Progressive Palaeontology 2024

Bristol

17th June – 20th June

Abstract Booklet

Palaeontological Association Code of Conduct

It is the expectation of the Palaeontological Association that meeting attendees behave in a courteous, collegial and respectful fashion to each other, volunteers, exhibitors and meeting facility staff. Attendees should respect common sense rules for professional and personal interactions, public behaviour (including behaviour in public electronic communications), common courtesy, respect for private property and respect for intellectual property of presenters. Demeaning, abusive, discriminatory, harassing or threatening behaviour towards other attendees or towards meeting volunteers, exhibitors or facilities staff and security will not be tolerated, either in personal or electronic interactions.

Digital images and social media

Do not photograph a poster or record a talk without the author's express permission. While the default assumption is to allow open discussion of presentations on social media, attendees are expected to respect any request by an author to not disseminate the contents of their talk or poster.

Reporting unacceptable behaviour

If you are the subject of unacceptable behaviour or have witnessed any such behaviour, you can report it (anonymously if you choose to) via the online reporting form (link below). Anyone experiencing or witnessing behaviour that constitutes an immediate or serious threat to public safety, or a criminal act is expected to contact the appropriate law enforcement agency. Those witnessing a potential criminal act should also take actions necessary to maintain their own personal safety.

Online Reporting Form: https://www.palass.org/association/report-member-code-conduct-violation

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Introduction and Info for Virtual Attendees

Progressive Palaeontology (ProgPal) is an annual, free-to-register conference organised by students for students, and is supported by the Palaeontological Association. We aim to provide a welcoming, supportive space for early-career researchers to present their work in a conference environment and spend time with their peers from other institutions. We are excited that the University of Bristol is hosting Progpal in 2024 and we hope that you all enjoy all that we have to offer!

This year's logo, designed by Natalia Jagielska, comprises of three important icons of the History and Palaeontology of Bristol: *Thecodontosaurus antiquus*, the Clifton Suspension Bridge and the University of Bristol Wills Memorial Building Tower. *Thecodontosaurus* is a Late Triassic dinosaur that was named and described from fossil material in Durdham Down near Clifton in Bristol (Ballell, 2022). Today a model of this dinosaur greets earth science students within the halls of Wills Memorial Building.

Info for Virtual Attendees and Discord Server

We will be operating a hybrid conference that aims to make as much content as possible available to those who are not able to attend in person. Where the presenter permits, talks will be recorded and uploaded to the Palass Youtube channel (https://www.youtube.com/@ThePalaeontologicalAssociation) as soon as possible. We have set up a Discord server that we will be monitoring throughout the conference for those who wish to ask questions, chat about their research or just to hang out with their peers!

Join the Progpal 2024 Discord here: https://discord.gg/vxshF8uN

Meet the Committee

Isaura Aguilar Pedrayes

PhD Student (2nd Year)

“I look into the evolution and diversity of toothrow morphology and jaw mechanics in ornithischian dinosaurs. The purpose of my PhD study is to evaluate hypotheses concerning toothrow functional morphology and jaw efficiency”.

Favourite fossils: Pterosaurs and dinosaurs

Thomas Farrell

PhD Student (2nd Year)

I work on the evolutionary history of Ecdysozoa - a major division of protostome phyla which includes arthropods, tardigrades, nematodes and penis worms among others. I particularly study fossil ecdysozoan worms from the Cambrian-aged Sirius Passet Lagerstätte of North Greenland, doing taxonomy and phylogenetics to understand the deep-time relationships between ecdysozoan phyla. I’m attending ProgPal remotely as I am attending a worm conference in Japan this week!

Kirsten Flett

PhD Student (2nd Year)

My research uses fossils from the Ediacaran and the Cambrian to establish the developmental evolution of animal body plans. I am currently working on the Weng’an Biota of Doushantuo to try and answer a decades old question: are they animals?

Meet the Committee

Hady George

PhD student (1st year)

My research is on biomechanical diversity and evolution of the lower jaw across the fish-tetrapod transition. I study a combination of extant fishes and amphibians, as well as extinct early tetrapods to investigate how vertebrates adapted to feeding out of water.

Favourite fossils: dicynodonts, Lebanese Lagerstatten fossils

James Rawson

PhD Student (3rd Year)

My research focuses on the relationship between form and function in vertebrates, particularly in skulls and jaws. My PhD project aims to test functional hypotheses around the origin of the mammalian jaw joint.

Benton Walters

PhD student (1st year)

I research flight in vertebrates and how the evolution of wings is constrained by function across birds, bats, and pterosaurs. My work involves testing functional performance of all possible wing shapes to determine whether flying animals are optimally adapted and why there is strong homology between flying vertebrates. I also prepare fossils in my spare time, both with pneumatic tools and in thin section.

Favourite fossils: Washington State crabs, seeds, Burgess Shale critters etc.

Conference Schedule

17th June 2024 - Pre-Conference Event

14:00 Registration open and poster hanging - Life Sciences Building Atrium

18:00-20:00 Pre-conference Event: An insight into Palaeomedia - Wills Memorial Building, G27

18th June 2024 - Day 1- Workshops, Poster session and Icebreaker

09:00 Registration open and poster hanging – Life Sciences Building Atrium

13:00-14:00/14:15-15:15 How to Avizo Workshop – Life Sciences Building Tomography Lab

13:00-13:45/14:00-14:15 Tour of the Bristol Museum and Art Gallery collection – Bristol Museum and Art Gallery

16:00-19:00 Poster Session – Life Sciences Building, Atrium

17:00-19:00 Icebreaker – Life Sciences Building Atrium

19:00 Impromptu pub trip

19th June 2024 - Day 2 - Presentations and Annual Dinner

08:30 Registration opens – Life Sciences Building Atrium

09:00 Opening Remarks – Physics Building, Mott Lecture theatre

09:15 Keynote Talk by Abi Crane

09:45 Coffee Break

10:00 Talk session 1 – Invertebrates and Origins (1hr 15)

11.15 Coffee Break

11.30 Talk session 2 – Palaeoenvironment and climate (50 mins)

12.20 Lunch & LGBTQ+ Meetup

13:20 Talk session 3 – Anatomy, Morphology and Function (1hr 15)

14:35 Coffee Break

14:50 Talk session 4 – Macroevolution and Big Data (1hr 5 mins)

15:55 Coffee Break

16:10 Talk session 5 – Palaeoecology (50 mins)

17:00 Awards and Auction

19:00 Annual Dinner - *The Mall, Clifton*

20th June - Day 3 - Field Trip to Penarth

09:00 Coach departs for Penarth – Woodland Road, BS8 1US

16:00 Coach departs Penarth to return to Woodland Road

Key Addresses:

Life Sciences building, 24 Tyndall Avenue, Bristol, BS8 1TQ

Wills Memorial Building, Queens Rd, Bristol BS8 1RJ

Mott Lecture Theatre, Physics Building, Tyndall Avenue, BS8 1TL

The Mall, 66 The Mall, Clifton, Bristol BS8 4JG

Getting around Bristol

Getting to Bristol

In line with our goals to reduce this meetings carbon footprint, we encourage delegates to use public transport to attend where reasonably possible.

Rail: Bristol's main train station is Bristol Temple Meads which has good rail connections to the rest of the country, though you may need to change at Birmingham New Street if coming from the North. The station is a short walk from the centre of the city and most of the accommodation options.

Coach: National Express, Megabus and Flixbus all run long-distance coach routes to Bristol from various locations. National Express takes you to Bristol Bus and Coach Station, Megabus and Flixbus go to Bond Street. These locations are very close to each other and to the university.

Air: Bristol Airport has daily flights to numerous cities across Europe, including connections to major changeover hubs such as Amsterdam. The airport is connected to the city centre by the Bristol Airport Flyer bus service which is inexpensive and runs regularly.

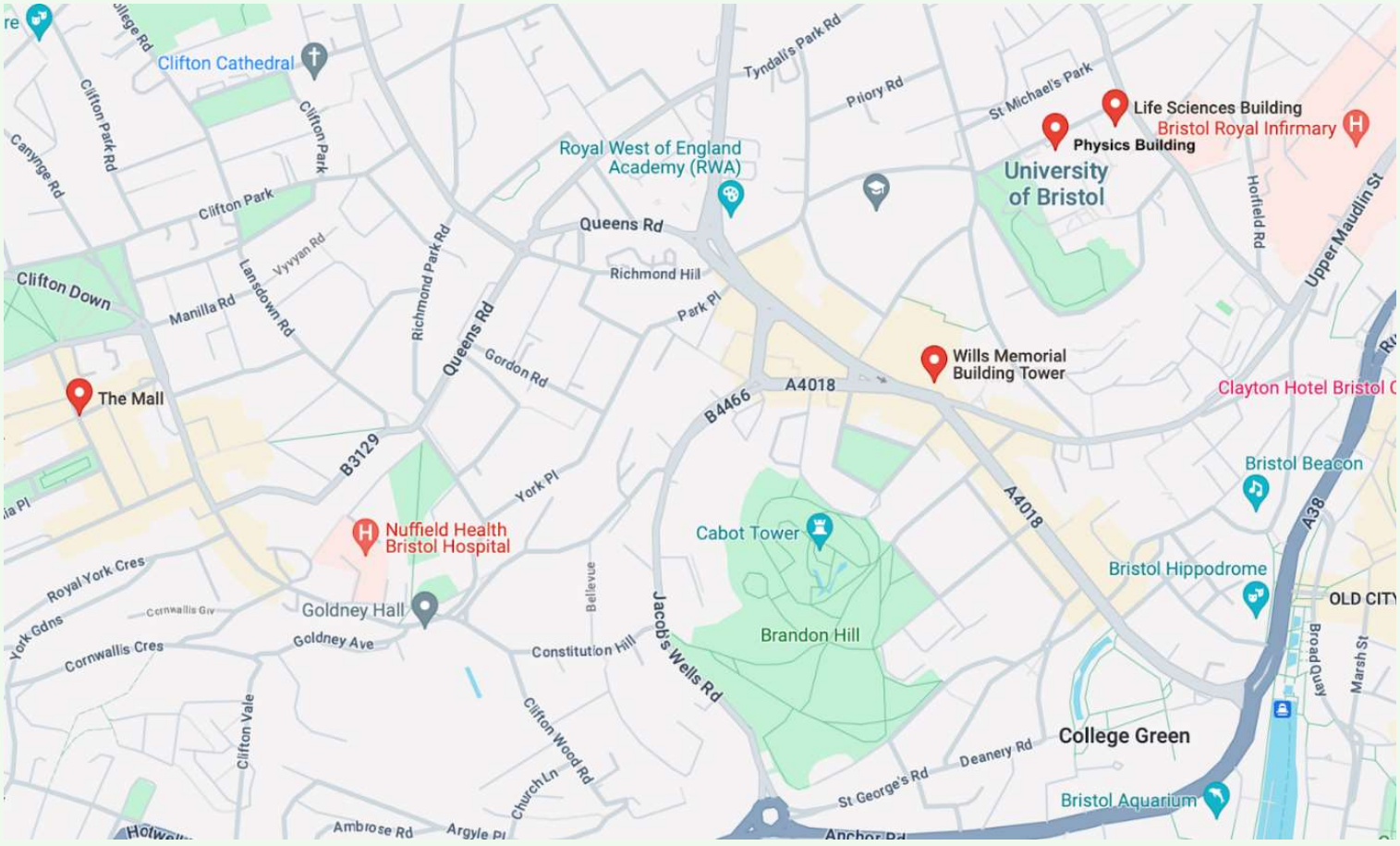
Car: For delegates wishing to travel by car, Bristol is connected to the M4, M5 and M32 motorways. Note that parking within the city centre is extremely expensive, and we are unable to organise onsite parking at the university. There are multiple park and rides available with buses running to the centre of Bristol. There is a clean air zone in place in Bristol city centre so please note that costs will incur for driving within this zone if your car does not meet the emission standards.

Getting to the Uni

The university is located north of the city centre and is a 30-minute walk from the Bristol Temple Meads station or a 20-minute walk from the Bus and Coach Station. Taxis are readily available at Bristol Temple Meads but are less common from the Bus and Coach Station. Uber and Bolt are also available as well as electric scooters and bikes are dotted around the city.

The two main locations for the conference will be the Physics building and the Life Sciences Building which are both found next to each other on Tyndall Avenue, BS8 1TQ. We recommend searching for these by name if using google maps.

Both locations are located uphill from the city centre and the gradients can be very steep. There are buses which will drop you off opposite the Wills Memorial Building, but the Life Sciences and Physics Buildings are poorly serviced by buses from the city centre with only the number 72 to Frenchay dropping off on this street, and accessing this building will require walking up some steep inclines. We have secured generous funding from the Company of Biologists to provide taxis to any delegates who would find this a problem.



Map of the University area of Bristol, showing key locations for the conference: Wills Memorial Building, Life Sciences Building, Physics Building, The Mall restaurant.

Pre-Conference Event – An insight into Palaeomedia

From 1999's Walking With Dinosaurs to recent series like *Earth*, *Life on Our Planet*, and *Prehistoric Planet*, palaeontology continues to make a big impact in science-driven television. Programmes like these, alongside specials like the BBC's *Attenborough and the Sea Dragon*, show that audiences are keener than ever to see cutting-edge palaeontological research presented on screen.

But how do you become part of making one of these ground-breaking films, and what is it like to work at the interface between research and popular media in palaeontology? The organisers of Progressive Palaeontology 2024 at the University of Bristol are delighted to present an evening of talks and discussion on the topic of working in palaeontology media.

Zoe Cousins

Zoe is a filmmaker and researcher for the BBC Natural History Unit and has worked on many different documentaries including both seasons of the award-winning documentary series *Prehistoric Planet* and the recent *Attenborough and the Giant Sea Monster*. Her expertise spans many aspects of filmmaking, from shooting and producing to writing and directing.

Dr Tom Fletcher

Tom is a senior scientific researcher for Silverback Studios, where he has consulted on natural history documentaries including *Prehistoric Planet* and *Life on Our Planet*. He authored the companion book to *Life on Our Planet* and has a PhD in palaeobiology. When he's not working on documentaries, he's continuing his research into the hydrodynamics of sharks and their relatives.

Professor Emily Rayfield

Emily is a Professor of Palaeobiology at the University of Bristol and is an expert on the biomechanics of a variety of animals from early tetrapods to dinosaurs. She has consulted on several documentaries including *Life on Our Planet* and starred in *Attenborough and the Giant Sea Monster*.

Dr Tahlia Pollock

Tahlia is a postdoctoral research associate at the University of Bristol, and specialises on the form and function of teeth, especially the canines of mammals. She consulted on *Attenborough and the Giant Sea Monster* and was the expert behind the fascinating tooth-penetration force analysis presented in the documentary.

Dr Andre Rowe

Andre is a postdoctoral research associate at the University of Bristol and specialises in digitally measuring stress and strain in theropod dinosaur skulls. He starred in *Attenborough and the Giant Sea Monster*, demonstrating how we can use digital analyses to understand the remarkable power of a giant pliosaur's bite.

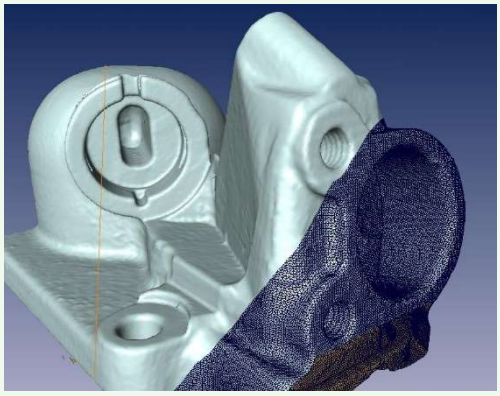
Workshops and Events

Workshops

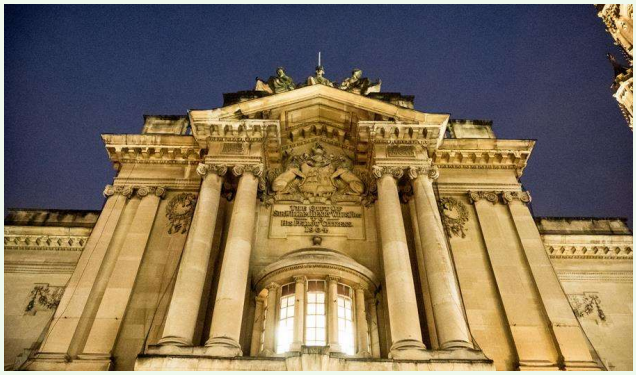
Workshops will run on the afternoon of the 18th of June. Conference volunteers will be there to guide you through the buildings, and you will receive your workshop time in your conference pack as well as via email before the conference.

