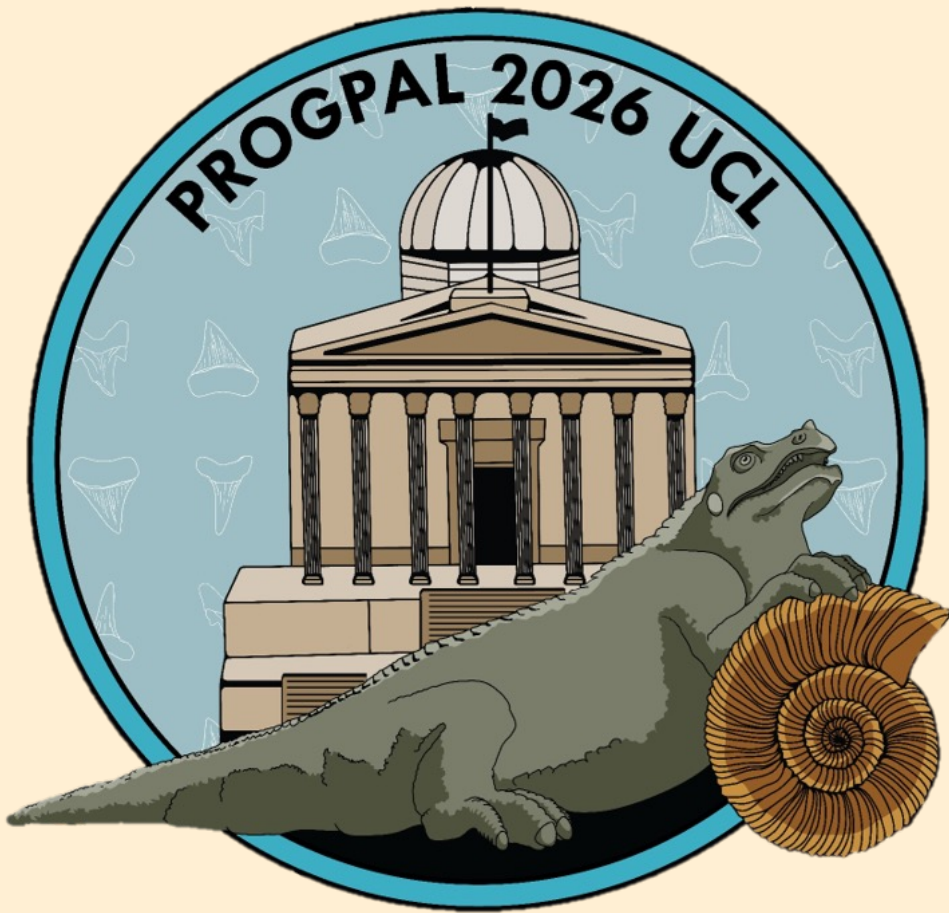


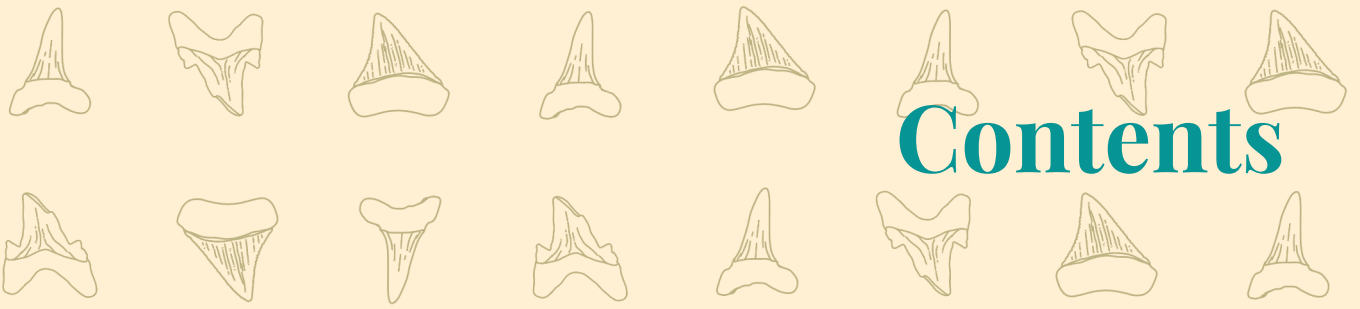
Progressive Palaeontology



Programme Abstracts

22 - 25 June 2026

University College London



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Introduction Conference Information

Welcome to London!

Since opening in 1826 as a central hub for research and innovation, UCL has showcased a range of strengths in palaeontological research, with its departments of Earth Sciences and Life Sciences drawing from numerous disciplines including climatology, geochemistry and biology, in order to answer the most pressing palaeontological questions. In 2026, UCL celebrates 200 years of innovative, ground-breaking research and teaching the next generation of scientists and policy makers.

Progressive Palaeontology (ProgPal) is the Palaeontological Association's annual student conference. ProgPal aims to bring together this future generation and help them develop into confident, robust researchers. We believe that UCL's bicentennial celebrations will prove to be an inspiring and appropriate backdrop for ProgPal 2026, and one which delegates will feel proud to be part of. Below we lay out the proposed events, workshops and field-trip as well as possible venues and accommodation. ProgPal is run by postgraduate students for postgraduate students. We look forward to welcoming you to this supportive and friendly meeting.



Welcome to Progressive Palaeontology, a postgraduate student conference of the Palaeontological Association (PalAss). PalAss is a charity that promotes the study of palaeontology and its allied sciences through publications, sponsorship of meetings and workshops, provision of web resources and a large annual programme of awards and grants.

Membership fees for students are just £20 a year. Members receive many benefits including the Association's newsletter, online access to the PalAss journals *Palaeontology* and *Papers in Palaeontology*, a discount on Field Guides and other books, and eligibility for Association awards and grant schemes including the Postgraduate Travel Fund.

Our flagship Annual Meeting is a major international conference in December with subsidized registration for students, and contributions to travel costs are made to a large percentage of student members who are presenting their work. The President's Prize and Council Poster Prize are awarded to the best presentations from early career researchers at the meeting each year, each with a certificate and one year's free membership.

The Association has a public engagement group that involves postgraduate student members as volunteers at outreach events. PalAss has members all over the globe and we welcome new members at www.palass.org. You can also find us on social media.

Dr Jo Hellawell

Executive Officer

The Palaeontological Association



Introduction Conference Information

Venues

[Kathleen Lonsdale Building, 5 Gower Place, London, WC1E 6BS](#)

The majority of ProgPal26's scientific sessions will be taking place in the Kathleen Lonsdale Building (KLB), home to the Earth Sciences Department. Registration will be open on Monday, Tuesday and Wednesday in the foyer of KLB. KLB126 will host the main talk sessions, and is located on the first floor of the building.

Check out the AccessAble access guide for the Kathleen Lonsdale Building here: <https://www.accessable.co.uk/ucl/access-guides/kathleen-lonsdale-building>

[Institute of Education, 20 Bedford Way, London, WC1H 0AL](#)

The poster session will be held in room W3.01 within UCL's Institute of Education (IoE). Afterwards, we'll head down to the fantastic IoE bar (£5 pints? In London?!) for the palaeo pub quiz icebreaker event.

The AccessAble guide for the IoE is available here: <https://www.accessable.co.uk/ucl/access-guides/institute-of-education-bedford-way-20>

Accessibility

Both ProgPal and UCL are committed to improving accessibility and providing an environment that supports equal access and inclusion to the wider community. We want to ensure that our conference is accessible to all participants. Our venues are wheelchair accessible, with step-free entry and accessible toilets.

For more information click here: <https://www.ucl.ac.uk/estates/our-campuses/inclusive-environments>

If you have any further concerns, please reach out to us at progpal2026@palass.org

Please note: we will be keeping all conference venues as nut-free as we possibly can over the course of the conference, as some delegates are severely allergic to nuts. Delegates are asked to **please make sure they avoid bringing nuts or products containing nuts into the conference spaces.**

Introduction Conference Information

Getting to the venues

Underground: The closest tube station to UCL is Euston Square, mere seconds away from the entrance to the main conference venue, the Kathleen Lonsdale Building. Euston Square station lies on the Hammersmith and City, Metropolitan, and Circle lines. Warren Street (Northern and Victoria lines), Euston (Northern and Victoria lines), Goodge Street (Northern line) and Russell Square (Piccadilly line) are also all within a fifteen-minute walk of the UCL campus. The Institute of Education, ProgPal26's second conference venue, is most closely served by Russell Square station.

Train: Multiple train stations are in close proximity to UCL's Bloomsbury campus including Paddington, Waterloo, King's Cross St Pancras and Euston.

Bus: UCL's Gower Street site is served by many Transport for London bus routes. Buses travelling from north to south stop in Gower Street, immediately outside UCL's main gate, while those travelling from south to north stop outside Warren Street station, about five minutes' walk from UCL. Services to these stops include route numbers: 10, 14, 24, 29, 73, 134, 390.

UCL's website has extensive information and resources to help you get to campus: <https://maps.ucl.ac.uk/public-transport/> And, for the latest live service updates and to plan your routes whilst getting out and about in London, please check out www.tfl.gov.uk!

Conference Map

All the venues in use at ProgPal 26 have been added to [this Google Map](#) - check it out!





Introduction Conference Information

There are three different types of presentations for delegates presenting their research at ProgPal 2026. The main scientific sessions will each consist of seven presentations (in the order of a lightning talk, two full talks, a second lightning talk, two further full talks, and closing with a lightning talk). The conference schedule is busy - delegates are reminded that keeping to time and allowing fellow presenters their full allocated slots is really important!

Full talks

Full talks are 15 minutes in total with 12 minutes of speaking time; speakers should plan their talks to allow for three minutes of questions, and switching between speakers.

Lightning talks

Lightning talks are five minutes in total with 3 minutes of speaking time. Speakers should prepare their presentations to allow for one minute of brief questions, and switching between speakers.

Posters

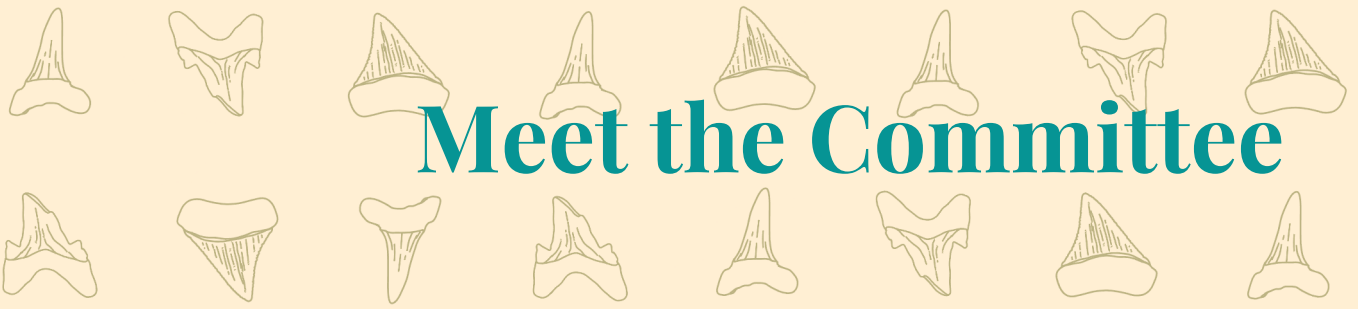
Posters will be available for viewings through the conference, and will also benefit from a dedicated poster session on Tuesday 23 June. Posters should be printed in A0 portrait. Delegates will need to print these prior to the conference and bring physical copies with them. Delegates should stand by their poster during the poster session.

Keynote talk

Our keynote talk will lead the scientific sessions on Wednesday 23 June, and will be 30 minutes in total. The keynote talk has been chosen from among the abstracts submitted for presentation at ProgPal 2026.

Uploading presentations

Slides for talks must be submitted in advance of the main scientific sessions of the conference. Slides should be submitted via email to progpal2026@palass.org by 5pm on Monday 22 June.



Meet the Committee

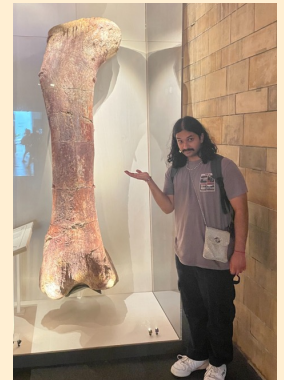


Charlie Scherer

I research the ontogenetic changes in theropod cranial and endocranial anatomy and any behavioural or ecological variation which can be inferred during ontogeny. I use CT-data and geometric morphometric analyses to study some of the earliest, smaller theropods, like *Coelophysis*, as well as some of the gigantic, latest theropods like *T. rex*. My project aims to provide a better understanding of theropod ontogeny and ecology through a macroevolutionary lens by comparing cranial and endocranial ontogenies from a wide range of theropod and other archosaurs.

Aamir Mehmood

I work on the diversification, biogeography and macroevolutionary patterns in penguins. Penguins have a long evolutionary history dating back to the Palaeocene and have a very consistent record up until the modern day. This makes them an excellent model to test hypotheses of transoceanic dispersal and macroevolutionary transitions such as shifts in body size, wing morphology and diving efficiency.

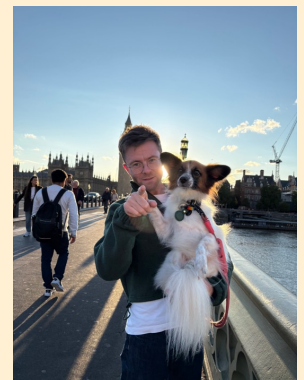


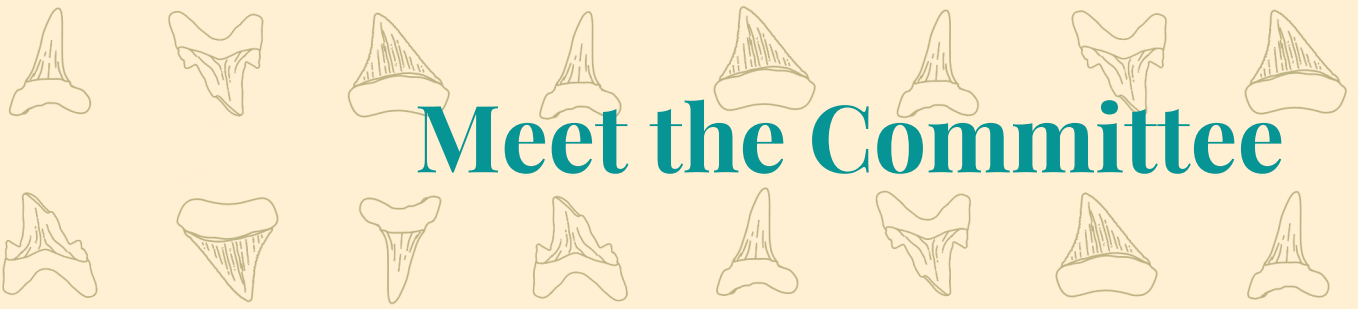
Mingjing Zhang

I research the ecology of Cambrian predators using a combination of computational methods within palaeontology. I aim to understand the different feeding strategies of radiodonts and their potential prey in the Cambrian. Radiodonts (such as *Anomalocaris*) are renowned apex predators with paired feeding appendages, compound eyes, and huge bodies with lateral swimming flaps. I will use computational methods to understand functional morphology of radiodont frontal appendages and thereby reveal how they fed and their likely prey.

Jack Hooper

I am interested in understanding the timing and dynamics of major transitions in the history of life. For my PhD, I'm hoping to characterize the pattern of metazoan incursions from the seafloor into the water column throughout the Phanerozoic as an example of such a transition. I'm hoping to figure out whether different animal clades have entered the plankton in bursts or consistently throughout the Phanerozoic, and whether there are any interesting patterns hidden within that story! I'm using the ostracod crustaceans as a case study, as a diverse extant group with an excellent fossil record.





Meet the Committee



Amara Reed

I work to reconstruct past ungulate migrations using stable isotope analysis of fossil teeth. Driven by seasonal variations in resource quality and quantity, the continuous movements of migratory herds are vital for shaping and maintaining grassland ecosystems, modifying vegetation profiles, and supporting large predator populations. Stable isotope analysis of fossil teeth can be used to reconstruct past animal behaviour, and I employ strontium, carbon, and oxygen isotope analyses of sequentially sampled fossil teeth to characterise mobility strategies of ungulates in the Omo-Turkana Basin (Ethiopia and Kenya), as well as Laetoli and Olduvai Gorge (Tanzania).

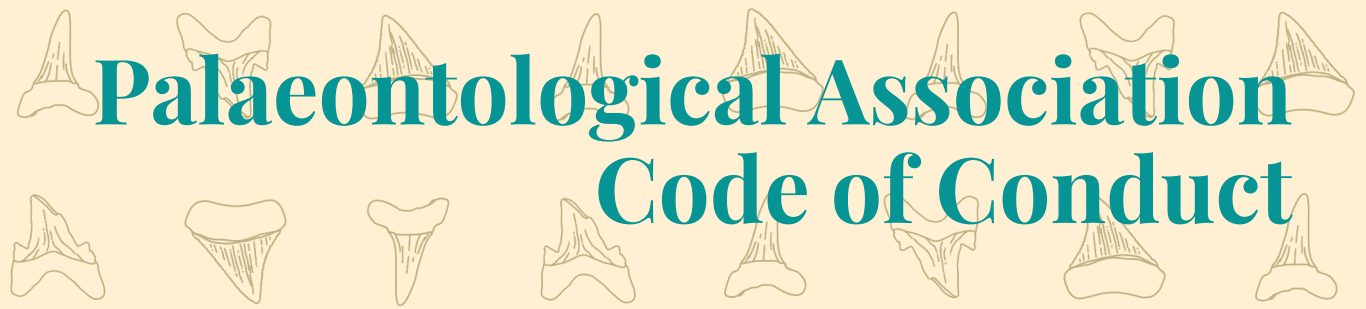
Elias Warshaw

I research the ontogeny of dinosaurs and its impacts on characteristics of their macroevolution, such as rates of evolution and diversification. Through a combination of simulations and geometric morphometric analyses of dinosaur crania, I am aiming to investigate the extent to which variation in these macroevolutionary traits across dinosaurs can be explained as a consequence of variation in their respective developmental strategies. This work will hopefully paint a clearer picture of how dinosaurs were so successful, and why (with the exception of birds) they all went extinct at the close of the Cretaceous.



