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The Palaeontology Newsletter

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Reminder: The deadline for copy for Issue no 83 is 10th June 2013.

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Editorial

One of the more sombre duties of the Editor of the *Newsletter* is to receive notification of the deaths of members of the wider palaeontological community. *Newsletter* 82 carries two obituaries, one for Professor Jan Bergstrom and the other for Dr Alec Panchen. Both contributed greatly to their chosen areas of palaeontology. Professor Bergström played a major role in the study of Precambrian and Cambrian fossils, especially arthropods. Dr Panchen was an authority on the evolution of early tetrapods. Beyond their own work, both men helped the academic careers of many students who followed them into their respective areas of research.

Alec Panchen's death was separated by only a few months from that of Stan Wood. Dr Tim Smithson, who contributed the obituaries for both Alec Panchen and Stan Wood that have appeared in the *Newsletter*, wrote to me in the covering email that accompanied Alec's obituary,

> 'It feels like the end of an era for me with my PhD supervisor, Alec, and the person who discovered the material I studied for my PhD, Stan Wood, dying within six months of each other.'

The *Newsletter* is a print production and these articles are obituaries, biographies of the recently deceased. However, these articles provide ample evidence of the tremendous contributions that these people have made to the palaeontological community as colleagues, mentors and advocates for our discipline. Although it is a term more often linked with speeches, we should perhaps regard these articles as eulogies, literally the 'good words', about those commemorated in these pieces. Hopefully, these good words published on behalf of the Association can provide some comfort to bereaved family and friends by demonstrating the regard their efforts were held in by the palaeontological community.

As Editor, I also wish to set the precedent of publishing shorter memorial notices of the deaths of members submitted to the *Newsletter*. Many other societies publish notifications of the death of members in their magazines or newsletters and it seems appropriate that the Palaeontological Association does the same. Beyond the commemorative function of such notices, they can be of practical benefit. Family and colleagues of the deceased will hopefully be spared dealing with letters and email sent sometime after the person has died. People who have lost touch with the deceased person may be able to attend a funeral or memorial that they would otherwise have missed. Curators will be aware that loans to the individual will need to be returned by someone else at the institution of the dead person. Much of the reportage in the *Newsletter* is of happier events, such as the Sylvester-Bradley awards and our medal recipients, but it is right that the *Newsletter* covers the sadder news of the loss of members as well.

Al McGowan
University of Glasgow

Newsletter Editor
<newsletter@palass.or g>

Association Business

Annual Meeting 2013

Notification of the 2013 Annual Meeting, AGM and Annual Address.

The 2013 Annual Meeting of the Palaeontological Association will be held at the University of Zurich, Switzerland, on 13–16 December, organised by Dr Christian Klug and colleagues in the Palaeontological Institute and Museum.

Nominations for Council

At the AGM in December 2013, the following vacancies will occur on Council:

- President Elect
- Vice President
- Internet Officer
- Ordinary Members (3)

Nominations are now invited for these posts. Please note that each candidate must be proposed by at least two members of the Association and that any individual may not propose more than two candidates. Nomination must be accompanied by the candidate's written agreement to stand for election and a single sentence describing their interests.

All potential Council Members are asked to consider that:

> 'Each Council Member needs to be aware that, since the Palaeontological Association is a Registered Charity, in the eyes of the law he/she becomes a Trustee of that Charity. Under the terms of the Charities Act 1992, legal responsibility for the proper management of the Palaeontological Association lies with each Member of Council'. Further information on the responsibilities of Trustees can be obtained from <**secretary@palass.org**>.

The closing date for nominations is 1st October 2013. They should be sent to the Secretary: Prof. Richard J. Twitchett, School of Geography, Earth and Environmental Sciences, Plymouth University, Plymouth PL4 8AA, UK; email: <**secretary@palass.org**>.

The following nomination has already been received:

President Elect: Prof. David A. T. Harper

Grants in Aid

Grants-in-Aid: Meetings

The Palaeontological Association is happy to receive applications for loans or grants from the organizers of scientific meetings 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 organizer(s) of the meeting on the online application form. Such requests will be considered by Council at the March and the October Council Meetings each year. Enquiries may be made to <**secretary@palass.org**>; requests should be sent by **1st March** or **25th September** 2013.

Grants-in-Aid: Workshops and short courses

The Palaeontological Association is happy to receive applications for loans or grants from the organizers of scientific workshops or 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 organizer(s) of the meeting on the online application form. Such requests will be considered by Council at the March and the October Council Meetings each year. Enquiries may be made to <**secretary@palass.org**>; requests should be sent by **1st March** or **25th September** 2013.

Awards and Prizes AGM 2012

Lapworth Medal: Prof. Euan N. K. Clarkson

David Harper writes: For some fifty years Professor Euan Clarkson DSc, FRSE has been a force for good in palaeontology, both nationally and internationally. I have known Euan for some 35 years, participating in many joint projects, some expeditions and a significant number of joint publications. Euan has made ground-breaking advances in three main areas of our science: understanding vision in trilobites (and early arthropods in general); the conodont animal (linked to more general taphonomic processes in Carboniferous deposits); and the evolution of Early Palaeozoic marine faunas (especially trilobites, their ontogeny and life styles). I can briefly summarize some of these achievements:

1. Clarkson's annual address to the Association, published in *Palaeontology* (1979), reviewed his early and seminal papers in this field, including his highly-cited *Nature* publication on trilobites and the optics of Descartes and Huygens. This set the agenda for much future work on the earliest visual systems on our planet. Clarkson's own research in this field continues unabated with recent papers on

vision in tiny, planktonic trilobites, arthropods from the Cambrian Lagerstätten, and entirely new, unimagined types of visual systems in Early Palaeozoic trilobites.

2. In the early 1980s Euan identified the true conodont animal in collections of the BGS from the Carboniferous Granton Shrimp Bed. The discovery may have been serendipitous – Euan was in progress with a major study of the arthropods from this Carboniferous Lagerstätte – but nevertheless it solved one of the great contemporary mysteries of palaeontology. His three co-authored papers on the animal itself, its anatomy and its affinities have been highly cited and formed the basis for serious study of these highly important animals and their place on the tree of life and in ancient ecosystems. These and his jointly authored papers on the arthropods provided much new information on marine life in the Carboniferous, but importantly too were in the vanguard of studies on the taphonomy of exceptionally-preserved faunas.
3. The origin and evolution of Early Palaeozoic faunas are critical for our understanding of modern climates and ecosystems. Euan has focused on two key areas, the Cambrian of Scandinavia and the Silurian of Scotland. His meticulous descriptions and clear illustrations of a series of key faunas from the Cambrian of Denmark and southern Sweden together with the Silurian rocks of the Pentland Hills have unravelled how these animals grew, functioned and combined into environmentally-influenced benthic communities at a critical time in Earth history.

His research continues apace, with five publications in international journals during 2011. His knowledge and skills have been generously shared with countless generations of young researchers in addition to his own 15 PhD students. In fact a significant number of relatively senior palaeontologists arguably owe their careers in palaeontology to Euan's eloquent and expansive testimonials.

There is, however, one key area that demonstrates without any doubt his deep knowledge and understanding of our subject. Clarkson's textbook 'Invertebrate Palaeontology and Evolution' has educated and informed generations of students through its lucid text and beautifully constructed illustrations. The four editions (1979, 1986, 1992, 1998) have sold over 100,000 copies, and for many years this book has been the industry standard in its field.

Euan has never been shy in supporting the geological and palaeontological community. In recent years he has served, for example, as a Trustee of the Natural History Museum (1987–1992), Vice President of the Palaeontographical Society, President and Vice President of the Edinburgh Geological Society, and President of the Palaeontological Association; he has served on the editorial boards of the *Scottish Journal of Geology*, *Lethaia* and *Transactions of the Royal Society of Edinburgh* (where he was also executive editor).

During his career Euan has been a popular invited lecturer at many conferences, and also in geological societies in the UK and elsewhere in Europe. Not surprisingly, Clarkson has been recipient of many awards and distinctions including the Clough Medal (Edinburgh Geological Society), T. N. George Medal (Geological Society of Glasgow), the Keith Medal (Royal Society of Edinburgh) and the Coke Medal (Geological Society).

Euan, in an exceptional academic career, has demonstrated a formidable breadth and depth to his research programmes. His curiosity has taken him to all manner of unfamiliar worlds, elucidating the life and times of ancient animals, and where his research has both excited and inspired future generations of palaeontologists. I can think of no more deserving recipient of the Lapworth Medal.

President's Prize: Dr Harry Dowsett

Thijs Vandenbroucke writes: Harry Dowsett is one of the foram micropalaeontologists who has taken the discipline up a level, and made palaeontology relevant in palaeoclimate reconstructions and even in forward climate modelling efforts. He is, and always has been, the driving force behind the USGS PRISM program, one of the early and very successful palaeoenvironmental reconstruction programs that integrated climate proxy data based on fossils with numerical climate models such as GCMs. Harry has been instrumental in getting palaeoclimate modellers, palaeoceanographers and palaeontologists to interact, which has led to various iterations of PRISM, up to the current PRISM 3D.

In a nutshell, and in his own words, PRISM is a collaborative data analysis and climate modelling effort that strives to: i) accurately and comprehensively reconstruct and understand Pliocene climate and climate dynamics in order to gain insight into a warmer-than-present world that may resemble a future climate; ii) to construct Pliocene palaeoenvironmental/palaeoclimatic boundary conditions as an aid to general circulation model experiments designed to explore the impacts of climate forcings and feedbacks. More information can be found at <**http://geology.er.usgs.gov/eespteam/prism/index.htm l**>.

Harry Dowsett has written or contributed to over 100 papers and reports, including high-profile publications in *Science*, *Nature Geosciences*, *Paleoceanography*, *Philosophical Transactions of the Royal Society A* and *Geology*. Pliocene research is not my own field of research, though I have always admired the way Harry animated a multidiscliplinary and iterative project from a palaeontological background, and his approach and methods have been an inspiration for my own work in the Ordovician.

Hodson Award: Dr Jakob Vinther

Phil Donoghue writes: I have known Jakob Vinther since shortly after he began his PhD with Derek Briggs in Yale. He impressed me from the first instance, because of his piercing insight, our common interest in deep evolutionary history, his ignorance of disciplinary boundaries and, in consequence, his willingness to deal with data of whatever nature to solve the scientific problem at hand. It is my opinion that Jakob is a scientist of a calibre that appears perhaps only once every generation; the breadth and depth of the publication record at this nascent stage in his career is a testament to this.

Jakob has effectively established himself as a global leader in two areas. Almost as a hobby, Jakob pioneered the interpretation of fossil bird and dinosaur plumages as preserving pigment bodies – structures that had previously been interpreted as fossil bacteria. Further, Jakob made the conceptual leap that it would be possible to infer the colour of feathers based on the shape of the pigment bodies. Since Jakob reported this in *Biology Letters*, he has published on the coloration of dinosaurs and fossil birds in three articles in the journal *Science*. Not bad for a hobby.

Jakob's main line of research is more aligned with my own. He is a palaeontologist who uses fossils to reconstruct the pattern of character evolution in the assembly of phylum-level animal body plans – a fundamental prerequisite for evolutionary developmental biologists who seek to explain the origin of such body plans in terms of evolutionary changes in the molecular genetic controls on development. He has published two papers in *Nature*, among numerous other journals. Jakob's work goes further, however, in seeking to reconcile molecular and morphological data in attempting to uncover the evolutionary relationships of the living members of phylum-level clades such as molluscs and annelids, to better uncover the relationships of their fossil relatives. Thus, Jakob is as comfortable analysing fossils as he is cloning coding and non-coding genes for molecular phylogenetics.

Jakob graduated with his PhD only in the past couple of years, but he has an enviable publication record of more than 23 papers, including in *PNAS*, *Nature* and *Science*. I have no doubt that he will become one of the leading minds in our field.

Mary Anning Award: Alice Rasmussen

Alice Rasmussen with her PalAss certificate and her son Leif, with whom she frequently works.

Jesper Milàn, Tove Damholt and Bodil Wesenberg Lauridsen write: When Alice Rasmussen retired from her work, running horticulture, she followed her lifelong passion for fossils. For the last 25 years she has spent most weekdays searching for fossils on two unique geological localities: the limestone quarry Faxe Kalkbrud and the sea-cliff Stevns Klint. She has spent most of her spare time preparing the fossils, curating the growing collection, or presenting the story of ancient life to thousands of schoolchildren, locals and tourists.

These numerous hours of fossil collecting have so far resulted in a very large collection of considerable scientific value. The collection is maintained in a highly professional manner, with well-prepared and neatly labelled fossils carefully identified and well-documented. Because of Alice Rasmussen's professional standards and famed hospitality, the fossil collection is popular and widely known among European amateurs and professionals. A large number of specimens from the collection has been described in scientific papers, including Jakobsen & Collins, 1997; Schnetler *et al.*, 2001; Schwarzhans, 2003; Schnetler & Petit, 2006; Sigwart *et al.*, 2007; Milan, 2010; Lauridsen & Damholt, 2011; and Milan *et al.*, 2011a,b. Lastly, her collection of shark teeth across the K/Pg boundary has been a vital part of a PhD study performed at the Natural History Museum of Denmark, and the invertebrate collection from Faxe forms the basis of a postdoctoral study at the University of Copenhagen.

To honour her valuable contribution to science three fossils are named after Alice: *Scisurella aliceae* (Schnetler *et al.*, 2001); *Unitas aliceae* (Schnetler & Petit, 2006); and *Bythitidarum rasmussenae* (Schwarzhans, 2003). Twenty specimens from the collection are now declared Danekræ (Fossil Trove) and donated to the Danish State according to the Danish Museum Act, as they are evaluated to be of "unique scientific or exhibition value".

A number of specimens have been donated to another passion of Alice Rasmussen – the local geological museum of Faxe. Alice was for many years a member of the museum board, and fought for the establishment of a new museum. When the proposed construction of the new Geomuseum Faxe became a reality in 2008, Alice took a very active part in the planning of the new exhibition. On several occasions she was dissatisfied with the quality of the fossils in the state-approved museum collection, and donated several of her finest, and most scientifically-important, specimens to the new exhibition. Recently, Alice Rasmussen has been the driving force in the publication of two atlases of fossils from Faxe Kalkbrud and Stevns Klint in cooperation with the museum.

For more than twenty years Alice Rasmussen has been a beloved guide to schoolchildren and tourists visiting Faxe Kalkbrud, and, with her never-ending enthusiasm, she has opened the eyes of thousands of people to the wonders of past life. Earlier, the quarry was mostly regarded as a noisy, dusty nuisance, but the popular guided tours slowly expanded the local knowledge of the wonders of the quarry and its fossils, and for her work showing-off the quarry, the city council of Faxe awarded Alice Rasmussen the Culture Prize in 1998.

List of scientific papers comprising specimens found by Alice.

JAKOBSEN, S. L. and COLLINS, J. S. H. 1997: New Middle Danian species of anomuran and brachyuran crabs from Fakse, Denmark. *Bulletin of the Geological Society of Denmark*, **44**, 89–100.

LAURIDSEN, B. W. and DAMHOLT, T. *in press*. Faxe Kalkbrud – et mylder af liv på frodige koralrev dybt på havets bund. *In* B.E.K Lindow and J. Krüger, (eds). *Enestående brikker i Jordens puslespil*. Gyldendal. 52–66 pp.

MILÀN, J. 2010. Coprolites from the Danian limestone (Lower Paleocene) of Faxe Quarry, Denmark. *New Mexico Museum of Natural History and Science Bulletin*, **51**, 215–218.

MILÀN, J., LINDOW, B. E. K., LAURIDSEN, B. *in press* a. Multiple bite traces in the first find of a turtle carapace fragment, middle Danian (Lower Paleocene) bryozoan limestone, Faxe, Denmark. *Bulletin of the Geological Society of Denmark*.

MILÀN, J., RASMUSSEN, B. W. and LYNNERUP, N. *in press* b. A coprolite in the MDCT-scanner – internal architecture and bone contents revealed. *New Mexico Museum of Natural History and Science Bulletin*.

SCHNETLER, K. I., LOZOUET P. and PACAUD J.-M. 2001: Revision of the gastropod family Scissurellidae from the Middle Danian (Paleocene) of Denmark. *Bulletin of the Geological Society of Denmark*, **48**, 79–90.

SCHNETLER, K. I. and PETIT, R. I. 2006. Revision of the gastropod family Cancellariidae from the Danian (Early Paleocene) of Fakse, Denmark. *Cainozoic Research*, **4**, 97–108.

SCHWARZHANS, W. 2003. Fish otoliths from the Paleocene of Denmark. *Geological Survey of Denmark and Greenland Bulletin*, **2**, 1–94.

SIGWART, J. D., ANDERSEN, S. B. and SCHNETLER, K. I. 2007. First record of a chiton from the Palaeocene of Denmark (Polyplacophora: Leptochitonidae) and its phylogenetic affinities. *Journal of Systematic Palaeontology*, **5**, 123–132.

Popular Guidebooks by Alice Rasmussen:

RASMUSSEN, A. and NISS, C. 2002. *Koralbanken – Faxe Kalkbrud*. Amtscentret Næstved, 35 pp.

DAMHOLT, T., and RASMUSSEN A. 2005. *Fossiler fra Faxe Kalkbrud*. Østsjællands Museum, 44 pp.

DAMHOLT, T., RASMUSSEN, A. and RASMUSSEN, L. 2010. *Fossiler fra Faxe Kalkbrud – revideret og udvidet udgave*. Østsjællands Museum, 48 pp.

RASMUSSEN, A., RASMUSSEN, L. and HANSEN, T. 2011. *Fossiler fra Stevns Klint, Møn og Nordjylland*. Østsjællands Museum, 89 pp.

Small Grant Awards AGM 2012

The small grants awarded for 2013 by the Association include the Sylvester-Bradley, Callomon and Whittington awards. Council agreed that the following applicants should receive awards: J. T. Clarke (Whittington Award: £559); S. M. Ferrari (Sylvester-Bradley Award: £1,500); J. J. Hooker (Callomon Award: £1,500); P. E. Jardine (Sylvester-Bradley Award: £1,480); V. E. McCoy (Sylvester-Bradley Award: £830); R. Nawrot (Sylvester-Bradley Award: £1,104); M. L. T. Raveloson (Sylvester-Bradley Award: £1,500); M. Smith (Sylvester-Bradley Award: £1500).

Lagerstätten and Mesozoic fish diversification

John T. Clarke
University of Oxford

Teleost fish are the dominant group of vertebrates today; they comprise 29,000 species, assume a bewildering array of morphologies, and have come to occupy nearly every environment imaginable. The overwhelming success of teleosts has enticed workers to identify key innovations to explain their prolific diversification. The most fashionable hypothesis is that genome duplication on the teleost stem is the sole cause of their diversity today; an appealing idea given that the sister group of teleosts – the holostean fish – lack duplicated genomes and consist of just eight species today. However, to meaningfully test the notion that genome duplication drives diversification, I must reconstruct the taxonomic, morphological and functional diversity of holosteans and teleosts at the time of the duplication (the Mesozoic) and determine whether the pattern we see in the fossils is consistent with this claim.

The dataset required for this study cannot be based upon the literature alone; it is the wealth of fish material in museum collections that provides most of these data. Data collection is almost complete, yet two significant gaps remain: the Jurassic fishes from Solnhofen and Holzmaden in Germany. With aid from the Small Grants scheme, I can finally incorporate the full diversity of these two Lagerstätten into the dataset and discover the extent to which they determine the overall patterns of diversification I recover.

Palaeontological survey of Argentinean Jurassic gastropods

Silvia M. Ferrari
Museo Paleontológico, Trelew-Chubut, Argentina

Although several authors have contributed to the palaeontological knowledge of Argentinean Jurassic marine gastropods, these faunas are still less well known than coeval gastropod assemblages from other regions of the world. Recent work has reported seven gastropod families from the Jurassic of Chubut Province, comprising 12 genera and 19 species. Most of these genera represent the first occurrences in the Argentinean Jurassic, and at least ten new species seem to be endemic to the Patagonian region. Some genera show palaeobiogeographical connections with other Jurassic gastropod associations from the Western Tethys, Peru, Antarctica, New Zealand, India and Africa, and are represented also in Patagonia. However, Jurassic gastropods from the Neuquén Basin are poorly known, and only the most abundant or conspicuous species have been described so far. For instance, 15 species were reported in late Pliensbachian beds at southern Neuquén. The potential inclusion of Argentinean Jurassic marine gastropods in palaeobiogeographical studies awaits updated systematic revisions, and the characterization of some endemic species would bring a more complete data set to compare these faunas with coeval gastropod associations from other regions of the world, being the necessary base to get a correct interpretation of their palaeobiogeographical distribution in Gondwanaland.

Abbey Wood excavation

Jeremy J. Hooker
Natural History Museum

Abbey Wood, a Site of Special Scientific Interest in the London Borough of Bexley, is famous for its Early Eocene mammals, which include some of the oldest primates, bats, horses and cloven-hooved mammals in the world. So far 47 species have been found and substantially more are expected. They occur in the marine Lessness Shell Bed, into which they were washed from the nearby land. They lived in an environment that resembled a modern tropical forest, as shown by their ecological diversity signal and by floras from other sites. Similarities to contemporaneous faunas in North America show that intercontinental faunal interchange was taking place via an unglaciated Greenland. This connection would soon be broken by the opening of the North Atlantic.

Previous excavations at the site have essentially exhausted the shell bed in the enclosure originally allocated by Bexley Council for excavations. The aims of the project are therefore to search for a continuation of the shell bed outcrop outside the enclosure and, when found, carry out an excavation to bulk sample in order to increase knowledge of the mammal fauna. This is likely to produce more new species and better representation of those already known, giving us a better idea of the palaeoecology of the fauna and more precise intercontinental correlation.

Geochemistry and palynology: a proof of concept study

Phillip E. Jardine
University of Birmingham

The relationship between climate change and floral diversity is of fundamental interest to macroecologists, biogeographers and palaeobiologists. The fossil sporomorph (pollen and spore) record provides a proxy for vegetation change and can be sampled at high stratigraphic resolution. Relating climatic variables to this record in a robust and spatially limited modelling framework is problematic however, and previous studies of regional floras have had to rely on broad correlations with the global oxygen isotope curve, or indirectly use climate estimates from stratigraphically patchy leaf macrofossil deposits. Employing a novel biomarker-based method that uses branched glycerol dialkyl glycerol tetraethers [GDGTs] from the membrane lipids of soil bacteria to estimate temperature overcomes these issues, because the same sediment sample can be split for palynological and organic geochemical analyses, maintaining stratigraphic resolution and consistency for time series analysis. However, the presence of both sporomorphs and GDGTs within a section needs to be demonstrated before significant funding can be applied for. This project will assess the abundance of sporomorphs and GDGTs in the Eocene sedimentary successions of the US Gulf and Atlantic coastal plains. This information will form a pilot dataset in a larger application to a national research funding body, to test thoroughly the relationship between climatic change and floral diversification and dispersal.

Isotope analysis of Mazon Creek concretions

Victoria E. McCoy
Yale University

The goal of this project is to investigate exceptional fossilization within concretions by characterizing the isotope composition of examples from the Mazon Creek fossil site. Concretions are an important source of exceptional fossils across the United States and Europe in the Carboniferous and Triassic; Mazon Creek exemplifies the transitional coal swamp environment which most commonly gives rise to this mechanism of fossilization. These analyses will address ion source, rate of concretion formation and porewater salinity, each of which is known to impact fossilization within concretions. This investigation will reveal the relative contribution of each factor to that process. Both fossilization and concretion formation require a source of ions, which might be seawater, sediment or the organism. The source of ions constrains whether this is a limiting factor, and whether concretion growth will isolate the developing fossil from the ion source. The source of concretion forming ions constrains which ions need to be present in the environment and which need to be released from the organism through decay.

The rate of concretion growth may indicate how concretion formation affects fossilization: quick growth may inhibit decay, but the effect of slower growth must be more complex. The most abundant and best-preserved fossils occur near the transition from fresh to brackish water, indicating that a salinity transition may affect exceptional fossilization within concretions.

Extinction, invasion and body size in Mediterranean bivalves

Rafal Nawrot
University of Vienna

The opening of the Suez Canal in 1869 re-established the link between the Mediterranean (MED) and Indo-Pacific realms that last existed during the Middle Miocene, allowing hundreds of tropical species to spread from the Red Sea (RS) to the Eastern MED, with molluscs being among the most prolific invaders. As MED bivalve assemblages are increasingly becoming a mixture of faunal stocks with different evolutionary histories, their large-scale body-size patterns may reflect not only energetic or ecological constraints, but also historical contingencies. However, the impact of both the Pliocene extinctions and the recent shift in biogeographic affinities of MED bivalves on their regional size–frequency distribution (SFD) remains unexplored. Building on already available data on body size of recent MED and RS bivalves, I want to test the hypotheses that: 1) a distinct shape of the present-day SFD of native MED bivalves results from a selective nature of the Pliocene extinctions in this region, and 2) that the ongoing invasion of tropical RS species into the Eastern MED is restoring the pre-extinction body-size patterns. A survey of the palaeontological collections housed at the Museum of Natural History in Turin and the Museum of Natural History in Florence will provide crucial data on shell size and stratigraphic distribution of Pliocene species, and will be supplemented by records from primary literature.

Biostratigraphy of Majunga Jurassic continental succession

M. Lova Tantely Raveloson
University of Antananarivo

The Majunga Basin was filled by almost exclusively continental Karoo Supergroup sediments (Permian to Lower Jurassic in age) and by younger sequences, mainly marine, that were deposited from the Middle Jurassic to the present. Lower Jurassic sequences (200–175 Ma) are characterized by continental facies, although marine intercalations are progressively more abundant toward the northeast. The Middle and Upper Jurassic are represented by open marine deposits up to 500 m thick overlying terrestrial sequences (sandstones and argillites with plant remnants and lignite beds). Cretaceous strata are primarily marine up to the Coniacian (85 Ma), when the Majunga Basin began to accumulate both marine and terrestrial deposits (see also Besairie, 1972; Razafinfrazaka *et al.*, 1999; Rogers *et al.*, 2000, and Fanti, 2012 for extensive discussion). This research project aims to relocate some of the 1950s localities that were only marginally excavated: such localities will be integrated into the newly-built GIS database.

Priapulid Diversity Beyond the Burgess Shale

Martin Smith
University of Cambridge

The Cambrian "Explosion" catapulted the priapulid worms – today a minor phylum of scavenging burrowers – to a dominant position in early animal communities. Unfortunately, owing to their lack of mineralized parts, they have a sparse fossil record that has long been restricted to soft-bodied fossils from exceptional sites such as the famous Burgess Shale. Recent investigations of Small Carbonaceous Fossils (SCFs), however, have exposed a wide diversity of isolated priapulid-like teeth from numerous sites across the globe. These teeth display myriad morphologies, many of which intergrade; as such, they indicate a previously-overlooked diversity of priapulids and represent a key window into the group's early evolution. Through electron microscopic examination of the Burgess Shale's articulated priapulids, I will describe the morphology and ontogeny of teeth in fossil priapulid taxa. This will allow isolated SCFs to be attributed to known taxa, and allow taxonomic diversity to be distinguished from intraspecific variation. This new insight will reveal the true diversity represented by SCFs, unlocking the phylogenetic, biostratigraphic and palaeobiological potential of these ubiquitous fossils. SCFs sample diverse palaeocommunities from across the globe; a better understanding promises to cast new light on priapulid diversity and evolution, and their role in Cambrian communities.

ASSOCIATION MEETINGS

57th Annual Meeting of the Palaeontological Association
University of Zurich, Switzerland *13 – 16 December 2013*

The 57th Annual Meeting of the Palaeontological Association will be held at the University of Zurich, Switzerland, organised by Christian Klug, Heike Goetzmann and colleagues from the Palaeontological Institute and Museum.

Symposium & Annual Address
The meeting will begin with a symposium on Friday 13th December, followed by the Annual Address and an evening reception on the Uetliberg.

The topic for the Annual Symposium this year is 'Fossilised ontogenies and evolution'.

Keynote speakers confirmed are Prof. Nigel Hughes (University of California Riverside), Prof. Jukka Jernvall (University of Helsinki), Dr Rainer Schoch (Staatliches Museum fuer Naturkunde Stuttgart), Prof. Hans Kerp (Universitaet Muenster), Dr Zerina Johanson (Natural History Museum London), Dr Alex Nuetzel (Bayerische Staatssammlung fuer Palaeontologie und Geologie Munich).

The Annual Address will be given by Prof. Michael Coates (Department of Organismal Biology and Anatomy, University of Chicago).

Conference
The Conference itself will commence on Saturday 14th December with a full day of talks and posters, followed by the Association AGM. In the evening there will be the Annual Dinner.

Sunday 15th December will comprise a dedicated poster session and talks. The time allocated to each talk will be 15 minutes. The organizers will seek to avoid parallel sessions, but will include them if necessary, for part of each day, to accommodate as many speakers as possible.

Venue and travel
The conference will take place at the Universitaet Zentrum, University of Zurich, which is a ten-minute walk (uphill) from the main station (HB = Hauptbahnhof). Accommodation we have reserved is nearby, so no further public transport will be needed to get to the lecture halls from these hotels. However, to get to the Conference dinner, we will use public transport. Tickets will be provided and we will guide you to the venue in small groups.

Getting to Zurich
For those who wish to avoid flying, Zurich can be reached by combining rail (*e.g.* via Paris, TGV usually takes about 4-5 hours to Zurich) or bus links, which might be more or less cheap but obviously more time-consuming. For the majority, flying will be the best option.

Plane
Zurich is served by Zurich Airport Kloten (ZRH), which is located north of Zurich City Centre. There are currently direct air links (including EasyJet) into Zurich from a large number of airports globally, and, in particular, from Britain, continental Europe and North America. If you want to get a good bargain, early booking is recommended. It is usually worthwhile consulting search engines such as,

for example, <**http://www.jetcost.co.uk /**> or <**http://www.ebookers.com /**>, which would search several other providers and airlines.

