



3rd Palaeontological Virtual Congress

Book of Abstracts

December 1–15th, 2021



3rd Palaeontological Virtual Congress

Book of Abstracts

Palaeontology in the virtual era

From an original idea of Vicente D. Crespo

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Following the two previous and successful editions of the Palaeontological Virtual Congress (PVC), organized in December 2018 and May 2020, we sat to seriously think about the necessity of having a 3rd Edition in 2021. The PVC had started in 2018 as an original idea to promote virtual participation from around the globe by overcoming all kinds of physical, financial and other types of barriers. The onset and development of the COVID19 pandemic quickly made virtual conferences the only way to share knowledge and the 2nd PVC played an important role in the communication of the palaeontological community with 60% increased participation. However, another year of restrictions and virtual conferences, the potential burnout and Zoom fatigue, made us wonder whether the community would accompany our efforts.

To our delight, participation has doubled compared to 2020, but even more importantly, the number of contributions rose significantly. In the 3rd PVC, more than **520 scientists** from **56 different countries** gathered virtually to watch more than **282 contributions**, a staggering **75%** additional content compared to 2020. Also, we have noticed another important trend: the increase of recorded presentations. In the PVC we offer two types of presentations: static slideshows (both short and longer talks) and pre-recorded video presentations. In 2018, pre-recorded video presentations represented only 4% of the total contributions, whereas in 2020 this number rose to 22%. In this year's edition, pre-recorded video presentations represent 38% of the total content! It looks like the emergence of virtual conferences during these challenging times has created a new trend in scientific communication.

Following the sharp increase in the number of contributions, the 3rd PVC hosts an even greater diversity of topics. Besides the traditional Sessions of the Paleozoic, Mesozoic, Cenozoic and General Palaeontology, the 3rd PVC also hosts 7 Keynote presentations and 8 Thematic Sessions.

Our keynote speakers present talks on *Palaeoecological Interpretations from Fossil Bone Microstructure* (Prof. A. Chinsamy-Turan), *A Jurassic*

Geothermal System in Patagonia (Dr. I. Escapa), *The Origin and Early Evolution of Organ Systems* (Dr. X. Ma), an *Overview of the Vertebrate Fossils from Portugal* (Prof. O. Mateus), *Melanin through Deep Time* (Prof. M. McNamara), *Pleistocene Mammalian Footprints from Chile* (Dr. K. Moreno), and on *Peccaries as a Window into Paleobiology* (Dr. D. Prothero).

Our Thematic Sessions gathered contributions on topics like *Virtual Palaeontology* (organized by Ferreira G.S., Hartung J. & Kampouridis P.), *Palaeontological Heritage in the 21st Century* (organized by Cruzado-Caballero P., Castillo-Ruiz C. & Guerrero-Arenas R.), *Conservation Paleobiology – Bridging Past and Future* (organized by Abondio P., Dimitrijević D. & Hohmann N.), *The Multiple Perceptions of Fossils* (organized by Aguilar-Arellano F. J. & Guerrero-Arenas R.), *Palynology, Palaeoenvironment and Palaeoclimate* (organized by Bertini A., Combourieu-Nebout N. & Niccolini G.), *New Advances on Stratigraphy and Paleontology in Taiwan* (organized by Jih-Pai Lin, Chien-Hsiang Lin & Wei-Chia Chu), *Molecular Palaeontology* (organized by García-Vázquez A. & Grandal-d'Anglade A.), and the *Co-evolution of life and environment during the key geological transitions* (organized by Jing Lu, Zongjun Yin & Zhuo Feng).

Finally, the participants will enjoy three Virtual Field Trips, one in the Canary Islands (by C. Castillo and P. Cruzado-Caballero) and two in Taiwan (by L. Chen-Wei and H. Chia-Hsin, and collaborators).

All those contributions presented in this volume show that, contrary to our dear organisms of the past that form the focus of our studies, the paleontological community has not gone extinct during these challenging times.

We would like to thank all our colleagues for organising and coordinating the different workshops. We also want to thank all the authors for submitting their contributions and the numerous reviewers that have made this volume and congress possible. We would also like to give special thanks to all Palaeontological and Geological Societies, Editorials, Museums, and Universities that have supported this initiative.



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PALAEOECOLOGICAL INTERPRETATIONS FROM FOSSIL BONE MICROSTRUCTURE

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Keywords

Bone histology, Paleobiology, Bone microstructure, Osteohistology



Professor [Anusuya Chinsamy-Turan](#) is a world renowned palaeo-biologist based in the Department of Biological Sciences at the University of Cape Town in South Africa. Her research on the microscopic structure of bones has led to a better understanding of the biology of a variety of extinct animals, such as, dinosaurs (including birds), the flying reptiles, and the mammal-like reptiles (therapsids). Professor Chinsamy-Turan has published extensively - both in high-ranking international scientific journals as well as, in the popular press. She is former President of the Association of South African Women in Science and Engineering (SA WISE), former Deputy President of the Academy of Science of South Africa and has served as Director of Iziko Museums Natural History Collections, and has chaired the Advisory Board of Scifest Africa, the biggest Science Festival in Africa. She currently Chairs the Awards Committee of the US-based Society of Vertebrate Palaeontology and is a board member for the Jurassic Foundation (USA). She is also a Fellow of the Royal Society of South African, the University of Cape Town and The Word Academy of Sciences. She has published two academic books, *The Microstructure of Dinosaur Bone* (Johns Hopkins University Press, USA, 2005) and *"The Forerunners of Mammals: Radiation. Histology. Biology"* (Indiana University Press, USA, 2012), as well as four popular level books entitled, *"Famous Dinosaurs of Africa"* (RandomHouseStruik, SA, 2008); *"Fossils for Africa"* (Cambridge University Press, 2014); *Dinosaurs of Africa* (RandomHouseStruik, 2021); *Dinosaurs and other Prehistoric Life* (Dorling Kindersley, UK, 2021).

In this talk I will provide an overview of some of the highlights of my research in the field of palaeobiology. Through various case studies I will demonstrate how studies of fossil bone microstructure (histology) has provided insights into various aspects of the biology the nonmammalian therapsids, dinosaurs (including birds), as well as some highly derived recently extinct giant birds, such as the dromornithids from Australia, and the apyornithids from Madagascar. By studying fossil bone histology, we have been able to unravel how sauropods grew to gigantic proportions, how dinosaurs were affected by disease, and how growth patterns of birds evolved. I will also give you a glimpse into recent and current research in my lab that examines ecological adaptations, ontogenetic growth, as well as skeletal diseases of a wide spectrum of extinct and extant vertebrates.





A JURASSIC GEOTHERMAL SYSTEM IN PATAGONIA (ARGENTINA): AN ENORMOUS SOURCE OF INFORMATION ON THE DIVERSITY AND ECOLOGY OF MESOZOIC ECOSYSTEMS

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Keywords

Jurassic, Patagonia, Ecology, Paleobotany



Ignacio Escapa is CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas) researcher in the Egidio Feruglio Paleontological Museum (Trelew, Argentina) and paleobotany curator at the same institution. His research focuses on Jurassic and Triassic gymnosperms from Patagonia and Antarctica, using phylogenetic methods to analyze the position and impact of key fossil species. He is particularly interested in understanding the early evolution of modern conifer lineages in Gondwana. Recently, his work has been focused on structurally preserved plants from Patagonia, which show exquisite preservation that allows for reconstructions at the organism-level (i.e., “whole plants”). Ignacio has also led several outreach projects that valorize the fossil record in Patagonia, including books, story contents, and open museum activities.

The record of biotic interactions in ancient ecosystems is crucial for reconstructing community trophic structures and the evolution of ecological roles through geological time. Despite their scarcity, fossil-bearing chert deposits constitute an important source of information in the fossil record because both hard parts and soft tissues of included organisms become preserved in remarkable cellular detail, and in their original context and spatial distribution. An example of these is the Middle-Late Jurassic chert deposits of the Bahía Laura Complex in the Deseado Massif of Patagonia (Argentina), which bear exceptionally preserved organisms in hot-spring settings, comparable in preservation to those of the Devonian Rhynie chert (Scotland). The geographic distribution of the Patagonian hot springs is much broader, including more than twenty localities, distributed in a 60000 km² area. Preliminary research carried out mainly in three of the localities (i.e., La Bajada, San Agustín, Cañadón Nahuel) indicates the presence of a broad spectrum of organisms, including different lineages of vascular plants (e.g., horsetails, ferns, conifers), bryophytes, fungi, oomycetes, cyanobacteria, algae, amoebas, ciliates, arthropods and several organisms of uncertain taxonomic affinities. The specimens are found isolated in the chert matrix, or associated in parasitic, mutualistic, and saprotrophic engagements. The diversity, abundance, and exceptional preservation of organisms in these fossils provide a unique window into the geological past that offers a substantial contribution to the reconstruction of middle Mesozoic terrestrial ecosystems.





THE ORIGIN AND EARLY EVOLUTION OF ORGAN SYSTEMS

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Keywords

Cambrian, exceptional preservation, organ systems, metazoan evolution



Dr. Xiaoya Ma is a professor at Yunnan University in China, as well as a senior lecturer at the University of Exeter in the UK. Her research focuses on understanding the origin and early evolution of animal life, especially major branching events during the early Cambrian. She uses interdisciplinary approaches to study the morphology, phylogeny, taphonomy and paleoecology of a broad range of Cambrian animals from exceptionally well-preserved fossil assemblages, such as the Chengjiang biota.

The origin, evolution and diversification of organ systems represent the basic pathways of metazoan evolution and hold the key to unlocking the deep phylogeny of major animal groups. A key transition in evolutionary history occurred during the late Ediacaran to the early Cambrian periods. Although recent studies have shown that at least some Ediacaran organisms are likely to be metazoans or even bilaterians, the affinities of Ediacaran fossils have long been a subject of debate due to their bizarre body plans, and most of them became extinct at the Ediacaran-Cambrian boundary at 541 Ma. Shortly after the boundary, all major animal groups suddenly appeared globally in the Cambrian fossil record, establishing a metazoan-dominated marine ecosystem. This landmark evolutionary event is known as the “Cambrian Explosion” and remains one of the most profound yet enigmatic evolutionary events in the history of life on Earth. In contrast to Ediacaran fossils, most Cambrian fossils are bilaterians with specialised organ systems (e.g., digestive, visual, nervous, and cardiovascular systems). Therefore, the rapid radiation of animal body plans at the beginning of the Cambrian is also a record of rapid innovation and evolution of organ systems. With recent developments in new imaging and analytical techniques and methods, there have been breakthroughs in gaining a more detailed understanding of organ systems from exceptionally preserved Cambrian fossils. This talk will summarise our current understanding of the origin and early evolution of organ systems and their evolutionary implications.





OVERVIEW OF VERTEBRATE FOSSILS FROM PORTUGAL, FOCUS ON MESOZOIC DINOSAURS

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Keywords

Portugal, Lusitanian Basin, Dinosaurs, Paleontological Heritage, Societal impacts



Born in 1975 in Portugal, Octávio Mateus is Associated Professor of Paleontology in the Faculdade de Ciências e Tecnologia -Universidade Nova de Lisboa [NOVA University of Lisbon]. His education background is Biology (Graduated from University of Évora) and Paleontology (PhD from the Univ. Nova de Lisboa, in 2005). His main interest is dinosaur paleontology, so he has studied Late Jurassic dinosaurs of Portugal, but also worked in other reptiles (mosasaurs, plesiosaurs, crocodiles, turtles, etc.). Author of more than 200 scientific articles, conferences proceedings, and book chapters. He erected more than 30 new taxa to Science, as the *Lourinhanosaurus antunesi* (1998), *Dinheirosaurus lourinhanensis* (1999), *Tangvayosaurus hoffeti* (1999), *Draconyx loureiroi* (2001), *Lusotitan atalaiensis* (2003), *Europasaurus holgeri* (2006), *Allosaurus europaeus* (2006), *Diceratus* (2008), *Microceratus* (2008), *Prognathodon kianda* (2008), *Miragaia longicollum* (2009), *Angolachelys mbaxi* (2010), *Angolatitan adamastor* (2011), *Lusonectes sauvagei* (2012), *Torvosaurus gurneyi* (2014), *Zby atlanticus* (2014), among others. He lives in Lourinhã, where he is engaged with the Museum of the Lourinhã, known for its important dinosaur collection. Since 1991, Octávio Mateus has organized dinosaur bones, tracks and eggs excavations in Portugal. He and the team collected many dinosaurs and other vertebrates, including sauropods, theropods, stegosaurs, crocodiles, and turtles. One of his main scientific project is in Angola, where he discovered the first dinosaur from that country, in the scope of a paleontology project on vertebrates of Angola, the PaleoAngola Project, with geologists and paleontologists from Angola, Southern Methodist University (USA) and Natuurhistorisch Museum in Maastricht (Netherlands). His interest for dinosaurs has taken him to the United States, Brazil, Greenland, Laos, Tunisia, Mozambique, Mongolia, Morocco, South Africa and Angola. Since the age of four, Octávio has searched for dinosaur fossils with his parents co-founders of the Museum of Lourinhã. They raised Octávio in Lourinhã, an area rich in Late Jurassic dinosaurs and, very early in his career, Octávio excavated a dinosaur nest with them, finding embryos inside the eggs. Member no. 1 and founder of the Sociedade Portuguesa de Paleontologia.

Sedimentary rocks cover about one fifth of Portugal and a smaller fraction of that is fossiliferous. The Lusitanian basin Triassic to Cretaceous rocks provided thousands of fossils, from plants, microfossils, invertebrates and vertebrates. Dinosaurs are known in the country since 1863. The most productive formations are the Late Jurassic Lourinhã and Alcobça Formation, and the Cretaceous Papo Seco Formation. This includes an outstanding abundance of Jurassic mammals and bones and eggs and tracks of dinosaurs. Some highlights are: The Upper Triassic temnospondyl *Metoposaurus*, the Lower Jurassic plesiosaur *Plesiopharos*, the Upper Jurassic: dinosaurs bones from Lourinhã (*Lourinhanosaurus*, *Torvosaurus*, *Dinheirosaurus*, *Lusotitan*, *Zby*, *Miragaia*), the dinosaurs eggs and tracks and the mammals from Guimarota. The Lower Cretaceous provided the theropod *Baryonyx*, and the Upper Cretaceous the crocodile *Portugalosuchus*. The Cenozoic is rich in Miocene vertebrates and pleistocene and quaternary fauna. The ziphiid cetacean *Globicetus* shows evolutionary curiosities. In some cases, such as in Lourinhã, paleontology drastically changed the region and brought positive impacts in the society.





MELANIN THROUGH DEEP TIME

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Keywords

Fossil colour, melanin, Konservat-Lagerstätten, macroevolution, soft tissue



Maria McNamara is Professor of Palaeontology at the School of Biological, Earth and Environmental Sciences at University College Cork. Her primary research interests are in the field of soft tissue preservation in fossils, with particular focus on fossil colour and on feather evolution. She uses advanced microbeam and spectroscopic techniques to explore the ultrastructure and chemistry of soft tissues in fossils and their extant analogues, with a strong emphasis on taphonomic experiments to help bridge the gap between ancient and modern materials. Her current research on ancient biomolecules, including melanin and keratin, is supported in part by two ERC grants (Starting and Consolidator Grants). Maria is committed to public engagement to help diversify palaeontology and STEM more broadly and to inspire an appreciation of the natural world amongst the public.

The recovery of evidence of melanin in diverse fossils from the Carboniferous to the Pliocene has established a new field in palaeontology that is of much interest to the academic community, media and public alike. Reconstructions of the original hues and colour patterns of ancient vertebrates are, for the first time, supported by physical and/or chemical data. These reports potentially shed light on visual signalling and, by extension, the behaviour and ecology of extinct vertebrates. A second, complementary research strand has emerged that is focussed on non-signalling applications of fossil melanin in taxonomy, physiology and anatomy. Evidence of ancient melanin is clearly abundant, but how can we realise its full palaeobiological potential? In this talk I will present a case for a more holistic marriage of melanin biology and preservation with a broader phylogenetic approach in order to yield more useful macroevolutionary insights. Leverage of cutting-edge analytical approaches and better integration of taphonomic principles will underpin efforts to explore the role of melanin in vertebrate evolution.





PLEISTOCENE MAMMALIAN FOOTPRINTS NEAR THE CITY: THE SOCIAL IMPACT WE SHOULD BE AIM AT

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Keywords

Lamaichnum, *Proboscipeda*, paleoichnology, interglacial, outreach



Karen Moreno is a paleobiologist from Southern Chile. She did her PHD in The Bristol University (2003-2006) on Dinosaur footprints from the Late Jurassic-Early Cretaceous from Chile and ornithopod-theropod biomechanical modelling, which included a 2 year predoctoral fellowship at the Smithsonian Institution, Washington DC, USA. Then she obtained a research assistantship in Stephen Wroe's Lab in Sydney, Australia (2006-2008); worked as an adjunct researcher at the Museum D'Historire Naturelle in Paris, France (2008-2009); CNSR postdoctoral position at the Laboratory of Molecular Anthropology and Image Synthesis UMR 5288 (2010) and then in Toulouse France as a Maitrè de Conferance in the University of Paul Sabatier (2011). She got a research/lectureship position back in her home contry at Universidad Austral de Chile in 2012, where she collaborated in the creation of the first and still only Master in Paleontology in Chile, where she actually is the Director; and also is currently the president of the Chilean Asociation of Paleontology (ACHP: www.achp.cl).

A Natural Sanctuary at scarce 3 kilometers from Puerto Montt's downtown, in Punta Pelluco, preserves tenths of mineralized Cypress tree trunks in live position for which the site was protected by law back in the 70's. This site recently showed the presence of mastodont and camelid footprints stepping sometime after a glaciator afterwash that cut through the logs, which are found in stratigraphically lower layers, and are dated close to the C14 maximum detection capability of 50.000 AP. At the moment, it remains as a nearby beachside in which visitors are unaware of the espectacular paleontological eye opening panorama and is rather focused on leisure tourism and fishing. In the present talk, I'll expose the challenges that any high impact scientific information has to reach the local community, even in very popular subjects such as paleontology, and to call for attention to the need to work on this with a global perspective.





PECCARIES AS A WINDOW INTO PALEOBIOLOGY

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Keywords

peccary, Tayassuidae, databases, biogeography, systematics



Donald Prothero has taught college geology and paleontology for over 40 years, at Caltech, Columbia, Cal Poly Pomona, and Occidental, Knox, Vassar, Glendale, Mt. San Antonio, and Pierce Colleges. He earned his B.A. in geology and biology (highest honors, Phi Beta Kappa, College Award) from University of California Riverside in 1976, and his M.A. (1978), M.Phil. (1979), and Ph.D. (1982) in geological sciences from Columbia University. He is the author of over 48 books (including 8 leading geology textbooks, and several trade books), and over 333 scientific papers, mostly on the evolution of fossil mammals (especially rhinos, camels, and horses) and on using the earth's magnetic field changes to date fossil-bearing strata. He has been on the editorial boards of journals such as *Geology*, *Paleobiology*, *Journal of Paleontology*, and *Skeptic* magazine. He is a Fellow of the Linnean Society of London, the Paleontological Society, and the Geological Society of America, and also received

fellowships from the Guggenheim Foundation and National Science Foundation. He served as President of Pacific Section SEPM (Society for Sedimentary Geology) in 2012, and served for five years as Program Chair of the Society of Vertebrate Paleontology. In 1991, he received the Charles Schuchert Award for outstanding paleontologist under the age of 40. In 2013, he received the James Shea Award of the National Association of Geology Teachers for outstanding writing and editing the geosciences. In 2015, he received the Joseph T. Gregory award for service to vertebrate paleontology. In 2016 he was named a "Friend of Darwin" by the National Center for Science Education. He has been featured on numerous TV documentaries, including *Paleoworld*, *Walking with Prehistoric Beasts*, *Prehistoric Monsters Revealed*, *Monsterquest*, *Prehistoric Predators: Entelodon and Hyaenodon*, *Conspiracy Road Trip: Creationism*, as well as *Jeopardy!* and *Win Ben Stein's Money*.

The family Tayassuidae (peccaries or javelinas) is a group of New World suiform artiodactyls with an ecology much like that of the family Suidae, the true pigs of the Old World. In the last 37 m.y., tayassuids have evolved and diversified in isolation in North America (and eventually South America) independent of the suids. Even though there are only three living genera in the Americas today, peccaries were once much more diverse. Previous studies recognized only 7-12 genera of peccaries in North America, but I recognize 26 genera and 35 valid species in North. The earliest tayassuids included the genera *Perchoerus* and *Thinohyus* from the late Eocene to late Oligocene. In the early and middle Miocene, the main lineages of Tayassuinae diversified, with a variety of bizarre ridges and crests flaring out from their cheekbones. Their facial features are reminiscent of those of warthogs, and of the extinct entelodonts, which presumably protected the eyes during combat between boars, and may have also signaled age and status of individuals in a sounder. Much of what is written online and in the paleobiological databases about peccaries is now obsolete. Fossils of the group are so rare and unpredictable in their occurrence that peccaries cannot be used for robust biogeographic analyses. Peccaries provide a good example of how a substantial revision of a long unstudied group can shed light on aspects of paleoecology, and also reveal problems in databases that uncritically mine obsolete data from the old literature: "Garbage in, garbage out".



A revolution is happening in Palaeontology by the fast increase in computational power and accessibility to new technologies, particularly computed tomography (CT scan), which allows the transformation of real unique fossils into easily replicable and shareable digital models. Computational models can be submitted to a set of techniques and methods, gathered under the label Virtual Palaeontology, most of which are currently common practice.

Even classical morphological descriptions of fossils are augmented by segmenting each bone separately, potentially revealing previously hidden traits. Analyses of neuroanatomy, innervation and arterial circulation, limited in the past by availability of fossilized natural or invasive latex casts, are now easily approachable through the reconstruction of digital endocasts. Likewise, quantitative analyses of morphology, such as geometric morphometrics, although possible, have become much more widespread in the virtual framework with the possibility of using 3D data and specimens restored back to their in vivo morphology. Beyond promoting the usage of already available tools and techniques, many methods previously unattainable can be now applied to fossil data. These include finite element (FEA) and multibody dynamics analyses (MDA), computational fluid dynamics and even mapping of chemical composition using synchrotron-based μ X-ray fluorescence (μ XRF), all of which offer more quantitative and experimental approaches for palaeontologists. Beyond the methodological innovation, the easiness of sharing data via online repositories promises not only to increase the replicability of palaeontological research but also to make it a more accessible field, especially for those researchers lacking travel funds.

The main goal of this session is to offer a space for those interested in Virtual Palaeontology to present and discuss their latest research results and the methodological advancements in the field. We wish also to discuss the accessibility of data and best practices to share results and datasets.



Virtual Palaeontology: novel solutions for old (and new) questions

Organisers

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Thematic Session



FEEDING ECOLOGY AND PALEOENVIRONMENT OF THE EARLY PLEISTOCENE GERAKAROU HERBIVORE MAMMAL COMMUNITY (MYGDONIA BASIN, GREECE) AS INFERRED BY DMTA ANALYSIS

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Keywords

Quaternary, Microwear (DMTA), Feeding ecology, Paleoenvironment



The Early Pleistocene is well-represented in the fossil record of Southeast Europe, especially Greece. Several questions remain unanswered, notably regarding the regional paleoenvironmental succession, which impacted the local faunal composition and dynamics during that time period. The fairly rich Early Pleistocene fossil site of Gerakarou-1 (2–1.8 Ma), situated in northern Greece (Mygdonia Basin), can provide important insight into the environmental conditions of that time and area, especially since it is roughly contemporaneous with the first appearance of *Homo* in Dmanisi, Georgia (1.85–1.77 Ma). Dental microwear texture analysis (**DMTA**) of fossil ungulates from Gerakarou-1 allowed us to infer their dietary preferences and thus decipher the vegetal resources and environmental conditions. The sample includes 89 individuals belonging to one equid, two cervid, four bovid, and one suid taxon. Analyses were done using five scale-sensitive fractal analysis parameters and five surface texture analysis parameters. We used as a comparative baseline 194 specimens belonging to seven extant ruminant species of known dietary categories, ranging from grazers to browsers. Mixed feeders were found to have been dominant at Gerakarou-1. However, there were distinct dietary differences between the Cervidae analyzed. With an intermediate complexity value (about 1.5) and a high mean anisotropy (5.8×10^{-3}), *Croizetoceros ramosus gerakarensis* was the most distinct grazer, while the values of *Eucladoceros tegulensis* reveal more browsing habits. This implies the presence of mosaic environments at Gerakarou-1 in which herbaceous, bush and tree vegetal layers were available as food resources and habitats for ungulates.



DIFFERENTIATED APPENDAGES IN *ISOXYS* ILLUMINATE ORIGIN OF ARTHROPODIZATION

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Keywords

Cambrian fossil record, euarthropod evolution, *Isoxys* appendages, ventral appendages arthropodization

Isoxys is a worldwide distributed bivalved arthropod that occupies a key position in euarthropod evolution. Some anatomical structures of *Isoxys* have been reported and usually *Isoxys* is regarded as transitional between Radiodonta and upper stem-group members. However, more anatomical observations are often hindered by its large bivalved carapace. Thus, the position of *Isoxys* within the euarthropod tree remains debated. Our fossil material demonstrates the presence of fully arthropodized ventral appendages in *Isoxys* from the early Cambrian Chengjiang biota (South China). Micro-computed tomography reveals exceptional details of the pyritized biramous limb morphology in *I. curvirostratus* and *Isoxys* sp. *Isoxys curvirostratus* has a pair of raptorial frontal appendages with six podomeres attached behind large spherical eyes, which are followed by two series of differentiated biramous limbs: 1) four pairs of short cephalic appendages each bearing prominent endites and a strongly curved terminal claw with a possible feeding function; 2) ten pairs of elongate trunk appendages for locomotion. Each limb bears an endopod with more than 12 well-defined podomeres, and an exopod with a slender shaft carrying approximately a dozen of paddle-shaped lamellae. The trunk of *I. curvirostratus* lacks evidence of dorsal arthropodization. We conclude that ventral-appendage arthropodization evolved before the trunk arthropodization. Our findings not only clarify the enigmatic appendicular organization of *Isoxys* but also clarify the phylogenetic position of early euarthropods. We also suggest that the head of *Isoxys* forms a functional unit with 6 segments bearing successively eyes, raptorial frontal limbs, and four pairs of appendages.





A NEW SPECIES OF THE CAMBRIAN BIVALVED EUARTHROPOD *PECTOCARIS* WITH AXIALLY DIFFERENTIATED ENDITIC ARMATURES

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Keywords

Chengjiang, arthropod, *Pectocaris*, appendage, differentiation

Although first described in 1999, *Pectocaris* remains a poorly known euarthropod genus in the early Cambrian. As of now, two species, *Pectocaris eurypetala* and *Pectocaris spatiosa*, are known from the Chengjiang biota. Here, we use microcomputed tomography, X-ray microscopy, and other traditional research methods reporting a third species, *Pectocaris inopinata*, which bears a pair of stalked eyes attached to an anterior sclerite, a pair of short but stout antennae, 29–35 cephalothoracic segments each corresponding to a pair of biramous appendages, 11–12 limbless segments carrying two rows of ventral spines, as well as one row of dorsal spines, and a pair of broad telson flukes decorated with short marginal spines. Most strikingly, the endopods of the anterior trunk appendages are each axially differentiated with two rows of setulose endites proximally and strong paired claws distally, in contrast to the endopods of the posterior trunk appendages that carry two rows of setulose endites and lack strong claws. The phylogenetic analysis shows that *P. inopinata*, the other two *Pectocaris* species, together with their close relative *Jugatacaris agilis* belong to the same monophyletic clade. The axially differentiated enditic armatures in *Pectocaris inopinata* suggest that in addition to filter feeding, this genus may also occupy the ecological niche of scavengers and predators. Accordingly, in order to adapt to the environment and occupy different ecological niches, the Cambrian bivalve arthropods evolved different body structures and predation strategies.





SEGMENTING THE EVOLUTIONARY HISTORY OF EARLY CROCODYLIANS

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Keywords

Crocodylia, phylogeny, Eocene



Crocodylia, the crown group of Crocodyliformes, has a long evolutionary history whose origins are traced back to the Late Cretaceous. The Paleogene was critical for the diversification of major lineages and the most complete fossils come from a number of iconic fossil Lagerstätte deposits. These include the Eocene localities of Messel and Geiseltal in Germany and the Green River Formation in the USA, each having yielded articulated skeletons. Despite or due to their completeness that potentially can provide interesting data but requires a considerable amount of work, modern osteological descriptions are mostly lacking for these taxa: interpretation of anatomy has been hindered by skeletal articulation and fossil compression. For long, CT-scanning these fossils faced major technical challenges owing to their relatively large size, however, partnership with industrial companies and academic institutions holding the latest appropriate devices now helps overcoming this obstacle. We produced high resolution CT-scan images for some key species, including the basal crocodylian *Boverisuchus magnifrons*, the early alligatorine *Hassiacosuchus haupti*, and the early caimanine *Tsoabichi greenriverensis*. As a preliminary result, five previously unknown skull characters were able to be scored for *H. haupti*, specifically for the premaxilla and basioccipital, contributing to the phylogenetic understanding of the species. The present ongoing project certainly helps on providing access to obscured morphological data, contributing to the crocodylian morphological dataset. The novel morphological insights gained for these often neglected species combined with DNA data from extant species now enable an unprecedented view on the evolutionary relationships and biogeographic history of early Crocodylia.



A NEW WAY OF VISUALIZING DATA FROM THE PALEOBIOLOGY DATABASE

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Keywords

3D, model, maps, R, Paleobiology Database



In recent years, there has been an increasing trend in the use of technologic tools and programming in paleontological research. One of the most used programming languages is R, a free software environment for statistical computing and graphics. Several useful packages have been used and created by paleontologists in R. Probably, the most popular is the PaleobioDB package, which allows to download and visualize data from the Paleobiology Database. Unfortunately, its visualization functions and provided maps are very simple and limited. After testing several tools for plotting, we found a new way of plotting data in a 3D format using the package Rayshader. It allows to add a new dimension that can be very useful to analyse, not only the geographical distribution of occurrences, but also changes of occurrences through time. The added third dimension by plotting in 3D can be used to compare the time span of occurrences for a taxonomic group in an area, and in this way, to formulate hypotheses about extinction patterns within a geographic context. An additional utility of plotting maps in 3D is that they can be exported to print them in a 3D printer, and thus, providing tactile material for universal accessibility in museum exhibitions for people with visual impairment. Here we provide some practical examples to show the results of creating a 3D plot map using the Paleobiology Database, and we explain some advantages and limitations related to this technique.



PHOTOGRAMMETRIC MODELING AND OPTIMIZATION OF A STROMATOLITE BIOHERM FROM THE YACORAITE FORMATION (MAASTRICHTIAN-DANIAN, ARGENTINA): A TOOL TO PRESERVE AND ENHANCE THE PALEONTOLOGICAL HERITAGE

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Keywords

3D modeling, retopology, digital repositories, stromatolites, Quebrada de Humahuaca



The virtualization of the fossil record has aroused an increasing attention. Fossils, as well as outcrops, can be digitized by various techniques, e.g., laser scanner, photogrammetry and/or computed tomography. One of the less explored applications involving 3D models is related to digital preservation and enhancement of the paleontological heritage. Here we present a 3D modeling experience, using high resolution digital photogrammetry and post-processing method of fossil stromatolites from a Maastrichtian outcrop in Maimará (Quebrada de Humahuaca, UNESCO World Heritage Site, Jujuy, Argentina), well known for its ichnological and paleontological record. To model the outcrop, 408 photographs taken over a 18x7 m area were processed using the software Agisoft Metashape. The obtained 3D model (3.63 GB and about 41 million faces) was optimized to facilitate visualization and promote dissemination. Optimization consisted in simplifying the geometry of the model maintaining its original appearance and without changing the overall topology. Retopology was conducted using the software Instant Meshes, while different textures were generated through the software Blender. The resulting 3D model has 31000 faces (4.36 MB), being externally very similar to the original. It can be viewed through any device for domestic use (e.g., laptop, tablet, smartphone) on digital repositories (e.g. Sketchfab), which allows the user to also share relevant information about the real specimens, such as their geological context or paleontological importance. 3D modeling of the fossil record and its optimization represent a very powerful and reliable tool in education, promotion of science and heritage preservation.



HOW TO BRING TAXONOMY INTO THE THIRD DIMENSION: DEVELOPING GUIDELINES FOR THE USE OF 3D DATA IN TAXONOMICAL PRACTICE

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Keywords

3D model, cybertaxonomy, digitization, museum collections, digital curation

Digitization of natural history collections has created new and complex challenges for the scientific community; for instance, the management and nomenclature of newly acquired digital data. Currently, the Distributed System of Scientific Collections (DISSCo) provides research infrastructure dealing with the digital unification of European natural science assets under common curation and access policies/practices following FAIR principles. However, consensus among the (palaeo)biology and natural history communities concerning several topics in digital collections, such as cybertaxonomy, remain debated. We (3DigiPal working group) would like to address these issues within palaeontology and discuss necessary future approaches. Our initial aim is to adequately define quality indicators for 3D models entering digital collections/repositories, how they represent the physical specimens, and how they can then be used in developing accurate research projects. Concurrently, this corresponds with several ethical concerns (e.g., digitization projects in developing countries, or digitization of private collections). Additionally, we want to highlight the importance of digital collection curators/managers, their role, and how to efficiently manage digital collections with regard to their future proofing and updating. Finally, we will work on adequate definitions/terms for identifying specific types of 3D models and accompanying files following the recommendations from international nomenclature codes. Thereby, we aim to delineate the way(s) in which digital collections are curated (i.e., evaluated, stored, hosted) and, throughout their life cycle, managed within the ever-evolving digital landscape. We invite anybody interested in these ongoing discussions to join and participate in the 3DigiPal group.





THE CRANIAL ENDOCAST OF THE LARGEST RODENT AND A COMPARATIVE ANALYSIS OF THE ENCEPHALIZATION IN CAVIOMORPHS

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Keywords

Endocranial morphology, Caviomorpha, *Josephoartigasia*, encephalization quotients

The high ecomorphological diversity of caviomorph rodents in South America includes extinct forms that have reached great dimensions. The largest known rodent was the Dinomyidae *Josephoartigasia monesi* from the Pliocene of Uruguay. This work aims to study the neuroanatomy and encephalization of *J. monesi* (MNHN 921, San José Formation, Uruguay) using virtual endocranial models. For this study 69 specimens of most caviomorph families were also scanned (CT-Scan). To estimate the encephalization quotient (EQ) of each specimen, we employed the endocranial volume converted to brain mass and estimated the body mass based on the average of linear regressions from eight cranial linear measurements. The EQ was estimated based on an equation designed specifically for rodents. Our preliminary results demonstrate that the cranial endocast of *J. monesi* shows: a long olfactory tract, gyrencephaly, superior sagittal sinus forming a longitudinal ridge on the endocranial surface, marked rhinal fissure, and absence of evident paraflocculi. The estimated body mass is 845 kg, and the volume of the endocast is 192,144 mm³. The estimated EQ of *J. monesi* is 0.31. This is a low encephalization coefficient when compared to extant caviomorphs, which we analyzed here (Erethizontidae: 1.04–1.77, Caviidae: 0.75–1.18, Cuniculidae: 1.04–1.44, Dasyproctidae: 1.13–1.33, Chinchillidae: 0.85–1.49, Dinomyidae: 0.97, Echimyidae: 0.76–1.13, Abrocomyidae: 0.94, Octodontidae: 0.88–0.99), a pattern also found recently in neopiblemids (0.36), another lineage of giant rodents. It has been hypothesized that the adaptive value of a low energetic cost and other ecological factors could explain the presence of relatively small brains in giant Neogene rodents.





HOW TO BUILD A SHELL? USING FINITE ELEMENT ANALYSIS TO UNDERSTAND THE EARLY EVOLUTION OF THE TURTLE SHELL

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Keywords

Testudinata, *Proganochelys*, functional morphology, biomechanics, FEA



The turtle shell is a unique evolutionary innovation that encases the animal's trunk, including its girdles. The pelvic girdle is either joined to the shell by soft tissue (Cryptodira and most extinct turtles) or sutured to it (Pleurodira and Proterochersidae). The latter limits femoral protraction during locomotion, but previous Finite Element Analyses (FEA) showed that the rigid connection between those elements contributes to stress distribution yielding similar structural strength to cryptodires, while enabling different shapes to evolve, such as flatter and anteriorly longer shells. Interestingly, the earliest turtles also had sutured girdle elements to their shells: the pelvic girdle in *Proterochersis*, and the epiplastral processes (EP; considered homologous to the clavicles) of the plastron in *Proganochelys* and australochelyids. Here, we explored the functional significance of this trait in *Prog. quenstedti* simulating different scenarios with and without the EP using FEA. Preliminary results show that for dorsoventrally directed forces the stress distribution on the shell of *Proganochelys* is more like in pleurodires than cryptodires, but for mediolateral forces it approaches the cryptodiran strength pattern. We show that the EP function akin to suturing the pelvic girdle but anteriorly instead, redistributing stress to different areas, thus reducing the load on weaker regions of the shell. We submit that during their early evolution, turtles evolved two distinct solutions to structural weakness which required additional struts in the shell. Next, we will analyse models of *Proterochersis* to evaluate the effects of suturing the pelvic girdle in an early turtle, further testing this hypothesis.



CARBONACEOUS COMPRESSIONS IN ECHINODERM FOSSILS: EXAMPLES FROM THE DEVONIAN OF BRAZIL

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Keywords

Ponta Grossa Formation, Echinoderm Lagerstätte, Elemental mapping



Although carbonaceous compressions have been one of the most important modes of soft tissue preservation throughout the geological record, curiously they have not been well registered for any echinoderm fossils so far. Based on this taphonomic gap, we report here analyses of encrinasterid ophiuroids preserved in mudstone beds of the Ponta Grossa Formation, a Devonian epicontinental siliciclastic unit in southern Brazil, regionally known for yielding mold fossils of intact echinoderms. In particular, the analyzed samples correspond to negative molds of *Encrinaster pontis* specimens well-marked by a thin black-brownish film, which typically extends over the surfaces of the disc and proximal arms, and is easily distinguishable from the surrounding matrix. To validate the chemical composition, one of these specimens preserved on a small sample (UFPR 0651 PI) was separated for analysis under Energy-Dispersive X-Ray Spectroscopy (EDS), which revealed high rates of carbon confined along the dark film, as well as notable iron and sulfur contents relative to the matrix. Therefore, it is quite probable that these carbon-rich films are the first records of carbonaceous compressions in fossil echinoderms, apparently as a direct product of the compression of large visceral organs present in the ophiuroid disk, such as the stomach and gonads, whereas the co-enrichment of iron and sulfur suggests concomitant pyrite permineralization. Because of the richness of articulated echinoderms and notable occurrence of organic traces preserved as carbonaceous compressions, we propose the Ponta Grossa Formation as a new echinoderm Lagerstätte from the Devonian of Brazil.



NEW DENTITION INFORMATION OF *CHAOHUSAURUS BREVIFEMORALIS* FROM THE LOWER TRIASSIC OF CHAOHU (ANHUI PROVINCE) REVEALED BY HIGH-RESOLUTION COMPUTED TOMOGRAPHY

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Keywords

Chaohusaurus brevifemoralis, Early Triassic, prey preference, CT scan



Tooth morphology, implantation, and replacement are important to understanding the feeding biology but this is poorly known for basal ichthyosauriformes. Here we studied the teeth of a specimen of *Chaohusaurus brevifemoralis* Huang et al., 2019 (GMPKU P-3086), one of the most basal ichthyosauriforms from the Lower Triassic of South China using micro CT scanning and 3D reconstruction. The reconstructions reveal some new information: the implantation is subthecodont based on the presence of a dental groove with shallow sockets at the bottom. The size and shape of the teeth vary periodically and appear as an odd-even pattern. There are two rows of teeth at the posterior parts of the dentary and maxilla, indicating that the lingual row comprises replacement teeth for the labial row, and each replacement tooth is positioned disto-lingual to its predecessor. Anterior teeth only form a single row, indicating that the replacement tooth is in the distal position of the functional tooth. The teeth are small relative to the skull width. The posterior teeth are blunt while the anterior teeth are slightly more slender, indicating a crunching function for the dentition, possibly for: *Claraia wangi*, *Posidonia* sp., *Periclararia circularis*, *Procolombites* sp., and *Ankitokazocaris chaohuensis*. The dentition pattern of *Chaohusaurus brevifemoralis* is similar to that of *Grippia longirostris* and *Utatusaurus hataii*. The reconstruction of the prey preference of basal ichthyosauriforms is important to reveal the trophic structure of the Early Triassic marine ecosystem, and further discussing the extent to which marine ecosystems had recovered from the end-Permian mass extinction.



THE INTERNAL HORN CORE AND INNER EAR MORPHOLOGY OF AN EARLY BOSELAPHINE BOVID BASED ON HIGH-RESOLUTION X-RAY COMPUTED TOMOGRAPHY

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Keywords

Boselaphini, Bovidae, *Miotragocerus*, inner ear, frontal sinus

Boselaphini is a tribe of early bovids belonging to the subfamily Bovinae. They contain only two extant genera, but they were very abundant and diverse during the late Miocene. During that time, they are common faunal elements all over Eurasia and occur in famous fossil localities such as Pikermi, Samos, Hadjidimovo, Maragheh, and the Siwaliks. Despite their abundance and diversity, their ingroup taxonomy, phylogenetic relationships, as well as their ecology are still under discussion. Here we show the potential of high-resolution X-ray computed tomography for phylogenetic relationships of early boselaphine bovids. The study is based on the internal morphology of the horn core as well as the morphology of the inner ear of one skull of *Miotragocerus monacensis* from the late Miocene hominid locality Hammerschmiede (Allgäu, Germany). The results of the μ CT-analysis of the internal horn core reveal that a deep invading cornual diverticulum of the frontal sinus is already visible in *Miotragocerus monacensis* proving its presence in early bovids. For the first time, we provide a 3D reconstruction of the inner ear of an early bovid. The endocast shows well-developed, round semi-circular canals, a tight cochlea having 2.5 turns, a pouch-like prominent endolymphatic sac, and well-visible secondary lamina. The extraordinarily good preservation and high level of detail show the potential of X-ray computed tomography for early bovids and could help addressing phylogenetic as well as taxonomic issues, if more scans of early bovids are available in the future.





MODELING THE HISTOGENETIC SWITCH FROM ENAMELOID TO ENAMEL

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Keywords

Biomodélisation, EmbryoMaker, Evolution, Mineralized skeleton, Vertebrates



Enamel and enameloid are hypermineralized tissues that can be found on the surface of vertebrates' teeth and odontodes. Contrary to enamel, whose origin is exclusively epithelial, enameloid is characterized by a dual epithelial and mesenchymal origin. The earliest evidence of enamel are found in stem-osteichthyans from the Silurian, while enameloid was already present in some stem-gnathostomes of the Ordovician. It has been suggested that enamel derived from enameloid, but it is still unclear what developmental processes would have had to be modified to induce this transition. It has been hypothesized that a delayed epithelial cell activity, a prolonged epithelial cell activity or a modification of the epithelial cells' production (from mostly collagen to mostly enamel proteins) could explain this transition. We built a cell-based histogenetic model based on simplified properties common to all current vertebrates. Depending on the parameters coding for the rules governing the behaviour of the secreting cells, the simulations are able to reproduce a large array of variation in terms of relative amount of dentin, enameloid and enamel. This allows us to explore the putative role of various developmental parameters in the enameloid to enamel transition. Our preliminary results suggest that more than one developmental parameter has to be modified to enable the transition, and that both the timing and the position of the nucleation of the mineralization front are driving the resulting proportions of enameloid and enamel.



HIGH RESOLUTION COMPUTED TOMOGRAPHY FOR PORES AND BIOEROSION OF *UVIGERINA* SP.: ADVANCES AND LIMITS

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Keywords

High resolution, Computed tomography, Foraminifera, Bioerosion, Pores

Foraminifera are important proxies for paleo-environmental reconstruction. They are visually determined with a light microscope (LM) and a scanning electron microscope (SEM). Both methods are non-destructive 2D surface analyses. SEM resolution offers very fine observation of the pores and microboring. Pores can be used for the oxygen content analysis coupled with geochemical analysis. The bioerosion from other organisms like fungi and cyanobacteria are visualised as boreholes on the surface and are used for the living environment interpretation. Semi-destructive or destructive preparations are needed for internal evaluation such as test dissolution or cutting. The 2D analysis also lacks the relational of 3D observations. The use of laboratory high resolution computed tomography (HRCT) for the 3D internal and external evaluation of foraminifera, of their pores and bioerosion, gives a better understanding of the distribution and relation of the pores to each other and to the morphology. This non-destructive technology is relatively young and its capabilities are quickly evolving in higher resolution, better contrast and therefore more precise datasets. Its capabilities coupled with easy access offer the best chance for quick and complete morphological evaluation. In our study, we measured 3 *Uvigerina* sp. of 3 sizes and compared the visibility of the determination criteria as well as their pores and bioerosion. We observed that the determination of the species was possible from all three sizes. The smaller features from all specimens could be analysed and measured hence specific post-processing and thorough segmentation.





RE-APPRAISAL OF THE LATE MIOCENE ELASMOTHERE *PARELASMOTHERIUM SCHANSIENSE* USING HIGH RESOLUTION X-RAY COMPUTED TOMOGRAPHY

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Keywords

Late Miocene, China, Elasmotheres, Dentition, Computed Tomography



Elasmotheres are amongst the most iconic large mammals ever to roam Eurasia and Africa, including the huge Siberian unicorn (*Elasmotherium sibiricum*). Several elasmothere taxa are documented during the late Miocene in Asia, including the large, single-horned *Parelasmotherium*. The type species, *Parelasmotherium schansiense* Killgus, 1923, was originally erected from three associated upper cheek teeth, including the D4, M1, and the unworn M2, from the late Miocene of Kutschwan (Shanxi, China). Its diagnosis was based on the following dental characters: the large size, the hypsodonty, the presence of cement, the wrinkled enamel, and the relatively low enamel thickness of the teeth. Herein we present the re-examination of the holotype of *P. schansiense* using high resolution X-ray computed tomography conducted at the Centre for Visualisation, Digitization, and Replication at the University of Tübingen, Germany. The μ CT-analysis reveals thus far unknown morphological features of the unerupted P4, found below the D4, and the M2. The P4 exhibits well-developed double crochet and crista that fuse at a very early wear stage, forming a 'pseudometaloph', while the metaloph never fully closes. Both the M1 and M2 feature strongly wrinkled enamel, when moderately worn, almost comparable to *Sinotherium*. This allows comparisons to the other *Parelasmotherium* species, *Parelasmotherium simplum* and *Parelasmotherium linxiaense*, the validity of which and relationship to *P. schansiense* have been questioned in the past. Furthermore, enabling comparisons to other Miocene members of elasmotherines, like the more primitive *Hispanotherium* and *Iranotherium* and the more derived *Sinotherium* in order to depict a more exhaustive evolutionary framework.



CONCAVICARIS WOODFORDI (EUARTHROPODA: PANCRUSTACEA?) INSIGHT INTO THE THYLACOCEPHALAN ANATOMY USING MICRO-COMPUTED TOMOGRAPHY

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Keywords

Thylacocephala, Late Devonian, virtual palaeontology, internal anatomy, shield structure, Euarthropoda

Known from at least the Silurian to the Cretaceous, Thylacocephala is an enigmatic extinct group of euarthropods with possible pancrustacean affinities. Previous studies show that they are characterized by a folded protective shield, hypertrophied compound eyes, three pairs of raptororial appendages, 8 pairs of gills and an 8 to 22-segmented trunk. Despite this knowledge on the anatomy of thylacocephalans, many questions remain, especially on the anatomy of Palaeozoic representatives. Among Palaeozoic taxa, *Concavicularis* is the most common one, with many representatives described from outcrops in the U.S.A. The upper Devonian Woodford Shale (Upper Fammenian, Oklahoma, USA) has yielded several euarthropods, among them two species of Thylacocephala: *Concavicularis elytroides* and *Concavicularis woodfordi*. Micro-computed X-ray microtomography was used to re-explore the anatomy of a well-preserved specimen of *C. woodfordi*, showing fine details of the shield structure, gills, posterior trunk appendages and of the digestive system. A marginal infold of the shield as well as an anon-mineralised inner layer are described for the first time in a thylacocephalan. *C. woodfordi* shares similarities with *Concavicularis submarinus* also from the Fammenian, including the morphology of the shield and the internal anatomy. The digestive system displays similar features with the one from Mesozoic taxa, such as *Dollocaris ingens*. This provides important information in order to reconstruct the evolution of this taxon.





3D REPRESENTATION OF FRONTAL SINUSES OF LATE MIOCENE BOSELAPHINES

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Keywords

frontal sinus, CT, late Miocene, Boselaphini



The advancement of technology allows us to represent digitally the external morphology in detail of fossils, but also to reveal hidden internal features that were previously inaccessible. The cranial internal structures of fossilized mammals are to this day one of the most poorly described features. Boselaphini appear to be an ideal case study because they present an exceptional cranial diversity in terms of size and shape and also possess extensive frontal sinuses that vary within species. These internal features are considered to be of phylogenetic importance and of different function and use. The present study focuses on the crania of two boselaphine genera (*Tragoportax* and *Miotragocerus*) from Upper Miocene Greek localities, that are now digitally visualised with the aid of X-ray computed tomography. This method allows a more detailed description concerning their previously inaccessible internal anatomy, including pneumatization and endocranial anatomy. Herein, we demonstrate the unique internal morphology that these species possess, so as to explore the variance inside this group in terms of frontal sinuses. Presenting a quantitative approach of the frontal sinus morphology that is comprised by wide frontal sinuses conforming closely to the shape of the frontal bone and that extend up to the base of their horn cores. Sexual dimorphism is also detected through the volumes of the frontal sinuses. The volume of the sinuses was strongly correlated to the frontal bone size and cranial volume.



RE-EVALUATION OF THE CAMBRIAN EUARTHROPOD *RETIFACIES ABNORMALIS* IN THE LIGHT OF COMPUTED TOMOGRAPHY

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Keywords

Cambrian arthropod, ventral morphology, computed tomography, phylogeny

Retifacies abnormalis is an euarthropod characterized by mesh-like ornaments on its dorsal exoskeleton from the early Cambrian Chengjiang Biota, Yunnan Province, China. Although many phylogenetic studies have included the coding of *R. abnormalis*, the knowledge about the ventral organization of this animal has remained limited since 1999. Here, we employ a non-destructive method, i.e. micro-computed tomography (micro-CT), to illustrate the ventral morphology of *R. abnormalis* that are often hidden in the fossil slabs. Other methods such as light and fluorescent microscopies have also been used to extract the information preserved on the surface of the fossil slabs. Our data demonstrate that *R. abnormalis* has five cephalic appendage pairs in three different forms: a pair of uniramous antennae, three pairs of uniramous appendages, and one pair of biramous appendages with a similar organization to the subsequent thoracic (10 pairs) and pygidial appendages (5 to 6 pairs). Each antenna consists of approximately twenty podomeres, with several setae on almost all podomere boundaries. Eight podomeres including a sharp terminal claw are found in each uniramous head appendage. It seems that all the biramous appendages consist of a multi-lamella exite, an exopodite with over ten lamellae, a five-podomere endopodite, and a protopodite. Based on the new data, we re-analyze the phylogeny and suggest a modified phylogenetic position of *R. abnormalis*.





NEW METHODS IN FINITE ELEMENT ANALYSIS FOR INFERRING ECOLOGICAL TRAITS IN THE FOSSIL RECORD

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Keywords

Finite Element Analysis, Vertebrates, Morphology, Fossil, Comparative Methods



The application of finite element analysis (FEA) in the vertebrate fossil record has provided new insights about the functional constraints, as well as the adaptive value of different morphologies. The results obtained in comparative FEA works have been analysed in two main categories: 1) qualitative comparisons of stress (or strain) distribution maps and 2) quantitative analyses that involve the statistical analysis of the numerical results obtained from FEA. Recently, we have advanced some powerful and original methods for the effective post-processing of FEA outputs in a quantitative manner that were specifically designed to compare several different FEA models. These new methodologies have been tested in an extensive comparative set of multivariate data by applying them to two different classic biomechanical cases: 1) the study of chewing performance in FEA models of different mammal mandibles and 2) the study of the locomotor behaviour of different primate groups by analysing their ankle morphology. The obtained results clearly show that it is possible to effectively distinguish dietary preferences and locomotor behaviours when analysing biomechanical data derived from FEA by means of multivariate statistics. These data were also used in evolutionary comparative analyses such as estimating phylogenetic signal and computing ancestral state reconstructions. Moreover, the use of machine-learning algorithms to process all these quantitative data allowed us to predict dietary and locomotor classifications for the fossil taxa under study. The presented methods are opening a new path to introduce computational and biomechanical models into evolutionary frameworks and palaeobiological studies.



ENDOCRANIAL ANATOMY OF THE TUATARA AND THE FIRST DESCRIPTION OF THE ENDOCAST OF A FOSSIL RHYNCHOCEPHALIAN

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Keywords

Endocranial Cavity, *Clevosaurus brasiliensis*, *Sphenodon punctatus*, Sphenodontia

The casts of endocranial cavities (endocasts) provide neuroanatomical and biological information about the taxa. Studying endocasts of extinct animals improves the understanding of the diversification of the brain of vertebrates. Digital endocasts, obtained through Computed Tomography (CT), have made the study of the endocranial cavities more accessible. Despite being a well-known taxon, there are no studies so far focused in endocasts of rhynchocephalians. Currently represented only by *Sphenodon punctatus* (“tuatara”), endemic to New Zealand, Rhynchocephalia was very diverse during the beginning of the Mesozoic. In the Upper Triassic of Brazil, its most abundant representative is *Clevosaurus brasiliensis* (Caturrita Formation, early Norian). This study aims to describe the brain endocasts of *S. punctatus* (YPM 9194) and *C. brasiliensis* (MCN-PV 2852). The models were generated from CT scans. The endocast volume, length and width are: 1325.08 mm³, 41.02 mm and 9.62 mm for *S. punctatus*, and 111.89 mm³, 18.5 mm and 5.98 mm for *C. brasiliensis*. In both species, the cerebral hemispheres, optic lobes, and cerebellum are undistinguishable, the olfactory tract is dorsoventrally and transversely narrow, widening at the olfactory bulbs, the dorsal surface of prosencephalon and mesencephalon is diamond-shaped, and the lateral faces of the medulla oblongata are parallel. Some characteristics of *C. brasiliensis*, in comparison to *S. punctatus*, are: endocast volume smaller in relation to cranium size; endocast proportionally longer in relation to the length of the cranium; olfactory tract and portion posterior to the pituitary proportionally shorter, and cerebral hemispheres proportionally wider.





FINITE ELEMENTS ANALYSIS SUGGESTS A DEFENSIVE ROLE FOR OSTEODERMS IN TITANOSAUR DINOSAURS (SAUROPODA)

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Keywords

FEA, Sauropods, Titanosaurs, Osteoderms, Cretaceous



Titanosauria is the only sauropod clade to exhibit the presence of osteoderms. Many functions for these unusual elements have been proposed, such as interspecific and intraspecific display, and thermoregulation. Several titanosaur osteoderms have large internal cavities, which has led to osteoderms being hypothesized as mineral reservoirs to be used during periods of stress. The idea that titanosaur osteoderms could act as defensive structures was also proposed along some of their first records, but their relative scarcity and apparent fragility call this hypothesis into question. In order to test a possible defensive function, we used finite element analysis to simulate bites of two putative predators, an abelisaurid theropod and a baurusuchid crocodyliform, on titanosaurian osteoderms from the Late Cretaceous of Brazil. Two similarly-sized osteoderms were used, one that went from internal resorption and one composed of solid, spongy bone. Our results indicate that the solid osteoderm exhibited lower overall Von Mises stress when compared to the hollow osteoderm. These results indicate that titanosaurs may have used their osteoderms as defensive structures as long as they did not undergo extreme bone tissue loss (e.g., during extreme dry seasons or in gravid or nesting females). Also, that solid titanosaur osteoderms could withstand bite forces of likely titanosaur predators whereas hollow ones could not, raising the possibility that some titanosaur osteoderms could have played a role in defence. This potential function could especially benefit titanosaurs during early ontogenetic stages, if juvenile osteoderms were proportionally larger and closer to each other.



ECOLOGICAL NICHE MODELING OF THE SOUTH AMERICAN LATE PLEISTOCENE MEGAFUNA: EXPLORING REGIONALIZATION AND CONNECTIVITY

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Keywords

Species Distribution Modeling, Last Glacial Maximum, Maxent, Migration, Ecoregions



The late Pleistocene megafauna of South America represents a unique assemblage of large mammals that occupied almost all parts of the continent. These species were important parts of their ecosystems, with roles related to seed dispersal, nutrient transport, and biotic connectivity, among others. Most of these taxa became extinct at the end of the Pleistocene, coinciding with the establishment of warmer climatic conditions and the expansion of human populations in the continent. Here, we explore the climatic adaptations and potential distribution of 39 herbivorous taxa (including Artiodactyla, Perissodactyla, Proboscidea, Notoungulata, Litopterna, and Xenarthra) belonging to the late Pleistocene megafauna using Ecological Niche Models (ENMs). We compiled occurrence records of the studied taxa assigned to the Last Glacial Maximum (LGM) and used available paleoclimatic data for the corresponding period to implement ENMs. Furthermore, we performed cluster analyses to explore groupings of taxa based on climatic preferences. Our results show that the studied taxa can be grouped in three clusters, which roughly represent preferences for different precipitation and temperatures. Furthermore, the geographic projections of the climatic niches estimated for these taxa support the regionalization of faunas coinciding with previously proposed ecoregions in South America during the LGM. Finally, we used connectivity modeling algorithms to analyze the landscape connectivity during the late Pleistocene and discuss potential migration routes and corridors of megamammal taxa between available habitats and ecoregions.