George Watts

My research focuses on *Myotragus*, an extinct insular bovid that exhibits a range of distinct morphologies. Specifically, I investigate how insularity has shaped limb morphology and influenced locomotor performance in this species. Using geometric morphometric methods, I examine the extent to which the limb morphology of *Myotragus* deviates from that of its extant relatives and assess the functional implications of these differences. I hope to determine whether the unique morphology of *Myotragus* reflects a departure from the patterns observed in its extant relatives.



Palaeontological Association Code of Conduct

All ProgPal attendees are reminded that during registration they agreed to be bound by the Palaeontological Association Code of Conduct for events.

Behavioural expectations:

It is the expectation of the Palaeontological Association that all ProgPal attendees will 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, and respect for private property.

Demeaning, abusive, harassing or threatening behaviour, discrimination on the basis of race, ethnic origins, immigration status, religion, age, marital status, parental status, sex, sexual orientation, gender identity or expression, socioeconomic background, educational background, or disability will not be tolerated. Inappropriate physical contact, unwelcome sexual attention, including verbal or physical actions of a sexual nature 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:

Respect for the intellectual property of presenters should be maintained at all times. Photographing or recording a presentation without the author's express permission is forbidden. 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. Questions and discussion should be constructive, respectful, and focus on data and ideas rather than individuals.

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 'Report code of conduct violation' form (on the PalAss webpage: <https://palass.org/meetings-events/report-code-conduct-violation>). Alternatively you can notify a designated member of the ProgPal organizing committee on site. Anyone experiencing or

Palaeontological Association Code of Conduct

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 (in the UK for the police, or for fire or medical emergencies, call 999). Those witnessing a potential criminal act should also take actions necessary to maintain their own personal safety.

Resulting actions:

The disciplinary action taken by the Palaeontological Association will be decided upon based on the individual circumstances of the code of conduct violation, its severity and whether it was a single event or a repeated infringement. The subject of the enquiry (the party or parties whose behaviour is reported to be in breach of the Code of Conduct) can be warned or asked to leave the meeting venue if satisfactory evidence has been presented in support of the violation of the Code of Conduct in order to ensure immediate safeguarding of the complainant before the investigation is completed. Further reprimands may include, but are not restricted to, a written reprimand or warning, removal from Association positions, suspension from presenting at Association meetings, suspension from attending future Association activities (including events, field-trips, short courses and meetings), suspension from submission of manuscripts to *Palaeontology* and *Papers in Palaeontology*, suspension of Association membership, expulsion from the Association, and/or denial or revocation of grants and awards.





Detailed Conference Schedule

Monday 22 June: Registration and pre-conference workshop

12:00-17:00: Registration

Kathleen Lonsdale Building, Foyer

16:00-18:00: Workshop - Biogeography in Deep Time

Kathleen Lonsdale Building, Room 126 (first floor)

Delegates will learn about some of the computational methods used at UCL to study biogeographic history and will have the opportunity to apply these methods in a practical-based session. Delegates will be required to bring their own laptops with R installed - installation instructions are provided later in this programme!

Tuesday 23 June: Pre-conference workshops, Posters, and Icebreaker

09:00-17:00: Registration

Kathleen Lonsdale Building, Foyer

10:00-11:00: Workshop - NHM Vertebrate Palaeontology Collection tour

Meet outside staff entrance to the Natural History Museum on Exhibition Road, SW7 5BU, at 9:45 am

11:30-13:45: Workshop - NHM Invertebrate Palaeontology Collection tour

Meet outside staff entrance to the Natural History Museum on Exhibition Road, SW7 5BU, at 11:15 am

12:00-13:00: Workshop - Grant Museum tour

Meet outside the entrance to Kathleen Lonsdale Building at 11:45am.

12:00-13:00: Workshop - PalAss guide to Publishing

Kathleen Lonsdale Building, Room 126 (first floor)

14:00 - 16:30: Poster session

Institute of Education, Room W3.01

17:00 - 19:00: Icebreaker - Palaeo-Pub Quiz

Institute of Education, Institute Bar (keep an eye out for ProgPal committee members and volunteers on the doors!)



Conference Schedule Detailed

Wednesday 24 June

09:00-17:00: **Registration**

Kathleen Lonsdale Building, Foyer

09:00-09:15: **Opening remarks**

Kathleen Lonsdale Building, Room 126
Charlie Scherer, ProgPal Committee Chair

09:15-09:45: **Keynote Speaker**

Kathleen Lonsdale Building, Room 126

The mammalian backbone is structured by body size and locomotor mode

Sidney Leedham

09:45-10:00: **Coffee break**

Kathleen Lonsdale Building, First Floor Hub Space

10:00-11:30: **Session 1 - Invertebrate Palaeontology**

Kathleen Lonsdale Building, Room 126

10:00-10:05: Lighting talk

Analysis of a possible semi-aquatic lifestyle of the trigonotarbid, *Palaeocharinus* (Arachnida, Arthropoda), in the Rhynie Cherts

Beau Jones

10:05-10:20: Full talk

Using microCT and Bayesian phylogenetic methods to investigate the evolution of Cambrian echinoderms

Lucy Jackson

10:20-10:35: Full talk

Who ate the trilobite, twice?

Petter Nordenhaug

10:35-10:40: Lighting talk

A dive into deep-sea lobsters: a Bayesian total-evidence approach to the phylogeny of polychelidan lobsters

Myrthe van der Helde

10:40-10:55: Full talk

Quantifying metazoan 'locomotion space'

Harry Savage



Conference Schedule Detailed

10:55-11:10: Full talk

Disparity analyses are robust to ancestral state estimation uncertainty

Caleb Scutt

11:10-11:15: Lighting talk

A massive, hook-bearing cephalopod from the Late Cretaceous of Denmark illuminates the termination of gigantism in Coleoidea

Christian Voiculescu-Holvad

11:15-11:30: **Coffee break**

Kathleen Lonsdale Building, First Floor Hub Space

11:30-13:00: **Session 2 - Anatomy**

Kathleen Lonsdale Building, Room 126

11:30-11:35: Lighting talk

***Dipteronotus* (Osteichthyes, Neopterygii) from the Middle Triassic of Devon, and the building of Mesozoic ecosystems**

Emma Ayres

11:35-11:50: Full talk

The evolution of cranial circulation and innervation of baenid turtles

Scott Bellotti

11:50-12:05: Full talk

Functional decoupling between forelimb reduction and scapular musculature in carcharodontosaurid theropods

Damiano Palombi

12:05-12:10: Lighting talk

An articulated skeleton of *Phuwiangosaurus* suggests greater species-level diversity of Southeast Asian sauropods

Thitiwoot Sethapanichsakul

12:10-12:25: Full talk

The Shrewley Shark: insights into an enigmatic Triassic chondrichthyan through μ CT and a palaeoenvironmental analysis

Ryan Tokeley



Conference Schedule Detailed

12:25-12:40: Full talk

Reconstruction of *Jeholornis* and the role of iridescence in early paravian plumage

Elisabeth Wilkinson

12:40-12:45: Lighting talk

Breaking the mammalian 'rule of seven' is associated with first rib repatterning in *Xenarthra*

Elizabeth Webb

12:45-14:00: **Lunch break**

13:00-13:30: **LGBTQ+ Meetup**

Kathleen Lonsdale Building, Room 126

14:00-15:15: **Session 3 - Functional morphology**

Kathleen Lonsdale Building, Room 126

14:00-14:05: Lighting talk

Evolution on rugged terrain: how complex fitness landscapes shaped the Cambrian Explosion

Charles Bates

14:05-14:20: Full talk

Landmark-free morphometrics reveal repeated simplification of head-neck junction in tetrapods

Annabel Worth

14:20-14:35: Full talk

High functional optimality in mammalian jaws revealed through theoretical morphologies

Harry Berks

14:35-14:40: Lighting talk

Functional changes in Lepidosauria over the K-Pg mass extinction

Thomas Chilton

14:40-14:55: Full talk

Biomechanical limits of hopping in the hindlimbs of giant extinct kangaroos

Megan Jones



Conference Schedule Detailed

14:55-15:10: Full talk

Microraptorine flight evolution: the effect of body size on *Microraptor's* flight

Alexandra Rose McCombie

15:10-15:15: Lighting talk

The functional performance of spiral feeding structures in Cambrian echinoderms

James McDermott

15:15-15:30: **Coffee break**

Kathleen Lonsdale Building, First Floor Hub Space

15:30-16:45: **Session 4 - CT and Ecosystems**

Kathleen Lonsdale Building, Room 126

15:30-15:35: Lighting talk

Microvertebrates from the Weald Clay Formation (Lower Cretaceous, Barremian) of Smokejacks Brickworks, Ockley, Surrey, UK

Aman Chhaya

15:35-15:50: Full talk

Computed tomography reveals multiple origins of extreme caudal vertebral pneumaticity in sauropod dinosaurs

Samantha Beeston

15:50-16:05: Full talk

From Caribbean apex predator to Cuban remnant: Holocene range collapse of *Crocodylus rhombifer* informs its future conservation

Sachin Bhardwaj Lock

16:05-16:10: Lighting talk

Isotopic temperature indications from *Aequipecten opercularis* in the Red Crag Formation (Pliocene-Pleistocene, UK)

Kate Runciman

16:10-16:25: Full talk

"Reptilian domination" and human impacts on large predators in Pleistocene Australia

Adam Lindholm



Conference Schedule Detailed

16:25-16:40: Full talk

Convergent patterns in mass-dependent scaling of Weber number of gliding mammal membrane wings

Claudia Baldry

16:40-16:45: Lighting talk

Does AI dream of segmented CT? Understanding the effects of modality on deep learning segmentation

Fraser Weston

17:00-18:00: **ProgPal Auction, Awards, and Closing remarks**

Kathleen Lonsdale Building, Room 126

19:00-22:00: **Conference Dinner**

Rex Cross Cocktail Bar And Restaurant (44-46 Caledonian Rd, London, N1 9DT)

Thursday 25 June: Post-conference field-trip

09:30-16:00: **Field-trip to Abbey Wood Fossil Pit**

09:30-10:00: **Travel to Abbey Wood station**

[Abbey Wood](#) (513 Abbey Wood Rd, Abbey Wood, London SE2 9HA) is served by the Elizabeth Line, Thameslink and southeastern rail services.

~10:00: **Arrive at pit**

12:00-13:00: **Lunch**

Please note lunch cannot be provided; **delegates attending must bring a packed lunch.**

15:00-16:00: **Travel back to UCL**



Workshop: Biogeography in Deep Time

This year, ProgPal's pre-conference event will be a biogeography seminar with an accompanying computational workshop highlighting some of the methods used to study historical biogeography in extinct and extant animals. Leading both the seminar and workshop will be UCL's own Prof. Paul Upchurch. Paul has studied archosaur biogeography extensively and uses the very same methods in this workshop to examine the processes which likely drove the radiation of many charismatic groups, including the long-necked sauropod dinosaurs. During the opening seminar, attendees will be provided with an overview of biogeographic processes and their impacts on evolution before getting to grips with the R package BioGeoBEARS (BGB) to analyse the biogeographic history of a clade in real time, before finally learning how to interpret BGB results and what these can tell us about the biogeography of extinct animals. To ensure that this workshop runs smoothly, we ask that all attendees taking part in the workshop download and install the necessary software beforehand.

Instructions for downloading R and BioGeoBEARS

R can be downloaded from the CRAN project website: <https://cran.r-project.org>. Please ensure that you download the correct version of R which matches your Operating System (e.g., Windows, Linux, macOS). Download the latest version of R by selecting the 'Latest Release' version with .pkg file name. For example, the most recent release of R is v4.6.0, and the file name associated with this is 'R-4.6.0-arm64.pkg'. Once the files have downloaded, you will need to install them using your computers setup wizard (usually done by opening the downloaded application).

For a more user-friendly experience with R, you can also download RStudio, which is the same as base R, but has a much nicer user interface. RStudio can be downloaded from posit: <https://posit.co/products/open-source/rstudio>. Click on the 'Download RStudio' button and follow the instructions to download the application. Once it is downloaded you can open RStudio like any other app on your computer.



Pre-Conference Workshop

Downloading BioGeoBEARS and other necessary packages:

Open R/RStudio and run the following code to install BioGeoBEARS from Github:

```
install.packages("devtools", dependencies=TRUE)
install.packages("rexpokit", dependencies=TRUE)
install.packages("FD", dependencies=TRUE)
install.packages("snow", dependencies=TRUE)
install.packages("parallel", dependencies=TRUE)
install.packages("cladoRcpp", dependencies=TRUE)
install.packages("GenSA", dependencies=TRUE)
```

You have to load BioGeoBEARS from Github now with the following command:

```
library(devtools)
devtools::install_github(repo='nmatzke/BioGeoBEARS',
force=TRUE)

library(devtools)
install_version("kexpmv", version = "0.0.3", repos =
"http://cran.us.r-project.org")
```

Load the following packages:

```
library(rexpokit)
library(cladoRcpp)
library(BioGeoBEARS)
library(GenSA) # GenSA is better than optimx (although somewhat slower)
library(FD) # for FD::maxent() (make sure this is up-to-date)
library(snow) # (if you want to use multicore functionality; some systems/R
versions prefer library(parallel), try either)
library(parallel)

packageVersion(pkg="BioGeoBEARS")
```

This code should show you the latest version of BioGeoBEARS and it should enable you to run the analysis during the workshop!

If you encounter any problems with installing R or BioGeoBEARS prior to the workshop, please contact us at progpal2026@palass.org



Workshops and Museum Tours

Workshops and Museum Tours

This year's ProgPal is offering conference delegates the choice of four workshops which will take place on the first day of the conference, Tuesday 23 June.

PalAss Guide to Publishing

Dr Sally Thomas, PalAss' Publications Officer, will lead a session on the publishing process. Delegates will learn how to prepare a manuscript and navigate the post-submission process, as well as how to peer-review a manuscript. This includes selecting the right journal for your work, understanding peer review, and handling reviewer comments on your manuscript. This event aims to help delegates gain the confidence to successfully publish their work.

NHM Invertebrate Palaeontology Tour

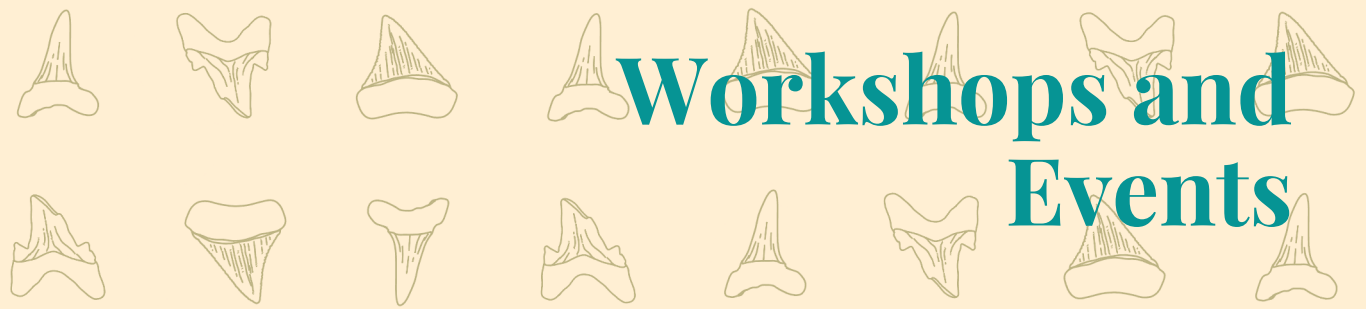
London's Natural History Museum is home to a huge array of invertebrate fauna, ranging from sponges, to annelid worms and cephalopods. The Invertebrate Collection is comprehensive - encompassing all seven continents and representing the whole Phanerozoic. Delegates will be able to view a number of specimens usually hidden from public view.

Grant Museum Tour

The Grant Museum of Zoology is UCL's very own natural history museum, home to over 100,000 specimens from all over the world. This tour will highlight a number of interesting palaeontological specimens that this collection has to offer. In addition to the guided tour, delegates will be able to wander around the museum and see extant specimens from throughout the Tree of Life. Delegates will be escorted to and from the museum by a member of the ProgPal committee.

NHM Marine Vertebrates Tour

London's Natural History Museum is home to one of the most extensive and exquisite collections of marine reptiles in the UK, with many specimens collected by Mary Anning. On this guided tour, delegates will be taken into the collections to view the highlights of the marine reptiles collection not usually seen by the public.



Workshops and Events

Icebreaker

Our icebreaker will be held at the Institute Bar, part of the Institute of Education and will include a palaeo-themed pub quiz, along with an opportunity to socialize in the Bar afterwards. The Bar stocks a variety of alcoholic and non-alcoholic beverages. Delegates will also be able to take advantage of the Bar's amazing student discount, a must for a London-based conference. Look out for ProgPal committee members and volunteers to welcome you to the IoE Bar!

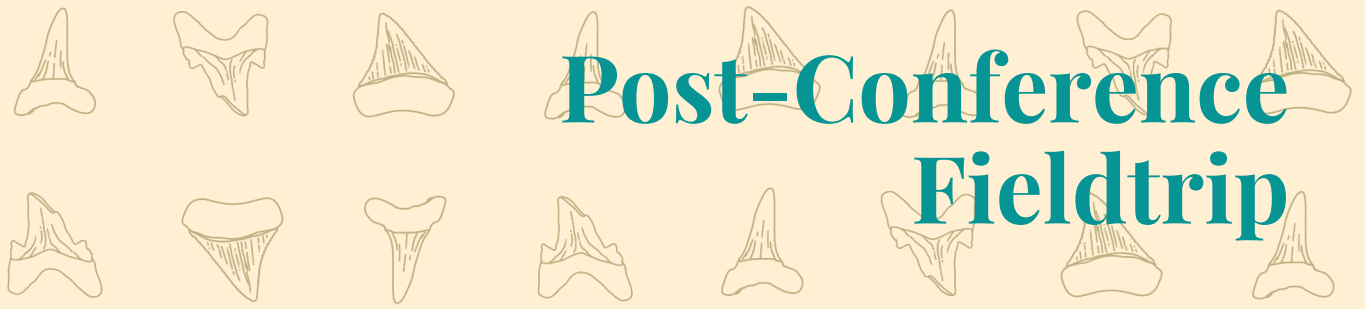
Prize-giving and Auction

After the main talk sessions on Wednesday, we will be giving out prizes for the best poster and the best talk! Our sponsor PeerJ have waived open access publication costs for the best poster and the best talk delivered at ProgPal 2026.

We will also be holding the annual ProgPal auction! We will be auctioning off classic books from the history of science and other rare palaeontological themed items to help raise money for future iterations of the conference.

