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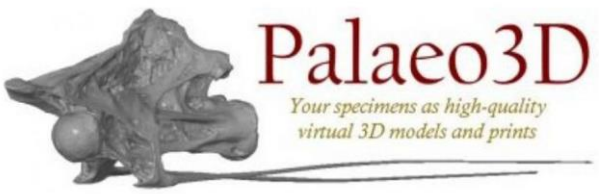

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ABOUT THE LOGO

The logo is realized by MARZIO MEREGGIA. The logo of the 18th conference of the EAVP is set on the concept of speed – the rapid digital connection allowed people to nullify distances and keep connection, even in this difficult historical moment.

Therefore, the EAVP is carried by a generic dromaeosauridae which, running on the world, connects everyone. This animal has been chosen because of its simple and elegant shape, and the feeling of speed and efficiency it conveys. The dromaeosauridae is the symbol of an ancient nature which continues to connect all enthusiasts and researchers, tearing down the geographical distances that keep minds apart.

How to cite an abstract from this volume

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Welcome to the 18th conference of the EAVP, the first online meeting of our association.

The pandemic emergency made it impossible to organize the in-person meeting in Benevento as we all had hoped. However, we couldn't miss another EAVP meeting.

Therefore, this year we are meeting online, trying to make the experience the closest to the in-person meeting possible, in order to offer the delegates the opportunity to share knowledge, build new networks and reinforce the old ones.

We have received 137 communications, with more than 150 delegates from 24 countries. All the abstracts have passed a peer review process and are part of this special volume of *Palaeovertebrata*, the official journal of the EAVP.

This year we are also offering a variety of workshops, roundtables and symposia on different topics. These include the annual "Pride EAVP: An LGBTQ+ Roundtable" and "Women in Palaeontology Roundtable Discussion", together with the workshops on "Gendered Perspective in Palaeontological Research: from Definition to Action", "International Palaeontology Education: Virtual Teaching and Real-World Learning", "Stepping out of Academia: Why, When and How?", "Introduction to Hypothesis Testing in Statistics", "The Early-Middle Pleistocene Transition: Marked Mammal Turnover and Ecosystem Dynamic" (included in the early event for the XXI INQUA Congress in Rome 2023, "A Mediterranean Perspective on Quaternary Sciences").

To conclude, we are hosting two symposia on "Palaeoart: Diversity on and behind the Canvas" and "3D fossils, Robotic and Experimental Palaeontology".

We wish you all a happy and productive meeting. And see you in Benevento next year!

The Host Committee

MATTEO BELVEDERE, VERONICA DÍEZ DÍAZ, RAFFAELE SARDELLA

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SUTURES AND SKULL MECHANICS IN THE 'ANAPSID' *CAPTORHINUS AGUTI* – WHAT ARE THEIR IMPLICATIONS FOR EARLY AMNIOTE EVOLUTION?

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***Keywords**: Functional morphology, Biomechanics, Network analysis, Permian, Reptilia*

Ancestrally, the temporal region in the tetrapod skull was completely covered by dermal bone. This 'anapsid' condition was probably still present in the ancestral amniote; however, temporal openings like fenestrae or emarginations evolved at least twice independently in the subsequent early amniote radiations and have been retained, modified, and sometimes lost again in the branches leading to mammals and reptiles. Yet, the functional backgrounds for the initial evolution of these openings are yet to be understood. They have been hypothesized to be bound to changes in jaw muscle attachment and responses to cranial forces. However, even in extant 'anapsids' like sea turtles the completely covered temporal region is a secondary evolution derived from ancestors with an emarginated cranium. Hence, they are no perfect analogue for the functional morphology in ancestral amniotes. Here, we use micro-computed tomography of a skull of the early Permian stem-reptile *Captorhinus aguti* as a model for an ancestral 'anapsid'. We describe in detail its skull sutures and discuss the cranial mechanics, as well as the likely arrangement of the jaw adductor musculature and how this would affect cranial force distribution. We perform a network analysis on the configuration of the cranial bones and combine these results with the suture morphology and assumed muscle arrangement to predict the most likely loci for the development of temporal openings. If the initial evolution of temporal openings was related to force distribution, we expect our predictions to match the observed positions of temporal openings in other early amniotes.

INTEGRATIVELY APPROACHING ECOMORPHOLOGICAL CONVERGENCE IN SLOW ARBOREAL XENARTHRANS

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Keywords: *convergent evolution, phylogenetic comparative methods, 3D geometric morphometrics, cross-sectional geometry, trabecular architecture*

Similar morphotypes that evolved in taxa which independently acquired the same lifestyle is the ideal case of ecomorphological convergence. The mammalian taxon Xenarthra is nowadays represented by 'tree-sloths', anteaters and armadillos. The clade is considered a suitable case to study convergence due to its astonishing ecological diversity including instances of convergent evolution. However, the latter were often identified qualitatively and/or examining a limited number of taxa and traits. Here we tackle slow arboreal ecology, previously considered exclusive of the two genera of 'tree-sloths' within xenarthrans but recently ascribed to the silky anteater as well. Using phylogenetic comparative methods, morphological convergence was quantified on a set of functional humeral and femoral traits coming from different sources, in slow arboreal and non-slow arboreal xenarthrans (including extinct sloths). Through microCT-scanning, we collected external shape, diaphyseal and epiphyseal internal structure data, exploiting 3D geometric morphometrics, cross-sectional geometry and trabecular analysis, respectively. With an integrative approach, traits preliminarily found as correlated with ecology were tested for convergence. The humeral phenotype of slow arboreal xenarthrans exhibits incomplete convergence: 'tree sloths' show a strong convergence but the silky anteater, while being more similar to 'tree sloths' than other anteaters, retains a unique morphotype. Varying degrees of ecological similarity and/or specific inherited constrains may potentially explain incomplete convergence. Conversely, the femoral phenotype of all slow arboreal xenarthrans exhibits a high degree of ecomorphological convergence. This work uncovered previously unidentified patterns of convergence through a multi-pronged approach. It may help to shed light on complex patterns behind convergent evolution.

ARE FOSSILS ENOUGH? PALEONTOLOGICAL TOURISM BASED ON LOCAL DISCOVERIES

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***Keywords**: theme parks, dinopark, paleontological tourism*

Among the wider audience, dinosaurs (and other Mesozoic tetrapods) are the most popular extinct organisms. Every discovery of new (especially large) species is mentioned in national and international media, thus local fossil discoveries might be a good basis for the development of local tourism. Statistical data, the number of Internet searches and a short survey might enable the determination of whether or not small villages and towns where Mesozoic reptiles remains were found under certain conditions can compete with larger conurbations with sometimes more numerous tourist attractions. To determine this, several sites from Poland, Portugal and the USA with dinosaur fossils were analyzed. The occurrence of additional tourist infrastructure (i.e. dinosaur theme parks) turned out to be an important factor for the development of tourism based on dinosaur fossil remains.

CROCODYLUS ANTHROPOPHAGUS FROM OLDUVAI DK LOCALITY (NORTHERN TANZANIA)

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Keywords*: Olduvai Gorge, crocodile, Tanzania, Early Pleistocene, Crocodylidae*

In this study, we describe a new crocodile skull from the world-renowned palaeontological and archaeological site of Olduvai Gorge (Tanzania). The fossil, discovered and collected in 2016 during an annular solar eclipse and therefore nicknamed "Black Sun," was found in a new trench excavated by the THOR (Tanzania Human Origins Research) team at site DK East, located about 500 m east from the Leakey DK trenches. The site is one of the most famous in Olduvai Gorge, being among the chronologically oldest and earliest studied by Mary Leakey. It yielded hundreds of stone tools

and faunal remains over the decades, including some outstanding hominin fossils such as the nearly complete cranium, OH 24, referred to *Homo habilis*. Palaeobotanical and sedimentological data suggest that the paleoenvironment at DK was a marginal lacustrine wetland characterized by abundant grasses and many other plants such as papyrus. This type of environment was suitable for crocodiles.

The morphology of the Black Sun cranium allows referral to *Crocodylus anthropophagus*, a Pleistocene species found only in Olduvai, in layers spanning from Bed I to Bed IV (~1.8-0.9 Ma). Black Sun represents the earliest (~1.9 Ma) cranial material of *C. anthropophagus* discovered to date. Thanks to its good preservation, the specimen serves as the basis of a new phylogenetic analysis which confirms a strict relationship between *C. anthropophagus* and *Crocodylus thorbjarnarsoni* from the Plio-Pleistocene of Kenya. It offers further intriguing insights on a possible African origin of *Crocodylus*.

VULPES PILUM MUTAT NON MORES: OVERVIEW OF *VULPES-ALOPECOIDES*-LIKE FOXES FROM THE PLIO-PLEISTOCENE OF EURASIA

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***Keywords**:* Vulpes*, ecology, Pleistocene, Eurasia*

Extant red fox, *Vulpes vulpes* (Linnaeus, 1757), is a small- to medium-sized mesocarnivorous canid whose earliest records are reported to the early Middle Pleistocene in Europe. Its origin has always been related to the Early Pleistocene European *Vulpes alopecoides* (Del Campana, 1913), for the numerous comparable morphological and morphometric features. Despite the available knowledge on its characteristics, at present no ecological or phylogenetic insights have been given for this species, particularly regarding the possible relationships with Pliocene Asian species, *Vulpes beihaiensis* Qiu & Tedford, 1990 from Yushe Basin (ca. 3.5-3.0 Ma; China) and *Vulpes galatica* Ginsburg, 1998 from Çalta-1 (4.0 Ma; Turkey).

Here we review the record of *V. alopecoides*-like foxes from Eurasia. The sample analyzed comprises European, Middle-Eastern and Asian records and span from the Pliocene until the beginning of the Middle Pleistocene. From our analyses several orders of outcomes are discussed. The revision of the fox material from Çalta-1, in sights of its possible affinities with other Plio-Pleistocene foxes and particularly to *V. alopecoides* and *V. vulpes* is taken into consideration. We compare the degree of intraspecific variability between the extant *V. vulpes* and its plausible ancestor *V. alopecoides*. To these, we add one of the earliest European record of the red fox and consider its morphology and implication in the biogeographic context of Europe. Lastly, we add some consideration on the ecological preferences of these small-sized foxes of Eurasia.

A NEW QUANTITATIVE METHOD FOR DENTAL MESOWEAR ANALYSIS ON *APODEMUS SYLVATICUS* (RODENTIA, MURINAE)

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***Keywords**: small mammals, wood mouse, Middle Pleistocene, Iberian Peninsula.*

Dental mesowear is a technique used to reconstruct the dietary traits of extinct species. It is based on the occlusal relief and shape of the teeth. Mesowear develops throughout the animal's life and reflects the diet over the last years of life. For this study we have selected a Murinae, *Apodemus sylvaticus*. This taxon is omnivorous and its dental morphology is bunodont. The analyzed sample belongs to the Middle Pleistocene small mammals from Cova dels Xaragalls (Tarragona, Spain). There are many publications in which this method has been applied to ungulates and humans, but there are only few studies in rodents. The original method used in ungulates was modified to adapt it for the analysis of small mammals. This modified method provides qualitative and quantitative information.

Our sample consists of first lower molars (m1) of *Apodemus sylvaticus*. We have analyzed the occlusal relief and occlusal morphology by using Digital Microscope. Specifically, we measured the height of m1 from the tartar line to the highest point of the crown, at three points, from the proximal to the distal part of the labial view. Moreover, we also measured the morphology in occlusal view.

The results indicate significant differences between individuals. Some of them have more wear in the anterior part and others in the posterior part, despite the fact that due to their chewing system this wear should be more homogeneous. These differences are more related to the degree of abrasion from their diet. These dietary changes could be due to seasonal paleoenvironmental changes.

THE LIMPING HADROSAUR FROM THE FAR EAST

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***Keywords**: fracture; dinosaurs; Maastrichtian; Lambeosaurinae; paleopathology*

Bone fractures are the most common type of injuries preserved in the fossil record. Poor healing of deep lesions could lead to infection and misalignment of the fracture parts, causing the animal to limp and jeopardize their survival. A wide variety of fossilized fractures have been identified in dinosaur remains, and the type of bone response can provide information about their resilience and ability to survive even major traumatic events. Here we describe a pathological ulna in the lambeosaurine dinosaur *Amurosaurus riabinini*, from the Udurchukan Formation (Maastrichtian, Upper Cretaceous) of Blagoveschensk (Amur Region, Russia). Its distal region is hypertrophied and swollen, and its distal articular surface is engulfed within this callus formation. CT-scanning identified an oblique fracture resulting from an impact fracture. No signs of infection were detected, and the bone was still healing prior to the moment of death. The impact is referrable to as a pilon fracture, which usually results in a shortened bone due to compression of the longitudinal axis. Furthermore, misalignment of the fracture parts as a result of the ongoing healing process appears to have resulted in a malunion of the two fragments. During locomotion, the wrist might have suffered from continuous weight-bearing pressure that placed stress upon the fracture site and caused the animal pain. This would have physically impaired its locomotory ability, forcing it to walk on three legs, while limping on the fourth.

NEW MID TO LATE PLEISTOCENE FAUNA AND LITHICS FROM THE MIDDLE ATBARA, SUDAN

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***Keywords**: Pleistocene, Africa, Nile Basin, Vertebrates, Paleolithic*

Fieldwork in eastern Sudan since 2018 has resulted in the recovery of a diverse vertebrate fauna from the middle stretches of the Atbara River, the last major tributary of the Nile before it reaches the Mediterranean. Previous work had characterized the geology and identified fossil and Paleolithic remains, but a detailed understanding of the fauna and geochronology remained lacking. New high-density OSL and ^{14}C dating indicate a chronology spanning ~200 to ~15 ka. One new site appears to be ~450 ka in age, which could make it the oldest dated vertebrate fossil site from the entire Cenozoic of Sudan. The new fossil collection comprises over 500 specimens representing ~30 species. These are mostly extant taxa, providing an opportunity to examine sub-specific (morphoclinal) variations between North African and East African populations and to reconcile the fossil record with extant molecular phylogeography. Extinct forms include *Palaeoloxodon ("Elephas") jolensis*, *Kolpochoerus majus*, *Syncerus antiquus,* and a hipparionine equid. Hominins are represented by robust postcranial remains likely attributable to *Homo sapiens*. Excavation of a new Paleolithic site dated to ~150 ka reveals the late persistence of Acheulean technology in eastern Sudan at a time when it had been replaced by the Middle Stone Age in many other parts of the continent. Paleosol carbonates indicate diverse grassland-woodland habitats, and sedimentary analyses indicate a complex fluvial history influenced by Pleistocene climate and regional tectonics. The Middle Atbara project is opening up a new regional window onto Pleistocene biogeographic regionalization and the emergence of modern African ecosystems.

FIRST SKELETAL REMAINS OF THE ENIGMATIC BASAL DIAPSID *HELVETICOSAURUS* FROM ITALY (BESANO FORMATION, MIDDLE TRIASSIC, MONTE SAN GIORGIO UNESCO WHL)

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Keywords: Helveticosaurus*, Diapsida, Monte San Giorgio, Besano Formation, Middle Triassic*

In this communication, we introduce the first unequivocal remains of *Helveticosaurus* from Italian outcrops of the Besano Formation. The fossils consist of large bones embedded in three slabs of laminated carbon-rich dolomite, collected in 1952 from the waste material of the Piodelle-Selva Bella mines, near Besano (Varese). The fossiliferous slabs are deposited in the collections of the Museo di Storia Naturale di Milano (MSNM) with two different catalog numbers (MSNM V927a,b and MSNM V928). An associated ammonoid suggests that the three slabs come from the ammonoid-bearing layers of the Besano Formation, *R. reizti* or *N. secedensis* zone (~ 242 MA). *Helveticosaurus zollingeri* was described by Peyer in 1955 on a specimen collected in 1935 from the Grenzbitumenzone (= Besano Formation) of Cava Tre Fontane (Canton Ticino, Switzerland). So far, the only Italian record of *Helveticosaurus* is represented by a single dubious tooth.

MSNM V927 contains at least 9 proximodorsal vertebrae and 9 ribs, as well as the distal end of the left scapula and fragments of several gastralia scattered under the ribs; MSNM V928 includes at least 10 posterodorsal ribs and at least 9 fragmentary gastralia. All bones are comparable in size to those of the *Helveticosaurus zollingeri* holotype (PIMUZ T 4352); the characters detected render the MSNM specimen more similar to *Helveticosaurus* than to any other taxon and therefore we assign it to *Helveticosaurus* cfr. *zollingeri*. This new finding is a consequence and part of the revision of the Besano fauna of the MSNM collections. The rediscovery of this unique specimen further encourages a revision of the Besano fossils that are housed in the historical collections of natural history museums.

TAPHONOMY AND MORPHOLOGY OF A BALAENID SKELETON FROM THE PLIOCENE OF REGGIO EMILIA

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***Keywords**: Balaenidae, Mysticeti, Phylogeny, Pliocene, Taphonomy*

A partially-articulated balaenid skeleton from the Pliocene of Emilia Romagna (northern Italy) is described and compared to the published record of Balaenidae worldwide. The specimen includes two mandibular rami, cervical, thoracic and parts of the lumbar and caudal vertebrae, part of a forelimb and the pelvis. The ribcage is still articulated but the lumbar and caudal vertebrae are scattered and lack the original life articulation. Shark teeth were found in close association to the skeleton. The skull is absent. Comparative morphology of the cervical vertebrae and of the dentary supports the inclusion of the specimen within Balaenidae (right and bowhead whales). A phylogenetic analysis showed that the specimen is closely related to the Pliocene species *Archeobalaena dosanko* from Japan and supports the inclusion of the specimen in an early-diverging balaenid branch that is the sister group of the crown Balaenidae including the extant *Balaena* and *Eubalaena* and the fossil *Balaenula*. The size of this whale was reconstructed based on new regression equations and an extended dataset of living and fossil balaenids; based on this analysis, the total body length was estimated in *c.* 11 m and the weight was estimated in *c.* 10.5 tons.

A BALAENOPTERID SKELETON FROM THE PLIOCENE OF PIEDMONT: A PRELIMINARY ANALYSIS

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***Keywords**: Mysticeti, Phylogeny, Pliocene, Taphonomy, Piedmont,*

A partial balaenopterid skeleton was discovered in the Argille Azzurre Formation (early Pliocene) near the village of Chiusano, Piedmont, north-west Italy in 2008. The specimen includes a partial skull, five thoracic vertebrae, a single ulna and several ribs. The supraoccipital shows a strong transverse compression and an acute anterior border, the supraorbital process of the frontal is abruptly depressed from the interorbital region of the frontal and is wide and flat, the temporal crest projects laterally covering the medial wall of the temporal fossa in dorsal view. The five thoracic vertebrae are in close proximity but the original life articulation is lost. The ulna shows a well-developed olecranon process. The shape and relationships of the supraorbital process of the frontal support the inclusion of this specimen within Balaenopteridae; the supraoccipital shape suggests that it is a representative of *'Balaenoptera' cortesii* var. *portisi*. This taxon is well represented in the Pliocene of Piedmont by at least 3 other specimens from Montafia, Bagnasco and from another unidentified locality in the Asti territory. Possibly additional specimens of this species are found in Emilia Romagna documenting a widespread presence in the Pliocene Gulf that occurred where today there is the Pianura Padana; such a Gulf connected the Piedmont to the Adriatic Sea. Relevant specimens are usually found in the Sabbie d'Asti Formation (late Lower Pliocene) but the Chiusano specimen was found in the Argille Azzurre Formation (early Lower Pliocene) documenting an earlier presence of this taxon than expected.

PRELIMINARY DATA ON AN EARLY PLIOCENE BALAENOPTERID FROM CENTRAL ITALY

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***Keywords**: Anatomy, Mysticeti, Pliocene, Taphonomy, Tuscany*

In 2007, a new baleen whale skeleton was brought to light from the early Pliocene of southern Tuscany, near Montalcino (Siena Province). The skeleton was prepared thanks to a dedicated project (namely, the 'Brunella Project') in 2016-2019 and is now being studied. The mandibular rami and the earbones of this specimen including a posteriorly-faced mandibular condyle, the relatively long distance between mandibular condyle and coronoid process, the transversely elongated pars cochlearis of the periotic and the ventral keel in the tympanic bulla show diagnostic characters of the family Balaenopteridae. Analysis of microfossils associated to the specimen indicate that it dates back to the Zanclean (*c.* 4.3-4.5 Ma), thus representing one of the few early Pliocene records of baleen-bearing Mysticeti in the Mediterranean basin. About 55% of the skeleton is represented; the skeleton is disarticulated with only two portions close to the original life articulation. Shark teeth, fish otholiths, molluscs, barnacles and fragments of wood were found in close proximity to the bones.

Taphonomic analyses showed that after death, the carcass of this baleen whale deposited on the sea floor where it was subject to movements probably due to scavenging vertebrates. Bite marks probably due to shark scavenging are found in several bones together with fragments of rocks stuck in a vertebra suggesting that the whale decayed in a high energy environment.

REASSESSING THE EUSUCHIAN PHYLOGENY WITH POSTCRANIAL INFORMATION: CHARACTERS SUPPORTING ALLODAPOSUCHIDS AS MEMBERS OF CROCODYLIA

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***Keywords**: Allodaposuchidae, maximum parsimony, postcranial skeleton, systematics*

The clade Allodaposuchidae (Eusuchia, Late Cretaceous of Europe) is currently composed of 9 species. Most of them are known from cranial remains exclusively, and are usually recovered as basal eusuchians in their respective phylogenetic analyses. Nevertheless, some specimens have associated postcranial elements, and the clade is relocated within Crocodylia when these taxa are included in phylogenetic analyses.

In order to assess differences in phylogenetic hypotheses, three consecutive analyses were performed: a first including all species with cranial and postcranial characters; a second, on which all postcranial characters were removed for this clade; and a last one, scoring the postcranial information from those specimens with associated skeletal remains as a general condition for allodaposuchids (i.e., excluding these taxa as single OTUs). The results demonstrate that a basal position is only recovered when the analyses are completely based on cranial characters; whereas the phylogenetic emplacement of allodaposuchids shifts to Crocodylia when postcranial characters are considered, regardless of the taxa included.

The postcranial characters supporting this clade as member of Crocodylia are (I) the uncrested axial neural spine (C12[1]), (II) the insertion of M. teres major and M. dorsalis scapulae (C28[1]), and (III) the morphology of the olecranon process of the ulna (C29[0]). The first and the second characters are shared conditions with borealosuchids, planocraniids and some brevirostres, differing from that observed in gavialoids and basal eusuchians. The third one relates allodaposuchids with borealosuchids.

Currently, >77% of the dataset corresponds to cranial characters. However, filling gaps in the postcranial information could improve phylogenetic hypotheses.

THE VERTEBRATE FAUNAL ASSEMBLAGE OF AS PONTES BASIN (OLIGOCENE-MIOCENE, A CORUÑA, SPAIN)

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***Keywords**: Anura, Pisces, Crocodylia, Mammals, marsh-lacustrine palaeoenvironment,*

The As Pontes Basin is a 12-Km^2 strike-slip fault basin developed in northern Galicia (north-western Spain). This basin, NW-SE oriented, is divided into two sub-basins. It was infilled by non-marine Tertiary deposits during 7 my (from late Oligocene to early Miocene), reaching up to 400 m in thickness. Sediments correspond to swampy and lacustrine facies associations in the center of the basin and to alluvial deposits in the margins. The basin was mined by the electricity industry (1972-2007), which extracted brown coal. During this activity, numerous fossil remains of plants and vertebrates were recovered from some coal beds and lacustrine laminated levels, which were preliminarily studied in the past decades. Recently, the delivery of this fossil collection to a public repository has allowed to begin new paleontological research.

Among vertebrates, crocodyliform remains are the most abundantly found, mainly represented by isolated teeth, osteoderms and disarticulated vertebrae, cranial and appendicular bones. Those remains were assigned to the genus *Diplocynodon* (Alligatoroidea). Other fossil remains consist of shell fragments of turtles, and one almost complete anuran specimen, pending for an exhaustive taxonomic study. In addition, previous studies suggested the presence of two rodent species, two fish taxa (perciforms and cypriniforms) and a poorly preserved macrofossil tentatively referred to Anthracotheriidae, but none of these taxa is currently represented in the fossil sample.

Plant remains consist of leaves, wood and fruits. They are referred to Simaroubaceae, Oleaceae, Salicaceae, Pinaceae and Juglandaceae. Additionally, Myricaceae, Lauraceae and Polypodiales have also been identified in palynological studies. This vegetal association points to a humid, warm, subtropical palaeoenvironment.

PRELIMINARY MANDIBULAR MORPHOLOGICAL STUDY OF *CANIS LUPUS FAMILIARIS* FROM EL PORTALÓN SITE (SIERRA DE ATAPUERCA, BURGOS)

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***Keywords**: morphometric, Holocene, dogs, Bronze Age, evolution*

El Portalón from Cueva Mayor is one of the archeo-paleontological sites located in the Sierra de Atapuerca (Burgos, Spain) with chronologies ranging from Pleistocene to Holocene. Bronze Age constitutes a very important legacy in the central region of the Iberian Peninsula. This period covers most of the domestication processes of wild animals. One of the species proposed to have been domesticated in this context is the wolf (*Canis lupus* L.). It is essential to analyse the differences between dogs and wolves from a morphometric perspective due to the difficulty of evincing a specific haplotype in domestic animals (dogs). This work aims to analyse mandibular features on six mandibles of *Canis lupus familiaris* of Bronze Age from the El Portalón site. Also, we compare these remains with current specimens of *C.l.signatus* and *C.l.familiaris* to study evolutionary changes related to domestication. We use traditional and geometric morphometric techniques for a more complete analysis. The fossil record of this research is practically complete, and we focus on the measured variables and landmarks on specific areas of the mandibles like mandible size and dental series length. Our results suggest that the fossil remains from the El Portalón site are characterized by a smaller size of the mandible and a shorter length of the dental series (especially by the carnassial).

X-RAY VISION INTO PALAEOPATHOLOGY

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***Keywords**: pathology, CT, fossils, bones, teeth*

Fossil remains record a lot of information about the life history of the extinct animal. This also involves phases of disturbed development and stress conditions. Non-invasive imaging techniques using X-rays have always been of crucial importance to identify and interpret palaeopathologies. Here, I present cases of fossil evidence of traumatic and non-traumatic pathological conditions in extinct vertebrates. For example, micro-computed tomography (µCT) analyses of fossil teeth allowed us to detect an inflammation-induced disease and a stress-induced abnormal development in extinct rhinoceroses from the Miocene. The latter is very likely to have occurred *in utero*. Some cases of palaeopathology are clear, whereas others may be under debate. Taphonomic processes influence the structure of the bones and teeth and may potentially lead to abnormalities due to fossil preservation. Such pseudopathologies highlight the importance to distinguish *intra vitam* from *post mortem* modifications. Overall, detecting palaeopathologies and identifying the underlying etiology is an effective tool for retrospective assessment of specific phases in the life history of extinct animals as well as animal-environment interactions.

THE LATE EARLY MIOCENE RECORD OF *MELISSIODON DOMINANS* (Dehm, 1950) FROM MOKRÁ-QUARRY SITES (MORAVIA, CZECH REPUBLIC)

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***Keywords**: Melissiodontini, Mokrá Plateau, Burdigalian, Carpathian Foredeep Basin, Moravian karst*

The genus *Melissiodon,* which is known from the early Oligocene to the early Miocene of Europe, is a rare fossil cricetid, since only in a few localities its remains have been recovered. Currently, two species are recognized during the early Miocene: *Melissiodon schlosseri,* only known for a few teeth from MN2 localities of Central Europe; and *M. dominans*, reported from several European localities along the early Miocene. Four fissures from Mokrá-Quarry (i.e., 1/2001, 2/2003 and 4/2018 from the Western Quarry and 3/2005 from the Central one) stand as one of the best documented sites from which *M. dominans* has been recovered during the early Miocene (MN4). Overall, these fissures have yielded more than 35 teeth, from which 26 are recovered from MWQ2/2003. Some of the latest early Miocene *M. dominans* findings, such as Rembach and Fortshart (both MN4), show smaller size than the type population (Wintershof-West, MN3), which led to thought of a tendency towards size decrease of the species in its last stages before its extinction. However, the remains of all Mokrá-Quarry fissures fall within range of *M. dominans* from the type locality, and in fact, they are larger than those from Rembach and Fortshart. Besides size, there are some clear morphological differences between *M. dominans* from Mokrá-Quarry sites and the other MN4 sites, like a posterior spur of the lingual anterocone on M1 and a well-marked anterocone on M2. The preliminary results presented here suggest the existence of different morphotypes of the species right before its extinction at the end of the early Miocene.

