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A SCRATCH IN MATHEMATICS – COMPARING CLAWS IN BILATERIAN ANIMALS USING THE LOGARITHMIC SPIRAL AS A FRAME

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Nature and mathematics go hand in hand. Examples of all-day equations can be found everywhere when looked at closely. A good example of this is the "spira mirabilis", the logarithmic spiral. The mathematical concept behind this spiral is found over and over again in different formations of nature. This spiral was already recognized in the arrangement of sunflower seeds, the curvature of nautilus shells, and the architecture of spider webs. One aspect that makes the logarithmic spiral so unique is the nature of its tangential vectors. The tangential angle created by the intersection points between a radiance vector and the curvature of the spiral is equal all along the spiral. We used this mathematical basis of the logarithmic spiral to analyze and quantify claw shapes within polar coordinates.

$$r(\varphi) = ae^{k\varphi} \text{ with } a, k \in R \; k \neq 0$$

All analyzed claws were placed at the same point, the proximal end of the inner curvature with $\varphi = 0$ on point $a \neq 0$. This is the start of the logarithmic spiral in our fixed polar coordinate system. We positioned already predestinated radiance vectors (vectors that start at the origin of the system and cut through the inside and outside curvature of the claw). This ensured that the starting point of each claw-curve measured is identical. The change of variables is in r and φ, which stand for the height of the claw measured from the origin of the system and the angle of the considered radiance vector which cuts the claw shape. The claws were redrawn in a vector graphic program (Inkscape) to ensure that they are scalable. This facilitates that the claws all are measured through the same part of the logarithmic spiral and are comparable throughout every size. It allows us to compare claws despite their extreme size difference: for example the claws of between an isopodan crustaceans (less than 1 mm) and the ungual claw from a *Therizinosaurus* (more than 100 mm). The claws needed to be rescaled to provide a comparable base inside the equation since we wanted to use only one coordinate system which all claws were analyzed with. The calculation was programmed and executed with MATLAB. In this first run-through, we compared the claws from Euarthropoda (mostly crustaceans, Ornithodira (pterosaurian and dinosaurian ornithodirans including birds), and Pantherinae (big cats), which are all known to be used to pierce the flesh of prey. When a predator penetrates struggling prey with its claws, force vectors come into effect ripping on the claw. The probability of damaging the claw is lowest when the claw is curved logarithmic. With this, the logarithmic spiral provides a comparative frame for only distantly related organisms with fixed points and angles that can be compared.

AVICULOPINNA AND THE EARLY HISTORY OF THE BIVALVE FAMILY PINNIDAE

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The bivalve family Pinnidae is known from the Mississippian until present. Pinnids are often difficult to collect, so they are underrepresented in fossil collections and were apparently neither abundant nor particularly diverse. In their preferred environmental zone of shallow marine mud-dominated sediments, however, fossil pinnids occur in great numbers similar to modern occurrences of pinnids. The early geologic history of the family is obscured by ill-defined genus and species concepts. From the beginning of the study of late Palaeozoic pinnid species, descriptions were influenced by assumptions of character states when such features were not clearly observed due to incomplete preservation. Subsequently, these inaccuracies became incorporated into the generic concepts and were perpetuated in later works. A series of missteps in subsequent redescriptions led to reports on the presence of shell characters that are not present in other specimens from the source strata. These errors in descriptions and reconstructions have provided a basis for the suggestion that older taxa in the family differ from younger and may not belong to the family Pinnidae.

Specimens of *Aviculopinna* Meek from the upper Permian Zechstein Basin of central Europe provide new data that confirm definite pinnid bivalve characters in late Palaeozoic genera and species, including a distinctive equivalved, elongate-triangular shell, a dorsomarginal fold that holds the ligament, and a thick outer columnar prismatic shell layer, all of which provide evidence for confident assignment of the genus to the Pinnidae. The type species *Aviculopinna pinnaeformis* Geinitz from Thuringia and the specified genus characters are supplemented by comparison to well-preserved specimens of the closely related or even conspecific *Aviculopinna neukirchensis* Langenhan from Zechstein 1 strata of Nowy Kościół, Poland.

The suggested synonymy of *Aviculopinna* Meek with *Pteronites* McCoy as published in the Treatise on Invertebrate Paleontology is invalid, and the genus *Aviculopinna* is limited to occurrence in Permian strata, thus, excluding many species presently identified as being members of the genus. The type species of *Pteronites*, *P. angustatus* McCoy, from the Mississippian, however, lacks most characters common to pinnids and, thus, *Pteronites* is excluded from the Pinnidae and placed in the Pterineidae. An evaluation of the subterminal beak *versus* terminal beak concept in pinnids concludes that it does not support the assumption of an evolutionary divergence within the pinniform bivalves of the late Palaeozoic, also corroborated by Carboniferous taxa of *Sulcatopinna* Hyatt and *Meekopinna* Yancey.

Pinnids from the Late Pennsylvanian and Permian of North America show characteristic microstructural patterns of the shell resulting from a *Pinna*-type shell secretion in contrast to the atrinids. If this observation is further substantiated, the divergence of *Pinna*-type and *Atrina*-type pinnids must have occurred before the Permian.

Occurrences of *Aviculopinna neukirchensis* from Nowy Kościół in life position confirm that the life habits of *Aviculopinna* were similar to those of Recent pinnids. Additional occurrences of shell concentrations on a bedding plane indicate many specimens living in clusters close together, a common feature of modern pinnids and fossil pinnid occurrences. The presence of pinnids in strata subject to storm wave action indicates life within a shallow marine, inner shelf depositional setting.

SKELETAL FRACTION SCALING IN TERRESTRIAL AND AQUATIC AMNIOTES

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Alterations of the bone inner organization has been associated with a myriad of secondary adaptations to water in tetrapods. This has classically been documented based on localized assessment of bone structure, i.e., thin-sections or computed tomography (CT) data for a limited number of skeletal elements. However, the overall skeletal fraction is the relevant parameter to assess body density modifications, which is argued to be one of the main functions of bone mass alterations. I gathered data for overall skeletal and body masses for extant mammals in order to examine the scaling of the former in a phylogenetically informed context. I have also estimated these parameters in extreme amniotes, both extant and extinct (using CT data or surface models). Terrestrial amniotes' skeletal mass scales with positive allometry, with a skeletal fraction (skeletal mass / body mass) of ca. 9 % to be expected for a 100-kg animal. On the other hand, cetaceans' scaling is isometric, and their skeletal fraction is lower, ca. 5%. Sirenians fall in between, their fraction ranges from 5 to 8 %. Confronting the estimations made for extinct sirenians to these scaling values suggest that these animals' overall mass is most likely underestimated. Data for the overall skeletal and body masses of other tetrapods should be gathered to test whether these observations apply to non-mammalian clades.

EARLY AND MIDDLE TRIASSIC FOSSILS ILLUMINATE THE ENDOSKELETAL ANATOMY AND INTERRELATIONSHIPS OF †PERLEIDIDAE (ACTINOPTERYGII)

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Neopterygii nowadays encompass the vast majority of ray-finned fish species. Following a somewhat cryptic early evolutionary history during the late Paleozoic, Neopterygii and their closely related taxa produced impressive radiations in the aftermath of the End-Permian Mass Extinction, which are well documented by fossils. †Perleididae comprises relevant fossil examples from different landmasses, which radiated in mostly durophagous niches during the Triassic. Historically viewed as primitive neopterygians, †perleidids play a central role in discussions on the early evolution of the clade. Yet, important aspects of the anatomy (e.g., the cranial endoskeleton) of †perleidids remain poorly known or characterized, while the monophyly and systematics of the group, and especially of its namesake genus †*Perleidus*, remain unclear. To address this gap of knowledge, we reappraise the anatomy and interrelationships of one of the oldest known representatives of the family and genus, as well as of the type species of †*Perleidus*. Our survey of numerous two-dimensionally preserved fossils of '†*Perleidus*' *woodwardi* from the Early Triassic (early Olenekian) of Spitsbergen illuminated previously unknown anatomical aspects of the species, such as the presence of epaxial rudimentary and principal rays in the caudal fin, or the composition of the snout and cheek. In addition, our μCT-aided study of an uncrushed skull of '†*P*'. *woodwardi* led to the most complete reconstruction of the cranial and pectoral endoskeleton of a stem-neopterygian known to date. '†*P*'. *woodwardi* exhibits many unprecedented endoskeletal features, such as the presence of a maxilla that is loosely integrated —but not fully mobile— into the cheek, or the presence of perforate suprapharyngobranchials associated with the first branchial arch. Our re-examination of the type series of †*Perleidus altolepis* from the Middle Triassic (late Ladinian) revealed the presence of two morphotypes that can be distinguished largely on the basis of caudal fin anatomy. The results of our phylogenetic analyses, including data from our observations on '†*P*.' *woodwardi* and †*P. altolepis*, reinforce the recently proposed monophyly of †Perleididae, to the inclusion of both Early and Middle Triassic species. However, the monophyly of the Early Triassic genus †*Teffichthys* is challenged.

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PHYLOGENETIC PLACEMENT OF †*PARALATES CHAPELCORNERI* [TELEOSTEI: GOBIOIDEI] FROM THE UPPER EOCENE USING NEW MORPHOLOGICAL CHARACTERS FOR THE DISTINCTION OF ODONTOBUTIDAE AND RHYACICHTHYIDAE

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The Rhyacichthyidae and Odontobutidae [Teleostei: Gobioidei] form the sister group to all remaining gobioid families according to molecular data. They represent the most ancestral families of gobioids according to morphological characters, but cannot yet be diagnosed by synapomorphies. Due to this, identification of fossil material as belonging to one of these families is difficult. In this study, new morphological characters of odontobutids and rhyacichthyids have been compiled based on µCTs (two species of each family). The results show that 53 characters derived from the morphology of the atlas vertebra, palatine, hyoid arch, pelvic girdle, urohyal and otoliths can be used to differentiate between Odontobutidae and Rhyacichthyidae. In the next step, these characters have been used to elucidate the relationship of the fossil gobioid †*Paralates chapelcorneri* from the Upper Eocene of southern England, whose family assignment was unknown before. Our data show that both comparative anatomy and phylogenetic analysis can resolve this fossil as a stem-member of the Odontobutidae. †*Paralates chapelcorneri* is thus the first known skeleton-based fossil of an odontobutid. It confirms the occurrence of this group since the Eocene, as has previously been suggested only based on otoliths. Additionally, the otoliths of "*Umbra valida* Stinton, 1977" actually represent two further species of †*Paralates*, †*P. validus* from the Upper Eocene of southern England (Hampshire Basin) and †*P. bleicheri* from the Middle Eocene of the Upper Rhinegraben. The new data reveal that the ancient distribution of odontobutid fishes ranged across central and northern Europe while today it is restricted to southeastern Asia.

INVESTIGATING THE TRUE DIVERSITY OF TRUE CRABS: THE GROUP CARCINIDAE AS A FIRST EXAMPLE

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Brachyura, the group of true crabs, is an evolutionary successful group of crustaceans that conquered marine, limnic and terrestrial habitats during their evolution. The reason for their success might be related to their overall highly specialised body form. The ontogeny of true crabs includes a phase with several planktic larval stages and a transitional larval phase with a single stage, the megalopa. Carcinidae is an ingroup of Brachyura, most commonly known by its representative, the European shore crab, *Carcinus maenas*. We analysed the morphological diversity of Carcinidae in the modern fauna and through time, using the outline of the shield as a proxy. While first representatives of Brachyura occurred already in the Jurassic, the diversification of most lineages did start only in the Cretaceous. Using geometric morphometrics as a comparative frame for Carcninidae in combination with ancestral state reconstruction reveals, that this lineage has diversified most strongly during the Eocene. This is in line with observations on other representatives of Decapoda, being positively affected by the Eocene coral reef formation. We also find a strong ontogenetic signal in our data set. Megalopa larvae show a very conserved morphology across the group. Adults show a larger morphological diversity, most likely due to adaptations to different habitats and life styles, while the function of the megalopa remains the same. The ancestral state reconstruction of the shield shape in Carcinidae indicates quasi-hexagonal form as the plesiomorphic one, indicating an epi-benthic or swimming life style for the ground pattern of the group. The approach demonstrates that quantitative morphology is capable of detecting aspects of diversity not recognisable by other approaches.