Annual Dinner

This year, the conference dinner will be held in Rex Cross Cocktail Bar and Restaurant, a family-run Italian restaurant located just around the corner from King's Cross station and only a 15-minute walk from the conference venues. Delegates will enjoy a delicious, hearty three course dinner in the beating heart of central London!



Post-Conference Field-Trip: Abbey Wood Fossil Pit

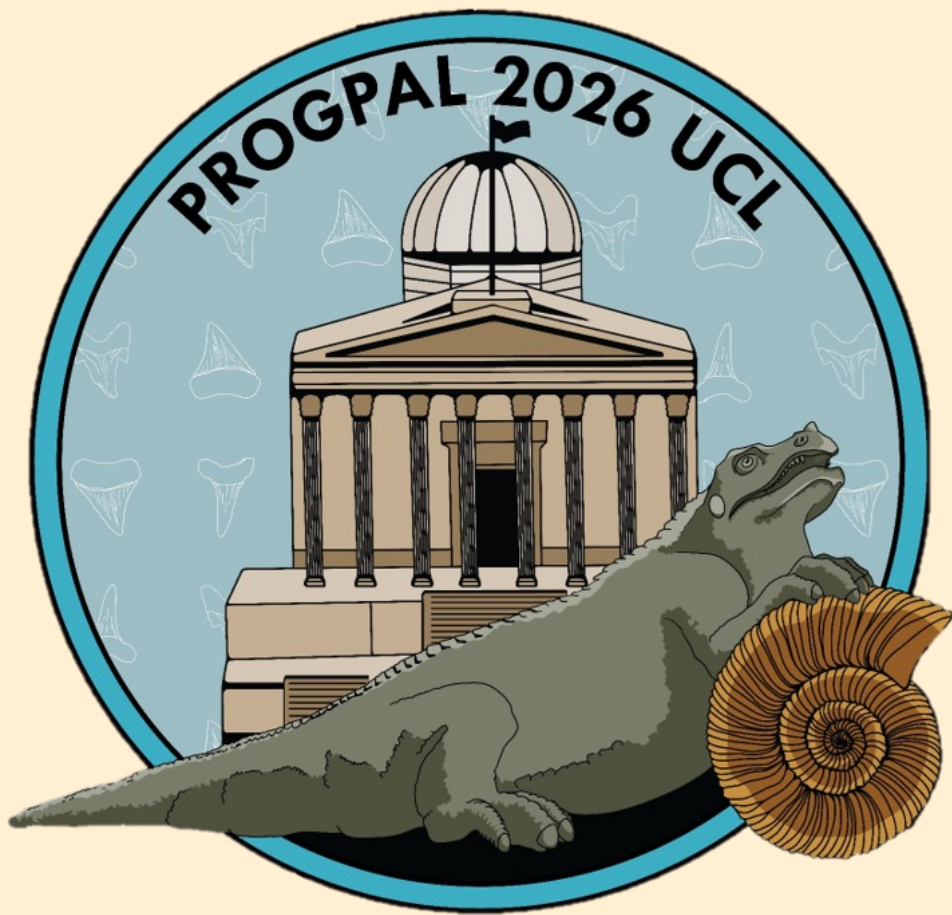
This year’s field-trip will be at Abbey Wood, a vast woodland, park and a ruined abbey. Located in South East London, the fossil site is dated to the Eocene, approximately 55 million years old. It’s famous for the profusion of shark teeth, fish bones and scales and shells. Remains of turtle, crocodile, birds and rare small mammal teeth can also be found - so a cool souvenir is virtually guaranteed!

Some notes for delegates: we regretfully can’t provide lunch, so **please don’t forget to bring something to eat!** Travel to the site will be on London public transport via the snazzy new Elizabeth Line - delegates should meet at the entrance to Abbey Wood station. Otherwise, there will be no fees for this trip. Sieves and other fossil hunting equipment will be provided!

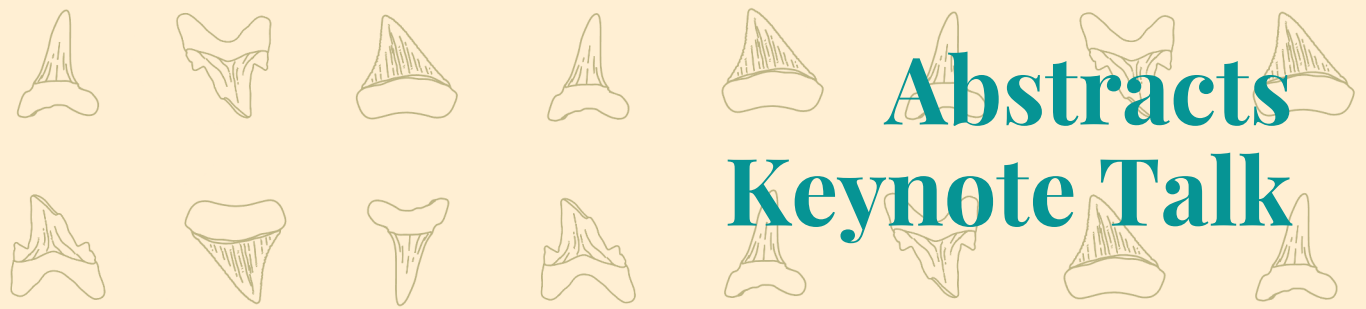
Aamir will be our committee member present on the day - if you’re attending and running late or get lost at any point, you can contact him at (+44) 07789 530 796

Thanks also to UCL’s Dr Stephen Pates, who will be accompanying delegates on the trip.





Abstracts

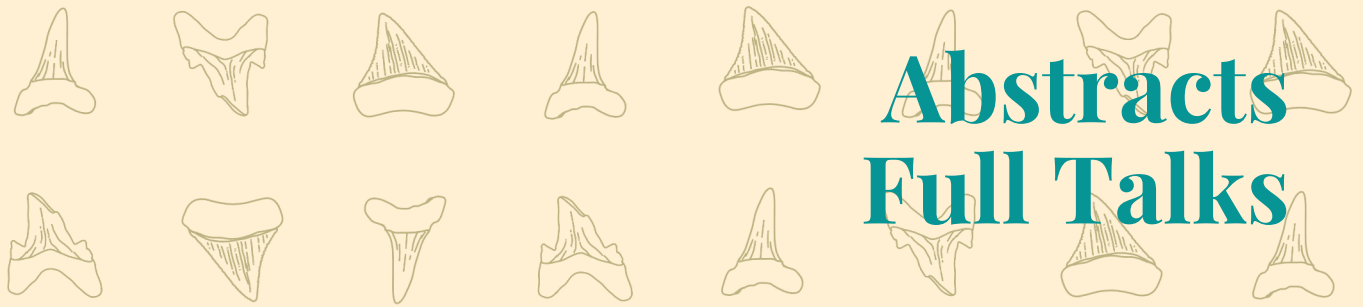


The mammalian backbone is structured by body size and locomotor mode

Sidney Leedham^{1,2}, Katrina E. Jones³, Natalie Cooper², James Charles¹ and Karl T. Bates¹

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The regionalised backbone of mammals is key to their ecological diversity, with roles in body support, locomotion, and respiration. Despite this, we lack a clear understanding of how intrinsic scaling constraints and extrinsic ecological pressures interact on a macroevolutionary scale to structure functional diversity in the backbone. We used measurements of precaudal vertebrae from 224 extant mammal species across 25 orders to investigate variation across regions of the backbone. Phylogenetically informed models indicate unifying principles governing responses of the backbone to increasing body size, with the thoracolumbar region becoming relatively shorter, and individual vertebrae taller and narrower, indicating greater passive stiffness. Scaling relationships vary among vertebral regions and with locomotor mode, implying that functional adaptation results from the interaction of structural allometry and regionalisation. We show that the relationship between vertebral morphology and body size is non-linear, with shifts around a body mass of 1 kg, and propose that changes in limb posture between small and large mammals modify the interactions between size, axial function and whole-body mechanical trade-offs during locomotion. We provide new insight into how the backbone functions as a modular structure to facilitate functional adaptation under mechanical constraint, and its fundamental role in mammalian locomotor diversity.



Abstracts Full Talks

Convergent patterns in mass-dependent scaling of Weber number of gliding mammal membrane wings

Claudia J. Baldry¹, Stephen M. Jackson², Bharathram Ganapathisubramani¹, Neil J. Gostling¹ and Jorn A. Cheney¹

¹University of Southampton, UK; ²Australian Museum Research Institute, Australia

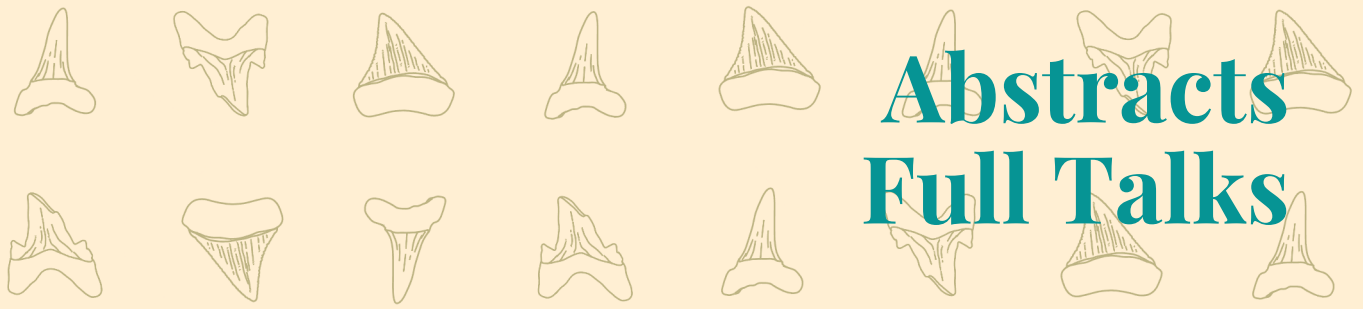
Gliding represents a possible intermediate stage in the evolutionary origins of powered flight and has evolved at least six times independently among extant mammalian lineages, spanning over two orders of magnitude in body mass. Despite diverse origins, gliding mammals have converged on similar membrane wings formed from thin, compliant sheets of skin. This convergence provides an opportunity to identify the mechanical and aerodynamic constraints shaping early aerial locomotion in mammalian lineages for which the fossil evidence is sparse. Membrane wings deform under aerodynamic loading, altering wing camber (billowing) and influencing lift production. The magnitude of this deformation is governed by the Weber number (We), the ratio of aerodynamic force to membrane tension. Higher We values typically increase camber, enhancing lift and glide duration, but may also affect glide efficiency and stability. Identifying how We scales with body size is critical in understanding the earliest stages of aerial capability. To test this hypothesis, we measured skin thickness and wingspan from museum specimens. We calculated We across species differing in lineage, body size, and patagial attachment to assess scaling patterns. Contrary to predictions of aerodynamic similarity or isometry, We exhibits positive allometry with body mass, meaning larger gliders exhibited higher than expected We values. Marsupial gliders show consistently lower We than similarly sized eutherians, yet both groups share a common scaling pattern. This indicates that there are convergent effects of body mass on wing deformation in evolutionarily disparate lineages, raising novel questions about the role of stability in the evolution of gliding.

Computed tomography reveals multiple origins of extreme caudal vertebral pneumaticity in sauropod dinosaurs

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Postcranial skeletal pneumaticity (PSP) is common in the presacral vertebrae of sauropod dinosaurs, but seemingly rare in their caudal vertebrae. Where identified, evidence for caudal vertebral PSP in sauropods is primarily based on the presence of external features, such as lateral fossae. However, such fossae can only be regarded as unequivocally pneumatic if communication between them and internal pneumatic bone texture can be confirmed. Here, I present novel CT scan data of the caudal vertebrae of six Middle-Late Jurassic sauropods. These new data are synthesised with a comprehensive critical appraisal of purported external and internal evidence for caudal vertebral PSP in Sauropodomorpha. A repeated pattern of PSP invading the anterior caudal vertebrae is observed, with at least five independent acquisitions and/or reversals. Furthermore, extreme caudal vertebral PSP, in which pneumaticity extends into the middle-posterior region of the tail, is not restricted to saltasaurines, with this having also evolved independently in diplodocines and brachiosaurids. Finally, I find that both small- and large-bodied sauropods, including those with relatively short and long tails, evolved (and lost) caudal vertebral PSP. Therefore, the development of caudal vertebral PSP in sauropods does not appear to correspond with changes in body shape or mass. Instead, it might result from the opportunistic nature of pneumatic diverticula. However, given the high degree of inter- and intra-specific plasticity in its phylogenetic and serial distribution, the evolution of PSP into the tail of sauropods might have been driven by a set of as-yet unknown, complex selective pressures.



The evolution of cranial circulation and innervation of baenid turtles

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¹University of Fribourg, Switzerland; ²Royal Tyrell Museum of Palaeontology, Canada; ³University of Alberta, Canada; ⁴SNSB, Umwelt-Museum Oberfranken, Germany; ⁵Denver Museum of Nature & Sciences, USA; ⁶Ohio University, USA

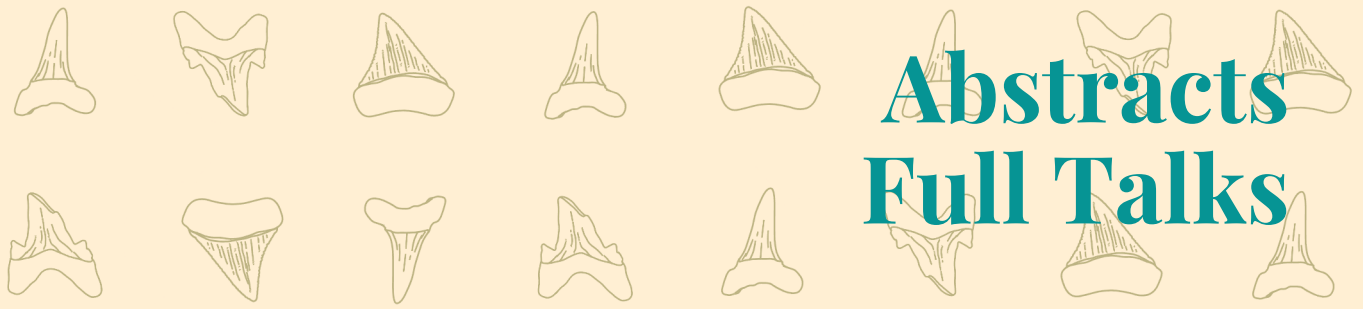
How much evolutionary information can be hidden inside a turtle skull? The vertebrate head houses essential sensory and neurovascular systems, yet much of this soft-tissue anatomy is rarely preserved in fossils. However, because arteries and nerves often run through bony canals, they leave a traceable imprint that can be used to reconstruct these systems deep in time. While cranial arteries and nerves are generally considered conservative across amniotes, even subtle variation may hold key phylogenetic signals. Here, we test this idea in Baenidae, a diverse group of freshwater turtles with a fossil record spanning the Early Cretaceous to Eocene of North America, with a particular focus on *Plesiobaena antiqua*, a common and well-preserved baenid species from the Campanian Dinosaur park Formation of Alberta, Canada. Using micro-computed tomography (μ CT), we analysed four skulls and digitally reconstructed their cranial circulation and innervation systems. Our results reveal interspecific variation within baenids, including the presence of a canalis caroticus lateralis and differences in the course of the canalis caroticus basisphenoidalis and canalis nervi abducentis. For example, the consistent presence of a reduced canalis caroticus lateralis in *Plesiobaena antiqua* suggests multiple independent losses within Baenidae and highlights the phylogenetic relevance of reduction rather than complete absence. These findings not only imply the baenid turtles understanding but also point to a broader significance for character evolution across Paracryptodira. By exposing hidden anatomical diversity, this study highlights the power of μ CT data to refine phylogenetic hypotheses and sheds new light on the evolution of the vertebrate head.

High functional optimality In mammalian jaws revealed through theoretical morphologies

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¹University of Bristol, UK

The vertebrate mandible provides an ideal system to test the evolutionary relationships between form and function, offering rich extant and fossil sampling, and playing a key role in feeding biomechanics. Furthermore, the jaw can be modelled as a simple lever system, presenting a well-established functional trade-off between strength and speed. Here, we quantify jaw shape diversity across Mammalia and evaluate the impact of the strength-speed trade-off in this key vertebrate clade. Using Elliptical Fourier analysis, we quantified lateral jaw shape in 2,063 extant and extinct mammal species, representing all 27 extant and 25 extinct orders. To investigate functional jaw properties throughout morphospace we evaluated the mechanical performance of theoretical jaw morphologies across the morphospace. Rotational efficiency and median von Mises stress during a bite-muscle load simulation act as proxies for speed and strength respectively. Combining the subsequent functional landscapes in a Pareto optimality ranking, revealed high optimality in the strength-speed trade-off. Extreme morphologies linked to specialized ecologies, e.g. filter-feeding, show reduced optimality, suggesting relaxation or overriding of the trade-off in these groups. Our findings showcase the importance of biomechanical trade-offs in morphological evolution, revealing how mammalian jaws have evolved to balance competing mechanical demands across a great range of ecologies.



From Caribbean apex predator to Cuban remnant: Holocene range collapse of *Crocodylus rhombifer* informs its future conservation

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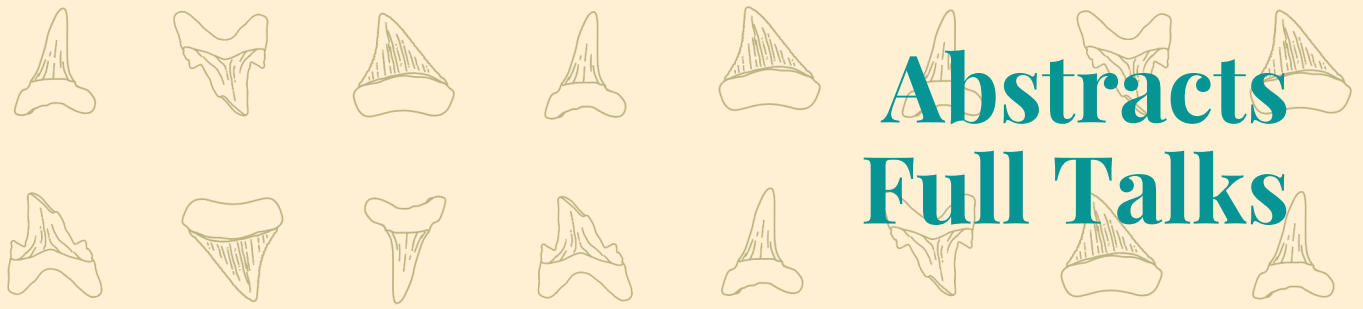
The Cuban crocodile (*Crocodylus rhombifer*) is today one of the most critically endangered and range-restricted extant crocodylian species. Its present endemism belies a recent history that saw its populations span the West Indies. Despite a rich fossil record, the chronology and causes of the species' decline over the course of the Holocene remain largely unknown. Using a holistic approach, incorporating data from the fossil record and historical archives into species distribution models, we disentangle the compounding factors that drove a formerly widespread species to the brink of extinction. Extinction chronology mapping strongly implicates anthropogenic drivers of extinction, suggesting extinction events correlating with the spread of Taíno peoples over the past millennium and accelerating following the arrival of Europeans in the late 15th century. With exceptions, the observed pattern of range collapse is generally consistent with the theory of island biogeography, with larger and less-isolated landmasses providing the most enduring refugia. Estimates of body sizes from Holocene specimens suggest patterns of evolution driven by insular biogeography, with smaller landmasses generally associated with smaller morphologies. New estimates for the upper limits of *C. rhombifer* body sizes suggest the necessity of a revision of our understanding of the species' palaeoecology. This longer-term approach to assessing threats to species survival can track extinction events and anthropogenic forces across much longer timescales than are usually considered in conservation, contributing novel baselines for species status, an increased understanding of extinction dynamics, and a more robust assessment of species vulnerability and resilience to human pressures.