ALIVERIA SP. NOV. AMONG OTHER FLYING AND GROUND SQUIRRELS (RODENTIA, MAMMALIA) FROM THE EARLY MIOCENE OF MOKRÁ-QUARRY SITES (MORAVIA, CZECH REPUBLIC)

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***Keywords**: Pteromyinae, Sciurinae, postcranial, Burdigalian, Carpathian Foredeep Basin, Moravian Karst*

Mokrá-Quarry is an open-cast limestone mine located on the Mokrá Plateau, 12km ENE of Brno, Czech Republic. The micromammal assemblage comes from several karst fissures from the Western Quarry (1/2001 Turtle Joint, 2/2003 Reptile Fissure and 4/2018), and from the Central Quarry (3/2005). Several sciurid remains (dentognathic and postcranial) have been recovered from the early Miocene of Mokrá-Quarry sites: *Palaeosciurus,* belonging to the subfamily Sciurinae (ground and tree squirrels); and *Miopetaurista, Blackia* and *Aliveria* of the subfamily Pteromyinae (flying squirrels). Sciuridae found in the different fissures range from one (MWQ4/2018) to four different genera (MCQ3/2005). *Aliveria* nov. sp., has been identified in all four fissures, being especially abundant in MCQ3/2005. The postcranial remains consist of several isolated calcanei and astragali. However, the calcanei attributed to cf. *Palaeosciurus* show clear morphological features belonging to ground squirrels (i.e., cruciform-shaped and a short and round sustentacular process). The characters recognized in the other calcanei and astragali are clearly different from ground squirrels, however, do not show clear diagnostic element of Sciurinae or Pteromyinae, making unambiguous assignment to tree or flying squirrels difficult. Thus, these remains have been identified as Sciuridae indet. The presence of both ground and/or tree squirrels in the different fissures is in concordance with an open landscape with patches of woodland proposed for Mokrá-Quarry sites.

TAPHONOMY OF THE PISCO KONZENTRAT- AND KONSERVAT-LAGERSTÄTTE (MIOCENE, PERU)

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***Keywords**: cetaceans, marine vertebrates, fossilization, rapid burial, fossil preservation*

Among the most outstanding Cenozoic marine Fossil-Lagerstätten worldwide, the Peruvian Pisco Formation is renowned for its exceptional preservation and abundance of fossil vertebrates, especially cetaceans. We present an updated overview and interpretation of taphonomic data gathered during fifteen field campaigns (2006-2019) on 890 fossil marine vertebrates from the Miocene strata of the Pisco Formation exposed in the Ica Desert. In order to assess the factors that led to the formation of such an exceptional Konzentrat- and Konservat-Lagerstätte, we made observations that range from the taxonomic distribution, articulation, completeness, disposition and orientation of skeletons, to the presence of bite marks, associations with shark teeth and macro-invertebrates, bone and soft tissue (i.e., baleen) preservation, and the formation of attendant carbonate concretions and sedimentary structures. We propose that the exceptional preservation and abundance of the Pisco Formation specimens cannot be ascribed to a single cause, but rather to the interplay of favorable palaeoenvironmental factors and suitable timing of mineralizing processes, such as: i) low concentration of dissolved oxygen at the seafloor; ii) the early onset of mineralization processes; iii) rapid burial of the carcasses; and iv) original biological richness in the southeastern Pacific. Our observations provide a comprehensive overview of the taphonomic characteristics of one of the most significant fossiliferous deposits of South America and lead to the

elaboration of a complex scenario for the preservation of its marine vertebrates that might serve as a reference for explaining the formation of other marine vertebrate Fossil-Lagerstätten worldwide.

VERTEBRATE TAPHONOMY BASED ON RARE-EARTH GEOCHEMISTRY: A TOOL FOR DETERMINING PALAEOECOLOGICAL AND BIOSTRATIGRAPHICAL SIGNIFICANCES OF MIXED VERETBARTE ASSEMBLAGES

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***Keywords**: REE, Trace-element geochemistry, vertebrates Miocene, Late Cretaceous*

The main purpose of this study is to determinate different geochemical proxies in fossil vertebrate remains, which assist the separation and identification of various palaeocommunities in mixed assemblages, contributing to more detailed palaeoecological and palaeoenvironmental reconstructions. Fossil bioapatite has a strong affinity for rare earth elements (REE), which are only sparingly present in body fluids, but soil and pore waters often contain somewhat larger concentrations of these elements. When bones and teeth are exposed to these during fossilization, the concentrations of REEs increase dramatically in a relatively short time, hence the buried remains record fingerprints or signatures diagnostic of the burial environment. Based on these listed features, the bones that recrystallized in different depositional settings inherit different REE compositions, and thus variations in the REE signatures within a bonebed can be used to infer post-depositional transport and mixing of vertebrate assemblages and to unravel the accumulation histories of such mixed faunas. Several important vertebrate localities (Vălioara, Romania; Penanjong beach, Borneo, Brunei; Danitz-puszta and Máriahalom localities, Hungary) were investigated ranging in age from Cretaceous to Miocene, where the fossil remains were mixed and reworked from different deposits with different ages complicating their accurate stratigraphic and palaeoecologic interpretations. The research studied three main goals: 1) determination whether the observed vertebrate material contains bones derived from more than one early diagenetic environment; 2) identify the geographic and stratigraphic origin of reworked and unprovenanced assemblage; 3) investigate REE uptake mechanism into vertebrate fossils.

SEDIMENTOLOGICAL, GEOCHEMICAL AND PALAEONTOLOGICAL INVESTIGATIONS OF LATE CRETACEOUS (MAASTRICHTIAN) VERTEBRATE FOSSIL LOCALITIES FROM THE VĂLIOARA VALLEY (DENSUŞ-CIULA FORMATION, HAŢEG BASIN, ROMANIA)

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Keywords*:* Magyarosaurus*,* Allodaposuchus*, Rare Earth Element geochemistry, dinosaurs, bonebeds*

At the beginning of the 20th century, the Hungarian palaeontologist Ottokár Kadić discovered a rich and diverse Late Cretaceous fossil reptile assemblage around Vălioara in the Haţeg Basin, including several dinosaurs as well as the types of the sauropod *Magyarosaurus* and the crocodyliform *Allodaposuchus*. These fossils were collected from seven main localities and are now housed in the collections of the MBFSZ of Hungary. However, the collection was mixed due to unfortunate historical circumstances and thus this unprovenanced material currently can't be used for detailed/reliable paleoecological investigations. Nevertheless, as a result of archive research, the map of the Kadić excavation sites has been found. It shows the exact positions of the seven localities around Vălioara, and allows matching these localities with the historically collected specimens

through geochemical methods. Using Kadić's map, we georeferenced, relocated and re-excavated these vertebrate-bearing outcrops, and documented their sedimentological context. Detailed sedimentological and stratigraphical investigations indicate that this Vălioara material represents one of the oldest known Late Cretaceous faunal assemblages from the entire basin. In order to determine potential geochemical differences and variability between the sites, we selected bone fragments with stratigraphic position recorded during our fieldwork. Their rare-earth element compositions were then determined and used as independent proxies to assess the stratigraphic origin of the different vertebrate fossils from the historic collections. Our sedimentological, geochemical and palaeontological investigations at Vălioara contribute to a deeper understanding of the distribution, evolution and palaeoecology of the Haţeg vertebrate faunas during the latest Cretaceous.

FANCY FRILLS AND MIGHTY BITES: FRILL FUNCTION IN THE LATE PERMIAN WEIGELTISAURIDAE (DIAPSIDA)

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***Keywords**: Gliding reptiles, Frill function, Weigeltisauridae, Permian, Computed Laminography*

The Weigeltisauridae, known from the Lopingian of Madagascar, Germany, England and Russia, are the first known gliding reptiles – and vertebrates. Despite their gliding capacity being commonly accepted, the significance of their unique, highly ornamented cranial morphology remains poorly understood.

The detailed examination of weigeltisaurid specimens from Madagascar and Germany based on direct observation and Computed Laminography allowed for a complete redescription and reconstruction of the cranium of weigeltisaurids. The skull of these animals forms an elongate frill at the back of the head, adorned with several bony spikes, and is strongly reminiscent of the head of extant chamaeleonids and ceratopsian dinosaurs.

While the presence of the frill is not sexually dimorphic, as in more recent reptiles, the length, shape and ornamentation of the frills show substantial interspecific variability. The frill bones bear sharp elongate crests indicating a broad surface of origin for the temporal musculature in weigeltisaurids, suggesting an increased bite force compared with similar-sized reptiles. Similar morphologies and increased bite forces have been described in chamaeleonid squamates and ceratopsian dinosaurs, indicating a convergent acquisition.

In addition, by analogy with extant frilled animals, we suggest that the highly ornamented frill of weigeltisaurids, adorned by tubers and spikes, may have served as a display structure, as a deterrent against predators or competitors, and as a defensive structure.

A LARGE ANGUIMORPHAN SUGGESTS THE PRESENCE OF VARANIFORMS IN THE IBERIAN PENINSULA PRIOR TO THE K-PG BOUNDARY

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***Keywords**: vertebrate paleontology, Mesozoic, Upper Cretaceous, Squamata, metatarsal*

Basturs is a Maastrichtian (Upper Cretaceous) fossil site located in the eastern area of the Tremp Syncline (Lleida, Catalonia, Spain). It is regarded as one of the European paleontological regions that have yielded one of the largest collections of hadrosaur skeletons in the continent, being also relevant for its record of sauropod eggs. We report here a previously undescribed fossil remain from Basturs, housed in the Museu de la Conca Dellà (Lleida, Spain). The specimen corresponds to a partial left hindlimb preserving two distal tarsals and the metatarsals II to V. It is attributable to Squamata, and more specifically to Anguimorpha, a clade so far not identified at this site. More specifically, it is potentially attributable to Varaniformes, a group which had not been recognized until now in the Cretaceous record of the Iberian Peninsula. These fossil remains correspond to a large individual, with an estimated snout-vent length close to 60 cm. Therefore, it is identified as one of the largest Mesozoic terrestrial lizards so far known, and possibly the largest from the European fossil record. Other large squamate remains are known for the Maastrichtian record of the Iberian Peninsula, but all of them were attributable to Mosasauria instead of terrestrial taxa.

THE ORIGIN OF PLACENTAL MAMMALS ACCORDING TO THE FOSSIL RECORD

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***Keywords**: placentals, mammals, evolution*

Recent molecular clock analyses have suggested that placental mammals originated in the mid- to late Cretaceous, before the Cretaceous-Paleogene (K-Pg) mass extinction. However, there are no unequivocal fossils of placental mammals from the Cretaceous to support this. Definitive fossils of placental mammals only appear after the K-Pg boundary, at which point they rapidly radiate leading into the 'Age of Mammals'. Here we use the Bayesian Brownian Bridge model to estimate the age of origin of placental mammals based on the fossil record. The model uses fossil diversity through time to inform a random walk from the clade's present-day diversity back to the estimated origin of the clade within a Bayesian framework. This model works well with clades that have poor fossil records, such as the early placental mammals, and does not require a phylogeny, thereby mitigating the lingering uncertainty over the branching pattern at the root of the placental tree of life. Our results support a Cretaceous origin for placental mammals, in agreement with the molecular data, and demonstrate that the group was already present before the K-Pg mass extinction and experienced a radiation during the Paleogene. The Bayesian Brownian Bride model can therefore help to reconcile paleontological data with molecular data when estimating the origin of clades.

THE MID-LATE PLEISTOCENE FOSSIL BIRDS OF GROTTA DEL CAVALLO (APULIA, SOUTHERN ITALY): PALEOENVIRONMENTAL AND PALEOCLIMATIC IMPLICATIONS

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***Keywords**: Avian assemblages, Late Quaternary*, *Neandertal*, *Taphonomy*

Avian fossil remains are increasingly used to reconstruct past environmental and climatic scenarios. Here we present the results of the analysis of the fossil bird assemblages from the 4-m thick sedimentary succession of Grotta del Cavallo (Nardò, Apulia), dated from MIS7 to MIS3. The taxonomic analysis detected the presence of a rich avian assemblage with at least 35 species, that allowed to reconstruct with unprecedented detail the habitat near the cave. The landscape was dominated by grasslands and wetlands, locally interspersed with open woodland and rocky outcrops. The wetlands, currently absent from the area, were likely located in front of the cave, where a vast coastal plain, currently underwater, periodically emerged due to the regression during cool climatic phases. An increase in water bird taxa and species richness during MIS 3 is likely related to the expansion of wetland areas or to the shorter distance of the wetland settings from the cave, compared to MIS 6. The presence of *Branta leucopsis*, an arctic breeder, and other bird species currently spread at high altitudes, suggests climate conditions cooler than the present ones. We also detected the first fossil occurrence ever of *Larus genei*, the first Italian occurrence of *Emberiza calandra* and the oldest Italian occurrence of *Podiceps nigricollis*. Taphonomic analysis indicates that the assemblage mainly accumulated through short-range transport and the feeding activities of nocturnal raptors. The few remains that show anthropic modifications linked to butchering and cooking activities represent the earliest Italian proof of bird consumption by Neanderthals.

RANGE OF MOTION IN VERTEBRAE OF STEM TETRAPODS

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***Keywords**: Permian, Stem Tetrapods, Vertebrae, 3D-Printing*

Early tetrapods evolved complex vertebral morphologies that persisted from the Late Devonian until the Permian extinction. The vertebrae of early and stem tetrapods were composed of separate, non-fused elements. Despite their ubiquity researchers have found difficulty in modelling the role of complex vertebral morphologies on single joint behavior. Only three families of extant taxa have complex vertebrae and the homology and applicability as modern analogs in understanding stem tetrapods remains a mystery. To estimate vertebral range-of-motion in ancient tetrapods we used multi-material 3D printing to investigate the form function relationships of single intervertebral joints in five well preserved and understood Permian tetrapods. These taxa represent different habitats, vertebral forms, and maximum sizes. We measured both the range of motion and passive stiffness of our 3D printed spines in lateral, dorsal and ventral flexion. We find that vertebral composition is more related to overall range-of-motion rather than habitat or body size. We also demonstrate that linear and angular measurements that are correlated with vertebral range-of-motion in extant taxa are not correlative in our Permian taxa, demonstrating a need for more empirical studies. Our is the first study using modern 3D modeling and printing techniques to investigate form-function relationships in vertebral forms that were ubiquitous for over 250 million years and provides a crucial first step in understanding the role of complex vertebrae in stem tetrapod locomotion.

NEW DATA ON CROCODYLOMORPH LOCOMOTION BASED ON *CROCODYLOPODUS MEIJIDEI* TRACKS

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***Keywords**: footprints, neosuchians, Berriasian, Lower Cretaceous, Huérteles Formation*

Crocodylomorph footprints are a valuable source of data about how extinct crocodylomorphs moved since we can directly compare them from living and extinct taxa. *Crocodylopodus meijidei* was described in the Huérteles Formation (Berriasian) in the Cameros Basin (Iberian Range, Spain). It is one of the few ichnotaxa that shows walking tracks of crocodylomorphs. A review of the type material provides new significant data about the morphological variations, the main differences with tracks produced by extant and extinct taxa, and the locomotion of the trackmakers. Three different size classes of small to medium-sized trackmakers are distinguished in the sample on the basis of footprint length (2.5 to 7 cm). These variations might reflect either distinct ontogenetic stages or differences due to sexual dimorphism (or both). Comparisons with other crocodylomorph ichnogenera and extant footprints show that the main differences are in trackway features as a consequence of distinct locomotor patterns or behaviors (e.g. swimming tracks). These features are an intermediate-gauge trackway with relatively high pace angulation, absence of tail, belly, drag marks or overprinting of the manus. These data indicate that the trackmaker walked in an agile way and in a more erect position compared to extant crocodylians, and possibly had its center of mass more anteriorly located. Considering the osteological features observed in crocodylomorphs from the Lower Cretaceous of Europe, the trackmaker of *C. meijidei* is assumed to be a small neosuchian crocodylomorph no larger than 1.10 m in total length, possibly a goniopholidid, an atoposaurid or a bernissartid.

BONE COMPACTNESS PROFILE: AN IMPORTANT ASPECT TO DETERMINE PALEOENVIRONMENTAL CHANGEOVER IN TRIASSIC TEMNOSPONDYL AMPHIBIANS

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Keywords: *Bone profiling, compactness, temnospondyls, India*

India has a rich heritage of Triassic temnospondyls through Early, Middle and Late Triassic. Polished bone sections of different temnospondyl bones were analysed for bone compactness profile. Compactness of a bone is defined as ratio between surface occupied by bone tissues and total bone surface. Studies have been performed using software Bone Profiler. Amphibians being very sensitive to changes in environmental patterns living both in land and water makes them ideal host. Bones from Early, Middle and Late Triassic reveals a steady decrease in bone compactness. Temnospondyls from Early Triassic Panchet Formation just after recovery from Permo-Triassic mass extinction shows very high bone compactness modelled by MCMC (0.953). The bones sections considered in Early Triassic mostly belonged to the post-glenoid area of trematosaurid belonging to the genera *Aphaneramma*. This value can be corroborated with post extinction miniaturization of fauna, harsh paleoclimate and reduced growth/dwarfism. Sections of femur from *Cherninia denwai* and *Paracyclotosaurus crookshanki* both capitosaurid from the Middle Triassic Denwa Formation were studied. They show reduced value of bone compactness (0.501) suggesting that these temnospondyl bones were more porous inferring greater osteoporosis thereby a more aquatic mode of life. A lesser bone compactness also indicates greater growth trajectory as compared to Early Triassic, suggesting favourable climate with abundant rainfall and more nutrients. Bone compactness of Late Triassic metoposaurids *Panthasaurus maleriensis* (0.303) from Late Triassic Maleri Formation is lesser than Middle and Early Triassic temnospondyl (0.5922, 0.829), indicating a more agile, aquatic mode of life with aggressive predation as opposed to previous concept of metoposaurs being more sluggish bottom dwellers. Lesser porosity indicates to fast growth of *P. maleriensis* and its large size.

BODY-SIZE EVOLUTION AND BIOGEOGRAPHIC HISTORY IN THE LATE CRETACEOUS EUROPEAN "ARCHIPELAGO" ENLIGHTENED BY THE FIRST ITALIAN MULTI-INDIVIDUAL DINOSAUR LOCALITY

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***Keywords**: Italy, Cretaceous, Ornithischia, body-size, insularity*

The latest Cretaceous Adriatic Carbonate Platform (AdCP) system in the paleo-Mediterranean area stands as one of the most complex and debated topics related to the evolution of land vertebrates in the area surrounding the Tethys Sea. Italy holds the sole Late Cretaceous dinosaur-dominated site of the AdCP, namely the Villaggio del Pescatore locality (VdP). The VdP site was discovered thirty years ago in the Late Cretaceous-Paleogene beds exposed near Duino Aurisina, northeastern Italy, and produced, among fish, crustacean and plant remains, an exquisitely preserved skeleton of the diminutive hadrosauroid *Tethyshadros insularis*. The type specimen was originally described as a pygmy taxon, showing peculiar adaptations connected to insular conditions. This taxon is here re-examined based on additional specimens from the type locality, making the site the first, multi-individual dinosaur locality of Italy. Sole representative of the latest Cretaceous paleo-Mediterranean archipelago, *T. insularis* offers unmatched data to infer environmentally-driven body-size trends in non-avian dinosaurs. Histological analyses indicate juvenile features in the type specimen, whereas a second, larger individual, was approaching somatic maturity. Consequently, we revised the former description of the holotype, documenting the morphological variation in this taxon, and highlighting the ontogenetically variable characters. Finally, we investigated the phylogenetic position of *Tethyshadros* using a phylogenetic comparative framework, which combines ancestral state reconstruction and multiple regime Ornstein-Uhlenbeck models. Such approach enables to evaluate

whether the evolution of body-size was following a significant and accelerated trend of reduction in this clade, in order to further test the interpretation of this taxon as an ‘aberrant’, insular dwarf.

A REAPPRAISAL OF TRIONYCHID TURTLE *RAFETUS BOHEMICUS* (LIEBUS, 1930) FROM THE EARLY MIOCENE OF BŘEŠŤANY CLAY (MOST BASIN, CZECH REPUBLIC)

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***Keywords**: Fossil Testudines, Trionychidae, Burdigalian*

Several almost complete shells, skulls and postcranial bones of trionychid turtles from the Most Basin (NW Bohemia, MN3 mammal zone) have never been published or revised. Here we present the reappraisal of the trionychid turtles from the Most Basin (Czech Republic) together with the revision of *Rafetus bohemicus* from Břešťany Clay, including new diagnostic characters. Our study focused on the skull characters, which have more value in taxonomy compared to complete shells. The preliminary results show that *Rafetus* differs from *Trionyx*, in having: (A) a slightly shorter and broader snout; (B) a non-concave medial edge of the maxilla; (C) a short intermaxillary suture; (D) and a large intermaxillary foramen. The skull characters here presented will allow to differentiate *Rafetus bohemicus* from *Trionyx vindobonensis* in the European record during the early Miocene. The biogeographic distribution of both trionychid species is still unclear, however, it seems that *Rafetus bohemicus* inhabited Central and Eastern Europe (restricted by Parathetys sea and Carpathian mountain range in the south), whereas *Trionyx vindobonensis* occupied Western, Southern and partly Central Europe.

OREOPITHECUS BAMBOLII AND ITS ECOSYSTEM: MORE THAN A CENTURY OF RESEARCHES ON A PECULIAR HOMINOID-BEARING SITE

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***Keywords**: latest Miocene, endemism, insularity, paleoenvironment*

The fossil hominoid *Oreopithecus*, the only western European hominoid to survive the Vallesian Crisis, became extinct at ca. 6.7 Ma. *Oreopithecus* was part of the endemic faunal complex, also known as "*Oreopithecus* Zone Faunas" (OZF), that inhabited a late Miocene emerged land(s) in the northern Tyrrhenian area (nowadays Tuscany and Sardinia). Albeit most of the OZF mammals have phylogenetic affinities with European species, some authors interpreted a few taxa (the alcelaphine *Maremmia*, the neotragine *Tyrrhenotragus*) as of possible African origin. Remains of *O. bambolii* are extremely abundant in the so-called V1 assemblage from the lignite layer at Baccinello and other coal mines in the region. This assemblage is characterized by low taxonomic diversity and a high level of endemism. The reconstructed vegetation for this level is that of a lowland mixed mesophytic forest. The stratigraphically younger V2 assemblage resembles V1 but it is characterized by the occurrence of new immigrants such as *Eumaiochoerus*. The entire OZF became extinct when southern Tuscany became fully connected with the newly formed Apennine chain. Stable carbon and oxygen isotope record from organic matter in paleosols along the Baccinello Basin succession showed plant ecosystem stability through time and space, suggesting that environmental change was not an underlying cause for the extinction of *Oreopithecus* and associated fauna.

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SHAPE MY FOSSIL UP. APPLICATION OF NEW METHODS FOR 3D VIRTUAL RECONSTRUCTIONS

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***Keywords**: Target Deformation, 3D, Geometric Morphometrics, R, Mammals*

In the last ten years, 3D virtual reconstruction has become popular in Paleontology, allowing to restore and reconstruct the original morphology of the specimens studied. Herein, we provide the application of a new digital reconstruction protocol, named Target Deformation (TD), which extends beyond traditional symmetrisation and virtual aligning procedures by using target specimens as a guide for the reconstruction. The new method, open source and developed in R Environment, has been tested on the holotype of *Equus stenonis*, a nearly complete, yet medio-laterally crushed and badly compressed skull of the Early Pleistocene of Europe. As references to guide the virtual reconstruction, we have used two yet well-preserved fragmentary *E. stenonis* skulls from the Early Pleistocene Italian and Georgian localities of Olivola and Dmanisi. The two specimens were retrodeformed and aligned on each other by using geometric morphometrics and eventually used to restore the shape of *E. stenonis* holotype via warping. The feasibility of Target Deformation was attested by showing how the TD 3D models settle perfectly within the natural variability of

European *E. stenonis* skulls. Furthermore, herein we show the application of the TD to other two heavy damaged fossil skulls of two emblematic Early Pleistocene carnivorans, *Canis arnensis* and *Homotherium crenatidens*. These case studies show the potential of using broken or otherwise fragmentary specimens to guide a virtual reconstruction for badly distorted and damaged specimens. The application of TD will increase the availability of comparative specimens for taphonomic, morphological, systematic and phylogenetic studies in Palaeontology.

A KIMMERIDGIAN STEGOSAUR TRACKWAY FROM GALVE, TERUEL PROVINCE (SPAIN)

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***Keywords**:* Deltapodus*, Stegosaur, Ichnology, Jurassic, Teruel*

Deltapodus is an ichnotaxon produced probably by stegosaurian trackmakers. The manus leaves a crescent-shaped impression and the pes impression is elongated, with three short digits and a rounded 'heel'. *Deltapodus* has been found in the USA (Morrison Fm.), China (Lianmuqin Fm.), North Africa (Iouaridène Fm.) and various sites in Europe, such as the United Kingdom (Ravenscar Group) and France (Angeac-Charente site). In the Iberian Peninsula, traces are known in Portugal (Lourinhã Fm.) and in several Spanish provinces such as Asturias (Lastres Fm.) or Teruel (Villar del Arzobispo Fm.). The global temporal range of these tracks is from Middle Jurassic to Early Cretaceous.

This work describes two new isolated tracks and a trackway attributed to *Deltapodus* at the Rios Bajos site, in Galve, Teruel (Spain). For the study of these ichnites, photogrammetry was applied, and 3D models of the remains were obtained. With this technique, tracks could be measured and compared with those of other sites such El Castellar (Villar del Arzobispo Fm.): the type locality of *Deltapodus ibericus.* The trackway has three pes tracks, the manus are not preserved. The ichnites are elongated (one third longer than wide), with three short digits and the 'heel' rounded. In addition, digit II sinks much deeper than the rest, the stride length is variable, and there is a strong angle of divergence between consecutive pes.

All tracks are preserved on massive, bioturbed limestone attributed to the Higueruelas Formation (Kimmeridgian, Upper Jurassic). This would be the earliest *Deltapodus* trackway in the province of Teruel.

A NEW RICH UPPER CRETACEOUS LEVEL WITH TERRESTRIAL VERTEBRATES AT OARDA DE JOS (ALBA COUNTY, ROMANIA)

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***Keywords**: terrestrial environment, vertebrates, Maastrichtian, Transylvania, Romania*

In Romania, Upper Cretaceous (Maastrichtian) terrestrial deposits are exposed in three sedimentary basins: Hațeg, Rusca Montană and Transylvanian Basin, outlining a portion of the so-called former 'Hațeg Island'. This paleogeographic entity (probably an island) is famous worldwide due to its endemic terrestrial vertebrates, including dwarf dinosaurs, firstly reported since the end of the 19th century. From the Transylvanian Basin originates the first ever Maastrichtian vertebrate remain discovered in Romania. Field-works carried out in the last years, in the southwestern part of the Transylvanian Basin (Metaliferi sedimentary area), led to the discovery of a rich and diverse vertebrate assemblage unearthed from the fluviatile Maastrichtian deposits of the outcrop labeled 'ODB', at Oarda de Jos (Alba County). The erosion by the Sebeș River water stream exposed in the riverbed a mudstone that yielded both macro- and microvertebrates. This lens-like accumulation extends on several square meters, but its thickness can't be approximated. The level consists of two-colored type of mudstone: dark-grey and blueish. The coarser dark-grey portion is by far richer in fossil remains. To date, approximatively 300 kg of these sediments have been screen-washed. We preliminarily report here an extremely rich vertebrate assemblage including fish, albanerpetontids, frogs, lizards, turtles, crocodilians, dinosaurs (theropods, ornithopods and sauropods), pterosaurs and mammals. The dark-colored teeth and bones are indicative for a fast burial of the remains in a low content of oxygen environment. The majority of remains are isolated, indicating a rather short pre-burial transport for at least some vertebrate remains of this assemblage.