Another option is to fly to Basel/Mulhouse airport. A bus takes you to the main station in Basel city, from where fast trains to Zurich take about one hour. So in total, the journey from Basel airport to Zurich would take about 1h 30min.

Transferring from the airport
There are frequent connecting "S-Bahn" (city trains) and regular trains from the airport to the city centre (main station = Hauptbahnhof). You can use all of those, where Zurich HB is indicated (some faster, some slower) with the same ticket from the vending machine in the airport (around £2–3; you can pay in Euros, Swiss Francs, Maestro, Postbank card). The transfer takes 10 to 15 minutes.

Getting to the Universitaet Zentrum-building (University of Zurich)
Once you've reached the main station (Zurich HB), leave the building towards the River Limmat. Be careful, because there is also the River Sihl, which is also close to the train station. You can always ask because most of the locals speak English well and are very helpful. Cross the Limmat until you reach a large roundabout with a bus stop and a tram stop. From there, you can:

- walk up the stairs: <**http://www.plaene.uzh.ch/KO2#ankerma p**>;
- take tram 6, 9 or 10 to the stop ETH/Universitaetsspital then follow the map;
- take the cable car (Polybahn). The entrance is next door to Starbucks. It costs one franc (it is included when you have a valid ticket for Zone 110); there is a vending machine at the entrance. It is a romantic short ride, which takes you to the Polyterrasse, which is a large terrace providing a nice view over the town. Cross the terrace, and turn left into Karl Schmid-Strasse. The entrance is between the two fish ponds.

We will provide detailed maps online in the Autumn. As always, we will put up signs to guide you, once you are close to the lecture halls.

Train
Zurich is served by one main railway station: Zurich HB (main station = Hauptbahnhof). There are TGVs from Brussels and Paris, ICEs from Frankfurt, Stuttgart and Berlin, and the Cisalpino from Milano. They are all rather comfortable and fast. Be sure to check if you need reservations.

Local public transport: Tram and bus
Public transport is excellently organised in Switzerland and the costs are reasonable. In Zurich, there is a tram stop or a bus stop roughly every 300 m. You can get short-distance tickets (only to the destinations listed on the vending machine), one-hour tickets (in Zurich for Zone 110, which is the majority of the city) and 24-hour tickets for Zone 110. Zurich is not a very big city, so many places can easily be reached walking. Bear in mind, however, that there are many hills and walking through Zurich might involve climbing many stairs.

Taxi
There are usually abundant taxis in operation in the city centre at any given time. Zurich taxis belong to the most expensive taxis worldwide, so I recommend using them only if you are rich or lack another choice. It is possible to hail a taxi from the street, but convenient taxi ranks in the city centre are located on the Hauptbahnhof and around other bigger train stations.

Registration and booking

Registration and booking (including abstract submission) will commence in June 2013. Abstract submission will close in September (exact date to be confirmed); abstracts submitted after this time will not be considered. Registration after this date will incur an additional administration charge of approximately €30, with the final deadline in November 2013. Registrations and bookings will be taken on a strictly first-come-first-served basis. No refunds will be available after the final deadline.

Registration, abstract submission, booking and payment (by credit card) will be available online via the Palaeontological Association website (<**http://www.palass.org /**>) from June 2013.

Accommodation

This must be booked separately!

Rooms in a variety of hotels, hostels and guest-houses at a range of prices are available in Zurich city centre and can be reserved through the usual channels. In addition, we have organised discount rates at some hotels close to the University. More information on these and alternative accommodation will be provided in the next edition of the *Newsletter* and on the website in due course.

Bookings can be made individually (for students: why not try couch-surfing?) or via the following link (some hotels, where we made reservations and where we obtain a cheaper rate):

<**http://www.zuerich.com/en/kongresslandingpages/kongress31.html**>

Think about sharing a room to save costs, if necessary!

Further details of our suggested choices will be available on the website.

Travel grants to student members

The Palaeontological Association runs a programme of travel grants to assist student members (doctoral and earlier) to attend the Annual Meeting in order to present a talk or poster. For the Zurich 2013 meeting, grants of less than £100 (or the € equivalent) will be available to student presenters who are travelling from outside Switzerland. The actual amount available will depend on the number of applicants and the distance travelled. Payment of these awards is given as a disbursement at the Meeting, not as an advance payment. Students interested in applying for a PalAss travel grant should contact the Executive Officer, Dr Tim Palmer (e-mail <**palass@palass.org**>) once the organisers have confirmed that their presentation is accepted, and before **1st December 2013**. Entitle the e-mail “Travel Grant Request”. No awards can be made to those who have not followed this procedure.

Why not make a stay of it?

Switzerland at any time of the year is an excellent destination for a short break; why not come a few days early and see what the country has to offer? Alternatively, if anyone travelling with you is not enthralled by the idea of three days at a PalAss conference there is plenty to do. We’ll provide further details in the next *Newsletter* (and are happy to advise if we can). In the meantime, try

<**http://www.myswitzerland.com/en/home.html**>

<**http://www.zuerich.com/en/Visitor.html**>

We look forward to seeing you in Zurich in December!

Progressive Palaeontology

Leeds 2013

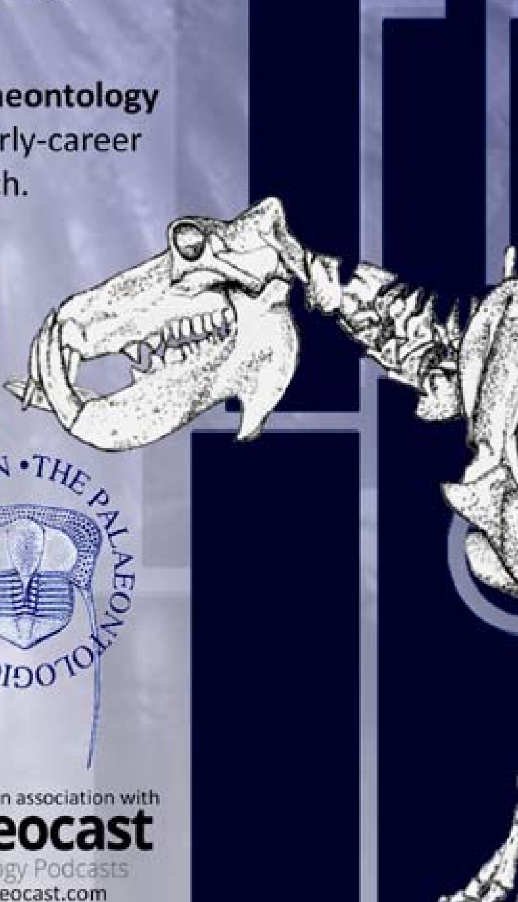
22nd-24th May

School of Earth and Environment,
University of Leeds

Join us for the annual **Progressive Palaeontology** conference, a great opportunity for early-career palaeontologists to share their research.

Abstract submission deadline:
24th April

Registration closes: ***10th May***



Email **progpal@palass.org**, or for further details and updates visit **palass.org**, friend us on Facebook (**Prog Pal 2013**), or follow us on Twitter**@ProgPal2013**.

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news

Palaeontology news round-up

After a rather grim appraisal of the academic job market by the Newsletter Reporter, Dr Liam Herringshaw, in *Newsletter* **80**, it is a pleasure to flesh out Professor Michael Benton's remarks at the Annual Meeting, in which he indicated that several people with a palaeontological or palaeobiological element to their research had been appointed to lecturerships of varying durations. Here is a list Mike provided of the appointments he is aware of. Please let us know of any further successes.

- Richard Butler University of Birmingham
- Davide Pisani University of Bristol
- Jakob Vinther University of Bristol
- Steve Brusatte University of Edinburgh
- Marcello Ruta University of Lincoln
- Rob Sansom University of Manchester
- Roger Benson University of Oxford
- Luke Mander University of Plymouth
- Nicholas Minter University of Portsmouth

Professor Euan Clarkson – in addition to being presented with the Association's highest honour, the Lapworth Medal, at the Annual Dinner in Dublin (see p. 4) – received an extra prize at the conclusion of the Annual Meeting.

Prior to the Annual Dinner, delegates were treated to a tour of the Jameson Distillery to find out more about the craft of making whiskey. The guide remarked to Professor David Harper that Euan knew a tremendous amount about whisky/whiskey. To reward this feat of scholarship a litre bottle of 12 year-old Jameson Distillery Reserve, inscribed "This bottle has been specially labelled for Euan Clarkson at the Distillery", was presented to Euan by Dave.

The final recent success for palaeontology as a discipline was the recent announcement that the Geological Society of London has awarded the R. H. Worth prize to Hans Hagdorn, who has dedicated many years to the study and promotion of the Muschelkalk Basin. A visit to the Muschelkalk Museum in Ingelfingen, Germany or an inspection of Hans' publication record leaves no doubt of his worthiness for this award, which the GSL gives "in recognition of meritorious geological research carried out by amateur geologists, or for the encouragement of geological research by amateurs."

Palaeontological Association sponsoring at EGU 2013: 7–12 April 2013, Vienna, Austria

As part of its sponsoring of the European Geosciences Union General Assembly 2013, the Association is offering an additional number of postgrad travel grants, for student members who will present their research during the PalAss-sponsored sessions (see programme on the EGU 2013 website). The same specifications and requirements as for our standard postgraduate travel grants apply, with the exception of the imposed deadline (which is a lot closer to the meeting than usual). For further practical details, please have a look at our website.

EGU 2013: <**http://www.egu2013.eu /**>.

PalAss postgraduate travel grants:

<**http://www.palass.org/modules.php?name=palaeo&sec=awards&page=19 0**>.

PalAss-sponsored sessions at EGU 2013 (session programme tbc):

SSP 1.1 POSTER ONLY Open session on stratigraphy, sedimentology and palaeontology (co-sponsored by IAS & PalAss)

SSP 1.2 Mesozoic stratigraphy, palaeoceanography and palaeoclimate

SSP 1.3 European Shale Basins: a new frontier in unconventional hydrocarbon exploration

SSP 2.1 High-resolution geological time scales: improvements, accuracy and applications

SSP 4.1 Should I stay or should I go – the role of climate in early expansions of humans.

Best wishes,

Thijs Vandenbroucke
Meetings coordinator

Canadian couple seeking support to build a world-class Fossil Institute

Aiming at 'one-of-a-kind' collection of 350 Ma Lower Carboniferous fossil evidence:

Blue Beach, Nova Scotia, Canada is internationally acknowledged by today's leading researchers as the oldest fossil site in the world showing evidence of the first four-legged, terrestrial, air-breathing creatures to move from water on to land: the tetrapods.

The first discovery of the 350 million year old fossil vertebrate footprint evidence at Horton Bluff (Blue Beach) was by Sir William Logan in 1841. Much later, in the 1940s and 1950s a researcher from Harvard (Dr Alfred Romer) looked for evidence of these primitive land animals and instead found a 'gap' that spanned the first 30 million years of the Carboniferous Period. This famous gap was later named 'Romer's gap' and not a single fossil bone had ever been discovered within the time of the gap, suggesting the most important chapters in the history of today's land animals were missing.

In 1966, the first fossil bones of these missing land animals were discovered at Blue Beach, dating to the middle of Romer's gap. Palaeontologists descended on the site with renewed interest, but after 35 years of sporadic fieldwork they met with little overall success.

Then in 1995, citizen palaeontologist Chris Mansky began systematically collecting and researching the fossils and has amassed a cornucopia of fossil evidence on these tetrapods along with several thousand specimens documenting various fish, some of the earliest forests and a trace fossil collection that has been called "A Rosetta Stone for Lower Carboniferous trace fossil studies".

Eleven years ago, Chris Mansky and Sonja Wood built a 'home-based' fossil facility to display and house some of the large collection of the fossils gathered from the shoreline adjacent to their property. The collection has re-attracted the attention of renowned palaeontologists from all over the world, and its specimens have been the subject of increasing study with the results appearing in many peer-reviewed science journals and publications.

Convex Palaeosauropus *trackway, Lower Carboniferous of Blue Beach, Nova Scotia, Canada: one example from the world's oldest diverse tetrapod tracksite in the collections of the Blue Beach Museum.*

With the strong encouragement of local and international scientists, members of the local communities, and initial financial contributions from levels of government, the couple began the process to create a world-class institution, since the expanding collection and vision for a proper research and education facility far exceed the resources of the current building. They envision the new professionally-designed and much larger Blue Beach Fossil Museum telling the story of those first land animals and their world based on their fossil remains – a story that began 350 million years ago that ultimately leads to ourselves.

The new Museum would be a nexus for palaeontological research, public education and outreach, and geo- and eco-tourism, all contributing to new scientific discoveries.

The couple have made significant progress with the creation of a not-for-profit Society with Canadian Registered Charitable Tax Status, and have obtained local permit approvals and assessments to move forward with the project. They are now poised to sell the sub-divided portion of the Blue Beach property for the purpose of accelerating the process to create the Museum. To do

An early tetrapod jaw fragment (dentary with tooth-bases) of an undetermined early land animal from Romer's gap, only known from Blue Beach, Nova Scotia, Canada.

so will require an experienced team of workers and of course additional financial resources.

They would thus welcome interested investors to participate in the creation of this new world-class geoscience museum, and therefore invite you to share their dream by becoming a Founding Patron or making donations to the project.

If you are interested in being a part of this exciting project, Chris and Sonja welcome the opportunity to discuss this with you; please contact them as shown below.

Christopher F. Mansky (BBFMS Curator) & Sonja E. Wood (BBFMS Director)
The Blue Beach Fossil Museum Society,
127 Blue Beach Rd., Hantsport, Nova Scotia
B0P 1P0 Canada
(902) 684-9541
<bbfossils@xplornet.co m>
<http://www.bluebeachfossilmuseum.com />

Associated femora and tibia of earliest known whatcheeriid tetrapod, from the Lower Carboniferous of Blue Beach, Nova Scotia, Canada.

On loan to the University of Calgary.

From our Correspondents

The human touch

As co-presenter at an artistic gathering, Filou was a just a little special. Dark, elegant, self-possessed, with eloquent gaze: the audience was, naturally, captivated. Any trace of nervousness – for the lecture hall was packed – soon passed. Morale, for the record, was fortified, mid-presentation, with a small helping of tuna paste, straight from the tube. In fifteen minutes, amid clicking cameras, the spirit of Andy Warhol was brought to bright and brilliant life. For Filou the professional cat[1], focus of attention in Berlin's Haus der Kulturen der Welt, embodied the changing of a planet[2]. Filou represented the battleground of the Anthropocene – that idea of a geological, human-driven epoch propounded by the Nobel Prize-winning atmospheric chemist Paul Crutzen. Filou, naturally, was on the winning side.

It has been quite a victory for *Felis catus*, or perhaps *Felis domesticus* as the junior[3] synonym. This beast has done very well for itself. No-one knows quite how many domestic cats there are in the world, but estimates range from 250 million to 500 million, spread over every continent[4] and on most islands too. Let us compare that with its more magnificent relative, the tiger, a species in which cunning and strength of limb and sharpness of tooth and claw has suddenly become not quite … *enough*. The tiger is an icon of the conservation movement. So, there are quite a few biologists out there counting tigers, coming to a consensus that there are now few more than 3,000 left in the wild, about 3% of the already depleted numbers of a century ago.

That means that for *each* tiger, there are now of the order of 100,000 ordinary[5] house cats on the Earth, singing to the Moon at midnight, cornering the tuna paste market, nabbing the comfortable spot by the fireside, and busily having kittens. How many cats are 100,000? – for we are now almost in the realm of the kind of numbers normally associated with geological time, and the brain begins to give way. Well, I measured the lecture theatre at the Haus der Kulturen der Welt to have an area of some 900 square metres[6]. Counting all the spaces beneath the banks of seating, and the tops of all the lights on the ceiling, and the surfaces of the speakers, and the podia – well, that might take it up to 1,500 square metres. Now, let's pack in domestic cats at ten to the square metre. They'd have to sit upright – no room to lie down – and there would be thin cats sitting on the shoulders of fat cats, cats hanging from the ceiling lights, cats sitting on the windowsills. It might exhaust a lifetime's worth of diplomacy and organizational powers, but one might eventually squeeze 15,000 cats into that lecture hall. It would be a sight to bring a happy beam to Mark Twain's face and to absolutely, clinically, terrify Napoleon Bonaparte[7]. And

1 Yes, Filou was a cat that was paid to be a cat. Very avant-garde, this, and a trick that, in respective terms, not many humans have managed.
2 The project at the HKW will go on for most of the next couple of years: catch it if you're there.
3 Loosely speaking: in my junior days *F. domesticus* seems to have been the standard nomenclature, in Lancashire schoolkid circles, at any rate.
4 And yes, Antarctica too: several cats have hitched a ride on British Antarctic Survey ships to live on the bases.
5 The shade of Colette now frowns; to her, no cat was ordinary.
6 I measured, by pacing; second nature, just like in the old days.
7 That well-known ailurophobe: see *Newsletter* **78**.

– to gather together enough fireside cats to be the equal of just a single individual of the world's remaining wild tigers, one would need to repeat this trick another six and two-thirds times.

It is a measure of how the Earth has changed. It is not, though, the largest measure of change. There is an order of magnitude more humans than cats on Earth[8]. We are somewhat larger than the average mog, and, like cats, we are always hungry. That indefatigably inquisitive researcher Vaclav Smil has taken our measure by the most objective criterion of all: collective weight. Considered simply as body mass – no matter whether as wet weight or dry weight – we now bulk up to about a third of terrestrial vertebrate body mass on Earth. Most of the other two-thirds, by the same measure, comprise what we keep to eat: cows, pigs, sheep and such. Something under 5% and perhaps as little as 3%, is now made of the genuinely wild animals – the cheetahs, elephants, antelopes and the like.

Is it the natural order of things, on land at least, for one vertebrate species to be so dominant, with humans just being the latest to take on the mantle of top cat? Well, no, as history, in its guise as palaeontology, seems to be telling us. Anthony Barnosky, in 2008, described the natural order of things, at least from earlier in the Quaternary. In those days, humans were just one of some 350 large ('megafaunal') vertebrate species, with energy and biomass distributed among them. Clearly, there's now been quite a change – but there's more to it than that.

Given the precipitate drop in the numbers of wild vertebrates, one might imagine that vertebrate biomass as a whole has gone down. One might, though, have to think again. Humans have become very good at, firstly, increasing the rate of vegetable growth, by conjuring nitrogen from the air and phosphorus from the ground, and then directing that extra growth towards its brief stopover in our captive beasts, and thence, to us. By this legerdemain – a key factor in the currently supercharged carbon, nitrogen and phosphorus cycles – the total vertebrate biomass has increased by something approaching an order of magnitude above 'natural' levels (staggering, isn't it: see Barnosky 2008, once more, especially figure 5 therein). This state of affairs will persist for as long as we can continue to coax nitrogen out of the air (virtually indefinitely, thanks to the ingenuity of messrs Haber and Bosch – as long as the energy supply holds out, that is) and phosphorus from the ground (somewhat more uncertain, this[9]).

The land animal makeover is just one of the many extraordinary phenomena that make up this geologically best and worst of times. The Anthropocene is certainly taking stratigraphy into new dimensions, and has hijacked a good deal of my life these last few years. So far I have tiptoed around it in these columns, rather, not least because of my involvement in the ticklish question of whether it should be formalized or not to become part of the Geological Time Scale (the jury is still out, and the deliberations and the seeking of further evidence may take quite some time still). But, as the Palaeontological Association generously, if perhaps rashly, enabled me to take part in the Anthropocene session co-convened by Mark Williams and Mike Ellis at the American Geophysical Union (AGU) meeting in far-off San Francisco late last year, it is probably time to dive in.

Where to start? There is just so much that is new that it can quite make one lose one's bearings as to what is geology and palaeontology and what … isn't. For instance, one might start, quite

[8] Unless the few poor harassed cat census-takers have mis-counted badly. I sometimes wonder about this.
[9] As pondered on in *Newsletter* **78**.

traditionally, at home: the home, that is, represented by our houses and factories and hospitals and universities – and palaeontological museums, too. This is the province of architecture and building and plumbing and of that most subtle and arcane of disciplines, the mastery of municipal planning regulations.

But is it stratigraphy, too? Well, all the soil and rock that has been moved in construction, including the ground-up remains of previous habitations, has certainly been within the realm of practical lithostratigraphy for quite some while. The British Geological Survey, an institution that combines practicality in the field with an absence of anything that one might construe as gratuitous radicalism, was mapping areas of Made Ground and Worked Ground even in my days there. These days, the classification is yet more elaborate, involving quite a few categories of urban strata – and it might yet move into *formal* lithostratigraphic territory, complete with designated type sections[10].

These are strata – but they are also, of course, biogenic (assuming that we categorize ourselves as biological) or, more particularly, they are trace fossil systems, of quite extraordinary scale. What are the largest natural burrow systems? On land, the likes of rabbits, badgers and prairie dogs are usually quoted, but the wolf can probably outdo them, excavating their lairs down, it is said, to four metres or so. In the sea, that prodigious mudshrimp *Callianassa* can reach almost as far, with burrow systems down to the best part of three metres below the sea floor. For the new hole-digger on the block, though, that's just peanuts. Human megacities today cover thousands of square kilometers each, foundation pilings can reach down a hundred metres, mines and collieries commonly reach down more than a kilometre, while boreholes commonly reach several times that. Among that practical institution, the British Geological Survey, the word 'anthroturbation' is beginning to be used for this kind of herculean excavation.

How far can one go? Our houses and factories in themselves are not usually regarded as geological strata (or ichnofabrics) on geological maps, though the distinction might be regarded as artificial. After all, buildings sprout from the Made Ground rather as mushrooms sprout from compost, and they are made of eminently geological stuff: silica, baked mud and lime, metals (once razed to the ground to make room for the next generation of domichnia, these materials will, in geological cartography, officially assume stratal status).

Let us take this idea a little further[11]. Let us think planes and trains and automobiles. Now, at the AGU meeting, Peter Haff made the point that Nature is quite good at moving liquids and gases across the Earth's surface, but is less effective with solids, other than those that piggyback on river flows and such[12]. Humans, though, have become quite good at moving solids, in large amounts (to build up our cities, to take the wheat and cattle to market, to get ourselves to the office and back, and so on), and do this with purpose – and often, being human, uphill.

So one might treat our modern means of travel as something novel on the face of the Earth. But, on the other hand, we might seek much more natural – and also much more ancient – analogues. Go to any stream today that is not too polluted, and one might find on its bed a caddis fly larva, crawling along within a mobile home constructed of coarse sand and granules,

[10] One of many aspects to be described in Colin Waters *et al.* (ed.) *Stratigraphical Aspects of the Anthropocene*, a Special Publication of the Geological Society of London that, touch wood, looks set to be appear later this year.

[11] Yes, I am aware of the dangers of losing geological bearings – but the warning was posted earlier, if you recall.

[12] See also Haff 2011.

carefully stuck together. Go to any sea floor with a microscope, and there are likely agglutinated foraminifera there, living proof that one does not even need to be multicellular to be able to construct a perfectly good home (I am a little hazy as to how mobile might be these protozoa, once weighed down with their home-made armour).

For a closer match in engineering finesse, though, one has to go to the early Palaeozoic, and those enigmatic and beautiful zooplankton, the graptolites, and the vanished skills that they possessed. I still sometimes find it hard to assimilate the idea that the elaborate tube-like fossils that we see are not skeletons in any normal sense, but are the remains of built constructions, made co-operatively at that, by teams of millimetre-scale blobs of be-tentacled jelly. Yet, the evidence that these were animal architects of the highest order is overwhelming. And the trace fossils that they built – for they seem to be closer to that realm than to that of body fossils – were, of course, mobile. They had to be, for if the graptolites had just drifted passively, they would have starved: they needed to move through water, to filter-feed in water that they had not already exhausted of food particles; diffusion alone would not have been enough.

The mobility, too, must have been co-operative. No headstrong boy racers, these: rather some idiosyncratic hybrid of quinquereme, submarine, dirigible and wagon train. An ungainly assortment of analogues, to be sure, and perhaps not too closely fitting at that – but, whatever, these were arguably some of the most finely constructed ichnomobiles ever made. Looking at the scanning electron micrographs of the finest examples of these fossils – the kind of things that Anna Kozlowska or Alf Lenz produce so routinely, with the evident traces of the 'mortaring' by which the organisms applied the finishing touches to their mobile homes – one can be forgiven for thinking that Lotus and Rolls-Royce still have a lot to learn.

The human engineers are learning quickly, mind, and passing on their knowledge to their apprentices. And because they are making *lots* of things, and because quite a few of those things are durable, so cultural and technological evolution is being imprinted into strata to become what can only be a kind of warp-speed biostratigraphy. What sort of things? Well, it's not so much whole cars and planes and ships. What escapes the breakers' yards has to pass through the ravages of erosion and, while a few will survive in some shape (shipwrecks in rapidly sedimenting parts of the sea floor, for instance), these will be the dinosaurs of any future palaeontology – rare, avidly sought museum pieces of no use whatsoever to practical biostratigraphers. As a lifelong palaeontologist who has spent *lots* of time in the field, for example, I have never found even a scrap of a dinosaur[13].

It's the small fry that count, and Colin Waters, at the AGU meeting, showed a lovely diagram, produced by he and his BGS colleagues, of some of the things that have come and gone in their millions in the space of centuries or even decades – nickel-cadmium and mercury batteries, common from the early/mid twentieth century, largely banned in the last few years (now we mainly have alkaline batteries, a post-1950 invention). Anything out of Bakelite (early twentieth century). Almost all plastics (post-1950). Almost everything made out of aluminium (ditto). Compact discs (post-1980, driving short-lived magnetic tapes into virtual extinction). If one begins to look around, then one can see this kind of stuff everywhere. Part of this essay has been scrawled in draft with a ball-point pen – made of plastic and ink and a ball-nib of the mineral

[13] A couple of ichthyosaur vertebrae have been plundered – but as these are marine reptiles and not dinosaurs, they of course don't count.

tungsten carbide (very hard-wearing and unknown in nature[14]). How many of these post-~1950 phenomena have been made? The Bic Cristal Company *by itself* claims to have made a hundred billion ball-point pens (and rising). How far have these things travelled? Well, our rubbish – ichno-artefacts, one might say – now gets everywhere, even to the bottom of the deep sea, as most surveys of parts of the sea floor now routinely turn up human junk[15].

Assessing this kind of thing has hardly begun, though one can scavenge among the literature of other disciplines to try to get an idea of the scale and reach of the phenomenon. We're in territory (not yet very clearly defined) that seems to lie on the fringes of modern industrial archaeology, urban ecology, *non*-urban ecology, waste management, environmental monitoring: somewhere in there, a new form of stratigraphy is trying to emerge.

If we turn away from ichno-artefacts, to real biology as it begins to transmute into future palaeontology, then life scarcely gets any easier. The Earth's biosphere is changing, we know, and species are disappearing, in part in response to the changes in vertebrate biomass changes noted above. This change is being monitored by an army of field zoologists, biologists, botanists. There is, understandably, some accent on the kind of organisms that are of less use to biostratigraphers: cute, furry, terrestrial and high up the food chain. The units of measurement are also not helpful: species, for the most part, while most large-scale studies of past biodiversity on Earth, including scale of mass extinction, tend to be carried out – to preserve the researchers' sanity – at the scale of family or thereabouts.

How, then, to compare present, past and inferred future? Answer: with difficulty, and again it is Anthony Barnosky and his colleagues who have made the most recent headway (2011). The upshot is that a global mass extinction event has not yet happened – but that it will happen in a few centuries if current rates of species loss continue – and especially if the very many current 'highly endangered' taxa simply drop out of existence (that 'current rates' scenario does not, mind, factor in the effects of climate change).

Biostratigraphy, though, is not so much about species extinctions and appearances, as about what common fossil elements appear or disappear in the stratigraphic section of any given place or region. And here it is generally the species invasions – a global phenomenon that is in full swing – that currently loom much larger than extinction levels. Again, this is a phenomenon that, in contemporary form, tends to have its own subset of biologists working on it. There are networks such as DAISIE[16], for instance, that produce excellent and thought-provoking compilations – but again it is not straightforward to translate those compilations into models of ongoing biostratigraphic change. There are long lists of species, with distribution maps showing history of spread. What is much harder to find is how those occurrences amount to a recognizable proportion of any *preservable* fauna or flora of any place, and therefore of how weak or strong the resultant biostratigraphic signal it might produce. Barnosky, speaking at the AGU meeting, said that, among the marine invertebrates of his local San Francisco Bay, the post-1950 assemblages are clearly distinguishable from earlier Holocene and indeed earlier Quaternary ones. This is because, since the post-war increase in shipping traffic, numbers of new species of

[14] Meaning that as *non-human* nature, of course.

[15] The scale and nature of the stuff we have tipped overboard is detailed by Ramirez-Llodra *et al.* (2011).

[16] DAISIE stands for 'Delivering Alien Species Inventories for Europe'. The daisy, ironically, is quite native to Europe – but it is now a vigorously invasive species in the USA, Australia and New Zealand.

molluscs, crustaceans and so forth have been brought in, found the place to their liking, stayed, and thrived.

This change extends down to the microfauna, and goes beyond relative numbers of species in an assemblage. Among the benthic foraminifera of San Francisco Bay, one is an invasive species, *Trochaminna hadai*, hailing from the seas around Japan, that probably arrived mid-century (Lesen & Lipps 2011). It liked its new home, and promptly went on to dominate most assemblages.

San Francisco Bay just happens to be one place that has been studied in this fashion. But, how about Liverpool Bay, or Skegness, or the Gulf of Cadiz, or the Bay of Naples – or the shelf seas that lie offshore? Have many biostratigraphic comparisons been made to show how standard shelly assemblages of the present compare with those earlier in this interglacial or in previous interglacials? Perhaps there's quite a lot of work of this sort out there, but if so, it has largely passed me by.