Using microCT and Bayesian phylogenetic methods to investigate the evolution of Cambrian echinoderms

Lucy Jackson^{1,2,3}, Frances Dunn³, Timothy Ewin², Bertrand Lefebvre⁶, Andrew Meade¹, Martina Nohejlová⁷, Chris Venditti¹, Samuel Zamora^{4,5} and Imran Rahman^{2,3}

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The over 500-million-year fossil record of echinoderms reveals many extinct groups with body plans that do not closely resemble modern forms. The high disparity and lack of shared morphological traits among early echinoderms makes resolving their phylogenetic relationships difficult, and therefore much about the early evolution of echinoderms during the Cambrian period remains unknown. However, modern palaeontological methods, including high-resolution X-ray microtomography and Bayesian phylogenetic approaches, offer a powerful set of tools to begin to tackle this problem. Using these techniques, we investigated the in-group relationships of the ctenocystoids, a group of Palaeozoic echinoderms with bilateral to weakly asymmetrical body plans which lacked a robust systematic framework. Fossil material from the middle Cambrian of western Gondwana studied using microCT has revealed multiple new species, including four assigned to the previously monotypic genus *Courtessolea*. We present a phylogeny for ctenocystoids based on a new morphological character matrix consisting of 66 characters analysed using a fossilised birth-death model of evolution implemented in the phylogenetic software BEAST2. The results of our analyses have transformed our understanding of the interrelationships of ctenocystoids and their evolution. This framework for ctenocystoids has formed the foundation for studying the relationships of ctenocystoids to another aberrant Cambrian group - the cinctans - and will continue to be expanded to incorporate other extinct groups.



Biomechanical limits of hopping in the hindlimbs of giant extinct kangaroos

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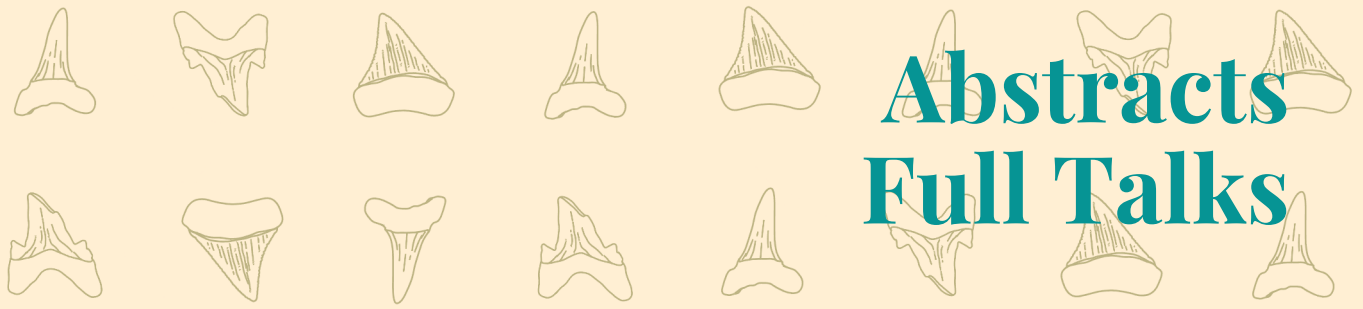
The locomotor abilities of animals depend upon their body size. Today, kangaroos are the largest hopping mammals, but some of their Pleistocene relatives were larger still—more than twice as heavy as any modern kangaroo. So, is there an upper size limit of bipedal hopping? Previous analyses have recovered an upper limit of ~ 140–160 kg based on allometry but have suggested that incorporating changes in hindlimb scaling patterns among giant species would alter these conclusions. Here, we test this proposal by integrating scaling data from modern kangaroos with direct observation of the hindlimb bones of giant fossil kangaroos. We test two potential limiting factors on hopping—bone strength, and tendon size. We find that (a) the metatarsals of giant kangaroos would be capable of resisting the bending moments involved in hopping, and (b), the calcanea (heel bones) of giant kangaroos could accommodate tendons large enough to resist the loads generated during hopping. While hopping may not have been their primary mode of locomotion, our findings suggest that it may have formed part of a broader locomotor repertoire, for example for short bursts of speed.

"Reptilian domination" and human impacts on large predators in Pleistocene Australia

Adam Lindholm¹ and Roger Close¹

¹The University of Oxford, UK

The terrestrial vertebrate fauna of Pleistocene Australia has long been recognized for its uniqueness, and includes megafaunal marsupials, reptiles, and birds. Notably, this fauna has a very low diversity of large marsupial predators, but includes multiple large reptilian predators. This has led to the idea of "reptilian domination" of large predatory niches, which could either reflect outcompetition of marsupials by reptiles or an innate inability of marsupials to occupy predatory niche space. Here, we use the Paleosynecological Model (PSEco) to quantify competition for available prey biomass between >1 kg mammalian, reptilian and avian predators for eight Middle–Late Pleistocene localities across Australia. We find that larger (>50 kg) predators are generally under higher competition, having a limited ability to satisfy their expected nutrient requirements, while smaller predators are under less pressure. The largest mammalian predator, *Thylacoleo*, experiences higher or similar competition to large reptiles. This is most consistent with "reptilian domination," and could be rooted either in reptilian metabolic advantages in a nutrient-poor continental system or incumbency effects of reptilian occupation of vacant niches earlier in the Cenozoic. We also modelled humans as a predator in each locality. Humans generally experience moderate levels of competition, lower or broadly equivalent to competition experienced by *Thylacoleo* and large reptiles. This indicates the potential for an additional, locally-variable anthropogenic driver of end-Quaternary Australian megafaunal extinctions, where competition for prey resources prevents large predators from reaching sustainable population densities, alongside previously-proposed drivers of faunal overkill and non-anthropogenic climatic and environmental changes.



Abstracts Full Talks

Microraptorine flight evolution: the effect of body size on *Microraptor*'s flight

Alexandra Rose McCombie¹ and Michael Pittman¹

¹The Chinese University of Hong Kong, Hong Kong

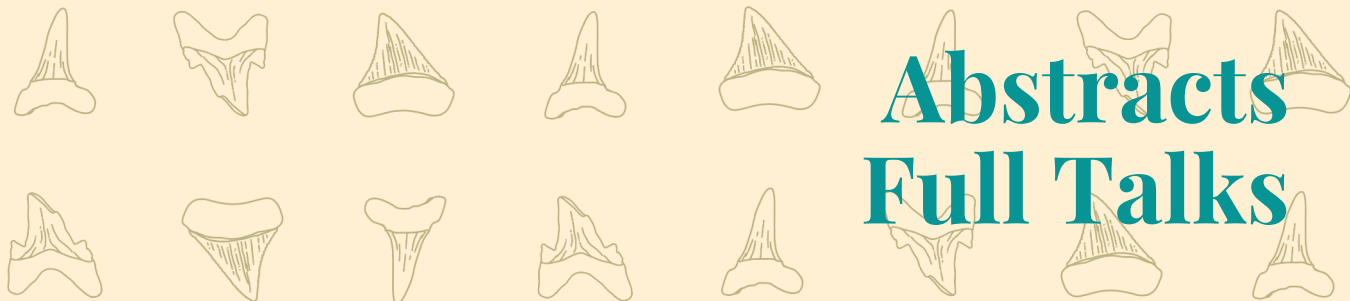
The evolution of flight in birds and theropod dinosaurs is one of the most iconic and important major evolutionary transitions in the history of life. What began as a few volant species of feathered theropod dinosaurs, from the group Paraves, culminated in the evolution of the diverse range of birds we know today. However, despite extensive research, where and when flight evolved in paravian dinosaurs remains hotly debated. Amongst the groups suggested to have evolved powered flight independently are the microraptorines, a clade of small, feathered dinosaurs living alongside early birds, whose evolution may provide key insights into this critical transitional period. By using laser-stimulated fluorescence (LSF) soft-tissue details previously unseen were revealed in multiple *Microraptor* specimens. By using feather and body measurements taken from LSF data the potential for powered flight across various *Microraptor* specimens of various sizes was estimated, using wing loading and specific lift as proxies. Results found that all specimens, regardless of body size, met the threshold for wing loading. However, the largest individuals did not pass specific lift, even at the highest estimated muscle mass-specific power output values, suggesting they may have been confined to gliding or short bursts of powered flight. The results showcase the importance of testing multiple specimens, as well as understanding how ontogeny affects flight ability. This study represents the beginning of an integrative exploration into microraptorine flight capability, testing the theory that flight evolved multiple times in paravians.

Who ate the trilobite, twice?

Petter Nordenhaug¹, Magne Høyberget², Jørn Harald Hurum¹ and Øyvind Hammer¹

¹University of Oslo, Norway; ²Rennesveien Mandal, Norway.

The early Cambrian marks a critical interval in the establishment of complex marine ecosystems, characterized by the diversification and increase of structured trophic interactions. While predation on trilobites and the presence of trace fossils are both well documented from this period, integrated evidence linking multiple behaviours within the same ecosystems is rare. Three early Cambrian biotas from the Ringstranda Formation of southern Norway (Stokkeelva, Tømte, and Skyberget) preserve not only soft tissue, but a multitude of trophic interactions, including sediment burrows, large coprolites, and microborings within trilobite exoskeletons. All of these structures are now visualized in μ CT, highlighting spectacular three-dimensional interactions. A plethora of large coprolites contain identifiable skeletal remains, including trilobites, brachiopods and various tubicolous taxa, providing direct evidence of macropredation. Host internal burrow systems are also identified in some of these, indicating secondary colonization by infaunal detritivores. Microborings are present in trilobites preserved alongside these coprolites, often developed in the cephalon, suggesting systematic exploitation of organic tissue by other taxa than macropredators. Together, these data document multi-tiered benthic ecosystems in which predation, scavenging, detritivory, and substrate engineering were closely linked. The co-occurrence of coprolites, burrows, and skeletal borings provides a rare, integrated record of energy flow and nutrient recycling in early Cambrian marine environments, highlighting multiple pathways for the recycling of organic material back into the ecosystem.



Functional decoupling between forelimb reduction and scapular musculature in carcharodontosaurid theropods

Damiano Palombi¹, Alejandro Otero², Juan Canale^{1,3} and Peter Makovicky⁴

¹CONICET Museo Municipal Ernesto Bachmann, Argentina; ²Museo de La Plata, Argentina; ³Universidad Nacional de Río Negro, Argentina; ⁴University of Minnesota, USA

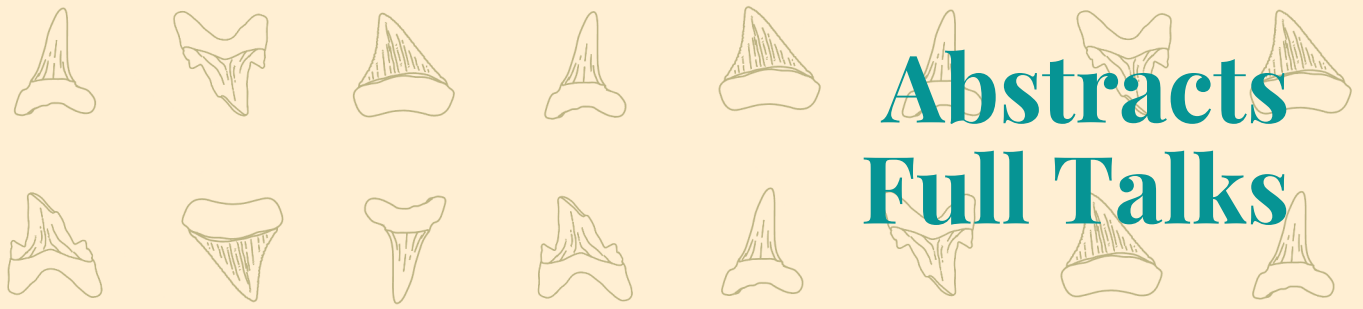
Meraxes gigas exhibits marked forelimb reduction alongside an elongate scapula bearing extensive muscle attachment sites, suggesting a functional decoupling between the arm and pectoral girdle and raising questions about the role of scapular musculature in these theropods. Using the Extant Phylogenetic Bracket, this study investigates osteological correlates of dorsal scapular muscles in Theropoda, with a primary focus on carcharodontosaurids (*Meraxes* MMCh-PV-65; *Giganotosaurus* MUCPv-Ch1; *Mapusaurus* MCF-PVPH-108.50) and comparative data from other clades. We document the presence of a dorsomedial scapular groove associated with the insertion of *M. trapezius* and *M. levator* scapulae, as well as evidence for a ventral insertion for *M. serratus superficialis* in taxa with reduced forelimbs including *Ceratosaurus* (UUVF 317), *Majungasaurus* (FMNH-PR 2836), *Tarbosaurus* (MPC-D 107/2), *Tyrannosaurus* (FMNH-PR 2081), and *Sinraptor* (IVPP 10600). Our results show that carcharodontosaurid scapulae exhibit a particularly well-developed dorsomedial groove and increased mediolateral blade thickness at these muscle attachment sites. In contrast, theropods with proportionally larger forelimbs, such as therizinosaurids, dromaeosaurids, and megaraptorids, lack this feature. We propose that in carcharodontosaurids and other large-bodied theropods with reduced forelimbs, dorsal scapular musculature was functionally decoupled from the forelimb and instead contributed to stabilizing the shoulder and supporting neck movements. This interpretation is consistent with the co-occurrence of reduced forelimb, enlarged skulls, and hypertrophied cervical vertebral neural spines. These results emphasize a functional integration of the head-neck-shoulder system in carcharodontosaurids, with *Meraxes* providing key anatomical evidence.

Quantifying metazoan 'locomotion space'

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¹University of Manchester, UK; ²University of Oxford, UK

Locomotion is fundamental to the survival and evolution of most animals, being used for foraging, escape, mating, and migration. A wide variety of locomotion strategies are utilised by animals to burrow, crawl, swim, jump, and fly, many of which appear to have evolved convergently in different phyla. Previous kingdom-wide comparative studies of the Metazoa have focused on morphology, finding that most extant phyla occupy a distinct region of morphospace, and that this 'clumpiness' is driven by extinction of intermediate taxa. Here, we present the first kingdom-wide quantitative assessment of animal locomotion. We treat locomotion strategy as a suite of discrete, non-morphological characters, create a novel dataset containing extant representatives from all animal phyla, and ordinate this data to create metazoan 'locomotion space'. Our results show that metazoan locomotion space is less 'clumpy' than morphospace, and while there are regions of high taxon density, in no cases are they exclusive to any phylogenetic group. Conversely, when limiting the analysis to individuals of a single phylum, the resulting locomotion space is generally more 'clumpy' and phylogenetic clustering is apparent. Overall, our results highlight the differences between the evolution of morphology and locomotion strategy, and we conclude that the evolution of locomotion is a more flexible process that more frequently results in convergence across the Metazoa.



Disparity analyses are robust to ancestral state estimation uncertainty (*withdrawn*)

Caleb Scutt^{1,2}, Natalie Cooper², Gavin Thomas¹ and Thomas Guillaume¹

¹University of Sheffield, UK; ²Natural History Museum, UK

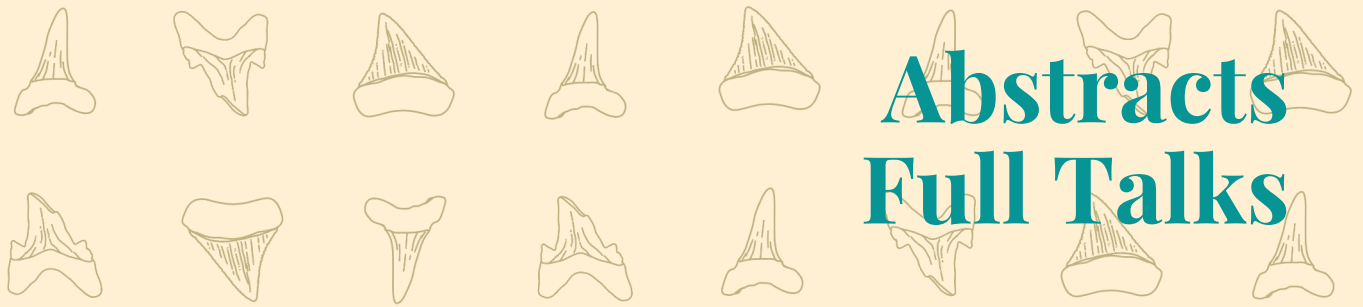
Morphological trait datasets and phylogenies are routinely paired to investigate macroevolutionary patterns during disparity analyses. However, incomplete fossil sampling can distort disparity estimates, obscuring true evolutionary signals. Ancestral state estimation can be used for both continuous and discrete traits to extend these analyses beyond incomplete fossil data, such as investigations into disparity through time. However, the order of ancestral state estimation in the disparity pipeline, and the inevitable uncertainty in these estimates, complicate their integration. Determining the most robust workflow for integrating ancestral state estimation in disparity analyses remains a critical methodological challenge. Using simulations to attain a ground-truth disparity value, we evaluated different approaches to performing ancestral state estimation and incorporating uncertainty across varying continuous and discrete trait models, fossil sampling densities and disparity metrics. Ancestral state estimation generally improved recovery of true disparity relative to tip-only analyses, though the optimal approach depended on the interaction between trait model and fossil sampling density. For continuous traits, probabilistic approaches were most accurate but were sensitive to model misspecification under low fossil sampling density. For discrete traits, pre-ordination methods were most reliable and probabilistic approaches outperformed point estimates under low sampling, while point estimates became increasingly accurate as sampling density increased. Fossil sampling density was a stronger predictor of disparity accuracy than estimation method choice, underscoring that methodologies are only as powerful as the data provided. Our findings offer a practical decision framework for selecting the most appropriate workflow given the sampling density and trait characteristics of a dataset.