FINITE ELEMENTS ANALYSIS OF SLOTHS' MANDIBLES SHOWS DIFFERENCES IN ECOMORPHOLOGICAL ADAPTATIONS AMONG TAXA

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Keywords

Mastication, Diet, Folivora, Xenarthra

Sloths are a group of xenarthrans represented today only by two distantly-related extant genera of arboreal and folivorous small mammals. However, the fossil record of the clade is composed of many more taxa, with a much more diverse morphology, including giant terrestrial forms with no clear modern analogues. In this context, several approaches have been implemented in order to explore the ecological adaptations of fossil taxa and, in particular, their dietary preferences. In this work we used Finite Elements Analysis (FEA) in order to explore the ecomorphology of sloths and possible differences among taxa related to dietary adaptations. 3D models of the mandibles of 11 taxa were obtained (two extant and nine extinct) representing members of all the major clades within the group. We modeled the three major muscles involved in mastication (masseter, temporalis, and pterygoid) and simulated unilateral mastication in four different conditions, one for each tooth along the toothrow. The results were analyzed qualitatively regarding the distribution of von Mises stress (vMs) and quantitatively using the average vMs, strain energy (SE), and mechanical efficiency (ME, calculated as output bite force divided by input muscle force). Differences in the distribution of high-vMs areas and lower SE values were found among taxa predicted to be grazers in comparison to those predicted to be browsers. Furthermore, we observed considerably higher vMs and SE values in taxa with caniniform, which could indicate its involvement in sexual display rather than in food processing or more strenuous activities.





ANATOMICAL NETWORK ANALYSIS: A NOVEL SOLUTION FOR OLD QUESTIONS

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Keywords

Virtual Palaeontology, Networks, Morphology, Complexity, Modularity



While a revolution is happening following recent developments of new technologies that allow virtual modelling of unique fossils, another similar revolution is taking place at the same time. Following the pioneering work of Borja Esteve-Altava and Diego Rasskin-Gutman, the science of network theory has been applied to anatomy, creating a new branch: Anatomical Network Analysis. The connected parts that form a skeleton are conceptualized as the nodes of a network, connected by links that represent sutures, contacts, and articulations; altogether, they allow to create a model and to describe the topological organization of the anatomical structure focusing on the connectivity pattern between the various elements. Through successive levels of abstraction, Anatomical Network Analysis allows describing and comparing both the entire structure and each individual element as well, using different metrics. Anatomical Network Analysis is novel, fast, and relatively easy to use, without the use of any special equipment. It promotes collaboration within and across disciplines and provides complementary answers to old questions that deal with morphological complexity and integration, modularity and development. The purpose of this communication is to present this methodology via published and unpublished applications in diverse projects related to palaeontology, which will exhibit the great potential and value of this methodology.



CONTROLLED FEEDING EXPERIMENTS WITH JUVENILE ALLIGATORS REVEAL MICROSCOPIC DENTAL WEAR PATTERNS ASSOCIATED WITH HARD-OBJECT FEEDING

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Keywords

Microwear, DMTA, diet reconstruction, Crocodylia, dental wear



Dental wear analyses are classically applied to mammals because they have evolved heterodont dentitions for sophisticated mastication. Recently, several studies have shown a correlation between pre-assigned and analytically inferred diet preferences in extant reptiles through dental microwear texture analysis (DMTA), a method using quantitative assessment of microscopic wear marks to reconstruct diet material properties. First tentative applications of DMTA to extinct reptiles have followed. However, for large and small mammals, microwear analyses have undergone a long time of ground-truthing through direct feeding observations, stomach content analyses, and feeding experiments. Such data is currently lacking for reptiles, but necessary to further extend DMTA especially to Archosauria, as application to dinosaurs could be of great interest to the scientific community. We here present data from a pilot feeding experiment with five juvenile American alligators (*Alligator mississippiensis*). Each individual received a diet of assumed different mechanical properties for ~4 months: reptile pellets (control), fish, quails, rats, or crawfish. All individuals initially received the same pellet diet, and we found them to show similar surface texture patterns before they were switched to their designated experimental diet. From the first feeding bout on, DMTA differed across the diets. The crawfish feeder showed consistently higher surface complexity, followed by the rat feeder. Quail and fish-feeding resulted in similar wear signatures. Fast tooth replacement likely affected microwear formation, but we were able to detect a general hard (crawfish, rat) versus soft (quail, fish) DMTA signature. Such patterns can support identification of hard-object feeding in the fossil record.



WHAT CAN WE LEARN ABOUT THE EARLY CAMBRIAN EUARTHROPODS WITH HELP FROM COMPUTED TOMOGRAPHY?

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Keywords

Cambrian euarthropods, ventral morphology, micro-CT, Arthropod Head Problem

Euarthropod fossils from the early Cambrian Chengjiang Biota, Yunnan, China have played an important role in understanding the early evolution of this successful group of invertebrates. Compared to fossils from other Cambrian Lagerstätten (e.g., the Burgess Shale), the relatively heavy pyritization of the exoskeleton of those Chengjiang fossil euarthropods enables the combination of micro-Computed Tomography (micro-CT) with computer-based 3D rendering techniques, to reveal previously unknown morphological details. Such details include the structures on the ventral side of these early euarthropods, which are often preserved inside the fossil slabs but are key in understanding the precise morphology of the animals as well as their phylogeny. Based on the new data, we can make more accurate cases in species identification and taxonomic assignment such as the cases of *Xandarella spectaculum* and *Xiaocaris luoi*. We can also tackle long-standing questions pertaining to the early evolution of euarthropods, such as the evolution of their limbs (e.g., *Ercaicunia multinodosa*, *Naraoia spinosa*, *Retifacies abnormalis* etc.), their ontogenetic modes (e.g., *Leanchoilia illecebrosa*), and the famous “Arthropod Head Problem”. We aim to involve many more euarthropod species from Chengjiang (e.g., fuxianhuiids, megacheirans, trilobitomorphs), and build up a useful, informative database for future studies.



The aim of this session is to offer a forum to discuss the current situation about the status of the palaeontological heritage around the world. We encourage the potential contributors to share their experiences and opinions about the needs, barriers, and downsides of the recognition and preservation of palaeontological heritage and how its protection is framed within the Sustainable Development Goals “SDG” of the UNESCO 2030 agenda.

Another topic of discussion is whether the palaeontological patrimony should be linked with the geological heritage or whether it should be managed separately. In addition, it is necessary to review the characterisation criteria of movable and immovable palaeontological goods for their inclusion as palaeontological heritage. Since different proposals for evaluation criteria and conservation figures at a global, regional or local level have been used in several countries, it would be interesting to discuss coincidences and differences of the diverse points of view.

All this, together with the unstoppable increase in the digitisation of paleontological remains and sites, makes us wonder if a redefinition of the Palaeontological Heritage of the 21st century is necessary. We would like to extend our invitation to potential proponents to share their strategies for getting society involved in effective conservation plans at mid- and long term.

Palaeontological Heritage in the 21st Century

Organisers

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Thematic Session



DISSEMINATION METHODS IN PALAEOLOGY: HOW TO EMPHASIZE THE VALUE OF A PALAEOLOGICAL SITE

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Keywords

Palaeontological Dissemination, Paleontological Sites, Palaeontology Teaching, Palaeontological Heritage, Social Palaeontology



One of the objectives of enhancement of paleontological sites is to share with society the knowledge obtained from their study. Thus, requires effective dissemination that manages not only to inform the greatest number of people, but also to incite curiosity to know more. The task of bringing palaeontological and scientific knowledge correctly to general audience arousing their interest is not easy. For this reason, before carrying out any dissemination strategy some aspects must be evaluated, such as the target audience, the difference between the real and potential palaeontological value of a site or its possible heritage interests. According to this, here is proposed to define different types of dissemination:

- 1) Dissemination of Scientific Value: to give detailed information of the fundamental features that define the geological site (sedimentology, palaeontology, geomorphology, etc.) Aimed at an audience with enough educational level and basic ideas about the discipline.
- 2) Dissemination of Didactic Value: Information on palaeontological aspects of the site that are in accordance with the contents included in educational curricula. Aimed at teachers and students of formal education.
- 3) Dissemination of the Touristic-Recreational Value: provide notions of palaeontological information using attractive resources of the area as leitmotif (fossil remains and palaeoenvironmental reconstructions). Aimed at a wider audience, who do not necessarily have previous ideas about palaeontology.

In line with this proposal, it should always be highlighted the possible need for protection and conservation of the palaeontological heritage of a site, as it can be the first step to increase its real value.



GUIDELINES FOR THE INVESTIGATION OF FOSSIL REMAINS OF PALAEOLOGICAL INTEREST IN MEXICO: OBJECTIVE AND APPLICATION STATUS

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Keywords

Palaeontological heritage, INAH, Council of Palaeontology



The National Institute of Anthropology and History (INAH) is the Mexican federal agency in charge of the preservation and protection of palaeontological assets, based on Article 28bis of the Federal Law on Archaeological, Artistic and Historic Monuments and Zones. Through the regulation of research activities, attend to fortuitous fossil finds, register paleontological collections, as well as authorize permits for the export and import of fossils for research and/or exhibition purposes. The Palaeontology Council (**ConPal**) is a collegiate and consultative body of the general direction of INAH, integrated by specialists in palaeontology research and teaching from different institutions nationwide. The mission of the council is to generate guidelines to regulate research, teaching, and use of fossils of palaeontological interest. In the case of the regulation of research activities, the ConPal considered the stages of prospecting, collecting, preparing, studying, and safeguarding, with which the precautionary measures to preserve and conserve palaeontological goods can be established, creating the document “Guidelines for the investigation of fossil remains of palaeontological interest in Mexico”. These guidelines consist of eight chapters and associated formats that consider the type of research, how it should be developed, the type of reports, the safeguard collections, the register of localities, the publications, and the criteria that allow establishing the palaeontological interest. The text is available online INAH’s website (www.consejopaleontologia.inah.gob.mx). The implementation of those regulations will serve as a departure point for evaluating, and possibly modifying the initial proposal, based on the study cases in Mexican territory for the development of palaeontological heritage research, and its monitoring.



DINOSAUR TRACKS IN AN ALBIAN BRAID DELTA SYSTEM OF THE BILLAO CAPE GEOSITE, BISCAY (GORLIZ, BASQUE CANTABRIAN BASIN)

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Keywords

Cabo Billano, dinosaur tracksite, ichnoassociation, Geoheritage, Albian

The Geodiversity Strategy of the Autonomous Community of the Basque Country (2020) aims to assess the geodiversity of this territory and its geological heritage. For this purpose, 150 sites of geological interest (geosites) were identified as the basis for a plan of geodiversity management and conservation. One of these geosites is the Billao Cape Complex (LIG 125), located in the city of Gorliz, on the coast of Biscay. It takes part of the Western Biscay Coast Area of Natural Interest, which also includes the Armintza LIG 24. Both geosites are characterized by impressive outcrops of coastal to deep marine Albian sedimentary successions forming a nice example of tectonically controlled sedimentation with igneous activity. The Billao Cape geosite has also a key palaeontological interest as evidenced by the record of dinosaur tracks and other trace fossils. The tracksite is in the Monte Grande Formation (lower Albian), interpreted as a retreating braid delta that was formed during a transgressive event related to a hyperextension phase in the basin leading to the opening of the Bay of Biscay. Four track-bearing levels (two of them previously described) with more than a hundred dinosaur ichnites, including theropod trackmakers, possibly sauropods and undetermined dinosaurs, were identified. The invertebrate ichnoassociation contains *Ophiomorpha*, *Skolithos* and locally *Teichichnus*. The Gorliz dinosaur tracksite is one of the very few worldwide localities where Albian dinosaur tracks have been found in deltaic facies, and one of the few localities with dinosaur footprints of this age in the southwestern European island archipelago.





FOSSIL HERITAGE CONSERVATION IN THE MUNICIPALITY OF SANTANA DO LIVRAMENTO, SOUTHERN BRAZIL: FIRST STEPS

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Keywords

Dinosaur, Cerro Palomas, footprints



“Natural Heritage” refers to all elements of biodiversity and geodiversity, including flora, fauna and geological structures. It encompasses areas of conservation importance, whether due to scientific, historical or scenic beauty. Fossils, as remains or evidences of living beings from the past, are a very important part of this natural heritage, as they provide unique information about the evolution of life and the planet over time. This work aimed to highlight the importance of paleontological heritage, using as an example an outcrop in southern Brazil. The Cerro Palomas outcrop, at the municipality of Santana do Livramento (Rio Grande do Sul, Brazil), was described in 2007. Sixteen sauropod dinosaur tracks (undertracks) were identified, in addition to burrows of invertebrates. They are part of Guará Formation, where the only dinosaur track record for the Brazilian Jurassic are known, being a record of great scientific and conservation importance. Currently, due to the lack of protection, around nine footprints are visible; all of them very eroded. The protection of fossil heritage has several benefits: fossils are attractive and promote tourism, moving the municipal economy; additionally fossils generate scientific interest in all audiences and bring recognition to the city that houses them, in addition to the aforementioned scientific importance. Thus, Santana do Livramento municipality, through dialogue with the authors, recognized the presence of these fossils and built signs indicating the footprints. Today, this and other neighbor municipalities are working to expand the protection of their fossil heritage through the construction of barriers and shelters.



THE FOSSIL CEPHALOPOD COLLECTION OF GEORG GASSER (1857–1931)

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Keywords

Historical Collections, Wunderkammer, Mollusks, Ammonoidea



The paleontological collection of the self-taught naturalist Georg Gasser (1857–1931), formerly exhibited in his “Wunderkammer” (cabinet of curiosities), is considered the original core of the Museum of Nature South Tyrol. The collection is the object of a project funded by the same Museum, in order to inventory, catalog, and digitalize the specimens that still need a complete revision. Through its valorization, the collection will get back to the community as Gasser wanted. Actually it is composed of about 1.500 fossils of which slightly more than 75% are fossils of animals, and of these 79% are invertebrates. Mollusks are the dominant group. Cephalopod remains constitute 42% of the total number of mollusks. Unfortunately, about 35% of the specimens lack detailed information. The biggest portion of the cephalopod collection originates from Central Europe, especially from Germany and from the territories of the former Austro-Hungarian Empire. Historical *Fossilagerstätten* and famous fossiliferous lithostratigraphic groups like the Triassic Muschelkalk and the Jurassic Solnhofen Plattenkalks of the German states of Baden-Württemberg and Bavaria, are well represented by ammonoids, nautiloids and coleoids. The stratigraphically oldest specimens date back to the Silurian and Devonian and originate from Germany, Poland and from Bohemia (now part of Czech Republic). The youngest specimens originate from the Cretaceous of Rügen (Germany). Rare samples come from the Gault Formation of England. Peculiar is the fact that ammonoids from Northern Italy, and especially from the Trentino-South Tyrol area, are relatively rarely represented in the collection.



THE FOSSIL PLANT COLLECTION OF GEORG GASSER (1857–1931)

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Keywords

Historical Collections, Paleobotany, Preservation, Carboniferous, Central Europe



The historical paleontological collection of Georg Gasser (1857–1931) at the Museum of Nature South Tyrol, Italy, is composed of 1500 fossils. A project funded by the same Museum has the aim of inventorying, cataloging, digitalizing the specimens that still need a complete revision. Actually the 20% (244 specimens) of the collection is composed by plant remains. Unfortunately various re-collocations over time have brought to a loss of samples and data. 150 specimens were determinable at least at major taxon level. It does not surprise that the largest part of the entire collection comes from the Carboniferous of Germany and the Czech Republic. The Carboniferous specimens include lycophytes, ferns or seed ferns fronds, and horsetail stems; being scarce the Cordaitaleans. At the moment Paleogene plants are 14 from the floras of Bad Häring and Mount Promina. Besides at the actual state of work the Neogene is represented by 14 specimens, mostly Miocene plant remains (Angiosperms) from Münzenberg (Germany). Triassic specimens (11) come from the Keuper of Zirl (Austria) and from the Middle Triassic Wengen Formation (Dolomites). Permian specimens (ferns) come from Mölten/Meltina (South Tyrol), Ilmenau (Germany) and other localities of Czech Republic (Rakovnik, Staré Oldřůvky). The plant fossil assemblage of the Gasser collection mainly come from the most famous Central European mining areas, documenting the most important floras of the geographical areas that were at the beginning of twentieth century under the control of Austrian-Hungarian Empire (Austria, Germany, Croatia, Romania, Poland, Czech Republic, South Tyrol).



ALPONE VALLEY AND ITS PALEONTOLOGICAL COLLECTIONS WORLDWIDE

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Keywords

Historical Collections, Paleobotany, Preservation, Carboniferous, Central Europe

Alpone Valley, in the eastern Lessini area (Veneto, Italy), has a great paleontological heritage, with a rich documentation of the Cenozoic flora and fauna. In particular, one of the most famous Eocene fossiliferous sites is located in this valley, which is known worldwide especially for its fossil fishes: Bolca. However, Bolca is not the only paleontological site in the area, at least two more Eocene localities are known for their invertebrate fauna: Roncà and San Giovanni Ilarione. During historical and present excavation campaigns, lead now by the Natural history museum of Verona, many specimens have been collected from these sites and part of them is now hosted both in Italian and in international museums or collections. A research project has been carried out to collect information about the distribution and the consistency of this incredible paleontological heritage. Although this is constantly a work in progress, due to the large amount of data and the great dispersion of the collections, a preliminary overview can be presented, with the aim of stimulating new collaboration, and a network between museums. Besides, this work is part of the process of promoting the natural and cultural values of Alpone Valley and supporting its nomination as UNESCO World Natural Heritage Site.





THE VERTEBRATES OF THE “GEORG GASSER” COLLECTION

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Keywords

Historical Collections, Vertebrates, Fishes, Reptiles



The South Tyrol Nature Museum in Bolzano/Bozen houses one of the most significant historical fossil collections of the alpine region, compiled at the turn of the 19th and 20th century by Georg Gasser (1857–1931). The collection suffered various relocations after Gasser’s death, affecting the preservation of the fossils and the presence and quality of the labels. A series of dedicated research projects is now providing the restoration and digitization of this important palaeontological heritage. Currently, the collection comprises about 1500 fossils. More than 200 specimens belong to vertebrates. Fishes, reptiles, and mammals are the taxonomic categories represented. The collection of vertebrates is composed of specimens that mainly come from Germany (137), with additional samples originating from Italy (24), Austria (5), England (2), Spain (2), USA (2), and the Czech Republic (1). The remaining 32 samples lack any geographic information. Well represented are some well-known Fossilagerstätten such as Mansfeld (Permian), Solnhofen (Jurassic), Bolca (Eocene), and Ulm (Miocene). About 41% of the vertebrates are represented by mammals, mainly from Quaternary sites, with some exceptions from the Neogene and Paleogene. Fishes amount to 44% of the entire collection. The rarest among the vertebrates are the reptiles (10%), focused mainly on Mesozoic findings, including teeth and osteoderms from the Triassic of Aixheim and *Dakosaurus maximus* from the Jurassic of Sigmaringen, both German localities. A single ichthyosaur vertebra comes from the Jurassic of Tuttlingen (Germany), and there are also some teeth of placodonts, including one from Trento (Italy). Cenozoic reptiles are represented by one tooth from the Neogene of Menorca (Spain).



THE FOSSIL COLLECTION OF GEORG GASSER (1857–1931): CONSERVATION AND MANAGEMENT OF A HISTORICAL PALAEOLOGICAL HERITAGE

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Keywords

Historical Collections, Conservation, Management



At the turn of the 19th and 20th century the self-taught naturalist Georg Gasser (1857–1931) compiled one of the most extensive collections of minerals, fossils and zoological specimens then to be seen in Tyrol. What survives of his vast collection is today stored in the South Tyrol Nature Museum in Bolzano/Bozen. While Gasser is primarily known as a mineralogist, his palaeontological collection received little attention until very recently. A research project by the Museum is now closing this gap by restoring, studying and digitizing this historical collection. One of the aims of the project is to infer what interests lead Gasser in choosing the specimens he acquired, and how he acquired them. The presence of fossils from primarily Germany and secondly from northern Italy and Austria testifies that the collecting effort was guided both by the geographic proximity of these localities and by the accessibility of contacts, facilitated by the common German language. The value of the specimens is not always linked to their state of conservation, but sometimes to their rarity, to the fame of the source area or to the unusual origin and preservation. Although rare, some labels give information about the date of collection or, exceptionally, on the collector. An interesting and exclusive example is the remain interpreted, on the label, as a vertebra of *Zeuglodon*, object of a special donation from the prince of Salm-Salm, an historical region located in Rhineland-Palatinate. This particular evidence provides a glimpse on the network of relationships that Gasser had.

Conservation paleobiology is an emerging field that applies data, concepts, and theories from diverse disciplines, including paleontology, geology, and paleoecology, with the purpose of biodiversity conservation and ecosystem management. Currently, humanity is facing grave consequences from rapid climate change, pollution, biosphere alteration, and species extinctions. However, direct ecological observations of anthropogenic impacts and environmental change rarely span more than the last few decades. To understand more fully how ecosystems have responded to multiple stressors through time we need to seek answers in the past. Geohistorical records can help overcome the temporal limitations of traditional ecological monitoring. They provide insights into ecosystem changes and biotic responses to major environmental perturbations over long timescales, thus facilitating reconstructions of past ranges of variability and supporting the theoretical foundations of future conservation efforts.

We invite contributions from paleontology and related fields including (but not limited to) archaeology, anthropology, and historical ecology. We are particularly open to submissions on the topics of near-time and deep-time perspectives on eco-evolutionary processes during episodes of rapid (natural and anthropogenic) environmental change and potential biases affecting the fossil record. In addition, we encourage submissions on collaborations with practitioners and conservation efforts that use historical data.

We hope to gather exciting and thought-provoking contributions that will stimulate discussions between scientific disciplines and practitioners around urgent questions in conservation paleobiology.

This session is supported by the Conservation Paleobiology Network (CPN)



Conservation Paleobiology – Bridging Past and Future

Organisers

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Thematic Session



BIOASSEMBLAGES RECORDED FROM HOLOCENE SEDIMENTS REVEALING THE PHASES OF ENVIRONMENT OF DEPOSITION IN LOWER BENGAL BASIN, INDIA

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Keywords

Holocene, Lower Bengal basin, Bioassemblage, Biostratigraphic Zone, Environment of deposition



Study of diverse biological remains of diverse eco-system including mangrove in the C14 dated Holocene sediments has generated rich data revealing the palaeoecological change and the phases of environment of deposition that occurred in the Lower Bengal basin, India, during the Holocene. Environment assessment analysis of each of the bioclasts e.g. wood fragments, leaf cuticle, leaf fragments, pollen grains, non-pollen palynomorphs, vertebrate and invertebrate remains etc. collected from measured sections of the four locations Kumirmari, Dakshin Harishpur, Taldi and Canning has been considered through comparison with the extant equivalent ecoforms. All sections were studied on the basis of bioassemblage pattern and chronostratigraphy to propose the Holocene Biostratigraphic Zones. Six distinct Holocene (**H**) Biostratigraphic Zones (**BZ**) of Lower Bengal basin (**LBb**) were established from four sections, LBbH.BZ.I-VI with the characterization of the corresponding depositional environment. The bioassemblages encountered from the sediments of the study area were deposited at two different periods. In Kumirmari and Dakshin Harishpur, the depositional period was from 4450 ± 170 to 1970 ± 80 yr BP until recent, whereas in Taldi and Canning it was between c. 11000 to c. 5000 until recent. The successive phases of environment of deposition identified through palaeobiological records are mixed brackish water and fresh water tidal mangrove with regular inundation (Phase I), tidal mangrove with regular inundation (Phase II), *Phoenix* sp. dominated mangrove upland (Phase III), swampy mangrove to tidal mangrove (Phase IV), brackish water mixed fresh water *Heritiera* sp. forest (Phase V) and fresh water grassland to fresh water swampy condition (Phase VI). The biostratigraphy has revealed the transgression of sea in Taldi and Canning area during 10000 to 7687 yr BP followed by regression of sea in these areas and further initiation of 2nd phase of transgression during 7687 to 6000 yr BP resulting submergence of swampy vegetation in these areas. This transgression phase continued up to the initiation of the next phase during 4450 to 3500 yr BP when mainly due to the regression in the preceding zone, seaward extension of coastline and shifting of swampy vegetation occurred in Kumirmari and Dakshin Harishpur area.



FROM THE PRESENT TO THE PAST: USING CONSERVATION PALEOBIOLOGY TO ASSESS BODY SIZE OF MOLLUSKS AND ANCIENT GATHERING ZONES

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Keywords

sambaqui, shell mounds, fisher-gatherers, *Amarilladesma mactroides*, southern Brazil



Data and parameters that have been used in recent paleobiology research are essential for achieving results that must be as reliable as possible. For example, comparing the body size of valves from **sambaquis** (ancient Brazilian shellmounds, 10,000–1,000 yrs BP) with extant bivalves is a hard task because we are not sure about how past populations collected the specimens and which hypothesis tests and data to use in this comparison. To evaluate these concerns, we applied Mann-Whitney (mw), t-test (tt), and bootstrapping (bt) analyses to assay different scenarios regarding *Amarilladesma mactroides* (Reeve, 1854) valves from two sambaquis (~3,000 BP) and two transects (recent coast) from Rio Grande do Sul, Brazil. When comparing ancient and recent valves, we observed that the average body size in sambaquis is larger than recent valves (tt, $p = 0.0005$; mw, $p = 0.006$; bt, $p = 0.03$). But when comparing the valves at different levels of the swash zone (one of the transects), the body size only differs in the medium level (tt, $p = 0.004$; mw, $p = 0.005$; bt, $p = 0.005$), where both recruit and juvenile organisms are found. So, probably the ancient human groups collected adults and larger organisms in upper and lower zones. Through Conservation Paleobiology it was possible to assess the body size difference between **sambaquis** and recent valves, infer the probable gathering zone of those past populations and show that the body size of valves found in **sambaquis** is biased and would be carefully employed in comparison with recent valves.



HONG KONG CORALS: A CASE-STUDY ON USING THE PAST TO RESTORE THE FUTURE

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Keywords

Coral Reefs, Historical Ecology, Conservation, Restoration, Stable Isotope Analysis



Hong Kong — a city within China's Greater Bay Area (GBA) that is home to over 160 million people — represents an area of great coral biodiversity coupled with incredible human influence. Over the last several decades, exponential population growth and rapid development have led to the degradation of the surrounding marine environment, including a 40% decline in coral diversity in parts of the GBA. Here, using the first coral paleontological record for the region we tell the story of Hong Kong's coral reefs through time, and outline how they went from a homogenous and highly diverse system to one that is now segmented and declining. Then, we use a dataset of $\delta^{15}\text{N}$ values from coral sub-fossils extending back 7000 years to create the first "ground-truthed" historical nutrient baseline. Results faithfully track significant shifts in water-nutrient regimes and identify that pollution from increased development without proper treatment is likely the cause of the significant decline in coral diversity seen today. Using this historical baseline data and modern-day pollution context to infer the appropriate steps needed, members of our team are now restoring corals that previously thrived in parts of Hong Kong back to their historic home. To date, over 95% of the reintroduced corals have survived. Furthermore, we have documented several coral associated invertebrates at the site, showing that this restored habitat is indeed increasing biodiversity. We conclude that historical research that identifies major stress targets for local improvements can be used as a multi-faceted model by other researchers who hope to give marine animals their greatest chance for future survival.



MEASURING SHARK DERMAL DENTICLE SHEDDING RATES TO INFORM ECOLOGICAL INTERPRETATIONS OF FOSSIL DENTICLE ASSEMBLAGES

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Keywords

Denticles, Ecology, Sharks

Shark dermal scale (denticle) accumulation in the fossil record can provide information about the abundance and composition of past shark communities. Denticles are shed continuously, such that a single shark leaves a scattered composite of many isolated denticles in sediments. However, the rate of denticle shedding as well as how these rates vary among shark species with different life modes are unknown, limiting the interpretation of denticle assemblages. To better understand the process of denticle shedding and calibrate the relationship between absolute shark abundance in the environment and denticle deposition in sediments, we captured denticles shed by two shark species in a large aquarium over nine months. We then simulated how these aquarium-derived shedding rates shape the relationship between shark abundance and denticle accumulation. Bonnethead sharks (*Sphyrna tiburo*) — a more active, benthopelagic species with small, thin denticles — shed 3.6 times faster on average than zebra sharks (*Stegostoma fasciatum*) — a more sedentary, demersal species with large, robust denticles. Over the study, bonnethead shark shedding rates declined while zebra shark shedding rates increased slightly. Finally, denticle assemblage composition corresponded with the relative abundance of denticles on each species' body, consistent with natural shedding rather than selective loss. These measurements build on previous advances in the identification, quantification, and recovery of denticles from sediments to reconstruct ancient shark communities and define pre-exploitation baselines for management. Overall, we show that shark taxa contribute unevenly to the denticle record, indicating that shedding rate measurements can help inform and constrain ecological interpretations of denticle assemblages.





CONSERVATION STRATEGIES IN SOUTHERN MEXICO BASED ON LATE PLEISTOCENE FAUNAL BASELINES

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Keywords

Conservation Paleobiology, Mixteca Alta Oaxaqueña, paleontological baselines



This study aims to propose Late Pleistocene ecological baselines that can be used to assess the degree of Recent environmental impact in the Mixteca Alta Oaxaqueña, a large area in southern Mexico. This area has been historically exposed to different episodes of disturbance over the last six centuries. We analysed Recent and Late Pleistocene assemblages of rodents and terrestrial snails, since both groups have been used successfully as palaeoenvironmental proxies. We collected fossil and modern specimens in several field trips, since 2010 to 2015. Two baselines were proposed to assess the resistance of Recent ecosystems and to determine ecosystem health. First, we compared the alpha and beta diversity of fossil and modern assemblages to assess resistance to change over time. Second, we compared the ecosystem services provided by the fauna in both periods. Late Pleistocene faunal assemblage is composed of six continental gastropod taxa and three species of micromammals. Recent faunal assemblage comprises five taxa of continental gastropods and six taxa of micromammals. Concerning beta diversity, species turnover between Late Pleistocene and Recent is higher in rodents ($\beta W = 0.8$) than in gastropods ($\beta W = 0.454$). *Peromyscus difficilis*, Succinidae, Lymnaeidae and Physidae gastropods have persisted in the area since the Late Pleistocene. The low diversity of some taxa suggests a possible low resistance of San Antonio Acutla's ecosystems. Our results indicate that the degradation processes did not affect the Mixteca Alta in the same way. Recent ecosystems were not substantially degraded compared with the Late Pleistocene baselines. Information obtained by prehistoric baselines will be useful for effective design of conservation strategies, since all conservation plans in the area do not consider historical information, in order to have more elements to propose specific strategies.



DROUGHT AND MEGAFANAL EXTINCTIONS IN SW MADAGASCAR

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Keywords

stable isotopes, radiocarbon, aridification, deforestation



Climate drying could have transformed ecosystems in southern Madagascar during recent millennia, thereby contributing to the extinction of endemic megafauna. The magnitude and areal extent of Late Holocene aridification, however, are poorly known, as are the responses of endemic animals and livestock to drying. We measured stable oxygen isotope ($\delta^{18}\text{O}$) values of monospecific freshwater ostracods and elemental concentrations in a lake sediment core to infer the past ~1600 years of climate change around Lake Ranobe, SW Madagascar. We inferred past changes in habitat and diet of introduced and now-extinct endemic megaherbivores using bone collagen stable isotope ($\delta^{13}\text{C}$ & $\delta^{15}\text{N}$) and ^{14}C datasets. During a dry interval ~1000-700 years ago, extinct pygmy hippos and giant lemurs disappeared from the vicinity of Ranobe. However, simultaneous appearance of introduced cattle (zebu), high charcoal concentrations, and other evidence of human activity confound inference of solely drought-driven extirpations. Unlike values in endemic megafauna, relatively low collagen $\delta^{15}\text{N}$ values among cattle suggest they survived dry intervals by exploiting patches of wet habitat. Although megafaunal extirpations coincided with drought in SW Madagascar, coupled data from bone and lake sediments do not support the hypothesis that extinct megafauna populations collapsed solely because of drought. In the face of projected climate drying, we argue that sustainable conservation of spiny forests in SW Madagascar should support local livelihoods by ensuring that zebu have access to mesic habitat. Additionally, current interactions between pastoralism and mesic habitats should be studied to help conserve the island's biodiversity.



TAPHONOMY OF FOSSIL LEAVES ON THE SANTA MARIA FORMATION, PARANÁ BASIN, BRAZIL

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Keywords

Denticles, Ecology, Sharks



The Santa Maria Formation corresponds to the Upper Triassic of the Paraná Basin, and outcrops only on the southern margin of the basin, in the state of Rio Grande do Sul, Brazil. Its leaf fossil content is exceptionally well-preserved and is mainly represented by plant remains from the *Dicroidium* flora. The samples for this study were collected on the banks of BR-392 road, by **NEPALE** — Nucleus of Studies in Paleontology and Stratigraphy of the Geological Engineering course at the Universidade Federal de Pelotas (**UFPel**). The samples are red laminated mud rocks (red beds) and contain a large number of preserved leaves fossilized by impression. The leaves are eve-pinnate compound, with rounded tips and smooth edge, the petioles are on average 4cm in length. These characteristics classify them within the genus *Dicroidium*. The leaves have petioles connected to the branch, maintaining a high degree of preservation and indicating short or no transport, thus they can be considered a paraautochthonous association. Considering the necessary conditions for the preservation of plant fossils and that an outcrop near is interpreted by other authors as a meandering fluvial system, it can be inferred that the sedimentation environment was of low energy and with episodes of large volume of mud sedimentation, which reduced the contact of these remains with oxygen, making the action of decomposing microorganisms unfeasible. The Upper Triassic was warm and dry in Parana Basin, so these outcrops indicate a short period of different local climatic conditions.



HOLOCENE PALEOLIMNOLOGICAL CHANGES IN SOUTHEASTERN MOZAMBIQUE: AN OSTRACOD-BASED STUDY

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Keywords

Ostracoda, Quaternary, Lake Nyalonzelwe



Ostracods are ubiquitous bivalved aquatic micro-crustaceans with a rich fossil record. Despite their potential in revealing critical transitions in lake ecosystems related to past climatic changes and anthropogenic impacts, ostracod-based studies remain rare for this region. We present ca. 7,300 calibrated years before the present (cal BP) of limnological change inferred from the fossil ostracod assemblages from Lake Nyalonzelwe (Inhambane, Mozambique). The core is 595 cm long and was sampled at 10 cm intervals for all proxies. Ostracod data indicate the predominance of brackish water conditions from ~7,300 to ~1,000 cal BP, an assemblage dominated by *Cyprideis*. These results are supported by the sedimentological, geochemical, and other biological proxy data. At ~1000 yrs species turnover occurred, with a gradual increase in species diversity, represented by freshwater genera as *Sclerocypris* and *Zonocypris*. At this time point, we observe an increase in organic carbon content and decrease in inorganic carbon, combined with a rise in mud content. This paleolimnological change may result from an arid to a wet phase transition and/or to the introduction of agriculture in the region (a hypothesis supported by the pollen data). A sharp increase in organic matter content was observed in the last 500 yrs, coinciding with the absence of ostracods from the record. Possibly this environmental change was linked to an abrupt arid event also recorded in the region by other studies. Our ostracod-based study contributes to a greater understanding of Holocene environmental changes and their drivers in Mozambique.

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ISOTOPE PALAEOECOLOGY OF SOUTHEAST ASIAN LARGE MAMMALS WITH IMPLICATIONS FOR FUTURE SPECIES CONSERVATION PLANS

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Keywords

Stable Carbon Isotope, Paleodiet, Ecological Niche, Refugia, Quaternary



Southeast Asia is a centre of global importance for terrestrial biodiversity with species of conservation concern due to its native habitat loss today. During the past few decades, stable carbon isotope analyses of mammalian tooth enamel are powerful tools to explore diets and habitats of past and extant sympatric species and to test the species co-occurrence patterns through time. However, this approach has infrequently been applied to the palaeoecological study of threatened and endangered mammal taxa in Southeast Asia. Here we gather the relevant literature on paleoecological applications of stable carbon isotope ratios in tooth enamel to demonstrate diets and habitat preferences of the Pleistocene to present-day large mammals in Southeast Asia. Stable carbon isotope compositions of tooth enamel of the extant Southeast Asian mammal taxa have shown that the Holocene climate and environmental changes have driven a range contraction of suitable habitats for some mammalian species such as extant Sambar deer, Sumatran serows, and gaurs that have had significant shifts in diets and habitats towards more closed C₃ canopies. However, some megaherbivore species such as Javan rhinoceroses have maintained their habitat preferences in closed forests over time. It is conceivable that the loss of savannah in the region has played a pivotal role in forcing ecological adaptations of many large grazers but in promoting the survival of some browsing species. Further investigations, using the stable isotope approach, into the optimal ecological niches of Pleistocene and Holocene mammals will be useful to guide the future habitat restoration for some threatened and endangered species in the region.



OCEAN ACIDIFICATION FROM PRE-INDUSTRIAL TIMES UNTIL NOW — A STORY TOLD BY PACIFIC CORALS

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Keywords

Coral-Based Reconstruction, Ocean Acidification, Pacific Ocean, Anthropocene, *Porites* sp.



The acidification of our oceans induced by the uptake of anthropogenic CO₂ emissions is unique in Earth's history in its short temporal scale of existence. Global surface ocean pH has decreased by 0.1 units since the Industrial Revolution. Moreover, carbonate ion concentrations and the saturation state of aragonite have lowered. Here we present paleoclimatic reconstructions generated by the analysis of two *Porites* sp. coral cores, sampled in the southwestern Pacific at Tonga (20°16'S; 174°49'W at 3.5m depth) and Rotuma Island, Fiji (12°29'S; 177°06'E at 11m depth). Coral skeletal materials were analyzed using a multi-proxy approach ($\delta^{18}\text{O}$, Sr/Ca, Li/Mg, U/Ca, Sr-U) to provide optimal sea surface temperature and hydroclimate reconstructions spanning the period from 1779 to 2004, while complementary B/Ca and $\delta^{11}\text{B}$ analysis on both cores allowed for the reconstruction of surface seawater carbonate chemistry changes and long-term pH variability. Coral $\delta^{18}\text{O}$ ratios from both cores suggest similar freshening and/or 0.47-0.63°C warming of the regional sea surface over the last three decades of the 20th century when converted using a previously published $\delta^{18}\text{O}$ to SST sensitivity of -0.21‰ per °C. Tonga *Porites* sp. $\delta^{11}\text{B}$ signature indicates a long-term secular decreasing trend suggesting an increasing rate of acidification since 1779, with a pronounced depletion since the 1950s by -0.0626‰ per year. We also observe a concurrent depletion of coral $\delta^{13}\text{C}$ indicating the changes to the oceanic DIC reservoir (Tonga: -0.028‰; Rotuma: -0.027‰ per year since 1968) and the uptake of anthropogenic CO₂ in the tropical Pacific lowering the ¹³C isotope signature, also known as the oceanic Suess effect.

Fossils are known to have been integrated into some cultures as medical, magical, religious, and folkloric pieces for a long time. These insights tell us that fossils can have different meanings, including identity, and not always in a purely scientific context. The main objective of this session is to know the different meanings that fossil specimens have in society.

We encourage the discussion of the consequences of these different perceptions. In some countries, for example, laws allow the sale and purchase of fossils or fossiliferous rocks. These specimens are perceived as ornamental pieces, a kind of jewel, or a decorative slab; consequently, the appreciation of their aesthetic value trumps scientific or educational significance. Another case is when fossils are recognized as the exclusive national property of the country where they are found. The consequences involve permission requirement for research, a final deposit of specimens, and rights to future studies of the fossils.

We hope that the experiences derived from this session can contribute with elements to propose more efficient strategies to involve society in the recognition of paleontological work. Paleontologists must consider the multiple points of view of society and be able to integrate them into policies and guidelines for the conservation of paleontological resources.

The Multiple Perceptions of Fossils

Organisers

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Thematic Session



A FOSSIL WHALE AND THEIR CULTURAL IMPACT IN A LOCALITY OF GUERRERO, MÉXICO

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Keywords

Megaptera, México, Whale Museum

From 2016 to 2017 a large skeleton was recovered in the locality of Punta Maldonado-El Faro, municipality of Cuajinicuilapa, Guerrero. The remains were exposed by water erosion in the bed of a stream, which has eight meters depth. The specimen has 75% of the bone pieces, among which the vertebral column, the ribs, the fins, a part of the skull, and the jaw stand out. It has been identified as a cetacean as a cetacean of the Family Mysticetidae, of the genus *Megaptera*. In addition to the scientific importance, this presentation shows some considerations about the social impact of this finding. Since several interpretations of the paleontological context were made by the local population and visitors. Some have an anecdotal character, giving us an idea of the local people's socio-cultural conditions and the importance of these explanations. Also, the actions to preserve the specimen and give it a patrimonial perspective were important with the opening of the Whale Museum in the town, where the inhabitants currently keep the specimen, in collaboration with INAH.





PERCEPTION OF BEE ICHNOFOSSILS IN A SEMIRURAL VILLAGE FROM SOUTHERN MEXICO

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Keywords

Celliformidae, Mixteca Alta de Oaxaca, social use, palaeontological folk

Paleontological specimens are commonly referred in several cultures as objects with many values. In this work, we report the perception of ichnofossils produced by mining bees in Santiago Yolomécatl, a semirural village in the northeastern of Oaxaca, south of Mexico. The ichnofossil locality is inside the town, in the limit of a transit road. There are several cells, systems and tunnels structures, all identified as Celliformidae indet. The inhabitants of the village known the structures as “balitas” (small bullets) because of their cylindrical form. People relate these structures with bullets used during the Mexican Revolution of 1910. During several workshops and interviews, we talked to the people about the nature of the structures, but we received a lot of comments and replies concerning the origin and use of the ichnofossils. In this work, we discuss the obstacles to persuade people to associate these structures with a biological origin, and the strategies for using the information obtained from the inhabitants to establish lines of action for the long-term conservation of the ichnofossils.





ETHNOPALEONTOLOGY IN PERU: A PRELIMINARY OVERVIEW

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Keywords

ammonite, fossil, illas, Inca, culture



The work aims to explain how fossils have been appreciated by Peruvian people in ancient and modern times. We divided the research into two groups: the XXI century and archaeology context. For the research, we used bibliographic information, testimonies, and fossils taxonomic identification. In the first category, we use eight items in sociocultural influence (artistic or esthetical concept, economic or objects commerce, psychic and spiritual utilities, ludic and symbolic meaning) as preliminary results some reports mention fossils was uses as “**illas**” (Andean magical object for good provenance in cultivars and animal husbandry) or a physical manifestation of jungle’s spirits like “**Tunche**”, ritual objects in shaman’s table (Pachamama ritual with the uses of ammonoids and sea urchins) and uses as objects for ritual, for example, the oyster specie *Nicaiolopha nicaissei* Vyalov, 1936 commonly known by people as demon’s hand. The archeologist context refers to Incas and Nasca culture. We know as testimonial references that some fossils Cenozoic whales are used as an offering in Nasca cultures and some gods due to “whale-man” maybe refers some whales fossils in the desert because they represent it with articulations as whales basal ancestors. On the other hand, archaeologists found fossils in Pachacamac’s temple we supposed as a gift for earthquake god and some fossils logs are now as kis-huar that means sacred Inca’s tree. This preliminary information shows us the necessity to design specific project research with a multidisciplinary teams and local people. Now a day, fossils steal represents an important significance in some towns with some mystical meaning.

In this session, we intend to assess the role of palynology (pollen, spores, dinocysts and other NPPs) as an important field of geological, stratigraphical, environmental and climate research during the Cenozoic. Participants are invited to present methodological, biodiversity, human/faunal and human/ environment approaches, and significant and /or multiproxy records in the frame of paleoenvironmental and palaeoclimatic past reconstructions.

Subjects based on high-resolution analyses, climate change, connectivity and biodiversity conservation are also welcome. We would like to encourage contributions in order to promote the exchange of knowledge, especially the virtual meeting among researchers and students from different parts of the world.

Palynology, Palaeoenvironment and Palaeoclimate

Organisers

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Thematic Session



THE END OF LATE GLACIAL IN NORTHEASTERN IBERIA: SMALL MAMMAL ASSEMBLAGES FROM CUDÓ CAVE (MONT- RAL, TARRAGONA)

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Keywords

Predatory Activities, Paleoeology, Paleoclimate, LGM, Northeastern Iberia



Late Pleistocene is characterized by high fluctuation of climatic conditions, with the Last Glacial Maximum (LGM) known to be one of the coldest periods. This event is marked by the maximum extent of polar and mountain ice caps and the drop of sea surface temperatures. It is detected by various palaeoecological proxies, in both marine and continental records. This work explores how the environment of northeastern Iberia changed under the effects of the Late Pleistocene climatic changes. Small mammal assemblages from Cudó cave (Tarragona, Spain) were used because their well-known reliability for paleoenvironmental reconstructions. Based on the taxonomic identification and the taphonomic analysis, several methodologies covering both qualitative and quantitative approaches were used to obtain the paleoenvironmental information corresponding to level 107 and level 105 of Cudó cave (31.2 – 24.4 and 15.5 – 10.2 ka cal BP respectively). The results obtained from the analysis point out raptors (category 3 – 4) as the main accumulator of the small mammals. The paleoenvironmental reconstruction shows that both levels experienced colder (-7.2°C/-4.4°C) and wetter (+848mm/+586mm) climatic conditions than nowadays. Moreover, in level 107 the environment was dominated by mid-European species and rocky landscape, while in level 105 it was dominated by Mediterranean species and woodland habitat. These conditions are consistent with the trend in northeastern Iberia following several climatic events before and after the LGM coinciding with the period of Cudó cave assemblages.



IDENTIFICATION AND ENVIRONMENTAL BACKGROUND OF CHARA REMAINS IN THE SEQUENCE OF LAKE ST. LÁSZLÓ AT PÜSPÖKFÜRDŐ

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Keywords

Characeae, Holocene, Environment, Lake



The thermal lake system, which was used from the 18th century as a spa, was naturally formed in the floodplain of the stream Pece, fed by thermal springs, in Püspökfürdő (Băile Unu Mai) on the eastern border of Oradea (Romania). In 2011 a geological section (8,4 m deep) was sampled in the basin of the thermal lake of Püspökfürdő. Within the framework of a Hungarian-Romanian research collaboration, 30 kg of sediment were taken every 20 cm in this section. We used multiproxy analysis (organic matter and carbonate content, palaeobotanical analysis, sedimentary analysis, malacological analysis) on the samples. Chara oospores were recovered from two horizons (samples between 440–460 and 520–540 cm) characterised by low organic matter and high carbonate and calcareous mud content. Both of the radiocarbon-based dated charcoal remains can be dated back to the Early Holocene (11,200–10,900 and 10,300–10,200 cal. years). The pollen composition suggests that temperate trees were already dominant in the area of the lake system, with the scattered presence of Scots pine in some samples. The same levels are dominated by the extinct ecotypes of *Melanopsis staubi* and *Melanopsis sikorai* snails. Although the proportion of the recovered *Chara* cf. *hispidata* oospores are subordinate and support the results of these multiproxy analyses with the presence of a carbonate-rich lake system characterized by high dissolved Ca and Mg salts content and relatively poor plant cover in the Early Holocene.



PALEOENVIRONMENTAL ANALYSIS OF A PEAT BOG SINCE 17,550 CAL YR BP, PAMPA BIOME, SOUTHERNMOST BRAZIL

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Keywords

Pampa Biome, Palynology, Peat bog

The paleoecological significance of a peat bog located in the Cacequi municipality, Pampa Biome of the Rio Grande do Sul State, southernmost Brazil, was traced by integrated studies of palynology, geochronology and stratigraphy. The peat bog deposit consists of clayey silt with many organic-rich strata marked at their base by sands. Pollen content shows a predominance of families corresponding to a grassland vegetation (Poaceae, Asteraceae, Apiaceae, Rubiaceae and Amaranthaceae) with very few representatives of tree families (Myrtaceae and Fabaceae). Radiocarbon ages cover the last 17,550 cal yr BP. During this time dry conditions were progressively replaced by wet conditions as shown by the increase in families such as Haloragaceae, Typhaceae, Polygonaceae and Alismataceae. The grassland families associations identified in the uppermost zone of the peat bog are practically the same as those described in studies of floristic composition in the municipality of Cacequi and its surroundings, where Poaceae, Asteraceae, Fabaceae and Rubiaceae were identified as the most abundant families. The present results show that although in the last 17,550 years climatic humidity increased, the grassland formations remained predominant but showed changes their composition (grassland associated to Myrtaceae at the bottom and grassland associated with Myrtaceae, Rutaceae and Vochysiaceae at the top), with higher humidity rates occurring around 8,000 years B.P.





HUMAN - ENVIRONMENTAL INTERACTIONS DURING THE LAST TWO MILLENNIA FROM A PRODELTA SUCCESSION OF NORTHERN ITALY (PO DELTA)

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Keywords

Late Holocene, palynology, Late Antiquity, delta dynamics



When properly framed into a multidisciplinary (palynostratigraphic) approach, thick deltaic late Holocene successions formed in proximity to the coastland are promising for investigating the relationships between vegetation, sediment dynamics and anthropisation. In this study, a 27 m-long cored succession from the Po delta (mainly consisting of prodelta muds of the last ca. 2 ky) was analysed for its palynological content (48 samples). Backed by previous meiofaunal studies and radiocarbon dates, a stratigraphically-constrained cluster analysis (**CONISS**) allowed to identify several phases of landscape evolution. After the initial predominance of the mixed oak-holm oak-alder forest, the onset of the Roman Period is suggested by the decline of alder and the rise of chestnut recorded at the offshore-prodelta transition. The Late Antiquity saw a first peak in aquatics followed by the abandonment of settlements (marked drop in cultivated taxa); afterwards, a prolonged increasing trend of hygrophytes and aquatics took place, at the end of which cereals reappeared. The following Early Middle Ages show relatively constant humid conditions and scarce anthropisation. In the Late Middle Ages a slight increase in montane taxa, followed by a steady increase in hygrophytes and aquatics and a decline of cultivations, was found close to the Volano-Goro delta lobe transition, marking a major phase of hydraulic network reorganisation ("Ficarolo avulsion"). The Modern Age was characterised by relatively stable environmental conditions; *Zea mays*, a late XVI century marker for the Italian peninsula, was retrieved at ca. 7 m core depth. The topmost portion documents delta emersion and the complete clearing of the forest.



PALYNOSTRATIGRAPHY AND PALEOBATHYMETRIC STUDIES OF XAD-1 WELL, NIGER DELTA BASIN, NIGERIA

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Keywords

Palynostratigraphy, Paleobathymetry, Palynomorphs, Biozones

A palynological analysis was carried out on 162 ditch cuttings of XAD-1 well within the depth interval of 1373 – 4300 m for palynostratigraphic and paleobathymetric purposes. The well is located in offshore depobelt of Niger Delta Basin, at Latitude 4°47'N and Longitude 5°50'E. Samples were recovered from the lower portion of the Agbada Formation including thick shale/mudstone, sandy mudstone and thin sandstone. Palynomorphs were extracted from the sediment by a standard physical-chemical procedure. The ditch cuttings yielded 123 taxa recorded abundantly throughout the studied section. These included diagnostic marker species like *Zonocostites ramonae*, *Praedapolis africanus*, *Cicatricosisporites dorogensis*, *Retibrevitricolporites protrudens/obodoensis*. Middle Eocene to Early Miocene was assigned to the studied section using age diagnostic marker species. Five main palynostratigraphic zones were established based on the stratigraphic range of palynomorphs. The biozones include *Monoporites annulatus* – *Margocolporites rauvolffii*, *Pachydermites diderixi* – *Doualaidites laevigatus*, *Racemonocolpites hians* – *Numulipollis neogenicus*, *Cicatricosisporites dorogensis* – *Praedapollis africanus* and *Grimsdalea polyonalis* – *Striatricolpites catatumbus* Zones. Paleobathymetric interpretation was done by the integrated analysis of palynomorphs assemblages including dinoflagellate cysts and other algae, pollen grains (including bisaccatae ones) and spores. The paleobathymetric ranges inferred from the studied section are estuarine (littoral) – inner neritic (0 – 40 m) and inner neritic – outer neritic (40 – 200 m). This suggests a significant depth of burial of sediments including micro-fauna and flora which is necessary for hydrocarbon accumulation and generation.





EOCENE SOUTHERN ATLANTIC OCEAN DINOFLAGELLATE CYSTS: REGIONAL CORRELATION AND PALAEOENVIRONMENTS

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Keywords

Dinoflagellate cysts, Statistical analysis, South America, Antarctica, Eocene

The Eocene was a time of regional tectonic events and climatological changes, related to the opening of the Drake Passage that separated South America from Antarctica. Knowledge of the timing of the Drake rifting can help us understand the new oceanographic regime and its consequences. In this sense, dinoflagellate cysts (dinocysts) are useful tools for biostratigraphy and palaeoceanographic reconstructions. For this purpose, we analyzed dinocyst assemblages from lithostratigraphic units adjacent to the Drake Passage, including the Man Aike (MA), the Upper Member of the Río Turbio (umRT) and Leticia (Le) formations, outcropping in the Austral-Magallanes Basin, southern Patagonia, and the La Meseta Formation (LM), from the James Ross Basin, Antarctica. Our quantitative information of the dinocyst assemblages of the aforementioned units together with recently published radiometric data were taken into account to update the biostratigraphic scheme for the Austral-Magallanes Basin, adjusting the ages of the dinocyst biozones and bioevents proposed for the umRT. The statistical compositional analysis of the quantitative dinocyst assemblages performed in this work allowed us to confirm the correlation of the formations, showing a high equivalence between the middle Eocene (Bartonian, 41 – 37 Ma) assemblages (lower part of the umRT, MA, Le and LM), distinguishing them from the upper Eocene (< 36 Ma) ones (upper part of the umRT). In addition, the statistical results revealed different palaeoenvironments. Whereas the Bartonian assemblages represent relatively warm waters in inland shelf environments, those of the Priabonian indicate coastal areas with cold, nutrient-rich surface waters.





QUATERNARY ENVIRONMENTS IN THE GULF OF CORINTH INFERRED FROM POLLEN AND DINOFLAGELLATE CYST ASSEMBLAGES

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Keywords

Pollen, Dinocysts, Corinth Gulf, Mediterranean Sea, Quaternary

The new sedimentary record from the Gulf of Corinth (Greece), retrieved within the IODP Expedition 381 (Corinth Active Rift Development) registers environmental and climatic variability continuously over the last one million years. The Gulf of Corinth is a semi-enclosed basin, sensitive to climate forcing and sea level fluctuations. The Gulf was repeatedly isolated from the Mediterranean Sea during glacial/low-stand intervals, resulting in the amplification of paleoenvironmental gradients. Palynological analyses performed within the QECCoRA project aim to: a) investigate the glacial-interglacial vegetation history in the southernmost Balkan tree refugium at a millennial scale; b) constrain the timing of relict tree taxa extinctions over the Quaternary; and c) distinguish global from local drivers of environmental change by studying the alternation between marine, transitional, and isolated intervals and its impact on local ecosystems. First results from the top ~200m show significant shifts of the vegetation composition in response to climate variability, whereas the fluctuation in vegetation cover appears less pronounced. Mesophilous tree percentages increase during interglacials, and remain abundant even within glacials, while Mediterranean species form a substantial part of the vegetation throughout the study interval. Dinoflagellate cyst assemblages show distinct alternations between marine and brackish conditions suggesting changes in surface water salinity, productivity, and temperature. Ongoing palynological analysis downcore will produce a skeleton paleoenvironmental record spanning the Quaternary and will be decipher environmental and climatic conditions in the study area addressing a major goal of the IODP Exp. 381.





PALYNOLOGY FROM DINOSAUR-BEARING BEDS IN ALPUENTE AREA (VILLAR DEL ARZOBISPO FM, VALENCIA, SPAIN)

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Keywords

Pollen, NPP, Late Jurassic, transitional environments

The deltaic sediments of the Villar del Arzobispo Formation, in Alpuente Area (Valencia, Eastern Spain), include a rich paleontological heritage, Upper Jurassic in age (apparently Kimmeridgian–Tithonian). The diversity of organisms is attested by numerous vertebrates (sauropods as turiasaurs, diplodocoids and macronarians, theropods, stegosaurs, ornithopods, crocodiles, or turtles), as well as remains of invertebrates and occasionally of plant (mostly pteridophytes, cycads, and conifers). Here we present the preliminary data from the first palynological study of the Villar del Arzobispo Formation in the region. A total of 35 palynological samples were analyzed following standard procedures. Solely 16 samples contain palynomorphs. These samples, from different sites, show some abundant genera (*Classopollis*, *Sphaeripollenites*, *Klukisporites*, *Araucariacites*, *Cyathidites*, *Deltoidospora*, and *Concavissimisporites*). Although pollen and spores were the most abundant palynomorphs, other Non-Pollen Palynomorphs (NPPs) have also been recognized, including prasinophytes, dinoflagellate cysts, foraminiferal test linings, fungal spores, scolecodonts and scales of lepidoptera. Palynomorphs assemblages suggest that the plant communities in Alpuente Area during the Late Jurassic were dominated by trees of the Cheirolepidiaceae family and other conifers. However, the diversity and abundance of spores of pteridophytes / mosses (*Interulobites*, *Polycingulatisporites*, *Cyathidites*) would indicate that these groups were important elements in the plant communities too. Most of the mentioned taxa have a wide stratigraphic range; some of them are very common in both the Jurassic and Cretaceous. However, the presence of some key taxa suggests an Upper Jurassic age for the studied sedimentary samples.





