altogether *nice* man, generous in spirit and well-liked, from the brief biography written by W. W. Watts, and published in the – as the cover of the reprint puts it – *Transactions of the Caradoc and S.V. Field Club*. It would have been clear to one and all in those

<sup>1</sup> Or, more precisely, murdered, by an early ancestor of the Great Rationalization Process.

<sup>2</sup> OK then, several.

<sup>3</sup> For a time he combined with Herbert Lapworth, Charles Lapworth's nephew, and in his spare time a fine geologist and palaeontologist in his own right, in working on construction of the Elan valley reservoir dams. In the entanglement of geology and engineering, this was a small and influential micro-world.



days that 'S.V.' stood for 'Severn Valley', those being days of the universal understanding that preceded contemporary globalization – the two being not at all the same thing. Cobbold, in his prime, had been a co-founder of another organ of that estimable organization, the splendidly entitled *Record of Bare Facts* one that he published quite a lot of his considerable material in.

He was thus in the company of the likes of W. G. Fearnside, and O. T. Jones, of Gertie Elles and Ethel Wood and Edward Greenley (and up in less antique strata, of Arkell and Rowe and such). They were good field men (and here one includes the redoubtable Miss Elles) – the map that O. T. Jones drew of the Rheidol Gorge can be used today, with graptolite bands located to the nearest foot (or quarter-inch in the case of the enigmatic 'green streak' mudstone layer of the *leptotheca* Zone). Cobbold, now, is probably best known for hammering wonders out of the Cambrian rocks of the Welsh Borders, notably the Comley Limestone, which at first sight is as unprepossessing a rock layer as one can stumble upon in the gloom of a soft Shropshire day: a rock that combines toughness and nondescriptitude in equal proportions, where the resident trilobites do not (I remember well my perplexed visit to Comley Quarry) leap out and clamour for the attention of the questing eyeballs.

Cobbold, fuelled (perhaps) by more than enough tea to keep the kidneys in tip-top condition, set about his task with patience and determination, and from this foot-thick bed of sort-of-limestone extracted a shoal of trilobites, sufficient to show that somehow this modest bed conceals within it enough time for no less than three Cambrian trilobite biozones to be represented. It's the kind of ultra-condensation of rock that makes one wonder how any of those arthropods could survive – skeletally, as it were – being buried at an average rate of a micron or so a year. But survive they did, and those grimly persistent (even when deceased) arthropods went on to form part of the new, finely subdivided scaffolding of time of the Palaeozoic era. He wasn't just an assiduous collector in the field. He grew adept at excavating these fragmentary trilobites out of the tough rock using a mounted needle and magnifying glass, and made fine pencil sketches to accompany his descriptions<sup>4</sup>.

In the junkyard of discarded carapaces that can be gleaned from the Comley Limestone, there was an assortment of stray bits and fragments, the scrapings of the Comley barrel. One was given a name: *Strettonia comleyensis* – but this name only encompassed part of the corporeal trilobite. There was a head, and also a tail – which only possibly, but not certainly, belonged to the head. But no thorax.

This part-trilobite stayed in morphological limbo until, in early 2008, two citizens of Shropshire, Steve Butler and Keith Hotchkiss, decided that a whole trilobite would be better than a half-trilobite, both philosophically and practically: they wished to make and presumably sell a mug emblazoned with the completed fossil<sup>5</sup>. They had the inspired idea of approaching that nonpareil of Cambrian trilobite taxonomy, Adrian W. A. Rushton<sup>6</sup> and of persuading him to help evolve *Strettonia* into its full glory. This was done by post, as they drew a possible sketch of the whole beast, upon which AWAR then commented, and then they redrew, followed by yet more

<sup>4</sup> His drawings, though sharp and accurate, were 'optimistic' and tended to fill in what he thought should be there; his most successful illustrations were made 'while he was still a young man of sixty': Rushton, A. W. A. 1995. Edgar Stirling Cobbold 1851–1936. *Trilobite Papers* 7, 18–21.

<sup>5</sup> The giants of Wall Street were unlikely to have been quivering in their boots at the prospect – but in a more perfect world they should have been.

<sup>6</sup> Indeed, nonpareil in stratigraphical palaeontology. Period.



comments. This went on for six months until a harmonious and plausible trilobite – a *detailed* harmonious and plausible trilobite – was evolved. The process of evolution is all faithfully captured in the pages of the *Proceedings of the Shropshire Geological Society*. It's a gem of imagination, of precise attention to detail, of a sense of how far one can go in feeling through – on the basis of a lifetime of extraordinary scholarship – the nature of absent body parts, all with a lightness of touch perfectly appropriate to the job in hand. The final mug is splendid, too – and deserves to sell a million copies.

To start with, it was decided to follow Cobbold's original intuition – that the head and the tail were of the same beast: not certain, but a reasonable inference. From that, then, on to the first sketch, a rather scrawny beast, with tail as big as head. '*Well imagined*' AWAR wrote, but '*needs some polishing*'. With this, there were notes on anterior borders, facial sutures, thoracic axes, and such. The next drawing showed an amended and happier-looking trilobite of more *embonpoint*. Nevertheless, there was still some evolving to do – '*I think the glabella is a bit too narrow compared with the width between glabella and eye*'; '*there is something strange about the appearance of the librigenae*' – and more in the same vein. Another couple of back-and-forth drawings and commentaries. There was clearly progress. '*Your new version looks most convincingly trilobite-like*', though nevertheless there was still a '*Nevertheless I suggest that...*' On, then, through a couple more versions with further fine tuning '*I would be happier if you made the eye-lobes a little more curved at their front ends...*' Finally ... '*I think your latest drawing is admirable ... I hope it does its job as an emblem and that someone, somewhere, will find an articulated specimen. In the meantime we have yours!*'

There was then, clearly, a transfer of finished artifact. The last correspondence reads '*The mug is a very neat production, with informative colouring. I will keep it at the NHM, at least for the moment, because I want to use it in the presence of Richard Fortey and see what he makes of it. I expect him to look keenly at it, but remain puzzled...*' The level of puzzlement of Richard Fortey, faced with an imagined *Strettonia* ('*quite a peculiar trilobite, and not well known*') is alas not recorded. It is a task for future chroniclers to complete.

More widely – and even without enigmatic and vanishingly rare half-trilobites – I've always held the Cambrian in a kind of awe, the kind of awe reserved for mysterious and mist-shrouded antiquity, of an infant metazoan ecosystem proceeding by trial and error, in waves of dyings and of radiations and global chemical dislocations. The worlds of the Ordovician and Silurian that I have traversed in person, as it were, seem normal by comparison – a settled and humdrum old world where the main biological actors have settled into their roles, and the supporting cast are yawning and reading the paper and catching a crafty fag in the wings.

The beginning of the Cambrian, the transition from the three-billion-plus-year old microbial world to the metazoan realm, is, of course, the most show-stopping entrance of all. From the time of Darwin, it has set in train the usual questions. What took the creepy-crawlies so long? – for instance. Or, once set in motion, how did the Earth's main phyla invent themselves almost simultaneously<sup>7</sup>? These questions have been so oft debated and still so unresolved that one feels quite tired just hauling them out into print, once more. Better, perhaps, to consider the slightly more oblique but tractable questions of the effect of this slow-motion explosion. The way, for

<sup>7</sup> Well, over a few tens of millions of years. This will help amplify such plot as this column might or might not develop, of course.



instance, that burrowing acts as a chemical bridge between sediment and water – that idea has been around for quite a while. Then, the newer notion that the evolution of filter-feeders – first sponges, then brachiopods and their ilk and such, cleaned the ocean waters from their long-held Precambrian state of being a kind of a stagnant, oxygen-scavenging soup, where dead microbes and such took an age to settle and decay, into something much fresher and clearer – and suitable for colonization by those oxygen-guzzling metazoans<sup>8</sup>. These are sideways ways to try to get a feel of how the Earth changed, but they seem not to give quite the dull headache – from the head too oft banged upon that brick wall of unconstrainable hypothesis – of those more time-worn primary questions.

Questions of cause and effect apart, there is a more immediate practicality to this large step-change in the biosphere's anatomy. It would go on to give us nice easily distinguishable strata: from, say, a productid brachiopod here, or a rhynchonellid one there, or a few monograptid graptolites in these rocks of that hillside, with a scattering of archaeocyathids (that nod to the Cambrian, here) in the valley below. With things like that, one knows where one is (and by delving for some hours among the monographs, one knows where one is *precisely*). It's the start of stratigraphy as we mostly know it<sup>9</sup> – which is in its purest form a thing of the last eon, our very own Phanerozoic. And the boundary of that, and of the Palaeozoic Era, is that of the Cambrian Period (and of the Terreneuvian Epoch and of the Fortunian Age, too, to complete the full set).

And *that* boundary – arguably the most important on Earth – was settled just a touch over 20 years ago, in 1992 after much head-scratching – that itself took a couple of decades, about where, precisely, within the slow-motion 50-million-year unfolding of the Cambrian explosion, it should be placed. This, of course, was a human decision, a selection of convenience (or perhaps of despair), a slicing through of the Gordian knot of complicated history so that one more neat pigeonhole – though in this case a giant row of racking – can be constructed in the fabric of Earth time.

Where to place it? It wasn't at what was most people's effective boundary in the past, the appearance of the charismatic trilobites, the Cambrian's trademark fossil. These appeared, fully armoured, about 521 million years ago. Nor was it at the coming to light of those little enigmas, the 'small shelly fossils', which had put in an appearance some five million years earlier. Rather, it was where a particular kind of burrow, the en echelon blobs of something called *Treptichnus pedum*, had been found to appear within the impressive strata of the equally impressive shoreline crags of Fortune Point, in Newfoundland, that was chosen. These eon-determining priapulid worms<sup>10</sup> began to churn those strata some 542 million years ago, a little under ten million years after earlier 'treptichnid' and other trace fossils took the stage – which was in itself ten million years at least after the disc-like *Aspidella* (*i.e.* we're now back at 560 million years ago) began to shift itself sideways in steps of about a quarter of a body width, in those same Newfoundland sands<sup>11</sup> – which in itself was only twenty million years after those iconic but thoroughly mysterious Ediacaran organisms – *Charnia* and all its friends – appeared on Earth.

<sup>8</sup> Lenton *et al.* 2014.

<sup>9</sup> Yes, I know we now have isotopes, and astrocycles and sequence boundaries and such, but really – it's the fossils that count.

<sup>10</sup> Their (probable) unmasking is detailed by Vannier *et al.* 2010.

<sup>11</sup> The evidence is in Menon *et al.* (2013).



Confused? Well, so you should be. There's nothing there in that history that is simple or straightforward or can emerge as a single unambiguous transformative moment. But within that welter of possibilities, a distinctive new type of burrow seemed both practically reasonable (you can see it in rocks even without a hand lens) and geohistorically significant – it's part and parcel of all those changes to global elemental cycles associated with the churning of sea floor sediment.

Not so fast, though. This particular boundary – among some practitioners of the black arts of Cambrian stratigraphy – soon appeared to be creaking at the seams. It creaked to the extent that, a little while ago, there was a call<sup>12</sup> to start from the beginning again, and look for a new beginning (or base, if we are thinking in material terms) to the Cambrian, and hence to the Palaeozoic and the Phanerozoic too<sup>13</sup>. So, not much more than half a century after the grand search for a golden spike was begun, we may have gone full circle. Our eon is un-moor'd once more, it seems, and needs fixing. It's another example of the spike being not so much golden, as a thing of rusty iron – an old saying of Peter Rawson's, which I soon realized was apt in almost all stratigraphic circumstances – to be pulled out and replaced when an old boundary begins to cough, splutter, misfire and trail clouds of black smoke as new demands are made of it.

So what's up with the Cambrian? Well, the reign of the current golden spike level (2.3 m above the base of Member 2A of the Chapel Island Formation at Fortune Head, to be exact) got off to a mildly inauspicious start when Jim Gehling and colleagues found the boundary indicator, *Treptichnus pedum* itself, a little over three metres and also a little over four metres below the boundary level – and so in a different stratigraphic unit. There were also indications of a fault just below that – so it was hard to tell how far this particular worm-track might range lower in the stratotype section if the section had not been dislocated in this fashion.

Of course, that doesn't mean that the boundary level changes if the key indicator fossil is found to range lower. A golden spike is a golden spike, the stratal plane that it impales being the level to try to correlate to from wherever in the world, by whatever means possible. But to have the reference level now somewhere within the time range of *T. pedum*, rather than at its base, clearly increases the error bars when one is trying to correlate to that level.

That is one difficulty. There arose another problem<sup>14</sup> that affects pretty well every organism – but that seems to be quite vividly developed in our chosen worm. Thus, any creature evolves (somewhere); then spreads across some part of the world (taking some time to do this); and, even as it migrates, it will congregate in some places but shun others. *Treptichnus pedum* was no exception. The sea-floor-that-was-to-become-Newfoundland seems to have been an early home. It arrived a little later – as far as can be judged (still early in the Fortunian Age, though) – in those more distant shores that were to become the Great Basin of the USA, and south Australia, and Finnmark. Quite some time later (late in the Fortunian), it reached south China; and absurdly late (after the end of the Terreneuvian Epoch, no less) it appeared in Greenland-to-be. Even then, it was picky: shallow marine sandy sea floors were agreeable, and coarse sandy floors especially so, but it didn't venture into deep waters, and didn't like carbonate environments much.

<sup>12</sup> Chapter and verse in Babcock *et al.* (2014).

<sup>13</sup> The Terreneuvian and Fortunian thus being at risk of homelessness until new arrangements can be made.

<sup>14</sup> A problem for us, the geologists that is, to try to make use of its mortal remains; the worm itself was blissfully unaware of the stratigraphical frustration that it was set to cause, half a billion years after it was going about its daily routine in its own home.



This is quite understandable for an apprentice member of the worm tribe, but non-ideal for a fossil with the responsibility for defining an eon. *T. pedum* did, mind, have neighbours, or more likely competitors. Round about the same time (a little later in Newfoundland) there appeared better-known (and longer-ranging) worms such as those that made the traces known as *Arenicolites*, and *Skolithos*, and *Helminthopsis*. These help with correlation, but each has a different range in detail – and the organisms producing them tended to occupy similar terrain on the sea floor, but did not venture into, or leave their imprints on, deep water sediments.

But there are older burrow traces too – such as *Planolites*, for instance, which go down into the Ediacaran strata of the Precambrian, and those early treptichnids. Fossilized burrow systems are no more immune from the standard run of taxonomical uncertainties than are any other kind of fossil. Thus, the species *pedum* now placed within *Treptichnus* has been placed within *Phycodes* and also within *Manykodes*, while some among those of the earlier, Ediacaran forms of *Treptichnus* might fall within the range of variation of *pedum* itself – if the range of variation of the latter can be reliably constrained.

We're in the usual jungle made up of the filigree patterns produced when geography and biology intertangle, with that poor orphan, time, lost in there somewhere. Is there any way to carve a path through this taxonomic morass, to more reliably throw time-lines across continents? The new-ish kid on the block here is the ups and downs of global carbon chemistry, expressed via different proportions of light and heavy carbon isotopes preserved within strata. As more carbon isotope records have been gathered and matched up over the last couple of decades, they seem to show good consistency – good enough, indeed, for one particular interval of strata marked by an excess of the light carbon isotope (BACE, it's called, standing for **B**Asal **C**ambrian carbon isotope **E**xcursion) to be increasingly used *de facto* to locate the base of Cambrian strata around the world.

So, locate BACE in Newfoundland and we have the answer? Alas, the strata there are too sandy, and too strongly cooked by the heat of metamorphism to yield a decent carbon isotope signal. So, while BACE is now widely being used elsewhere, its position can't be pinned down relative to the official global standard at Fortune Head. Hence, the official global reference is beginning to be bypassed in favour of unofficial but more practical means of locating a boundary – even as it is realized that that probably isn't exactly the same boundary.

So what to do? The paper provides no answers, but simply notes that there is a range of options. One can, say, do nothing, and retain the Fortune Head golden spike level with all its awkwardnesses. Or, one can choose another boundary at another level using either the appearance of another fossil (a small shelly fossil, say, or go back to old times by using the appearance of a trilobite – in which case the Cambrian boundary would change by as much as 20 million years, the preceding Ediacaran Period lengthening by the same amount – while the mighty Phanerozoic Eon would lose about one twenty-fifth of its duration). Or, one can define a new boundary using the BACE carbon isotope event (in which case the boundary level would change by a smaller, but unknown and probably unknowable amount).

So, it looks to be interesting times at the beginning of our eon, and at the dawn of the mysterious and seemingly now imperfectly-defined Cambrian Period. The good thing about such rethinking of the formalities, of exactly where golden spikes should be placed, is that one usually emerges



from the process understanding the history of that time period, in its deepest sense, a whole lot better. But what *that* in turn means is that there is much scope for energetic, and indeed Cobboldian, hammering of the rocks, to garner evidence fit for modern times. Time to put the kettle on, therefore, and then to go out into the hills. Perhaps a whole *Strettonia* will turn up in the process, just to remind us that this is all a mug's game – but one that puts *informative colouring* on the most exciting bits of Earth history.

**Acknowledgements:** my thanks to Tom Harvey and Adrian Rushton for helping to guide me through this unfamiliar terrain. The mis-steps along the way are entirely my own, though.