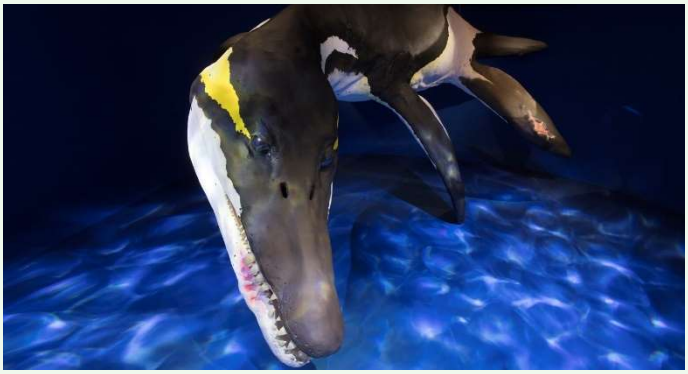
How to Avizo: Representatives from ThermoFisher will be running a tutorial in our tomography lab talking about all things Avizo. You will have the opportunity to learn how to use Avizo and get the chance to play around with the software. There will be two Avizo workshops, one from 13:00-14:00 and the other from 14:15-15:15 in the tomography lab of the Life Sciences Building.

Avizo®



Bristol Museum and Art Gallery Tour: This tour of the Bristol Museum and art gallery will give you an insight into the collections we hold and is hosted by museum staff who can answer any and all questions you may have. Please take a look at the museum website for a peek at what is to come on this tour. There will be two museum workshops, one from 13:00-13:45 and the other from 14:00-14:45 at the Bristol Museum and Art Gallery. We will meet in the museum foyer (entrance is on Queen's Road) 5 minutes before the start of the tour.





Workshops and Events

Events

Icebreaker: We will be holding an icebreaker event on the evening of the 18th of June in the Life Sciences Building Atrium. This is a great opportunity for delegates to network and socialise in a relaxed environment. Beverages, both alcoholic and non-alcoholic will be provided along with snacks.

LGBTQ+ Meetup: We will hold this year's LGBTQ+ meetup during the lunch break on the 19th outside in the Royal Fort courtyard (between the Life Sciences Building and the Physics Building) if the weather permits. Otherwise, it will take place in the Mott lecture theatre.

Awards and Auction: We will be presenting awards for best poster and best talk at the end of the final talk session. We will also be hosting a live auction where we invite you to bid on a variety of exciting palaeo related items!

Annual Dinner: The annual dinner will take place on the evening of the 19th of June at The Mall in Clifton Village. The Mall is a restaurant and bar in the friendly neighbourhood of Clifton Village. Please arrive by 7pm.

Post-conference Field Trip - Penarth

The post-conference fieldtrip (20th June) will visit the Late Triassic - Early Jurassic coastal marine localities of Penarth, South Wales. Penarth is a very prolific collecting site for marine invertebrates such as bivalves, brachiopods, gastropods, ammonites and echinoids. Chunks of the Rhaetian bone bed containing bones and teeth from chondrichthyans, actinopterygians and marine reptiles are also present. We will also visit a large, exposed dinosaur trackway on the beach thought to have been made by Triassic sauropodomorphs (Falkingham et al., 2022).

Travel and Logistics

The coach will depart on Thursday morning at 09:00 from Woodland Road behind the Wills Memorial building (where it meets Cantock's Close). The journey to Penarth is roughly an hour and 15 minutes. We will park in the Cliff Parade Free Car Park (CF64 5BP) above the beach before and walk down to the foreshore. We will aim to visit the beach either side of the pier, with a break in the middle to grab lunch at the nearby cafes, restaurants and chippies. Public toilets are available both at the pier and at the car park. We will depart from Penarth at approximately 16:00, with the aim to be back at Woodland Road for 17:15.

Safety and equipment

The beaches of Penarth are rocky and uneven, and slipping is a potential risk. Please bring appropriate footwear (i.e. walking boots) and avoid loose or algae covered rocks. The cliffs of Penarth are somewhat unstable and debris falls are reasonably common. Only approach the cliffs if wearing a hard hat, we will provide a limited number on the day but feel free to bring your own. We will arrive at Penarth around two hours before low tide, and we expect the tide level to rise throughout the afternoon. The whole of Penarth beach is a designated SSSI, meaning that only loose float, and not bedrock, can be hammered. If using a hammer, please ensure you wear eye protection.

Progpal 2024

Abstracts

Keynote Talk:

What's in a Bird? Understudied Bird Anatomy Yields New Insights into Avian and Non-Avian Dinosaurs

Abi Crane

Keynote Talk

What's in a Bird? Understudied Bird Anatomy Yields New Insights into Avian and Non-Avian Dinosaurs

Abi Crane[1,2], Katherine A. Williams[3], Claudia Baldry[1], Kathryn E. Rankin[4], Claire E. Clarkin[1], Juan Benito[2], Albert Chen[2], Daniel J. Field[2], Neil J. Gostling[1]

[1]University of Southampton; [2]University of Cambridge; [3]University of Portsmouth; [4]μ-VIS X-ray Imaging Centre, University of Southampton.

As the only dinosaur clade known to have survived the K-Pg mass extinction, crown-group birds (Neornithes) are an invaluable resource for understanding extinct dinosaurs. Despite their ubiquitous presence in modern ecosystems, there remains aspects of bird anatomy and morphology which remain relatively obscure and poorly understood. Our research details understudied aspects of the bird skeletal system with the aim of providing insights into the morphology, phylogeny and biology of extinct avian and non-avian dinosaurs. Here we outline two specific examples of using modern bird anatomy to shed light on their extinct ancestors: the avian mandible and medullary bone.

The detailed morphology and configuration of the lower jaw bones is among the least understood aspects of avian anatomy due to a high level of fusion among these bones. *Asteriornis maastrichtensis*, the 'wonderchicken' from latest Cretaceous Belgium, is one of the earliest crown-group birds and is known from a near-complete, three-dimensionally preserved skull. The exact phylogenetic position of *Asteriornis* is uncertain, being thus far proposed as a member of total-group Galloanserae (water- and landfowl) or stem-group Palaeognathae (the ratites and tinamous). Despite the pivotal importance of *Asteriornis* for understanding the early evolutionary history of crown birds, the anatomy of its mandible has yet to be assessed in detail. Here we use microCT to characterise and compare the mandibular anatomy of major crown bird lineages, key near-crown stem-birds and *Asteriornis* for the first time. Our results show that taphonomic damage to the *Asteriornis* holotype makes the presence of a retroarticular process (one of the few skeletal synapomorphies of Galloanserae) impossible to discern. Of the features preserved, the *Asteriornis* mandible shows key characters typical of crown-Galloanserae and especially crown-Galliformes (landfowl). This work uses detailed anatomical study of modern birds to provide further evidence for a total-clade galloanseran affinity for *Asteriornis* and yield unprecedented insight into early crown bird jaw morphology.

Medullary bone is a tissue found inside the bone cavities of female birds which is poorly known due to its ephemeral nature, being present for only a short period of the reproductive cycle. Being found only in females, it has long been suggested that medullary bone could allow the sex determination of fossil specimens. Reports of fossil medullary bone in avian and non-avian dinosaurs have been controversial, primarily due to the difficulties in distinguishing medullary bone from superficially similar bone pathologies such as avian osteopetrosis. Lists of criteria, primarily using two-dimensional osteohistology, have yet to form a comprehensive framework through which all medullary bone can be positively identified, and all pathology excluded. Here, we use high-resolution microCT to characterise the three-dimensional structure of medullary bone in modern birds for the first time. Our results show that medullary bone can be characterised by several three-dimensional features, which can also be used to distinguish this tissue from the lesions produced by avian osteopetrosis. These three-dimensional characters can be added to the growing framework of criteria to identify medullary bone in the fossil record and thus help determine the sex of extinct avian and non-avian dinosaurs.

Progpal 2024 Abstracts Session 1: Invertebrates and Origins

Session 1 – Invertebrates and origins

Full Talk – Revealing Early Eumetazoan Evolution Though Quantitative Analysis on Trace Fossils

Zhengyuan Chen[1,2], Zekun Wang[1], Imran Rahman[1,3]

[1]The Natural History Museum; [2]Imperial College London; [3]Oxford University Museum of Natural History

Trace fossils are records of organism-substrate interactions, which can provide valuable insights into the evolution of animal behaviours and body anatomy in deep time. This significance is particularly pronounced in intervals marked by sparse body fossils, such as the Ediacaran–Cambrian transition. However, the interpretation of trace fossils from this period faces problems like subjective description and simple morphology, which have impeded our comprehension of early eumetazoan evolution. In this study, we tried to employ innovative quantitative techniques to establish meaningful connections between the trajectory of simple horizontal traces and their biological signals. By digitising photos of trace fossils and carrying out spectrum analysis in R, we were able to detect repeating patterns from trace trajectories within fossils dating from Ediacaran to Cambrian Stage 4. We took the maximum spectrum bandwidth as the quantitative measure of the trajectory randomness, a crucial aspect of organismal behaviour. Comparative analyses are conducted among 9 ichnogenera, the results revealed trajectory variations that are not so evident by naked-eye observations. By drawing parallels to extant putative trace makers, we provided quantitative support on the linkage between trace trajectory and the body anatomy/behaviour of the trace maker. We also found a discernible diminishing trend in trajectory randomness through the Ediacaran-Cambrian transition, commencing approximately 543 million years ago. We believe this may indicate early radiation of eumetazoan body plan and sensation in the most terminal Ediacaran, which may represent a deeper root of the Cambrian Explosion.

Lightning Talk – The first analytical investigation into ammonite shell colour patterns: *Pleuroceras apyrenum* and *Pleuroceras solare*; lower Jurassic, Germany.

Jonas Dill[1], Axel Munnecke[1], Valentina Rossi[2], Anna Merkel[1], Thomas Clements[1]

[1]Friedrich-Alexander-Universität Erlangen-Nürnberg; [2]University College Cork

In ammonite fossils, it is rare to find the unaltered, original, aragonitic shell in the fossil record. However, specimens of *Pleuroceras apyrenum* and *Pleuroceras solare* from a clay pit in Buttenheim, Germany (upper Pliensbachian, Jurassic) preserve not only unaltered shells but also preserve distinct dotted patterns that have been interpreted as colour but have never been studied. We investigated if these patterns represent actual in vivo ammonite shell colour using fluorescence microscopy, SEM-EDX analysis, and Raman spectroscopy. Our data show that the 'colour patterns' consist of multiple longitudinal rows of distinct three-dimensional dark spots connected by dark lines that run parallel to each other, following the shell's spiral. These structures are formed via a depression in the shell's nacreous layer and are infilled with framboidal pyrite. We interpret these structures as biological in origin and that they may have been pigmented in vivo. Here, we show evidence that ammonite shells (in some species) had distinct colour patterns and model the taphonomic processes that controlled the preservation of these patterns at the Buttenheim site, shedding new light on these charismatic animals' appearance and way of life.

Session 1 – Invertebrates and origins

Full Talk – Using Confocal Laser Scanning Microscopy (CLSM) to understand the anatomy of *Prototaxites*, an enigmatic organism from the early Devonian Rhynie chert

Laura Cooper[1], Alexander Hetherington[2]

[1]University of Edinburgh; [2]University of Edinburgh

Almost everything about *Prototaxites* has been shrouded in mystery and debate since its discovery and description in the mid-19th century. Found from the late Silurian to the late Devonian, *Prototaxites* fossils comprise a dense network of microscopic tubes forming a solid, sometimes trunk-like, structure of up to eight meters tall. This makes *Prototaxites* the largest terrestrial organism for all but the very latter part of its existence. First described as a woody plant, this organism has also been placed in taxonomic groups as diverse as algae and lichen, with a growing consensus that this taxon is more similar to extant fungi. However, there are no clear modern parallels to this enigmatic organism, and very little is known about its lifecycle or nutrition. *Prototaxites* has been found in the Rhynie chert, an early Devonian site famous for exceptional preservation of early terrestrial taxa through silica permineralisation, permitting the three-dimensional structure of tissues of fossils from this site to be studied by a variety of methods. CLSM is a high-resolution microscopy technique that can be used on permineralised fossils to produce crisp, 3D images of fine details. I will present my ongoing work using CLSM imaging to describe the largest *Prototaxites* specimen found from the Rhynie chert, combined exceptional preservation and cutting-edge imaging techniques to describe aspects of *Prototaxites* anatomy not previously described, and therefore providing insight into the growth, nutrition and habit of this strange organism from the dawn of terrestrial life.

Lightning Talk – Testing the evidence for gill slits in early echinoderms

Lucy Jackson[1], Frances Dunn[2], Imran Rahman[3], Ross P. Anderson[2]

[1]University of Oxford; [2]Oxford University Museum of Natural History; [3]Natural History Museum, London

Deuterostomes are a supra-phyletic group encompassing a number of ecologically and evolutionarily significant phyla, including chordates (e.g., vertebrates) and echinoderms (e.g., starfish and sea urchins). Despite a close phylogenetic relationship, there are very few morphological characters which unite these disparate groups. One possible exception is the presence of pharyngeal gill slits, openings in the pharynx which are used for filtering food particles and respiration, identifiable in all deuterostomes except modern echinoderms in which they are assumed to have been secondarily lost. We can use the fossil record, which provides our only direct evidence of character change through time, to test this hypothesis. *Cothurnocystis elizae*, a stylophoran echinoderm from the Upper Ordovician of Scotland, possesses serially-aligned structures termed cothurnopores, which were historically interpreted as gill slits, but this interpretation is highly controversial. Here we undertake a quantitative morphometric analysis of gill slits across extant and extinct deuterostomes, building on recently published work and using novel microCT data, to provide a new description of cothurnopore morphology in *C. elizae*. We find no support for the hypothesis that cothurnopores in *C. elizae* are homologous to pharyngeal gill slits, instead suggesting that they are a unique echinoderm respiratory structure. Our phylogenetic analysis recovers *C. elizae* and other stylophorans as early diverging stem-group echinoderms and, therefore, that gill slits were lost earlier in echinoderm evolution than previously thought. We anticipate that these results will lead to further studies exploring the timing and sequence of acquisition of the unique modern body plan of echinoderms.

Session 1 – Invertebrates and origins

Full Talk – Dissecting the single cell biology of odontode evolution in development and fossils

Rongxin Zhang[2]

[1]*University of Warwick*

Odontodes first evolved on the body armour of stem gnathostomes, comprising enameloid ornament, dentine, and dermal bones. They have undergone tremendous morphological transformations from covering large dermal plates to denticles and teeth. In the past 2 decades, palaeontologists delineated key steps and novelties in stem and crown gnathostomes by combining high resolution XRT and single cell resolved histological examinations in a firm phylogenetic framework. However, the underlying cellular and molecular mechanisms responsible for the diversification, refinement and sculpting of basic odontode epithelium itself remain largely unknown. I am studying this process by live imaging of genetically tagged epithelial and mesenchymal tissues in murine odontogenesis in real time. By combining genetic lineage labelling and confocal live imaging, I performed computational single-cell tracking and statistical analysis of several thousand cells, identified 7 discrete epithelial subpopulations based on their migratory properties, segmented the process into 4 new distinct phases as morphological drivers for incisiform dentition, and was able to find differences in molariform teeth. I discovered a remarkably complex epithelial behavioural diversity of epithelial and mesenchymal “actors” involved in critical stages of odontode morphogenesis. Moreover, the new migratory processes during cell invagination that I discovered can provide the substrate for a more refined paradigm of heterochronic shifts of inter-epithelial interactions. These can shed light onto key odontode transformations from stem gnathostome dermal ornament to the basic patterns of dentition in (polyphyletic) placoderm to that of early osteichthyans. I hope this work can inspire new interfaces between developmental genetics and paleontology.

Lightning Talk – Cenozoic marine invertebrate functional diversity, over space and time

Lydia Woods[1]

[1]*University of Leeds*

Functional diversity plays a crucial role in governing ecosystem structure and functioning. Studies indicate that functional diversity exhibited varying degrees of change across major climatic events, often independent of species diversity. Despite a lack of mass extinction events in the Cenozoic, major climatic perturbations such as the Paleocene-Eocene Thermal Maximum and the Eocene-Oligocene Transition present potential disturbances to marine ecosystems. Furthermore, the modern latitudinal species diversity gradient (LDG) is believed to have intensified during the Cenozoic, when global climate transitioned from a greenhouse to an icehouse state. However, there exists no contemporary nor deep-time understanding of a global latitudinal functional diversity gradient (LFDG). Here, we investigate marine invertebrate functional diversity from the Campanian to the Piacenzian in order to answer the following questions: (i) What are the temporal trends in global marine invertebrate functional diversity through the Cenozoic Era? (ii). Did a latitudinal functional diversity gradient form in the Cenozoic Era, and did this coincide with the formation of the modern latitudinal species gradient? (iii) Did major climatic events and transitions drive changes in the latitudinal functional diversity gradient? As a result, we observe differences in the global pattern of marine invertebrate functional richness compared to invertebrate species richness across the Cenozoic. We expect to find a latitudinal functional diversity gradient forming by the early-mid Cenozoic. Finally, we expect to observe differences in the pattern of functional diversity between latitudes, through the Cenozoic.