LITHOLOGY CONTROLS AMMONOID SIZE DISTRIBUTIONS

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Body size distributions of organisms across environments in space and time are a powerful source of information on ecological and evolutionary processes. However, most studies only focus on selected parameters of size distributions (e.g., central tendency or extremes) and rarely take into account entire distributions and how they are affected by the collection style and facies. Here we analyze the impact of facies, region, taxonomy and collection style over size distributions using diameter as a proxy of Late Devonian ammonoids in their entirety using non-metric multidimensional scaling and PERMANOVA based on Kolmogorov distance. The effects are then compared with effects on mean sizes. In all analyses, lithology was the dominant effect, with sizes higher by 59% in marls and by 33% in limestones, as compared to black shales. The effect of complete sampling style was a decrease in size by 11%. Kurtosis was an important parameter differentiating size distributions, with platykurtic distributions in marls and leptokurtic distributions in limestones, suggesting that this parameter may reflect different degrees of time averaging. Most size distributions were positively skewed, but most strongly in marls. Complete sampling led to skewness values close to zero (symmetrical distributions) and high kurtosis.

Samples from higher paleolatitudes were on average smaller, but contained outliers with the largest sizes, highlighting the need to analyze entire distributions. Lithology and collection differences need to be accounted for when evaluating size differences across space (polar gigantism) and time (Lilliput effect). Similarly, differences in facies may affect species determination.

No need to pull a long face – Head shapes in louse flies and their closer relatives

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The mouthparts of blood sucking parasites are often highly specialized to specific hosts. This accounts also for various representatives of the group Diptera, also known as flies. Among the specialised parasitic flies are louse flies (Hippoboscidae) and their closer relatives the bat flies (Nycteribiidae, Streblidae) and the tsetse flies (*Glossina*). All four groups have specificities concerning their hosts: louse flies parasitise different mammals and birds, bat flies, as the name suggests, are parasites of bats and tsetse flies parasitise pigs and their closer relatives (Suidae, Artiodactyla), but also on other mammals. For all groups samples from all over the world were considered, from the modern fauna. Clear fossils included are relatives of the modern tsetse fly. The mouth parts of all specimens, representing more than 20 species were documented using digital composite microscopy, only few specimens had to be considered based on literature data. Based on these images outlines of the mouthparts were redrawn as vector graphics using the free software Inkscape. These outlines were further analysed with the biostatistics software R using the package momocs. This package performs an Elliptic Fourier analysis, allowing to express the shape as a chain of numerical properties followed by a Principal Component Analysis. Differences between shapes are tested using MANOVA also performed in R. To evaluate variance and the influence of the interpreter for one species of louse fly (*Lipoptena cervi*), more than 20 individuals were used and compared. The analysis provides a quantitative frame for comparing different factors affecting the shape of parasitic mouthparts including phylogenetic background and specialisations to specific hosts.

FUNCTIONAL DIVERSITY OF SCLERACTINIAN CORALS THROUGH TIME

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Morphological traits of reef-building corals can reflect the functions of corals and the functional diversity of entire reefs. For example, corallite diameter and corallite integration have been used to infer photosymbiosis in corals, while the growth form manifests the structural complexity of the reef. A combination of traits may thus be particularly useful to delineate the functional diversity of coral communities. In the Phanerozoic, some coral species were less prone to extinction because they shared a combination of traits that made them less vulnerable. For example, during the Pleistocene, faster-growing coral species with larger maximum colony sizes, lower corallite integration, larger corallite sizes, and lower degree of branching have proven to be more resilient to climate-driven stressors. Morphological traits have the advantage of being well preserved in the fossil record and measurable across different taxa. Here we selected four traits (corallite diameter, corallite integration, degree of branching, and the type of budding) to compare the functional diversity of coral communities in the Pleistocene and today. We found that the species with a higher degree of branching, smaller corallite size, and medium corallite integration group together on the trait space. These traits are associated with higher photosymbiotic efficacy. Moreover, the functional richness (i.e., the volume of the multidimensional space occupied by all species within functional space) of the scleractinian corals was higher in the Pleistocene than it is today. Trait-based approaches allow us to understand in more depth the ecological effects of crises in the past and to project responses of reef-building corals and reef ecosystems to climate change in the future.

TAXONOMICAL REVISION AND PHYLOGENETIC PLACEMENT OF A LOWER MIOCENE GOBY FROM WESTERN TURKEY

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The fossil record of gobioids (Percomorpha) is surprisingly small when compared with the today's overwhelming diversity of the group and trying to assign fossils to extant families has turned out to be difficult or impossible in many cases. In this study, the fossil material of a gobioid from the Lower Miocene near Karalar Köyü in Western Turkey, previously identified as "*Pomatoschistus* cf. *bleicheri*", is re-examined. The material comprises 60 articulated skeletons, in 25 of these also remains of otoliths in situ were preserved. Methods include morphometric, meristic, osteological and otolith studies as well as analysis of comparative material based on microscopy, X-ray imaging, micro-CT scans and literature. Additionally, a previously published total evidence matrix (combining molecular and morphological data) based on 29 extant and 10 fossil gobioid species was expanded by adding further 19 extant species, as well as the fossil from Western Turkey. Phylogenetic trees were reconstructed using maximum parsimony and Bayesian inference analyses. The results indicate that the previous genus and species assignment of the Lower Miocene gobioid from Western Turkey cannot be supported and that it represents a new species. Based on its character combination of six branchiostegal rays plus a T-shaped palatine and similarities in meristic counts, the species can be assigned to the genus †*Eleogobius* Gierl & Reichenbacher, 2015. †*Eleogobius* n. sp. is placed in the phylogenetic tree in a monophyletic group with †*E. gaudanti* Gierl & Reichenbacher, 2015, and in a position that can be described as "in-between" the extant gobioid family Thalasseleotrididae and the clade combining the Oxudercidae and Gobiidae. This position is also confirmed by the morphological comparison, as it shows a mosaic of characters typical for various families. The new species is part of an Early to Middle Miocene freshwater gobioid fauna that is unrelated to extant freshwater gobioids. The newly gained insights regarding this fossil help in a better understanding of the evolutionary history of gobioids. Moreover, with the expanded total evidence matrix, a basis is created for future studies on the phylogenetic placements and systematics of gobioid fossils.

NEW FOSSIL VERTEBRATE FOOTPRINTS FROM THE LATE TRIASSIC (CARNIAN) OF NORTHERN BAVARIA

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The preliminary results of an ichnological survey performed in 2021 on material recovered or spotted by private collectors in the Hassberge Formation of northern Bavaria (Upper Franconia) are presented here. Materials consist in four sandstone slabs from private collections and a series of sandstone blocks still *in situ* in a local quarry. All of the slabs are characterized by different types of invertebrate traces and vertebrate tracks, yet we aim here to focus on the presence of the ichnotaxon *Evazoum*, which is for the first time identified in Bavaria. Along with *Evazoum*, we present also a quadrupedal form, still taxonomically undetermined, represented by a short trackway on a single block and a few more isolated footprints of the same type on two smaller sandstone blocks at the same locality. All slabs are from the Coburger Sandstein, the uppermost member of the Hassberge Formation, which is exposed in the area at a few localities, either in abandoned or active quarries. Typically, the Coburger Sandstein shows alternation of yellowish sandstones, interpreted as river channel deposits, interbedded with finer sediments (varicoloured silt- and claystones), which represent overbank deposits in a general setting of *playa* lake environments. All of the footprints are preserved as counter-prints, the sandstone filling the original print mark made on silt or clay, which is rapidly lost when layers are exposed during the exploitation of the quarry. The Coburger Sandstein is considered late Carnian in age. So far we identified four slabs with *Evazoum* in association to other vertebrate tracks (*Brachychirotherium* isp, *Procolophonichnium* cfr. *lockleyi*, *Rhynchosauroides* isp.). Three slabs were found among heaps of discarded rock fragments produced by the construction of a road bridge over the Bundesautobahn A 73, between Coburg and Waldsachsen, whereas the fourth slab originated from a quarry at Breitbrunn. These new specimens, the first from Bavaria, increase the record of *Evazoum* from Germany and from Europe as a whole. The quadrupedal trackway was found on a loose sandstone block inside the Eltmann quarry, from which it was extracted. The quadrupedal trackway consists in sixteen footprints organized in a single continuous sequence. A few more tracks of the same type have been found on two other blocks close to the bigger one, with five and three footprints each. Pes marks are longer than wide, whereas manus are wider than long. The average length of the foot is about 9 centimetres, the manus being 4.5 centimetres in average. Digit traces are visible on some of the tracks. Back and front footprints symmetrically alternate one to another on the two sides of the trackway. The trackway gauge is wide. So far, we find no unequivocal match with any known ichnotaxon previously recognized in the area or elsewhere from the same time span. Potentially, a new ichnotaxonomic label might be necessary for this form.

EINSIEDLERKREBSE FÖRDERN DAS WACHSTUM VON RHODOLITHEN AUF DEN AZOREN: IMPLIKATIONEN FÜR DEN FOSSILEN RECORD

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Da Gastropodenschalen aus Aragonit bestehen, haben sie ein geringeres fossiles Erhaltungspotential als Mollusken mit kalzitischen Schalen, wie die meisten Bivalven. Eine Ausnahme sind biogene oder abiogene Inkrustierungen, etwa in marinen Lebensräumen durch Kalkrotalgen (Corallinaceen), welche einen Schutz vor Diagenese bieten. Dazu kommt, dass leere Gastropodenschalen sehr schnell von Einsiedlerkrebsen besiedelt werden, was ihre frühe Einbettung verhindert. Stattdessen bleiben die Gehäuse am Meeresboden und werden irgendwann zerstört. Unsere Fallstudie von der Insel Pico (Azoren) zeigt eine spannende Kombination dieser beiden Faktoren, erweitert um einen zusätzlichen Aspekt: Durch Einsiedlerkrebse besiedelte Gehäuse sind oft besonders dick mit Corallinaceen und vermetiden Röhren inkrustiert. Gelegentlich leben weitere Krebse in den Röhren, was zu regelrechten Einsiedlerkrebs-Kolonien in einem einzelnen Aggregat führen kann. Sobald die Öffnungen keinen Lebensraum mehr für Krebse liefern, werden die Schalen zu Rhodolithen. Das sind Kalkalgenknollen, die lose dem Sediment aufliegen, und allseitig wachsen. Der Übergang ist dabei fließend.

Ziel dieser Arbeit ist es herauszufinden, ob es einen konkreten Zusammenhang zwischen Gastropoden, Einsiedlerkrebsen und Rhodolithen gibt. Hierfür wurden die beiden Standorten Maré und Calheta de Nesquim von Pico Island (Azoren) beprobt und fotografisch dokumentiert. Anhand der Fotos wurden Größe und Breite, sowie Farben und Oberflächenbeschaffenheiten untersucht. Mittels eines Binokulars wurde die Oberfläche der Gastropodenschalen im Detail untersucht. Dieser Vorgang wurde mit geschnittenen und gebrochenen Proben wiederholt. Hier zeigte sich, dass sich sowohl Schwämme als auch inkrustierende Foraminiferen, Napfschnecken und vermetide Schnecken auf dem Gastropoden befanden. Die Bruchflächen wurden im Rasterelektronenmikroskop analysiert, um die Zellen der Rhodolithen für die Artbestimmung sichtbar zu machen. Dabei konnte festgestellt werden, dass sich überraschend viele Diatomeen auf der Oberfläche befinden. Die Bestimmung der Kalkalgen-Arten erfolgte bisher noch nicht. Vorläufige Auswertungen der Daten deuten darauf hin, dass in Maré vor allem die Gastropodenart *Stramonita haemastoma* vorkommt, in Calhetade Nesquim der Einsiedlerkrebs *Calcinus tubularis*. Hinsichtlich der Farben der Gastropodenoberfläche wiesen die Proben in Maré mehr unterschiedliche Farben auf als in Calhetade Nesquim. Zudem ergab die Auswertung, dass die Proben sowohl in Maré als auch in Calheta de Nesquim primär zweifarbig sind. Bezüglich der durchschnittlichen Länge der Proben zeigte sich kein großer Unterschied zwischen beiden Standorten. Anders in der Breite – so sind die Proben in Maré deutlich schmaler als in Calheta de Nesquim.

Um den Einfluss der Gastropoden auf die Größe der Komponenten zu untersuchen, ist es notwendig, einen Vergleich zwischen den Gastropoden-Arten der Standorte zu ziehen. Weiterführende Experimente können zeigen, ob die Einsiedlerkrebse von den Rhodolithen profitieren, beispielsweise durch Tarnung der Schale. Gleichermaßen könnte untersucht werden, ob durch die Bewegung der Einsiedlerkrebse die Nährstoffzufuhr für die Rhodolithen erhöht wird und ob Einsiedlerkrebse eine verkrustete Schale bevorzugen oder nicht.