## Jan Zalasiewicz

### REFERENCES

- BABCOCK, L. E., PENG, S., ZHU, M., XIAO, S. and AHLBERG, P. 2014. Proposed reassessment of the Cambrian GSSP. *Journal of African Earth Sciences* **98**, 3–10.
- BUTLER, S. G., HOTCHKISS, K. A. and RUSHTON, A. W. A. 2012. The “evolution” of the trilobite *Strettonia comleyensis*. *Proceedings of the Shropshire Geological Society* **17**, 22–32.
- LENTON, T. M., BOYLE, R. A., POULTON, S. W., SHIELDS-ZHOU, G. A. and BUTTERFIELD, N. J. 2014. Co-evolution of eukaryotes and ocean oxygenation in the Neoproterozoic era. *Nature Geoscience* **7**, 257–265.
- MENON, L. R., MCILROY, D. and BRASIER, M. D. 2013. Evidence for cnidarian-like behavior in *ca.* 560 Ma Ediacaran *Aspidella*. *Geology* **41**, 895–898.
- RUSHTON, A. W. A. 1995. Edgar Sterling Cobbold 1851–1936. *Trilobite Papers* **7**, 18–21.
- VANNIER, J., CALANDRA, I., GAILLARD, C. and ZYLINSKI, A. 2010. Priapulid worms: pioneer horizontal burrowers at the Precambrian–Cambrian boundary. *Geology* **38**, 711–714.
- WATTS, W. W. 1936. Edgar Sterling Cobbold. *Transactions of the Caradoc and Severn Valley Field Club*. 1 pl., 13 pp.



Photo: Anna Taylor

*The Mug, in the safe hands of Adrian Rushton.*

You can follow the ‘evolution’ of *Strettonia comleyensis* at <[http://www.shropshiregeology.org.uk/sgspublications/Proceedings/2012%20No\\_17%20022-032%20Butler%20Strettonia.pdf](http://www.shropshiregeology.org.uk/sgspublications/Proceedings/2012%20No_17%20022-032%20Butler%20Strettonia.pdf)>





# R for palaeontologists

## 3. Statistical tests Part 1 – Comparisons and correlations

### Introduction

In the two previous introductory articles in this series my aim was to introduce you to the basics of the R language and to cover some of the essentials for any analysis, *i.e.* loops and functions. I appreciate that getting used to how to process data using these methods, especially those in the previous article, can take a while to get your head round. As such I don't want to scare anyone away who may be keen to develop their analytical skills and may wish simply to perform basic statistical tests on their own data, in the first instance at least. So in the next couple of articles I will focus on the basics of statistical analysis in R; all the code for these analyses will be simple and not involve the need to understand loops fully at this stage.

R is capable of performing all of the commonly-used statistical tests (many with a single command) without the need to write any additional code or install any other packages. Many if not all of the tests I will discuss here are located in the **stats** package that was automatically included when you installed R. To see a full list of the functions contained in this package type **help(stats)** then click on 'Index' at the very bottom of the page.

In this article I will introduce some of the most commonly used statistical tests, explaining when it's best to use them and how to implement them in R. All the examples I have provided here use the same datasets from the last two articles which are available at the PalAss website (at <http://www.palass-pubs.org/newsletters/downloads/number85/asaphidae.txt>), along with details on how to load these files into the R environment.

Before I begin I briefly want to mention a previous *Newsletter* contributor; Norman MacLeod's PaleoMath series (available at [http://www.palass.org/modules.php?name=palaeo\\_math](http://www.palass.org/modules.php?name=palaeo_math)) covers a wide range of palaeontological analytical techniques such as regression and multivariate analyses, *e.g.* Principal Components Analysis (PCA). While I intend to demonstrate how some of these methods can be carried out in R the PaleoMath series is an excellent resource for those interested in the theory and usage of these analyses and is also written with the novice in mind.

### Null hypotheses and p-values

While there are many different statistical tests that can be used to examine every facet of your data they all have one aim in common, to significantly differentiate any pattern in your data from one that could be caused by random variation: that is, is your observed pattern likely to have a cause beyond chance alone? This is referred to as a null hypothesis, usually denoted as  $H_0$  which in simple terms says that there is no pattern in your data. If we had two samples labelled A and B that represented potentially two different species, and we wanted to know if they differed significantly from one another, the null hypothesis could be written as follows:

$H_0$  = sample A is not significantly different to sample B



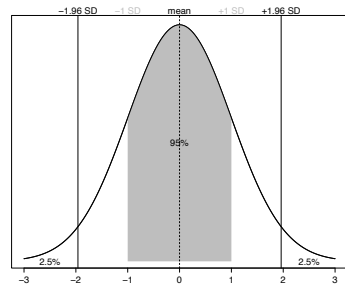
So our aim is to reject the null hypothesis in favour of an alternative hypothesis ( $H_1$ ) that might be:

$$H_1 = \text{sample A is significantly different to sample B}$$

In many tests the distinction between these two hypotheses is made using a  $p$ -value that is returned in most statistical tests. Fundamentally the  $p$ -value represents the probability that null hypothesis is true. Typically, the value of 0.05 is used as an arbitrary cut-off (a critical value or alpha,  $\alpha$ ) that means that the null hypothesis has only a 5% chance of being true. So if we were to use a statistical test to compare samples A and B and that test returned a  $p$ -value of 0.01 we could say that the null hypothesis has a 1% chance of being true and therefore we can reject it in favour of  $H_1$  and say that the samples are significantly different.

**The normal distribution and calculating variance**

The normal (also called a Gaussian) distribution is one of the most commonly used distributions in all of statistics and whether your data fit this distribution or not can influence which test you select for your analysis. The shape of the normal distribution is described by two things: the mean (the average value of the sample) and standard deviation (the amount of spread of the data). The standard deviation ( $\sigma$  or SD) represents a measure of the variance around the mean of a sample. In a normal distribution 95% of all data points lie within  $\pm 1.96$  standard deviations (SD) of the mean (Figure 1).



*Figure 1. The normal (Gaussian) distribution. The mean value is shown by a dashed line. A grey box represents all data  $\pm 1SD$ . Plotted percentage values indicate how much of the sample is within and outside  $\pm 1.96 SD$  respectively.*

Standard deviation is defined as the square root of the variance for that sample. In order to calculate that we first need to know the sum of squares which is the sum ( $\Sigma$ ) of the squared difference between each observation and the mean (equation 1 below). Knowing this we can then calculate the variance by dividing the sum of squares by the degrees of freedom (the number of observations minus one) (equation 2 below). Finally we can take the square root ( $\sqrt{\quad}$ ) of the variance to provide us with the standard deviation of our sample (equation 3 below).

- (1) Sum of squares =  $\Sigma(\text{observation} - \text{mean})^2$
- (2) Variance = sum of squares /  $n-1$
- (3) Standard deviation (SD) =  $\sqrt{\text{Variance}}$

**Data types and statistical tests**

The data commonly included in statistical analyses can be broadly categorized as either qualitative or quantitative. Qualitative or categorical data describes data consisting of a number of groups or categories such as taxonomic groups or size classes (e.g. 'large' and 'small'). Quantitative data can be further separated into continuous and discrete data. In continuous data the values can be any number, such as measurements of length or temperature, and include



fractional elements (e.g. 3.14), whereas in discrete data not all values are possible and usually consist of integers (e.g. number of individuals).

Broadly speaking statistical tests can be categorized in a number of ways depending on what they do and the assumptions they make. Here I will briefly discuss two distinctions: descriptive *versus* inferential, and parametric *versus* non-parametric tests. Descriptive statistics are used when you want to summarize or show the data in a way to highlight some property of the data, such as the average of all the data (e.g. calculating the mean) or how the data are distributed (e.g. standard deviation). Whereas, inferential statistics are used when we want to analyse a sample of data in order to infer patterns about a larger population, or to test hypotheses regarding one or more samples. An example of inferential statistics would be in using a statistical test to examine the previously discussed null hypothesis ( $H_0$ ) that Sample A is not significantly different from Sample B.

The distinction between parametric and non-parametric tests is determined by the type of data they are designed to handle. In the former it is assumed that the data follow a specific distribution, whereas the opposite is true for non-parametric tests should the data be non-normal. It is common that parametric tests have their non-parametric equivalent (for example the Mann-Whitney U test is the non-parametric version of the *t*-test).

### Descriptive statistics

After a period of data collection you will have either one or multiple samples that you will want to ask some questions about, such as what is the mean of these samples? Or do they display a normal distribution? In order to demonstrate the functions that allow you to examine your samples we will use the 'Asaphidae body-size' dataset. Starting with the first question: let's say you want to ask what is the mean body-size of the genus *Asaphus*. You can use the function **mean** that only requires an array of values:

```
mean(asaphidae["Asaphus"],na.rm=TRUE)
[1] 19.22518
```

However, the option *na.rm=TRUE* is required here as **mean** won't return a value if any of the elements are missing (NA) – which you can see is the case if you examine **asaphidae["Asaphus"]** in detail. To make things a little easier to follow I will assign all the non-missing values to their own variable called **asaphus**. Remembering the convention of exploring matrices as [row, column], below I ask for all entries in the column "Asaphus" but use the function **is.na** to get only the values in that column that do not have any missing values: *i.e.* when **is.na** (are any of the values NA) is equal to FALSE:

```
asaphus <- asaphidae[is.na(asaphidae["Asaphus"]) == FALSE, "Asaphus"]
```

Now we can ask what the mean is of the *Asaphus* sample by using:

```
mean(asaphus)
```

... which will return the same value as previously:

```
[1] 19.22519
```



We can also ask for the median value by typing:

```
median(asaphus)
```

... which will return:

```
[1] 18.15
```

In addition, if you wanted to know the minimum, maximum and 1st quantile values you could use **min(asaphus)**, **max(asaphus)** and **quantile(asaphus,0.25)** respectively, though in fact all this information can be gained from the function summary which returns all these values together:

```
summary(asaphus)
```

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
3.30	14.86	18.15	19.23	21.77	166.00

Finally, as discussed at the start a common measure of the spread of the distribution is the standard deviation (SD). This can be easily calculated using the function **sd**, as in the following:

```
sd(asaphus)
```

```
[1] 13.26326
```

So the standard deviation ( $\pm$  1SD) from the mean of *Asaphus* is roughly 13; the values for  $\pm$  1SD are retrieved by the following commands:

```
mean(asaphus) + sd(asaphus)
```

```
[1] 32.48844
```

```
mean(asaphus) - sd(asaphus)
```

```
[1] 5.961929
```

### Testing for a normal distribution

A common visual way to test for the normality of a distribution is the quantile-quantile (Q-Q) plot that plots the ranked quantiles of your data against a distribution of theoretical quantiles taken from a normal distribution. A normal sample will show a straight line, while a non-normal distribution displays a deviation from a straight line, typically as an S-shape. We can see the difference between normal and non-normal data if we compare the *Asaphus* data with a randomly-generated dataset of 1,000 values taken from a normal distribution using the function **rnorm**.

```
X <- rnorm(1000)
```

To see the difference between the two distributions you plot them using **hist(X)** and **hist(asaphus)**.



A Q-Q plot can then be generated for both the random and the *Asaphus* datasets using the code below. In Figure 2 you can see that the *Asaphus* data on the right do not show as straight a line as the randomly-generated data on the left. It should be noted that as **X** is generated randomly your plot will differ from Figure 2.

```
par(mfrow=c(1,2))
qqnorm(X)
qqline(X)
qqnorm(log(asaphus))
qqline(log(asaphus))
```

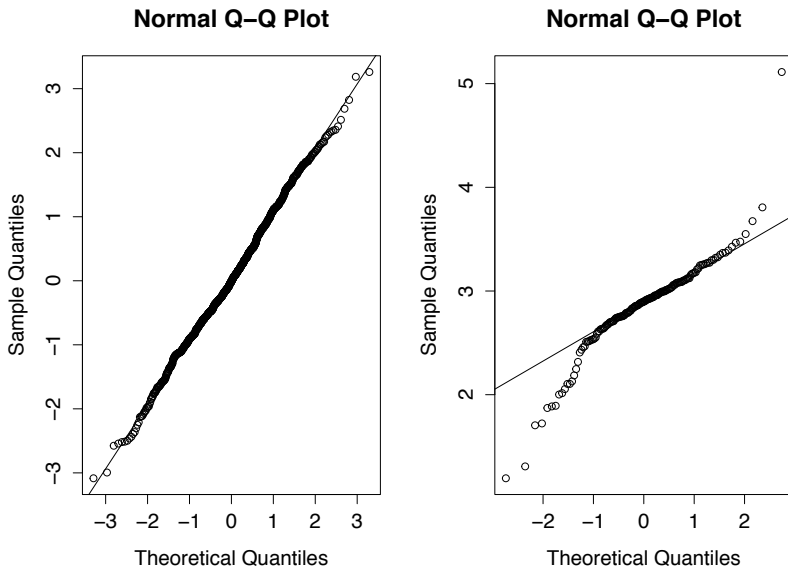


Figure 2. Quantile-Quantile (Q-Q) plots for randomly generated data taken from a normal distribution (left) and for the trilobite genus *Asaphus* (right).

A formal test for normality is to use the Shapiro-Wilk test using the null hypothesis ( $H_0$ ) that the data are normally distributed. The function for this is **shapiro.test** as follows:

```
shapiro.test(X)
shapiro.test(asaphus)
```

This will return the test statistic (W) in each case and the associated *p-value*. The results of this test mirror those of the Q-Q plots where the *p-value* for **X** (0.1818) is above the critical value of 0.05 and therefore  $H_0$  cannot be rejected. On the other hand **asaphus** has a *p-value* lower than 0.05 which allows us to reject  $H_0$  and show that the distribution is significantly different from normal.



## Two sample comparisons

More commonly, rather than examining one sample in detail, you will want to compare two or more samples to determine whether they are significantly different. I discuss a number of commonly-used classical tests below. For this we will need another couple of samples with which to compare. We will now include the measurements from two other genera: *Opsimasaphus* and *Neosaphus*:

```
neosaphus <- asaphidae[is.na(asaphidae["Neosaphus"]) == FALSE, "Neosaphus"]
opsimasaphus <- asaphidae[is.na(asaphidae["Opsimasaphus"]) == FALSE,
"Opsimasaphus"]
```

We can use boxplots to view and compare the distributions of these three genera (Figure 3). Here Figure 3 is plotted on a log scale using the option `log="y"`.

```
boxplot(asaphus,opsimasaphus,neosaphus,log="y",names=c("Asaphus","Opsimasaphus",
"Neosaphus"),ylab="Length (mm)")
```

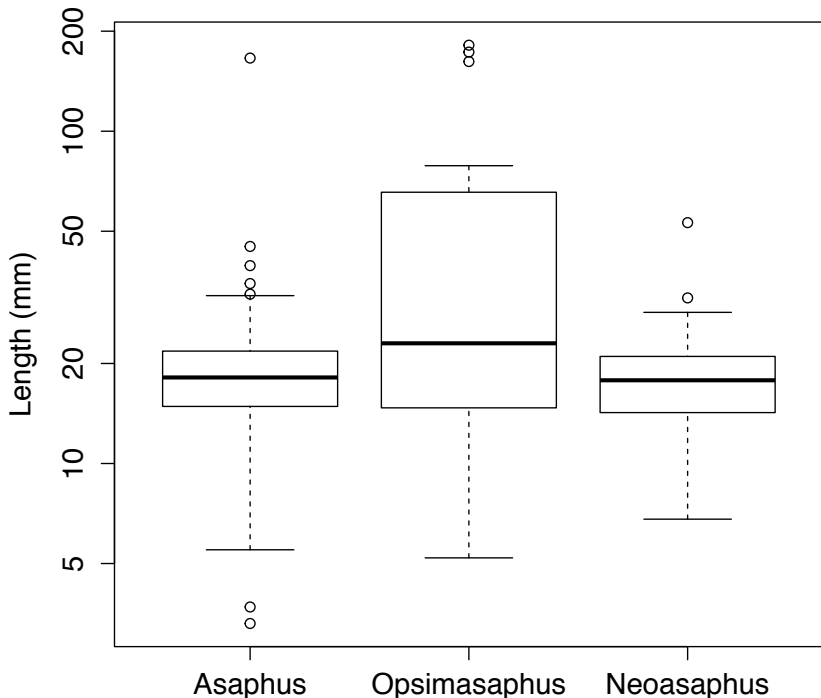


Figure 3. Box plots for the body-size of three trilobite genera plotted on log-scale.

The first test I want to discuss is called the Student's *t*-test and is used to compare the mean values between two samples of continuous data that have a normal distribution. The null hypothesis for the *t*-test is that both samples are drawn from populations with the same mean value. The function for the *t*-test is called `t.test` and can be implemented as follows:

```
t.test(asaphus,opsimasaphus)
```



I should mention that you don't need to separate the data into individual variables in this case as each of the tests discussed here will accept missing (NA) values and will return the exact same answer if you just select the columns you want to analyse:

```
t.test(asaphidae[, "Asaphus"], asaphidae[, "Opsimasaphus"])
```

The *t*-test will return a lot of information looking like this:

```
data: asaphus and opsimasaphus
t = -4.7126, df = 72.871, p-value = 1.143e-05
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-31.62247 -12.82477
sample estimates:
19.22519 41.44881
```

The important information here is the test statistic (*t*) and the *p*-value which in this case is well below the critical value of 0.05, suggesting that we can reject the null hypothesis that the samples have equal means and conclude that the samples are significantly different.

In opposition to this we can examine whether *Asaphus* and *Neosaphus* are statistically different using the same method:

```
t.test(asaphus, neoasaphus)
```

In this case the null hypothesis cannot be rejected as the *p*-value, at 0.6093, is well above the critical value; this is also evident if we look at the distributions in Figure 3.

Now, I mentioned that an assumption of the *t*-test is that the data are normally distributed. As we have already seen this is not true of the *Asaphidae* data provided here. Therefore, we should use the non-parametric version of this test which is called the Mann-Whitney U test (also known as the Wilcoxon rank-sum test). The function for this is called **wilcox.test** and can be run in the same way as for **t.test**:

```
wilcox.test(asaphus, opsimasaphus)
```

This will also return the statistic (*W*) along with the associated *p*-value. The results of this test are similar to those of the **t.test** in that the *p*-value is less than 0.05, so the null hypothesis can again be rejected.