MULTIBODY SIMULATIONS OF DIPLODOCID TAIL MOTION

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Keywords: *Biomechanics, Sauropod, Tail, Whiplash*

Sauropod dinosaurs are iconic animals known for their elongated necks and tails, with an evolutionary history that spanned from the Triassic up to the end of the Cretaceous. Their body plan remained largely unchanged during all this time with minor adaptations in certain subclades. The elongated tail evolved as a counterbalance to the long neck but was probably coadopted for other purposes, as well, at least in some clades, as e. g. Flagellicaudata. Since the discovery of the first flagellicaudatan tails in the late 1800s a defensive use was proposed for the tails, due to their morphological resemblance to bull-whips. However, this hypothesis has been tested only by two computer simulations in the 1990s. Here we propose new computer simulations performed with ADAMS software. Two simplified tail models were tested, one inspired by data previously used in the literature which are most similar to apatosaurine tails, and a second model, based on data obtained from diplodocine tails. The two models have a total length of 12,34m, composed of 82 rigid bodies representing the vertebrae, connected by revolution joints in order to perform a multibody simulation to estimate the maximum velocity achievable by imposing a rotation at the first eight vertebrae of the tail. The analyses show that both models were able to surpass the speed of sound and that the different morphologies strongly affect the results, with the diplodocine tail tip reaching up to four times higher velocities than the apatosaurine one while being subjected to the same input. This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS/CCCDI – UEFISCDI, project number PD 136 /2020, within PNCDI III (to AAS).

REVISION OF THE PACHYCORMID FISH SAUROSTOMUS ESOCINUS AGASSIZ FROM THE EARLY JURASSIC (TOARCIAN) OF EUROPE: SYSTEMATICS, DISTRIBUTION AND ECOLOGY WITH NEW INSIGHT INTO THE ORIGIN OF FILTER FEEDING IN PACHYCORMIDAE

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Keywords: *Pachycormiformes*, *Early Jurassic*, *Palaeoichthyology*, *Posidonienschiefer*, *Palaeoecology*

The type and only species of the genus *Saurostomus*, *S. esocinus* AGASSIZ, is a poorly studied representative of Pachycormiformes from the Toarcian of Europe. The holotype, comprising an isolated dentary from the Lias (Posidonienschiefer) of Germany is lost and was most likely destroyed during WWII. Despite subsequent works addressing the genus, neither a neotype nor a comprehensive description has been provided for *Saurostomus*. Here we rectify this by designating a neotype of *S. esocinus* and provide an updated diagnosis and detailed anatomical description based on 33 specimens ranging from 0.5 m to 1.8 m in estimated standard length. *Saurostomus* can be clearly differentiated from *Pachycormus*, with which it is often synonymized, based on both cranial and postcranial characters, notably by recurved teeth, fringing caudal fulcra and absence of the suborbitals. In addition to the German Posidonienschiefer Formation, material confidently assigned to *Saurostomus* has been identified from coeval-aged localities in Luxembourg, France and the United Kingdom, including the Strawberry Bank Konservat-Lagerstätten (Somerset). Interestingly, *Saurostomus* displays basal transitional characters, particularly in the skull, which are associated with the gigantic filter-feeding pachycormid clade; most notably, a widened gape, elongation of the mandible, increased body size and absence of the post-orbital series. The basal cranial configuration and predeceasing stratigraphic range of *Saurostomus* predates *Ohmdenia*, and strongly suggests *Saurostomus* as the basal-most transitional form of the filter feeding clade. Revised stratigraphic and palaeoecological data for *Saurostomus* demonstrates appearances prior to and post-dating the eTOAE, with gastric contents indicating predation on cephalopods in the upper-water column.

PRELIMINARY STUDY OF THE SMALL MAMMALS CLASSICAL COLLECTIONS FROM THE EARLY PLIOCENE SITES OF BEREȘTI AND MĂLUȘTENI (EASTERN ROMANIA)

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***Keywords**: Berești, Mălușteni, small mammals, Pliocene, Romania*

The most diverse Pliocene vertebrate assemblage of Romania are the classical neighboring sites of Berești and Mălușteni. The first publication of the small mammal material was made by Ion Simionescu in 1930 for the site of Mălușteni, and in 1932 for the site of Berești. In all, four species of insectivores, ten of rodents, and two of lagomorphs, including four new species were described by this author. Part of this material was revised by Costin Rădulescu and Petre Samson in the second part of the 20th century. Among other results, these authors highlighted the synonymy of *Arvicola pliocenicus* with *Mimomys moldavicus*, and the description of the new species *Talpa neagui* and *Trischizolagus dumitrescuae*. This contribution presents the first preliminary results revising the material that still exists in the collections of the University of Bucharest, "Emil Racoviță" Institute of Speleology from Bucharest, and "Alexandru Ioan Cuza" University of Iași. In total, about 200 dental, mandibular, and maxillary remains housed in the above-mentioned institutions have been analyzed. Most of the analyzed specimens were confirmed as belonging to the lagomorphs *Trischizolagus dumitrescuae* and *Ochotona ursui*. The rodents still found in these collections were assigned to *Castor fiber*, *Trogontherium* sp., *Prospalax priscus*, cf. *Pseudocricetus* sp., *Spermophilus* cf. *praecox*, whereas various insectivore humeri were assigned to *Archaeodesmana* sp., *Talpa* cf. *fossilis*, and *Talpa neagui*.

MULTIES OF THE DAWN – THE OLDEST MULTITUBERCULATE OCCURRENCES IN THE UPPERMOST CRETACEOUS OF TRANSYLVANIA, AND MOSAIC EVOLUTION WITHIN THE KOGAIONIDAE

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***Keywords**: Late Cretaceous, Multituberculata, Kogaionidae, Romania, mosaic evolution*

Kogaionid multituberculates formed a Late Cretaceous-Paleocene cimolodontan radiation that was endemic to Europe. Their peculiar anatomy makes it difficult to pinpoint their precise phylogenetic position and systematic affinities within Cimolodonta, which in turn hinders understanding their origin and evolutionary history. Their initial patchy fossil record, represented by isolated teeth, was markedly improved in the last decades through discovery of well-preserved, occasionally fairly complete skulls and partial skeletons in the uppermost Campanian-Maastrichtian of the Transylvanian region in western Romania. Most of these latest Cretaceous kogaionids differed from their Paleocene relatives by a lower cusp count on M1 (especially in the incomplete lingual row), a relatively more elongated P3 (a hallmark kogaionid feature), and a morphologically more complex m1. Such anatomical dichotomy between Late Cretaceous and Paleocene members of the clade appeared to suggest that kogaionid evolutionary trends included simplification of m1 structure, shortening of P3, and cusp addition to the lingual row in M1. Prospecting in the southwestern Transylvanian Basin recently revealed a new multituberculate locality yielding a small sample of isolated teeth. Its stratigraphic position suggests a possibly latest Campanian age, making it the oldest known kogaionid occurrence, slightly older than the previously known oldest member of the clade, also discovered in the same area. Despite their chronostratigraphic and palaeogeographic position largely comparable to those of other Transylvanian kogaionids, these early representatives are more reminiscent of the Paleocene kogaionids in their M1 and P3, but had very complex m1s, suggesting that mosaic evolution took place within the clade.

ELECANIMIMUS (THEROPODA, ORNITHOMIMOSAURIA) SKULL: FROM LAMINATED LIMESTONE TO 3D RECONSTRUCTION AND RETRODEFORMATION

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***Keywords**: Ornithomimosauria, Theropoda, Dinosauria, CT-Scan, Early Cretaceous*

Fossils from *Konservat-Lagerstätten* are usually exceptionally preserved, allowing to decipher key paleobiological aspects of the fossil record. An example is *Pelecanimimus polyodon* from the Early Cretaceous of Las Hoyas (Cuenca, Spain). The skull of the type specimen is almost complete and well preserved, and presents some characters like the presence of more than 200 teeth, which are crucial to understand ornithomimosaurian evolution. The skull is contained in two complementary slabs of limestone. Some taphonomic processes such as the pre-burial burst of the occipital area and the strong crushing resulting from its preservation in laminated limestones prevent the analysis of several morphological features and the disarticulation of the bones.

The skull of *Pelecanimimus* was CT-scanned, and segmentation of the complete skull and isolation of each individual cranial bone were carried out. The reconstruction of the skull required an assemblage of bones with fragments preserved in the slab and counterslab, then the articulation of complete bones and teeth and finally the reintegration of missing parts, most done by mirroring more complete counterlateral bones. Retrodeformation was carried out both manually and automated based on landmark symmetry.

The resulting 3D image of the skull of *Pelecanimimus* has allowed us to carry out a detailed description, showing features previously hidden by matrix or by other bones, enabling potential taphonomical, biomechanical and eco-morphological studies. For example, the reconstruction of the dentition and retrodeformation are the basis for making a muscular reconstruction and a biomechanical analysis of the skull, which will help to decipher the evolution of foraging behaviour of Ornithomimosauria.

A NEW SPECIES OF PORCUPINE (*HYSTRIX*) FROM THE LATE PLIOCENE OF POLAND AND ITS PALEOBIOGEOGRAPHICAL IMPLICATIONS

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***Keywords**: rodents, porcupines, Pliocene, Villafranchian, Poland*

Generally accepted strictly fossil species of the genus *Hystrix* known from Europe are *H. caucasica*, *H. depereti*, *H. parvae*, *H. primigenia* and *H. refossa*. Because the occlusal pattern of dental enamel in *Hystrix* is highly variable in ontogeny and, simultaneously, highly conservative, these species are distinguished mainly based on measurements, the level of hypsodonty, and the shape of the third molars. Because the earliest occurrences of *H. primigenia* (MN 11), *H. depereti* (MN 12?), and *H. refossa* (MN 16) have been reported from the Balkan Peninsula and Anatolia, it seems probable that these species spread across Europe in several waves of migrations from Anatolia. European extinct porcupines are known mainly from western Europe, the Balkans, the Carpathian Basin and the south part of European Russia, and findings outside these areas are relatively rare. The *Hystrix* specimen from Węże 2, a MN 16 site in southern Poland, is a fragmentary left maxilla with P4–M2, belonging to a young individual, with P4 freshly erupted. The finding makes Węże 2 one of the northernmost occurrences of fossil porcupines in Europe. The Węże 2 form corresponds to a *Hystrix* specimen recovered from the nearby site of Węże 1 (MN 15) in sharing a distinct anterolingual flexus dissecting the anteroloph of P4. Thus, this character is not an individual aberration and distinguishes specimens from Węże 1 and 2 sites from those of all coeval *Hystrix* species. The presence of this dental structure in the Węże 2 specimen fully supports a new species status for both Polish findings.

CYBERTAXONOMY IN VERTEBRATE PALAEONTOLOGY

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***Keywords**: Cybertaxonomy, Cybertype, Digital Specimen, Digitization, Vertebrate Palaeontology*

Taxonomy is facing a new challenging era, driven by the increase on the development and use of digitization and digital technologies. Through the digitization of natural history collections, an impressive amount of digital data and metadata is being created, gathering photographs of the specimens and labels together with geographical maps, histological samples, DNA sequencies, CT images, 3D models, etc. This data network forms the "Digital Specimen" (*sensu* DISSCo) or "Extended Specimen" (*sensu* iDigBio), and intends to be the perfect example of a FAIR object: findable, accessible, interoperable and reusable. However, taxonomy should also address the importance of this digital simulacrum when it represents a physical type specimen. The International Code of Zoological Nomenclature (ICZN) has no approach to this issue yet. Some researchers in Zoology have already used the term "Cybertype", e.g., Godfray in 2007, defining it as a "new form of type specimen […] to be displayed on the web using the very best current imaging methods — often far superior to normal examination — […]". More detailed descriptions of the cybertype were published later. Indeed, as a supplement to the physical specimen, the Cybertype adds value to the material collections and facilitates its sharing preservation from loss (e.g., fre, floodings, etc), and reduces the handling of the original material.

As the concepts of Cybertaxonomy and Cybertype have been already discussed in Zoology, but not in our field, this talk asses the current situation in Palaeontology: can we properly describe what a Cybertype could be? What kind of information and files should be included within it? How can its permanence be guaranteed?

CONTINENTAL VS. ISLAND DRIVEN NANISM: INSIGHTS FROM A NEW TITANOSAURIAN (DINOSAURIA, SAUROPODA) FROM THE UPPER CRETACEOUS OF BRAZIL

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***Keywords**: Saltasauridae, Paleohistology, Paleoecology, Bauru Basin, South America, Europe*

Although body size increase seems to be a general trend in Sauropodomorpha, episodes of nanism have evolved multiple times in different sauropod lineages throughout the Jurassic and Cretaceous intervals. Different evolutionary processes could be associated with these events, which may include biotic or abiotic pressures, or even a combination of both. Some cases stand out, as they can be associated with the effect known as “island miniaturization”. Others are best explained as a reflection of niche segregation and adaptability to a specific feeding strategy.

The first case has already been proposed for some Late Cretaceous European titanosaurs (e.g., *Magyarosaurus*, *Lirainosaurus*, *Atsinganosaurus*). Except for *Magyarosaurus* (a possible autapomorphic nanoid), these taxa recently seem to be close related with Saltasauridae, a clade of small-sized Gondwanan titanosaurs. Indeed, some saltasaurids could have encompassed a nanoid clade, given these forms were recovered in costal environments likewise its Europeans counterparts. Here we present a new nanoid titanosaurian from the Upper Cretaceous deposits of the Bauru Basin (Brazil), which has been recovered within Saltasaurinae. However, it was recovered in a strict continental geological unit, differing from other South American or European nanoid titanosaur occurrences, the insularity of which has been suggested as the main reason for their small size. The nanism observed in this new form could be assessed through histological analysis and was associated with a probable phyletic nanism trend, enforced by the evolution of an endemic fauna in response to the stressed environmental conditions of Bauru Basin, characterized by prolonged drought periods and scarcity of resource supply.

THE IMPACT OF MOLECULAR SCAFFOLDS ON THE FOSSIL AGE OF CROCODYLIA

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***Keywords**: Crocodylia, Eusuchia,* Portugalosuchus*, systematics, phylogeny*

A recently described taxon from the upper Cenomanian of Portugal (ca. 95 Ma), *Portugalosuchus azenhae*, has been hypothesized to represent the oldest known fossil crocodylian (crown clade of Crocodylomorpha). This predates the previous oldest fossil (77.9-83.6 Ma) as well as molecular divergence estimates (91 to 86 Ma) and infers ghost lineages tracing back into the mid to early Cretaceous. Based on an incomplete skull, morphological phylogenies recovered this species in a poorly supported sister relationship with all other non-gavialoid crocodylians. *P. azenhae* is increasingly used as a calibration point in crocodylian divergence estimates. Therefore, the robustness of its phylogenetic position warrants confirmation. Particularly, reassessment in a molecular topological framework finds gavialoids more derived than the placement of *P. azenhae* by morphological phylogenies. In order to test the phylogenetic position of *P. azanhae*, we added a molecular scaffold to the original morphology-based analysis. This resulted in a placement outside Crocodylia and highlights the significant impact of a molecular scaffold for the placement of extinct basal crocodylians, especially that the morphological support for a basally diverging Gavialoidea is low, whereas molecular support for a derived position (as sister to Tomistominae) is high. Additionally, we found that 16 characters state scorings of the original *P. azenhae* dataset are irreproducible. Reanalysis of the rescored dataset, without the addition of a molecular scaffold, resulted in a placement either as a stem-crocodylian or a gavialoid. Thus, *P. azenhae* should be best disregarded for time calibrating crocodylian trees.

THREE-DIMENSIONAL RECONSTRUCTION OF VERTEBRATE MORPHOLOGY AND QUANTIFICATION OF TAPHONOMIC DEFORMATION

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***Keywords**: 3D modeling, stem-bird, retrodeformation, Cretaceous*

Taphonomic and diagenetic processes during decay, burial, and fossilization often distort the original morphology of fossil remains. Fossil birds are especially vulnerable to taphonomic deformation due to their relatively small size and comparatively delicate skeletons usually characterised by thin bone walls. Such distortion may hinder interpretations of detailed morphology, influence taxonomic diagnoses, and affect phylogenetic hypotheses if important morphological information is directly affected by deformation. Here, we present an idealized three-dimensional reconstruction of the sternum of the crownward stem-bird *Ichthyornis dispar* through application of a novel reconstruction workflow, combining retopology with retrodeformation, and addressing both symmetrical and asymmetrical elements. All known *Ichthyornis sterna* were CT-scanned and segmented to obtain three-dimensional models of the bones free of any matrix. Well-preserved areas of the different *Ichthyornis* sterna were combined into a single, idealized composite representation through superimposition and alignment of the retopologised models, and the composite was subsequently retrodeformed. Our workflow enabled the quantification of the deformation of the individual specimens with respect to our reconstruction, and the determination of major global as well as local taphonomic deformation axes. The proposed workflow can be integrated with geometric morphometric approaches to enable quantitative morphological comparisons between multiple specimens, as well as the direct interpolation of ‘mediotypes’ of axial elements (e.g., missing vertebrae, haemal arches, or ribs).

THREE-DIMENSIONAL POLYGONAL MUSCLE MODELLING AND LINE OF ACTION ESTIMATION IN LIVING AND EXTINCT TAXA

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***Keywords**: three-dimensional, modeling, musculature*

Biomechanical musculoskeletal models rely on accurate muscle parameters, such as muscle masses and lines of action, to estimate force production and leverage of individual muscles. Unfortunately, these parameters are often obtained through destructive techniques (i.e. dissection) in extant taxa, frequently hindering the measurement of all subject-specific parameters from a single individual, thus making it necessary to combine multiple specimens and/or sources. Estimating these parameters in extinct taxa is even more challenging, as soft-tissues are rarely preserved and the fossilised bones provide relatively little information about the size and path of a muscle. Here we describe a new protocol that facilitates the estimation of muscle parameters (i.e. muscle volume and path) for extant and extinct taxa. We created three-dimensional volumetric reconstructions for hindlimb muscles of the extinct stem-archosaur *Euparkeria capensis* and extant Nile crocodile, and for shoulder muscles of a western lowland gorilla, to demonstrate the broad applicability of this methodology across living and extinct animal clades. Additionally, our method can be combined with surface scan data captured during dissection, thus facilitating downstream analyses. We evaluated the estimated masses and line of action estimates against physical measurements and common practices used in biomechanics to ensure their compatibility with existing methods and test their accuracy in estimating missing muscle parameters. Our estimated masses generally compare favourably with segmented iodine-stained (diceCT) muscles and fall within or close to the range of observed masses, thus strongly indicating that our estimates are reliable. This method has potential for diverse applications in evolutionary morphology and biomechanics.

COMPARISON OF LIMB ANATOMY IN THE ARMOURED LATE TRIASSIC AETOSAURS IN CONTEXT OF THE NEW FINDINGS FROM KRASIEJÓW LOCALITY. IMPLICATIONS ON THE AETOSAURS MODE OF LIFE

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***Keywords**: Crurotarsi, Aetosauria, limbs, scratch-digging, locomotion*

Aetosaurs anatomy is unique among the Late Triassic Pseudosuchians. They have a small triangular skull, in some species ended with a shovel like-expansion; extensive dermal armour that covers their entire body; and a robust skeleton, especially limbs and girdles. Due to similarity of limb morphology with modern pangolins, armadillos, or aardvarks, enhanced ability for scratch-digging was reported for a few aetosaur species, including Krasiejów aetosaur *Stagonolepis olenkae*. However, the possible digging capability in limbs was never revived in the context of the entire group. Taphonomically and morphologically variable material of *Stagonolepis olenkae* allow for revisions of the aetosaur anatomy, and comparison of the features associated to digging in other less complete forms. It appears that the morphology of limbs is very conservative in aetosaurs. It seems that all known species, regardless of skull morphology, size, and age have features associated with a scratch-digging, mainly: short forearms and crus, well-developed attachments for muscles used in digging, presence of structures that restricts joints movements of and prevents bones from dislocation. Those characters allow to increase strength of the move, which is necessary for digging, but decrease ability to outran predators. Presumably, aetosaurs developed their extensive dermal armour to compensate for this loss, convergently to armoured dinosaurs, and mammals.

CROOKED TEETH IN FRASNIAN TRISTICHOPTERID FISH – TAPHONOMY, PATHOLOGY, OR REPLACEMENT IN PROGRESS?

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***Keywords**: Synchrotron, Computed Tomography, Frasnian, Tristichopteridae, Dentition*

Most jawed vertebrates continuously replace their dentition, and a large diversity of tooth replacement modes are known. Sarcopterygii have a deep evolutionary history notably including the origin and radiation of tetrapods. Understanding tooth replacement in early sarcopterygians will therefore help to resolve the ancestral tetrapodal condition. Most early sarcopterygians combine labial rows of small marginal teeth with lingual pairs of larger fangs. These fangs and teeth are shed and replaced in essentially static positions. Several sarcoptergian groups – notably onychodonts and porolepiforms – feature parasymphysial “tooth whorls” that facilitate lingual-to-labial tooth rotation during its functional life, not unlike the dental replacement mode of sharks. Investigations of dental replacement patterns in early sarcopterygians have mostly focused on such “tooth whorls”, and information on replacement in the tooth rows and fang pairs is lacking.

To assess dental organisation and replacement modes among Frasnian (Late Devonian) tristichopterids, fish members of the tetrapod stem group, we investigated the dental arrangement patterns in a specimen of *Eusthenopteron* from the Escuminac Formation of Miguasha (Québec, Canada) and a specimen of an undescribed tristichopterid from the Whitemire Beds near Nairn in Scotland. These fossils were non-destructively imaged in three dimensions (3D) with conventional computed tomography (CT) and synchrotron microtomography, respectively. Both tristichopterids preserve marginal teeth in proximally, distally, and/or lingually skewed orientations lacking a clear pattern. The potential biological, taphonomical, or pathological causes for this organisation are examined. Virtual 3D extraction of the functional and replacement teeth reveals their spatial relations and thus informs on eotetrapodiform dental development.

EVIDENCE OF SEDIMENTARY REMODEL OF JURASSIC THEROPOD EGG CLUTCHES (LOURINHÃ, PORTUGAL)

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***Keywords**:* Lourinhanosaurus*,* Preprismatoolithus*, Anisotropy of Magnetic Susceptibility, Embryos, Kimmeridgian, Lusitanian Basin*

The “Paimogo nest” (Lourinhã, Portugal) is an assemblage of up to 100 eggs of a theropod dinosaur and three eggs of an undetermined crocodylomorph, including the oldest embryonic bones of a theropod dinosaur, most probably the allosauroid *Lourinhanosaurus*. The clutch was found in reddish paleosoils of the Lourinhã Formation (Late Kimmeridgian, Lusitanian Basin), representing fluvial floodplains.

The theropod eggs, attributed to the oogenus *Preprismatoolithus,* are larger (13x10 cm) and have angustiprismatic eggshells. The crocodylomorph eggs represent the holotype of the oospecies *Krokolithes dinophilus*; these are smaller (7x4 cm) and show crocodyloid eggshell. The high number of eggs and the presence of two oogenera suggest a coalesce of biological and geological events in the assemblage formation. We approached the problem using a multidisciplinary study. Geochemical analysis group the theropod eggs in two classes, suggesting at least two independent origins. Analysis of the sedimentary structures, coupled with a study of the Anisotropy of Magnetic Susceptibility (AMS) indicate the eggs were accumulated by a low-energy sedimentary process. However, the oological features show intact eggs, crushed due to lithological pressure being the only taphonomic alteration. Thus, two females laid the eggs in different clutches or a single female laid at least two non-synchronic clutches, which were later reworked by the floodplain dynamic. Our results suggest that the presence of complete, highly packed eggs, even those bearing embryos, is

not sufficient for assuming a clutch or a nest. Detailed sedimentological and taphonomic studies are needed before inferring the biology of the egg laying species.

MAMMAL TRACKS AND TRACKWAYS FROM THE EARLY OLIGOCENE OF SAIGNON (VAUCLUSE, SE FRANCE)

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Keywords: *ichnology, tracks, Oligocene, mammals, paleoecology*

The early Oligocene Saignon tracksite (Vaucluse, southern France), bears more than a thousand tracks and dozens of trackways of mammals and birds.

The tracksite is composed of two main levels, D2 and D6 (Calcaire de La Fayette Formation, Rupelian, MP21). D2 yields numerous tracks and trackways attributed exclusively to mammals. D6 is, instead, characterized by the occurrence of bird tracks. Here we present a review of the tracks from the main surface of tracksite (D2).

The entire tracksite was digitized using drone photogrammetry, whereas for selected tracks and trackways high-resolution digitization was also carried out through photogrammetry. This study focuses on the best-preserved tracks and trackways attributed to small and large perissodactyls and medium- to large-sized artiodactyls.

The small perissodactyl tracks are referred to *Lophiopus* isp., whereas the artiodactyls to *Bifidipes velox*. The large perissodactyl tracks are referred to *Rhinoceripeda* isp. The probable trackmaker is identified as *Ronzotherium*.

The occurrence of *Rhinoceripeda* is one of the first, albeit indirect, evidence of the presence of *Ronzotherium* in France. More broadly, the Saignon ichnoassemblage document the early Oligocene paleontological context of western Europe, which is marked by the Grande Coupure faunal change from the endemic European faunas to ones with major components of Asian origin.

SYNCHROTRON CT CHALLENGE: SCANNING *HETERODONTOSAURUS*, A 1.5 M LONG DINOSAUR TO INVESTIGATE VARIOUS ANATOMICAL FEATURES

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***Keywords**: X-ray, Synchrotron, Computed Tomography*

Recently, the nearly complete skeleton of a full-sized *Heterodontosaurus* (~ 1.5 m) has been discovered in the bed of a small seasonal river in South Africa. While the full size of the specimen greatly exceeded the capabilities of synchrotron light sources, it was fortuitously excavated as multiple discrete blocks no larger than 18 cm – conveniently, the maximum field of view available at the ID17 beamline of the ESRF. However, these blocks are of a geometry and aspect ratio that is suboptimal for X-ray CT. The complicated aspect ratio of the individual blocks was compensated for by imaging two of them simultaneously, and filling recessed areas with aluminium beads. Before analysing the data, several processing steps were necessary. During the experiment, several acquisitions were done to cover the specimen's vertical axis. Having kept an overlap of 50% between consecutive scans, it was possible to correct ring artefacts by using part of the fossil imaged on two different areas of the detector. Further complicating the experiment were metallic inclusions in both the sediment and the actual fossil of *Heterodontosaurus*. The effects of the inclusions were buffered using a thresholded high pass filter, effectively decreasing the grey level close to the value of the sediment. After months of processing, *Heterodontosaurus* was finally analysed. Segmentation of the skeleton has revealed unexpected, novel, and important anatomical information pertaining to the individual's life history and physiology, and made it possible for the first time to test macroevolutionary hypotheses for the respiratory and locomotory evolution of ornithischian dinosaurs.

USE OF ULTRAVIOLET LIGHT FOR THE PREPARATION OF A THEROPOD TOOTH

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***Keywords**: Preparation, Conservation, Ultraviolet Light, Theropod tooth*

The following work presents how the ultraviolet light has been employed for the preparation of fossil material. The chosen lights are two UV-A LED lamps with a wavelength of 395-400nm. This light has been used for the retreatment work of a theropod tooth, previously consolidated on the field. We used a reflex camera, model Canon EOS 1200D with the EF-S 18-55II lens, plus a polarizing filter for this lens to capture the fluorescence of the different minerals properly. With these tools, we were able to differentiate more clearly the matrix from the fossil material and in which parts we can find acrylic or vinylic resin (like Paraloid B-72 or similar) from previous consolidation treatments. These different materials can be differentiated because each one emits a different brightness when ultraviolet light hits the material. The behavior of the minerals and other components are different under ultraviolet light within the non-visible spectrum. These light and other tools such as a bench magnifier were used to work more accurately on the theropod tooth. Due to this procedure, we could perform a more careful process of cleaning, extracting, and protecting the tooth.

EVOLUTIONARY PATTERNS OF LOCOMOTORY CAPABILITIES IN STEM-GNATHOSTOME VERTEBRATES

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***Keywords**: stem-gnathostomes, swimming speed, phylogenetically-informed models, ancestral state reconstruction, evolutionary model fitting*

The ecological context of early vertebrate evolution is envisaged as a long-term trend towards increasingly active food acquisition and enhanced locomotory capabilities culminating with the emergence of jawed lineages that constitute the vast majority of the current vertebrate diversity. However, supportive evidence for this perspective has been drawn almost exclusively from the ecology of living jawless and jawed vertebrates, despite knowledge of extinct phylogenetic intermediates that can inform our understanding of this formative episode of vertebrate evolution. Using phylogenetically-informed models for predicting swimming speeds from caudal fin morphology, ancestral character state reconstruction and evolutionary model-fitting we show that the evolution of locomotory capabilities in early vertebrates followed complex trajectories, with no support for a trend towards more active lifestyles in the line leading to jawed groups. In fact, ancestral swimming speeds predicted for the first jawed vertebrates are the lowest among all the lineages of early vertebrates. Indeed, microsquamous jawless vertebrates are estimated to have the highest swimming speeds, supporting their greater potential for dispersal than their more heavily armoured counterparts. This explains the disparate palaeobiogeographic patterns of microsquamous versus macrosquamous groups, characterized by cosmopolitanism and endemism, respectively. Ultimately, our results offer a new enriched perspective on the ecological context that underpinned the assembly of vertebrate and gnathostome body plans, challenging the prevailing hypotheses by supporting a more complex scenario characterized by the presence of intricate evolutionary pathways of locomotory capabilities.