Full Talk – Ontogenetic implications of bite stress in the eubrachythoracid arthrodire *Compagopiscis croucheri*

Sophie Pollard[1], Emily Rayfield[1], Antonio Ballell-Mayoral[1]

[1]University of Bristol

Ontogenetic trends in the functionality of the placoderm jaw can provide vital insight into how the first jawed vertebrates interacted with their environment throughout life, thereby facilitating a more detailed knowledge of the gnathostome rise to power throughout the mid to late Devonian period. Based on previous insight into the functional ontogeny of *Dunkleosteus terrelli*, it was hypothesised that there would be a negative trend in size-relative jaw strength with increasing ontogeny in the eubrachythoracid arthrodire, *Compagopiscis croucheri,* which has a much higher abundance of three-dimensional articulated remains, making it a good candidate for functional analysis. Overall von Mises stress in nine lower inferognathals of *C. Croucheri*, at varying ontogenetic stages, was obtained using Finite Element Analysis, which was then interpreted alongside morphometric data and quantitative observations of tooth ware. Although no significant allometric trend could be found among the group, relative jaw strength was inferred to increase isometrically with ontogeny, suggesting that *C. Croucheri* underwent little change in feeding strategy throughout life, albeit adjusting for scale. This result, however, contradicts the trend among the majority of studied gnathostomes, in which a significant positive allometric trend in jaw strength appears to be the norm. A need for further study is made clear, not only to better characterise function through ontogeny in placoderms, but also to establish a more complete view of functional ontogeny across the gnathostome lineage as a whole.

Progpal 2024 Abstracts Session 2: Palaeoenvironment and Climate

Session 2 – Palaeoenvironment and climate

Lightning Talk – Microfacies, Benthic foraminiferal biostratigraphy and diagenetic analyses of the Eocene limestone exposed in the Yadgar Section, Muzaffarabad, Pakistan

Aamir Ali[1]

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This study focuses on the identification of larger benthic foraminifera, characterization of microfacies, and diagenetic analysis of the Margalla Hill Limestone, based on field and petrographic data from the Yadgar Section, Muzaffarabad, Pakistan. The Margalla Hill Limestone, approximately 75 meters thick at the Yadgar Section, is predominantly composed of nodular limestone with subordinate marl and shale. It is bounded by the Patala Formation below and the Chorgali Formation above. The Microfacies analysis identified four main microfacies: Mudstone (MF-I), Mudstone to Wackstone (MF-II), Wackstone (MF-III), and Wackstone to Packstone (MF-IV). Based on these microfacies assemblages, the Margalla Hill Limestone is interpreted to have been deposited in the foraminiferal shoal and inner ramp to the proximal outer ramp area of the Tethyan carbonate platform. Benthic foraminiferal assemblages identified in this formation include Nummulites atacicus, Nummulites, Lockhartia, Assilina, Ranikohtalia, Discocyclina, Operculina, Kathina, and Laffittenia. Diagenetic features observed in the Margalla Hill Limestone include pressure dissolution (stylolites), calcite-filled microfractures, multiple calcite veins, disorientation/dislocation of bioclasts, micritization, neomorphism, and fossil dissolution. The larger benthic foraminiferal assemblages suggest that this formation represents the biostratigraphic interval equivalent to the Shallow Benthic Zone (SBZ 8-11) of the Ypresian stage of the Lower Eocene. Additionally, Stage III of the carbonate platform, as defined by Scheibner et al. (2005), has been established in the studied section. This inclusive analysis provides valuable insights into the depositional environment, paleoecology, and diagenetic history of the Margalla Hill Limestone in the Yadgar Section, contributing to our understanding of the geological evolution of the region.

Lightning Talk – Ichnofossils and Earthworms, an Analysis of Triassic Palaeosols at Bendricks Bay, South Wales

Louis McCartan[1], **Jakob Vinther**[1]

[1]*University of Bristol*

Earthworms (Crassiclitellata) are regarded as ecosystem engineers and represent vital components of terrestrial ecosystems. Within soils, earthworms comprise the majority of animal biomass and directly influence soil aeration, nutrient availability, toxicity, and acidity. The significance of earthworms in contemporary terrestrial environments is widely appreciated, however, this appreciation does not extend into the geological past. The fossil record of earthworms throughout geological time is poor, with earthworm body fossils being either ambiguous, or poorly documented. Therefore, this study aims to improve the fossil record of earthworms through the analysis of trace fossils. Molecular evidence suggests earthworms may have been present as early as the Carboniferous, however, this is not reflected in the fossil record. Bendrick's Bay, South Wales presents a series of exposed palaeosols deposited within a lake margin environment during the Late Triassic, within Bendrick's Bay a palaeosol bed comprising numerous root structures, the bases of tree stumps and ichnofossils has been analysed in detail. Understanding the structures within this bed provides a more comprehensive understanding of the depositional environment at Bendrick's Bay during the Late Triassic. Amongst trace fossils within this bed, traces morphologically comparable to the earthworm ichnogenus *Edaphicnium lumbricatum* have been identified, representing some of the earliest traces attributable to earthworms. Other soil invertebrates, including millipedes produce pellet lined burrows, morphologically comparable to those of earthworms. Potential earthworm traces have been distinguished from those of other invertebrates allowing for the identification of likely earthworm trace fossils within the Late Triassic.

Session 2 – Palaeoenvironment and climate

Full Talk – Temperate to tropical palaeoclimates on the northwest margin of Europe during the middle Cenozoic (~34—16 Ma)

Jessica McCoy[1], Martha Gibson[2], Emma Hocking[1], Jennifer O'Keefe[3], James Riding[4], Raymond Roberts[5], Stewart Campbell[5], Geoffrey Abbott[6], Matthew Pound[1]

[1]Northumbria University; [2]West Virginia University; [3]Morehead State University; [4]British Geological Survey; [5]Natural Resources Wales; [6]Newcastle University

Palaeoclimate reconstruction of the warmer and wetter Oligocene to early Miocene intervals (33.9—15.97 Ma) allows us to better understand the climate dynamics of an earth system with similar pCO_2 levels, palaeogeography, and an Antarctic ice sheet. These reconstructions have implications for allowing us to better understand 21st century anthropogenic climate change. Previous studies suggested that late Oligocene North Atlantic sea-surface temperatures increased, whereas corresponding pCO_2 levels declined (700—300 ppm). The recent IPCC AR6 report identified the Miocene as an interval of interest. We consider the British Isles, as its climate is influenced by oceanic heat outputs, therefore the northwest Europe provides a unique perspective on terrestrial climate processes. Oligocene to early Miocene records of palaeovegetation from across the British Isles were taken from secondary sources. We applied the Bayesian probability-density-function-based reconstruction model, Climate Reconstruction Software, on the nearest living relatives of listed fossil taxa. We present the first Oligocene to early Miocene palaeoclimate record of northwest Europe utilizing a new method of assigning Köppen-Geiger (K-G) climate classifications to reconstructions. We propose Oligocene to early Miocene palaeoclimates were mostly warmer than present, as K-G classifications ranged from temperate, warm-summer signals with no overall dry season (*Cfb*) to those of tropical rainforest climate (*Af*). Monsoonal K-G classifications (*Cwb*) were driven by precessional (26-kyr) forcing. Our palaeoclimate reconstruction of the Mochras borehole, showed large declines in mean annual and winter temperatures, suggesting the presence of sediment deposited during the Oligocene-Miocene Transition for the first time on the northwest edge of Europe.

Lightning Talk – Understanding the Jurassic climate system and ecology under elevated carbon dioxide and temperatures

Rhicert William Reynolds[1], Gregory Price[1], Rhodri Jerrett[2], Alina Marca[3], Uwe Balthasar[1], Paul Dennis[3]

[1]University of Plymouth; [2]University of Manchester; [3]University of East Anglia

The Jurassic warm interval saw atmospheric CO_2 exceed our current concentrations. A significant feature of this warmer world was the presence of large epicontinental seaways such as the Mid-Late Jurassic Sundance Sea of North America. At its greatest extent it stretched from modern day Utah to the Arctic Ocean. These seaways are the dominant source for much of our information about ancient marine climates and biodiversity as they afford easy access to geological and palaeontological samples compared with deeper marine deposits. However, there is growing evidence that these seaways were decoupled from open-ocean conditions because of variations in water mass, depth, salinity, and stratification. Ubiquitous in the Sundance Formation, Belemnitida are prolific in Western Laurasia by the Jurassic. They are often regarded as key to understanding Mesozoic marine ecosystems and are relatively easily identifiable. However, there is limited discussion on the role they play in the ecosystem within a restricted seaway. This presentation presents methods of collecting, and early analytical results of, samples taken from southern latitudes of the Sundance Sea (Wyoming, and Utah) using Optical Emission and Mass Spectrometry. It details how elemental (Ba/Ca, Sr/Ca) and stable isotope ($\delta^{18}O$, $\delta^{13}C$) analysis of Belemnitida samples are used to reconstruct temperature, carbon cycling, and genera trophic structure within the invertebrate dominated Sundance ecosystem: thus, inferring climate patterns within the Oxfordian North America, and, how this is critical to reconstructing the role epicontinental seaways play in terms of ocean circulation, carbon cycling, biodiversity, and climate amelioration.

Session 2 – Palaeoenvironment and climate

Lightning Talk – Climate change and a marine megafaunal extinction

Amy Elizabeth Shipley[1], Tracy Aze[1], Catalina Pimiento[2,3], Andrew Beckerman[4], Jennifer Dunne[5], Alexander Dunhill[1]

[1]University of Leeds; [2]University of Zurich; [3]Swansea University; [4]University of Sheffield; [5]Santa Fe Institute

The Plio-Pleistocene boundary (2.58mya) witnessed the extinction of ~36% of marine megafauna whilst smaller-bodied marine taxa remained unaffected. This pattern of extinction is unusual in the fossil record where smaller taxa are more often selected against. The mechanisms behind this extinction event are uncertain but hypotheses propose (1) loss of shallow shelf area reduced the productive neritic zone habitats that megafauna relied upon for feeding, and (2) a drop in primary productivity over this event reduced the energy available to support taxa of larger size in higher trophic levels. However, these hypotheses are yet to be quantitatively tested and little is understood about how these factors may vary on a regional scale with only global extinction patterns being investigated so far. We assessed the role different environmental factors played in the extinction of marine megafauna during this event, both globally and within different ocean basins. Global extinction rates were calculated from fossil occurrence data collected at stage level from the Oligocene to the Pleistocene. Regional extinction and extirpation rates were then calculated for multiple marine basins across this period. Multivariate models were used to test the relationship between these global and regional extinctions and different environmental drivers (shallow shelf area, SST, sea level and primary productivity) over the marine megafaunal extinction boundary. We expect our results will corroborate previous hypotheses on the drivers behind these extinctions, providing insight into the impact of environmental stressors on large-bodied marine taxa and further expand upon the research into this currently understudied extinction event.

Full Talk – Sedimentary controls on Ediacaran macrofossil and matground distributions

Catherine E. Boddy[1], Brennan O'Connell[1], William J. McMahon[1], Alexander G. Liu[1]

[1]University of Cambridge

The Ediacaran macrobiota include fossils of some of the earliest known animals, and provide insights into the early evolutionary history of animal life. However, sedimentary controls on Ediacaran macrofossil distribution remain poorly resolved. In the relatively deep-marine deposits of Newfoundland (Canada), distal turbiditic burial events separated by long intervals of sedimentary stasis facilitated preservation of a diverse assemblage of Ediacaran macrofossils. Conversely, shallow-marine environments within the same basin contain no macrofossils, despite evidence for Ediacaran organisms at comparable bathymetries in coeval global localities. The paucity of fossil content has left Newfoundland shallow-marine deposits largely understudied. Here we conduct sedimentological and palaeontological analysis of five formations within the St. John's and Signal Hill Groups of Newfoundland, to test hypotheses regarding fossil–facies relationships. We recognise a wide variety of sub-environments within a deltaic system, and describe a range of abiotic and microbial surface textures from these deposits. The presence of biological surface textures provides evidence that surfaces at the sediment–water interface, or "true substrates", were routinely preserved. True substrates have the potential to host surficial organisms and preserve them in deep time, and yet, shallow-marine deposits of Newfoundland entirely lack macrofossils. Macrofossils are present in potentially analogous facies of a similar age in Russia and Australia, which may indicate a dependence on specific sedimentary parameters. We find the observed distribution of Ediacaran fossils and any drawn inferences on community ecology and diversity through space and time are highly dependent on both the rate of sedimentation and depositional setting.

Progpal 2024 Abstracts Session 3: Anatomy, Morphology and Function

Session 3 – Anatomy, Morphology and Function

Lightning Talk – Introduction to Plio-Pleistocene Crocodyliforms from Bangladesh: A Palaeogeographical and Phylogenetical perspective

Dino Chu[1], Md. Ibrahimul Bari[2], Mahir Yasir[3], Tamzid Farhad Khan[4], Shabiha Mahabub[5], Sanjukta Chakravorti[6]

[1]University of Birmingham; [2]Indian Institute of Technology Bhubaneswar; [3]Independent researcher; [4]University of Liberal Arts Bangladesh; [5]Ideal School and College, Motijheel, Dhaka; [6]Stuttgart State Museum of Natural History, Germany

Historically, the geology of Bangladesh has been mapped precisely during the British colonial period. However palaeontological studies were less carried out because fossils were rare in the region as the majority of fossil-yielding beds underlie deep beneath the recent top acidic soil deposits. However, efforts have been taken recently to discover fossils from the region and a patch of discontinuous fossil bed referred as Nandigram Formation with konzentrat-lagerstätte qualities was recovered from the Bogura district in Bangladesh that contains numerous terrestrial vertebrate fossil remains. Preliminary stratigraphic analysis and faunal assemblage comparative studies conclude the newly discovered bed is almost identical to those in the renowned Indian Siwalik Group fauna. In 2023, a complete fossilised tooth from a crocodylomorph with a few bones was found very close to the Bangladesh-India border region of Chapainawabganj district suggesting the Nandigram formation is continuous. Both materials from the previous site and the newly discovered site have uncovered crocodile remains to expose a diverse group of crocodylomorphs from the Plio-Pleistocene epoch of Bangladesh. The tooth found at the new site has more morphological resemblance to the giant gavialid crocodilian, *Rhamposuchus*. The Bogura site has yielded teeth that possess the key features that are essentially identical to *Gavialis sp*. and *Crocodylus porosus*. These discoveries provide new insight that broadens our interpretation on the palaeobiogeography of the region, shedding light on the interconnectedness of terrestrial ecosystems from the Pliocene to Pleistocene.

Lightning Talk – Reinvestigation of skeletal morphology in *Confuciusornis sanctus* using high-resolution µCT scanning

Grace Broderick[1], Guillermo Navalón[1], Daniel J. Field [1,2]

[1]University of Cambridge; [2]Museum of Zoology, University of Cambridge

Of the exceptionally preserved Mesozoic avian taxa emerging from the Northeast region of China, *Confuciusornis sanctus* is one of the most commonly represented taxa with over a thousand specimens unearthed. Most existing anatomical research of this taxon is limited to two-dimensional investigations of slab prepared fossils and only one comprehensive systematic description has yet been undertaken. Here, we aim to exhaustively document the skeletal morphology of *C. sanctus* using high resolution x-ray computed tomography (CT) data from two specimens in order to reevaluate its morphology in light of insights gained into Mesozoic avialan morphology since its most recent monographic treatment over twenty years ago. The pectoral region of *Confuciusornis* is of particular interest due to the unusual features of the scapulocoracoid and humerus, which may be relevant for understanding the early stages of avialan powered flying potential. The ability to visualize these elements using high-resolution three-dimensional data reveals previously unappreciated morphological details of the scapulocoracoid. For instance, including a depression on the coracoid's lateral surface may reveal a modern-like configuration of the supracoracoideus muscle pulley. Likewise, a detailed reexamination of the humerus has allowed us to observe a distinct ridge seemingly analogous to the bicipital crest in modern avians. We expect that further three-dimensional work on the skeletal morphology of *Confuciusornis* will reveal additional data into its anatomy, providing unprecedented insight into several aspects of the palaeobiology of an iconic Mesozoic bird.