Biostratigraphy apart, there is a raft of further stratigraphic proxies out there that needs to be brought into the mix. There are chemical signals, physical sedimentary signals beyond the urban strata, climate signals – and so on, and so on. They range from the already striking – the change in carbon isotopes (from fossil fuel burning) and nitrogen isotopes (from fertilizer use) – to the barely begun, such as the warming-related sea level rise[17].

There's a lot to do here that is descriptive: to assess and weigh up the severity (as it were) of the symptoms of the Anthropocene, to judge whether the term is justifiable geologically. To do this, of course, one also has to understand better the Holocene (and the late Pleistocene, indeed), to see whether the 'Anthropocene' signals are simply a seamless continuation of trends that began much earlier. If so, the case for a separate Anthropocene interval becomes that much weaker. Indeed, the remarkable work done by the likes of Bill Ruddiman, Erle Ellis and Jed Kaplan suggests that the extent and importance of effects from early agriculture have been generally under-estimated. In the 'early Anthropocene hypothesis' that stems from such work, the clearing of forests, and the growth of rice paddies and croplands from about mid-Holocene (and earlier) times may have kept CO_2 levels stable enough to prevent the slide into the next glacial phase. So, defining the Anthropocene might become not a case of separating off a human-dominated world, and its material deposits, from an earlier natural one, but of judging if there is a clear separation between two scales and extents of human influence: one that is, say, pre-Industrial Revolution to one that has emerged more recently.

All this work, though, may help us describe the Anthropocene. It will not, though, really help us understand this phenomenon, except in purely mechanistic terms (thus: if *this* or *that* type of pressure is applied to a planetary system – how will it respond?) But, if the driver of many Earth processes is now increasingly a human one, then we need to know *what* is driving the driver. Here we are in territory that is, once more, unfamiliar to the discipline of stratigraphy, but is – *must be* – of fundamental importance to understanding this particular phase of Earth history.

What drives humans to do what they do? Survival and the passing on of one's genes comprises the simplest and the most pat of answers, but with humans, this really won't do. We are too complicated and neurotic a species for only the normal biological drives to be invoked – as one

[17] Some assessments of these stratigraphic signals are listed at the back; more are underway. All in all, there's still a fair bit of work to do.

might do for the lives of salmon, or of fruit flies, or even of lemmings. To understand the geology that we create, we need to venture into the realm of Aeschylus and Balzac, Chaucer and Dickens, and so on, and so on, all the way to Yeats and Zola[18], and beyond. We need, here, the insights of the people who had a go at charting the heights and measuring the depths of the complex and ever-changing mix of fear, ambition, pride, love, hate, altruism and selfishness that ebb and flow and find an endless variety of different combinations – and that may be expressed successively, of course, just within one human individual between the hours of dawn and dusk on a single day.

Mere survival is clearly not enough, for many individuals do not stop their activities – and hence their impact on the Earth – once their security has been assured. One has only to look at Alexander the Great, or Henry Ford, or Andrew Carnegie, or any latter-day steel baron or airline entrepreneur. What makes them run? And, to extend this line of speculation, do such individuals really change the course of a history of a world that now out-reaches the human one?

Has the course of Earth history, then, been altered not just by cosmic accidents – a good or bad position within an emerging star system, say, or chance collision with another planet – but also by the chance discoveries that influenced the growth of the mass of humans: by Louis Pasteur, or by Fritz Haber, or by 'Colonel' Edwin Drake, who first successfully drilled for oil?

This is akin to the varying views on human history, in those days when the Earth merely acted as passive backcloth for the real action. Tolstoy, for instance, ascribed the fate of empires in *War and Peace* to the larger currents of humankind, which the old, fat, half-blind General Kutuzov – forever procrastinating, falling asleep at war councils – exploited to outwit and outlast Bonaparte. The dice were already loaded by the opposed pressures of the millions of men on each side – and by the Russian winter. Not so, though, said Alexander Solzhenitsyn, in his own monumental *August 1914* (written with Tolstoy firmly in his sights), the will and the actions of a few remarkable men *can* alter history – though most of the generals he described were only remarkable in their stupidity and pigheadedness[19]. Kutuzov, to him, simply got lucky. I'm not aware that this particular question has been resolved. But Solzhenitsyn, at least, was aware that the Earth can't be simply taken for granted. An apple, he once said, can only feed so many maggots.

So, without Fritz Haber, would large-scale nitrogen fixation not have happened – or happened with such a delay that humanity's sharp rise in numbers would have been halted, for want of food? Or without Edwin Drake's doggedness (and luck) would the oil economy have been significantly postponed, and would carbon dioxide levels now be 50 ppm lower than they are? Or, alternatively, without these exceptional individuals – to take the Tolstoyan line – would their breakthroughs have happened anyway, within a year or two? – as humanity had both the need and the technological platform, and other individuals were somewhere there, only a hair's breadth from making the critical discovery.

It's a moot point. But with such drivers (contingent or not), history now looms larger – perhaps almost literally, as with more humans on Earth the tapestry on which the human narrative is woven must perforce be ever larger, but just as finely detailed [20]. But this backcloth seems likely,

[18] And naturally, there are lessons – perhaps even deeper ones – to be had from close attention to the Archers, Big Brother, Crossroads…

[19] One will resist the urge to say general pigheadedness.

[20] And the Fates – those inexorable three sisters Clotho, Lachelsis and Atropos – that weave the tapestry of our individual destinies are, presumably, growing ever more frazzled with the workload.

in a generation or two, to undergo, literally, a sea change. For the marine transgression, lagging behind those steeply climbing greenhouse gas levels, and the rising temperatures, will catch up one day. Now, this more-than-remote possibility is generally considered in terms of human living space, as our houses and our prime farmland are perforce abandoned. But part of our sense of history may become submerged also.

For, as empires have grown and collapsed and human generations have succeeded each other one by one, the Earth's geography has stayed comfortably stable as far back as written history goes, to reinforce the idea of an eternal landscape as fixed stage for the never-ending comédie humaine. That is, as far as the written word stretches back (with due allowance for Noachian echoes). And one can walk among the achievements of distant generations, on the fine streets of Amsterdam, say, and by the canals of Venice. When that will no longer be possible, one wonders what will go through the minds of those standing at the new shore's edge, and gazing out on the stranded remains of those abandoned, once-magnificent edifices?

The realization that a substantially new world is emerging, that one might regard as that of the Anthropocene, is creating, one might say, a new climate of history. In an essay with that very title, the historian Dipesh Chakrabarty noted that preoccupations of the recent past – such as the evolution of the post-colonial world, globalization, the analysis of capital, Marxist or otherwise, are no longer enough in themselves. The perspective has stretched, and such that the ages-old distinction between human and natural history is now collapsing – or perhaps, more precisely, needs to be collapsed. Nature is no longer timeless, as once assumed by students of human history (that included, I was intrigued to see, Stalin, in his *Dialectical and Historical Materialism*, which probably sold many copies, given the means of persuasion at his disposal). Nor is Nature endless, and this will set constraints on how human history will develop, and in dealing with these constraints, our actions and decisions might not always be – as Chakrabarty wrily notes – rational. Old habits of human interaction may die hard, to go by the way that (say) Ghandi's experiments in the mode and dynamics of social and political change[21] seem now to be generally ignored.

That does not, of course, stop one at least aiming for rationality. One of the Anthropocene's emerging tentacles is reaching out to the rules that govern our use of the oceans. In San Francisco, Davor Vidas, an international lawyer, spoke of questions of Earthly permanence and of the International Law of the Sea: the framework of rules that binds both humans and national ambitions – specifically the much-disputed *territorial* ambitions – once away from dry land. This framework, in its most recent version, is scarcely two decades old. Its antecedents stretch back to the *Mare Liberum* of 1609, penned initially as retrospective justification for piracy by the sharp-witted Dutch jurist Hugo Grotius[22]. From the *Mare Liberum* to the present version, the assumption is that the sea's geometry is changeless. That is clearly no longer true – at, currently, three millimetres vertical rise a year. The next iteration, Vidas said, should therefore reflect the new Anthropocene realities of constant change in the relation between land and sea. It is a shift in legal perspective that is fundamental – and seems a daunting prospect, too, in that the current legal framework, built around that prospect of a changeless ocean, is complex enough as it stands.

[21] … which Akeel Bilgrami's essay illuminates nicely: <**http://www.mkgandhi.org/articles/philgandhi.ht m**>
[22] This cautionary tale is set out in elegant and quite thought-provoking detail in Vidas 2011.

Goodness knows where all this will lead to[23]. Stratigraphically, the cat is out of the bag, and one way or another we have to chase it wherever it leads us, up garden paths, through merry dances, into deep water, into quicksand. Who would be fool enough, I sometimes wonder, to wish to measure (let alone diminish) the footprint of humanity? (even as our collective heel sinks a little deeper into the ground).

As for the cats themselves, of course, they can simply bide their time. They have happily hitched a ride with us, as we make our adventurous journey through time and space. But since we have not really domesticated them[24], they do not, of course, really need us. Once we have gone, they will likely still be here, fending for themselves, and making kittens. One day, surely, those kittens will incarnate the patterns of post-extinction radiation, and grow up to be the next tigers, in the forests of the post-Anthropocene night.

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See also: <**http://www.quaternary.stratigraphy.org.uk/workinggroups/anthropocene** />

[23] Though goodness, as was once stated in more exotic circumstances, may have nothing to do with it.

[24] It is closer to being the other way around.

PalaeoMath 101
Landmarks and Semilandmarks: Differences without Meaning and Meaning without Difference

In my last essay I showed how it was possible to use the information contained in landmarks to improve the alignment between boundary outline segments that are defined by a series of semilandmarks—the extended eigenshape approach (see also MacLeod 1999). This procedure raises the question of whether there are fundamental differences between landmarks and semilandmarks that should be respected in the context of any morphometric analysis and, if so, what techniques might be available for accomplishing this task.

Before beginning this discussion I should, in the interest of full disclosure, point out that while many practitioners or morphometricians recognize a fundamental distinction between landmarks and semilandmarks that's so basic it's hardly ever commented upon, I represent a bit of an anomaly among this practitioner group insofar as I have never really understood either the need for, or the advantages of, drawing such a distinction. In part the existence of this unfortunate blind spot in my own approach to the characterization and analysis of form stems from my personal preference for practicality over theory, consistency over special pleading, and most importantly, from my inherent suspicion that fewer errors are likely to be made if an analysis is designed to remain as close as possible to the measured geometries of the forms in question. When I undertake a morphometric analysis I always remain keenly aware that, by choosing to sample a form using either landmarks or semilandmarks, I am always under-representing the true complexity of the geometries presented to us by nature, in some cases profoundly so. If hypotheses are formulated carefully, so that there is a close match between those aspects of the forms under evaluation and those aspects that are actually being measured, this problem can be minimized. But it never goes away entirely.

Over the years I've often seen inexperienced practitioners falling into the trap of assuming that, just because they've decided to measure some specific aspect(s) of an organism's body or a component structure thereof, their results apply to the whole of the body or structure; even to those parts they have specifically not measured or sampled. Because of this I've come to see the decisions we make regarding how to sample a set of forms as the most important decisions made in any morphometric analysis. As a result, I've spent an inordinate amount of time pondering the question of how best to represent the shapes nature presents to us, given the mathematical tools we've devised for transforming what our eyes see into a form that our computers can help us assess. So, in the last three essays of this column I'm going to indulge myself a bit and focus on areas of morphometric analysis that I see as being among the most advanced and also, counterintuitively, among the most basic.

Let's get started by considering the relationship between landmarks and semilandmarks as tools for characterizing form. You'll remember from our previous discussions that landmarks are specific points on a biological form or image of a form located according to some rule.

Landmarks with the same name are presumed to correspond in some sensible way over the forms of a data set. (Slice *et al.* 2008, MacLeod 2008). It is commonly accepted across the community of morphometric practitioners that landmarks come in three varieties.

> **Type I**: a mathematical point whose [topological] homology is provided by biologically unique patterns on the form (*e.g.*, juxtaposition of tissue types, small patch of some unusual histology).
>
> **Type II**: a mathematical point whose [topological] homology is provided only by geometric, not biological or histological, criteria (*e.g.*, point of maximum curvature along a boundary).
>
> **Type III**: a mathematical point having at least one coordinate that's 'deficient' in the sense that its location is logically dependent on the location of other landmarks and/or the orientation of the specimen as a whole (*e.g.*, either end of a longest diameter, or the bottom of a concavity).

Type I landmarks are the best landmarks to use, but few locations on any form—and even fewer across forms that represent different species, genera, families, *etc.*—conform to this restrictive definition. Type II and Type III landmarks both represent concessions to practicality in terms of using mathematical points to describe complex geometries. Type II landmarks are difficult to locate precisely and consistently from form-to-form, but in principle are locations that can be represented by a single point. Type III landmarks are even more problematic because they are dependent either on the orientation of the object being measured, or the placement of other landmarks. Indeed, the definition of Type III landmarks often relies on both criteria. Nevertheless, in order to get work done in morphometrics we commonly allow landmarks to be defined by any and all of these criteria. Moreover, once defined in whatever way a data analyst sees fit, the entire set of landmarks is regarded as being equal in terms of the role each landmark plays in subsequent data analyses, with no distinctions being drawn between Type I, Type II or Type III landmarks once their definitions have been reported in the Materials and Methods sections of a technical report.

Contrast this with the manner in which semilandmarks have been treated in the morphometric literature. While Bookstein (1991) does not use the term 'semilandmark', it is clear from his discussion of Type III landmarks that he includes all "constructions [of landmarks] involving perpendiculars or evenly-spaced radial intercepts and the like.", including "Points taken as 'farthest' from other points", in this category (both quotes taken from p. 65). Bookstein (1991) describes all Type III landmarks as being "deficient" in geometric information because their placement depends on the placement of one or more other landmarks. Nevertheless, Bookstein (1991) regards Type III landmarks as landmarks and notes that this is an approach to the delineation of form encountered commonly throughout multivariate morphometrics. Subsequently, Bookstein (1997a, 1997b) formalized the term semilandmark to refer to corresponding members of a series of points that are located relative to one another by some consistent rule (*e.g.*, equal linear spacing from preceding point, equi-angular spacing according to a radius vector originating from the centroid of a closed form), with the set collectively expressing the geometry of a curve or curve segment.

Irrespective of the fact that Type III landmarks are commonly employed throughout geometric morphometrics and that all Type III landmarks are deficient in geometric information via their logical dependence on the locations of other landmarks (or semilandmarks), this sense of problematic usage rooted in the recognition of information deficiency has come to be more-or-less associated uniquely with semilandmarks. The question I'd like to raise, however, is whether it's really this easy? Are semilandmarks—either individually or as a group—so dependent on the existence of information from other parts of the form that their information content is degraded in practical terms to the extent that they form a unique and somewhat suspect category of geometric information?

Type I landmarks are (rightly) preferred for morphometric analysis because the only criteria used in their location are supplied by the biology of the forms themselves. A classic example is the point of intersection of three bones in the vertebrate cranium. Such a configuration of structures does define a point that corresponds in a topological sense across all forms in which the identity of the structural elements can be determined independently and whose relative configurations are stable across the sample of specimens of interest. As I have argued elsewhere, this criterion does not ensure that the point in question conforms to the concept of biological homology, which is a hypothesis that equates whole structures to one another rather than individual points on or within structures (see MacLeod 1999). Therefore, attempts to enfold the concept of the landmark in the cloak of unique biological respectability, and exclude semilandmarks therefrom, are … strained at best. But after dispensing with this morphometric myth (that is neatly skirted around in the formal definition of a landmark, see Slice Bookstein, Rohlf: <**http://life.bio.sunysb.edu/morp h**>, we are left with practicalities. Landmarks that are located at points internal to the outline or other boundary of a form do indeed exhibit a high degree of spatial freedom with regard to their location relative to other structures. But all landmarks placed on a boundary outline of a form, and that use the existence of that outline or boundary in their definition, exhibit diminished independence of placement that derives from the simple fact that they are constrained to lie on the form's outline or other boundary.

Once the (to my mind mistaken) notion that all landmarks have anything necessarily to do with biological homology and exhibit inherently greater degrees of independence from aspects of the form than semilandmarks *per se*, we're in a much better position to appreciate the geometric challenge posed by the need to characterize outlines/boundaries as opposed to point locations internal to an object's outline and/or away from a boundary of interest. Boundary outlines are often complicated structures whose forms encode information about their own shapes, their own sizes, and their positions relative to other aspects of the form. Most analyses of biological morphology need to locate these structures and represent their forms in order to test reasonable biological hypotheses. But owing to their complexity such structures cannot be represented by a single point location or landmark in the way some (not all) other structures of interest can be located. A representation involving multiple points is required; and therein lies the rub. The problem of semilandmarks in the context of a morphometric analysis does not derive fundamentally from the geometric dependence of the locations of individual semilandmark points relative to one another. Rather, it derives from the fact that, in many instances, so many semilandmark points are used to represent the form and position of a boundary outline that variation in these structures can overpower the information provided by those aspects of the form that can be represented by unitary landmarks. For this reason discussions of the use of semilandmarks inevitably focus on strategies that can be used to down-weight their influence relative to that provided by landmarks. As with so many of the decisions we must make in any form of data analysis, the real issue boils down to a question of balance (see Bookstein 1991, Zelditch *et al.* 2004).

What are the strategies we might use to achieve an appropriate balance between landmark and semilandmark datasets in the context of a morphometric investigation, and how well do they work? Perhaps the simplest is to refuse to allow any of the information contributed by semilandmarks to participate in any way in the analysis of geometric morphometric data. Under this strategy the semilandmark points are, either tacitly or explicitly, regarded as representing an 'image' of the form that can be carried along passively in the context of an analysis whose outcome is controlled entirely by the information provided by landmarks. In these cases the point of including semilandmark data at all appears to be either (1) to make more aesthetically appealing graphics, and/or (2) to aid interpretation of the landmark-based analytic results. Usually this approach to the "analysis" of semilandmark data is implemented by passively mapping the semilandmark data onto a deformation field such as that specified by coordinate point shape models (see MacLeod 2009a) or a thin-plate spline (see MacLeod 2010; see Fig. 1). Such analyses are sometimes referred to as "image warping". Of course the problem with this approach is that the biological information encoded by the semilandmark data—information that is often of direct relevance to the analysis being undertaken—is not being used to inform the analytic result.

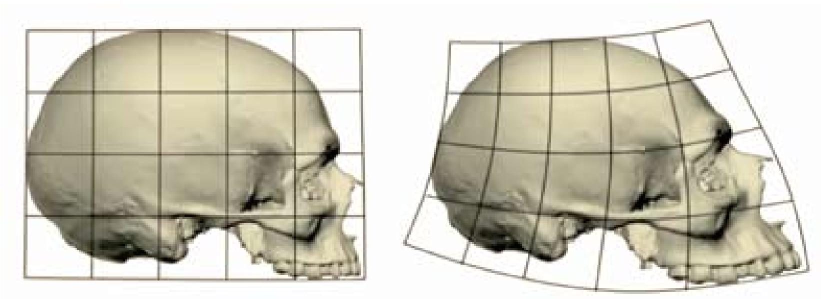

Figure 1. Example of an image of a human cranium being deformed passively using the geometric conventions of a thin-plate spline. This sort of analysis of semilandmark data can be used to inform biological interpretation of the deformation, but in doing so it must be remembered that no information from the image was used to inform the analysis.

In some cases sequestration of the information provided by an assessment of boundary curve form may be appropriate. In other cases it clearly is not. This is a judgement that must be made by the data analyst. Regardless, in all cases it is a decision the data analyst makes knowing that other approaches are available that can be used to combine the information provided by these two types of morphometric descriptors.

An obvious alternative series of approaches to the challenge posed by boundary curves involves numerical adjustment of the weight assigned to semilandmark data in the context of an analysis. Zelditch *et al.* (2004) suggest that landmark data be weighted differentially relative to semilandmark data by assigning a weight coefficient to each coordinate point used to achieve *Procrustes* superposition, and making a distinction between landmarks and semilandmarks in the design of this weighting scheme. There are two disadvantages to this approach. First, as the resulting shape coordinate data will not lie within the Kendall shape space (see MacLeod 2009b), distortions will be introduced to the ordination of forms within the linear projection space used by geometric morphometricians to represent similarities and differences across a sample of shapes and/or model the character of geometric changes represented by that space. This is, perhaps, not as serious an issue as it might appear on first inspection since the projected positions of specimens within the shape space, and the models calculated on the basis of the shape space, will be accurate representations of the character of shape variation as specified by these weighted data. In other words, not being able to employ the elegance of the Kendall shape space does not mean we are unable to obtain the ordinations and/or models we seek or that these ordinations/model are not useful. A more serious concern has to do, inevitably, with how to go about determining which of an essentially infinite set of possible weighting schemes is most appropriate to our sample and to the biological problem at hand. Unscrupulous practitioners could, of course, inappropriately influence the result of an analysis through informed adjustment of the weighting scheme. But even well-meaning data analyses can employ different, though equally well justified, weighting schemes that produce different analytic results. Without biologically informed guidance to specification of the weighting scheme—guidance that is unavailable at present—there is no way to determine which of the many different results that can be generated in this way to believe.

A strategy related to the differential weighting of landmarks and semilandmarks is to allow both types of information to participate in the *Procrustes* alignment of data collected from the specimens, but to reduce the number of semilandmarks used in the subsequent analysis of these data. Reduction of the discrepancy between the number of landmarks and the number of semilandmarks used in a *Procrustes* PCA or *Procrustes* CVA analysis has the effect of down-weighting the influence of the semilandmark dataset without requiring specification of a particular weighting scheme. But the problem of choice remains. Which semilandmarks do you remove from consideration, and why? What's the biological justification for removing some, but not others? How does your particular choice in this regard affect the results you obtain? And how to you resolve conflicts between results that are obtained by removing different points from consideration? There are no easy or fully satisfying answers to these questions at present.

For me, the way out of this weighting conundrum (in most cases) is to focus on the analysis of only those aspects of the form that really are critical to testing specific hypotheses, and to use complexity weighting (see MacLeod 2012) to determine the number of semilandmark points necessary to represent the shape of an outline or boundary curve to a consistent level of geometric accuracy for all specimens across a sample. In far too many cases I see analyses in which too many aspects of a form were included in the dataset. This renders the analysis overly complex and can serve to obscure biologically important aspects of form variation in a morass of information from different regions of the form. Qualitative systematists routinely atomize the morphologies of the specimens they analyse into their component parts and conduct what are, in effect, separate analyses of each character and/or character complex. If more morphometricians adopted this approach—as opposed to trying to include all aspects of a form in a single analysis

—simpler and more informative comparisons could be made (*e.g.*, compare the results obtained by Naylor 1996 and MacLeod 2002). Improving the focus of a morphometric problem by reducing its scope also often provides the flexibility necessary to achieve a better balance between data derived from landmarks and semilandmarks, especially when complexity weighting is employed. Indeed, it's often surprising how few semilandmark points are required to represent a seemingly complex curve to an *a priori* specified level of geometric fidelity.

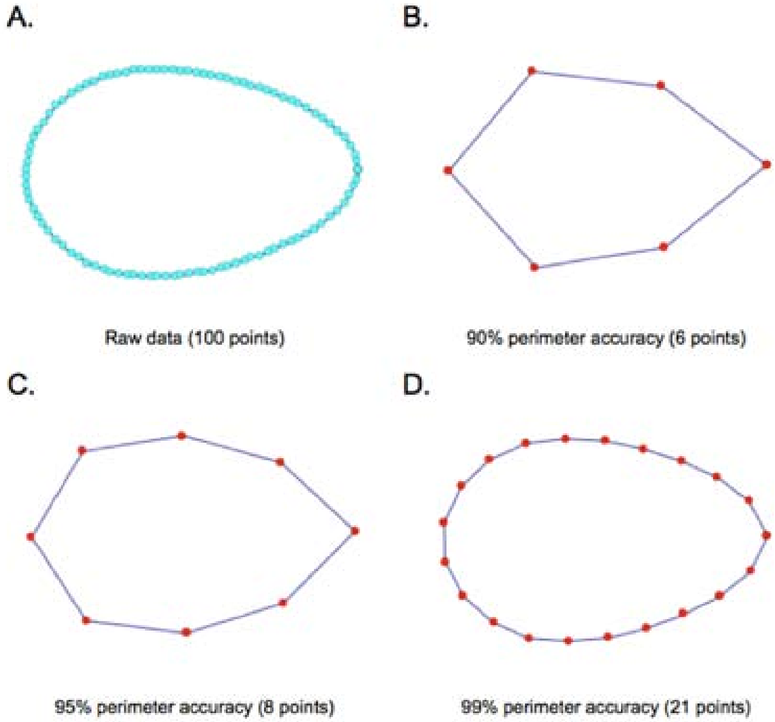

Figure 2. Estimation of the number of equally spaced semilandmark points necessary to represent the geometry of the boundary outline of an Apus apus *(Swift) egg as assessed by complexity weighting (see MacLeod 1999, 2012). Note that the apparent irregularities in the spacing of the raw data points are due to rounding error in the calculation of the digital plots from which this figure was assembled.*

Even more importantly, as the spacing between adjacent semilandmark points increases, the degree of constraint exerted on the location of any individual semilandmark point by points preceding it in the sequence decreases. In this way there exists a complete spectrum of dependencies between landmark points which includes semilandmarks; from Type I landmarks whose positions are virtually independent of all other points around them to adjacent semilandmarks along an oversampled outline or boundary curve whose inclusion adds little biological or topological information, but much (needless) computation, to a data analysis problem.

All the semilandmark data weighting methods described above have one thing in common that is also important to appreciate. They all reflect primary assessments of the form or forms in question. Regardless of the density of landmark specification and/or semilandmark sampling, under the schemes proposed above all the data collected represent assessments of observed morphology of the specimens included in the sample. To my mind this is something of an inviolable requirement of all morphometric investigations. We might argue about sampling methods, landmark definitions, and semilandmark spacing schemes. But so long as our data represent observed biological reality at least we're not going to have to argue about the reality of the shapes themselves. While this might seem such an obvious requirement it doesn't need discussion, there is a popular procedure used to analyse semilandmark data that I have concerns about in this area; the so-called sliding semilandmark approach.

The method of sliding semilandmarks was developed by Green (1996) and Bookstein (1997) as a way of addressing the issue of semilandmark interdependence. Basically, this procedure takes a series of user-designated semilandmark points that have been transformed into a Kendall shape space via *Procrustes* alignment and adjusts their positions iteratively along lines tangent to the boundary outline curve, sliding them backwards or forwards along these tangents until the bending energy is minimized between the semilandmark configurations of each specimen and the *Procrustes* reference configuration (usually the mean shape). This procedure is applied, specimen-by-specimen, until each specimen's total bending energy is minimized relative to the reference. Once all specimens have been reconfigured in this manner, the new shape-coordinate configurations are collected together and submitted to a PCA, CVA, allometric regression or some other procedure to assess modes and patterns of form or shape variation across the sample. As noted by Zelditch *et al.* (2004), the justification for changing the positions of the semilandmarks is that these are, to some extent, the product of a sampling convention (usually equal inter-semilandmark spacing) that is artificial biologically and so contributes a component of shape variation that is not part of the biology of the system. In the view of users of this approach they are "correcting" their data for the artificial constraint of equal semilandmark spacing and achieving a better biological placement of the semilandmarks relative to one another.

While the mathematics that underpin the sliding semilandmark method are unquestionably elegant (though too complex to be described in detail here; see the references I've given above for a full presentation of the mathematics), I remain unconvinced that this approach has either theoretical or practical value. Even more importantly, application of this method produces shape data that might look reasonable on first inspection, but that correspond to no shapes that have ever been observed in nature. Allow me to explain.

There are three issues that bother me about sliding semilandmarks, any one of which I regard as a fatal flaw. The first, and most obvious, is that adjustment of the semilandmark positions is not taking place along the boundary outline curve itself. Rather, the semilandmarks are being slid along tangents to the boundary outline curve. This convention is purely one of computational convenience. It is easier to calculate the new positions of the semilandmark points if they are adjusted along a linear trajectory than along a complex, curvilinear function. But the situation is, in a sense, even worse than this. In implementing this procedure it is usually the case that a relatively wide inter-semilandmark sample spacing is used to constrain the boundary outline curve (Fig. 3). The coarseness of this spacing means that the tangents used to constrain

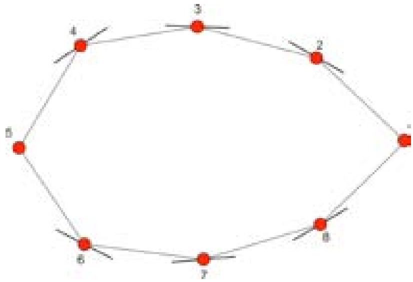

Figure 3. Lines drawn tangent to the curve of an Apus apus *egg outline sampled using 8 equally spaced points. Here only points 2-4 and 6-8 are regarded as semilandmarks. These tangents are defined as the line that forms a constant angular relation with the chords drawn between the semilandmark in question and points preceding and following it in the point sequence. It is along these lines that adjustments to the semilandmark positions occurs. Note that any change in the position of any of the semilandmarks along these tangent lines takes the landmark away from the measured boundary outline curve. Note also that the orientations of these tangent lines themselves —as assessed under even the comparatively high-relation sampling scheme used here (95% accuracy of the perimeter, see Fig. 2C)—is inaccurate relative to the actual curve (see Fig. 2A).*

adjustment of the semilandmark positions are themselves poor estimates of the true tangents to the boundary outline curve at the semilandmark points. Even if that were not the case, however, adjusting the semilandmarks along tangents to the boundary outline curve forces the points in question to be moved off the boundary outline curve *to positions at which there is no boundary outline curve*. This violates what is, for me, a fundamental requirement of all morphometric procedures; that the forms or shapes submitted to analysis represent the true geometries of the forms and shapes present in the sample of biological specimens from which the data were collected (Fig. 4). In addition, constraining the semilandmarks to be slid along “tangents” to the boundary outline curve represents (to me) as artificial a constraint as enforcing strict equality of inter-semilandmark spacing. This procedure does not relax the artificiality of semilandmark placement; it compounds it, and does so in a manner guaranteed to produce a result that is both artificial and unreal.