SOME NEW DATA ON THE PALAEOFLORA OF THE PALEOCENE KONSERVAT-LAGERSTÄTTE MENAT (PUY-DE-DÔME, FRANCE)

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Recent studies on fossil floras from the Paleocene have demonstrated that the recovery of terrestrial vegetation from the devastating events at the Cretaceous-Paleogene-boundary followed different regional and temporal patterns, strongly depending on the distance to the Chicxulub impact site. For Europe, the late Paleocene (Thanetian) Fossil-Lagerstätte Menat in the Auvergne (France) is a key locality for our understanding of Early Paleogene terrestrial ecosystems. As it is amongst the oldest localities with a rich and well preserved fossil record, i.e., plants, insects and vertebrates, in Western and Central Europe following the mass extinction event at the Cretaceous-Paleogene boundary, it can provide unique insights in the development of terrestrial ecosystems in Europe after this event.

At this locality, fossiliferous diatomites have been quarried since the beginning of the 19th century and these diatomites as well as organic-rich clays have been mined and processed for various industrial purposes until 1964. The fossil-bearing sediments have been deposited in a former maar lake and the locality has yielded a wealth of outstandingly preserved fossil insects and plant macro-remains

In the course of a pilot study on the palynology of the late Paleocene (Thanetian) maar deposits of Menat (Puy-de-Dôme, Auvergne, France), selected palynomorphs were analysed with the single grain technique. This technique allows for a consecutive analysis of individual grains by means of light microscopy and Scanning Electron Microscopy (SEM). The current study demonstrates the occurrence of diverse lineages of palynomorphs comprising algae, spores and pollen. So far 45 different types of palynomorphs were analysed and wherever possible assigned to families encompassing chlorococcalean and zygnematalean algae, ferns, gymnosperms, and angiosperms. The latter group was the most diverse among the analysed palynomorphs. The palynomorphs analyzed so far with the single grain technique represent only a small, non-representative selection of palynomorphs that occur in the palynoflora of the maar lake of Menat.

The current preliminary palynological data, together with new data from plant macro-remains, largely support previous interpretations, that the surroundings of the lake were covered by forests with a large percentage of deciduous trees, including a number of typical arctotertiary forms, representing one of their oldest appearances within Western and Central Europe in the Menat flora. However, some of the previous taxonomic determinations on which this interpretation has been based, must be questioned in the light of the new data from palynomorphs as well as macro-remains.

PERMIAN ACANTHODIANS – WOLVES IN CHAINMAIL?

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The food webs in Early Permian (Asselian) rivers and lakes of the Saar-Nahe Basin (SW Germany) were extremely complex, as documented in detail by a large number of well-preserved fossils and food residues. Acanthodians were an important member of these trophic webs. Acanthodians were a group of fish that existed only in the Paleozoic, from the early Silurian (Llandovery) to the late Early Permian (Kungurian), with maximum diversity during the Early Devonian. Acanthodians are considered the earliest known gnathostomes. Although formerly placed among stem osteichthyes, they are currently considered to be stem chondrichthyes. With two genera, i.e. *Acanthodes* AGASSIZ, 1833 and *Westrichus* HEIDTKE, 2003, and 11 species, the acanthodians are common and diverse fossils in the freshwater sediments of the Saar-Nahe Basin. The slender, eel-like fishes were up to 80 cm body length, the large eyes were located anteriorly on the head, surrounded by five sclerotic ring bones, the skeleton was slightly ossified. Their most striking feature was the elongated fin spines. These thin, slightly curved spines were anterior to all five body fins (two long, wing-like pectoral fins, a small, fringe-like ventral fin, a moderate triangular anal as well a moderate triangular dorsal fin), with the exception of the heterocercal caudal fin. These structures probably served as a defense against predators, as can still be observed in modern sticklebacks. In addition, the body was covered chainmail-like with juxtaposed square scales with smooth surface. All body features indicate these fishes to be good swimmers of the open, near-surface to middle water layers. Unlike older, toothed acanthodian forms, Permian representatives were completely toothless. This and the large gill baskets with elongate, comb-like gill rakers suggest specialization as filter feeders of the zooplankton. Despite their spiny armor, food remains in xenacanthid sharks (*Triodus*), amphibians (*Glanochthon*, *Archegosaurus*), and bony fishes (*Elonichthys*) reveal that acanthodians served as common food for a variety of aquatic vertebrates. However, sporadic finds also document that the "harmless" microphagous acanthodians were more actively involved in the food web of their time than is generally assumed. While young and smaller specimens up to 30 cm in total length most likely were pure filter feeders, a change in diet occurred with further growth and the formation of robust, pen-like gill rakers. Remains of larger individuals (>35 cm) are found with conchostracans (*Estheria*), ostracods and small crustaceans (*Uronectes*) in the digestive tract. In addition, two fossils of *Westrichus*, respectively, show fin spines of several smaller acanthodians and in one case also remains of two small tetrapods (*Apateon*?) inside. According to their body size, these are all captured juveniles. It is not clear yet whether the large-bodied acanthodians purposefully hunted other aquatic vertebrates or simply swallowed everything they could obtain and overwhelm. It is also impossible to say whether the remains of the small acanthodians were juveniles of the same species (= cannibalism) or of a different acanthodian species. Overall, the findings demonstrate that the Permian acanthodians were not pure freshwater microphages, but that they also actively captured a wide range of different prey of invertebrates and vertebrates.

THE FIRST COMPLETELY THREE-DIMENSIONALLY PRESERVED SHARK EGG CAPSULE OF THE MORPHOTYPE *PALAEOXYRIS*

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The best-known and most common fossil chondrichthyan egg capsule morphotype is *Palaeoxyris* (also known by its synonym *Spirangium*), which has been found in predominantly freshwater deposits of Europe, Asia, Australia, and North America. The capsule is characterized by a distinct three-part division of a fusiform body, which gradually tapers into a shorter, pointed beak at the anterior end and a long and slender pedicle (tail) at the posterior end. The body consists of three or more parallel bands that are helically twisted in a clockwise direction. The band margins were originally accompanied by likewise spirally twisted membranous flanges (collarettes). Currently, 26 species of *Palaeoxyris* are known from Early Carboniferous (Viséan) to Late Cretaceous (Turonian) non-marine strata. Species differentiation in *Palaeoxyris* is mostly based on the number and possible breadth pattern of the capsule-forming bands. Hybodontiform sharks are considered the most likely producers of *Palaeoxyris* due to rare co-occurrences with skeletal shark fossils, but mainly because of their coincident stratigraphic range. When the empty egg capsules were embedded in sediment, compression and superposition of their three-dimensional, helically twisted bands often produced the taphonomic phenomenon of a transverse rhombic pattern that gives compressed *Palaeoxyris* fossils a cone-like appearance. However, there are stone core finds in which the former capsule cavity has been filled with sediment, thus producing a cast of the original capsule interior. Such three-dimensional specimens of *Palaeoxyris* have been found repeatedly, although much less frequently than compressed remains. However, none of these uncompressed specimens has been complete so far, always missing parts of the beak and/or pedicle. Here, we report the discovery of a three-dimensionally preserved *Palaeoxyris* found in late 2021 by one of us (NT) in Early Jurassic gravels in the Klocksin gravel pit near Krakow am See in Mecklenburg-Vorpommern, northeastern Germany. The current age rating of the capsule-bearing bed varies between Early and Middle Jurassic. Lithology and fossil plant remains resemble Pliensbachian deposits from the vicinity of the find site, but clarification by pollen analyses is still pending. The fusiform stone core of the capsule, composed of six bands, is 82 mm long and 12 mm wide at its widest point. According to size, shape and banding characteristics it clearly belongs to the morphotype *Palaeoxyris*. Since the stone core is a cast of the inner cavity of the former *Palaeoxyris* egg capsule, external capsule structures and appendages such as collarettes and attachment tendrils, have not been preserved. It is remarkable that both the pedicle (which is longer than the body and beak together) and the beak are completely preserved. According to the size measurements, size ratios, pedicle shape with axis-parallel band pattern, and the number, width and breadth pattern of the bands this specimen can be assigned to *Palaeoxyris muensteri* PRESL, 1838. This *Palaeoxyris* species is known so far from the Late Triassic (Rhaetian) to the Early Jurassic of Central Europe and southern Scandinavia mainly by compressed specimens. With this find, a complete, three-dimensionally preserved specimen of *Palaeoxyris* is now available for the first time.

A CULINARY TIP OFF – PTEROSAURIAN SKULL AND TOOTH SHAPE AND THEIR BEARING ON DIET

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The first group of vertebrates to ever take to the air is Pterosauria, an ingroup of Reptilia. Pterosaurians dominated the skies of the Mesozoic from the Late Triassic to the very end of the Cretaceous. The only other flying vertebrates of the Mesozoic, Birds and their early relatives, only started taking flight in the Late Jurassic to Early Cretaceous, although representatives of this group are still present today. This presents two interesting scenarios. Firstly one in which animals suddenly have access to a completely new way of locomotion enabling new feeding opportunities. And secondly possible competition for space and food as a second group of vertebrates also developed the ability to fly.
The ecological ramifications of the first scenario have had some studies devoted to them, especially regarding the feeding ecology of pterosaurians. These studies have largely used qualitative analysis and simple distance morphometrics, although some more recent papers have used dental microwear analysis. These studies often come to interesting conclusions that further discussions about the topic, but most of them often only work with a few individual features of the skull or jaw. Similarly the second scenario and its implications for the ecology of pterosaurians have only been suggested but no further research has been done. In this study we aimed at a broader exploration of the skull and tooth morphospaces of early pterosaurians and early birds and their relatives. To this end we compiled all available skulls, jaws and teeth of the relevant groups from the literature as well as some from our own documentation in collections in Germany. We then attempted a quantitative shape analysis of the skull and tooth shape using Elliptic Fourier Analysis (EFA). This method enabled us to quantify the outlines of material and to compare the shapes within and between groups.
Between groups, the tooth shape spans from elongated and curved teeth to shorter more triangular ones. Within Pterosauria some representatives of Archaeopterodactyloidea show differences between immature and adult specimens in both skull and tooth shape. Especially early branching representatives of the group show these differences between stages. Later branching relatives then show fewer and fewer differences between stages. Head shapes of immatures of early branchings of Archaeopterodactyloidea and early relatives of modern birds share some similarities. Our findings are in line with the previously suggested idea that the emergence of birds during the Jurassic resulted in ecological competition between these and pterosaurians. The results indicate some form of niche partitioning between stages in some early branching representatives of Archaeopterodactyloidea. Some of the changes in dentition and skull shape throughout group history of Pterosauria could have been influenced by birds that competed for the same food sources as the immature pterosaurians.

FORGOTTEN FOR A QUARTER MILLENIUM – THE TYPE MATERIAL OF THE ICONIC CRINOID *ENCRINUS LILIIFORMIS* LAMARCK, 1801

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J. B. de Lamarck in 1801 established the valid name *Encrinus liliiformis* for the Muschelkalk 'stone lily'. He designated two syntypes, which, however, were regarded as missing or forgotten since the late 1760s. Only recently one of them was identified as one of Lamarck's syntypes in the collections of the Bergakademie Freiberg (Saxony). According to contemporary witnesses the crinoid was found near Schraplau or Farnstädt respectively (Querfurt Depression; Saxony-Anhalt, Central Germany) about 1740 and was obtained by the Halle professor J. J. Lange. In 1755 it was published by G. W. Knorr in Nuremberg in a large-size copper engraving. As early as in 1768 the Jena professor and expert in fossils J. E. I. Walch was unable to localize the crinoid despite all his enquiries. Lange had already sold the specimen to the Saxony Oberberghauptmann (chief mining director) Baron von Gartenberg. Afterwards, the Muschelkalk slab from his possession probably came into the local collections shortly before the founding of the Bergakademie Freiberg (Saxony) in 1765. Several individuals of the brachiopod *Tetractinella trigonella* on the bedding plane allow to unequivocally assign the finding horizon to the *Tetractinella* Bed close to the base of the Trochitenkalk Formation. The syntype first mentioned by Lamarck from the Trochitenkalk of the Asse Hill (Lower Saxony) was already described and illustrated as fig. 1 on plate 1 by M. R. Rosinus in 1719. This specimen was probably obtained with the Schlotheim collection in 1833 by the Berlin Natural History Museum but could not yet be located. However, the crown on his plate 1, fig. 2 from the same locality that belonged also to Rosinus' collection is still preserved in the Berlin collection (Quenstedt-Katalog E 4).