THE EARLY JURASSIC ROTZO FORMATION OF NORTHERN ITALY: THE OLDEST RECORD FOR PACHYCORMIFORMS AND THALATTOSUCHIANS?

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***Keywords**: Early Jurassic, Calcari Grigi Group, Rotzo Formation, Pachycormiformes, Thalatthosuchia*

The Rotzo Formation, a shallow water carbonate succession that belongs to the Calcari Grigi Group (Trento Platform, Northern Italy), is best known for its invertebrate and palaeobotanical fossil record. The vertebrate fossil content is poorly known, with dinosaurian ichnofossils being the only well-known association.

The recent study of a museum collection, housed at the MUSE-Museo delle Scienze (Trento, NE Italy), gave new insight into the composition of the vertebrate assemblage of the Rotzo ecosystem, where ginglymodians, pycnodontiforms, hybodontids, chimaeriforms, pachycormiforms and thalatthosuchians thrived in a ramp-lagoon environment.Thrive

The presence of the latter two taxa is utterly unexpected: the stratigraphical record of both Pachycormiformes and Thalatthosuchia starts from Toarcian while the Rotzo Formation is dated to the Pliensbachian based on biostratigraphy and carbon-isotopes. The presence of these two clades, already known from younger Jurassic Formations of Northern Italy, supports the already proposed “European affinity” of the Southern-Alps faunas and provides the opportunity to test for a new palaeobiogeographical model for both Pachycormiformes and Thalatthosuchia. Unfortunately, the paucity of specimens available, with only few teeth reported in the studied collection, does not allow for definitive conclusions. New field work will be carried out in the near future to test this hypothesis.

A NEW FUNNEL-BEAKED FILTER-FEEDING PTERODACYLOID PTEROSAUR FROM THE LATE JURASSIC OF WATTENDORF, SOUTH GERMANY

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Keywords: *Pterosauria, Pterodacyloidea, Late Jurassic, South Germany, filter-feeding*

For filter-feeding pterosaurs, all belonging to Ctenochasmatidae, the function of the filter system can be determined from the morphology of the dentition and the shape of the rostrum, perhaps with the exception of the South American *Pterodaustro* with its remarkable anisodonty between the upper and lower jaws. This is not the case in the new specimen from Wattendorf. The upward curvature of the rostrum resembles that of *Pterodaustro* and, to a lesser degree, that of *Ctenochasma*. The tooth count in the upper jaw is 99, in the lower jaw 110 on each side. The transverse margins of the rostral spatula of both jaws are edentulous. Small hooklets at the tips of the tooth crowns appear to prevent full occlusion. At maximum occlusion, the edentulous part of the rostrum leaves an aperture permitting water intake. This configuration allows for two potential feeding mechanisms: thrust feeding by pushing the anterior third of the rostrum through plankton-rich water or pump feeding while wading in shallow water with rapid jaw movements accompanied by oscillating movements of throat poach and tongue. The filtering principle is comparable to that of an eel basket with a wide intake and a concentration funnel. The latter hypothesis is supported by the dimensions of the retroarticuar process suggesting a powerful depression musculature of the mandible, necessary for the generation of buccal underpressure. In both cases the keeled palate would have directed the water flow posterolaterally trough the dental sieve, which would have retained the plankton.

SMALL MAMMAL TAPHONOMY FROM CHALCOLITHIC AND MIDDLE BRONZE AGE LEVELS FROM EL MIRADOR CAVE (SIERRA DE ATAPUERCA, BURGOS, SPAIN)

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***Keywords**: small mammals, taphonomy, El Mirador cave*

Predators are the principal agent that bring micromammals to fossil sites and the palaeoecological value of the small mammal species recorded is increased with the palaeoecological information that their predators provide. Thus, taphonomic analyses are necessary to recognize the predator involved in the accumulation of a small mammal assemblage. Likewise, taphonomy also provides information from post-depositional processes to identify mixtures (produced before and after burial of the original assemblage) and environmental changes. Here, we present the results of the first taphonomic study of small mammals from Levels MIR5 (Chalcolithic) and MIR4 (Middle Bronze Age) of the El Mirador cave (Sierra de Atapuerca, Burgos, Spain), which are especially rich in small mammal remains. Previous palaeoecological analyses indicate more humid conditions and an open humid landscape in MIR5, whilst a rather cool, arid phase with an increase in open dry landscapes is observed in MIR4. This change may respond to the 4.2 ky Bond Event or to the intensification or human impact on the landscape. Taphonomic results revealed the involvement of an opportunistic predator (European Eagle owl, *Bubo bubo*) and the absence of reworking processes. Therefore, small mammal fauna is autochthonous and may be considered representative of the area around the cave. The absence of significant differences between the levels analyzed in post-depositional alterations related to environmental conditions (i.e., manganese oxide depositions) does not sustain the climatic aridification observed in MIR4. Results obtained support human impact as the main factor in the degradation of vegetation communities in MIR4.

MEET *AMPHICYNODON LEPTORHYNCHUS*, A 30 MYR OLD EMBLEMATIC SMALL CARNIVORAN FROM THE QUERCY PHOSPHORITES: LOCOMOTOR ADAPTATIONS OF THE FORELIMB AND PALEOECOLOGY

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***Keywords**:* Amphicynodon, *locomotion, palaeoecology, Quercy Phosphorites*

The Amphicynodontidae is a family of early arctoids, whose phylogenetic position within Carnivora is still debated and whose ecology has not been discussed so far, despite their abundance and diversification in the early Oligocene fossil record. This presentation provides the first insights on the ecology and functional anatomy of *Amphicynodon leptorhynchus*, a member of the first radiation of Arctoidea. Among the numerous localities of the Quercy Phosphorites, Itardies (MP23) is of particular interest in the study of the Amphicynodontidae, as it has yielded hundreds of well-preserved remains that can be attributed to this latter species. We describe in detail the forelimb anatomy of this 30 Myr old genet-sized carnivoran to assess its locomotor behavior, in comparison to 11 extant carnivorans with different locomotor adaptations. Despite general similarities with the digger model, most features shown by the forelimb *A. leptorhynchus* converge towards adaptations to climbing, such as a great range of mobility of the articulations, grasping abilities, a powerful musculature providing stability and a strong control of the movement when climbing on vertical supports. All those adaptations imply a lifestyle similar to that of small extant climbing carnivorans such as the red panda or the kinkajou, that live mostly in trees, descending to the ground basically for foraging, although some other climbing carnivorans can also live in rocky areas.

FIRST *HOPLOACERATHERIUM* MANDIBLE (RHINOCEROTIDAE, MAMMALIA) FROM THE LATE MIOCENE LOCALITY OF HÖWENEGG (HEGAU, GERMANY)

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***Keywords**: Mammalia, Rhinocerotidae, Late Miocene, Höwenegg, Germany*

The Late Miocene (Vallesian, MN9) locality of Höwenegg (Hegau, Germany) is renowned for the extraordinary preservation of complete skeletons of extinct mammals. The ongoing reassessment of the Höwenegg rhinocerotid collection, including material from the new excavations, has documented the presence of two different hornless rhinocerotid taxa (Subfamily Aceratheriinae): the smaller and relatively more robust *Aceratherium incisivum*, and the larger but slender *Hoploaceratherium* sp. The occurrence of a third, horned rhinocerotid species, *Lartetotherium* cf. *sansaniense* (Subfamily Rhinocerotinae), has been also recognised based primarily on postcranial elements. In the present study, a fairly complete but moderately crushed mandible of the scarce *Hoploaceratherium* sp. is reported for the first time. It is compared with the mandibles of the dominant *Aceratherium incisivum*, which is represented among others by two fairly complete skeletons. All three Höwenegg rhinocerotid taxa are low-crowned browsers that have favoured forested habitats with dense cover and abundant water. The significant size differences observed between the two hornless rhinocerotids may indicate a resource partitioning to reduce interspecific competition. The biostratigraphical implications are also of particular interest, since the fossil-bearing volcano-sedimentary deposits of the locality have been radiometrically dated at ca. 10.29 (+/-0.07) Ma. The Höwenegg rhinocerotid assemblage differs from the one at the classic Vallesian (MN9-10?) locality of Eppelsheim (Germany), where the more advanced two-horned *Dihoplus schleiermacheri* has replaced *Lartetotherium sansaniense*. On the contrary, it resembles closely the rhinocerotid association from the early Vallesian (MN9) vertebrate locality of Rudabánya (Hungary).

NECK MYOLOGY, RANGE OF MOTION AND FEEDING STYLE OF *CARNOTAURUS SASTREI* (THEROPODA: ABELISAURIDAE)

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***Keywords**: myology, neck, feeding, Abelisauridae,* Carnotaurus

The complete and well-preserved osteological fossil record of the craniocervical region in some large theropod dinosaurs has made it possible to assess different feeding styles. We have reconstructed the cranio-cervical myology and range of motion of the abelisaurid *Carnotaurus sastrei* from virtual vertebrae scanned via photogrammetry. The results presented here were compared with previous analysis carried out for *Ceratosaurus*, *Allosaurus* and *Tyrannosaurus*.

We found a slightly dorsally sloping but straight neck in neutral pose for *Carnotaurus*, whereas other previously studied theropods show S-shaped necks in neutral pose. This neck concavity was linked to the insertion of head dorsiflexor *m. transversospinalis capitis* at the tips of the neural spines. The reduction of the neural spine and taller epypophyses in *Carnotaurus* suggest a reduced *m. transversospinalis capitis* but broad attachments for head dorsiflexor/laterodorsiflexor *m. complexus* and neck dorsiflexor/laterodorsiflexor *m. longus colli dorsalis.* Aliform processes in cervical ribs allowed larger insertions for head lateroflexor *m. iliocostalis capitis.* Stronger neck torsion movements were likely due to mediolaterally widened prezygapophyseal articular facets.

Neck muscle morphology is closely linked to feeding styles: Tyrannosaurids stand out for strong dorsiflexive and lateroflexive movements due to larger moment arms, labelled puncture and pull/shake feeders. *Allosaurus*, strike and tear feeder, and *Ceratosaurus*, slice and rake feeder, would have applied less powerful but faster movements. The cervicodorsal vertebral features of *Carnotaurus* suggest a greater capacity for neck and head lateroflexion and dorso-lateroflexion and neck torsion. These movements prove a peculiar feeding style for *Carnotaurus*, different to those previously proposed for other theropod dinosaurs.

NEW TAXONOMIC DATA REGARDING FISHES OF THE FAMILY CLUPEIDAE FROM THE OLIGOCENE, OUTER CARPATHIANS OF POLAND

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***Keywords**: Actinopterygii, Clupeidae, taxonomy, Oligocene, Outer Carpathians*

Clupeidae is a family of ray-finned fishes that includes herrings, shads and sardines. They are relatively small in size, often forming large schools, mainly feeding on plankton. The Oligocene-Lower Miocene sediments of the Menilite-Krosno series from the Outer Carpathians of Poland hold a unique record of fish fossils – including clupeid fossils. Clupeids from this region are represented by 5 genera: *Alosa*, *Clupea*, *Pomolobus*, *Sardinella* and the newly-described *Maicopiella*. Species described from this region include: *Alosa* cf. *sagorensis*, *Sardinella sardinites* and *Maicopiella longimana.* The latest discoveries suggest that taxonomic diversity within the Carpathian basin is different to what was previously reported and wastebasket taxons were used, however the precise taxonomical composition is unknown. Here, we show new taxonomic, osteological and morphological data regarding clupeid fishes in the region. We compared the investigated fishes to fossil and extant clupeids. We examined 39 complete and several nearly complete specimens, analyzing and describing crucial diagnostic features, such as: opercular structure, abdominal scutes, branchiostegal rays, jaws, as well as meristic and morphometric data. The hyoid arch is for the first time documented for clupeids from this region. Our results demonstrate the presence of a new genus of clupeid fish containing *Maicopiella longimana* from the Carpathian basin, proving previous modern hypotheses regarding different taxonomical composition in this basin in the Oligocene. Our investigation provides insight on anatomy of fossil clupeids, useful for creating connections between extinct and extant species. Furthermore, it contributes to broadening our knowledge regarding the taxonomic composition of fishes in the Paratethys.

TESTING HYPOTHESES ON HETEROSTRACAN FEEDING USING COMPUTATIONAL FLUID DYNAMICS

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***Keywords**: early vertebrates, heterostracans, suspension feeding, denticle orientation, computational fluid dynamics (CFD)*

Teeth constitute a key innovation underpinning the evolutionary and ecological development of jawed vertebrates. As the earliest jawed vertebrates already possess teeth, we have to study tooth-like structures in stem gnathostomes to learn more about the evolutionary origin of teeth. Heterostracans are a group of extinct, jawless vertebrates that possess denticle-covered plates in their oral cavity. However, virtually nothing is known about the structure, development or function of these. How did heterostracans feed? Did they use their oral plates as actual teeth for predation or are these structures an adaptation for suspension feeding? The lateral sides of the anterior part of the heterostracan oral plates are covered with rows of forward-pointing denticles. The forward-facing orientation of these denticles has previously been hypothesised to be a specific adaptation for suspension feeding. To test this hypothesis, we used computational fluid dynamics (CFD), an emerging technique in palaeontology. CFD allows us to model fluid flow and visualise turbulences and velocity patterns around 2D models of heterostracan oral plate denticles. In our analyses we compared flow and velocity patterns of different models with forward-facing denticles to alternative models with rear-facing denticles. Independent of denticle orientation, similar velocity and turbulence patterns develop in the spaces between the individual denticles as well as on the upper surface of the denticles. In general, the models do not show substantial differences in their flow and velocity patterns. We therefore reject the hypothesis of the forward-facing heterostracan oral plate denticles being a specific adaptation for suspension feeding.

ADVANCED IMAGING APPROACHES TO DOCUMENT THE ANATOMY, PALEOBIOLOGY, PALEOENVIRONMENT AND/OR TAPHONOMY OF FOSSILS

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***Keywords**: Synchrotron X-rays, Mass spectrometry, UV-visible photoluminescence*

Just like the hammer and the magnifying glass, X-ray micro-computed tomography (µCT) has now become an essential tool for paleontologists, allowing them to access the internal morphology of fossils with an unprecedented level of detail and no, or only limited, sample preparation. A series of other advanced imaging approaches have also proved very promising to provide new insights into fossils, and in particular into flat fossils for which µCT largely fails because of the strong difference in X-ray absorbance along its flat and long dimensions. Among them, synchrotron X-ray fluorescence (XRF) major-to-trace elemental mapping not only provides new morphological information in revealing hidden anatomies, but also offers unexpectedly detailed paleobiological, paleoenvironmental and taphonomic information through the characterization of the organic and elemental compositions of the fossils. Synchrotron X-ray diffraction (XRD) mineralogical mapping offers important taphonomic insights through minerals identification and distribution, as well as their crystals structure, size and orientation. Synchrotron scanning transmission X-ray microscopy (STXM) and X-ray Raman scattering (XRS) can document the chemical nature of carbon in 2D or 3D in organic fossils such as precambrian microfossils or insects trapped in amber. Among advanced laboratory-based imaging techniques, time-of-flight secondary ion mass spectrometry (ToF-SIMS) provides surface molecular, inorganic and elemental compositions, and multispectral UV-visible imaging improves and/or unveils unexpected anatomical details in a wide range of fossils. Here, I will present an overview of these advanced imaging approaches, and give an outlook of *some exciting developments to come.*

NEW OCCURENCES OF *CELTEDENS* (LISSAMPHIBIA; ALBANERPETONTIDAE) FROM THE LOURINHÃ FORMATION

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***Keywords**: Upper Jurassic, Portugal, Phylogeny, Morphometry*

Albanerpetontidae form an enigmatic extinct group of highly derived small ballistic tongue feeding amphibians. They ranged from the early Bathonian to the early Pleistocene, and have been recovered from Europe, North America, Asia and North Africa. Due to their small size, their fossil record is fragmentary and scarce, most generally recovered as isolated fragmented bones from vertebrate microfossil assemblages. The Late Jurassic Guimarota microfossil assemblage yielded thousands of albanerpetontid specimens, although only partial results and identification have been formally published.

Here, we present new material from the Lourinhã Formation, including cranial and postcranial elements. The specimens come from four different localities, ranging from Kimmeridgian to Tithonian: Valmitão, Zimbral, Porto das Barcas, and Peralta. Frontals share an hourglass-outline frontal bone with a curved orbital margin, and a broad blunt internasal process, diagnostic features of the genus *Celtedens*. The phylogenetic analysis, based on the new material described, supports this attribution based on the shape of the internasal process, but it was not able to resolve the polytomy of the genus. Morphometrics analyses based on 17 frontals from Lourinhã and Guimarota show some morphological variations, such as the width of the ventrolateral crests, the relative proportion of the internasal process, and the dorsal ornamentation (from vermicular, to concave, honeycomb pits), and suggest a size component in the variation observed. However, it is not yet clear if such variation would be intraspecific (ontogenetic, sexual or other) or interspecific (between two closely related species).

USING COMPUTER FLOW SIMULATIONS TO ASSESS THE HYDRODYNAMIC EFFECTS OF EXTREME BODY MORPHOLOGY AND SIZE IN MESOZOIC MARINE REPTILES

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***Keywords**: marine reptiles, locomotion, computational fluid dynamics, evolutionary rates*

Various groups of Mesozoic marine reptiles evolved streamlined body shapes and efficient lift-based swimming modes, as seen in modern aquatic mammals. Ichthyosaurs had low-drag bodies, akin to modern dolphins. Plesiosaurs on the other hand, had strikingly different morphologies with long hydrofoil-like limbs and greatly variable neck/trunk proportions, displaying some of the most extreme body shapes observed in aquatic tetrapods. Long necks evolved in this group are often assumed to add excess skin drag and raise the energy cost of swimming, constraining swimming speed. Despite recent attempts to evaluate the hydrodynamic impact of long necks, their effect on the energy expenses of swimming remains unexplored.

Here, we use computational fluid dynamics simulations on full-body reconstructions of derived plesiosaurs, ichthyosaurs and modern cetaceans at a range of speeds and sizes. Our results show that the limbless bodies of plesiosaurs generated low drag, similar to derived ichthyosaurs and modern cetaceans of the same mass, regardless of their fineness ratio, although drag is significantly higher if the flippers are accounted for. Additionally, necks about three times the trunk length, increase substantially the cost of forward swimming for a constant trunk length. However, this effect was dampened by the enlargement of trunks during plesiosaur evolution.

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

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***Keywords**: 3D modeling, 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*. 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). 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.

PALEOECOLOGY OF *KHORATPITHECUS AYEYARWADYENSIS*. ECOLOGICAL NICHE MODELLING USING STABLE ISOTOPES

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***Keywords**: hominoid, Southeast Asia, Miocene, paleoecology, isotopic niche modelling*

Southeast Asia was a key area for hominoid diversification in the Miocene. Many different species are known from a large area spanning from India to southern China. The focus of this study is *Khoratpithecus ayeyarwadyensis* from the Irrawaddy Fm. (~9 Ma) in Myanmar.

We used carbon and oxygen stable isotope analysis of the carbonate fraction of the enamel of this hominoid as well as its associated mammalian fauna to reconstruct its paleoecology and to conduct modelling of the isotopic niches of these fossil animals. With our data we explored if *Khoratpithecus* was frugivorous, where in the forest canopy it foraged, and we characterized the vegetation type and its density in the habitat of this fossil pongine. The isotopic niches were modelled using Bayesian statistics with the R package SIBER. In contrast with previous studies, we propose an ecological rather than a dietary or trophic niche, given the specific isotopes we analyzed.

K. ayeyarwadyensis was then compared to other members of the pongine clade such as contemporaneous *Sivapithecus* and *Indopithecus* from Pakistan and India, respectively, as well as Pleistocene *Gigantopithecus*, and Pleistocene and extant *Pongo*. With this approach, we wanted to explore if there is evidence for ecological continuity in the pongine clade or if the variety of subsistence strategy was, like species diversity, greater in the past than it is now.

An improved understanding of *Khoratpithecus* and comparing it to other contemporaneous fossil hominoids is crucial to understand the evolutionary ecology history of the extant orangutans (*Pongo)*.

NICHE PARTITIONING OF THE BEARPAW FM, ALBERTA, CANADA, MOSASAURS AS EVIDENCED BY MICROWEAR AND GEOCHEMISTRY

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***Keywords**: Cretaceous, Alberta, mosasaur, feeding ecology*

The Campanian Bearpaw Formation sediments in Alberta, Canada, represent the northern part of the Western Interior Seaway. Though rich in marine vertebrates and invertebrates, the mosasaur component of the ecosystem is by far the most dominant, with nearly two-thirds of all vertebrate remains found attributed to this group of aquatic squamate reptiles.

Well-preserved specimens of large-bodied *Mosasaurus missouriensis* and *Prognathodon overtoni* are particularly common. A less commonly found, smaller mosasaur is *Plioplatecarpus primaevus*.

Various mosasaurs have been studied for taxonomic and morphological purposes, but the mosasaur ecological community structure has not received much attention. In particular, the presence/absence of intraspecific niche partitioning in this area is unclear. Therefore, the most common mosasaur species have been tested for dental microwear, microscopic scratches on tooth wear facets which give insights on diet, and on dental geochemical composition, as another tool for assessing dietary preferences.

Microwear analysis on the mosasaur teeth finds differences between *Mosasaurus*, as a more generalist taxon, and *Prognathodon*, as more of a hard food item consumer. *Plioplatecarpus* displays a tendency towards softer prey items, but also displays several indicators of consuming hard food items.

Geochemical analysis using EDX and isotope analysis using comparative plesiosaur and fish dental material, partitions the mosasaurs further into separate ecological niches, though there is some degree of overlap, especially between *Mosasaurus* and *Prognathodon*. PCA analysis shows a grouping of *Plioplatecarpus* with hybodont sharks, and some overlap between *Mosasaurus*, *Plioplatecarpus*, *Cretodus* sharks, and plesiosaurs. *Prognathodon* clusters closer together with sawfish, which are interpreted as durophagous.

A REAPPRAISAL OF A HISTORICAL PALEONTOLOGICAL SITE IN CENTRAL ITALY PROVIDES INSIGHTS ON THE DISPERSAL OF THE WILD BOAR (*SUS SCROFA*) INTO EUROPE

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***Keywords**: Suidae, Artiodactyla, Quaternary, Pleistocene, Mid-Pleistocene Revolution*

The wild boar, *Sus scrofa*, is one of the widest-ranging and most adaptable large mammals of the world. Yet, our knowledge of the early evolutionary history of this species is still limited. Here, we present a revaluation of the historical paleontological site of Palombara Marcellina (central Italy), which was excavated at the end of the nineteenth century. The geologic reassessment of the site, combined with an $^{40}Ar/^{39}Ar$ dating, allows to refer the mammal fauna from Palombara Marcellina to the early Middle Pleistocene. As such, this is one of the earliest occurrences of the wild boar in the European record. Moreover, it represents one of the most informative samples of this species for the considered time span. In particular, several skull fragments belonging to a single individual were digitized, virtually restored, and reassembled, providing unique insights on morphological and biometric variability.

Sus scrofa dispersed into Europe during the Early-Middle Pleistocene Transition, when an increase in the amplitude of climate oscillations, and hence a sharpening of the contrast between glacial and interglacial periods occurred. In Europe, this event is associated to a significant renewal of the mammal paleo-communities, with the arrival of some taxa that still persist today, due to their adaptability.

PACHYCROCUTA BREVIROSTRIS AND OTHER HYENAS AT THE EARLY–MIDDLE PLEISTOCENE TRANSITION IN EUROPE

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***Keywords**: Hyaenidae, Carnivora, Quaternary, faunal turnover, Mid-Pleistocene Revolution*

The giant short-faced hyena (*Pachycrocuta brevirostris*) was a widespread and successful carnivoran since its dispersal into Europe ~2.0 Ma. For more than 1.0 Myr it represented a major taphonomic agent in the region, and its putative role as a competitor or even as a limiting factor for the dispersal of early hominins populations *Out of Africa* fueled research and debate. It eventually disappeared from Europe during the Early-Middle Pleistocene Transition (EMPT), in a period of great climatic and faunal changes. However, the timing of this event and its potential connection with the arrival of two other hyenas, *Crocuta crocuta* and *Hyaena prisca* are unclear. Part of the problem rests on the uncertain chronology or attribution of some remains dated within the EMPT.

Here, we review the European fossil record of the giant short-faced hyena, with a special emphasis on its last occurrences. It seems likely that the newcomers dispersing into Europe during the EMPT do not actively outcompeted *P. brevirostris*, but rather benefitted from the niche left open by the disappearance of the giant bone-cracking predator.

A NEW STUDY ON THE HOLOCENE BROWN BEAR FROM ATLAS (MOROCCO)

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Keywords: *North of Africa, Isotopic analysis, El Hammar, El Hattab, Holocene*

The brown bear (*Ursus arctos* Linnaeus 1758) is a mammal of the family Ursidae with a wide distribution in Eurasia and North America. The Atlas brown bear inhabited North Africa until the 19th century, being the only ursid that occupied this continent. However, little is known about its origin, distribution, morphology or ecology.

In this work we present the last results about brown bears samples from El Hammar and El Hattab II caves (Morocco). The excavations between 2001 and 2003 delivered fifty-seven remains of *Ursus arctos*, dating from the beginning of the Holocene for El Hammar and around 8 ka BP for El Hattab II.

In both caves, the brown bear is present in almost all layers but seems to decrease in the more recent levels. We will discuss the reason for this decline in relation with the retraction of the geographical distribution of this species. We include a metric analysis and, for the first time in the North of Africa, results of isotopic analysis (C and N) on bone collagen from bears and other coeval mammals, in order to get insights about their diet and their role in the ecosystem.

BARYONYCHINE (THEROPODA: SPINOSAURIDAE) MAXILLA FROM THE LOWER CRETACEOUS ENCISO GROUP OF LA RIOJA (SPAIN)

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***Keywords**: Lower Cretaceous, Cameros Basin, Enciso Group, Spinosauridae, Baryonychinae*

Spinosaurids are a group of tetanuran theropods known from Lower Cretaceous and Cenomanian sites in Asia, Europe, North Africa and South America. In the Iberian Peninsula, several localities have yielded spinosaurid remains, mainly consisting of isolated teeth. Baryonychines have been documented from the upper Barremian-lower Aptian deposits of the Enciso Group in Igea (La Rioja, Spain). These remains consist of a maxilla fragment, isolated teeth, and a left hindlimb. Two baryonychine tooth morphotypes have been identified, which could belong to two different taxa or to the same taxon. CPI 477 is a left maxilla fragment characterized by the following spinosaurid features: exceptionally elongate anterior ramus, cylinder-like median shelf, wavy lateral wall in ventral view, elliptical alveoli, and anteriorly angled anteriormost alveoli. The Igea specimen differs from spinosaurine maxillae because its external naris is more anteriorly located, resembling those of baryonychines and *Irritator*. Nonetheless, the external naris of *Irritator* seems to be proportionally smaller. The Igea maxilla would have substantially contributed to the ventral margin of the external naris, similar to the condition characterizing *Baryonyx* and different from that of *Suchomimus*. Therefore, even if smaller in size, it seems that the Igea specimen CPI 477 mostly resembles the maxilla holotype of *Baryonyx.* All the alveoli are devoid of *in situ* teeth, but the first preserved one has a root of a functional tooth and a replacement one. This can help to better assess the affinities of the Igea maxilla and to shed light on the tooth replacement process in spinosaurid theropods.

THE OUTSTANDING SAMPLE OF *LYNX PARDINUS* FROM THE LATE PLEISTOCENE LOCALITY OF INGARANO (SOUTHERN ITALY)

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***Keywords**: Felidae, Carnivora, Quaternary, Taxonomy, Paleobiogeography*

The pardel lynx, *Lynx pardinus*, is considered one of the most threatened living felids, currently distributed in restricted areas of the Iberian Peninsula. The evolutionary history of this medium-sized felid, as well as its relationships with the Middle-Late Pleistocene “cave lynx” from Mediterranean Europe, have fuelled a decades-long debate among specialists.

In this contribution, we present the richest European sample of *Lynx pardinus* from the Late Pleistocene (about 40,000 years) of Ingarano (Southern Italy). The collection counts 415 lynx remains represented by 346 postcranial and 68 craniodental elements, including two almost complete crania. This material was collected in the 1990s and previously attributed to *Lynx lynx* without a detailed study. The richness of the Ingarano sample allowed to acquire data on the morphological and biometric variability of fossil pardel lynx.