My second objection to sliding semilandmarks is that the parameter used to control the sliding for the purpose of achieving a more biologically reasonable shape coordinate configuration—bending energy—has no biological status whatsoever. No known developmental, ecological, or evolutionary process operates in such a way as to minimize the bending energy of the mathematical points that morphometricians use to represent biological form(s). Bending energy is nothing more than an arbitrary index that morphometricians use to describe spatial similarities and differences between shapes. This index is the result of a mathematically simple calculation (see MacLeod 2010) and expresses shape change as a deformation metaphorically analogous to the form an infinitely thin, uniform, semi-rigid plate would take if it were bent to touch the ends of the pair-wise form/shape displacement vectors that characterize each landmark location.

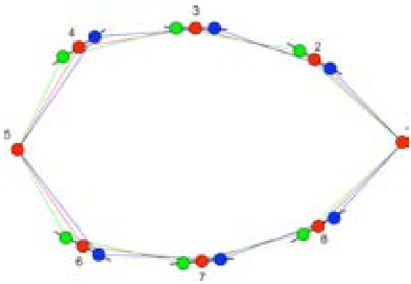

Figure 4. Simple illustration of the range of shape error that can be generated under end-member repositionings of semilandmarks uniformly toward one end of the sample form (blue shifts) or the other (green shifts). Note that representational errors are greatest in those regions of the form where the rate of curvature is the greatest. These are precisely the regions that contain the most shape variation and so are usually of the greatest biological interest.

Bending energy provides a mathematically convenient means of summarizing overall degrees of form-shape difference as a distance. That's all. Since organismal bodies are not infinitely thin, uniform, semi-rigid plates, and since no biological process takes the slightest account of bending energy as a controlling parameter, the minimization of bending energy has no biological status. For this reason bending energy *per se* cannot be used as a basis for the adjustment of semilandmark positions to a configuration that is any more, or less, biologically reasonable than the original configuration. In addition, the algorithms used to find the minimum bending energy provide neither a unique, nor a global, solution to the minimization problem. Alternative configurations of landmark displacements can have the same bending energy and there is no guarantee that the solution found in any specific instance will be optimal globally.

As serious as my previous objections to sliding semilandmarks are, they pale (for me) beside my third objection, which is that for the overwhelming majority of cases—especially those cases in which boundary curves have been sampled at a level of resolution commensurate with their geometric complexity—sliding semilandmarks to new, bending-energy-minimized configurations makes little or no practical difference to the results obtained. Obviously, for a boundary outline curve that has been sampled densely (*e.g.*, Fig. 2A, 2D) there is little scope for the semilandmarks to be adjusted lest they move past each other in the sequence; which would effectively destroy the geometry of the boundary outline. For curves that are less densely sampled, there is scope for substantial movement along the (inaccurately placed) tangents. Nevertheless, in practice semilandmarks are rarely slid to radically new positions. To illustrate this, consider the following sample of bird egg outline shapes (Fig. 5).

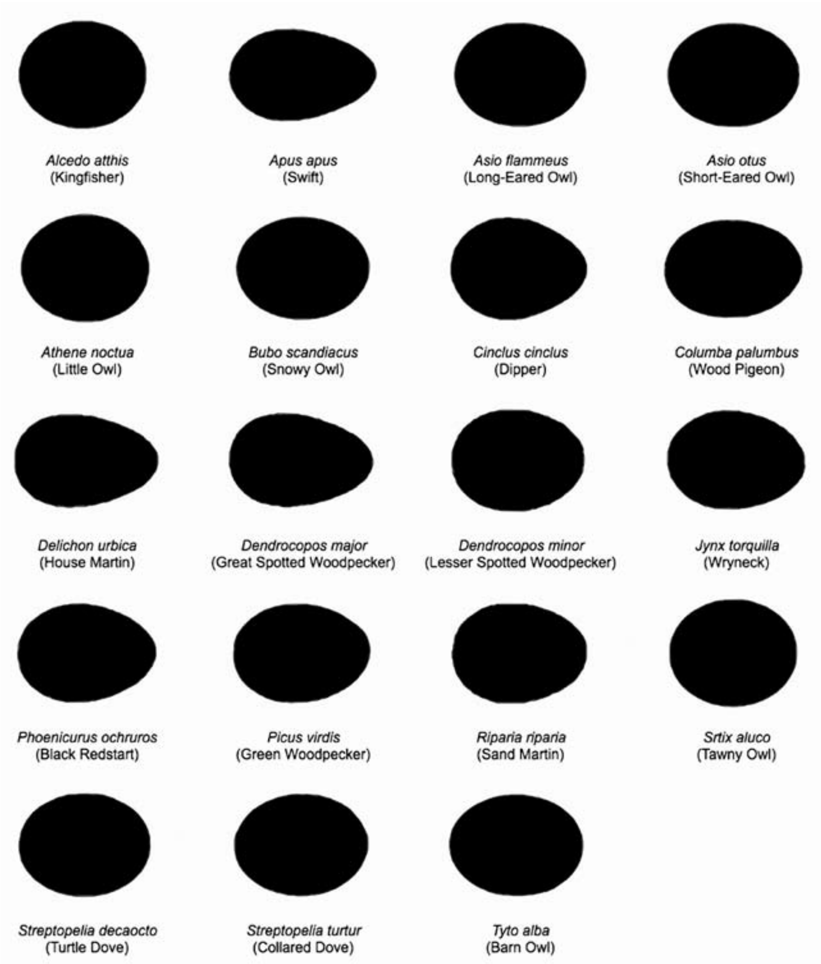

Figure 5. Outlines of a small sample of bird eggs that will serve to illustrate typical results of a sliding semilandmark analysis.

The original outlines were all collected at a resolution of 100 equally spaced points. These were then interpolated to 10 points for the purposes of analysis. This interpolation achieves a geometric accuracy of 97.5 percent of the measured outline's perimeter across the sample. In all cases the point at the narrow end of the outline's major axis was used as the starting point for digitization. Both endpoints of the major axis (points 1 and 5) were regarded as landmark points, with points 2-4 and 6-10 designated as semilandmarks.

Jim Rohlf's tpsRelW program was used to conduct the sliding semilandmark analysis. Both raw *Procrustes* and sliding semilandmark-adjusted *Procrustes* datasets were saved, and these were submitted to *Procrustes* PCA analysis to summarize the extent to which semilandmark sliding affected the results. A plot of the ordination results of both analyses is provided as Figure 6.

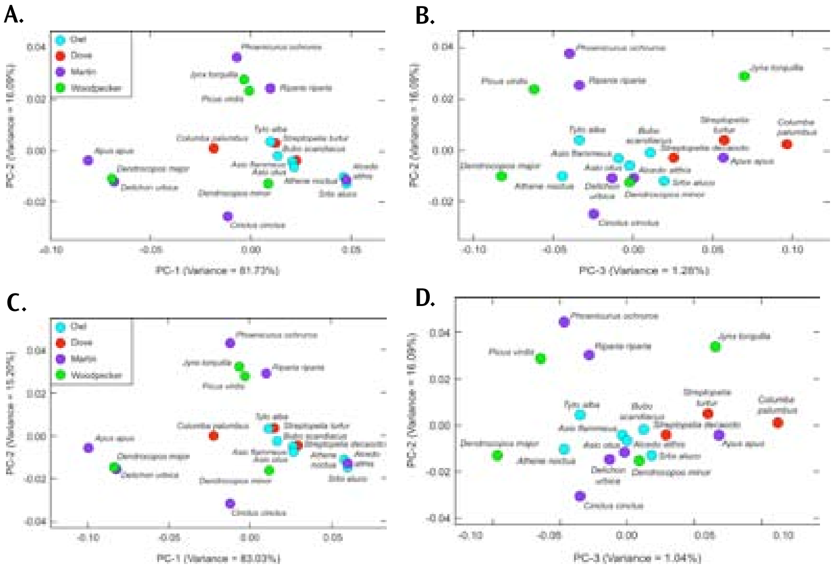

Figure 6. Results for raw (A, B) and sliding semilandmark (C, D) Procrustes *PCA analyses. See text for discussion.*

As can be seen by close comparison of the PCA space ordinations in figures 6A-6B (raw *Procrustes* PCA) and 6C-6D (sliding semilandmark *Procrustes* PCA) the datasets are very similar. Aside from minor differences in the eigenvalue coefficients and a slight drift of the *Dentrocopus minor* (Lesser Spotted Woodpecker) egg shape toward the *Strix aluco* (Tawny Owl) egg shape on the PCA-3 axis, they are essentially identical. It is highly doubtful that any important information was gained by employing the semilandmark sliding procedure. Moreover, when the propensity for—I would say guarantee of—error as a result of the sliding operation is taken into consideration, it is debatable which result is the (marginally) more accurate. Were I a betting man I'd put my money on the raw *Procrustes* PCA result, always.

The differences between landmarks and semilandmarks are real in the sense that they are different types of mathematical tools that were developed originally to quantify different aspects of biological form. You can use one type of tool to perform the function of the other (*e.g.*, use landmarks to quantify boundary outline curves) in the same way that you can use a screwdriver to hammer a nail into a piece of wood. The question isn't one of capability, but of appropriateness. In the same way that mechanical jobs get done more quickly, more easily, and with a better result when you use the proper tools in the proper way, morphometric analyses proceed more quickly, and interpretations are arrived at more easily with less ambiguity, when you use the proper conceptual and mathematical tools. So don't be afraid to use semilandmarks in your analyses. In many situations they will be your only realistic hope of obtaining results that are relevant to the biological problem you're interested in. Even in those cases in which it is profitable to combine semilandmarks and landmarks in the same analysis, a little creativity will usually lead to a form sampling solution that allows both types of data to participate in the analysis in ways that enhance and clarify, rather than obscure and complicate, the result.

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Don't forget the *PalaeoMath 101* web page, at:

<**http://www.palass.org/modules.php?name=palaeo_math&page= 1**>

>>*Future* Meetings of Other Bodies

Volcanism, Impacts and Mass Extinctions: Causes and Effects
The Natural History Museum, London *27 – 29 March 2013*

London's Natural History Museum will host an international, multi-disciplinary conference that brings together researchers across the geological, geophysical and biological disciplines to assess the state of research into the causes of mass extinction events. The main goal of this conference will be to evaluate the respective roles of volcanism, bolide impacts, sea level fluctuations and associated climate and environmental changes in major episodes of species extinction.

Check the conference website at <**http://massextinction.princeton.edu/**> for more information.

Huguenots of Spitalfields Festival
London, UK *8 – 19 April 2013*

This is a two-week festival celebrating the legacy of the Huguenot silk weavers who came to live in Spitalfields in London at the end of the 17th century to avoid religious persecution in France.

On Tuesday 16th April, Dr Margaret Clegg, Head of the Human Remains Unit at the Natural History Museum, London will give a talk at Christ Church, Spitalfields entitled 'Life and Death in Spitalfields: the human remains from Christ Church crypt 30 years on'.

Tickets cost £7, with £5 concession tickets available. Tickets can be booked in advance at <**http://www.spitalfieldsmusic.org.uk/whats-on/other-events/life-after-death/**> or telephone 020 73771362.

The 6th International Congress on Fossil Insects, Arthropods and Amber
Byblos, Lebanon *14 – 18 April 2013*

The Lebanese University, Faculty of Sciences II, and Municipality of the city of Byblos together with the International Palaeoentomological Society invite you to the 6th International Congress on Fossil Insects, Arthropods and Amber in Lebanon. This congress will take place in Byblos, the ancient biblical city that gave the alphabet to the World.

A series of scientific sessions and special group meetings will be organised. The mid-conference field excursion will visit the Jeita cave archaeological site, and the post-conference field excursion will visit the Lower Cretaceous outcrops (containing amber) of Mdeyrij-Hammana, Central Lebanon, and Jezzine, Southern Lebanon.

The conference venue will be in the *ontoch* (monastery) of Saint John-Mark (built in 1766), Byblos city. The opening ceremony will be held in the Lebanese University, Faculty of Sciences II, Fanar. The official language of the congress is English.

Selected papers submitted for the Congress will be published by Brill in special issues of *Insect Systematics & Evolution* and *Terrestrial Arthropod Reviews* and in a book that will contain papers dealing with geology, chemistry and taphonomy of amber and fossil insects outcrops; see <**http://brill.nl/ise**> and <**http://brill.nl/tar**>.

Please contact Prof. Dany Azar (e-mail <**azar@mnhn.fr**>) for more information.

30th Midcontinent Paleobotanical Colloquium
Chicago Botanic Garden in Glencoe, Illinois, USA *26 – 28 April 2013*

The Plenary Speaker will be William DiMichele, National Museum of Natural History, Smithsonian Institution. There will also be an excursion to Garfield Park Conservatory and Field Museum paleobotanical collections.

Please contact the organizers for more information: Patrick Herendeen, Chicago Botanic Garden (e-mail <**pherendeen@chicagobotanic.org**>) or Ian Glasspool, The Field Museum (e-mail **iglasspool@fieldmuseum.org**).

The Carboniferous–Permian Transition
New Mexico Museum of Natural History and Science, Albuquerque, New Mexico, USA *20 – 22 May 2013*

This is an international meeting devoted to all aspects of Carboniferous–Permian geology, with special emphasis on the Carboniferous–Permian transition.

In addition to talks and posters, there will be a pre-meeting fieldtrip to the Carboniferous–Permian transition section at Carrizo Arroyo, central New Mexico, an afternoon trip to the Late Pennsylvanian Kinney Brick quarry, and a post-meeting fieldtrip to Pennsylvanian-Permian rocks exposed in Joyita Hills–Cerros de Amado east of Socorro, New Mexico.

Proceedings of the symposium and a field guide will be published by the New Mexico Museum of Natural History and Science. Contributions on all aspects of Carboniferous and Permian geology are appropriate for the proceedings. Contributions to the proceedings can range from abstracts to full length articles. You do not need to attend the meeting to contribute to the proceedings volume. For further information contact Spencer G. Lucas (e-mail <**spencer.lucas@state.nm.us**>).

Rio Ptero 2013 – International Symposium on Pterosaurs
Museu Nacional/UFRJ, Rio de Janeiro, Brazil *23 – 26 May 2013*

We will accept contributions on pterosaurs and related topics. You will be able to examine pterosaurs and other fossils in the collections of Museu Nacional (MN/UFRJ) and Museu de Ciências da Terra (DNPM) while in Rio. Palaeoartists who wish to expose their work during the course of the meeting are also welcome.

Please visit the conference website for more information:
<**http://www.museunacional.ufrj.br/riopterosaur/museu_nacional.html**>.

2013 International Conference on Geology and Geophysics
Beijing, China *16 – 18 June 2013*

The 2013 International Conference on Geology and Geophysics (ICGG2013) is organized by the Engineering Information Institute and co-sponsored by Scientific Research Publishing. It brings together industry professionals and academics from companies, government agencies and universities around the world to exchange information.

All the accepted papers will be published by *Open Journal of Geology* (ISSN: 2161-7570), a peer-reviewed open-access journal that has been tracked for impact factors by Thomson Reuters (ISI) and indexed by CrossRef, DTU, Worldcat, *etc*. Researchers around the world will have full access to all the published articles, ensuring greater visibility of your published work. For more information, please visit the journal website at <**http://www.scirp.org/journal/ojg/**>.

Please visit the conference website at <**http://www.engii.org/workshop/icgg2013/**> for more information. The deadline for full paper and/or abstract submission is 15th March 2013; acceptance notification is scheduled for 25th April 2013.

11th European Course on Basic Aerobiology (ECBA)
Vinnitsa, Ukraine *4 – 10 July 2013*

The next, 11th, ECBA will take place in Vinnitsa, Central Ukraine in a joint collaboration of the European Aerobiology Society (EAS), the Vinnitsa National Pirogov Memorial Medical University (VNMU), and the Ukrainian Association of Aerobiologists (UAA).

Please visit the conference website at <**http://11bca.vnmu.vn.ua/**> or contact Victoria Rodinkova (e-mail <**11bca@vnmu.edu.ua**>) for more information.

Pollen & Spore Master Class
Utrecht, The Netherlands *8 – 12 July 2013*

This course aims to provide instruction on the taxonomy of terrestrially derived palynoflora, chronstratigraphy, palaeoecology and palaeoclimate throughout the Phanerozoic. Age-specific topics and lectures will be accompanied by extensive microscope workshops. There will be a half-day field-trip to the type locality at Maastricht.

Expected course fees: €300 (students), €600 (Academic/Consultant), €1000 (Industry). For more information please contact Thomas Demchuk (e-mail <**thomas.d.demchuk@conocophillips.com**>).

2nd International Congress of Agora Paleobotanica
Ariño, Teruel, NE Spain *9 – 13 July 2013*

A CONGRESS IN THE COUNTRYSIDE is an international meeting supported by the Agora Paleobotanica which will last four days in Ariño, a small village in Teruel region, northeastern Spain. Agora Paleobotanica is a new organization originating from the OFP (Phrancophone Organization of Palaeobotany).

The meeting provides an open forum for all that is exciting and new in the fields of palaeobotany and palynology conducted by palaeobotanists of the Southwest European region. It also offers a range of field-trips visiting different Early Cretaceous sites of primitive angiosperms of Albian–Cenomanian age, such as the Castellote Cretaceous trunk site, Dinopolis museum with a large number of palaeontological remains including dinosaurs and Miocene macroflora site (Konservat-Lagerstätten) in Rubielos de Mora.

Details are at <**http://www.grupopaleobotanicaiberica.es/eventos/congresos/arino2013.htm**>. Please contact <**arino2013@grupopaleobotanicaiberica.es**> for further information. The abstract submission deadline is 30th May 2013. The deadline for early-bird registration is 15th May 2013.

11th INTECOL Congress, Ecology: Into the next 100 years
London *18 – 23 August 2013*

The '11th INTECOL Congress, Ecology: Into the next 100 years' will be held in London as part of the centenary celebrations of the British Ecological Society. The theme of the Congress is advancing ecology and making it count, and will present world class ecological science that will truly move the science forward.

Activities will include a symposium on 'Process-based approaches in macroecology', an international macroecology social, and a workshop with Thiago Rangel.

Further information is available on the INTECOL 2013 website at <**http://intecol2013.org/**>. The deadline for early-bird registration is 5th May 2013.

9th European Palaeobotany–Palynology Conference
Padua, Italy *26 – 31 August 2014*

The Italian group of palaeobotanists and palynologists is very glad to be able to invite all of you to Padova in 2014 for the next EPPC.

Padua (Padova in Italian) is a picturesque, historic city in Northern Italy (about 40 km west of Venice), with a dense network of arcaded streets, large communal "piazza" (squares) and many bridges crossing the various branches of the Bacchiglione.

All scientific sessions will be held at the new Department of Geoscience, and the famous Botanical Garden and Museum of Geology and Palaeontology will be involved in this conference. Field-trips are planned in the fascinating landscapes of the Dolomites, Sardinia, Emilia-Romagna, Latium and Tuscany.

For further information contact the conference secretary (e-mail <**Evelyn.Kustatscher@naturmuseum.it**> or look for updates on the conference website at <**http://www.geoscienze.unipd.it/9th-european-palaeobotany-palynology-conference**>.

The 61st SVPCA, the 22nd SPPC, jointly meeting with the GCG
National Museums Scotland and University of Edinburgh *27 – 31 August 2013*

The 61st Symposium of Vertebrate Palaeontology and Comparative Anatomy (SVPCA) and the 22nd Symposium of Palaeontological Preparation and Conservation (SPPC) will be holding this joint meeting with the Geological Curators' Group (GCG).

This year the meeting will include a symposium celebrating the life and contribution to vertebrate palaeontology of Stan Wood. The meeting will be followed by a field trip to important Palaeozoic fossiliferous sites in the Scottish Borders.

Platform and poster presentations on all aspects of vertebrate palaeontology are invited for SVPCA, and on all aspects of geological and palaeontological preparation, conservation and curation for the combined SPPC/GCG meeting. Further details for both meetings will be available in the first circular, which will be circulated in March. If you are interested in attending either of these meetings and would like to be included on the mailing list, please contact Stig Walsh (e-mail <**s.walsh@nms.ac.uk**>) for SVPCA or Vicen Carrió (e-mail <**v.carrio@nms.ac.uk**>) for SPPC/GCG.

Organisers: Nick Fraser, Stephen Brusatte, Stig Walsh and Vicen Carrió.

International Summer School "Methods of Palaeoenvironmental Researches"
Moscow, Russia *11 – 14 September 2013*

The international scientific community is invited to an International Summer School on 'Methods of palaeoenvironmental researches' in order to discuss the latest developments in pollen analysis and data interpretation. Further information will be available at <**http://pollendata.org/**>.

2nd International Joint Congress APLE-APLF on "Pollen Diversity and Function in a Changing Environment"
Madrid, Spain *17 – 20 September 2013*

The Spanish and French Palynological Societies, APLE and APLF, will join for their next Symposium in Madrid on 17–20 September 2013. Under the general title of 'Pollen Diversity and Function in a Changing Environment' and organized by CSIC and Complutense University palynologists, the two societies will meet to present and discuss their recent findings on relevant palynological topics.

Further information is available at <**http://pollen2013.com/**>. The deadline for abstracts is 19th April 2013.

17th Evolutionary Biology Meeting at Marseilles
Marseilles, France *17 – 20 September 2013*

The Evolutionary Biology Meeting at Marseilles is an annual congress, which has gathered high-level experts in evolutionary biology since its creation in 1997.

The following subjects will be discussed: Evolutionary biology concepts and modelisations for biological annotation; Biodiversity and Systematics; Comparative genomics and post-genomics (at all taxonomic levels); Functional phylogeny; Environment and biological evolution; Origin of Life and exobiology; Non-adaptative versus adaptative evolution; The «minor» phyla: their usefulness in evolutionary biology knowledge.

Further information is available on the conference website at <**http://sites.univ-provence.fr/evol-cgr/**>.

4th International Palaeontological Congress (IPC 2014) to include the 47th AASP-TPS (AASP – The Palynological Society) Annual Meeting
Centro Científico Tecnológico, Mendoza, Argentina *28 September – 3 October 2014*

Local organizers are planning a comprehensive Congress with an intellectually motivating scientific programme. The Congress will create opportunities for participants to present and share experiences, explore new directions and debate topics among specialists from across the globe. The meeting will include the 47th AASP-TPS Annual Meeting.

A varied array of meeting styles with a combination of keynote lectures, special symposia on leading issues, interactive workshops, technical sessions, and short courses promises to hold sessions of interest to all palaeontologists.

Delegates will have the opportunity to enjoy a wide range of conference excursions to rich and well-known Argentinean palaeontological sites involving a combination of scientific and touristic attractions. The schedule of field-trips covers superbly exposed sedimentary successions, representing a great diversity of marine and continental palaeoenvironments, and encompasses nearly all of the stratigraphic record.

Organisers for the 47th AASP-TPS Annual Meeting are now calling for Symposium topics. If you have any great ideas for palynology-related symposia, please feel free to contact Thomas Demchuk (e-mail <**tdemchuk@swbell.net**>.

Please see the conference website at <**http://www.ipc4mendoza2014.org.ar/**> for further details.

46th Palynological Society Annual Meeting
San Francisco, USA *20 – 24 October 2013*

The 46th AASP-TPS (AASP: The Palynological Society) Annual Meeting will be a joint meeting with DINO 10, Canadian Association of Palynologists, and the North American Micropaleontology Section of SEPM (NAMS).

The meeting will be held in the heart of San Francisco at the Hotel Whitcomb, which has been chosen for its location, its historic elegance, its proximity to everything San Franciscan, and its excellent conference facilities. A large block of rooms has been reserved at the conference hotel for delegates. Field trips will include a pre-meeting field-trip to Napa Valley, Muir Woods, Golden Gate Bridge, *etc.*, and a post-meeting field-trip to either Sierra Nevada or Santa Cruz.

San Francisco (SF) is located on beautiful San Francisco Bay in coastal central California on the west coast of the United States. SF is a tourist destination recognized worldwide with such major attractions as the Golden Gate Bridge, Alcatraz Island, cable cars, beautiful beaches, redwood forests, Napa Valley wine country, *etc*. These popular features should help attract palynologists and their families from around the world to visit and maybe spend a few extra days vacationing in the Bay Area. To take advantage of the excellent weather during early Fall, the meeting is scheduled for 20–24 October 2013 – 30 years to the week after the 16th annual meeting held in SF in 1983.

Further information will be available in due course on the Palynological Society website at <**http://www.palynology.org/**>, or contact Lanny Fisk (e-mail <**Lanny@PaleoResource.com**>.

10th North American Paleontological Convention
Gainesville, Florida *February 2014*

The meeting will be hosted by the Florida Museum of Natural History (University of Florida) from 15th to 18th February (Saturday to Tuesday). Pre-conference and post-conference field-trips are tentatively planned for 13–14 and 19–20 February.

Check the Paleontological Society website at <**http://www.paleosoc.org/**> for updates.

Commission Internationale de la Microflore du Paléozoïque International (CIMP)
Ghent-Liège, Belgium *6 – 11 July 2014*

This meeting will include general CIMP sessions, chitinozoan workshops and a field-trip between Ghent and Liège. For more information please contact <**p.steemans@ulg.ac.be**>.

9th European Palaeobotany-Palynology Conference
Padua, Italy *26 – 31 August 2014*

The Italian group of palaeobotanists and palynologists is very glad to be able to invite all of you to Padova in 2014 for the next EPPC. Padua (Padova in Italian) is a picturesque, historic city in Northern Italy (about 40 km west of Venice), with a dense network of arcaded streets, large communal "piazza" (squares), and many bridges crossing the various branches of the Bacchiglione.

All scientific sessions will be held at the new Department of Geoscience, and the famous Botanical Garden and Museum of Geology and Palaeontology will be involved in this conference. Field-trips are planned in the fascinating landscapes of the Dolomites, Sardinia, Emilia-Romagna, Latium and Tuscany.

For further information contact the conference secretary (e-mail <**Evelyn.Kustatscher@naturmuseum.it**>) or look for updates on the conference website at <**http://www.geoscienze.unipd.it/9th-european-palaeobotany-palynology-conference/**>.

9th International Congress "Cephalopods – Present and Past" (ISCPP 9) and the 5th International Coleoid Symposium
University of Zurich, Switzerland *4 – 14 September 2014*

This series of cephalopod meetings was launched in the seventies in York. Thereafter, they were held every three or four years in various cities including Tübingen, Granada, Vienna, Fayetteville, Sapporo and Dijon. It is the only occasion in which cephalopod workers meet from around the world. 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 slightly more palaeontologists. This might change at the 2014 meeting, however, since it will host the International Coleoid Symposium for the first time.

Traditionally, two field-trips are offered in association with the meeting. On this occasion, trips are planned to the Fossillagerstätten of southern Germany, and fossil localities yielding cephalopod fossils in Switzerland, each of which will last a couple of days. Details of these field-trips will be announced in due course.

For further information please visit the conference website at <**http://www.pim.uzh.ch/symposia/ISCPP9/index.php**>.

4th International Palaeontological Congress (IPC 2014) to include the 47th AASP-TPS (AASP – The Palynological Society) Annual Meeting
Centro Científico Tecnológico, Mendoza, Argentina *28 September – 3 October 2014*

Local organizers are planning a comprehensive Congress with an intellectually motivating scientific programme. The Congress will create opportunities for participants to present and share experiences, explore new directions and debate topics among specialists from across the globe. The meeting will include the 47th AASP-TPS Annual Meeting.

A varied array of meeting styles with a combination of keynote lectures, special symposia on leading issues, interactive workshops, technical sessions, and short courses promises to hold sessions of interest to all palaeontologists.

Delegates will have the opportunity to enjoy a wide range of conference excursions to rich and well-known Argentinean palaeontological sites involving a combination of scientific and touristic attractions. The schedule of field-trips covers superbly exposed sedimentary successions, representing a great diversity of marine and continental palaeoenvironments, and encompasses nearly the whole stratigraphic record.

Organisers for the 47th AASP-TPS Annual Meeting are now calling for Symposium topics. If you have any great ideas for palynology-related symposia, please feel free to contact Thomas Demchuk (e-mail <**tdemchuk@swbell.net**>).

Please see the conference website at <**http://www.ipc4mendoza2014.org.ar/**> for further details.

6th International Symposium on Lithographic Limestone and Plattenkalk
Museo del Desierto, Saltillo, Mexico *2014 (dates to be determined)*

The Museo del Desierto invites you to the 6th International Symposium on Lithographic Limestones and Plattenkalk. This multidisciplinary meeting is planned to address aspects of the study of lithographic limestones and plattenkalk deposits across all disciplines, from palaeontology (taxonomy, palaeoecology, taphonomy), to geology (stratigraphy, sedimentology, palaeoenvironments), and also mineralogy and petrology of Plattenkalk deposits and related Fossil-Lagerstätten. The meeting is organized in collaboration with the Institute of Earth Sciences of the University of Heidelberg, Germany. We plan field-trips to the famous plattenkalk deposits of Vallecillo and Cuatro Cienegas.

Please consider submitting manuscripts for the LAK conference proceedings. These are planned to be published in the *Revista Mexicana de Ciencias Geologicas*, which is indexed in several citation indices, including the Science Citation Index. Impact Factor (2010) is 1.136. The *Revista* is an open-access journal.

Please visit the conference website at <**http://isllpsaltillo.uni-hd.de/**> for updates.

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 will follow in due course.

Please help us to help you! Send announcements of forthcoming meetings to <**newsletter@palass.org**>.