PALYNOLOGY AND PALAEOENVIRONMENTS OF THE LOWER CRETACEOUS CARBONATE SUCCESSION OF ARRIFES (ALGARVE BASIN, SOUTHERN PORTUGAL)

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Keywords

palynology, palynofacies, lithofacies, Lower Cretaceous, carbonates, Dinoflagellate cysts

This research presents the first detailed study based on palynology, palynofacies and lithofacies of the Arrifes section, a Lower Cretaceous outcrop succession from the Algarve Basin. 48 samples were collected and studied, and the first assessments of age and palaeoenvironmental interpretations were established. The palynological data suggest that the succession was deposited from the latest Hauterivian (first occurrences of *Subtilisphaera perlucida* and *S. scabrata*) to the late Barremian (first occurrence of *Odontochitina operculata*) age. From the latest Hauterivian to the earliest late Barremian age, sedimentation mainly occurred in a nearshore environment, marked by the abundance of peridinioid dinocysts, particularly the Subtilisphaera group with high sporomorph occurrences. Contrariwise, in the late Barremian, a more marine signature is recognised by the increase of neritic to open marine gonyaulacoid dinocysts (abundant *Oligosphaeridium* and frequent *Odontochitina* forms). During this period, fluctuations in the water column were confirmed by alternating nearshore deposits with shallow-water carbonates and dinosaur tracks, indicating a transition amongst marine and subaerial depositions. The palynofacies analysis confirms this palaeoenvironmental assessment. Despite the low diversity of palynological samples, a consistently Tethyan correlation was recognized. These new data lead to a reinterpretation of the age and lithostratigraphic models in the central Algarve Basin.





VEGETATION CHANGE IN SE SICILY DURING THE LAST 3000 YEARS

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Keywords

Marine palynology, Late-Holocene, Roman Humid Period, Little Ice Age



Marine palynology represents a powerful tool to obtain continuous and chronologically well constrained records of past vegetational changes and climatic oscillations. The new high resolution marine pollen record SW104-ND2_ND2 collected in the Sicily Channel, spanning the last 3000 years, represents an excellent opportunity to integrate palaeocological and palaeoclimatic information from continental sites. It provides a regional perspective of Late Holocene climatic variability and of the anthropic processes that affected the largest island of the Mediterranean. The strategic position of the record, right in the center of the Mediterranean Basin, allows to investigate the intricate interplay of the climatic patterns acting over the Central Mediterranean, North Africa, and continental Europe. A comprehensive reconstruction of palaeovegetational changes in this bioclimatic transitional zone revealed changes in floristic composition and vegetation structure that correspond to known historical climatic phases such as: the Roman Humid Period, The Dark Age Cold Period, the Medieval Climate Anomaly, and the Little Ice Age. The observed land cover changes are consistent with fluctuations in solar activity and cyclicity of independent stratigraphic evidence at a global scale. The recurrence of forest cover expansions and reductions depicts an alternating pattern suggesting repeated hydroclimatic changes in relation to positive and negative phases of the North Atlantic Oscillation (NAO). At the same time, the detailed analysis of vegetational trends provided by cultivated plants and anthropogenic indicators offers new detailed information on the extent of human impact on the landscape in relation to historical management policies and land use.



EARLY EOCENE HYPERTHERMALS AND TRANSGRESSION FROM KUTCH BASIN OF WESTERN INDIA — ARE THEY RELATED?

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Keywords

Hyperthermal, Transgression, early Eocene, India, Kutch



We have studied an early Eocene sedimentary sequence from an opencast lignite mine at Umarsar, Kutch Basin, western India in terms of lithostratigraphy, molluscan assemblage and $\delta^{13}\text{C}_{\text{org}}$ stratigraphy. A green shale facies (GS) containing marine molluscan fossils is bounded by unfossiliferous grey/brown/black shales and lignites of terrestrial origin. The abundance of *Ostrea* sp., an eurytopic bivalve, in the amber-containing lowest part of GS indicates the initial stages of a marginal marine environment. The depositional environment gradually changes to a relatively open terrigenous shelf as the faunal diversity increases in the younger parts of GS. The common members of the fauna here are corbulid, carditid and venerid bivalves, and cerithioid gastropods. The early Eocene Hyperthermal (EEH) events ETM2/H1 and H2 were recorded from this transgressive interval. ETM2 coincides with the marine intervals in other lignite-bearing sequences from western India. Other EEH events were recorded from the terrestrial parts of the sequence. The presence of the Paleocene Eocene Thermal Maximum (PETM) at the lower part of this sequence indicates that this early warming triggered an intensification of the hydrological cycle inducing a terrigenous influx in the coastal basin. The sea retreated after H2, paving the way for the resumption of terrestrial sedimentation. The association of a transgression with ETM2, and none with PETM, poses a question as to the causal link between warming and transgression. An anticlockwise sense of movement and an abrupt slowdown of the Indian plate may be additionally responsible for the transgression.



VEGETATION RESPONSE TO WARM PERIODS WITHIN AND AFTER THE MID PLEISTOCENE TRANSITION IN THE WESTERN MEDITERRANEAN

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Keywords

Interglacial climate, Mediterranean vegetation, Marine pollen analysis, Model-data comparison

Investigating past warm periods is of particular interest for developing reliable scenarios of future climate-driven change in the fragile Mediterranean landscapes and ecosystems. However, due to the paucity of studies, important questions remain about their intensity, duration, and regional expression during the Pleistocene. This work is based on high resolution pollen analyses that allow a direct comparison between atmospherically driven vegetation changes and sea surface temperature variability in the same sediment sample set from the International Ocean Discovery Program (IODP) Site U1385 (Expedition 339). This site, also known as the “Shackleton Site”, was collected on the SW Iberian margin, which is considered a prime location for tracking past climate changes. Additionally, this area has been identified as one of the most vulnerable regions to the ongoing global climatic changes. Revealing the processes behind the vegetation response to Marine Isotope Stage (MIS) 11 and MIS 31 provides insights on the nature, timing and causes of past climate changes under the different baseline climate states before and after ~1 million years, i.e. the 41,000 and 100,000-year cyclicity worlds, respectively. Moreover, the discussion of Site U1385 paleoclimate records in the light of modelling experiments allows determining the dominant forcing and feedback mechanisms explaining the regional expression, in terms of forest expansion and atmospheric changes, of the best orbital analogues of the Holocene (i.e. MIS 19c and MIS 11c) and the lukewarm interglacial MIS 13.



The field of stratigraphy and paleontology is fundamental to geosciences in general. Despite the long tradition of studies, there are excellent potentials for research in Taiwan due to emerging techniques and innovative approaches. Moreover, unstudied new fossils have been collected and accumulated over the years in Taiwan. New studies attaining higher resolution on the spatiotemporal dynamics of past faunas have provided insights into past biodiversity patterns. The aim is to show the diversity of research topics that are important for understanding the Earth History and biosphere in the past, particularly in the less known tropical-subtropical West Pacific. Participants of the Stratigraphy and Paleontology session (ST1) of the annual meetings of the Geological Society located at Taipei are encouraged to submit their abstracts to this session.

This session is sponsored by:

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New advances on stratigraphy and paleontology in Taiwan

Organisers

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Thematic Session



A CASE STUDY OF *SINAECHINOCYAMUS MAI* (TAIWANASTERIDAE) AND CLYPEASTEROIDS PHYLOGENY

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Keywords

Scutelloida, Clypeasteroidea, molecular evolution, monophyly, Next Generation Sequencing

With the rapid development of modern molecular technology, sequencing data from non-model species has become unprecedentedly abundant. Paleontology is a field that profoundly benefits from interdisciplinary cooperation. Aside from the traditional morphology analysis, modern paleontologists and taxonomists can also leverage novel technical breakthroughs in molecular biology to peek into the evolutionary past. Morphological analysis comprises one of the most essential parts of paleontology research, and Evo-Devo researches might give valuable insights into the mechanism of the observed pattern, adding another dimension to the study. We also used *Sinaechinocyamus mai*, an endemic species in Taiwan with fossil and extant records, as a case study to exemplify the power of using sequencing data in phylogenetic analysis. We exemplified the value of sequence analysis in the phylogeny study by reanalyzing previous data with the new transcriptome data of *S. mai*. The enigmatic phylogenetic relationship and body plan establishment of Scutelloida and Clypeasteroidea are discussed.





RESTUDY OF FOSSIL SPECIMENS OF GENUS *SINAECHINOCYAMUS* (ECHINOIDEA; CLYPEASTEROIDA) WITH NEW OCCURRENCES FROM TAIWAN

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Keywords

Genus *Sinaechinocyamus*, Clypeasteroidea, morphological analysis

Sinaechinocyamus is a small echinoid that belongs to the member of Clypeasteroidea. In this study, a total of 321 fossil and extant specimens of genus *Sinaechinocyamus* were collected from 9 sites. From the perspective of fossil ages, *Sinaechinocyamus* may have appeared in the northern part of Taiwan since the late Miocene, and gradually distributed to the southern Taiwan in the late Pliocene. Today it is mainly distributed in the coastal area from Hsinchu to Tainan in Taiwan. In morphological analyses, the fossil and extant specimens of *Sinaechinocyamus* performed individual variations within and among regions. Therefore, it may be insufficient to use morphological differences as the basis for the classification of *Sinaechinocyamus* species.





OCEAN WARMING AND ENVIRONMENTAL CHANGE DURING THE PLEISTOCENE-HOLOCENE TRANSITION CAUSED THE DEMISE OF ECHINOID *SCAPHECHINUS MIRABILIS* IN TAIWAN

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Keywords

Sand dollar, Clumped isotopes, Sea level change, Quaternary geology, Toukoshan Formation



Scaphechinus mirabilis is a temperate sand dollar species, yet abundant fossil specimens have been found in the Pleistocene Toukoshan Formation in Miaoli County of the subtropical island of Taiwan. Environmental factors leading to its demise in Taiwan are still elusive due to a dearth of paleoenvironmental data from this region. In this study, we analysed stable oxygen and carbon isotopes, as well as clumped isotopes (Δ_{47}) of fossil specimens from Taiwan to shed light on past climatic conditions that allow them to thrive. Fossil sand dollars from Toukoshan Formation are generally well-preserved, with little compaction in the internal stereom and the interconnecting pores still retaining their original geometry. Isotopic measurements were carried out using isotopic ratio mass spectrometers. Radiocarbon dates indicate that the fossil sand dollars from this formation are from Marine Isotope Stage 3. Temperature estimates derived from clumped isotopic signature of fossil specimens from Taiwan and a modern specimen from Mutsu Bay, Japan are in agreement, suggesting no substantial change in the thermal niche of the species. Notably, this means that the seawater off northwest Taiwan during MIS3 was substantially colder ($>10^{\circ}\text{C}$) than modern-day. Such cold waters off northwest Taiwan were likely a result of lower greenhouse forcing during the last glacial in combination with the absence of warm surface current from the south, which was possibly re-routed as land-bridge formed between Taiwan and mainland China during sea-level low-stand. Consequently, the study area was under a stronger influence of China Coastal Current that transports cool waters from higher latitudes, allowing *S. mirabilis* to thrive for generations before being driven to local extinction by warmer waters and rising sea level during the Pleistocene-Holocene transition.



BOREHOLES ON GASTROPOD *TURRITELLA* FROM PLEISTOCENE STRATA IN HENGCHUN PENINSULA, TAIWAN

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Keywords

Quaternary geology, Paleoecology, Predator prey interactions, Szekou Formation, Mollusca

Shell drilling provides a unique aspect to investigate prey and predator relationship. This study documents predator-prey events in *Turritella filiola* fossils from Szekou Formation (Pleistocene) in Hengchun Peninsula, Taiwan. Sediments (5.24 kg) collected contain 1450 shells, including *T. filiola* (n = 818). The drilled percentage in all shells and *T. filiola* are 42.07% and 40.83% respectively. Results show predators had no preference in *T. filiola* versus other shells. Borehole diameter of the shells with single borehole is 0.96 mm on average in size. Dominant drilling predators were naticids based on drill hole types. Incidences of drilling occur more frequently (45%) in the middle size class of *T. filiola*. However, there are also 25% of shells drilled in the lowest size class. This indicates “size refugia” didn’t exist for Szekou community. The drill hole diameter also relates to the size of the drilling predator. Drill hole diameter shows a modest positive correlation with the shell length. There are 89.22% of boreholes on whorls and only 10.78% of boreholes on sutures. The drilling position choices also indicate the predators preferred to drill at the thinner shell wall. Among the drilled *T. filiola*, 19.16% of specimens contain more than one drill hole, indicating some of the drilling predations were not fatal. Poor choices of drilling positions or inappropriate prey choices cannot be ruled out.





MICRO-CT: CURRENT STATUS OF DEVELOPMENTS AND APPLICATIONS

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Keywords

Micro computed tomography, micro-CT, Tomographic image

Micro computed tomography (**micro-CT**) is a non-destructive 3D imaging technique that provides internal microstructure of a specimen without damaging the sample. Micro-CT has applications both in medical & preclinical imaging, which is widely used in medicine, pharmacy, biology, archaeology, materials, electronics, geology and other fields of research. In recent years, use of micro-CT scanning continues to grow in palaeontological research. Here we focused on micro-CT imaging, reviewing relevant principles, technologies, and applications. The primary limitations of micro-CT imaging are relatively poor soft tissue contrast and the associated penetrating power. We focused on achieving high image quality with high penetrating power and ever more powerful computational resources (e.g., dual energy CT, real time dose estimation, image reconstruction strategies based on iterative, statistical, and gradient sparsity regularization).





AGE AND GROWTH OF *PALAEOLOXODON HUAIHOENSIS* FROM PENGHU CHANNEL, TAIWAN: SIGNIFICANCE OF THEIR AGE DISTRIBUTION BASED ON FOSSILS

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Keywords

Pleistocene, Subtropical West Pacific, Elephant age group, Lamellar frequency, Tooth morphology

Specimens of the ancient elephant *Palaeoloxodon huaihoensis* have been reported near the Penghu Channel during commercial fisheries activities in the past decades. Collections of such dental material have been deposited in the National Museum of Nature Science (NMNS), Taiwan; however, relatively few studies of *P. huaihoensis* were published, especially about its age estimate. This study reconstructs the age distribution of *P. huaihoensis* by estimating the length of dental material, enamel thickness (ET), and plate counts, which is directly derived from the extant African forest elephant *Loxodonta africana*. In the same age group, the number of lamellae was higher in *P. huaihoensis* than in *L. africana* based on significant differences in habitat and the living environment. Results show that the individuals of *P. huaihoensis* mainly comprised adults with a median age between 33–34.5 years and differed significantly from that of *Mammuthus primigenius* in the European Kraków Spadzista site. The age distribution pattern suggests the presence of harsh environmental conditions and intense intraspecific competition among *P. huaihoensis* during the Last Glacial Period.





A DIVERSE EARLY PLEISTOCENE SHARK TEETH ASSEMBLAGE FROM SOUTHWESTERN TAIWAN

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Keywords

Carcharodon, *Carcharhinus*, Liuchungchi Formation, Elasmobranch, Shark community

Despite rich marine fossils in the Plio-Pleistocene strata in the Western Foothills of Taiwan, comprehensive studies on the elasmobranch records are scarce. Here, we examined the teeth of sharks from the early Pleistocene Liuchungchi Formation in Chiayi, southern Taiwan. The Liuchungchi Formation (1.90–1.35 Ma) has been famous for its diverse marine fossils, including mollusks, crabs, sea urchins, barnacles, and fish. It consists of dozens of sedimentary successions with thick sandstone and shale layers that indicate offshore to shoreface environment. A total of 570 shark teeth belonging to 5 families and 7 genera were analyzed to reconstruct the associated fossil shark community; these include: *Carcharodon* (Lamnidae, n= 45), *Isurus* (Lamnidae, n= 8), *Galeocerdo* (Galeoceridae, n= 4), *Hemipristis* (Hemigaleidae, n= 4), *Sphyrna* (Sphyrnidae, n= 4), *Carcharhinus* (Carcharhinidae, n= 477), and *Rhizoprionodon* (Carcharhinidae, n= 6). *Carcharhinus* spp. (n= 477) and *Carcharodon carcharias* (n= 45) accounted for the highest proportion in the fossil assemblage. The community represents pelagic sharks inhabiting both inshore and offshore environments.





A REVIEW OF MARINE FISH FOSSILS FROM TAIWAN

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Keywords

Fish otoliths, Plio-Pleistocene, Shark teeth, West Pacific

Marine fossils, including fish fossils, are frequently found in the Western Foothills of Taiwan; however, related paleontological studies are significantly rare. There has been a gap in knowledge and notable stagnant research activities since the late '90s. I noted that the rarity of well-preserved materials and Lagerstätten, as well as the lack of systematic sampling design, are several of the major challenges. Yet, new collections of fish fossils have been accumulated from several field expeditions at several promising horizons over the past two years. In addition, a survey on museum inventories revealed several old and unstudied specimens yet to be examined. Reviewed data indicate a total of known 47 taxa, but mainly in the form of small fossils such as the teeth of sharks and otoliths of bony fishes. I highlight the high abundance and broad distribution of these tiny fossils in the Plio-Pleistocene formations in Taiwan, their applications of reconstructing the past marine fish communities through time and the significances of bridging the poorly known paleodiversity in the subtropical West Pacific.





IN SITU PRESERVATION OF PHOLADIDAE (MOLLUSCA) FROM CHINSHUI SHALE IN WESTERN TAIWAN

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Keywords

Stratigraphic facing, index fossil, Plio-Pleistocene boundary, ichnofacies, black shale

A total of 30 pholadid specimens collected from the Chinshui Shale (late Pliocene) at the Laotinliao Creek, Touwu Township, Miaoli County, Taiwan. Among them, 18 specimens can be used for length/width measurements and 8 specimens that are preserved with diagnostic characters. They are identified as *Pholas tzayi* Hu, 1992 reported from the same unit. Although *P. tzayi* has been reported, this is the first documentation of the in situ preservation of this fossil species in the field based on modern analogus. Its preferred orientation, vertical to bedding, and completeness of intact shells allow stratigraphic facing interpretations with siphonoplax pointing upward. *P. tzayi* is endemic and adapted to tranquil muddy substrate below the fair weather wave base. Thus, it is absent in the overlying unit Chuolan Formation that deposited in shallower settings. *P. tzayi* only occurred in the Chinshui Shale. Age is approximately late Pliocene, close to the Plio-Pleistocene boundary. Since it is relative short lived; thus, a good candidate as an index fossil in the region. Due to the fact that *P. tzayi* was found buried in situ and no signs of escape, the possible causes of death are discussed.





STEREOMIC MICROSTRUCTURES IN CLYPEASTEROIDA: A CASE STUDY OF PLEISTOCENE SAND DOLLARS FROM WESTERN TAIWAN

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Keywords

Paleontology and Stratigraphy; Cenozoic; *Scaphechinus mirabilis*; Toukashan Formation; Stereom

This study focuses on the stereomic microstructures (stereoms) preservation of fossil sand dollar *Scaphechinus mirabilis* from Taiwan. By comparing with modern analogues, the normal adult size ranges from 3 to 7 cm in size and they inhabit shallow subtidal areas in Japan, Korea, China and Russia. Although there is no reported occurrence of the living population, abundant fossil occurrences of *S. mirabilis* are reported to the Miaoli region, Taiwan. The main goals of this study are to document types of stereom preserved in the *S. mirabilis* fossil assemblage and help us to understand the growth of endoskeletal plates of Clypeasteroida during ontogeny. Based on 86 thin sections made, galleried and labyrinthic stereoms are commonly associated with the oral plates and tubercles. Rectilinear stereom is associated with the aboral surface of petaloids. Preservation of growth lines of internal pillars preserved in fossil specimens of *S. mirabilis* can help us to interpret their growth directions.





FIRST SKELETAL RECORD OF *PAGRUS MAJOR* (SPARIDAE, PERCIFORMES) FROM THE LATE PLEISTOCENE OF SUBTROPICAL WEST PACIFIC, SOUTHERN TAIWAN

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Keywords

Late Pleistocene, Szekou Formation, Dentition, Taxonomy, Paleoecology

Fish fossils are only occasionally found in Taiwan, and such fossils have rarely been appropriately analyzed and described. Despite their sparse records, several Plio-Pleistocene localities rich in marine organisms have yielded well-preserved specimens potentially provide insight into the rarely identified fish fauna in the tropical-subtropical West Pacific. We describe a sandstone nodule containing fish skeletons from the Late Pleistocene Szekou Formation in southern Taiwan. The specimen includes nearly complete left jaws, fragmentary right jaws, and part of the anterior body. The skull morphology and the distinct dentition of the specimen suggest a member of Sparidae. The morphological analysis based on dentition and a comparison with 151 recent specimens belonging to 14 species in the area enabled us to assign the fossil to *Pagrus major*. Furthermore, the characteristics of the sparid tooth pattern are beneficial in regional generic identification. The occurrence of the specimen provides the first evidence of the species from the region. Finally, the specialized tooth pattern and the estimated size indicate that the fish was a middle-to-top predator that fed on small fish and invertebrates in a neritic lagoonal environment.





USING GEOMETRIC MORPHOMETRICS TO EXAMINE CONVERGENT DISCOIDAL OUTLINES IN CLYPEASTEROIDA (SAND DOLLAR) GENERA *DENDRASTER* AND *ARACHNOIDES*

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Keywords

Paleobiology, Echinoidea, Ontogeny, PCA analysis, Geometric morphometrics



Many irregular echinoid members of the order Clypeasteroidea (sand dollars) have obtained a distinctive circular outline or morphology. This unique morphology, flattened and rounded in appearance, may provide adaptive advantages to their shallow water, burrowing, niches member occupy. While there has been various morphological and morphometric studies conducted on Clypeasteroidea there remains little understanding on exactly how this unique morphology has been obtained across the group. This analysis utilizes geometric morphometric methodologies to quantify morphological variation in fossil clypeasteroid specimens of *Dendroaster* from the western United States and compared with extant *Arachnoides* material from Taiwan. The goals of this study works to quantify morphological and ontogenetic variation within and across the examined genera in an attempt to quantify how a circular morphology has developed in these genera. Results of the study suggest morphological and ontogenetic variation is strongest in the aboral/oral surfaces for the landmark and semilandmark analyses of ambitus morphology and curvature shape change; with loci of variation concentrated at the junction of the ambulacral/interambulacral regions and the ambitus margin. Other examined morphologic structures, the petaloid and posterior profile, do not show easily discernable patterns or trends in their morphological variation. Potential explanations for these results include interspecific variation within the examined genera, environmental influences on morphological variation, or other unexamined variables. Importantly, the results of this study demonstrate the utility and application of geometric morphometric methods in addressing morphological and evolutionary questions pertaining to Clypeasteroidea and sand dollars in general.



FOSSIL EARTHQUAKES PRESERVED ON FOSSILS: A CASE STUDY OF DEFORMED SPECIMENS OF *SCAPHECHINUS MIRABILIS* FROM MIAOLI, TAIWAN

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Keywords

Pleistocene, Quaternary Geology, Clypeasteroidea, Toukoshan Formation, Tectonic deformation

Taiwan is situated within the subduction zone between Philippine Sea Plate and Eurasian Plate; thus, the effect of tectonism is significant during the fossil diagenesis. The goal of this study is to find out the tectonic effects and earthquake-triggered responses preserved on Pleistocene fossils. Two major geologic structures, Futoukeng Fault and Tunghsiao Anticline, occur in Xihu of Miaoli. As a result, there are deformed specimens of fossil sand dollar *Scaphechinus mirabilis* with observable structures, such as distortion and fractures, recovered from strata in the studied area. Based on the particle moving path, types of fossil deformation can be classified with strain and change of volume. Based on rheological differences, tectonic-affected specimens could be divided into brittle and ductile deformations. Furthermore, there are three types of fracture, including joint, fissure, and shear, and there are four modes of displacements, including opening, sliding, tearing, and closing. A total of 80 specimens examined, there are 12 samples with obvious brittle deformation, and 19 samples with shear strain. Results of strain analyses on individual specimens will be discussed.





CHANGE OF POPULATION AND GROWTH RATE OF LARGE YELLOW CROAKER (*LARIMICHTHYS CROCEA*) IN TAIWAN SINCE PLEISTOCENE

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Keywords

Liuchungchi Formation, Tainan Science Park Archaeological Site Assemblage, Fish sclerochronology, Conservation paleontology

Overfishing in recent decades has been known to influence the community structures and life histories of fish, while the quantification and evaluation of the impact is a challenge yet to be solved in fishery management. As teleostean otoliths could be preserved and discovered generally in outcrops, be used in taxonomy, and be used to reconstruct life history by sclerochronological approaches, it is a high potential material to discuss long-term change of fish under different kinds of stresses. In this research, the authors focused on the critically endangered Sciaenidae species large yellow croaker (*Larimichthys crocea*) in the Northwest Indo-Pacific by using early Pleistocene fossils from outcrops, middle Holocene otolith remains from archaeological sites and modern specimens in Taiwan. After comparing its role in different eras, sclerochronological and isotopic analyses were also conducted to understand the change of growth rate since nearly two million years ago. The primary result pointed out an acceleration of fish growth in recent population which may be the result of overfishing recently in East Asia.





MOLECULAR AND CHEMICAL COMPOSITION OF FOSSIL SAND DOLLAR FROM TAIWAN

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Keywords

Molecular Paleontology, High Magnesium Calcite, Proteomes, Clypeasteroidea, Cenozoic



Taiwan is situated between the Euraisa Plate and Philippine Sea Plate. The main island of Taiwan is divided into several tectonic zones, including Coastal Plain, Western Foothills, Hsueshan Range, Backbone Range and Coastal Range. Cenozoic and often fossiliferous strata with shallow marine deposits are commonly exposed on the western side of the island. *Scaphechinus mirabilis* A. Agassiz, 1864 is one of the most common fossil sand dollars in Taiwan. Dense aggregates of *S. mirabilis* have been reported from the Toukoshan Formation (Pleistocene) in Miaoli County of Taiwan since 1940s; thus, fragments of *S. mirabilis* are available and can be tested and examined further for molecular preservation. Sea urchins, in general, their tests are composed of stereomic microstructure. Stereom is composed of trabeculae and interconnecting pores, and the organic materials bind in the interconnecting pores. To survey whether organic materials exist in fossil specimens or not, we include both living and fossil specimens of *S. mirabilis* and four other urchin species in this study analysed with two methods: titration and SDS-PAGE. Chemical compositions are measured by titration due to high magnesium calcite in tests. Another method is to detect organic material within tests. In previous proteomic analysis, it has been confirmed that the spicule matrix protein SM30 protein family does exist in extant adult tests. By a revised protocol of SDS-PAGE, we try to survey proteins or peptides in fossil tests. Results show that the main contents are calcium carbonate (CaCO_3) and magnesium carbonate (MgCO_3), but their ratios vary among species.



MECHANICAL ANALYSIS OF DINOSAUR EGGSHELLS AND SHEDS NEW LIGHT ON THE CONTACT-INCUBATION BEHAVIOR IN DINOSAURS

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Keywords

Eggshell, Dimensionless Number, Dinosaur Egg, Contact-Incubation



Extant avian eggs may be regarded as perfect designs by nature. It meets contradictory demands: it must be fragile enough to let chick out, meanwhile, it has to be stiff enough to bear the load induced by its parents during contact-incubation. In our previous work on avian eggshells of over 100 species, a dimensionless number C (or C number) that quantifies the shell relative stiffness across various egg sizes was defined and is constant among Neornithes. Extant birds are sole living descendants of non-avian dinosaurs, but it is still questionable that how non-avian dinosaurs contact-incubated. To study mechanical properties of fossil eggs, finite element analysis allowed us to create egg models. Besides, to simulate deformation of dinosaur eggs under the contact-incubation scenario, several exquisitely preserved troodontid and oviraptorosaurian clutches were studied as adult-associated clutches, which were seen as the evidence for contact-incubation. The result shows that C number of oviraptorosaurian eggs is lower than that of Neornithes, indicating that they are more fragile and less likely contact-incubated than avian eggs. The simulation result from troodontid clutches shows the capacity of bearing the body mass of parents, thus supporting the hypothesis of contact-incubation in troodontids and echoing the absence of a center devoid egg in their clutches. We further suggest that the center devoid of eggs present in the unique ringed oviraptorosaurian clutch countervails the lower C number. Our study not only questioned the presumed contact-incubation behavior in oviraptorosaurian dinosaurs but detailed revealed various reproductive strategies along the non-avian dinosaur-bird transition.

Molecular palaeontology reaches where classical palaeontology cannot. The presence of biomolecules preserved in fossils makes it possible to recover information about past events that would otherwise be very difficult to obtain.

The most frequently used molecules in palaeontology are DNA, proteins, amino acids or fatty acids, although inorganics like phosphates and carbonates are also used. Those are preserved inside bones, shells, trees, seeds, bacterial formations, sediments, etc. The principal techniques are ancient DNA, proteomics, stable isotopes, radiocarbon dating and amino acid racemization. Ancient DNA has made it possible to identify species, establish phylogenetic relationships and the divergence between taxa, hybridisations, migrations, distributions in the past, physical characteristics not fossilized, etc., which otherwise would not have been possible simply by observing bone remains. Proteomics, likewise ancient DNA, allows us to identify species or know their phylogenetic relationships, although due to its better preservation, it allows us to go further back in time than DNA. Stable isotopes bring us closer to palaeoecology thanks to the knowledge of the diets and mobility of living beings of the past, and radiocarbon dating and amino acid racemization help us to chronologically frame the remains. We welcome all researchers from the field of palaeontology or archaeology with a focus on ancient DNA, proteomics, stable isotopes or other molecular techniques to send contributions in order to improve and share their knowledge in this field.

Molecular Palaeontology

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Thematic Session



SINGLE COMPOUND NITROGEN ISOTOPIC ANALYSIS: A NEW TOOL FOR PALEODIETARY RECONSTRUCTIONS

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Keywords

Collagen, Amino Acids, Paleodiet, Nitrogen-15



The nitrogen isotopic ratio ($^{15}\text{N}/^{14}\text{N}$) in bone collagen is a powerful indicator able to provide dietary data on ancient mammals. The relative amount of ^{15}N increases with the position along a trophic chain, distinguishing predators from their prey. However, most trophic systems are complex with variable ^{15}N baselines, therefore complicating the picture. One way to avoid this baseline problem is to use the ^{15}N abundances of single amino acids (AA) from ancient collagen, specifically from source and trophic amino acids. Source AAs do not change much in abundance along a trophic chain, while trophic AAs do, allowing a detailed reconstruction of trophic position independent of the ^{15}N baseline. This approach enables the proportion of meat versus plant to be determined in the diet of potentially omnivorous mammals, such as cave bears and Neanderthals. Although technically challenging, this approach may be applied more widely to any omnivorous species and thus help refine the reconstruction of past trophic systems. Using the isotopic content of specific AAs specifically linked to metabolic processes, it could be possible to address physiological conditions such as hibernation or starvation. This will require further benchmarking based on modern case studies and experimental work. Combined with additional isotopic tracers, such as the single compound carbon isotopic analysis, this new direction of isotopic paleodietary studies could provide more refined information about ancient species including extinct ones and the ecosystems they lived in. We will present here some applications of this approach and discuss its potentials and challenges ahead.



PREGLACIAL PALAEOECOLOGY OF WOLVES AND BROWN BEARS ON BOTH SIDES OF BERINGIA

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Keywords

Stable Isotopes, Brown Bear, Wolf, Upper Pleistocene, Paleoecology



The mammoth steppe was a biome that spread from western Europe to northern North America during the Late Pleistocene. A review of 429 isotopic records from Eastern and Western Beringia preceding the Last Glacial Maximum has been made, including herbivores that were present on both sides (mammoth, horse, bison, and reindeer), in addition to all available carnivores (brown bear, wolf, cave lion, scimitar cat and short-faced bear). Herbivores of W Beringia have a higher $\delta^{15}\text{N}$ (from +1 to +2.7‰) and a more negative $\delta^{13}\text{C}$ (from 0 to -1.1‰) compared to E Beringia, probably due to environmental differences across the Bering land connection. This is not the case of the wolf and the brown bear, where the difference between W and E Beringia is +4.8 ‰ and -0.6 ‰ for the bear, and +4.1 ‰ and -0.8 ‰ for the wolf. The other carnivore that is present in both sides is the lion, but the difference is more similar to those of the herbivores (+2.9 ‰ and -0.2 ‰). The overlap of isotopic values of the lion with the wolf and the bear in E Beringia is small, while this overlap in W Beringia is noticeable. As there were fewer competitors in W Beringia, bears and wolves had the possibility of predate larger herbivores, while their role in E Beringia would be more restricted to scavenging, hunting smaller-sized prey and increasing plant material in their diets. Two of individual bears with higher $\delta^{15}\text{N}$ of W Beringia present a large size, which supports this greater contribution of animal matter in their diet.



MOLECULAR PALEONTOLOGY APPLIED TO SITES WITH FRAGMENTED REMAINS: THE CASE OF COVA DOS SANTOS (NW SPAIN)

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Keywords

Zooms, Stable Isotopes, Leopard, Rhinoceros, Cave Bear



Highly fragmented skeletal remains present a problem in palaeontology and archaeology as their taxonomic identification is not always possible. In recent decades, molecular techniques have been developed that allow the characterisation of these type of remains. **ZooMS** (Zooarchaeology by Mass Spectrometry) is a rapid molecular technique based on the premise that the amino acid sequence of the collagen, shows small differences between genus and/or species that can be deciphered by using the MALDI-TOF spectrometer. Stable isotopic analysis of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in bone collagen is used for the study of palaeodiets and palaeoecology. By combining these two techniques, it is possible to obtain much more information from sites with fragmented skeletal remains. Cova dos Santos (a karstic cavity located in Abadín, Lugo, NW Spain) has 198 m of total length and 18.6 m of vertical development. Three zones are defined in this cavity. The main room is characterised by its wide vault, and fragmented bones of small herbivores were found among the blocks on the floor. On the west side of this room there are karst tuffs with polished surfaces and blioglyphs (scratches of young bears). The southern area consists of a labyrinthine network of interconnected passages, where fragmentary skeletal remains of medium and large vertebrates were found. A total of 50 bone remains were recovered, most of them fragmented. 23 bones were identified morphologically, and when possible, a metrical analysis was undertaken. ZooMS was applied to 20 previously unidentified fragments, of which 6 were identified to species level, 13 to genus, and one was impossible to identify with this technique. 23 skeletal remains were isotopically analysed. Combining these methods with radiocarbon dating, it has been possible to identify different taxa such as *Ursus spelaeus*, *Ursus arctos*, *Panthera pardus*, *Cervus elaphus*, Rhinocerotidae, and to confirm the occupation of this cave since at least 43000 years ago calBP. The presence of domestic species, such as *Ovis aries*, *Equus* sp. and *Gallus gallus*, also shows the use of this cave in more recent times.



VALIDATION OF RED DEER (*CERVUS ELAPHUS*) OXYGEN ISOTOPE COMPOSITION IN ENAMEL CARBONATE ($\delta^{18}\text{O}_{\text{EC}}$) TO RECONSTRUCT PALEOTEMPERATURES AND PALEOSEASONALITY: EVIDENCE FROM MODERN IBERIAN SPECIMENS

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Keywords

Bioapatite carbonate $\delta^{18}\text{O}$, *Cervus elaphus*, Oxygen isotopes, Palaeoclimate, Paleoseasonality



Paleoclimate reconstruction based on oxygen isotope composition in herbivore teeth is a common practice in archaeology and palaeontology. While being cosmopolitan, there are limited studies that have tested the potential utility of red deer isotopes as a useful paleoclimate proxy. Our study examines modern specimens from Riaño y Mampodre (León) and El Hosquillo (Cuenca) under known conditions to elucidate the relationship between enamel carbonate $\delta^{18}\text{O}$ values ($\delta^{18}\text{O}_{\text{ec}}$), local precipitation, and annual and seasonal temperatures. Serial sampling across seven *Cervus elaphus* third molars yielded a mean number of ten samples per molar. These samples reveals a pattern related to that observed in meteoric waters over less than a year, although this pattern appears highly variable even in individuals born in the same year. Two of the samples show a clear maximum (summer) and minimum (winter) $\delta^{18}\text{O}$ value that allowed reconstructing an estimated nine month period for mineralization of the M3 enamel, a shorter but consistent period to what is known from radiographic studies. While the correspondence between individual maximums, minimums, range, and mean $\delta^{18}\text{O}_{\text{ec}}$ values and climatic data is poor, the values for the whole of the population appear to be approximate. It appears then that red deer $\delta^{18}\text{O}_{\text{ec}}$ from third molars of multiple individuals may be a useful proxy to recover information about past climate temperature and seasonality. This study highlights the usefulness of modern analog analyses to understanding ancient ecosystems, particularly for species that are still extant.



IDENTIFICATION BY PEPTIDE FINGERPRINTING OF A MARINE MAMMAL IN THE HOLOCENE FAUNA OF THE AREALONGA SUBMERGED FOREST (LUGO, NW IBERIAN PENINSULA)

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Keywords

Bone Collagen, Mass Spectrometry, Taxonomy

The coastal deposits known as submerged forests are the remains of ancient forest floors rich in logs and stumps, frequent on the Atlantic coasts of Spain, France, or the British Isles. Post-glacial coastal dynamics caused their burial by the advance of dunes prior to sea level rise. Today, this same process is exposing them and irremediably eroding them. In addition to the plant macro-rests of various tree and shrub species, in some cases, bone remains of terrestrial fauna were found preserved within the peaty deposits and the trunks. At Arealonga (Cantabrian coast of Lugo, Spain), remains of deer, horses, bovids and other terrestrial mammals were recovered. The presence of a thick bone fragment indicated the presence of a large mammal. Peptide fingerprint analysis of the collagen identified the bone specimen as belonging to an odontocete cetacean, most probably an orca (*Orcinus orca*). This analysis is based on the digestion of the bone collagen with trypsin and the separation by MALDI-TOF mass spectrometry of the collagen peptides generated. The combination of certain peptides that serve as markers allows taxonomic identification. This rapid and low-cost technique is very useful for identifying bone remains that can no longer be identified by traditional morphological study.





A ZOOMS ANALYSIS ON MAMMAL BONE REMAINS FROM EL HATTAB-II AND KEHF EL HAMMAR (NORTH OF MOROCCO)

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Keywords

ZooMs, brown bear, lion, northern Morocco



In archaeological or palaeontological deposits, taxonomic identification of animal remains is not always straightforward due to the high degree of fragmentation that bones tend to present. In the last decade, a molecular biology technique, called **ZooMs** (zooarchaeology by mass spectrometry) has been developed for the identification of bone fragments. Bone collagen, with a good degree of preservation, is extracted and broken into smaller peptides with trypsin. The obtained set of peptides can be identified by **MALDI-TOF** (Matrix-Assisted Laser desorption/ionization, time of flight). Some of these peptides are characteristic of a certain taxon, and their presence or absence will allow us to differentiate the taxon of the sample, functioning as molecular markers. In this work this technique has been applied to 8 bone remains from the cave sites of Kefh el Hammar and Hattab II, both located in northern Morocco. In those two sites, the bone sample is usually fragmented and therefore taxonomic identification was only possible in a low percentage of the remains. However, the application of ZooMs allowed us to identify brown bear (*Ursus arctos*) remains and one lion (*Panthera leo*) bone, not previously described among the cave fauna. The results obtained broaden the faunal spectrum and the number of remains identified, in order to carry out further studies, mainly stable isotope analysis and palaeogenetic studies, which are currently underway.



A MOBILITY STUDY OF FAUNAS AND HUMANS USING SR ISOTOPES: THE SITE OF CHAN DO LINDEIRO IN O COUREL (LUGO, GALICIA, NW IBERIAN PENINSULA)

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Keywords

Bos primigenius, *Homo sapiens*, $^{87}\text{Sr}/^{86}\text{Sr}$, Mesolithic



Strontium is present in trace amounts in all kind of rocks, and in water, soils, plants and animals. In animal bones, Sr replaces calcium in the bioapatite. The ratio $^{87}\text{Sr}/^{86}\text{Sr}$ in geological materials depends on the age and composition of the geological formations. Thus, $^{87}\text{Sr}/^{86}\text{Sr}$ in animal tissues reflects that in the underlying bedrock -just the bioavailable fraction- and therefore can be used to track faunal movement across regions of varying geology. To determine the mobility patterns of target animals, and in the absence of an established baseline, it is necessary to have unambiguously local samples to compare the $^{87}\text{Sr}/^{86}\text{Sr}$ values. Another problem is the possible post-mortem contamination of apatite with Sr from the substrate, so samples of dental apatite, which is less prone to diagenesis than bone, are preferable but not always available. In this work we carried out an analysis of Sr isotopes in three aurochs (*Bos primigenius*) and a woman, all of similar chronology (~ 9300 calBP), which were found together in Chan do Lindeiro cave in O Courel (Galicia, NW Iberian Peninsula), trying to find out if all of them were of local origin or came from other regions, since aurochs are not a typical species in the area, for this aim and their discovery together with the woman has connotations related to incipient pastoralism. To this end, we compared the values recorded in their apatite with those of local domestic livestock (from protohistoric to medieval times), finding differences that point to a non-local origin for the woman and at least one of the aurochs. However, the results of these analyses may be altered by the preservation of the skeletal remains, so this possibility is explored in more detail.

The evolution of life is intertwined with the geological changes of the Earth's environment in deep time. Of particular importance, how and when this coevolution happens during the key geological transitions is central in understanding some of the most remarkable events in the history of life. Recent technological innovations in both the earth and life sciences have generated unprecedentedly detailed and comprehensive datasets, providing a promising yet challenging prospective on this topic, using big data analytics and the development of statistic methodology. The main goal of this session aims to invite researchers to present their latest progresses in palaeobiology, sedimentology, palaeoceanography, palaeoclimatology, palaeogeography, and evolutionary developmental biology. In addition, they will discuss the current synthesis in the pattern and mechanism of the co-evolution of life and environment in several key transitions, from the interdisciplinary perspectives.

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Co-evolution of life and environment during the key geological transitions

Organisers

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Thematic Session



EARLY ARTIODACTYLS FROM THE MIDDLE EOCENE OF THE ERLIAN BASIN, INNER MONGOLIA, CHINA

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Keywords

Erlian Basin, middle Eocene, early artiodactyls, Lantianiinae, Homacodontidae



Early artiodactyls are rarely reported from China, and most are restricted in the middle Eocene Shanghuang fissure-fillings of Jiangsu, China. Here we report the first records of small artiodactyls from the middle Eocene deposits of the Erlian Basin, Inner Mongolia, China. A new small artiodactyl, represented by several isolated lower molars and a single upper molar, is unearthed from the Irdin Manha Formation. The lower molars of the new specimens are similar to those of lantianiinae *Elaschitherium*, which was previously known from the Shanghuang fauna and composed of two species. But the new material differs from *Elaschitherium* in having a more anteroposteriorly compressed trigonid, a relatively more mesially placed entoconid, and the endohypocristid and preentocristid forming a rudimentary hypolophid. The upper molar (M1/2), however, is clearly different from that of *Elaschitherium* in having a more quadrilateral outline, a seleodont crown, a distinct mesosyle, and a large, conical hypocone joining the protocone by a prehypocrista. Some of those characters on the upper molar are reminiscent of North American homacodontids, such as *Hylomeryx*, *Bunomeryx*, and *Mytonomeryx*. The lower molars and the upper molar are probably associated and collectively represent a new genus, although the probability that they belong to different taxa cannot be excluded. These specimens of early artiodactyls from the Erlian Basin suggest a more diverse artiodactyl group than previous thought from the middle Eocene of the Erlian Basin, and will shed light on the early evolution and dispersal of early artiodactyls.



INTEGRATED PHYLOGENOMICS AND FOSSIL DATA RESOLVE THE EVOLUTION OF BEETLES

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Keywords

Cretaceous Terrestrial Revolution, macroevolution, Coleoptera, co-evolution, timetree

With over 380,000 described species and possibly several million more yet unnamed, beetles represent the most biodiverse animal order. Recent phylogenomic studies have arrived at considerably incongruent topologies and widely varying estimates of divergence dates for major beetle clades. Here we use a dataset of 68 single-copy nuclear protein coding genes sampling 129 out of the 196 recognized extant families as well as the first comprehensive set of fully-justified fossil calibrations to recover a refined timescale of beetle evolution. Using phylogenetic methods that counter the effects of compositional and rate heterogeneity we recover a topology congruent with morphological studies, which we use, combined with other recent phylogenomic studies, to propose several formal changes in the classification of Coleoptera: Scirtiformia and Scirtoidea *sensu nov.*, Clambiformia *ser. nov.* and Clamboidea *sensu nov.*, Rhinorhipiformia *ser. nov.*, Byrrhoidea *sensu nov.*, Dryopoidea *stat. res.*, Nosodendriiformia *ser. nov.*, and Staphyliniformia *sensu nov.*, alongside changes below the superfamily level. The heterogeneous former superfamily Cucujoidea is divided into three monophyletic groups: Erotyloidea *stat. nov.*, Nitiduloidea *stat. nov.*, and Cucujoidea *sensu nov.* Our divergence time analysis recovered an evolutionary timescale congruent with the fossil record: a Carboniferous origin of Coleoptera, a Paleozoic origin of all modern beetle suborders, and a Triassic–Jurassic origin of most families. While fundamental divergences within beetle phylogeny did not coincide with the hypothesis of a Cretaceous Terrestrial Revolution, many polyphagan superfamilies exhibited increases in richness with Cretaceous flowering plants.





THE FISH DIVERSITY AND THE PALAEOENVIRONMENT OF XIAOXIANG FAUNA IN EASTERN YUNNAN, CHINA

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Keywords

Silurian, Xiaoxiang Fauna, fish diversity, sedimentary facies, palaeoenvironment

Since *Guiyu oneiros* from the Xiaoxiang Fauna was reported in 2009, the Silurian vertebrates of Eastern Yunnan have been under vigorous investigation. A series of pivotal fossil discoveries provided the critical data for our understanding of the origin of major vertebrate groups such as the jawed vertebrates, the gnathostome crown-group, the osteichthyans, and the sarcopterygians. Of equal importance, these fossil data also contributed to a reliable subdivision and correlation of the Chinese Silurian fish-bearing beds. The detailed investigation of the geology of these fish-bearing beds also offer an opportunity for the study of the palaeoenvironment background, and its synergistic evolution with the vertebrate fauna. Xiaoxiang Fauna includes two vertebrate assemblages, Yangtze and Hongmiao assemblage. Yangtze assemblage occurs in the Ludlow Red Bed of the Kuantu Formation in Qujing, Yunnan. Recently, we analyzed the Palaeoenvironment of Kuantu Formation by lithofacies investigation and microscopic analysis of 129 thin sections, combined with biofacies analysis. The results show that the sedimentary environment of the Kuantu Formation gradually changes from an offshore dominated by clastic deposits to a platform dominated by carbonate sedimentary. Moreover, the changes in the depth of the palaeoenvironment are not dramatic. A stable living environment, coupled with the warmly climate due to the palaeogeographic position, may provide a critical cradle for the extraordinary diversity and exquisite perseverance of the Xiaoxiang Fauna.





A SHORT-LIVED OXIDATION EVENT DURING THE EARLY EDIACARAN AND DELAYED OXYGENATION OF THE PROTEROZOIC OCEAN

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Keywords

DOM (Dissolved Organic Matter), carbon isotope perturbations, strontium isotopes, sulfur isotopes, uranium isotopes, Metazoans

The Ediacaran Period was characterised by major carbon isotope perturbations. The most extreme of these, the ~570 Ma Shuram/**DOUNCE** (Doushantuo Negative Carbon Isotope Excursion) anomaly, coincided with early radiations of benthic macrofauna linked to a temporally-restricted expansion in the extent of marine oxygenation. Here we document an earlier negative excursion (the ~610 Ma **WANCE** (Weng'An Negative Carbon Isotope Excursion) anomaly) in the Yangtze Gorges area, South China, that reached equally extreme carbon isotope values and was associated with a similar degree of environmental perturbation. Specifically, new uranium isotope data evidence a significant, but transient, shift towards more oxygenated conditions in tandem with decreasing carbon isotope values, while strontium and sulfur isotope data support an increase in continental weathering through the excursion. We utilize a biogeochemical modelling approach to demonstrate that the influx of such a weathering pulse into an organically-laden, largely anoxic ocean, fully reproduces each of these distinct isotopic trends. Our study directly supports the hypothesis that a large dissolved marine organic pool effectively buffered against widespread oxygenation of the marine environment through the Proterozoic Eon, and in doing so, substantially delayed the radiation of complex aerobic life on Earth.





LAST SURVIVORS AND EARLY FORERUNNERS OF TETRAPODS FROM THE LATE PERMIAN OF NORTH CHINA AS INDICATORS OF LOCAL PALEOENVIRONMENTS

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Keywords

Tetrapods, late Permian, north China, Paleoenvironment



The Permo-Triassic Transition was a key period in the Earth History, characterized by mass extinction, faunal turnovers and environmental changes. Tetrapods provide an important source of information in understanding how life and environments co-evolved during this period. Here we report two unusual cases of tetrapod occurrences in North China. *Seroherpeton yangquanensis* from the Lopingian of Shanxi, China was the last occurrence of Embolomeri, a clade most abundant during the Carboniferous and not previously known since middle Permian. The clade Embolomeri were large crocodile-like predators adapted in the tropical swamp forests, the diversity loss of which was associated with the global aridification since the early Permian. The appearance of it in the Erdos Basin during the Lopingian indicated a warm and humid local environment, a last resort for its survival. Another case is a new species of archosauriform from the Lopingian of Xinjiang, which documents the first occurrence of Archosauriformes in China. This clade, later becoming dominant during the Mesozoic, was only previously known in China since the Triassic. The early occurrence of this small-sized archosauriform during the Permian indicates that no drastic climate change occurred in Xinjiang during the Permo-Triassic transition.



THE LATE DEVONIAN ESCUMINAC LAGERSTÄTTE AND THE FISH-TO-TETRAPOD TRANSITION

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Keywords

Elpistostegalian, Terrestrialization, Origin of Tetrapods



One of the key evolutionary steps during vertebrate history is the fish-to-tetrapod transition which preceded the aquatic-to-terrestrial environmental shift. The terrestrialization of vertebrates implies a cascade of evolutionary events in which transitional forms adapted to changing habitats. Although some purported tetrapod trackways are dated from the Middle Devonian, well-documented skeletal evidences support a transition during the Frasnian. Recognized as a UNESCO world heritage, the Middle Frasnian Escuminac biota from Miguasha (Canada) is considered as one of the best sites to document this transition. The assemblage includes more than 21 000 vertebrate specimens belonging to 20 species ranging phylogenetically from anapsid-like forms to elpistostegalian. Recently, *Elpistostege* was suggested to be a tetrapod owing to the presence of digits within pectoral fins. Thirteen aquatic (e.g., ctenophore, scolecodont, spinicaudatan, parastylonurid) and terrestrial (e.g., scorpionid, gigantoscorpionid, millipede) invertebrates co-occurred with fishes; most of them are extremely rare with the exception of the spinicaudatan *Asmusia*. For the past 30 years, a great deal of sedimentological, geochemical (sediments and bony tissues), palynological and palaeoecological data have been gathered to document the Escuminac palaeoestuary. The Escuminac Formation is interpreted as a wave-dominated estuarine depositional environment. Tidal deposits yielded exceptional and abundant fossils. Among them, large-sized *Elpistostege* have been found in laminated facies. Size distributions of the 20 vertebrate species suggest that most of them were estuarine residents, while some such as *Elpistostege* were non-resident. Taphonomical investigations of *Elpistostege* specimens provide clues on the palaeoenvironmental setting of burial sites as well as potential feeding and living habitats.



THE RAPID EVOLUTION OF LUNGFISH DUROPHAGY

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Keywords

Early Devonian, lungfish, durophagy, evolution



Major changes in mid-Paleozoic aquatic ecosystems have been attributed to the expanded dietary breadth of jawed vertebrates following their first definitive appearance in the Silurian. Paleobiological hypotheses implicate innovations in durophagy — the consumption of prey items protected by hard shells or exoskeletons — as driving major ecological and evolutionary shifts in marine settings over the Phanerozoic. Lungfishes represent the first and longest-ranging lineage of durophagous vertebrates, but how and when the various feeding specializations of this group arose remain unclear. *Youngolepis praecursor* is a common member of the diverse sarcopterygian assemblage from the Lower Devonian Xitun Formation of Yunnan, China. Current consensus places *Youngolepis* at the base of the lungfish lineage, branching between the Porolepiformes and *Diabolepis*. *Youngolepis* is therefore a pivotal taxon for investigating the origin of lungfish anatomical specializations. Two articulated specimens of *Youngolepis praecursor* from the type locality preserve these critical aspects of morphology. Micro-computed tomography (μ CT) reveals that *Youngolepis* is radically more lungfish-like than previously anticipated, with substantially reorganized palatal dentition, geometry, and suspension relative to primitive rhipidistian conditions. The entopterygoid has a thickened and expansive horizontal lamina that bears patterned, radial rows of teeth like the toothplates of *Diabolepis* and other primitive lungfishes. These attributes, which are further amplified in more crownward lungfishes, reflect biomechanical transformations consistent with the processing of hard prey. *Youngolepis* captures the earliest stages in the development of a trophic strategy that has characterized a major vertebrate lineage for over 415 million years.



SHARP CHANGES IN PLANT DIVERSITY AND PLANT-HERBIVORE INTERACTIONS DURING THE EOCENE–OLIGOCENE TRANSITION ON THE SOUTHEASTERN QINGHAI-TIBETAN PLATEAU

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Keywords

Plant-herbivore interactions, uplift, Eocene, Oligocene, climate change



Herbivore damage patterns on fossil leaves are essential to explore the evolution of plant-herbivore interactions under paleoenvironmental changes and to better understand the evolutionary history of terrestrial ecosystems. The Eocene–Oligocene transition (EOT) is a period of dramatic paleoclimate changes that significantly impacted global ecosystems; however, the influences on plant-herbivore interactions during this period are largely unknown. We identified taxonomic composition of the flora, and investigated well-preserved herbivore damage on fossil leaves from two layers of the Lawula Formation in Markam County, southeastern Qinghai-Tibetan Plateau (QTP), China. Besides, paleoclimate conditions were reconstructed using fossil plant assemblages. The plant assemblage from the latest Eocene layer (MK-3, ~34.6 Ma) was dominated by Fagaceae and Betulaceae, whereas Rosaceae and Salicaceae were the most abundant in the earliest Oligocene layer (MK-1, ~33.4 Ma). In MK-3, 932 out of 2,428 fossil leaves were damaged and presented 41 damage types (DTs). The richest functional feeding groups (FFGs) in this layer were hole feeding, margin feeding, and galling. In MK-1, 144 out of 599 leaves were damaged and presented 20 DTs, with the major FFGs being hole feeding, margin feeding, and skeletonization. Generally, MK-3 had a significantly higher damage frequency (DF) and more DTs compared to MK-1. The decline in temperature, accompanied by the mountain uplift during the EOT on the QTP margin, led to changes in plant composition, with a consequent decrease in herbivory quantity and diversity. Our results shed new light on the influence of paleoenvironmental changes in shaping the evolution of biodiversity as well as the ecosystem on the plateau.



ONTOGENETIC CHANGES AND GROWTH CURVE OF THE JURASSIC CERATOPSIAN *YINLONG DOWNSI*

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Keywords

Bone Histology, Ontogeny, Ceratopsia, Jurassic, China

Yinlong downsi is one of the earliest ceratopsian dinosaurs from the Late Jurassic of Xinjiang, China, and is represented by a dozen individuals, but its ontogenetic changes have been poorly studied. Here we studied the ontogenetic and intraspecific variation of this species, and reconstructed a growth curve based on a relatively large sample size. The results indicate that the ontogenetic changes include an increased size of the rostral bone relative to the premaxilla, parietals that extend more posteriorly, an increased angle between the posterior margin of parietal and squamosal, and enlarged lateral nodes on the squamosal. Noticeably, the rostral bone and parietals are more prominent in later-branching ceratopsians. Some intraspecific variations are also identified, such as the presence of a caniniform premaxillary tooth and a hook-like fourth trochanter in some specimens. The cortex of the tibia mainly consists of fibrolamellar bone tissues, but parallel-fibered bone and LAGs are very common through ontogeny, suggesting a moderate growth rate. Three ontogenetic stages were identified: juvenile, subadult and young adult, but still not fully grown due to the lack of EFS. The reconstructed growth curve suggests that *Yinlong* may reach sexual maturity at 9 years old, which is similar to that of *Psittacosaurus*.