THE EVOLUTION OF EARLY PROTOGNATHIDS AND THEIR SIGNIFICANCE FOR THE REDEFINITION OF THE DEVONIAN/CARBONIFEROUS BOUNDARY

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Representatives of the conodont genus *Protognathodus* are widely distributed in uppermost Famennian and Tournaisian strata. The increasing cup ornamentation enables to characterize a phylogenetic lineage within early protognathids, from *Pr. collinsoni* Ziegler, 1969 to *Pr. semikockeli* Hartenfels et al., 2022 and *Pr. kockeli* (Bischoff, 1957). Within the latter, Hartenfels et al. (2022) recognized three new morphotypes, based on the number of rows of nodes or ridges of fused nodes on each side of the cup, parallel to the carina.

The cup of *Pr. collinsoni* bears one node or several scattered nodes on one or both sides of the surface. In some specimens, two nodes are arranged in parallel to the carina. Such morphotypes are intermediate towards *Pr. semikockeli* but were part of the original *Pr. collinsoni* type series (Ziegler 1969). Advanced forms of *Pr. collinsoni* display numerous nodes without any regular orientation and may be recognized as a distinctive morphotype. Previously, they may have been identified by some authors as *Pr. kockeli*.

Protognathodus semikockeli differs from its ancestor *Pr. collinsoni* in a row arrangement of cup nodes on one side, where a row is defined by at least three nodes. In some specimens the nodes are fused to a ridge. The total number of cup nodes is not decisive for taxonomy, nor the position of nodes/ridge on the left or right side of the cup. Such intermediates between *Pr. collinsoni* and *Pr. kockeli* were previously known but they were either assigned to *Pr. collinsoni*, expanding the original diagnosis sensu Ziegler (1969), or to *Pr. kockeli*, in the sense of the emended diagnosis sensu Corradini et al. (2011). At Borkewehr (Rhenish Massif, Germany) and in other sections (e.g. Puech de la Suque, Montagne Noire, France), *Pr. semikockeli* occurs in the first limestone bed immediately above the conodont-free Hangenberg Shale/Sandstone equivalents. Therefore, its FAD (first appearance datum) is not useful for a future Devonian/Carboniferous Boundary definition.

In the type material of *Pr. kockeli*, the holotype has two rows of nodes on both sides of the cup, while illustrated paratypes show at least one row of nodes on each cup side. Additional nodes closer to the cup margins initiate second outer rows. This excludes specimens separated by Hartenfels et al. (2022) as *Pr. semikockeli* from the variability of the type series. It seems that the number of rows increases in some specimens during ontogeny. With respect to ontogeny and variability, Hartenfels et al. (2022) proposed a new emended diagnosis of *Pr. kockeli* that enables an easy identification independent of size and an easy distinction from its ancestor *Pr. semikockeli*.

With the introduction of *Pr. semikockeli*, Hartenfels et al. (2022) ensured the use of *Pr. kockeli* s.str. as a potential biostratigraphic tool for a new definition of the Devonian/Carboniferous Boundary, within the frame of successive other stratigraphic markers. It avoids the problem that the siliciclastic intercalations of the Hangenberg Crisis normally lack a conodont record, while its position near the current GSSP level will maintain stratigraphic stability (Aretz & Corradini 2021).

CONVERGENT EVOLUTION AND HOW TO FIND IT, USING QUANTIFIABLE TRAITS IN "FLYING CRUSTACEANS"

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Although animal life appears almost unlimited in overall form variation, we in fact see repetitively the same shapes evolving independently. Especially when looking back into the fossil record, it is sometimes surprising that a morphology that we thought was modern and restricted to a specific evolutionary lineage had already evolved in the past in a rather different lineage. The phenomenon is generally addressed as convergence. Yet, besides the fact that convergence is widely recognised as "similar morphologies in distantly related lineages", the question often remains: how similar is similar? I present several cases of convergence within the group Insecta using quantifiable characteristics of specimens from the modern fauna and the fossil record. Among the different cases are some types of mimicry, but also clear cases of convergence due to similar functional needs. Especially apparent are similar morphologies due to similar selective pressures for grasping and holding prey items. Besides convergent evolution of new shapes, I can demonstrate also cases of convergent losses and by this convergent cases of disruptive selection. Although often causal relationships remain unclear, convergencies can also represent substitutions, either due to active displacement of one group by another, or due to cases in which the loss of diversity in one group opens new possibilities for another one. In summary, I demonstrate that using fossil and extant representatives of numerous distantly related lineages in a frame of quantifiable traits offers the detection of cases of convergent evolution and evolutionary processes behind it.

HOLD ON TIGHT: EVOLUTIONARY CHANGES IN THE MORPHOLOGY OF THE MAJOR CLAW IN LOBSTERS AND THEIR RELATIVES

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At a first glance, clawed lobsters and crayfish closely resemble each other, at least for the untrained eye. Representatives of both groups, Homarida (clawed or true lobsters) and Astacida (crayfish), possess a pair of large claws distally on the appendages of the 10th body segment. However, when looking in detail, there is a quite large variation in the shape of the large claws: some claws are massive and wide, being able to produce large forces, others have very slender fingers with long and thin tooth-like spines providing a comb-like look. In addition to the strong morphological differences in the claws due to occurrence in different lineages, also other factors strongly influence the morphology of the claw. The claw on the left and right body side can be highly differentiated, especially in clawed lobsters. Also sexual dimorphism may occur, resulting in strongly different claw shapes between males and females. Finally, also during individual development the claw shape changes, hence different ontogenetic stages of a single species differ often strongly in claw morphology. We explore the shape of the claw of Homarida and Astacida with quantitative methods. Our data set is based on illustrations in the literature and on collection material, covering more than 500 individuals of the groups Homarida and Astacida, including adult females and males as well as immatures of various developmental stages. In addition to extant representatives, we also include fossil ones from various geological periods. We used Elliptic Fourier transformation combined with principle component analysis (PCA) for quantifying the morphology of the claw. Based on our results, certain claw shapes are only present in fossil representatives, but do not occur anymore in the modern fauna. Furthermore, the differences in claw shape during ontogeny are much more pronounced than originally assumed. These results indicate that the ecological functions of the claw change in the course of the individual development of clawed lobsters and crayfish.

HISTORY OF VENOM-INJECTING APPENDAGES IN EUARTHROPODA

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Venoms, injected toxins, have evolved many times independently in crustaceans in the wider sense. Such venoms are employed for defensive and offensive purposes. Venom allows a predator to subdue a prey animal with significantly less danger of the prey fighting back. Venom is often injected into the prey with highly modified mouthparts. Such venom-injecting mouthparts, again, have evolved many times independently; examples include: 1) Larvae of lacewings (Neuroptera, a group closely related to beetles, including about 6,000 extant species). In lacewing larvae, each upper and corresponding lower jaw form a so-called stylet for injecting the venom, but also for injecting saliva and finally sucking out the liquified tissues. Most well-known lacewing larvae are the pit-building larvae of antlions (Myrmeleontidae). 2) Remipedian crustaceans (Remipedia, assumed to be the sistergroup to Insecta), are aquatic, living in anchihaline caves. In these caves, freshwater and saltwater meet and are sharply separated through the different densities of the water types. In remipedian crustaceans, the maxillulae (≈ lower jaws) distally form the venom-injecting apparatus. 3) Centipedes (Chilopoda), which are terrestrial predators like lacewing larvae, use their first trunk appendages (maxillipeds) for injecting the venom. Ancestrally, all three examples, lacewing larvae, remipedians, and centipedes, use the same principle mechanics for injecting the venom: two structures that are counteracting in order to allow a reliable puncture of the surface of the prey. We use Elliptic Fourier transformation and principle component analysis (PCA) for exploring and comparing the evolutionary differentiation of the venom-injecting mouthparts within the three groups. We also incorporate fossils into the analysis in order to have also a deep time perspective reaching back at least into the Devonian.

QUANTITATIVE MORPHOLOGY RECOGNISES LOSSES IN DIVERSITY OVER TIME WHERE OTHER METHODS DO NOT, EXEMPLIFIED BY THE ANALYSIS OF LACEWING LARVAE

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Tracing biodiversity through time bears quite some challenges. The most tricky aspect is comparing the biodiversity of the modern fauna with that of faunas of the past, as the modern fauna usually includes many more species, individuals, and biomass due to the preservation bias. While there are some notable exceptions (as, for example, swordtails), in most cases the modern fauna outweighs everything in the past with most types of measures. Yet, there are some measures that can be more easily corrected for common biases than others. One of these is quantitative morphology. In this way, it is possible to recognise changes of morphological diversity as a proxy for biodiversity. Such an approach has some additional advantages as it allows the inclusion of fossils of challenging taxonomic status. As an example, I present the change of the quantitative morphology of lacewing larvae through time. Lacewings spend major parts of their life time as larvae, hence the larvae are in fact the better proxy for ecological interactions, but can often not be treated with common taxonomic approaches. When looking at the general taxonomic frame, lacewings have been recognised as having declined over time, although the fossil record only holds a bit over 1,000 species, while the modern fauna has about 6,000 species. The shape diversity of heads and mouthparts of lacewing larvae analysed over the last 130 million years clearly demonstrates that the morphological diversity of lacewings has overall declined: while some lineages indeed diversified over time, this increase could not compensate for the overall loss. This example demonstrates the potential of quantitative morphology for recognising changes in biodiversity including the modern fauna.

A MIOCENE FLORA FROM THE TOUPI FORMATION IN JIANGXI PROVINCE, SOUTHEASTERN CHINA

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Here we report a fossil flora from the Miocene Toupi Formation in Jiangxi Province, southeastern China, including megafossil genera *Pinus*, *Podocarpus*, *Calocedrus*, *Cinnamomum*, *Quercus*, *Lithocarpus*, *Carya*, *Palaeocarya*, *Acer*, and *Yua*. Among them, *Yua jiangxiensis* He & Wang, 2021 is the first fossil record of the genus in Asia. A palynological analysis in this study reveals that the palyno-assemblage contains *Selaginella*, *Pteris*, *Pinus*, *Picea*, *Quercus*, *Fagus*, *Carya*, *Ilex*, and Rutaceae. Based on Integrated Plant Records (IPR) vegetation analysis, it is suggested that the fossil flora represents an evergreen broad-leaved forest, and the occurrence of tropical and subtropical *Cinnamomum* supports a warm and moist climate in the region during the middle Miocene.

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FOSSIL PLANT ASSEMBLAGE OF THE LOWER JURASSIC MOUNT CARSON LAKE DEPOSIT, TRANSANTARCTIC MOUNTAINS, NORTH VICTORIALAND, ANTARCTICA

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During the Ninth German Antarctic North Victorialand Expedition (GANOVEX IX) in 2005/2006, a peculiar fossil deposit was discovered at the eastern ridge of Mount Carson, Transantarctic Mountains. A single bed of a silicified pyroclastic debris flow – intercalated within otherwise barren lake deposits of the Lower Jurassic Exposure Hill deposits – contains stromatolitic crusts, conchostracans and abundant silicified plant fragments. The only taxon that has so far been described from this deposit is *Polyphacelus stormensis*, a structurally preserved fern that is closely comparable to the widespread adpression fossil *Clathropteris* (Dipteridaceae). A comprehensive analysis of the diverse fossil content of this unusual deposit, however, is still lacking. To this end, more than 200 hand specimens of the Mount Carson lake deposit, collected in 2005/2006 and later during GANOVEX XI in 2015/2016, were cut, polished and analyzed under a stereomicroscope. Additionally, thin sections of selected specimens were prepared. Our on-going study reveals that besides the common remains of dipterid ferns, the deposit hosts a great variety of other fern axes, leaves and also fertile structures that can be assigned to Matoniaceae, Osmundaceae, and Cyatheales. The plant assemblage also includes abundant *Equisetum*-like horsetails and Bennettitales. Taken together, the Mount Carson lake deposit offers a rare view into a highly diverse silicified plant assemblage from the Lower Jurassic.