Meeting REPORT

56th Annual Meeting of the Palaeontological Association
University College Dublin, Ireland *16 – 18 December 2012*

Dublin gave palaeontologists a warm winter's welcome on Sunday 16th December, as they descended on the halls of UCD. After a welcome address given by Stephen Daly, Head of UCD's School of Geological Sciences, the conference kicked off with a thematic symposium dedicated to "Taphonomy and the Fidelity of the Fossil Record."

Firstly, **Derek Briggs** opened our eyes to the limits of the fossil record and delighted us with beautiful examples of soft tissue preservation. Next, **Alan Channing** made the case that in hot spring environments taphonomic filtering is replaced by ecological and ecophysiological filtering. He was followed by **Susan Kidwell**, who spoke about the use of death assemblages in evaluating modern ecosystems. She concluded that it is a great time for taphonomy and palaeoecology, which have promising applications in conservation biology.

After a short break, **Maria McNamara** took us on her whistle-stop tour of colour in the fossil record. Through her experiments and many striking images of colour in insects and theropods, she cautioned that more taphonomic experiments are needed to study how colour alters during fossilization. Next, **Rob Sansom** spoke about how decay affects the position of organisms in phylogenetic trees, making the case for a careful revision of phylogenetic placements. The symposium was brought to a close with **Clive Trueman**'s talk on the tissue chemical records of animal behaviour: he explored how new developments in isotope ecology may help palaeoecologists understand the behaviour of past organisms and ultimately bridge the gap between the fields of modern ecology and palaeoecology.

The take-home message from the Symposium was that much remains to be done in the field of taphonomy and that exciting research lies ahead.

Later, delegates packed the lecture theatre in anticipation of the Annual Address, which was delivered by **Chris Stringer** and entitled "*New views on the origin of our species*." After reminding us what it means to be human in terms of shared behaviours with our primate cousins such as using tools, to the uniquely human use of modern technologies, he took us through different ideas that try to explain where we originated. Modern genomic-scale studies have shown that *Homo sapiens* doesn't have a purely African origin, but there is a small, though significant signal of introgression from archaic modern humans into early modern humans. In fact, it appears that we interbred with Neanderthals and Denisovans, as well as another archaic source. This fascinating address certainly reminded us that our genome is a patchwork, and it paved the way for much discussion during the icebreaker reception, hosted by Fáilte Ireland. Colleagues, friends, seasoned researchers and students all mingled by the Christmas tree in the Astra Hall of UCD.

Monday morning's presentations kicked off in style with the wonderful Cambrian arthropods! **Greg Edgecombe** started the session by shedding new light on the neuroanatomy of exceptionally preserved arthropods. **Allison Daley**'s talk on *Anomalocaris* from the Burgess Shale presented

Figure 1: Delegates at the Ice-Breaker reception discussing the Symposium presentations.

new information on the morphology of anomalocaritids. And how could one forget the photos she showed us of her beloved soft toy *Anomalocaris*? Next, a foray into the lesser known but equally fascinating *Sidneya* by **Martin Stein**. This was followed by **Martin Smith**'s re-investigation of *Nemalothallus*, a carbonaceous fossil previously reported to be an early-Palaeozoic land plant. Exceptional preservation of cuticle from the Silurian of Gotland allows the fossils to be interpreted as extinct coralline red algae. Finally, **Lea Devaere** taught us about an Early Cambrian microfauna from Southern France, and **Thomas Harvey** took us through his fascinating array of Small Carbonaceous Fossils (SCFs) from the Middle to Late Cambrian of Canada.

Following a short break, the next sessions were parallel and topics ranged across the palynology of the 2004 tsunami deposits of Thailand, amber deposits, to plant biodiversity reconstructions from pollen assemblages. **Sarah Gabbott** spoke about lampreys and hagfish, in the context of the evolution of visual systems. She presented new data from analysis of fossil cyclostomes, suggesting that the ancestral vertebrate had a functional visual system. In the same session, **Mark Purnell** captured everyone's attention with his experimental decay of velvet worms, speaking of the rates of decay in different parts of the lobopod body and how they relate to phylogenetic analysis. **Christian Klug** showed us beautiful examples of soft-part preservation in Cretaceous ammonites, including stomach, oesophagus, crop, jaws, radulae and other more enigmatic structures. He noted that fossil lagerstätte have great potential for more cephalopod soft tissues. So exciting times lie ahead!

Mike Howe presented a new project, which aims to create an online database of type fossils held by several major museums, with high-resolution photographs and 3D scans (for more information see <**http://gb3dtypefossils.blogspot.co.uk/**>).

The afternoon sessions included talks by **Neil Davies** on the relationship between terrestrialization of plants and animals and Palaeozoic diversification of alluvial sedimentary facies. He made the case that changes in geomorphology, in particular expanding alluvial niches, played a significant role in driving terrestrialization of early continental life. With **Jan Rasmussen**'s talk, we delved into time series analysis in distal shelf environments in the Middle Ordovician of Baltica. In a parallel session, **Paul Taylor**'s talk critically re-examined the claim that the oldest bryozoan may coincide with the oldest pennatulacean. Many more talks entertained the delegates before a short coffee break and the final session of the day.

What better topic to kick off the next session than dinosaur trackways? **Peter Falkingham** explained how computer simulations can be used to reconstruct foot motion. Next up, **Carys Bennett** had us all spellbound with her pelagic trilobite eyes and the potential of oxygen isotopes from their calcitic lenses as a palaeotemperature proxy, while **Graeme Lloyd** later spoke of a new method for dating phylogenetic trees that helps bridge the molecular-fossil gap.

Soren Hemmingsen and **Michael Benton** concluded the session by launching the first issue of *Virtual Palaeontology*, freely available online and dedicated to the origins of biodiversity.

Delegates then made their way to the Old Jameson Distillery for the Annual Dinner. Following on from a drinks reception, we were treated to the Jameson whiskey tour, topped off with a complimentary tasting of the famous spirit. After a delicious meal, PalAss president **Michael Benton** presented the annual awards. The *Hodson Award* went to **Jakob Vinther**, a young researcher who has established himself as a global leader in the study of coloration in dinosaur and fossil birds and in the uses of fossils in reconstructing the pattern of character evolution in bilaterian phyla.

Figure 2: Pre-dinner drinks in the reception area of the Old Jameson Distillery.

Harry Dowsett was the recipient of the *President's Medal*, awarded for his contribution to palaeoclimate studies and to the field of Neogene foram evolution. And, as Mike Benton noted, personally identifying over a million foraminifera certainly deserves a prize!

This year the *Mary Anning Award* finally went to a woman, for the first time since it was established in 2002: the recipient was **Alice Rasmussen**, who passionately collected, curated and prepared fossils, as well as planning fossil exhibitions and writing popular guidebooks. Her collections provided material for more than ten publications and a PhD thesis.

The *Lapworth Medal*, the Association's highest award for lifelong achievement and a contribution to science at the highest international level, went to **Euan Clarkson**, who made major contributions in four areas, namely vision in trilobites, the conodont animal, Carboniferous arthropods, and the evolution of Early Palaeozoic marine faunas.

Sleepy-eyed delegates made their way to the poster session early on Tuesday morning. Pastries and coffee, together with aesthetically pleasing posters, worked well in reviving and awakening the spirit.

Una Farrell kicked off the morning's talks by introducing a new project that involves databasing and georeferencing palaeontological collections from the Ordovician, Pennsylvanian and Neogene, from three palaeobiogeographic regions: the Cincinnati region, the American mid-continent and the Gulf-Atlantic Coastal Plains. Once realised, the project will be of great use in studies of species distribution through time. In the same session, **Laurent Darras** spoke about jaw morphology and trophic ecology in early vertebrates. The theme of jaw microwear was also taken up by **Sarah Joomun**, who spoke about dietary variation and faunal change in Palaeotheriidae across the Eocene–Oligocene boundary.

Among many more excellent talks, **John Finarelli** spoke about body mass data from extant and fossil canids, thereby highlighting the importance of including fossil data in macroevolutionary studies. Interestingly, dogs have a well-sampled fossil record.

After lunch, **Michael Streng** illuminated us regarding fake predation traces in the Cambrian. He showed how a simple hole in the shell doesn't imply predation and made the case that the early fossil record of predation should be reassessed. It was generally agreed that **Alexander Liu**'s talk on a new Ediacaran rangeomorph community was one of the best contributions of the entire meeting: with great clarity he took us through the new discovery of extraordinarily preserved soft-bodied Ediacaran organisms on the MUN Surface in Newfoundland. Enigmatic filamentous structures, which may be giant sulphur bacteria, are preserved alongside the rangeomorphs.

The final session's talks ranged from the fossil record of gastropods, to that of bioirrigation. **Brigitte Schoenemann** took us through the advances in our understanding of trilobite vision and **Andy Gale** helped in solving Darwin's dilemma: the apparent gap in the fossil record between Mesozoic–Recent stalked barnacles and Cenozoic-Recent acorn barnacles. Now, newly recovered barnacle assemblages from Dorset and Sweden include new taxa that provide evidence for two critical morphological transitions in barnacle phylogeny.

The session was concluded by the announcement of the prize winners: the poster prize went to **Emma Locatelli** for her poster on pre-burial preservation potential of land crabs; the prize for best talk went to **Nicholas Longrich** for his insight into how snakes and lizards (Squamata) were affected by the Cretaceous–Palaeogene mass extinction. Through careful revision of fossil squamates from the Maastrichthian and Palaeocene of western North America, he showed that the end-Cretaceous mass extinction was far more severe than previously believed. In addition, post-extinction recovery was prolonged, thereby underscoring the role of mass-extinctions in driving diversification.

But one final delight awaited delegates before the close of the meeting: **Andy Knoll**'s UCD Earth Institute Lecture entitled "*Systems Paleobiology: Physiology as the link between biological and environmental history*." Introduced by Chris Bean, Director of the UCD Earth Institute, Andy Knoll took us on his marvellous, interdisciplinary journey from vascular plants, to the end-Permian mass extinction, to the surface of Mars. He argued that the need to understand the relationship between life and Earth can be met by expanding physiological research, since "evolution plays out on a dynamic planet." What a fitting end to the conference!

But the fun didn't have to end for everyone: some delegates took the opportunity to attend the British Sedimentological Research Group (BSRG) annual meeting, kicking off that very evening in UCD. Sincere thanks to Paddy Orr, the organizers and the volunteers for all their hard work. Forgive the dinosaur reference, but the meeting was a roaring success!

Anthea Lacchia
Trinity College Dublin

Figure 3: The Annual Dinner in full swing.

MYSTERY FOSSIL 22

Wayne Itano discovered this in a drawer at the Natural History Museum last Winter and he and I pondered the label and both came to the conclusion that it ain't no fish. But what is it? Perhaps Mystery Fossil readers can help improve NHM's database!

From Dr Susan Turner
<**paleodeadfish@yahoo.com**>.

[The Editor reckons this might be an openly coiled ammonoid. Devonian ammonoid workers, please let us know what you think.]

OBITUARIES

Jan Bergström
1938 – 2012

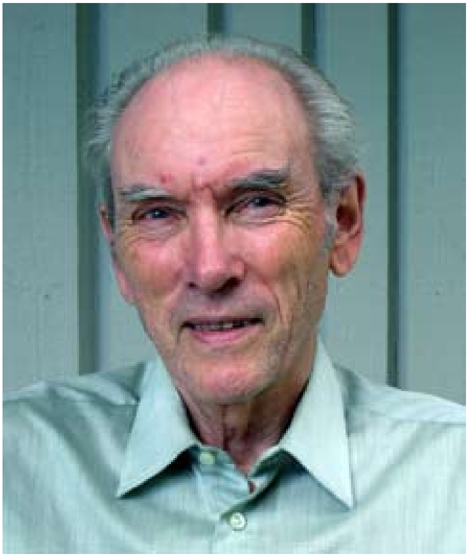


Figure 1. Jan Bergström in 2010.
Photo courtesy Karna Lidmar-Bergström.

After a nearly two-year-long and bravely-fought battle with cancer, Professor Jan Bergström died peacefully on 17th November 2012, aged 73. Having published more than 90 articles and monographs on early arthropods and on Cambrian aspects of geology, he was one of the scientific leaders internationally, in both the Cambrian and the arthropod research communities. However, this was only a portion of his exceptionally diverse research that extended from the Precambrian to the Pleistocene and dealt with palaeontological topics ranging from trace fossils to hominids and even the evolution of photosynthesis. He also published important papers on metazoan evolution and systematics, the Mesozoic and Cenozoic tectonic evolution of southern Scandinavia with special regard to the Tornquist Zone, and biostratigraphy and biogeography.

His deep interest in archaeology and Norse mythology is documented in more than a dozen papers. His prolific publication list includes about 165 scientific articles and monographs, approximately 35 conference abstracts, close to 100 popular and educational articles, and more than 100 encyclopaedia contributions, not counting newspaper articles. His work made him widely known nationally and internationally, and he carried out extensive joint work with leading palaeontologists around the world. He received several major honorary awards and was elected a member of the Royal Swedish Academy of Sciences in 1990.

Jan Bergström was born in the city of Halmstad on the south-west coast of Sweden, where he attended public schools before starting his academic studies at Lund University in 1958. Here he gained a comprehensive background in botany, geography, zoology, and geology, and also met his future wife Karna. During his geology study years in the late 1960s, he was a member of a close-knit and illustrious group of graduate students in palaeontology that included, among others, Sven Laufeld, Gonzalo Vidal, Anita Löfgren, Lennart Jeppsson, and Stig Bergström. Jan Bergström's university studies culminated in 1973 with a Ph. D. dissertation on the morphology, taxonomy, and mode of life of trilobites. This book, which was published in the monograph series *Fossils and Strata*, contained a great deal of new ideas and interpretations, and made him internationally known. It received the highest academic grade and resulted in the offer of a position as docent (lecturer) at the Geology Department in Lund. He taught there up to 1978, when he accepted a position as State Geologist (and later Senior State Geologist and Head) of the Scanian Division of the Geological Survey of Sweden, which is located in Lund. He worked there for 11 years with various projects on mainly Scanian geology and his own arthropod research until 1989, when he became Professor and Head of the Palaeozoology Department at the Swedish National Museum of Natural History in Stockholm. He formally retired from this position in 2005 but continued vigorous and wide-ranging research until the last weeks before his death.

Although his topically and geographically very wide-ranging research makes it difficult to adequately identify his most significant contributions, we will note a few of his major areas of research. His early work dealt with brachiopods from the Upper Ordovician of Sweden, and his monograph on the *Hirnantia* fauna from Västergötland (1968) still remains an international standard reference. He maintained an active interest in this group and was one of the co-authors of a recent *GFF* article on Upper Ordovician brachiopods from southern Sweden. He was one of the internationally leading specialists on Palaeozoic trilobites, and through the years, he published more than 25 articles on this group, including his Ph. D. dissertation. In the 1970s and early 1980s, he carried out very extensive arthropod work in cooperation with Wilhelm Stürmer in Germany, who had developed a novel X-ray technique, the use of which made it possible to study previously unrecognized but important morphological structures in the remarkably well-preserved arthropods from the Devonian Hunsrück Shale in Germany. This cooperation resulted in more than a dozen papers that revolutionized our understanding of the morphology of these unique fossils.

The discovery of another, and scientifically probably even more important, fossil Lagerstätte at Chengjiang in the Yunnan Province of southern China resulted in a new, and highly productive, research phase for Jan Bergström. The cooperation with Hou Xianguang, the discoverer of the Early Cambrian Chengjiang fauna, and others resulted in the publication of more than 25 articles and two books that greatly added to the previously very incomplete knowledge about the morphology of Early Cambrian marine soft-body organisms and the composition of their ecosystems.

Figure 2. Jan Bergström in the Drum Mountains, western Utah, 5th August 1981.
Photo by Per Ahlberg.

As a researcher, Jan Bergström had not only a very wide range of interests but he also possessed an exceptional power of observation and unusual ability to interpret the morphology and function of anatomical structures. He had great scientific curiosity, and a remarkable analytical ability that was supported by his solid background knowledge in geology and zoology. Although he was not a dominating personality, he stood firm in his interpretations and conclusions, some of which, although as a rule sound, were at least initially not accepted by everybody. Personally, he was very kind and helpful to colleagues, had a good sense of humour, was always willing to discuss scientific matters, and was generous with advice. His many collaborators and other friends around the world will sorely miss him, and it is sad that a very productive career in geological research has come to a premature end.

A dedicated family man, Jan Bergström is survived by his wife, their two children, and two grandchildren.

Stig M. Bergström
The Ohio State University

Per Ahlberg
Lund University

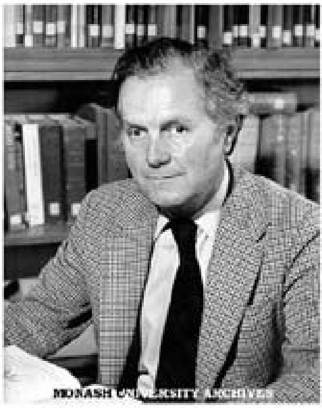
Alec Leonard Panchen
4 October 1930 – 17 January 2013

An Appreciation

In the nineteenth century the coal fields of Great Britain provided the first glimpse of the extraordinary variety of animals and plants that lived among the equatorial waterways 330 million years ago. This rich fauna and flora includes the Carboniferous tetrapods, amongst which are the antecedents of all amphibians and amniotes alive today. In a career spanning more than 40 years, Alec Panchen did more than anyone in the UK to help us understand their diversity and evolutionary history.

After completing his PhD in 1956 with Rex Parrington at the University of Cambridge, Alec joined the staff of the Department of Zoology at the University of Newcastle upon Tyne. It took him a while to identify a research area that he could make his own, but eventually he settled on the collection of Coal Measures amphibians in the Hancock Museum in Newcastle, which had been neglected since D. M. S. Watson's work in the 1920s. In 1964 Alec published the first of a series of monographs in the *Philosophical Transactions of the Royal Society of London*, on a group of early tetrapods which at the time were considered to be close to the origin of amniotes, the anthracosaurs. Using modern preparatory techniques, most notably the industrial airbrasive machine, Alec revealed anatomical details never seen before, and in his beautifully illustrated descriptions he set a benchmark that his research students have since struggled to match.

Ironically, as Alec became the established authority on Carboniferous anthracosaurs he began to doubt their close affinity to amniotes. He set out his concerns in his contribution to the Parrington *Festchrift* published in 1972, and came very near to suggesting that microsaurs were as likely to be the closest amphibian relatives of amniotes as the anthracosaurs. Today, no one would be too



Alec in 1980 at Monash University, Australia,

Alec (right) with Stan Wood (left) in 1975 at the Dora open cast site,Cowdenbeath, recovering the skull of *Proterogyrinus pancheni*. Photo Tim Smithson

concerned at such a proposal but at the time it was quite radical, and his natural caution prevented him from being so bold. He returned to the question of amniote origins on numerous occasions, and when we wrote about it together in 1988 even we couldn't agree, producing alternative schemes of the inter-relationships of the reptiliomorph clade.

Alec was an enthusiastic field naturalist who particularly enjoyed bird watching and collecting and photographing butterflies. For a number of years he ran a very successful palaeontology field course for second year undergraduates based at the Leonard Wills Field Centre in Somerset. As well as collecting and identifying fossils from the Triassic and Jurassic rocks of the north Somerset coast, he introduced students to the pleasures of ammonite zonation at Watchet and the challenges of finding fossils in the fissure fills in the Mendip Hills. Many of the final year undergraduate research projects Alec supervised were based on material collected on the field course, most notably the fossils in the Rhaetic Bonebed which proved to be the apprentice piece for three of his later PhD students.

Alec was an inspiring and enthusiastic teacher. His lectures were always well prepared, engaging and challenging. As well as his final year course on vertebrate evolution, he gave lectures on genetics, human origins and evolutionary theory, and in later years ran a seminar series on the history and philosophy of natural science. Alec took a keen interest in evolution and development, and the latest piece by Stephen J Gould in *Natural History* was often the basis of an animated discussion in the 'Tea Room'. He coupled this with a professional interest in the methods of classification and phylogeny reconstruction, and he enjoyed the cut and thrust of the argument during the early days of 'cladism'. Many of these intellectual themes were combined in his book *Classification, evolution and the nature of biology*, published by Cambridge University Press in 1992.

Alec was a modest man, quite reserved and naturally cautious, but he was prepared to take risks when selecting research students and appointing staff. Fortunately, for all concerned, his judgement was always sound. Perhaps his boldest decision was to give Stan Wood his first job in palaeontology in 1976, shortly after he had discovered tetrapods and other vertebrates at the Dora open cast site near Cowdenbeath in Scotland. They worked together for three years and Stan was always the first to say that he would not have gone on to make his discoveries at Bearsden, East Kirkton and most recently in the Scottish Borders had it not been for Alec's support at the start of his collecting career. In all, Alec supervised ten PhD students, whose topics ranged from Palaeozoic fishes and Carboniferous tetrapods to marine reptiles and butterfly genetics. Most of us were able to contribute to his *Festchrift* published in 1998, and this includes a comprehensive synopsis of Alec's career by Andrew and Angela Milner as well as a complete bibliography of his publications.

Alec was elected to the Royal Society of Edinburgh in 1991 in recognition of his contribution to vertebrate palaeontology. He laid the modern foundations of the study of Palaeozoic tetrapods in the UK and supervised, supported and encouraged a new generation of vertebrate palaeontologists at the start of their careers.

Tim Smithson
Cambridge

MILNER, A. R. and MILNER, A. C. 1998. Dr A. L. Panchen FRSE: an appreciation. *Zoological Journal of the Linnean Society*, **122**, 1–7.

Sylvester-Bradley REPORTS

Scale characters of basal chondrichthyans

Plamen S. Andreev
School of Geography, Earth and Environmental Sciences, University of Birmingham, UK

Introduction

The fossil record of the earliest known chondrichthyan-like fishes is dominated by Lower Palaeozoic scale taxa of currently uncertain systematic affinities. The latter largely stems from an historical reluctance to incorporate scale characters into classification schemes of stem chondrichthyans that can test their phylogenetic significance, and is coupled with a scarcity of studies on the squamation of articulated Palaeozoic chondrichthyans.

The research outlined in this report aims to bridge this gap in our knowledge by contributing data to a PhD project that aims to produce the first scale-based phylogeny of stem chondrichthyans. The data presented here were collected over a two-and-a-half-week period, during which the scale morphology of articulated Devonian and Carboniferous chondrichthyans, primarily from the collections of the Field Museum (Chicago, IL – collection prefix PF) and the Carnegie Museum of Natural History (Pittsburgh, PA – collection prefix CM), was documented. The diverse nature of the examined material has allowed the characterization of the scale cover of taxa belonging to major divisions of stem and crown chondrichthyans—Ctenacanthiformes, Symmoriiformes, Hybodontiformes, Eugeneodontiformes, and Petalodontiformes. This has helped advance our understanding of scale character distribution at the base of the chondrichthyan evolutionary tree.

Results

Ctenacanthiformes: The studied material comprises teeth and scales associated with partially articulated jaw cartilages, branchial and hyoid arches of the Upper Devonian taxon *Ctenacanthus terrelli* (CM 76833—Cleveland Shale). Observed scales display compound crowns composed of multiple odontodes arranged in weakly defined rows; odontode size increasing from anterior to posterior. Most specimens are preserved in crown aspect, with only few scales revealing their shallow bases and a distinct neck-like constriction marked by a series of canal openings. The described above scale characteristics are diagnostic for a variant of *Ctenacanthus*-type morphogenesis (Karatajute-Talimaa, 1992), which affects crown growth by addition of rows of simple acuminate odontodes away from a scale primordium, accompanied by synchronous deposition of basal tissue.

Symmoriiformes: Reviewed here is the squamation of the symmoriids *Cobelodus aculeatus* (UF 576 holotype—Moscovian, Mecca Quarry Shale), and *Orestiacanthus fergusi* (CM 41054B—Serpukhovian, Bear Gulch Limestone Member), along with one member of Falcatidae, *Damocles serratus* (CM 35473A, 48760A—Serpukhovian, Bear Gulch Limestone Member).

A patch of disarticulated scales was discovered at the posterior region of the cranium upon examination of the type specimen of *Cobelodus aculeatus*. The crown of each scale consists of a posteriorly arched conical cusp ornamented with deep, apically converging ridges and supported by elliptical base, dotted with canal openings in the proximity of the crown junction. These elements are suggested to be analogous to the cluster of dorsal head scales developed in other symmoriiforms, contrary to their original interpretation as being part of the dentition (Zangerl and Case, 1976).

The investigated specimen of *Orestiacanthus* exhibits evenly distributed scale cover over the entire body surface, with larger, more specialized, scales lining the cephalic lateral line canals, dorsal head surface, and the apex of the spine brush. Despite observed differences between head and body squamation, scales from these two regions conform to the same general type: unicuspid (mono-odontode) crowns and broad pyramidal bases with a central sub-basal concavity. Lund (1984) has proposed that the squamation of *Orestiacanthus* is sexually dimorphic, with females lacking extensive scale cover of the body, similarly to the condition in *Falcatus* (Lund, 1985). The male specimens of *Damocles serratus* inspected here are devoid of body scales, except those formed along the lateral line canal, although in every other respect their squamation matches closely that of *Orestiacanthus*.

Hybodontiformes: Examination of two specimens of the basal hybodonts *Onychoselache traquari* (NMS 1998.35.2—Visean, Mumbie Quarry) and *Tristychius arcuatus* (HM V8299—Serpukhovian, Manse Burn Formation) confirms previous reports (Dick, 1978; Coates and Gess, 2007) of limited scale cover development in both genera. The post-branchial scales detected in *Onychoselache* are simple mono-odontode elements with smooth, posteriorly recurved crowns and thick flared bases, predominantly distributed around the margins of the pectoral fins. Similar scales are borne by the pectoral fins of *Tristychius* and these differ substantially from the denticulate scales described by Dick (1978) from the same region. Additionally, *Onychoselache* possesses large head scales, referred to in the literature as cephalic spines (Coates and Gess, 2007), characterised by polyodontode crowns whose constituent odontodes are reminiscent of the crowns of body scales.

In comparison to *Onychoselache* and *Tristychius*, more derived Palaeozoic and Mesozoic hybodonts exhibit fully developed body squamation of supposedly mono-odontode scales with complex crown morphologies (Maisey, 1983; Wang *et al.*, 2009).

Eugeneodontiformes: Preserved scales were detected in articulated specimens of the caseodontoid genera *Ornithoprion* (*O. hertwigi*—PF 9967, Moscovian, Carbondale Fm.) and *Caseodus* (*C. eatoni*—PF 2496, 2511, Moscovian, Logan Quarry Shale). Additional studied material included isolated scales from the collection of the Field Museum referred to *Agassizodus* (PF 2417—Moscovian, Logan Quarry Shale).

The examination of *Ornithoprion* specimen PF 9967 revealed pointed mono-odontode scales associated with dentition, which have been interpreted previously as mucous membrane scales (Zangerl, 1966). Inspection of radiographs of a more complete specimen (B82-311) could not identify the second, allegedly growing, type of scales figured by Zangerl (1966, fig. 17, 18). Scales of comparable morphology, though, were found in *Caseodus*; these possess the characteristic combination of high pyramidal bases and complex multi-lobate crowns.

Also consistent with this morphotype are the scales of *Agassizodus*, which bear a striking resemblance (segmented crowns, neck canal openings) to the Lower Devonian chondrichthyan scale genus *Polymerolepis*.

Petalodontiformes: Studied material consists of one partial (CM 46137) and one complete (MV 7698—type specimen, Fig. 1a) skeleton of the Bear Gulch petalodontiform *Belantsea montana*.

The squamation of *Belantsea* is distinctly heteromorphic and evenly covers the entire body surface. Specialized head scales are present in the type specimen lining the anterior jaw margins, dorsally and ventrally of the dentition. These are bulbous elements with irregular stellate outlines (Fig. 1b), which judging from fractured scales possess an undivided central pulp canal, and are being interpreted as mono-odontode. The main portion of the head and body squamation, though, consists of small scales characterised by lanceolate crowns with distinct serrated margins (Fig. 1c). This morphology results from a particular arrangement of needle-shaped elements (interpreted as

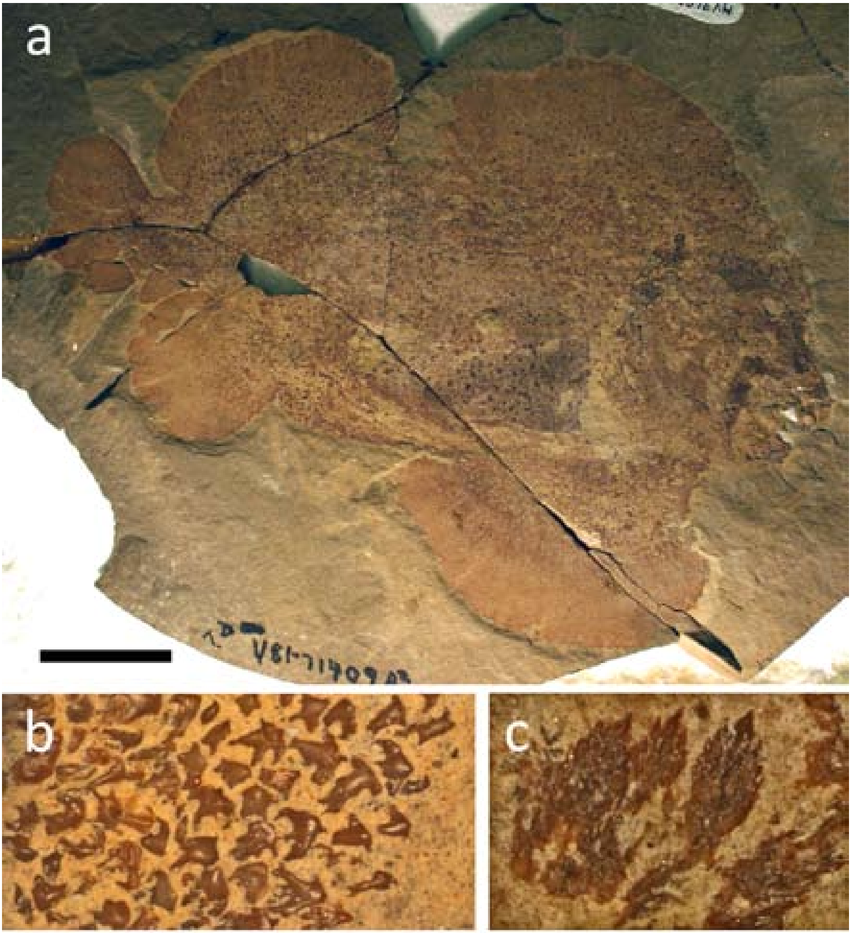


Fig. 1. (a) The holotype (MV 7698) of *Belantsea montana*; (b) detailed view of rostral scales (MV 7698); (c) a group of dorsal head scales from CM 46137. Scale bar = 5 cm.

individual odontodes), which are longest medially and become progressively shorter towards the lateral parts of the crown.