THE MAMMALIAN DIAPHRAGM AS AN EVOLUTIONARY NOVELTY

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Keywords

Evo-Devo, Embryonic Development, Developmental Constraint, Mammalian Evolution, Skeletal Muscle



The respiratory systems mediate between living bodies and surrounding environments. In the vertebrate evolution, mammals and birds evolved efficient respiratory systems, respectively, to accomplish high oxygen uptake from the atmosphere. While in the dinosaur-bird lineage, the highly compliant airsacs had become involved in ventilation, in the mammalian lineage, the diaphragm, a skeletal muscle settled deep in the thorax, had evolved to forcibly expand the low compliant bronchoalveolar lungs during ventilation. Since the other vertebrates do not possess muscles corresponding to the diaphragm, the evolutionary origin of the diaphragm had remained unclear until recently. We have been working on this question through analyses on both embryonic developments and fossils. In the mammalian embryos, the diaphragm and forelimb muscles develop from adjacent masses of migratory muscle precursor (**MMP**) cells, which are derived from consecutive somites. On the other hand, according to the fossil record, in the pelycosaur-grade condition, the forelimb was placed cranially in a position similar to the distribution of the MMP cells of the diaphragm in the modern mammals. Based on comparative morphology of the brachial plexus, the diaphragm was likely acquired through a duplication of the subscapular muscle concomitant with a caudad shift of the shoulder girdle (i.e., increase of cervical vertebrae) during evolution. The diaphragm had evolved by the Permo-Triassic boundary, and it is possible that the drop of atmospheric oxygen level enhanced the canalization of diaphragm development by selection, which eventually brought about a developmental constraint on the number of cervical vertebrae as seven.



STROMATOPOROIDS FROM THE MIDDLE DEVONIAN JIWOZHAI REEF OF SOUTH CHINA AND THEIR PALAEOECOLOGICAL IMPLICATION

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Keywords

Stromatoporoid Fauna, Reef-Building Palaeoecology, Givetian Reef, South China Block



Stromatoporoids are the major constructors of a Givetian (Middle Devonian) fossil reef in shallow marine epicontinental facies, at Dushan, Guizhou Province, South China. Stromatoporoids, together with other reef building and dwelling components (rugose corals, tabulates, chaetetids and others), form a high diversity community, making the Jiwozhai reef a palaeobiodiversity hotspot. Using 772 specimens (and total of 1740 thin sections), eleven species belonging to nine genera are recognized, including *Gerronostromaria grossum* (Clathrodictyida), *Pseudotruperetostroma celluloseum* and *Salirella bücheliensis* (Stromatoporida), *Clathrocoilona spissa*, *Stictostroma saginatum* and *Synthetostroma actinostromoides* (Stromatoporellida) and ?*Habrostroma laminosum*, *Parallelopora* sp., *Stachyodes costulata*, *Sta. fasciculata* and *Sta.* sp. (Syringostromatida). Among them, clathrodictyids and stromatoporellids are the overwhelming contributors in the reef limestones. Stromatoporoid growth form, size, substrate and growth interruption are considered as key autecological parameters to evaluate their growth behaviour and contribution in the reef. *Clathrocoilona spissa* is the most abundant in this stromatoporoid fauna, with a small-sized skeleton (maximum 40 mm in basal dimension and commonly less than 2 mm in thickness) and encrusting habit, thus is interpreted not to have well stabilised sediment and was vulnerable to sedimentation. In contrast, *Gerronostromaria grossum*, although less abundant, created a larger laminar growth form (up to 500 mm in basal dimension and up to 40 mm thick) is interpreted to have had a prominent advantage that expand laterally on bioclastic and clay-rich micritic substrate and was resilient to episodic sedimentation events; *G. grossum* is therefore interpreted to be the (biologically) dominant stromatoporoid in the assemblage.



TOOTH REPLACEMENT PATTERNS IN THREE JURASSIC CERATOPSIDS INDICATING THE EVOLUTION OF DENTITIONS AND DIET IN EARLY-DIVERGING CERATOPSIDS

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Keywords

Ceratopsia, Tooth replacement, Computed tomography, Jurassic, China



The Ceratopsid dental system is characterized by high-angled tooth crowns, split tooth roots, and multiple teeth in a single alveolus, but the origin and early evolution of this unique dental system are poorly known. Here we present a computed tomographic analysis of the dentitions of three early-diverging ceratopsians: *Yinlong* from the early Late Jurassic of Xinjiang, China; *Chaoyangsaurus* from the Late Jurassic of Liaoning, China; and a new specimen of *Hualianceratops* discovered from the same formation as *Yinlong*. Our study revealed significant new information of the dental system for these early ceratopsians, including no more than five replacement teeth in each jaw quadrant; nearly full resorption of the functional teeth during tooth replacement in *Yinlong* and *Chaoyangsaurus*; and occlusion with low-angled, concave wear facets that differ from the shearing occlusal system seen in neoceratopsians. Only *Yinlong* bear rare remnants of functional teeth within some alveoli. *Yinlong* also presents an increase in maxillary tooth alveoli and a decrease in the number of replacement teeth during ontogeny, and the remnants of functional teeth are remained in the largest individual. This information indicate that early-diverging ceratopsians have a relatively slow tooth replacement rate. Combined with palaeobotanical and palaeoenvironmental data, *Yinlong* is likely to use gastroliths to triturate foodstuffs, and the difference in diet strategy might have influenced the replacement pattern.



A NEW SPECIMEN OF *NANHSIUNGCHELYS* (TESTUDINES: CRYPTODIRA: NANHSIUNGCHELYIDAE) AND ITS LIFESTYLE IMPLIED BY FLUID DYNAMICS SIMULATION

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Keywords

Nanhsiungchelys, lifestyle, fluid mechanics, Cretaceous, China

Nanhsiungchelyids is a group of large turtles living in the Cretaceous of Asia and America. Here we report a new specimen of nanhsiungchelyids from the Upper Cretaceous Nanxiong Basin, China, which includes a well preserved skull and the anterior part of the postcranial skeleton. It could be assigned to *Nanhsiungchelys* based on the weakly developed cheek and temporal emarginations, a deep nuchal emargination and a pair of anterolateral processes on the carapace, and the special network sculptures on skull and shells. However, it differs from the previously known species of *Nanhsiungchelys* by lacking of trumpet-shaped snout and having relatively large anterolateral processes. The new phylogenetic analysis of nanhsiungchelyids supports that this new specimen and *Nanhsiungchelys wuchingensis* form a sister group. Noticeably, the carapace of *Nanhsiungchelys* and *Anomalochelys* have special anterolateral processes, which are unique in Mesozoic turtles and their function is still unclear. Here, we test the function of anterior processes by fluid dynamics simulation, and the result suggests that these processes can reduce resistance (~16.7%) while swimming in water. It has been controversial that whether the lifestyle of nanhsiungchelyids is terrestrial or aquatic, and our result suggests that *Nanhsiungchelys* is more adapted to an aquatic or semi-aquatic life.





FIRST RECORD OF THE MYRMECOPHILOUS GROUND BEETLE (COLEOPTERA, CARABIDAE, PAUSSINAE) FROM ROVNO AMBER, EOCENE

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Keywords

Paussinae, ground beetles, amber, Eocene



The Paussinae, as monophyletic group within the Carabidae (Coleoptera), consist of the four tribes: Metriini, Ozaenini, Protopaussini and Paussini. The representatives of the last two tribes are myrmecophiles with morphological adaptations to life in ant nests. The adults Paussinae are characterized by a derivative regime of chemical protection, as well as for the Brachininae. Today the number of extant species of Paussinae is about 800. The single Cretaceous paussine species of the monotypic genus, *Kryzhanovskiana* Kataev et Kirejtshuk, 2019, was described from Burmese amber. The most fossil paussine records are from Baltic amber: 20 extinct species belong to six extinct genera — *Succinarthropterus* Kolbe, 1926, *Pleurarthropterus* Wasmann, 1927, *Cerapterites* Wasmann, 1925, *Protocerapterus* Wasmann 1926, *Arthropterites* Wasmann, 1925 and *Eopaussus* Wasmann, 1926. One middle Eocene species of *Pleurarthropterus* was described from Eckfeld Lagerstätte; two species of the genus *Paussopsis* Cockerell, 1911 were described from Florissant Lagerstätte (late Eocene), but one of them probably belongs to the weevils of the subfamily Entiminae (Legalov, pers. comm.). Five extinct species reported from Dominican and Mexican ambers belongs to recent genera — *Protopaussus* Gestro, 1892 (one species), *Eohomopterus* Wasmann, 1925 (three species) and *Homoptera* Westwood, 1841 (one species). Apparently, the new fossil beetle from Rovno amber belongs to the tribe Paussini Latreille, 1806 based on the following morphological characters: apex of elytra rounded; antennal club nine-segmented, parallel; head with the strongly vaulted eyes somewhat narrower than pronotum; pronotum transversal, cordate and with narrow marginal edge; elytra slender.



FIRST SYNINCLUSION OF TIGER AND GROUND BEETLES: *GORIRESINA* (CICINDELIDAE) AND *LEBIINE* (CARABIDAE) FROM ROVNO AMBER

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Keywords

Eocene, Coleoptera, Iresiina, Lebiini



The beetles founded in the large piece of amber belong to two families of Adephaga — Cicindelidae (Cicindelini: Iresiina) and Carabidae (Lebiini: Dromiusina); there are no other beetles and ants among the syninclusions. The Rovno amber forest was situated on the southern coast of the Subparatethys. The Priabonian climate there was warmer than in the Baltic amber forest and winters were milder. This is confirmed by the discovery in the syninclusion the tiger beetle, which represents the new genus of the extant tropical subtribe Iresiina. Only two specimens from two genera of this subtribe are known from Baltic amber. The extant species of Iresiina are inhabitants both in the open and closed habitats (shrubs, forests). It is known that species oriented to closed habitats actively use trunks of different trees or shrubs as a hunting arena. As the authors of the species have shown, the new tiger beetle, *Goriresina fungifora* Matalin et al., 2021, is a predator capable of hunting on the trees as well. Both the ground and tiger beetles could hunt on the ground and on the trees. The finding of two active and rather large predatory beetles in one piece of amber indicates the abundance of their prey in the Rovno amber forest and a rather considerable variety of *Geoadephaga*, at least in the absence of a strong ants press. Except *G. fungifora*, only one Rovno adephan species was described, i.e. dromiusine *Antepphilorhizus pripiatiensis* Kirichenko-Babko et al., 2021.



THE PLANT FOSSILS FROM THE EARLY PERMIAN ATHESIAN VULCANIC GROUP (NORTHERN ITALY)

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Keywords

Megacaldera, Macrofossils, Permineralization, Impressions, Compressions



The mega-caldera of the Athesian Volcanic Complex is one of the biggest supervolcanoes in Earth history. The explosive super-eruptions that created the Athesian Volcanic Group during the early Permian extended over a time span of 15 million years. The volcanic rocks are intercalated with sedimentary successions deposited during periods of volcanic quiescence. These fluvio-lacustrine sediments are particularly interesting since they yield a wide variety of fossils, including plants, animal traces and the oldest vertebrate of the Alps. The sediments crop out in numerous small basins. The plant fossils are preserved as impressions, compressions, but also permineralized trunks are present, some of which still standing in original position. One of the most important and well-known localities is Tregiovo (Val di Non, NE Italy), but recently more plant remains were collected from the localities of Sinich/Singo, Gork and Laugen/Monte Luco, all located close to Bozen/Bolzano (South Tyrol). The plant remains belong mostly to the conifers, including the genera (*Dolomitia*, *Hermitia*, *Feysia* and *Quadrocladus*). Shoot fragments are frequent, cones are relatively rare. Abundant are also ferns and/or seed ferns (*Peltaspermum*, *Lodevia* and *Sphenopteris*). Rare are remains of sphenophytes (*Annularia*), ginkgophytes (*Sphenobaiera*), and at least three incertae sedis taxa (*Taeniopteris*, Morphotype 1 and Morphotype 2).



UPPER-UPPERMOST FAMENNIAN (DEVONIAN) CORALS AND STROMATOPOROIDS FROM THE CHANGTANZI FORMATION, LONGMENSHAN, SOUTH CHINA: IMPLICATIONS FOR THE RECOVERY OF METAZOAN REEFS AFTER THE F-F MASS EXTINCTION

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Keywords

Stromatoporoids, Metazoan reef, F-F extinction, Hangenberg crisis



Corals and stromatoporoids are the most important metazoan reef contributors from the Late Ordovician to Late Devonian. However, this reef community suffered greatly in the Frasnian/Famennian mass extinction, and the succeeding reefs were characterized by the dominance of microbes throughout most of the Famennian stage, yet the recovery of metazoan reefs in the Late Devonian has rarely been documented. In this study, we report the occurrence of upper-uppermost Famennian coral-stromatoporoid biostrome from the Changtanzi Formation, Longmenshan, South China, representing one of the best-known examples of metazoan reefs after the F/F extinction. A total of 17 species of stromatoporoids and corals are identified in the formation. Besides, the formation is also characterized by the occurrences of abundant sponge *Parachaetetes*. The Changtanzi Formation can be separated into two assemblages by the differences of stromatoporoids and tabulate corals, particularly species of *Platiferostroma*, *Spinostroma*, *Fuchungopora*, *Roemerolites*, and *Michelinia*. After the Hangenberg crisis, only two species of solitary rugose corals, *Hebukophyllum* sp. and *Neozaphrentis* sp. are observed, indicating the extinction of coral-stromatoporoid metazoan reefs. Biotic interactions between corals and stromatoporoids are frequently found, indicating the recovery of reef-building community similar to those prior the extinction event. Although the majority of the interactions belong to post-mortem types, live-live interactions between corals and stromatoporoids do exist. The assemblage of corals and stromatoporoids in Changtanzi Formation resemble those from the other Famennian outcrops of South China, but possess obvious differences especially in species level, indicating an endemism feature among the benthic organisms during the upper-uppermost Famennian.



ACANTHODIAN SCALE REMAINS (STEM CHONDRICHTHYES) FROM THE LOWER DEVONIAN OF QUJING, YUNNAN, CHINA

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Keywords

Chondrichthyes, Morphology, Histology, Devonian, Paleobiogeography

Acanthodian scale remains were extracted from bone beds of the Lower Devonian Xitun Formation (Qujing, Yunnan Province, China) by treatment with dilute acetic acid. Based on both morphological and histological examinations, we have identified five species of *Nostolepis*, including two new species. We extend the duration of *N. striata* in China from the Pridoli of Silurian (Yulongssu Formation) to the Lower Devonian in Qujing and report the first occurrences of *N. amplificata* and *N. consueta* in this region. The study has also identified the presence of *Cheiracanthus*, *Tareyacanthus*, *Hanilepis* and *Changolepis*, as well as a new scale-based genus with a peculiar hard tissue structure. *Cheiracanthus xitunensis* was described and most of the upper horizontal plate in each crown growth zone filled with enamel according to the section and SEM results, where enamel was confirmed within the stem Chondrichthyes first time. The genus *Cheiracanthus* diagnosis was revised the same time. *Tareyacanthus magnificus* was described here and the morphology diagnosis was revised as scales with parallel ridges extending half length of the crown or tend to converge towards the posterior corner. *Changolepis* was recognized to possess compound, polyodontode crowns, instead of the placoid-type scales of derived crown chondrichthyans. A new acanthodian genus of *Fibrillosus* is identified at last. This new genus is based on scales with common morphologic but a very special histologic characters. This study increases the diversity of the Lower Devonian Xitun Fauna and provides a better understanding of the paleogeographic distribution of acanthodians.





NEUROCRANIAL ANATOMY OF ACHOANIA FROM THE LOWER DEVONIAN (LOCHKOVIAN), CHINA

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Keywords

early osteichthyan, HRCT, cranial endocast, anatomical features



The psarolepids include the earliest known osteichthyans, i.e., *Guiyu*, *Sparalepis*, *Achoania* and *Psarolepis*. They combine features of osteichthyans and stem gnathostomes, which are crucial to the understanding of the origin and early evolution of osteichthyans. However, our understanding on the character transition sequence of the neurocranial structures of this clade remains obscure, and their phylogenetic relationships among stem osteichthyans are still controversial. Here we reinvestigate the braincases of *Achoania* based on high-resolution computed tomography (HRCT). All specimens were from the Lower Devonian (Lochkovian) Xitun Formation of Qujing, Yunnan, China. HRCT reveals that the premaxilla of *Achoania* is triangle-shaped with two teeth rows. The internal tooth row combines large conical teeth, while the external row consists of minute teeth. The nasal capsules are large and round, and the olfactory tracts are robust with an angle of less than 90 degrees, which recalls the condition in stem gnathostomes. On the other hand, the large and anteroventrally extended hypophysial fossa is similar to that of porolepiform *Glyptolepis*. These new revealed neurocranial features of *Achoania* will add to our knowledge on the evolution of early osteichthyans, and help us to clarify the phylogenetic position of psarolepids.



NOVEL EVOLUTION OF A HYPER-ELONGATED TONGUE IN A CRETACEOUS ENANTIORNITHINE FROM CHINA AND THE EVOLUTION OF THE HYOLINGUAL APPARATUS AND FEEDING IN BIRDS

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Keywords

Enantiornithes, bony hyoid, Jehol Group, feeding

The globally distributed extinct clade Enantiornithes comprises the most diverse early radiation of birds in the Mesozoic with species exhibiting a wide range of body sizes, morphologies, and ecologies. The fossil of a new enantiornithine bird (IVPP V13266) from the Lower Cretaceous Jiufotang Formation in Liaoning Province, northeastern China, preserves a few important skeletal features previously unknown among early stem and extant birds, including an extremely elongate bony hyoid element, combined with a short rostrum. The long hyoid provides direct evidence for specialized feeding in this extinct species, and appears similar to the highly mobile tongue that motivated by the paired epibranchials seen in living hummingbirds, honeyeaters, and woodpeckers. The association of food collection with tongue protrusion might have been a key factor in the independent acquisition of long hyobranchial in early birds.





THE RISE OF BONY VERTEBRATE BODY PLAN

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Keywords

Silurian, jawed vertebrates, osteichthyans, body plan



Osteichthyans (bony vertebrates), as the largest vertebrate group, gave rise to two main clades. One became the most successful tribe swimming in the water, the other, gained ground about 380 million years ago, evolved tetrapods that includes humans. For a long time, Silurian bony fishes were only known from few scattered scales and dermal bone fragments, resulting difficulties to understand their general body plan, phylogenetic position, and critical details such as feeding morphology. Here we investigated a new, exquisitely preserved specimen of *Megamastax amblyodus*, the largest Silurian vertebrate, and possibly the earliest vertebrate apex predator, from the Kuantu Formation (Late Ludlow, about 423 million years ago) of Yunnan, China. HRCT scanning reveal exquisite details of the neurocranium, palatoquadrate, dermal skull roof, cheek bones, operculum, and dentition. Strikingly, the inner dentition comprises series of “tooth cushions”, a unique type of osteichthyan dentition previously only known in the Baltic Silurian as isolated micro remains of *Lophosteus*. The braincase lacks an intracranial joint and has chondrichthyan-like enclosed aortic canals. The dermal cheek bones resemble those of primitive osteichthyans such as *Psarolepis* and basal actinopterygians, but the skull roof pattern differs dramatically from known osteichthyans and instead resembles the “maxillate placoderm” *Entelognathus*. The squamation is composed of very small and thin rhomboid scales and lacks large median dorsal plates. Such unexpected combination of chondrichthyan, osteichthyan and “maxillate placoderm” characters suggests that *Megamastax* occupies a position very close to the origin of gnathostome crown-group, opening novel perspectives on how early osteichthyan evolved their body plan.



EARLIEST ANT MIMICS — LIFE HISTORY AND EVOLUTION OF ALIENOPTERIDAE

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Keywords

Dictyoptera, evolution, nymph, mimicry, pollination

Alienopteridae is among the most perplexing fossil insects and once important members of Cretaceous Dictyoptera (now including cockroaches, termites and mantises). However, the precise nature of its life history, evolution, and phylogenetic affinity remains controversial and open to debate. Here we report new alienopterid nymphs from mid-Cretaceous Kachin amber (approximately 99 Ma). The only species of the previously erected order Aethiocarenodea is identified as a junior synonym of alienopterid nymphs. Geometric morphometric analyses suggest that alienopterid nymphs exhibit distinct morphological specializations that were most likely associated with ant mimicry. Remarkably, mimetic association between these nymphs and stem-group ants provides the earliest record of ant mimicry (myrmecomorphy), which is contemporary with the earliest ants and their eusociality, and with the earliest evidence of myrmecophily. We discuss different interpretations of the life history of alienopterid adults, especially wasp mimicry, and conclude that *Teyia* was likely a wasp mimic. The nymphs and adults of *Teyia* resemble different models, which provides the first fossil record of transformational mimicry, implying that this convergent syndrome had already evolved by the Early Cretaceous. In addition, one alienopterid nymph laden with pollen clumps provides evidence of gymnosperm pollination and a previously unknown gymnosperm-insect association. Extinct dictyopterans may have been among the earliest pollinators, with a hitherto undervalued role in pollination ecology. Our phylogenetic analysis provides evidence that Alienopteridae and Umenocoleidae are sister groups and that the two families constitute a monophyletic group (Alienoptera) sister to Mantodea.





TRACE FOSSIL AS PROXY FOR BIOTIC RECOVERY AFTER THE END-PERMIAN MASS EXTINCTION

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Keywords

Trace fossil, ichnological parameter, ecosystem reconstruction, biotic recovery, Early Triassic

Trace fossils represent records of the activity of both epifaunal and infaunal animals, providing significant information to understand Earth's past environments and ecosystems. More and more ichno-metrics (quantitative ichnological indicators) have been proposed and applied to assess the mechanisms and timing of biotic recoveries following mass extinctions. However, detailed assessment of the robustness and the scope of their applications is needed before we place them on more solid theoretical grounds. After a critical review of a range of popularly used ichnological parameters including ichnodiversity, bioturbation index, ichnofabric index, bedding plane bioturbation index, burrow size, complexity, tiering, key ichnotaxa and some new parameters (e.g., ichnodisparity), we provide a detailed summary of the significance and caveats of each parameter. We suggest that bedding plane bioturbation index remains to be explored to indicate recovery while ichnodisparity holds potential to assess biotic recovery in future studies. Key ichnotaxa (e.g., *Rhizocorallium* and *Thalassinoides*) that are produced by malacostracan crustaceans, among other organisms, can be reliable indicators of environmental stability and ecosystem recovery. Further, we propose that the overall low bioturbation intensities may have substantially influenced marine elemental cycling during the Permian–Triassic transition that led to a possible drawdown of sulfate concentration in the Early Triassic oceans through enhanced pyrite burial.





A NEW DIPNOAN GENUS FROM THE MIDDLE DEVONIAN WITH UNDESCRIBED DENTITION SCHEMA

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Keywords

Dipnoi, Middle Devonian, dentition, China



A new tooth-plated lungfish is described from the Qujing Formation (late Eifelian, Middle Devonian) of Huize County, Qujing, northeastern Yunnan, China. It bears a new undescribed dentition schema. It differs from other lungfishes in its small proportion of tooth-bearing part on pterygoid (less than a quarter), the extensively developed anteromedial edentulous portion of pterygoid, and tooth rows fewer in number (only four). The highly specialized tooth plate is a unique character of lungfishes. Campbell and Barwick proposed three characteristic schemas of lungfish dentition, i.e., dentine plates, tooth plates, and denticulated plates. Ahlberg et al. further classified the lungfish dentition into four schemas by employing two odontogenetic processes: dentition coated by radial tooth ridges formed from sheet dentine, like *Dipterus*; median callus of sheet dentine and marginal resorbed tooth rows with a new denticulated surface, like *Holodipterus*; sheet dentine at the medial margin alongside worn petrodentine, containing no teeth, like *Dipnorhynchus*; and denticulated surface with marginal biting ridges formed from sheet dentine, like *Uranolophus*. Here, we adopted Ahlberg et al.'s schemas. However, the dentition of the new lungfish cannot be referred to either of these four schemas, showing a new schema of lungfish dentition. Phylogenetic analysis reveals that the new taxon is more plesiomorphic than *Dipterus*, yet crownward of *Melanognathus*. As the ninth Devonian lungfish genus in China, the new taxon displays a novel schema of lungfish dentition and increases the diversity of early lungfishes.



A NEW HUMP-BACKED COLOBODONTID (NEOPTERYGII, ACTINOPTERYGII) FROM THE EARLY MIDDLE TRIASSIC OF PANZHOU, GUIZHOU, CHINA

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Keywords

Osteology, Phylogeny, Colobodontidae, Neopterygii



The Neopterygii, comprised of the teleosts, gars, bowfins and closely related fossil taxa, is the most diverse clade of ray-finned fishes. As a group of large-sized marine stem neopterygians, the family Colobodontidae is recognized by molariform teeth and ornament-rich ganoid scales; and they were found from the Middle to Late Triassic strata in Europe and South China. *Feroxichthys panzhouensis*, a new species of colobodontid fish, is described based on a well-preserved specimen with the skull roof partly missing from the early Middle Triassic (Anisian) of Panzhou, Guizhou, China. The discovery extends the geographical distribution of *Feroxichthys* from eastern Yunnan into western Guizhou, and displays the morphological diversity of colobodontids. The new species is easily distinguished from other colobodontids due to some derived features on the dentition (e.g., stronger but fewer teeth in dentary and dumpy crushing teeth in maxilla) and hump-backed body type. This special body form has independently evolved multiple times in Triassic neopterygians, according to the phylogenetic analysis; and it suggests a morphological adaptation to structurally complex habitats on the basis of ecological studies of modern ray-finned fishes with a similar body form. Moreover, although all colobodontids are potential durophagous predators, *F. panzhouensis* shows a more obligate durophagous diet than other colobodontids due to blunted, crushing teeth along its maxilla. Therefore, the new species provides new insights into the morphological and ecological diversity of neopterygian fishes from the Triassic marine ecosystems in South China.



A NEW INDEX TO QUANTIFY COMPLEXITY OF SHELL ORNAMENTATION

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Keywords

Complexity, Morphology, Shelled Animals, Ornamentation, 3d Fossil Model



The morphology helps to reconstruct biological morphological evolution in geological history and the interaction between organisms and ecological factors, and has an important role in macro-evolutionary, ontogenetic, functional morphological, taxonomic and phylogenetic studies. Morphological complexity represents the complex degree of biological structure and has significant links to morphology-function relationships and phylogenetic progresses. Measures of complexity include statistics of cell types or number of organs, matrices of clade characteristics derived from phylogenetic system, fractal dimensions, surface roughness and rugosity. However, a quantitative measure of morphological complexity in shelled animals is still lacking. Here we used the latest 3D scanning technology and artificial modeling to create a new index (Ornamentation Index; **OI**) to quantify the complexity of ornamentation, i.e., the proportion of the extra area caused by ornamentation. The OI is designed to reflect the degree of folding caused by ornamentation, regardless of the effect of body shape and size. We used this method to evaluate the shell complexity of shell fossils by the following procedure: 1) scan and build a fossil model with a handheld 3D scanner Artec Spider; 2) capture the curve of smooth part of shells through 3ds Max to construct an idealized 3D digital model, which maintains the original geometric proportions of the shell conch without ornamentation; 3) calculate the area of idealized smooth model (S') and the area of fossil model (S). The Ornamentation Index is defined as: $OI = S/S' - 1$. OI index was used to measure nine ammonoid species. The results show that the most complex species was *Douvilleiceras mammillatum* ($OI = 15.40\%$; Rugosity = 1.906; $S/V = 0.25$). The OIs of smooth and unornamented specimens are all lower than 0.75%. Unlike the S/V ratio, where the fractal dimension of surface roughness is influenced by the shape and size of ammonoids, and the OI can accurately distinguish the shell ornamentation complexity between different specimens.



THE DAWN OF COMPLEX ANIMAL FOOD WEBS: A NEW PREDATORY ANTHOZOAN (CNIDARIA) FROM THE CAMBRIAN OF CHINA

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Keywords

Cnidarian phylogeny, Macrophagous predation, Cambrian animal food webs



Cnidarians diverged very early in animal evolution; therefore, investigations of the morphology and trophic levels of early fossil cnidarians may provide critical insights into the evolution of metazoans and the origin of modern marine food webs. However, there has been a lack of unambiguous anthozoan cnidarians from Ediacaran assemblages, and undoubted anthozoans from the Cambrian radiation of metazoans are very rare and lacking in ecological evidence. Here we report a new polypoid cnidarian, *Nailiana elegans*, represented by multiple solitary specimens from the early Cambrian Chengjiang biota (~520 Ma) of South China. These specimens show eight unbranched tentacles surrounding a single opening into the gastric cavity, which may have born multiple mesenteries. Thus, *N. elegans* displays a level of organization similar to that of extant cnidarians. Phylogenetic analyses place *N. elegans* in the stem lineage of Anthozoa and suggest that the ancestral anthozoan was a soft-bodied, solitary polyp showing octoradial symmetry. Moreover, one specimen of the new polyp preserves evidence of predation on an epifaunal lingulid brachiopod. This case provides the oldest direct evidence of macrophagous predation, the advent of which may have triggered the emergence of complex trophic/ecological relationships in Cambrian marine communities and spurred the explosive radiation of animal body plans.



OCCURRENCE OF *TANNUOLINA* IN THE LOWER CAMBRIAN OF HAZARA BASIN, NORTH PAKISTAN AND ITS BIOSTRATIGRAPHICAL SIGNIFICANCE

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Keywords

Tomotiids, *Tannuolina*, Cambrian Stage 2, biostratigraphy, Pakistan

Diverse isolated sclerites of *Tannuolina* (tomotiids) are recovered from the Hazira Formation in the eastern Hazara Basin, North Pakistan. The sclerites include two morphs, i.e. mitral and sellate types, and the sellate ones contain two sub-types, the sella-bearing and non-sella sclerites. Through morphological comparison, they can be identified as *Tannuolina zhangwentangi* Qian & Bengtson, 1989. The large mitral and sellate sclerites (about 1 cm) illustrated herein manifest they have a relatively consistent morphology during the size increasement. This is the first time of *T. zhangwentangi* recovered from the Indian subcontinent, previously not known outside South China. Our work shows that the SSFs assemblage from basal Hazira Formation formerly named as the “informal halkieriid-bearing Zone” is more possible to be correlated with the *Watsonella crosbyi* Assemblage Zone rather than the *Sinosachites flabelliformis*–*Tannuolina zhangwentangi* Assemblage Zone of South China as roughly inferred in the previous studies. The middle and upper part of Hazira Formation exclusively bearing *T. zhangwentangi* can be evidently correlated with the *S. flabelliformis*–*T. zhangwentangi* Assemblage Zone of South China representing the uppermost Stage 2. Moreover, this study not only indicates the utility of *T. zhangwentangi* for intercontinental biostratigraphical correlation, but also suggests that the Terreneuvian SSFs biostratigraphy between Indian subcontinent and South China are quite consistent, comprising of three (at least two) correlative SSFs Assemblage Zone (Zone I, III, IV of South China). Additionally, our result also supports a close palaeogeographical linkage between these two regions in early Cambrian.





NEW DATA REVEALING THE COMPLEXITY OF THE EVOLUTIONARY DETAILS OF EARLY PARAVIANS

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Keywords

Dinosauria, Paraves, ecomorphology, paedomorphosis



Paraves is one of the most unique lineages of theropod dinosaurs, and Mesozoic paravians are among the best studied dinosaur groups as they represent the transitional stage from the basal theropod dinosaurs to modern birds. Many new paravian fossils were reported recently, which dramatically increased our understanding of the diversity of these animals, and provided a valuable opportunity to review the evolutionary history of the Mesozoic paravians as well as their roles in understanding the origin of birds. High disparities of osteological features and ecological proxies have been detected in Mesozoic paravians, possibly indicating the complexity of the ecomorphological adaptations during the paravian evolution. Based on quantitative comparisons between extant and fossil animals, non-avialan paravians have already shown potentials of flapping flight that is independent from the avialan lineage. While cranial profiles of many non-avialan paravians generally resemble relatively primitive theropods, multivariate analyses also confirm that small-sized non-avialan paravians have a cranial profile similar to early avialans, showing paedomorphosis in the cranial morphology like birds and probably caused by a similar growth strategy. Quantitative analyses based on newly acquired data indicate that early-diverging paravians have already obtained morphological and ecological features that were traditionally regarded as unique for avialans.



THE LATEST DEVONIAN STROMATOPOROID BIOSTROMES ON THE GUILIN ISOLATED PLATFORM: EVIDENCE FOR THE RECOVERY IN THE AFTERMATH OF THE F-F MASS EXTINCTION

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Keywords

Metazoan reef, Stromatoporoid biostrome, F-F extinction event



The Frasnian-Famennian extinction event significantly affected marine invertebrates, such as stromatoporoids and rugose corals, which led to the collapse of metazoan reef ecosystem. Famennian reefs were then mainly constructed by cyanobacteria (i.e. microbial reefs), and clearly diminished compared to the peak reef-building period of the preceding Givetian to middle Frasnian times. On the Guilin isolated platform, South China, stromatoporoid biostromes were particularly prevalent in the Strunian successions and exhibit unique features that may provide insights into marine environmental conditions during latest Devonian. The Huilong and Etoucun sections contain several dm- to m-thick, low relief biostromal reefs in the Etoucun Formation, which are biostratigraphically constrained by foraminifera association (DFZ7) of Strunian age. The rigid framework of the reefs was built primarily by in situ dense, laminar and domical stromatoporoids. The reef fauna is dominated by Stromatoporoid *Gerronostroma*, associated with some tabulate corals, gastropods and foraminifera. Spatio-temporal distributions of stromatoporoid biostromal reefs reveal that they were widespread in the Palaeotethyan region during the latest Devonian, and that a stable, complex marine ecosystem was fully recovered. The biostromal reef builders went to extinction at top of the Etoucun Formation on the Guilin isolated platform, and the abrupt transition of level-bottom communities was most likely due to global cooling event and a possible eustatic sea-level drop, rather than anoxic conditions and Hangenberg black shale event.



HISTOLOGICAL STUDY OF A MID-CRETACEOUS CROCODYLIFORM FROM NORTHEASTERN CHINA: COMMENTS ON BONE MICROSTRUCTURES AND LIFESTYLE INFERENCES

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Keywords

bone microstructure, advanced neosuchian, mid-Cretaceous, Paralligatoridae, northeastern China

Here we use a histological approach to convey the knowledge of a particular Asian affinity Paralligatoridae, *Yanjisuchus longshanensis*, specifically by inferring its histogenesis, age estimation at the time of death, and as well as its lifestyle inferences. The radius and metatarsal consist of a thick cortex with multiple growth marks and mostly avascular. The dorsal rib consisted of a relatively thin parallel-fibred cortex, a large medullary cavity, and numerous erosion cavities in the perimedullary region. Meanwhile, the 'diploë' osteoderm consisted of three distinct layers, which were formed from the highly remodeled superficial of parallel-fibred bone, the cancellous inner core region mainly of woven bone with the marginal of highly vascular fibrolamellar bone, and the basal cortex exhibiting slow-forming somatic tissues organized from the parallel-fibred bone of cyclic growth marks. External ornamentation is rigorous and mainly maintained by preferential bone growth. Also, Sharpey's fibers are formed both on the superficial and deep cortices of the osteoderm, hence, suggesting a metaplastic origin. Osteosclerotic bone patterns of the radius and metatarsal, and compactness of the osteoderm, correlate to a semi-aquatic lifestyle. The study prominently showed that the individual is a sub-adult despite the absence of external fundamental system. Histological evidence derived from this study suggest that *Yanjisuchus longshanensis* possessed similar microstructural morphology to extant crocodylians.





THRESHOLDS OF TEMPERATURE CHANGE FOR MASS EXTINCTIONS

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Keywords

climate change, global warming, extinction, evolution, Phanerozoic



What are the causes of mass extinctions in Earth history? This has been a classic question in palaeontology and evolutionary biology. Climate change is a critical factor affecting biodiversity. However, the quantitative relationship between temperature change and extinction is unclear. Here, we analyse magnitudes and rates of temperature change and extinction rates of marine fossils through the past 450 million years (Myr). The results show that both the rate and magnitude of temperature change are significantly positively correlated with the extinction rate of marine animals. Major mass extinctions in the Phanerozoic can be linked to thresholds in climate change (warming or cooling) that equate to magnitudes $>5.2^{\circ}\text{C}$ and rates $>10^{\circ}\text{C}/\text{Myr}$. The significant relationship between temperature change and extinction still exists when we exclude the five largest mass extinctions of the Phanerozoic. The results of this study have implications for present climate change and ecological responses. Since 1850, the global mean temperatures have risen by about 1°C . The heavy fossil fuel use scenario (SSP5-8.5) predicts the global mean temperatures would rise by more than 5°C by 2100, which would reach the climate threshold for Big Five mass extinctions in Earth history. If global warming exceeds this threshold, the marine organisms and ecosystems could suffer disaster impact.



COMPUTATIONAL FLUID DYNAMICS CONFIRMS DRAG REDUCTION ASSOCIATED WITH TRILOBITE QUEUING BEHAVIOUR

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Keywords

trilobite, queuing behaviour, computational fluid dynamics, drag reduction



Queuing behaviour has been documented from Cambrian to modern oceans. Trilobites, one of the most abundant and widely distributed arthropods of the Paleozoic, were also found to be forming queues. For example, queues of Devonian trilobites *Trimercephalus* were reported in Kowala Quarry, Poland. It was previously hypothesized that this behaviour provided energy savings through hydrodynamic drafting, with trilobites in following positions hypothesized to produce less drag than those leading. In this study, we established a 3D model of Devonian trilobite *Trimercephalus chopini*, then carried out computational fluid dynamics (CFD) simulations of the queuing behaviour and calculate the drag forces of everyone. The results show that the drag forces of trilobites following in the queue were substantially lower than the leader (~65–79% lower at velocities of 0.5–2 cm/s). Drag reduction was positively correlated with the movement speed of the trilobites but decreased with increasing distance from the leader. Drag reduction was up to ~86% with distance of 0 cm and decreased to 0% for the first following trilobite when the following distance was greater than about six times its body length. This agrees with fossil evidence preserving trilobites in queues in close proximity to each other. The results also show that drag reduction was still significant (~86.8% at 2 cm/s) even in the longest queues from the fossil record. This study supports the hypothesis of drag reduction of trilobites following in the queue, which compensated for the energy cost of movement. This would have been particularly advantageous during mass migration.



A DISTINCTIVE LYCOPHYTE MEGASPORE FROM THE UPPER PERMIAN OF SOUTHWEST CHINA

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Keywords

Lycophyte, Megaspore, Ultrastructure, Late Permian, China

Lycophytes are an important group of plants in the late Permian floras of Southwest China. However, our understanding of these lycophytes is based mostly on the study of megafossil specimens. Here, we describe a unique lycophyte megaspore, from the upper Permian Xuanwei Formation of Yunnan Province, Southwest China. The megaspore is trilete and characterized by having prominent membranous triradiate flanges, long bifurcate spines, an arcuate ridge expanded into a zona, and triangular to polygonal reticulate sculpture. The ultrastructure of the megaspore wall consists of four layers. The innermost layer is the foot layer, a thin and solid basal lamina covered by a dense layer containing small and parallel sporopollenin grains. A thick spongy layer is developed exterior to the dense layer and consists of elongate, curved, and intersected sporopollenin units with porous zones. The outermost layer is a condensed layer of variable thickness forming the processes. The morphological and ultrastructural characteristics indicate the new megaspore belongs to a herbaceous isoetalean. This is the first detailed investigation of megaspores from the upper Permian of China using both scanning and transmission electronic microscopies. Our result sheds new light on the diversity of late Permian lycophytes in the Cathaysian flora in the tropics of the eastern Tethys Ocean.





FIRST CARNIVOROUS FUNGUS FROM SANTONIAN TAIMYR AMBER

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Keywords

mycelium, Basidiomycota, Agaricomycetes, clamp connections, Cretaceous

Mycelium from the Yantardakh Lagerstätte (Santonian of Taimyr, PIN RAS) is reported. It is the first record of mycelium from the Cretaceous of North Asia. Mycelium hyphae are arranged mostly parallel, weakly branched, septate. The clamp connections indicate the Basidiomycota affinity. Hyphal outgrowths derive from the main hyphae at the right angle and are of two types: rather long ones, mostly 35 μm long and occasionally up to 45 μm are common, while short, peg-like, 12-16 μm long are more rare. Arthroconidia and large spherical structures, 12,5 μm , looking like exudate drops are observed upon hyphae. A single hyphal ring is found. It is similar to trapping loops of the extant Basidiomycota. Altogether, this ring, numerous drops, and peg-like hyphal outgrowths may be interpreted that this mycelium belongs to nematophagous fungus of Agaricomycetes. It is the first indication of the presence of nematodes in the Taimyr amber forest.

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ULTRASTRUCTURE AND IN-SITU CHEMICAL CHARACTERIZATION OF INTRACELLULAR GRANULES OF EMBRYO-LIKE FOSSILS FROM THE EARLY EDIACARAN WENG'AN BIOTA

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Keywords

Ediacaran, Weng'an Biota, Megasphaera, subcellular structure, taphonomy

Embryo-like fossils from the early Ediacaran Weng'an biota provide a window of exceptional fossil preservation onto the period of life history in which molecular clocks estimate the fundamental animal lineages to have diverged. However, their diversity and biological affinities have been proven controversial because they are morphologically simple and, consequently, their interpretation lacks phylogenetic constraint. The subcellular structures preserved in these embryo-like fossils might help to understand their cytology, biology and diversity, but the potential of these structures has not been fully realized because detailed microscale physical and chemical investigations are lacking. Here, to remedy this deficiency, we performed a comprehensive study to characterize their micro- and ultra-structures as well as in-situ chemical components. Our results reveal three types of subcellular structure that differ in size, shape, and mineral components: (1) relatively small and spheroidal granules in embryo-like fossils with equal cell division pattern; (2) relatively large, spheroidal or polygonal granules in embryo-like fossils with unequal and asynchronous cell division pattern; and (3) irregular multi-layered rim-bounded granules in embryo-like fossils with unequal and asynchronous cell division pattern. We propose that the three types may be rationalized to a single taphonomic pathway of preferential mineralization of the cell cytoplasm, preserving an external mould of subcellular granules. We followed the previous interpretation that the spheroidal and polygonal granules should be fossilized lipid droplets or yolk platelets. The distinction between these subcellular structures are largely results of postmortem degradation such as autolysis. The widely preserved lipid droplets or yolk platelets within these Ediacaran embryo-like fossils is compatible with the inference that interpreting them as large yolk embryos with maternal nourishment and direct development.





THE PROTEROZOIC MACROFOSSIL *TAWUIA* AS A POSSIBLE SIPHONOUS MACROALGA

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Keywords

Proterozoic macrofossil, *Tawuia*, siphonous macroalgae, primary plastids

Proterozoic carbonaceous macrofossils are key to understand the evolution of early eukaryotes and how they acquired macroscopic sizes. However, phylogenetic interpretation of these macrofossils is challenging because most of them are morphologically simple and lack diagnostic cellular structures. *Tawuia* is a tomaculate carbonaceous macrofossil that is common in Proterozoic successions but has been variously interpreted as a bacterium or a eukaryotic alga. Here we report exceptionally preserved specimens of *Tawuia* that show evidence of a siphonous construction, asymmetric division, and recalcitrant cell walls. These features indicate that *Tawuia* is probably a siphonous macroalga. Insofar as *Tawuia* has been known from lower Mesoproterozoic strata (ca. 1.6 Ga), it provides a key age constraint on the origin of eukaryotes, primary plastids, and siphonous macroalgae.





EPIDERMAL ANATOMY OF *BAIERA* FROM THE UPPER TRIASSIC OF CHINA

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Keywords

Ginkgophyte, Epidermal anatomy, Late Triassic, China



Baiera Braun is a leaf genus of fossil ginkgophytes. The genus first appeared in the Permian and was especially diversified during the Late Triassic to the Early Cretaceous. However, our knowledge of Late Triassic *Baiera* leaves is limited mainly to gross morphology, whereas anatomical characteristics are largely unknown. Here, we report well-preserved *Baiera* leaves from the Upper Triassic Xujiahe Formation of Sichuan Province, Southwest China. The leaves are fan-shaped with a slender petiole. The lamina is immediately divided into two primary segments, each being further subdivided into numerous lobes by successive dichotomies. The apices of the distal lobes are commonly divided into a pair of blunt teeth or two linear lobes. Stomata are present on upper and lower cuticle surfaces with lower surfaces generally having a higher stomatal density; each stoma possesses two slightly sunken kidney-shaped guard cells and 2–6 subsidiary cells. On upper surfaces, epidermal cells are rectangular or polygonal in shapes and arranged irregularly. Epidermal cells are slightly elongate above vein courses; the anticlinal walls of epidermal cells are strongly undulate. Lower surfaces are divided into coastal and intercoastal fields. In intercoastal fields, epidermal cells are polygonal, to rectangular or spindle-like in shape, whereas in intercoastal fields, epidermal cells are elongate-rectangular; anticlinal walls of the epidermal cells are straight or slightly curved. The apertures of the stomata are mostly longitudinally orientated.



OSSIFIED MECKELIAN CARTILAGE AND INNER EAR MORPHOLOGY IN AN EARLY CRETACEOUS EUTHERIAN

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Keywords

Ossified Meckelian cartilage, Inner Ear, Eutherians, Early Cretaceous, Jehol Biota



The ossified Meckelian cartilage has been reported as a vital connection between the middle ear and dentary in Mesozoic mammaliaforms, while the Meckelian cartilage is never ossified and plays a transient role in embryonic development in extant mammals. It still remains unknown whether the Meckelian cartilage was ossified in earliest eutherians. Here we report on a new Early Cretaceous eutherian represented by a partial skeleton from the Jiufotang Formation that fills a crucial gap between the earliest eutherians from the Yixian Formation and later Cretaceous eutherians. The new specimen reveals, for the first time in eutherians, that the Meckelian cartilage was ossified but reduced in size, confirming a complete detachment of the middle ear from the lower jaw. Seven hyoid elements, including paired stylohyals, epihyals, and thyrohyals and the single basihyal are preserved. For the inner ear the ossified primary lamina, base of the secondary lamina, ossified cochlear ganglion, and secondary crus commune are present, and the cochlear canal is coiled through 360°. *Cokotherium* displays an alternating pattern of tooth replacement with P3 being the last upper premolar to erupt similar to the basal eutherian *Juramaia*. Parsimony analysis places *Cokotherium* with *Montanalestes*, *Sinodelphys*, and *Ambolestes* as a sister group to other eutherians.



A NEW IMBRICATE ECHINODERM FROM CAMBRIAN OF NORTH CHINA ILLUSTRATES SPATIAL DISTRIBUTION AND EARLY EVOLUTION OF BLASTOZOANS

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Keywords

eocrinoids, Mantou Formation, North China, Cambrian



Imbricate eocrinoids, first appeared in Cambrian Stage 4, are probably the most basal blastozoans. Early fossil records of this group provide crucial evidence to illustrate dispersal of echinoderms. Although echinoderms have a global distribution since Cambrian Miaolingian, distribution of earliest imbricate eocrinoids has been restricted to Laurentia and west Gondwana. Here we report a new imbricate eocrinoid based on well-preserved specimens from the Cambrian (Series 2, stage 4) Mantou Formation in Jiangsu Province, North China. The new taxon is characterized by a long aboral imbricate cup and a slightly domed tessellate oral surface with epispines. The aboral body extension is covered with spiny imbricate plates. Straight ambulacra, which supports coiled uniserial brachioles, is mount on the central part of the oral surface. The new taxon documents the earliest occurrence of imbricate eocrinoids in North China Block. This newly discovered species not only enriches the biodiversity of early blastozoans but also extend their global distributions. Comparing with contemporary imbricate eocrinoids in Laurentia (*Lepidocystis*, *Kinzercystis*), the new occurrence sheds new light on biogeographic relationship between North China Block and Laurentia. Through generating a new diversity curve of Cambrian echinoderms, a possible link between the early echinoderm diversification and ROECE (Redlichiiid-Oleneliid Extinction Carbon Isotope Excursion) during Cambrian is also suggested herein.



THE GENETIC HISTORY OF SOUTHERN CHINA

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Keywords

ancient DNA, ancient human populations, deeply diverged ancestry, pre-farming, China prehistory

Despite several genetic studies focused on Southeast Asia, little is known about ancient populations from East Asia, especially in southern China. In order to fill this gap, we produced and analyzed genome-wide data from ancient individuals from different regions of southern China, dating from 12 to 0.03 thousand years ago (ka). Sampling in Fujian, a province in coastal China, shows that by the Early Neolithic (ca. 12–9ka), ancestries in northern and southern East Asia were fairly diverged, and both have profoundly impacted present-day East Asians across Asia and the Pacific. Sampling in Guangxi, a province bordering southeast Asia, revealed a deeply diverged East Asian ancestry found to belong to a previously unknown distinct population unrelated to the ancestry found in ancient hunter-gatherers from Southeast Asia, and not closely related to the East Asian ancestry found in present-day populations. By 9–6 ka, populations admixed from this and other distinct regional ancestries were present in pre-agricultural Guangxi. Admixture between these distinct ancestries in southern China prior to the proposed population movements associated with the spread of agriculture document a previously unknown population mobility, and show a greater genetic diversity in the past than is found in the region today.





NEW HYBODONT SHARKS (CHONDRICHTHYES, ELASMOBRANCHII) FROM THE EARLY TRIASSIC CONTINENTAL DONGCHUAN FORMATION (YUNNAN PROVINCE, CHINA)

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Keywords

Hybodont, Early Triassic, Continental, Dongchuan Formation, Yunan

Hybodontiform shark teeth, cephalic spines, fin spines and placoid scales are discovered for the first time from the continental, earliest Triassic Dongchuan Formation near Huize County (Yunnan Province) in south-west China. The isolated teeth are assigned to two unidentified hybodontiforms and a new species of *Parvodus*, which represents the oldest record of this genus, extending the stratigraphic distribution of this small-toothed lonchidiid shark lineage into the Early Triassic. This new species, together with the other hybodontiform remains reveal that hybodontiforms adapted to freshwater environments in the Early Triassic rather than Jurassic in China. Besides, those new materials from Dongchuan Formation provides new evidence of shark diversity patterns in the aftermath of the end-Permian mass extinction event in fresh waters, when freshwater environments might have acted as centers of origin for elasmobranchs rather than being a refugial area for Paleozoic sharks.





THE CENOZOIC FISH FAUNA OF THE TIBETAN PLATEAU

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Keywords

Cenozoic, Tibetan Plateau, fossil fishes, systematics, paleozoogeography



The past two decades have witnessed a renewed vigor in research on geological history of the Tibetan Plateau and the newly emerged paleontological evidence has added a crucial, biological dimension to the scientific quest. Here we review the evolution of the fish fauna in the Tibetan region and its implications for interpreting the growth of the plateau during the Cenozoic. The present fish fauna on the Tibetan Plateau is dominated by the cold and high altitude adapted fishes, e.g., the snow carps (Schizothoracinae, Cyprinidae) and plateau loaches (*Triplophysa*, Nemacheilidae), a natural consequence of the uplift of the plateau. Based on new discoveries of fossil fishes from the Eocene to Pliocene, we have found that (1) the late Eocene central Tibetan region hosted an assemblage of tropical and subtropical fishes (climbing perch, silurid catfish and some small barbine carps), which suggests that the hinterland of today's Tibetan Plateau was low and humid at that time; (2) immediately after the hard collision between the Indian and Asian plates in the early Cenozoic, some freshwater fishes (e.g., the air-breathing climbing perch) that probably originated in Southeast Asia might have followed an "Into Africa via the Docked India" routine to shape their modern African-Asian disjunct distribution; (3) the modernization of the fish diversity on the Tibetan Plateau occurred no earlier than the Pliocene. Admittedly, the results we have presented so far are preliminary, and the vast uninvestigated Cenozoic fluvial and lacustrine deposits on the Tibetan Plateau promise more fossil findings and greater research opportunities ahead.



WIDESPREAD MIMICRY AND CAMOUFLAGE AMONG MID-CRETACEOUS INSECTS

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Keywords

Cretaceous, mimicry, camouflage, insect, amber



The avoidance of detection by predators and parasites is critical to survival. Two complex mechanisms for such avoidance are mimicry and camouflage, with fossils providing valuable insight into the evolution of these strategies. Such fossil evidence is, however, rare, and the frequent partial and lopsided occurrence. Here, we report a diverse insect assemblage exhibiting these adaptations from mid-Cretaceous Kachin amber (99 million years ago), including plant mimesis in Tridactylidae (pygmy mole crickets) and debris-carrying camouflage in Gelastocoridae (toad bugs) and Psocodea (bark lice). Critically, Mesozoic plant mimesis in Tridactylidae is supported by our Siamese Network analysis, a Deep Learning model and potentially powerful tool for investigating ancient mimicry. Together with previously known records, our fossils demonstrate that most extant debris-carrying insects (eight groups with direct camouflage) had evolved exogenous camouflage by the mid-Cretaceous. Our results suggest that a complex biological response was already widespread among insects in mid-Cretaceous ecosystems during the rise of angiosperms, probably in response to similar selective pressures as experienced by their extant counterparts.



THE DISCOVERY OF *PELTOPERLEIDUS* (LOUWOICHTHYIFORMES, NEOPTERYGII) FROM THE MIDDLE TRIASSIC OF ASIA, AND ITS PHYLOGENETIC AND BIOGEOGRAPHIC IMPLICATIONS

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Keywords

Triassic, Louwoichthyiformes, Neopterygii, phylogeny, biogeography



The previously alleged 'perleidid' genus *Peltoperleidus* is a small-sized stem-neopterygian taxon with two or three horizontal rows of notably deepened flank scales. Until recently, members of this genus were known only from the Ladinian (late Middle Triassic) or near the Anisian/Ladinian boundary in southern Switzerland and northern Italy. Here, I report the discovery of the oldest species of *Peltoperleidus* based on three well-preserved specimens from the Anisian (~244 Ma) of Luoping, eastern Yunnan, China. The discovery extends the geological range of *Peltoperleidus* by approximately two million years and documents the first record of the genus in Asia. The Chinese species resembles *P. triserioides* from Europe in possessing three horizontal rows of deepened flank scales; by contrast, other species of the genus generally have two horizontal rows of deepened scales (independently evolved in *Altisolepis*). Phylogenetic studies recover the Chinese species at the base of *Peltoperleidus* and corroborates the affinities of *Altisolepis* with the Fuyuanperleididae-Luganoiidae clade, challenging the previous placement of *Altisolepis* in the Peltopleuriformes. *Peltoperleidus* shares certain derived features with louwoichthyids, but its morphology is distinct enough from that of louwoichthyids, to warrant the erection of a new family (Peltoperleididae) within the Louwoichthyiformes. Although small-sized, peltoperleidids are likely durophagous predators with dentition combining grasping and crushing morphologies. The older age and basal position of the Chinese species implicate that the Peltoperleididae was probably originated in the early Middle Triassic of South China, and the Palaeotethys Ocean would have provided an east-west corridor for dispersal of this clade into Europe.



INCREASED GROWTH DISTURBANCES IN EARLY TRIASSIC BIVALVES

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Keywords

Permian-Triassic mass extinction, environmental fluctuations, shell growth, disturbance lines, bivalves

The growth disturbance of organisms is important for understanding interannual-level environmental fluctuations. The bivalve shells can record the environmental disruptions, e.g., sudden changes in temperature, salinity, PH and light intensity, as growth disturbance lines during their own life history. The growth disturbances in bivalve shells include three types: (1) the distortion of concentric ornamentation, (2) the dislocation of radial ornamentation, and (3) the abnormal convex change of shell surface. Here, we analysed the variation of growth disturbance of bivalve fossils during the Permian and Triassic intervals based on 800 bivalve fossils from South China and a bivalve dataset collected from the published literatures. The results show an increased proportion of disturbed bivalves in the Early Triassic compared with other intervals in the Permian and Triassic, suggesting that the marine environmental disturbances at interannual level was relatively frequent during The Early Triassic. Further data collections and experimental investigations are necessary to confirm and explain this phenomenon.





THE PERMIAN-TRIASSIC FORAMINIFERAL EXTINCTION OF SELONG SECTION AT THE SOUTHERN MARGIN OF THE NEO-TETHYS

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Keywords

Neo-tethys, Selong section, Permian-Triassic mass extinction, foraminifera



The Permian-Triassic interval witnessed the largest biological mass extinction in the Phanerozoic, resulting in the disappearance of more than 80% of marine species and accompanied by climatic and environmental degradation events. To date, studies on the timing and pattern of the Permian-Triassic mass extinction are mainly focused on low-latitudes South China and the western margin of the Paleo-Tethys while lack of studies on the Neo-Tethys region and comparative studies among various paleolatitudes. In the present study, we focused on the foraminiferal taxonomy and evolution from the Selong section which is located in the mid-latitudes of the southern margin of the Neo-Tethys and deposited in the shallow-marine carbonate platform. A total of 75 species in 31 genus have been identified. The foraminifera fossils suffered extinction at the end of the Changhsingian, which is consistent with that of South China at low-latitudes, indicating that the extinction event is synchronous at different paleo-latitudes areas. Meanwhile, a total of 49% of the foraminiferas in the Selong section became extinct at the end of the Changhsingian, while the foraminiferal extinction rate in the main phase of latest Permian mass extinction was as high as 97% in South China shallow-marine sections, suggesting a lower extinction rate of foraminifera at higher latitudes. In addition, a total of 41 species in 21 genus of foraminiferas were found in the Griesbachian in the aftermath of the end-Permian mass extinction in the Selong section, which is significantly higher than that in South China during the same period. In summary, we found that the foraminiferal extinction events in the latest Permian were synchronous, but the foraminiferal extinction rate in the mid-latitude region was lower, with more abundant and longer-lived disaster and opportunistic foraminifers, which probably due to the relatively low impact of the Permian-Triassic warming event on the higher latitude regions.