Session 3 – Anatomy, Morphology and Function

Full Talk – Bizarre didactyl dinosaur reveals digit loss is not evolutionarily linked to forelimb reduction in oviraptorosaurs

Amelia Mead[1], Gregory Funston[2], Steve Brusatte[1]

[1]University of Edinburgh; [2]Royal Ontario Museum

Forelimb reduction and digit loss are seen extensively across different clades of non-avian theropod dinosaurs but the evolutionary drivers behind these changes are poorly understood. Previous studies recover clade-wide trends of negative forelimb allometry throughout Theropoda, whereby the forelimb becomes proportionally smaller with increasing body size, and suggest this trend is so pervasive it cannot be explained by multiple adaptive events. However, higher resolution studies into specific clades are necessary before accepting this hypothesis. *Oksoko avarsan* is the only known functionally didactyl oviraptorosaur and its recent description highlights Oviraptorosauria as a unique and overlooked case study for investigating forelimb evolution. We use phylogenetic statistical techniques, principal component analysis (PCA), and evolutionary modelling to test for an association between digit loss and forelimb reduction in oviraptorosaurs and investigate the potential driving forces behind these changes. Unexpectedly, we uncover evidence of decoupled evolution between digit III and the rest of the forelimb, consistent with the division of the forelimb into two evolutionary modules. These modules display distinct patterns of evolution. There is evidence of directional evolution in digit III and weak support for random drift in the rest of the forelimb, however high phylogenetic signal indicates the true pattern is more complex, potentially involving an adaptive radiation. Interestingly, the four distinct forelimb morphotypes recovered by PCA and clustering analysis do not directly correlate with patterns of dietary niche partitioning between oviraptorosaurs. Overall, forelimb reduction and digit loss are not tightly associated across Oviraptorosauria and are likely driven by distinct evolutionary forces.

Lightning Talk – Exploring the diversity of pointed tooth forms using theoretical morphometrics

Charlie Caldicott[1], Emily Rayfield[1], Tahlia Pollock[1]

[1]University of Bristol

The constraint of form has historically been a debated point in the study of morphometrics, as certain forms may be deemed geometrically or genetically impossible. Pointed teeth are found repeatedly throughout the animal kingdom and the fossil record in vertebrates and help them both capture and process food. Due to their wide distribution, different pointed teeth shapes have arisen, each suited to different functions. Questions may arise as to whether any of these tooth forms can be deemed optimal for their function, and if an optimal form is possible due to the variety of constraints found in nature. In order to assess this, a collection of pointed teeth from a wide variety of vertebrates were collected and processed in both Geomagic Wrap and Avizo, before being converted into 3D shapes in Rhino. These 3D shapes were then subjected to both a Procrustes and Principal Component Analysis in order to generate theoretical morphospace occupation of teeth. The teeth are then subjected to multiple tests to measure optimality, including stress via Finite Element Analysis (FEA) and puncture performance tests. The performance metrics of the theoretical teeth are then placed onto an optimality landscape to assess optimality in nature without constraint. Using this newly developed methodology, the ecology of extinct animals can be measured by placing the shape of the tooth of the extinct organism on the optimality landscape and comparing it with other taxa; increasing our knowledge of extinct animal behaviour, even when material may remain fragmentary.

Session 3 – Anatomy, Morphology and Function

Lightning Talk – A preliminary report on new, and re-evaluated, Southeast Asian sauropodomorph dinosaur specimens

Thitiwoot Sethapanichsakul[1], Sita Manitkoon[2], Phornphen Chantasit[3], Sasa-On Khansubha[3], Philip D. Mannion[1], Paul Upchurch[1]

[1]University College London; [2]Mahasarakham University; [3]Sirindhorn Museum

Southeast Asia (SEA) has experienced a significant rise in sauropodomorph dinosaur research, with 27 publications appearing mainly in smaller journals and sometimes written in local languages over the past two decades. The increasing volume of publications and the challenge of accessing information highlight the necessity for a comprehensive review of SEA sauropodomorph taxa, encompassing unnamed and currently taxonomically indeterminate specimens. Previous studies have suggested the presence of various sauropodomorph groups in SEA, including non-sauropod sauropodomorphs, 'basal' sauropods, vulcanodontids, mamenchisaurids, diplodocoids, brachiosaurids, and somphospondylan titanosauriforms, in addition to the three established taxa: the 'basal' sauropod *Isanosaurus*, and the somphospondylans *Phuwiangosaurus* and *Tangvayosaurus*. Our preliminary study of the available specimens has confirmed some of these identifications, whereas others are yet to be substantiated. Presently, we can confirm the presence of a well-preserved non-sauropod sauropodomorph, a basal sauropod species distinct from *Isanosaurus* based on morphological differences in the femur, and the first Early–Middle Jurassic eusauropod from the region, previously reported in the local language. Furthermore, recent analysis of sauropod remains from the Aptian–Albian Khok Kruat Formation in northeastern Thailand, has identified a large somphospondylan distinct from *Phuwiangosaurus* of the older Valanginian–Hauterivian Sao Khua Formation based on morphological disparities in the dorsal vertebrae and humerus. New data from fieldwork and observations of existing specimens is essential in the revision of character scores and the production of an updated phylogeny for sauropods that will form the basis for testing macro evolutionary hypotheses.

Full Talk – First occurrence and new species of *Macropoma*, a latimeroid coelacanth from the Cretaceous Gault Clay Formation of southern England

Jack Norton[1], Samuel Cooper[2], Emma Bernard[3]

[1]University of Portsmouth; [2]Staatliche Museum fur Naturkunde Stuttgart; [3]Natural History Museum, London

Among palaeontology and ichthyology resides coelacanths, a clade of sarcopterygian fishes with an extraordinary temporal range of Devonian to recent while retaining a conservative bauplan. *Macropoma* Agassiz is a Mesozoic genus of coelacanth represented by four species; *M. willemoesii* from the Tithonian of southern Germany, *M. speciosum* from the Turonian of the Czech Republic, *M. lewesiensis* and *M. precursor from the Cenomanian to Turonian of southern England. Here we describe a new species of Macropoma* from the Albian, Gault Clay Formation of Folkestone, southern England. To support referral of the new specimen to *Macropoma*, XCT scans were completed at the Natural History Museum in London to better study the underside and internal cranial anatomy. Micropalaeontological analysis using biostratigraphically useful nannofossils in the matrix was undertaken to precisely date the specimen, confirming Gault Clay origins*. Macropoma sp. nov.* shares affinities with other species of *Macropoma* including the autapomorphic sigmoid curve in the ventral margin of the quadratopterygoid. The specimen also presents several features to differentiate it from other species of the genus including (1) unique dermal ornamentation (2) unusually massive gular plates and (3) an angular which is longer and more steeply angled. Allocation of this specimen to *Macropoma* makes it the first occurrence of the genus from the Albian, and the first coelacanth recorded from the Gault Clay Formation, thereby filling an outstanding gap in the temporal range of latimerid coelacanths. The assignment also makes this species an ancestor of *M. lewesiensis,* the first coelacanth discovered by Mantell in 1822.

Session 3 – Anatomy, Morphology and Function

Lightning Talk – New dinosaurs from Ashdown Quarry: anatomy, taphonomy & phylogeny

Madeleine Carruthers[1]

University of Cambridge

The identification of distinct species in the fossil record has proven challenging throughout the history of vertebrate palaeontology. A classic example of this problem within Dinosauria is the taxonomy of iguanodontians found in the English Wealden succession (Early Cretaceous). Current consensus recognises just *Iguanodon bernissartensis* and *Mantellisaurus atherfieldensis* from the Upper Wealden (Barremian-Aptian), and *Barilium dawsoni* and *Hypselospinus fittoni* from the Lower Wealden (Valanginian). However, studies drawing comparison between the Wealden and other Early Cretaceous localities worldwide have argued that greater diversity seems probable. This study describes two newly excavated collections of iguanodontian material (BEXHM 2002.50 & BEXHM 2014.26) from Valanginian-Stage bone beds at Ashdown Quarry. BEXHM 2002.50 is suggested to represent a novel taxon, though insufficient material has been excavated to formulate a reliable diagnosis. BEXHM 2014.26 is found to represent a new taxon, *Bexhillisaurus brockhurstii* gen. et sp. nov, for which potentially diagnostic traits are discussed. Both of these results indicate greater iguanodontian diversity in the Lower Wealden than previously described, however improved correlation with historical records and stratigraphy is required to investigate sympatry of Valanginian taxa identified. This greater diversity is discussed in comparison to Early Cretaceous iguanodontian-bearing sites globally, in relation to predicted faunal turnover rates and evolutionary direction towards the extremely diverse hadrosaurian iguanodontians in the Late Cretaceous.

Lightning Talk – A New Lepidosaur from the Middle Triassic (Anisian) Otter Sandstone of England

Dan Marke[1], **Michael Benton**[1]

[1]*University of Bristol*

Lepidosauria is a diverse clade of diapsid reptiles represented in the modern day by snakes, lizards and amphisbaenians (Squamata) and the Tuatara (Rhynchocephalia) that are believed to have first originated during the Middle Permian. However, a sparse fossil record of early lepidosaurs poses problems to our current estimates of when the divergence of these groups occurred. With 12,000+ extant members, they are among the most specious clades of terrestrial vertebrates and understanding their evolutionary history has wide implications in the fields of macroevolution, phylogenetics and biodiversity science. The Otter Sandstone (Helsby Sandstone Fm.) has produced a diverse assemblage of Triassic reptiles including procolophonians, rhynchosaurs and other isolated or indeterminate remains. Here, we present an analysis of the oldest known lepidosaur specimen from the Anisian of the Middle Triassic (247.2-242mya). BRUSG-XXXXJ comprises a near-complete skull articulated with several cervical and thoracic vertebrae, pectoral girdle as well as numerous disarticulated elements including vertebrae, limb bones and the pelvic girdle. The nature of many recent lepidosaur fossils, being extremely small and/or crushed; necessitates specialised imaging techniques like computed tomography and digital segmentation of microCT and synchrotron scans to visualise these fossils in three dimensions. These high-resolution scans have informed a phylogenetic analysis of BRUSG-XXXXJ, using a combined molecular-morphological approach as well as Bayesian analysis; both determining the affinities of this new specimen within the clade Lepidosauria as well as providing a new point of calibration for dating the evolutionary history of this incredibly diverse group of vertebrates.

Session 3 – Anatomy, Morphology and Function

Full Talk – Constraints, drivers, and trends in the evolution of the gorgonopsian skull

Elias Warshaw[1,2], Suresh Singh[1], Michael Benton[1]

[1]University of Bristol; [2]Badlands Dinosaur Museum

Gorgonopsians (Synapsida: Therapsida) were a diverse and widespread clade of carnivores which dominated predatory niches during the late Permian until their extinction at the Permian-Triassic boundary. At the height of their diversity, this clade included both dog-sized representatives and massive saber-toothed taxa which have drawn frequent comparison to the saber-toothed cats of the Cenozoic. This broad disparity has long been suggested to reflect significant ecological diversity within gorgonopsians. However, despite well over a century of study, the success of this clade and the evolutionary mechanisms underlying it remain poorly understood. Here we show that gorgonopsian evolution was defined by repeated convergence in functional morphology by distantly related species, highlighting a predominant role for functional constraint in guiding the evolution of the group. Using two-dimensional geometric morphometrics, we failed to find a significant phylogenetic signal in gorgonopsian cranial shape. Furthermore, we found significant covariation in shape between topological modules of the skull, indicating an absence of strong constraints on shape evolution imposed by patterns of integration. By contrast, we recovered a significant relationship between cranial shape and function as quantified by linear morphometrics of features highly relevant to feeding ecology. These findings contribute to longstanding debates within evolutionary biology concerning the relative contributions of functional, historical, and structural constraints in defining the course of evolution, providing support for evolutionary models which emphasize the macroevolutionary effects of competition and adaptation. Additionally, comparison with other carnivorous clades highlights intriguing commonalities, hinting at evolutionary pathways which have been utilized across deep time.

Progpal 2024 Abstracts Session 4: Macroevolution and Big Data

Session 4 – Macroevolution and Big Data

Full Talk – Function, ecology and macroevolution of the mammalian masticatory system

Harrie Williams[1], Philip Cox[2], Anjali Goswami[3], Roger Kissane[1], Karl Bates[1]

[1]University of Liverpool; [2]University College of London; [3]London Natural History Museum

Mammal masticatory function and performance are underpinned by the anatomy of both bony and muscular morphology, but currently few macroevolutionary studies have considered both tissues in an integrated fashion. This study attempts to address this knowledge gap by quantifying variation in muscle and skull morphology across extant mammals, and specifically whether function and phylogeny contribute to the relationship. Statistical correlation tests were conducted on muscle mass data of placentals and marsupials sourced from dissections and literature, as well as quantifications of skull size. Results highlight a strong correlation between proportional masses of the masseter and temporalis muscle groups. Taxonomically, Carnivora and Chiroptera exhibit proportionally the largest temporales, Rodentia proportionally the largest masseters, and Euungulata and Lagomorpha the largest pterygoids. Functionally, we find major differences in herbivores and carnivores in proportional masses of the temporalis and masseter, while the pterygoid is found to be pronounced in grazing mammals. Preliminary results suggest variations in proportional masses of these muscle groups correlate with skull shape. For example, the masses of all three muscle groups show significant relationships with the sagittal crest of the crania, and the distance between the incisors and the subsequent tooth. Proportional pterygoid mass also shows a significant correlation with skull and mandible length and orbit diameter. These initial correlations reiterate the influence of phylogeny and function on the hard and soft tissues of the masticatory apparatus, suggesting it may be possible to develop predictive relationships, thus allowing more accurate estimation of muscle mass in extinct animals from fossilised osteology.

Lightning talk – Phylogenetics of the Palaeozoic Echinoderm Class Soluta

Harry Savage[1], Imran Rahman[2], Frankie Dunn[3]

[1]University of Oxford; [2]Natural History Museum; [3]Oxford University Museum of Natural History

The Soluta are a globally-distributed extinct class of echinoderms that persisted from the late Cambrian to the Early Devonian. Their body plan consists of three sections: a plated theca; a feeding appendage bearing ambulacra; and a stalk-like appendage split into three parts, the proxistele, mesistele, and dististele. Most solutans are highly asymmetrical, and thus they are anomalous within the Echinodermata, a phylum characterised by pentaradial symmetry in all extant species. Due to poor understanding of solutan ecology and a lack of a rigorous phylogenetic hypothesis, it is difficult to reconstruct the class's evolutionary history. Using CT scanning and segmentation, we created three-dimensional models of the Gondwanan solutan Minervaecystis vali. This revealed a previously unknown spike-like modification on the middle dististele, suggesting possible links to isolated posterior "minervaecystid" appendages from the Cambrian of Laurentia. This novel morphological data informed a comprehensive phylogenetic analysis of the Soluta, with a maximum-likelihood time-calibrated phylogeny produced under the fossilized-birth-death model to test the group's evolutionary relationships quantitatively and robustly for the first time. The results support prior divisions of the class into three families: Minervaecystidae, Iowacystidae, and Dendrocystitidae, but raise questions about the validity of previously described orders Syringocrinida and Dendrocystitida, suggesting that Iowacystidae and Dendrocystitidae form a clade that diverged after the Minervaecystidae.

Session 4 – Macroevolution and Big Data

Lightning Talk – Exploring the Impacts of Discordant Datas on Different Bayesian Phylogenetic Inference Models

Tim Brandler[1], Laura P.A. Mulvey[1], Joëlle Barido-Sottani[2]

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Over recent years inference under the fossilized birth-death (FBD) process has grown to be the gold standard for phylogenetic reconstruction and divergence time estimation. Especially total-evidence approaches - simultaneous incorporation of genetic sequences, morphological characters and associated times of fossils - have been tested to lead to robust estimates for both divergence times and topology. However, the impact of conflicts between these two distinct sources of information - molecular and morphological - remains unexplored. A source for this conflict to arise is incomplete lineage sorting (ILS), where different loci in a clade do not coalesce into a shared most recent common ancestor, therefore support discordant topologies. Impacts of this gene tree discordance on phylogentic inference is subject to extensive neontological research, however has mostly been ignored in Palaeontology, despite its presence violating the FBD assumptions. Ogilvie et al. (2021) combine the multispecies coalescent (MSC) model with the FBD process and present a method that matches its assumptions with the presence of ILS.To gain insights on differences in accuracy of the inferred topologies and divergence times under the FBD-MSC to the regular FBD, we run inferences on simulations, providing benchmarks for the inferred estimates. Palaeontology's innate focus on morphotaxa provides an excellent framework, as this allows for simulating morphological data directly along the species tree and introduce levels of ILS for gene trees only. This study will establish how total-evidence approaches in Paleontology are affected by discordant data and help find ways to mitigate this effect in empirical studies.