It is possible that while two samples may not differ in terms of their means, they may have a different shape in terms of distribution, varying in either the overall variance or amount of skewness. In order to test whether two samples vary in their distributions we can use the Kolmogorov-Smirnov test in which the null hypothesis is that both samples are drawn from the same distributions. The function for this is **ks.test**, and is similar to the Mann-Whitney U test in that it does not require the data to be normal:

```
ks.test(asaphus, opsimasaphus)
```

```
ks.test(asaphus, neoasaphus)
```

The results of this test are similar to those for other tests in that the *p*-value is lower than the critical value, allowing us to reject the null hypothesis in the first example but not for the second.



### Linear correlations

Correlations are an important and commonly-used statistical test, used when you want to examine whether two sets of data show a statistical relationship. Many different types of correlation tests exist, but I will focus here upon linear correlations, which test whether the variables either increase or decrease together, and specifically the Pearson product-moment correlation coefficient (the default for the functions in R). In the case of a perfect linear fit (either positively or negatively) all the data points would lie on a straight line when plotted against each other (Figure 4). For a correlation test two continuous variables containing the same number of values are required, although these can contain missing values which I will come on to later, such as:

```
x <- c(-3,-1,1,2)
```

```
y <- c(-2,-1,2,3)
```

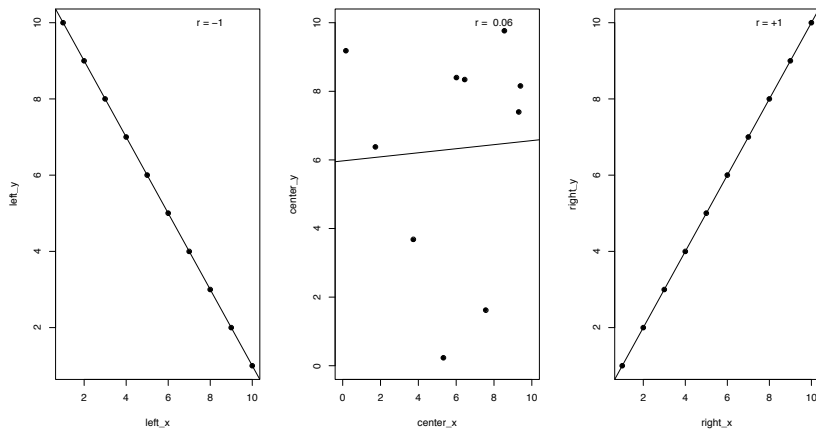


Figure 4. Plots of three kinds of correlation coefficients ( $r$  or  $R$ ); a strong negative correlation (left), a weak positive correlation (centre) and a strong positive correlation (right).

Fundamentally, a linear correlation test operates in the same way as the two-sample tests, in that the null hypotheses ( $H_0$ ) is that there is no correlation between the two variables and the probability of this being true is represented by a  $p$ -value.

The Pearson product-moment correlation coefficient (typically written as  $r$  or  $R$ ) is a measure of the linear correlation between the two variables. Values can range from -1 to +1, representing where end members demonstrate a perfect negative or positive correlation respectively, with 0 indicating no correlation (Figure 4). Pearson's  $r$  is defined as the covariance of the variables divided by the product of their standard deviations (SD). For variables  $x$  and  $y$  this can be calculated as follows:

$$\text{cov}(x,y) / (\text{sd}(x) * \text{sd}(y))$$

which will return the value:

```
[1] 0.9788389
```





The function for calculating Pearson's  $r$  is called **cor** and will return the same value:

```
cor(x,y)
[1] 0.9788389
```

If you want to calculate the significance of this correlation in order to reject or accept the null hypothesis the function to use is **cor.test**:

```
cor.test(x,y)
Pearson's product-moment correlation
data: x and y
t = 6.7648, df = 2, p-value = 0.02116
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.2996062 0.9995757
sample estimates:
 cor
0.9788389
```

As shown above this will return a set of values similar to the previous two-sample tests that contain the test statistic ( $t$ ), degrees of freedom ( $df$ ),  $p$ -value and the correlation coefficient value ( $r$ , marked as **cor**). We previously knew that there was a strong positive correlation between these two variables as the correlation coefficient is close to 1, but we also know that this correlation is significant as with a  $p$ -value of 0.02 it is less than the critical value of 0.05 so the null hypothesis can be rejected.

Another statistic that is commonly quoted along with the results of linear correlations is the  $r$ -squared value ( $r^2$  or  $R^2$ ), also known as the coefficient of determination. In the case of linear correlations this is typically calculated as the squared value of the correlation coefficient and represents how much of the variation of one variable is explained by the second. So in the case of **x** and **y** the  $r^2$  value can be calculated as follows:

```
0.9788389^2
[1] 0.9581259
```

This tells us that 95% of the variation in **x** can be explained by **y**.

Finally, we can use real data to examine the relationships using the **extrinsic** dataset available at <<http://www.palass-pubs.org/newsletters/downloads/number85/extrinsic.txt>>. This contains variables representing diversity, environmental parameters and rock area for the Phanerozoic taken from Mayhew *et al.* (2012).

If we wanted the correlation coefficients for all columns in the dataset we can again use the function **cor**, which will return the  $r$  values for every pair-wise combination of columns:

```
cor(extrinsic)
```



However, if we wanted to examine the relationship between temperature and subsampled diversity (SQS) we can type the following:

```
cor.test(extrinsic["Temperature"], extrinsic["SQS"])
```

Pearson's product-moment correlation

data: extrinsic["Temperature"] and extrinsic["SQS"]

t = -1.6848, df = 49, p-value = 0.09839

alternative hypothesis: true correlation is not equal to 0

95 percent confidence interval:

-0.47871608 0.04444625

sample estimates:

cor

-0.2340037

In this instance there is a weak negative correlation between these two variables as the  $r$  value is only -0.234 and the  $p$ -value is greater than 0.05 at 0.098, which means the null hypothesis cannot be rejected here. The lack of correlation between diversity and temperature in this case can be seen if we view the data graphically (Figure 5) using:

```
plot(extrinsic["Temperature"], extrinsic["SQS"], pch=19, xlab="Temperature",  
ylab="Diversity (SQS)")
```

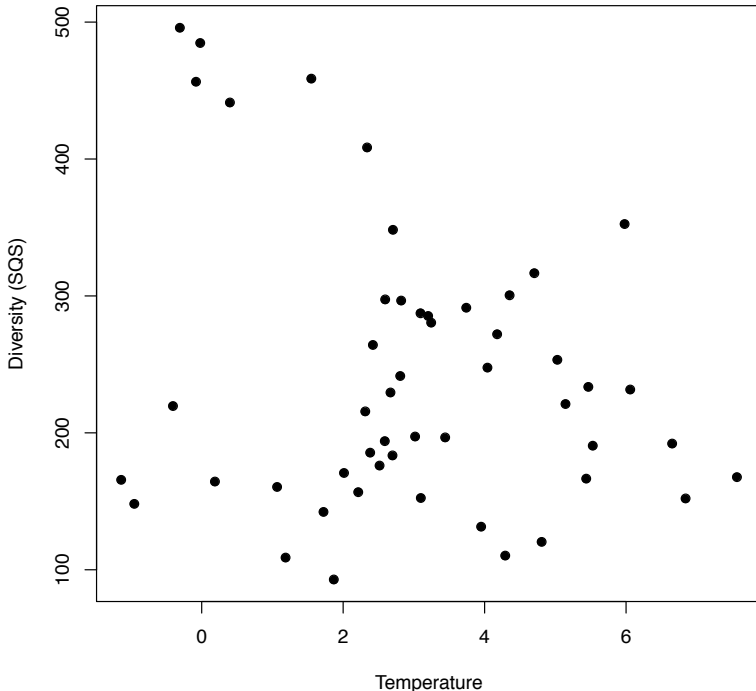


Figure 5. A simple plot showing an example of a weak correlation between temperature and diversity.



Now in order to calculate the  $r^2$  value we could simply type:

```
-0.2340037^2
```

... which would give us:

```
[1] -0.05475773
```

However, if we wanted to conduct multiple comparisons this would be very time-consuming; as such it would be useful to save the results of this analysis in a new variable, **results**, so any information you want can be easily extracted:

```
results <- cor.test(extrinsic["Temperature"], extrinsic["SQS"])
```

To see all the names for the objects that are now contained in **results** we can use the **ls** function:

```
ls(results)  
[1] "alternative" "conf.int" "data.name" "estimate" "method" "null.value"  
"p.value" "parameter" "statistic"
```

So if we wanted to see just the  $p$ -value or the correlation coefficient (contained within "estimate") we can type:

```
results$p.value  
[1] 0.09838648  
results$estimate  
[1] -0.2340037
```

Then to calculate the  $r^2$  value we can use the following:

```
results$estimate^2  
[1] -0.05475773
```

Finally, along with a Pearson's correlation (the default for **cor** and **cor.test**) you can also implement a Spearman's rank correlation or Kendall's tau correlation using the *method* argument and the options "spearman" and "kendall" respectively:

```
cor.test(extrinsic["Temperature"], extrinsic["SQS"], method="spearman")  
cor.test(extrinsic["Temperature"], extrinsic["SQS"], method="kendall")
```

### Missing values

I mentioned briefly about the presence of missing (NA) values in your data. When running **cor.test** for the correlations this does not make a difference as any pairs of data that contain missing values are removed prior to the analysis, as you can see if we add in a new value to **x** and a missing value to **y**.

```
x2 <- c(-3,-1,1,2,5)  
y2 <- c(-2,-1,2,3,NA)  
cor.test(x,y)$estimate  
[1] 0.9788389  
cor.test(x2,y2)$estimate  
[1] 0.9788389
```



However this is not the case when using `cor`, which will return a NA if either of the values contain missing elements; try comparing `cor(x,y)` with `cor(x2,y2)` and you will see that the latter will not return a value. In order to get around this the argument `use` is required, which with the options "complete.obs" or "na.or.complete" will only include the pairs of observations which both contain values:

```
cor(x2,y2,use="complete.obs")
```

Now if you go back and try `cor(extrinsic)` you will see there are many comparisons that do not return a value; however if you run `cor(extrinsic, use="complete.obs")` those entries will now contain a correlation coefficient.

**Table 1. The syntax and null hypotheses ( $H_0$ ) for several classical statistical tests for comparing one or two samples.**

Test	R command	Null hypothesis ( $H_0$ )
Shapiro-Wilk	<code>shapiro.test</code>	The sample is taken from a population with a normal distribution
Student's t-test	<code>t.test</code>	The samples are taken from populations with equal means
Fisher's F test	<code>var.test</code>	The samples are taken from populations with equal variances
Kolmogorov-Smirnov	<code>ks.test</code>	The samples are taken from populations with equal distributions
Mann-Whitney's U	<code>wilcox.test</code>	The samples are taken from populations with equal median values
Linear correlation	<code>cor.test</code>	There is no correlation between the two variables.

### Some final cautions regarding correlations

While implementing linear correlations in R is a simple matter there are a few cautions I feel I should point out. Firstly, the examples I've used here involving the `extrinsic` dataset are merely here to illustrate how to perform correlations, not necessarily as the most appropriate approach for this kind of data. This example typically falls into the category of time-series analyses which itself has a range of different techniques associated with the processing of the data (such as the removal of long-term trends by detrending) before undertaking any one of a number of different statistical tests. For the time being I will leave the basics of time-series analyses for a later article.

The second point to be made is that as in the last example the lack of a correlation doesn't mean that there is no relationship at all between your variables, just that there is no linear trend – but there may be a non-linear (e.g. quadratic) trend. The final point to make here concerns the old adage of "correlation does not imply causation", which emphasizes the point that if you find a significant correlation this does not suggest that changes in one variable have directly caused changes in the second. It is possible that both are independently controlled by a third variable or a combination of multiple variables. Also known as the third variable problem, this has implications in all branches of scientific inquiry. An example of this in current palaeontological research is the common-cause hypothesis (Peters and Foote, 2001) that suggests that while the observed diversity seen in the fossil record and the amount of sampling used to gather that information are positively correlated they may be both, independently, controlled by a third



factor such as long-term fluctuations in sea-level. Therefore, while a highly significant correlation may not imply causation it may provide areas for further investigation.

### Summary

This article is intended as an introduction to conducting statistical analyses in R and the interpretation of the results of these tests. In the next issue I will continue with statistical tests, focusing also on modelling through regressions.

### Mark A. Bell

*Department of Earth Sciences, University College London*

<mark.bell521@gmail.com>

### REFERENCES

MAYHEW, P. J., BELL, M. A., BENTON, T. G., and MCGOWAN, A. J., 2012, Biodiversity tracks temperature over time, *Proceedings of the National Academy of Sciences*, **109**(38), p.15141–15145.

PETERS, S. E. and FOOTE, M., 2001, Biodiversity in the Phanerozoic: a reinterpretation. *Paleobiology*, **27**, p.583–601.

### FURTHER READING

CRAWLEY, M. J., 2005, *Statistics: an introduction using R*, John Wiley and Sons, 342pp.

DYTHAM, C., 2010, *Choosing and using statistics: A biologist's guide*, Wiley-Blackwell, 320pp.

HAMMER, Ø. and HARPER, D. A. T., 2006, *Paleontological data analysis*, Blackwell Publishing, 368pp

You can find the support material for this column, such as the data files *extrinsic.txt* and *asaphidae.txt*, in the Newsletter section of the PalAss website, at <[www.palass.org](http://www.palass.org)>.



## >> **Future** Meetings of Other Bodies



### **Co-evolution of Life and the Planet 2014 Conference: Future perspectives in Earth System Science**

The Geological Society of London, Burlington House 4 – 6 November 2014

The Earth that sustains us today has arisen out of planetary scale co-evolution of the physical and biological worlds. The complexity of these interactions necessitates a multidisciplinary 'Earth System Science' approach. Two years on from 'Life and the Planet 2011', this two-day meeting will explore advances in our understanding of the coupled evolution of life and the planet.

The four main themes of this meeting are: 1) Precambrian origins of the modern Earth System; 2) Key events in the evolution of marine ecosystems; 3) Geological constraints on biological evolution in the polar regions; 4) Descent into the Icehouse during the Cenozoic Era.

Please check the conference website at <<http://www.lifeandplanet.net/2014-life-and-planet.html>> for updates.



### **Radiation and Extinction – Investigating Clade Dynamics in Deep Time**

Linnean Society of London, Burlington House, London 10 – 11 November 2014

*[Sponsored by the Linnean Society of London, the Palaeontological Association and University College London's Environment Institute]*

Determining the causes and drivers of evolutionary dynamics is central to our understanding of life on Earth. What factors shaped the modern biota? Why did some groups go extinct, whilst others survived and radiated? Why are some groups so much more diverse than others? What will happen to organisms as the Earth continues to warm up?

These issues cannot be addressed solely by studying the present day: only by examining evolution on longer, deep-time scales can we hope to understand what controls and drives these processes. Increasingly sophisticated quantitative methods are becoming ever more available to try and answer such questions, allowing us to explore rates and patterns of evolution, test evolutionary models, and examine the effects of intrinsic and extrinsic drivers on biodiversity, using entirely palaeontological, and mixed palaeontological, neontological, and genomic data sets.

This two-day meeting will bring together a diverse array of researchers developing and applying methods for reconstructing deep-time macroevolutionary patterns in biodiversity, with a particular focus on analytical approaches that take advantage of the wealth of data available in the fossil record. Dan Rabosky (University of Michigan) will deliver the plenary talk, with additional confirmed presentations from Tracey Aze (University of Oxford), Natalie Cooper (Trinity College Dublin), Mario dos Reis (University College London), John Finarelli (University College Dublin), Matt Friedman (University of Oxford), Melanie Hopkins (American Museum of Natural History), Graeme Lloyd (University of Oxford), Emily Rayfield (University of Bristol), Marcello Ruta (University of



Lincoln), Graham Slater (Smithsonian National Museum of Natural History), Jeroen Smaers (Stony Brook University), Tanja Stadler (ETH Zürich), Gavin Thomas (University of Sheffield), and Chris Venditti (University of Reading). Additional speakers will be added as confirmed. Speakers will detail both methodology and application for a range of taxonomic groups, time intervals, and macroevolutionary themes corresponding to radiation, extinction, and clade dynamics in deep time.

Further information can be obtained and bookings made via the meeting website at <<http://www.linnean.org/Meetings-and-Events/Events/>>.



**The Micropalaeontological Society Annual General Meeting 2014**

The Oxford University Museum of Natural History, UK 19 – 20 November 2014

The theme for this year's event is "Microfossil phylogenies and their applications". The effectively infinite abundance and continuous fossil record of many microfossils means they offer unique possibilities to reconstruct evolutionary patterns from direct observation of the geological record. This symposium will highlight recent achievements in the field and their applicability in both research and industry.

The conference, a drinks reception and then dinner, will be hosted in the splendid Oxford University Museum of Natural History. This is one of the finest Victorian buildings in England and was the site of the famous 1860 debate between Darwin and Bishop Wilberforce – a debate that might have been rather different if they had known about planktonic microfossils.

Please see the conference website for more information: <<http://www.tmsoc.org/agm2014.htm>>.



**12th International Symposium on Fossil Cnidaria and Porifera**

Muscat, Oman 8 – 12 February 2015

Planned symposium topics are based on: Biology and Paleontology, Cnidaria and Porifera through time, Cnidaria and Porifera through space, and Phanerozoic bioconstructions.

Please check the conference website for updates, at <<http://www.12sfcp2015.guttech.edu.om/>>.



**15th International Nannoplankton Association Meeting**

Bohol Island, Philippines 7 – 16 March 2015

Pre-conference field-trip: 7–8 March, Bohol Island.

Post-conference field-trip, 14–16 March, Palawan Island.

Further information is available by e-mailing the organisers, to <[ina15philippines@gmail.com](mailto:ina15philippines@gmail.com)>.



**“Planktic gastropods: biology, ecology and palaeontology” in association with the Malacological Society of London**

The Natural History Museum, London 1 April 2015

To register your interest in presenting a talk, please contact Deborah Wall-Palmer (e-mail <[deborah.wall-palmer@plymouth.ac.uk](mailto:deborah.wall-palmer@plymouth.ac.uk)>).