DIVERSE AND COMPLEX DEVELOPMENTAL MECHANISMS OF EARLY EDIACARAN EMBRYO-LIKE FOSSILS FROM THE WENG'AN BIOTA, SOUTHWEST CHINA

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Keywords

Ediacaran, embryo-like fossils, Weng'an Biota, holozoan, cell division patterns

Origin and early evolution of animal development remain one of many deep, unresolved problems in evolutionary biology. As a compelling case for the existence of pre-Cambrian animals, the Ediacaran embryo-like fossils (EELFs) from the Weng'an biota (~609 million-year-old, Doushantuo Formation, South China) have the great potential to cast light on the origin and early evolution of animal development. However, their biological implications can be fully realized only when their phylogenetic positions are correctly established, and unfortunately, this is the key problem under debate. As a significant feature of developmental biology, the cell division pattern (CDP) characterized by dynamic spatial arrangement of cells and associated developmental mechanisms is critical to reassess these hypotheses and evaluate the diversity of the EELFs, however, their phylogenetic implications have not been fully realized. Additionally, the scarcity of fossil specimens representing late developmental stages with cell differentiation accounts for much of this debate too. Here, we reconstructed a large number of EELFs using submicron resolution X-ray tomographic microscopy and focused on the CDPs and associated developmental mechanisms as well as features of cell differentiation. Four types of CDPs and specimens with cell differentiation were identified. Contrary to the prevailing view, our results together with recent studies suggest that the diversity and complexity of developmental mechanisms documented by the EELFs are much higher than is often claimed. The diverse CDPs and associated development features including palintomic cleavage, maternal nutrition, asymmetric cell divisions, symmetry breaking, establishment of polarity or axis, spatial cell migration and differentiation constrain some EELFs, if not all, as total-group metazoans.





TERRESTRIALIZATION AND THE ORIGIN OF LAND VERTEBRATES – EVIDENCE FROM THE EDEN PROJECT (SE AUSTRALIA)

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Keywords

Tetrapodomorph fishes; tetrapod origins; Australia, Antarctica, Gondwana



The 'Fish-Tetrapod Transition' (aquatic vertebrates evolving onto land) was a major transformation linked to terrestrialization of the biota during the Middle Palaeozoic. Evolution of a diverse land vegetation evidently changed geological processes (erosion, sedimentation), and lignin synthesised by vascular plants locked more organic matter into sediments, decreasing atmospheric carbon dioxide. Evolution of the first forests by the Late Devonian contributed to a more oxygenated atmosphere, causing deposition of 'Old Red Sandstone' facies red sediments in many regions. These produced the first tetrapod fossils (*Ichthyostega*, *Acanthostega*), in Upper Devonian strata of East Greenland. A Middle-Late Devonian origin for tetrapods from the tristichopterid fish lineage was assumed to have occurred on the northern paleocontinent of Laurussia, both groups later dispersing into Gondwana, the largest Devonian landmass. Vertebrate trackways, and various new 'stem-tetrapods' discovered in older Devonian strata across China, Australia and Antarctica, contradicted that hypothesis. A diverse assemblage of complete 'tetrapodomorph' lobe-finned fishes, recently discovered near Eden (far south coast of New South Wales), includes *Edenopteron*, the largest known semi-articulated Devonian tristichopterid, which is most closely related to Australian and Antarctic taxa rather than northern tristichopterids. Other new tetrapodomorphs resemble poorly-known taxa from Antarctica. Our research project to extract and study these new forms will clarify tetrapodomorph inter-relationships, and the time and place of origin for all land vertebrates.



A NEW STEM NEOPTERYGIAN FROM THE EARLY TRIASSIC, EASTERN GUIZHOU, CHINA

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Keywords

Neopterygian, Perleididae, Early Triassic, Phylogeny



As the most prosperous group of extant ray-finned fish, Neopterygii underwent a rapid evolutionary radiation during the Early Triassic. Early Triassic neopterygians are known from nearly all continents and distributed mainly in the Dienerian and Smithian. So far, 11 Neopterygii genera have been recovered from the Lower Triassic in China. However, there is no record of Dienerian neopterygians in China. Here, we report a new stem neopterygian from the lower Daye Formation at Guiding, Guizhou, China. The co-occurrences of ammonoids and conodont suggest a Dienerian age. The new species is characterized by the following features: the presence of six branchiostegal rays, three supraorbitals and two suborbitals, a moderately developed anterodorsal process of subopercle. Results of a cladistic analysis recover the new species as a sister taxon of *Teffichthys* and a polytomy of *Plesioperleidus*, *Paraperleidus*, (*Plesiofuro*+*Meidiichthys*) within the Perleididae. Similar to other durophagous fishes in Africa and Europe, the new genus is a medium-sized fish that probably prey on bivalves and crustaceans. The discovery of this new stem-neopterygian fish expands our knowledge of the diversity and ecological adaptation of the Perleididae in the Early Triassic. It is the first reported Dienerian fish from China, indicating a global distribution of Perleididae in the Early Triassic.



APPLY INFORMATION THEORY IN PALEONTOLOGY

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Keywords

Paleontology, information theory, data-driven, communication, signal processing



Paleontology has developed with enormous uncertainty. Major changes towards data-driven studies are taking place in earth sciences with skyrocketing amount of data being accumulated and the applications of machine learning methods. Although conventional paleontology is often seen as a branch of earth sciences, its nature is hindering these changes, for example the fragmentary fossil materials, preservation biases, and difficulties in combining morphological and molecular data. There lacks a theoretical framework to describe the preservation and extraction of paleontological information, although the word information has been extensively used. Here we demonstrate the deep connections between information theory and conventional paleontological studies that primarily rely on fossil morphology, highlighting the key concepts including source entropy and channel capacity. While the continuous emergences of data-driven paleontological studies indicate that many studies are limited by the dearth of data, some may have encountered the information bottlenecks. The introduction of information theory offers paleontologists not only a standard evaluating how informative the original data are, but also a potential general model describing paleontological research by treating it as a communication system through geological ages. As many earth sciences disciplines focus on ancient events, information theory may provide even broader impact in the more general earth sciences field.



KYLINXIA, A TRANSITIONAL CAMBRIAN FOSSIL ILLUMINATES THE EARLY EVOLUTION OF ARTHROPODS

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Keywords

Arthropod, Cambrian, Chengjiang, Phylogeny, Evolutionary novelties



Deciphering the origin and early evolution of arthropods remains a challenge in animal evolution. The Cambrian fossil record has shown that the radiodonts, namely the oldest apex giant predator *Anomalocaris* and its allies, are the sister group to the euarthropods. However, there are a number of evolutionary novelties between radiodonts and euarthropods, forming a huge evolutionary gap in the origin of euarthropods. *Kylinxia*, a chimeric fossil recently discovered from the early Cambrian Chengjiang Lagerstätte of Yunnan, China, shows distinctive euarthropod characters such as a sclerotized exoskeleton, a segmented trunk, and jointed legs. Meanwhile, *Kylinxia* also integrates the morphological characters present in ancestral arthropod forms, which include the bizarre five eyes as in *Opabinia* and the iconic raptorial appendages as in *Anomalocaris*. Such a special combination of characters in *Kylinxia* supports that the first appendages in radiodonts and euarthropods are homologous, which also suggests the chelicerate chelicerae and mandibulate antennae derived from *Anomalocaris*-like raptorial appendages. Phylogenetic analysis resolves *Kylinxia* as the earliest diverging euarthropod known, which is placed right between radiodonts and other euarthropods. *Kylinxia* thus represents a crucial transitional fossil that fills up the 'missing link' between radiodonts and euarthropods, providing an important reference point in the origin of euarthropods.



BAYESIAN TIP DATING APPROACH

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Keywords

Bayesian inference, tip dating, timetree, fossilized birth-death, relaxed clock



Dating the tree of life is fundamental for understanding the evolutionary process and co-evolution of life and environment. Traditional stepwise approach does not take full use of the data and fails to account for uncertainties from various sources. The recently developed Bayesian total-evidence tip-dating approach has the advantage of combining morphological characters and geological ages from fossils and morphological and molecular data from extant taxa, and properly incorporates uncertainties from data and parameters in the statistical inference. The method utilizes the fossilized birth-death process for the timetree, the relaxed clock model for the evolutionary rates, and the Markov process for the character changes. This tip-dating approach has been productively applied to various biological groups to study their evolution. In particular, the evolution of Mesozoic birds is the focus of this presentation. Recent studies applying the approach have shown that the high evolutionary rates during early avian evolution are largely correspond to extensive morphological modifications refining the flight capability. The bird biodiversity evolution is influenced mainly by long-term climatic changes and also by major paleobiological events such as the Cretaceous–Paleogene extinction.



EARLY SPINY PLANTS DIVERSITY IN THE LATE EOCENE SUBTROPICAL WOODLANDS OF CENTRAL TIBET

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Keywords

Spiny plants, diversity, late Eocene, woodland, central Tibet

Spinescence is an important plant functional trait possessed by many plant species for physical defence against mammalian herbivores. Spinescence must have been closely associated with both biotic and abiotic factors in the geological past, but its evolution is poorly known due to a dearth of fossil records, with most studies focussing on spatial patterns and spinescence-herbivore interactions in modern ecosystems. Numerous well-preserved Eocene (~39 Ma) plant fossils bearing seven spine morphologies recovered recently from the central Tibetan Plateau, combined with molecular phylogenetic analyses, show a rapid Eocene diversification of spiny plants in Eurasia. These spiny plants occupied a woodland landscape, as evidenced by numerous grass phytoliths and macrofossils found in the same strata. Our study shows that the regional aridification and expansion of herbivorous mammals may have driven the diversification of functional spinescence in central Tibetan woodlands, ~24 million years before similar transformations took place in Africa.





EXPLORATION ABOUT THE EVOLUTION OF HUMAN LIMB DIAPHYSEAL STRUCTURE IN PLEISTOCENE EURASIA

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Keywords

biomechanical analysis, morphometric mapping, limb bone, East Asia



Morpho-functional studies of human limbs can provide key information on the locomotor patterns, habitual behaviors, and subsistence strategies of past populations. In comparison to the well-studied limb fossils from Pleistocene to Holocene Europe, limb remains from East Asia were rare, and the evolutionary process of human limbs in this region had not been sufficiently investigated. Meanwhile, present understanding of the overall evolutionary pattern of human limb structure and function is mainly built on linear measurements and cross-sectional geometric (CSG) properties at limited cross-sections, which are insufficient to reveal the full information hidden beneath the limb diaphysis. Therefore, we collected high-resolution micro-CT data from human limb fossils of Pleistocene Eurasian, including 7 humeri and 10 femurs from early modern humans (EMHs), Neanderthals, and *Homo erectus*. Their morphological and biomechanical properties, such as cortical bone thickness (CBT), external radius (ER), bending rigidity (SMA), and torsional rigidity (J), were quantitatively visualized and compared by morphometric maps and continuous CSG properties across the complete limb diaphysis than only limited cross-sections. The results indicated that the femora of EMHs from Asia and Europe shared similar distribution patterns of CBT, ER, SMA, and J, which were distinct from Neanderthals and *Homo erectus*. Meanwhile, between EMHs from North and South China and Neanderthals, the CBT, ER, and J had similar distribution patterns but differed in the overall magnitude along the humeral diaphysis, and the SMA layouts were various. These findings contribute to developing a more comprehensive understanding of human limb structural variation across Eurasia during the Pleistocene and Early Holocene.



VEGETATION CHANGE AND EVOLUTIONARY RESPONSE OF THE LARGE MAMMAL FAUNA DURING THE MID-PLEISTOCENE TRANSITION IN TEMPERATE NORTHERN EAST ASIA

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Keywords

Pollen, Climate change, Co- evolution, Quaternary, Adaptation, Ecosystem

The response of terrestrial ecosystems to climatic transitions is an important topic in global change research. Here we present new pollen data from a drilling core from the North China Plain which illustrate the nature of vegetation evolution in the temperate zone of Asia during an interval spanning the Mid-Pleistocene Transition (MPT), ~1.2-0.7 Ma. The results show that the most important event occurred at 1.2 Ma when there was a decline in coniferous forest and a significant increase in *Artemisia*, Chenopodiaceae and Poaceae grassland. There was a continued degradation of the regional vegetation and its replacement by woody grassland about 0.7 Ma. Vegetation change was synchronous with the MPT and was accompanied by a major turnover of the large mammalian fauna. More than one half of the mammalian species became extinct in the course of the forest recession; however, they were replaced by new mammalian species after 0.7 Ma. Comparison of the vegetation and faunal records indicates that the process of forest replacement by grassland in the northern temperate zone during the Middle Pleistocene was associated with an acceleration of the rate of turnover of the large mammalian fauna, in terms of extinctions and appearance of new species.





A NEW SPECIES OF THE IRON MAIDEN ANT BASED ON AN ALATE FEMALE FROM BURMESE AMBER (HYMENOPTERA: FORMICIDAE: †*ZIGRASIMECIA*)

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Keywords

amber, ant, Cretaceous, Kachin, *Zigrasimecia*

The iron maiden ant, which was first described as †*Zigrasimecia* Barden & Grimaldi, 2013, received its nickname for bearing a unique mandible and ferocious mouthparts covered by spiky, columnar-shaped denticles. Here, we describe a new species based on an alate female preserved in 99-Ma Kachin amber — †*Zigrasimecia goldingot* — which displays several diagnostic features shared with the known species of this genus. Such features include the peg-like mandibular setae, setae of the labrum, clypeal denticles, and an omega-shaped head capsule. Our findings suggest a high diversity among †Zigrasimeciinae and support the grouping of this subfamily. Our work adds to the biodiversity of †*Zigrasimecia* and †Zigrasimeciinae, and explores the morphological and functional aspects, as well as the early appearance of the unique mouthparts in this ancient ant group.





A NEW EARLY SILURIAN LAGERSTÄTTE FROM SOUTH CHINA REVEALS AN INITIAL RADIATION OF JAWED VERTEBRATES

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Keywords

early Silurian, jawed vertebrates, initial radiation

Molecular studies point to the origin of jawed vertebrates in the Late Ordovician (~450 million years ago, Ma), in contrast to a long dearth of undisputable fossil evidence before and in the immediate aftermath of end-Ordovician Mass Extinction. Until now, the earliest unequivocal fossils of jawed fishes allowing the reconstruction of detailed morphology came from the late Silurian Xiaoxiang Fauna (~425 Ma), the sole exception being an early Silurian spinal chondrichthyan restored from disarticulated micro-remains. Here, we report a newly discovered Konservat-Lagerstätte, resembling Burgess-shale type deposits, from the early Silurian (middle Telychian, ~436 Ma) of Chongqing, South China. The Chongqing Fauna is marked by the presence of a large number of diverse, exquisitely preserved jawed fishes with complete bodies, differing significantly in taxonomic composition and in preservation from the later Xiaoxiang Fauna. The dominant species, a placoderm or jawed stem gnathostome *Xiushanosteus mirabilis*, combines characters from major placoderm subgroups and sheds light on the transformation of skull roof pattern near the crown gnathostome node. The probable chondrichthyan *Shenacanthus vermiformis* exhibits an unprecedented complete trunk shield forming a ring, previously considered unique and diagnostic in placoderms, in addition to chondrichthyan characters such as the posteriorly positioned gill. This fish-dominated fauna provides, for the first time, detailed insights into the body plan of the first jawed vertebrates, and reveals the initial radiation of jawed vertebrates in early Silurian, greatly reducing the discrepancies between fossil and molecular range data of early jawed vertebrates.



Palaeozoic

General Session





BRACHIOPOD FAUNA OF THE UPPER SERPUKHOVIAN IN THE BECHAR BASIN: PALEOECOLOGICAL AND ENVIRONMENTAL INDICATIONS

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Keywords

Brachiopods, Hydrodynamics, Substrate, Platform, Coquina



In the Bechar Basin, the Djenien Formation constitutes the essential the Upper Serpukhovian, divided into a marl-sand-calcareous lower member and a calcareous upper member. The benthic fauna shows a preference for the carbonate environment and is very abundant and diverse, including crinoids, brachiopods, bivalves, bryozoans, gastropods, corals, foraminifera and algae. Brachiopod associations are generally either shell-supported or matrix-supported, found mostly in proximal platform environments, and exceptionally in mid to distal platform transitions. Brachiopods in packstone to grainstone biosparite limestones are dominated by productides. Their concavo-convex shell and their anchorage by spines ensure them better stability in a high energy environment. In similar conditions, the presence of forms with permanent peduncular attachment, such as athyrides (*Composita*), terebratulides, and rhynchonellides, indicate mid to proximal platform hydrodynamic conditions. Cohabitation with Gigantoproductids (*Beleutella*, *Latiproductus*) seems unlikely, considering the taphonomic aspect. In certain levels or lenses with muddy facies, corresponding to brief periods of calm, *Anthracothyrina* (Spiriferida) dominate, whose winged shells allow good stability on a loose substratum. In addition to the implications of the nature of the substratum and hydrodynamics, the monospecific accumulation of *Composita* suggests a shallow and hyperhaline environment. This salinity factor would be at the origin of the strong dolomitization of the limestones in the upper part of the Djenien Formation. Finally, the shell beds (*Gigantoproductus*, *Anthracothyrina*, *Semicostella*) would be closely related to storm events, punctuated in the proximal environments and still felt, exceptionally, in the transitional mid to distal platform setting.



REDESCRIBING THE 'SAUKIANDA FAUNA': EXCEPTIONAL TRILOBITES FROM THE MARIANIAN (CAMBRIAN SERIES 2) OF THE SIERRA NORTE DE SEVILLA UNESCO GEOPARK

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Keywords

Alanís, Cazalla de la Sierra, Guadalcanal, Trilobita, Cambrian Stages 3 and 4

In 1940, German palaeontologists Rudolf and Emma Richter described an outstanding trilobite association, both for their abundance and prominent preservation, from the territories between the localities of Cazalla de la Sierra and Alanís, northern Seville, Andalusia. They named this trilobite association '*Saukianda* fauna' due to the ample presence of a new trilobite genus and species: *Saukianda andalusiae* Richter and Richter. Subsequently, the rocks hosting these trilobites were named 'Benalija Beds' by W. Fricke in 1941, and later renamed as 'Alanís Beds' by W. Simon in 1951. Nowadays, 'Alanís Beds' are included in the Sierra Norte de Sevilla UNESCO Geopark, and they extend from northern Seville to southern Badajoz, constituting one of the richest trilobite-bearing formations from the Marianian Stage of Iberia. This formation shows a trilobite record composed by *Saukianda andalusiae* Richter and Richter, *Strenuaeva sampelayoi* Richter and Richter, *Alanisia guillermoi* (Richter and Richter), *Resserops resserianus* Richter and Richter, *Delgadella souzai* (Delgado), *Serrodiscus speciosus* (Ford), *Andalusiana cornuta* Sdzuy, *Termierella seviliana* Sdzuy, and *Protaldonaia morenica* Sdzuy. Our current works over this territory are focused on constraining the stratigraphic range of each of the trilobites mentioned above into the 'Alanís Beds', together with its regional correlation with other Marianian (Cambrian Stages 3 and 4) outcrops from Iberia (e.g. Toledo Mountains, Iberian Chains) and also its international correlation with other Cambrian domains worldwide (e.g. Morocco, Australia, Avalonia, Baltica, Siberia). This work is a contribution to the project IGCP 652.





EARLY DEVONIAN ORGANIC-WALLED MICROFOSSILS FROM CORDOBÉS FORMATION, LA PALOME WELL (DURAZNO GROUP, NORTE BASIN, URUGUAY)

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Keywords

palynology, Pragian, Emsian, Gondwana, Malvinokaffric Realm

An Early Devonian transgressive-regressive sedimentation cycle in the southernmost portion of the intracratonic Paraná Basin, known in Uruguay as the Norte Basin, is documented in the Durazno Group (from base to top: Cerrezuelo, Cordobés and La Paloma Formations). The Cordobés Formation was deposited during a maximum flooding transgressive event, and contains the characteristic Malvinokaffric marine invertebrates that inhabited Gondwanan cold marine waters. Palynological analysis of this unit have been recently undertaken in parallel with hydrocarbon exploration activity. In order to expand our knowledge regarding Devonian palynofloras of Uruguay, we document palynological assemblages from Cordobés Formation from cutting samples of a water well located in the city of La Paloma (UTM X=633311; Y=6378724), Durazno Department. The samples are dominated by acritarchs, associated with prasinophytes, chlorophytes, chitinozoans, scolecodonts and miospores. Among the more relevant microplankton taxa found are specimens of the genus *Bimerga*, *Cordobesia oriental-uruguayensis*, *Estiastra uruguai*, *Evittia remota*, *Evittia sommeri* 'early form', *Leiofusa fastidiona*, *Navifusa bacilla* 'short form', *Palacanthus ledanoisii*, *Polyedryxium fragosulum*, *Polyplanifer turbatum*, *Pterospermopsis circumstriata*, *Schizocystia pilosa*, *Tasmanites* sp., *Triangulina alargada*, *T. cylindrica*, *Veryhachium woodii*, and *Winwaloesusia distracta*. Miospores include *Biornatispora elegantula*, *Brochotriletes foveolatus*, *Cirratiradites diaphanus*, species of *Dibolisporites*, *Dictyotriletes emsiensis*, *D. richardsonii*, *D. subgranifer*, *Distaverrucosporites steemansii*, morphon *Dyadospora murusattenuata*, *Emphanisporites rotatus*, *Knoxisporites riondae*, *Retusotriletes maculatus*, *Scylaspora costulata*, *Synorisporites papillensis* and *Synorisporites verrucatus*. Despite the cosmopolitan distribution of most Early Devonian microplankton, some of the recorded taxa, as well as miospore species, are restricted to Gondwana. The stratigraphic distribution of selected taxa suggests a Pragian-Emsian age for the studied interval.





ICHTHYOFAUNAL ASSEMBLAGE FROM THE LATE PERMIAN OF LESZCZYNA QUARRY (SW POLAND)

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Keywords

Actinopterygii, Euselachii, carbonate rocks, SW Poland, Late Permian

During the Late Paleozoic, the rapidly subsiding Zechstein Basin (comprising massive salt deposits) was located at 20-30° N, in the centre of the Pangean supercontinent. Zechstein rocks extend from the UK, through Germany and Poland, to Latvia and Lithuania, and western Belarus. There are several locations where Zechstein rocks are exposed and easily accessible. One such place is located in the Leszczyna Basin, near the village of Leszczyna in SW Poland. The Leszczyna Basin is a small tectonic unit in the north-western part of the Sudete Mountains. The studied area thus is located in the SE coastal part of the Zechstein Sea and the investigated outcrops are situated in the eastern part of the basin, in the Leszczyna Syncline. This area is known for preserving a variety of invertebrate and vertebrate taxa, but no fish remains have been formally described from the Leszczyna outcrops up to now. For the current study, we examined 111.8 kg of carbonatic material from the Late Permian, which represents the first record of an ichthyofaunal assemblage from the 'Leszczyna' quarry in SW Poland. The fossil-bearing samples were chemically prepared using standard chemical dissolution technique in buffered formic acid. The collected samples yielded of some isolated Euselachii dermal denticles and rare finds of the Actinopterygii teeth. A description of this new material enables a better understanding of the poorly known Late Permian fish diversity of SW Poland and to compare it with an already known ichthyofaunal assemblage from the 'Nowy Kościół' quarry in SW Poland.





REDATING THE LOWER TALCHIR FORMATION (WARDHA BASIN, CENTRAL INDIA) TO THE UPPER PENNSYLVANIAN BY PALYNOMORPHS

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Keywords

Palynostratigraphy, Palynozonations, Late Paleozoic, Talchir Formation, India

The Talchir Formation corresponds to the Gondwana (Permian–Carboniferous) Sequence in India and its age assessed herein in the light of palynostratigraphic record associated with radiometric dating generated in Gondwana. The lower part of this formation in the Well 131 drilled at Penganga area of Wardha Valley Coalfield (Maharashtra State, central India) analysed. Two assemblages were demarcated based on the stratigraphic distribution of spores (23 taxa), pollen grains (35 taxa), and phytoplankton. Palynoassociation I (PI) recognized in the two basal core samples yielded few *Punctatisporites* spores and monosaccate pollen grains. Palynoassociation II (PII) delimited in the overlying three core samples characterized by more diversified and abundant spores and pollen grains than in the other two overlying samples. Several guide taxa such as, *Concavissimisporites grumulus*, *Converrucosisporites confluens*, *Cyclogranisporites gondwanensis*, *Verrucosisporites andersonii*, *Latusipollenites quadrisaccatus*, *Marsupipollenites striatus*, *Pakhapites fusus*, *Striatoabieites multistriatus*, *Vittatina subsaccata*, *Vittatina vittifera* are consistent with palynozones radiometrically constrained to the latest Pennsylvanian–early Cisuralian in Argentina, Brazil, Africa, and Australia. Therefore, we propose a Kasimovian to Ghezelian–Asselian age for the PI and PII associations of the Talchir Formation. A correlation with the *Potonieisporites neglectus* and *Plicatipollenites gondwanensis* Zones of Tiwari & Tripathi, respectively significantly improves the stratigraphic correlations of the Indian palynozones in Gondwana.





“PEÑA BENEITA”: FROM ENGRAVED SCHEMATIC ART TO A NEW PALAEOICHOLOGICAL SITE IN THE ALCAÑICES SYNFORM (NUEZ DE ALISTE, ZAMORA, SPAIN)

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Keywords

Cruziana, Skolithos, Paleozoic, geological heritage, Iberian Peninsula



“Peña Beneita”, meaning “blessed rock” in old Spanish, is located north of Nuez de Aliste (Zamora, Spain) and has been long considered a protohistoric schematic rock art site. A new interpretation of the site is here provided changing radically the significance of the record, from archaeological to palaeontological site. Geologically, it is located at the western end of Alcañices synform, and stratigraphically it belongs to Rábano Formation that it is made up of a succession of shales and greywackes with intercalations of cherts, limestones, metavulcanites and quartzites. The succession is classically attributed to the Silurian-Lower Devonian transition, but recent studies show the olistostromic character of the formation in which some major blocks display ages ranging from Upper Cambrian to Middle Devonian. The site is a thin-bedded and fractured quartzite outcrop, with an area of 130 m², that exhibits numerous ichnofossils referred to the ichnogenus *Cruziana*, preserved as endoreliefs and, very exceptionally, as bilobed negative epireliefs without scratch marks observed. The fossil traces, from 5 to 7 cm wide, reach a variable length of up 1 meter and sometimes present unusual circular traces. Concentrations of vertical burrows, associated with the ichnogenus *Skolithos*, have also been identified. “Peña Beneita” constitutes a new contribution to the geological heritage of the province of Zamora, especially considering that paleontological evidence is very scarce in the area.



PREDATION OR SCAVENGING? A CASE ON OPHIUROID FOSSILS FROM DEVONIAN OF BRAZIL

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Keywords

Ponta Grossa Formation, Echinoderm, Paleoecology, Biotic interaction

Although abundant in the modern seas, ophiuroids are an echinoderm group rarely observed in the fossil record due to the delicate multi-elemental structure of their endoskeletons, which consist of hundreds of weakly connected ossicles. Consequently, the ophiuroid skeleton is fully disarticulated within a few days of the death, rapidly scattering its numerous ossicles over the seafloor. Based on this, we report here the analysis of encrinasterid ophiuroids preserved in two shale samples (CP. I 6434, UFPR 0605 PI) from the Ponta Grossa Formation, a Devonian epicontinental siliciclastic unit in southern Brazil. In particular, the specimens correspond to negative molds of *Encrinaster pontis* with selective skeletal disarticulation, that is, at least one intact arm, including the delicate whip-like tip, while the other arm segments typically show lateral and ambulacral series of ossicles severely disarticulated. These fossil records are exceptional because no portion of the ophiuroid skeleton is more rigidly bound together than any other, so it is highly unlikely that only certain arms will remain fully articulated for a longer period than the other arm segments of the same specimen. Curiously, this atypical pattern of preservation is compatible with neither transport-induced disarticulation nor the disarticulation sequence expected for unbioturbated calm seafloors. Thus, we suggest that these fossils may represent an effect of (i) ophiuroid predation or (ii) benthic activity of scavengers and/or detritivorous groups on fresh carcasses of ophiuroids. Potential organisms for this may have been asteroids, gastropods, and other ophiuroids, which are also recorded near these shale beds.





A REDESCRIPTION OF *MILLEROPSIS PRICEI* (AMNIOTA, PARAREPTILIA) USING HIGH-RESOLUTION NCT WITH IMPLICATIONS FOR THE INTERRELATIONSHIPS OF EARLY REPTILES

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Keywords

Parareptilia, Millerettidae, South Africa

We redescribe the millerettid parareptile *Milleropsis pricei* from the late Permian of South Africa using high-resolution nCT based on three mostly complete skulls. Previously undescribed anatomy, including the morphology of the premaxilla, palate, and braincase are revealed. We find a monophyletic Millerettidae, here including *Milleropsis* and *Milleretta rubidgei* united by several synapomorphies, including: an anterolateral process of the parietal, presence of an anterior vomerine buttress, and large, anteroventrally orientated vomerine apertures. Millerettidae is found to be one of the earliest branching groups of parareptiles. We also test the phylogenetic position of Millerettidae in a phylogeny of early amniotes, including *Eunotosaurus*, variously considered a millerettid or a stem-turtle in previous studies. An initial phylogenetic analysis finds *Eunotosaurus* to be a derived caseid and finds Pantestudines (*Eorhynchochelys*, *Odontochelys*, and *Proganochelys* here) to be early branching archosauromorphs. *Eunotosaurus* placement is supported by cranial characters including: anterodorsally sloping supranarial process of premaxilla, dorsolaterally sloping antorbital surface of maxilla that overhangs tooth row, and a posterior process of postorbital contacting the supratemporal. Pantestudines placement is supported by braincase characters: presences of a crista prootica and laterosphenoid; and other characters: presence of a preacetabular process on the ilium, and presence of a lateral tubercle on a hooked, fifth metatarsal. These preliminary findings raise the possibility of support for phylogenetic hypotheses that have been previously suggested, but received little support so far. Furthermore, these findings suggest that many features considered to be parareptilian or strictly in testudines are indeed widespread in early saurians, particularly in non-archosaurian archosauromorphs.





YOU'RE A STRANGE ANIMAL—MORPHOLOGY AND RELATIONSHIPS OF THE ENIGMATIC CAMBRIAN GENUS *STENOTHECOIDES*

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Keywords

Stenothecoida, Cambrian, Small Shelly Fauna, Brachiopoda, Mollusca

First appearing in early Cambrian, pre-trilobite, small shelly faunal assemblages, stenothecoids have proved difficult to classify owing to an odd combination of morphological features. The calcareous bivalved shell is inequivalved, unlike known Cambrian bivalves, and the individual valves are asymmetrical unlike any brachiopods. Internal shell features described to date show no definitive clues that would ally them with any higher taxa. Earlier studies have placed stenothecoids in four different phyla, although most authors consider them a distinct class of molluscs. Stenothecoid affinities are now clearer owing to silicified material assignable to *Stenothecoides* recovered from limestone units in the middle Cambrian Burgess Shale of British Columbia, Canada, and from the Wheeler Formation of Utah, USA. New morphologic details include opposing triangular bosses internally at both the valve apices, and an emargination of the valves at the umbo that was likely for the exit of a pedicle. The latter, together with fibrous microstructure (replicated in silica) resembling the secondary shell of articulate brachiopods, indicates phylogenetic proximity with the Brachiopoda, not the Mollusca. Internal shallow troughs arranged in a chevron pattern are interpreted as mantle canals and peripheral grooves on the perimeter of the valve interior are likely setal grooves. We classify *Stenothecoides* as a stem-group brachiopod and propose that the bivalved shell evolved independently from that of the crown group brachiopods via sclerite reduction from a calcareous, tubular, multisclerite, eccentrothecimorph, tommotiid ancestor. Stenothecoids enlarge the known disparity of Pan-Brachiopoda to include bivalved, inequilateral, calcareous shells with unique apical structures.





IN THE SHADOW OF A GIANT REEF: PALAEOECOLOGY OF A MESOPHOTIC CORAL COMMUNITY FROM THE GIVETIAN AFERDOU EL MRAKIB REEF (ANTI-ATLAS, MOROCCO)

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Keywords

Devonian, Morocco, Aferdou el Mrakib, Mesophotic coral ecosystem



The southernmost Devonian reefs are those from the NW Gondwana shelf. One of the most prominent localities with reef communities in this area is the Givetian Aferdou el Mrakib reef, located in the Moroccan Anti-Atlas. A characteristic feature of the Aferdou region is the presence at the NE reef margin of numerous small bioherms, informally referred to as “cystiphyllid banks” because of the abundance of solitary rugose corals of the family Cystiphyllidae. The banks probably developed during the early stage of the reef development, most likely at a depth of at least several tens of meters. Here, we present preliminary results on the palaeoecological and taxonomical analysis of the reef community from these structures. Except for the abundant cystiphyllid rugose corals, dominant are platy and encrusting coenitid (e.g. *Roseoporella*, *Platyaxum*) and alveolitid (e.g. *Alveolites*) tabulate corals. Platy morphology of coral colonies is generally recognized as an adaptation to photosymbiosis and is especially common in mesophotic coral ecosystems (MCE). Therefore, the presence of these growth forms may indicate their development within the lower part of the photic zone. The community contains also laminar morphotypes of *Stromatoporella* stromatoporoids, abundant encrusters (e.g. *Rothpletzella*, *Wetheredella*) and accessory invertebrate fauna. The community shares major taxonomical and ecological similarities with the already described MCEs from S Laurussia. This pattern illustrates a high degree of cosmopolitanism among the Givetian MCEs, similar to that observed in the case of coeval shallower-water reef ecosystems. In addition, we show that the Devonian corals such as *Roseoporella* could dramatically change their morphology depending on the light conditions, analogously to the morphological plasticity observed in the modern scleractinian *Portites sillimana*.



PALYNOLOGY, PALYNOFACIES, AND GEOCHEMISTRY OF LOWER-MIDDLE PERMIAN STRATA IN THE PARANÁ BASIN, URUGUAY

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Keywords

palynomorphs, palynofacies, organic matter, stable isotopes, paleoenvironment

The palynology and palynofacies of 33 samples from borehole 943 (**DINAMIGE**; northeastern Uruguay), comprising the Frayle Muerto (**FMF**), Mangrullo (**MF**), Paso Aguiar (**PAF**), and Yaguarí (**YF**) formations, were analyzed. Total organic carbon (**TOC**) analysis, Rock-Eval pyrolysis, and isotopic analyses were also performed. The lower FMF is characterized by trilete spores and secondarily, bisaccate smooth pollen. In the middle and upper FMF, an increase and diversification of bisaccate striate pollen is observed, suggesting the replacement of paleofloras composed mainly of lycopsids and filicopsids by more diverse gymnosperm associations. From the lower PAF, microfloras are dominated by bisaccate striate grains, but a relevant increase in cingulizionate-cavate and monolete spores is noted, indicating seasonally warmer and humid climates. The assemblages are assigned to the Kungurian-Wordian interval. Palynofacies suggest dysoxic-anoxic proximal marine environments related to fluvial-deltaic discharges and nearshore environments in the lower and middle FMF, respectively; very low-energy suboxic-anoxic marine environments in the upper FMF and MF; proximal-distal variations in the lower and middle PAF; and high-energy proximal marine settings with variable oxygenation in the upper PAF and lower YF. Strongly depleted $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}$ values, down to -15‰ VPDB, suggest organic matter oxidation and fresh water influence in the basin. Fluctuations in $\delta^{13}\text{C}_{\text{org}}$ are not related to the composition of the palynological residue or TOC values. Rising trends in $\delta^{15}\text{N}$ toward the top of the FMF and MF are probably related to transgressions. Finally, UV-fluorescence, TOC, Rock-Eval pyrolysis, and IAT indicate a low- to non-hydrocarbon-generating potential for the studied units.





A EUARTHROPOD WITH 'GREAT APPENDAGE'-LIKE FRONTAL HEAD LIMBS FROM THE CHENGJIANG LAGERSTÄTTE

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Keywords

Chengjiang, Euarthropoda, 'great appendage'

Bushizheia yangi, a euarthropod from the early Cambrian Chengjiang biota of China, possesses a fully arthrodised body and limbs. The morphology of the frontal appendages of *B. yangi* bears a resemblance to the 'great appendage' of radiodonts, a morphologically and ecologically diverse group of arthropods that played diverse roles in early Palaeozoic ecosystems. However, we cannot be certain whether these limbs in *B. yangi* are protocerebral or deutocerebral. *B. yangi* also possesses a pygidium, and the association of these characters — raptorial appendages and a pygidium — is an important observation for assessing the range of morphologies evolved by early euarthropods. No eyes were visible on the single specimen preserved in dorsal view, yet they may have been situated under the anterior border of the head shield. Alternatively, if *B. yangi* lacked visual perception it may have been an ambush predator that caught unsuspecting prey with its anteroventral appendage.





COMPUTER MICROTOMOGRAPHY AS A VALUABLE METHOD SUPPORTING RESEARCH ON DEVONIAN CALCAREOUS MICROPROBLEMATICS ON THE EXAMPLE OF *EIFELIFLABELLUM OPUNTIA* LANGER, 1979

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Keywords

microproblematics, foraminifera, Devonian, Holy Cross Mountains



Calcareous Devonian microproblematics are microscopic fossils of doubtful biological affiliation. They are very diverse, from spherical, fan-shaped and even amorphous. Traditionally, studies on such microfossils are based on randomly cut thin-sections giving confusing shapes that can be falsely assigned to different taxonomic groups. In order to avoid this, the microproblematics should be extracted from the rock (extraction improves the quality and resolution) in the maceration process (using Glauber's salt) and then viewed in 3D. The extracted microfossil can be analyzed in a scanning electron microscope (SEM), which can be used to acquire higher-resolution 2D images of the exposed surfaces, but there is no insight into its internal structure. In order to collect information of inner structures of microproblematics microcomputer X-ray tomography (micro-CT) can be adopted. Based on micro-CT scans computer-aided visualization has enabled paleontologists to gain important insights into fossils anatomy and preservation without specimen damage. Here, computer microtomography has been used as a complementary method to the SEM to compare *Eifeliflabellum*, a calcareous Devonian microproblematic, to *Semitextularia* similarly looking foraminifera, both from the Middle Devonian of the Holy Cross Mts, Poland. Both specimens differ in terms of wall structure and interior morphology. CT-scans have shown that *Eifeliflabellum* is different from *Semitextularia* in terms of internal structure, which in *Semitextularia* is more homogeneous. Diagenetic changes can blur the original structure of the skeleton, therefore a special caution should be exercised in the interpretation with the use of x-ray scans based on variations in density of the studied material.

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PRELIMINARY DATA ON FORAMINIFERA AND PHYTOCLASTS OF THE LONTRAS SHALE, ITARARÉ GROUP, BRAZIL

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Keywords

Foraminifera, Lontras Shale, Microfossil, Itararé Group, Post-glacial deposits

The Lontras Shale is a Fossil-lagerstätte of the Brazilian Paleozoic, due to the vast diversity of exceptionally-preserved fossils as fishes, sponges, conodonts, insects and plants. In this work we intend to demonstrate new evidence about foraminifera and phytoclasts for the Lontras Shale deposits, in the Paraná Basin. Sampling was carried out on intervals of 1.2m guided by the fissility of shales, and 11 samples of 1.5kg each were collected. To date, 6 samples were completely analyzed while 5 samples are under preparation. From the collected material, 600g of each 1.5kg were partitioned and underwent attacks with 15% solution of hydrogen peroxide for 24 hours. After that, the samples were washed with abundant water under sieves of 420µm, 400µm, 297µm, 149µm and 75µm. Then, all fractions were observed under a stereomicroscope with 40x magnification, and the portions obtained were sorted into total fraction. After the analysis, 252 microfossil-like structures were identified. These structures were separated by preservation level and 33 were analyzed in a scanning electron microscope (SEM) where they were photographed and examined under energy dispersive spectroscopy (EDS). Preliminary results identified carbon-rich phytoclasts with rectangular cell structures with uniform and continuous spacing (possibly related to *Agathoxylon* Hartig and *Abietopitys* Kräusel found in the same deposit); agglutinated foraminifera (*Sacamininna?*) with single tests and uniformly sized fragments in their shells and benthic foraminifera with tubular shells rich in calcium carbonate. Despite its exploratory nature, this study offers some insights into the micropaleontology of the Lontras Shale, and hopes that in the future these preliminary data can help further research.





RECONSTRUCTING EARLY PERMIAN TERRESTRIAL ENVIRONMENTAL CHANGES WITHIN A MEGA-CALDERA CONTEXT USING PALYNOFACIES

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Keywords

palynofacies, early Permian, terrestrial paleoenvironments, depositional conditions

The study of palynofacies (particulate organic matter) using a light microscope together with geochemical analyses allows the reconstruction of paleoenvironments and depositional conditions of marine or continental sediments. We undertook palynofacies analysis on early Permian (Cisuralian) alluvial and lacustrine sediments deposited in small and closed basins that are represented by epiclastic layers intercalated and chronologically constrained between the radiometrically dated volcanic rocks of the Athesian Volcanic Group (South Tyrol, northern Italy). We analysed 34 samples from the Grissian and Gork sections (Bolzano Province). The recovered organic components were classified as phytoclasts (woody tissue, membranes, opaque phytoclasts, charcoal); palynomorphs: spores (smooth/ornamented), pollen (monosaccate, bisaccate, asaccate); algae; fungal spores/hyphae; and amorphous organic matter. Palynomorphs are abundant in many samples, and are mostly well-preserved. In some samples from the Grissian section they are pyrite-infilled. Opaque phytoclasts have high percentages in a few samples from both sections. The dominance of small-size phytoclasts and the abundant palynomorphs, especially in Gork section, suggest a lacustrine environment, with low water energy at deposition, and a rather complex vegetation in the area. Our palynofacies results will be then compared with geochemical data obtained from the same samples. We also plan to analyse the amorphous organic matter with fluorescence microscopy to better investigate their origins.





LIVING WITH THE SUPERVOLCANO: EARLY PERMIAN PALYNOMORPHS FROM EPICLASTIC LAYERS IN A MEGACALDERA PRESERVED IN THE ITALIAN ALPS

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Keywords

early Permian, Southern Alps, palynomorphs, mega caldera

Past and recent mega-eruptions had a huge impact on the climate and ecosystems. The study of the effects of volcanic disturbances on the ecosystems of the past is difficult because of the rarity of sedimentary deposits directly associated with volcanic products. In the eastern Italian Alps, widely outcropping remains of a mega caldera (Athesian Volcanic Group) built up by 15 million years of explosive volcanic activity during the Cisuralian (early Permian) preserved also intercalated epiclastic layers (alluvial and lacustrine), i.e., the Tregiovo basin. This chronostratigraphically well-constrained succession stores fossil plant macro- and microremains, as well as vertebrate and invertebrate remains and their traces. A multidisciplinary project aims to reconstruct the different ecosystem components and how they were influenced by the volcanic activity. Here, we present the preliminary results of the palynological investigations done on the epiclastic sediments containing mostly pollen grains and less abundant spores with different degrees of preservation. Most of the pollen taxa, which include *Lueckisporites*, *Nuskoisporites*, *Potonieisporites*, *Jugasporites*, *Gardenasporites*, and *Vittatina*, are associated to drought tolerant gymnosperms that characterized tropical terrestrial ecosystems during the early Permian.



Mesozoic



General Session



A REPRESENTATIVE OF THE CONTROVERSIAL ORDER †LOPHIONEURIDA (INSECTA: THIRIPIDA) IN ALBIAN SPANISH AMBER

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Keywords

Acercaria, Thysanoptera, systematics, Cretaceous, Spain

Acercaria is a group of insects comprising the extant orders Psocodea, Thysanoptera, and Hemiptera. The extinct orders †Lophioneurida (late Carboniferous–Late Cretaceous), †Permopsocida (early Permian–Late Cretaceous), †Miomoptera, and †Hypoperlida (both late Carboniferous–late Permian) are also included within Acercaria. †Lophioneurida is grouped together with Thysanoptera in the superorder Thripida, although the systematic validity of †Lophioneurida is controversial as it could be a monophyletic group or a paraphyletic grade. Four families (†Lophioneuridae, †Moundthripidae, †Westphalothripidesidae, and †Zoropsocidae) are putatively included in †Lophioneurida, comprising 18 genera and 48 species. If the †Westphalothripidesidae and the †Zoropsocidae are Thripida, their phylogenetical placements within this order are dubious. Lophioneurids show a short mouthcone with symmetrical mandibular and maxillary stylets. They could have been omnivorous showing a punch-sucking feeding habit on plant tissues. Currently, the only known lophioneurids in amber are Cretaceous in age, from Lebanon (one species, Barremian), Myanmar (one species, Cenomanian) and Taimyr (two species, Santonian). Here, we report the first lophioneurid found in the Albian (Lower Cretaceous) amber of San Just, in eastern Spain. It is preserved in a dark amber piece, so few body anatomical characters are visible. The wing venation is nearly complete, and it is very similar to that of *Jantardachus reductus* Vishniakova, 1981 (Lophioneuridae) from the Taimyr amber. The specimen from San Just probably belongs to the same genus. Lophioneurids showed a diversification in the Permian, but they remain rarely found during the Cretaceous, probably due to niche competing after the diversification of the Tubulifera and Aeolothripidae (Thysanoptera), most likely with a similar life habit.

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THE WASP FAMILY †SERPHITIDAE (HYMENOPTERA) FROM LOWER CRETACEOUS SPANISH AMBERS

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Keywords

Albian, Bipetiolarida, Iberian Peninsula, palaeobiology, taxonomy



The study of extinct Cretaceous families of Hymenoptera is crucial as it provides unique glimpses into the diversification of the group during a dramatic period in evolutionary history. The †Serphitidae were a family of parasitoid wasps, with representatives distributed worldwide during the Cretaceous, ranging temporally from the Albian through the Campanian. The family is sister to the monogeneric †Archaeoserphitidae, and together with the Mymarommatoidea, they comprise the clade Bipetiolarida, characterized by the bipetiolate metasoma. Currently, the †Serphitidae comprise 21 species in the genera *Microserphites* (†Microserphitinae), *Supraserphites* (†Supraserphitinae), *Serphites*, *Aposerphites*, and *Jubaserphites* (all three within †Serphitinae). Until now, four serphitid species were known from Spanish ambers (Peñacerrada I, El Soplao, and San Just localities). Here, we report seven new specimens from the amber-bearing outcrops of Ariño, El Soplao, and San Just. Those from Ariño correspond to the oldest known serphitid wasps. The amber from this site is found in a dinosaur bonebed dated as early Albian. One specimen belongs to *Aposerphites*, while the other six belong to *Serphites*. Considering the latter, two specimens might be assigned to *S. lamiak* Ortega-Blanco, Delclòs, Peñalver and Engel, 2011, while three seem to represent a new species and another is too poorly preserved. Their study is in progress, so taxonomic determinations might change as more is learned. These specimens increase the known diversity of †Serphitidae during the Early Cretaceous and help to know new information about the palaeobiogeography of the group in Iberia. The palaeobiology of the group is obscure, although a parasitoid life cycle has been previously proposed. The description of new serphitid wasps provides interesting anatomical information that could help to understand their biology and may also shed light on interrelationships of and within the family.

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PHYLOGENY OF FOSSIL POLYCHELIDAN LOBSTERS

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Keywords

phylogeny, evolutionary history, Decapoda, palaeoenvironment, cladistic analysis

Polychelidan lobsters are a clade of decapod crustaceans characterized by having four or five pairs of claws. They were diversified and inhabited various environments during the Jurassic, and are now less diverse and restricted to deep waters. We still do not have a clear overview of the 69 described species of fossil polychelidans, including their phylogenetic relationships. Our recently published phylogenetic analysis (Audo et al. 2021, *Journal of Systematic Palaeontology* 19(6)) includes 35 fossil polychelidans and offers the first high-resolution study of their relationships, uniting fossil and extant polychelidans. It shows that polychelidans are divided into five main lineages – two monospecific (*Palaeopentacheles roettenbacheri* and *Rogeryon oppeli*) and three clades (Eryonidae, Coleiidae and Polychelidae). We were able to identify several trends in polychelidan evolution: (1) diversification of the main lineages probably predates the Late Triassic; (2) Eryonidae probably evolved fossorial adaptations independently from Polychelidae; (3) a trend, suggested by some authors, to live in deeper water disappears when accounting for the bathyal distribution of each monophyletic group across time; (4) several lineages conquered shallow water palaeoenvironments independently; and (5) fossil relatives to the surviving family, the polychelids, inhabited deep water as early as the Early–Middle Jurassic. We can therefore conclude that extant polychelidans are not refugees that adapted to deep water, but survivors of a group that was once more diverse both morphologically and ecologically.





A FRESHWATER PALAEOECOSYSTEM FROM A NEW LOCALITY OF THE CERRO DEL PUEBLO FORMATION (CAMPANIAN) IN COAHUILA, MEXICO

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Keywords

Campanian, Freshwater, Saurischian, Ornithischians, Testudines



The Cerro del Pueblo Formation has multiple outcrops where late Campanian fossil remains from different paleoecosystems have been reported. Due to the presence of vertebrate and invertebrate remains; as well as plants, it is possible to obtain a more complete picture of the Late Cretaceous ecosystem of southern Laramidia, in particular that present in Mexican territory. This project reports a new locality recently discovered by an amateur paleontologist in Coahuila, Mexico. The material was surface collected and is repositied in the Museo del Desierto in Saltillo. Among fossil vertebrate remains, we have thus far identified several turtle and dinosaur taxa families. Four turtles families have been identified, including Trionychidae, Chelydridae, Dermatemydidae, and Adocidae. Five dinosaurs families thus far identified include the saurischians Tyrannosauridae and Dromaeosauridae, and the ornithischians Hadrosauridae, Parksosauridae, and Ceratopsidae. Dinosaurian remains dominate the recovered fossils with 65.29% of the vertebrate material. The most abundant taxon are hadrosaurids with 30.61%, followed by soft-shell turtles with 26.53%, with dromaeosaurids third at 10.2%. This locality shows a typical freshwater ecosystem for the Late Cretaceous of southern Laramidia as the majority of primary and secondary terrestrial consumers are dinosaurs, as the channels of a deltaic system are an especially attractive environment for herbivorous vertebrates, followed by carnivores. In addition to the vertebrates, the site also preserves the fossilized remains of gastropods, bivalves, coprolites, and wood.



TITANOSAUR OSTEODERMS AS SUBSTRATE FOR DERMESTID BIOEROSION, AN EXAMPLE FOR THE UPPER CRETACEOUS OF LO HUECO (CUENCA, SPAIN)

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Keywords

Ichthyology, Bioerosion, Dermestidae, Lo Hueco, Upper Cretaceous

The Lo Hueco fossil site has yielded several complete specimens of osteoderms that have been attributed to titanosaurs. Titanosaurs are the only sauropod dinosaurs known to bear dermal armor. Titanosaur osteoderms have a unique bulb and root morphology. The bulb is a sub-circular region, well delimited by a cingulum that was probably covered by a spine in the living animal. The bulbs occur in different morphologies, but it is common that they present a flat dorsal surface in lateral view. It has been recognized that there is a special abundance of bioerosion structures (*postmortem*) on the dorsal surface of these bulbs, without affecting the root of osteoderms. Such traces, consisting of hollow and oval chambers with concave flanks, have been identified as the ichnogenus *Cubiculum*. They are interpreted to be the result of a pupal behavior probably conducted by dermestids (Coleoptera). It is proposed that there is a preferential distribution of these borings in the area of non-mineralized collagen fibers that connect the bone surface of the osteoderm and the external spines of the integument of these dinosaurs. A preliminary neoichnological study, focused on the boring behavior of the modern dermestid *Dermestes frischii*, has resulted in the observation that the larvae of these beetles are able to generate pupal chambers comparable to those observed on the titanosaur osteoderms; mainly in those contact areas between bone tissue and cartilage. In summary, different consistence of tissues (i.e. bone, cartilaginous or osteodermal) could be considered as a preferential factor influencing the occurrence and distribution of dermestid bioerosion.





VERTEBRATE MICRO-REMAINS FROM THE LOWER CRETACEOUS AGRIO FORMATION (NEUQUÉN BASIN, ARGENTINA)

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Keywords

Fish teeth, Ichthyoliths, Agua de la Mula Member, Lower Cretaceous, Neuquén Basin

Fish skeletal debris, composed of minute-sized teeth and dermal scales highly resistant to dissolution, occurs in marine and non-marine palaeoenvironments, especially in the deep-sea. Although parataxonometrically classified and generally rare, ichthyoliths have been used to interpret abundance and diversity of fish communities, and as biostratigraphic markers in otherwise barren, muddy sediments. Here we describe three teleost teeth from marly shales (*Crioceratites schlagintweiti* Zone) and calcareous shales (*Crioceratites diamantensis* and *Paraspiticeras groeberi* zones) of the Lower Cretaceous (Hauterivian) Agua de la Mula Member (Agrido Formation), which formed in a mixed siliciclastic-carbonate marine homoclinal ramp system, under low energy and dysoxic conditions. Specimens were picked from three washing residues (90 g total weight) that yield foraminiferal assemblages with low abundance and species richness. The specimens are between 0.5 and 1.5 mm long, triangular in outline, and have a smooth external surface with straight margins. Adopting the system of morphological descriptors for ichthyoliths, the specimen with flattened cusp and circular section in occlusal view can be referred to type a8/b1/c1/d1, while two teeth showing acute cusps and with sub-oval and acute laterally section can be referred to types a9/b1/c5/d2/e1/f1/g1/h0 and a9/b2/c5/d2/e4/f3/g1/h0, respectively. The new material enriches the poor vertebrate fossil record of the marine members of the Agrido Formation, to date composed of scattered remains of marine 'reptiles', pycnodontiform fishes, hybodont and lamniform sharks, and adds further faunal components exploiting different, as yet unrecorded, niches.

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DINOTURBATION IN THE EXU FORMATION (CENOMANIAN, UPPER CRETACEOUS) FROM THE ARARIPE BASIN, BRAZIL

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Keywords

Dinoturbation, Exu Formation, dinosaur tracks, Araripe Basin



Fossil footprints are generally recognized by morphological features from the autopodium registered on the unconsolidated substrate; therefore, they can also be understood as biogenic primary deformation structures. These structures are produced by foot pressure on a depositional surface, and transmitted downward inside a bed or a bedset. In some cases they are difficult to recognize, as they can be misinterpreted as load or liquefaction inorganic features related to sediment compaction, usually triggered by earthquakes and not to trampling by terrestrial vertebrates. In the Araripe Basin (Northeastern Brazil) many dinosaur footprints and tracks are observed in outcrops, mainly in the Lower Cretaceous Rio da Batateira and Santana formations (Crato Member in the latter) of Aptian age. They are often observed as load casts produced by dinosaur trampling, allowing evaluation of substrate consistency besides the potential trackmaker identification. We present here the first record of footprints in the overlying Exu Formation (Cenomanian), a succession of fine-grained sandstones interbedded with siltstones and occasionally mudstones, sedimented in channel bars of ephemeral streams and floodplains characterized by an arid climate. Footprints, 20 cm long and 30 cm wide, are evident on a vertical cross-section of a sandstone bed as concave-up deformations of the lamina-set. Digit impressions or other morphological features of the footprints are not recognized. The characterization of the dinosaur footprints enhances the understanding of the genetic interpretation of deformational structures and paleoenvironmental scenarios of the Late Cretaceous from Northeastern Brazil.



JURASSIC MARINE VERTEBRATE REMAINS FROM THE UMBRIA-MARCHE DOMAIN (CENTRAL ITALY): STRATIGRAPHICAL CONTEXT AND PALAEOECOLOGICAL SIGNIFICANCE

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Keywords

Marine vertebrates, Jurassic, Palaeoecology, Western Tethys, Rifting

Isolated and fragmentary vertebrate fossil remains can provide useful constraints in reconstructing faunal composition and palaeoecological relationships in marine palaeoenvironments. The vertebrate record of the Jurassic succession of the Umbria-Marche Domain is represented by scattered remains from different lithostratigraphic units and ages, in distinct palaeostructural contexts within PCP-basin systems. The record is represented, to date, by: i) a trackway, named *Accordiichnus natans*, of an indeterminate marine 'reptile' (Pliensbachian); ii) teeth remains referred to *Oxyrhina* sp. (Toarcian - Erbaense Zone) and *Sphenodus* spp. (Pliensbachian, Bajocian?, Kimmeridgian); iii) a probable ichthyosaur rib (early Kimmeridgian) and a relatively complete, mostly articulated ophthalmosaurid ichthyosaur, *Gengasaurus nicosiai* (holotype, MSVG 39617) (late Kimmeridgian-earliest Tithonian); iv) multicuspid shark teeth referred to Hexanchiformes (late Kimmeridgian-earliest Tithonian), associated to *Gengasaurus nicosiai* and probably suggesting scavenging; v) polygonal teeth with domed or flat occlusal surface referred to *Asteracanthus* sp. (Toarcian) and *Asteracanthus* cf. *magnus* (Kimmeridgian); vi) button-like teeth (Kimmeridgian) referred to neoginglymodian actinopterygians. From a palaeoecological point of view, the fossil specimens likely represent indicate active nektonic carnivores, including different fast-swimming, fusiform sharks equipped with tearing and cutting dentitions, and durophagous sharks and bony fishes exhibiting, respectively, extreme crushing and tritorial (plus probably nipping) dentitions. The durophagous fauna fed on the rich invertebrate fauna (e.g. bivalves, gastropods, echinoids, crustaceans, brachiopods) dwelling the sea-floor of PCP-basin systems, whose enucleation and development related to the Early Jurassic Western Tethys Rifting most likely played a role in increasing niche availability in a purely pelagic domain.