Full Talk – Biological and Mechanical Implications of Mandibular Mass Distribution in Terrestrial Mammalian Herbivores

Adrian Maurice O' Driscoll[1], Nathan Jeffery[2], Sam Cobb[1]

[1]University of York; [2]University of Liverpool

Therian mammals have a distinctive tooth-bearing bony mandible and the distribution of bone along the dentary varies within and between species due to differences of form and function. Mass distribution and its functional significance have been well studied in mammalian locomotion, but mastication has been overlooked. This study investigated changes in mandibular mass distribution with increasing size and the covariance of mass properties with muscular and morphological adaptation. We hypothesized that with increasing size, mass shifts posteriorly, decreasing rotational inertia and energetic costs of chewing. Further, we hypothesized that browsing and grazing taxa exhibit characteristic mass distributions and that these pattens can be used to infer dietary behaviour of extinct herbivores. Using computed tomography and surface scanning, we estimated mass distributions and mass property data and regressed these against anatomical and morphological metrics to investigate their covariance. Distribution data were estimated for 98 specimens, representing 76 species across eleven Orders (Artiodactyla, Cingulata, Dinocerata, Diprotodontia, Embirthopoda, Litopterna, Notoungulata, Perissodactyla, Pilosa, Proboscidea, Pyrotheria). The ratio of rotational inertia to mandible length largely separates browsers and grazers, and similarly, highly selective and volume feeders. Rotational inertia exhibits negative allometry with, and is an accurate predictor of, masseteric attachment area. This suggests, with increasing size, rotational inertia becomes increasingly more challenging to contend with during mastication and when holding the jaw closed at rest. Our results suggest large herbivorous mammals evolved a model of highly efficient mastication by the Eocene which has persisted to the present despite subsequent morphological and adaptive variation.

Session 4 – Macroevolution and Big Data

Lightning Talk – Veggiesaurus rex: Investigating the role of climatic factors in the origins of herbivorous theropods

Eren Tasimov[1], Alexander Farnsworth[2], Laura Mulvey[1], Stephan Lautenschlager[3], Emma Dunne[1]

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Throughout the Mesozoic, most non-avian theoropod dinosaurs were famously carnivorous. However, by the Early Cretaceous (145 –100.5 Mya), some theropods, such as the therizinosaurs, ornithomimosaurs, oviraptorosaurs and possibly troodontids, had adopted a herbivorous or an omnivorous diet and were beginning to diversify. What exact factors caused or influenced this dietary shift is still poorly understood. Recent studies have illuminated how past climate change has played a key role in driving dinosaur diversity patterns, providing a testable hypothesis for the role of climate in the evolution of herbivory in theropods. We investigated if paleoclimate influenced the distribution of Early Cretaceous dinosaurs by combining paleobiogeographic data of dinosaur occurrences with paleoclimatic data from a general circulation model (HadCM3L). Our results suggest that the climatic niche range of herbivorous theropods was relatively constrained compared to most other herbivorous dinosaurs during the entire Early Cretaceous. They were most abundant in regions with lower mean annual temperatures and an increasingly higher variation in seasonal temperature, suggesting a key role of global temperatures in constraining their biogeographic patterns. The coelurosaurian heritage of most herbivorous theropods may explain these observations, as coelurosaurs (more derived, bird-like theropods) possessed adaptations, such as feathers or meso-/endothermy, that make them suited for cooler climate. Ongoing research is specifically testing this hypothesis by applying a phylogenetic framework in the form of a time-calibrated informal supertree to investigate if the climatic preferences displayed by early herbivorous theropods are ancestral to all coelurosaurians or if they were developed independently.

Full Talk – How to guide biomimetics and bioinspiration by studying functional optimality and morphological evolution

Tom Munro[1], Philip Donoghue[1], Emily Rayfield[1], Pablo Sebastian Milla Carmona[1]

[1]University of Bristol

Biomimetics is an important field that relies on using biological principles to guide engineering by mimicking biological structures. Bioinspiration is similar but only takes inspiration for designs from living organisms and fossils including pterosaurs for flight and fossil plants for material systems. Both biomimetics and bioinspiration assume that biological structures have evolved functional optimality, but this is rarely true as morphology is constrained by many factors including phylogeny and ecology. We have used functional morphometrics to test this assumption using odonatan wings and biomimetic flying robots as a model. We have created a theoretical morphospace to test for functional optimality without a prior assumption that empirical shapes have evolved optimally, something that previous studies have failed to do. This method allows us to determine whether it is valid to assume that biological structures are functionally optimal, understand why they might not be functionally optimal and use this knowledge to better guide biomimetic and bioinspired designs. Studying theoretical shapes, combined with phylogenetic and environmental constraints, has allowed us to determine what shapes would be functionally optimal. This has then been combined with an allometric analysis on wing and body size to determine the optimal wing shape and size for a dragonfly-inspired drone for different sizes, and for different environments they could be used in. The outcomes of this research have far-reaching implications to the fields of biology and engineering and could change the way we use both extant and extinct organisms to aid man-made designs in all areas of biomimetics.

Session 4 – Macroevolution and Big Data

Lightning Talk – Spatio-temporal calibration of endogenous viral elements through the host fossil record

Alice de Sampaio Kalkuhl[1], Robert J. Gifford[2,3]

[1]Trinity College Dublin; [2] MRC-University of Glasgow Centre for Virus Research; [3]Stellenbosch University

Endogenous viral elements (EVEs) are vertically inherited, virus-derived sequences, some of which are shared across species through integration in a shared common ancestor. These orthologous EVEs provide insight into the evolutionary timelines of ancient viruses. Here, were used published orthologous EVEs derived from Bornaviridae, Filoviridae, Flavivirdae, Parvoviridae, and Retroviridae to determine an ancestral host taxonomy for which we determined divergence times and retrieved fossils of possible hosts during the germline integration of the EVE from the PBDB. We then mapped the fossils to determine palaeogeographic patterns in the viruses' evolutionary history. Overall, we were able to show expansion and contraction of likely host ranges. Additionally, this approach constitutes a novel method in using fossils for a palaeogeographic calibration of EVE germline incorporation.

Progpal 2024 Abstracts Session 5: Palaeoecology

Session 5 – Palaeoecology

Lightning Talk – Beans on toast or fruit salad for breakfast? Investigating early primate origins by exploring what they ate

Matteo Battini[1], Mark Andrew Purnell[1], Sarah Gabbott[1], Stephen Brusatte[2], Thomas Williamson[3]

[1]University of Leicester; [2]University of Edinburgh; [3]New Mexico Museum of Natural History and Science

Primates are a personable group of mammals whose evolution has been closely studied due to our shared history. However, the focus of this work has been towards the hominin-end of the tree, despite the group originating sometime in Late Cretaceous. As a result, little is known about the origin of the crown group, Euprimates. It is thought that a shift in diet early in primate evolutionary history was the driver behind the acquisition of the crown group's defining traits. However, the direction of this shift is a matter of debate. Some believe it was an insect-rich diet that led to the acquisition of these traits, others believe fruit played a larger role. Regardless, both camps argue that the fossils support their hypotheses. To address this, I ran a meta-analysis of the available literature to test the validity of these hypotheses. 127 unique interpretations for 9 basal primate families from 42 publications were classified into five dietary categories (frugivory, granivory, herbivory, insectivory and omnivory) and four evidence categories (comparative anatomy, functional morphology, spatiotemporal associations and dental topographic metrics). Statistical tests were employed to test the null hypothesis of independence between families/genera and dietary categories, and to identify the families/genera contributing to the difference between expected and observed values. Only one family, the Microsyopidae, showed hints of a shift in diet in the Thanetian, during which more herbivorous representatives first appear. However, these results are based on interpretations, therefore, quantitative reanalysis of the fossil material is recommended to corroborate them.

Full Talk – *Indarctos anthracitis*: Dietary ecology and insularism in an enigmatic Late Miocene bear

Andrea Faggi[1], Saverio Bartolini Lucenti[1,2], Cecilia Loddi[1], Lorenzo Rook[1]

[1]University of Florence; [2]Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona

The uppermost Miocene sedimentary record from the Italian peri-Tyrrhenian areas, specifically Tuscany and Sardinia, reveals the occurrence of a unique paleobiogeographic region. This region stands out for its peculiar vertebrate ecosystem, displaying endemic features that differentiate it from the contemporaneous mammal faunas of Europe and Africa and are commonly known as the Tusco-Sardinian paleobioprovince. The occurrence of fossil carnivores in insular ecosystems is predominantly constituted by otters, whereas other carnivores are generally absent from endemic insular faunas. The Baccinello-Cinigiano Basin fauna represents an exception to this rule due to the occurrence of the endemic bear Indarctos anthracitis. This occurrence represents a uniqueness in the fossil record as insular records of bears are lacking in the fossil record (especially this old). Here, we revise and describe in detail all the material attributed to I. anthracitis. The results of comparative morphological and morphometric analyses allow us to reaffirm the distinction of this taxon from the other Indarctos species. Indarctos anthracitis probably originated from Indarctos atticus, a large sized species with Eurasian distribution, and went towards size reduction as a result of evolution in an impoverished and unbalanced insular environment. This partially disagrees with what is seen in modern populations of bears confined on islands, which are usually characterized by similar (or even larger) size. A preliminary study of the dental microwear, despite the small sample size, allows us to hypothesize the dietary ecology of this endemic carnivore and better clarify how this enigmatic bear survived in an impoverished environment.

Session 5 – Palaeoecology

Lightning Talk – Palaeoecological and aerodynamic impact of the role of hind limbs within Pterosaur flying apparatus

Maxime Flaunet[1], David Unwin[1], Rab Smyth[1]

[1]University of Leicester

Pterosaurs were a diverse group of extinct flying vertebrates that played key roles in Mesozoic ecosystems. Pterosaur wings investigations have focused on the forelimb, while the contribution of the hind limbs, now generally agreed to have formed part of the flight apparatus, has been mainly ignored. This study assessed the contribution of hind limbs by focusing on three models: Narrow wing (N.W.M) excluding the hind limbs, Standard (S.T.M) and Extended (E.X.M) reconstructions incorporating those into the wings and extended . Surface area of wing panels was calculated for 42 specimens distributed among 32 species spanning the known diversity of pterosaurs. Dataset was used to calculate wing area, aspect ratio and wing loading. Cross-comparison of the three models shows increases in wing area ranging from 1.8-2.1 times greater for the S.T.M and 2.1-2.5 times greater, compared to the N.W.M wing areas (2.8-16.8 m^2). Aspect ratios decrease from 8.6-23.9 for the N.W.M to 4.8-10.5 for the S.T.M and 3.9-8.4 for the E.X.M, as do wing loadings (N.W.M = 15-284.9; S.T.M = 7.6-129.4; E.X.M = 6.4-104). Clade specific variation occurs, as taxa with long hind limbs (e.g. Azhdarchoids) show much greater variation between models than taxa with medium/short hind limbs (e.g. Rhamphorhynchines). Collectively, these results demonstrate that wing reconstructions are highly sensitive to hind limbs inclusion/exclusion and posture. This is important for future studies of wing shape and function in pterosaurs.

Lightning Talk – Modelling terrestrial ecosystem evolution across 'Olson's Extinction' and the rise of therapsid synapsids

Rosa Parkin[1], Micheal Benton[1], Suresh Singh[1]

[1]University of Bristol

The early Permian saw the establishment of the first, fully terrestrial ecosystems, with the emergence of new specialised herbivorous and carnivorous synapsids. However, following an apparently barren interval which bridged the early-middle Permian fossil record (~273 Ma) known as 'Olson's Gap,' the early, 'pelycosaurian' synapsid assemblages were superseded by more advanced therapsids. This occurred against a backdrop of significant climatic change as the late Palaeozoic ice ages transitioned to drier, seasonal conditions. The concurrence of a significant faunal turnover and environmental changes has led to suggestions that Olson's Gap represents a mass extinction (Olson's Extinction) rather than a sampling gap, when the rich assemblages of North America disappeared, and attention has to switch to Russian and South African assemblages. However, this interval remains vastly understudied, with current palaeobiological understanding relying heavily on mid-20th Century literature. Previously, faunal turnovers have been studied in terms of species or generic richness over time, but an ecological approach can shed new light on these events. Utilising ecometric data and new quantitative, analytical methods, focusing on trophic relationships, networks, and energetics has allowed us to provide a new perspective on terrestrial evolution through the early-middle Permian. This has allowed us to identify shifts in terrestrial trophic networks that point to a reorganisation of tetrapod feeding dynamics, shedding new light on the intricacies of the fauna spanning this interval, and the ecosystems which lead to mammals and reptiles as we know them today.

Session 5 – Palaeoecology

Full Talk – Predatory theropod diversity in the Morrison Formation enabled through ecological niche partitioning

Cassius Morrison[1,2], James Gregory[3], Christopher Jackson[3], Katlin Schroeder[4], Jordan Bestwick[5], Philip Mannion[1], Laura Porro[1], Paul Bills[3], Liam Blunt[3], Paul Barrett[1,2]

[1]University College London; [2]Natural History Museum; [3]University of Huddersfield; [4]Yale University; [5]Paläontologisches Institut und Museum, Universität Zürich

Most predatory theropod dinosaurs, excluding spinosaurs, have long been thought to retain the plesiomorphic dinosaurian condition of carnivory. The presence of numerous, sympatric medium- to large-bodied predatory theropods in the Upper Jurassic Morrison Formation raises questions regarding ecosystem structure. Establishing dinosaurian diets has often relied on tooth morphology or stomach contents, both which have limitations, such as convergent morphology in the case of the former or capturing fall-back foods rather than usual diet with the latter. Moreover, tooth morphology usually recognises broad dietary guilds, such as herbivory or carnivory. Studies on extant and extinct archosaurs and lepidosaurs has shown that dietary guilds can be determined for fossil taxa more precisely, including categories like hard or soft invertebrate diets, carnivory, piscivory, among others, by using Dental Microwear Texture Analysis (DMTA). Using confocal microscopy and dental moulds, the 3D surface textures of a multitaxic theropod tooth samples were analysed at 100x magnification to determine their ecological guild parameters. Preliminary results suggest that predatory theropod diets were more diverse than previously thought, with Torvosaurus and Ceratosaurus showing evidence for piscivory and some tyrannosauroids potentially exhibiting non-carnivory in their diets. Consequently, niche partitioning likely occurred between sympatric theropods due to dietary specialisations that prevented direct competition. Furthermore, variation of DMTA along the tooth rows within individual theropod jaws, based on serial variation in the microwear patterns between teeth, suggests that the jaws were used for prey acquisition in different ways. This provides an additional means for testing biomechanical models of skull function.

Lightning Talk – The diversity of arctic mixosaurids and their heterodont dentition

Petter Nordenhaug[1]

[1]Natural History Museum of Oslo

The Triassic deposits of Svalbard offer a great variety of ichthyosaur fossils. The Middle Triassic Botneheia Formation preserves a large number of fragmented mixosaurid ichthyosaur specimens, a clade of smaller-sized marine reptiles containing several species with a long and complex taxonomic history. The six currently recognized species, across the two genera Phalarodon and Mixosaurus, are in large part differentiated by their heterodont dentition of posterior pointed, blunt, or now revealed, shearing teeth. All three Phalarodon species are at this time thought to be represented at Svalbard, with presumably two species being preserved a few meters from each other. µ-Computed Tomography and X-ray gives us new insight into several specimens from the Botneheia Formation due to their great density contrast between sediment and bone. We can thereby create detailed imagery of the mixosaurid anatomy, revealing complex dentition not represented in past studies, which may be relevant to taxonomic division. A description of around 10-15 newer mixosaurid individuals from Svalbard, supported by radiography, may help us solve questions about diversity, ecosystem roles, morphological features and why no specimens of Mixosaurus have been found in the arctic so far.

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Poster Session

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Slimehead Size Through Time: Testing the Temperature-Size Relationship in Trachichthyidae

Chloe Griffiths[1,2], Richard Twitchett[2], James Witts[2], Emma Bernard[2]

[1]University College London; [2]Natural History Museum (UK)

Rising global temperatures may lead to a decrease in the size of fish, which may impact their reproductive success and offspring survival. Particularly vulnerable families such as Trachichthyidae, which reproduce slowly, may be susceptible to population declines as a result. However, research into the effects of climate warming on this family is limited. This study aimed to investigate changes in the body size of the extinct Trachichthyidae species *Hoplopteryx lewesiensis*, in response to past climate warming and over time in the Late Cretaceous. Standard length was measured in complete specimens and estimated in incomplete specimens. Geochemical analyses were used to estimate the paleoenvironment of each specimen, and nannofossil biostratigraphy was used to determine their geological age. Relationships between standard length and 1) Temperature estimates derived from δ18O values, 2) δ13C values, and 2) Geological time were analysed. Here I show that the standard length of *Hoplopteryx lewesiensis* specimens assumed to be adults (top 20% largest specimens) did not decrease significantly with increasing estimated temperature ($r(9) = -.36$. $p = .27$). Likewise, there was no significant relationship between δ13C values and adult body size ($r(9) = -.66$, $p = .32$). Maximum body size significantly fluctuated between different Upper Cretaceous nannofossil zones and stages ($\chi^2 = 25.000$, $p = <.001$, $df = 5$ and $\chi^2 = 14.868$, $p = <.001$, $df = 2$, respectively). These findings provide further insights into the potential impacts of current climate warming on fish body size and highlight the importance of museum collections for testing temperature-size relationships.