**7th International Brachiopod Congress: The Brachiopod World**

Nanjing, China 22 – 25 May 2015

The theme of the Congress will be “The Brachiopod World”. Scientists around the world who are interested in fossil and living brachiopods and related topics are invited to attend. The Congress venue will be the Nanjing International Conference Hotel in the vicinity of Nanjing City proper, at the foot of the beautiful Purple Mountain, where more than 200 heritage and scenic tourist sites are located together with more than 620 species of vascular plants.

The Congress will include keynote speeches, scientific sessions, posters, pre- and post-conference field excursions. Within the four-day indoor meeting, all of our distinguished colleagues will have opportunity to refresh, update, and exchange their knowledge on Brachiopoda and related areas. As always, the Congress will bring internationally known scientists together to share experiences and ideas on the latest developments of brachiopod study.

For further information, please see the conference website: <<http://www.7ibc.org/>>.



**Palaeozoic Echinoderm Conference**

Zaragoza, Spain 14 – 21 June 2015

This Conference will celebrate the career of Dr Andrew Smith, a world-renowned specialist in echinoderms who retired in late 2012.

The Conference will focus on Palaeozoic echinoderm communities; presentations will review the current state of knowledge for a range of groups, highlighting recent advances and identifying topics of uncertainty and possible future research paths. There will be short workshops on Spanish fossil material and new analytical techniques, and a field trip will take place close to Zaragoza (Iberian Chains) and in the north-western part of Spain, between the cities of León and Oviedo (Cantabrian Mountains).

For further details and to be added to the conference mailing list, please contact Samuel Zamora (e-mail <[s.zamora@igme.es](mailto:s.zamora@igme.es)>).





**Systematics Association Biennial Meeting**  
University of Oxford, UK 26 – 28 August 2015

This three-day meeting will take place in The University Museum of Natural History and the Department of Zoology, with accommodation available in historic Christ Church College. Sessions will include: Systematics & Ecology, Systematics & Evolution, Systematics & Taxonomy and Systematics & Fossils.

Please check the Systematics Association website at <[www.systass.org](http://www.systass.org)> for updates.



**Flugsaurier 2015, The International Meeting of Pterosaurology**  
University of Portsmouth, UK 26 – 28 August 2015

In 2015, Flugsaurier, the International Meeting of Pterosaurology, will be held in the United Kingdom for the very first time. Flugsaurier 2015 will be held at the University of Portsmouth in conjunction with the Symposium of Vertebrate Palaeontology and Comparative Anatomy which will be held afterwards in Southampton.

Anyone who would like to be included on the mailing list so that they receive the first circular should contact Dr Dave Martill (e-mail <[david.martill@port.ac.uk](mailto:david.martill@port.ac.uk)>).



**The Annual Symposium of Vertebrate Palaeontology and Comparative Anatomy**  
National Oceanography Centre, Southampton 31 August – 3 September 2015

The meeting will be preceded by Flugsaurier 2015 (to be held in Portsmouth). Pre-conference field-trips are planned, in conjunction with Flugsaurier, to visit the famous Jurassic coast in Dorset on 29–30 August. A post-conference field-trip on 4th September will follow the formal SVPCA sessions.

Please check the website for updates, at <[http://svpca.org/years/2015\\_southampton/index.php](http://svpca.org/years/2015_southampton/index.php)>.



**5th Polar Marine Diatom Workshop**  
Salamanca, Spain 2015

Further details will follow in due course, meanwhile please check the website for updates, at <<https://sites.google.com/site/polarmarinediatomworkshop/>>.



**7th International Conference on Fossil Insects, Arthropods and Amber**  
National Museum of Scotland, Edinburgh *26 April – 1 May 2016*

This is the first time that this Conference will be held in the UK. It will consist of three days of talks on fossil non-marine arthropods (especially insects) and the scientific study of amber, plus two optional one-day field-trips.

To be added to the mailing list for the 1st circular, please e-mail Dr Andrew Ross (<[a.ross@nms.ac.uk](mailto:a.ross@nms.ac.uk)>).



**14th International Palynological Congress and the 10th International Organization of Palaeobotanists Congress (IPC XIV/ IOPC X 2016)**  
Salvador, Brazil *late September – early October 2016*

Local organizers are planning the Congress to occur after the Olympics in Brazil. Further details to come.



**DIN011**  
EPOC Laboratory, Bordeaux University, Bordeaux, France *2017*

Further details to come.

---

*Please help us to help you! Send announcements of forthcoming meetings to*  
<[newsletter@palass.org](mailto:newsletter@palass.org)>.

---



# Meeting REPORTS



ASW150 Symposium

Natural History Museum, London 21 May 2014

The Arthur Smith Woodward 150th Anniversary Symposium was held on 21st May 2014 in the Flett Theatre at the Natural History Museum (NHM) in London. Almost 200 people registered an interest in the Symposium, with an audience of approximately 170 on the day. There were nine speakers covering both scientific and historical aspects of the life and work of this great British scientist.



*Dr John Maisey of the American Museum of Natural History giving his presentation on “Woodward’s Giant Coelacanth’s”*


Throughout the day the Flett Theatre Foyer hosted displays of information as well as books and items for sale by the sponsors (the Palaeontological Association was one) plus a display of memorabilia from the NHM archive and from Woodward family members.



*Display of personal memorabilia of Sir Arthur Smith Woodward from the Natural History Museum archives and the Woodward family.*


Also on display in the foyer were twelve excellent posters, again covering scientific as well as historical themes. One poster by Dr Angela Milner of the NHM discussed the famous Lady Smith Woodward tablecloth that is hung in the Palaeontology Building at the NHM. Many delegates took the opportunity to join a short tour to view the tablecloth and hear further details about it and the embroidered signatures on it from Angela and from Aileen Bevan, one of many Museum volunteers helping on the day.





## THE SMITH WOODWARD TABLECLOTH


Angela Milner, Department of Earth Sciences, The Natural History Museum



Smith Wood Woodward and the tablecloth... (text continues)


1879, Smith Woodward reported the 'bones of Dinobirds'... (text continues)

At the time (1900-1910) the tablecloth... (text continues)



Smith Woodward reported the 'bones of Dinobirds'... (text continues)

At the time (1900-1910) the tablecloth... (text continues)



*The Lady Smith Woodward Tablecloth poster by Dr Angela Milner.*

During the morning and lunch breaks delegates were able to visit the Palaeontology Building foyer to view a display of fossil fish type specimens described by Smith Woodward. He described nearly 300 type specimens of which about two thirds are in the NHM collections. Only approximately 10% of these could be displayed in the space available.



*Mesodon daviesi Woodward (NHMUK PV OR 41387) from the Purbeck limestone, Swanage, Dorset – just one of the Smith Woodward type specimens on display at the Symposium.*



Also on display in the Palaeontology Building foyer was a set of eighteen medals and commemorative plaques on loan from the British Museum (BM). This collection was donated to the BM by Margaret Hodgson, the daughter of Sir Arthur and Lady Smith Woodward, in 1963, the year Lady Smith Woodward died. Another medal on display was the Royal Medal of the Royal Society, awarded to Smith Woodward in 1917. This was kindly loaned by Mrs Ruth Niblett, the daughter of Margaret Hodgson and one of the ten Woodward family members attending the Symposium.



*The Royal Medal of the Royal Society awarded to Arthur Smith Woodward in 1917*

Many thanks to the Palaeontological Association for their generous sponsorship of this event and to the Curry Fund of the Geologists' Association who sponsored the printing and binding of an Abstracts Booklet (including programme and delegate list) that all attendees received a copy of. This booklet contained a one- or two-page summary of all the presentations and posters. The abstracts for the talks may be found on the NHM website (<<http://www.nhm.ac.uk/research-curation/earth-sciences/fossil-vertebrates/fossil-vertebrate-research/fishes/woodward150/programme/index.html>>) along with the programme and biographies of the speakers.

### Presentations

- Karolyn Shindler (NHM Library Associate): "A Splendid Position" – the life, achievements and contradictions of Sir Arthur Smith Woodward.
- Joe Keating (Bristol University/NHM): The Ontogeny of Vertebrate Phylogeny.
- Mike Smith (NHM, Volunteer): The NHM Fossil Fish Collection – Woodward's role in the development and use of this priceless resource.
- Chris Duffin (NHM, Scientific Associate): Confusion and Chimaeras – Woodward and the Problems of Palaeozoic Chondrichthyans.
- Charlie Underwood (Birkbeck College, U.L.): The Understanding of the Mesozoic and Cenozoic Chondrichthyan Fossil Record.
- Matt Friedman (University of Oxford): What Woodward Did Not See: bony fishes of the English Chalk and London Clay revealed by CT scanning.
- John Maisey (Curator, AMNH): Woodward's Giant Coelacanths.
- Peter Forey (NHM, Scientific Associate): Arthur Smith Woodward's Catalogue of Fossil Fishes and its theoretical underpinning.
- Paul Barrett & Angela Milner (NHM): Arthur Smith Woodward's contributions on fossil tetrapods. (CANCELLED)
- Chris Dean (University College London): Arthur Smith Woodward and human evolution.



## Posters

- Hermione Beckett and Matt Friedman (University of Oxford): Relationships and Divergence Times in Lizardfishes (Aulopiformes): new insights from computed tomography.
- Anthony Brook (West Sussex Geological Society): Sir Arthur Smith Woodward in Retirement in Sussex 1924-1944.
- Sandra D. Chapman (NHM): Sir Arthur and Lady Smith Woodward and the Franz Baron Nopcsa Connection.
- Donald Devesne (Muséum national d'Histoire naturelle, Paris, France) *et al.*: What (really) is *Whitehippus tamensis*, an Eocene teleost from the London Clay?
- Daniel J. Delbarre (University of Oxford) *et al.*: New insights into the anatomy and relationships of *Aipichthys nuchalis* from the Late Cretaceous (Cenomanian) English Chalk.
- Alison Longbottom (NHM) and Roger Close (University of Oxford): The iconic genus *Brychaetus* Woodward 1901. New insights using CT scanning investigation.
- Angela Milner (NHM): The Smith Woodward Tablecloth.
- Paul Siedlecki (Birkbeck College, Univ. of London): Inside the *Burnhamia daviesi* (Woodward).
- Mike Smith (NHM): Arthur Smith Woodward – Awards and Medals.
- Mike Smith (NHM): Arthur Smith Woodward's Fossil Fish Type Specimens.
- Lorna Steel (NHM) & Eric Buffetaut (CNRS, Ecole Normale Supérieure, Paris, France): Arthur Smith Woodward and the Jurassic Crocodile.
- Monique Welten (NHM) *et al.*: Teeth inside and outside the mouth: a micro-CT analysis of topographic relationships in sawfish and sawshark dentitions (Elasmobranchii; Chondrichthyes)



**9th International Symposium: Cephalopods – Past and Present**

**with 5th International Symposium: Coleoid Cephalopods through Time**

Paläontologisches Institut und Museum, Universität Zürich *September 2014*

## Summary

From 4th to 14th September 2014, the 9th ISCPP was held in combination with the 5th International Coleoid Symposium at the University of Zurich (lectures on 7th to 10th September), organised by Christian Klug, Heike Götzmann and colleagues. This series of cephalopod meetings was launched in the 1970s in York. Thereafter, they were held each third to fourth year in various cities including Tübingen, Granada, Vienna, Fayetteville, Sapporo, and Dijon. It is the only occasion on which cephalopod workers with both palaeontological and neontological approaches meet from the entire planet, and usually it is an equally friendly and stimulating meeting. There are normally three to four days of scientific presentations. The interesting and important aspect of this meeting is that both biologists and palaeontologists meet, although there traditionally have been more palaeontologists. In the 2014 meeting, the symposium Cephalopods – Present and Past hosted the International Coleoid Symposium for the first time.

Traditionally, two field-trips are offered around the meeting. This time, we organised a first three-day field-trip to Fossilagerstätten of southern Germany, a second one-day trip to the Jurassic of the canton Aargau (Switzerland) and a third four-day trip to Mesozoic fossil localities yielding cephalopod fossils in Switzerland and eastern France, each lasting a couple of days.



## Lectures

In total, 84 abstracts for oral presentations and 45 abstracts for posters were accepted. Among the oral presentations, 63 were part of the rather palaeontological sessions on cephalopods excluding coleoids, mostly fossil (7–9 September), and 21 dealt with coleoid cephalopods, mostly Recent (9–10 September). Two talks were cancelled. It is not reasonable to summarise all talks here, so I will briefly give an overview of the keynotes only.

**Björn Kröger** (Finnish Museum of Natural History, Helsinki) reported on the initial cephalopod diversification during the Cambrian. Both the initial radiation and the Ordovician radiation were intense and produced a stunning early diversity and disparity. Still on 7th September, **Sonny A. Walton** (Museum für Naturkunde Berlin) presented his results on the ontogeny of ammonoids. **Isabelle Kruta** (American Museum of Natural History, New York) talked about the new possibilities by the use of CT-scans for cephalopod-palaeontology. As an example, she presented arm-hook-like structures from ammonite body chambers. **Dieter Korn** (Museum für Naturkunde Berlin) entitled his presentation “The taxonomic geometry of the Palaeozoic ammonoids”. He found that most genera contained about five species and searched for possible explanations for this pattern. **Hugo Bucher** (University of Zürich) explained the major results of his and his workgroup’s research on the end-Permian extinction and the Early Triassic rediversifications. **Evgeny S. Sobolev** (Trofimuk Institute of Petroleum Geology and Geophysics SB RAS, Novosibirsk) is one of the leading experts on Triassic nautiloids and showed how they were distributed over the globe. Later, **Horacio Parent** (Universidad Nacional de Rosario) introduced a new interpretation of the function of ammonite aptychi. On the same afternoon, **Larisa A. Doguzhaeva** (Swedish Museum of Natural History, Stockholm) spoke about soft-tissue attachment of Cretaceous ammonites. **Neil H. Landman** (American Museum of Natural History, New York) ended the session on Cretaceous ammonites with a talk on their extinction, which actually might have occurred slightly after the Cretaceous/Palaeogene boundary. The last ammonite session began with **Benjamin J. Linzmeier’s** (University of Wisconsin-Madison) talk on the possible habitats as reflected in his fine measurements of stable isotopes in excellently preserved ammonite shells. **Peter. D. Ward** (University of Adelaide) was supposed to hold a keynote on Recent pearly Nautilus, but he could not come because of serious health issues. A short summary of his results was presented by Neil Landman for him.

**Dirk Fuchs** (Hokkaido University, Sapporo) opened the “5th International Symposium Coleoid Cephalopods through Time” with his presentation on the locomotion system of fossil squids and its meaning for both systematics and phylogeny. This day ended with the conference dinner in the Restaurant “Weisser Wind”. Before the dinner, the members of the scientific committee honoured **Neil Landman** (New York) and **Royal H. Mapes** (Ohio) for their lifetime achievements and important contributions to cephalopod research. Notably, both colleagues had their focus on ammonoids, but both also worked on coleoids including Recent species.

The next day was fully dedicated to squid research. **Yasuhiro Iba** (Hokkaido University, Sapporo) started the day with a talk on the earliest belemnites. He provided evidence that belemnites originated in the Triassic and pointed at the possibility of a Permian origin. **Inger Winkelmann** from the University of Copenhagen showed that she found evidence that the specimens of giant squids that have been found worldwide are genetically very similar and probably belong to one species. The final keynote was by **Henk-Jan Hoving** (GEOMAR Helmholtz Centre for Ocean Research Kiel). He presented new footage of various squid documenting highly specialized life cycles of deep-sea cephalopods.





### Field trips

During the pre-conference field trip, we visited important German Fossilagerstätten which are famous for exceptionally preserved cephalopod remains. On 4th September we went to the excellent museum at Holzmaden, followed by a visit to the nearby quarry in Ohmden. The same evening, we drove to Eichstätt in Bavaria, where we spent both nights. On 5th September we began with a visit to the Juramuseum in the Willibaldsburg, one of the three famous museums of the important Eichstätt-Solnhofen region. In addition to Archaeopteryx-originals, this museum is also home to some spectacular cephalopod fossils. We then visited the quarry in Mörsheim, where the Mörsheimer Schichten are exposed. In the afternoon, we first visited the Bürgermeister Müller Museum in Solnhofen, which offers exquisite fossils of the region, also including Archaeopteryx and squids with soft-body tissue remains as well as other cephalopods. Later in the afternoon, we went to the quarry where most Archaeopteryx-specimens were found. Ammonoids with aptychi *in situ* occur in great abundance. On our way back to Zürich on 6th September, we first were guided to the Werksmuseum of the Holcim cement-factory at Dotternhausen, followed by a visit to their Posidonia-Shale quarry. This quarry is well-known for its abundant ammonites and belemnites as well as sporadic coleoid finds. The last stop was at the Nusplingen quarry, a Kimmeridgian Fossilagerstätte of growing importance, which yielded exceptionally preserved ammonoids (with stomach contents), coleoids (with mandibles *etc.*), belemnites (with ink sac, arm hooks and mandibles) as well as nautilids (also with mandibles).

The second field-trip was guided by Heinz Furrer on 11th September. He brought the participants to Jurassic outcrops in the canton of Aargau. In addition to the visits to the Schümel quarry in Holderbank (Oxfordian) and the quarry in Frick (mainly Early Jurassic), they went to see the museum in Frick.