No scale data from other petalodontiforms are available at present with which to compare the distribution of scale characters within the Order.

Conclusion

The data from this study, combined with the limited information on the squamation of Palaeozoic chondrichthyans, suggest that a particular morphogenetic scale type is consistently found within all the examined chondrichthyan Orders – apart from Petalodontiformes for which we still lack sufficient data. However, more extensive and detailed studies are needed to test the phylogenetic significance of scale-derived characters in chondrichthyans and whether those can be implemented to resolve the relationships of stem members of the clade.

Acknowledgements

I wish to thank Ian Glasspool (Field Museum) and Amy Henrici (Carnegie Museum of Natural History) for their assistance during my work with the fossil vertebrate collections of the two respective institutions.

Acknowledged here is also the contribution of Dr Ivan Sansom (University of Birmingham) and Prof. Michael Coates (University of Chicago) who supported my grant application and provided study material and helpful comments in the course of the conducted research.

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Re-evaluation of Goniopholidid (Crocodilia, Metamesosuchia) material from Central Asia: phylogenetic and biogeographic implications

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Goniopholidids represent one of the groups of crocodilian most closely related to the radiation of crown crocodilians. They are, despite occupying such an interesting point in crocodilian evolution, comparatively understudied, and relatively poorly understood. There is debate over whether Goniopholididae is a true clade, and of the inter-relationships of its constituent members.

The geographic distribution of the group covers all of Laurasia, as well as one uncontroversial Gondwanan species (Sereno 2009). However, research has hitherto focused on those species and specimens in Europe, North America, and, more recently, Thailand and China. Species assigned to Goniopholididae have been known from Central Asia since the 1970s (Efimov 1975), but for a variety of reasons have not been studied since their discovery. Occupying a geographically intermediate position between the European *Goniopholis* and *Nannosuchus*, and the Eastern and American taxa such as *Sunosuchus thallandicus* and *Eutretauranosuchus*, the Central Asian taxa can inform on patterns of dispersal and biogeographic history, as well as contributing to the phylogenetic information in order to further investigate the relationships of Mesozoic crocodilians. This study aimed to bring these specimens into a modern phylogenetic analysis and to resolve some questions regarding goniopholidid monophyly.

The Sylvester-Bradley Fund provided the money to travel to the Paleontological Institute, Moscow (PIN) in order to access the specimens first hand, and also the original discoverer of the three species – *"Sunosuchus" shartegensis* (Efimov 1988), *Kansajsuchus extensus* (Efimov 1975), and *Turanosuchus aralensis* (Efimov 1988), from, respectively, Mongolia, Kazakhstan and Tajikistan. All three had been described as goniopholidids originally, and are in varying states of preservation, from an almost complete but fragile and poorly preserved skull, to highly detailed but unconnected fragments. Interpretive drawings (*e.g.* Figure 1) were produced both by hand while in Moscow and digitally at a later date from photographs taken in Moscow.

After detailed description of each specimen, they were coded into a data matrix, previously produced by Marco Brandalise de Andrade (Andrade 2010), and incorporating 101 crocodilian taxa when the three Central Asian forms were included, with 480 characters. The crocodilians selected to be included in the cladistic analysis ranged in time from the Triassic to the modern day, and across every continent except for Antarctica, providing both temporal and phylogenetic diversity.

The three species were re-evaluated as to their position within the crocodilian radiation, with *"Sunosuchus" shartegensis* being, on the basis of this cladistic analysis, most closely related to another fragmentary species – *Sunosuchus thallandicus*. Despite *"Sunosuchus" shartegensis* being resolved as nearest to another *Sunosuchus*, the genus as a whole was determined to be polyphyletic in this analysis, with *S. miaoi* separate, and the earlier *S. junggarensis* more closely related to the

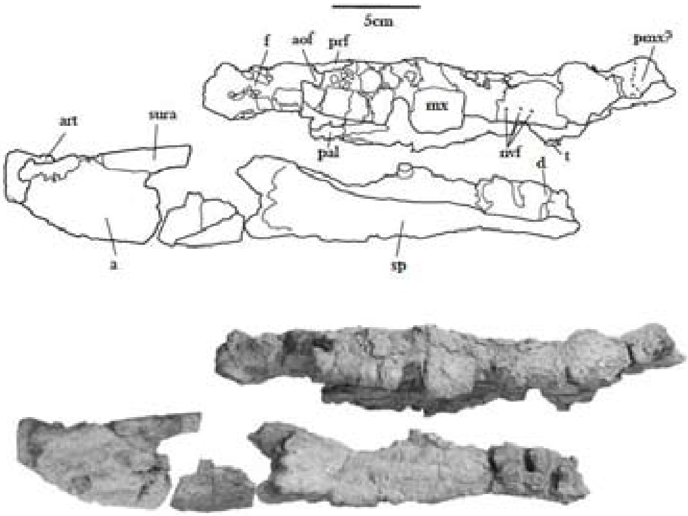

Figure 1. Interpretive drawing of the skull fragments of "Sunosuchus" shartegensis*, as seen from the right-hand aspect. Abbreviations used: a=angular, aof=antorbital fenestra, art=articular, d=dentary, f=frontal, mx=maxilla, nvf=neurovascular foramina, pal=palatine, pmx=premaxilla, prf=prefrontal, sp=splenial, sura=surangular, t=tooth.*

American *Eutretauranosuchus*. Hence, the genus *Sunosuchus* is in need of revision, and under the phylogenies produced by this analysis, only *S. miaoi*, the type species, can be considered to be part of *Sunosuchus* proper. *"S." shartegensis* is also shown to be unusual for a goniopholidid in that it possesses what appears to be an antorbital fenestra. Such a structure is only known from *Calsoyasuchus* in Goniopholididae, a basal North American taxon (Tykoski *et al.* 2002), and it is notable that it appears in a more highly nested form.

Kansajsuchus is considered, as a result of this analysis, to be the sister taxon of *"Sunosuchus" shartegensis* and *S. thailandicus*. *Kansajsuchus* and *"S." shartegensis* are both relatively large (*ca*. 6–8 metres long) freshwater crocodilians. It is unknown whether this taxon has an antorbital fenestra, as that area of the skull has been lost. In particular, *Kansajsuchus* is distinctive because of its very striking teeth, which are very strongly ridged, and which have a pair of very strong ridges on the posterior aspect.

Turanosuchus aralensis is an extremely scrappy specimen, and it behaved erratically in attempts to place it phylogenetically. Little more can be said beyond that it is neosuchian, and probably goniopholidid (about 80% of the most parsimonious trees involving *Turanosuchus* placed it within Goniopholididae). It is composed solely of a poorly preserved mandibular symphysis, as well as posterior portions of the left mandible, and some very poorly preserved maxillary material.

The distribution of taxa on the goniopholidid tree (Figure 2) suggests that goniopholidid distribution across Laurasia forms similar biogeographic patterns to the ceratopsian dinosaurs,

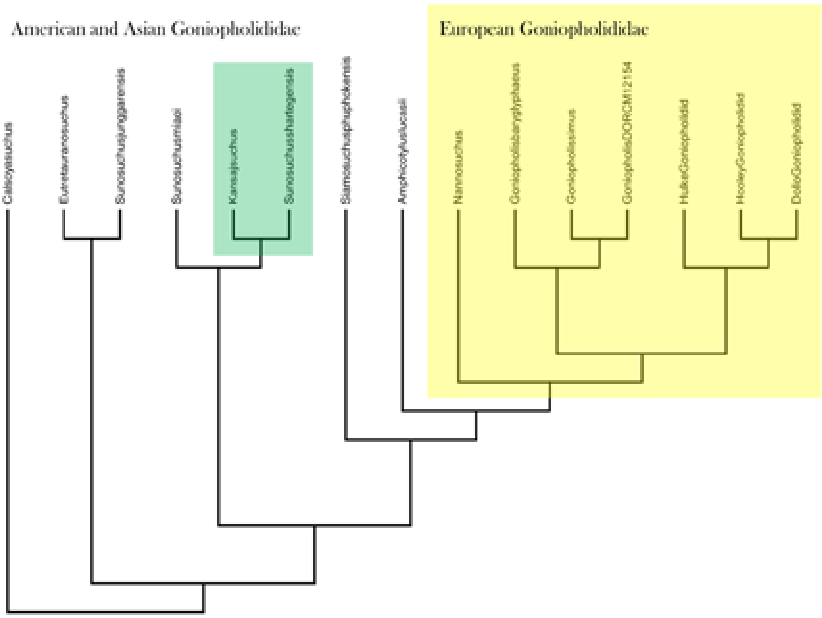

Figure 2: Relationships of all Goniopholidid taxa in analysis, excluding Turanosuchus*, indicating a monophyletic European branch of Goniopholididae. As a whole, monophyly of Goniopholididae is supported, with* Calsoyasuchus*, a North American Jurassic form, the most primitive.* Kansajsuchus *and* “Sunosuchus” shartegensis *are sister taxa; their position on the tree is indicated by the green rectangle.* Sunosuchus *is shown to be paraphyletic, suggesting that there is yet much work to be done on revising the systematics of Goniopholididae.*

with the American and Asian forms forming a paraphyletic and more basal grouping relative to the monophyletic European taxa (Osi *et al.* 2010). This indicates that, due to the presence of barriers such as the epicontinental seas which were present between Europe and Asia during the Jurassic and Cretaceous, freshwater and brackish water crocodilians were unable to cross the large saltwater expanses as easily as traversing the rivers and coastal environments, and that dispersal to Europe was therefore very unlikely. However, like ceratopsians, one small group appears to have dispersed from Central Asia to Europe, where they diversified into the few genera that have been discovered there, leaving a monophyletic group. With little to prevent the goniopholidids from travelling between North America and Asia, these taxa are well mixed phylogenetically, with no clear biogeographic divisions in their evolutionary history.

Acknowledgements

Thanks are due to the Palaeontological Association and the Sylvester-Bradley fund for allowing this work to take place through their generous funding; to Mike Benton and Marco Brandalise de Andrade for their input and ideas while supervising this project; to Lorna Steel (British Museum of Natural History), Andrey Sennikov, Mikhail Efimov and Yuri Gubin (all Paleontological Institute, Moscow) for their permission to view their specimens during preparatory and final museum visits, Marcelo Ruta and Simon Powell for help on the technical aspects of the project.

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Functional anatomy in the transition Prosauropoda–Sauropoda

Alejandro Otero
CONICET – Museo de La Plata, La Plata, Buenos Aires, Argentina

The transition from basal sauropodomorphs to sauropods is one of the most dramatic evolutionary transformations recorded in the history of dinosaurs, but is currently poorly understood (but see Bonnan and Yates, 2007; Yates *et al.*, 2010). Key points in the origin of Sauropoda are the transformations of the postcranium related to the acquisition of the quadrupedalism and graviportal locomotion from the bipedalism present in basal sauropodomorphs (Reisz *et al.*, 2005; Bonnan and Yates, 2007; Yates *et al.*, 2010). The objective of the project is to increase the knowledge of morphological, evolutionary, and functional aspects of sauropodomorph dinosaurs, understanding the locomotor transition between basal sauropodomorphs and sauropods. The project focuses on the anatomy and function of the appendicular skeleton of *Anchisaurus* (Fig. 1), *Seitaad* (Fig. 2), and *Sarahsaurus* (Fig. 3) and its comparisons with South American representatives. Then integrate these new anatomical and functional inferences within a phylogenetic framework to determine the sequence of appearance of appendicular characters of functional significance in the evolutionary transition from basal sauropodomorphs to sauropods.

Some of the best-preserved articulated remains of basal sauropodomorphs and sauropods are known from the Upper Triassic and Lower Jurassic of South America, but detailed functional studies of these forms have not been conducted. The basal sauropodomorph *Mussaurus patagonicus* from the Late Triassic of Patagonia, Argentina presents an almost complete ontogenetic series, ranging from whole skeletons of hatchlings to adult individuals, covering post-hatchling, juvenile and sub-adult specimens as well. The availability of almost complete ontogenetic series and its phylogenetic position close to Sauropoda makes *Mussaurus* a key taxon to illuminate the basal

Fig. 1. Postcranial skeleton of Anchisaurus *(YPM 209)*

Fig. 2. Left manus of Seitaad *(UMNH VP 18040)*

Fig. 3. Axial skeleton of Sarahsaurus *(TMM 43646-2-82)*

sauropodomorph–sauropod transition. Combined with a survey of other known (albeit less complete) ontogenetic series of sauropodomorphs, this represents a unique opportunity to conduct this project and understand the evolutionary/developmental processes behind sauropodomorph locomotor adaptations.

My postdoctoral research focuses on the anatomy and phylogenetic relationships and function of *Mussaurus patagonicus*. This research is being conducted at Museo de La Plata and supported by the Argentinean National Research Council (CONICET). To achieve the goals of this study, it is imperative to examine several sauropodomorph specimens around the world. In this sense, North American sauropodomorphs comprise an important part of the taxon sampling.

The Whittington Award gave me the opportunity to travel to The United States and visit the following collections: Yale Peabody Museum (YPM) in New Haven, CT; Utah Museum of Natural History (UMNH) in Salt Lake City, UT; and Texas Memorial Museum (TMM) in Austin, TX. The examined specimens were *Anchisaurus polyzelus* (YPM), *Seitaad ruessi* (UMNH), and *Sarahsaurus aurifontanalis* (TMM).

An exhaustive postcranial anatomy and phylogenetic relationships of *Mussaurus patagonicus* with detailed comparisons with other taxa could be assessed as the first results of this project (Otero and Pol, 2012a,b). In this regard, *M. patagonicus* is regarded as a basal member of Anchisauria and placed within the core of the transition through Sauropoda together with *Yunnanosaurus* and *Aardonyx*.

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I would like to thank the Palaeontological Association and the Whittington Award Committee for giving me the opportunity of travel to the United States in the context of this project. Also I wish to extend my gratitude to all the people who allowed me access to the collections in their care: D. Brinkman and C. Norris (YPM), R. Irmis (UMNH), and C. Sagebiel and T. Rowe (TMM).

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John Green: Natural History Illustrator and Palaeoartist

Collecting and classifying fossils has long been a passion of mine, from my earliest recollections of finding brachiopods in my back garden, in Grantham in Lincolnshire, at the age of six. As an amateur palaeontologist, my current research interests lie in the latest Jurassic and Early cretaceous ammonite faunas of Lincolnshire, as well as the biostratigraphy of the overlying Upper Cretaceous chalk.

After obtaining a B. A. (Hons) in scientific and natural history illustration, from Lancaster University in 1998, I have worked as a freelance artist, specialising in the area of portraiture. Nevertheless, my enthusiasm for palaeontology runs a close second, and as such, I have found myself drawn to the re-creation of ancient environments, and their associated flora and fauna. When out in the field, I often wonder how a locality appeared, 180 million years ago, together with its ancient life.

Representation of palaeontological subject matter is ultimately a marriage of science and art, and as such the use of one's artistic licence is always tempered by the need for scientific accuracy. I have found, from my own experience as an example, that the handling of many invertebrate fossil specimens over the years inculcates a sense of familiarity, that greatly assists accurate representation of them, coupled with my own training as a scientific illustrator. Bringing an ancient environment and its animals "back to life" in a representational form is a process that can be challenging, yet immensely rewarding.

I would be happy to assist palaeontologists who require any visual representation or reconstruction work, regarding their discoveries or current research interests. Feel free to contact me (e-mail <**john@lincolnshireportraits.co.uk**>, tel 07541 134819).

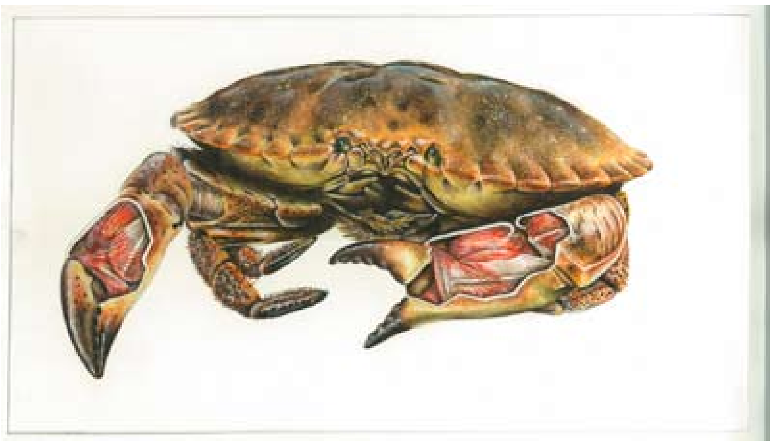


*Figure 1. Scientific illustration of the recent Edible crab (*Cancer pagurus*) showing cutaway of the claws, and corresponding muscle attachment areas. © John Green.*

Figure 2. Reconstruction of a chalk sea environment of the Late Cretaceous period, featuring the ammonite Lewesiceras *sp, sponges, brachiopods,* Inoceramus *sp. and the regular and irregular echinoids,* Echinocorys *sp. and* Tylocidaris *sp. © John Green.*

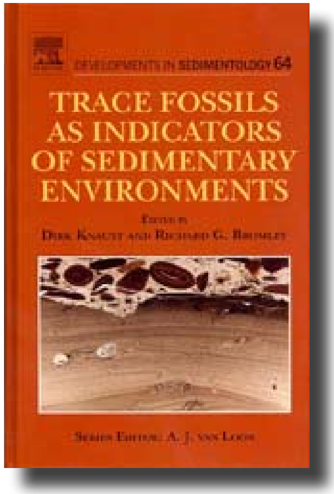
Figure 3. The marine crocodile, Steneosaurus *sp. from the Toarcian of Europe, surrounded by a varied fauna, including fish, ammonites and belemnites. © John Green.*

Figure 4. Reconstruction of the Early Cretaceous Wealden ecosystem of Southern England, featuring the Baryonyx walkeri*, crocodillians, and associated fauna and flora. © John Green.*

The New Ichnology

Trace Fossils As Indicators of Sedimentary Environments

Dirk Knaust and Richard G. Bromley, eds. 2012. Elsevier. 924 pp. $195.
ISBN 978-0-4445381-3-0.



Having spent the last few years doing much more work on trace fossils than body fossils, I've been meaning for a while to write a newsletter article about ichnology. Trace fossils and palaeontologists seem to endure a passing relationship: they often meet, but rarely spend a lot of time together. Few palaeontologists would describe themselves as ichnologists, and trace fossils don't tend to make much of an appearance at PalAss annual meetings.

As a consequence, most palaeontologists (indeed, probably most geologists) seem to think of ichnology as the discipline of Dolf Seilacher, Richard Bromley, George Pemberton, and Pete Crimes. The discipline of domichnia, pipe rocks, and ichnofacies; the discipline that enjoyed a heyday in the 1960s and 70s and hasn't changed much since. I was taught by Pete Crimes, and followed many of his approaches when I taught ichnology myself. Since I started studying trace fossils in more detail, however, I've been exposed to a shift in ichnological approaches, techniques, and thinking. There is a new ichnology coming to the fore.

The catalysts to finally write this piece were two-fold. Firstly, last Summer, I co-organized **Ichnia 2012**, the 3rd International Congress on Ichnology, in St John's, Canada. Researchers from across the globe came together to present their latest findings, and to inspect some of the ichnological treasures of Newfoundland. Significantly, my senior colleagues told me it was the first major ichnological meeting at which none of Seilacher, Bromley, Pemberton and Crimes were in attendance.

Then, a few weeks ago, a review copy of *Trace Fossils As Indicators of Sedimentary Environments* landed on my desk. I decided I would use the book's contents as a means to examine the field.

For many years, the definitive ichnological text has been Bromley's *Trace Fossils: Biology, Taphonomy and Applications* (1996). In the last few years, though, trace fossil treatises have appeared quite frequently: from *Trace Fossils: Concepts, Problems, Prospects* (Miller 2007), to *Trace Fossil Analysis* (Seilacher 2007), to *Ichnology: Organism–Substrate Interactions in Space and Time* (Buatois and Mangano 2011).

During the Ichnia 2012 meeting, Dirk Knaust was promoting his soon-to-be-published book, co-edited with Richard Bromley. Dirk confessed it had been a labour of love, and he should be congratulated on managing to get more than 80 authors to contribute. He should also be congratulated on the diversity of topics the book addresses. Although the title makes clear its primary aim, *Trace Fossils As Indicators of Sedimentary Environments* explores a number of other ichnological fields too.

At more than 900 pages long, and with 28 chapters in six parts, this new contribution is a weighty tome. As such my review can only ever be somewhat cursory, but the key questions are: is it good, is it necessary, and – perhaps more importantly – does it reflect the new directions in which ichnology is moving?

The first part – 'History, Concept and Methods' – begins with a multi-author overview of the origins of ichnology. From prehistory to the modern schools, via Darwin and da Vinci, Andrea Baucon and colleagues discuss the many stages by which the science has developed, and examine the state of play today. It is a detailed and pretty thorough review, though I did find it curious that no mention was made of the man who actually *invented* the word ichnology – naturalist William Jardine – or his pioneering work on vertebrate trackways from the Permian of south-west Scotland.

Further chapters in Part I then assess ichnotaxonomy (Rindsberg) and systematics (Knaust), ichnofacies (MacEachern *et al.*) and ichnofabrics (Ekdale *et al.*), sequence stratigraphy (MacEachern *et al.*), ichnostratigraphy (Mangano *et al.*), bioerosion (Wisshak), ichnological analysis techniques (Knaust), and neoichnology (Dashtgard and Gingras).

Ichnotaxonomy will always be a controversial and problematic area, but Knaust's proposal for a new flowchart-based nomenclatural system, utilizing a hierarchy of morphological criteria, is worthy of consideration. Building on the work of Goldring *et al.* (1997), its basic premise is that by recognizing key ichnotaxobases in succession (burrow orientation–branching–shape–fill–lining), a reasonable name can be assigned to the specimen. An electronic, portable version could be readily used in the field or core lab, and would enable Earth scientists of all backgrounds to make sensible identifications of trace fossils. If supported by a high-quality image database, it would be an extremely valuable new tool.

Rather more briefly discussed in Knaust's methodological chapter are the computer-based techniques for analysing trace fossils and ichnofabrics, which have developed in recent years and offer the possibility of better characterizing ichnotaxa in three dimensions. These will be particularly valuable to ichnotaxonomy if specimens from type localities are used.

Employing biological and ecological studies of bioturbation is also critical to improving our understanding of trace fossils. This field is developing too, and Dashtgard and Gingras give a useful overview. The bioerosion paper by Max Wisshak is interesting also, with the possibility that specific microscopic boring structures could be used as proxies for temperature, salinity, and light levels in ancient environments.

Part II examines continental and glacial systems, with chapters by Netto *et al.* (glacial environments), Melchor *et al.* (fluvial environments), Scott *et al.* (lacustrine environments), and Ekdale and Bromley (eolian environments). Ichnological research in all such settings is in its infancy compared with that of marine environments, but the papers show that progress is being made. This is perhaps seen most clearly in the chapter on fluvial ichnology (Melchor *et al.*) which assesses the morphology and ichnotaxonomy of fluvial traces, the ichnofacies present (eight are recognized), and the depositional settings indicated.

Shallow marine siliciclastic systems are the focus of Part III. The much-missed Jordi de Gibert, who died suddenly last year, shortly after the Ichnia 2012 meeting in Newfoundland, is lead author on the rocky shorelines paper. de Gibert was one of the leading proponents of integrated ichnology, combining trace fossil and neoichnological studies to better understand marine ecosystems through time. Elsewhere in Part III, estuarine ichnology is examined in detail by Gingras *et al.*; Nicola Tonkin reviews deltaic successions, Desjardins *et al.* look at the trace fossils found in tidal–sub-tidal settings, and Pemberton *et al.* study shorefaces.

Part IV moves on to the ichnology of deep marine siliciclastic systems. An important point about deep marine ichnology, made by both Hubbard *et al.* in their chapter on slopes, and Uchman and Wetzel in their study of deep-sea fans, is that 'shallow marine' trace fossils need not have been made by organisms transported into deep water. A doomed pioneer hypothesis is often used to explain such ichnotaxa, but overlooks evolution and modern deep marine ecology: many network-building bioturbators are specialized for living in offshore, slope, and basinal settings. As Wetzel and Uchman also demonstrate in their examination of the trace fossils and bioturbation of hemipelagic and pelagic basin plains, further neoichnological studies of deep marine environments are required. The recent work of Seike *et al.* (2012) offers an exciting new direction in this field.

In Part V (marine carbonate systems), Knaust *et al.* review shallow marine carbonates, Tapanila and Hutchings study the ichnology of reefs and mounds, Savrda examines chalks and deep-marine carbonates, and Zonneveld *et al.* explore the biogenic structures found in mixed siliciclastic-carbonate systems. The Tapanila and Hutchings chapter on reefs and mounds is particularly noteworthy in that it starts with an overview of modern traces and tracemakers, then looks at reef ichnology through geological time, and finally moves on to the environmental controls on bioerosion. The modern is used to understand the past, and – in contrast to most other chapters – ichnofacies are not mentioned at any point.

The final section consists of two chapters, examining the impact of ichnology on hydrocarbon reservoirs and aquifers, respectively. The former is a topic of increasing significance in petroleum plays, as is well-explained by Gingras *et al.* in their case-study-rich and state-of-the-art chapter. The latter gets much less attention, though. The paper by Cunningham *et al.* is informative and shows the importance of ichnofabrics in affecting groundwater flow in carbonate aquifers, but could have benefited from including siliciclastic aquifers also.

The final section of the book – the epilogue – might easily be overlooked, at only two-and-a-quarter pages long. I found it particularly interesting, though, as it hints that the book didn't quite turn out the way the editors had hoped. Most of the chapters follow quite traditional methods, employing long-established ichnotaxonomy, ichnofacies, and ethological terms. The epilogue, in contrast, argues that the ethological classification is flawed, and that 'a new approach' is needed. It also notes that the precise definitions of ichnofacies and ichnofabrics 'often remain unclear'.

Perhaps unsurprisingly, given the extraordinary array of ichnological topics he has studied (not to say invented), Dolf Seilacher's presence throughout the book is strong. He may not have contributed a paper, but his influence pervades many pages. However, I would have liked to have seen a more critical examination of the Seilacherian approach to both ethology and ichnofacies.

Other than in the epilogue, concerns about ethology are scarcely mentioned, though they are unquestionably valid. If ichnology is to progress in new directions, it must be informed by greater integration with studies of modern animal behaviour, using approaches and terminology that enable meaningful communication with biologists and ecologists, as emphasized in a recent paper by Roy Plotnick. He notes that ethological terms used in ichnology are almost unknown outside the field, and are especially meaningless to most biologists. Terms such as 'cubichnia' and 'repichnia' do not represent behaviours, he argues, but 'interpretations of the morphology of sedimentary imprints made by a range of possible behaviors …[and] a disparate range of organisms' (Plotnick 2012, p. 464). They should be abandoned in favour of a system that parallels as closely as possible that used in behavioural ecology and biology. I am inclined to agree.

Similarly, though MacEachern *et al.* make their case for it in Part II, the ichnofacies paradigm is as much an ichnofacies paradox. The basic premise is enticing, but the number of caveats now required to make many ichnofacies work serves to make them increasingly problematical in value. What does the *Skolithos* Ichnofacies really mean, for example? MacEachern *et al.* try to be definitive about its environmental constraints and settings, emphasizing its occurrence in sandy, shallow marine environments. Chapters in the book, however, describe it as occurring in terrestrial, fluvial, lacustrine, shallow- and deep-marine settings, and not only in sandy substrates. If ichnologists apply such a broad concept to one ichnofacies, can it really be meaningful, and what hope is there for non-ichnologists to understand it?

Furthermore, though MacEachern *et al.* state that many originally bathymetric ichnofacies are now at best only passive indicators of water depth, it is acceptable to prefix them with 'proximal' or 'distal'. I have done it myself. If the paradigmatic *Cruziana* Ichnofacies is not bathymetric, however, how can subsets of it be described as though they are? And to stay with *Cruziana*, the notion that evidently time-restricted ichnotaxa must continue to be the bases for naming ichnological assemblages, evidently devoid of the nominative ichnotaxon, is absurd. You might as well try to recognize an agnostid biofacies in the Oligocene. MacEachern *et al.* acknowledge this, but offer no solution.

Ichnofacies are not going to disappear; nor do I think they should, but a critical assessment of the topic would have been helpful to the book. There is a clear need to avoid using such terms unless you are exactly sure what they mean. This is also true of ethological categories: if you can't be certain the term being used is accurate and unambiguous, it is probably wiser to describe trace fossil assemblages or ichnofabrics in a more neutral fashion.

My only other concerns come from the format of the book itself. Hyperlinks to supplementary information are rendered rather meaningless on the printed page, and although the chapters are all available online (for a price: <**www.sciencedirect.com/science/bookseries/00704571/64**>[1]), this makes me wonder what incentive there is to buy the hard copy. Of greater issue is the size and quality of the images. In trying to make a very large book smaller, it seems the publishers have sacrificed the illustrations. Many figures are miniscule and almost unreadable, whilst numerous photographs include barely identifiable trace fossils. This is not an issue exclusive to this book: many of the images in Buatois and Mangano (2011) are also too small or not sharp enough, whilst Seilacher's (2007) book has lots of his beautiful drawings, but insufficient

1 I recognize the irony that this is a hyperlink that will appear on a printed page.

photographs with which the interpreted morphologies can be verified. This unavoidably visual discipline is in dire need of a high quality pictorial guide.