DIE HAI- UND ROCHENFAUNA VON RENGETSWEILER, BADEN-WÜRTTEMBERG (OBERE MEERESMOLASSE, UNTER-MIOZÄN)

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In der Sandgrube der Firma Steidle bei Rengetsweiler (Lkr. Sigmaringen, Baden-Württemberg) finden sich Sedimente der Oberen Meeresmolasse (OMM), welche ins Untere Ottnangium (Unter-Miozän) eingestuft werden. In diesen wurden 21 verschiedene Hai- und Rochengattungen nachgewiesen (*Aetobatus*, *Alopias*, *Araloselachus*, *Carcharhinus*, *Carcharias*, *Carcharodon*, *Centrophorus*, ?*Dasyatis*, *Galeocerdo*, *Hemipristis*, *Isistius*, *Isurus*, *Mitsukurina*, *Notorynchus*, *Otodus* (*Megaselachus*), *Pachyscyllium*, *Physogaleus*, *Pseudocarcharias*, *Raja*, *Rhizoprionodon*, *Squatina*, ?*Triakis*). Zusätzlich konnten noch vier nur als "cf. Dasyatidae" bestimmbare Zähne verifiziert werden. Die meisten Taxa haben rezente Nachfahren, nur die Gattungen *Araloselachus*, *Otodus* (*Megaselachus*), *Pachyscyllium* und *Physogaleus* sind heute ausgestorben. Bezüglich der Lebensweise finden sich alle Übergänge vom bodenbewohnenden Lauerjäger (*Squatina*) bis zum aktiven Schwimmer (*Alopias*, *Carcharodon*, *Isurus*, *Otodus* [*Megaselachus*]). Die meisten Taxa mit rezenten Verwandten waren in der Schelfregion beheimatet oder diese war Teil ihres Lebensraumes. Auch die heute ausgestorbenen Gattungen lebten vermutlich im neritischen Bereich. Die Arten der Gattungen *Centrophorus*, *Isistius*, *Mitsukurina* und *Pseudocarcharias* leben im Mesopelagial. Bei der Ernährungsweise dominierten Fisch- und/oder Invertebraten-Fresser. Zwei Taxa sind "Allesfresser" (*Galeocerdo*, *Notorynchus*). *Otodus* (*Megaselachus*) jagte marine Säugetiere, welche auch zum Nahrungsspektrum von ausgewachsenen Exemplaren von *Isurus* gehören. Abgesehen von den erwähnten mesopelagischen Taxa sprechen die Hai- und Rochenfauna, die Beifauna (Knochenfische, Invertebraten) sowie die Sedimentologie für einen vollmarinen, neritischen Lebensraum mit warm-gemäßigter Wassertemperatur. Die Tiefwasser-Bewohner *Centrophorus*, *Isistius*, *Mitsukurina* und *Pseudocarcharias* kamen eventuell zur Nahrungssuche gelegentlich in die Flachwasser-Regionen.

HAIE UND ROCHEN IN DER NAHRUNGSKETTE DER OBEREN MEERESMOLASSE (OMM) (UNTER-MIOZÄN) VON BADEN-WÜRTTEMBERG

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Hai- und Rochenzähne sind mit die häufigsten Fossilien in der untermiozänen Oberen Meeresmolasse (OMM) von Baden-Württemberg. Anhand der Zahn-Morphologie lassen sich diese in verschiedene Grundtypen einteilen. In der OMM finden sich die folgenden Typen: Pack-Gebiss, Fanggebiss, Schneide-Gebiss, Pack-Schneidegebiss, Knackgebiss und Mahlgebiss. Zusätzlich waren auch noch Filtrierer in der OMM vorhanden. Die Zahnform ist eng an die Ernährungsweise gekoppelt. So ernähren sich zum Beispiel Arten mit einem Mahlgebiss von hartschaligen Organismen. Ein Fanggebiss eignet sich demgegenüber gut zum Packen von glatten oder schnell schwimmenden Fischen. Somit lässt sich auch bei Zähnen von heute ausgestorbenen Taxa etwas über ihre bevorzugte Nahrung aussagen. In der OMM finden sich Zähne von Haien und Rochen aller Ernährungstypen. Neben piscivoren Arten waren Invertebraten-Fresser sowie omnivore Taxa präsent. Auch Filtrierer (*Keasius*) konnten nachgewiesen werden. Ganz oben in der Nahrungskette standen Vertreter der Haigattung *Otodus* (*Megaselachus*), welche in der OMM eine Länge von ca. 10 Metern erreichten. Diese Großräuber jagten marine Säugetiere. Überreste von Meeressäugern sowie anderen potenziellen Beutetieren wie Knochenfischen, Bivalven, Gastropoden, Krabben und Seeigel finden sich in den Sedimenten der OMM.

THE EVOLUTION OF EGG-LAYING STRATEGIES IN DICTYOPTERAN INSECTS – CLUES FROM THE FOSSIL RECORD

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Dictyoptera today comprises the groups of cockroaches (Blattodea incl. Isoptera) and mantises (Mantodea) together with about 10.000 species and a nearly worldwide distribution. One remarkable autapomorphy of this group is that they form specific egg-packages, the oothecae, in which up to several dozens of eggs are encapsulated. Today a variety of different forms of oothecae can be found, but also the strategy of oviposition differs among the groups. Within these strategies also different types of oviparity, ovoviviparity and viviparity occurs: In some groups within cockroaches, the ootheca is laid directly after production, in other groups it can be retracted in a brood pouch until the nymphs hatches.
Fossils of dictyopteran representatives are quite common and show that cockroach-like insects where already abundant in the Carboniferous more than 300 million years ago. However, the evolution of oviposition strategies within Dictyoptera is still unclear in many aspects, also the origin of the ability to produce oothecae itself is still under discussion. One reason for that might be, that despite the robustness of the oothecae, their fossil record is really sparse with only about 20 fossils in total.
We present several new examples of fossil oothecae in Cretaceous and Eocene amber and discuss their implication for the evolution of oviposition strategies in dictyopteran insects.

WHAT ARE THE ODDS? SEXUAL DIMORPHISM CAN EXPLAIN MORPHOLOGICAL DIFFERENCE BETWEEN THE TWO LARGE EXTINCT NEW WORD MONKEYS *CAIPORA BAMBUIORUM* CARTELLE AND HARTWIG, 1996 AND *CARTELLES COIMBRAFILHOI* (HALENAR AND ROSENBERGER, 2013)

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The large extinct Platyrrhine monkeys *Caipora bambuiorum* Cartelle & Hartwig, 1996 (Atelinae) and *Cartelles coimbrafilhoi* (Halenar & Rosenberger, 2013) (Alouattinae) were erected based on well-preserved cranial and postcranial fossils from two individuals found in the same chamber of Toca da Boa Vista (TBV), Northeastern Brazil. However, accounts of their findings are brief, and previous contributions have neglected the fact that these individuals were found close to each other. Here, we explore whether these two individuals represent a male and a female from the same species. First, we provide new information about the context of the paleontological findings. Second, we quantified the cranial shape variation in Atelidae monkeys using 28 three-dimensional landmarks captured in 739 adult specimens, including all living genera and the two fossils. To evaluate if differences between the fossil species are compatible with levels of sexual dimorphism observed in Atelidae species, we compared the Mahalanobis distance between sexes for each extant species to that between fossils. Lastly, we employed maximum parsimony phylogenetic analyses in three datasets combining morphological and molecular data (extant species only): a) females + *C. bambuiorum*; b) males + *C. Coimbrafilhoi*; and c) extant and extinct species. Our results show that: i) individuals died in the chamber after potentially entering the cave together and getting lost at least 30 kyr ago; ii) the morphological differences between fossils falls within the range of sexual dimorphism of Allouatinae, but is in the range of Atelinae species divergence; and iii) the phylogenetic analysis suggests that the fossils could either represent a male and female of the same Atelidae species or closely related Atelinae species. Our results suggest that sexual dimorphism or close kinship can account for the differences between the two fossils. In the later case, the paleontological record from TBV could represent evidence of an interspecific relationship in Platyrrhine monkey.

A REVIEW OF FOSSIL PSEUDOSCORPIONS

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Pseudoscorpions are a group of mesodiverse arthropods with c. 4.000 species distributed across the globe. They belong to the class Arachnida (spiders, scorpions and their kin), and resemble scorpions in their general appearance except that they lack a stinger and are much smaller. Despite being one of the first land colonizers and having fossil origins in the Upper Devonian, pseudoscorpions have a sparse fossil record, which is reviewed here. Currently, 53 valid fossil pseudoscorpion species are known. The oldest fossils are from the Upper Devonian (ca. 385 Ma), whereas all other pseudoscorpion fossils are from Mesozoic and Cenozoic deposits and are mostly preserved as amber inclusions. This fragmentary and skewed fossil record may be caused by their small body size, and preferred microhabitats such as leaf litter, moss and soil, which hamper preservation. Among amber pseudoscorpions, most species are known from Cenozoic deposits with the vast majority found in the European ambers (Baltic, Bitterfeld and Rovno) of Eocene age, whereas most Mesozoic fossils come from Burmese ambers (Late Cretaceous). There is also a strong bias in the amber record towards pseudoscorpions living close to trees, e.g., under tree bark or near tree roots, while pseudoscorpions from litter habitats are underrepresented. Despite this fragmentary and biased record, fossil species provide insights into pseudoscorpion morphology, biogeography and paleoecology. The close resemblance between fossil species and their extant relatives suggest that most pseudoscorpion families exhibit extreme morphological stasis over millions of years. The presence of some tropical families in European ambers indicates major range shifts and extinction events over time. More recently, the discovery of Southeast Asian pseudoscorpion tribes in Burmese inclusions imply these groups have been living in stable forest habitats since the Cretaceous. Finally, we discuss the challenges in identifying pseudoscorpion fossils, advanced imaging techniques used to observe their cryptic morphology, potential causes for the massive gap in the fossil record and significance of fossils for dating evolutionary trees.

COCKROACH OOTHECA OVER TIME - A PROVEN MATERNAL INVESTMENT FOR OVER 100 MILLION YEARS

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Insect reproductive strategies are as diverse as the group itself. Besides the great abundance of adult insects, larvae, and nymphs in the fossil record, there are only rare finds of preserved insect eggs. However, fossil remains of insect eggs are of great interest because they provide important information about ecological adaptations and the evolution of reproductive strategies of insect groups in deep time. A distinctive reproductive strategy is the formation of oothecae – egg-packages with a protective case. The ability to produce oothecae is considered as an apomorphy of the group Dictyoptera (which today comprises cockroaches and praying mantises). Within cockroaches, the oval, slightly convex, sclerotized cases contain 4 to 50 eggs arranged in two parallel rows and exhibit interspecific diversity in size, structure, and composition. The oothecae can be deposited directly, carried around in a brood sack or attached to the abdomen and are likely an important aspect for the wide distribution of cockroaches and their ability to inhabit different types of habitats. Despite the rigidity and high abundance of cockroaches in fossil records, only few fossil remains of oothecae are known today. The oldest known record is dated to 125 million years ago, suggesting that this type of maternal investment is present since the early Cretaceous. We compared more than 10 fossil oothecae (Burmese and Baltic amber, plate fossils) with respect to particular characteristics such as the number of egg chambers, surface microstructure, and keel specificity with emphasis on changes over time.

LATE DEVONIAN ICE AGE: TRIGGER FOR THE 1ST ORDER HANGENBERG MASS EXTINCTION AT THE DEVONIAN-CARBONIFEROUS BOUNDARY

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Oxygen isotopes measured on conodonts from European, North African and Asian pelagic limestone sections provide novel insights into the onset of the Late Devonian (Famennian) glaciation, the precursor of the long-lasting Carboniferous-Permian icehouse climate. We show that the transition from greenhouse to icehouse already started in the middle-late Famennian, between two 1st order mass extinctions: the Kellwasser Event at the Frasnian-Famennian boundary (371.1 Ma) and the Hangenberg Event at the Devonian-Carboniferous boundary (359.3 Ma).

Our data reveal repeated significant pulses in $\delta^{18}O_{phosph}$ of 1-2‰ from several localities of the northern margin of Gondwana (Graz Paleozoic), indicating cooling steps of 4-8 °C. These are time-equivalent with cooling steps and pulses in $\delta^{18}O_{phosph}$ (1-2‰) from other paleogeographic settings of the southern margin of Laurussia within the Rheic Ocean (Franconia, Rhenish Massif, Montagne Noire, Moravian Karst, Carnic Alps, Anti-Atlas, Iranian plate). Cooling steps are time-equivalent with northern glacial advance on southern Gondwana as evidenced by coeval glacigenic sediments previously recorded. Carbon isotopes show positive excursions that are time-equivalent to succeeding warming pulses. The carbon isotopes indicate removal of ^{12}C from the ocean-atmosphere system and enhanced C_{org} burial due to an increased primary productivity, as well to enhanced oxygen deficiency in sea water. Further, oxygen isotopes show a major increase in $\delta^{18}O_{phosph}$ from 18.4 to 21.9‰ within 6 Ma, caused by a major marine temperature fall. This can be explained by climate cooling as well as significant ice build-up due to major glacial advance resulting in a major sea-level fall of at least 100-200 meters. This long-term trend of increasing $\delta^{18}O_{phosph}$ and major cooling is coeval with the long-term trend of increasing $\delta^{13}C$ and enhanced C_{org} burial. Icehouse climate is also indicated by a particularly high $\delta^{18}O_{phosph}$ gradient of 4-5‰ between subtropics and tropics, comparable high to that of the Cenozoic (Quaternary) Ice Age. The major $\delta^{18}O_{phosph}$ gradient is between the northern margin of Gondwana, and the southern margin of Laurussia (Rheic Ocean), and indicate cold subtropic regions, and warm, salinity-influenced regions. Global climate change and C_{org} burial also affected a series of biocrises and lithoevents (Annulata Event, Dasberg Event, Drewer Event) prior to the disastrous extinctions among marine and terrestrial organisms at the Devonian-Carboniferous boundary (Hangenberg Event), and initiated the major evolutionary step during the Carboniferous period.