The third field-trip started immediately after the last lecture on 10th September. We first drove to the Alsace, where we spent two nights. The first outcrop is also a Holcim quarry in Héming, where the Muschelkalk (Middle Triassic) crops out. It is extremely rich in ceratitids and nautilids, which we collected on the 11th. On 12th September, we moved on to see the Hauterivian and Barremian in the Veveyse-valley near Lausanne and the Toarcian Podionia-Shale at the Teysachaux. We spent the night in Solothurn and visited the Argovian Jurassic the next day. First, we focused on the Callovian to Oxfordian deposits in the Jura-Cement-quarry at Auenstein. Then we drove to Anwil and visited the excavation that was jointly organised by colleagues from Bern, Basel and Basel Land. Finally, we examined the fine exhibit of Anwil-fossils at Oltingen. The following night we slept on the summit of Säntis, because we had planned to visit the Cretaceous exposures between pillar 2 and Tierwies on the last day (14th September). We started off from pillar 2 in bright sunshine, with ibexes accompanying us the entire morning, from the Schrattenkalk to the Seewer Kalk. Especially the Garschella and Seewer Kalk yielded many ammonites, nautilids and belemnites. At midday we went to Tierwies and examined the Altmann Member, which yielded a medium-sized Emericeras and Cymatoceras. Above all, the very international participants of the field-trips were quite impressed by most of the outcrops and the museums.

### Summary

With ca. 110 participants from 26 countries and all parts of palaeontology and neontology of cephalopods, this event can be considered a great success. We received almost exclusively positive feedback and we are convinced that the foundations for numerous new scientific relationships and collaborations have been created.



### Number of attendees:

*Country: Number of persons:*

USA: 16	Luxembourg: 3	Hungary: 1
Germany: 13	Spain: 3	Georgia: 1
Russia: 13	India: 2	Finland: 1
Japan: 12	Austria: 2	Falkland Islands: 1
Switzerland: 11	Italy: 2	Denmark: 1
France: 8	Australia: 2	Brasil: 1
United Kingdom: 5	Thailand: 1	Belgium: 1
Czech Republic: 4	Netherlands: 1	Argentina: 1
Sweden: 3	Ireland: 1	

### Output

A proceedings volume is planned to be printed in the *Swiss Journal of Palaeontology* in 2015.

### Publications

KLUG, C. and FUCHS, D. (eds., 2014): Abstracts and programme – 9th International Symposium Cephalopods – Present and Past in combination with the 5th International Symposium Coleoid Cephalopods through Time: 1–150. Paläontologisches Institut und Museum, Universität Zürich.

KLUG, C. and ETTER, W. (eds., 2014): Field guide to the excursions “Fossilagerstätten of the southern German Jurassic” and “Mesozoic ammonoid localities of Switzerland and eastern France”. – 9th International Symposium Cephalopods – Present and Past in combination with the 5th International Symposium Coleoid Cephalopods through Time: 1–50. Paläontologisches Institut und Museum, Universität Zürich.



*Delegates at the Joint 9th ISCPP/5th ISCCT meeting.*



*And a second view of the Joint 9th ISCPP/5th ISCCT meeting:*

This combined meeting, which also included pre-Conference and post-conference long field excursions, was ably co-ordinated by Christian Klug (Zürich) and Dirk Fuchs (Sapporo). There were 118 attendees from a wide range of locations, though it was noticeable that there were only five delegates from the UK. There was a fairly packed programme of talks and posters, spread over the four days at the museum in Zürich. With 2.6 days allocated to the 'cephalopods', the remaining 1.3 days were devoted to the coleoids. All aspects of palaeobiology, biology, stratigraphy, morphology and evolution were covered in fairly equal measure. Each major session was opened by a keynote lecture, many of which provided useful reviews for those who are not experts in the various fields represented by the meeting. The area that was least represented was biostratigraphy, which is rather surprising as both Palaeozoic and Mesozoic ammonoids/ammonites provide the backbone of much stratigraphic research.

Some readers may wonder at the presence of a micropalaeontologist at such a conference, although a quick scan of the abstract volume will show that statoliths – the stato-acoustic 'bones' present in the heads of many fossil and extant teuthids – are now well-known in microfossil residues.

The next coleoid meeting is planned for the USA in 2016 while the cephalopod symposium may take place in Morocco in 2018.

The meeting was a very friendly affair with the characteristic 'icebreaker' and mid-conference evening dinner in the old quarter of Zürich. There is to be a conference volume, probably in the *Swiss Journal of Palaeontology*, though the timescale for this is currently unclear.

**Malcolm Hart**

*Plymouth University*



## — OBITUARY —

# David James Carter DFC 1922 – 2013

David Carter DFC was one of the founding members of the Palaeontological Association. He assumed the role of 'wine monitor' during the meetings that led to the foundation of the Association, working closely with his Imperial College colleague, Gwyn Thomas.

David was gifted in two areas: art and geology. After distinguished service as a navigator in Bomber Command during World War II, for which he was awarded the Distinguished Flying Cross, he entered Imperial College to study geology. Though he never completed a PhD, he developed a reputation for his use of micropalaeontology in oil exploration in the Far east, India, Pakistan and Spain. It was this industrial experience that led to the invitation for him to join the Channel Tunnel Study Group and provide the biostratigraphical control on the tunnel alignment. An initial zonation was published in 1961 and in the mid-1960s David was engaged in the full site investigation. In 1970–1972 he, with MBH, undertook the micropalaeontological investigations at the site of the proposed Thames Barrier.

With work on the Channel Tunnel begun, and cancelled, in 1973 David joined Tony Barber, Mike Audley-Charles and others in a major research project attempting to understand both the stratigraphy and tectonic history of Indonesia. This work was acknowledged in 2010 when Haig & McCartain created a new genus of foraminifera which they named *Carteriella* in his honour.

As we all know, the Channel Tunnel and the Thames Barrier were eventually constructed and stand as a reminder of David's work in biostratigraphy. A fuller account of David's career and life in micropalaeontology (and art) is available in the *Newsletter* of The Micropalaeontological Society.

### **Malcolm Hart**

*Plymouth University*

With contributions from Mike Audley-Charles, Tony Barber, Haydon Bailey, Deryck Bayliss, Marjorie Curtis, Colin Harris, John Murray and Martin Norvick.



Photo: John Murray



# *Undergraduate Bursary* **REPORTS**

## *Variations in seasonality of productivity over the last 20 kyr in the bathyal NE Atlantic using foraminifera*

**Curtis Bracher, Christopher W. Smart, Malcolm B. Hart, Deborah Wall-Palmer**

*School of Geography, Earth and Environmental Sciences, Plymouth University, Drake Circus, Plymouth, Devon, PL4 8AA, UK*

A Palaeontological Association Undergraduate Research Bursary 2014 was awarded to Curtis Bracher (Stage 2 BSc Geology student from Plymouth University) to work on a micropalaeontology research project supervised by Christopher Smart, Malcolm Hart and Deborah Wall-Palmer. The aims of the project were: (1) to document and understand past variations in seasonality of productivity over the last 20 kyr using foraminifera at a bathyal NE Atlantic site (ODP Site 980); (2) to compare the records with published stable isotope data from the same site; and (3) to compare the records with other sites. The methods employed included sample preparation using standard micropalaeontological techniques; picking and identification of foraminifera from sediment samples (using light and scanning electron microscopy); and the analysis of the foraminiferal data using relevant statistical methods and comparisons of the data with other relevant published data (e.g. other faunal records, geochemistry).

The project involved the analysis of benthic foraminifera (shelled protists) (>63 µm) from Ocean Drilling Program (ODP) Hole 980B (55°29.094'N, 14°42.137'W, 2168 m water depth), NE Atlantic Ocean. This drill site was chosen because it has an excellent, complete, well-recovered, undisturbed, carbonate-rich and long late Quaternary sequence covering the time interval of interest. Furthermore, the site has an excellent, high-resolution age control based on AMS radiocarbon analyses and benthic foraminiferal stable oxygen and carbon isotopes (Oppo *et al.*, 2003). A key aspect of the study area is that today seasonal inputs of phytodetritus (phytoplankton detritus) to the ocean floor following the spring bloom in surface water primary productivity exert a strong influence on benthic foraminifera and other organisms (Gooday and Lamshead, 1989; Lamshead and Gooday, 1990; Gooday and Hughes, 2002). Benthic foraminifera respond rapidly to the presence of phytodetritus arriving on the sea floor by quickly colonising and feeding on the detritus, reproducing rapidly and building up large populations. In the area of ODP Hole 980B, the main 'phytodetritus species' are *Eponides pusillus*, *Nonionella iridea* and *Cassidulina obtusa* (e.g. Gooday and Hughes, 2002). It has been suggested (e.g. Smart *et al.*, 1994; Thomas *et al.*, 1995) that 'phytodetritus species', which have an excellent fossil record, can be used as proxies of variations in seasonality of productivity in the geological past.

*Eponides pusillus*, *N. iridea* and *C. obtusa* ('phytodetritus species') (Fig. 1) were found to be abundant in ODP Hole 980B during the last 20 kyr, and variations in their abundance are interpreted as resulting from changes in the seasonality of productivity. The main focus of the study developed



into an analysis of the benthic foraminifera from the Holocene interval (last 11.7 kyr). Our study shows that during this time, changes occurred in the accumulation rates, species composition and diversity of the benthic foraminiferal faunas. During the Holocene, the 'phytodetritus species' comprise a significant component of the assemblage (often >50%). A trend towards increased percentages of 'phytodetritus species' occurred from 10 kyr to the present day suggesting that the seasonality of productivity increased during this time. This trend towards increased seasonality of productivity is consistent with benthic foraminiferal records from other sites in the NE Atlantic (Thomas *et al.*, 1995; Smart, 2008).

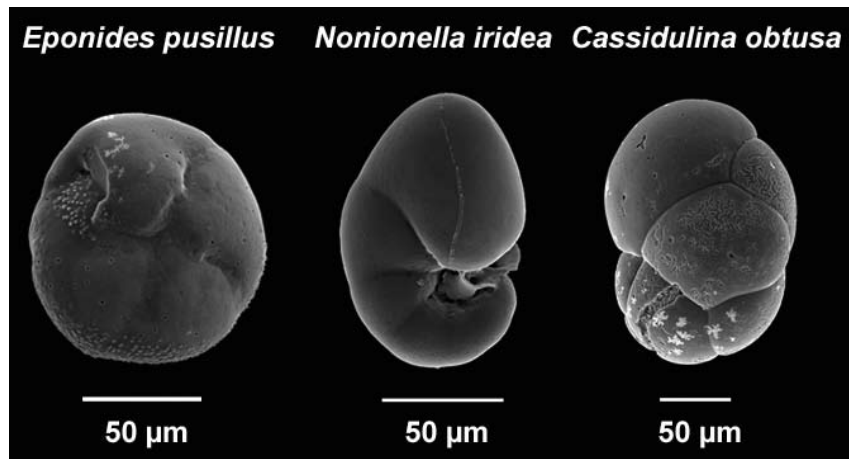


Fig. 1. SEM images of the 'phytodetritus species' from the Holocene of ODP Hole 980B.

#### REFERENCES

- GOODAY, A. J. and LAMBSHEAD, P. J. D., 1989. The influence of seasonally deposited phytodetritus on benthic foraminiferal populations in the bathyal northeast Atlantic: the species response. *Marine Ecology Progress Series*, **58**, 53–67.
- and HUGHES, J. A., 2002. Foraminifera associated with phytodetritus deposits at a bathyal site in the northern Rockall Trough (NE Atlantic): seasonal contrasts and a comparison of stained and dead assemblages. *Marine Micropaleontology*, **46**, 83–110.
- LAMBSHEAD, P. J. D. and GOODAY, A. J., 1990. The impact of seasonally deposited phytodetritus on epifaunal and shallow infaunal benthic foraminiferal populations in the bathyal northeast Atlantic: the assemblage response. *Deep-Sea Research I*, **37**, 1263–1283.
- OPPO, D. W., McMANUS, J. F. and CULLEN, J. L., 2003. Deepwater variability in the Holocene epoch. *Nature*, **422**, 277–278.
- SMART, C. W., 2008. Abyssal NE Atlantic benthic foraminifera during the last 15 kyr: Relation to variations in seasonality of productivity. *Marine Micropaleontology*, **69**, 193–211.
- SMART, C. W., KING, S. C., GOODAY, A. J., MURRAY, J. W. and THOMAS, E., 1994. A benthic foraminiferal proxy of pulsed organic matter paleofluxes. *Marine Micropaleontology*, **23**, 89–99.
- THOMAS, E., BOOTH, L., MASLIN, M. and SHACKLETON, N. J., 1995. Northeastern Atlantic benthic foraminifera during the last 45,000 years: changes in productivity seen from the bottom up. *Paleoceanography*, **10**, 545–562.



# Feeding ecology of the deep-bodied fish *Dapedium* from the Lower Lias of Dorset

Fiann Smithwick

University of Bristol

THE deep-bodied semionotiform fish *Dapedium* was named in 1822. Despite almost 200 years of collecting, the genus has been little studied in regards to its anatomy, and even less in terms of its ecology. A long-held assumption is that the robust, stout mandibles of *Dapedium* indicate a durophagous feeding habit. This assumption has however never been tested beyond simple anatomical observation. Along with detailed anatomical descriptions and illustrations (Fig. 1) of a number of previously undescribed specimens, including an exceptionally well-preserved individual held in the Philpot Museum at Lyme Regis, I undertook quantified analyses of the mechanical function of the lower jaw of 98 specimens of *Dapedium* to test the assumption of durophagy.

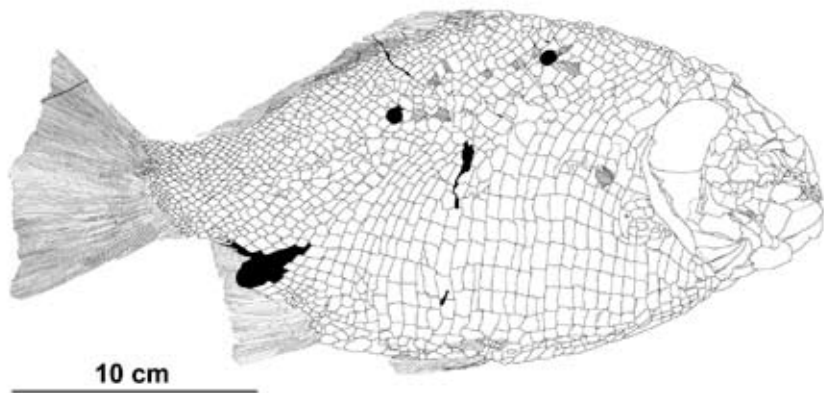


Fig. 1. A schematic illustration of a typical well preserved specimen of *Dapedium* created using Adobe Photoshop Elements 5.0 (Adobe).

Force transmission through the lower jaws was quantified using the MandibLever model of Westneat to ascertain the lower jaw closing and opening mechanical advantage (MA) and effective mechanical advantage (EMA) of a range of *Dapedium* species and size classes (Westneat 2003). This model incorporates muscles and skeletal elements to reconstruct the linkage system in fish jaw mechanics, and calculates among other metrics, MA as the ratio of the lower jaw inlever (both opening and closing) to the lower jaw outlever, and EMA from the same data along with the adductor muscle insertion angle and contractile properties. To allow the model to be used for the extinct fossil fish *Dapedium*, the musculature of the skull and jaws had to be reconstructed based on skeletal anatomy and comparisons to a range of extant fish taxa. The model was run with multiple replicates per specimen so that the likely most extreme possible points of muscle origin and insertion could be considered, to ascertain the full range of potential function of the muscles and lower jaws.

MA appears to show a generalised pattern between force and velocity trade-offs between species analysed in previous studies of living fishes (Westneat 2003; Kammerer *et al.* 2006). Higher closing



MA indicates that more force of the adductor muscles is transmitted to the jaw tip and teeth, while lower closing MA implies less force, but higher velocity in jaw closing. Durophages are therefore expected to show MA at the higher end of the spectrum. All of the specimens analysed via the MandibLever model showed high closing MA values, in line with the known MA of modern durophagous fishes. EMA was also found to be high, with an agreement of the MA results to within almost 99%.

Study of the skull anatomy of *Dapedium* also revealed a number of features relevant to its feeding ecology. The dentition was found to be far more extensive than previously described, with dense batteries of teeth lining much of the buccal cavity. These teeth show exceptionally high closing MA values, therefore likely providing *Dapedium* with the means to transmit shell crushing forces within the mouth once prey had been caught. Indirect evidence of predation was also discovered in the analysis. A specimen of *D. punctatum* was found to have within its open mouth, a small fish, likely a *Dorsetichthys*, which appears to represent the final meal of this individual (Fig. 2). Combined with other indirect evidence, such as potential scavenging in *Dapedium* from the Upper Lias of Germany, it was concluded that although the genus had the anatomy and jaw mechanics of a durophage, the more likely feeding ecology of the genus was a generalist diet, but with the ability to crush hard shells if required. *Dapedium* was rare in the latest Triassic, but radiated substantially in the Early Jurassic, and perhaps it owed its apparent success to the possession of durophagy, at a time when various Triassic durophages, such as the placodont reptiles, had disappeared (Kelley *et al.* 2012).



Fig. 2. Possible evidence of predation by a specimen of *Dapedium punctatum* on a smaller fish, which appears embedded on the larger fish's teeth.





## REFERENCES

- KAMMER, C. F., GRANDE, L. and WESTNEAT, M. W. 2006. Comparative and developmental functional morphology of the jaws of living and fossil gars (Actinopterygii: Lepisosteidae). *Journal of Morphology*, 267, 1017–1031.
- KELLEY, N. P., MOTANI, R., JIANG, D. Y., RIEPPEL, O. and SCHMITZ, L. 2012. Selective extinction of Triassic marine reptiles during long-term sea-level changes illuminated by seawater strontium isotopes. *Palaeogeography, Palaeoclimatology, Palaeoecology*. DOI: <<http://dx.doi.org/10.1016/j.palaeo.2012.07.026>>.
- WESTNEAT, M. W. 2003. A biomechanical model for analysis of muscle force, power output and lower jaw motion in fishes. *Journal of Theoretical Biology*, 223, 269–281.

# *On the Evolution and Function of Colour Patterns in Moray Eels*

**James Teoh**

*University of Bristol*

The Monte Bolca Lagerstätte hosts some of the most complete and exquisitely preserved fossil specimens of fishes found in the world. The conditions for preservation were so ideal that one can still clearly pick out pigmentation patterns in some of the specimens. *Paranguilla tigrina*, an extinct moray eel with several extremely well preserved specimens, was singled out for this study. This is due to the highly diverse modes of life found in extant moray eels (*Muraenidae* spp.) species. Before inferring how *Paranguilla* might have lived, we first posed the question: Is there a significant correlation between colour patterns and mode of life for moray eels?