Studying Early Life on Earth and its Implications for the Search of Life on Mars: The Gunflint Formation as a Case Study

Katy Field[1]

[1]The University of Edinburgh

Organic walled microfossils (OWMs) are microfossils where only the cell wall remains and is composed of resistant organic geopolymers referred to as kerogen. There are broadly three categories of OWMs, genuine microfossils, fossil mimics termed pseudofossils, and the ones who remain of unclear origin termed dubiofossils. Early OWMs can be very difficult to identify as they are often simple in structure meaning abiotic processes can produce structures that are morphologically similar. Through the use of microchemistry (FTIR), this project aims to study traces left behind from early life present in the Gunflint Formation (1.88Ga) by analysing the kerogen present in the OWMs. This shall primarily determine two things, firstly if the kerogen is original or if it has since been replaced through oil migration. Secondly, if the kerogen is original, are unique signatures produced which can be used to resolve taxonomic affinities. Preliminary results indicate that the OWMs present in the formation have been preserved with their original kerogen and that the results could be used to resolve taxonomic affinities and identify microfossils from pseudofossils. Being able to more definitively identify and analyse early OWMs and thus Precambrian microfossil assemblages will allow us better insights into the history of life on Earth and what traces this life leaves behind. Reducing the ambiguity in which we can identify traces of life from ancient rocks is extremely important, especially with the current Mars missions from the ESA and NASA which aim to collect and analyse rocks for biosignatures.

Poster Session

Taxonomy and Phylogenetic Relationships of a Non-Crocodyliform Crocodylomorph from the Triassic Fissure-Fill Sediments of Cromhall Quarry

Ewan Bodenham[1]

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Cromhall Quarry is one of several fissure fill deposits located in the Bristol Channel area. These Upper Triassic and Lower Jurassic sediments are well-known for their diverse assemblages of mostly small-bodied tetrapods including *Terrestrisuchus gracilis* from the Pant-y-Ffynnon fissure fill. This gracile, terrestrial form is known from nearly 200 specimens and has been recovered in recent phylogenetic analyses as an early diverging crocodylomorph, only distantly related to Crocodyliformes (the group that contains all living crocodylomorphs). Following a recent re-evaluation of the *Terrestrisuchus gracilis* material, Spiekman et al. (2023) noted that specimen NHMUK PV R 10002, which was recovered from the Cromhall Quarry fissure fill, exhibits distinct morphological differences in limb proportions and carpal morphology relative to *Terrestrisuchus gracilis*. However, this specimen has not previously received a full formal description. In this poster, I present an anatomical description, taxonomic assignment, and phylogenetic interpretation of specimen NHMUK PV R 10002 and discuss the implication to our understanding of the early evolution of crocodylomorphs.

Are Sister-Clade Fossil Constraints Useful Alternatives for Molecular Clock Dating Groups with Poor Fossil Records?

Thomas Tanswell[1], **Jakob Vinther**[1]

[1]*University of Bristol*

Molecular clocks are powerful tools that use genetic data to calculate dates for when lineages diverged, but they need constraining by fossils. Unfortunately, not all clades have good fossil records causing less precise outputs, however a sister clade might. Using conchiferan molluscs (Cephalopoda, Gastropoda, Bivalvia, and Scaphopoda) we will assess whether sister-clade fossil calibrations are capable of improving the molecular clock outputs of clades with poor fossil records. Conchiferans are being used because of their excellent fossil record allowing good precision when fossil calibrations are included. Absence from the fossil record will be simulated by removing fossil constraints from the analyses. Four clades produce 16 possible combinations of constraint presence/absence, ranging from all constrained to no clades constrained. The analyses will then be repeated for the different clock models (independent and autocorrelated), substitution models (homogeneous and heterogeneous), and a constrained (538Ma) versus lenient (565Ma) root. This amounts to 128 permutations. Each permutation's accuracy and precision will be quantified then compared to the ideal (all clades constrained) permutation and the permutation with no clade-specific constraints to see how they differ. Due to the different clock and substitution models being used, the outputs of this research will be applicable to a wide range of researchers regardless of the clade they are studying. If sister-clade calibration is found to be a valid strategy for dating clades with poor fossil records then it will be applicable to many groups, from invertebrates like sponges and earthworms, to vertebrates from tropical environments such as primates.

Poster Session

Mystery Silesaurs of Zambia

Jack Lovegrove[1,2], Paul Barrett[1,2], Paul Upchurch[2]

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Recent discoveries in Africa highlight the importance of areas outside western Gondwana (South America) to our understanding of early dinosaur and avemetatarsalian evolution. For example, the archosaur fauna of the Tanzanian Manda Formation contains three key avemetatarsalian taxa; potentially the earliest dinosaur *Nyasasaurus*; the most completely known aphanosaur, *Teleocrater*; and the silesaurid *Asilisaurus*. The description of the silesaurid, *Lutungutali sitwensis*, from the Ntawere formation of neighbouring Zambia hints that a similarly diverse array of avemetatarsalian taxa may exist within that formation. Another notable aspect of these two faunas is the presence of unusually large silesaurs, a partial femur from the Manda formation suggests an individual of up to 3 m in length and another from a potentially even larger individual has been reported from the ntawere formation. It is currently unclear whether these are new taxa or later ontogenetic stages of existing taxa from these formations. Two specimens from the NHM collections are currently being described with the aim of shedding light on the mysterious avemetatarsalian fauna of the Ntawere formation. These specimens, NHMUK PV R37051 and NHMUK PV R37052, represent an unusually large silesaurid femur and an associated avemetatarsalian specimen of uncertain affinities respectively. It is hoped that osteological and histological description of NHMUK PV R37051 and osteological description of NHMUK PV R37052 will shed some light on the taxonomic and size diversity of the avemetatarsalian fauna of the Ntawere formation.

Using past archives from the Pleistocene to the present day to constrain baselines in UK avian biodiversity.

Bethany Pittard[1], Ryan Felice[1], James Hansford[2], Philip Mannion[1]

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Contemporary change in natural systems is occurring at an unprecedented rate and magnitude. Currently, 40% of birds are in population decline, with 20% of species at risk of extinction. Little availability of long-term avian monitoring data means timescales are relatively short compared to those needed to establish both biodiversity baselines prior to anthropogenic interference, and useful conservation goals. To overcome the limiting factor of a narrow temporal lens, we aim to utilise the UK fossil record to provide the only empirical data on long-term interactions between biodiversity, climate, and human impacts from the Pleistocene to present. Determining whether extinction is random or selective is crucial in understanding past biodiversity change and for better predicting anthropogenic extinction outcomes. Here, we use and contribute to the Paleobiology Database to compile a comprehensive dataset of UK avian occurrences from ~5 Ma to historical times, producing the first sampling-standardised regional baselines for avian biodiversity estimates prior to human impact. Combining this taxonomic data with collecting ecomorphological data, such as body size proxies from avian fossils, morphospace occupation methods, and Species Distribution Modelling, this enables identification of extinction dynamics across different taxonomic groups and ecomorphological categories. This study dovetails with the IUCN Green Status of Species, which incorporates longer-term species trajectories to measure against historical baselines. With this new database, we are meaningfully contributing to UK conservation efforts against expected ongoing climatic and environmental changes that is expected to result in substantial loss in avian biodiversity, poleward dispersal and body size selective extinction.

Poster Session

Reinvestigating the rooting system of a Lower Carboniferous lycopsid, *Oxroadia*, through 3D reconstruction

Jeremy Wyman[1], Alexander Hetherington[2], Jennifer Westermann[2]

[1]University of Edinburgh, Department of Geosciences; [2]University of Edinburgh, Institute of Molecular Plant Sciences

Whilst the scientific consensus is that roots evolved separately in the plant clades euphyllophytes and lycophytes, the evolution and origin of rooting systems in lycophytes remains a point of lively scientific discussion. Various hypotheses have been proposed to explain the evolution of rooting systems in lycophytes including origins from shoots or leaves, while others claim that they arose as de novo organs. This study seeks to contribute to this debate by creating 3D reconstructions of the rooting system of *Oxroadia* a genus of Early Carboniferous low-lying lycopsids from Scotland. *Oxroadia* has long been considered a "taxonomic football," but it is currently placed as an early-diverging member of Isoetales which also contains the famous arborescent lycopsids. All Isoetaleans have a rhizomorph; a rooting meristem from which rootlets develop in a regular pattern. This rhizotaxy (pattern of rootlet attachment) in Isoetaleans is a highly conserved trait across the entire clade, however it is unclear when it evolved. By modelling *Oxroadia*'s rooting system, we will be able to determine if the species developed rootlets in a regular rhizotaxy and compare to other members of the Isoetaleans. The analysis is based on reinvestigation of two previously described *Oxroadia* specimens. Here using the digital reconstruction software SPIERS, these specimens will be digitised, aligned, and turned into a tomographic dataset which will then be brought into Blender. Visualising the rhizotaxy will allow us to generate new data about the evolution of rooting in Isoetaleans and lycopsids more broadly.

The earliest avian eggshells from Australia shed light to the origin of Oceanic ratites

Xavier Panades I Blas[1,2,3], Michael Archer[4], Suzanne Hand[4], Trevor Worthy[5], Àngel Galobart[1,2,3], Albert Sellés[1,2,3]

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Despite flightless ratites being one of the most enigmatic and studied bird clades, their origins remain elusive. There is a disagreement of 35 Ma between the molecular clocks and the fossil record. While the molecular clocks place the origin and divergence of several palaeognathid clades between the end of the Mesozoic era and the beginning of the Palaeogene, the oldest fossil remains are from the early Neogene. Here, we introduce the earliest avian eggshells discovered in Australia. This finding notably narrows the time gap between the palaeognathid fossil record and the estimates provided by the molecular clock by several million years.

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Poster Session

An alternative hypothesis for the decline of spore plant dominance and its consequences for North American forests

Arthur Owens[1], **Jakob Vinther**[1]

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Plants, whether they reproduce by spore or seed are known for their innate hardiness and ability withstand prolonged disruption to their environment. As such plants only have two recorded mass extinctions in the fossil record, which correlate to the loss of coal forests and spore plant dominance as they were replaced by upland seed plants. This floral takeover is currently held as the consequence of climatic changes leading into the warmer and drier Permian, however, research on modern spore plants highlights their tolerance for salt and droughts, with some horsetails found today in the Atacama Death Valley. This implies the presence of a secondary driver maintained in the modern day preventing greater spore establishment. A potential deeper origin of earthworms places them in the Carboniferous, a link from post-invasion floral turnover in North America today to the loss of the coal forests. Earthworms are disastrous for spore plants such as clubmosses today when their habitats are invaded by worms, with cascading effects impacting vertebrate behaviour and even survival. By investigating the literature of how earthworms impact spore plants today this project investigates earthworm contributions to the fall of the spore plants and the consequent warming of the Permian. This project highlights further avenues of research by placing earthworm impacts in a novel context and highlights the evolutionary differences between spore and seed plants that left them vulnerable to earthworm mediated changes to soil chemistry, fungal and microbial communities.

Paleoecology And Physiology Inferred From Oxygen and Carbon Isotopes Of Fossil Fish And Cephalopods

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Understanding the relationship between environmental perturbations, physiological traits of organisms, and their evolutionary consequences is important because it allows us to predict the impact of anthropogenic climate change on current ecosystems, and to better quantify the role of climate change in deep time evolutionary trends. Physiology provides the link between physical and biotic changes in the environment and their effects on an individual animal. Field metabolic rate (the energetic cost of living) integrates a wide range of potential physiological and behavioural responses to environmental change. Monitoring how individual field metabolic rate varies in response to environmental change within and across species can therefore provide a sensitive test of climate-organism interactions. In my PhD, I am using a novel proxy based on the stable carbon isotope compositions of carbonate biominerals, to reconstruct field metabolic rates in modern and fossil marine animals. We aim to use our proxy to determine relative metabolic rates across taxa and to quantify how sensitive animal physiology is to temperature change. Initially I have applied the proxy to modern fish otoliths, successfully demonstrating among-species differences in metabolic level and thermal sensitivity of metabolic rate. Next we extend analyses to fossil otoliths from the London Clay, exploring metabolic rates of fish taxa currently confined to cold, deep waters in the shallow, warm waters during the Eocene Thermal Maximum. Finally, I will extend the proxy from fishes to ammonite cephalopods, aiming to compare relative metabolic rates across body morphologies, ecological and environmental contexts.

Poster Session

The Evolution of Symmetry Across Animal Phylogeny

James McDermott[1,2,3], Imran Rahman[1,2], Frances Dunn[2], Ferdinand Marlétaz[3]

[1]The Natural History Museum; [2]Oxford University Museum of Natural History; [3]University College London

Symmetry is a fundamental property of the major animal body plans that originated over half a billion years ago. However, little is known about how and why different types of symmetry evolved during the initial radiation of animals. To address this, we performed quantitative analysis of changes in symmetry state across animal phylogeny using both the literature and direct observations of fossil material in museum collections. We compiled a database of key character traits (including symmetry state) together with ecological and environmental information for living and extinct taxa from across the animal kingdom. We established the rate of evolution of symmetry states across the early Palaeozoic and provided the first test of whether there was a Cambrian Explosion in symmetry states. Our phylogenetic results were then compared to ecological and environmental parameters to assess potential drivers of change. The results of this study provide the palaeontological context needed for further research into why specific symmetry types evolved and persisted across animal phylogeny.

Evaluating the mechanistic importance of ocean deoxygenation in ancient extinctions

Przemyslaw Gruszka[1], Richard George Stockey[1]

[1]University of Southampton

Ocean deoxygenation is a critical threat to modern marine ecosystems in a warming world. Episodes of globally enhanced ocean anoxia, are often associated with hyperthermal events and have been recognised as a potential mechanism driving marine extinction events in the past. However, the distributions of dissolved oxygen in modern oceans are extremely heterogeneous, with the expansion of localised oxygen minimum zones (OMZs) being a key concern. Significantly, utilizing 3D biogeochemical models of ancient oceans indicates that oxygen distributions in ancient oceans were similarly heterogeneous, while the OMZs were expected to have dramatically increased in volume during ancient warming events. In this project, we aim to test the hypothesis that expanding oxygen minimum zones were a key driver of marine extinction during ancient hyperthermal events and examine how marine ecosystems were affected at varying degrees of spatial resolution. Here, we present a new methodological approach integrating 3D models of dissolved marine oxygen with regional reconstructions of marine animal palaeodiversity across spatio-temporal environmental gradients. We provide new quantitative constraints on the role of warming-driven ocean deoxygenation on marine biodiversity, evaluating the impact of expanding oxygen minimum zones on the spatial distribution of marine ecosystems and diversity dynamics. This approach supports the utility of integrating oceanographic and ecophysiological models with spatial biodiversity reconstructions to improve our mechanistic understanding of environmental drivers of marine extinction in deep time. By deploying this approach more widely we hope to add to a growing body of evidence describing the impact of ancient climate change on marine biodiversity.

Poster Session

Inferring the nature of the first land plant spore

Jack Hooper[1], Philip Donoghue[1], James Clark[2]

[1]University of Bristol; [2]University of Bath

The evolutionary origin of land plants (Embryophyta) fundamentally transformed the Earth system. However, we cannot yet reliably interpret the fossil record which documents this transition, and so our understanding of the timing of this event remains unresolved. Whereas the first unequivocal land plant megafossil is mid-Silurian, molecular clock analyses suggest a mid-Cambrian origin. The spore fossil record may reconcile these timelines, but we need a framework for interpreting these fossils phylogenetically. The earliest unequivocal embryophyte fossil spores appear in the Lower Ordovician, whereas assemblages of cryptospores of disputed affinity extend back into the mid-Cambrian. The aim of the study presented here is to infer the nature of spore characters in the ancestral embryophyte. This will be achieved through probabilistic ancestral state reconstruction, based on morphological data derived from a taxon sample of extant embryophytes. This probabilistic reconstruction of the pattern of trait evolution across the land plants will provide a framework for interpreting the spore fossils which capture the transition to land. This rich microfossil record will later be used to define a new set of fossil tip-calibrations to inform Bayesian molecular clock analysis. Taken together, these findings will determine a new timeline for the terrestrialisation of embryophytes and the impact of this evolutionary transition on the Earth system.

Exploring function of early dinosaur tooth morphologies through comparative computational and physical mechanical tests

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Dinosaurs exhibited numerous dietary adaptations which allowed them to occupy a wide array of ecological niches throughout their dominance. Some of these unique adaptations appeared during their initial radiation, many of them linked to their dentitions. The feeding habits of dinosaurs have been historically hypothesised from morphological studies of dentition in comparison with extant analogues to infer dental function and diet. However, these methods lack biomechanical evaluation and have not quantified the tooth mechanics involved during feeding and food processing. This research seeks to integrate computational finite element analysis of tooth function alongside physical puncture tests to provide deeper insight into tooth mechanics and food-tooth interactions during feeding in early dinosaurs. Our analyses use hypothetical models representative of the three tooth types seen in early ornithischians, sauropodomorphs and theropods. Multi-directional loading scenarios will allow insight into tooth mechanics during diverse loading scenarios such as biting, shaking and dental occlusion, representative of the inferred diversity of their feeding habits. Physical tests, using 3D-printed tooth models, will compare performance in puncture upon different testing materials of varying properties, such as differing elastic properties and toughness to assess the interaction of different tooth shapes against different food types. This study will provide a more nuanced understanding of the specific tooth mechanics during feeding in early dinosaurs, approaching from multiple empirical angles (both physical and computational), previously underutilised in early dinosaur dental studies.