The Shrewley Shark: insights into an enigmatic Triassic chondrichthyan through μ CT and a palaeoenvironmental analysis

Ryan Tokeley¹, Ivan Sansom¹, Richard Dearden¹, Stuart Burley³ and Jon Radley²

¹University of Birmingham, UK; ²The Warwickshire Museum, UK; ³Warwickshire Geological Conservation Group, UK

Due to their low preservation potential, chondrichthyan skeletal fossils are exceptionally rare, as such, specimens of calcified cartilage provide crucial insights into the anatomy, evolution, and lifestyle of ancient sharks. This rings particularly true for the Triassic period, where due to the terrestrial and arid conditions in many parts of the world, only a handful of calcified cartilage fossils are known worldwide. Using computed tomography and phylogenetic analyses, six fossils of chondrichthyan calcified cartilage are described here, consisting of a partial braincase, jaws, neural arches, and fins. A palaeoenvironmental analysis was also performed on the host rock, the Carnian, Arden Sandstone Formation of Warwickshire, UK. The fins and neural arches have been tentatively assigned to the Hybodontiforme *Palaeobates keuperinus* whereas the braincase and jaws are confidently assigned to the Jalodontiforme *Keuperodus brodiei*. These specimens represent the first known occurrence of chondrichthyan cartilage both from the late Triassic and the order Jalodontiformes. *K. brodiei* is likely representative of a Palaeozoic hangover taxon, bearing a similar basicranial and jaw structure as well as a close phylogenetic relationship to the Devonian *Phoebodus*, suggesting Jalodontiformes are more closely related to Phoebodontiformes than previously realized. However, unlike *Phoebodus* and all other jalodontids, *K. brodiei* occupied freshwater lake margins and channels, revealing a marine-freshwater transition within Jalodontiformes towards the end of their lineage. Possible links to the Permian-Triassic mass extinction and Carnian Pluvial Episode are suggested as drivers of adaptation and radiation in *K. brodiei* and its ancestors.



Abstracts Full Talks

Reconstruction of *Jeholornis* and the role of iridescence in early paravian plumage

Elisabeth Wilkinson¹, Jakob Vinther¹, Innes Cuthill¹ and Julianne Kiely²

¹University of Bristol, UK; ²The Open University, UK

Plumage of birds is held at two trade-offs in modern ecosystems. The morphological trade-off between flight efficiency, ornamentation and insulation, and the colouration compromise between camouflage, display, thermoregulation and biochemical properties. These plumage trade-offs present in modern bird taxa must also have been present in the fossil record of avian theropods and early birds. *Jeholornis*, an early Cretaceous basal avialan known for its unique “two-tailed” plumage, which is thought to serve in display, makes an intriguing candidate in paleo-colour studies. Here, the plumage of *Jeholornis* is described in detail from an undescribed specimen, and its colouration is reconstructed based on analysis of melanosome morphology. The morphologies of melanosomes suggest iridescence in the feathers of the body, wings, and tail integument, accompanied by a set of ginger-red covert feathers. This plumage patterning is consistent with the complex social or sexual displays observed in modern birds, with the orange wing spots hinting at potential sexual dimorphism. This type of colour patterning is new to the fossil record of dinosaurs and early birds. The presence of iridescence in an early avialan such as *Jeholornis* provides further insight into the role of iridescence in the evolution of Paravians and its widespread dispersal in crown group birds.

Landmark-free morphometrics reveal repeated simplification of head-neck junction in tetrapods

Annabel Worth¹, Charlotte Brassey², Emily Rayfield¹ and Katrina Jones¹

¹University of Bristol, UK; ²Manchester Metropolitan University, UK

The appearance of the tetrapod neck represents a key innovation that allowed for forelimb independence from the head, and subsequent locomotor diversification. The atlas-axis complex, comprising the first two vertebrae of the neck, displays remarkable morphological variation amongst crown tetrapods. In particular, the mammalian atlas-axis is considered highly specialised to permit greater head mobility. However, the transformations and selective pressures that gave rise to the mammalian head-neck junction remain elusive. Here we ask: what drives mammalian atlas-axis morphology, and how does this compare to other tetrapods? We studied the atlas-axis of 60 mammals and 20 non-mammalian tetrapods using both comparative observation and landmark-free morphometrics. Dragonfly was used to generate three-dimensional meshes from CT data gathered from Morphosource or surface scanning of museum specimens. Quantitative shape analysis was achieved using the software Deformetrica 4.3.0 and analysed using phylogenetic comparative methods. The mammalian atlas-axis is highly simplified compared to the ancestral tetrapod condition, comprising only two elements: a ring-shaped atlas and an axis with a pronounced odontoid. This morphology has allowed functional compartmentalisation of dorsoventral flexion and axial twisting. Whilst we find morphological variation amongst different mammal clades, most striking was the convergent simplification of the atlas-axis in many tetrapod lineages. Parallel evolution of a simplified atlas-axis amongst tetrapods, most extreme in birds and mammals, implies a shared selective regime and highlights the region’s functional importance. However, further study is required to compare developmental trajectories and underlying genetic changes that drive atlas-axis morphological variation, and to elucidate its precise function.



Dipteronotus (Osteichthyes, Neopterygii) from the Middle Triassic of Devon, and the building of Mesozoic ecosystems.

Emma Ayres¹, Robert Coram¹, Christopher Duffin² and Michael J. Benton¹

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The Permian-Triassic mass extinction initiated the establishment of modern terrestrial and aquatic ecosystems, triggering bursts of diversification of many groups. These include the Neopterygii, which are the majority of extant bony fishes. Neopterygians from the first 10 million years of the Triassic are known worldwide, especially from South China and Europe, but primarily from marine deposits which are still incomplete. Here we describe new material of the neopterygian *Dipteronotus cyphus* from the terrestrial Otter Sandstone of Devon, a common deep-bodied fish from the Middle Triassic (Anisian) of England. The species was named in 1854 and referred to since, but here we provide a detailed description, including results from CT scanning, with new information obtained on cranial anatomy which will be further integrated into the knowledge of its postcranial morphology, providing evidence on ecology and function. A phylogenetic analysis of 'perleidiform' fishes closely related to *D. cyphus* helps resolve the uncertain tree topology of stem neopterygians. As one of the many specialised morphologies arising in the first half of the Triassic, *Dipteronotus* is part of the neopterygian diversity and functional explosion, this time adding information on their evolution in fresh waters.

Evolution on rugged terrain: how complex fitness landscapes shaped the Cambrian Explosion

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Understanding the origin of morphological variation is a fundamental question in evolutionary biology. Several studies have quantified Kingdom-level patterns in morphological disparity, but none have tested the myriad processes proposed to underpin them. One such process is the roughening of fitness landscapes, proposed as an explanation for the burst in animal disparity seen in the Cambrian Explosion. We use TREvoSim, an individual-based eco-evolutionary simulator, to test this idea in ways not possible using the fossil record alone: we modulate fitness landscapes through the introduction and removal of fitness peaks, also altering the degree of ecospace fragmentation and the strength of selection. We compare the resultant disparity and the 'clumpiness' of morphospace occupation, for which novel metrics are introduced. Disparity increases with increasing fragmentation of ecospace regardless of the presence of selection, but morphospace occupation only becomes clumpier under selection, suggesting that a combination of the two could explain the patterns in disparity produced by the Cambrian Explosion. More broadly, our results suggest that morphological disparity is an emergent property of fitness landscape roughness, and therefore that the roughening of fitness landscapes is a viable mechanism for saltational jumps in morphological disparity throughout the history of life on Earth.



Abstracts

Lightning Talks

Microvertebrates from the Weald Clay Formation (Lower Cretaceous, Barremian) of Smokejacks Brickworks, Ockley, Surrey, UK

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Smokejacks Pit is one of the best-known mainland sites in the English Wealden Group, yielding abundant fossils of molluscs, crustaceans, insects, plants, fish, and reptiles. Most famously, the holotype of *Baryonyx walkeri* was discovered at Smokejacks in 1983. However, the microvertebrate-bearing bone beds in the lower part of the exposed succession have until now been largely neglected. This is in large part due to the non-calcareous matrix making acid preparation infeasible. Here we report the rich fauna of the microvertebrate bone beds, with specimens obtained through chemical preparation of a number of bone-bearing blocks using sodium hydrogen carbonate and washed through sieves of sizes 80 mm, 250 µm, and 90 µm. Recovered specimens exhibit a range of taphonomic states, from nearly pristine and with limited association to highly abraded, with preferential preservation of bone over teeth. The recovered fauna includes five species of hybodont sharks (*Lonchidion breve*, *L. striatum*, *Parvodus parvidens*, *Planohybodus ensis*, *Egertonodus basanus*), at least four taxa of bony fishes (*Scheenstia mantelli*, *Belonostomus* sp., Pycnodontiformes cf. *Coelodus*, Teleostei cf. *Leptolepis*), one crocodyliform taxon (Goniopholididae cf. *Hulkepholis*), and extremely rare remains of frogs and salamanders. The Smokejacks assemblage provides additional data about vertebrate faunas of the mainland Wealden Group, while also being distinct from other faunas in terms of taphonomy and relative abundances of taxa.

Functional changes in Lepidosauria over the K-Pg mass extinction

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Functional traits are indicative of the roles played by organisms in their environments and their life history strategies. Changes in functional diversity over extinction events, therefore act as a model for ecosystem change as well as providing an insight into extinction selectivity in response to biotic and abiotic drivers. With over 8,500 species, Lepidosauria is the second largest group of extant tetrapods. Despite being such a large superorder, their evolution, in particular their ecological diversification, is not well researched. Lepidosaurians likely filled a variety of roles within their ancient ecosystems, from giant marine mosasaurs to terrestrial herbivores and very small insectivores, acting as apex predators as well as important prey species. Using a novel database of over 600 extinct species and measures diet, habitat, size class and other size measurements. We investigate whether functional traits impacted survival rates of lepidosaurs over the K-Pg and whether certain functional traits impacted recovery time. We also test if changes in functional diversity result from the demise of certain families/clades or whether these changes were a result of certain functional characteristics being disadvantageous. The information gained will further our understanding of lepidosaur diversity change and help identify extant groups that may be at the highest risk of extinction today as well as increasing our understanding of extinction selectivity and the ecosystem functional recovery post extinction events.



Analysis of a possible semi-aquatic lifestyle of the trigonotarbid, *Palaeocharinus* (Arachnida, Arthropoda), in the Rhynie Cherts

Beau Jones¹, Alexander Hetherington¹, Ryo Tanaguchi¹, Laura Cooper¹ and Rachel Wood¹

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Why are spiders so hairy? This is a question I have toiled over for the past year. The Rhynie cherts (~407 Ma), a fossilised Devonian hydrothermal hot spring system, contain the most complete early terrestrial ecosystem. Taxonomically diverse fossilised arthropods within the cherts are preserved in a precipitated silica sinter in cellular detail, providing unparalleled insight into the function of early land animals. Here, we present a new workflow for 3D imaging the arthropods of the Rhynie - focussing on the predatory trigonotarbid arachnid, *Palaeocharinus* - utilising historic thin section collections, high resolution microscopy, and 3D segmentation. With this workflow we were able to image and identify sensory hair structures which may have allowed these creatures to float on the dense hot spring waters to hunt without breaking water surface tension, similarly to modern fishing spiders from the group Pisauridae. Using comparative extant species from literature and museum collections, we conducted a number of quantitative and morphological tests in order to gauge the physical likelihood of *Palaeocharinus*' ability to perform pond-skating behaviour. Ultimately, this research lends key insights into the very beginning of animal terrestrialisation, highlighting a previously untested theory for predation at the start of life on land.

The functional performance of spiral feeding structures in Cambrian echinoderms

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Spiral patterning can be seen across the animal kingdom, from the shells of molluscs to the tusk of the narwhal. The fossil record shows spiral and non-spiral radial symmetry in the echinoderm body plans that emerged in the Cambrian, many of which persisted for tens of millions of years. However, the function of these distinct symmetries remains uncertain, with some suggesting that spiral feeding structures could enhance food gathering and others suggesting that spirality is a plesiomorphic trait. To address this, we investigated feeding performance in diverse early echinoderms with spiral and non-spiral feeding structures, placing these results in a phylogenetic context to better understand the evolutionary history of spirality. Computational fluid dynamics analysing flow patterns around feeding structures found reduced drag in spiral forms compared with non-spiral, and that taxa with spiral feeding structures were less effective at feeding from recirculating flow. Additionally, ancestral state reconstruction was used to determine whether spiral symmetry was the ancestral form of radial symmetry in echinoderms or a derived trait. The results provide insight into the function and evolution of spiral symmetry in early echinoderms, with implications for understanding spiral structures in animal body plans more widely.



Isotopic temperature indications from *Aequipecten opercularis* in the Red Crag Formation (Pliocene-Pleistocene, UK)

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The Pliocene-Pleistocene transition was a time of dramatic global climate change, defined by widespread cooling and increased variability. Previous oxygen isotope studies of the Coralline Crag Formation (CCF; Pliocene, UK) go against this global picture, suggesting benthic winter temperatures similar to modern and summer temperatures lower than modern. These CCF temperatures go against global trends, yet similar techniques have not been applied to East Anglian Pleistocene deposits. In this study, oxygen isotope techniques are employed to build on the CCF work into the earliest Pleistocene of the subsequent Red Crag Formation (RCF). Seven *Aequipecten opercularis* specimens from the RCF were serially sampled for shell carbonate across the lifespan of each individual. Shell carbonate oxygen isotope ratios were measured and used to calculate palaeotemperatures, producing a seasonally resolved temperature profile for each specimen. Palaeotemperature values were used to estimate RCF climate settings and change in mean climate state between the RCF and CCF. RCF temperature results ranged from 6.9-23.3°C, with a mean winter minimum of 8.9°C and summer maximum of 20.5°C. There was good agreement between samples, with no indications of a multimodal climate system. This study indicates that despite global cooling across the Pliocene-Pleistocene transition, benthic temperature results from the Pleistocene of the RCF were significantly warmer than comparable estimates from the Pliocene CCF. This discrepancy could be indicative of shifts in environment more complex than previously anticipated. The RCF temperature and seasonality results allow for new insight into a poorly understood and complex climate transition.

An articulated skeleton of *Phuwiangosaurus* suggests greater species-level diversity of Southeast Asian sauropod

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Sauropod fossils dominate the Mesozoic vertebrate fossil record of Southeast Asia, with many specimens attributed to *Phuwiangosaurus sirindhornae*, a somphospondylan titanosauriform from the Early Cretaceous Sao Khua Formation of Thailand. In total 13 localities across Northeastern Thailand have yielded material attributed to this taxon. The Phu Kum Khao locality of Kalasin Province, represents one of these localities and is one of the most abundant sauropod localities within the region, yielding material attributed to three taxa: *Phuwiangosaurus* and two additional forms interpreted as a titanosauriform and a diplodocoid. Here, we describe an exceptionally well-preserved, articulated skeleton from this locality, tentatively identified as *Phuwiangosaurus*. The specimen includes an articulated axial series comprising three cervical, six dorsal, five sacral, and 52 caudal vertebrae, along with 17 dorsal ribs, 10 sacral ribs, and 9 chevrons. Disarticulated appendicular elements include a scapula, left humerus, ulna, both ilia, right ischium, left femur, and three metatarsals. Based on newly acquired and re-evaluated anatomical data, we coded *Phuwiangosaurus* into three specimen-level operational taxonomic units: the holotype, the Ban Nah Krai subadult, and the articulated specimen described here. Phylogenetic analysis under maximum parsimony, using a matrix of 156 taxa and 570 characters, recovers all three within Euhelopodidae as sister taxa. We tentatively assign all specimens to *Phuwiangosaurus*, although they may represent distinct species. This material clarifies diagnostic features and suggests greater species-level diversity within the genus, contributing to our understanding of early somphospondylan radiation in Southeast Asia.



Abstracts

Lightning Talks

A dive into deep-sea lobsters: a Bayesian total-evidence approach to the phylogeny of polychelidan lobsters

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Polychelidan lobsters (Eucarustacea, Decapoda, Polychelida; Late Triassic-Recent) are characterized by a flattened carapace and four-five clawed walking limbs. Extant representatives are blind and live in the deep sea. There is a remarkable contrast between the morphology and ecology of modern polychelids compared to extinct polychelidans, which occupy more diverse habitats and exhibit greater morphological diversity. Due to their modern habitat and the exceptional preservation extinct taxa require, the study of polychelidan lobsters is challenging. This has left many questions unanswered regarding their evolution and development. Additionally, there is little overlap between neontological- and paleontological research, despite the diversity that extinct polychelidans can contribute to phylogenies based on extant taxa. This research aims to bridge this gap and combines fossil and extant taxa into a Bayesian total-evidence phylogeny. Existing datasets were combined and new taxa were added, resulting in a character matrix encompassing 88 morphological characters; 1,394 molecular characters, and 39 taxa. The inclusion of more characters in phylogenies resulted in a lower node height uncertainty. The main polychelidan clades (Eryonidae, Coleiidae and Polychelidae) are shown to be robust and uncertainties surrounding the relationships between- and within these clades are pointed out. There is a topological distance between fossil- and extant taxa, resulting from the abrupt absence in fossil occurrences following the Early Cretaceous. The limited morphological diversity of extant taxa is likely the result of a Late Jurassic extinction. Post-Jurassic taxa lived exclusively in deep waters, where greatly reduced preservation potential led to their disappearance from the fossil record.