Using traditional and CT-based methods we analysed and compared the lynx specimens from Ingarano with a large sample of extant and fossil (Pliocene–Late Pleistocene) lynxes from Europe.

Our results allowed (1) to revise the taxonomy of European fossil lynxes, (2) to redefine the geographical distribution of the Late Pleistocene *L. pardinus*, and (3) to offer new insights on the evolutionary history of this iconic European felid.

Finally, we also present the preliminary data on the inner cranial anatomy (brain and paranasal sinuses) obtained through CT analyses.

A STUDY OF DENTAL SEQUENCE IN PLEISTOCENE HYENAS THROUGH X-RAY TECHNIQUES

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Keywords: *Hyena, juvenile, development, X-ray, behaviour*

Spotted hyenas rear their cubs together at a communal den where juveniles practically spend their first year of life. Throughout this time, the individuals confront a suite of social and ecological changes. This produces different well-marked stages of behaviour. The mortality profile calculated through the age of death of juvenile individuals from the fossil record can provide useful data to analyse these patterns of within-den behaviour. Archeo-paleontological methods of age estimation in hyenas are focused on separating young from adults, and they commonly use tooth wear and replacement. Thus, a more detailed study of juvenile development is necessary. Dental development is considered the most appropriate method for age assignment because it is only minimally altered by external factors. We propose five ontogenetic categories for Pleistocene spotted hyena cubs. Each category corresponds to a specific moment of tooth development depending on the calcification of the crown, root elongation and inner features of the tooth. We have applied X-ray imaging technique on cranial remains and isolated teeth from Canyars (Barcelona, Spain) and Cueva del Camino (Madrid, Spain), both in the Late Pleistocene. The results suggest that this method is more accurate to classify the age of cubs, especially on isolated permanent germs. Following current ethological research, our categories would correspond with important changes in the cub behaviour. Analyses of mortality profiles on the hyena assemblage support this possibility. Therefore, the age classification proposed here can be used to compare the behaviour of extant and extinct hyena cubs at their dens.

3D PRINTING FOR BIOMECHANICAL STUDIES OF SHELL SHAPE AND STRENGTH

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***Keywords**: mollusk, shell strength, shell shape, compression*

3D printing has previously been emphasized as an educational tool in paleontology. However, the rapid development of this printing technology has revolutionized studies of ancient life by creating experimental opportunities previously unavailable to investigators. The fossil record and constraints of the fossilization process create unique challenges for paleontological studies, making it difficult to perform biomechanical tests on specimens themselves. However, with the appropriate choice of materials and careful experimental design, 3D printed specimens can serve as valid proxies for extinct and extant organisms. Here, we discuss two example applications of 3D printing for experimental bulk compression tests to understand the influence of vertebrate durophagous predators on their molluscan prey during the Mesozoic. We tested how shell shape influences mechanical resistance to shell-crushing predators using various brittle 3D printed materials. These experimental studies revealed potential tradeoffs between bivalve shell shapes, which permit behavioral and mechanical defenses. Additionally, with similar compression experiments on 3D printed shelled cephalopod septa we demonstrated that the increasing complexity of internal shell walls was unlikely to have increased shell strength against attacks by durophagous predators. Both experimental studies indicate that it is possible to conduct compression tests on 3D printed shells, which serve as a proxy to understand how shell shape influences shell strength, allowing investigators to better understand the role of durophagous predation pressures during a critical interval in the development of marine ecosystems.

ON THE ORIGIN OF CAIMANINAE: INSIGHTS FROM IMPROVED FOSSIL PHYLOGENIES

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***Keywords**: Crocodylia, Caimaninae, paleobiology, phylogenetics, morphology*

An incomplete fossil record and unstable phylogenies of extinct taxa hamper reconstructing the early evolution of Caimaninae. We describe previously unpublished articulated fossils of a key species, *Tsoabichi greenriverensis* from the early Eocene Green River Formation of North America, exhibiting further character evidence for the caimanine affinities of this taxon. Parsimony analysis of modified morphological taxon-character datasets coupled with a critical review of character evolution and published phylogenies reveals that fossil evidence for Paleogene crown-group and Late Cretaceous total-group representatives is unreliable due to uncertain character evolution in early Alligatoridae. The earliest unambiguous fossil age for total and crown-group Caimaninae is 63.5 Ma and 18.06 Ma. These calibration points follow best practices and are vital for better constrained estimates of time calibrated analyses. Phylogeny continues to imply two separate Caimaninae dispersals between North and South America, but instead of a northward back-dispersal, we find two Paleogene dispersals to South America an equally likely hypothesis. Miocene taxa of Central America previously assigned to the stem lineage ancestral to South American Caimaninae are reinterpreted as part of a Neogene northward expansion of the crown-group.

3D WHOLE-BODY RECONSTRUCTION OF THE PSEUDOSUCHIAN *GRACILISUCHUS STIPANICICORUM* ROMER, 1972, FROM MICROCT DATA

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***Keywords**: Musculoskeletal model, MicroCT,* Gracilisuchus*, Pseudosuchia, palaeobiology*

The small, terrestrial pseudosuchian (crocodile-line archosaur), *Gracilisuchus stipanicicorum* from the Late Triassic of Argentina, is known from well-preserved, articulated material from eight specimens (PULR, MCZVP, CRILAR-PV). Although this material has already provided great insight into the anatomy and palaeobiology of this animal, even more can be gleaned through the use of microCT scanning and further digital preparation of the fossils into an articulated 3D model. Here, we present the first digital model of this kind of *Gracilisuchus*, a composite of the best-preserved elements of four specimens, focussing on the most complete, PVL 4597. A small amount of additional material from the related pseudosuchians *Erpetosuchus* and *Batrachotomus* has also been added to fill in gaps in the forelimb and shoulder girdle where *Gracilisuchus* material is unknown. We take this opportunity to explain the methods and assumptions used to construct our novel 3D model. Our reconstruction is being prepared as a biomechanical musculoskeletal model that can be used to assess questions of *Gracilisuchus*' palaeobiology and palaeoecology, such as those about its enigmatic locomotor ability. The results from these analyses will be used alongside those obtained from similar models of other extinct and extant archosaurs to compare locomotor ability and function in this group in order to characterise their functional disparity, and evolution in the crocodile-line archosaurs.

LARGE CARNIVORE GUILDS DURING THE PLEISTOCENE OF EUROPE – BEFORE AND AFTER THE ARRIVAL OF *HOMO*

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***Keywords**: carnivores, guild structure, dynamics, ecological niche, Pleistocene*

The Pleistocene terrestrial ecosystems of Europe were dominated by powerful carnivores, such as large canids (e.g., *Canis*, *Lycaon*), hyenas (e.g., *Chasmaporthetes*, *Pliocrocuta*, *Pachycrocuta*, *Crocuta*) and large felids (e.g., *Megantereon*, *Homotherium*, *Panthera*), which were the top predators of this epoch, and competed constantly for the acquisition and exploitation of animal (food) resources. Additionally, the arrival of *Homo*, having a meat-eating behavior, in western Eurasia at the late Early Pleistocene had a profound impact on the carnivore community dynamics.

By employing an ecomorphological/behavioral approach, the present study contributes to the investigation of the community structure, dynamics, and evolution of the Pleistocene large carnivore guilds of Europe. Emphasis is given to important renewals, the ecological niches, the composition of the guilds in terms of dietary preferences and foraging strategies, and to the intraguild competition, including hominin-carnivore interactions, for access to food resources. Combined are four ecomorphological/behavioral parameters (body mass, diet, hunting strategy, sociality) of large carnivores that practice hunting and/or scavenging on large prey. Four chronofaunas are separated: 2.5-2.0 Ma (middle Villafranchian, i.e., before the arrival of *Homo*), 1.8-1.0 Ma (within the late Villafranchian and Epivillafranchian, i.e., during the first human colonization of western Eurasia), 500-300 ka (late Galerian-early Aurelian, i.e., when human presence is well recorded almost throughout Europe), and 120-10 ka (Late Pleistocene, i.e., comprising the last diversified European large carnivore guild). 3D guild structure diagrams are analyzed and compared, including comparisons with the modern savanna-ecosystem of Serengeti in Tanzania, and the results are discussed and interpreted.

MYSTERY HISTOLOGY OF THE LONG BONES OF *OZIMEK VOLANS* - GLIDING MEMBER OF LATER TRIASSIC FAUNA FROM KRASIEJOW

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***Keywords**: Late Triassic, Krasiejów, palaeohistology, lamellar bone, flying adaptations*

Ozimek volans is one of the most mysterious representatives of the Late Triassic fauna from Krasiejow. Phylogenetically it belongs to “protorosaurians”, however, the elongated limbs and proposed gliding abilities are not known among that group and make Ozimek more similar to Pterosauria, than to any other protorosaurians. Thus, it is interesting, if the unusually for protorosaurians mode of life is also reflected in the bone histology. The goal of that study is to investigate if bones of *Ozimek*, beside the morphological elongation, show any specific histological adaptations to flying. Two long bones of Ozimek (femur UOPB 1148a and humerus UOPB 1148b) were sectioned to obtain details about histological framework. In both bones, large medullary cavity and thin walls built from lamellar bone, with rare, simple vascular canals are visible. However, the most characteristic feature of cortex are numerous lamellae, which are visible as regular, dense packed rings around the entire section. The bones of Ozimek, on the histological level, are more similar to bones of small bats, with compact structure, low or moderate vascularization and slow remodelling, than to birds and pterosaurs with high vascularized fibro-lamellar bones. Probably, bats and also Ozimek grew too slowly to form laminar bone, but compact, low vascularized cortex could be well adapted to deal with high loading, with the simultaneous limitation of the weight. In that case, well ordered collagen fibers in successive lamellae seems to be a key adaptation to better distribution of the stress, originating during the gliding, along the bone.

DEVELOPMENT OF THE VERTEBRAL COLUMN IN *STENOPTERYGIUS QUADRISCISSUS* (REPTILIA, ICHTHYOSAURIA) FROM THE LOWER JURASSIC OF SOUTHWESTERN GERMANY

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Keywords: Stenopterygius*, Lower Jurassic, ontogeny, vertebral column, Ichthyosauria*

Ichthyosauria is a diverse marine reptile clade with derived secondary aquatic adaptations. More specifically, parvipelvian (post-Triassic) ichthyosaurs possess streamlined bodies, a body shape shared with extant cruising marine predators like lamnid sharks or tunas. *Stenopterygius* is a parvipelvian ichthyosaur famous for its abundant and exceptionally well-preserved record from the Lower Jurassic Lagerstätten of southwestern Germany. We qualitatively studied the development of the vertebral column in an ontogenetic series of *Stenopterygius quadriscissus* to understand potential ontogenetic changes underlying the acquisition of this specialized body shape. Following onset of centrifugal endochondral ossification of the centra in the earliest embryonic stage available, the ossification of the neural arches and spines in the precaudal series occurs. Ossification is delayed in the caudal region. In later stages, perichondral ossification and differentiation of the apophyses is observed while endochondral ossification of the articular surfaces is ongoing. Development of an antero-posterior gradient in the degree of amphicoely is initiated perinatally, while endochondral ossification of the region of attachment of the annulus fibrosus and zygopophyses start after birth. The lateral projection and detachment of the apophyses from the anterior edge of the centrum is seen in large juveniles. In adults and large juveniles, haemapophyses or ventral keels are present in the postflexural series and a change in the orientation of neural spines (syncliny) is observed in the tailbend region. These results demonstrate that ossification of the axial skeleton is not complete prior to birth in ichthyosaurs and this may have functional implications for axial flexibility in juveniles.

WHAT'S INSIDE A SAUROPOD LIMB? THREE-DIMENSIONAL EXAMINATION OF THE LIMB LONG BONE MICROANATOMICAL PATTERN OF *NIGERSAURUS TAQUETI* (DINOSAURIA, SAUROPODA)

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***Keywords**: Sauropodomorpha, graviportality, inner structure, body support, Saurischia*

Several terrestrial vertebrates reached gigantic dimensions, the most extreme case being sauropod dinosaurs, with forms exceeding several dozen tons and meters. In accordance with their heavy weight, these taxa usually show limb bone microanatomical features related to this condition, such as a thickening of the cortex around the growth center and a spongiosa fulfilling the medullary area. However, the distribution of these features is very poorly documented, mostly by 2D cross sections for only a few taxa on a limited number of bones that may not reflect the diversity of 3D patterns in heavy taxa. Here we provide the three-dimensional examination of the appendicular microanatomical pattern in a sauropod by the first integrative study of the six limb long bones (humerus, radius, ulna, femur, tibia and fibula) of the rebbachisaurid *Nigersaurus taqueti*. Thanks to 3D X-Ray microtomography, the best-preserved bones were scanned, accounting for between-bones, individual and size variation. As expected, the limb long bones of *Nigersaurus* are fulfilled by a spongiosa in the medullary area. The zeugopod bones are more compact than the stylopod ones. However, the cortex thickening is not as sharp as expected when compared to many extant heavy taxa. The relatively unexpected pattern of *Nigersaurus* questions about the body mass of sauropods that could have been lower than expected for a given size. This statement is congruent with the developed skeletal pneumaticity of these animals, participating in enlightening the body, and to their columnar limb architecture, helping in the role of weight-bearing.

FROM TOAD TO FROG: OSTEOLOGICAL DESCRIPTION AND TAXONOMIC REATTRIBUTION OF THE 'MUMMIFIED' HOLOTYPE OF *BUFO SERVATUS*, AN EOCENE ANURAN, BASED ON MICRO-CT EXAMINATION

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Keywords: *Anura, Tomography*, *Quercy*, *Eocene*, Thaumastosaurus

The Quercy Phosphorites are a set of Eocene-Oligocene deposits from South-West France that yielded numerous vertebrate fossils, including amphibians, mostly as isolated bones. However, in 1873, several exceptional amphibian specimens were discovered, with the external surface of the unmineralized tissues preserved, and were commonly referred as "mummies". In the 19th century, they were described without any knowledge of their internal anatomy. Since 2012, we have started scanning these "mummies", revealing the preserved internal soft tissues and articulated skeleton. A first specimen was attributed in 2013 to *Thaumastosaurus gezei* and we here present our results from the tomography of a second "mummified" anuran, previously identified as *Bufo servatus*. The tomography showed a preserved articulated skeleton, and its osteological characteristics are similar to the first scanned anuran "mummy", representing different ontogenetic stages. Both are now both attributed to *Thaumastosaurus servatus* nov. comb. The new anatomical information is used to assess the affinities of *T. servatus*, which appears to belong to the Pyxicephalidae, an African anuran clade. *Thaumastosaurus* thus represents both the oldest occurrence of this clade in the fossil record and its first occurrence outside of Africa. Its presence in Europe highlights a faunistic exchange with Africa during the Eocene, also documented for several clade of squamates. The presence of this African herpetofauna in Europe might be linked to the warmer climate during the Eocene. However, most of this herpetofauna, including *Thaumastosaurus*, disappeared from the region around an extinction event (named the "Grande Coupure") that took place around the Eocene/Oligocene transition (~34 Ma).

GROWTH AND FEEDING ECOLOGY OF CONIFORM CONODONTS

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***Keywords**: conodonts, feeding behavior, growth ecology*

Conodonts were the first vertebrates to develop mineralized dental tools, known as elements. Recent research suggests that “complex” euconodonts fed as macrophagous predators and/or scavengers, but we do not know how this feeding habit emerged in the earliest coniform conodonts. We focus on the primitive *Proconodontus muelleri* from the late Cambrian and the more derived *Panderodus equicostatus* from the Silurian. We tested the following hypotheses: (1) *Panderodus* and *Proconodontus* processed hard food and (2) both species shifted towards higher trophic levels during ontogeny. We employed backscatter electron imaging, energy-dispersive X-ray spectroscopy and synchrotron radiation X-ray tomographic microscopy to identify growth increments and Sr/Ca ratio as proxy for the trophic position.

Growth increments (27 in *Pa. equicostatus* and 58 in *Pr. muelleri*) were formed in bundles of 4-7 increments in *Pa. equicostatus* and 7-9 in *Pr. muelleri*. We interpret the bundles as analogous to Retzius periodicity in vertebrate teeth. Based on optimal resource allocation models, internal periodicity might explain indeterminate growth in both species. We interpret the almost linear growth of both individuals as an indicator that these taxa were not prey to higher-level predators. Our findings show that periodic growth was present in early conodonts and preceded tissue repair. We found no microwear and the Sr/Ca ratio did not change substantially during ontogeny. Trophic ecology of coniform conodonts differed from the predatory lifestyle of “complex” conodonts. We propose that conodonts adapted their life histories to top-down controlled ecosystem during the Nekton Revolution.

PLANKTIVORES WITH BITE: SUSPENSION-FEEDERS WITH TEETH END THE EDENTULOUS CLADE OF PACHYCORMIDS AND SHOW A LATE-IN-LIFE TROPHIC SHIFT TO MOLLUSCIVORY

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***Keywords**: Pachycormiformes,* Leedsichthys*, dental plasticity, ontogenetic series, trophic shift*

Pachycormids occupy a key-position within Actinopterygii, as part of the Holostei-Teleostei Transition. Due in part to their restricted ossification, remains of suspension-feeding pachycormids are invariably frustratingly incomplete, making interspecific comparisons for phylogenetic purposes as problematic as intraspecific comparisons for ecological or ontogenetic objectives. One consequence of this is that amongst the hypodigm of 70+ specimens of *Leedsichthys*, there are a very limited number of common bones between specimens, which furthermore often have their extremities destroyed through the vagaries of preservation and recovery, making comparisons even more difficult. The five individuals of *Leedsichthys* whose remains preserve maxillae (including three of the five individuals used in 2013 to assess the size, age and growth in this animal) were examined. The fragility of the weakly ossified remains rendered comparison difficult, but a growth series was established amongst the five based on commonly-preserved stretches of the maxilla, within which the largest individuals were found to exhibit the eruption and presence of maxillary dentition. This observation is consistent with previous interpretations of marine trace fossils as showing *Leedsichthys* ilio/durophagously feeding on shellfish in the seabed, in the same way as contemporary gray whales and Pacific walruses have been observed to do on the Bering Shelf, Alaska. The occurrence of dentition at the upper limit of the animal's recorded ontogeny not only illustrates an at least partial trophic shift for these planktivores in later (>10m) adulthood, but also questions the safety of using dentition and its presumed absence as characteristics in future pachycormid phylogenies.

A NEW PROTEID SALAMANDER (URODELA; PROTEIDAE) FROM THE MIDDLE MIOCENE OF GERMANY

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Keywords*: Europe, Neogene, Hambach,* Mioproteus*,* Proteus

The urodele family Proteidae currently accounts for eight extant species within two genera and at least four extinct species within three genera. The clade has a clear disjunct geographic range, with the extinct *Paranecturus* and the extant *Necturus* in North America and the extinct *Mioproteus* and the extant *Proteus* in Europe and Asia. The fossil record is rather scarce, but a recent phylogenetic analysis supported a Eurasian clade including both fossil and living species found east of the Atlantic Ocean. However, a new proteid from the middle Miocene of northwestern Germany challenges the idea of all Eurasian members of the group deriving from a single lineage separated from the North American ones at least prior to the Oligocene. This new proteid taxon is based on five isolated atlases found in late Orleanian (MN 5) sediments in Hambach 6C, and it displays features that are unknown in any other proteid, such as the presence of secondary dorsal crests, small and posteriorly-directed postzygapophyses, and (in at least some specimens) a wide and deep ventral fossa between the occipital joints. A phylogenetic analysis recovered the new taxon in an early-branching position within Proteidae, sister to all other proteids but the Late Cretaceous *Paranecturus*. It thus suggests the presence in Europe of a second proteid lineage, currently known only in the middle Miocene, that appears unrelated to the *Mioproteus*/*Proteus* clade.

THE IBERIAN EPIVILLAFRANCHIAN LARGE MAMMAL ASSEMBLAGES

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***Keywords**: Pleistocene, Quaternary, Epivillafranchian, EMPT, Iberia*

The latest Early Pleistocene (Epivillafranchian; 1.2-0.8 Ma) is one of the best-known geological periods in the Iberian Peninsula thanks to the abundance of chronologically well-known sites as well as for their species diversity. Among these sites, the most remarkable are: the Vallparadís Section (ca. 1.2-0.6 Ma), the Incarcal complex (ca. 0.8 Ma), La Boella (ca. 1.0-0.8 Ma), Bòbila Ordis (ca. 1.2-0.8 Ma) and Cueva Victoria (ca. 0.9 Ma). In the last decade, different studies have been performed in the above-mentioned sites permitted to make several inferences about the onset of the so-called *'Early-Middle Pleistocene Transition'* (EMPT) in the lower latitudes of the Iberian Peninsula.

Concerning large mammals, the Iberian Epivillafranchian is characterized by the first record of several species such as *Dama vallonetensis*, *Megaloceros savini*, *Ursus deningeri*, *Bison schoetensacki* and the re-appearance of *Sus strozzi*. Moreover, most of the species present in the Late Villafranchian sites of Orce survived until the beginning of EMPT, such as: *Mammuthus meridionalis*, *Equus altidens*, *E. sussenbornensis*, *Stephanorhinus hundsheimensis*, *Hippopotamus antiquus*, *Homotherium latidens*, *Megantereon* sp., *Panthera gombaszoegensis*, *Puma pardoides*, *Lynx pardinus*, *Pachycrocuta brevirostris*, *Canis* (*Xenocyon*) *lycaonoides*, *Canis mosbachensis*, *Vulpes alopecoides* and *Meles meles*.

Despite the alternation of periods of wet climate and arid conditions during the EMPT, most of the above-mentioned taxa did not vanish from the Iberian taphocoenoses until the isotopic stage MIS21, in the Early-Middle Pleistocene boundary.

A VELOCIRAPTORINE TIBIA FROM LO HUECO (UPPER CRETACEOUS, CENTRAL SPAIN)

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***Keywords**: Dinosauria, Theropoda, Dromaeosauridae, Campanian-Maastrichtian, Cuenca*

Theropod diversity from the Upper Cretaceous site of Lo Hueco (Cuenca, Central Spain) is not yet well established. To date, these dinosaurs are represented by isolated remains being preliminarily attributed to abelisaurids and to different maniraptoran clades identified based on teeth. Here an isolated partial left tibia articulated with the proximal tarsals is described and its taxonomic affinities are discussed. The tibia is relatively robust with almost straight medial and lateral margins. Distally, the proximal tarsals are fused together. They are firmly articulated with the tibia, but the suture is still visible. The proximal area of attachment for the fibula is a shallow posterolateral concavity delimited by a sharp lateral fibular crest and a less pronounced parallel ridge on the posterior face of the tibia. The fibula has a strongly twist to articulate on the anterior face of the tibia distally. This specimen exhibits several maniraptoran synapomorphies such as the plate-like and high ascending process of the astragalus and the broadly rectangular distal end of the tibia. Additionally, the combination of features showed by these elements is compatible with those of velociraptorine dromaeosaurids and confirms the presence of this clade previously identified in Lo Hueco based on isolated teeth. Several non-dental elements from the European Upper Cretaceous have been tentatively assigned to velociraptorines, but most of them show ambiguous combination of features and are currently interpreted as indeterminate dromaeosaurids. Therefore, the tibia from Lo Hueco would confirm the presence of velociraptorines in the Late Cretaceous of the Iberian Peninsula.

BONE SHAPE IN HEAVY MAMMALS: EVOLUTIONARY COVARIATION OF FORELIMB BONES WITH SIZE, BODY MASS AND BODY PROPORTIONS IN RHINOCEROTOIDEA

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***Keywords**: body mass, functional morphology, geometric morphometrics, graviportality, rhinoceros*

In quadrupeds, the convergent evolutionary trend towards an increase of body mass through time involves changes in constraints linked to weight support. Limb bones are assumed to be particularly modified in heavy quadrupeds, but few studies tried to untangle the complementary effects of mass, size and body proportions on their shape. The superfamily Rhinocerotoidea show a strong diversity of body mass, size and proportions, including small tapir-like forms, giant long-legged species and robust short-legged ones. Here, we explore the evolutionary variation in shape of the forelimb bones and its relation with mass, size and gracility (i.e., degree of limb length relatively to the body height) in Rhinocerotoidea using 3D geometric morphometrics. Our results indicate a general increase of robustness and greater development of muscular insertions in heavier and taller species, counteracting the effects of gravitational constraints when body mass increases. The shape of the humerus is related to both mass and size as well as gracility and exhibits a strong phylogenetic signal. Conversely, the shapes of the radius and ulna are significantly associated with gracility only, underlining a more important link to the mass repartition on the body than to the absolute mass itself. Our results indicate a deep functional breakdown between the stylopodium and the zeugopodium bones in Rhinocerotoidea. Our work also confirms the uniqueness of the giant Paraceratheriidae in the superfamily, displaying a long bone shape variation related to both a high body mass and a cursorial forelimb construction, challenging the classic opposition between these two extremes.

A COMPLETE, THREE-DIMENSIONAL EARLY PERMIAN AÏSTOPOD (TETRAPODOMORPHA) ILLUMINATES THE PHYLOGENY, ONTOGENY AND TERRESTRIALIZATION OF EARLY LIMBED AND LIMBLESS VERTEBRATES

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***Keywords**: Aïstopoda, µCT, scales, terrestrialization, Tetrapoda*

A complete, articulated, three-dimensional and stunningly well prepared skeleton from the Saar-Nahe basin (western Germany) resembles *Oestocephalus*, but has more and longer vertebrae. Despite the young ontogenetic stage indicated by size and skull proportions, the shape range of the dorsal scales is that of *Colosteus*. As in *Keraterpeton* and, as we find, *Oestocephalus*, the dorsal scales bear microscopic honeycombed sculpture. This is also seen on the ventral scales of the new specimen, which are nonetheless as narrow as in other aïstopods. The presence of the braincase and the first complete, undistorted aïstopod palate is confirmed by µCT; hyobranchial bones, endochondral girdles or a tail-fin skeleton are absent. The pointed tail is not laterally flattened, and the scales do not leave room for a soft-tissue tail fin; no gill slit is apparent in the scale cover behind the head. These terrestrial features contrast with the lateral-line canal previously identified in *Coloraderpeton* and suggest that the new specimen, together with the phlegethontiids from the contemporaneous fossil forest floor of Chemnitz (eastern Germany), represents a transition to terrestrial life independent from Tetrapoda. Yet, despite the plesiomorphies in the braincase, lower jaw and scales of Aïstopoda, phylogenetic analysis of an improved and greatly enlarged dataset finds no support for a whatcheeriid-grade position, and less support for a colosteid-grade position (as recently proposed) than for an amphibian one. Only *Andersonerpeton*, a lower jaw described as an aïstopod, joins *Densignathus* in the whatcheeriid grade. Redescriptions of additional supposed “lepospondyls” will be needed to resolve this conundrum.

THE LATEST MIOCENE-EARLIEST PLIOCENE HIPPOPOTAMIDS OF THE CIRCUM-MEDITERRANEAN AREA

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Keywords: *Hippopotamidae*, *latest Miocene, earliest Pliocene, Mediterranean area*

The peri-Mediterranean area was intensively colonized by hippopotamids during the latest Miocene-earliest Pliocene. Unfortunately, most of the remains are scarce and fragmented. Remains attributed to *Hexaprotodon? pantanellii* and ascribed to late Miocene were collected from the Casino Basin, Siena, Italy. These specimens should be properly re-assigned as Hippopotamidae indet. *He.? siculus* was unearthed from Gravitelli, Scirpi and San Pier Niceto, Messina, Italy. Unfortunately, these late Miocene remains went completely lost in the catastrophic 1908 earthquake. *He.? crusafonti* material was gathered from several latest Miocene Spanish localities and from an early Pliocene French locality. The peculiar mandibular symphysis of this species allows to indicate it more properly as *Archaeopotamus crusafonti*. *He.? sahabiensis* was collected from As Sahabi, Libya, and dated around 6.5 Ma. The teeth show several archaic features, such as sub-selenodont or selenodont aspect of the molars' cusps. *He.? hipponensis* was collected from the lower Pliocene locality of Pont-de-Duvivier, Algeria and it was documented by very scarce material. Some other remains were later unearthed from the early Pliocene deposit of Wadi Natrum, Egypt, and initially attributed to *He.? hipponensis*. Some further studies on these Egyptian remains highlighted a close affinity with *He. protamphibius* and attributed them to the sub-species *He. protamphibius andrewsi*. Although represented by fragmentary material, a re-analysis of the latest Miocene-earliest Pliocene hippopotamids from the circum-Mediterranean area could shed light on the evolutionary history of this group as well as resolving their phylogenetic relationships.