LATE JURASSIC TO EARLY CRETACEOUS BENTHIC FORAMINIFERS OF SOUTH TIBET, TETHYAN HIMALAYAS: BIOSTRATIGRAPHY, PALAEOECOLOGY, PALAEOBIOGEOGRAPHY

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Keywords

benthic foraminifera, micropalaeontology, palaeoceanography, foraminiferal biozonation, south Tethys Ocean

In China, the marine Jurassic to Cretaceous Boundary is constrained to the sedimentary successions of South Tibet. Although most of the fossil groups of the Tethyan Himalayas have been studied for more than a century, foraminiferal researches were initiated in the past 20 years. Our work underlines the occurrence of 6 foraminiferal biozones formerly named: (1) *Textularia haeusleri*; (2) *Trochammina quinqueloba* acme zones; (3) *Pseudoreophax cisovnicensis*, *Globulina prisca*; (4) *Lenticulina ouachensis*, *Textularia bettenstaedti*; (5) *Ammobaculites crespinae*, *Haplophragmoides chapmani*; (6) *Glomospira charoides*, *Dorothia oxycona* assemblage zones. The J/K boundary is currently delineated since the base of the Shale Unit, Gucuo Formation. Indeed, the associated *P. cisovnicensis*, *G. prisca* Zone yields typical Early Cretaceous foraminifera. This result disagrees with previously published studies performed on ammonites which indicated a latest Tithonian age for this part of the section. Therefore, the J/K Boundary was traditionally delineated in the middle to upper interval of the overlying volcanoclastic unit based on to the first occurrence of typical Valanginian to Barremian ammonite. The present biozonation for this part of the section differs by having typical Aptian to Albian foraminifera. At that time, South Tibet was located in the northern edge of India, South of Gondwana. Its northern part was located in a deep marine environment, whereas its southern part was part of the outer neritic shelf. At that time, foraminiferal assemblages were significantly influenced by palaeogeographical changes. The composition of the benthic foraminiferal assemblages reflects a combination of Tethyan, North Atlantic, and local endemic faunal influences.





LATE JURASSIC FISHES FROM TORRES VEDRAS, PORTUGAL

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Keywords

Hybodontiformes, Neopterygii, Late Jurassic, Torres Vedras, Portugal



Torres Vedras municipality, in the central-western section of Portugal, within the Lusitanian Basin, is well-known for its vertebrate fossil assemblage, especially for the case of dinosaurs. Fossil elasmobranchs and actinopterygians were poorly documented on its coastal outcrops so far. Here we describe new fossil shark and neopterygian specimens, collected on the surface of the marine deposits at the top of Praia Azul Member, Lourinhã Formation, dating between upper Kimmeridgian-lower Tithonian, and on the surface of the transitional deposits of Cambelas fossil site, Freixial Formation, dating between the middle-upper Tithonian, Upper Jurassic. Fossils are now housed in the CI2Paleo of Sociedade de História Natural. Sharks are represented by 38 isolated teeth, whose dental characters agrees with those of *Hybodus reticulatus*, as per diagnostic evidences, especially its reticulated, spongy root, and well-developed enameloid ridges on both crown faces. The presence of this taxon in the Upper Jurassic Portuguese record is therefore confirmed. Neopterygian specimens are represented by a set of 29 isolated or partially articulated body scales attributed to cf. *Ginglymodi*, based on the presence of smooth ganoine covering the scales, and the rectangular-oblong to rhomboidal-like scale shape; and 38 isolated or partially articulated teeth referred to *Pycnodontiformes* indet., based on its more or less pillow-shape, smooth convex occlusal surface, and for being arranged in longitudinal rows, forming a more or less dense pavement. The results of this study certainly improve our understanding about the fish diversity of the Upper Jurassic of Portugal.



A NEW LOWER VALANGINIAN AMMONITE FAUNA FROM SW SICILY

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Keywords

Ammonites, Valanginian, Sicily, Systematics, Biostratigraphy, Paleobiogeography

This is the first systematic study of the ammonites of the Lower Cretaceous Lattimusa Formation in Sicily. The studied outcrop is located on the northern slope of Monte Magaggiaro (Contrada Diesi, Agrigento, SW Sicily), and belongs to the Saccense Domain. In the up to 5-cm-thick fossiliferous layer the specimens are preserved in random orientation and most are juveniles or inner parts of phragmocones, but all the species found could be coeval, so no condensation is likely. The macrofauna consists also of solitary corals, gastropods, bivalves, aptychi, belemnites and brachiopods. A total of 356 ammonite specimens and fragments were investigated, representing 7 families, 15 genera, and 25 species. One genus and one species belonging to the Olcostephanidae are new. Some taxa have never been recorded from Italy: *Lytoceras juilleti* (d'Orbigny, 1841), *Kilianella lucensis* (Sayn, 1907), *Kilianella grossouvrei* (Sayn, 1889), *Sarasinella eucyrta* (Sayn, 1907), *Sarasinella* sp., *Protancyloceras cristatum* Arnould-Saget, 1951, *Protancyloceras* sp., whereas others have never been recorded from Sicily: *Vergolicerus salinarium* (Uhlig, 1887), "*Thurmanniceras*" *pertransiens* (Sayn, 1907), *Neocomites premolicus* Sayn, 1907, *Bochianites* sp., *Protancyloceras punicum* Arnould-Saget, 1951, and *Protancyloceras bicostatum* Arnould-Saget, 1951. The composition of the fauna, especially the presence of "*T.*" *pertransiens* and *N. premolicus*, indicates the *Neocomites premolicus* Subzone, the base of the "*Thurmanniceras*" *pertransiens* Standard Zone of the basal Valanginian. The fauna clearly belongs to the Tethyan Realm for the abundance of Phylloceratoidea, Lytoceratoidea and Neocomitidae, and for the lack of Boreal taxa. Similar faunas are known from the basal Valanginian of Tunisia and the Betic Cordillera.





A NEW ANKYLOSAUR TRACK FROM THE GUARÁ FORMATION (UPPER JURASSIC OF RIO GRANDE DO SUL, BRAZIL)

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Keywords

Dinosaur, Cerro Torneado, footprints



The Guar Formation (Upper Jurassic, Paran Basin) has a wide geographic distribution, extending from the western Paran state of Brazil to northern Uruguay. It is a large sedimentary sequence consisting of fine-grained to conglomeratic sandstones of fluvial and eolian origin. In this formation, sauropod, theropod, ornithopod and ankylosaur dinosaur tracks have already been found, as well as burrows of vertebrates and invertebrates. In 2019, a new ankylosaur footprint was found in the Guar Formation of the southwest of the Rio Grande do Sul state, Brazil. This new material was found at the Cerro Torneado (RSCT) outcrop, in the municipality of Rosrio do Sul. The isolated footprint is 24 cm long and 30 cm wide. As it is preserved as an undertrack, the footprint can only be identified by deformations in the sandstone layers, as there is no relief. Fine anatomical details are difficult to distinguish, although tetradactyly and paraxony are quite evident. Other features that suggest this footprint was produced by an ankylosaur are: radially arranged digits, a broad pes sole, a slightly asymmetrical track outline and the approximate measurements of the digits in width and length. The finding shows the difficulty in finding and interpreting the footprints formed in eolian deposits, given its preservation. However, prospecting efforts have shown that the Guar Formation has great potential to contribute to the knowledge of the Jurassic (ichno)fauna of South America.



STRATODUS FROM MAASTRICHTIAN DEPOSITS OF AL JAFR BASIN, SOUTHEASTERN OF JORDAN

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Keywords

Gill arches, Stratodontidae, Dercetidae, Enchodontoidei, Middle East

Stratodus is an enigmatic member of Aulopiformes (lizardfishes and kin), represented mostly by isolated jaw fragments. Recent discoveries have provided a more complete morphological picture of the genus, revealing an elongate body and somewhat long snout, jaw bones bearing several rows of curved teeth, tripartite osteoderms, and palmate-fringe-like neural arches. The anatomy of other internal structures remains largely unknown, and phylogenetic placement of *Stratodus* remains problematic. *Stratodus* has been considered as Aulopiformes incertae sedis, as member of Dercetidae, and lately as a representative of its own family, Stratodontidae. Temporally, the four species attributed to *Stratodus* are distributed throughout the Late Cretaceous (late Coniacian to Maastrichtian) with some records reaching up to the Eocene. The geographical distribution of this taxon encompasses the Late Cretaceous shallow seas from the Middle East (Israel, Jordan, and Syria), Western Africa (Mali, Morocco, and Niger), and the United States (Western Interior Seaway). Here we report *Stratodus* cf. *oxypogon* from the Maastrichtian beds of the Muwaqqar Chalk Marl Formation exposed 30 km northeastern of Al Jafr town, southeastern Jordan based on a fossil that preserves the lower jaws, parts of the gill arches and hyoid arch. The specimen is recognized as *Stratodus* based on articulated and elongate lower jaws and palatines, and palatines bearing several rows of small, curved teeth, a diagnostic characteristic for the genus. Also, the specimen exhibits five elongate and toothless ceratobranchials, and laterally compressed posterior ceratohyals. The specimen is identified as *S.* cf. *oxipogon* based on the cuneiform mandibular symphysis and uniform acute teeth. The discovery of this species in Jordan represents a new geographic occurrence, and the preservation of the gill arches sheds light on details of internal anatomy with a possible bearing on the phylogenetic placement of the genus.





ORNITHOPOD DINOSAUR REMAINS FROM THE PAPO-SECO FORMATION – LUSITANIAN BASIN, PORTUGAL

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Keywords

Early Cretaceous, dinosaurs, Papo-Seco Formation, Portugal

Ornithopod remains are reported from the Papo-Seco Formation, at Cabo Espichel area (Sesimbra County), in western central Portugal, south of Lisbon. The material was collected in three palaeontological sites: Boca do Chapim, Areia do Mastro and Praia do Guincho. Vertebrate fossils from Cabo Espichel are known since the 19th century. Dinosaur and crocodile teeth were first reported from the Papo-Seco Formation at Boca do Chapim. Later, turtle remains and crocodile teeth and bones, as well as dinosaur remains have also been described. In Boca do Chapim, several ornithopods remains have been found. In the Areia do Mastro locality, vertebrate remains, including fishes, crocodyliforms, pterosaurs and dinosaurs (*Baryonyx* sp., *Mantellisaurus*, Iguanodontidae indet. and Sauropoda indet.) have been described. At Praia do Guincho site, a natural cast of an ornithopod footprint has been discovered. The fossils of the Papo-Seco Formation (lower Barremian, Lower Cretaceous) are found in limestones, marls and sandstones. They occur in a succession interpreted to have originated in a carbonate lagoon environment. We present new remains and the review of ornithopod already described from the Papo-Seco Formation. The reanalysed materials are referred to Ornithopoda indet., Ankylopollexia indet., Styracosterna indet., Iguanodontidae and *Mantellisaurus* sp.





CROCODYLOMORPH TRACE FOSSILS FROM THE AREIA DO MASTRO FORMATION (BARREMIAN), CABO ESPICHEL, LUSITANIAN BASIN (PORTUGAL)

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Keywords

crocodylomorpha, Cretaceous, Portugal, footprints, swimming traces



At least 700 crocodylomorph trace fossils were discovered in 2021 at Ribeira do Chapim tracksite (Cabo Espichel, Sesimbra, SW Portugal) in one limestone bed on top of the Areia do Mastro Formation (lower Barremian), deposited in a carbonate shallow lagoon environment, under a tropical climate. This bed is exposed in two different areas, both with footprints and swimming trace fossils of crocodylomorphs. These two track-bearing surfaces measure 70 and 45 m². The footprints are similar and most of them are tetradactyl. However, there are also some pentadactyl footprints, most of the pes footprints presents a heel mark. The footprints have several sizes: the smaller footprints are 10 cm long by 10 cm wide (manus) and 15 cm long by 10 cm wide (pes) and the larger footprints are 14 cm long by 15cm wide (manus) and 27 cm long by 20 cm wide (pes). The arrangement of some sets of prints allows us to identify five trackways. The swim traces are elongated, with 1 to 4 digit impressions, and are located throughout all the surface. Moreover, a deep and longitudinal trace is documented, which we interpreted as a possible tail drag mark. This new tracksite is the third site with ichnological evidence of crocodylomorphs in the Lusitanian Basin, and the first for the Cretaceous. The presence and abundance of walking and swimming trace fossils in the same track-bearing layer made by several crocodylomorphs that were walking floating or diving underwater is unusual in the fossil record and will allow us to learn more about the paleoecology of this kind of tetrapod and discuss the possible relationships between their behavior and the environment in which they lived.



A *PTERODONTA* DOMINATED EVENT SHELL BED FROM EARLY CRETACEOUS OF BARMER SUB-BASIN, WESTERN INDIA

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Keywords

Shell bed, Gastropoda, Pterodonta, Early Cretaceous, western India

We report an event shell bed represented by a *Pterodonta* dominated assemblage from the Early Cretaceous (Aptian-Albian) marine sequence of Fatehgarh Formation, Barmer sub-basin, western India. This shell bed constitutes a low diversity gastropod assemblage (8 species) and it is dominated by the species *Pterodonta* sp. The shell bed is 1.5 m, thick, interbedded in between two red colored, very fine-grained sandstone units with a lateral extent of 600–700 m. The lithology of the shell bed is characterized by massive medium-grained sandstone with the shells arranged like pavement when seen in planar view. Taphonomic analyses of the shell bed done on a grid of (4x4) sq. ft., reveals that the specimens are closely associated with moderate to poor size sorting. The modal size range is between 2.4 to 2.6 cm. Most of the specimens have poor shape sorting, sub-angular to rounded shape, highly abraded with fragmentation about 40%. However, no biological modification is observed. A rose diagram plotted for visualizing orientation of the shells, reveals a polymodal trend of the long axes of the shells. The shells are loosely packed with a relative shell to matrix ratio of 1:3. The overall ecology of this gastropod assemblage is characterized by epifaunal herbivore grazers found mostly in open shallow subtidal environments. This assemblage has likely been the product of a high energy event, where the entire community was transported to a short distance as by sediment gravity flow and then rapidly dumped and buried under sediment.





LUZ BEACH (LAGOS, PORTUGAL) — A UNIQUE PLACE FOR AN EDUCATIONAL AND TOURISTIC GLIMPSE OF THE GEOLOGICAL CYCLE AND FOSSIL RECORD

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Keywords

Praia da Luz, Algarve, Portugal, Geosciences



Luz beach, near Lagos, in the south of Portugal, is a privileged place for teaching of geosciences, for its accessibility, but also for its unique geologic and paleontological record. The natural heritage is preserved in a restrict area with easy access for schools and tourists, as we observe sedimentary, magmatic and metamorphic rock formations as well as vertebrate, invertebrate and plant fossil records, from Aptian to Albian. In the sedimentary rocks we can find marls, limestones and sandstones, preserving paleontological content from various paleoenvironments. To the west, there are sandstone levels rich in gastropods *Nerinella algarbiensis* (coastal marine environment influenced by the tides), and to the East, fragments of carbonized plants (continental influence), fragments of charophyte and ostracods (brackish lagoon waters), gastropods and bivalve molluscs (marine environment) may be observed. In September 2021, still being studied, over 45 sauropod dinosaur tracks of various sizes were discovered in the Lower Cretaceous levels. At its eastern extremity, a magmatic intrusion (Upper Cretaceous, ~75Ma) reveals an elliptic volcanic chimney formed by dark colored rocks, with geodes and xenoliths, classified as lamprophyre. The contact metamorphism between the sedimentary succession and the magmatic intrusion caused a change in color and hardness of the rocks giving origin to metamorphic rocks surrounding the volcanic chimney. Praia da Luz constitutes therefore an *in situ* museum, allowing the exploration of the rock cycle, concepts of geology, paleontology and environmental changes, as well as complementing and differentiating the touristic offer of the region.



SAWSKATES (RAJIFORMES, SCLERORHYNCHOIDEI) AND THE CONCEPT OF PRISTIFICATION

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Keywords

Sclerorhynchoidei, sawskates, pristification, convergent evolution



Two extant clades of chondrichthyans, sawfishes (Pristoidei) and sawsharks (Pristiophoriformes), convergently evolved saws. A saw is an elongated, dorsoventrally-compressed rostrum with lateral rows of enlarged denticles. It functions as both a sensory organ and a weapon for detecting and dispatching prey. An extinct clade from the Cretaceous, Sclerorhynchoidei, also had saws and were previously considered to be sawfishes. However, sclerorhynchoids are distinguished from pristoids by several notable characteristics. The rostral denticles attached directly to the edges of the rostrum and were not embedded in alveoli. They were continually replaced, which resulted in extreme rostral asymmetry in some genera. Further rows of large denticles lined the sides of the head and the dorsal side of the body. The pectoral and pelvic fins were adjoining, both dorsal fins were located behind the pelvic fins, and the caudal fin was greatly reduced. Additionally, recent phylogenetic analyses have recovered Sclerorhynchoidei as the sister clade to skates (Rajoidei). All this evidence indicates that sclerorhynchoids are a third clade that convergently evolved saws. I propose they should be called 'sawskates' to separate them from sawfishes and emphasize their affinities to skates. The repeated evolution of saws has been recognized but not named, for which I suggest the term 'pristification'. These terms are intended for use in science communication; while specialists are aware of the relationships of saw-bearing fishes, the general public is usually not. This remarkable case of convergent evolution should be made accessible to a wider audience.



A NEW APPROACH IN THE STUDY OF DINOSAUR EGGS FROM NATIONAL NATURAL RESERVE OF SAINTE-VICTOIRE (SOUTH-EASTERN OF FRANCE)

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Keywords

dinosaur eggs, Upper Cretaceous, National Natural Reserve of Sainte-Victoire

The South of France is known for its exceptional deposits that contain dinosaur eggs in the Upper Cretaceous. The site at the National Natural Reserve of Sainte-Victoire (RNSV) has been the subject of systematic paleontological excavations since 2015. Inside Grands-Creux locality has revealed an abundance of dinosaur eggs as corroborated by previous studies, but had never been the subject of stratigraphic excavations. The four sectors (distributed on 264m²) currently excavated have revealed the presence of 524 dinosaur eggs, assignable to the Megaloolithidae oofamily. The use of detailed methods of excavation and documentation never used before in this sites, such as spatial analysis, photogrammetry, and taphonomic studies, provide new data on the nesting behaviors of dinosaurs, whose eggs are attributed to the megaloolithidae oofamily. These methods have allowed the testing of two new hypothesis: the variation of clutch morphology over time, and the presence of two oospecies. Studies are also on going at second locality (Champ de tir), situated a hundred meters away from Grand-Creux. It has provided more than 460 eggs. Interestingly, some of them, are complete and present pathological structures. Comparison between both sites will shed light on dinosaur clutch/egg variability and stratigraphic variations at small geographical scale.





SPINOSAURID REMAINS OF THE LOWER CRETACEOUS ENCISO GROUP (CAMEROS BASIN): PRELIMINARY RESULTS OF THE STUDY OF THE IGEA HINDLIMB (LA RIOJA, SPAIN)

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Keywords

Theropoda, Spinosauridae, Iberia, Cameros Basin, Early Cretaceous



The revision and recent discoveries of new theropod material in the Iberian Peninsula shows that spinosaurids were more common and diverse than previously expected with the description of *Vallibonavenatrix*, the identification of *Baryonyx* and the probable spinosaurid *Camarillasarus*. Findings of spinosaurid remains in the Enciso Group (upper Barremian-lower Aptian) in Western Cameros Basin are becoming habitual, making it interesting for the study of this clade. A nearly complete left hindlimb was previously attributed to *Baryonyx*. This specimen was found in the La Virgen del Villar-1 site and consists of femur, tibia, fibula, astragalus, calcaneus, three metatarsals, two phalanges and the hallux. Furthermore, other remains like fragments of a neural arch and ribs have been recovered, presumably from the same individual. Based on a previous phylogeny of basal tetanurans, the rounded cnemial crest of the tibia and the hourglass-shaped outline of metatarsal III suggest tetanuran affinities. The fibular crest extends to the proximal end of the tibia as a low ridge as in some basal tetanurans. Besides, the medial epicondyle of the femur is rounded in shape and the medial fossa is shallow as in Megalosauroidea. The orientation of the long axis of the medial condyle of the femur is posterolateral in distal view and similar to what it can be seen in spinosaurids. Therefore, the preliminary study of this specimen suggest it belongs to Spinosauridae. Nevertheless, a more detailed study is needed in order to establish if it can be assigned to *Baryonyx* or to another spinosaurid.



MICROFOSSILS FROM THE TRIASSIC OF SOUTH CHINA PROVIDING NEW INSIGHTS ON THE SHARK EVOLUTION

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Keywords

Chondrichthyes, Elasmobranchii, Euselachii, Triassic, China

The Middle-Late Triassic succession of the Nimaigu Section (Wusha area, Xingyi City, Guizhou Province, South China) has yielded the Middle-Late Ladinian Xingyi Fauna and the overlying younger Carnian Guanling Biota. Herein, we report a newly discovered chondrichthyan fauna strata intermediate between the above mentioned vertebrate faunas. Six taxa of chondrichthyans were described, including two elasmobranchs of uncertain affinities (aff. *Rosaodus* sp., *Rosaodus xingyiensis*), three euselachians (Euselachii gen. et sp. indet., *Favusodus orientalis*, *Keichouodus nimaiguensis*) and a possible Holocephalian (aff. *Arctacanthus* sp). The mosaic of features, consisting of both a cladodont crown and euselachian-type root, were documented in non-durophagous sharks of the fauna. It provides new insights on the shark evolution between the “cladodontomorph” and euselachian sharks.





A NEW PHYTOSAUR FROM THE LATE TRIASSIC OF JAMESON LAND, GREENLAND

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Keywords

Mystriosuchus, phylogeny, Malmros Klint, Norian, paleogeography

Phytosaur material from the Late Triassic Malmros Klint Formation of the Fleming Fjord Group (central East Greenland) comprises more than 150 disarticulated fossil bones of young, sub-adult and adult specimens belonging to at least four individuals, hosted in the Natural History Museum of Denmark (NHMD). The material was found in thin fluvial overbank sandstones interbedded with lacustrine mudstones. The absence of most skull bones, with only partial rostrum, posterior lower skull and a postorbital, allows only a preliminary phylogenetic analysis in TnT using OTUs (Operational Taxonomic Units) to facilitate comparisons between known and undetermined species, which nevertheless shows that the material probably belongs to a new species of the genus *Mystriosuchus* (supported by the presence of a narrow slit interpremaxillary fossa). This is the first *Mystriosuchus* confirmed outside of Europe, supporting the strong European faunal influence in East Greenland in the Late Triassic found before with other species of aetosaurs, temnospondyls and early dinosaurs. The mid-late Norian age range of the *Mystriosuchus* taxon provides an additional important age constraint on the vertebrate-bearing middle part of the Malmros Klint Formation.





SCLEROBIONT BIOIMMURATION AND BIOTIC INTERACTIONS ON SMALL CALCAREOUS SPONGES FROM THE EARLY CRETACEOUS AGRIO FORMATION OF ARGENTINA

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Keywords

biotic interactions, sclerobionts, sponges, bioimmuration, oysters



In early Hauterivian beds of the Agrio Formation (Neuquén Basin, west-central Argentina) a shale interval including a patch of oysters and small sponges is recorded in Cerro Marucho locality (southern basin area). It provides an opportunity to study the paleoecology of sponges, which are an underrepresented group for the unit. Sponges were assigned to Class Calcarea, genus *Endostoma*. They are small, up to 45 mm high, and conformed a low-relief meadow that colonized a soft-sediment seafloor. Some sponges exhibit an elongated globular-shaped; although most are represented by branch fragments. Sponges settled on disarticulated oyster valves. Sclerobionts are very common in sponges: of 139 specimens, 91.37% are encrusted by at least one sclerobiont. The commonest are oysters (*Ceratostreon* sp. found in 74.1% of sponges), followed by several species of serpulids (recorded in 62.59% of sponges), various cyclostomes bryozoans (in 43.17% of sponges) and agglutinated foraminifers (28.06% of sponges). In addition, oysters were commonly partially or completely overgrown by the sponge; at least 38.13% of sponges showed one or more bioimmured oysters, indicating that oysters settled on living sponges. Associations among sclerobionts are also quite common; at least 10 pairs of overgrowths among sclerobiont species were recorded, with 27 total occurrences. Most of them are interpreted, however, to have occurred *post mortem*. These Early Cretaceous calcareous sponges provide interesting insights on the interactions of these organisms with a high variety of taxa, and highlight the importance of a positive feedback mechanism with oysters, by using them as settlement substrate and viceversa.

This is the C-181 contribution of IDEAN.



PLANKTONIC FORAMINIFERAL AND CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY OF THE CRETACEOUS GORU FORMATION, SULAIMAN RANGE, LOWER INDUS BASIN, PAKISTAN

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Keywords

Planktonic foraminifera, calcareous nannoplankton, biostratigraphy, Goru formation, Sulaiman Fold-Thrust Belt.



The Cretaceous Goru Formation in the western Sulaiman Range (Murree Brewery section) is mostly comprised of limestone, shale and marls. The Formation is 105m, thin to medium bedded mudstone, light grey to reddish brown in color having black shale intercalations. A total of 17 samples were collected from the outcrop. An integrated biostratigraphic study including both Planktonic foraminifera and calcareous nannoplankton was carried out. The identified zones in the Murree brewery section are; a). Planktonic foraminiferal zones: *Biticinella breggiensis*, *Rotalipora tacinensis*, *Rotalipora appenninica*, *Rotalipora globotruncanoides*, *Rotalipora cushmani*, *Whiteinella archaeocretacea*, *Helvetoglobotruncana helvetica* and *Marginotruncana sigali* and b). calcareous nannoplankton zones are; *Prediscosphaera columnata* zone (CC8), *Eiffellithus turriseiffelii* zone (CC9), *Microrhabdulus decoratus* zone (CC10), *Quadrum gartneri* zone (CC11) and *Lucianorhabdus maleformis* zone (CC12). Based on these zones, Middle Albian to Late Turonian age ("Middle" Cretaceous) has been assigned to the Goru Formation. A black shale bed of 0.5m is present, possibly representing the OAE2 (Oceanic Anoxic Events). This bed is devoid of both planktic and benthic foraminifera. The TOC (Total Organic Carbon) value for this interval is 0.77 indicating fair source rock potential. A 2m red shale interval was also observed above this black shale unit, which biostratigraphically falls within Turonian based on planktonic foraminifera, therefore they may possibly be representing the Turonian Cretaceous Oceanic Red Beds (CORBs). Additionally, three microfacies including Radolarian-rich planktonic wackestone-packstone (MF-1), Calcisphere rich planktonic wackestone-packstone microfacies (MF-2) and Mixed-Planktonic foraminiferal wackestone -packstone microfacies (MF-3) were also identified. Based on these microfacies, a deep basin-outer ramp depositional setting has been assigned to the Goru Formation.

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DINOSAUR TRACKSITES FROM PORTUGAL, FOCUSED ON THE CARBONATED PLATFORM OF NORTH AND CENTRAL LUSITANIAN BASIN

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Keywords

dinosaur tracks, tracksite, Mesozoic, Lusitanian Basin, Portugal



Portugal has a rich Mesozoic geological and paleontological heritage. The existing dinosaur fossils (bones, eggs, and tracks) are from Middle Jurassic to Late Cretaceous ages, with most being from the Late Jurassic. Portuguese dinosaur tracks are known from dozens of places, being this country one of the richest in Europe, concerning this aspect. Nevertheless, the number of discovered dinosaur tracksites continues to increase. Here, part of the data collected for a master thesis is presented, for which ten dinosaur tracksites are studied: Vale de Ventos (Middle Jurassic), Praia do Pedrógão, Pedreira/Amoreira, Praia do Salgado, Serra de Mangues, Salir, Serra do Bouro, Sobral da Lagoa, Consolação (Upper Jurassic) and Praia do Magoito (Lower-Upper Cretaceous). These occur in sediments that correspond to the carbonated platform of north and central Lusitanian Basin. The tracks described show a high diversity of trackmakers, being sauropod, theropod, ornithopod and thyreophoran tracks among the findings. Praia do Salgado tracksite is Kimmeridgian in age (Alcobaça Formation). Here are seen three layers with dinosaur tracks: the lower layer contains poorly preserved sauropod tracks, an isolated possible thyreophoran track, and an isolated track of unknown affinity; the second layer has poorly preserved sauropod trackways; and the upper layer contains twelve trackways, eleven of them with tracks that are preserved as elongated dinosaur tracks with metatarsal impressions (some with hallux impression), and two isolated tracks of unknown affinity. These elongated tracks are an unique case in the country, in Kimmeridgian rocks, being the reason why this site is highlighted here.



HETEROSALENIA (ECHINODERMATA: ECHINOIDEA) FROM THE CRETACEOUS IN MEXICO

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Keywords

Echinoid, Tlayua Quarry, Tlaxiaco, Cretaceous, Jurassic

The genus *Heterosalenia* is a genus of echinoids in the family Saleniidae, which includes eight species ranging from the Middle Jurassic to the Upper Cretaceous, and is widely distributed in Saudi Arabia, Europe, Jamaica, and Mexico. This genus is characterized by the presence and position of a single suranal plate incorporated into the apical system. Some authors propose that the species within the genus can be separated into two groups: a Jurassic complex characterized by having ambulacral plating simple (unigeminate) adapically and a Cretaceous group which has trigeminate plating throughout; due to this difference, the Jurassic species should probably be separated into a new genus. In Mexico, *Heterosalenia* was known by the single report of *H. tlaxiacensis* from the Jurassic of Oaxaca state. Recently, a new specimen of the genus was collected in the Cretaceous Lagerstätten of the Tlayua Quarry, Puebla state. In the previous results presented in this work, we describe both *Heterosalenia* specimens from Mexico, their morphological, stratigraphic, and geographic relationship with the other species of the genus, with a special focus on the morphological discrepancies observed in *H. tlaxiacensis* compared with the other Jurassic species.





A FRESH NEW START: REVIEWING ECHINODERMS' FOSSIL RECORD IN THE MEXICAN NATIONAL PALEONTOLOGICAL COLLECTION

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Keywords

Echinodermata, Alpha diversity, Taxonomy, Cretaceous, Stratigraphy



The National Palaeontology Collection (National Autonomous University of Mexico) is the largest and the most important paleontological collection in the country due to the relevance of its specimens, curation, and service to the scientific community; but this collection requires a taxonomic update. In the present work, we present a revision of the nomenclature, taxonomy, and geological information (nomenclature, age, or unit) of all the echinoderms deposited into the Collection of Types of the National Collection of Palaeontology, which includes the type series and vouchers (catalogued as types). We verified the collection database with the specimens and their labels; the nomenclature and taxonomy of taxa were revised based on the most recent references; the geological information was derived from the original publications, updated, and complimented with more recently published data, in congruence with the Stratigraphic Lexicon of Mexico, published by the Mexican Geology Office. We found 385 records classified in 107 species: 19 Crinoidea, 1 Asteroidea, 1 Ophiuroidea, 84 Echinoidea, and 2 Holothuroidea. These records come from 69 localities, 52 assigned to 31 formations/units across the country, and 17 not yet assigned; 14 formations/units and 6 localities are reported for the Cretaceous. San Juan Raya (Puebla) is the most diverse formation with 12 species, and the Tlayúa Formation (Puebla), due to its excellent quality of preservation, is the only one with fossil ophiuroid and holothuroid species reported in Mexico. This review sets a new beginning of a series of publications focused on the analysis of the interpretation of the Mexican fossil echinoderms and applying novel approaches.



DINOSAUR FOOTPRINTS FROM THE UPPER JURASSIC CASTELLÓN FORMATION (TACURÚ GROUP), TARIJA DEPARTMENT, BOLIVIA

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Keywords

Jurassic, Footprints, Sauropods, medium-gauge, Palaeoecology

Bolivia has an outstanding vertebrate ichnological record from uppermost Cretaceous deposits, and besides, recently a Triassic locality was reported. To date, there has been no record of Jurassic dinosaur tracks. We report a site from the Entre Ríos area (Autonomous Department of Tarija) within the Upper Jurassic Castellón Formation, with a surface preserving about 350 dinosaur tracks, that extends the record of ichnological localities in Bolivia through the three periods of the Mesozoic Era. With the exception of five tridactyl tracks, all remaining footprints exhibit sauropod characteristics. Three medium-gauge, quadrupedal trackways composed of large pes impressions appear sub-parallel with one oriented in the opposite direction of movement. The best preserved trackway shows pes impressions of about 95 cm and 75 cm in mean length and width, respectively. The trackmaker was about 3.80 m tall at the hip and walked at a speed less than 5 km/h. Morphology and purported geologic age points to a non-neosauropod eusauropod trackmaker, even if a member of Titanosauriformes, like a somphospondyl producer, cannot be discarded. Some dozens of small-sized sauropod tracks, less than 15 cm in pes length, appear associated with two trackways. This inherent configuration constitutes a case study to test the main clues currently accepted to discriminate herd behaviour among trackmakers. It likely suggests that other clues must be considered to strengthen identification of synchronism among track formations, that together with the trackmaker identification, is a *conditio sine qua non* vertebrate ichnologists can confidently speculate about gregariousness.





VIRTUAL PALEOHISTOLOGY OF THE CONIFER *GEINITZIA REICHENBACHII* FROM THE CRETACEOUS OF WESTERN FRANCE

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Keywords

Geinitziaceae, permineralization, Cretaceous, synchrotron microtomography, Charentes



New prospecting conducted in the Aquitaine Basin (western France) over the last few years have led to the discovery of exquisitely preserved Cenomanian-Senonian plants inside silica-rich nodules. One of these plants is the conifer *Geinitzia reichenbachii* (Geinitz) Hollick & Jeffrey that was a common representative of the Cretaceous Laurasian floras. However, the inner structures of this taxon have never been investigated in detail and our knowledge of its paleoecology remains very limited. In order to observe both inner and hidden structures of specimens, we used a non-destructive imaging technique: propagation phase contrast X-ray synchrotron microtomography (PPC-SR μ CT). This approach revealed that leafy axes of *G. reichenbachii* are fossilized in three dimensions, preserving cuticle as well as all tissues. Epidermis, hypodermis, palisade parenchyma, spongy parenchyma, transfusion tracheids, and most of tissues of the vascular cylinder are clearly discernible. PPC-SR μ CT revealed numerous resin ducts sometimes filled by persisting amber. Additionally, surfaces of some leaves preserved drops and flows of fossil resin. *G. reichenbachii* was reported in a range of marginal-littoral paleoenvironments being adapted to withstand intense sunlight, and coastal areas exposed to hot temperatures coupled with salty sea wind and dry conditions. Because amber-bearing beds are abundant in the Aquitaine Basin and *Geinitzia* is one of the main components of the Cretaceous floras from this area, this raises the question of a possible role of *Geinitzia* in the production of the so called “Charentese amber”.



IN SITU SPORES OF MARATTIALEAN FERNS FROM THE LATE TRIASSIC OF AUSTRIA, SWITZERLAND, AND SWEDEN

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Keywords

Late Triassic, land plants, Marattiales, palynomorphs, sporomorphs

The Late Triassic successions of Europe have yielded, among other things, the rich and well-documented palaeofloras of Lunz am See in Austria, Neuwelt near Basel in Switzerland (both Carnian), and Billesholm in Sweden (Rhaetian). These include fertile fronds of marattialean ferns with conspicuous sporangia. In situ spores have been extracted from the sporangia and described already in the past, but the range of their morphological variations remained unexplored. Knowing these variations is important for the interpretation of dispersed spores and may provide insights into phylogenetic relationships and ecological influences. We studied the in situ spores of several marattialean fern species (*Asterotheca merianii*, *Mertensides bullatus*, *Danaeopsis* spp.) with a focus on intra- and interspecific variability. The spores of *A. merianii* and *M. bullatus* are very similar with an approximately circular amb, a monolete or pseudotrilete (triletoid) mark, and a smooth or microgranulate surface. They correspond to the dispersed genus *Leschikisporis*. Their sizes and the appearance of the monolete/pseudotrilete mark differ widely within individual plants, while the ornamentation of the spores varies mostly between individuals. The spores of *Danaeopsis* spp. are generally circular, trilete, and smooth-walled and correspond to *Todisporites*. The species partly differ in the average length of the rays of the mark and in the thickness of the spore walls. In samples with sufficient yield, abnormal spores that we interpret as abortive can be observed. These are smaller, denser, and often darker than regular spores. They occur with varying frequency in different individuals, which may indicate pathological conditions or natural hybridisation.





THE INCREASING DIVERSITY OF FOSSIL LUNGFISH. RECENT FINDINGS FROM THE LATE TRIASSIC OF GREENLAND AND POLAND

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Keywords

lungfish, Triassic, Greenland, Poland, phylogeny

Lungfish were common components of the Late Triassic freshwater faunas. These durophagous predators and omnivores are known from numerous paleontological sites in North America and Europe. Nevertheless, new findings still provide interesting data about their distribution and diversity in this period. Here, I present a description of the lungfish remains collected from the three Norian sites: Jameson Land (East Greenland), Kocury, and Poręba (Poland). Except the lungfish from the Jameson Land, they are represented only by isolated dental plates. Morphology of the fossils from the Jameson Land indicates that they belong to *Ptychoceratodus rectangulus*, previously known from the middle–upper Norian Löwenstein Formation (Germany). The dental plates from Poręba differ from them, due to the elongation of the first occlusal ridge. Nonetheless, they still exhibit similar ‘ptychoceratodontid-like’ structure. The elongation of the first ridge turns to extreme in the dental plate from Kocury locality, resembling *Metacerodus* spp. from the Cretaceous period. Differences between these populations can be explained as phylogenetic changes or spatial diversity of the lungfish during the Norian. Preliminary comparisons with previously known lungfish populations from the Triassic, and Jurassic suggest a persistence during the Late Triassic of at least two lineages of the ptychoceratodontid lungfish with significantly different dental plates morphology.





SPIDER WEB REMAINS IN CRETACEOUS AMBER

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Keywords

Araneae, strands, prey, artifacts



Spiders are renowned hunters that often efficiently capture prey using a web, the early evolution of which remains obscure as it rarely fossilizes. We report several Cretaceous spider web portions, not single silk strands, preserved in 110- and 105-million-year-old amber (Albian) from five Spanish localities. A partial spider web without prey from the Ariño amber (Teruel; ca. 110 Ma old) is among the oldest known, together with putative records in Hastings amber (UK). Four further web portions, one with prey stuck on them, are from the Peñacerrada I amber (Burgos). Two arthropod assemblages trapped in web portions are preserved in the San Just amber (Teruel); one of them corresponds to a previously published gummy orb web. One web portion without prey from the Arroyo de la Pascueta amber (Teruel) likely belonged to an orbicular spider web. Another web portion with a trapped hymenopteran from the El Soplao amber (Cantabria) provides the oldest known record of spider egg sacs. The silk of some of these web portions was elastic and bore sticky droplets, thus it was almost certainly produced by araneoid spiders. Other specimens show a simpler structure, namely as parallel silks virtually in a plane. Due to the resemblance between spider web portions and artifacts such as diverse organic structures and rare amber internal fractures, several criteria for correctly identifying spider webs preserved in amber are proposed. Spanish amber provides some of the oldest records of spider web portions and unambiguous direct evidence of insect entrapment in spider webs.

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GIANT SHADOWS IN LATE TRIASSIC SEAS: HISTOLOGICAL ANALYSIS ON PUTATIVE AND GENUINE GIANT ICHTHYOSAURS BONES

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Keywords

Bone histology, Ichthyosaurs, Rhaetian, Osteons, Aust Cliff, Bonenburg

Large to very large unidentified fossil bone shafts from European Late Triassic deposits have been puzzling the paleontological community since the second half of the 19th century. Over the centuries, differing hypothesis have been proposed regarding the nature of these fossils: amphibian, ichthyosaurian and dinosaurian/archosaurian. In this study a comprehensive histological description and comparative analysis was executed to test what we coin as the "*Huene-Lomax hypothesis*"; i.e. an ichthyosaurian affinities for large bone fragments of uncertain origin recovered from different Rhaetian fossil localities across Europe. Resulting histological comparison of the material in exam, found a common combination of unusual histological features (e.g. primary interstitial coarse fibers, high vascularization, preferential development of secondary osteons into primary osteons) shared with bonafide giant ichthyosaurs. Our study is therefore unable to find histological evidence to reject the *Huene-Lomax hypothesis*, further supporting the widespread presence of large sized ichthyosaurs at the Tr-Jr boundary. Finally, the aforementioned shared histological features, suggests the presence of a yet-to-discover biological or phylogenetic signal possibly related to the acquisition of large sizes in gravity-free aquatic environment in late Triassic ichthyosaurs.





EARLY ARCHOSAURIFORMS FROM THE LOWER TRIASSIC OF SOUTH AMERICA

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Keywords

Sanga do Cabral Formation, Proterosuchidae, Erythrosuchidae, Archosauromorpha

Archosauriform remains from the Lower Triassic are often related to the Proterosuchidae and the Erythrosuchidae, members of a grade that eventually will lead to the rise of the Archosauria. South American proterosuchid remains are rare, with a single specimen from the Permo-Triassic Buena Vista Formation (Uruguay). The Sanga do Cabral Supersequence, which includes the Brazilian Sanga do Cabral Formation, has a growing fossil record, thus far composed of procolophonids, temnospondyls, and early-branching archosauromorphs. In this work, new materials assigned to Proterosuchidae and Erythrosuchidae are presented, being the first conclusive records of these groups for the Lower Triassic of Brazil. The new specimens consist of isolate cervical and dorsal vertebrae, some with the typical morphology of proterosuchid-grade archosauriforms, while others display the unique anatomy of *Chasmatosuchus*. Besides morphological comparisons, our identification also relied on a cladistic assessment of the new material. Proterosuchid earliest occurrences come from the uppermost Permian of Russia. This clade is widely spread among well-explored Lower Triassic formations, flourishing during the recovery phase from the end-Permian mass extinction. The presence of non-archosaurian archosauriforms in southwestern Gondwana reinforces the rapid diversification of archosauromorphs during the Early Triassic, with communities already displaying a considerably high morphological diversification of continental predators. The Sanga do Cabral Formation fossil assemblage revealed to be an important piece in the understanding of how the first adaptive radiation of archosauromorphs occurred, posteriorly giving rise to some of the most diverse Mesozoic and Cenozoic clades: dinosaurs, birds and crocodiles.





PREDATOR-PREY INTERACTION TRACES PRESERVED IN A DINOSAUR BONE FROM THE UPPER CRETACEOUS BAURU BASIN, BRAZIL

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Keywords

Predation, Ichnology, Bauru Basin, Cretaceous



By studying trace fossils we can reconstruct ancient organism's behavior and interactions. Regarding organism's interactions, predation may be the most common ecological relationship. Among vertebrates, teeth are the most important physical structure to predatory life. Carnivorous animals use their teeth to capture prey and often these structures leave traces in the prey's tissues that may fossilize. In this work, we analyzed traces in a large sauropod rib from the Upper Cretaceous Bauru Basin, Brazil. The fossil was collected in the Ibirá municipality region, in the Adamantina Formation strata (Campanian). The Adamantina Formation is a large fluvial deposit with an abundant fossil vertebrate record, including theropod and sauropod dinosaurs, crocodyliforms, chelonians, lepidosaurs, mammals and fishes. The material is currently deposited at the Paleoecology and Paleoichnology Laboratory of the Federal University of São Carlos, Brazil. It consists of a partial rib of a large titanosaurian sauropod, with eight subparallel traces, identified as tooth traces. The traces consist of long and narrow grooves with serrated borders, indicating they were produced by a large organism with ziphodont dentition. The grooves were produced by teeth dragging against the bone surface. The size and pattern of the traces indicate they were produced either by an abelisaurid or megaraptoran. Several isolated abelisaurid teeth were found in the same site, as well as an isolated megaraptoran vertebra. This is the first feeding trace showing a sauropod-theropod interaction in this locality, adding to our knowledge of ecology and feeding behavior of Upper Cretaceous Bauru Basin theropods.



THE FIRST UNAMBIGUOUS NOASAURID (CERATOSAURIA, THEROPODA) FROM EUROPE (LATE JURASSIC OF PORTO DINHEIRO, LOURINHÃ, PORTUGAL)

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Keywords

Elaphrosaurinae, Noosauridae, Dinosauria, Lourinhã Formation, Kimmeridgian



The fossil record of non-avian theropods from Portugal mainly comes from the Kimmeridgian-Tithonian (Upper Jurassic) Lourinhã Formation of the Lisbon province, which currently includes Megalosauroidea, Allosauroidea, Coelurosauria, and Ceratosauria. Material from another theropod (ML 2050, Museum of Lourinhã), an adult with an estimated body length of one to two meters, was unearthed in the Upper Kimmeridgian Amoreira-Porto Novo Member at Porto Dinheiro beach (Lourinhã, Portugal). This specimen is one of the most complete theropods from Portugal and consists of semi-articulated postcranial elements, including dorsal and caudal vertebrae, dorsal ribs, gastralia, chevrons, scapulocoracoids, right humerus, pubic fragments, an almost complete left foot, and portions of the right femur, tibia and fibulae. A theropod-focused phylogenetic analysis performed on a published dataset of 87 taxa, coded for 1,781 morphological character states, placed ML 2050 among ceratosaur theropods. Another phylogenetic analysis focused on ceratosaur (31 taxa, 220 character states), further revealed that ML 2050 is an elaphrosaurine noosaurid closely related to *Elaphrosaurus bambergi* from the Kimmeridgian Tendaguru beds (Tanzania). This new specimen is currently the only definitive noosaurid from Europe and the third noosaurid taxon from the Northern Hemisphere, after *Limusaurus inextricabilis* and CCG 20011, both from the Oxfordian of China. Noosaurid ceratosaur encompasses slender small- to medium-bodied forms essentially with elongated necks and specialized jaws. Because noosaurids show one of the poorest records of dinosaurs in the world, and most come from the Late Jurassic and Cretaceous of Gondwana, ML 2050 provides pivotal information on the paleobiogeography, osteology and early history of Noosauridae.



CALCAREOUS NANNOPLANKTON EXTRACTION FROM THE UPPER TRIASSIC TO LOWER JURASSIC KARDOLINA SECTION, BELIANSKE TATRY, SLOVAKIA

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Keywords

Triassic-Jurassic boundary, calcareous nannoplankton, coccolith extraction

During the time of the Late Triassic, the formation of the Central Atlantic Magmatic Province propagated changes governed by relatively short-term pH oscillations which disturbed the global oceanic biogeochemical cycles. In the Belianske Tatry, Slovakia, the Kardolina section following the Triassic/Jurassic boundary contains a record of a rapid marine transgression which continues in the lower Jurassic. Extraction of coccoliths from the carbonate rocks is challenging due to the diagenetic formation of the epitaxial overprint. The aim of this research was to study early calcareous nannoplankton during the mass extinction event by a modified method of the coccolith extraction. The samples were crushed in mortar and dry-sieved over a 0.02 mm sieve. The crushed sediment was frozen and then boiled in water with added dispersion agent. We sieved the sample with a 0.0063 mm sieve and diluted to the uniform volume. We had assembled a multi-staged apparatus that enables a repeated wet vacuum powered acoustic microfiltration of particles smaller than 0.001 mm, and two decanting stages that end with the collection vessel. Finally, the calcareous nannoplankton was studied from the smear slides and under the SEM in 200 fields of view. Using this approach, we could identify that calcareous nannoplankton is mostly represented by recrystallized broad shielded coccoliths with narrow central areas, likely the individuals of the *Cyclagelosphaera* sp. Also commonly represented are genera of *Lotharingius* sp. and *Similiscutum* sp. We have also enriched the sample with the nannoliths belonging to *Prinsiosphaera triassica* (Jafar 1983), *Eoconusphaera zlambachensis* (Kristan-Tollman 1988).





MIDDLE JURASSIC (BATHONIAN) MARINE GASTROPODS FROM THE JAISALMER BASIN, WESTERN INDIA

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Keywords

Jaisalmer Formation, Fort Member, Systematic, Endemic species, Palaeobiogeography

Jaisalmer Basin, situated at the western margin of the Indian plate, is constituted by Mesozoic marine sediment deposits belonging to shallow to mid-shelf environments ranging from the Triassic to the Early Cretaceous. The basin is well-known as a storehouse of diverse Jurassic ammonite fauna. However, although gastropods are also present in the same sediments, this fossil group receives less attention than ammonites. Our recent studies have reported the biostratigraphic distribution of gastropods from the Lower to Upper Jurassic sediments of the Jaisalmer Basin. In the present study, we provide for the first time a detailed description of some of the marine gastropod faunas. The specimens were collected from the Bathonian horizon situated 1 km north of Jaisalmer city, included within an oolitic, sandy, bioturbated limestone belonging to the Fort Member (Early to Middle Bathonian) of the Jaisalmer Formation (Bajocian to Oxfordian). These newly reported specimens include five species belonging to four genera: *Ampullina* sp. 1; *Ampullina* sp. 2; *Pietteia* sp.; *Ptygmatis* sp.; and *Talantodiscus* sp. All these species are endemic to western India and represents the first occurrence of their respective genera in Jaisalmer. One species of each genus *Pietteia*, *Ampullina*, and *Talantodiscus* was also recovered from the neighboring Kutch Basin but they are younger in age. Three out of four genera were originated in the Tethyan Realm, the fourth one is from south-western Pacific Realm and migrated to the western India during the late Middle Jurassic (Bathonian). Our new finding therefore extends the spatio-temporal distribution of all these four genera.





A FIRST APPROACH TO THE DIVERSITY OF THE UPPER CRETACEOUS OOLOGICAL RECORD OF THE VILLALBA DE LA SIERRA FORMATION (CAMPANIAN-MAASTRICHTIAN, CENTRAL SPAIN)

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Keywords

dinosaurs, eggs, eggshells, Europe, Iberoamerica



Campanian-Maastrichtian outcrops from the Villalba de la Sierra Formation along the Cuenca and Guadalajara provinces (Spain) have yielded abundant oological remains. The Portilla and Zafra de Zánacara localities (Cuenca) have provided isolated eggshell fragments, while the Poyos site (Guadalajara) has provided a large amount of remains ranging from eggshell fragments to clutches with complete eggs. All the remains studied so far have a discretispherulitic eggshell morphology, from which three types can be differentiated mainly by their thickness and the traits of their external ornamentation (size, density and degree of tubercule fusion). Eggshell type I, identified in the complete eggs from Poyos locality and resembling specimens from Auca Mahuevo (Neuquén, Argentina) and Costa de la Coma (Lleida, Spain) attributed to Fusioolithidae, is ~1 mm thick, with partially fused units, tubocaniculated pore canals and dispersituberculated ornamentation. This type has an overall low density but irregularly distributed and spaced small tubercules with rare instances of tubercule fusion. Eggshell type II, recorded at Zafra de Zánacara and Poyos, has a slightly thicker eggshell with a dense ornamentation, resembling a compactituberculated morphotype but with small nodes that frequently fuse forming anastomosed structures. Eggshell type III, present at Portilla and Zafra de Zánacara, was previously described as *Megaloolithus siruguei* in Portilla and resembles specimens from several sites from northeastern Spain, southern France and Romania. These eggshells are ~2 mm thick with a tubocaniculated pore system and a relatively dense compactituberculated ornamentation, composed by large tubercules that rarely fuse.



SEDIMENTOLOGICAL AND MICROPALAEONTOLOGICAL RECORDS OF THE CENOMANIAN/CAMPANIAN UNCONFORMITY IN THE GEYIK DAĞI AREA, CENTRAL TAURIDES, TURKEY

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Keywords

benthic foraminifera, Cretaceous, unconformity, carbonate platform, Taurides

The Cretaceous shallow-marine carbonate platform sequences in the Geyik Dağı area, which is located at the western part of the Central Taurides, record a long-term emersion period of this platform part in the Tauride Carbonate Platform. The disconformable surface is evident, widespread, and noticeable in the field. The biostratigraphic studies based on benthic foraminifera and sedimentologic analyses allowed to determine that this major disconformity spans the Turonian to Santonian. The strata underlying the disconformable surface are composed of beige coloured, thick-bedded to massive limestones including rudist, gastropod, and large bivalve shells and laminated limestones. They are characterized by the presence of frequent emersion breccia layers. The limestones contain index Cenomanian species; *Biplanata peneropliformis*, *Pseudorhapydionina dubia*, *Biconcava bentori*, *Vidalina radoicicae*, *Coxites zubairensis*, *Merlingina cretacea*. The uppermost part of the Cenomanian strata is characterized by the occurrence of widespread microbial structures that is a marker horizon prior to the post-Cenomanian major disconformity. The erosional surface is also marked by karstic cavities which are filled with mostly red sediments. This disconformity surface is covered by breccias/conglomerates and carbonate sandstones with black pebbles, respectively. The overlying beige coloured, thick-bedded to massive rudistid limestones are characterized by the occurrence of *Siderolites* sp., *Lepidorbitoides* sp., *Orbitoides* sp., as well as long-ranging species; *Pseudocyclammia sphaeroidea*, *Moncharmontia apenninica*, *Scandonea samnitica*, *Dicyclina schlumbergeri*. The limestones overlying the disconformity can be assigned to the Campanian-Maastrichtian based on the ranges of *Siderolites*, *Lepidorbitoides*, *Orbitoides* assemblage. This major disconformity can be the result of the combination of regional tectonic and eustatic events.





THE FIRST RECORD OF THE *EOSIDERASTREA* LÖSER, 2016 (CNIDARIA, SCLERACTINIA) IN THE BRAZILIAN CRETACEOUS

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Keywords

Scleractinia, Cretaceous, Sergipe basin, Brazil



The coral family Siderastraeidae is an important group of extant marine invertebrates that occurs worldwide. Their early members date from late Valanginian and became diversified during the Early Cretaceous. *Eosiderastrea* is the most common and oldest genera, restricted to Cretaceous, with constant occurrence from the Valanginian to Santonian. This study deals with the first record of *Eosiderastrea* in the Brazilian Cretaceous. The distinction *Eosiderastrea* species are mainly based on the calicular symmetry and measures of septae (number and cycles) and walls (thickness). It was recognized in the Riachuelo Formation, Sergipe Basin, *E. harrisi* (Wells, 1932), characterized by massive, hemispherical and placoid colony with small, tall, asteroid, elongate and cylindrical coralites bounded by a thin synapticular wall. The calicular outline is circular to sub circular, thick and equal peripherally and depressed with smooth and little arched upper margins. Synapticulae fused or joined in the space between calices. Compact septa, lamellate, straight, sub equal and slightly elevated with granulated and non-confluent distal margins, arranged in eight systems and three cycles. Costae prominent, confluent and thicker in inner margins. Small columella and trabecular, fused to the septal inner edges. The genus diversified during Hauterivian to Albian, reaching highest diversity in Cenomanian; it is absent in the early Barremian, late Albian, Turonian and Coniacian, probably due to a lack of adequate sampling. *Eosiderastrea* is worldwide distributed, specially abundant in Tethys, except during the Albian when it was more abundant in the Western Atlantic.



BORING TRACES ON OYSTERS FROM THE LOWER CRETACEOUS (BERRIASIAN-LOWER VALANGINIAN) OF THE NEUQUÉN BASIN, WEST-CENTRAL ARGENTINA: FIRST RECORDS OF BORING POLYCHAETES, ACROTHORACIC CYRRIPEDS AND PREDATORY INTERACTIONS

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Keywords

biotic interactions, ichnology, *Oichnus*, predation, palaeoecology

A number of boring traces were recorded on oysters of early Berriasian-early Valanginian age (Vaca Muerta and Mulichinco formations). Particularly, six ichnogenera corresponding to two ethological classes were recorded on 188 valves (from a total of 2060) belonging to the genera *Aetostreon*, *Ceratostreon* and *Nanogyra*. Five domichnia ichnogenera were identified: closely spaced groupings of small circular borings, assignable to *Entobia* isp., and club-shaped borings, assignable to *Gastrochaenolites* isp., commonly recorded previously on oyster valves from the Neuquén Basin and associated with drilling sponges and bivalves, respectively. Galleries with more or less sinuous branches, assignable to *Maeandropolydora* isp. and *Caulostrepsis* isp., commonly associated with polychaete activity; and slit to comma-shaped borings, assignable to *Rogerella* isp., commonly associated with acrothoracic cirripeds activity, were recorded for the first time for this time interval of the Neuquén Basin. These borings point to the presence of organisms and palaeoecological interactions previously unknown for this horizon. In addition, both complete and incomplete circular individual borings were recorded, assignable to praedichnia *Oichnus* isp., usually associated with predation by gastropods or octopods. The frequency of drilling predation is low (*A. latissimum*: 0.028; *A. subsinuatum*: 0.037; *N. brevisulcata*: 0.032; *C. hilli*: 0.0063) and similar to that obtained for other Early Cretaceous examples. This type of predatory drill trace is particularly scarce in the Lower Cretaceous of South America. Hence, these records would help fill the so-called Mesozoic stage gap (Permian-Lower Cretaceous), in which these predatory interactions are rarely recorded, primarily related to little specialized and/or facultative predatory organisms.