To evaluate this question, pictures were collected of 166 species of moray eels alongside ecological data, mainly from <[fishbase.org](http://fishbase.org)> and consultation with experts in the field. The moray eels were then classified into eight pigmentation pattern categories and a data matrix was constructed to include ecological parameters alongside pattern classifications. Statistical analyses were then done on the data matrix to reveal interesting and statistically significant correlations between moray eel colour patterns and certain ecological parameters. These correlations allowed us to infer the mode of life of *Paranguilla*.

It was found that moray eels, which have a frontal half-body countershading, tend to be ambush predators. It was also discovered that species with well-defined spots tend to live in shallower depths, predate upon hard-bodied prey, and have a protogynous sexual system. *Paranguilla*, which is described to have well-defined spots and frontal half-body countershading, can thus be inferred to be a durophagous ambush predator that resides in shallow waters with a protogynous sexual system. The above inference agrees well with the palaeoenvironment inferred from the geology of Monte Bolca.

The study will be continued further using phylogenetic comparative methods to elucidate the evolutionary history of the pigmentation patterns and also to reconstruct ancestral states. In conclusion, the study can be deemed a great success and also bodes well for future studies of other exquisitely preserved fossil specimens using similar methods.



The research for this study was financially supported by the Palaeontological Association Undergraduate Research Bursary. I would like to thank my principal supervisor, Jakob Vinther of Bristol University, for his guidance throughout the study. In developing the ideas presented here, I have received helpful input from Joshua Reece of Valdosta State University, Innes Cuthill of Bristol University, and Matthew Friedman of Oxford University.



Figure 1. Photograph of an exceptionally preserved fossil specimen of *Paranguilla tigrina* showing preservation of pigmentation patterns in the Geological and Palaeontological Museum of Padova University. © Jakob Vinther.

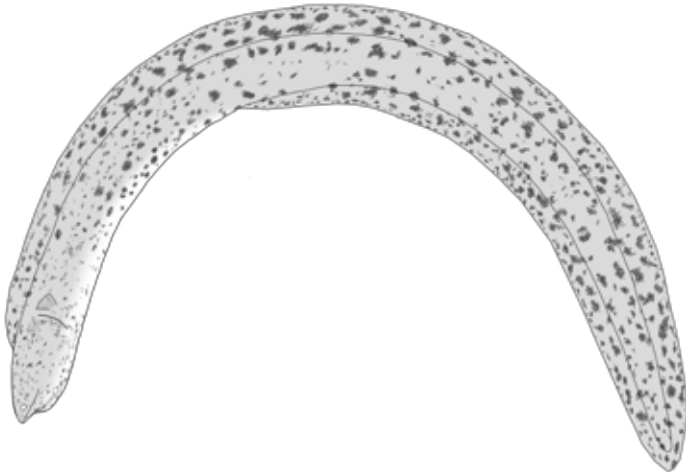


Figure 2. Interpretive drawing of *Paranguilla tigrina*'s live pigmentation patterns based on photograph of same specimen. © James Teoh.



# Sylvester-Bradley REPORT

## *The Taxonomy of British Jurassic Pterosaurs*

**Michael O'Sullivan**

*School of Earth and Environmental Sciences, University of Portsmouth*

Pterosaurs are volant ornithomorphs that first appeared in the fossil record in the Upper Triassic. Over the next 160 million years they evolved a variety of different morphologies and occupied numerous ecological niches. The first formal pterosaur description was published more than 200 years ago (Collini 1784) and they have retained a relatively prominent place in Mesozoic palaeontological research. Despite this, pterosaurs have been a relatively poorly understood group until recently. After a burst of taxonomic interest in the 1800s, most of the 20th century focused on the aerial capabilities of pterosaurs and whether or not they were capable of powered flight (Heptonstall 1971, Padian 1983). Ecologically pterosaurs received remarkably little focus, with the broad assumption that the majority were aerial piscivores (Wellnhofer 1990). All this has changed in the past two decades, with pterosaurology undergoing something of a renaissance. More than a third of pterosaur taxa have been erected since the turn of the century (Hone 2012), pterosaurs are now considered active flyers (Witton and Habib 2010) and they are now believed to have occupied a wide variety of ecological niches. One area which remains somewhat understudied however is pre-Upper Jurassic pterosaur diversity.

Pterosaur diversity has been viewed as low prior to the Upper Jurassic before undergoing a diversity explosion. However studies performed by Butler *et al.* (2009) suggest this is not the case. When the pterosaur record was tested against the number of fossil-producing sites in the Jurassic and Cretaceous it became clear that in the Jurassic, pterosaur diversity strongly correlated with the number of sites. In contrast, the Cretaceous pterosaur diversity record appears to be independent of the number of fossil sites. The artificial increase in diversity seen in the Upper Jurassic/Early Cretaceous is at least partially the result of a lagerstätte effect from sites such as the world-famous Solnhofen Limestone in Germany. This means we have a surprisingly poor understanding of the true diversity of Jurassic pterosaurs.

The UK provides a unique opportunity in that while it has very few Jurassic pterosaur sites, they have produced some excellent material. The UK has several Jurassic pterosaur taxa, including the Lower Jurassic *Dimorphodon* and *Parapsicephalus* from the Lias; three species of the Middle Jurassic pterosaur *Rhamphocephalus* from the "Stonesfield Slate"; and the Upper Jurassic *Cuspicephalus* from the Kimmeridge Clay. There are also several specimens historically identified as either *Pterodactylus* or *Rhamphorhynchus*. Not only is this an unusual amount of Jurassic pterosaurs for a country lacking Konservat-Lagerstätten, but the Lower Jurassic material includes several partial skeletons and the only three-dimensional Lower-Middle Jurassic pterosaur skull. Furthermore the "Stonesfield Slate" (actually several independent Bathonian units but most importantly the Taynton



Limestone Formation) has the largest number of Lower-Middle Jurassic pterosaur specimens in the world with more than 400 disassociated pterosaur specimens, including appendicular and cranial material. The Upper Jurassic material comes from the Oxford Clay and the Kimmeridge Clay formations. These formations have both produced several dozen pterosaur specimens, and in the case of the Kimmeridge Clay this includes associated appendicular material and cranial elements. Recently a new monofenestratan taxon, *Cuspicephalus scarfi*, was erected based on a near complete skull (Martill and Etches 2012). Despite this wealth of material, the Jurassic pterosaur record of the UK has not undergone a major revision in the light of current taxonomic advancements, despite some concern over the validity of *Rhamphocephalus* (Unwin 1996). My thesis is designed to provide a major re-evaluation of all British Jurassic pterosaur taxa and pterosaur-bearing formations. The goal is to test the validity of all established genera and to examine the entire collection for any diagnosable material which may have previously gone unrecognised, with particular focus on the “Stonesfield Slate” material. In total, this thesis will review material from more than 20 institutions worldwide and approximately 460 individual pterosaur specimens.

In 2013, I applied for and was granted the Sylvester-Bradley Award by the Palaeontological Association. I applied for it in order to fund several museum visits in order to expand my Jurassic pterosaur photographic database and record details of comparative pterosaur material. The comparative material was especially important as the Bathonian material in particular is relatively scrappy and it is important to build up a solid basis for identification. The funding was also used to replace some broken computer equipment that was required to construct a database of all viewed material. The award has allowed the project to take a major step towards completion, leading to several significant preliminary results.

Of the three established Lower and Middle Jurassic pterosaur taxa mentioned above, only *Dimorphodon* has not undergone review as part of this project, as it is easily the most well-established and least contested genus. On the other hand *Parapsicephalus* has previously been synonymised with the German taxon *Dorygnathus* as another species, *Dorygnathus purdoni*. The skull of *Parapsicephalus* was acquired on loan from the British Geological Survey and underwent thorough re-examination. Preliminary results suggest it is taxonomically distinct from *Dorygnathus* and should be retained as unique taxon. Furthermore material which may be assignable to *Parapsicephalus* has recently come to light which suggests that it may have been an unusually large Lower Jurassic pterosaur with a potential wingspan of around 2m.

*Rhamphocephalus prestwichi* has a relatively complex taxonomic history in the 19th century. The taxon was erected by Seeley (1880) for an isolated skull table, and he went on to synonymise all pterosaur material from the “Stonesfield Slate” into *Rhamphocephalus*, including two taxa identified as species of the German taxon *Rhamphorhynchus*, *Rhamphorhynchus bucklandi* and *Rhamphorhynchus depressirostris*. Lydekker (1888) recognised this synonymy while retaining the individual species, leaving us with three species of *Rhamphocephalus*. Several authors have questioned the pterosaurian nature of the *Rhamphocephalus* holotype (Unwin 1996, Buffetaut and Jeffery 2012). The holotype specimen has been extensively reviewed, and while the results have yet to be finalised, it does not appear to be pterosaurian. It is probable that *Rhamphocephalus* is an invalid pterosaur taxon and that all three species should now be considered invalid. This means there are currently no named pterosaurs from the British Middle Jurassic.



The Upper Jurassic Oxford Clay is dominated by indeterminate material identified as *Rhamphorhynchus* or *Pterodactylus*. Upon review, none of these taxa (*Pterodactylus manselli*, *Rhamphorhynchus jessoni* and others) can be considered valid, and the vast majority are merely indeterminate. The Kimmeridgian pterosaur collection includes several well-preserved specimens, several of which have been identified as various species of *Rhamphorhynchus* and *Pterodactylus* but, as with the Oxford Clay, all previously established species appear to be unsupported. *Cuspicephalus* remains uncontested.

As mentioned above, this project has also been reviewing collections in the hope of expanding upon the existing British diversity. In this regard it has been surprisingly successful. Two new diagnosable taxa have been identified, a family previously unknown in the UK has been found in the Lower Jurassic, several new morphotypes have been recognised in the Middle Jurassic, and Upper Jurassic pterodactyloid material has been described. In 2013, a Toarcian pterosaur humerus from Scunthorpe was donated to the Natural History Museum, London. This humerus has a distinctive deltopectoral crest and has been identified as the first example of a campylognathoidid pterosaur in the UK. While *Rhamphocephalus* can no longer be considered a valid pterosaur taxon, this does not mean the Middle Jurassic is taxonomically depauperate. At least five distinct pterosaur morphotypes have been identified which, while not generically or specifically diagnosable, are nevertheless distinct enough to be different animals. At least one of these morphotypes is based on a jaw which appears to belong to a surprisingly derived rhamphorhynchine pterosaur. Furthermore, a jaw previously assigned to the genus *Rhamphocephalus depressirostris* possesses several unique autapomorphies and has been recognised as a new genus of basal rhamphorhynchine pterosaur. A paper is currently being written describing this new taxon and will hopefully be submitted for publication by the end of the year. While most of the pterosaur species from the Upper Jurassic (excepting *Cuspicephalus*) are now considered invalid, a new species has been recognised. Based off of more recently discovered material from The Etches Collection in Dorset, this new specimen is not only diagnosable but represents the second species of one of the most famous pterosaur genera. A descriptive paper has been submitted for publication and is currently in review.

The preliminary results of this thesis suggest that far from being a period of low pterosaur diversity, the Lower and Middle Jurassic was a dynamic time for pterosaurs, with far more potential taxa than has previously been identified in a single country. This supports theories presented by Butler (2009) and I believe it highlights the need for a fresh perspective on pterosaur studies. While the Cretaceous remains the most informative era for pterosaurs, greater focus on the Jurassic will not only expand our understanding of pterosaur taxonomy and diversity, but may significantly expand our understanding of pterosaur evolution and ecology.

I would like to thank my supervisor David Martill; my co-workers Steven Vidovic and Mark Witton; and the curators of the numerous institutions I visited for their hospitality and accommodation. I would also like to thank The Palaeontographical Society and The Palaeontological Association for their generous funding of my studies.



## REFERENCES

- BUFFETAUT, E. and JEFFREY, P. 2012. A ctenochasmatoïd pterosaur from the Stonesfield Slate (Bathonian, Middle Jurassic) of Oxfordshire, England. *Geological Magazine*, **149**, 552–556.
- BUTLER, R. J., BARRETT, P. M., NOWBATH, S. and UPCHURCH, P. 2009. Estimating the effects of sampling biases on pterosaur diversity patterns: implications for hypotheses of bird/pterosaur competitive replacement. *Paleobiology*, **35**, 432–446.
- COLLINIO, C. A. 1784. Sur quelques Zoolithes du Cabinet d'Histoire naturelle de S. A. S. E. Palatine & de Bavière, à Mannheim. *Acta Theodoro-Palatinae Mannheim 5 Pars Physica*, 58–103.
- HEPTONSTALL, W. B. 1971. An analysis of the flight of the Cretaceous pterodactyl *Pteranodon ingens* (Marsh). *Scottish Journal of Geology*, **7**, 61–78.
- LYDEKKER, R. 1888. *Catalogue of the fossil Reptilia and Amphibia in the British Museum (Natural History), Part 1*. London, 2–42.
- MARTILL, D. M. and ETCHES, S. 2012. A new monofenestratan pterosaur from the Kimmeridge Clay Formation (Upper Jurassic, Kimmeridgian) of Dorset, England. *Acta Palaeontologica Polonica*, **58**, 285–294.
- PADIAN, K. 1983. A functional analysis of flying and walking in pterosaurs. *Paleobiology*, **9**, 218–239.
- SEELEY, H. G. 1880. On *Rhamphocephalus prestwichi*, Seeley, an ornithosaurian from the Stonesfield Slate of Kinton. *Quarterly Journal of the Geological Society of London*, **36**, 27–30.
- UNWIN, D. M. 1996. The Fossil Record of Middle Jurassic Pterosaurs. In: MORALES, M. (ed). The Continental Jurassic. *Museum of Northern Arizona Bulletin*, **60**, 291–304.
- WELLNHOFER, P. 1975. Die Rhamphorhynchoidea (Pterosauria) der Oberjura-Plattenkalke Süddeutschlands. Teil II. Systematische beschreibung. *Paläontographica A*, **148**, 132–186.
- WITTON, M. P. and HABIB, M. 2010. On the Size and Flight Diversity of Giant Pterosaurs, the Use of Birds as Pterosaur Analogues and Comments on Pterosaur Flightlessness. *PLoS ONE*, **5**, e13982. doi: <10.1371/journal.pone.0013982>.



# Yorkshire Fossil Festival

## Scarborough 12 – 14 September



After nearly a decade of highly successful annual fossil festivals in Lyme Regis, Dorset, it was high time such fossil-based family fun and frolics found their way up north. So the inaugural Yorkshire Festival, from 12th to 14th September, was eagerly anticipated. Will Watts did a brilliant job of coordinating the Festival, which was organised jointly by Scarborough Museums Trust, Hidden Horizons and the Palaeontological Association, and hosted by the iconic Rotunda Museum in Scarborough, designed by none other than William 'Strata' Smith, 'Father of English Geology'. The Festival attracted over 5,000 enthusiastic visitors, so hopefully the answer to the most frequently asked question of the weekend (*'is this going to be an annual event?'*) will be a yes.

Exhibitors at the Festival included York Museums Trust, The Natural History Museum, London, Oxford University Museum, The Geological Curators' Group, Yorkshire Geological Society, Rotunda Geology Group, Scarborough and Ryedale Astronomical Society, The Geological

Society, BGS, Emerald Ant, Hidden Horizons, Yorkshire Wildlife Trust Living Seas Centre, The Stephen Joseph Theatre and Scarborough Sea Life Sanctuary.

The PalAss stand featured a 'When am I?' activity, put together by Fiona Gill (Outreach Officer), Caroline Buttler (Education Officer) and Liam Herringshaw (Publicity Officer), working with artist James McKay (University of Leeds). James painted dioramas of four distinct ecosystems from different geological periods (Silurian reef, Carboniferous coal swamp, Jurassic sea and Ice Age tundra) and these were complemented by fossils from the collections of Leeds University and National Museum Wales. Visitors had to consult a chart depicting the Earth's changing environments, faunas and floras through time, and try to figure out which period they had 'time-travelled' back to. The sensory impact of James's stunning paintings was enhanced by sound effects, specially created for each period by University of Leeds postgraduate student Tom Fletcher (though the buzzing of giant Carboniferous insects tended to induce slight paranoia in those of us staffing the stand every time we wandered into the coal swamp). The other 'time lords' on the stand were Tim Palmer, Sally Thomas and Lucy McCobb, helping to whisk school children and members of the public back to a variety of palaeontological paradises or purgatories (depending on your views on giant reptiles and freezing temperatures).



Several primary school groups took part enthusiastically in the activity as part of schools' day on the Friday. The afternoon of schools' day was an opportunity for local sixth formers to explore the exhibits and discuss geological careers. There were plenty of degree options for them to consider, with the Universities of Leeds, Hull, Sheffield, Durham, Newcastle and Glasgow all represented at the Festival.

The Festival included two excellent and very topical talks. Professor Hugh Torrens gave a very interesting account of William Smith's life and links with Yorkshire, ahead of bicentenary celebrations of the publication of his iconic map next year. Dr Mike Romano provided a fascinating summary of dinosaur footprints from the Yorkshire coast, many of which could be seen on display in the Rotunda Museum. The Yorkshire Geological Society led a special coastal walk to visit some of the sites discussed in the talk. Dinosaur fans had the opportunity to meet Dean Lomax, author of "Dinosaurs of the British Isles" and purchase a signed copy of his book.

The Festival also offered an opportunity for members of the public to visit the Rotunda Museum for free, and to join special William Smith walks led by Rotunda Geology Group.

Fans of reptilian intestinal cinema will be saddened to hear that Horace the Pliosaur gave his last shows at the Festival, but we hear that he will be reincarnated soon and look forward to meeting him in his next guise.