NEW OCCURRENCES OF SMALL MORADISAURINE CAPTORHINID EUREPTILES FROM THE PERMIAN OF MALLORCA (WESTERN MEDITERRANEAN)

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***Keywords**: Captorhinidae, Moradisaurinae, lower Permian, Cisuralian, Balearic Islands*

Moradisaurine captorhinid eureptiles were a cosmopolitan and successful group of high-fibre herbivores that lived in the arid low latitudes of Pangaea during the Permian. They are known to be quite diverse in southern North America, with lower-middle Permian fossil deposits that have been intensely sampled over the years. In other areas, such as the island of Mallorca (western Mediterranean), moradisaurines are known to be present, but the fossil deposits containing them have barely been studied in detail so far. Here we report fossils of two tetrapods from a newly-discovered lower(?) Permian site, excavated in 2019, which have been preliminarily identified as two small moradisaurine captorhinid eureptiles. The largest of the two consists of a semi-articulated, almost complete skeleton, whereas the smaller one has been identified based on two hemimandibles, a fragment of maxilla and some dorsal vertebrae, all found in close association. These moradisaurines represent, to date, the sixth reported occurrence of this group in the Permian of the western peri-Tethys, with large moradisaurines present on Mallorca (indeterminate species) and Menorca (under study), and small moradisaurines present on Menorca (under study) and northern Africa (*Acrodenta irerhi* and another indeterminate species). With the preliminary description and identification of those remains, this contribution presents this new lower(?) Permian site, recording some denizens of a previously unknown palaeoecosystem of equatorial Pangaea. New data from such latitudes is especially relevant because the fossil record of the lower Permian of the western Mediterranean area has traditionally suffered from severe undersampling.

CONSERVED CRANIAL DEVELOPMENT AND EARLY ONTOGENY IN TRIASSIC AND JURASSIC ICHTHYOSAURS

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***Keywords**: Ichthyosauria, ontogeny, cranium, ossification, prenatal development*

Ichthyosaurs are a diverse clade of viviparous Mesozoic marine reptiles, characterized by a series of dramatic cranial adaptations for underwater pursuit predation. A handful of taxa are known from lagerstätten deposits and are represented by a wide range of ontogenetic stages, including gravid females. In order to evaluate the ontogenetic trajectory underlying cranial adaptations, we studied cranial pre- and postnatal ontogeny in 40 specimens of *Stenopterygius* (Lower Jurassic, Central Europe), 20 specimens of *Mixosaurus* (Anisian-Ladinian, Northern Hemisphere) and the holotype of *Besanosaurus* (Anisian, Italy and Switzerland), which contains a single embryo. In *Stenopterygius* we recognized four ontogenetic stages on the basis of relative timing of cranial ossification. Dermatocranial elements ossified earlier than chondro- and splanchnocranial elements, as in other diapsids; embryos of *Mixosaurus* and *Besanosaurus* corroborate that this observation is a general pattern within ichthyosaurs. In *Stenopterygius* we observed that among dermatocranial elements, the circumorbital elements are more advanced in ossification throughout development, whereas the frontal and parietal lag behind. In the basioccipital and parabasisphenoid of *Mixosaurus*, we observed remnants of the basal tubera early in ontogeny; basal tubera are lost in parvipelvian ichthyosaurs. In the late-stage embryos of all three genera, the parietal and frontal are fused, but the midline antimeric connections of these elements remain open. We hypothesize that this weak midline ossification functions as a fontanelle to protect the cranium from compression damage during birth. These results show that despite their derived shape, ichthyosaur crania show substantial developmental similarity to those of other diapsids.

EXPLORING THE PHYLOGENETIC AND FUNCTIONAL SIGNALS OF THE NAVICULAR BONE IN PRIMATES: *ANCHOMOMYS FRONTANYENSIS* AS A CASE STUDY

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***Keywords**: Foot anatomy, Strepsirrhini, Eocene, Phylogenetic signal, Covariance analysis*

As an important component of the midfoot region, the navicular bone is considered to be a good indicator of locomotion in fossil primates. However, the study of this bone has been set apart in favour of other tarsal bones such as the calcaneus or the astragalus, more abundant in the fossil record. For the first time, 3D geometric morphometric analyses have been carried out to quantitatively assess the morphology of this bone and its relevance to infer the locomotor repertoire in early primates. To do so, a sample of 3D reconstructions of 85 specimens, including 8 naviculars of the Eocene adapiform *Anchomomys frontanyensis*, and locomotor and substrate usage data of extant primates have been used. Our results indicate the presence of a moderately strong phylogenetic signal in the navicular shape, as well as a significant amount of allometry. Furthermore, a significant co-variation between the type of locomotion and navicular shape has been found, even when phylogeny was considered in the analyses. In contrast, no significant co-variation was found between substrate usage and navicular shape. These results suggest that the morphology of this bone is influenced by locomotor behaviour but not by substrate preference. Finally, the new analyses performed confirm the results of previous works that suggested active quadrupedalism as the main locomotor mode of this fossil primate, which was probably more capable of leaping than other adapiforms and had similar leaping capabilities than extant cheirogaleids.

EXTINCT LAGOMORPHS FROM MEDITERRANEAN ISLANDS (MIOCENE-HOLOCENE): REVIEWING ECO-EVOLUTIONARY RESPONSES TO INSULARITY

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Keywords*: body size, conservation paleobiology, gigantism, insular regimes, life history, lifestyle, small mammals, teeth size*

Knowing the evolutionary history of taxa and their biological responses to past ecological perturbations (e.g. isolation) might be significant for the proper design and implementation of management actions for endangered populations. In the case of lagomorphs, 25% of species are at risk (vulnerable or endangered) and 41% show decreasing trends of population. Anthropogenic actions and climatic change have strongly impacted on their ranges, leading to habitat fragmentation. These home-range limitations (ecological islands) and restricted dispersion, together with climatic change acceleration, may push them to extinction. With a view to help address their conservation issues, the present study reviews the biological responses of extinct lagomorphs (stem-lagomorphs, leporids and ochotonids) to insularity, assessing Mediterranean islands from the Late Miocene-Holocene period. Eco-evolutionary parallel patterns have been identified in this mammalian order, regarding adult body size (64% of taxa are larger than forerunners), teeth size and morphology (100% are hypsodonts, and 55% show masticatory surfaces larger than forerunners), locomotion (55% are non-cursorial taxa, and 45% increase the use of other locomotion skills) and life history (28% shift towards the slow end). In certain teeth features, though, (e.g., enamel complexity), ochotonids show opposite trends to the rest of lagomorph groups. These biological responses have also been observed in other small-sized insular endemics. New insights into the paleobiology of these species will establish a more accurate baseline, which will be very useful for conservation purposes.

ENLARGED TOOTH AREA IN THE SARDINIAN *PROLAGUS* LINEAGE (LAGOMORPHA, EARLY PLEISTOCENE-HOLOCENE): IS IT A RESPONSE TO ECOLOGICAL STRESSORS OF ISLANDS?

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Keywords*: abrasive diet, body size, eco-evolutionary adaptations, endemic species, island rule, life history, megadontia, paleobiology, post-canine dentition*

Several eco-evolutionary adaptations have been identified in extinct insular endemic ochotonids (Lagomorpha, Mammalia), regarding adult body size, teeth morphology and dimensions, locomotion as well as life history. The present paper provides new insights into this topic, assessing the scaling relationship of teeth size to body mass (BM) in the anagenetic lineage *Prolagus figaro* – *Prolagus sardus* (Early Pleistocene-Holocene) from Sardinia (Italy). Standardized measurements were taken on tibiae (N=505), m1 (N=493) and lower toothrow (N=417) recovered from 9 fossil sites, which were arranged in relative chronological order. BM of the specimens was predicted using dimensions of tibia, whereas teeth size index (TSI) was calculated as a ratio between observed and predicted (considering BM) values for the area of the m1 (m1AA) and the lower toothrow (TRLAA). Our results pointed out that Sardinian *Prolagus* had statistically larger post-canine teeth than expected for its weight ($p<0.05$, ANCOVA test), both when ochotonids and leporids were considered as control groups. Together with an increased hypsodonty and a more complex enamel pattern of the occlusal surface, these teeth features identified in Sardinian *Prolagus* may respond to an abrasive diet, which is traditionally proposed for islanders. However, we believe that other biological factors (e.g., extended lifespan) might play a pivotal role in the selection of this longer lasting dentition. Future research on the life history of the extinct insular ochotonids may help us to disentangle this issue.

TWO LATETEST CRETACEOUS EGG LOCALITIES IN THE EXTERNAL SIERRAS (SOUTHERN PYRENEES, HUESCA PROVINCE, NE SPAIN)

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***Keywords**: Megaloolithidae,* Megaloolithus sirugei*, Maastrichtian, Sauropoda, nesting ground*

Sauropod oological remains are abundant in the northern and south-eastern Pyrenees, but scarce in the central region of the Southern Pyrenees (CRSP). Here we report two localities yielding eggs attributable to the oogenus *Megaloolithus*, located in Upper Cretaceous outcrops of the External Sierras (CRSP, Huesca, Spain).

In the CRSP, the Mesozoic succession is characterized by extensive stratigraphic unconformities and hiatus due to its marginal position in the Mesozoic Pyrenean basins. The Upper Cretaceous overlays the Triassic rocks, through a discontinuity that represents a non-depositional hiatus. The Cretaceous rocks are overlain by the Eocene Guara Formation. The eggshell-bearing layers are included in a continental terrigenous unit (Maastrichtian-Danian) traditionally named the “Garumnian facies”.

La Raya site (Peñas de Riglos municipality) was first mentioned by Pierre Souquet in 1967, who described eggshells “similar to those from the Begudian of Provence”. It is a small, ten-meter-thick outcrop where eggshell fragments and one isolated egg have been identified. On the other hand, the Ermita de Santa Marina site (Loarre municipality), discovered in 2019, is a 500m^2 outcrop, which has yielded a nesting ground with at least four different clutches, over 60 eggs, and thousands of eggshell fragments.

The compactituberculate ornamented subspherical eggs (~15 cm diameter) have ~3 mm-thick discretispherulitic eggshells composed of elongated shell units, thus being tentatively assigned to *Megaloolithus siruguei*. Survey between these localities, 8 km apart, shows the continuity of the egg-

bearing layer suggesting that the oological record of the CRSP might be on par with their Catalan and French equivalents.

PALAEOENVIRONMENTS AND TAPHONOMY OF THE MICHELBACH VERTEBRATE *LAGERSTÄTTE* (MIDDLE TRIASSIC, S GERMANY)

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***Keywords**: tetrapods, sedimentology, palaeosols, palaeoclimate, Keuper*

The Middle Triassic was a crucial time interval for vertebrate ecosystems, when they were recovering from the largest biotic crisis of Earth history, the end-Permian mass extinction. Vertebrate communities underwent a complete remodelling, the so-called modern faunas were established and the archosaur lineage dominated ecosystems. Here we present the recently re-uncovered *fossil-lagerstätte* from Michelbach, Southern Germany. The locality corresponds to the Sandige Pflanzenschiefer and Anthrakonitbank units (Lower Keuper, Ladinian), building up a ~1.7-m-thick succession of marly mudstones and carbonates representing a relatively complex sedimentary setting. Tetrapod and fish remains are found in specific greyish-greenish mudstone layers. Molluscs (mostly bivalves) and plant remains (including small coal seams) are less abundant. Sedimentological and taphonomic data indicate a low energy intermittently water-logged setting (likely marginal lacustrine), where carcasses accumulated during dry periods, as the presence of mud-cracks and (partially) articulated skeletons of temnospondyl amphibians (*Trematolestes* and *Gerrothorax*) accounts for. Otherwise, the abundant isolated bones (including temnospondyl, archosauriform, and choristoderan remains), sometimes fragmented but preserving delicate details, suggest occasional reworking and potential storm events. Three successive cycles of palaeosols are identified, showing an aridification trend under relatively strong seasonality (from Vertisols to Calcisols). A layered dolomite with a basal bone-bed and roundish moulds of gypsum nodules overlies the palaeosols, suggestive of a marine transgression in a relatively arid climate. This *fossil-lagerstätte*, together with others (slightly younger) from the Lower Keuper of Germany, allows to reconstruct the palaeoenvironmental evolution of Middle Triassic vertebrate ecosystems.

NEW DATA ON THE MULTITUBERCULATE *TOMBAATAR SABULI* (ALLOTHERIA, MAMMALIA) FROM THE LATE CRETACEOUS OF MONGOLIA: CLUES FROM CRANIO-MANDIBULAR ANATOMY

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Keywords: *Multituberculata, Djadochtatherioidea, skull, Mesozoic, Mongolia*

Tombaatar sabuli from the Gobi Desert of Mongolia belongs to Djadochtatheriidae, a speciose family of Late Cretaceous multituberculates within the superfamily Djadochtatherioidea. Its exact relationships with other djadochtatheriids are unclear; currently it is considered a sister clade to either *Mangasbaatar* or the entire *Djadochtatherium–Catopsbaatar* clade. This uncertainty stems partly from the incompleteness of the *Tombaatar* cranial material known so far; the holotype is a partial skull (the incomplete rostrum and anterior braincase). Here, we describe new material of *T. sabuli*, which is a nearly complete cranium with both jugal arches intact, and the left mandible; the latter has not been known hitherto in this genus. The specimen is juvenile, because we can actually observe dental replacement of the incisors and the molars are not fully erupted. It has the relatively long frontals, lack of the thickening of the premaxilla at the palatine surface of the bone, a relatively slender mandible, and p4 is large and not trapezoidal. We used microcomputed tomography (μCT) to investigate the internal structure of our specimen, which confirmed the I3 position on the suture between the premaxilla and maxilla, the same as in the holotype. This new material will help clarify the phylogeny of djadochtatheriids and their paleobiogeography.

A NEW PLEISTOCENE FOSSIL VERTEBRATE LOCALITY FROM CHIHUAHUA, MEXICO

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***Keywords**: Pleistocene, Chihuahua, Mexico, Rancholaebrean*

During the summer of 2013, a field team from the Museo del Desierto Chihuahuense discovered vertebrate fossils in a new locality near the town of Julimes, in the State of Chihuahua, Mexico. The assigned age was late Pleistocene (Rancholabrean Land Mammal Age). The material was found in a caliche matrix, on the banks of an intermittent stream, possibly due to a pluvial drainage system. To date, 22 skeletal elements have been rescued, prepared, and identified and have been preliminarily determined to belong to proboscidians, equids, rodents, bovids, and xenarthrarns.
Likewise, these records provide valuable information that will allow making inferences about the paleoenvironments present in this region of the Chihuahuan Desert during the last stage of the ice age, in addition to increasing the probability of discover new megafaunal fossil deposits in the surroundings of this area.

DIGITAL PRESERVATION OF A NEW ENDANGERED SWIMMING DINOSAUR TRACKSITE FROM THE LOWER CRETACEOUS OF LA RIOJA (SPAIN)

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***Keywords**: Paleoichnology, La Rioja, swimming dinosaurs, photogrammetry, conservation*

The Cameros Basin in La Rioja (Spain) has yielded thousands of dinosaur footprints since the first paleontological descriptions in the 1970s. With more than 10000 footprints and between 110 and 156 tracksites, the Cameros Basin represents an area with an extraordinarily high density of dinosaur ichnological remains, worldwide. A problem arises when it comes to the conservation and protection of this heritage and potential new discoveries. Deterioration of ichnological remains is due to weathering and constant, natural landscape evolution, but these same processes may lead to the uncovering of new paleosurfaces and to new discoveries. Photogrammetry is a great tool to preserve ichnological information before it is modified by weathering and erosion. This is the case for a new tracksite discovered in Laguna de Cameros (La Rioja, Spain) on the Leza riverbank. Here, a rockslide exposed a footprint-bearing palaeosurface which was discovered by a local person. After notification, the tracksite was examined, and it was determined that the footprints were natural casts of dinosaur footprints made by several bipedal dinosaurs, some of them in a pseudo-natatory behaviour. Evaluation of the surrounding area indicated that erosive phenomena, such as rockfalls, are a high potential risk to the tracksite, and its situation impedes its protection against deterioration or destruction. The best way to conserve the information contained in the tracksite was the production of a detailed 3D model. This 3D model will allow the further study of these footprints and their preservation (for palaeo-heritage) even when the natural evolution of the landscape will likely destroy it in the near future.

ONTOGENETIC GROWTH IN THE PLEISTOCENE PRONGHORN *STOCKOCEROS* FROM SAN JOSECITO CAVE, MEXICO

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***Keywords**: pronghorn, Pleistocene, Stockoceros*

Furlong (1943) first described large samples of adult and juvenile limbs of the Pleistocene pronghorn *Stockoceros conklingi* from San Josecito Cave, Nuevo Leon Province. The abundance of juvenile specimens allows the determination of growth trends in ontogeny, and comparison of the growth trends in other pronghorns. We measured the four main limb bones (humerus, radius-ulna, femur, tibia), taking both the length of the bone (minus epiphyses in juveniles) and the midshaft circumference (following the conventions of Kilbourne and Makovicky, 2012), the length of the bone (minus epiphyses in juveniles) and the midshaft circumference (following the conventions of Kilbourne and Makovicky, 2012). Sample sizes were: 105 humeri, 122 radius-ulnae, 64 femora, 60 tibiae. The Reduced Major Axis (RMA) fit was calculated for all four limbs using both R and PAST software (RMA is more appropriate than a Least Squares Correlation, because there is no dependent or independent variable). All four limb bones showed slopes of less than 1.0, suggesting that their growth is negatively allometric, growing thicker as they mature, rather than more gracile or growing isometrically (humerus slope = 0.82; radius-ulna = 0.73; femur = 0.88; tibia = 0.89). The RMA run in R software determined that all four limbs were significantly more robust, but in the PAST software, only the radius-ulna was significantly distinct from the isometric slope of 1.0, using 95% bootstrapped confidence intervals. This might be because the r^2 value for some slopes was low (0.5), although others were quite high (0.8 to 0.9 for most of them). This is very similar to the modern *Antilocapra americana*, which was significantly more robust in three limbs, and only isometric in the radius (Prothero et al., 2020).

THE EARLY PLEISTOCENE *STEPHANORHINUS* (RHINOCEROTIDAE) RECORD OF EURASIA

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***Keywords**:* Stephanorhinus*, morphology, biogeography, dispersal*

Several *Stephanorhinus* species were present in Eurasia during the Early Pleistocene: *S. kirchbergensis*, *S. etruscus*, *S. hundsheimensis*, *S. yunchuchenensis*, *S. jeanvireti*, and *S. lantianensis*. *S. etruscus* occurred for the first time in Europe during the latest Pliocene, being represented by a few remains close in size and morphology to Upper Valdarno specimens and then smaller than *S. jeanvireti*. This latter species was generally reported from latest Pliocene/earliest Pleistocene sites and recently documented in a younger locality (Colțești, southwestern Romania). *S. hundsheimensis* was established on Middle Pleistocene specimens from Hundsheim (Austria), but it was also documented from several latest Early Pleistocene sites. *S. yunchuchenensis* was recorded only in one locality in Yushe Basin (Shanxi Province), and, even if the exact location is uncertain, its age is estimated on regional geological information. The expanded nasal bones of this species can be related with sexual dimorphism. *S. lantianensis* was established on an almost complete cranium of an old individual; the species was at first documented at Gongwangling (Lantian Country, Shaanxi Province). *S. kirchbergensis* was reported in several Early Pleistocene localities of China and it occurred only at the beginning of the Middle Pleistocene in Europe. *S. kirchbergensis* co-occurred in Nihewan Basin with *C. nihowanensis* thus providing the evidence of a niche partitioning during the Early Pleistocene. The scanty record from Kazakhstan and neighbor areas during the considered time span does not allow to depict a clear framework of the species there represented (even if dubitatively assigned as *S. etruscus*).

THE DIVERSE TORTOISES FROM THE LATE MIOCENE OF HÖWENEGG (GERMANY)

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***Keywords**: Tortoises Miocene, Germany, Testudininae,* Titanochelon

The Late Miocene (MN9) locality of Höwenegg is well known for its diverse faunal assemblage during a key time period of the Neogene. Several articulated and nearly complete skeletons of mammals, fishes and a large amount of turtle specimens have been excavated in the past decades. Four different species of tortoises and freshwater turtles from at least three cryptodiran clades (Testudinoidea, Trionychidae, Chelydridae) have been recognized. The identified testudinoid specimens are highly fragmented, and only some of these are complete or partial shell elements. Here, we present our preliminary results on Höwenegg's tortoises that comprise at least two different small- and medium-sized species. The small tortoises show morphological affinities with the coeval "*Testudo*" *antiqua* complex, showing most of the known features of this group. These specimens allow us to contribute to the recent discussion on the taxonomy of this complex. However, some specimens are larger and comparably thicker, with deeply notched nuchals and no cervical. However, given the disarticulated nature of the material we are unable to observe all diagnostic characters of European geochelonians with clarity, and in some cases, there might be a mixture of characters present in testudininans. Therefore, the peculiar morphology of the sample from Höwenegg raises the question whether it belongs to a small geochelonian of the *Titanochelon* clade or to a large testudininan without a cervical – a new taxon in any case.

PALEOPATHOLOGIES AFFECTING ICHTHYOSAURS THROUGH TIME

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***Keywords**: Ichthyosaurs, palaeopathologies, evolution, avascular necrosis, injuries*

The study of palaeopathologies provides information about health and behaviour of organisms on ancient palaeoecosystems. We surveyed 624 ichthyosaur specimens from three lagerstätte: the Middle Triassic Besano Formation (BF; 242 Ma, Swiss-Italian Alps), the Early Jurassic Posidonienschiefer Formation (PF; 182 Ma, Germany) and the Middle-Late Jurassic Oxford Clay Formation (OCF; ~163 Ma, England). We analyzed factors affecting the prevalence of osteopathologies, and quantified the type of bone anomalies macroscopically observed and the anatomical units affected to assess if the incidence of osteopathologies is related to changes in palaeoecology and/or body plan. Pathologies in *Ophthalmosaurus* predominantly occurred in the skull (20%; 16/81) and pectoral girdle/forefin (12%; 10/84), a higher value in comparison with the similar sized Early Jurassic *Stenopterygius* (4% in skulls and 2% in forelimbs). The highest prevalence of pathological specimens was observed in the OCF (15%: 29/188) followed by the PF (14%: 32/236) and lastly the BF (6%: 12/200). Pathologies are concentrated in the anterior portion of skeletons in *Ophthalmosaurus*, similar to in Early Jurassic ichthyosaurs, supporting a link between body plan, swimming style and osteopathologies. *Ophthalmosaurus* was the only taxa with presence of avascular necrosis from all the surveyed specimens, suggesting contrasting palaeoenvironments compared with older formations. Besides avascular necrosis we also detected ankylosis of phalanges and cases of possible tumor in the pectoral girdle of *Ophthalmosaurus*. Future CT scanning is required to confirm this diagnosis.

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A NEW FOSSILIFEROUS MAMMAL LOCALITY FROM THE VILLAFRANCHIAN OF GREECE: PRELIMINARY RESULTS.

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***Keywords**: Villafranchian, Greece, Aghia Kyriaki*

Aghia Kyriaki is a recently discovered Early Pleistocene fossil mammal locality found at the South-Western part of Central Greece. More specifically, the locality is situated near the homonymous settlement of Aghia Kyriaki at an altitude of approximately 1300 m and belongs to the Pindos Mountain range. The locality consists of a karstic cavity formed in the Upper Cretaceous platy limestones formation of the Pindos zone, and is filled with coarse grained deposits, reddish-brown clay, as well as fragments of limestone and chert. The cavity was originally larger but was recently damaged during the cutting of the new road that exposed the fossils.

The preliminary systematic palaeontological study of the Aghia Kyriaki assemblage enabled the determination of the following mammal taxa: *Gazella borbonica*, *Ursus etruscus*, *Hemitragus sp*. and Arvicolidae indet., suggesting a putative Middle Villafranchian chronology, similar to other Mediterranean localities such as Saint Vallier (France), La Puebla de Valverde (Spain) or Dafnero (Greece). Further research will shed light on this interesting assemblage and will enable us to make more detailed comparisons with other classical Villafranchian European localities.

THE NEVERENDING STORY OF THE IBERIAN EOCENE ENDEMISM: A NEW PALAEOTHERIIDAE GENUS (PERISSODACTYLA)

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***Keywords**: Palaeotheriidae, Iberian Peninsula, Eocene, Endemism*

During the Eocene, in the European archipelago, the most abundant and diverse components of the perissodactyl fauna were the palaeotheres (Family Palaeotheriidae, Equoidea, Mammalia). In western Iberian Eocene fossil record (Duero, Almazán, Oviedo and Miranda-Treviño basins), a wide diverse and endemic association of palaeotherids and lophiodontids has been described. To date, five genera and sixteen species of equoids (mostly paleotheres) and five taxa of lophiodonts (aff. but with differences at specific level to European fauna), which are unknown in the northeastern Iberia (southern Pyrenean basins) and elsewhere in Europe, have been identified. Here we present a new endemic genus of palaeothere represented by two species of small to medium size (8-26 kg): one from the middle Eocene of Mazaterón (Almazán Basin, Soria) and the second from the late Eocene of Zambrana (Miranda-Treviño Basin, Álava). As it occurs with *Iberolophus*, the new taxon shows unusual dental features, which do not closely match that of any known ungulate mammal. It is characterized by a marked tooth row shortening, a slight teething thrust, and the presence of only two non-molariform premolars in combination with large molars and a long post-canine diastema (PCD). The Mazaterón species is larger in size than the Zambrana species and exhibits more primitive dental features (e.g., less reduced premolars and shorter PCD). The new finds here reported support the hypothesis of a different perissodactyl fauna in western Iberia during the middle and late Eocene relative to other areas of Europe, such as northeastern Iberia and Central Europe.

TESTING THE INHIBITORY CASCADE MODEL FOR LIMB DEVELOPMENT ON EXTANT AND FOSSIL AMPHIBIANS

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***Keywords**: Limb development, Salamanders, Temnospondyls*

It has been proposed that limb development is regulated by a balance between auto-regulatory 'activator' and 'inhibitor' signals. This model, known as inhibitory cascade (IC), predicts explicit variation patterns in limb proportions. The IC model has been regarded as a developmental 'rule' because it has been documented that adult limb proportions in amniotes follow the IC predictions at the intraspecific and macroevolutionary levels. However, these predictions have not been tested in amphibians, disregarding the unique limb development of salamanders and temnospondyls, the putative stem group of Lissamphibia. Salamanders are the only living tetrapods in which limbs develop following a preaxial polarity (i.e., preaxial elements form earlier) and that can fully regenerate their limbs throughout their entire lifespan. It has been proposed that temnospondyls presented both preaxial polarity and limb regeneration. We study herein whether the intraspecific variation patterns of limb proportions of two extant salamander species and the Paleozoic temnospondyl *Apateon pedestris* match the IC predictions. We recovered that these variation patterns are similar among the three species studied and deviate from the IC predictions. These results: 1) support the hypothesis that the particular limb developmental mechanisms of salamanders are similar to those of temnospondyls; and 2) suggest that the IC model might not be applicable to these groups. Further studies will assess whether the intraspecific patterns recovered are also observed at the macroevolutionary level to test whether the developmental mode of salamanders and temnospondyls might have biased limb morphological evolution in these groups.

SEXUAL DIMORPHISM IN THEROPOD DINOSAUR FEMORA FROM THE LOWER CRETACEOUS OF FRANCE

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***Keywords**: sexual dimorphism, 3D geometric morphometrics, dinosaur, femur, intraspecific variability*

Sexual dimorphism refers to phenotypic differences between individuals from the same species. Whether these morphological differences are discrete or continuous, they often shed light on the evolution of sexual selection mechanisms through evolutionary history. This is of particular interest when studying the evolution of non-avian dinosaurs, among which no sexual dimorphism has been carefully shown to date. Indeed, the lack of statistical representativeness, and of evidence for contemporaneity between individuals are challenging most hypotheses about sexual dimorphism among non-avian dinosaurs. Here, we show that femora from a large population of coeval theropod dinosaurs from the same species are dimorphic. We studied 10 complete femora and 18 distal epiphyses of a new ornithomimosaur from the Berriasian bonebed of Angeac Charente (France) using a 3D geometric morphometric approach. Our results highlight two femoral morphotypes: the first with a straight shaft and a latero-medially enlarged distal epiphysis; the second with a sigmoid shaft deviated toward the lateral side and a latero-medially narrower distal epiphysis. We attribute this morphological variation to sexual dimorphism because there was no significant size effect and a sigmoid shaft would be in accordance with a larger pelvic width among the female morphotypes. Our results are consistent with previously demonstrated sexual dimorphism at femoral and pelvic levels in close extant relatives to dinosaurs (crocodilians and birds) and more distant ones (chelonians and mammals). Our study emphasises the crucial need for accounting for the functional ability of carrying eggs among theropod female morphologies when studying sexual dimorphism.