An initial ice-sheet formation was promoted by a south-pole position of Gondwana. In the initial cooling phase, ice albedo obviously was the main climatic feedback mechanism. Its influence became stronger during north drift of Gondwana. Together with humid events and orbitally-forced cooling pulses, this led to the initiation of continental and marine cooling. The rapid ice advance towards the subtropics due to the rapid north-drift of Gondwana accelerated the impact of climatic feedbacks (e.g., ice albedo, carbon burial) and made the cooling trend irreversible. It is hypothesized here that a Late Devonian Ice Age can be regarded as the trigger for the 1st order Hangenberg mass extinction Event at the Devonian-Carboniferous boundary, and triggered the major step in evolution in the Late Paleozoic.

THE EFFECT OF FOSSILS ON A MORPHOLOGICAL PHYLOGENY OF HERRING-LIKE FISHES (TELEOSTEI: CLUPEIFORMES)

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The effect of fossils on the accuracy and the resolution of phylogenetic trees has long been debated. Fossils may have a beneficial effect on tree inference, as they increase taxon sampling. On the other hand, fossil taxa frequently introduce missing data, which can lead to inaccuracies, incongruence with other phylogenies or poor resolution. A good candidate taxon to examine the effects of fossils on phylogenies are fishes of the order Clupeiformes (e.g., herrings, sardines, anchovies) because they possess a well-preserved and diverse fossil record with ca. 150 named species. Their phylogenetic relationships have only recently been clarified, based on DNA, and no morphological phylogeny has been published so far for these fishes. Here, we describe the impact that fossils have on a phylogeny of the Clupeiformes, which is based on a new matrix of morphological characters. There are 28 fossil species included in the matrix, dating from the Early Cretaceous to the Pliocene, and 80 modern species. Scorings for the extant taxa were obtained based on prepared skeletons, cleared and stained, X-rayed and CT scanned specimens as well as on the literature. The matrix contains 209 characters, nine of which are newly established. Phylogenetic analyses were conducted by using parsimony methods in TNT. When only modern taxa are considered, most major clupeiform lineages are recovered as monophyletic. However, of the former four "clupeid" lineages (sensu Lavoué et al. 2014), only Alosidae turned out as monophyletic, whereas the family Dorosomatidae was subdivided into eight groups. The inclusion of fossils in our analyses did not cause any major groups to become non-monophyletic; on the contrary, fossils helped to solve polytomies and also reduced the number of dorosomatid groups to three. The affinities of 15 out of the 28 fossil taxa are, according to our tree, different or more precisely defined that previously presumed and reach to the level of subfamily or genus. In summary, the inclusion of fossils in this dataset not only provided new insights into the relationships of fossil clupeiforms with their modern counterparts, but it also improved the resolution and increased the congruence of our morphology-based tree compared to well-supported molecular phylogenies.

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PALEOSYNTHESIS: THE GERMAN SEED FOR GLOBAL COLLABORATION

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Paleontology is a so-called rare subject, which shares with other rare subjects that it holds a unique and interdisciplinary canon of knowledge but at the same time being in a precarious situation at many universities. The main reason for the insecure situation is probably the small number of actors covering a huge range of topics. The situation may improve with a focus on (yet to be identified) big questions and an advanced methodological toolkit.
The Paleosynthesis project was launched in 2019 to strengthen paleontology with interdisciplinary synthesis workshops, summer schools and various outreach activities such as a Fossil Discovery App for mobile phones. Approaching halftime of the externally funded project (funding provided by the Volkswagen Foundation), we reflect upon the achievements and shortcomings of the project. This talk aims at a greater engagement of the German paleontological community in the project, be it in interdisciplinary workshop proposals or in the development of large-scale questions.

NEW FINDINGS OF NYMPHS OF THE ORTHOPTERAN GROUP ELCANIDAE IN 100 MILLION-YEAR-OLD AMBER AND A FUNCTIONAL-MORPHOLOGICAL DISCUSSION ABOUT THE POTENTIAL FUNCTION OF THEIR METATIBIAL SPURS

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Orthoptera is a rather well known polyneopteran in-group, including grasshoppers, crickets, katydids and others. Most people recognise representatives of Orthoptera immediately based on their characteristically enlarged hindlegs that are specialised jumping appendages. Elcanidae is an extinct, mostly Mesozoic in-group of Orthoptera; its phylogenetic position within (or related to) Orthoptera is not universally agreed upon, probably due to their more plesiomorphic characters such as long antennae and ovipositors.

Herein, we show four new findings of nymphal specimens of Elcanidae in Cretaceous Kachin amber (ca. 100 million years old). All of these four nymphal specimens are rather small and their overall body shape suggests that these are earlier nymphal instars. Representatives of Elcanidae can be readily recognised by characteristic enlarged spurs on the tibia of their hindlegs. These spurs can have three distinct shapes, as described in the literature, leaf-like, spine-like, or lobe-like (or oar/paddle-like) shaped. Even though the spurs have these characteristic shapes, in-groups of Elcanidae cannot be separated by spur shape alone. Since these spurs are rather characteristic of Elcanidae, and mostly of larger size, the question arises of what they were used for, especially also since these spurs were apparently moveable.

There are currently three interpretations regarding their function mentioned in the literature: 1) the spurs were used for steering during flight with widely spread hindlegs, 2) the spurs were a specialisation to not sink into sand (or water), or 3) the spurs helped them take off from the water surface (as part of a predator-avoidance strategy). Based on the new fossil specimens, we discuss whether these different aspects would be plausible and what can be inferred from their morphology about aspects of their behaviour and lifestyle.

BRINGING THE PERMIAN FOSSIL FOREST OF CHEMNITZ BACK TO LIFE

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Since at least the mid-18th century, the city of Chemnitz in Saxony (Germany) has been internationally known as a finding locality of fossil wood of Early Permian (late Sakmarian/early Artinskian) age, preserved in pyroclastic deposits. Curiously, the term 'fossil' has been coined 200 years earlier by the Chemnitz mayor and polymath Georgius Agricola (1494–1555). Systematic excavations conducted by the Museum für Naturkunde of Chemnitz since 2008 have yielded complete trees from roots to foliage, allowing for the reconstruction of organ relationships, and led to the discovery of a diverse, well-preserved terrestrial fauna of gastropods, arthropods and vertebrates. This justifies Chemnitz' status among world's most important Late Palaeozoic fossil lagerstätten, at least for the continental realm.
Chemnitz is to become one of two European Capitals of Culture in 2025. This perspective inspires the development of cultural program offers and promises a rise in touristic attractiveness of the whole region. To better highlight the most unique sight of the city, the Museum für Naturkunde Chemnitz is preparing a digital experience of the Permian forest, designed to create a realistic impression of the former 291 million year old ecosystem. As a first step, digital models of selected animals and plants from the Chemnitz Fossil Forest are produced based on fossil documentation and scientific reconstructions, and placed into a Virtual Reality (VR) framework where they can be immersively explored by, e.g., using a VR headset. To further enhance the realistic impression, implementing scientific reconstructions of certain animal movements will allow for rendering animated 3D objects.
The newly described temnospondyl amphibian *Chemnitzion richteri* Werneburg et al., 2022 served for the first case study of 3D reconstruction. The US-American palaeoartist 'Calliesauria' developed a digital sculpt based on photographs and interpretative drawings of the animal as well as information available from similar zatracheid amphibians. Integument and soft part anatomy were inferred from comparison to recent forms. The close dialogue with the authors of the taxon ensured the accuracy of modeling. The model includes rigs that can be displaced for changing the initial posture or animating movements in an anatomically sound way.
The digital 3D model allowed us to create physical representations of the animal by means of additive manufacturing (AM). For a temporary exhibit presenting the new taxon, a 3D-printed model was colored by hand by the AM enterprise. Given the changeability of the digital model, life-sized printed copies in different postures can be easily produced for future tasks.

The project is developed as part of "dive in. Programme for Digital Interactions" of the Kulturstiftung des Bundes (German Federal Cultural Foundation) with funding by the Federal Government Commissioner for Culture and the Media (BKM) through the NEUSTART KULTUR programme.

ASSESSING ARACHNID DIVERSITY IN AMBER DEPOSITS

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Biodiversity change can be assessed via zoological collections for around the past few centuries, but at that time it was already affected by human activity. Documenting and examining biodiversity changes in fossil taxa and the drivers behind these shifts is important to better understand how much present-day biodiversity loss is caused by anthropogenically-induced factors. In our ongoing project on arachnid palaeodiversity in different amber deposits are examined to assess the effect of ecosystem shifts and climate variability on biodiversity from the Eocene until today and to analyze evolutionary trends and biogeographical scenarios. In addition, the analyzed arachnids can be used as additional indicators for ecosystem and climate parameters. Our aim is to compare past changes with current diversity trends in order to better predict the future of our arachnid fauna.

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DO WE REALLY UNDERSTAND THE MIOCENE CLIMATE OPTIMUM?

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The flora of Parschlug (Styria, Austria) was deposited in the Parschlug Basin, one of several basins along the Mur-Mürz fault system of the Norian Depression. The depositional settings in these basins are similar and fossil floras are known mainly from coal seams overlying clays assigned to lake-facies. Radiometric dates (fission track from single zircon crystals) from volcanic sediments in the adjacent basins indicate that the Parschlug flora is very likely to have been deposited during the Miocene Climate Optimum (MCO, currently 16.9 to 14.7 ma).

Recent work enhanced the floristic spectrum for Parschlug by c.50 % from formerly 83 to 123 taxa/morpho-species. Integrated Plant Record Vegetation Analysis has been used to determine the major vegetation type as subhumid sclerophyllous forest". Thermophilous mixed deciduous broadleaved forests" of Europe and, more precisely, "Northeast, North and central Iberian supra-Mediterranean *Quercus faginea*-forests", and "Thracian downy oak-bitter oak forests" have been recognised as the most similar modern forests by applying the tools Drudge 1 and 2 (Similarity Approaches).

Climate for Parschlug has been assessed by CLAMP (Climate Leaf Analysis Multivariate Program), i.e., WMMT 22.8 °C, CMMT 1.7 °C, 3-WET 534.9 mm, 3-DRY 94.7 mm, MAT is 12.3 °C and MAP 1100–1200 mm (extrapolated), and was compared to the climates in the regions of modern vegetation proxies. Results indicate distinct seasonality both in temperature and precipitation. The specific combination of climate parameters inferred for Parschlug is, however, not represented in the climates of those modern vegetation proxies.

Based on numerous European fossil floras, a divergence in taxonomic (at the generic level) and leaf physiognomic similarity already reported earlier, is confirmed by the new results from Parschlug. Taxonomic data point towards continuous East Asian similarity since the Paleogene, while leaf physiognomy indicates a clear shift towards European similarity from the early Miocene onwards. This implies different climatic development in Europe and Asia while floristic similarity between Europe and East Asia persisted.

Globally, the MCO is the warmest period of the Neogene and the subsequent Middle Miocene Climate Transition (MMCT) is a phase of climatic deteriorations. Climate proxies derived from marine and terrestrial, biotic and abiotic sources in central Europe are often perceived as indicating a linear transition from a rather equable warm and humid climate during the MCO to cooler and more seasonal conditions in the MMCT. For example, so-called "Younger Mastixioid" floras, requiring equable warm and perhumid climate, are regarded as characteristic of the MCO. However, records of pollen and macro floras signalling increased seasonality (especially in precipitation) during the MCO are increasing and include Parschlug, the Mecsek Mts. flora (Hungary) and pollen records from the NW margin of the Central Paratethys. Seasonality in precipitation is also indicated by stable isotope data ($\delta^{13}C$ and $\delta^{18}O$) from bivalve shells from the Styrian and Vienna Basins from the beginning of the Langhian. Apart from MAT and MAP the degree of seasonality in both precipitation and temperature are the most relevant climatic parameters. By including these parameters the fossil records suggest previously unrecognised but distinct climatic fluctuations during the MCO.