**Lucy McCobb**

*National Museum of Wales*



*You can see some more photos at*

< <https://www.flickr.com/photos/liamherringshaw/sets/72157647637532412/>>.

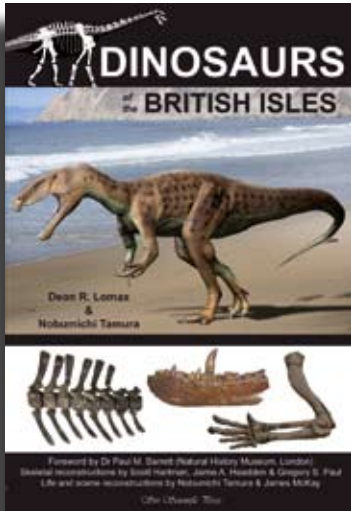




# Book Reviews

## Dinosaurs of the British Isles

Dean R. Lomax and Nobumichi Tamura. 2014. Siri Scientific Press. 414 pp. £33.00 (paperback). ISBN: 978-0-9574530-0-5. Available direct from the publisher at <[www.siriscientificpress.co.uk](http://www.siriscientificpress.co.uk)>.



Dinosaurs are a 'British invention,' proclaim Dean Lomax and Nobumichi Tamura in the first line of their new guide to dinosaur fossils from across Great Britain. It's a playful phrase, and perhaps a little boastful, but it has a ring of truth. England was the epicentre of early dinosaur research, where naturalists in the early 1800s first realized that reptilian behemoths ruled the land tens of millions of years ago. Nearly 200 years later, dinosaurs are now known from every continent, and new discoveries from China and the Americas seem to go viral in the press every couple of weeks. British dinosaurs have been overshadowed, despite their pivotal role in the history of palaeontology and the surprising fact that over 100 dinosaur species have been named from the British Isles, spanning the formative years of dinosaur evolution in the Triassic until nearly the final chapters of dinosaur history in the Cretaceous.

It seems like the oft-ignored British dinosaurs are in need of a marketing boost. Stepping in to provide the PR are Lomax and Tamura, whose *Dinosaurs of the British Isles* is a gloriously illustrated and comprehensive chronicle of dinosaur bones, teeth, and footprints from England, Scotland, Wales and Northern Ireland. Lomax is a 20-something self-educated palaeontologist from Yorkshire with boundless enthusiasm for all things prehistoric. Tamura is a talented palaeoartist from California. They have come together to produce a book that is encyclopaedic in its treatment of British dinosaurs, but also readable for a lay audience.

*Dinosaurs of the British Isles* is easily the single best reference on British dinosaurs that has ever been produced. Beginning with the Triassic and continuing in chronological order until the Late Cretaceous, all British dinosaur species and major faunas are profiled. Basic information on the locality, size, classification, and important specimens is given for each species. What really sets the book apart are the illustrations. These include over 400 figures, among them hundreds of photos of the most important British dinosaur fossils, reconstructions of what many of these creatures would have looked like in life, geological maps showing where to find dinosaurs in Great Britain today, palaeogeographic maps depicting the position of Britain throughout the Age of Dinosaurs, and photos of field sites.



As somebody who studies British dinosaurs, I am certain that this book will be one of the rare volumes that I actually take down from my bookshelf to use. It is a one-stop resource for whatever you want to know about those dinosaurs that once called Britain home – where the most important field sites are, where the types and other major specimens for each species are located, which bones are known for which dinosaurs, what ages certain faunas are, where British taxa currently fit into the family tree, and the evolutionary story of Dinosauria. The only major shortcoming is that it is not extensively referenced. Relevant papers are not cited in the text and the ‘further reading’ section at the back of the book is far from exhaustive. It may be difficult, therefore, for readers without specialist knowledge of British dinosaurs to use this book as a stepping-stone to the scientific literature.

What immediately comes across while reading this book is that the authors have a rousing passion for Britain’s dinosaurs. The type of passion that drives one to get up before dawn and scrounge for fossils on a windy coast, week after week; the sort of zeal that motivates somebody to become an expert on palaeontology without formal training; the type of mad love that leads somebody to write an encyclopaedia on all of the dinosaurs from the country where dinosaur research began. This book was clearly an enormous amount of work, but many palaeontologists, curators, collectors, and enthusiasts assisted the authors by providing photos and information. The authors gratefully salute this assistance, and the acknowledgements section and list of photography credits reads like a phone book of Britain’s foremost dinosaur workers. That two passionate authors and an equally enthusiastic research community could come together on a book like this is a great achievement. With this kind of gusto so obviously characterizing the current state of British dinosaur research, I have no doubt that the next 200 years will be as productive as the last.

**Steve Brusatte**

*School of GeoSciences, University of Edinburgh*

<Stephen.Brusatte@ed.ac.uk>

### **Rough and Tumble: Aggression, Hunting, and Human Evolution**

Travis Rayne Pickering. 2013. University of California Press, Berkeley and London, xiii + 208 pp, with 12 figures. £19.95 (hardback). ISBN: 978-0520274006, also available as an e-book.

In this lively and accessible book, Travis Rayne Pickering attempts to unpick the ‘Rough and Tumble’ roles of aggression, violence and hunting in human evolution. Synthesising a wide range of data from archaeology, palaeoanthropology, human and primate ecology and behaviour, genetics and psychology, interwoven with historical vignettes from the science of human evolution, particularly the works of Raymond Dart, Robert Broom, and Jane Goodall, Pickering argues that hunting underlies what it means to be human. However, he also strongly argues that hunting, which has been linked to human violence and aggression at least since the time of Dart (1953; the ‘killer ape’ hypothesis), should be decoupled. Pickering moreover proposes that the emotional detachment of using tools to distance the hunter from his prey was central to that decoupling.

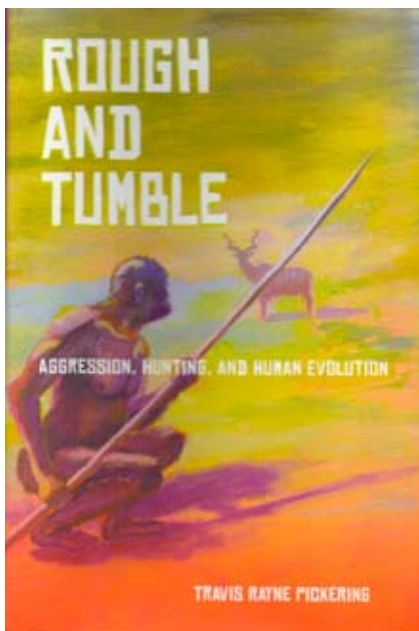
Using data from primate research, Pickering asserts that hunting in great apes, and especially in chimpanzees, our closest living relatives, is fundamentally different from that seen in modern humans. Chimp hunting, excluding the savannah chimpanzees of Fongoli procuring bush babies



using pointed sticks, can be seen as emotionally-driven violence to target prey smaller than the attacking group. The targets can be bush meat (pigs and monkeys) or an isolated male from another tribe. However, for proto-humans this hunting approach would have been hopelessly inadequate, especially given the human propensity for 'big game' hunting: selecting animals with a larger body size than ourselves. Rushing into the kill in a highly emotional state would simply not be effective: humans hunt more cerebrally. Only with careful planning, organisation and group cooperation could early humans have been capable of downing large prey, and thereby competing with carnivorous species such as lions.

Pickering argues that meat-eating is essential for a big-brained, short-gutted ape like modern humans. He links meat-eating to brain development: the brain is the greatest consumer of fuel in the body, consisting of just 2% of human body mass, but requiring around 20% of the body's daily energy and oxygen intake. This large brain, coupled with the small gut in humans (when compared to the gut seen in typical great apes), could not supply the required human energy needs with an ape-like diet. This means early humans were required to eat high energy foods: and this means meat. The evidence for early human hunting, rather than solely scavenging or processing left-over carcasses (difficult to determine from the archaeological record, but highly unlikely based on observation of modern ecosystems), is compelling: for instance cut marks on fossil bones indicate removal of the most energy-rich parts of the carcass, parts usually consumed first by a predatory organism.

Of course meat-eating requires hunting, but humans are placid hunters when compared to our chimpanzee cousins, relying on calm restraint and emotional detachment at the time of the kill. Such hunting, out-thinking rather than out-muscling prey, required intellect, and hence a much larger brain, better muscular control, and group hunting, for a physically weak (human) animal relative to its prey and potential predators. Hunting large prey also permitted development of food sharing, and potentially led to sexual division of labour in early human communities (although there is little archaeological evidence, and even in modern societies this division is not clear cut). Hence, Pickering argues, the advent of ambush hunting of large prey, some two million years ago, both expanded the diet of humans into higher energy foods ('with meat, a little gets you a lot': p.16) and led to changes in social dynamics amongst early humans, including food sharing. As evidence for these social changes he cites the lack of sharpening of the upper canine against the lower premolar (the  $C/P_3$  complex) seen in the human lineage since at least *Ardipithecus ramidus* (Suwa *et al.* 2009). This one feature indicates a very different social system in humans when compared to the great apes, with reduced intragroup aggression, including during mate selection.





Pickering constructs a plausible hypothesis for the role of human hunting and the decoupling of hunting from aggression and violence in our early ancestors. However the author occasionally falls into the common pitfalls of human evolutionary studies: concentrating on the predominantly male pursuit of obtaining meat as the main driver of human evolution, and assuming our ancestors were culturally poor and brutish (e.g. 'our pea-brained and culturally impoverished ancestors' p.85). Early modern humans were undoubtedly omnivorous hunter-gatherers, although "gatherer-hunters" would probably more correctly reflect the time spent, and energy gained, from the two activities. Although meat-eating may well have been an important driver of human evolution, many of the same arguments could also be applied to the gathering side of the equation (social cooperation, food-sharing, etc.). Relegating adult females (and the largely unmentioned babies and juveniles; excluding the raptor prey Taung child) to the 'tedium of plant foraging' (p.54, a pursuit also requiring considerable knowledge and brain power) or the 'meat-for-sex' role (p.54, after all females also want to reproduce to produce viable offspring that contain their genes) – seems unjustified. For the evolutionary success of the human lineage, the survival and wellbeing of females and young is essential. This book thereby underplays the important role of gathering in ancient hunter-gatherer societies, as well as the potentially central role of food processing (Organ *et al.* 2011; Wollstonecroft 2011), which provided access to otherwise unavailable sources of nutrition (both plant and animal) for early human societies. A more nuanced view of hunting, as an essential part of human evolutionary development, is therefore still required.

This wonderful little tome packs a considerable punch in terms of scholarship and research, and represents a good investment both in value for money and time spent reading. Pickering's writing has an undoubted passion for human evolution, and as Professor in the Department of Anthropology at the University of Wisconsin and Director of the Swartkrans Paleoanthropological Research Project in South Africa, he imbues this book with considerable academic integrity. The book is short, with just 130 pages making up the Introduction, five chapters and coda of the main text. However, this is supported by extensive notes and references, which greatly expand on the text. *Rough and Tumble* is written in a clear, stimulating and persuasive style, and bridges the popular and academic science markets. Such a short, readable book could in no way provide comprehensive coverage of human evolution, or even the evolutionary role of aggression, violence and human hunting (what book could?). However, it is a well-organized and useful summary of these topics, with its own unique contribution. In this way *Rough and Tumble* is comparable to *The Selfish Gene*, *The Blind Watchmaker* (Dawkins 1976, 1986) or *Por Qué Somos Como Somos* (Punset 2008), in making its subject eminently accessible whilst adding to the science of human evolution. Pickering has thereby produced a book that should be read by anyone who has an interest in human evolution, but which will be extremely useful to the undergraduate student, or the academic outside the field of human evolutionary studies writing a course including elements of the topic.

**Leslie Noë**

*Department of Geosciences*

*Universidad de Los Andes, Bogotá, Colombia*

*Catalina Zorro-Lujá*

*Department of Anthropology*

*Universidad de Los Andes, Bogotá, Colombia*

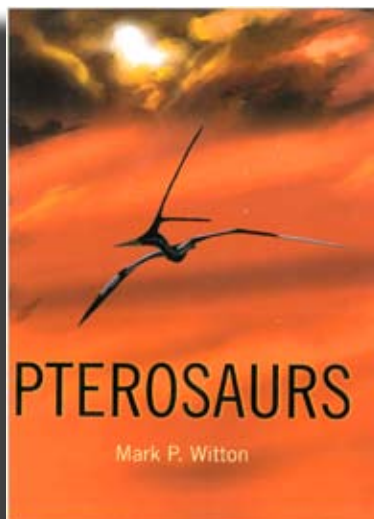


## REFERENCES

- DART, R. A. 1953. The predatory transition from ape to man. *International Anthropological and Linguistic Review*, 1 (4), 201–217.
- DAWKINS, R. 1976. *The Selfish Gene*. Oxford University Press, New York.
- DAWKINS, R. 1986. *The Blind Watchmaker*. Norton & Co, New York.
- ORGAN, C., NUMM, C. L., MACHANDA, Z. and WRANGHAM, W. 2011. Phylogenetic shifts in feeding time during the evolution of *Homo*. *Proceedings of the National Academy of Sciences*, 108 (35), 14555–14559.
- PUNSET, E. 2008. *Por qué somos como somos*. Aguilar, Madrid.
- SUWA, G., KONO, R. T., SIMPSON, S. W., ASFAW, B., LOVEJOY, C. O. and WHITE, T. D. 2009. Paleobiological implications of the *Ardipithecus ramidus* dentition. *Science*, 326 (5949), 94–99.
- WOLLSTONECROFT, M. M. 2011. Investigating the role of food processing in human evolution: a niche construction approach. *Archaeological and Anthropological Sciences*, 3, 141–150.

## Pterosaurs: Natural History, Evolution, Anatomy

Mark P. Witton. 2013. Princeton University Press. 304 pp. £24.95.  
ISBN: 978-0-6911-50611.



*Pterosaurs: Natural History, Evolution, Anatomy* is an excellent, and much-needed book on extinct flying reptiles. It is written and illustrated by Dr Mark Witton, a pterosaur palaeontologist who happens also to be a palaeoartist. As the last major pterosaurian book was written nearly ten years ago, and much has changed in our understanding of the pterosaur world since then, this book is well timed to fill a large gap.

*Pterosaurs* starts out with two chapters overviewing what we used to think about pterosaurs, how that has changed, and a history of pterosaur research. Right away, the reader is introduced to two themes that continue throughout the book: first, Witton's unique writing style that is friendly, accessible, and a bit colourful at times, but still scientific and descriptive where necessary; and second, of course, his artwork.

The first piece of art (other than the cover) is a great piece of two flying *Rhamphorhynchus* with the sun behind them. While the style of writing can be a little hard to get used to at first, I found it fun and much less dry than other scientific books, making it easier to read. I often found myself chuckling as I read statements comparing anurognathids to the Cookie Monster.

Chapters 3–8 start getting more scientific, with discussions of general pterosaur biology and anatomy, the evolution of pterosaurs, and locomotion, both in the air and on the ground. Witton reviews all of the literature, including some of the more far-fetched ideas, relatively equally, and



throws in some personal thoughts. I particularly enjoyed the chapter on pterosaur flight where he does a good job of reviewing the current thoughts on pterosaur flight abilities, including mass estimates, aerodynamics, and more. While I found most of the art to be appealing, it was also informative, such as figures 5.8 and 5.9 which show detailed muscular reconstructions, or fig. 7.6 which shows how the wing membrane may have folded during quadrupedal terrestrial locomotion, something I've never seen done so clearly before.

The bulk of the book (Chapters 10–25) comprises a systematic description and summary of each major pterosaur clade from the very first pterosaurs of the Late Triassic all the way to the latest Cretaceous azhdarchids. Each group is described in detail with an introduction into the history of the group (including evolution, material, palaeogeography), anatomy (both osteology and soft tissue if known), locomotion (aerial and terrestrial), and palaeoecology. These descriptions are accompanied by maps indicating where the fossils have been found, and photographs of fossils, drawings of specimens, and colourful reconstructions.

The book ends with a chapter on the extinction of pterosaurs, summarising what we know (or in this case perhaps more accurately – what we don't know) about what happened to pterosaurs in the end. While we know they went extinct, we don't know why the giant azhdarchids were the last to survive, and what happened to the rest (although more recent papers claim to have solved this).

While I enjoyed this book immensely, there were a few things I would have liked to see. As a pterosaur palaeontologist (or pterosaurologist as Witton says), I would have been happy with some specimen numbers, lists of taxa (synonyms if known, holotypes, localities, *etc.*), and more detailed photographs or drawings to help see some of the features discussed, or to look up more details about the specimens. I found myself often thinking I would like to know exactly which specimen was being discussed, or what feature was mentioned. I think the addition of this would have made it a more valuable scientific resource, but I recognise that this book was not aimed at pterosaurologists specifically, and therefore would have taken an immense amount of time for something that would not appeal to most of the target audience.

On the other hand, I think my favourite part of the book is the artwork combined with the science. As the author is a palaeontologist, you know that the palaeoart is at least based on actual scientific evidence (where available). I love the colours that are used, the interesting landscapes, and the living restorations. It helps to truly imagine what these animals may have looked like and how they would have behaved. The fact that it was both written and illustrated by Witton is a remarkable feat.

I would recommend this book to anyone interested in pterosaurs – palaeontologists, amateurs, students interested in learning more, and even pterosaur specialists who are looking for a resource that puts all of the history of pterosaur research together. Furthermore, at £25 on Amazon, it is eminently affordable for students, researchers, and amateurs alike. I think this will be a valuable resource for years to come.