In conclusion, then, is *Trace Fossils As Indicators Of Sedimentary Environments* good, is it necessary, and does it reflect the direction in which ichnology is moving (and the directions it ought to be)? The answer to all three elements of the question is 'partly'. Its aims are admirably broad, but perhaps almost unachievable. I would rather have read a shorter book that gave Dirk Knaust's own thoughts on ichnology, especially from his applied perspective. It is clear from his contributions that he has many interesting points to make and ideas to offer. Sadly, these get rather lost in the midst of some insufficiently distinctive or novel chapters. As a consequence, if you're looking to buy a new ichnology textbook, I would have to recommend Buatois and Mangano (2011) instead.

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Scottish Fossil Code: reviewed

The first review of the effectiveness of the Scottish Fossil Code has been completed four years after its publication in April 2008. Although there are encouraging signs that collectors are adhering to the best practice guidance contained in the Code, work is still required to promote the Code among certain sections of the collecting community that continue to collect in a reckless manner, and additional safeguards are required at the most vulnerable fossil locations.

Scottish Natural Heritage (SNH) was given the duty to prepare the Scottish Fossil Code (SFC) under the Nature Conservation (Scotland) Act 2004. The Act also included provision for SNH to review the SFC from time to time, and if required to revise it. The Code was the Scottish Government's response to perennial irresponsible fossil collecting that was affecting vulnerable fossil localities.

The review has revealed that the Code is well regarded nationally and internationally. It has proved to be a comprehensive document that is fit for purpose, containing advice on best practice in the collection and storage of fossils found in Scotland. Indications are that publication of the Code has resulted in fossil collectors generally being more responsible in terms of on-site collecting activity. However, it is clear there is unwillingness among collectors to seek permission from landowners to access land for the purpose of collecting and retaining fossils, and therefore by definition irresponsible collecting is still widespread.

Despite a degree of non-adherence to the Code, there is no indication that there are deficiencies in the Code document as such. What the review has revealed is that there may have been deficiencies in the promotion of the Code, particularly amongst those who collect in a particularly irresponsible or reckless manner. Consequently, rather than revising the Code, non-adherence will be addressed through renewed and better targeted promotion, with the following key actions:

1. a highly targeted approach being taken to promote the Code amongst certain sectors of the collecting community most likely to undertake reckless collecting. Promotion of the Code to that collector grouping will highlight the possibility of prosecution being an implication of the Code not being adhered to; and

2. renewed promotion of the Code among land owners, occupiers and owners of mineral rights, who have particularly vulnerable fossils and fossil-bearing resources. This will include the provision of guidance that will help these 'land managers' to draw the distinction between those who collect small amounts and have minimal impact on a site, and those who collect on a large scale irresponsibly to the point of causing reckless damage.

In addition to the preparation and implementation of a new promotion plan, SNH is considering instigating a volunteer-based system in which interested members of the community may form site monitoring groups, that can keep an eye on particularly vulnerable sites in their vicinity for instances of reckless collecting. Such groups would have close links to landowners, countryside rangers, SNH and Police Wildlife Liaison officers. This new development has come about in response to the worst instances of recklessly irresponsible collecting that have taken place in Scotland in recent years on the Isle of Skye and South Threave in Ayrshire.

To aid development of the plan, help improve effectiveness of the Code and to work towards the end of reckless collecting activity, SNH is keen to establish the views and support of the collecting community. We are also keen to learn of collectors' experience of using the Code. If you would like to offer a view please contact Colin MacFadyen at SNH (e-mail <**colin.macfadyen@snh.gov.uk**>).

Dinosaur footprint at a beach locality in Trotternish, north Skye. Evidence shows that slabs of rock in which the prints occur have been hammered in an attempt to form portable samples for easy carriage off the beach. Voluntary monitoring of this site will help safeguard new fossil discoveries and arrange rescue before they are damaged or stolen.

Scottish Fossil Code

If collecting fossils in Scotland, please do so responsibly and follow the advice on best practice in the collection and storage of fossil specimens outlined in the Scottish Fossil Code. The Code may be viewed and downloaded from <**http://www.snh.gov.uk/protecting-scotlands-nature/safeguarding-geodiversity/protecting/fossil-code/**>.

Essentials of the Code:

Seek permission: *You are acting within the law if you obtain permission to extract, collect and retain fossils.*

Access responsibly: *Consult the Scottish Outdoor Access Code prior to accessing land. Be aware that there are restrictions on access and collecting at some locations protected by statute.*

Collect responsibly: *Exercise restraint in the amount collected and the equipment used. Be careful not to damage fossils and the fossil resource. Record details of both the location and the rocks from which fossils are collected.*

Seek advice: If you find an exceptional or unusual fossil do not try to extract it, but seek advice from an expert. *Also seek help to identify fossils or dispose of an old collection.*

Label and look after: *Collected specimens should be labelled and taken good care of.*

Donate: *If you are considering donating a fossil or collection choose an Accredited museum, or one local to the collection area.*

Colin MacFadyen
Scottish Natural Heritage

Cretaceous squamate diversity and the K/P boundary: new evidence from China

Susan E. Evans (UCL) and Paul M. Barrett (NHM)

The extinction event at the end of the Cretaceous (K-P) eliminated the non-avian dinosaurs, but the fates of other tetrapod lineages varied, and an understanding of differences within and between groups has the potential to shed light on the nature of the event itself. Most information on squamates (lizards, snakes, and their relatives) during the Cretaceous–Paleogene transition has come from a limited number of sites in North America (*e.g.* Gilmore 1942; Gao and Fox 1996). These give the impression of a major extinction of terrestrial lizards at the end of the Cretaceous, but most of the recorded losses were within a single clade of large Asian-American teiid relatives known as boreoteiioids (or sometimes polyglyphanodontids) (Nydam *et al.* 2007). As many of these lizards appear to have been herbivorous, their extinction is plausibly linked to the major climatic and ecological changes at, or post, K-P. However, without data from other continents, it is difficult to judge whether this was a local or global effect.

Fossil localities in the Gobi desert of China and Mongolia have yielded spectacular Late Cretaceous lizard assemblages (*e.g.* Gao and Norell 2000) broadly similar to those of North America but with an even larger radiation of boreoteioids (*e.g.* Alifanov 2012). However, Paleogene lizards are known only from localities further south (Anhui and Hunan), mainly from very fragmentary specimens that have been difficult to interpret (*e.g.* Li *et al.* 2008). New lizard material recovered from the Late Cretaceous of southern China, in combination with further material from the Early Cretaceous of Liaoning and from the Eocene of Hunan, has the potential to expand our knowledge of squamate history in Asia through the Cretaceous and into the Paleogene. In addition, it will help to elucidate how different herbivore lineages responded to the major environmental changes that occurred during the K-P extinction event.

The original plan was to make a short visit to the IVPP in Beijing before continuing on to Guangxi Province in southern China in June–July 2010. We aimed to look at new Late Cretaceous lizard material from Jiangxi Province held at the Guangxi Natural Sciences Museum (Nanning) with our colleague and collaborator Dr Jinyou Mo. From there, we had planned a joint field trip to Jiangxi in order to visit the original lizard localities and to try and find new material. Unfortunately, in the week before our travel, southern China suffered torrential rainfall which resulted in widespread flooding that left key roads impassable and our main destination under water. We therefore had to abandon the fieldwork and reschedule, focusing our attention on the lizard and dinosaur material in the Guangxi Natural Sciences Museum (Fig. 1). Nanning is an attractive city, surrounded by subtropical, low green hills; it combines a relaxed, picturesque old city with an adjacent ultra-modern new business district, and Jinyou made us very welcome. The museum research area is small but had the added advantage of being positioned above a small French restaurant, run by a charming ex-pat Frenchman and his Chinese wife, which was a great place to sit back over coffee and quiche and talk fossils! Work on the Jiangxi lizard material is still ongoing, but the locality has produced important three-dimensional material, including a new genus of a large predatory lizard, *Chiangsia* (Mo *et al.* 2012, Fig. 2), that seems to be closely related to *Estesia* from contemporaneous

Figure 1. View of the Guangxi Natural Sciences Museum, Nanning, China.

deposits in the Gobi. Of the three or four genera of boreoteiioids also present, one (*Tianyusaurus*) is remarkable in being the only squamate known to date that has a complete lower temporal bar (Lü *et al.* 2008; Mo *et al.* 2009).

From Nanning, we returned to Beijing to spend time at the IVPP in Beijing, dividing our time between lizards (with Yuan Wang) and, in Paul's case, the occasional foray into dinosaurs (with Xing Xu). A new locality within the Early Cretaceous Jiufotang Formation of Liaoning has yielded exquisite specimens of *Yabeinosaurus* (Evans and Wang 2012), one of the first tetrapods to be described from the Jehol deposits in 1942 when this region was little known (Endo and Shikama 1942). One of the new *Yabeinosaurus* specimens was found to contain about 15 near-term embryos (Wang and Evans 2011), providing the earliest-known record of lizard viviparity, a trait that is relatively common amongst extant taxa. At the opposite end of the temporal range, new Eocene lizard material from Hunan Province is represented by more than 100 nodules, most of which contain unprepared or partly prepared lizard skulls – the largest collection of its kind anywhere. We completed a full survey of the material, and a description of two prepared specimens is in progress, but the nodules are challenging as they do not CT-scan successfully and are difficult to prepare chemically. Nonetheless, together with a re-examination of previously described but fragmentary material from the Palaeocene and Eocene of Henan and Anhui, the material suggests that an Eocene radiation of robust-toothed Asian iguanians may have succeeded the Cretaceous boreoteiioids.

Although dinosaurs were not the main focus of the research trip, Paul Barrett took time out to search the IVPP collections for a set of 'missing' fragmentary type specimens for genera erected by the Chinese palaeontologists C.-C. Young in the 1940s and 50s and Zhiming Dong in the 1980s. Paul found them in an old forgotten store cupboard, allowing some enigmatic taxa – previously known only from sketches – to be reassessed. These included the only known 'phytosaur' from China,

Figure 2. Anterior view of the skull of the Late Cretaceous lizard Chiangshia

Pachysuchus, which turned out to be a prosauropod dinosaur (Barrett and Xu 2012), and material of the ornithopod '*Gongbusaurus*' which Paul and Xu are working on currently. He also spent a day at the museum in Hohhot, Inner Mongolia, to examine a new hadrosaur specimen that is currently under study, and finished a major new description of the postcranial skeleton of the little ornithopod *Jeholosaurus* (Han *et al.* in press).

Work on many of these projects is continuing. We would like to thank the Palaeontological Association for the funding that permitted our visit, as well as our colleagues in Nanning (Dr JinYou Mo) and Beijing (Prof. Xing Xu, Prof. Yuan Wang) for their welcome and continued collaboration.

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Book Reviews

Living Dinosaurs: the Evolutionary History of Modern Birds

Gareth Dyke and Gary Kaiser, eds. 2011. Wiley-Blackwell, UK. 422 pp. £55.
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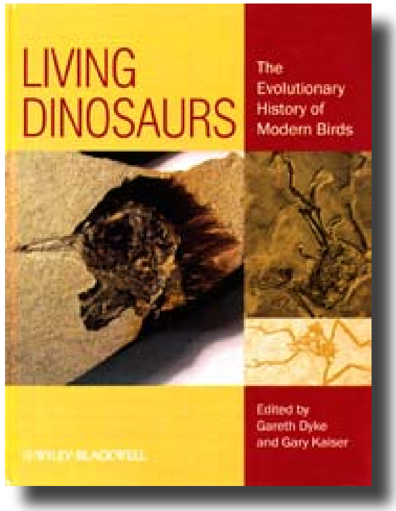

Within the last fifteen years, the origin and evolution of birds has become one of the "hot" topics in palaeontology, in the wake of spectacular discoveries, notably from China, which have enormously increased our knowledge of the early stages of avian evolutionary history. A spate of papers on fossil birds has resulted, but surprisingly enough relatively few books have been published on the topic in recent years. The aim of this collection of 16 papers, according to Gareth Dyke and Gary Kaiser, is to bridge the gap between palaeontologists working on fossil birds and ornithologists. Needless to say, all authors in this volume embrace the view that birds "are related to some dinosaurs", as Joel Cracraft puts it in his foreword, or, to be more straightforward, that birds are simply "living dinosaurs", to quote the title of the book. The reader should therefore not expect to find here one of the "last ditch" papers that are still being produced by the diminishing group of researchers who still question the dinosaurian origin of birds. From that point of view, the contents of the book certainly reflect the present status of scientific opinion on that matter.

Although the subtitle of the volume suggests that it mainly deals with the evolution of *modern* birds, a large part of it is devoted to birds that cannot be called modern. The first paper in the collection, by Peter Makovicky and Lindsay Zanno, is in fact mainly about non-avian theropods and the gradual appearance of avian features (including physiological and reproductive traits) during their evolution – leading to a conclusion that few palaeontologists would question, namely that "to date, no credible alternative to the theropod ancestry of birds enjoys much support from the fossil record". The following paper, by Peter Ward and Robert Berner, is more controversial. Their main contention is that the success of dinosaurs and, ultimately, birds is directly linked to their air sac system, which enabled them to survive a period of low oxygen levels in the Late Triassic (which the authors consider as having caused the extinction of various non-dinosaurian tetrapod groups). This is an intriguing suggestion – whether it will be largely accepted is a moot point. One of the longest papers in the book, by Jingmai O'Connor, Luis Chiappe and Alyssa Bell, is about the "pre-modern" birds that were dominant during the long Mesozoic part of avian evolution. This is a very useful review, complete with character matrix, of the various groups of archaic birds that evolved mostly during the Cretaceous, and disappeared at the Cretaceous–Palaeogene boundary.

The first paper in the book dealing mainly with modern birds is a thoughtful, at times rather philosophical, reflection by the late Bradley Livezey on "progress and obstacles in the phylogenetics of modern birds". In it, Livezey discusses various controversial issues, including the sometimes contradictory contributions of palaeontology and molecular biology. Although his conclusion sounds rather pessimistic, the points he raises are definitely worth taking into consideration by researchers interested in avian phylogeny. The question of the contribution of palaeontology to our understanding of modern bird evolution is taken up in the following paper, by Gareth Dyke and Eoin Gardiner, who analyse the avian fossil record of Neornithes and discuss the vexed question of the possible Cretaceous origins of modern bird groups – suggested by molecular data but not much supported by palaeontological evidence. Their conclusion is that the fossil record of birds is not as faulty as sometimes assumed, and the idea that modern birds were "cryptic" in the Cretaceous is improbable.

The subsequent papers can be seen as case studies on specific groups of modern birds. Daniel Ksepka and Tatsuro Ando thus review the evolution of penguins, a group with a good fossil record that allows interesting inferences about the development of their unusual adaptations, and the influence of palaeogeography and climate change on their evolutionary history, up to the present. The paper by Herculano Alvarenga, Luis Chiappe and Sara Bertelli deals with a completely extinct group, the Phorusrhacidae (also known as "terror birds"). This group of medium-sized to giant terrestrial and carnivorous birds enjoyed a considerable radiation in South America during the Cenozoic, and their classification is still a matter of discussion. The cladogram proposed in this paper certainly shows that many details of their evolution are still poorly resolved. The short section on biogeography is already somewhat outdated, because of recent reports of phorusrhacid fossils from Africa and Europe. Estelle Bourdon then reviews another extinct group, the Odontopterygiformes, or pseudo-toothed birds, which had a very broad distribution over the oceans of the world during the Cenozoic. The paper is mainly a phylogenetic analysis of this singular group, with little about its palaeobiology and palaeogeography. Bourdon's controversial conclusion that the Neognathae are paraphyletic has already drawn fire from other experts, notably Gerald Mayr.

Whereas the above-mentioned papers are mainly based on palaeontological evidence, Keith Barker's study on passerines uses molecular approaches, notably DNA sequencing, to unravel the complex phylogeny of the most diverse group of modern birds. An interesting conclusion is that "passerine birds are likely to represent one of the six most notable radiations of vertebrates remaining on the planet".

The following paper, by Bret Tobalske, Douglas Warrick, Brandon Jackson and Kenneth Dial, deals with several aspects of one of the most important characters of the majority of birds, namely their ability to perform flapping flight. Both morphology and behaviour are involved in that exercise, and are analysed here in some detail, notably on the basis of experiments on living birds. A special section is devoted to the amazing hovering abilities of hummingbirds. Stig Walsh and Angela Milner then provide an interesting essay on the avian brain and senses, combining anatomical and biological evidence with the results of recent investigations on the brains of various fossil birds, largely based on CT-scans. This new evidence has markedly improved our understanding of the evolution of the avian brain and its timing – it has now become clear that all Neogene and younger taxa had entirely modern brains.

The next paper, by Joseph Brown and Marcel Van Tuinen, brings us back to the question of the antiquity of modern birds. It contains a thorough discussion of molecular clocks used for dating major episodes in bird evolution, with results that often are difficult to reconcile with the fossil record. Despite this, the authors' conclusion is generally optimistic as far as joint efforts by molecular biologists and palaeontologists are concerned. The contribution by Chris Organ and Scott Edwards is a brief review of what is known about the major events in avian genome evolution, a relatively recent field of investigation that may lead to some rewriting of the avian phylogenetic tree.

Bent Lindow brings us back to the question of what happened to birds at the Cretaceous–Palaeogene boundary, and whether the basal neornithine diversification took place before or after it. Although some of the data used by Lindow in his discussion of events at the K/Pg boundary are rather outdated, his remarks on the prevalence of *ad hoc* hypotheses to explain why certain groups of organisms (including some birds) survived those events are well-founded, and so is his conclusion that only the discovery of much more abundant avian fossil material from the earliest Palaeocene will shed some light on the question.

Gary Kaiser's contribution on marine and aquatic birds addresses phylogenetic, anatomical and behavioural issues to show how modern birds belonging to various groups have adapted to water-related modes of life, including diving and specialised types of flight. Interestingly, he concludes that the frequent lack of agreement between palaeontological and molecular results should be no cause for concern.

The final paper, by Gavin Thomas, is about the future. What will happen to birds in a world threatened by habitat destruction and climate change? There are many recorded instances of rapid population decline, and, not unexpectedly, Thomas's general conclusion is not encouraging: avian diversity is facing "a bleak and uncertain future". What perhaps is lacking is a comparison with what palaeontology and archaeozoology can possibly tell us about avian diversity changes in the past.

The book is generally well produced. Although the number of figures varies greatly from one paper to another, the black-and-white illustrations are generally useful and of reasonable quality, with some exceptions (the thumbnail-sized photographs on Fig. 6.1 are almost illegible). The colour plates at the centre of the book are another matter. Some of them are too small to be really useful, and what is the benefit of printing a moderately convincing reconstruction of the pseudo-toothed bird *Dasornis* twice, once in black-and-white and once in colour? Most of the colour plates, which have probably increased the cost of the volume, could have been dispensed with and replaced by black-and-white figures.

To sum up, this book is a collection of contributions which are interesting and useful in their own right, but could just as well have been published as individual papers in journals (because of this, it would have been convenient to provide abstracts for all papers). They do not add up to a synthesis or comprehensive review of what we know about the evolution of modern birds. Rather, they provide an overview of the diversity of the approaches used to reconstruct that evolutionary history. This apparently was the aim of the editors, and they should be thanked for putting together a thought-provoking volume that will be of use to all researchers interested in avian evolution, whether they are palaeontologists or ornithologists.

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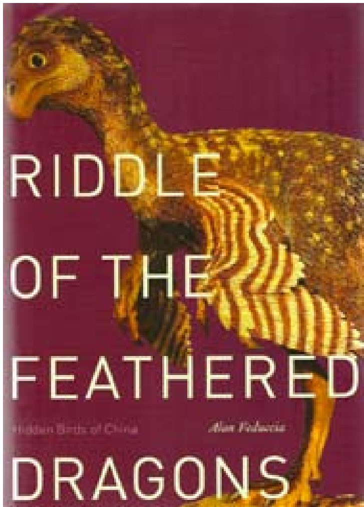
Riddle of the Feathered Dragons

Alan Feduccia. 2012. Yale University Press. 358 pp. £45.
ISBN 978-0-300-16435-0



Are birds dinosaurs? How did they learn to fly? Can cladistics be relied upon? Feduccia's introduction and first chapter romp through the recent history and debate relating to these questions, and he appears to take considerable pains to argue both sides of the story: setting out the questions themselves, both sides of the argument and frequently quoting others' jeers at his own views, while taking even more pain to tip the balance of the arguments, subtly, but inexorably his way, and to ensure the criticisms aimed at him backfire on those that made them. It is good writing!

By the end of the introduction, the reader knows Feduccia thinks little of cladistics: he specifically notes the problem that morphological features to be analysed in any one study can be chosen to obtain the required results, later going into some detail about how modern cladistic approaches tend to group animals as ecological equivalents without regard for how in fact they are related. He confirms his hypothesis by using examples of extant species whose DNA or molecular comparisons have overturned a cladistic approach, wryly observing that we don't have this luxury for extinct species and concluding by asking the rhetorical question "what if we did?" He continues to not mention the quality or quantity of modern cladistic studies for which he has been widely criticised, not least by Chiappe 2012, which concisely sets out the counterarguments.

The first chapter also contains an excellent but odd attack on the problems of non-peer-reviewed or pseudo-scientific publications; odd because the very book in which they are written is not peer-reviewed, but excellent in that Feduccia exposes most of the more dubious sensationalist papers which sadly do taint the wider press coverage of genuinely exciting discoveries. Critics may not be surprised to learn that his own publications do not feature here.

The book goes on to pose what the question of birds being dinosaurs (or not) actually means – and this is very clearly expressed – with the *status quo* being concisely set out; *i.e.* that *everyone* agrees that birds and dinosaurs are archosaurs, that the current orthodoxy is that birds are derived theropod dinosaurs, closely related to dromaeosaurs or deinonychosaurs, and that, although not expressly stated at this point, Feduccia disagrees.

Feduccia's penchant for naming others in the field and detailing what they think or have said is evident throughout. This shows a masterful grasp of the subject, but can be disconcerting, as without prior knowledge, it is hard to know whether the person he refers to is scientific friend or foe. The effect is used most interestingly in the second and third chapters that give a summary of the history of avian evolution, from Darwin and his surprisingly conservative thoughts on *Archaeopteryx*, to Owen and Huxley, through to the modern protagonists.

This leads nicely into a discourse on the 'ground-up' *versus* 'trees-down' origin of flight theories, in which Feduccia argues convincingly for the trees-down view, though one wonders whether the question asked more openly would lead to more answers and less bickering. He tacitly acknowledges that there may be more 'science' in the cladist's argument for ground-up origins, but that there are serious problems with the view, which have not been resolved since it was first proposed.

His argument that the careful, uniformitarian observer may have sounder conclusions is an ongoing theme of the book, which if applied to politics might be stated as: "if you want to know what is happening in politics, ask someone who isn't interested"! This might seem a childish argument in our age of advanced science, but the political allegory holds much weight, and many of the most important scientific discoveries have been mere observations. Despite the lucidity and sensibleness of his arguments, Feduccia may not win many allies by ignoring so many cladistic studies and by stating that "when we cut through all the hyperbolic rhetoric, one thing is certain, *Archaeopteryx* flew!" It is also possible that Feduccia is better at debunking theories of his peers than providing convincing evidence for his own.

The longest single section of the book is devoted to how the recently discovered Chinese avian fossils have added so much to our knowledge. It extensively reviews Mesozoic specimens and groups generally, and follows the now familiar theme of stating the key scientists and their theories, which works well here since there is less controversy with the Chinese finds, perhaps because the fossils themselves are so good. There is a clear explanation of how the more famous fossils and groups fit together, and the section concludes in a relatively conservative way: that the Chinese fossils have added hugely to our understanding of the adaptive radiation of birds in the Mesozoic, but that there is still a significant gap between these taxa and the Urvogel, *Archaeopteryx*, which lived 25 million years previously.

The next chapter, possibly a little lean for the scale of the topic, covers flightless birds. This is especially interesting as it concentrates on their dispersal and evolution through time and space, and begins to tie the previous chapters' threads together.

These threads are further woven in the final chapter which begins with a description of the two nineteenth century American greats: Cope and Marsh, the latter shown posing in a photograph with his students who look more like a bunch of gunslingers than field scientists. He probably had reason; in his first description of *Hesperornis* (the five-foot-long diving-bird) Marsh is surely alone amongst palaeontologists to claim that a full description of the new fossil was rendered impossible because of "the extreme cold, and danger from hostile Indians"!

The work of Marsh on North American toothed birds allows Feduccia's final chapter to take in other interesting characters and specimens: John Ostrom and his work on *Deinonychus*, pterosaur comparisons and even marine reptiles, while returning to *Archaeopteryx* and various other classic specimens, cleverly bringing the book to its conclusion.

Feduccia writes well and often entertainingly, and is extremely knowledgeable about his subject, its history, and his peers and their work. But his conclusion – perhaps because he has already explored the subject so thoroughly (albeit from his own viewpoint) – is rather weak, ultimately saying that, "the problem of avian origins is far from being resolved." That said, perhaps after this account of avian evolution, through history to date, this is the wisest conclusion to draw: in every field of knowledge, there is more to discover.

Yale University Press has done a wonderful job in producing a well set-out and beautifully illustrated tome, with a typically North American, resurrected eighteenth century typeface which makes the book feel as scholarly as the extensive and clear endnotes, references and very detailed index suggest. You might expect this quality given the £45/$55 asking price.

Even if you don't agree with Feduccia, I heartily recommend this book to anyone interested in avian evolution; it gives a good review of recent developments and controversy, and sets out the conflicting views concisely, if a little biased in favour of the author. Despite holding his own clear views on avian evolution, many of his arguments are convincing and he wins sympathy with them, though one wonders how many opinions he will ultimately sway. He is an advocate of looking at problems and theories in novel ways, which ultimately, even if such radical hypotheses do prove to be wrong, is a stimulating way of arriving at the truth. Most importantly, I felt that he wrote the book not to promote his own views, but to promote his science. You cannot ask for more than that.

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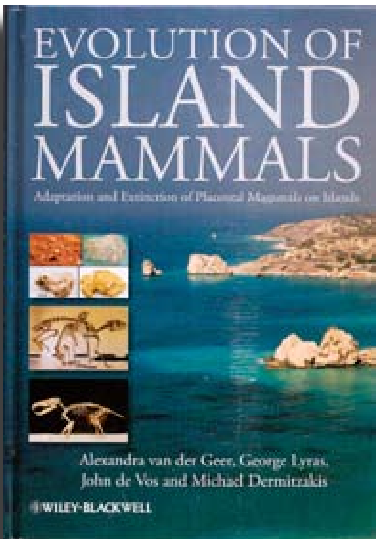
Evolution of Island Mammals: Adaptation and Extinction of Placental Mammals on Islands

Alexandra van der Geer, George Lyras, John de Vos and Michael Dermitzakis, 2010. Wiley- Blackwell, UK, 496 pp. £47.50. ISBN 978-1-4051-9009-1.



Published by Wiley Blackwell, this is a 496 page, lavishly illustrated hardback which delivers a great deal for its £47.50/€57.00/$109.95 price tag.

Evolution on islands is different from evolution on the mainland due to a variety of factors that are discussed in detail in this volume. Adaptive radiation affects island populations, for example the various species of Darwin's finches from the Galapagos Archipelago where beak morphologies have diversified as adaptations to various foods. Another example is the endemic Hawaiian Honeycreeper, of which twenty species have became extinct in the recent past, which shows a similar pattern of diversification from an ancestral finch into a variety of ecological niches.

However, this book deals with the insular placental mammals which, Van der Geer *et al.* admirably demonstrate, developed into weird and wonderful forms. Island species show gigantism (*e.g. Candiacervus major* from the Late Pleistocene of Crete which stood 1.65m at the shoulder and was the largest deer that ever lived) or dwarfism (for example, the Sicilian Pygmy Elephant *Elephas falconeri* and the Dwarf Hippopotamus *Hippopotamus lemerlei* from Madagascar).

Within these pages, there are elephants the size of pigs and gorilla-sized lemurs, giant dormice and hamsters, Balearic Mouse Goats and the Gargarno Moonrat (*Deinogalerix koenigswaldii*) – a giant hairy hedgehog three times the size of the European Hedgehog.

A particular favourite was the Giant Sardinian Otter (*Megalenhydris barbaricina*). Compared to the extant European species that weighs between 7 and 12 kg and is 92–140 cm long including the tail, and the endangered Brazilian Giant Otter (*Pteronura brasiliensis*) which reaches up to 1.7 m and 32 kg (♀ up to 1.5 m and 26 kg), *Megalenhydris* was a true giant.

Evolution of Island Mammals presents new material as well as reassessing fossil specimens in museum collections around the world. The authors highlight recent advances in knowledge of the evolution and extinctions of placental mammals from islands as diverse as Sicily and Indonesia. It is refreshing to see a book that does not restrict itself to the fossil faunas of North America and Europe.

The scope is worldwide and long-ranging, from the Oligocene to the early Holocene, and the authors discuss anthropomorphic effects driving past extinction events (habitat destruction and hunting) and current threats. The authors do not restrict themselves to comparative anatomy and classic evolutionary theory; they throw modern methods into the equation by discussing molecular clocks and genetics, bringing the discourse right up to date.

Part II is divided into a series of chapters that discuss the geology, palaeogeography, biozones and faunal units of specific islands. A particularly interesting section on historical palaeontology details the work of early collectors in each locality and folklore of the native populations, while addressing any taxonomic problems. Although the book is about endemic mammals, the authors do not treat them in isolation; they also discuss the bird, reptile and amphibian faunas present on each island.