DENTITION AND FEEDING IN PLACODONTIA: TOOTH REPLACEMENT IN *HENODUS CHELYOPS*

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***Keywords**: Tooth replacement, Dentition, Feeding behavior, Triassic, Placodontia*

Placodontia is a Triassic sauropterygian reptile group characterized by flat and enlarged crushing teeth adapted to a durophagous diet. The enigmatic placodont *Henodus chelyops* has numerous autapomorphic character states, including extreme tooth count reduction to only a single pair of palatine and dentary crushing teeth. This renders the species unusual among placodonts and challenges the interpretation of its particular dentition. The skulls of two *H. chelyops* specimens were visualized with synchrotron tomography to investigate the complete anatomy of their functional and replacement crushing dentition in 3D. All the teeth of both specimens were segmented, measured, and statistically compared to reveal that *H. chelyops* teeth are much smaller than the posterior palatine teeth of other cyamodontoid placodonts, except for *Parahenodus atancensis* from the Iberian Peninsula. The replacement teeth of this species are quite similar in size and morphology to the functional teeth. As other placodonts, *H. chelyops* exhibits vertical tooth replacement. This suggests that vertical tooth replacement arose relatively early in placodont phylogeny. Analysis of

dental morphology in *H. chelyops* revealed a concave shape of the occlusal surface and the notable absence of a central cusp. This dental morphology could have reduced dental wear and protected against failure. Hence, the concave teeth of *H. chelyops* appear to be adapted to process small invertebrate items, such as branchiopod crustaceans. These crushing palatine teeth are combined with a cutting edge with denticles and baleen-like grooves which could respectively be used to scrape the plants of the substratum and filter the plankton from the water.

PLESIOMORPHIC MORPHOLOGY IN AN EARLY PROTOSTEGID TURTLE FROM THE CRETACEOUS OF VENEZUELA

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***Keywords**: Protostegidae, Testudinata, Testudines, Venezuela, Cretaceous*

Whether advanced marine adaptations like that of extant sea turtles (Chelonioidea) evolved once or twice in turtles remains unresolved owing to the contested relationships of Protostegidae, a Cretaceous extinct pelagic clade. Fossils of protostegids are globally rare and the absence of species showing a transitional stage between littoral and pelagic adaptation precludes rigorously testing whether this clade is related to extant sea turtles or represents an earlier, convergent marine radiation. We report a new protostegid turtle from the Early Cretaceous Aptian Apón Formation of Venezuela based on a single, three dimensionally preserved, near-complete skull. This still unnamed taxon represents one of the oldest protostegids and is characterized by a narrow interorbital space, dorsolaterally oriented and relatively small-sized orbits, anteriorly sloping skull roof, relatively deep lower and upper temporal emarginations, and reduced vomer and cavum tympani. These traits are unlike those of other protostegid or chelonioid sea turtles but approximate the condition seen in freshwater turtles; we hypothesize them as plesiomorphic. Parsimony analysis recovers this species as a basal protostegid on the stem-lineage of crown-sea turtles, indicating a single pelagization event during turtle evolution. However, further (less derived) transitional forms are needed to rigorously test the global relationships of Protostegidae. The Venezuelan taxon nevertheless fills a considerable morphological gap in the early evolution of the group, perhaps corresponding to a littoral phase. It represents only the third described protostegid from the Early Cretaceous southwestern Atlantic.

RODENT'S ASSEMBLAGE FROM THE MIDDLE TO THE LATE PLEISTOCENE SITE OF AZOKH 1 CAVE (SOUTHERN CAUCASUS)

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***Keywords**: rodentia, taxonomy, taphonomy, palaeoenvironment, paleoclimate*

Azokh 1 Cave is located in Southern Caucasus, being an important site for the understanding of human evolution in its archaeological, paleontological, environmental and ecological context. The site presents a continuous archaeological record ranging from Middle Pleistocene to Late Pleistocene with some Holocene infill at the top of the sequence. Rodents are one of the most significant tools for the palaeoenvironmental and palaeoclimatic reconstruction because of their rapid evolution and their limited geographic range. Rodent's remains used in this study come from Unit V, Unit III-IV and Unit II. A total of 434 molars were identified following the keys of systematic paleontology, representing a minimum number of 237 individuals, composed of at least 13 taxa: seven arvicoline, two cricetine, two gerbilline, one dipodid and one murine species.

Unit III-IV do not yield enough material to draw palaeoecological inferences (MNI < 30). However, these inferences have been made for Units V (with a D/LAsp dating of 300ka), and II (with a ESR dating of ca. 184ka). Firstly, a preliminary taphonomic study (based on 90 molars and 100 incisors from both units) indicate that the rodent's assemblage was probably accumulated by a category 1 predator. Then, the inferred weather shows a relatively warm-temperate climate with continental conditions in both units. Finally, a landscape mainly composed by shrubland and steppe has been detected, indicated by the presence of the gerbils (*Meriones* spp.) and the Brandt's hamster (*Mesocricetus brandti*), with patches of deciduous forests and desert, similar to the one found nowadays in the area.

TOOTH MORPHOTYPES SHED LIGHT ON THE PALAEOBIODIVERSITY OF A TERRESTRIAL MIDDLE TRIASSIC VERTEBRATE ECOSYSTEM OF NE IBERIAN PENINSULA

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***Keywords**: Middle Triassic, Buntsandstein, Anisian, teeth, tetrapod*

The European Buntsandstein facies, of Early to Middle Triassic age, record a key period in tetrapod evolution. After the end-Permian biotic crisis, harsh conditions of global warming and aridity persisted during the Early Triassic, which induced a decrease in biodiversity, especially in equatorial Pangaea. The full recovery of vertebrate ecosystems took place in the Middle Triassic and is characterised by terrestrial tetrapod communities dominated by archosauromorph reptiles, followed by discrete presence of temnospondyl amphibians and lepidosauromorph reptiles, with a lesser representation of therapsids and procolophonomorphs. Palaeontological sampling on the northeastern Iberian Anisian record (Catalonia, Spain) provides new insights on the biodiversity at these latitudes. The Montseny area (Catalan Coastal Ranges), has provided several cranial and postcranial remains in the last decades. Among them, mandible and skull remains are particularly relevant because they provide information on the dietary habits of these organisms and also allow to evaluate the palaeobiodiversity on these ecosystems. In the present work, we identify five different tooth morphotypes: two correspond to capitosaur temnospondyls, one to archosauromorphs and two to procolophonomorphs. These findings help to fill a gap in the early Middle Triassic vertebrate diversity and distribution in southwestern Europe, and enable comparison with the Central European record, historically better sampled. Based on dental remains, and in contrast to the recovered ichnological record of the studied area, the earliest Middle Triassic terrestrial tetrapod ecosystems from northeastern Iberia were dominated by capitosaurs, followed in recorded diversity by anecdotic presence of archosauromorphs and procolophonomorphs, denoting sampling, palaeoenvironmental and/or taphonomic biases.

FIRST ATOPOSAURID (EUSUCHIA: ATOPOSAURIDAE) FROM MEXICO

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***Keywords**: Mesoeucrododylia, Atoposauridae, Early Cretaceous, Tlayua Formation, Mexico*

The Tlayua Formation (Early Cretaceous: Albian) near Tepexi de Rodriguez, Puebla, Mexico, is extremely rich in vertebrate fossils, mainly comprising chondrichthyans and osteichthyans but also more rarely remains of reptiles. Here we report on the external mold of a nearly complete and articulated skeleton of a small mesoeucrocodylian crocodylomorph assigned by us to Atoposauridae, mainly based on the short antorbital rostrum and the long legs with respect to the body suggesting a predominantly terrestrial lifestyle. The specimen is a juvenile lacking any osteoderms, and with its long gracile limbs strikingly resembles the European genera *Alligatorium* and Montsecosuchus. The Mexican specimen has proportionally slightly shorter legs than *Alligatorium* from the Late Jurassic laminated limestone of Southern Germany and more gracile limb bones compared with *Montsecosuchus* from the early Cretaceous of Spain. The new specimen thus represents a new type of atoposaurid for America and casts new light on the palaeogeography, diversity and evolution of Atoposauridae. The new atoposaurid would have been the second of this group after *Theriosuchus morrisonensis* from the Late Jurassic Morrison Formation, but the genus Theriosuchus is now referred to Neosuchia. If this holds true, the Tlayua atoposaurid would represent the only known atoposaurid crocodylomorph of America.

NEW ANALYSES OF THE "SOFT TISSUES" OF THE ITALIAN FOSSIL TETRAPOD *TRIDENTINOSAURUS ANTIQUUS*: INSIGHT ON TAPHONOMY AND CONSERVATION HISTORY

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***Keywords**: Early Permian, tetrapod, integument, conservation, taphonomy*

Tridentinosaurus antiquus Leonardi 1959 is a nearly complete reptile-like tetrapod (possibly a member of the Protorosauria group) found in the Early Permian volcanic succession in Trentino Alto Adige, Italy. Its phylogenetic position is currently uncertain. Soft tissues are reported in this specimen but their nature remains unclear. The specimen shows a defined black coloured body outline, alluding that most of the soft tissues are organically preserved. In the proximity of the shoulder and pelvic girdle, three-dimensionally preserved integumentary scales are evident; these are relatively small (ca. 1 x 2 mm) and rhomboidal in shape. We used scanning electron microscopy (SEM) coupled with energy dispersive X-ray (EDX) and micro X-ray diffraction (micro-XRD) analyses to investigate the mode preservation, ultrastructure and chemistry of the "soft tissues" of *T. antiquus*. Our study reveals that the integumentary scales are in fact osteoderms, formed by apatite with a pitted texture; no ultrastructure of the integument is preserved. The body outline and the abdomen are formed by anhedral crystals of apatite coupled with a small amount of carbon. The dark-coloured body outline composed of apatite crystals is incompatible with the interpretation of organically preserved tissues. We suggest that the body outline and the abdomen have been covered with a layer of black paint (e.g., Bone Black) perhaps to consolidate/protect the specimen. Our findings indicate the absence of soft tissues preserved in *T. antiquus* but the discovery of small rhomboidal osteoderms uncovers a new biological character that will support future phylogenetic studies of this ancient tetrapod.

ABNORMAL DEVELOPMENT OF PAIRED ENIGMATIC STRUCTURES IN THE DERIVED DICYNODONT *LYSTROSAURUS MURRAYI* (THERAPSIDA, ANOMODONTIA)

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Keywords: *Virtual paleontology, Triassic, Dicynodontia*

Derived dicynodonts, including *Lystrosaurus murrayi*, have edentulous lower jaws. As an interesting exception to this conventional wisdom, a well-preserved specimen of *L. murrayi* (MGGC-8850/1RE13 F) has abnormal, paired mandibular structures similar in overall morphology to dental teeth. The specimen pertains to the historical collections of the Museo G. Capellini (Bologna, Italy) and was collected in 1929 by M. Gortani during prospecting activities near Harrismith, South Africa. The specimen is articulated and includes a nearly complete skull, the first eight vertebrae and the proximal end of the right scapula. Reconstruction based on a Dual-Beam CT revealed unusual, paired structures similar to mandibular teeth, encased within the lower jaw, lingual to maxillary tusks. Different interpretations are possible for the abnormal mandibular structures in MGGC-8850/1RE13 F: 1) the dental lamina in the lower jaw, which would normally degenerate in derived dicynodonts, remained active and potentiated the odontogenesis; 2) the dental lamina was potent in the lower jaw throughout the ontogeny across dicynodonts but activated differentially; or 3) the mandibular patterning in our specimen was dorsalized, which resulted in an ectopic formation of upper jaw dentition in the lower jaws. Supranumerary or ectopic teeth are a commonly screened phenotype in modern mammalian models. Such variation distributes in a continuum – rarely does an edentulous jaw develop fully functional teeth that are present in outgroups. The absence of mandibular dentition

in other specimens of *L. murrayi* and in most other bidentalian dicynodonts suggests that MGGC-8850/1RE13 F represents a rare developmental abnormality or a case of atavism.

MODULARITY OF THE NECK IN TANYSTROPHEIDAE – INSIGHT FROM GEOMETRIC MORPHOMETRICS

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***Keywords**: Tanystropheidae, Triassic, geometric morphometrics, vertebrae modularity*

In vertebrate palaeontology, usage of geometric morphometrics (GMM) is often constrained by availability of well-preserved fossil material. One of the taxonomic groups that, despite abundance of fossils, remains unstudied with GMM methods is the Tanystropheidae. These Triassic archosauromorphs were characterized by substantial cervical vertebrae elongation, that reached its extreme extent in *Tanystropheus*. The main goal of this study is to investigate shape changes and modularity of the cervical vertebrae in tanystropheids to gain insight into the evolution of neck elongation in this clade. Moreover, the data could potentially be used in phylogenetic comparisons and in identifying the position of isolated vertebrae in the vertebral column.

The 2D GMM analysis was performed on 148 postaxial cervical vertebrae assigned to 14 species of tanystropheids and closely related archosauromorphs. The material included new undescribed remains of *Tanystropheus "conspicuus"* from Poland. To check for the influence of data loss generated by the exclusion of one dimension, 14 vertebrae of *T. "conspicuus"* were surface-scanned and included in a 3D GMM analysis. On each vertebra, 8 landmarks and 73 semilandmarks were located. The data were superimposed and compared using PCA and cluster analysis.

Our study allowed for identification of vertebral column modularity in the necks of some of the archosauromorphs, including *Protorosaurus speneri* and the tanystropheids *Macrocnemus* spp. and *Tanystropheus* spp. Some of the isolated *T. "conspicuus"* vertebrae were differentiated into morphotypes corresponding to their position in the vertebral column. Additionally, the results reveal that *"Tanystropheus" antiquus* vertebrae differ significantly from those of other *Tanystropheus* spp.

SYSTEMATICS AND PHYLOGENY OF AN ORNITHOPOD TOOTH FROM THE UPPER JURASSIC OF ALPUENTE (VALENCIA, SPAIN)

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***Keywords**: Ornithopoda, Tooth, Late Jurassic, Eastern Iberia, Dryomorpha*

Cranial remains of ornithopods are very scarce in the European fossil record and are mainly comprised by teeth. In the present work we describe a dentary tooth belonging to a small ornithopod from a Villar del Arzobispo Fm outcrop (Bypass fossil site; Upper Jurassic) at the municipality of Alpuente (Valencia, Spain). The tooth is 10.3 mm of height (7.5 mm crown) and 5.7 mm of width and strongly curved to labial side. Its crown is shield-shaped, without cingulum and with the enamel restricted to the lingual surface. In this face, there is a basiapical and subcentral (slightly distal) prominent primary ridge, and two basiapical and more modest secondary ridges located each of one near of distal and mesial carinae. Both carinae exhibit several tongue-shaped denticles extending from the top until middle height of the crown. Furthermore, this tooth has a well-developed oblique wear facet apically. Some of these features resemble those observed in the dentary teeth of dryomorph ornithopods. In fact, the result of our phylogenetic analysis resolves this tooth as Dryomorpha. Particularly, the ornamentation of the enamelled surface is very similar to dentary teeth of the contemporary dryosaurids *Dryosaurus* of North America and *Dysalotosaurus* of Africa, and the ankylopollexian *Uteodon aphanoecetes* of North America and Europe, but unlike the dentary teeth with two secondary ridges in the lingual surface of the ankylopollexians *Camptosaurus dispar* from North America and *C. prestwichii* from Europe. For these reasons, we assign the tooth to Dryomorpha indet.

THE COLLECTION OF THE MUSEO DEL DESIERTO CHIHUAHUENSE IN DELICIAS, MEXICO

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***Keywords**: collection, Chihuahua, Mexico, fossils*

The Museo del Desierto Chihuahuense (MUDECH), located in the city of Delicias, Chihuahua, was inaugurated in 2010 to show the public the richness of the Chihuahuan Desert. Its geological and paleontological collections have increased during the last decade, but have not been formally curated until a couple of years ago. These collections are deposited in the Paleontology Laboratory of the institution, and are also distributed in three of the four exhibition halls of the museum. A total of 90% of the specimens are derived from the state of Chihuahua, and 6% from other Chihuahuan Desert regions. The collection is subdivided into: vertebrates, invertebrates, paleobotany, ichnology and replicas; and the geological collection donated by MSc. Carlos García-Gutíerrez. Among the most notable specimens in this collection are: (i) a vertebra that is the first official report of the genus *Bison* for the Pleistocene of Chihuahua; (ii) fossil fruits from a new Cretaceous locality; (iii) the plastotype of the nodosaur *Acantholipan gonzalezi*; (iv) a selenite crystal from the Naica cave. The collection also houses 12 replicas of Mesozoic fauna, 9 Pleistocene megafauna and 8 paleo-sculptures. This makes MUDECH the most important natural history museum in the State of Chihuahua.

HIGHLIGHTS OF THE HISTORY OF VERTEBRATE PALEONTOLOGY IN TURKEY

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***Keywords**: Paleontology, vertebrate, fossil, Turkey*

Vertebrate fossil remains from Anatolia and surrounding regions have been known since ancient times, but a modern analysis of these fossils started only in the 19th century. The earliest vertebrate fossil collected by professional geologists was published in 1836 and the subsequent discoveries from the Turkish territories, including the modern-day Turkey and the former possessions of the Ottoman Empire, were identified by eminent paleontologists and zoologists during the second half of the 19th century and the earliest 20th century. All of these specialists involved in vertebrate paleontology in Ottoman Turkey were foreigners, as a natural consequence of the gradual disregard for natural sciences in the Ottoman education system. In contrast, training of native specialists in vertebrate paleontology began in Turkish universities and institutions after the proclamation of the Republic of Turkey. With the notable exception of a Devonian fish bone with an unresolved affinity, the vertebrate fossil inventory of Ottoman Turkey was primarily composed of Cenozoic mammals and fishes; in turn, very few fossil reptiles have been reported. Similarly, the most popular field of vertebrate paleontology in the Republic of Turkey has been the Neogene-Quaternary mammals, which appears to be a less strenuous option because of the guidance of the former discoveries and the wide occurrence of coeval basins. On the other hand, a growing number of non-mammalian tetrapod fossils have been reported since the 1970s and the upper Paleozoic and Mesozoic rocks of Turkey are also very promising, especially concerning reptile paleontology.

ISOLATED ELASMOBRANCH VERTEBRAE FROM THE CRETACEOUS OF SAXONY: TAXONOMIC AND PALAEOBIOLOGICAL EVALUATION

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***Keywords**: vertebral centra, Chondrichthyes, Cretaceous, Saxony*

A highly diverse chondrichthyan fauna is known from the Late Cretaceous (Cenomanian-Turonian) marine sediments of the present-day Elbe Valley in Saxony (eastern Germany). Besides abundant isolated teeth, two centuries of collecting have yielded several dozen separate elasmobranch vertebrae, mainly from two former limestone quarries of the late Turonian Strehlen Formation. For 25 of these centra, we determined parameters such as diameter, length, diameter at birth, number and radius of growth increments. Nine of the vertebrae have been classified into three neoselachian shark morphotypes, for which taxonomic identification and palaeobiological interpretation were attempted. Apart from qualitative and quantitative morphological characters such as the width/length ratio, growth trajectories have been used as a criterion for morphotype definition through comparison with literature data. We tentatively identify Morphotype 1 as *Cretoxyrhina* (Lamniformes), Morphotype 2 as *Cretodus* (Lamniformes) and Morphotype 3 as *Ptychodus* (incertae sedis), which is in agreement with teeth occurring in the fossil assemblage. For these presumably nine individuals, we provide minimum body length and individual age estimates. This study proves that taxonomic interpretation of an assemblage of diverse elasmobranch vertebrae without unequivocally associated teeth is possible, albeit with some uncertainty. Moreover, this demonstrates that growth trajectories derived from vertebral centra can be used at least to some extent to characterize taxa under comparable conditions.

ON THE COMPLETENESS OF THE PALAEOZOIC CHONDRICHTHYAN FOSSIL RECORD

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***Keywords**: fishes, temporal pattern, sampling bias, environment, quality*

The chondrichthyans (cartilaginous fishes) originated and first diversified in the early Palaeozoic. Their early fossil record is poor because of their predominantly cartilaginous skeletons, which are rarely preserved and cause bias towards disarticulated and isolated mineralised remains such as teeth, scales and fin spines. As a consequence, reconstructing their evolutionary history is challenging and overshadowed by considerable uncertainties in how the completeness of chondrichthyan fossils impact on the narrative. Here, we quantify the quality of the Palaeozoic chondrichthyan fossil record, by using a variation of the previously defined Skeletal Completeness Metric (SCM), an approach that calculates how complete the skeletons of individuals are compared to their theoretical complete skeleton. Information from museum collection visits and literature were compiled into a database of 838 chondrichthyan species. Temporal completeness patterns show major peaks in the Famennian, Serpukhovian, Moscovian, Asselian and Wordian and the lowest scores throughout the Silurian and the Tournaisian-Visean. Chondrichthyans show a significantly lower completeness distribution than any published tetrapod group, which increases significantly when isolated material, including teeth, scales and fin spines, is excluded. Completeness is then similar in range to the completeness of pelycosaurs and parareptiles, but lower than plesiosaurs and ichthyosaurs. Environmental influences through time show a higher completeness of chondrichthyans from freshwater deposits in the Lower Devonian, around the Devonian-Carboniferous boundary and again throughout the Permian, while marine environments yield more complete skeletons throughout the Carboniferous. Our results reveal relatively weak spatial biases influencing the Palaeozoic chondrichthyan fossil record, but relatively strong environmental and temporal biases.

LATE JURASSIC JURA SAUROPOD TRACKS: A PRELIMINARY STUDY OF THE TCHÂFOUÈ TRACKSITE USING GEOMETRIC MORPHOMETRICS

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***Keywords**: Sauropoda, dinosaur track, geometric morphometrics, Jurassic, Switzerland*

In the Upper Jurassic record of the Swiss Jura Mountains, numerous tracksites represent a rich ichnological record of dinosaur movement, diversity, and abundance on the expansive Jura carbonate platform. At the Courtedoux-Tchâfouè (CTD-TCH) tracksite (Ajoie, Canton Jura), in particular, extensive documentation of dinosaur tracks and trackways was detected by the 'Palaeontology A16' (PALA16) team prior to its destruction by the construction of Swiss federal highway A16. On this site, 71 sauropod trackways, documented on different stratigraphic levels within the Reuchenette Formation, have been largely attributed to the ichnotaxon *Parabrontopodus*. In our current study, we reassess the sauropod tracks and trackways of the CTD-TCH tracksite using both qualitative and quantitative descriptors with a focus on landmark-based geometric morphometric methods. The latter allows us to analyse and quantify shape and shape variation in these sauropod tracks and to make more precise comparisons with other Middle Jurassic to Early Cretaceous ichnotaxa (e.g., *Brontopodus*, *Breviparopus*). The use of geometric morphometrics for sauropod tracks has been neglected in recent years following what reported by the seminal paper by Rodrigues and Dos Santos (2002). Its application on the CTD-TCH dataset will allow us to test the correct approach in using geometric morphometrics and validate it as a powerful tool that can be integrated into the standard ichnotaxonomic approach.

THE GOOD, THE BAD AND THE FRAGMENTARY: TAXONOMY, NEUROVASCULAR ANATOMY, ECOLOGY AND PECULIAR TAPHONOMY OF CRETACEOUS ICHTHYOSAURS FROM THE NORTHERN APENNINES (ITALY)

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***Keywords**: Cretaceous ichthyosaurs, Platypterygiinae, trigeminal innervations, taphonomy*

In 2016, a new ichthyosaur rostrum fragment (251372) was found near Gombola (Modena province, Northern Italy). This new find enriches the record of Cretaceous ichthyosaur remains from the same locality, dating back to the late 1800s. Two other rostral fragments from Gombola (IPUM 30139, IPUM 30140) previously referred to *Platypterygius* sp. were re-examined. All specimens come from parts of the rostrum anterior to the narial openings, and CT scans allowed the observation of their internal anatomy.

All three specimens can be confidently assigned to the ophthalmosaurid subfamily Platypterygiinae, based on the strongly quadrangular tooth roots; the robust shape of the teeth and the coarse longitudinal ridges on the crowns are indicative of an apex-predator eco-morphotype. The CT scan of 251372 revealed maxillary and mandibular ramification of the trigeminal nerve (V); each channel is branching from the main body at the floor/roof of the alveolar grooves and connects with the respective fossa dentalis/premaxillaris.

All three specimens share similar taphonomic characteristics, such as displacement along the symphyseal axis due to lateral compression. 251372 clearly shows evidence of scavenging, among which the tip of a shark tooth embedded in the proximal end. Similar to other marine reptiles found in the Northern Apennines, all fragments present signs of a common taphonomic history: bones and teeth are highly dense, black in colour and barely permeable by X-rays. These features seem to be related to the particular deep-sea environment, where iron-manganese oxides and carbonates encrust the skeletal tissues, encasing and protecting the remains.

NEW *BARANOGALE* (MAMMALIA, MUSTELIDAE) FINDS FROM THE MIDDLE VILLAFRANCHIAN OF SOUTHERN GREECE

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Keywords: Baranogale*, Middle Villafranchian, Greece*

Remains of small carnivores are generally rare in the fossil record. In particular, the Mustelid genus *Baranogale*, although it has been known to date by a few specimens from important Villafranchian localities such as Saint Vallier (France) and Villany (Hungary), consists of a very rare find in the Balkan Peninsula, as it has been only found in two Middle Villafranchian localities, Varshets in Bulgaria and Dafnero in Northern Greece respectively. New finds from the Middle Villafranchian locality of Karnazeika (northeastern Peloponnesus, S. Greece) come to enrich the scarce fossil record. Herein, rich new dental material of this rare mustelid is described, and based on its morphological characters, the *Baranogale* from Karnazeika can be safely attributed to *B. helbingi*. However, in matter of size, like *B. cf. helbingi* from Dafnero but less extensively, it differs significantly from the typical representatives of this species. The probable presence of subspecies has already been discussed by previous researchers, but the scarce material was not enough for a safe establishment. Maybe the new finds from Karnazeika will brand now this hypothesis plausible for reconsideration.

THEROPOD PALEODIVERSITY OF THE UPPER JURASSIC OF THE CAMEROS BASIN (N. SPAIN)

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***Keywords**: theropod teeth, Upper Jurassic, Cameros Basin, diversity*

Isolated theropod teeth are an important evidence to know the diversity of this clade as well as its biogeographic and stratigraphic distribution. However, very precise identification of isolated teeth at lower taxonomic levels is complex, especially for those morphotypes related to poorly represented groups. Also, few have been reported in the Upper Jurassic of the Cameros Basin thus far.

Here, a set of isolated theropod teeth collected in Valdepalazuelos-Tenadas del Carrascal site from the Tithonian of the Cameros Basin are described and discussed. These teeth were grouped into six or seven distinct morphotypes based first on qualitative morphology and comparative anatomy. Multivariate statistical analyses of quantitative measurements, such as Principal Component Analysis (PCA) and Discriminant Linear Analysis (DLA), as well as cladistic analyses, were performed in order to assign each morphotype to a certain taxon.

The current analyses assign some morphotypes to Megalosauridae, Allosauroidea, Dromaeosauridae, basal Tyrannosauroidea and a non-megalosaurid megalosauroid possibly related to the piatnitzkysaurid *Marshosaurus*. The results of our study report for the first time a high diversity of theropods in the Late Jurassic of the Sierra de la Demanda (Cameros Basin).

This analysis indicates a great similarity of the theropod faunas from the Late Jurassic of the Gijón-Villaviciosa Basin, in Asturias (Spain) and other European chronocorrelative localities such as those from the Lusitanian Basin (Portugal) and Germany.