A massive, hook-bearing cephalopod from the Late Cretaceous of Denmark illuminates the termination of gigantism in Coleoidea

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Large-bodied coleoid cephalopods were a mainstay of Cretaceous seas, with gigantism arising in response to escalating predation pressure from macrophagous vertebrates. However, following a diversity peak ~85–75 million years ago, gigantic taxa disappeared altogether. Fossils of such coleoids are markedly absent from the Maastrichtian and throughout the Cenozoic. We sought to elucidate the causes for this apparent cessation of gigantism, which so far were poorly understood. To this aim, we examined a partial arm hook of a new coleoid from the Upper Cretaceous of Denmark. Nannofossil biostratigraphy analyses provided a ~69.5 million years old age estimate, evincing the first occurrence of a giant coleoid in the Maastrichtian. The new arm hook measures ~3 centimetres long, and a ~4-metre total body length is extrapolated. Morphological analyses incorporating high-resolution micro-computed tomography indicated affinities with the clade Belemnotheutidae, revealing the rise of gigantism in a lineage of otherwise diminutive cephalopods. This taxon expands the spatiotemporal distribution of large coleoids, establishing them as key components of pelagic ecosystems throughout the Late Cretaceous. Our findings suggest that gigantism trends persisted until the end of the Mesozoic, albeit declining during the latest-Cretaceous. The abrupt termination of these trends would have resulted from biotic collapse in the wake of the Cretaceous/Palaeogene mass extinction 66 million years ago. The novel taxon from Denmark illuminates the demise of giant coleoids and brings attention to the unresolved question over when and how gigantism reappeared in modern oceans.



Breaking the mammalian 'rule of seven' is associated with first rib repatterning in Xenarthra

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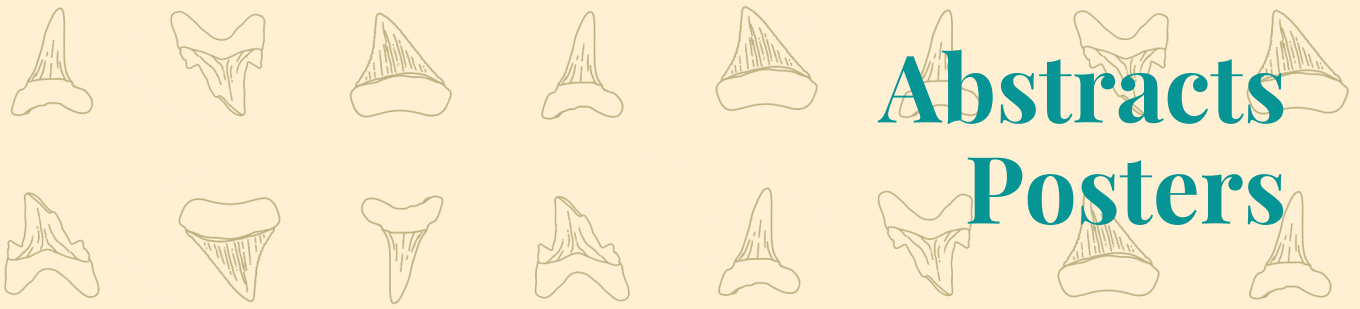
The fixed mammalian cervical count is a well-known case of evolutionary constraint. Two of the genera that break this are the tree sloths, within the clade Xenarthra, which have independently evolved variation in cervical count. In addition to a variation in cervical count, xenarthrans exhibit variation in the numbers of their ribs, suggesting widespread release from constraints in axial patterning, likely related to changes in hox gene expression. However, little is known about axial patterning of the ribcage, and how this relaxed constraint may impact its morphology. Here, we examine how variation in axial patterning in xenarthrans impacted ribcage morphology and regionalization? To address this question, we examined rib count (20 species) and rib shape in xenarthrans (323 ribs of 24 specimens). The xenarthran ribcage consists of 4 morphological regions, the first rib, sternal ribs, vertebral ribs and the final rib. Despite variation in the total ribcage length across the group, changes in rib count result from adding ribs equally to all regions indicating conserved regional patterning. The first rib was morphologically distinctive from the rest of the ribcage and potentially adaptive. However, this unique patterning of the first rib appears to be suppressed in sloths, which exhibit greater uniformity in rib morphology. Indicating that breaking the cervical constraint in mammals may be associated with repatterning of the first rib.

Does AI dream of segmented CT? Understanding the effects of modality on deep learning segmentation

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Computed Tomography (CT) has become an essential tool in modern palaeontological studies. The use of this technique provides a non-destructive method to analyse in situ fossil material without the loss of information (such as soft tissues) associated with manual preparation. Specimens are typically scanned using two major modalities: micro-CT (μ CT) and synchrotron. Both modalities use X-rays to highlight the differences between the matrix, inclusions, and the target bone. This study aims to overcome challenges regarding time, economic cost, and reproducibility of CT-segmentation research using machine learning. Machine learning algorithms are an open-source alternative to costly licensed software like Avizo or Mimics. Fossiliferous material from the Kilmaluag Formation on the Isle of Skye provides a practical dataset for this study due to its wide variety of taxa and the difficulties associated with manual preparation. In this study, we present meshes from two novel, self-supervised pipelines run in parallel utilizing a Simple Framework for Contrastive Learning of Visual Representations (SimCLR). When paired with a UNet encoder, SimCLR provides a taxon-independent, highly accurate (Dice value = 0.9034) pipeline that requires no input from manually segmented slices. This pipeline significantly improves upon current preliminary segmentations that use voxel thresholding, both in terms of quality and time. When assessed against changes in modality data from μ CT performs significantly better than that of synchrotron data. This result is attributed to the scan's complexity.



The pterygoid region in mammals and the evolution of suckling

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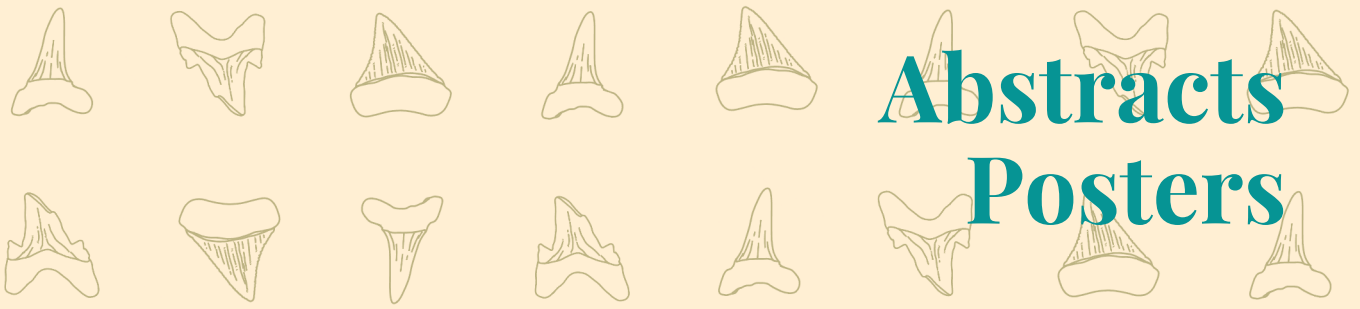
Throughout mammalian evolution from early synapsid ancestors to extant lineages, craniofacial structures associated with feeding have undergone substantial modification. Lactation is a defining mammalian characteristic, enabling postnatal nourishment via milk until independence. Extant mammals are divided into monotremes, marsupials, and placentals. Although they lactate, monotremes lack teats and instead secrete milk onto specialised abdominal skin patches. Therian mammals (marsupials and placentals) possess a specialised cranial element associated with the sphenoid bone, the medial pterygoid plate, from which the pterygoid hamulus arises as a posterior projection. This structure functions as a mechanical pulley for the tensor veli palatini, contributing to soft palate elevation and stabilisation during suckling and swallowing. In *Mus musculus*, the medial pterygoid plate develops late in gestation (~E15.5). It is not present as a discrete homologous structure in monotremes, although two elements occupy the equivalent anatomical region, corresponding to the pterygoid and ectopterygoid. Here, we examine the comparative development of the pterygoid region across mammals, including the mouse (*Mus musculus*), gray short-tailed opossum (*Monodelphis domestica*), platypus (*Ornithorhynchus anatinus*), and short-beaked echidna (*Tachyglossus aculeatus*). Using trichrome and haematoxylin and eosin staining alongside immunofluorescence for Runx2, Sox9, and 12/101, we characterise formation of the medial pterygoid plate and associated fibrocartilage in therians and assess possible homologous structures in monotremes. In therians, the medial pterygoid plate forms through coordinated intramembranous and endochondral ossification from distinct developmental domains. In monotremes, the pterygoid and ectopterygoid remain unfused throughout ontogeny. However, fibrocartilage below the ectopterygoid in historical monotreme specimens suggests that soft-tissue specialisations in this region may predate the therian condition. These findings refine interpretations of the pterygoid region as a therian-associated functional adaptation and suggest a more complex evolutionary history of cranial soft tissues in mammalian feeding.

Changes in supratemporal fenestra morphology as a result of dietary specialization in herbivorous dinosaurs

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The cranial fenestration of vertebrate skulls is an important feature for higher-order taxonomic classification but also plays a significant role in the biomechanical behaviour of the skull. The morphology (shape, size) varies greatly in dinosaurs. In particular, the supratemporal fenestra (STF), located on the top of the skull has been associated with jaw mechanics and bite force. However, the morphology of the STF and its correlation with diet, phylogenetic affinity, and jaw function have not been quantified. Here, we used a combination of two-dimensional geometric morphometric analyses and biomechanical modelling to characterize the morphology of the STF of different dinosaur clades and to evaluate the functional significance of different morphologies. Major variation across Dinosauria was observed, particularly in the herbivorous dinosaurs. Distinct fenestra morphologies were identified, with Ornithomimiformes and Sauropodomorpha demonstrating opposing STF morphologies (anteroposterior vs mediolateral elongation). We found that STF shape may be indicative of different feeding styles in herbivores; notably, there are differences in the extensive processing of plant matter in the jaws in many ornithomimiforms compared to rake-/bulk-feeding and gut processing in sauropods. A similar trend is not observable in theropods, which may be due to the lack of variation in feeding styles in carnivores more generally. Our results further demonstrate that the change in STF morphology across Dinosauria impacts the size and arrangement (i.e. orientation, length) of the jaw adductor musculature, underpinning the different feeding styles. Fenestrae with a predominantly mediolateral orientation allow for a larger jaw gape than other morphologies, thereby maximizing vegetation intake.



Cosmopolitanism during the Early Carboniferous (Tournaisian) in the context of Late Paleozoic trends

Lila Blake¹, Paul Wignall¹ and Alexander Dunhill¹

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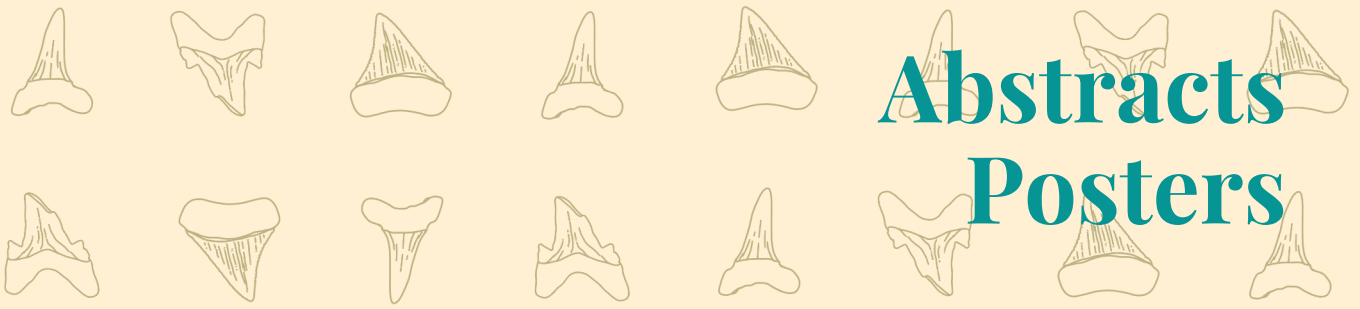
The global Hangenberg Crisis (~359 Ma) marks a major Phanerozoic extinction event and was followed by an exceptionally slow recovery interval; marine biodiversity was persistently low for greater than 20 million years, potentially making it the longest aftermath of any biotic crisis. Here, we examine the biogeographic dynamics of marine invertebrates across the Devonian and Carboniferous in relation to post-extinction recovery patterns. Using a series of biogeographic metrics (biogeographic connectedness, beta diversity, and Dice, Jaccard and Czekanowski coefficients) on a dataset of 4530 marine invertebrate genera, we identified two episodes of faunal cosmopolitanism: one in the Frasnian and a second in the Tournaisian. A third potential cosmopolitanism episode was identified in the Moscovian-Kasimovian but is likely to be an artefact caused by restricted spatial spread of samples, rather than a true biological signal. Comparison of the biogeographic connectedness (BC) values of newcomers, survivors, and all genera in the Famennian and Tournaisian indicate that post-Hangenberg faunal cosmopolitanism was driven by the selective extinction of endemics and the geographic expansion of survivors. Low β -diversity during the Tournaisian supports the idea of an ecologically undersaturated Early Carboniferous ecosystem in which there is a low degree of competition for niche space, and hence, weaker selection pressures, resulting in slower diversification rates. Increased faunal cosmopolitanism alone is unlikely to fully explain why recovery took so long, with additional factors, such as extreme environmental perturbations and palaeogeography likely also contributing.

An alluvial floodplain assemblage of Early Cretaceous ornithopods and theropods in Bexhill-on-Sea, East Sussex

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The Early Cretaceous aged Wealden Supergroup (c. 141–119 Ma) has yielded a variety of dinosaur footprints over 180 years across Southern England. These include ornithopod, theropod, thyreophoran, and sauropod trackmakers. The most extensive and earliest reported trackways occur in intertidal platforms at Bexhill-on-Sea - few of which have been systematically mapped before succumbing to erosion. Here, we describe and map an extensive series of 260 dinosaur footprints in the Late Valanginian (c. 134–132 Ma) Tunbridge Wells Sand Formation at Bexhill-on-Sea using photogrammetry. The trackways occur across multiple horizons of siltstones and mudstones - deposited in an alluvial floodplain setting. We assign these tracks to three main morphotypes, each influenced by substrate conditions, most likely representing large iguanodontian ornithopods and small coelurosaurian theropods. Such a density of trackways provides clear evidence of time-averaged milling behaviour as dinosaurs travelled without localised palaeogeographic constraint in all directions. Collectively, these trackmakers provide evidence of how dinosaurs behaved in open environments during the Early Cretaceous and a workflow for preserving vulnerable soft sediment track sites.



Evolutionary patterns in a diverse group of trilobites: morphological disparity and phenotypic trends in Asteropyginae

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¹University of Lincoln, UK

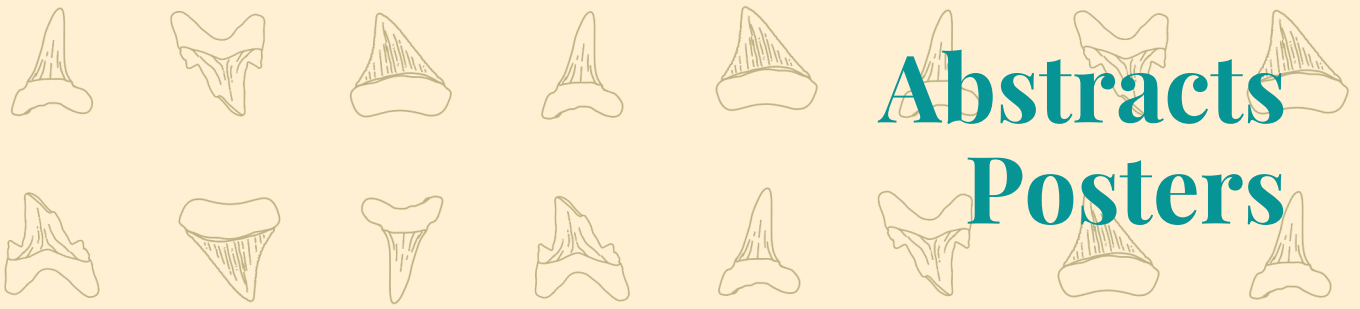
Trilobites were among the most morphologically diverse arthropods of the Palaeozoic, with over 20,000 described species spanning the entire era. Within this diversity, the Devonian subfamily Asteropyginae is notable for its extreme cephalic and pygidial morphologies, including exaggerated spines and highly derived cephalic outlines, exemplified by taxa such as *Walliserops*. Despite this, previous work has largely focused on cephalic shape alone or compared cranial and trunk evolution across broad trilobite groups, leaving patterns of morphological evolution within individual subfamilies poorly explored. Here, we investigate phenotypic disparity and evolutionary rates in both cephalic and pygidial morphology within Asteropyginae, testing whether extreme morphologies are associated with shifts in evolutionary tempo. Using outline-based morphometric analyses, we quantify shape variation across a wide range of asteropyginid morphologies and assess morphospace structure, disparity, and principal axes of variation for both anatomical regions. These data are integrated with a phylogenetic framework to estimate lineage-specific rates of morphological evolution. Both cephalae and pygidia occupy a broad and complex morphospace, with major axes of variation capturing pronounced changes in outline elongation, spine development, and regional expansion. Evolutionary rates vary substantially across the subfamily, with taxa exhibiting the most unusual morphologies—such as *Walliserops* and *Heliopyge*—showing markedly elevated rates of evolution relative to more conservative forms. These results demonstrate that asteropyginid trilobites underwent highly heterogeneous evolutionary dynamics, and that exceptional morphological novelty is closely associated with accelerated evolutionary rates. Our findings highlight the importance of subfamily-level analyses for understanding how extreme forms arise during arthropod evolution.

Biomechanical simulation of locomotion of the ornithischian dinosaur Heterodontosaurus

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As in living animals, locomotion in extinct animals like non-avian dinosaurs is a fundamental aspect of their biology. Computational biomechanical tests on digital models are increasingly used to study dinosaur locomotion, which include predictive simulations that generate an optimum gait cycle of animals without reference experimental data. Such computer simulations have been created for several dinosaurs, but these mostly focus more on saurischians while ornithischians have received less attention. This project helps address this issue by creating gait simulations of the Early Jurassic ornithischian *Heterodontosaurus tucki*. The project uses a composite musculoskeletal model created from CT and surface scans of two *Heterodontosaurus* specimens. Muscle-tendon units were added and joint ranges of motion established in OpenSim before simulations were run on the model using the Matlab software code PredSim. Preliminary results suggest a maximum velocity of approximately 4 ms⁻¹ and significant axial lateroflexion, likely to conserve angular momentum. Surprisingly, the simulations show limited hip flexion and proximal tail lateroflexion compared to theropods, but it is currently uncertain if this is because of anatomical differences between taxa or issues with the simulations. Limitations so far include clipping between the feet and unrealistic back dorsiflexion and arm postures, all of which we aim to address in future simulations. Future work will also focus on sensitivity analyses to determine simulation robustness to changes in model parameters like centre of mass and axial joint mobility, as well as more detailed comparisons with previously reported dinosaur locomotor biomechanics to understand the early evolution of dinosaur locomotion.