The decision to treat each island as a separate entity works well, and the book takes us to Cyprus (chapter 4), Crete (5), Gargano (now part of mainland Italy; during the Late Miocene and Early Pliocene, it was an island with a highly endemic insular mammalian fauna detailed in chapter 6), Sicily (7), Malta (8), Sardinia and Corsica (9), the Balearics (10), Madagascar (11), Java (12), Flores (13, with a history of the discovery of *Homo floresiensis* and the fierce debate on the true nature of this specimen, as well as other unique mammals), Sulawesi (Celebes in older literature, chapter 14), Phillipines (15), Japan and the Ryuku Islands (16 and 17), Californian Channel Islands (18) and the West Indies (chapter 19).

In **Part III**, island endemics are presented in a series of taxonomic chapters (20–26) covering respectively: proboscideans, lagomorphs, rodents, insectivores and bats, cervids and bovids, hippopotamuses and pigs, and carnivores.

The chapters include sections on geographical distribution and geological range, common trends in morphology, and taxonomic remarks.

Primates are not included in this overview since the lineages are too specific to allow comparison. Primate fossils and early hominid taxa are, however, fully discussed on their respective islands in earlier chapters in Part II.

The authors then discuss patterns and trends in the next chapter, including dwarfism and gigantism, increased size variation (*e.g.* in *Deinogalerix* and other taxa), size reduction of limb bones, increased grinding force, neurological changes and changes in metabolism.

Chapter 28 is a concise analysis of evolutionary processes affecting island faunas and the types of speciation involved using numerous well-chosen examples.

The final chapter discusses the extinction of insular endemics. The authors close by detailing the plight of the wonderfully named but little known Senkaku Mole (*Nesoscaptor uchidae*), now under serious threat of extinction due to introduced goats. For some species, it is already too late, for example the Falkland Islands Wolf (*Dusicyon australis*), deliberately eradicated by settlers in the 1860s.

The book is well illustrated, with numerous black-and-white photographs of sufficient size and resolution to be useful, 26 colour plates, line drawings and reconstructions of fauna discussed in the text. Locality maps are well drawn and of an adequate scale; all sites are detailed in the legends. Points of particular importance are highlighted in shaded boxes within the text. The comprehensive bibliography (over 870 references: pp. 404–461) is up to date; the index is very easy to use, allowing the reader to pick out genera of particular interest and compare or contrast representatives from different islands.

Intended for postgraduates and researchers rather than undergraduates, *Evolution of Island Mammals* is an excellent work of scholarship, and also an extremely engaging read for non-specialists.

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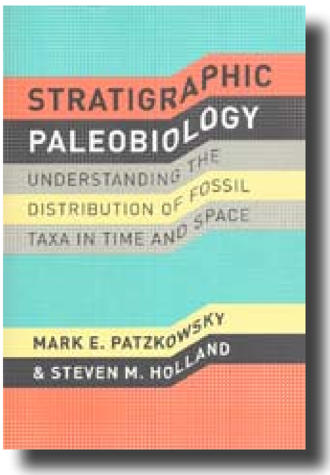
Stratigraphic Paleobiology: Understanding the Distribution of Fossil Taxa in Time and Space

M. E. Patzkowsky and S. M. Holland. 2012. University of Chicago Press. 259 pp. £22.50. ISBN: 978-0-226-64938-2.



Despite an uninspiring cover (in my opinion) in terms of both design and colour scheme, I held firm to the adage that you should not judge a book by its cover and delved into this volume with great anticipation of learning more about the stratigraphic elements of palaeobiological research. The contents list and a preface are followed by ten chapters and a glossary of stratigraphic terms, references and an index. All the chapter titles hinted at a broad coverage of topics that would be of interest to me, and that, on the whole, I had not seen covered in palaeobiological works elsewhere. I was eager to read on.

At only two full pages of text, the preface is rather brief but sufficient in explaining how the book had been conceptualized and what it seeks to achieve. The latter is expanded on in the *Introduction* (Chapter 1), which delves into pertinent questions such as, "Can the fossil record be read at face value?" and "What is stratigraphic paleobiology?", followed by a section on the core questions in the history of life, an explanation of the philosophical viewpoints of the authors, and a discussion of how the book is organized. All these sections are rather short and introductory, but they do serve to set the scene for an interesting read to follow.

Chapter 2 (*The Nature of a Sample*) follows on nicely by setting out the range and limitations of the sampling units, in terms of both spatial and temporal resolution, for potential palaeoecological studies in general. It covers how beds are deposited, highlighting the fact that the fossil record is more gaps than actual record and that it will not be particularly useful for generating high-resolution time series over short periods such as decades or even centuries (but is very useful over much longer time periods), and that the (often time-averaged) fossil assemblages tend not to reflect ecological communities in the sense that neoecologists would use the term. It also covers sampling techniques, minimum sample sizes, various elements of potential sample bias, and how to compare like with like, emphasizing that these are important issues for neoecologists and palaeoecologists alike, but that there are subtle differences to take into consideration due to the axiomatic differences associated with collecting data from extant and fossil systems respectively.

In essence, this chapter serves to merge the important elements of these two ecological disciplines. As with most of the book, this chapter focuses primarily on marine systems as a result of the authors' research interests, and some useful literature on other elements of the fossil record are lacking. For example, the authors comment that live-dead studies in modern settings have demonstrated that various diversity metrics, such as species richness, relative abundance and evenness are all relatively unaltered in death assemblages, but this is not true in all circumstances. In an interesting comparative taphonomic study of extant beetles, Smith (2000) found that the relative abundances of families in a live assemblage were significantly different from those found in the associated death assemblage.

Explaining *The Stratigraphic Framework* is the focus of Chapter 3, which seeks to explain the basic principles of the terminology-rich (a glossary of terms is provided) subject of sequence stratigraphy in less than 20 pages of text. The authors note this and provide suggestions for further reading in order to gain a more complete understanding of the topic. Although reasonably clearly written, I found this chapter rather laborious (reading it as a zoologist) as it explained the various sedimentary processes and resulting sequences, and expect that neoecologists (one of the anticipated audiences of the book) would do so also. Nonetheless, this chapter covers an essential element of stratigraphic palaeobiology, and the fact that this topic is of importance in providing a valuable time–environment framework for palaeobiologists does come through as the take-home message.

Chapter 4 explores the *Environmental Controls on the Distribution of Species* by explaining how organism niches and distributions vary along gradients in both marine and terrestrial systems. The description and interpretation is considered with regard to ordination techniques (detrended correspondence analysis and non-metric multidimensional scaling) and cluster analyses. Again, these are explained reasonably clearly with relevant supporting examples. The use of decision trees, although not mentioned, may be another way of analysing these types of data (see Penney & Langan, 2006 for an example of this application in palaeobiology). As with the previous chapter, various background reading is suggested to obtain a better understanding of ecological statistics. One slight concern is that the most recent of these references is 11 years old and it may be appropriate for readers to consult more recent publications for advances in methods and applications.

Stratigraphic Controls on Fossil Occurrences forms the focus of Chapter 5, which considers and models the structure and predictability of the fossil record in relation to differences in, for example, sedimentation rates in space and time, and how these impose a stratigraphic overprint which needs to be overcome in order to generate well-thought-out sampling designs aimed at identifying the underlying biological signal provided by the fossils. First and last occurrences of taxa are discussed in some depth with regard to stratigraphic architecture, and why it is important to appreciate that not all clustering of fossil occurrences necessarily reflects originations or extinctions (there is also a discussion of range offset principles). The authors stress that only through comparison of sequence stratigraphic architecture is it possible to differentiate between biologically generated clusters and those produced by stratigraphic architecture. Another benefit of their approach is that the sequence stratigraphic elements afford an opportunity to correlate independently of fossils, and hence avoid the circular reasoning of biostratigraphic correlations where fossils are used to create a temporal framework and then also to analyze biotic changes within that framework.

Chapter 6 looks at *The Ecology of Fossil Taxa Through Time*, revisiting the niche concept developed in Chapter 4 and how to attempt to quantify changes in niche dynamics over time, on the premise that a better knowledge of this will increase our understanding of the evolution of individual species, the evolution of clades, and the long-term change in regional ecosystems. However, despite the potential for niche change, predictable patterns are hard to find. The authors refer to changes in niche dimensions (with regard to taxa within them), but there is a potentially interesting area not discussed, *i.e.* the formation and occupation of new niches as a result of the formation of novel biomes with a no-analog climate, as a result of significant climate/ecosystem change. This chapter also highlights that palaeoecologists can address questions well beyond the scope of neoecologists, such as: Is there any characteristic pattern of change from the origin of a taxon until its final extinction? Such studies require the ability to tease apart aspects of the niche at very fine timescales, highlighting the importance of data collected in a high-resolution time–environment framework as afforded by sequence stratigraphy, even down to durations as short as 10–100 ky). However, also noted is that palaeoecologists are hindered by many uncontrollable factors not encountered by neoecologists who are usually able to make replicate samples rather easily, for example, extent, exposure and orientation of outcrops at different locations, spatial and temporal incompleteness of the fossil record, *etc*. This chapter finishes with the important observation that mapping phylogenetic data onto a regional time–environment framework will permit detailed examinations of important palaeoecological problems regarding the evolutionary ecology of individual lineages.

Morphological Change Through Time (Chapter 7) focuses on what is one of the least explored areas of stratigraphic palaeobiology, and hints at the potential for discovering new insights into the underlying processes of evolution. First to be considered is the way in which the stratigraphic record can overprint patterns of morphological evolution, which may result in erroneous interpretations. This includes an interesting account of how morphological clines further complicate matters and how only a few studies have approached this problem in a convincing way. The second half of this chapter deals with how to overcome these issues, including the use of approaches, such as Bayesian inverse modelling.

Chapter 8, *From Individual Collections to Global Diversity*, is concerned with how the investigation of the range of spatial and temporal scales afforded by sequence architecture has the potential to facilitate higher-resolution studies of regional diversity change over time. As a prerequisite, this chapter details some of the main metrics available for quantitative investigations of diversity and evenness, including weighting and rarefaction of unequal sample sizes. In contrast to earlier chapters, this one seems to draw more heavily on examples from the published literature to illustrate diversity partitioning in modern and palaeoecosystems, for example, with regard to latitude, extinction and invasive species. An important point raised here is that alpha and beta diversity are often ill-defined by both neo- and palaeo-ecological researchers, making strict comparisons of the published literature problematic.

The ultimate level of complexity is covered in chapter 9, *Ecosystem Change Through Time*. In contrast to neoecologists who work on current timescales, palaeontologists can make direct observations of long-term ecosystem change, including in relation to chemical and physical changes of the sediments from which their palaeodata originate. Following an introduction of historical concepts and recent innovations, the authors focus on how placing biotic gradients in a sequence stratigraphic time–environment framework can be used to address fundamental questions, such as stability, rate of change and cause of change in ecosystem composition and structure over time. Considerable new research is required to understand the full spectrum of ecosystem change, which appears to range from stasis to continuous change. The authors discuss quantifying stability as a means to compare and investigate the controls of ecosystem change through space and time. Techniques using correlations, rate-based approaches, similarity coefficients (only Jaccard is discussed) and ANOSIM are considered. It is noted that this is a highly complicated process to understand, given its immense complexity of component elements: for example, the broad spectrum of environments, time periods, taxonomic groups and spatio-temporal scales, in addition to the unknown 'causative' factors of change, which may be numerous. Nonetheless, identifying magnitude and rates of change will be accomplished most effectively in a well-defined time–environment framework. Integrating metacommunity models in such studies is proposed as an exciting new research area.

The final chapter (chapter 10), *From Beginnings to Prospects*, begins with what may have been expected in the preface, *i.e.* how the authors generated their ideas throughout their early research and their sources of inspiration. They go on to summarize the three main components required for stratigraphic palaeobiological research: an environmental framework based on sedimentological and geochemical data, a temporal framework based on sequence stratigraphic architecture and event stratigraphy, and appropriately collected palaeontological data collected within this framework. They emphasize how earlier chapters have demonstrated that their approach can facilitate many types of analyses, and propose promising directions for the future of stratigraphic palaeobiology. For example, metacommunity models with realistically-scaled evolutionary rates and environmental variations, and studies on regional scales (at shorter scales the record is too incomplete and at broader scales important ecological variation is lost).

The book follows a logical sequence with each chapter building on the previous one, and indeed, often refering to previous chapters in order to contextualize the current one. Regular reference is made to published works (often those of the authors) as examples demonstrating the principles they are trying to convey. There is a short glossary of common sequence stratigraphic terms, followed by an extensive list of literature cited throughout the text, followed by a three-page index. The book highlights key gaps in our knowledge and makes many suggestions for potential future research avenues, which no doubt some readers will pursue. Even without these suggestions, creative academics will constantly be asking themselves how these ideas can be applied to their own field of expertise, and certainly I have a few more new and novel project ideas from having read this book.

The volume includes two colour plates, 31 halftones and 19 line drawings. Copy-editing is reasonably tight, with only a handful of typographical errors noted. Readership is aimed at graduate students, in addition to professional palaeontologists, ecologists and evolutionary biologists. Neoecologists and evolutionary biologists would benefit from having some prior understanding of stratigraphic and palaeobiological principles as these are not fully explained, although suggestions for further reading are provided. I would certainly recommend this book as essential reading for new palaeoecology Ph. D. students in the process of developing their experimental/data collection methodology, because it will no doubt provide them with ideas that they (or their supervisors) may have overlooked.

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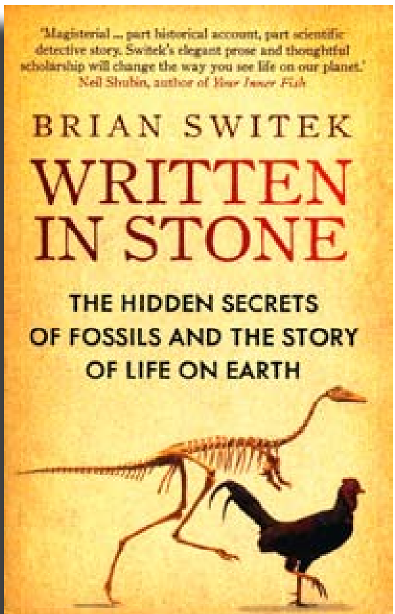
Written in Stone: the Hidden Secrets of Fossils and the Story of Life on Earth

Brian Switek. 2011. Icon Books, UK. 320 pp. £8.99. ISBN 978-1-84831-342-2



The hunt for transitional fossils to fill out the evolutionary Tree of Life is remarkably similar to the former search for organisms to fill gaps along The Great Chain of Being. This is especially true, I suspect, in the public perception of evolution, and partly due to strong politico-religious anti-evolution movements in various parts of the world. Brian Switek's first book fits into this popular perception of transitional organisms missing from life's evolutionary tree – and is about the search for those almost mythical 'missing links'. In addition, *Written in Stone* is an exploration of vertebrate palaeontology, and importantly the men of science, leisure and business (and in the past it largely was men) that sought, and continue to seek out fossils: the Rosetta stones for understanding the history of life on Earth.

The book commences with an evaluation of the concept of 'missing links', using the excessive hype over the unveiling of *Darwinius masillae* ('Ida' to the popular press). Switek intelligently covers the 'Ida as human ancestor' over-exuberance, and the subsequent, if more sober, scientific assessment of the position of *Darwinius* within the primate family tree. This acts as an exemplar of how important transitional fossils are in the public perception, and of how science shouldn't work: driven by the media and other interests that conflict with scientific endeavour. This leads into an important theme explored throughout the book: the importance of politics and culture in the progress of science. Unfortunately Switek, or his publishers, fall into the *Darwinius* trap, with the blurb on the inside front cover claiming "Brian Switek's book … is the first account of the remarkable discovery of these gap fossils and of the fascinating new stories they tell about the evolution of life". Clearly not true!

The second chapter heads back in time to explore the development of ideas regarding fossils, and the way natural historians took considerable time to recognize these 'bone shaped stones' as the remains of once living things. Starting with Steno's dissection of the head of a great white shark in Florence, and the recognition of *Glossopterae* or 'tongue stones' as fossil sharks' teeth, the narrative passes through Hutton's uniformitarianism and Old Earth concepts, to Georges Cuvier and the first evidence for extinction. The chapter ends with Charles Lyell's *Principles of Geology*, and hints at the work of Charles Darwin to come.

The following chapter tackles Darwin, Darwinian evolution and natural selection. However, it does more than simply give an outline of the evidence for evolution, but interweaves the personalities and prevailing concepts into a sense of time and place. We are told how the young Darwin could not abide the medical career he had commenced upon, but 'wasted' his time on natural history, which nicely illustrates how following an interest ultimately can be more fruitful than sticking to a disliked career. This is followed by Darwin's subsequent move to Cambridge, where he worked with John Henslow and came under the influence of Adam Sedgwick, the latter expanding Darwin's knowledge of natural history into the realms of geology.

The story of Darwin on the *Beagle* is briefly told, with earthquakes in Chile, mammals in Patagonia, finches on the Galapagos, and the mountains of evidence Darwin collected, with many fossil specimens sent to Richard Owen in London to be described. The influence on the young Darwin, and his fledgling ideas regarding evolution, of Thomas Malthus' *Essay on the Principles of Population* are explored, as is the 1844 publication of Robert Chambers' *Vestiges of the Natural History of Creation*. The ferocious response to *Vestiges* delayed the publication of Darwin's ideas on evolution, whilst he carefully accrued insurmountable evidence so that his ideas could not so easily be rejected. This, of course, nearly led to Darwin being usurped by Alfred Russel Wallace, who had essentially the same ideas on natural selection, although supported by much less evidence than Darwin had amassed. This acted as a prelude to the writing and publication of *On the Origin of Species*, and Switek shows how Darwin was assaulted anonymously in print by his former colleague, Richard Owen, and his geological mentor, Adam Sedgwick.

The fish–tetrapod transition is explored in the next chapter – just how did the first vertebrates manage to leave their watery home and come out onto land? The story begins with the discovery of the lungfish *Lepidosiren paradoxus* in Brazil, passing through the machinations of Owen and others, and on to the ground-breaking work of Jenny Clack on *Ichthyostega*, *Acanthostega* and other early tetrapods. The chapter culminates with the discovery and description of *Tiktaalik* from the Canadian Arctic. Next up are dinosaurs and birds, starting with Thomas Henry Huxley's profound insights. Inevitably *Archaeopteryx* plays a leading role, and the narrative is brought up to date with details of some Chinese feathered dinosaurs.

In subsequent chapters, Switek takes us on a romp through a succession of vertebrate groups: the mammalian jaw to ear bone transition; the evolution of whales; the museum classics of elephant evolution and horse limbs; and finally onto the human pedigree. The book is summed up in a final chapter with a retrospective on how palaeontological thinking has changed with time, and how scientific opinion can be strait-jacketed by a feeling of our own self-importance. Perhaps the most important points are that palaeontological wisdom is ever changing and will continue to change, and how we as a species need to see ourselves as just another fleeting by-product of evolution. Switek manages to show, without explicit statement, that Darwin was once again right (in terms of the single bush-like figure in *On the Origin of Species*) – there has been no upward 'march of progress' in the evolution of living things. The descent of humans, the modern horse, whales and elephants have all followed a complex, bush-like pattern of evolution. Let's hope this book helps students and non-professionals interested in evolution to appreciate this.

There are a few scientific blunders in *Written in Stone* that should have been picked up and corrected prior to publication. Brachiopods are not molluscs; figure 15 is *Temnodontosaurus* not *Ichthyosaurus*; and plesiosaurs, pliosaurs and placodonts did not become independently secondarily adapted to life in water, as all had a single common ancestor. In addition, many may not agree with Switek's assertion that natural selection occurs above the level of the individual during mass extinctions. American word usages appear in the European edition, which will grate with some readers of British English. I, for one, am more used to 'molluscs' than 'mollusks', 'autumn' than 'fall' and 'little finger' than 'pinky', and I have never heard punctuated equilibrium referred to as "punk eek". In addition, there are an irritating number of typos scattered throughout the text, and note 90 appears not just on the wrong page, but in the wrong chapter.

Written in Stone is aimed at an educated but non-professional audience, and in general does the job admirably. Switek writes with flair and verve, although his prose is at times a little flowery. However, he has an engaging and to some extent novel way of telling palaeontological stories, and does more than simply make the science more accessible and readable to a general audience. He weaves published stories into a historical narrative together with personalities and cultural perceptions, to illustrate the progress of science. Politics, culture and human frailty come together in our attempt to understand life's rich (vertebrate) tapestry to its full. As an overview, illustrating the history of science, and a review of the broad sweep fossils still play in vertebrate evolution, the book succeeds admirably.

At a retail price of £8.99, *Written in Stone* is comparable in price to other books in the popular science genre, but manages to pack a considerable punch, containing much information. Switek brings stories as closely up to date as is possible in print, with references up to 2009, but inevitably missing out on some of the most recent scientific literature. Images are generally well produced, although some are small, too light or too dark for optimal reading, and some contain superfluous shading with no benefit or explanation. However, despite these quibbles, this would be a useful addition to a personal popular science collection, or an academic library for use by undergraduates, or as light relief between research papers. In addition, Switek's prose might inspire all of us to improve our written work.

In summary, I would recommend *Written in Stone* to my early undergraduate students as an exciting and inspiring read. It is a useful starting point for the discussion of how science works, how science is influenced by politics and prevailing culture, as well as a jumping off point to show the explanatory power of evolution. It acts as an introduction to a wide range of topics in vertebrate evolution, but necessarily needs to be augmented by the most recent scientific literature. As a book for the general public, *Written in Stone* will make a valuable read.

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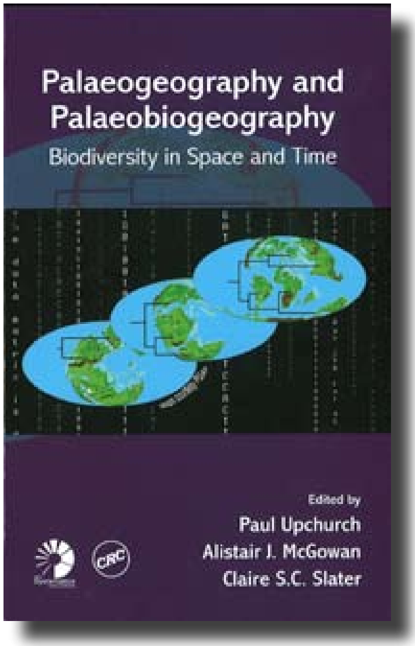
Palaeogeography and Palaeobiogeography: Biodiversity in Space and Time

Paul Upchurch, Alistair J. McGowan and Claire S. C. Slater, eds. 2011.
CRC Press, Florida, USA. 223 pp. £76.99 ($119.95). ISBN 978-1-4200-4551-2.



In the middle of my PhD I visited Cambridge to attend a conference-cum-workshop that included talks, posters and hands-on software sessions covering a broad range of palaeo(bio)geographic topics. It was a great experience to meet and interact with a group of international researchers who are unlikely to have been collected together at a single meeting before or since. That was April 2006 and this edited volume, which shares its title with the meeting, is the published product. (The belated appearance even extended to this review, which was delayed after my initial copy was stolen.)

Sadly its long gestation seems to have thinned out the number of contributions – even the editors only have a single paper between them – and its seven chapters result in a disappointingly slim volume, especially considering its price tag. Another casualty is the proportion of original research, with four of the seven chapters being essentially review articles. There is no introductory chapter. Instead a three-and-a-half page preface covers the original impetus behind the meeting and a brief summary of each chapter.

The first chapter proper, by Fabrizio Cecca and colleagues, covers a short introduction to the field of comparative biogeography and its sometimes obtuse and disputed terminological conventions. They emphasise the importance of time in understanding biogeography and the practical application of this: time slicing of phylogenetic trees. They then discuss three comparative approaches (Parsimony Analysis of Endemicity, Area Cladistics and Temporally Partitioned Component Analysis) to unravelling biogeographic histories, but argue instead for approaches that are more “synchronic” in nature – *i.e.* those that rely on discoverable patterns (cladograms), as opposed to "diachronic" approaches (ancestor–descendant lineages, centres of origin). This chapter was rather short and hard to follow, something that wasn't helped by the use of only a single figure.

The second chapter, by Daniel Brooks and Kalia Folinsbee, stays with the broader topic of comparative approaches, but concentrates on a single approach, not discussed in the chapter by Cecca *et al.*: Phylogenetic Analysis for Comparing Trees (PACT). They begin with something of a digression regarding complexity science (for a great popular science book on this check out Waldrop 1992, *Complexity*, Simon & Schuster, New York) before arguing that historical biogeography itself is complex and that its typically reticulated relationships are oversimplified by the use of simple area cladograms (where each area represents a single tip). The writing here is certainly colourful, with the maximum vicariance hypothesis (effectively used as a null) discussed using terms such as "vegetative state" and "brain dead", but I again found the discussion hard to follow. The upshot seems to be that PACT can produce much more complex area cladograms (each area being potentially multiple tips and present in combinations with other areas) and that this is more likely to be congruent with real biogeographic patterns.

Chapter three, by Alan Smith, is a really nice review of palaeogeography as a whole and would make a nice primer or reading list item for undergraduate geologists. It is mostly non-palaeontological, but covers the broad suite of techniques that underlie Phanerozoic global continental reconstructions. This begins with the basic maths of rotating objects on a sphere and moves on to the evidence for continental drift and how palaeomagnetism can be used to estimate palaeocoordinates of latitude and longitude. Hot spots as trackers of tectonic movement are also covered, along with the differences in certainty between Palaeozoic and post-Palaeozoic reconstructions. I was particularly interested to find out that there are actually two competing hypotheses for the configuration of Pangaea (formally termed A and B). I really liked this chapter and everything is well explained with a profusion of useful figures.

Chapter four, by David Hafner and Brett Riddle, serves as a very detailed case study of the biogeography of a specific region – the warm deserts of south-western North America. This work brings in a truly broad array of evidence, including molecular phylogeny, high-resolution species distribution data and geomorphology. Most interesting to me was an apparent vicariant event – thought to be the Vizcaino Seaway – that turned the lower half of the Baja peninsula into an island, but appears to have left no geological evidence. Despite the wealth of data, the authors conclude by urging more geological and palaeontological study in the area.

In chapter five Alycia Stigall discusses her previous work using GIS to look at geographic ranges in Devonian invertebrates. Good introductions to species range data and databases are provided, as well as to GIS software (although sadly much of this remains proprietary). The meat of this chapter concerns changes in geographic range through the Late Devonian extinctions in North America. Most interesting to me was the comparison of observed ranges with those predicted from a niche model ("GARP"), with close correspondence found between the two. Overall, this chapter serves as a useful primer to using GIS to examine palaeobiogeographic questions.

Chapter six, by Raoul Mutter, covers the palaeobiogeography of the little-studied early Mesozoic ray-finned fishes, and centres around a novel cladistic analysis for the group. The resulting phylogenetic hypothesis is then subjected to yet another cladistic biogeographic method: Liebermann's modified Brooks' Parsimony Analysis (BPA). This approach covers both dispersal ("geodispersal") and vicariance hypotheses, and is applied here to the full dataset (where the results were identical) and a subset, relating to just the Ptycholepidae. The latter was interpreted as showing evidence for three major biogeographical events in the group. That this chapter covers the fifth comparative biogeographic method mentioned in the book raises the question of why so many exist and what are their relative utilities – something that is sadly not covered in this volume.

The final chapter, by Alistair McGowan and Pascal Neige, is perhaps the pick of the bunch as it represents the kind of (palaeo)biological collaborative effort the original meeting was designed to foster. The topic here is the use of morphological disparity as a complement to taxonomic diversity in studying biogeographic patterns. The paper looks at two separate groups: living cuttlefish and Triassic ammonoids. The former show different distributional patterns between disparity and diversity, indicating that the two measures are decoupled. The latter shows that disparity is a poor predictor of endemism or cosmopolitanism, unlike size (with cosmopolitan species tending to be larger). The authors conclude by encouraging further use of disparity in biogeographic studies, noting the wide availability of free software to enable this.

Given the price tag this book is clearly aimed at primary researchers and is perhaps best compared alongside the 2005 Paleontological Society Papers, Volume 11 ("Paleobiogeography: Generating New Insights into the Coevolution of the Earth and its Biota", edited by Bruce Liebermann and Aylica Stigall Rode). Many of the same authors appear there, although that work is more squarely aimed at palaeontologists and is much cheaper (at around 20 USD). That volume also contained what I feel is a greater proportion of novel contributions. Those interested in a more general overview of the topic might also consider Bruce Lieberman's *Paleobiogeography: Using Fossils to Study Global Change, Plate Tectonics, and Evolution* (2000, Kluwer Academic/Plenum Publishers, New York). I found copies of this online listed at under £30.

Perhaps inevitably with an edited volume, the contributions here are variable in quality and novelty. This extends to the figures, which are sometimes clear and helpful, and at other times left me squinting, trying to distinguish between various shades of grey (there are no colour figures). Nevertheless, some of the reviews are useful primers, and the more novel works may inspire future research. Overall, however, the combination of hefty price tag, small size and limited novelty make it hard to recommend this volume to anyone but hardcore palaeo(bio)geographers.

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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**>), if you are interested in reviewing any of these.

- *From Clone to Bone* by Robert J. Asher and Johannes Muller.
- *Dinosaur Paleobiology* by Stephen L. Brusatte.
- *The British Silurian Crinoidea* by D. N. Lewis and S. K. Donovan.
- *Dinosaurs of Eastern Iberia* by A. Galobart, M. Suner and B. Poza.
- *Monisha and the Stone Forest* by Nigel Hughes.
- *Embryos in Deep Time* by Marcelo R. Sánchez.
- *Structural Biomaterials* (3rd edition) by Julian Vincent.
- *Early Miocene Paleobiology in Patagonia* by Sergio F. Vizcaino, Richard F. Kay & M. Susana Bargo.

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