This is contribution C-178 of IDEAN





THE AGE OF THE FIRST PULSE OF CONTINENTAL RIFTING ASSOCIATED WITH THE BREAKUP OF PANGAEA IN SOUTHWEST IBERIA: NEW PALYNOLOGICAL EVIDENCE

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Keywords

Upper Triassic, Variscan Unconformity, Palynology, Algarve Basin, Portugal



This work reports the first palynological age for the base strata of the Silves Sandstones of the Silves Group in the Algarve Basin, one of the Mesozoic sedimentary basins that border the Iberian Massif, located in Southern Portugal. The Silves Group is the oldest sedimentary unit of the Algarve Basin and was deposited unconformably over late Pennsylvanian turbidites of the Mira Formation, which were folded and faulted during the Variscan Orogeny. The Silves Group comprises a detrital red bed succession, representing the earliest sedimentation phase associated with initial rifting of Pangaea. The fossil record in the group is very scarce, macrofossils are rare, occurring predominantly in the top layers of this group, and do not accurately constrain the age of the entire group's deposition. However, the rare presence of the bivalves (*Eustheria* sp.), vertebrate remains of Phytosauria and a new *Metoposaurus* species, strongly suggests a Late Triassic age for this part of the stratigraphic succession. Samples recovered in an outcrop exposed in the central Algarve, of a grey mudstone bed positioned 2.5 m above the Variscan unconformity plane, yielded palynomorphs, that allowed the dating of the beginning of sedimentation in this basin to the early Carnian age (Late Triassic). The moderately well preserved and low diversity palynological assemblage comprises *Aulisporites astigmosus*, *Enzonalasporites densus*, *Ovalipollis pseudoalatus*, *Samaropollenites speciosus*, *Tulesporites briscoensis* and *Vallasporites ignacii*, indicative of a lower Carnian age.



ECHIOCERATIDAE (AMMONOIDEA) FROM THE OXYNOTUM CHRONOZONE (UPPER SINEMURIAN) IN THE NORTHERN IBERIAN PENINSULA

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Keywords

Ammonoids, Lower Jurassic, Portugal, Asturias, Cantabria

Echioceratidae is an ammonoid family, which originated in the early part of the Oxynotum Chronozone (upper Sinemurian, Lower Jurassic). Some of its species have been used to define biohorizons, which makes this family very useful for the correlation of Western Tethys basins. A total of 73 specimens have been studied. The material comes from four outcrops in different basins in Portugal and Spain (Iberian Peninsula): Pedra do Ouro (Lusitanian Basin), Camino (Basque-Cantabrian Basin), Peñarrubia and East Rodiles (Asturian Basin). These are some of the thickest sections of the Western Tethys. Morphologically, these specimens are evolute serpenticones ornamented with simple ribs. They are generally well preserved, although they are crushed due to compression and sedimentary post-burial compaction. Hence, ventral view is rarely visible. Suture lines have not been observed. Taxonomic analysis thus rests mostly on observations on the lateral views. There are three Echioceratidae genera described from the Oxynotum Chronozone (Simpsoni and Oxynotum subchronozones): *Gagaticeras*, *Palaeoechioceras* and the first appearance of *Plesechioceras* in Oxynotum Subchronozones, namely *P. platypleura* Dommergues, 1993. All of them are recorded in Asturian and Basque-Cantabrian outcrops. In the Pedra do Ouro section, only *Plesechioceras* has been found, as the Simpsoni Subchronozones was not documented from this outcrop yet. The taxonomical work, together with a precise stratigraphical documentation, will allow the identification of the biochronological succession of ammonoid species in detail. Furthermore, this will enable us to correlate the Iberian sections with those of other Western Tethys basins, and to test palaeobiogeographical hypotheses.





BLOOD VESSELS PROVIDED THE TEMPLATE FOR VERTEBRAL PNEUMATIZATION IN SAUROPOD DINOSAURS

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Keywords

arteries, pneumaticity, dinosaurs, sauropods, vertebrae



Pneumatization of the vertebral column was a key innovation in the evolution of gigantism in sauropod dinosaurs. In extant birds, pneumatic diverticula of the lungs and air sacs follow nerves and blood vessels as they develop. In extant amniotes, seven distinct groups of arteries and veins enter or exit the axial skeleton at distinctive locations: (1) lateral surface of the neural arch; (2) dorsal roof or lateral walls of the neural canal (neural arch elements); (3) ventral floor of the neural canal (centrum); (4) ventral surfaces of the transverse processes, or inner surfaces of the ribs; (5) lateral surfaces of the centrum; (6) ventral surface of the centrum; (7) medial surface of the haemal arch. In the skeletons of sauropods, pneumatic fossae and foramina have been documented at all seven of these locations, although not all locations may be pneumatized in a single individual, or even across a clade. The close correspondence suggests that sites of vertebral pneumatization in sauropods follow conserved patterns of vertebral vasculature in amniotes. The same relationship of pneumatic features to blood vessels probably existed in non-avian theropods and pterosaurs, but has not yet been documented. Despite sauropods having attained masses an order of magnitude greater than other terrestrial animals, this is evidence that they were built just like other animals, rather than being special magical monsters. Axial pneumaticity gives us a window on the fact that, at the most basic level, sauropod skeletons developed much like those of extant amniotes.



CHARACTERIZATION OF TRACE FOSSIL ON ECHINOIDS FROM THE JANDAÍRA FORMATION (UPPER CRETACEOUS), POTIGUAR BASIN, NORTHEASTERN BRAZIL

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Keywords

Echinodermata, Paleoecology, Ichnology, Ichnofossils



The study of the Potiguar Basin fossil echinoderms goes back less than 100 years. Since then, published investigations have focused mostly on the group's taxonomy. The current work aimed to identify, and classify trace fossils on irregular echinoid tests from the Jandaíra Formation, Potiguar Basin (Late Cretaceous), Northeastern Brazil. The specimens are repositied in the Department of Geology (DG) of the Federal University of Rio Grande do Norte (UFRN). There are currently three valid irregular echinoid genera in the Jandaíra Formation. Among the 220 irregular echinoids analyzed, 150 specimens were identified as *Petalobrissus* Lambert, 1916 and 70 as *Mecaster* Pomel, 1883, all collected in the surroundings of the Governador Dix-sept Rosado municipality in the state of Rio Grande do Norte. Ichnofossil analysis revealed linear, circular, and irregular traces, similar to the ones identified before in literature. Other trace morphotypes that do not fit into previous classifications were also found and are described here for the first time: zigzag, concave, and reticulate. Those traces morphotypes were also submitted to a preliminary Ichnotaxonomic identification, relating both classifications. All of the traces were probably produced by other invertebrate groups, such as annelids and mollusks, co-occurring in the same environment. This study thus provides new paleoecological information to the Jandaíra Formation and the first described ichnofossils on echinoid tests from the Potiguar Basin.



COPROLITES FROM THE MIDDLE TRIASSIC CHANG 7 IN THE ORDOS BASIN, CHINA: PALAEOBIOLOGICAL AND PALAEOECOLOGICAL IMPLICATIONS

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Keywords

Coprolites, palaeobiology, palaeoecology, the Late Ladinian, the Ordos Basin, China



Coprolites (fossilized faeces) are a valuable palaeobiological source for interpreting the diet, feeding behaviors and digestive physiology of the host animals, and thus for reconstructing predator-prey relationships and food chains within paleoecosystems. Here we investigated external morphology, internal structures, inclusions and geochemical composition of 53 vertebrate coprolites from organic-rich lacustrine sediments of the Chang 7, Yanchang Formation at Bawangzhuang section, Tongchuan City, Shaanxi Province, China. Morphologically, these coprolites were identified as 6 morphotypes of three groups, i.e. three heteropolar spiral forms, two amphipolar spiral forms and one non-spiral cylindrical form. Preserved inclusions (fish scales, bone fragments, teeth) indicate that producers of these coprolites were piscivorous animals. Comparing with previously studied coprolites, it may be stated that the all coprolites studied herein were inferred to be produced by fish: three heteropolar types of spiral coprolites derived from three different kinds of hybodonts; two amphipolar spiral coprolites came from coelacanth or sturgeons with simple spiral valves; non-spiral cylindrical coprolites may come from actinopterygians. Thus, biodiversity of the lacustrine paleoecosystem, in particular predators with higher-order trophic levels were greatly enriched. Furthermore, after the end-Permian mass extinction, a trophically multileveled lacustrine ecosystem with at least 5 trophic levels that is much more complex than previously thought was proposed to have occurred in the Late Ladinian (Late Middle Triassic) of the Ordos Basin.



A *KEICHOSAURUS*-BEARING REGURGITALITE FROM THE MIDDLE TRIASSIC XINGYI FAUNA, DINGXIAO OF XINGYI CITY, GUIZHOU, SOUTH CHINA

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Keywords

Regurgitalites, *Keichousaurus*, Xingyi Fauna, Middle Triassic, China

Regurgitalites are trace fossils that preserve valuable information on the diet and feeding behaviors of the producing animals, however such fossils are rarely reported. Herein, a compact mass of skeletal material from the Middle Triassic at Dingxiao section of Xingyi City, Guizhou, South China was well prepared and multi-analysed. Extensive disarticulation and sharp edge fracture of the bone inclusions and the absence of a phosphatic matrix revealed by chemical analysis supported that the bone mass is a regurgitalite rather than a coprolite. Virtual reconstructions of CT-scan slices indicated that the specimen contains abundant vertebrate bones and teeth, up to 80 percent in volume, and their anatomical characters support that they exclusively belong to the small-sized marine reptile *Keichousaurus*. Thus, associated with the vertebrate fossil taxa previously found in the host strata, a vomiting behaviour is tentatively proposed for the near-shore sauropterygians such as the nothosaurians *Nothosaurus* and *Lariosaurus*.



Cenozoic



General Session



NEW EVIDENCE OF THE PRESENCE OF COLD ADAPTED FAUNAS IN THE SPANISH NORTH PLATEAU

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Keywords

Spanish North Plateau, Upper Pleistocene, *Coelodonta antiquitatis*, La Mina



The site of la Mina is one of the three fossiliferous deposits located in the middle course of the Arlanza river, close to the village of Hortigüela (Burgos, Spain). The first field work intervention took place in 2006 with the excavation of four archaeological pits that suggested the presence of a mixed/rework deposit. Within this deposit, three different fossiliferous units, not stratigraphic levels *sensu stricto*, have been established on the basis of the mineralization, water abrasion and the presence of cut and bite marks. The lower unit has provided both lithic and fossil Palaeolithic remains, suggesting a Pleistocene occupation. A dating, by amino acid racemization, places the site at 52,5 ka BP. Among the 19 identified vertebrate taxa, seven rhinoceros dental remains have been recovered. Due to the state of preservation, only two of them can be analyzed in details: 1 P3 and 1 M1. Morphological characters such as open and deep synclines in buccal view, V-shaped anterior and posterior lingual valleys in lingual view, and the absence of mesial and distal cingules, allow us to assign the specimens to the woolly rhinoceros, *Coelodonta antiquitatis*. The measurements of the studied teeth are similar to those of other Eurasian woolly rhinos; they are smaller than those of *Stephanorhinus kirchbergensis* and larger than those of *S. hemitoechus*. La Mina provides a new record of the cold-adapted faunas in the Iberian Peninsula, in particular in the Spanish North Plateau, and provides new insights of the distribution of *C. antiquitatis* during the Late Pleistocene.



RARE FOSSIL AMPHIPODS FROM THE NEOGENE OF SHANXI, CHINA

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Keywords

Exceptional preservation, Gammaroidea, collective group, Xiaobai Formation, China

Amphipods are extremely diverse malacostracan crustaceans that have conquered many environments from oceanic abysses to the terrestrial realm. Despite their impressive modern diversity and abundance, they are particularly rare in the fossil record. Herein, we report the recent discovery of *Gammaroidorum yooling* Wei et al. 2021 from the Upper Neogene of Xiaobai Formation near Pandao village, Shanxi, China. Due to the limitation of the preservation, namely the non-preservation of setae, we were not able to assign the material to the genus level, so we used the collective group *Gammaroidorum* Jarzembowski, Chény, Fang & Wang, 2020. Although there are still doubts about the precise placement of this new species within amphipods, these fossils are important since they represent the first known fossil occurrence of an amphipod from China. Besides, these fossils have an unusual preservation, being almost transparent in most cases, and being most easily seen by reflected light on the fossil.





COMPOSITION AND DIVERSITY-ABUNDANCE PATTERN OF MOLLUSCS REVEAL HETEROGENEITY IN MICRO-HABITATS IN A LINEAR COASTAL SETTING FROM THE LOWER EOCENE OF WESTERN INDIA

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Keywords

Palaeoecology, Mollusc, Eocene, Shell beds, Transgression

A ~40 m. thick succession of the lower Eocene Cambay Shale of Mangrol mine, Cambay Basin, Gujarat, India, records vertical and lateral overlaps of different sedimentary environments, related to the linear coast. The Cambay Shale mainly comprises lignite seams and shales intercalated with mollusc-bearing shell beds. Abundant fossilized leaves, wood, amber, and terrestrial vertebrates were reported from these rocks. This study attempts to understand the palaeoecology of this basin, using the mollusc fossil assemblage as proxy. A less diverse and highly abundant fauna characterizes the molluscan shell beds. Only a few species belonging to the bivalve families Corbulidae, Carditidae, and Ostreidae, and the gastropod families Cerithioidae, Buccinidae and Rissoidae are very abundant. Ecological affinities of the fossil and living representatives of the taxa from the Mangrol mine have been studied. This study revealed the presence of a mosaic of environments, and affiliation of the faunal components to narrow ecological niches like mangrove marsh, mudflats of estuaries and lagoons, etc. An association of freshwater gastropod like *Melanoides*, brackish water molluscs like *Potamides*, *Batillaria*, *Faunus*, *Pseudobellardia*, *Rissoina*, *Caestocorbula*, *Ostrea*, anomiids, and several typical littoral zone gastropods like naticids, makes up the mosaic. The life habits and feeding preferences of the molluscs also exhibit some variety. The mollusc composition, their diversity-abundance pattern, and the cyclic nature of the occurrence of lignite, shale and shell beds are representative of a mud-dominated sheltered coastal environment that experienced fluctuations in nutrient availability, salinity and terrigenous influx, and multiple marine incursion events in response to repeated marine transgressions.





EVIDENCE OF TRACE FOSSILS FROM THE LANGHIAN (MIDDLE MIOCENE) SHALLOW MARINE DEPOSITS OF NORTHEASTERN ALGERIA

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Keywords

Ichtnology, Langhian, Palaeoenvironment, Shallow marine, Algeria

Trace fossils are poorly studied in northeastern Algeria. The main goal of this work is to provide the first evidence of ichnological data from the Ouenza area (Tebessa Basin). The Lower Langhian (Middle Miocene) of the Ouenza area is characterized by 140 m-thick marlstones and sandstones showing epichnial and endichnial, sub-horizontally to sub-vertically burrows. The recorded ichnotaxa from these deposits belong to cf. *Archaeonassa* isp., *Arenicolites* isp., *Diplocraterion* isp., *Helminthopsis* isp., *Palaeophycus tubularis*, *Skolithos* cf. *linearis*, cf. *Taenidium* isp., and *Thalassinoides* isp. This ichnoassemblage is dominated by post-depositional domichnial components (e.g., *Thalassinoides* isp.). The other ethological categories correspond to repichnia, praedichnia, and pascichnia. These trace fossils are produced mainly by worms (especially polychaetes and phoronids), crustaceans and other arthropods, and gastropods. They indicate deposition within a shallow marine environment with well-oxygenated water above the sea floor, under moderate- to high-energy conditions, with occasional storm events, characteristic of the *Skolithos* and the proximal *Cruziana* ichnofacies. The occurrence of vertical structures indicates opportunistic colonization of the storm-dominated sandstones (post-event community); whereas, the presence of horizontal structures is related to fair weather conditions. Furthermore, the studied ichnoassemblage together with the palaeontological data (such as the recorded bivalves) suggest adequate food resources both in substrate and water column under normal salinity conditions.





DATA SET OF POLLEN AND NON-POLLEN PALYNOMORPHS PRESERVED IN BALTIC AMBER FROM MAIG COLLECTION

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Keywords

Paleopalynology, paleoecology, Eocene, Baltic amber, inclusions



The Baltic amber, Eocene fossil resin, is well known for the preservation of a wide spectrum of the macroscopic inclusions of plants and animals. Thousands of extinct species were described based on those inclusions, yet still, not resulted in a clear view into the “amber forest”. The taphonomical and geological history of that fossil resin includes numerous redepositions which leads to the complicated taphonomical relations between inclusions. These fossils were segregated in space and time and may not represent similar biocenoses. In this study, we used selected material from the Collection of the Museum of Amber Inclusions University of Gdańsk (**MAIG**). Those 28 amber pieces were cut into slices, grind and polished to the form of amber slides with a thickness of 1 mm and thoroughly examined under light microscopes. The result of this study is a dataset of palynomorphs analysed for each sample separately. Different types of pollen grains and fungal spores were found. Moreover, two different types of palynomorph taphocenoses were recognised. One, comprising entrapped inclusions, representing biocenosis of living, resinous tree and palynomorphs and hyphae of fungus that intertwined already formed, probably “non-active” resin trap. These data-sets of palynomorphs taxa and their taphonomical interpretations may lead to more accurate reconstructions of biocenoses preserved in the samples as well as to the proposal of reconstruction of environments and conditions at times of their formation.



A PRELIMINARY TAPHONOMIC ASSESSMENT OF THE SMALL-VERTEBRATE ASSEMBLAGE FROM CALLAO CAVE, CAGAYAN, PHILIPPINES (~67 KY BP TO ~3.6 KY CAL. BP)

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Keywords

zoarchaeology, small vertebrates, taphonomy, Callao Cave, Philippines

The Callao Cave in northern Luzon, Philippines, was occupied intermittently from the Late Pleistocene (~67 ky BP and ~28 ky cal. BP) until the Neolithic (~3.6 ky cal. BP). It is an important site for understanding human evolution as remains of the extinct *Homo luzonensis* were discovered in its earliest levels. It also holds the earliest known fossils of endemic Philippine murids — *Apomys microdon* and three extinct giant cloud rat species (Muridae: Murinae: Phloeomyini): *Batomys cagayanensis*, *Carpomys dakal*, and *Crateromys ballik* — highlighting the potential of the site for assessing past biodiversity in the Philippines, especially of small mammals. This ongoing work seeks to reconstruct the taphonomic history of the assemblage as a prerequisite to more accurate interpretations of biodiversity trends, palaeoecological conditions, and anthropization through time. An intensive wet-sieving recovery method for microvertebrates was used, yielding more than 70,000 remains, of which 20% (N=14,829) were identified as the following taxonomic groups: mammals (chiropters, murids, and soricids), reptiles, amphibians, fish, and birds. Preliminary observations point to a progressive increase in mammalian remains from older to younger chronostratigraphic units, while the opposite was observed for reptiles and amphibians. Digestion was observed to affect 15% (N=21) of isolated murid molars, while other taxa have yet to be examined for this process. Some cave-dwelling bat taxa have also been identified, and the possibility of in situ deaths must be assessed. Further analyses of surface modifications and anatomical representation will be undertaken to recognize and assess the effects of biases introduced by different taphonomic processes.





OVERVIEW OF THE MURINAE FOSSILS IN THE CANARY ISLANDS

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Keywords

Murinae Canary Islands, *Canariomys*, *Malpaisomys*



Macaronesia is a region formed by 5 archipelagos of volcanic origin (the Azores, Madeira, the Savage Islands, the Canary Islands and Cape Verde), located in the mid-Atlantic, and by a small region to the northwest of the African continent. They are assigned to a single biodiversity hotspot, the Mediterranean Basin. Murids are the most abundant family of rodents, but in this region, they are scarce, both in current and fossil species. The most common murids in this region are the black and brown rats, and the house mouse, which have been introduced by humans. The Canary archipelago stands out, probably due to its proximity to the African continent, for being the only one in which we find extinct endemic species of this group. Three species have been described, *Malpaisomys insularis*, *Canariomys bravoii* and *C. tamarani*. Rats of the genus *Canariomys* have survived until the early Holocene, on the islands of Tenerife and Gran Canaria, respectively. The rats experienced a phenomenon of insular gigantism, reaching 30cm in length and weighing up to 1Kg. *M. insularis*, also known as lava mouse, was located on the islands of Lanzarote, Fuerteventura, and La Graciosa, also in late Pleistocene and early Holocene periods. The extinction of these species dates from around the fourteenth century, promoted by the predation of rats by the aborigines and other animals introduced, or the introduction of species that competed with them. In this work we will overview the murine collections deposited at the University of La Laguna in Tenerife.



BATS FROM PLIO-PLEISTOCENE KARSTIC SITES FROM ANDALUSIA (SPAIN)

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Keywords

Chiroptera, Iberian Peninsula, Pliocene, Pleistocene, paleobiodiversity

Bats (Chiroptera; Mammalia) are the second most diverse mammalian order nowadays, but their fossil record is relatively scarce worldwide, being largely associated with karstic fissures. Here we present new data obtained after studying the fossil bat remains found in several Andalusian (Spain) karst deposits (Moreda, Gilena, Estepa, Bélmez and Cueva de La Fosforita) that were excavated between 1986–1988 and remained unpublished. In all, fourteen fossiliferous levels of Plio-Pleistocene age are presented coming from these deposits, located in three Spanish provinces (Sevilla, Granada and Córdoba). The fissure of Gilena is the oldest, with an age established between late Villanyian to Biharian (MN17–18); Moreda has an age between late Ruscinian to early Villanyian (MN16); Estepa, belongs to the early Villanyian (MN16) and the sites of Bélmez, Cueva de la Fosforita, and Rambla Seca belong to the late Ruscinian (MN15). The fossil taxa identified comprise three different genera. *Rhinolophus* is represented by two species (*Rhinolophus* sp., and *Rhinolophus* cf. *lemanensis*), the first of which was found in Estepa and Moreda, and the latter in Cueva de La Fosforita. The genus *Myotis* is also represented by two species, both close to extant species (*Myotis* aff. *blythii*, and *Myotis* aff. *myotis*), the first in Cueva de La Fosforita, and the second in Gilena. Finally, *Rhinopoma hardwickii* has been identified in two sites, Bélmez and Cueva de la Fosforita and represents a genus and a family no longer present in Europe. These remains are the first found in the Iberian Peninsula of this genus. With this study, which is the first that deals with Late Neogene fossil bats from Andalusia, new data are given for a period with few bat records in the whole of the Iberian Peninsula.





MORPHOLOGICAL EVOLUTION OF THE CAVE BEAR (*URSUS SPELAEUS*) LOWER MOLARS: COORDINATED SIZE AND SHAPE CHANGES THROUGH THE SCLADINA CAVE CHRONOSTRATIGRAPHY

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Keywords

Geometric Morphometrics, Habitat Adaptation, Molars, Phenotypic Trajectory Analysis, Quaternary

Out of all extinct Quaternary megafaunal mammals, the cave bear *Ursus spelaeus* is among the most abundant in the fossil record. This species has been found to exhibit morphological adaptations to a variety of environments over both spatial and temporal scales. Here, we employ geometric morphometrics and phenotypic trajectory analysis to explore temporal morphological variation across the entire lower molar tooth row of *Ursus spelaeus* from three different units (4A < 130±20kya, MIS 5; 3 =MIS 4 and/or MIS 5; 1A ~38-40 kya, MIS 3) of the chronostratigraphic infilling of Scladina Cave, Belgium. We found that each molar type increases in size temporally though stratigraphic units from Marine Isotope Stage (MIS) 5 to MIS 3, with cusp position varying temporally in relation to a larger talonid grinding platform in MIS 3. Phenotypic trajectory analyses further shows parallel evolutionary trajectories in the shape changes of the first and second molar, but not in the third molar. These shape changes relate to a relative enlargement of the molar grinding platform, with the divergent pattern of M3 suggesting lower constraints and higher plasticity on this tooth leading to greater responses to environmental changes. The need to cope with harder fibrous plant material present in the palaeoenvironment potentially constrained morphological evolution of the cave bear until its disappearance throughout Europe.





A *NEREITES* ICHNOFACIES FROM THE LOWER MIOCENE OF ALGERIA

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Keywords

Nereites ichnofacies, Deep-sea, Turbidites, Lower Miocene, Algeria

Twenty-seven (27) ichnospecies, belonging to eighteen (18) ichnogenera were evidenced from the lower Miocene Tiaret Marl Formation in northwestern Algeria. This formation is attributed to a deep-sea fan system, characterized by the presence of graphoglyptid trace fossils which characterize the turbidite successions and the *Nereites* ichnofacies. The recorded graphoglyptids from this formation include *Cosmorhapse*, *Desmograpton*, *Helminthorhapse*, cf. *Megagrapton*, *Paleodictyon*, and *Urohelminthoida*. The other non-graphoglyptid traces are belonging to *Cardioichnus*, cf. *Chondrites*, *Gordia*, *Helminthopsis*, *Nereites*, *Ophiomorpha*, *Palaeophycus*, *Planolites*, *Scolicia*, *Tisoo*, *Tubulichnium*, and *Zoophycos*. The most diversified trace fossil within this ichnoassemblage is *Paleodictyon* with five ichnospecies: *P. majus*, *P. maximum*, *P. minimum*, *P. miocenicum*, and *P. strozzii*. The recorded graphoglyptids from the Tiaret Marl Formation are exclusively pre-depositional agrichnial trace fossils, preserved as hypichnia, and produced mainly by vermiform organisms. The non-graphoglyptid traces are preserved as epichnia, hypichnia or endichnia, and are dominated by pre- and post-depositional fodinichnial, pascichnial, cubichnial, domichnial and repichnial behaviors. The studied ichnoassemblage is referred to a succession of the *Nereites-Paleodictyon-Ophiomorpha rudis* ichnosubfacies, clearly suggesting a palaeobathymetric trend from lower to upper fan. Also, the comparison between the Tiaret Marl Formation and other flysch deposits indicates the presence of a considerable correspondence between the different peri-Mediterranean ichnoassemblages and those of the north Algerian Cenozoic turbiditic systems.





A PEACOCK MITE FROM THE MAIG COLLECTION – A TUCKERELLIDAE INCLUSION IN BALTIC AMBER

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Keywords

Tuckerellidae, fossil mites, inclusions, Baltic amber, fossil resins

The Acariformes mites are the most common group of arachnids preserved as inclusions in fossil resins. Among them, we can find rare groups, like the peacock mites: representatives of the family Tuckerellidae (Prostigmata). The fossil record of this family contains two species *Tuckerella fossilibus* and *Tuckerella weiterschani* described based on only three known specimens. Each of these three inclusions were found in a different fossil resin: *T. fossilibus* in Rovno (Eocene) and Bitterfeld amber (Eocene or Miocene?), and *T. weiterschani* in Baltic amber (Eocene). Another find of a tuckerellid mite from Baltic amber is presented in this work – a specimen from the Collection of Museum of Amber Inclusion in Gdańsk (MAIG). It differs from the previously described taxa in the chaetotaxy of the idiosomal setal set (V1, V2, c, d, e, f) and opisthosomal row h1 - h8. However, its systematic position requires verification. Misidentification of the life stage (even with optimal preservation of inclusions identified) might mislead the final, taxonomical interpretation. This case shows how important for future studies are the findings of rare taxa. Fossils of Tuckerellidae can give clues to the issues on interpretation of the Bitterfeld amber age and shed some light on the taphocoenosis of the so-called “amber forests”.





AVIAN AND MAMMAL FOOTPRINTS FROM A NEOGENE PERI-MARINE WETLAND (POZO SALADO, RÍO NEGRO PROVINCE, ARGENTINA)

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Keywords

Vertebrate tracks, Río Negro Formation, *Gruipeda*, *Porcellusignum*, Neogene

The vertebrate ichnofauna from the Neogene Río Negro Formation is represented by mammal and avian footprints reported from different localities of the coast of northern Patagonia and Pampean region. A new track-bearing locality in the unit was recently found close to Pozo Salado, on the tide-dominated Atlantic shoreline of the Punta Mejillón area (Río Negro province, Argentina). The trackmakers were crossing an emergent, fine- to medium-grained, sandy flat of a peri-marine wetland. Some tracks present folds in the surface related with microbially induced sedimentary structures, playing a significant role in track preservation. As suggested by extramorphological track features, the surface and subsurface remained compliant to producers of different size-classes, probably during a relatively long time of exposure and trampling. The tracksite presents abundant footprints but relatively low ichno-diversity. Avian tracks are the most common, although caviomorph and megatherian tracks have also been identified. Few footprints display clear morphology and were classified as *Gruipeda* cf. *maxima* and cf. *Porcellusignum* isp., two ichnotaxa classically related to gruiform/ciconiiform birds and hydrochoerid rodents, respectively. Shorebird and waterbird tracks are a component of the shorebird ichnosubfacies within the *Scoyenia* ichnofacies, classically accompanying a prominent suite of invertebrate traces like *Taenidium*, *Skolithos* and *Helminthoidichnites*, apparently lacking in the studied ichnoassociation. The new finding enriches the vertebrate track record from the Atlantic coast of the Río Negro province and invites to further discuss the reliability and significance of this type of tracks in refine palaeoenvironmental, palaeoecological and ichnofacial reconstructions.

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TOWARDS A PALAEOECOLOGICAL RECONSTRUCTION OF THE MIOCENE VERTEBRATE FAUNAS OF THE PISCO FORMATION (PERU): GLIMPSES INTO THE PAST OF THE HUMBOLDT CURRENT ECOSYSTEM

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Keywords

Cetacea, East Pisco Basin, Elasmobranchi, Fossil-Lagerstätte, Peru–Chile Current

Flowing northwards along the western coast of South America, the Humboldt Current hosts extremely high levels of biological productivity all-year-round. With the aim of developing a deep-time investigation of this unique ecological setting, we provide the first synoptic overview of the palaeoecological habits of the fossil marine vertebrates of the Pisco Formation, a shallow-marine sedimentary unit of southern Peru that is renowned worldwide for its abundant and well-preserved Miocene fossil content. By building upon palaeontological data gathered on hundreds of fossils (including cetaceans, pinnipeds, seabirds, turtles, crocodiles, and bony and cartilaginous fishes), palaeoenvironmental conditions and palaeoecological relationships are thus reconstructed for the three sequences that comprise the Pisco Formation and their marine vertebrate assemblages. Some aspects of the Pisco palaeoecosystems are then investigated in detail, and similarities and differences are highlighted with respect to the present-day Humboldt Current Ecosystem and other extant Eastern Boundary upwelling systems. Like today, the southern Peruvian shelfal ecosystems witnessed by the Miocene Pisco strata were based on sardines, which are locally known from several fossils (including stomach contents). At the same time, they notably differed from their modern equivalent in being dominated by extremely large-bodied apex predators such as *Livyatan melvillei* and *Carcharocles megalodon*.

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AFRICAN CENOZOIC METATHERIANS: A REVIEW

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Keywords

Mammalia, Africa, Metatheria, taxonomy, palaeobiogeography

The remains of the African metatherians (Mammalia, Theria) are scanty, restricted in time (Eocene–Miocene), and its taxonomy is still being debated. A new review of all African metatherians, or supposed metatherians, known up to now, allowed us to recognise three undoubtedly metatherian taxa: *Kasserinotherium tunisiense* (Peradectoidea?), from the early Eocene of Tunisia; *Peratherium africanum* (Herpetotheriidae), from the early Oligocene of Egypt and Oman, and an indeterminate Herpetotheriidae? from the early Miocene of Uganda. Regarding other materials once referred to the Metatheria, we reassign them to: (1) The Metatheria indet. from the Late Cretaceous of Madagascar as a Zhelestidae indet.; *Garatherium mahboubii* from Late early Eocene of Algeria as an adapisoriculid; *Ghamidtherium dimaiensis* from Late Eocene of Egypt as a probably Eulipotyphla; the remaining specimens are referred to two different species of Chiroptera. The arrival of the Herpetotheriids in Afro-Arabia was probably through Europe in one or more dispersal waves since the early Oligocene. By contrast, *Kasserinotherium*, suggests a Paleocene arrival from South America, because of the similarities it has with South American and Australian taxa. This last migration probably took place through a filter corridor such as the Rio Grande Rise–Walvis Ridge system, and it may also explain the enigmatic presence of polydolopimorphian metatherians in the Paleogene of Turkey. Another more radical hypothesis is that all European Marsupialiformes have an origin in South America, and dispersed via Africa by the Paleocene–earliest Eocene.





THE GENUS *LIGERIMYS* (RODENTIA; EOMYIDAE) FROM THE RIBESALBES-ALCORA BASIN (EARLY MIOCENE, SPAIN)

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Keywords

Rodents, Biostratigraphy, Aragonian, MN4, biochronology

The material studied in this paper were recovered in the Ribesalbes-Alcòra Basin, specifically near the village of Araia d'Alcòra (Castelló, Spain) in the eastern Iberian Peninsula. Fossil mammals have been found in this basin in seven sections where a total of forty-five different sites have been located. The material described here comes from fossiliferous deposits found in the Campisano ravine of the Araia/Mas d'Antolino outcrop. An early Aragonian age (MN4, early Miocene) has been inferred based on the presence of rodent taxa such as *Megacricetodon*, *Democricetodon* and *Ligerimys*. This rodent assemblage has allows for a more precise correlation of these sites to local biozone C of the geographically close Calatayud-Montalbán Basin (Aragon, east-central Spain). Two species of the family Eomyidae have been identified, *Ligerimys florancei* and *Ligerimys ellipticus*, the latter being one of the most abundant mammals in the Ribesalbes-Alcòra Basin assemblages. Based on the species of *Ligerimys* present, we have been able to divide the record of the Campisano Ravine section into two long local biozones, an older one with the presence of *L. florancei* and a more modern one with *L. ellipticus*. These two species have not been found together on any site. In addition, each local biozone is divided into two smaller sub-biozones, owing to the abundance of each species. Furthermore, we compare and correlate the studied assemblages with other localities from different Iberian basins based on the species of *Ligerimys* present and their relative abundance.





STABLE ISOTOPES ON OSTRACODS INDICATE MARINE INCURSIONS IN THE DACIAN BASIN DURING UPPER MIOCENE AND PLIOCENE

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Keywords

Ostracoda, Stable Isotopes, Upper Miocene, Pliocene, Dacian Basin

We present stable isotopes ($\delta^{18}\text{O}$, $\delta^{13}\text{C}$) data from Dacian Basin samples spanning the latest Miocene to Pliocene from Slănicul de Buzău Section, Romania. To minimize the effects of species dependent biosynthetic fractionation on the $\delta^{18}\text{O}$, $\delta^{13}\text{C}$ values we target single specimen measurements, preferentially on *Cyprideis* sp., and *Tyrrhenocythere* sp. The $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ records show both large variations, in order of 13‰ over the sampled 3 Myr interval. These values must indicate important changes in the Dacian Basin water properties. There are two intervals recording much heavier $\delta^{18}\text{O}$ values when compared to the rest of the record. One interval is at ~5.4 Ma and coincides with the “Bosphorion Flood”. We interpret this interval as a time when an influx of saltier, possibly also warmer water, affected the Dacian Basin. Because the second interval with heavier $\delta^{18}\text{O}$ values, at around 3.4–3.3 Ma coincides with the Mid Pliocene Warm period, we speculated that an influx of warmer, possibly also saltier water, affected the Dacian Basin. The $\delta^{13}\text{C}$ values do not follow the trends of the $\delta^{18}\text{O}$. At 5.5 Ma, during the “Bosphorion Flood”, the heaviest $\delta^{13}\text{C}$ values are recorded at +2‰. After this interval, until the end of our record at 3.3 Ma, there is a consistent decrease in the $\delta^{13}\text{C}$ values, although with some fluctuations. We interpret these $\delta^{13}\text{C}$ decreases as a steady change in the environmental conditions of the Dacian Basin, from more eutrophic at 5.5 Ma to more oligotrophic towards the 3.3 Ma.





A NEW FOSSIL RODENT ASSEMBLAGE FROM THE SOLIMÕES FORMATION (LATE MIOCENE), ACRE, BRAZIL

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Keywords

Rodentia, Caviomorpha, Neogene, Acre region, Brazilian Amazon

Caviomorpha is a clade of South American hystricognath clade rodents with great taxonomic and phenotypic diversity. Their stratigraphic distribution ranges from the middle Eocene to the present times. In the Solimões Formation, northwest Brazil, a rich Neogene fossil record has been documented over the last years. Here, we report preliminary data about a new fossiliferous assemblage from the Solimões Formation recovered in recent fieldwork in the Envira River, State of Acre. The specimens were collected in 2010 and 2019 from Neogene sedimentary strata exposed in this river and are housed at the paleontological collection of the Universidade Federal do Acre, Campus Floresta, Cruzeiro do Sul (UFAC-CS). The fossils were found using screen-washing with an aqueous hydrogen peroxide solution and subsequent fossil-handpicking under stereomicroscope. After these procedures, the specimens are being scanned with a micro-CT. The preliminary analysis identified a mandible with premolar and molars and many isolated molariform teeth. Our results suggest the presence of Octodontoidea (including *Acarechimys*-like), Erethizontoidea, Chinchilloidea (*Scleromys*-like dinomyids, Potamarchinae and Neopiblemidae), and Cavoidea (Hydrochoerinae). Based on previous records of Solimões Formation, the presence of potamarchines, neopiblemids, and hydrochoerines is in accordance with a Late Miocene age for these strata (typical Acre fauna). Although fossils have not yet been identified at a less inclusive level, it is possible to observe that this is the most diverse assemblage of Neogene rodents from the Brazilian Amazon.





METHODOLOGY AND PRELIMINARY RESULTS OF THE EXTERNAL APPEARANCE RECONSTRUCTION OF THE MIDDLE MIOCENE CERVID *HETEROPROX MORALESI* AZANZA, 2000

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Keywords

Cervidae, Mammalia, Phylogeny, Colour patterns, Paleoart

Methodologies that analyse the coloration and external appearance of extant species are very useful tools for one of the biggest problems in the paleoartistic reconstructions of extinct fauna: the choice of color patterns. Earlier works have been done using this methodology, applied for example in the Miocene bovid *Tethytragus*, proving that this methodology has high potential. This paper shows a proposal of the reconstruction of external appearance of *Heteroprox moralesi* Azanza, 2000, an early cervid of the middle Miocene of several fossil sites of Central Spain. The genus *Heteroprox* comprises a, likely forest-dweller, middle-sized basal deer of Eurasia. They have supraorbital pedicle, no burr and a small antler with few ramifications, normally two branches. As other species, either extinct (like *Procervulus*) or extant (like *Muntiacus* or *Elaphodus*), males of *Heteroprox* have well developed canines. For the reconstruction of the external appearance, the colour pattern of all the extant species of the family Cervidae have been studied with the method of maximum likelihood analysis, using the recent works about the phylogeny of the family Cervidae. The results show the probable basal colour pattern of the cervids, which can be used as a basis for reconstructing coloration and to hypothesize about external appearance of extinct taxa. Also, it has been taken in consideration the inferred habitat of *H. moralesi* to adjust the colour pattern comparing the final results of the analysis done in this article with the pattern of extant forest deer, and also with previous works that use this methodology.





SMALL MAMMAL TAPHONOMY FROM LATE PLEISTOCENE TO LATE NEOLITHIC LEVELS OF EL MIRADOR CAVE (SIERRA DE ATAPUERCA, BURGOS, SPAIN)

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Keywords

fumier, Holocene, predation, microfauna

El Mirador Cave is located on the southern slope of the Sierra de Atapuerca (Burgos, Spain). The site is characterized by the presence of "fumier" deposits due to the recurrent use of the cave for stabling livestock during Neolithic and Bronze Age occupations. These deposits consist of animal dung, which are periodically burnt resulting in the formation of burned, partially burnt and unburned layers. In this work, small mammals from Neolithic to Late Pleistocene levels were taphonomically analysed. Unfortunately, remains recovered from burned layers are scarce (MNE<100) and fragmented, consisting mainly of cranial elements. Unburned Holocene layers were characterized by a high number of skeletal remains (MNE>300), relatively high breakage and scarce post-depositional taphonomic alterations. Skeletal remains found in Pleistocene deposits (most especially MIR49) showed a higher presence of complete elements and post-depositional alterations (e.g., manganese oxide depositions and concretions). Concerning to the accumulation agent, results revealed the presence of a possible barn owl nest in levels MIR18 and 24. In levels MIR17, 50 and 51 a possible Category 2 predator is inferred, while in MIR49 a Category 1 predator is taphonomically identified. However, results obtained cannot be attributed to a predator which today inhabits the Iberian Peninsula, but at more boreal environments. Diversity analyses do not indicate major changes in the faunal composition of the levels so the presence of specialist predators may be discarded, and no reworking processes were observed. Therefore, small mammal fauna can be considered autochthonous and representative of the past ecosystems which surrounded the cave.





FIRST PRELIMINARY PALEOHISTOLOGICAL AND HISTOTAPHONOMIC STUDY OF BONE REMAINS FROM RANCHO LA BREA (LATE PLEISTOCENE, USA)

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Keywords

mammals, Equidae, paleohistology, histotaphonomy, North America

The asphalt deposits of Rancho La Brea (California, USA) are well known for the quantity and variety of its Late Pleistocene fossil record. However, there is little information regarding the taphonomy of vertebrate, and particularly the histology of the bone remains. This work investigates for the first time- the osteohistological features and histotaphonomic changes based on the bone microstructure evidence of *Equus occidentalis* recovered from different tar pits. Thin sections of femora, humeri and metapodials were assessed using petrographic and scanning electron microscope. All the samples are mainly constituted by fibrolamellar tissue, which reflects a relatively fast rate of bone deposition during the early stages of the growth. Some samples display an external fundamental system evidencing a decrease in the growth rate. Secondary remodelling is present with different intensity and location in all skeletal elements. Although the samples exhibit some fossil diagenetic alterations (i.e. enlargement of canaliculi, microtunnelling, microcracks, fissures and cavities infilling), the histological preservation is nevertheless excellent. No evidence of microorganisms attack altering the original histology was identified; this absence is possibly linked to this type of environmental context, asphalt deposits, which require specialized adaptations and, therefore, limits the microbial development. From a paleohistology viewpoint, the distribution and characterization of bone tissues and remodelling in the different skeletal elements are, in general lines, similar to that other extant and extinct equids. From a histotaphonomic viewpoint, the variations recorded indicate evidence of different taphonomic histories and preservation conditions among pits, which may be related to seasonal periods.





FIRST SPECIMENS OF *ANCYLOTHERIUM PENTELICUM* (MAMMALIA, CHALICOTHERIIDAE) FROM THE NEW EXCAVATIONS AT THE LATE MIOCENE LOCALITY OF PIKERMİ (ATTICA, GREECE)

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Keywords

Chalicotheriidae, *Ancylotherium pentelicum*, Late Miocene, Pikermi, Greece

The schizotheriine chalicothere *Ancylotherium pentelicum* is one of the most characteristic but rare elements of the Late Miocene mammalian faunas of the Eastern Mediterranean and adjacent regions. The classic locality of Pikermi, the type locality of the species, has been extensively explored and studied since the mid-19th century, revealing a rich and diverse vertebrate fauna of Turolian age. Since 2008, a new series of stratigraphically and taphonomically controlled excavations has begun under the direction of Prof. G. Theodorou of the National and Kapodistrian University of Athens, and under the auspices of the Rafina-Pikermi Municipality, and has yielded new and prolific fossiliferous sites (Pikermi Valley: PV1, PV3). The new material of *A. pentelicum* consists of a well-preserved, presumably associated, pair of a third and fourth metatarsal, a partially preserved radius, a phalanx, and an astragalus. The most striking feature is the development of a deeply concave articular facet for the Mt-IV on the Mt-III. This feature enhances the interlocking between these two metatarsals by reducing the abductive and adductive movements, providing also additional stability to the tarsometatarsal joint. The new specimens are compared with the known sample of *A. pentelicum*. The notable range of metrical variation observed among the metapodials of *A. pentelicum* may be indicative of sexual dimorphism, as has been previously discussed and also documented in other chalicotheriid species. In addition, this metrical variability may have been further affected by differential spatiotemporal evolutionary patterns among locally adapted populations in the Eastern Mediterranean and adjacent regions, within the anticipated boundaries of a single species.





SORICIDAE (SORICOMORPHA, MAMMALIA) FROM PLIO-PLEISTOCENE KARSTIC DEPOSITS OF ANDALUSIA

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Keywords

Eulipotyphla, Pliocene, Pleistocene, Andalusia, karst

The karstic deposits are abundant in the Spanish part of the Iberian Peninsula (IP). These offer some advantages over fluvio-lacustrine deposits, such as a larger number of fossil remains found. These are mainly small mammals, including shrews (Soricidae, Eulipotyphla). This work is focused on fossil dental remains of soricids discovered in fifteen fossiliferous levels of karstic origin from six localities in Andalusia (Southern IP). Overall, the ages of which levels vary between the late Ruscinian (MN15; early Pliocene) and the Biharian (MN18; Pleistocene). Thus, there are three levels in Gilena (Seville province) from late Villanyian (MN17) to the Biharian (MN18) and one in Estepa (Seville province) from the early Villanyian (MN16); one in Bélmez and other one in Cueva de La Fosforita (Córdoba province) from the late Ruscinian (MN15); and finally, four in Rambla Seca (Granada province) from the late Ruscinian (MN15), and five in Moreda (Granada province) from the late Ruscinian (MN15) to the early Villanyian (MN16). The shrew fauna found includes *Asoriculus gibberodon*, *Beremendia* aff. *minor*, *Petenya* aff. *dubia*, *Crocidura* cf. *kornfeldi*, *Myosorex meini* (the best represented taxon) and an indeterminate soricid. The greatest diversity of taxa was found in deposits of which the relative dating matches with the Pliocene Climate Optimum (early Villanyian; MN16). This diversity could have been benefited from the more humid and warmer conditions that occurred during this episode in southern Spain.





CENOZOIC DYNAMICS OF BETA DIVERSITY OF ANGIOSPERM WOODY PLANTS IN THE EAST ASIAN ISLANDS

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Keywords

climatic change, beta-diversity, paleoclimate, paleobiodiversity, fossil records

Distance-dependent increase of beta-diversity is a common macroecological pattern in current community assemblages. However, it is not clear whether such a modern biodiversity pattern exist in the fossil assemblages that often show different alpha diversity patterns in relation to paleoenvironments. This study focuses on beta diversity of Cenozoic angiosperm woody plants to better understand the impacts of paleoclimate on taxonomic sorting and dispersal limitations across different geological ages that are characterized by paleoclimate changes. Using a fossil data set (7,468 data points) in the East Asian archipelago throughout Cenozoic, we created a genus-level presence-absence matrix (comprising 310 genera and 95 families) across 18 regions that were hierarchically classified/grouped using 1° grid cells. We then calculated the turnover (β_{sim}) component of Sørensen's pairwise dissimilarity (β_{sor}) in each geological period and evaluated the response of taxonomic dissimilarities to the spatial/climatic distances in each geological period. We found a significant genus turnover that was positively correlated with geographical and climatic distance in cooler ages after the Last Glacial Period. During the warm periods in the early Cenozoic, especially from Oligocene to Miocene, there were neither clear spatial nor climatic distance-dependent turnovers. These results showed that a climate-induced sorting process regulates diversity pattern only in the most recent periods: specifically, angiosperm woody plants were sorted by climatic gradient in relation to geography. Moreover, the predominance of distance-independent turnovers in the early/middle Cenozoic suggested a relaxation effect of dispersal limitation that may enable niche filling of individual genera under warmer and stable paleoclimates.





FIRST RECORDS OF ANTHRACOTHERIIDAE (MAMMALIA: ARTIODACTYLA) IN MEXICO

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Keywords

Chiapas, Miocene, Oaxaca, Oligocene, Simojovel

Anthracothers have an extensive fossil record in Eurasia and Africa, spanning most of the Cenozoic. In North America they have been collected in middle Eocene to early Miocene localities from the Great Plains and the Gulf Coast of USA. In Central America, they were reported from the early Miocene of Panamá. Here we report an upper tooth and a lower one from the early Oligocene (Ar1) Iniyoo Local Fauna of northwestern Oaxaca, and a jaw fragment with p4-m2 from the earliest Miocene of Simojovel, in northern Chiapas. This material has diverse features that indicate they belonged to Anthracotheriidae, such as bunoselenodont lower molars with relatively conical internal cuspids and crescentic external cuspids, a rostro-labially directed premetacristid, a linguo-labially directed postmetacristid, a reduced hypoconulid, and a protoconid of p4 connected to the mesolingual and anterior conids by strong crests; upper molar with four cusps, a protocone without a posterior crest, a transverse valley extending from the lingual margin reaching the mesostyle, very crenulated enamel on the fossae and on the transverse valley, and well-developed shelf-like cingula on upper molar. These new records link the previous ones from temperate North America and tropical Central America and indicate that Anthracotheriidae had a very wide geographic distribution in North America during the Paleogene and the Neogene. Additionally, both records are the most southern in North America during the Oligocene and the early Miocene.





UNUSUAL SURFACE TEXTURE IN PRESACRAL VERTEBRAE OF THE PACIFIC MASTODON (*MAMMUT PACIFICUS*): A CASE REPORT

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Keywords

proboscidean, mastodon, vertebrae, resegmentation, paleopathology

An associated series of cervical and thoracic vertebrae (C1–T1) of a young female Pacific mastodon (*Mammut pacificus*) in the collections of the Western Science Center (WSC, Hemet, CA) preserve an unusual porous and woven texture on the posterior articular surfaces of the centra. Although the individual is small (max centrum diameter = 14cm), all epiphyseal growth plates of the vertebrae are closed. Our comprehensive survey of presacral vertebrae of *Mammut pacificus* in the WSC collections failed to turn up any other examples that preserved a similarly anomalous texture. Additionally, we have not found vertebrae in the literature with a similar texture. Possible explanations for the unusual texture include (1) aberrant fetal or post-partum development; (2) infections or degenerative changes during life; (3) decomposition processes; (4) unusual fossilization; and (5) weathering. The absence of the texture from other individuals from the same depositional system (Diamond Valley Lake, CA), and from other parts of the vertebrae in the affected individual, argues against the texture having been produced through decomposition, fossilization, or weathering. Evenness of the texture across the posterior articular surfaces, as well as an absence of osteophytes or degenerative changes in the bone, suggest that the condition was not overtly pathological in its causes or its effects. Restriction of the abnormal texture to the posterior surfaces of the vertebrae suggests that it is related to vertebral resegmentation early in embryonic development. Numerous large foramina in the woven bone suggest an unusual pattern of vascularization, possibly also related to resegmentation.





INCREDIBLE MISTAKES: RARE INSTANCES OF REVERSE DRILL HOLES IN CENOZOIC BIVALVE PREY

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Keywords

Bivalvia, failure, Gastropoda, Mollusca, predation

Failed predatory attacks occur commonly even after a predator captures its prey. The reasons predators often fail could be related to the prey's defence mechanisms; the predator's internal physical state, motivation, or available information; and/or external disturbances. Distinguishing between those factors is often difficult. Here we report on highly remarkable instances of failure (mistaken predation) for which only the predator can be blamed. Prey selection by drilling gastropods, which occurs through chemosensory and mechanoreceptive means, nearly always results in a circular drill hole in a molluscan shell. Complete drill holes often have a diameter at the outer surface of the shell that is wider than at the base where the hole penetrates the shell, and the outline of the hole is less irregular at the outer shell surface. In making prey selection decisions, predators use chemical and tactile stimuli to differentiate between live and dead prey. We found two bivalve shells, a Pliocene *Astarte incerta* and a Miocene *Astarte goldfussi* from the Netherlands, where the drill hole was clearly created from the shell interior to the outer shell surface (i.e., in shells of already dead bivalves). Given the slow drilling rate of modern drillers (0.01–0.02 mm/hr), such instances of mistaken predation were costly energetically. However, reverse holes are rare in the two assemblages studied (<1% of drill holes), implying that the driller's sensory and decision-making processes were generally reliable at distinguishing dead from live prey. These rare examples are the first evidence of this type of failed predation from the fossil record.





NEW MATERIAL OF THE FOSSIL *PSEUDOPUS PANNONICUS* (ANGUIMORPHA, ANGUIDAE) FROM THE LATE NEOGENE OF EASTERN EUROPE

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Keywords

Lizards, Osteology, Miocene, Pliocene, Moldova

Anguidae is a clade of widely distributed reptiles from which Anguinae is the most derived lineage. One iconic member of this lineage is the Sheltopusik, *Pseudopus* Merrem, 1820, currently ranging from South-East Europe to Central Asia. This taxon, represented by four known fossil and one extant species, appears in the fossil record around the early Miocene. One of these fossil species, *Pseudopus pannonicus* Kormos, 1911, is the largest anguine known in regards to its body size and has been described in numerous European fossil localities. It displays a particularly large distribution, both spatial (from Spain to Southern Russia) and temporal (from the late Miocene to the Early Pleistocene). However, the majority of the occurrences of this species are based on skeletal elements which have not been included in its original description, and only few studies focused on amending the diagnosis afterward. Moreover, the early taxonomic history of the species was problematic, including confusions and synonymization actions. We here report on previously unknown sets of cranial and vertebral remains attributed to *P. pannonicus*. The fossils were collected during the second half of the twentieth century from several late Neogene localities of Moldova and Northern Caucasus. Although these elements exhibit some variability, their overall morphology undoubtedly resembles that of previously described material *P. pannonicus*. This work is encompassed in a larger project aiming at the revision of *P. pannonicus*. Thus, the additional material from new localities should prove useful for future redefinition of the list of diagnostic features of this extinct taxon.





TAXONOMY, PALAEOECOLOGY AND STRATIGRAPHY OF THE MIDDLE MIOCENE MOLLUSK FAUNA FROM THE GRAČANICA COAL PIT NEAR BUGOJNO IN BOSNIA AND HERZEGOVINA

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Keywords

Long-lived lakes, Gastropoda, Bivalvia, Environmental change, Dinarides Lake System, Southeastern Europe

During the early and middle Miocene, the Dinarides Lake System (DLS) was a major hotspot of freshwater mollusk diversity in southeastern Europe. The numerous intramontane lake basins, originating from combined effects of tectonic subsidence and humid climate, accumulated thick lacustrine successions. Due to diagenetic overprint and leaching of these carbonate-rich deposits, insights into faunal contents have been restricted to only a few basins up to the present. We contribute to filling this gap by documenting for the first time a mollusk fauna from the Bugojno Basin in Bosnia and Herzegovina. The fauna originates from a coal-bearing succession representing gradual flooding of coastal wetlands followed upwards by the establishment of perennial lacustrine settings in the basin. Our taxonomic analysis documents 17 gastropod and two bivalve species. New to science are three species attributed to the genera *Prososthenia*, *Bania*, and *Illyricocongeria*. A palaeoecological analysis based on quantified samples shows distinct shifts in mollusk composition and abundance. The terrestrial taxa are restricted to the coal-bearing interval of the section; melanopsids, neritids and hydrobiids are abundant in deltaic and littoral settings, whereas bivalves are frequent in littoral and sublittoral environments. In line with previous results, which have evidenced a high degree of intralacustrine radiation in the DLS, the Lake Bugojno fauna shows a low to moderate level of similarity to other DLS faunas. The dissimilarity may partly also result from its younger age, as suggested by the presence or absence of regional biostratigraphic marker species.





A NEW SPECIES OF *MAOMINGOSUCHUS* FROM THE EOCENE OF VIETNAM SHEDS NEW LIGHT ON THE PHYLOGENETIC RELATIONSHIP OF TOMISTOMINE CROCODYLIANS AND THEIR DISPERSAL FROM EUROPE TO ASIA

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Keywords

Eocene, Crocodylia, Asia, Phylogeny, Biogeography

The subfamily Tomistominae is a monophyletic group of Crocodylia (Eusuchia) with only one living representative, the false gharial *Tomistoma schlegelii* from the Malaysian peninsula, Borneo, Sumatra and Java. The fossil record, however, is much more diverse, with representatives found in Europe, Africa, America, Asia and Australia. Tomistomine crocodylians originated in the late Palaeocene to early Eocene in the region around the western Tethys. During the middle to late Eocene, the first undisputed tomistomines from Asia belong to *Maomingosuchus petrolicus* from the Maoming Basin of China. Another tomistomine from the Eocene of the Krabi province of Thailand was described as *Maomingosuchus* sp. and might represent another species. Here we report a new *Maomingosuchus* species from the middle to late Eocene deposits of the Na Duong Basin in northern Vietnam. It is characterized by three autapomorphies: (1) a prominent process on the dorsal margin of the atlantal rib; (2) a prominent anterior iliac process; and (3) a ratio of the mediolateral width of the supratemporal fenestral bar to the width of the skull table lying in the range of 0.1 to 0.175. Based on phylogenetic analysis results, the Na Duong-*Maomingosuchus* n. sp. forms a monophyletic group with *M. petrolicus* and the Krabi-*Maomingosuchus*. The group was retrieved in a basal position forming the sister group to *Paratomistoma* + *Gavialosuchus* + *Melitosaurus* + *Tomistoma*, including the extant *Tomistoma schlegelii*. This phylogeny indicates three different dispersal events of Tomistominae from Europe towards Eastern Asia: (1) *Maomingosuchus*, (2) *Penghusuchus pani* + *Toyotamaphimeia machikanensis*, and (3) *T. schlegelii*.