A novel specimen story: mustelid limbs from the Siwaliks

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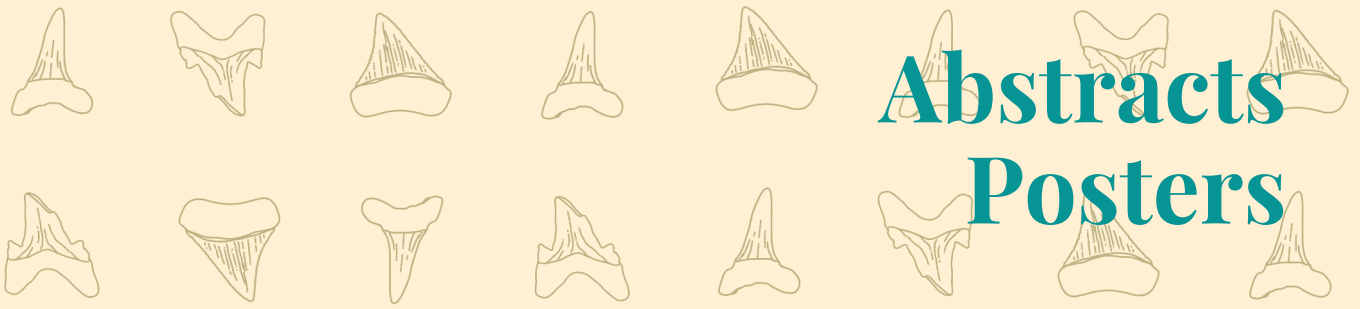
The mustelids are the largest family within order Carnivora, numbering at least 60 species between eight subfamilies. This group includes macrofauna like wolverines and the sea otter, along with the smallest living carnivoran, the least weasel. We studied a novel post cranial specimen from the Siwaliks formations, Indian Himalayas to better understand the type of small carnivorans living in the area between 20 and 6 million years ago. Using 3D reconstruction, body mass estimation, and comparative morphometric techniques we reconstructed the specimen's locomotor ecology and taxonomic placement to determine where it fit in the dynamic Siwalik ecosystem. Early results show a medium sized carnivore between 15 to 20 kilograms, similar in size to comparative species such as the wolverine and honey badger. It likely fulfilled the role of a small predator, taking advantage of fossorial or aquatic prey in the environment.

The palaeoneurology of the Triassic basal cynodont *Diademodon tetragonus* revealed for the first time through computed tomography

Thomas Ducrey¹ and Stephan Lautenschlager¹

¹University of Birmingham, UK

CT segmentation has been used as a non-destructive technique to reveal the structures residing inside of fossil skulls for over two decades. Reconstructing the endocranial contents of extinct taxa provides important insights into the evolution of the brain and sensory systems, particularly across major transitions such as the cynodont-mammalian lineage. This approach allows us to examine how neurosensory structures, including the brain and inner ear, change through time and to infer associated shifts in sensory capabilities. As a basal cynodont positioned early within the cynodont-mammalian transition, *Diademodon tetragonus* represents a key taxon for investigating the evolution of neurosensory anatomy in this lineage. Here, we present the first detailed palaeoneurological description of *Diademodon tetragonus* from the Triassic of Gondwana, based on CT segmentation of two specimens. Three-dimensional models of the brain, inner ears, nasal cavity, and vascular features, including the maxillary canal, were generated. Additional to the taxonomic description, we fit all of *Diademodon's* palaeoneurological features both qualitatively (through morphological comparison) and quantitatively (through geometric morphometrics and other plots) within a broader framework of eutheriodonts (3 therocephalians and 15 cynodonts) and Mammaliaformes. Altogether, this study fills a gap in our understanding of *Diademodon tetragonus*, one of the largest basal cynodonts, while refining broader interpretations of neurosensory evolution along the cynodont-mammalian transition.



Reconstructing *Euparkeria capensis*

Owain Evans^{1,2}

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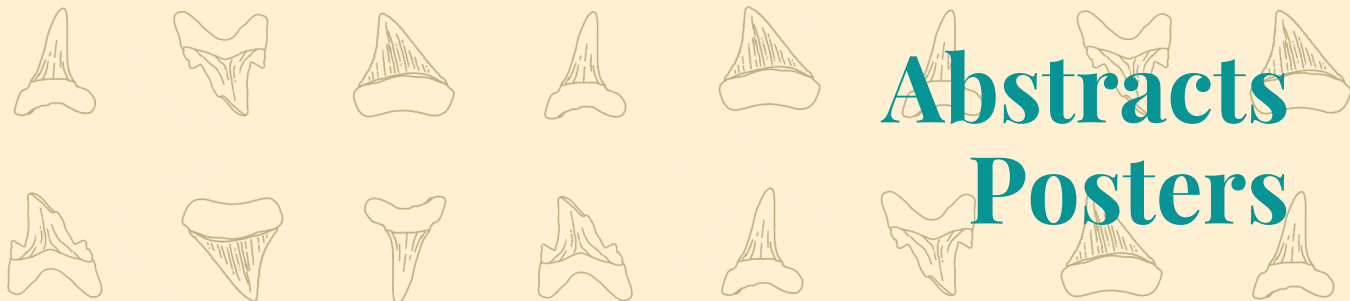
Euparkeria capensis is a small bodied Archosauriform from the Early Triassic of South Africa. It is one of the few representatives of a possible basal condition for Archosauria, and so is of great importance to vertebrate palaeontologists: especially those studying archosaur groups such as dinosaurs. However, there has been relatively little work to reconstruct the feeding ecology of this taxon, despite numerous possible hypotheses throughout the literature. Here, we have reconstructed the cranial architecture of *Euparkeria*, along with the associated adductor muscles of the skull. In this presentation, I will outline two distinct sections of our research. The first focusses on reconstructing fossil taxa using Blender; how this might be achieved, and our process. The second is what this reconstruction might tell us about *Euparkeria*'s cranial adaptations to feeding, and possible ecology.

Be curveful: the omission of membrane curvature and its consequences on pterosaur flight performances throughout the Mesozoic

Maxime Flaunet¹, Jordan Bestwick², Aldo Benites-Palomino¹ and Ryan Felice³

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Pterosaurs were the first vertebrate to evolve active flight during the Mesozoic era (220-66 Ma). Their wing shapes and aerodynamic performances have been the subject of long-standing contentious discussions. These were primarily driven by the uncertainty surrounding the membrane attachment and extent, leading to different aerodynamic interpretations. However, the curvature of their wing membrane has been largely ignored from biomechanical analyses due to taphonomic biases. In order to evaluate the consequences of this omission, the flight performances of 182 species across 11 pterosaur clades were assessed using a theoretical morphospace and Pareto Optimality techniques, evaluating aspect ratio, second moment of area and aerodynamic stresses in relation to diet, habitat and depositional settings. Pareto optimality tests revealed the flight performances were driven by ecology rather than phylogenetic relationships. Overall, 84% of species of the morphospace were biomechanically viable. Sensitivity to curvature omission was at its highest among slender winged shape piscivorous coastal taxa, with biomechanical viability varying around 33% in Pteranodontia and 73% in Ornithocheiromorpha. Conversely, terrestrial taxa including Azhdarchoidea and Ctenochastmatoidea characterized with broader wing profile showed negligible sensitivity, maintaining a viability between 85% and 100%. Within a temporal framework, pterosaur morphospaces drastically expanded from the late Triassic to the Early Cretaceous, while the optimality of aerodynamic components declined through the late Cretaceous accompanied with specialized flight modes. Collectively, these results demonstrate that ignoring the membrane curvature distorts our understanding of pterosaur flight performance, with potential impact on our understanding of their aerodynamic trajectories across the geological times.



The dawn of metazoan reefs and the importance of biostratigraphy in deep time

Iban Goñi¹, Timothy Topper^{2,3}, Marissa Betts⁴, Stephanie Richter-Stretton⁴, Bing Pan⁵, Luoyang Li⁶, Altanshagai Gundsambuu⁷ and Sébastien Clausen¹

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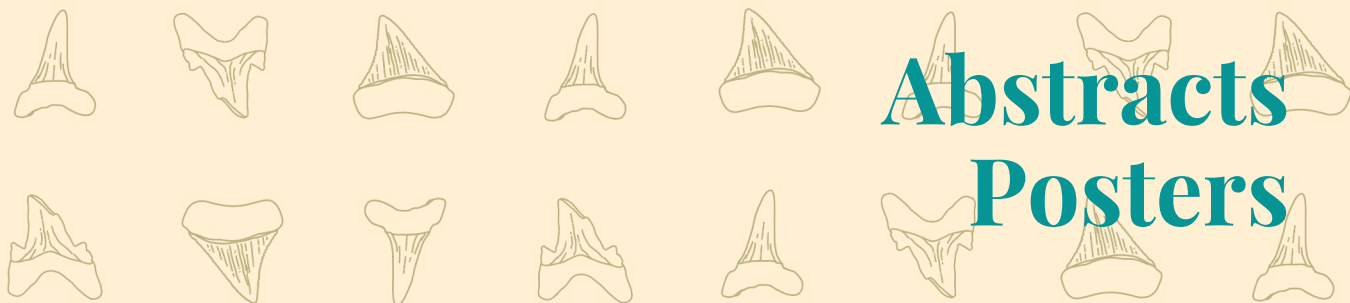
Southwestern Mongolia hosts extensive sedimentary successions spanning the Ediacaran-Cambrian transition, among which the Salaanygol Formation has shown exceptional fossil preservation, increasing the curiosity of palaeontologists. Archaeocyaths are characteristic reef-building sponges from the Cambrian, frequently used as biostratigraphic tools. They are well-documented within the Salaanygol Formation, but the unit's precise age remains contested. In the absence of radiometric dates, biostratigraphy and chemostratigraphy have been utilised, although both methods have yielded discordant age estimates. Previous biostratigraphic frameworks were based on archaeocyathan diversity, with limited attention to the co-occurring skeletal fauna. Here, we evaluated the faunal assemblage throughout the Salaanygol Formation, including various molluscs, brachiopods, and tomotiids. The composition of the assemblage suggests a Tommotian age (525-521 million years ago). Such results challenge the previous biostratigraphic dating based on archaeocyaths, supporting an older age for the unit, while they correlate with the chemostratigraphic interpretation. Consequently, this formation hosts one of the oldest archaeocyathan reef assemblages in the world. Coupled with thin-section analysis, this re-evaluation helps us to understand how the first metazoan-based reefs developed and their possible impact on the diversification of other clades.

Tooth tales: investigating mid-Cretaceous shark diversity and ecology

Chloe Griffiths¹, Charlie Underwood¹ and Richard Twitchett²

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Neoselachii, a monophyletic group comprising all extant sharks, rays, and their extinct relatives, emerged in the middle Early Triassic and have survived numerous mass extinctions and extreme climate-change events over the last 250 million years. Yet, all extant shark species are expected to face climate-related threats within the next century. The mid-Cretaceous, spanning the Albian to Cenomanian stages ($\sim 113.2 \pm 0.3$ to 93.9 ± 0.2 million years ago), experienced drastic climate and environmental changes. It is an ideal, yet relatively unexplored, interval for understanding neoselachian responses to climate-related threats. These responses are difficult to assess in extant taxa. This research will, therefore, investigate mid-Cretaceous neoselachian assemblages from the North Sea and the Anglo-Paris Basins. This will involve compiling a large dataset of neoselachian fossil teeth from bulk sampling and UK museum collections. Diversity and functional metrics will be calculated through taxonomic and ecological analyses of the teeth. These will be linked to multiproxy palaeoenvironmental data to quantify patterns in neoselachian diversity and ecology across space, time and environment. By revealing neoselachian responses to climate change in deep time, this research may offer insights into shark vulnerability and resilience in our changing world.



Reconstructing marine vertebrate trophic networks and diversity in the Middle Triassic of the Germanic Basin

Lily Hardeveld ook genaamd Kleuver¹, Carlos Martinez-Perez² and Emilia Jarochowska¹

¹Utrecht University, The Netherlands; ²University of Valencia, Spain

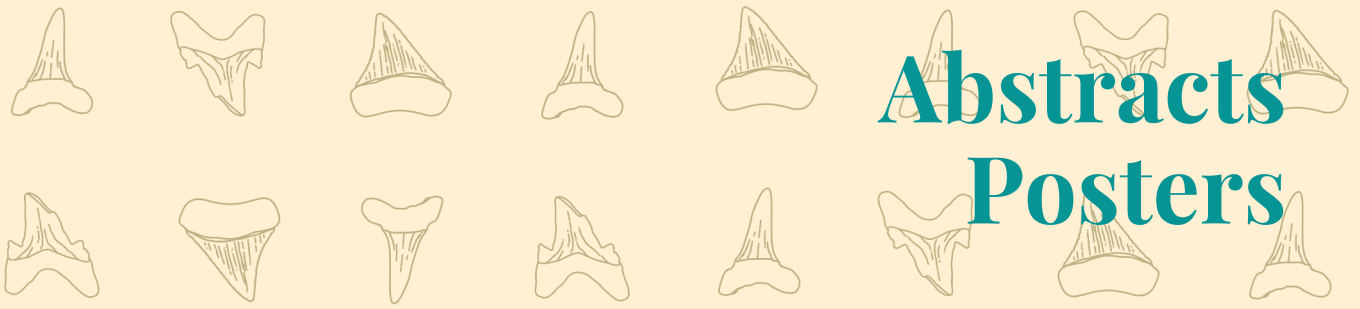
During the Middle Triassic Europe was largely covered by an epicontinental sea known as the Germanic Basin. This environment was still recovering from the greatest extinction event of all time, the Permo-Triassic Mass Extinction (PTME). To investigate the structure and changes of marine trophic networks during this period, we analysed trophic diversity using Sr/Ca and Ba/Ca ratios from bioapatite in microfossil teeth of fish and reptiles. Lower elemental ratios indicate higher trophic levels, enabling reconstruction of relative trophic positions within the same stratigraphic layers. Microfossils were collected from two sites: Winterswijk, The Netherlands (Anisian Age) and Henarejos, Spain (Ladinian Age), both part of the Muschelkalk, a marine carbonate deposit of dolomites and limestones. Taxa analysed include Osteichthyes (*Gyrolepis* sp., *Saurichthys* sp., Dapediidae), Chondrichthyes (*Acrodus* sp., *Lissodus minimus*, *Omanoselache butcheri*, *Pseudodalatias henarejensis*), and reptiles (*Nothosaurus* sp., cf. *Eusaurosphargis*, Placodontia). By comparing trophic diversities across and within these two sites, this study provides insights into the timing of the ecological recovery and shifts in marine vertebrate communities following the PTME, contributing to a broader understanding of post-extinction ecosystem restructuring.

Osteological range of motion estimates for ornithopod tails informing in vivo behaviours and ecology

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Osteological range of motion estimates for ornithopod tails informing in vivo behaviours and ecology. There remain few biomechanical analyses of locomotion in ornithopod dinosaurs, yet ornithopods display one of the most unique traits amongst tetrapods: ossified tendons along the vertebral column. Their structure changes from a longitudinally arranged array to a lattice-like structure in the later-diverging group, Hadrosauridae. The impact ossified tendons had upon behaviours and ecology through the evolutionary shifts to quadrupedality and gigantism in Ornithopoda is yet to be explored. It is thought that ossified tendons reduce ventrolateral flexion and may help to store elastic energy through the gait cycle. This study uses 3D digital simulations of osteological ranges of motion (oROM) as well as extant archosaur tail soft tissue biomechanical analysis to create a method for estimating the influence these ossified tendons had on tail biomechanics. We present preliminary findings from specimens which represent key phylogenetic landmarks in ornithopod evolution: an early-diverging group, Dryosauridae (*Dysalotosaurus*) and an intermediate group, Iguanodontidae (*Iguanodon*). Estimated tail flexion oROM of *Dysalotosaurus* is greatest laterally (average 14°), whereas dorsiflexion and ventroflexion are far less (average 2°). However, this does not include the impacts of ossified tendons which are thought to reduce ventroflexion. We discuss how these results compare with soft tissue-informed oROM data from extant Crocodylia and initial oROM data from *Iguanodon*, and how our findings aid in reconstructing the evolution of tail function in Ornithopoda.



Biogeography and diversity of fossil spores from the Devonian of Gondwana

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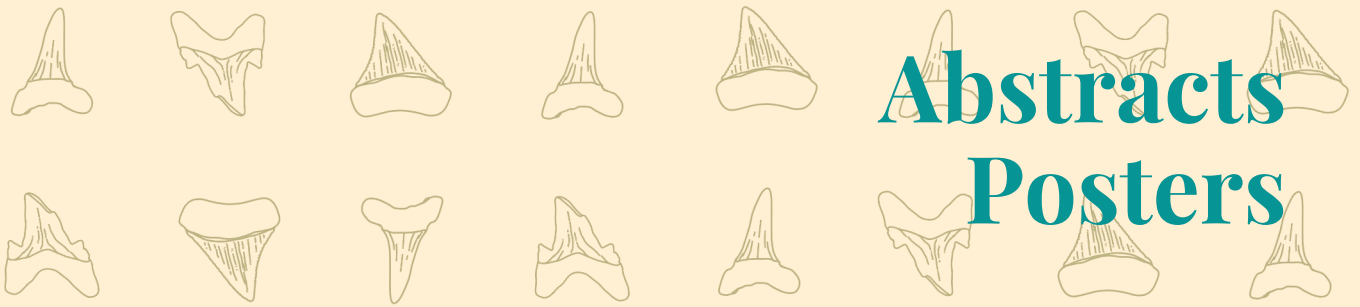
Plants underwent a series of major terrestrialisations during the Devonian, developing from low growing, marginal communities to global forests by the end of the period. However, the fossil record for plant tissues is inconsistent during this interval, so the more-complete spore record is key to our understanding of the biogeography and diversity of early terrestrial plant communities. Using fossil spores from Armorica (present-day Spain), Gondwana and the British Isles, here we reconstruct a detailed palaeobiogeographic model for Devonian floras. Several landmasses, including Armorica, are geographically isolated in the Devonian, and appear to show endemism in their floral communities. Species-richness is assessed both spatially and temporally, correlating changing plant diversity with increasing territorialisation and extinction events throughout the Devonian.