Poster Session

A Quantitative Analysis of Jaw Shape in Cretaceous Sharks to Explore the Evolution of Feeding Mechanisms

Jop van Dijen[1,2], Richard Dearden[1], Martin Rücklin[1,2]

[1]Naturalis Biodiversity Center; [2]Leiden University

Sharks are part of the ancient group Chondrichthyes that diverged from bony fish more than 400 million years ago. This long history of sharks on Earth, together with their incredible diversity, makes them an intriguing group of animals to study. However, most of our current knowledge on the evolutionary history of sharks is based on isolated teeth. By studying the phenotypic diversity, or disparity, of shark jaws, we can increase our knowledge on their feeding mechanisms. Furthermore, by studying other elements than teeth we can check if it is in line with research based on teeth. In this study, the 3D shape of the Meckel's cartilage of nine fossil shark specimens from the Cretaceous are analysed. The specimens represent a wide range of taxa in shark phylogeny. To analyse the fossils, CT scans were made of the specimens. From the CT scans, 3D models of the jaws were generated in Avizo. The disparity of the 3D model jaw shapes is analysed by using geometric morphometrics to quantitatively compare different jaw shapes. Original landmarks and semi landmarks are used to determine the shape. The processed data of the jaws is combined with a dataset of a recent study where the same analysis was performed on extant sharks. By including extinct species to their analysis, we can understand what the feeding mechanisms of the extinct species were.

Does Evolution Optimise Performance? Morphospace Occupation of Sarcopterygian Fish

Cass Nicholas[1], Emily Rayfield[1], Will Deakin[1]

[1]University of Bristol

Sarcopterygii is a clade which dates from the late Silurian to the present day, containing a diverse morphological variety and intriguing phylogenetic split. Initially, the clade experienced a rapid burst of speciation which lasted from the Devonian to the early Permian before a bottleneck and then diversity stasis were observed. Within the Devonian diversification, Sarcopterygii split into coelacanths (Astinistia) and tetrapodmorphs (Lungfish and Tetrapods), forming early hominin origins. Originally, these non-tetrapodomorphs were dominant species before their decline in The P-T Extinction, witnissing the rapid success of tetrapodomorph Sarcopterygii. The divergence of jaw morphologies within the tetrapodomorphs against the stasis of form coelacanths raises notorious questions: why do certain morphologies occur more frequently and is it a reflection of optimal functionality or a product of restraints? Using morphometric techniques, Sarcopterygii lower jaw mandibles were characterised into morphospace from empirical data to generate an understanding of all physically possible forms to determine impossible morphologies. These were then analysed through Elliptical Fourier Analysis and Finite Element Analysis to determine occupations within morphospace as well as stress distributions of theoretical jaws. These analyses reveal an intricate story of constraint and adoption at the base of the tetrapod stem, as well as insight into the clades' diversification. Having insights into past phylogenies and morphological drivers allows for vital inferences about modern population rates, conservation and extinction patterns.

Poster Session

The endocranial anatomy of new specimens of Ceratopsian dinosaurs

Adam Manning[1], Tom Williamson[2], Stig Walsh[3], Lawrence Witmer[4], Ryan Ridgley[4], Steve Brusatte[1]

[1]The University of Edinburgh; [2]New Mexico Museum of Natural History; [3]The National Museum of Scotland; [4]Ohio University

The palaeoneurology of non-avian dinosaurs is a key field within palaeontology to understand the behaviour and paleoecology of these animals. However, the palaeoneurology of the clade Ceratopsia (Dinosauria: Ornithiscisa) has been largely overlooked, due in part to a lack of specimens will well preserved braincases that are small enough to fit into CT scanners. Here, using segmented computed tomography (CT), we present descriptions of the endocranial anatomy of three new specimens of Ceratopsian dinosaurs: *Leptoceratops gracilis*, c.f. *Pentaceratops* and *Triceratops* sp. The endocranial anatomy of these new specimens is similar to the anatomy observed in other ceratopsians and largely reflects the basal archosaur form. *Triceratops* was the only specimen with olfactory apparatus preserved, and exhibits small olfactory bulbs. Both *Leptoceratops* and *Triceratops* have notable rounded lateral swelling corresponding to the cerebrum, optic lobe and cerebellum, although these expansions are large in *Leptoceratops*. The endosseous labyrinth of *Pentaceratops* and *Triceratops* are short and thick, similar to the labyrinths of other ceratopsians like *Pachyrhinosaurus*, indicating that they were not agile animals. These results suggest that basal ceratopsians like *Leptoceratops* had brains more dedicated to sensory processing, indicating they may have relied on their senses to evade predators compared to bigger, more derived ceratopsians like *Pentaceratops* and *Triceratops*. Further quantitative analysis of these endocasts in comparison to those in the literature is needed to test this hypothesis.

Doushantuo-type Microfossils in latest Ediacaran–Cambrian rocks of Mongolia

Orin Lole Durbin[1], Eliel S.C. Anttila[2], Francis A. Macdonald[2], Ross P. Anderson[1]

[1]University of Oxford; [2]University of California Santa Barbara

Microfossil assemblages that contain Doushantuo-Pertataka-type acanthomorphic acritarchs are found globally during the early Ediacaran. Phosphorites within the Khesen Formation, northern Mongolia, were the fifth Ediacaran-Cambrian phosphorite succession to preserve animal embryo-like microfossils alongside a diverse assemblage of large acritarchs that exhibit complex processes. Here, the assemblage is expanded to include the acanthomorphic acritarchs *Asterocapsoides wenganensis*, *Knollisphaeridium maximum* and *Mengeosphaera reticulata* alongside the previously reported *Appendisphaera grandis*, *Appendisphaera tenuis* and *Cavaspina basiconica*. The phosphorites also preserve species of the embryo-like taxon *Megasphaera*. Geological and geochemical data suggest a terminal Ediacaran to earliest Cambrian age (541-533 million years ago) for the Khesen Formation. This assemblage is, therefore, one of the youngest Doushantuo-Pertataka-type assemblages described. Notably, several taxa are shared with the iconic Weng'an assemblage, which is up to 35 million years older. The ranges of *Asterocapsoides wenganensis*, *Knollisphaeridium maximum* and *Mengeosphaera reticulata* are all extended by tens of millions of years. The newly determined age of the Khesen phosphorites emphasises the importance of this locality in understanding the Ediacaran-Cambrian transition.

Poster Session

Constraining the affinity of the cryptic Cambrian spinose microfossil *Corollasphaeridium*.

Thomas Green[1], Tom Harvey[1], Mark Williams[1], Brian Pedder[2], Pascal Olschewski[3]

[1]University of Leicester; [2]University College London; [3]Memorial University of Newfoundland

The Ediacaran–Cambrian transition represents a pivotal interval in Earth's history marked by the establishment of Phanerozoic-type animal-rich ecosystems. Some of the earliest proposed animal body fossils are spinose microfossils known from the Small Carbonaceous Fossil (SCF) record. However, accurately ascribing phylogenetic affinity to these microfossils is a major challenge because of the potential for convergent morphologies among animals, algae and protists. Here we evaluate the Cambrian microfossil *Corollasphaeridium*, which is currently classified among acritarchs (commonly thought to be phytoplanktonic organisms) but has sometimes been interpreted as an animal body part. New specimens from the lower Cambrian (Stage 4) Forteau Formation (Newfoundland, Canada) and the upper Cambrian (Furongian Series) Deadwood Formation (Saskatchewan, Canada and South Dakota, USA) confirm that *Corollasphaeridium* lacks an enclosed vesicle and should not be classified as an acritarch. The best-preserved specimens reveal a trumpet shaped calyx with 5–10 apical spines, a flaring and invaginated aperture rim and an ornamentation of anastomosed ridges. A comparison with metazoan and non-metazoan taxa suggests a closer similarity to the loricae of tintinnid ciliates or testate amoebae than metazoan cuticular fragments. Although specific synapomorphies with living groups have not been identified, together our results support an identity for *Corollasphaeridium* as a loricate protist, with modern analogues suggesting a planktonic ecology. Our findings highlight that Cambrian 'acritarchs' contain a cryptic record of organisms other than phytoplankton and metazoans and help clarify criteria for distinguishing genuine early animal remains.

Understanding mammaliaform ecology: a comparison and cranial analysis of *Hadrocodium wui* and extant mammals.

Molly Tumelty[1]

[1]Independent

Determining the specifics of the ecology of a species solely using the cranial skeleton presents certain challenges, particularly when focusing on fossoriality. The Early Jurassic mammaliaform *Hadrocodium wui* is known only by the cranium and mandible and shares morphological similarities with insectivorous digging species such as talpid moles. By doing a geometric morphometric analysis on the lower mandibles and finite element analysis on the crania, comparisons between *H. wui* and extant groups can be made. Extant mammals utilise a variety of burrowing techniques; forelimb digging, head-shovel digging, chisel-tooth digging, scratch digging etc. The overall weakness across the *Hadrocodium* cranium in the finite element analysis may rule out the use of the head during burrowing. This conclusion is strengthened by the comparison against a chisel-tooth digging mole-rat (*Nannospalax leucodon*) which exhibited far lower stresses in response to all loads. The weakness could also be a result of the reduction in thickness of the zygomatic arch across the cynodont to mammal transition. The lower mandible shape of *H. wui* was more similar to semi-fossorial/semi-aquatic talpid moles than fully fossorial moles potentially indicating a semi-fossorial lifestyle for *H. wui*. As a whole, the results imply that *H. wui* was not entirely fossorial and fed on a diet of softer invertebrates but also demonstrate potential for using the cranium to predict fossoriality.

Poster Session

Morphological changes in the supratemporal fenestra of the clade Dinosauria as a result of diet.

Thomas Beard[1]

[1]*Independent*

Fenestrae are significant morphological structures in the skulls of dinosaurs and other diapsids that benefit the skull structurally and in feeding. One of the fenestrae is the supratemporal fenestra which is a located on the top of the skull. It plays a role in jaw mechanics but is significantly under researched when in terms of fenestra morphology and diets within Dinosauria, especially in comparison to the highly studied mandible and tooth morphologies. By doing a principal components analysis of two-dimensional landmarks, the supratemporal fenestra morphology of different dinosaur clades can be compared to diet and feeding mechanics. Major variation across Dinosauria was observed, particularly in the herbivorous dinosaurs, with distinct fenestra morphologies identified. Ornithopoda and Sauropoda demonstrated opposing elongation of the supratemporal fenestra morphologies. Theropoda species demonstrated recurring fenestra morphologies of teardrop and arrowhead shapes with variation in the orientation of the fenestra tip. The different Ornithopoda and Sauropoda morphologies may show a relationship to feeding mechanisms; Ornithopoda had a chewing feeding process whilst Sauropoda adapted a raking method to consume vegetation. However, this trend is not seen in all clades. The theropods *Allosaurus* and *Ceratosaurus* shared environmental and dietary niches but had different fenestra morphologies. In conclusion, the morphology of the fenestra does change across Dinosauria clades and may have an impact on the diet. However, further study into the morphology of the fenestra is required in order to get a more definitive answer.

Ungual and Claw Sheath Morphology as a New Tool for Evaluating the Terrestrial Ecology of Pterosaurs

Stella Angelika Ludwig[1], **Robert S. H. Smyth**[2], **David M. Unwin**[2], **David M. Martill**[1], **Roy E. Smith**[1]

[1]*University of Portsmouth;* [2]*University of Leicester*

Pterosaurs were Mesozoic archosauromorph reptiles that appeared in the Late Triassic (ca. 215 Ma) and became extinct at the end of the Cretaceous (66 Ma). Pterosaur ecology is a crucial aspect for understanding Mesozoic ecosystems and food webs, yet their modes of terrestrial locomotion remain poorly constrained. Here, the terrestrial ecology of pterosaurs is reviewed using a novel methodological approach based on ungual and claw sheath morphometrics. Claw morphology presents an understudied yet promising model system for understanding the palaeoecology of extinct amniotes through comparisons with the ecomorphospace occupied by extant taxa. To facilitate a comprehensive ecomorphospace comparison, a dataset of pterosaur claw images encompassing a broad range of pterosaurs was compiled. This data reveals a hitherto unrecorded morphological diversity in pterosaur manual and pedal unguals, as well as variable relationships between ungual and claw sheath morphologies in different taxa. Furthermore, a strong link between pterosaur clade content and claw morphology is established in linear discriminant analyses. This information greatly further our understanding of the ecological diversity within Pterosauria, as well as the morphological diversity present in amniote claws.

Poster Session

Temporal and climate dynamics of marine invertebrate biogeographic range

Tim Breeze[1]

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The world is experiencing a loss of species and habitat at a rate unprecedented within human history. It has been convincingly argued that we are now in the midst of a sixth mass extinction event. One that, if unchecked, could exceed in impact the K-Pg mass extinction that heralded the extinction of the non-avian dinosaurs among other groups. Understanding the drivers of extinction during extreme climatic shifts is therefore an urgent priority. Geographic range has long been recognised as a key factor in buffering taxa from extinction, but the dynamics of this process is not well understood. A more complete understanding of how biogeographic range correlates with mass extinction may aid in current conservation and climate change mitigation efforts. This project aims to study these dynamics by utilising the excellent marine macro-invertebrate fossil record of the last 100 My. It will investigate how the biogeographic range of key marine faunas has changed over time using several metrics. It will correlate these temporal range dynamics with extinction rate to determine how shifts in biogeographical extent predict extinction and origination rate. It also aims to investigate the drivers of these shifts through the use of published climate proxy data including sea-level, surface temperature, oxygenation and acidification. All of these factors present a threat to present-day biodiversity due to anthropogenic climate change and by better understanding their past impacts the threat to our modern ecosystems can be better managed.

The mouth of *Pambdelurion whittingtoni* is not a radial oral cone.

Campbell Marsden Hendrick[1], **Thomas Farrell**[1], **Jakob Vinther**[1]

[1]*University of Bristol*

Arthropoda is the most diverse phylum of animals, accounting for the majority of animal species alive today. The soft body fossils of various Cambrian Laggerstätte have been instrumental over recent decades in uncovering the arthropod stem-group, revealing ancestral characters of the clade that have since been lost. One such character is a set of radially symmetrical cuticular structures surrounding the mouth, absent in crown-group arthropods but often present in related phyla of the larger clade Ecdysozoa. Such a radial structure has been proposed for *Pambdelurion whittingtoni*, a gilled lobopod from Greenland's Sirius Passet locality. The species represents a vital branch on the arthropod stem, expressing morphological features of both ancestral panarthropods and crown-group euarthropods. Many partially preserved specimens show multiple sclerotized plates surrounding the mouth, suggesting that a radial mouth cone like that seen in *Anomolocaris* is present. However, a new, exceptionally preserved specimen presents a nearly complete set of oral plates that are arranged bilaterally rather than radially. Here we describe this novel mouth cone and re-evaluate older material from both this species and the related taxon *Omnidens ampulus*, concluding that this feature is not of taphonomic origin, but a morphological feature. Clarity regarding this feature corrects an inaccuracy in our understanding of this important taxon and brings us one step closer to understanding the cryptic evolutionary history of the arthropods.

Poster Session

Use it or lose it? An investigation into the morphological and functional variation of metatarsal V within Macropodoidea

George Watts[1], Christine Janis[1], Emily Rayfield[1]

[1]University of Bristol

Although hopping is the most characteristic gait of kangaroos (Macropodoidea) the group exhibits surprising disparity in locomotory styles: including climbers, walkers, and bounders. Various extinct taxa also have divergent proposed gaits. Thus, the pedal morphology varies within the clade. The weight-bearing role of metatarsal V (which varies in relative robusticity to metatarsal IV) is unstudied. Digit V is reduced in large extant hoppers and lost entirely in the extinct short-faced kangaroo lineage (sthenurines). However, the sthenurine *Hadronomas* retains a robust fifth digit. Questions remain about the importance of digit V for different proposed locomotors, and the reasons behind its reduction/loss. Here we use linear measurement morphometrics of data from 86 macropod individuals and micro-CT scans of metatarsal bones from 10 kangaroos to investigate what drives morphological and functional variation. Linear measurement morphometrics show the relative robusticity of metatarsal V does vary with locomotion style. However, robusticity also varies with length of the foot in the subfamily Macropodinae: species with relatively long metatarsals have a thinner fifth metatarsal. Second moment of area analysis shows bending strength of metatarsal V varies. Although resistance values for metatarsal IV were similar among medium-sized taxa, the results showed the sthenurine *Hadronomas* and the possibly quadrupedal *Protemnodon* had a fifth metatarsal more resistant to bending than extant kangaroos. Although the reason behind digit loss in sthenurines is still obscure, a novel pattern of reduction in the macropodine fifth digit is identified. The hypothesis of disparate gaits in extinct kangaroos is supported.