PRIMARY OSTEOARTHRITIS IN *PROLAGUS SARDUS* (LAGOMORPHA, LATE PLEISTOCENE): HOW PALEOPATHOLOGIES CAN THROW LIGHT ON THE LIFE HISTORY OF EXTINCT TAXA

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Keywords

eco-evolutionary adaptations, gigantism, insular regimes, life-history theory, lifespan



Although paleopathology investigations have historically focused on the description of specific conditions, population studies can provide essential clues to deepen the understanding of biology and evolution of extinct species. The present research examined a total of 246 femora of *Prolagus sardus* (Ochotonidae, Lagomorpha) for evidence of primary osteoarthritis (OA). All the bones came from the well-known Dragonara locality (Sardinia, Italy), dated back to the Late Pleistocene (22,39–21,91 ka cal BP). We established the ontogenetic stage (juvenile, young adult, and adult) and the body mass for each specimen, as well as the OA status of the hip and knee joints (scale of 0 to 3). Results revealed that 24.9% of specimens had at least one joint affected, especially the hip joint. The presence of OA was not associated with a larger body mass (Kruskal-Wallis test and binary logistic model, $p > 0.05$), but there was statistically significant positive correlation between the presence of disease and the age (Cochran-Armitage and Jonckheere-Terpstra test, $p < 0.05$). Accordingly, the main risk factor of primary OA in domestic lagomorphs is aging, whereas the size is only significant when the specimen's body weight is over 5 kg. *Prolagus sardus*, which weighed approximately 700–750 g, showed OA prevalence similar that of domestic extant rabbits (20.9–26.1%), even though it was a wild species and subjected to natural selection. A slower life history (longer lifespan), proposed for insular giants following life-history theory, could be the main evolutionary trigger of the observed results, although other causes cannot be excluded.



BONE HISTOLOGY OF THE EXTINCT CAPE ZEBRA FROM ELANDSFONTEIN (MIDDLE PLEISTOCENE, SOUTH AFRICA)

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Keywords

bone histology, paleobiology, growth rate, *Equus capensis*, Pleistocene



The fossil site of Elandsfontein is located 95 km north from the South African city of Cape Town. Dated at 1.0 – 0.6 Ma, it is well known for the discovery of a hominin skullcap and some lithic artifacts. The site has further provided more than 40 different species of other mammals, including multiple remains belonging to the Cape zebra (*Equus capensis*). This extinct equid is closely related to the extant Plains zebra (*Equus quagga*), but it was larger in size and had more robust limbs and taller teeth. Despite being a common taxon during the Pleistocene of South Africa, little is known about the biology and development of the Cape zebra. Here, we histologically analyse 2 femora and 6 metapodia of *E. capensis* from Elandsfontein to shed some light on its paleobiology. For comparative purposes, we also studied 10 histological slides of *E. quagga* prepared from the same bones. In most of the fossil samples under analysis, the bone microstructure was extensively degraded by the diagenetic action of bacteria. Despite this, it was possible to identify some areas with excellent micropreservation. Bone cortices of *E. capensis* and *E. quagga* are both composed of fibrolamellar bone, but primary osteons are longitudinally oriented in the metapodia and circumferentially arranged in the femora. Preliminary analyses revealed a daily secretion rate of ~1 µm/day and ~1.2 µm/day for the lamellar bone of the primary osteons of *E. capensis* and *E. quagga* respectively, suggesting slightly slower rates of bone formation in the extinct Cape zebra.



NEW FOSSIL REMAINS OF *GALLOTIA AUARITAE* FROM LA PALMA (CANARY ISLAND, SPAIN)

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Keywords

giant lizard, cranial bones, heterodonty, Gallotiinae

The Canary Islands have a wide and varied fossil record, among which there are the remains of endemic vertebrates, such as lizards of the genus *Gallotia*. This genus is formed by six giant species (*G. stehlini*, *G. goliath*, *G. intermedia*, *G. bravoana*, *G. auaritae* and *G. simonyi*) and three little species (*G. atlantica*, *G. galloti* and *G. caesaris*), which together with the current genus *Psammodrommus* and the fossil genera *Janosikia*, *Dracaenosaurus* and *Pseudeumeces* form the Gallotiinae subfamily within the family Lacertidae. This investigation is based on osteological and biometric study carried out with 53 cranial and postcranial Holocene remains of lacertids from Roque de los Guerra (Villa de Mazo, La Palma). Based on the results of the morphological analysis of the different diagnostic characters of the genus *Gallotia*, and the species *G. auaritae*, these fossil remains were tentatively assigned to this species. The comparison of the sizes of the cranial bones analysed with the data of the other living and extinct species of giant lizards of the Canary Islands, places this species as the second largest within the endemic registry of lacertids. The presence of monocuspid and multicuspid teeth in their dentaries and maxillae hints to a hypothesis of a diet based mainly on plant matter for lizards of this species. In addition, previously undescribed bones have been described (e.g., the premaxilla). This has increased the knowledge of a species, which was only known from the osteology of some bones and an almost complete skull.





BRING INTO AN OPEN SCIENCE: A GROUND SLOTH FOSSIL FROM THE NEOTROPICS

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Keywords

Divulgtation, illustration, mandible, Megatheriidae, neotropics



Interacting with local communities in the field can be challenging, however, to divulge science and enhance the impact of paleontological research an artistic restoration is extremely useful. A partial right mandible of a giant ground sloth collected in northern Colombia and the lithology of the rock that contain it, allowed us to reconstruct the landscape prior to the aridification of the neotropics. Using comparative anatomy from virtual collections, we compared this fossil specimen with remains referred to the main extinct sloth families (Megatheriidae, Megalonychidae and Mylodontidae). The relative depth of the mandible, the reduced interdental space, the aligned series of four molariform teeth and its morphology, suggest that the fossil belongs to the Megatheriidae family. The proportions of the depicted skull were reconstructed from larger and more complete fossils like the megathere *Eremotherium*. The fur was inspired by the closest living relative, the two-toed sloth *Choloepus hoffmanni*, and the morphology of the rostrum was based on megathere cranial proportions. The fossil exhibits a low degree of mineralization and was collected in horizontal strata overlying late Miocene-Pliocene rocks grouped as the Sincelejo Formation, so we could speculate Pleistocene age for it. The associated fine-grained lithology and nearly horizontal attitude of the strata suggests that the sloth inhabited a low energy environment (meandering river). All information was compiled in a digital illustration portraying the geological changes that might have occurred in the neotropics prior to the extinction of South American megafauna.



UNDERSTANDING THE PAST TO PROTECT MODERN DIVERSITY: DOCUMENTING THE HISTORY OF HOLOCENE VERTEBRATE EXTINCTION IN THE CARIBBEAN

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Keywords

ancient DNA, extinction, phylogenomics, *Geocapromys*, *Nesotrochis*



Human impacts and manipulation have led to premature extinction for many species which inhibits our ability to understand the complete evolutionary history and the geographical origins of species within an area. Exposing how extinct species fill in gaps in how we recognize and understand anthropogenic impacts on present-day species diversity is critical to safeguarding current and future biodiversity. Here we present a research program spanning paleontology and archaeology focused on using radiocarbon dates and ancient DNA from avian and mammalian taxa in the Caribbean to elucidate Holocene biodiversity loss. The Caribbean is an extinction hotspot with most of the terrestrial mammals and flightless birds now lost. We highlight two examples, the Bahamian hutia (*Geocapromys ingrahami*) and the Haitian Cave-rail (*Nesotrochis steganinos*). Once widespread across The Bahamas, Bahamian hutia is now restricted to small cays in the archipelago. Radiocarbon dates and ancient DNA document an extinction of a northern Great Bahama Bank lineage that was likely transported to the Little Bahama Bank by Indigenous people. The Haitian Cave-rail was a flightless, osteologically enigmatic extinct bird that survived until European arrival in the Caribbean. It has been found in archaeological middens suggesting it was consumed by Indigenous people. Ancient DNA indicates that this species is more closely related to avian families now found only in the Old World. The Haitian cave-rail represents the first evidence of an endemic Caribbean radiation originating from the Old World. Our program provides critical evidence of significant loss of genetic diversity within the Caribbean.



NEW EVIDENCE FROM THE ENIGMATIC DAMSEFLY FAMILY LATIBASALIIDAE (ODONATA: ZYGOPTERA: CALOPTERA) FROM THE LATE PALAEOCENE OF NORTHWEST ARGENTINA

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Keywords

Latibasalia, Maíz Gordo Formation, Jujuy province, Argentina



Latibasaliidae is a rare and small group of damselflies from the late Palaeocene of Jujuy province in Northwest Argentina. The family has two species (*Latibasalia quispeae* Petrulevičius and Nel, 2004 and *L. elongata* Petrulevičius and Nel, 2004) with three specimens from Maíz Gordo Formation. In this contribution new structures are described from 10 fragmentary specimens and a complete fore(?) wing confirming the singularity of the family: a pterostigma with a honeycomb microsculpture, covering 8 cells with a slightly oblique basal side and a strongly oblique distal side followed by two rows of cells distally. Latibasalids are uncontroversially Caloptera but their position within the group remains doubtful. They were considered by Petrulevičius and Nel (2004, 2007) as Eucaloptera: Amphipterygida: Amphipterygoidea possibly related to Pseudolestidae. This attribution was made, among other characters, by the absence of secondary antenodal and antesubnodal crossveins. Huang et al. (2017) consider Latibasaliidae within the Epallagoidea, and as sister group of Zacallitidae (Eocene of USA), interpreting the sharing of a “convex longitudinal intercalary vein in the cubital field” as unique putative synapomorphy. I could agree in the Epallagoidea attribution because of the expanded cubital field, but I interpret the real nature of the strongest accessory intercalary “anal” vein in the cubital field as concave, showing possible relationships with the other family of the group, the Epallagidae. Anyway, latibasalids have two prominent (concave and convex) “anal” veins in a particular arrangement, of which we have to analyse the possible homologies to establish their phylogenetic relationships within the Caloptera.



PALEOENVIRONMENTAL CHANGES RECORDED IN THE PALYNOLOGY OF WESTERN MEDITERRANEAN AND NORTH ATLANTIC (MOROCCAN MARGINS) SEDIMENTS

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Keywords

Palynology, Pleistocene, Holocene, Pollen and Dinoflagellate cysts

This research is part of the international programs “Cold-water carbonate mounds in shallow and Deep Time” (COCARDE). It presents the results of the first palynological study of carbonate mound sediments of five boxcores in the North Atlantic off Morocco (Gulf of Cadiz) and the Alboran Sea on the Brittle Star I ride off Melilla, and two on-mound gravity cores of the Western Melilla Province (WMCP) carbonate mounds in the Moroccan Alboran margin, which were collected during the oceanographic cruise MD 194, EuroFleet Gateway-TORE in 2013. Dinoflagellate cysts are dominant in over the continental fraction of organic remains. Despite their low representativity, they are revealed as valuable tools for the paleoclimate interpretation during this study interval (14.02–3.47 ka). The terminal Pleistocene–basal Holocene limit is characterized by the dominance of cold taxa of dinoflagellate cysts (mainly *Nemathosphaeropsis labyrinthus* and *Spiniferites lazus*) indicate an outer neritic to oceanic environment. The dominance of tree and shrub pollen (**Deciduous *Quercus*, Evergreen *Quercus*, Ericaceae and *Olea***) coupled with the presence of altitudinal conifers (*Pinus*, *Cedrus*, *Abies* and *Picea*) confirms a cold climate in both continental and marine environments. During the lower-middle Holocene, the variations in the relative frequencies of dinoflagellate cyst associations reflect the evolution of the paleoenvironment from inner neritic to oceanic (the thermophilic *Spiniferites mirabilis* and *Impagidinium acculeatum* dominated the dinoflagellate cysts assemblages). The recorded microflora shows cyclicity during the lower Holocene from arid to semi-arid between 10.07 and 9.85 ka, to become arid again around 9.69 ka (based on the abundance of herbaceous and steppe plants pollen (**Asteraceae–Cichorioideae, Amaranthaceae–Chenopodiaceae, *Artemisia* and *Poacea***) In contrast, the paleoclimate conditions recorded during the Middle Holocene are semi-humid up to 6.29 ka (abundant trees and shrubs) and evolve to warm dry at 5.9–3.47 ka, as reflected by the abundance of herbaceous and steppe plants.





FEEDING BEHAVIOR OF *HIPPARION* SP. FROM THE PLIO-PLEISTOCENE SITE GUEFAÏT-4.2 (JERADA, EASTERN MOROCCO): INSIGHT FROM DENTAL WEAR ANALYSIS

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Keywords

microwear; mesowear; North Africa; Equidae

Hipparionines inhabited North America, Europe, Asia and Africa from the early Late Miocene to the Pleistocene. Although the dietary habits of this equid are well studied in eastern Africa during the Plio-Pleistocene, its record in North Africa is poor. These taxa have various ecological habits, from browsing to grazing, in the Old and New World. Guefaït-4, located in the Plio-Pleistocene basin of Aïn Beni Mathar-Guefaït (Jerada, eastern Morocco). The fossiliferous layer, which consists of clays and marls with nodular calcretes, has delivered a diverse faunal assemblage of vertebrates (reptiles, amphibians, and both small and large mammals). The aim of this study is to provide information on the feeding habits of *Hipparion* sp. from Guefaït-4.2 and to contribute to the debate on its browsing or grazing behavior. This species is different from the species assigned to *Eurygnathohippus*, including *H. pomeli* from Ahl al Oughlam, which is of similar age. Dental specimens of *Hipparion* sp. from Guefaït-4.2 were studied through mesowear and microwear analyses. The two techniques provide dietary information on two different timescales: mesowear averages the diet over months or even years, while microwear reveals the diet in the last days/weeks of an animal's life. A total of 90 molars were selected, moulded and screened under a stereomicroscope at 35× magnification. The specimens with bad preservation or other taphonomical defects were discarded. The final sample, including teeth showing well-preserved enamel surfaces, consists of 50 teeth for microwear and 29 for mesowear. The mesowear indicates relatively low levels of abrasion and the tooth microwear pattern, characterized by a low number of scratches and relatively high number of pits, suggests a diet comprised of leaves from trees/shrub and forbs. The two proxies provided consistent results suggesting browse dominated mixed feeding dietary traits for these hipparions.





FAUNAL SUCCESSION (LATE PLEISTOCENE-RECENT) OF SQUAMATA FROM PEREZ DE GALEANA, APAXCO, STATE OF MÉXICO, MÉXICO.

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Keywords

fossil, lizards, snakes, richness, turnover

The present work shows the faunal succession of Squamata from the Late Pleistocene-recent at Pérez de Galeana, Apaxco, State of México, by determining fossil taxa and comparing them with the present ones in the same area. The fossil material was recovered from the locality “Las Palmas”, by collecting clay sediments lodged in cavities of karstic origin generated in the predominant limestone rocks of the region, from which 51 fossil specimens of lizards and 141 of snakes were recovered. The fossils were found associated with *Equus conversidens*, *Dasytus novemcinctus* and cf. *Bassariscus* sp., due to this, an age corresponding to the late Pleistocene was assigned. An analysis of faunal turnover rates was carried out, taking into account the maximum specific richness (MSR) and net turnover (NR) between fossil and extant species. The observed net turnover was less than zero, which means that there is a balance in favor of present-day species (10 Pleistocene species and 12 present-day species); of the total number of species, eight are shared between the late Pleistocene and current time (in the same area), two are no longer present today (*Sceloporus horridus* y *Crotalus atrox*) and four are exclusive at present time (*Sceloporus torquatus*, *Sceloporus scalaris*, *Conopsis nasus* and *Thamnophis eques*). Their absence in the fossil assemblage may be explained by the incompleteness of the fossil record; however, the ecological requirements of the locally extinct fossil fauna do not match with the present ecological conditions of the area, suggesting that the climate has changed during the period in question.





ANTERIOR OSSICONE VARIABILITY IN *DECENNATHERIUM REX* RÍOS, SÁNCHEZ AND MORALES, 2017 (LATE MIOCENE, IBERIAN PENINSULA)

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Keywords

Giraffidae, Ossicone, Late Miocene, Cerro de los Batallones, Iberian Peninsula

The recovery of a new partial cranium of *Decennatherium rex* Ríos, Sánchez and Morales, 2017 bearing two anterior and two posterior ossicones from the Late Miocene deposits of the site Batallones-10 (MN-10, Cerro de los Batallones, Madrid Basin) sheds light on the complex variability of the cranial appendages of these extinct giraffids. The special features of the anterior ossicones of BAT10'18-C6-40, each formed by two bosses separated by a septum, increase the range of morphological variability found in the anterior ossicones of giraffids. Variability in posterior ossicone morphology is described in several sivatherine taxa, such as *D. rex* and *Sivatherium maurusium*, but anterior ossicone variability has never been discussed for four-ossiconed giraffid taxa. This new specimen accounts for the third morphotype found in *D. rex* anterior ossicones. BAT10'18-C6-40 is identified as an adult *D. rex* male on the basis of the development of its posterior ossicones. These are large and already show the first large bump which in this taxon is always located on the middle of the dorsal surface at a similar height on both ossicones. BAT10'18-C6-40 anterior ossicones are placed above the orbits as in the other *D. rex* males found so far, but they are much shorter and shaped differently as they do not present the typical conical shape with a blunt tip found in the rest of the Batallones sample. This new specimen represents a new example of cranial variability in *D. rex* and makes it the extinct giraffid with a highest anterior ossicone variability found so far in the fossil record.





THE CF. *PARADOLICHOPITHECUS* SP. (PRIMATES, CERCOPITHECIDAE) FINDS FROM THE NEW LOWER PLEISTOCENE SITE OF KARNAZEIKA (THE PELOPONNESE, SOUTHERN GREECE)

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Keywords

Papionini, MN17, Villafranchian, Greek peninsula

The Lower Pleistocene Karnazeika locality, lies in the Peloponnese, Southern Greece, and its fauna corresponds to the Middle Villafranchian biochronological unit (MN17), being the most southern Balkan fauna of that age. The recovered mammal assemblage includes, among others, a few remains of a large Cercopithecidae. Herein, the new material, including an upper second molar, a partially preserved proximal radius and, possibly, an upper first incisor is described. The teeth show advanced stages of wear but retain their typical papionin characters, such as a strong lingual cleft and four bilophodont cusps. The general morphology and wear pattern of the teeth rules out the possibility that the remains belong to the genus *Theropithecus*, whilst the general size of the corresponding material rules out the possibility of a *Macaca* representative as well. On the contrary, the studied material better fits the size range of *Paradolichopithecus* (Necrasov et al., 1961). Even though this genus only appears with the species *Par. arvernensis* in the Villafranchian of Europe, it is better to ascribe it, in the present study, as cf. *Paradolichopithecus* sp., due to the scarcity of the material. This Papionini taxon has only been found twice before in Greece, in the North, at the sites of Vatera and Dafnero. Despite the scarcity, the new material certifies the vast presence of this important taxon in Greece and its first presence to the southern part of mainland Greece, indicating its wide distribution in the Greek peninsula.





THE METATHERIANS (MAMMALIA, METATHERIA) FROM THE MIDDLE MIOCENE OF LA VENTA, COLOMBIA: A TAXONOMIC, PHYLOGENETIC AND PALEOBIOLOGICAL REVISION

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Keywords

South America, Colombia, La Venta, Mammalia, Metatheria

The mammalian association from the middle Miocene levels of La Venta, Colombia, is one of the most diverse for the Neogene of South America and an important reference for the study of extant mammal lineages (e.g., Didelphidae, having the earliest records of *Thylamys*, *Marmosa*, and probably *Tlacuatzin*). The metatherian remains previously described for this association did not include all the specimens and taxa available. The results presented here are part of a doctoral research, which studied almost the totality of the materials available for this fossil association. These specimens belong to collections from the United States (University of California Museum of Paleontology, Berkeley), Japan (Primate Research Institute of the Kyoto University) and Colombia (Colombian Geological Survey and Museum of Villavieja, Huila). This study contributed to the increase in the number of taxa recognized for the La Venta association and the knowledge about their anatomy, adaptations, phylogeny, and paleobiology. About 130 specimens were studied, representing at least 22 species, 17 genera, seven families, and four orders. The new taxa increase the proportion of metatherians for this mammalian association (more than 25%), being higher than in other important Neogene South American faunas, such as Quebrada Honda (middle Miocene, Bolivia) and Arroyo Chasicó (late Miocene, Argentina), and even slightly higher than that of Santa Cruz (early Miocene, Argentina). This proportion suggests that La Venta was South America's most diverse Neogene metatherian association. This research allowed to strengthen our knowledge of the metatherian association of La Venta as an obligatory reference for the study of the Neogene associations of tropical America and the Southern Hemisphere as a whole, and, as suggested by previous authors, could represent an obligatory reference in the analysis of Neogene radiations of the group.





A DIPLOGLOSSINE RECORD FROM THE PLEISTOCENE OF CUBA

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Keywords

Anguidae, Diploglossinae, Pleistocene, Cuba, Greater Antilles

Diploglossinae is a clade of the neotropical anguid lizards ranging from Mexico and the West Indies to South America. Only two genera of these lizards are known in the West Indies, *Celestus* Gray, 1839 and *Diploglossus* Wiegmann, 1834. Presumably, they both colonized the Greater Antilles more than 10 My ago, however, it is still not possible to confirm this scenario because of the extremely poor fossil record. The fossil diploglossines of the Caribbean region are reported from the Pleistocene and Holocene of Puerto Rico, Cayman Islands, Jamaica, Dominican Republic, and Guadeloupe Islands. No older records are known from the Caribbean region. New diploglossine material was recently collected from the late Pleistocene of El Abrón Cave, Cuba. The material includes three almost complete dentaries and one maxilla. These elements closely match corresponding elements of extant *Diploglossus delasagra* (Cocteau, 1838), which is the most common species of *Diploglossus* in Cuba. However, some differences are apparent in the size of bones, shape of facial process of maxilla, shape of the coronoid facet of dentary, and presence of an additional foramen of maxilla. It is still unclear if these differences are related to individual variation within *D. delasagra* or, instead, represent a different and possibly undescribed species. The diploglossine osteoderms, which are considered more diagnostic, are needed to resolve this question. The specimens of *Diploglossus* from El Abrón Cave represent the first fossil record of this genus in Cuba.

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FOSSIL RECORD OF DELPHACIDAE (INSECTA: HEMIPTERA: FULGOROMORPHA)

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Keywords

Miocene, taxonomy, nomenclature, classification

The planthopper family Delphacidae Leach, 1815 (Hemiptera, Fulgoromorpha: Fulgoroidea) is a relatively large (over 2200 species in ca. 430 genera) and worldwide distributed group of opophagous insects, feeding on plants. Their fossil record is very scarce, with the oldest one in the Eocene Baltic amber, and a few reports from the Oligocene and Miocene, many needing revisionary studies. The family is commonly accepted as a monophyletic unit, but origin of the family remains doubtful. Several previous studies based on either morphological or molecular evidence suggested that Delphacidae might have arisen from within the planthopper family Cixiidae – resulting in the paraphyletic status of the latter. A few new inclusions in Miocene Dominican amber representing Delphacidae were recently identified. These fossils are important, not only as new records enriching the knowledge on the group and its fossil record. They present combinations of morphological characters challenging some of taxonomic concepts proposed for the New World Delphacidae. The fossils are to be placed in Asiracinae: Ugyopini, but their placement at the genus level needs to be more deeply and carefully considered, possibly resulting in taxonomic and nomenclatorial changes among the Recent species accommodated in New World Ugyopini.





MICROFAUNA AND MICROFLORA ASSEMBLAGES OF THE ŞARKIKARAAĞAÇ COAL-BEARING SUCCESSION (ISPARTA, SW ANATOLIA): MULTI-PROXY PALEOENVIRONMENTAL AND PALEOCLIMATIC INTERPRETATIONS

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Keywords

Şarkikaraağaç, Ostracoda, palynoflora, lacustrine, paleoenvironment, paleoclimate

Regional tectonism during the late Cenozoic triggered the development of many sedimentary basins around the Isparta Angle (northern Taurids, SW Anatolia). Among these, continental Yalvaç, Beyşehir-Suçla and Iğın basins contain economic coal seams within the Neogene-Quaternary basin infillings. In this study, we first aimed to reveal microfauna and microflora assemblages of the coal-bearing succession discovered under the Şarkikaraağaç lowland (southeastern Yalvaç Basin). We also aimed to interpret this newly discovered succession's depositional environments and the age by performing ostracod-based paleoenvironmental, paleoclimatic, and biochronological investigations. In this context, two borehole cores gathered from the Şarkikaraağaç lowland have been investigated in detail. Within the systematic paleontology studies, 17 genera and 20 taxa of ostracods belonging to 4 ostracod families (Cyprididae, Candonidae, Ilyocyprididae, and Limnocytheridae) are determined. Fifteen known ostracod species are identified, while five taxa are left open to nomenclature. In addition, 32 families (2 spores, 6 gymnosperms, and 24 angiosperms) are also obtained regarding palynomorphs. The multi-proxy (ostracods, palynomorphs, mollusks, and diatoms) paleoenvironmental/paleoclimatic investigations point out that the coal-bearing lower levels of succession were deposited under the cool climatic conditions in vegetated, stagnant/slow-flowing, neutral-slightly alkaline, oligo-mesotrophic, and very shallow (littoral) lacustrine environment containing paleomires. It is also determined that freshwater-oligohaline aquatic conditions fed by flows were common during the deposition, and in several periods, declined water-level and relatively increased salinity conditions also prevailed. Additionally, the depositional age of the Şarkikaraağaç coal-bearing succession is suggested as late Miocene?-Pliocene, according to the ostracod and the palynoflora data.





MESOWEAR ANALYSIS OF RUMINANTS FROM MELITZIA CAVE, SOUTHERN PELOPONNESE GREECE

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Keywords

Mesowear analysis, Palaeolithic, Palaeocology, Melitzia

The purpose of this study is to analyze the dietary traits of ruminant taxa from the Late Pleistocene site Melitzia Cave using mesowear analysis, in an attempt to reconstruct the palaeoenvironment of the studied area. Dental mesowear is an extensively used method for the reconstruction of the overall diet of mammals and has been widely applied to ungulate teeth. This method is used in both archaeology and palaeontology, leading to the determination of palaeoenvironmental conditions. By evaluating the relative relief and sharpness of the molar's cusps, levels of attrition (tooth-on-tooth wear) and abrasion (tooth-on-food wear) can be estimated. This study presents a mesowear analysis, examining molars of the ruminant taxa (*Cervus elaphus*, *Dama dama*, *Capra ibex*) from the Late Pleistocene site Melitzia Cave. The layers date to the Upper Palaeolithic and more specifically to an age between 24,000 and 11,000 BP. Based on mesowear analysis, we reconstruct the vegetation of the surrounding area of Melitzia as an open woodland and evaluate the local environment on its suitability for human habitation. The study of the three taxa shows an overall moderately low level of abrasion, with *Capra ibex* preferring a slightly more abrasive diet. Overall, despite our limited data, the wear rates of the studied specimens can be attributed to the utilization of an extensive range of feeding elements, as would be expected for open woodland.





THE FIRST DEFINITE OCCURRENCE OF *CUON ALPINUS* IN THE UPPER PLEISTOCENE DEPOSITS OF SW ROMANIA

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Keywords

Canidae, Late Pleistocene, carnivores, dhole

Currently restricted to East, Southeast, South and Central Asia, the dhole, *Cuon alpinus* (Pallas, 1811), was also found across Europe during the Pleistocene. Although a rare find, it persisted in Late Pleistocene megafaunal assemblages of Europe, occupying a particular ecological niche as the sole hypercarnivore canid, current data suggesting it might have also endured until the earliest Holocene. A first report of a possible *Cuon alpinus* from Peștera Seacă din Ogașul Stoienilor, Isverna Village, Mehedinți County Romania, describing an almost complete hemimandible that lacked the lower third molar, was subsequently dismissed on morphological, dimensional, and molecular grounds, and, proven to belong to an oligodont gray wolf. Continued excavation in the same cave, led to the discovery of additional dentognathic material (a fragmentary maxillary bearing the fourth premolar and both molars, plus isolated upper molars) that were morphologically similar to that of the dhole (medial tubercles reduced, migrated posteriorly, making the teeth more streamlined than in wolves). A detailed morphological and dimensional analysis of these new specimens shows they are consistent in size and shape to other Late Pleistocene European dholes, and thus confirms them as a definite first occurrence of the species in Romania. This new occurrence adds to the palaeogeographic range of the species, which is far better known from fossil assemblages of Southern and Central Europe, as well as from the Caucasus, but very rare in Central-Eastern Europe. Preliminary radiocarbon dating yielded ages ranging from 15.7 to 11.7 ky cal. BP for the layers containing the *Cuon* specimens.





BOTHERSOME BURROWERS: TRACKING GOPHER (*THOMOMYS BOTTAE*) TIME-AVERAGING IN A LATE- HOLOCENE SITE IN CALIFORNIA

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Keywords

bioturbation, taphonomy, pocket gopher, Holocene, small mammals

Understanding the taphonomic biases affecting fossil deposits is necessary in order to extract their true ecological signals. In terrestrial sites, the mixing of fossil material by mammalian bioturbators can substantially increase time-averaging, obscuring or even erasing stratification. In particular, pocket gophers (*Thomomys* sp.) are known to burrow in Holocene sites and thereby complicate the contextualization of faunal remains. Not only is it unclear if bones have been transported vertically by gophers, but the gophers themselves have the potential to die in their burrows, adding young skeletal remains to older deposits. We establish the degree of bias introduced by gopher remains in a late-Holocene archaeological site in Woodside, California, by radiocarbon dating skeletal remains of *Thomomys bottae* and non-fossorial small mammals from the same stratigraphic units. The ages of *T. bottae* bones are younger overall, and span a wider range, than the distribution of ages from other small mammals from the same site and sediment layers. This suggests that a significant number of gopher remains have been introduced after the site's deposition as a consequence of burrowing. These results shed light on a common taphonomic process that affects archaeological and paleontological sites, and may prompt reevaluation of faunal community.





FIRST MAMMALIAN REMAIN FROM THE MIDDLE MIOCENE ANGASTACO FORMATION AT THE TONCO VALLEY, LOS CARDONES NATIONAL PARK, SALTA PROVINCE, ARGENTINA

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Keywords

Central Andes, Notoungulata, Typotheria, Hegetotheriidae

The Angastaco Formation (Payogastilla Group) comprises thick fluvio-eolian Oligocene-Miocene deposits that record the regional environmental changes promoted by the Andean orogeny. An arid paleoenvironment has been suggested for this unit based on geochemical data and the alleged absence of fossils probably given by an oxidising depositional environment. Here, we describe the first mammalian remain exhumed from the lower part of Las Flechas Member at the Tonco Valley, Los Cardones National Park (Salta Province, Argentina). The age of the fossiliferous strata is bracketed by absolute ages between 17.5 and 13.7 Ma (early-middle Miocene). The specimen IBIGEO-P 128 is an isolated hypselodont left upper molar (probably M1) identified here as Hegetotheriinae indet. (Notoungulata, Typotheria, Hegetotheriidae). This tooth is sub-trapezoidal in occlusal outline, being longer than wide; it exhibits a thick cement layer. The enamel layer is continuous around the crown, being much thinner at the mesio and disto-labial angles of the tooth; the labial face presents shallow, but conspicuous grooves; the lingual face is slightly convex without entoflexus; the distal face is smooth, and narrower than the remainder of the occlusal surface; the distal face and the ectoloph form an angle of approximately 90°, and no fossettes are observed. This report constitutes the earliest record of the family Hegetotheriidae in northwestern Argentina. The hypselodont condition of the specimen agrees with the suggested open environments for the unit. This discovery also emphasizes the need of exhaustive and systematic prospections at the Angastaco Formation.



General Palaeontology



General Session



TEACHING SCIENTIFIC METHOD IN SCHOOL ON THE EXAMPLE OF SECONDARILY AQUATIC VERTEBRATES

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Keywords

palaeontological education, non-formal education, aquatic problem, experiment-based learning



In Primary (Elementary) Schools, the dominant teaching method is a reading-listening model. Non-formal education institutions like 'children universities' or science fairs on the other hand implement teaching through experiments. Purposely-framed play is proved to be a more effective (in terms of long-time coding of information) method, but the scientific issues are often presented to children in isolation of scientific inquiry, like in the reading-listening model. The presented study aims to prepare a framework for experience-based workshops (lesson) but concerning the scientific method. To achieve that, workshops about the adaptation of primarily terrestrial vertebrates to the aquatic environment (solving problems in the transition from land to oceans or fresh waters) were conducted in the years 2018–2020 within 10 groups of Primary School students (around 150 participants). The additional aim was to explain common misconceptions in the teaching of evolution, palaeontology, marine biology, and biodiversity. As a result, an exemplary scenario with several experiments using simple props was prepared as well as a general framework for teaching the scientific method in Primary School students was set, taking into account misconceptions and problems raised by the teachers (e. g. financial problems of schools, abundance of equipment). The scenario includes six 'aquatic barriers' to overcome when adapting to the aquatic environment (propulsion, neutral buoyancy, salt, temperature, hear, and sight). Preliminary results show that this way of teaching is engaging and effective, nevertheless more qualitative data is needed to be gathered in the future.



THE STORY OF NEMATODES FROM BALTIC AMBER – CASES FROM MAIG COLLECTION

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Keywords

fossil nematodes, inclusions, taphonomy, Baltic amber



Extinct representatives of the phylum Nematoda and traces of their presence are known since the Devonian (410.8 Mya). Most of these fossils are somehow associated with plant or animal hosts (e.g., nematode eggs in coprolites and phoretic larval stages). Extant nematodes are known from an extremely wide spectrum of habitats, from free-living to strictly parasitic. It must be considered that the fossil record of the group is scarce, lacking paleoecological evidence of some habits observed in extant representatives. Nematoda fossil record comprises 49 genera with 91 species preserved as fossils and subfossils. Among them, 84 species are described as inclusions in fossil resins; most of these were Dauer larvae associated with arthropods. Research material for this study comes from Baltic amber pieces from the Collection of the Museum of Amber Inclusions University of Gdańsk (**MAIG**). Nematodes were identified in 9 pieces of amber, with at least 103 specimens preserved. The findings include: Dauer larvae juveniles, possible adults, representatives of free-living groups and not-determined nematodes entrapped by predatory fungi. We propose an interpretation of habitats of various nematode trophic groups entrapped in Baltic amber. Such data are crucial for paleontological studies of the group and gives a better understanding of the paleoecology of “amber forests” itself, of the conditions conducting the preservation of the inclusions, and the taphonomy of fossil resins themselves.



PLANT FOSSILS IN BRAZILIAN ELEMENTARY SCHOOL: A PROJECT

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Keywords

Life and evolution, children, teachers, educational resources

In the first years of Elementary School, part of the curricular components of the “Life and Evolution” Thematic Unit can be explored through plant fossils. However, the bibliography about plant fossils for children, in Portuguese, is scarce and outdated. There is also a scarcity of fossil plant replicas that can be used in activities with children. This project aims to develop new educational actions including teacher’s formation, by means of courses, workshops and lectures, planned according to the national educational standards, development and adaptation of educational resources (focused in plant fossils) and the perform of various activities related to dissemination of Paleobotany in public schools. This year, the priority will be for remote activities, due to the COVID-19 pandemic. These educational resources will be stored in the digital repositories of the Universidade Federal do Paraná (UFPR) and made available through social media and a digital site. The project has started in April, 2021, with research activities that includes the survey of educational resources and bibliographies in the electronic bases and internet sites, with the themes “plants”, “evolution” and “plant fossils”, which made possible to gather videos, texts and other media, with proposals for activities for use in schools with children. Thus, the teaching of plants in Elementary School will no longer be just descriptive of their characteristics and parts but will be able to address issues related to the understanding of evolutionary processes, diversity and the maintenance of life on the planet.





THE HASHTAG #UBIRAJARABELONGSTOBR, A FLAG AGAINST COLONIALISM IN PALAEOLOGY

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Keywords

scientific colonialism, parachute science, illicit fossil traffic, palaeontological heritage, social media



Most publications on Brazil's Araripe Basin fossils led by non-Brazilian authors do not report extraction and/or export permits, sometimes even admitting the fossils were commercially acquired (e.g. *Irritator challengerii*, *Susisuchus anatoceps*, *Ludodactylus sibbickii*, *Lacusovagus magnificens*, *Unwindia trigonus*, and *Tapejara navigans*). This represents a legal problem because in Brazil fossils are federal property since 1942, their extraction and export is regulated and their commerce is banned. Moreover, since 1990, research by foreign parties requires collaboration with local institutions and the return of all exported holotypes. The new Araripe dinosaur "*Ubirajara jubatus*" attracted considerable controversy. Its study did not include local authors nor reported required permits and the fossil was repositated at the Karlsruhe Natural History Museum (SMNK), in Germany. Brazilian scientists questioned its legality and ethics, and the case gained media publicity. The in press paper was temporarily removed shortly after its release and finally withdrawn in September 2021 due to "lack of evidence regarding its legal provenance". Brazilian scientists took to social media to quickly question its legality and ethics, and with the use of the hashtag #UbirajaraBelongsToBR this case gained media attention. The hashtag trended on Twitter between December 2020 and January 2021 amid the in press paper and its temporal removal, and trended again in September 2021, after the SMNK declared it would not repatriate the fossil. #UbirajaraBelongsToBR gathered researchers, fossil enthusiasts, palaeoartists and children, and was frequently associated with #DecoloniseScience. The protests attracted attention, likely generating pressure on the journal's decision. Social media mobilization can play an important role against fossil smuggling and help build more ethical and collaborative research.



CONSEQUENCES OF THE K/PG MASS EXTINCTION EVENT ON CHONDRICHTHYAN EVOLUTION IN THE TETHYAN REALM

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Keywords

Cretaceous, Palaeocene, diversity, cartilaginous fishes



The driving forces and the impact on diversity patterns of mass-extinction events are one of the key-questions in palaeontology. Although the K/Pg extinction event is not considered as the most severe, this last extinction has enormously influenced the evolution leading to the modern biota. Despite numerous studies dealing with the most prominent affected, the non-avian dinosaurs, little is known about the consequences on chondrichthyes (cartilaginous fishes) immediately after the ecological disaster. To date, there is only one study that has sampled a continuous sequence across an accessible boundary in the boreal realm (Denmark) in meaningful quantities. Interestingly, this study indicates a massive drop in diversity prior to the K/Pg extinction event and a rather short recovery time for this group. Here we report on the first high resolution sampling of cartilaginous fish teeth across a deep-water sedimentary succession in the Tethyan realm of Austria. The precise sampling of nine horizons, which represents in total about 1.300kg of sediment, will enable reliable snapshots for unlocking the magnitude of demise on deep-water inhabitants and the time span for faunal recovery. To provide a deeper insight into environmental changes and their influence on the Tethyan marine biota during this crucial time, we use further proxies, such as geophysics and isotope analysis, to reach the most meaningful interpretation. The synopsis of geological, sedimentological, and paleontological data allows a well-founded data base for faunistic comparisons with the reported assemblage of the boreal realm in consideration of different environmental settings.



TEACHING OF BRACHIOPODS AND BIVALVES ANATOMICAL ADAPTATIONS TO THE ENVIRONMENT FROM AN INCLUSIVE PERSPECTIVE

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Keywords

Palaeontology, Invertebrates, Haptic materials, High School, Motivation



The study of invertebrates is one of the aspects that is dealt within the first years of secondary education in Spain. Aspects related to their classification and characteristics of anatomy and physiology in some of the most important groups are studied. However, only occasionally do textbooks give an integrated view of biology and geology, as far as the environmental adaptations of each of these groups are concerned. Even rarer is the use of multisensory materials to make these topics accessible to students with functional diversity. With the aim to show the adaptations to the environment from an interdisciplinary point of view between biology and geology, and with an inclusive perspective, several invertebrates adaptations workshops have been implemented for secondary school students. In these workshops, fossils, recent specimens, foam models (e.g. brachiopod commissure shapes) and graphic material have been used to show anatomical adaptations of invertebrates. In this work, we show the activity concerning two groups, bivalves and brachiopods. Aspects such as the development of “wings”, ornamentation (thorns, domes, spines...) or the relationships between shell shape (elongated, rounded, flattened...) and the way of life have been exposed. The first results show higher scores in post-activity tests compared to pre-activity ones. Also, a great motivation for the use of haptic materials and for the multidisciplinary approach to these aspects it has been observed. In general, brachiopods are considerably less known than bivalves, and only few students know that these animals still exist, and their importance related to palaeoenvironmental or sedimentary studies.



A COMPLETE VIEW ON THE PALAEOLOGY OF PORTUGAL

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Keywords

Cenozoic, Mesozoic, Palaeozoic, fossils, Portugal



Whenever a new study begins, it is essential to know what has been done previously. Although Portugal has more than two centuries of research on Palaeontology, not many publications feature bibliographic reviews on the subject. The current project aims to disclose all fossil occurrences reported in the country by compiling the available data and creating a free access compendium. Three main data types will be gathered and organized through an exhaustive search and analysis of publications featuring fossil material found in the country. These data sets include references to other scientific publications, listed taxa, and the occurrences recorded for each of them. Through the statistical analysis, we aim to gather information on the taxonomic repartition, the total material known per taxon, and a listing of the species first described in Portugal. We also intend to estimate the scientific production per year, to create a checklist of authors, to emphasize the less studied groups, to list the researched outcrops, the current deposits of the collections, and the location of type materials. We aim to analyze the geographic distribution of outcrops, material, and taxa, with data visualization, while identifying palaeoenvironments, faunal and botanical associations, and areas with potential palaeontological material. Although this project is only in its early stages, from the 677 listed publications, we have so far completed the analysis of 9.60%. A total of 17619 fossils were attributed to the reviewed 318 species and superspecific identifications. Over 150 Portuguese outcrops were identified, but many of these are currently inaccessible.



PALAEOARTISTIC EXPERIENCE IN CREATING 3D MODELS OF EXTINCT ANIMALS FOR FILM

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Keywords

3D modeling, palaeoart, documentary, Krasiejów, CGI



We present our experience in working on computer models of extinct animals for the project of the first computer-animated palaeontological document about animals inhabiting Poland in the late Triassic. By now, species models have been created: *Parasuchus agnetis*, *Silesaurus opolensis* and *Stagonolepis olenkae*. To generate these models we used **Zbrush**, **Substance Painter** and **Blender**. There are plans to make at least models of species: *Polonosuchus silesiacus*, *Metoposaurus krasiejowensis*, and *Cyclotosaurus intermedius*. The goal for the film called “Prehistoric reptiles of Poland” is to focus on the fossil vertebrates from Upper Triassic strata at Krasiejów (southwest Poland). The film is supposed to be an palaeoartistic imitation of a nature film, with storytelling in Walking with Dinosaurs style, targeting families and people interested in prehistory, nature and science. Because we specialize in palaeoart and we are the initiators of the project, it will be different from the other similar productions in educational qualities and scientific accuracy of the reconstructed taxa.



NAMES DO COUNT – WHY REVISIONS ARE CRUCIAL FOR DATA ANALYSIS IN PALEONTOLOGY

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Keywords

taxonomy, biodiversity, databases, revision



Great efforts have been devoted during the last decades to digitalize paleontological data. These projects utilize literature data within a standardized taxonomic and stratigraphic frame and aim at detecting changes in diversity patterns on various temporal and spatial scales. Whilst this approach clearly has great potential, it carries the danger of producing “pseudo-revisions” by automated new combinations of higher systematic ranks. Moreover, we doubt that this approach can be used seriously for species-level analysis without careful and time-consuming revision of the input data. An example are our revisions of the Miocene gastropod families Cancellariidae, Columbellidae, Conidae, Costellariidae, Mitridae and Turritellidae from the Paratethys Sea. These revisions have revealed major problems in previous generic placements resulting in up to 80% of species ending up in new combinations. In some families, species-level identifications of putatively wide-spread species, seemingly known also from the Mediterranean Sea and the northeastern Atlantic, turned out to be incorrect. Prior to these Paratethyan revisions, relationships with the northeastern Atlantic would have been considered high. However, following these revisions, such relationships were found to be almost non-existent. Similarly, the apparent relationship with stratigraphically younger Pliocene faunas decreased drastically after revision. Furthermore, the literature data would have completely failed to detect the faunistic relation between Paratethyan faunas and those of the tropical eastern Atlantic. Finally, a survey of species identifications in Paratethyan literature shows that up to 80% of the species identifications have been wrong in families such as the Conidae and Turritellidae. Thus, putting these data uncritically into databases will produce more noise than signal.



LINKING THE BEHAVIORS AND BURROWS OF CARNIVOROUS SOIL ARTHROPODS: APPLICATIONS TO CONTINENTAL ICHNOFOSSILS

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Keywords

trace fossils, neoichnology, experimental, terrestrial



Predatory arthropods are known from terrestrial environments since the Silurian. Many of these animals have acquired behavioral adaptations suited for soil environments, including permanently fossorial habits. Ichnofossils are common in Paleozoic paleosols, yet most are of uncertain origin and may record a hidden diversity of predatory arthropods. These ichnofossils are especially important given the relatively poor preservation potential of soil invertebrates in the environments they inhabit. In order to better understand the use and morphology of predatory soil arthropod burrows, laboratory experiments were conducted with spiders and centipedes. Specimens were placed in narrow, sediment-filled terrariums for 7–30 days. The animals were observed continuously using digital recordings to monitor their behaviors and use of their burrows. Open burrows were cast and described qualitatively and quantitatively. The animals burrowed using various techniques including intrusion, excavation, and backfilling over short periods of time (1–3 days). Some burrows were occupied for short intervals (2–5 days), whereas others were permanently occupied. Burrows ranged from simple vertical shafts to complex networks that served as temporary to permanent dwellings and most were used as sites for ambush predation or as prey traps. Distinct burrow features were linked to predatory activities; including vertical shafts, U-shaped tunnels, multiple surface openings, and expanded chambers. Predatory arthropods produce unique burrows that can be linked to specific behaviors. These data can be applied to continental ichnofossils to improve our understanding of the evolution of terrestrial predatory arthropods, their distribution through time, and interpretations of the paleoecology of ancient soil ecosystems.



MORPHOLOGICAL FEATURES AND ONTOGENY OF *DICKINSONIA COSTATA* OF THE WHITE SEA AREA (RUSSIA)

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Keywords

Dickinsonia, Ediacaran, Vendian, Metazoa



Dickinsonia is one of the most recognizable genera of the late Precambrian Metazoa. Numerous remains of *Dickinsonia* were found in the Ediacaran of South Australia and the Vendian of the White Sea area. Its low flat body was divided into numerous “half-segments” (isomers) rapidly decreasing in size at the posterior end, where its generative zone was located. At the anterior end, there was a specialized lobe, usually small in size. The type species is *D. costata*, characterized by a wide-oval body outline and a relatively small number of large isomers outside the generative zone. The White Sea material shows that *D. costata* had an isomeric structure typical of *Dickinsonia*, with a characteristic displacement of the rows of isomers near the body axis. For the first time, feeding traces of *D. costata* are revealed from the White Sea material, and the morphology of the putative food-collecting pockets is described. The ontogenetic series of *D. costata* is traced from very small individuals (1–1.2 mm in length, presumably undifferentiated) to very large ones (390 mm with about 225 pairs of isomers). It is impossible to determine at what stage of ontogeny food-collecting pockets began to function, but the smallest feeding traces were found in an individual with a body length of 5.8 mm and 14 pairs of isomers. *D. costata*'s overall growth was allometric (shape and relative size of the anterior lobe, extent of differentiation, and proportions of the body were changing) and indeterminate. The study was supported by RSF grant 19-14-00346.



CURVATURE AND SHELL SIZE OF GIGANTOPRODUCTID BRACHIOPODS: A TAXONOMICAL KEY

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Keywords

shell spiral, taxonomy, brachiopod morphology, morphometry



Gigantoproductid brachiopods (Viséan - Serpukhovian) exhibit shells with a large morphological variability albeit few taxonomical characters and they usually are obliterated during diagenesis. Traditionally, variation in shell size and outline curvature have been used for qualitative differentiation among taxa. Gigantoproductid shells show a high degree of homeomorphism between some genera, although have significant differences in shell length and thickness. Recent studies have quantified systematically curvature variation from digitized valves of brachiopods, detecting deviations during ontogeny. In order to evaluate the shell curvature, length and thickness as taxonomical characters in gigantoproductids, these parameters have been analyzed in 37 ventral valves of 5 genera from Viséan–Serpukhovian of Spain, France and Morocco. Shells were cut along the plane of symmetry, producing two identical halves, which were polished, and lastly scanned. We digitized the outlines of the ventral valves and fitted them to a logarithmic spiral to quantify the curvature, deviations from a logarithmic spiral, and the distance difference from the beginning of the measured umbo respect to the umbo of a theoretical spiral. The studied valves show a large variation in length, thickness, and curvature among the studied genera, indicating the taxonomic significance of the selected traits. Valve length and thickness are positively correlated because the longest genera have the thickest shells, but curvature is independent of valve size. This novel method is a robust tool to differentiate gigantoproductid genera using ventral valves and has great potential for taxonomic delimitation in other brachiopod groups.



3D MODELLING METHODOLOGIES FOR PLANT FOSSILS FROM THE SOUTH OF TENERIFE (CANARY ISLANDS)

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Keywords

plant fossils, Canary Islands, 3D models, photogrammetry, protocols

The studies in which 3D technologies are applied in research or education in Palaeobotany are scarce, despite constituting a powerful tool in identifying plant fossils. In the present work, different methodologies to obtain 3D models of plant fossils with different typologies have been tested using the photogrammetry technique. The main objective is to determine which methodology obtains the best models to be used in outreach and research. For this, fossil remains of leaf, stem and flower impressions found in the Mid-Pleistocene fossil site of Bandas del Sur (Tenerife, Canary Islands), have been used. Two trials were carried out, one in which a single rock was modelled, and another in which five different rocks were used, all with different characteristics. In the first trial, the models were constructed using manual and turntable photogrammetry techniques, while in the second, only the latter was used. Several protocols were followed, varying different parameters (such as the type of background, number of pictures per angle, aperture of the diaphragm, etc.) in each of them, and introducing the photographs in the Agisoft PhotoScan software. Finally, 14 models were obtained, which were evaluated and classified based on the number of observable details. The results show that more than half of the models obtained are of high, very high or excellent quality and that the most appropriate method for modelling the specimens is the turntable photogrammetry.





THE FOSSIL VERTEBRATES OF GREECE: A STATE-OF-THE-ART

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Keywords

Palaeontology, Fishes, Reptiles, Mammals, Island Endemics

The sedimentary basins of Greece contain an important record of fossil vertebrates that has been known and studied for nearly two centuries. Here, we present our collective effort to review and summarize this fossil record. A combination of our original research and previously published records permits the complete reassessment of the identified vertebrate species in Greece, per family or clade. A historical analysis suggests the division of the vertebrate paleontological research in Greece into three principal stages: the Early Stage until the end of World War II, the Intermediate Stage roughly until the end of the 20th century (1980s–2010s depending on the taxonomic group), and the Modern Stage since then. Nearly 900 primary publications dealing specifically with Greek fossils have been published so far, and almost half of them appeared during the past two decades; the complete number of all references is much greater. Based on our reassessment, more than 1100 different vertebrate species are identified in more than 500 fossiliferous localities, spanning from the Silurian to the latest Pleistocene/Holocene; the vast majority is from the Neogene–Quaternary. At least 254 of these valid species were new to science, and named based on unique Greek fossils. Many additional taxa have been established based on Greek material, but they are currently treated either as subjectively invalid or unavailable. Presently, the active Greek palaeontological community is more populous and diverse than ever before. However, looking towards the future, the continuation of palaeontological research in Greece requires serious investment and fundamental structural changes.



FOSSILS AS DATA MODELS

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Keywords

taphonomy, fossil extraction, fossil preparation, fossil preservation, data model



Philosophers of science have recently used “data models” to describe processed, rather than raw, data. Processing data requires making decisions about how to portray the data, which data to include, how to interpolate the data, and more. The “data models” concept can be used by scientists to reflect on how these decisions affect their data products and the conclusions drawn. Sometimes, data processing involves altering physical objects. Fossil preparation is a standard case: fossil preparators need to use background understanding of taphonomy, lithology, and more to decide how to treat the extracted material and convert it into something usable. I will expand on the analysis of prepared fossils as data models to include the techniques that fossil preparators use but also other decisions and processes that shape the fossil specimens that are used by palaeontologists. There are natural “selection” procedures that determine which organisms fossilize, which parts of these organisms fossilize, whether these fossils survive until the present-day, whether these fossils are in accessible locations; there are decisions made by fossil preparators about which fossils are worth preparing, how to perform the extraction; and there are decisions about how to preserve these fossils to best serve the purposes of scientists. I will argue that it is important to make distinctions between the different kinds of “biases” that result in a prepared fossil – imposed by nature, by the norms of a profession, and by individual decision makers – but also to conceptualize these all as factors that affect the ultimate data model.

Virtual Field Trips

ANAGA PALAEO-PARK



**FOSSIL
LAGERSTÄTTEN
OF HENG-CHUNG
PENINSULA**

**A SMALL
TOWN WITH
FOSSILIFEROUS
STRATA LOCATED
NEAR A MAJOR
FAULT ZONE IN
CENTRAL TAIWAN**



ANAGA PALAEOPARK

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Keywords

Palaeontological heritage, Canary Island, Biodiversity Conservation, protection figure, volcanic islands

Video made by F. Gascó-Lluna



The Canary Islands are an Atlantic archipelago known for its high number of endemic species of fauna and flora. Its fossil record is exceptional in nature and greatly relevant due to its conservation in a geological and palaeobiological context of recent oceanic and (active) volcanic islands (Neogene and Quaternary). The paleontology area of the University of La Laguna with the financing of Fundación CajaCanarias and Fundación Bancaria “La Caixa” (20174REC20) is promoting the creation of a paleopark as a versatile protection figure, to preserve in situ the unique palaeontological information found in the palaeontological sites located in the Macizo de Anaga Biosphere Reserve (Tenerife, Canary Islands). Anaga’s fossil record is formed by Quaternary marine (Iguete de San Andrés) and terrestrial (Milán) fossil sites with a great socio-cultural, educational, socio-touristic and scientific potential (presence of zone fossils and important palaeobiological, taphonomic, geological, palaeoclimatological and geomorphological information). With the Anaga PaleoPark initiative, we envisage to count on a palaeontological reserve with geohistorical data really useful in Biodiversity Conservation. This Paleopark will contribute to the development of the Macizo de Anaga Biosphere Reserve Action Plan, reassessing the palaeontological resources and encouraging economic and human development of the area sustainable from a sociocultural point of view, by creating new cultural resources with 3D methodologies. We invite you all to come to our wonderful island and visit our rich Paleontological and Natural Heritage.



FOSSIL LAGERSTÄTTEN OF HENG-CHUNG PENINSULA

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Keywords

Cenozoic paleontology, Quaternary geology, fossil concretions, paleobotany, passive margin settings, active tectonic settings



Taiwan is situated in the collision zone of Eurasia Plate and Philippine Sea Plate. Located in the southernmost tip of Taiwan, Heng-Chung Peninsula represents the most recently emergent segment of the Taiwan arc-continent collision system, consisting of young foreland basin deposits to the west and Miocene accretionary prism strata to the east. Most of the fossils here were found in Western Heng-Chung Tableland, in where fossils are scattered in the creek banks. They are eroded from the Szekou Formation, dating back to the late Pleistocene (90–140 kya). Szekou Formation comprises mainly muddy sandstones to mudstones in shallow marine to lagoon settings. The strata yield a wide variety of fossils, including mollusks (up to 173 species identified), crabs, urchins and mammals (such as deer and rhinos). The research of these fossil species can be traced back to the Japanese colonial period (1895–1945) and yields significant impacts on paleontology of Taiwan. In this video, we'll present a detailed introduction on both the general geology and fossiliferous strata of Heng-Chung Peninsula. Representative fossil specimens, including fossil floras from Lilongshan Formation (Miocene), fossil echinoids from Heng-Chung Limestone and vertebrate fossils from Szekou Formation, are discussed.





A SMALL TOWN WITH FOSSILIFEROUS STRATA LOCATED NEAR A MAJOR FAULT ZONE IN CENTRAL TAIWAN

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Shigang is a small town in central Taiwan, which is situated in an active collision zone between Eurasian Plate and Philippine Sea Plate. In this area, continuous outcrop exposures along the Dajia River yield marine strata ranging from Late Miocene to Pleistocene. These strata contain a great diversity of fossils, including mollusks, crabs, sea urchins, turtle shells and whale bones. These precious fossils make Shigang become one of the most famous towns for fossil hunting in Taiwan. On September 21, 1999, a 7.3 magnitude earthquake devastated the central part of Taiwan. The earthquake caused 2,456 people dead, more than 10 thousands people injured and Shigang river dam was severely damaged. The catastrophe casted a shadow on local residents. Fault rupture uplifted a large part of riverbank and exposed the fossiliferous strata. Thus, many important discoveries, such as the vertebrate findings, are made after the earthquake. The local residents have recovered from the terrible disaster since and the fossils have become an indispensable part of local culture. In this video we are honored to interview the famous fossil collector “Papa Fossil”—Tien-De Li who spent almost 60 years on fossil collecting and has been one of important witnesses of the 921 earthquake. In 2019, he donated his fossil collection to help establish the Tien-De-Da-Yuan Museum located inside of the Shijiao Elementary School. The museum holds a collection of local fossils as witnesses of the 921 earthquake and serves a local center for promoting the education of paleontology.



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