Evolutionary patterns of paedomorphism in Temnospondyli

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Temnospondyls make up one of the most diverse and speciose group of early tetrapods. To date, some 300 species have been described, with an evolutionary history spanning over ~220 mya, from the Carboniferous to the Early Cretaceous, thus forming one of the oldest tetrapod clades to exist. While most temnospondyls share a broadly conserved semi-aquatic body plan, several distantly related clades (including dvinosaurians, dissorophoideans, and brachyopids) exhibit distinct paedomorphic skull morphologies characterised by broad proportions and reduced ossification. The phylogenetic separation of these groups suggests that paedomorphosis did not arise once but evolved repeatedly and independently during temnospondyl history. Here we test this hypothesis by quantifying cranial shape variation and evolutionary dynamics across paedomorphic temnospondyls using geometric morphometrics and phylogenetic comparative methods. 62 two-dimensional cranial landmarks per taxa were placed along key sutures and regions of the skull. These data were analysed through Bayesian phylogenetic comparative methods and used to quantify shape variation whilst assessing their morphospace structure, disparity, and principal axes of variation for the entire cranium. These data were further integrated with a time-calibrated phylogenetic framework to estimate lineage-specific rates of morphological evolution. By comparing analyses performed with and without phylogenetic correction, we report on the extent to which paedomorphic skull morphology reflects convergence rather than shared ancestry. Finally, by partitioning the skull into anatomical regions, we test whether paedomorphism is associated with heterogeneous evolutionary rates across the cranium, providing insight into how developmental processes have shaped repeated morphological outcomes in temnospondyl evolution.



The comparative biomechanics and hydrodynamics of Jurassic marine reptiles

Lucy H Holmes¹

¹University of Birmingham, UK

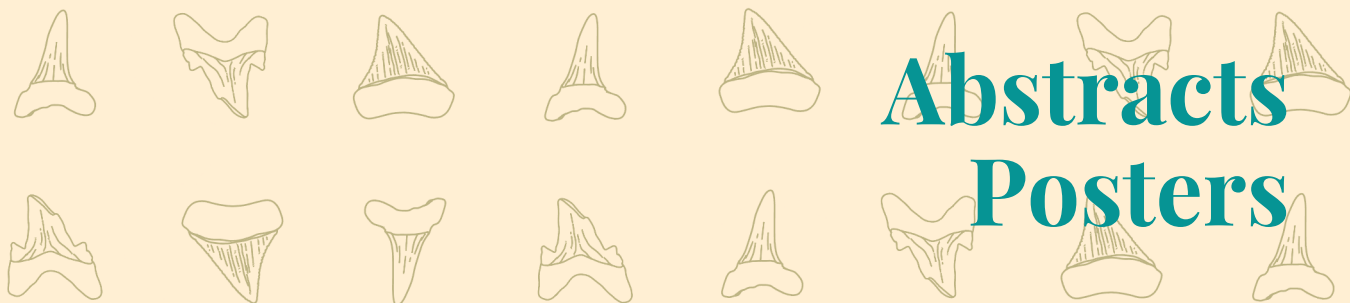
The Jurassic period featured a diverse array of marine reptiles, including plesiosaurians, ichthyosaurs, and marine crocodylomorphs, each exhibiting varied feeding strategies. While their anatomy and evolutionary relationships have been widely studied, their feeding biomechanics remain less understood. Investigating these biomechanics, alongside hydrodynamics, is essential for interpreting how these animals hunted, fed, and moved through aquatic environments. This study tested the hypothesis that species with broader skulls and larger jaw muscles would produce stronger bite forces but have smaller maximum gape angles, with the trade-off of increased hydrodynamic drag and reduced swimming efficiency. To examine this, twelve Jurassic marine reptile species across five phylogenetic groups were analysed, alongside two modern crocodylian species for comparison. Three-dimensional skull models were created using Blender, and jaw muscle attachment sites were reconstructed. These models enabled gape analysis through Blender and Python, while hydrodynamic performance was estimated using mandible and skull surface area data processed in ImageJ. The results challenge the initial hypothesis. Apex predators with robust skulls, such as *Pliosaurus* and *Dakosaurus*, displayed both large gape angles and substantial jaw muscle attachments, indicating the capacity for powerful bites without restricted gape. Although these features are associated with increased hydrodynamic drag, this disadvantage appears to have been mitigated by adaptations in the rest of the body. Consequently, these predators likely maintained effective swimming and hunting performance despite their cranial morphology.

Tempo and mode of trait evolution in bizarre Cretaceous sea urchins

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Fossil records document morphological changes in lineages through time and form the foundation of modern concepts of evolution, yet how best to interpret these records remains elusive, largely because of methodological limitations. Here, we revisit the tempo and mode of the classic anagenetic *Infulaster* - *Hagenowia* echinoid lineage by measuring specimens housed in museums across the UK and analysing them using likelihood-based statistical modelling. We aim to test the hypotheses that the observed trait changes represent adaptations to food shortage and predator avoidance. Our results indicate that an unbiased random walk best fits all studied traits, including those related to feeding (rostrum elongation and frontal sulcus reduction) and deeper dwelling (body size reduction and apical area shrinkage), suggesting stochastic, directional changes that gave rise to new feeding and tiering modes. Comparisons with environmental covariates indicate that neither sea level nor predation pressure alone appears to have dominated the evolutionary changes, providing no support for the hypotheses that these morphological innovations resulted from adaptation to food shortage or predator avoidance. As one of the few well-documented anagenetic palaeontological time series spanning speciation events, this lineage provides an important window into evolutionary dynamics and the origin of species in the fossil record.



The anatomy of the cervical vertebrae of the sauropod *Lingwulong shenqi* and its implications for pneumaticity in Diplodocoidea

Shumin Liu¹, Samantha Beeston¹, Xing Xu^{2,3}, Paul Upchurch¹ and Philip Mannion¹

¹University College London, UK; ²Chinese Academy of Sciences, China; ³Yunnan University, China.

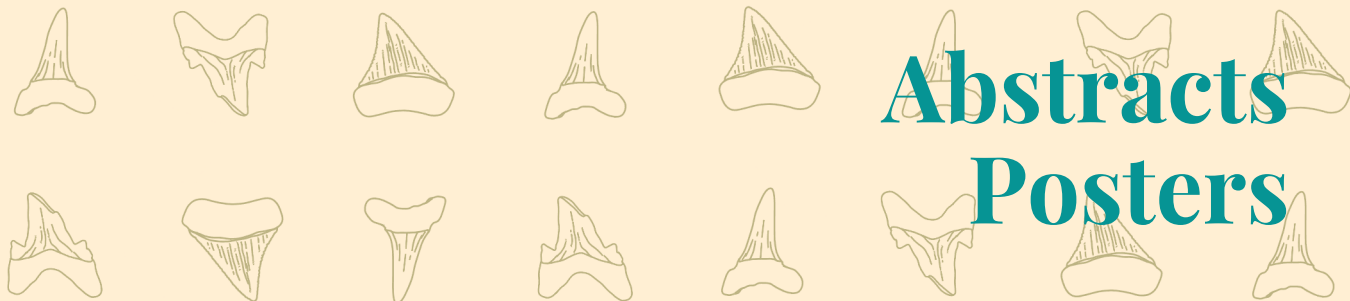
Lingwulong shenqi is known from several partial skeletons from the Middle Jurassic of northern China. Initial phylogenetic analyses recovered it as a dicraeosaurid diplodocoid, whereas more recently it has been placed in an earlier-diverging position within Diplodocoidea, as a stem-flagellicaudatan. Regardless, *Lingwulong* currently represents the stratigraphically earliest known diplodocoid and neosauropod, challenging previous hypotheses of the center of origin and diversification of these clades. Its phylogenetic position extends the spatiotemporal distribution of Diplodocoidea and implies a number of unsampled ghost lineages. The cervical vertebrae of most dicraeosaurids are comparatively less pneumatized than other groups, including diplodocids, presenting 'procamerate' conditions. Although abundant fossil materials of *Lingwulong* exist, only limited anatomical information has been published so far. Here, we present new anatomical data on the cervical vertebrae of *Lingwulong* based on their external morphology and, for the first time, their internal anatomy, using CT scan data. Our preliminary analysis reveals that *Lingwulong* possesses deep fossae penetrating the vertebral corpus, and the internal bone around these fossae is spongy, thereby indicating a 'procamerate' condition, the same as dicraeosaurids, but also early-branching members of Diplodocoidea, including Haplocanthosaurus. Our surveys of previously and newly prepared materials also documents a greater morphological variation in cervical vertebrae of *Lingwulong*, which includes both bifid and unbifurcated neural spines. These new data, along with anatomical information from the remainder of the skeleton, will help to elucidate the phylogenetic relationships of *Lingwulong* and early diplodocoids more broadly, as well as shed light on the evolution of pneumaticity within the clade.

Archaeological and modern baselines identify different constraints on declining UK birds (*withdrawn*)

Bethany Pittard¹, James Hansford², Joanne Cooper⁴, Jeremy Smith³, Ryan Felice¹ and Philip Mannion¹

¹University College London, UK; ²Queen Mary University of London, UK; ³British Trust of Ornithology, UK; ⁴Natural History Museum, UK.

Zooarchaeological collections document species occurrences across millennia of environmental change yet are rarely used as independent baselines for modelling species-environment relationships. Species distribution models (SDMs) typically rely on modern data from populations shaped by habitat modification, risking models that reflect human-altered distributions rather than fundamental tolerances. We ask whether archaeological and modern occurrence data yield different environmental associations as independent SDM baselines. We compare models trained on modern (GBIF/NBN Atlas), archaeological (Serjeantson, 2023), and combined datasets for two declining UK birds: the grey partridge (*Perdix perdix*), a climatically sensitive farmland specialist, and the Eurasian curlew (*Numenius arquata*), a habitat-limited wader, integrating Maxnet models with niche breadth analysis, land use reconstructions, and climate projections. Archaeological models achieved higher discrimination for both species (AUC = 0.877 vs 0.636; 0.753 vs 0.554), with the archaeological niche concentrated in a restricted subset of modern environmental space corresponding to each species' climatic optimum. Combining datasets did not improve discrimination. The archaeological model recovered clear climatic limitation for the grey partridge absent from modern models. For the curlew, weak discrimination confirmed distribution is structured by wetland availability rather than climate, with future projections yielding contradictory trajectories depending on baseline. Archaeological and modern baselines should be compared rather than pooled, as combining dilutes or contradicts the signals each captures. This distinguishes whether species are limited by climate or habitat, with different conservation priorities: farmland management for the grey partridge versus wetland restoration for the curlew. Zooarchaeological records deserve wider incorporation into SDM workflows for anthropogenically constrained species.



How evolution tamed the Leviathan: reconceptualising direction, integration, and causality in evolution (withdrawn)

Tim Rock¹, Gunnar Babcock², Daniel McShea³ and Matthew Wills¹

¹University of Bath, UK; ²Cornell University, USA; ³Duke University, USA

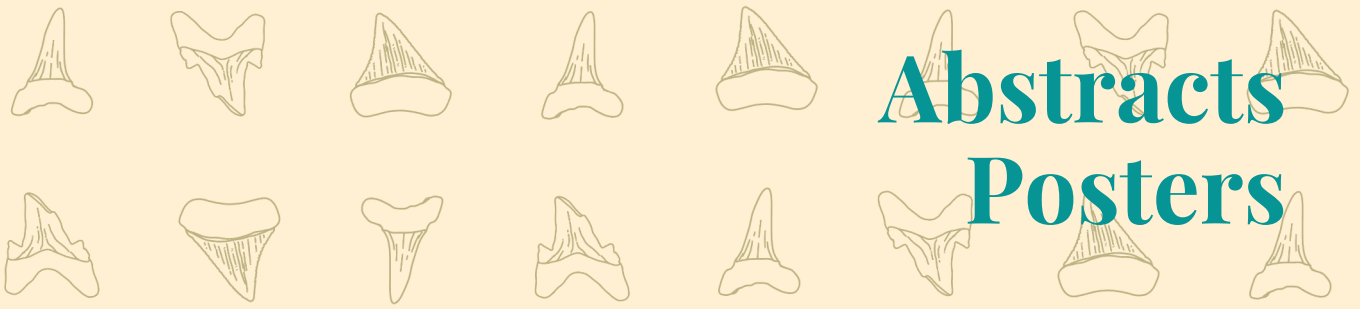
Biologists and palaeontologists have famously argued over the degree to which we can assign adaptive significance to the independent parts of an organism. While parts can be understood to 'selfishly' evolve relative to the various functional demands of the world around them, they are also inexorably bound by the integration of the organism to which they belong. Natural selection explains why some lineages persist and proliferate but does not inherently describe how directional patterns of evolution emerge within and across various lineages comprising these complex, multi-part organisms. This talk will introduce a new analytical framework to examine this phenomenon based on Field Theory. Field theory is a hierarchical view of goal-directedness that focuses on the relationship between higher-level structures called "fields" and the behaviour of entities embedded in them. In evolution, these higher-level fields are aspects of local ecology, and the embedded entities are organisms or populations with parts affected by that ecology. Our approach treats different ecological fields as analytically distinct sources of evolutionary direction that operate on areas of design space, rather than on whole entities. In doing so, we provide a framework for describing how local environmental conditions can operate on the independent parts of a biological entity, and how these interactions can manifest in directional evolutionary trajectories while accounting for integration between parts. To illustrate the wide utility of this framework and its benefits towards answering palaeontological questions, this talk will include several examples of field-directed evolutionary change from the fossil record.

Evaluating the role of sampling bias on the diversity and diversification of anseriform birds through deep time

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The avian fossil record is highly uneven in taxonomic, geographic, and temporal coverage, making it difficult to distinguish genuine macroevolutionary patterns from sampling artefacts and to evaluate 'rocks-versus-clocks' discrepancies in the timing of crown-bird divergences. This issue is particularly relevant for Anseriformes (waterfowl), whose Cenozoic fossil record is comparatively rich but taxonomically and spatiotemporally heterogeneous. To overcome these problems, I am compiling a global occurrence dataset of fossil Anseriformes (~230 species), alongside ecomorphological data. This will enable an evaluation of the underlying sampling structure, allowing me to test how sampling bias influences estimates of richness and turnover. Occurrences are compiled from the Paleobiology Database and primary literature, with standardisation of taxonomy, stratigraphic assignments, age ranges, and geographical information in order to quantify sampling intensity and temporal uncertainty within spatiotemporal bins. Richness will be standardised through shareholder quorum subsampling (SQS), and preservation plus origination/extinction rates will be estimated by using the Bayesian program PyRate. Initial results indicate strong temporal clustering of occurrences in the late Neogene-Quaternary and geographic concentration in Europe and North America. Many records also contain broad age ranges and variable geographic resolution, demonstrating the need for data cleaning before macroevolutionary analysis. Overall, this work will be extended across Aves and later integrated with morphometric data to place modern avian biodiversity loss in a deep-time context.



Non-avian theropod tooth form and function

Morgan Whitley¹ and Manabu Sakamoto¹

¹University of Reading, UK

Teeth are vital for vertebrate feeding, with morphological changes influencing tooth function. Non-avian theropods occupied a plethora of niches and sizes across 165 million years, making them ideal for exploring how phylogeny, diet, geological period and size influence tooth form and function. To characterise form variation between species, principal component analysis was conducted on the tooth outlines of 267 specimens of non-avian theropod dinosaurs. To represent the tooth functions of puncturing and cutting, Von Mises stress (VMS) was recorded for each specimen when force was applied to the tooth tips and along the distal edge respectively. The effects of phylogenetic groups, diet and geological period, as well as size represented by body lengths, body masses, mandible lengths and tooth lengths were also tested. A Bayesian multiple-response generalised linear mixed model was fitted on the PC axes with various combinations of explanatory variables to demonstrate which factors influence non-avian theropod tooth form and function. The results revealed reducing tooth curvature increased cutting VMS experienced during function. However, no significant trends were observed for tooth curvature with diet or phylogeny, despite herbivores and macro-carnivores showing substantially lower cutting VMS compared to other diets. This indicates that variation is with a specific aspect of tooth form—such as crown angle or distal-to-mesial length ratio—and representing the whole tooth outline masks this variation in more complex relationships—such as with niche. Future research should use tooth measurements to characterise form variation to determine which factors influence non-avian theropod tooth form and function.

Inferring early sponge evolution from morphological data

Linjun Zou¹, Davide Pisani¹ and Philip Donoghue¹

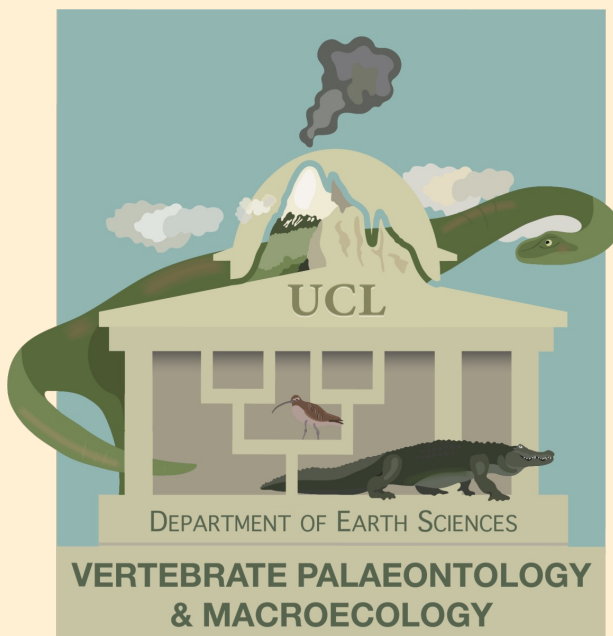
¹University of Bristol, UK

The sponge is widely considered one of the earliest-diverging metazoan lineages, and plenty of sponge and “sponge-like” fossils have been reported from Cambrian and Precambrian strata worldwide. Despite their morphological diversity and preservation of specialized features, their phylogenetic relationships remain weakly understood, largely due to the limited integration of fossil data in systematic analyses. Here, we compile a comprehensive morphological dataset integrating both fossil and extant sponges to investigate early sponge evolution. The dataset comprises over 300 discrete characters scored across 36 fossil species, 64 living species, and selected outgroups, capturing a wide range of skeletal and anatomical features. Characters are derived from fossil morphology, such as spicule types and spicule arrangements, as well as from extant taxa, incorporating soft-tissue-related traits like the aquiferous system. Bayesian phylogenetic analyses are employed to explore patterns of morphological variation and their implications for early sponge relationships. Preliminary results show some limitations in phylogenetic resolution, while still recovering informative relationships within early sponge groups, including affinities among the Protomonaxonids (Ascospongiaea), providing new insights into the structure of early sponge lineages. These results highlight both the potential of morphological data in resolving early sponge evolution and underscore the importance of fossil-informed frameworks for reconstructing early animal history.

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