NETWORK ANALYSIS REVEALS FUNCTIONAL CONVERGENCES OF FLIPPER MOTION IN SECONDARILY AQUATIC TETRAPODS

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Plesiosauria (Sauropterygia) are Diapsida that readapted to a marine habitat. They inhabited the oceans around the world from the Late Triassic to the Cretaceous-Paleogene boundary. A key characteristic of plesiosaurs are their two pairs of similar-looking hydrofoil flippers. These wing-like flippers have been discussed to be used in a rowing motion, underwater flight (like recent Spheniscidae, Chelonioidea, and may be Cetacea), or in a mixture of rowing and underwater flying (Otariinae, *Carettochelys insculpta*). Drag is used by rowers which enables them to manoeuvre in complex habitats. Underwater fliers use energy-efficient lift but trade it for maneuverability. Today, plesiosaurs are mostly viewed as using lift-based propulsion. Additionally, it has been proposed that plesiosaurs twist their flippers along the length axis actively by muscular activity so that they can use lift more efficiently. By using anatomical network analysis (AnNA), flipper twisting is investigated in the foreflippers of a plesiosaur, *Cryptoclidus eurymerus*, and in convergently evolved functionally analogous taxa. The latter were chosen based on the presence of a substantial lift-based phase during propulsion. These are: *C. insculpta* (Carettochelyidae, Testudines), *Zalophus californianus* (Otariinae*), Caretta caretta* (Chelonioidea, Testudines), *Spheniscus demersus* (Spheniscidae), *Megaptera novaeangliae* (Cetacea). Based on literature data, bone to bone and additionally muscle to bone contacts were coded in matrices in N x N format for the AnNA. By running "igraph" in "R" and using a walktrap algorithm morphofunctional modules were identified. Foreflipper AnNA revealed that - instead of only bone to bone - muscle to bone contacts need to be coded as well to detect reasonable functional units in the foreflippers of secondarily aquatic tetrapods. Further, AnNA led to the identification and description of myological mechanisms for flipper leading and trailing edge twisting in *C. caretta* and *Z. californianus* due to modular similarities to the plesiosaur. Additionally, *S. demersus* was found to actively twist the foreflipper leading edge, and *C. insculpta* and *M. novaeangliae* are incapable to actively twist their foreflippers.

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

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

This research is part of the project "Living with the supervolcano – How Athesian eruptions destroyed and preserved 15 million years of Permian life" financed by the Promotion of Educational Policies, University and Research Department of the Autonomous Province of Bolzano — South Tyrol nr. 11/34.

FOSSIL RECORD AND TAXONOMY OF CATURIDS (HALECOMORPHI, AMIIFORMES)

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Caturids are among the iconic Mesozoic fishes. They are currently accepted as the sister-group of Amiidae in the order Amiiformes (Neopterygii, Holostei, Halecomorphi), but their diversity, ingroup phylogenetic relationships and evolutionary history are still very poorly understood. They are mainly distinguished by the presence of laterally compressed and sharply carinate acrodin tooth caps, and haemal spines transversely broadly spatulate and strongly inclined towards the notochord. Between 1833 and 1895, more than 30 Late Jurassic caturid species were named by different authors. Most of these taxa have been placed under synonymy or referred to other fish groups, and the family is currently restricted to the two genera *Caturus* and *Amblysemius*, including four species. Among them, *C. furcatus* has become the wastebasket taxon for the group. Our thorough revision of the original descriptions, type material and more than 700 specimens in 61 collections worldwide, led to significant results, changing the picture of caturid diversity in the Late Jurassic.

Four nominal species represent unavailable names and should be excluded from synonymy lists. Whether due to insufficient information in the original descriptions, lack of diagnostic features in the type material, or to the complete lack of type material, 13 nominal species of caturids are regarded as nomina dubia. *Caturus latus* from Solnhofen is a valid taxon and *C. granulatus* from Kelheim is a species of *Amblysemius*. *Caturus velifer* from Cerin and *C. brevis* from Solnhofen, currently under synonymy with *C. furcatus*, actually represent taxa outside Amiiformes. *Strobilodus giganteus* from Kelheim is removed from Caturidae and Caturoidei. *Caturus cliftoni* from the Isle of Portland is referred to *Strobilodus*. Although previously synonymized with *Caturus*, *Thlattodus suchoides* and *Ditaxiiodus impar* from the Kimmeridge Clay are also referred to *Strobilodus*. Among the Early–Middle Jurassic species, almost nothing is known about *Uraeus gracilis* (*Pachycormus gracilis*) and *Caturus pleiodus*, which must be treated as a nomina dubia, and the validity of *Caturus bucklandi* from Lyme Regis, *Caturus meyeri* from Werther is also doubtful. An excellently preserved specimen from Brunn led to the recognition of a new caturid genus.

The scarcity of taxonomic studies on caturids in recent decades does not allow conclusions to be drawn with certainty. However, according to the information gathered regarding the fossil record of Caturidae, the group is restricted to the Jurassic and earliest Cretaceous and underwent significant diversification during the Late Jurassic. This diversification is not only evidenced by the increase in the number of taxa, but also by the dispersal of the group outside Europe, which had already begun in the Middle Jurassic.

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THE SPECIALISED INFORMATION SERVICE FOR GEOSCIENCES (FID GEO): SUPPORTING THE CULTURAL CHANGE TOWARDS OPEN SCIENCE IN GERMANY

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The shift towards Open Science practices is increasingly demanded by science policy. The transition to Open Access for text publications goes hand in hand with a growing demand to make data, scientific software and samples, freely and FAIRly available to the general public. A persistent problem here is the clear and permanent accessibility and re-usability of scientific publications. This development affects both the scientific publication culture as well as the information infrastructures and poses major challenges to the German-based geosciences community.
The specialized information service for geosciences (FID GEO) is a service funded by the German Research Foundation (DFG) and supports the cultural change towards Open Access publications. Hereby, FID GEO pursues a holistic approach to Open Science, including scientific literature, data, samples, and scientific software, and aims to promote their interconnection. FID GEO actively provides data and text publishing services through the affiliated repositories GFZ Data Services and GEO-LEOe-docs, as well as an on-demand digitization service of printed geoscientific literature and geological maps. The focus here is on the services and information systems that ensure permanently available and reliably citable publications of writings and data.
In addition, FID GEO aims to comprehensively inform the German-based geoscientific community about Open Science and FAIR data by bringing the discussions to the individual disciplines through various communication channels. To strengthen the open information culture in the geosciences, FID GEO collaborates with strategic (inter)national initiatives such as NFDI4Earth, COPDESS and OneGeochemistry.

IDENTIFICATION OF CALCIUM OXALATE IMPRINTS IN GYMNOSPERM AND ANGIOSPERM FOSSIL LEAVES

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Calcium oxalate (CaOx) is one of the most common biominerals in extant plants and is believed to serve a variety of functions such as calcium storage and herbivore defense. However, traces of calcium oxalate crystals have rarely been identified in fossil plants, and they are primarily known from fossil gymnosperms, where empty cavities have been reported from leaf cuticles of some Late Cretaceous and Cenozoic conifers. Here we investigated fossil leaves from different periods and sites. Our result in both gymnosperms and angiosperms showed casts of the CaOx. Furthermore, these micromorphological structures of fossil leaves in comparison to extant plants showed similarity in brick-shaped structures in the vascular system and CaOx druses or individual crystals. During fossilization CaOx druses would be substituted with organic matter and minerals containing Ca, Si, Al, S, and Fe. The identification of CaOx remains in leaf fossils provides novel insights on the fate of plant biominerals during fossilization. More importantly, it provides an additional aspect of the ecophysiology of fossil plants thus improving the accuracy of palaeoecological reconstructions and can provide a broader perspective on the evolution of CaOx and their rule in plant ecology across geological timescales.

EARLY CRETACEOUS MAMMALS FROM BALVE-BECKUM (NORTH RHINE-WESTPHALIA, GERMANY)

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One key period for the evolution of terrestrial vertebrates is the Late Jurassic to Early Cretaceous transition, which also marks the emergence of angiosperm plants. The Jurassic mammal faunas were dominated by stem mammals such as docodontans and morganucodontans, and typical Mesozoic crown mammals such as eutriconodontans, multituberculates, and dryolestidans. Except for the multituberculates, most Jurassic groups experienced a decline with the beginning of the Cretaceous and were replaced by "symmetrodontans" and tribosphenic stem therians (predecessors of modern mammals) in the Northern Hemisphere. European localities yielding Late Jurassic and Early Cretaceous terrestrial vertebrates and especially mammals are rare, and were until recently restricted to the western and southwestern part of that continent. The Balve-Beckum locality in the Sauerland area (North Rhine-Westphalia) for the first time provides insight into the Early Cretaceous mammal fauna of Central Europe. The sediments exposed at Balve-Beckum are soft clays within a deep paleo karst in Devonian limestones (Massenkalk) which are well-dated as Barremian-Aptian by pollen and sporomorphs. Remains of three major mammalian clades have been reported since 2020, pinheirodontid and eobaatarid multituberculates (*Bructerodo*n and *Cheruscodon*), "symmetrodontans" (*Cifellitherium*), and dryolestids (*Beckumia* and *Minutolestes*). The discoveries of two mammalian mandibles and articulated postcranial bones of dinosaurs underline the potential of the Balve-Beckum locality for more complete fossils. The dryolestids from Balve-Beckum are among the youngest in the Northern Hemisphere and demonstrate that they were more diverse in Europe in the Early Cretaceous than anticipated so far. According to the current hypothesis, the predominant pre-tribosphenic dryolestidans delayed the emergence of tribosphenidans (stem lineage representatives of modern mammals with crushing tooth function) in Europe. In summer 2022, a fully tribosphenic mammalian lower molar was discovered in Balve-Beckum, revealing that tribosphenidans co-existed with non-tribosphenic cladotherians in Central Europe in the Early Cretaceous. The Balve-Beckum mammal assemblage is also remarkably diverse, with nearly all major Cretaceous mammalian groups present, which were earlier this year complemented by a new eutriconodontan. Paleogeographically Balve-Beckum lies in an important region forming a bridge between the western European and the central and eastern Asian terrestrial Early Cretaceous vertebrate assemblages. During that time most of Europe was covered by a shallow epicontinental ocean due to higher sea levels, resulting in a number of scattered islands instead of one large continental area. Thus, the late survival of dryolestids in Balve-Beckum is possibly a phenomenon of insular isolation on the mid- to late Mesozoic European archipelago. Balve-Beckum for the first time provides insight into the Early Cretaceous turnover of mammal faunas in Central Europe.

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A NEW SPECIMEN OF THE RARE ICHTHYOSAUR GENUS *SUEVOLEVIATHAN* FROM THE EARLY JURASSIC OF GERMANY

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The ichthyosaurian genus *Suevoleviathan* has been recognized for almost 25 years, but is known from only a handful of specimens. Most of these represent small individuals, leading to a poor understanding of intraspecific variation and ontogeny in the genus. Despite this uncertainty, material referable to *Suevoleviathan* is distinct from all other Posidonia Shale ichthyosaurs, determined based on a suite of unique and easily recognized morphologies distributed across both the skull and postcranial skeleton. Phylogenetically, *Suevoleviathan* is often recovered as part of a poorly resolved cluster at the base of Parvipelvia, and thus is critical to understanding the early evolution of this highly specialized clade. Here, I report on a new specimen of *Suevoleviathan* from Holzmaden, and discuss new insights into the morphology of this rare ichthyosaur.

The new specimen is among the largest known, with a length of 441 cm. Preserved in laterodorsal view, it shows beige coloured material interpreted as soft tissue preservation in the anterior caudal region. The parietal foramen is situated between the parietal and frontal, the ilium has a simple morphology, and other cranial and postcranial characteristics are intermediate between *Suevoleviathan integer* and *Suevoleviathan disinteger*. Most interesting is the morphology of the anterior caudal region. Associated with the preserved soft tissue are caudal ribs as well as paired haemal arches, the first time such structures have been noted in *Suevoleviathan*. These haemal arches begin 4–5 centra posterior to the last presacral centrum, and extend over six centra. This distribution is identical to that noted for the contemporaneous *Eurhinosaurus*, although both haemapophyses and haemal arches are notably absent in the anterior caudal region of the closely related *Temnodontosaurus*. This distribution argues for a zone of evolutionary variability preceding the loss of ossified haemal arches in *Hauffiopteryx*, *Stenopterygius*, and Ophthalmosauridae. The combination of characters present in the new specimen supports the view that only a single variable species of *Suevoleviathan* is present in the Posidonienschiefer Formation.