THE EARLIEST *BISON* FROM THE MEDITERRANEAN AREA: A REVIEW

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***Keywords**:* Bison*,* Eobison*, Villafranchian, EMPT, Pleistocene*

Bison is one of the most common genera of artiodactyls of the Quaternary. Although during the last century a large number of *Bison* remains has been discovered and several species have been erected, the evolutionary history of this group remains unclear. Nowadays, it is commonly accepted that *Bison* is sister to *Leptobos*, a mid-sized bovine represented by two different lineages (or subgenera) and several species occurring throughout Eurasia, from Iberia to China, during the whole Villafranchian Land Mammal Age. The first forms of *Bison* sensu lato probably appeared in Asia, around the end of the Pliocene. Although in few sites the co-existence of *Bison* and *Leptobos* is reported, the latter replaced the former quite suddenly in the Eurasian herbivore guilds during the Late Villafranchian. Subsequently, during the Epivillafranchian and the Early-Middle Pleistocene Transition (EMPT), *Bison* became one of the most successful groups of bovids in Eurasia. The most primitive forms of *Bison* are commonly included in the subgenus *Eobison*, including relatively small-sized animals featuring a mixture of “primitive” and “derivate” characters. This subgenus comprises several species such as *Bison* (*Eobison*) *palaeosinensis*, *B*. (*E*.) *sivalensis*, *B*. (*E*.) *georgicus*, and *B*. (*E*.) *degiulii*, among others. In the last 30 years, the discovery/reappraisal of Late Villafranchian localities around the Mediterranean area such as Venta Micena (Spain), Mygdonia basin sites (Greece), and Pietrafitta (Italy) comprising large collections of *Eobison* remains, has been fueling the debate on the first appearance of these primitive bison in Europe and their relationships with *Leptobos*.

PALEOEPIDEMIOLOGY OF THE LATE TRIASSIC TETRAPODS FROM KRASIEJOW

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***Keywords**: paleopathology, osteopathology, traumas, Triassic, Mesozoic*

Pathogens, developmental abnormalities, dietary deficiencies, and traumas comprise the main causes lowering the reproductive success or causing death of animals in their natural environment. Many of them leave traces in skeletal tissues which can be preserved in the fossil material.

First described in 2001, the huge fossiliferous excavation site of Krasiejów (southern Poland) yielded thousands of Late Triassic tetrapod remains, including large temnospondyl amphibians and archosaurs, and is being successively investigated. The results of over 20 years of excavations supplement our knowledge of terrestrial biocenoses of the European Triassic. Krasiejów is an exceptional taphonomic window providing insight into the still poorly known terrestrial biotas of the European Late Triassic.

However, despite extensive studies of taxonomy and palaeoecology, there is still no comprehensive research of palaeopathologies. Thousands of specimens gathered from the outcrop comprise a great collection for palaeopathological and palaeoepidemiological studies. In the fossil populations, just like today, diseases were an important factor controlling the survival of animals. Therefore, examination of various maladies recorded in the Krasiejów assemblage can bring novel data about the health condition of ancient animals, their locomotion, feeding, the way they functioned in their environment, and environmental hazards they had to endure.

This far, we identified accident-related traumas, healed fractures, infection-related bone overgrowths, and other skeletal malformations in numerous remains, most notably belonging to aetosaurs and metoposaurs. Some of these conditions likely document the predator-prey interactions. The varied taxonomic distribution of some types of pathologies seems to reflect either physiological or ecological susceptibility of different species to various diseases and injuries.

MULTI-TAXIC PALEOHISTOLOGICAL ANALYSES GIVE INSIGHT INTO THE LATE TRIASSIC LOCAL PALEOENVIRONMENT OF KRASIEJÓW

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***Keywords**: Late Triassic, Krasiejów, palaeohistology, growth pattern*

The Late Triassic Krasiejów locality in southeastern Poland has been known for more than two decades. During this time, it yielded numerous, disarticulated skeletal elements belonging to both aquatic amphibians (non-amniotes) and aquatic, terrestrial and volant reptiles (amniotes). The main goal of this study, by using histological thin sections, was to test if (and how) the local climate impacts the growth pattern of animals originating from the same locality, a study which until now has not been performed for any other locality. The here analyzed data includes humeri and femora of *Metoposaurus krasiejowensis* and Cyclotosaurus *intermedius* (both temnospondyl amphibians), *'Paleorhinus cf. arenaceus* and *Stagonolepis olenkae* (both archosauromorpha). Despite the large phylogenetic range of the tested animals, all samples consist of lamellar-zonal bone with an alternation of thick zones and relatively thick annuli, also almost none of the section possesses annual Lines of Arrested Growth (LAGs). The lack of LAGs suggests that the local climate was rather mild without drastic episodes of drought, which could cause annual cessation of growth. We assume that the local environment had a great impact on the growth pattern and thus should always be taken into account during the histological interpretation.

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BUILDING A NEW COLLECTION AND COLLECTION SPACE FOR SAUROPOD DINOSAURS AT CENTER OF NATURAL HISTORY, HAMBURG

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***Keywords**: Sauropoda, Collections, Morrison Formation, Ontogeny*

Sauropod dinosaurs like *Brontosaurus* and *Diplodocus* from the Upper Jurassic Morrison Formation have shaped our image of dinosaurs and feature the halls of natural history museums worldwide. However, no sauropod is on display in Hamburg, the second-largest city in Germany. Therefore, the Hagenbeck Foundation recently acquired four mounted skeletons of a flagellicaudatan sauropod, which were up for sale in a local fossil gallery, and provided them to the Center of Natural History for study.

The skeletons were excavated close to Kaycee, Wyoming, by German fossil collectors. The locality represents a possibly monospecific bonebed with partly articulated material of several individuals. The collectors sold a prepared and mounted skeleton and unprepared material from the same locality to the fossil dealer in Hamburg, who finally offered for sale a “family” of four individuals with a juvenile and a baby. Although the “family” obviously remains speculative, and some mounts are probably composites, the fact that all four skeletons include abundant original cranial and postcranial material, and that three ontogenetic stages are represented makes this collection unique.

The bones were digitized with photogrammetry, and several elements including the skulls were microCT-scanned. The photogrammetric models of the single bones were used to virtually find the most space-saving arrangement of the bones in the new collection space so it can be adequately stored and accessed during the research phase preceding remounting and exhibition. This collection is an example of how commercial collecting in the USA can benefit science and science outreach worldwide.

15 YEARS OF FOSSIL CARNIVORE SKULL FEA: WHAT HAVE WE LEARNED AND WHAT IS NEXT?

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***Keywords**: finite element analysis, Carnivora, marsupials, biomechanics, 3D, skull*

The introduction of digital simulation approaches to the study of extinct organisms has revolutionized the field of functional morphology in vertebrate paleontology. In particular, the application of finite element (FE) simulations to fossils enhances the researcher's ability to test both new and longstanding functional questions about extinct species. Here I provide a synthetic analysis of fossil carnivore skull FE studies, as we come up on 15 years of research efforts. The 18 analyzed studies represent a disproportionately high ratio of Plio-Pleistocene specimens to older Cenozoic ones. Furthermore, studies have focused principally on fossils belonging to the Felidae, Hyaenidae, Canidae, Mustelidae, and Ursidae. The fossil carnivore taxon most frequently studied using FEA is *Smilodon fatalis* (4 publications). Of the 37 fossil taxon-model datasets analyzed, the biomechanic variable common to the largest number of studies was mechanical efficiency of canine bites (calculatable in 78% of models). All studies also share an extant analog or phylogenetic bracket approach, although the number of comparative living taxa included varies widely (from 1 to 18 species per study). Both standardized reporting of modeling parameters and core simulation output data, as well as increased sharing of models and in more universal data formats, are identified as key factors in fostering the continued development of broader and more informative FE datasets for carnivore skull biomechanics research. Current and future research directions are shifting from the study of 'exceptions' to the study of 'rules' governing the evolution of carnivore skull biomechanics.

THE MAMMALS FROM THE PALAEOLITHIC SITE OF MELITZIA CAVE (MANI PENINSULA) GREECE

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***Keywords**: Palaeolithic, Melitzia Cave, Palaeoecology*

Mani peninsula is considered an important region of Greece for palaeolithic research, as there is a considerable number of known excavated sites containing deposits with cultural remains from the Middle Palaeolithic, the Upper Palaeolithic and Neolithic period. Melitzia cave is a site with Upper Pleistocene deposits containing remains of numerous large mammals and small fossil vertebrates along with lithic artifacts, showing that the cave was inhabited by both humans and animals. The layers date to the Upper Palaeolithic and more specifically to an age between 24,000 and 11,000 BP (Before Present). The present study focuses on the recovered vertebrate assemblage, which is dominated by red deer. The examined specimens were identified anatomically and taxonomically, and thus the following taxa were determined: *Cervus elaphus*, *Dama dama*, *Capra ibex*, *Sus scrofa*, *Eqqus sp.*, *Lepus europaeus*, *Mustela nivalis*, *Felis silvestris*, *Vulpes vulpes*, *Crocuta crocuta spelaea*. The ecological character of the assemblage indicates a temperate climate with open woodland surroundings. The specimens are characterized by strong fragmentation, and many of them appear burned modified by the respective hominid inhabitants.

MODELLING THE PTEROSAUR ACTINOPATAGIUM – A SYNTHETIC APPROACH

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***Keywords**: pterosaur, actinopatagium, actinofibril, Mesozoic*

The actinopatagium, a fibre-supported membrane unique to pterosaurs, was the primary component of the flight surface. Despite being widely discussed, principal anatomical and functional aspects of actinofibrils remain poorly understood. To advance our understanding we used light microscopy, UV and laser-UV illumination and scanning electron microscopy to compile data on actinofibrils including their morphology, size, orientation, distribution, packing and preservation. Actinofibrils are preserved in at least four distinct modes permitting the discrimination of taphonomic artefacts from true anatomy. Our data set (75 specimens distributed among 25 species representing 11 out of the 20 principal clades) spans almost the entire known temporal range of Pterosauria. The data suggests that the wings of all pterosaurs, irrespective of their size or ontogenetic status, contained actinofibrils. Actinofibrils were present throughout the flight membranes and exhibit the same alignment in all specimens: parallel to the principal limb bones and perpendicular (or nearly so) to free membrane margins. Dermal in origin and composite structures, each actinofibril consisted of a helically wound bundle of very fine fibres <10 microns in diameter. These and other features suggest that they were most likely composed of collagen. Actinofibrils in distal regions of the flight patagia tend to be elongate, uniformly straight and tightly packed whereas those in proximal regions are shorter, more sinuous and often slightly more widely spaced. Mechanical roles, resisting compressive forces (parallel to their long axes) in the distal part of the wing and tensile forces in the proximal regions, seem most likely.

THE EFFECT OF AXIAL FLEXIBILITY ON LOCOMOTOR PERFORMANCE IN *TYRANNOSAURUS REX*

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***Keywords**: biomechanics, multibody dynamics, locomotion, Theropoda, Tyrannosauridae*

Extinct theropods had a much higher moment of inertia in the sagittal plane than extant animals, resembling two cantilever beams suspended at the sacrum. This has many implications for elastic energy storage and locomotor stability, but there is no direct method to investigate them. Musculoskeletal modelling provides an opportunity to test hypotheses regarding the mechanics of dinosaur locomotion. This serves to both further our theoretical understanding of locomotion, while also providing a biomechanical context to the evolutionary success of non-avian theropods.

To this end, we have developed a musculoskeletal model of an adult specimen of *Tyrannosaurus rex* (RGM.792000) in OpenSim. We have used direct collocation, a state-of-the-art mathematical approach, to generate walking and running gaits. The skeleton was reconstructed using high-resolution 3D surface scans. Body mass was estimated on a per-segment basis using convex hulls (total: 8531 kg), and locomotor musculature was informed by the literature and dissections. By using direct collocation, our model displays stable gait after optimization runs of ±20 minutes. This represents a drastic improvement over previous computational methods (3000 hours), allowing us to explore the behaviour at speeds ranging from 0.5 to 6.0 m/s. These results are preliminary, but the maximal speed is in agreement with earlier estimates. We expect that tail compliance served to reduce the metabolic cost of transport and limb bone stresses (thus increasing maximal speed) in large theropods. We are now combining this new reconstruction with a previously developed compliant tail model to quantify these effects.

EVOLUTION OF PLACENTAL MAMMALS ON ISLANDS

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***Keywords**: island biogeography, mammalian evolution*

Fossil insular mammals often show remarkable and sometimes even bizarre adaptations, including extreme dwarfism and gigantism, short limbs and ever-growing teeth. Although there are many important studies describing these extinct insular mammals, information on individual taxa, lineages and islands is scattered over many journals, often not widely available. Here, we present the results of the most comprehensive overview of the state of the art on the evolution, adaptation, and extinction of fossil insular mammals. Our overview is based on over 300 insular palaeo-species, which were endemic to at least 80 islands worldwide, and ranging in time from the Eocene to the Holocene, with a few Cretaceous cases. The analysis of the evolutionary processes underlying these unique adaptations helps us to understand general patterns of mammalian evolution, not only on islands but also on the continent and in fragmented habitats.

NEW ZEALAND'S EXTINCT GIANT RAPTOR (*HIERAAETUS MOOREI*) KILLED LIKE AN EAGLE, ATE LIKE A CONDOR

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***Keywords**: Haast's eagle, Harpagornis, finite element analysis, geometric morphometrics*

The extinct Harpagornis or Haast's eagle (*Hieraaetus moorei*) was the largest eagle that ever lived. First considered a predator, then a scavenger, the argument about whether it was an active hunter continues to be highly contentious. However, the veracity of proposed similarities with carrion-feeders has not been tested in detail. To infer the feeding behaviour of *H. moorei*, we combined geometric morphometrics and finite element analysis to compare the shape and biomechanical performance of the cranium and talons to those of five extant raptorial and scavenging birds. Unexpectedly, we found that the neurocranium of *H. moorei* is vulture-like in shape while its beak is eagle-like in shape. When simulating prey capture and killing, the mechanical performance of *H. moorei* is closer to extant eagles under biting loads but is closest to the Andean condor (*Vultur gryphus*) under extrinsic loads. The talons, however, are clearly eagle-like and capable to withstand extremely high loads when compared to the extant eagles. Results are consistent with the proposition that *H. moorei* quickly specialized to exploit large size preys. Our simulations suggest that the giant eagle was using its talon and beak to restrain and kill prey larger than itself, then

applying a feeding strategy similar to that of the Andean condor (*Vultur gryphus*) due to a conceivable preference for internal organs. Finally, we hypothesize that a modular evolution of the beak and the neurocranium may have favoured the rapid adaptation of *H. moorei* to a novel ecological niche.

CAUDAL MUSCULATURE REDUCTION AND A SHIFT IN LOCOMOTION MECHANICS IN TITANOSAURIFORM SAUROPODS: EVIDENCE FROM *TASTAVINSAURUS SANZI*

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***Keywords**: sauropoda, titanosauriformes, caudal musculature, locomotion, tastavins*

Titanosauriform sauropods were a diverse clade which have been usually regarded as producers of wide gauge trackways, with several osteological features in the hindlimb and pelvis likely related to changes in locomotion mechanics. However, how this transition in locomotion mechanics occurred in titanosauriforms is not well understood, partly due to conflicting phylogenies. The holotype of *Tastavinsaurus sanzi,* found in Xert Formation (late Barremian) in Teruel (Spain) is one of the most complete titanosauriform individuals from the Early Cretaceous of Europe. Its phylogenetic relationships are not well established, sometimes retrieved closer to Brachiosauridae, within Laurasiformes or as an early titanosaur. Several osteological features of this sauropod may be related to this transition in locomotion mechanics, with potential implications on its phylogenetic relationships.

The tail is more reduced in size relative to the presacral vertebrae than in earlier branching eusauropods. Also, caudal neural spines and chevrons are smaller relative to the centrum than in earlier branching Macronaria. This implies much reduced attachment surface for caudal muscles in absolute and relative terms, particularly for *M. caudofemoralis longus*. The transition point, however, is at a position closer to that of *Camarasaurus* or *Giraffatitan* than to titanosaurs. Muscles attaching to the posterior region of the ilium have also reduced attachment areas compared with the preacetabular region, twice as tall. This implies larger muscles related with leg protraction than retraction. *Tastavinsaurus* shows an intermediate condition from that of *Giraffatitan* and those in titanosaurs, suggesting a position closer to titanosaurs than to brachiosaurids regarding its hindlimb mechanics.

THE FOSSIL VERTEBRATES OF GREECE: A STATE OF THE ART

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***Keywords**: Palaeontology, Evolution, Fishes, Reptiles, Mammals*

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 WWII, 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.

SYNCHROTRON OSTEOHISTOLOGY RESOLVES 3D BONE VASCULAR ORIENTATIONS IN FOSSIL AND MODERN ARCHOSAURS

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***Keywords**: synchrotron tomography, osteohistology, bone vascularisation, archosaurs*

Bone vascular orientation represents a valuable osteohistological proxy that is challenging to characterise in physical samples. Using propagation phase-contrast synchrotron microtomography, we provide qualitative and quantitative 3D insight in the spatial interaction between circumferential, radial, and longitudinal canals irrigating modern and fossil archosaurian long bone cortices.

It is demonstrated that non-neoavian archosaurs feature a predominantly outward radiating plexus throughout the diaphyseal cortex that converges at or near the ontogenetic origin of the bone. Neoavian birds, however, develop a more intricate plexus arrangement that is not dominated by this radiating pattern. Non-neoavian pygostylians document the transition from a radiating peripheral plexus throughout the entire diaphysis to mostly radial vascular canals in the inner- and outermost cortex. We furthermore identify the archosaurian homologue to mammalian trans-cortical vessels that were recently described as vital components of the infraosseous circulatory system.

By virtually 'unrolling' the diaphyseal cortex into a planar geometry, the proportional ratios between circumferential, radial, and longitudinal components of the plexus can be quantified in a Cartesian environment. Assessment of these three principal vascular orientations along endosteal-periosteal transects resolves shifts in vascular plexus arrangement associated with fluctuating bone apposition rates. Unrolment of an ulnar diaphyseal interval of *Rhamphorhynchus* revealed a helical plexus component in the inner cortex that likely represents a structural adaptation for managing torsional forces during flight.

Our method provides novel tools for characterising and comparing bone vascular organisations across extant and extinct vertebrates.

EVOLUTIONARY PATTERNS IN CROCODYLOMORPH CRANIAL PNEUMATICITY

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***Keywords**: Adaptation, Crocodylomorpha, Macroevolution, Marine, Sinus*

During the first 50 million years of crocodylomorph evolution there was an incremental increase in cranial solidification. As this occurred diverticular infiltrations of the pneumatic sinuses expanded, with the marine thalattosuchians being an outlier by having reduced pneumatism. Loss of cranial pneumatisation is a common feature in extant diving and/or pelagic birds and mammals. In order to investigate whether there was a pneumatic loss during the land-to-sea transition seen in Thalattosuchia, and the evolution of the pelagic metriorhynchids, we CT-scanned and digitally segmented the cranial endocasts of 16 extinct and extant crocodylomorphs. Our results show that ‘protosuchians’ had the entire suite of braincase pneumatic structures seen in extant crocodylians, suggesting crocodylian braincase sinus patterns originated over 200 million years ago. However, ‘sphenosuchians’, ‘protosuchians’ and thalattosuchians lacked accessory paranasal diverticula, and had less complex antorbital diverticula compared to extant species. Thalattosuchian braincase pneumatism was reduced compared to other crocodylomorphs, lacking discrete diverticula (sinuses were confluent with the tympanic cavity and hard to individualise) and having a reduced number of diverticular infiltrations. This pattern was taken to the extreme in metriorhynchids, where

individualised braincase diverticula are rare or absent, and unique suborbital paranasal diverticula are present. Our results suggest a two-step change: one at the base of Thalattosuchia and another at Metriorhynchidae. We hypothesise a diving life style early in thalattosuchian evolution and that the reduction of bone-enclosed sinuses with the evolution of extracranial sinuses in Metriorhynchidae is consistent with cetacean macroevolutionary patterns.

WORKSHOP 1

GENDERED PERSPECTIVE IN PALAEONTOLOGICAL RESEARCH: FROM DEFINITION TO ACTION

P. Medina, A.R. Gómez-Cano

This workshop intends to shed light on the inextricable relationships between gender and science, introducing theoretical frameworks and concepts to participants. In order to face inequalities and biases in academia, a set of tools and ways of wording become critical to identify problems so often overshadowed in our workplace environments. That is why we will describe, identify and show the symbolic and material effects of these problems in palaeontology research and other related disciplines, and propose, through examples, different ways to face them.

WORKSHOP 2

THE EARLY-MIDDLE PLEISTOCENE TRANSITION: MARKED MAMMAL TURNOVER AND ECOSYSTEM DYNAMIC

R. Sardella, A. Iannucci, B. Mecozzi, F. Strani

The Early-Middle Pleistocene Transition indicates a fundamental transformation in the Earth's climate state, caused by the shift of the climate from 41 ky obliquity orbital cycles to a highly non-linear system dominated by 100 ky periodicity with asymmetric glacial/interglacial cycles. During the 1.2–0.9 Ma time span, a progressive faunal renewal in Europe occurred, which constituted the basis of the definition of a distinct biochron for the European Land Mammal Scale, the Epivillafranchian. Since the discoveries of the presence of Homo in the late Early Pleistocene, the timing and pattern of the dispersal and earliest occupation of Eurasia by Homo has been in the focus of the scientific debate. Given its geographical position, the entire Mediterranean region is considered a crossroads between Europe and Africa, East and West, and thus a promising region for examining the most likely causes and trajectories of the earliest dispersal of Homo. The early Middle Pleistocene ecosystems are generally described by their main components, climate, vegetation, and landscape forms. This workshop aims at gaining new insights into the multiple perspectives of early-middle Pleistocene terrestrial ecosystems and their dynamics before and after the earliest dispersal of Homo by various (palaeontological/palaeobotanical/geochemical) proxies. Furthermore, we would also like to discuss the taxonomy of large mammals, their dispersal across Europe and the biochronological inferences.

WORKSHOP 3

INTERNATIONAL PALAEONTOLOGY EDUCATION: VIRTUAL TEACHING AND REAL-WORLD LEARNING

T. Lepore (lead organizer).

In a year of unprecedented global pandemic, educators worldwide have had to pivot to online virtual learning, often with minimal training or resources. The need for a common language of science pedagogy and palaeontological education in an online sphere is all the more relevant for our learning communities, especially for our students. How can we maximize student experience in this virtual forum, and care for the needs of the learner in a holistic fashion, while balancing all of the duties of our scientific lives? This workshop will provide a fun, engaging, and thought-provoking opportunity for educators from different parts of the world to connect and build a palaeontological education resource for their own class. As we step into the 2021-2022 academic year, how will we centre best practices in palaeontology and science education, active learning, and a syllabus that reflects deeper dives into topics, without sacrificing the breadth or rigor of content? Workshop participants will spend the first two hours of the workshop identifying a part of their course syllabus they can shape to reflect active learning in an in-person or online environment; participants will outline and begin to design a course activity that utilizes active learning using digital technology, and they will need access to a smartphone or tablet; after a break, the second hour and fifteen minutes will allow participants to produce an introductory video for their activity. Participants will leave the workshop session with a new activity for their course, an introductory video, and a document they can share with students to help make their learning experience engaging and active, with real-world applicability. Workshop participants will have the opportunity to work in small groups to brainstorm activities with common interest / subject matter / course topics that can be shared among all participants after the workshop conclusion for use in future courses or educational endeavours.

WORKSHOP 4

STEPPING OUT OF ACADEMIA: WHY, WHEN AND HOW?

S. De Esteban Trivigno

EU agencies are aware that more than half of the PhDs that result from their programs (such as the Innovative Training Networks) will end up outside of academia, and promote researchers moving into the private sector. However, to be out of academia after a PhD is still considered as a "failure" by many researchers, and this translates into anxiety and depression for young scientists. This

workshop is intended to support those young researchers who in the future might find themselves out of the academic system, so they can take the best from their experience and knowledge and give it back in different ways to society. The workshop will provide delegates with some basic tools to set up their own business, so they can turn their ideas and passion into success stories. You may stop being an active researcher, but being a scientist is a life-long adventure.

WORKSHOP 4
INTRODUCTION TO HYPOTHESIS TESTING IN STATISTICS

S. De Esteban Trivigno

In this workshop the current scientific paradigm on statistical hypothesis testing will be explained, as well as its advantages and problems. The difference between parametric and non-parametric statistics will be highlighted, as well as the major assumptions of the statistical analysis. In vertebrate palaeontology, to have small sample sizes is something usual. This translates in a lack of statistical power in many analyses, exploratory methods that can be used when the data are not adequate to perform statistical testing will be introduced.

SYMPOSIUM 1
PALAEOART: DIVERSITY ON AND BEHIND THE CANVAS

F. Bertozzo, F. Manucci

During the 17th EAVP Meeting in Bruxelles (BE), our group organized a small symposium about the synergy between palaeontologists and palaeoartists for the first time, which received an exciting response from the participants. During the meeting, we also hosted a palaeoart exhibition with more than 30 artworks and prints from European palaeoartists, of which the prints were donated later to the auction. In the symposium, we presented four talks covering different topics about the relationships between art and science in vertebrate palaeontology. At the Online EAVP Meeting of 2021 we want to replicate what was done in 2019 in a similar format: a series of presentations and a related palaeoart exhibition (this late one, only if possible, given the virtual setting). Due to the current global pandemic situation, we still have to contact the possible speakers. However, we want to take advantage of the unfortunate period, and invite palaeoartists outwith Europe (US, Canada, Asia etc.) who could not otherwise participate to enrich the virtual engagement. Finally, thanks to the offered availability, there might be the possibility for an online virtual tour to Troco's Atelier to show how a traditional painter works. In the first part of the symposium, the talks will be presented, covering 25 minutes each, plus an introductory talk by Filippo Bertozzo of about 5 minutes at the beginning. About two hours in total are expected for this section, for which we are planning to invite four or five palaeoartists. The second part will be a virtual discussion moderated by us, where we invite an active discussion between the artists and athe udience, both about their own presentations and generally about palaeoart.

SYMPOSIUM 2
3D FOSSILS, ROBOTIC AND EXPERIMENTAL PALAEONTOLOGY

C. Böhmer

Fossils are the source of evidence about the history of life on Earth and have been carefully documented ever since their discovery. Yet not all preserved data has been accessible in the past. Technological advances of the last two decades have opened up novel ways of testing palaeobiological hypotheses. This involves acquisition of high-resolution 3D data of the internal and external morphology of fossils. For instance, cutting-edge imaging techniques such as synchrotron X-ray tomography has revealed previously unavailable information in unprecedented detail. High-performance computer modelling allows us to reconstruct the anatomy and to digitally simulate the biomechanics. In this regard, recent studies have recorded the actual kinematics of living animals

and modelled the movement in extinct taxa using computational techniques. Robotic replicas were used to reanimate fossils and have enhanced our understanding of the functional morphology in extinct taxa. Even artificial intelligence, such as machine learning –the fastest growing field in computer sciences –offers tremendous opportunities for palaeobiologists. Last but not least, rapidly growing digital repositories are not only an efficient way to archive and share 3D data, but also enable 3D printing to make rare fossils accessible and to provide digital models for teaching and learning. The chief goal of this symposium is to provide insights into the current state of the art in reconstructing past life with a special emphasis on robotic and experimental palaeontology as well as artificial intelligence. It reveals the promise and challenge that such approaches hold for answering fundamental questions in vertebrate palaeontology.

ROUNDTABLE 1

PRIDE EAVP: AN LGBTQ+ ROUNDTABLE (3RD EDITION)

A. Xafis, M. Jansen, K. Veitschegger

After two successful LGBTQ+ visibility roundtables, we are presenting for the first time Pride EAVP to all members of the Association. This year's topic is "The lack of LGBTQIA+ diversity in STEM. Ways to make labs and working groups more welcoming and hospitable". We invite everyone, regardless of gender identity and sexual orientation, to participate and share their story and opinion! We would also love to hear from the allies!

ROUNDTABLE 1

WOMEN IN PALAEONTOLOGY ROUNDTABLE DISCUSSION

F.M. Holwerda, A.R. Gómez Cano, J. Marigó, E. Teschner, V. Díez Díaz

As this year is different from others, our usual workshop will be postponed until we meet again in real life in 2022. However, after the popularity of the SVP online diversity roundtables, we'd still like to propose a way for Women in Palaeontology to get together and discuss ideas on how to improve diversity, the position of women in science, and anything else related to the topic that people would like to talk about. Topics could include (but certainly are not limited to):

The pandemic has certainly shown that women suffer more under lockdown measures than men do, as women are still the primary carers, and this has even been measurable in a significant drop in papers written by women over the last year. How could we help improve this?

Are there any other measures we can discuss to improve the general standing of women in science?

How about faculty positions, and the 'leaking pipe' problem that keeps coming back?

How do we stimulate the next generation of girls to choose a career in science?

These and any other issues you feel that need to be discussed can be brought forward. We're looking forward to talking with all of you again!