**Elizabeth Martin-Silverstone**

*University of Southampton*



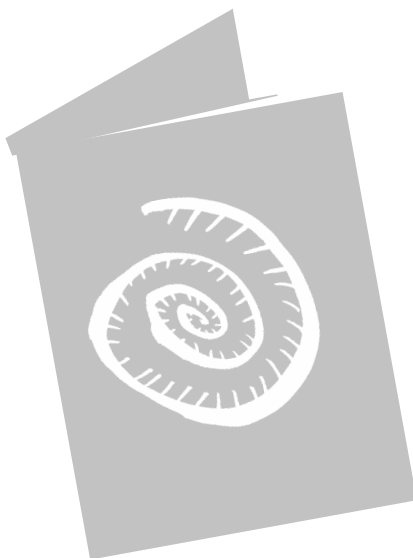
# Books available to review

The following books are available to review. Please contact the Book Review Editor, Charlotte Jeffery Abt (e-mail <[bookreview@palass.org](mailto:bookreview@palass.org)>), if you are interested in reviewing any of these.

- *Lower Jurassic foraminifera from the Llanbedr (Mochras Farm) Borehole, North Wales, UK*, by P. Copestake and B. Johnson.
- *Trilobites of the World: An Atlas of 1000 Photographs*, by P. Lawrance and S. Stammers.
- *Late Ordovician Ostracods of the Girvan District, southwest Scotland*, by M. Mohibullah, M. Williams and J. A. Zalasiewicz.
- *Anatomy, Phylogeny and Palaeobiology of Early Archosaurs and their Kin*, by S. J. Nesbitt, J. B. Desojo and R. B. Irmis (eds).
- *Fossil Insects: An Introduction to Palaeoentomology*, by D. Penney and J. E. Jepson, with artwork by R. Bizley.
- *Issues in Palaeobiology: a Global View Interviews and Essays*, edited by M. R. Sanchez-Villagra and N. MacLeod.
- *Mammoths and the Environment*, by V. V. Ukraintseva.

## **Dr Charlotte Jeffery Abt**

Book Review Editor,  
Department of Earth & Ocean Sciences,  
School of Environmental Sciences,  
University of Liverpool,  
4 Brownlow Street,  
Liverpool L69 3GP,  
UK





## Palaeontology

VOLUME 57 • PART 5

## CONTENTS

**Frontiers in Palaeontology**

- Early vertebrate evolution 879  
PHILIP C. J. DONOGHUE *and* JOSEPH N. KEATING  
<<http://dx.doi.org/10.1111/pala.12125>>

**Original Articles**

- New rodents (Cricetidae) from the Neogene of Curaçao and Bonaire, Dutch Antilles 895  
JELLE S. ZIJLSTRA, DONALD A. MCFARLANE, LARS W. VAN DEN HOEK OSTENDE *and*  
JOYCE LUNDBERG  
<<http://dx.doi.org/10.1111/pala.12091>>

- A eucrustacean from the Cambrian 'Orsten' of Sweden with epipods and a maxillary  
excretory opening 909  
DIETER WALOSZEK, ANDREAS MAAS, JØRGEN OLESEN, CAROLIN HAUG *and* JOACHIM T. HAUG  
<<http://dx.doi.org/10.1111/pala.12094>>

- A well-preserved isopod from the Middle Jurassic of southern Germany and implications 931  
for the isopod fossil record  
WALTER ETTER  
<<http://dx.doi.org/10.1111/pala.12095>>

- The evolution of canaliculate rudists in the light of a new canaliculate polyconitid rudist 951  
from the Albian of the Central Pacific  
SHIN-ICHI SANO, YASUHIRO IBA, PETER W. SKELTON, JEAN-PIERRE MASSE, YOLANDA M. AGUILAR  
*and* TOMOKI KASE  
<<http://dx.doi.org/10.1111/pala.12096>>

- New carnivoraforms from the early Eocene of Europe and their bearing on the 963  
evolution of the Carnivoraformes  
FLORÉAL SOLÉ  
<<http://dx.doi.org/10.1111/pala.12097>>

- The tommotiid *Kelanella* and associated fauna from the early Cambrian of southern 979  
Montagne Noire (France): implications for camenellan phylogeny  
LÉA DEVAERE, SÉBASTIEN CLAUSEN, ERIC MONCERET, DANIEL VIZCAÍÑO, DANIEL VACHARD *and*  
MARIE C. GENGE  
<<http://dx.doi.org/10.1111/pala.12098>>

- The early Ludfordian *leintwardinensis* graptolite Event and the Gorstian–Ludfordian 1003  
boundary in Bohemia (Silurian, Czech Republic)  
PETR ŠTORCH, ŠTĚPÁN MANDA *and* DAVID K. LOYDELL  
<<http://dx.doi.org/10.1111/pala.12099>>





- Skull morphology and phylogenetic relationships of a new Middle Triassic plagiosaurid temnospondyl from Germany, and the evolution of plagiosaurid eyes 1045  
RAINER R. SCHOCH, ANDREW R. MILNER *and* FLORIAN WITZMANN  
<<http://dx.doi.org/10.1111/pala.12101>>
- Finite element, occlusal, microwear and microstructural analyses indicate that conodonts microstructure is adapted to dental function 1059  
CARLOS MARTÍNEZ-PÉREZ, EMILY J. RAYFIELD, MARK A. PURNELL *and* PHILIP C. J. DONOGHUE  
<<http://dx.doi.org/10.1111/pala.12102>>
- The biological affinity of *Amsassia*: new evidence from the Ordovician of North China 1067  
NING SUN, ROBERT J. ELIAS *and* DONG-JIN LEE  
<<http://dx.doi.org/10.1111/pala.12106>>



## Palaeontology

VOLUME 57 • PART 6

## CONTENTS

**Frontiers in Palaeontology**

- The origin of annelids 1091  
LUKE PARRY, ALASTAIR TANNER and JAKOB VINTHER  
<<http://dx.doi.org/10.1111/pala.12129>>
- Deciphering the early evolution of echinoderms with Cambrian fossils 1105  
SAMUEL ZAMORA and IMRAN A. RAHMAN  
<<http://dx.doi.org/10.1111/pala.12138>>
- 
- Basal dinosauriform and theropod dinosaurs from the mid–late Norian (Late Triassic) of Poland: implications for Triassic dinosaur evolution and distribution 1121  
GRZEGORZ NIEDŹWIEDZKI, STEPHEN L. BRUSATTE, TOMASZ SULEJ and RICHARD J. BUTLER  
<<http://dx.doi.org/10.1111/pala.12107>>
- Early Cretaceous non-marine Ostracoda from the North Falkland Basin, South Atlantic 1143  
MICHAEL A. AYRESS and ROBIN C. WHATLEY  
<<http://dx.doi.org/10.1111/pala.12109>>
- The monophyly of Euparkeriidae (Reptilia: Archosauriformes) and the origins of Archosauria: a revision of *Dorosuchus neoetus* from the Mid-Triassic of Russia 1177  
ROLAND B. SOOKIAS, ANDREY G. SENNIKOV, DAVID J. GOWER and RICHARD J. BUTLER  
<<http://dx.doi.org/10.1111/pala.12110>>
- First decapod crustaceans in a Late Devonian continental ecosystem 1203  
PIERRE GUERIAU, SYLVAIN CHARBONNIER and GAËL CLÉMENT  
<<http://dx.doi.org/10.1111/pala.12111>>
- Carboniferous (Tournaisian) fish assemblages from the Isle of Bute, Scotland: systematics and palaeoecology 1215  
DAVID K. CARPENTER, HOWARD J. FALCON-LANG, MICHAEL J. BENTON and ELSA HENDERSON  
<<http://dx.doi.org/10.1111/pala.12112>>
- A new Hyperodapedon (Archosauromorpha, Rhynchosauria) from the Upper Triassic of India: implications for rhynchosaur phylogeny 1241  
DEBARATI MUKHERJEE and SANGHAMITRA RAY  
<<http://dx.doi.org/10.1111/pala.12113>>
- Natural assemblages of *Hindeodus* conodonts from a Permian–Triassic boundary sequence, Japan 1277  
SACHIKO AGEMATSU, HIROYOSHI SANO and KATSUO SASHIDA  
<<http://dx.doi.org/10.1111/pala.12114>>

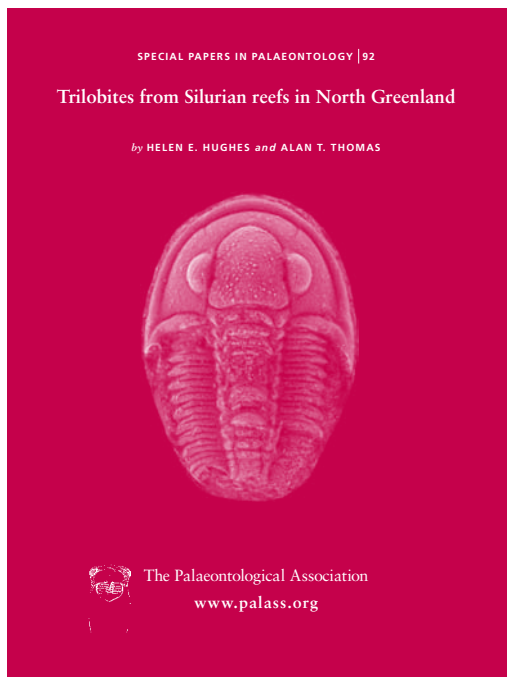


## Special Papers in Palaeontology No. 92

### Trilobites from the Lower Silurian reefs of North Greenland

Helen E. Hughes & Alan T. Thomas

**Abstract:** Varied and well-preserved trilobite faunas are described from Telychian (Llandovery, Silurian) reefs in North Greenland. The faunas, collected between Kronprins Christian Land in the east and Wulff Land some 600 km farther west, comprise 26 named species (23 new) and 39 under open nomenclature. These are assigned to 29 genera (four new). Members of the Illaenidae (one new species), Scutelluidae (nine new species, two new genera), Proetidae (seven new species, two new genera), Tropidocoryphidae (one new species), Aulacopleuridae, Scharyiidae, Cheiruridae (two new species), Encrinuridae (two new species), Calymenidae, Phacopidae, Lichidae (one new species), Odontopleuridae and Harpetidae are represented. The large number of new taxa reflects the lack of sampling of Silurian reef trilobite biotas. In the North Greenland reefs, trilobites occur predominantly in a cement-rich microbial lithofacies deposited between storm and fair-weather wave base, the fossils being concentrated in cavities and depressions on the reef surface. Several associations are recognized, which can be encompassed within the previously defined and long-ranging Illaenid–Cheirurid ‘Community’: the faunas have particularly close affinities with other Telychian Laurentian faunas described from similar environments. Species are not evenly distributed across the reef belt, however, and this smaller-scale variation is likely age-related, possibly reflecting the gradual foundering of the carbonate platform from east to west.





## Papers in Palaeontology

The first issue of *Papers in Palaeontology* will be published in 2015, but the following articles are already published in Early View (access through the Members' Area of the PalAss website):

A critical review of African species of *Eucyon* (Mammalia; Carnivora; Canidae), with a new species from the Pliocene of the Woranso-Mille Area, Afar Region, Ethiopia

LARS WERDELIN, MARGARET E. LEWIS *and* YOHANNES HAILE-SELASSIE

Article first published online: 7 OCT 2014

Cranial osteology of *Arctognathus curvimola*, a short-snouted gorgonopsian from the Late Permian of South Africa

CHRISTIAN F. KAMMERER

Article first published online: 7 OCT 2014

Conodonts in the Upper Ordovician Keisley Limestone of northern England: taxonomy, biostratigraphical significance and biogeographical relationships

STIG M. BERGSTRÖM *and* ANNALISA FERRETTI

Article first published online: 7 OCT 2014







## *Overseas Representatives*

- Argentina: DR M.O. MANCERNIDO, División Paleozoología invertebrados, Facultad de Ciencias Naturales y Museo, Paseo del Bosque, 1900 La Plata.
- Canada: PROF R.K. PICKERILL, Dept of Geology, University of New Brunswick, Fredericton, New Brunswick, Canada E3B 5A3.
- China: DR CHANG MEE-MANN, Institute of Vertebrate Palaeontology and Palaeoanthropology, Academia Sinica, P.O. Box 643, Beijing.  
DR RONG JIA-YU, Nanjing Institute of Geology and Palaeontology, Chi-Ming-Ssu, Nanjing.
- France: DR J. VANNIER, Centre des Sciences de la Terre, Université Claude Bernard Lyon 1, 43 Blvd du 11 Novembre 1918, 69622 Villeurbanne, France.
- Germany: PROFESSOR F.T. FÜRSICH, GeoZentrum Nordbayern, Fachgruppe Paläoumwelt, Universität Erlangen-Nürnberg, Loewenichstrasse 28, D- 91054 Erlangen, Germany.
- Iberia: PROFESSOR F. ALVAREZ, Departamento de Geología, Universidad de Oviedo, C/Jésus Arias de Velasco, s/n. 33005 Oviedo, Spain.
- New Zealand: DR R.A. COOPER, New Zealand Geological Survey, P.O. 30368, Lower Hutt.
- Scandinavia: DR R. BROMLEY, Geological Institute, Oster Voldgade 10, 1350 Copenhagen K, Denmark.
- USA: PROFESSOR PAUL SELDEN, The Paleontological Institute, University of Kansas, Lawrence, Kansas, 66045.  
PROFESSOR N.M. SAVAGE, Department of Geology, University of Oregon, Eugene, Oregon 97403.  
PROFESSOR M.A. WILSON, Department of Geology, College of Wooster, Wooster, Ohio 44961.

### ***TAXONOMIC/NOMENCLATUREL DISCLAIMER***

This publication is not deemed to be valid for taxonomic/nomenclatural purposes  
[see Article 8.2 of the International Code of Zoological Nomenclature (4th Edition, 1999)].

## Newsletter copy

Information – whether copy as such or Newsletter messages, review material, news, emergencies and advertising suggestions – can be sent to Dr Alistair McGowan, BioGeoD, 23 Glendinning Crescent, Edinburgh EH16 6DR (tel +44 (0)131 664 7702, e-mail <[newsletter@palass.org](mailto:newsletter@palass.org)>). The *Newsletter* is prepared by Nick Stroud, and printed by Y Lofa, Talybont, Ceredigion.

Deadline for copy for Issue No. 88 is 10th February 2015.

## Palaeontological Association on the Internet

The Palaeontological Association has its own pages on the World Wide Web, including information about the Association, and copies of the *Newsletter*. Internet Officer Alan R. T. Spencer can be reached by email at <[webmaster@palass.org](mailto:webmaster@palass.org)>. The locator is <<http://www.palass.org/>>.

## Advertising in the Newsletter

Advertising space in the *Newsletter* will be made available at the rates given below to any organisation or individual provided the content is appropriate to the aims of the Palaeontological Association. Association Members receive a 30% discount on the rates listed. All copy will be subjected to editorial control. Although every effort will be made to ensure the *bona fide* nature of advertisements in the *Newsletter*, the Palaeontological Association cannot accept any responsibility for their content.

£75 for half a page

£130 for a full page

These rates are for simple text advertisements printed in the same type face and size as the standard Newsletter text. Other type faces, line drawings *etc.* can be printed.

Rates for distribution of separate fliers with the Newsletter:

1,100 copies for worldwide distribution	£250
850 copies for worldwide distribution exclusive of North America	£200
600 copies for U.K. circulation only	£150

## THE PALAEOLOGICAL ASSOCIATION: Council 2014

President:	M. BENTON, Dept of Earth Sciences, University of Bristol, Wills Memorial Building, Queen's Road, Bristol BS8 1RJ
President Elect:	D. A. T. HARPER, Department of Earth Sciences, Durham University, Durham DH1 3LE
Vice-Presidents:	M. SUTTON, Earth Science & Engineering, South Kensington Campus, Imperial College London SW7 2AZ A. B. SMITH, Natural History Museum, Cromwell Road, London SW7 5BD
Secretary:	R. J. TWITCHETT, Earth, Ocean and Environmental Sciences, Plymouth University, Drake Circus, Plymouth PL4 8AA
Treasurer:	P. WINROW, Dept of Earth Science and Engineering, South Kensington Campus, Imperial College London SW7 2AZ
Newsletter Editor:	A. J. MCGOWAN, BioGeoD, 23 Glendinning Crescent, Edinburgh EH16 6DR
Publicity Officer:	L. HERRINGSHAW, Department of Earth Sciences, Durham University, Science Labs, Durham DH1 3LE
Book Review Ed.:	C. JEFFERY-ABT, Earth and Ocean Sciences, University of Liverpool, 4 Brownlow Street, Liverpool L69 3GP
Internet Officer:	A. R. T. SPENCER, Earth Science and Engineering, South Kensington Campus, Imperial College London SW7 2AZ
Outreach Officer:	F. GILL, School of Earth and Environment, University of Leeds, Leeds LS2 9JT
Education Officer:	C. BUTTLER, Department of Geology, National Museum of Wales, Cathays Park, Cardiff CF10 3NP
Meetings Coord:	T. R. A. VANDENBROUCKE, Université Lille 1, Avenue Paul Langevin, 59655 Villeneuve d'Ascq cedex, France

### Editor Trustees:

M. RUTA, School of Life Sciences, University of Lincoln, Riseholme Park, Lincoln LN2 2LG  
C. H. WELLMAN, Department of Animal and Plant Sciences, University of Sheffield S10 2TN

### Ordinary Members of Council:

R. J. BUTLER, Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham B15 2TT  
C. T. S. LITTLE, School of Earth and Environment, University of Leeds, Leeds LS2 9JT  
M. MUNT, Natural History Museum, Cromwell Road, London SW7 5BD  
R. OWENS, Department of Geology, National Museum of Wales, Cathays Park, Cardiff CF10 3NP  
D. S. WARD, 81 Croft Lane, Orpington, Kent BR5 1HB

### Co-opted:

J. LAWRENCE, National Oceanography Centre, Univ. of Southampton, European Way, Southampton SO14 3ZH

### Executive Officer:

T. J. PALMER, Inst. of Geography & Earth Sciences, University of Wales Aberystwyth, Aberystwyth, Ceredigion SY23 3BD

### Editor-in-Chief:

A. B. SMITH, Natural History Museum, Cromwell Road, London SW7 5BD

### Publications Officer:

S. THOMAS, 32 Royston Road, Whittlesford, Cambridgeshire CB22 4NW