Reconstructing the evolution of prehension mechanisms and mandibular shape in Lepidosauria.

Alex Kersley[1], Emily J Rayfield[1], Antonio Ballell Mayoral[1]

[1]University of Bristol

Lepidosauria is a diverse group of reptiles consisting of two orders, Squamata and Rhynchocephalia. While Rhynchocephalia is only represented by one extant species, squamates populate the globe with over 10,000 species. The ecological impact on species morphological variation has been studied within this past, with an emphasis on how diet impacts the mandible shape. Other ecological factors such as prey prehension has not been considered in terms of how this may impact the evolution of mandible shape in lepidosaurs. In order to determine what impacts the shape of the mandible the most, three separate factors were considered: prehension mode, diet, and phylogenetic relation. This was accomplished through a Geometric Morphometric (GMM) analysis and an ancestral state reconstruction. Outcomes of the GMM analysis resulted in all individual factors showing no significant correlation in impacting the mandible shape, with diet being proven the worst by far. While phylogeny and prehension had no correlation with mandible shape variation, they were the two factors which impacted the shape the most. Furthermore, it this is confirmed through ancestral state reconstruction by determining how mandible shape may have evolved in accordance with prehension mode. This has resulted in a conclusion that a focus based on prehension shape and diet needs to be considered closer. Focusing on collection of prehension data to maximise the accuracy of the study, as well as focusing on a suborder level.

Poster Session

Anatomy and Relationships of the Cretaceous shark *Synechodus dubrisiensis*

Alisha Dijkerman[1], Richard Dearden[1], Zerina Johanson[2], Martin Rücklin[1]

[1]Naturalis Biodiversity Center Leiden; [2]Natural History Museum London

Sharks, belonging to the class Chondrichthyes, are important carnivores in marine ecosystems, representing a unique evolutionary heritage and displaying a high degree of evolutionary distinctiveness. With nearly 25% of elasmobranch species threatened with extinction, it is imperative to focus conservation efforts on preserving distinct lineages and recognising key speciation zones. Fossil evidence is vital for deciphering the evolutionary saga of these creatures, yet shark fossils are predominantly limited to teeth, with three-dimensional specimens being exceptionally rare. One exception is *Synechodus dubrisiensis*, an extinct fossil shark from the Cretaceous chalk of the UK, whose three-dimensional neurocranium was described by John Maisey in 1984. However, the overall anatomy and phylogenetic position of this species are poorly understood. Based on its teeth, it does not belong to any living group of sharks and the morphology of its neurocranium shows both traits from modern and extinct groups of sharks. This study re-examines the anatomy and evolutionary placement of *Synechodus dubrisiensis* by making a 3D reconstruction of its neurocranium and jaws through the use of computed tomography scans on samples from the Natural History Museum, London. This technique allows for the reconstruction of both the internal and external structures of fossil specimens and can reveal details that were previously inaccessible without damaging the specimen. Our comprehensive analysis not only illuminates the anatomical features of *Synechodus dubrisiensis* but also clarifies its phylogenetic relationships, enhancing our comprehension of how sharks evolved and diversified during the Cretaceous period, a time of major environmental changes and faunal turnovers.

Using Pterosaurs to teach new methods: New phylodynamic models and the impact of different priors.

Joël R. Koelewijn[1]

[1]Utrecht University

The Fossil-birth death process allows more realistic phylogenetic trees, by taking into account three rates: The rate of speciation, rate of extinction and rate of fossilisation. One of the advantages is the ability to take into account ancestry in the fossil record. It also allows for the use of phylodynamics. This method originally developed in epidemiology allows for inferences to be made based on the shape of the tree, like about species richness. It can be hard to tell what impact the use of different priors has on the results of a phylogenetic analysis. By using these new methods on a very limited and fragmentary dataset, the effects these priors have on the results are amplified. Thus a dataset with early Pterosaurs and their sister group Lagerpetids, was used to test the differences between using different combinations of priors on estimates of richness inferred using the FBD process. The results show major changes in the tree topology, with one species even changing location from the Lagerpetid branch to the Pterosaur branch, showing the key importance of understanding which priors bring us closer to realistic assumptions. This approach can also help determine divergence times between groups, as done in this study for lagerpetids and Pterosaurs. Of note as well is that many species are found to be direct ancestors to later species, plus one Lagerpetid falling with the Pterosaurs instead.

Poster Session

An unusual occurrence of calymenid trilobites in offshore facies of the Silurian Welsh Basin

Dorian Marczykowska[1], Mark Williams[1], Tom Harvey[1], Chris Stocker[1], Derek J Siveter[2], David J Siveter[1], Jerry R Davies[4], Richard A Waters[3]

[1]University of Leicester; [2]Oxford University Museum; [3]National Museum of Wales; [4]British Geological Survey

Trilobites are important biostratigraphical and palaeoecological indices for reconstructing the history of the early Palaeozoic Welsh Basin. Here we describe a new assemblage of trilobites from the Tirabad Formation of the Builth Wells area, central Wales. The fauna consists of *Tapinocalymene nodulosa*, *T. vulpecula* and *Dalmanites sp*. associated with the beyrichiacean ostracod *Amphitoxotis repanda*. Mudstones of the Tirabad Formation also yield graptolites indicative of the late Wenlock Series (Silurian). Taphonomic data suggests the trilobites were transported downslope into the basin. They provide an important biostratigraphical tie between the more offshore setting of the Tirabad Formation, and those of the late Wenlock palaeo-shelf Coalbrookdale Formation to the East.

An ichthyosaur from the Upper Jurassic Kimmeridge Clay Formation of Oxfordshire, United Kingdom.

Benjamin Thomas[1], Megan Jacobs[1], David Martill[1]

[1]University of Portsmouth

A specimen of ophthalmosaurid ichthyosaur from the Upper Jurassic Kimmeridge Clay Formation of Oxfordshire, UK is described and its phylogenetic position tested. The specimen ACHM 1980.191.1601 is free of matrix and three-dimensionally preserved, being approximately 65% complete. It comprises a partial disarticulated skull and associated postcranial skeleton, including the pectoral girdle, partial forelimbs, much of the vertebral column and ribcage, and the left femur. Phylogenetic analysis using the latest available matrices for ophthalmosaurid ichthyosaurs indicates that the specimen is a platypterygiine and likely of the genus *Grendelius*. It displays several diagnostic features found in the holotype and the referred specimen of *Grendelius mordax*, notably in the humeri, pectoral girdle and rostrum, in addition to a combination of characters shared with other species of *Grendelius* from Russia. Extensive pathologies are present on the skull, especially on the jaws and are interpreted as healed bite marks. Scavenging marks attributable to fish and echinoids, in addition to the presence of encrusting organisms, indicate that the carcass was exposed on an oxygenated or slightly dysoxic seafloor after soft-tissue decay and prior to burial. This specimen extends the geographical and temporal range of *G. mordax* in the UK and may be the stratigraphically oldest occurrence of the species, likely coming from the Elegans ammonite biozone. The specimen adds to our knowledge of the osteology and anatomical variability of this species, while also contributing to the record of ichthyosaur palaeopathologies.

Poster Session

The Bull of the Recent

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Macroevolutionary analyses provide insights into past life assemblages, and the drivers of evolution. Hooved mammals (ungulates) include several key clades with important impacts on past and present environments. The evolutionary dynamics of equids in particular have had little empirical attention, which this project aims to highlight. Equids (horses, asses, and zebras) today comprise a single genus, Equus, with seven species indigenous to Eurasia and Africa. However, they used to be far more diverse, originating in North America before radiating to the Old World in the mid-Miocene, when their diversity peaked. By the Pliocene their diversity was declining, with extirpation from the New World at the end of the Pleistocene. It has been long assumed that this decline was due to competition with ruminant artiodactyls, primarily bovids, but this view is based on the current success of the latter group rather than actual analyses of evolutionary dynamics. Preliminary investigations indicate the competition model does not reflect the trends in North America and Africa at the generic level, but this has yet to be investigated in Eurasia. Occurrence data generated from the NOW database presents an overview at the genus-level, while analyses of species-level data using the novel programme PyRate considers life interactions. PyRate investigates rates of preservation, origination, and extinction to estimate the presence and intensity of competition, and also evaluates the impact of factors such as climate and ecological traits on patterns of diversification and extinction within the model. Initial runs indicate no impact of artiodactyl diversification on equids.

Moving in the flight direction: the macroevolution of pterosaurs

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Pterosaurs, the first vertebrates to evolve powered flight, were key components of Mesozoic terrestrial ecosystems from their origins in the Late Triassic to their demise at the end of the Cretaceous. Despite their popularity and ecological success, many aspects of their macroevolution are still poorly understood. In particular, it is not yet resolved, what factor(s) drove pterosaurs to evolve powered flight. Our objective was to uncover the processes that led to the first pterosaur taking flight and to link environmental disturbances with this major step in the group's evolution. We applied quantitative methods to infer missing data and to create a more comprehensive picture of pterosaur evolution. We used the Fossilized Birth-Death model (FBD) tip dating framework to recalibrate a comprehensive phylogenetic tree with the most accurate dating method. The environmental data needed for correlating changes in the environment with major steps in the evolution of pterosaurs is provided through a general circulation model, HadCM3L. Using non-metric multidimensional scaling (NMDS), we examined changes in pterosaur climate niche evolution and compared those to proxies for flight efficiency and other morphological traits (e.g. wing size). Lastly, we implemented phylogenetic comparative methods to infer the mode of evolution with which traits relevant to the evolution of flight evolved. Our study applies well-established methods to the infrequently studied field of early pterosaurs, thus contributing to a more in-depth understanding of the evolution of the first flight in vertebrates and its links to the environment.

Poster Session

Testing the hypothesis of parrot-like mandibles in oviraptorosaurs.

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Oviraptorosaurs (Dinosauria: Oviraptorosauria), a group of feathered Cretaceous theropods, are characterised by their distinctive craniocaudally short and dorsoventrally tall skulls, often adorned with a prominent bony crest. Although the earliest members retained teeth, oviraptorosaurs typically had beaked jaws, with the mandible often likened to that of parrots (Aves: Psittaciformes), renowned for their granivorous diet. This comparison has often been used by authors for functional inferences and as a reference for landmark placement in previous form-function studies. Our study aims to test the validity of this longstanding comparison between oviraptorosaurs and parrots from both morphological and functional perspectives, trying to identify the potential similarities and fundamental differences between the two clades. Here, we present the preliminary findings of our comparative morpho-functional analysis. Employing a combination of an Elliptical Fourier Analysis and two-dimensional semi-landmark analysis, we evaluated the shape variation of the lower jaws as well as their beaked portions. Additionally, we used a multivariate analysis to measure the variation of key mandibular functional traits. Our analysis supports the morphological resemblance between the two clades, particularly in the overall jaw shape. Functional analysis provides further insight, revealing a congruent picture with the geometric morphometric analysis. Notably, basal oviraptorosaurs possess the most distinctive morpho-functional traits, while the derived forms closely match the observations from parrots. Our current results suggest that the comparison between oviraptorosaurs and parrots extends beyond the superficial resemblance in shape, and it aligns with the growing body of evidence for a divergent diet from their carnivorous theropod ancestors.

The taphonomy and soft-tissue anatomy of conodonts from the Ordovician Soom Shale (South Africa) and the Carboniferous Granton Shrimp-bed (Scotland)

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Conodonts have a fossil record ranging from the Cambrian to end-Triassic, but is almost exclusively comprised of their biomineralized teeth. Soft-part fossilization is extremely rare but has yielded evidence regarding their evolutionary affinities with vertebrates. Two localities show extensive soft-part preservation: the Late Ordovician Soom Shale Lagerstätte (South Africa) and the Carboniferous Granton Shrimp-bed (Scotland). Taphonomic studies of these remains are limited, only undergoing tissue analysis and recorded as comprising of clay minerals (Soom Shale) and calcium phosphate (Granton Shrimp-bed). Using XRF (Bruker M4 Tornado) and E-SEM (Zeiss Sigma 300) the soft part anatomy revealed the textural details of features and their taphonomic modes. The Soom Shale conodont shows textures such as fibres in myomeres and eye musculature along with granulitic carbonaceous compressions in a 'potential liver'. The Granton Shrimp-bed conodonts show little textural variation – with most features indistinct from the matrix, with the exception of honeycomb textures in the eye musculature. Micro X-ray fluorescence analysis revealed all specimens are high in phosphorous, sulfur, calcium and carbon compared to their matrix. This suggests that soft tissues were preserved as calcium phosphate (phosphatized). Elevated sulfur may be due to 'sulfurization' and carbon represents recalcitrant anatomical aspects. Additionally, geochemical scans revealed previously unknown paired capsules in the head of *Promissum pulchrum*, thought to be associated with otic (hearing) processes. Taphonomic analyses highlighted new aspects of anatomy and that preservation modes across each of the two locations share some similarities but there are important differences that need further analysis.

Poster Session

Modelling Wildfire Activities and Drivers Through the Cenozoic

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The world is on fire. The wildfires currently raging in Chile, Greece, Canada and Australia, they have severe impact on economic, social and health outcomes. Understanding the history of wildfires in the past can help us better manage them in the present, and predict wildfires into the future. Here we want to look at the drivers of wildfires through time, focusing on the Cenozoic. It is believed that atmospheric oxygen, carbon dioxide and global vegetation cover (measured in biomass) play a role in wildfire occurrence. Using random forest machine learning in R, the relationship between wildfire occurrence and atmospheric oxygen, carbon dioxide, and global biomass estimates will be unpicked. It was found that because oxygen level has not changed much over the Cenozoic that it is not a strong relationship through that time period. Conversely, carbon dioxide and global biomass was found to have a stronger relationship with wildfire occurrence. As Using this relationship gathered from the random forest, we are able to predict wildfire prediction further back into the Phanerozoic, and predict wildfire occurrence into the future based on certain climatic scenarios. This research will be built upon to integrate wildfires into climatic and biogeochemical modelling using MATLAB to even better model how wildfires and Earth Systems interact with each other. This type of research is important because it cannot only highlight our understanding of the Earths historic relationship with wildfires, but it could help predict future wildfire occurrences.

Reconstructing the palaeoenvironments of the Lower Carboniferous Middle Hope Cove carbonate system

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The Carboniferous was a time where England lay close to the equator, on the southern margin of Larussia and had tropical climate, covered by the warm shallow seas of the Rheic Ocean, with coal swamps on land. In the southwest of the UK, marine and marginal marine conditions were prevalent. Here, the palaeoenvironments of the Middle Hope Cove succession from the southwest of England are being reconstructed. This area has only been examined briefly as part of a doctoral thesis and the current interpretation is one of an offshore volcanic high below the storm wave base, but this is not certain and is being investigated further. Modern analytical techniques that have not been applied to this area before such as thin section analysis, scanning electron microscopy and energy dispersive x-ray spectroscopy are being utilized. These methods will constrain the depth, temperature, energy levels and amount local sediment input of this marine system. This site is also one of the best places to examine the impact of contemporaneous volcanic activity on an ecosystem and carbonates in the UK. The effects of volcanism on the local environment have not been fully explored. The exact nature of this volcanism including the timing, location, extent and origin are being investigated utilizing the afore mentioned methods.

Age and Provenance of Placoderm Dermal armour (encased in a table-top) from the eastern Anti-Atlas, Morocco

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The provenance, precise age and potential identity of a Late Devonian placoderm from the Eastern Tafilalt of Morocco is investigated. The fossil has been removed from its geological and environmental context by local fossil dealers, having been prepared as part of a table-top. Thus, all data comes from the fossil itself and the limestone matrix surrounding it. Composition of the conodont fauna within the table-top, mineralogy and orientation of shelly fossils are used to determine the nature of the depositional environment. Conodont biostratigraphy is used to determine a precise age of the table-top which is integral in determining its origin. The conodont sample has been dated to between the *Pa. gracilis gracilis* and *Pa. marginifera marginifera* conodont zones of the early Famennian, late Upper Devonian (372.2 - 358.9 mya). Fish fossil material has been identified as the median dorsal plate of the armour of a brachythoracid arthrodire, most likely *Dunkleosteus terrelli*. The provenance of the fish fossil has been determined to be Jebel Bou Maiz, approx. 15 km south of Rissani. The conodont sample collected at Jebel Bou Maiz is unusually diverse and numerous (up to 3600 P1 elements per Kg), with a faunal composition unlike any of the surrounding regions or biofacies established by previous authors. This sample represents the first known record of a conodont assemblage at Jebel Bou Maiz, suggesting a more complex conodont palaeobiogeography in northern Gondwana. This project establishes a baseline for further work on the paleobiology of the site.

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