HEADS OR TAILS, A REVISED LOOK AT ICHTHYOSAUR BIRTH ORIENTATION

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Derived ichthyosaurs have long been thought to give birth exclusively tail-first. The main cited cause for this phenomenon is that head-first parturition would lead to increased risk of asphyxiation during birth. A gravid female of the early diverging ichthyosauriform *Chaohusaurus* was found to have fetuses in the posterior birth canal in a head-first birth position, and was interpreted as showing the ancestral, terrestrial condition. More recently the discovery of an *in utero* fetus in clear head-first position in the more derived, pelagic ichthyosaur *Cymbospondylus* challenged this idea. This prompted us to review birth orientation preference in the Middle Triassic ichthyosaur *Mixosaurus*, from the Monte San Giorgio locality, of which two new pregnant specimens were recently rediscovered. We also reviewed the literature on the Early Jurassic ichthyosaur *Stenopterygius*, upon which almost all of our knowledge of ichthyosaur reproduction is based, as well as the literature on extinct and extant birth orientations in aquatic and terrestrial amniotes. In contrast to exclusively head-first birth observed in *Chaohusaurus* and *Cymbospondylus*, *Mixosaurus* shows a mixture of birth orientations. Moreover, although tail-first birth is dominant in *Stenopterygius*, it is definitely not ubiquitous. Head-first birth is likely more prevalent than currently recognized, especially in the Triassic taxa. We therefore propose that a preference for tail-first birth only arose at the base of the more derived Merriamosauria. Based on the ichthyosaurian data as well as our detailed survey of birth position in amniotes, we find that the "increased asphyxiation hypothesis" is an unlikely explanation for tail-first birth orientation in the aquatic realm. We hypothesize instead that a birthing switch arose due to a mechanical forces during parturition or buoyancy issues during gestation.

USING SPECIES DISTRIBUTION MODELLING TO TRACK THE DISTRIBUTION OF EUROPEAN TEMNOSPONDYLS DURING THE EARLY LATE TRIASSIC GIPSKEUPER

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The Upper Triassic Keuper sequence yields many exceptional fossil localities in Germany and the former Central European Basin as a whole. With a time span of 35 million years, the Keuper is comprised of several different paleoenvironments represented in different lithostratigraphic formations. Fossil remains of temnospondyl amphibians can be seen as one of the stable faunal components that are found throughout the whole succession in the entirety of the Central European Basin. Since temnospondyls are hypothesised to be the ancestors of modern Lissamphibia, and the group albeit exhibiting potentially higher tolerances against ecological changes as well as showing generally higher plasticity for changing environments, temnospondyls might have still been susceptible to them. In the early Late Triassic after the deposition of the Erfurt Formation (Lettenkeuper) which encompasses a carbonate-siliciclastic succession in southern Germany and preceding the fluviatile dominated Stuttgart Formation (Schilfsandstein) the marine influenced sabkha to playa depositional setting of the Grabfeld Formation (Gipskeuper) was deposited. During this time interval, multiple widespread marine ingression events of the Tethys flooded the Central European Basin. Due to the size of the Central European Basin the different Keuper formation facies vary laterally and therefore represent environmental changes related to their paleogeographic location, but similar to what is recorded in the older Muschelkalk and earliest Buntsandstein succession, this is the only time during which only exceptionally rarely remains of temnospondyls have been found in this region. Here, we employ Species Distribution Modelling to track the distribution of European temnospondyls over the Gipskeuper period. To achieve this, we combined occurrence data assembled from the online sources, like the PaleobioDB, with data from Mesozoic climate model simulations using the R package "biomod2". Depending on presence points used and extension of the study area, the model shows different suitable areas that could have been used by these animals as potential dispersal habitats during the hundreds of thousands of years long period of the, at least in parts, putative highly unsuitable Central European Basin.

TOWARDS AN INTEGRATED LEAF TRAIT ANALYSIS: AN EXAMPLE FROM THE PALEOGENE

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Fossil leaves are often used to detect environmental changes over geological times. As primary photosynthetic organs, they are directly exposed to their environment, so that many of their traits reflect adaptions or responses to habitat conditions. Additionally, insect herbivory traces and derived herbivory metrics, as evidence of plant-insect interaction, are used to conclude on structure of past terrestrial trophic networks, local palaeoenvironmental conditions or host plant properties. The Integrated Leaf Trait Analysis is a new approach that combines the investigation of functional leaf traits and insect herbivory metrics to explore and quantitatively describe possible palaeoenvironmental fingerprints.

Here, the Integrated Leaf Trait Analysis is applied to two lower Oligocene volcanic floras, namely Seifhennersdorf (Germany) and Suletice-Berand (Czech Republic). Therefore, multiple qualitative and quantitative leaf traits were determined (e.g., Trait Combination Types (TCT), leaf area and leaf mass per area (LM_A)) and uni- and multivariate analyses were performed to describe characteristic leaf properties, as well as to understand the variability of traits within and between the sites. Furthermore, their relationship to insect herbivory metrics is explored. In Seifhennersdorf, insect herbivore traces were mainly observed on deciduous fossil-species characterized by low LM_A values, like *Betula alboides*, *Carpinus grandis* or *Carya fragiliformis*. By contrast, herbivory traces were frequently observed on evergreen species in Suletice-Berand (e.g., *Engelhardia orsbergensis*, *Sloanea artocarpites* and *Daphnogene cinnamomifolia*). In present day ecosystems, evergreen species show lower insect herbivory due to their traits (e.g., high LM_A levels of coriaceaous leaves, high content of plant secondary metabolites as defense compounds). In both fossil floras, species with simple toothed leaves and craspedodromous secondary venation (TCT F) show frequently more herbivory traces. That suggest that the TCT classification also could reflect trait combinations modulating plant-insect interaction. A relation that could be helpful in reconstructing ancient ecosystems.

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THE KUPFERZELL FOSSIL LAGERSTÄTTE AND PALAEOENVIRONMENTAL RECONSTRUCTION OF THE LOWER KEUPER (MIDDLE TRIASSIC, GERMANY)

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The Middle Triassic is a crucial epoch for the evolution of the so-called modern ecosystems. During this time interval, in the terrestrial realm, the major tetrapod groups radiated, and among them, the archosaur lineage started its domain, which lasted during the rest of the Mesozoic era. Even if the knowledge of Triassic tetrapod communities and their role in terrestrial ecosystems has increased in the recent decades, the paucity of fossil sites from this time interval has hindered a more complete understanding of how these ecosystems evolved. In order to shed light on how the Triassic tetrapod communities were and evolved, we are carrying out a series of multidisciplinary studies on the Middle Triassic (Ladinian) Lower Keuper successions (Erfurt Formation) of southwestern Germany. These facies were deposited in a vast epicontinental platform of the Central European Basin, with influence of the Tethys Sea. The Lower Keuper in the study areas consists of a 20–25 m thick succession of alternating siliciclastic and carbonate deposits, mostly grey to green mudstones and marlstones and yellowish to blueish dolostones and limestones, as well as occasional sandstones. The succession is divided in more discrete units, some of which very rich in fossils, forming exceptional fossil lagerstätten. Our investigations are particularly focused on the Untere Graue Mergel unit, which has delivered thousands of fossils, including tens of new tetrapod taxa in different localities. A particularly rich site is Kupferzell (northern Baden-Württemberg), excavated in a 3-month-long salvage campaign during the construction of the highway A6 in 1977. More than 30,000 fossils of tetrapods and fish were recovered, being dominated by two temnospondyls, *Gerrothorax* (~70%) and *Mastodonsaurus* (<30%), with other taxa being comparatively much less abundant. Recently, we carried out stratigraphic, sedimentological, taphonomic, and palaeoecological analyses mostly based on the Kupferzell material stored at the Staatliches Museum für Naturkunde Stuttgart. We reconstructed the stratigraphic succession and provided a palaeoenvironmental framework based on facies and microfacies analyses. This, together with the identification of taphonomic features, allows to identify the evolution of palaeoenvironments and how the vertebrate communities therein changed. The main fossiliferous deposits correspond to lake successions that underwent desiccation periods and had differential influence of marine settings. Preservation and relative abundance of vertebrate fossils slightly change throughout the succession, but the main tetrapod and fish taxa are invariably present. The relatively high diversity of fauna in the Kupferzell fossil lagerstätte is indicative of complex ecosystems. It is remarkable the presence of different large sized predators: the giant capitosaur *Mastodonsaurus* (as well as the smaller *Kupferzellia*) and the pseudosuchian archosaur *Batrachotomus*, the latter feeding on the former. When compared with coeval (e.g., Vellberg-Eschenau) and slightly older (e.g., Michelbach) fossil lagerstätten, Kupferzell shows evident differences in sedimentological features, but fairly the same tetrapod communities, indicating that ecosystems were stable. Of note, a combination of sedimentological, taphonomic and palaeontological analyses provides a broader perspective and a detailed reconstruction of past ecosystems and their evolution, in this case allowing a better understanding of the Triassic.

WHERE TRADITIONAL EXTINCTION ESTIMATES FALL FLAT: USING NOVEL COPHYLOGENETIC METHODS TO ESTIMATE EXTINCTION RISK IN PLATYHELMINTHS

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Today parasites comprise a huge proportion of living biodiversity and play a major role in shaping community structure. Given their ecological significance, parasite extinctions could result in massive cascading effects across ecosystems. It is therefore crucial that we have a way of estimating their extinction risk. Attempts to do this have often relied on information about host extinction risk, without explicitly incorporating information about the parasites. However, assuming an identical risk may be misleading. Here, we apply a novel metric to estimate the cophylogenetic extinction rate, Ec, of parasites with their hosts. This metric incorporates information about the evolutionary history of parasites and hosts that can be estimated using event-based cophylogenetic methods. To explore this metric, we investigated the use of different cophylogenetic methods to inform the Ec rate, based on the analysis of polystome parasites and their anuran hosts. We show using both parsimony- and model-based approaches that different methods can have a large effect on extinction risk estimation. Further, we demonstrate that model-based approaches offer greater potential to provide insights into cophylogenetic history and extinction risk.

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SURPRISINGLY DIFFERENT: THE *IN SITU* SPORES OF *ISOETITES* SPECIMENS FROM THE ANISIAN IN NORTHERN ITALY

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The palaeoflora of the Anisian Dont Formation at the Kühwiesenkopf/Monte Prà della Vacca section in the Dolomites (northern Italy) has been reported to contain four species of lycophytes, including *Isoetites brandneri*. From a paratype of this species, masses of *in situ* microspores and some megaspores have also been extracted and were interpreted originally as probably monolete and corresponding to the dispersed spore genus *Aratrisporites*. We have now restudied *in situ* material from the same specimen and another (fragmentary) one that was assigned to *I. brandneri* in its first description. Most of the microspores from the restudied specimen were again bound in spore masses, which have a granular organic matrix and hinder the observation of details. However, some isolated spores show that they are highly variable and unusual, with an often elliptic/bilobed cingulum/zona that resembles the sacci of bisaccate pollen surrounding an oval to almost circular and laevigate central body. They are mostly alete, but in rare cases showing a short trilete mark. Apart from the lack of a saccus reticulum, they resemble conifer pollen assignable to *Alisporites* or *Triadispora* when seen in polar view. By contrast, *in situ* spores from the second specimen previously assigned to *I. brandneri* show considerable differences to those from the other, more complete specimen, suggesting a biologically distinct species, here provisionally named ?*Isoetites* sp. The microspores from this specimen are trilete with long rays, having an oval or subcircular amb, often showing a (regular) cingulum and sometimes a low-relief rugulate ornamentation. Their morphology is thus more common for lycophyte spores, being broadly comparable to *Gordonispora* and *Densosporites*. A single megaspore was extracted from ?*Isoetites* sp. as well. It differs from previously described megaspores of *I. brandneri* in its smaller size (175 µm in ?*Isoetites* sp. versus 270–300 µm in *I. brandneri*) and in having more protruding sculptural elements, as well as a cavum. The megaspores of *I. brandneri* were compared tentatively to *Verrutriletes*, whereas the new specimen is better compared to *Bacutriletes*.

This study was funded by the Forschungsfonds der Landesmuseen of the Bozen-Bolzano province as part of the project "MAMPFT - Mikrosporen An MakroPflanzen-Fossilien der Trias".

ON THE EVOLUTION OF NERITIMORPH GASTROPODS

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Neritimorpha is the smallest extant subclass of the class Gastropoda. Most of its members are marine but it also includes species in freshwater and on land. Its oldest members have possibly an Ordovician age. Although their diversity and abundance is low in comparison with that of the other gastropod clades, they are continuously present throughout large parts of the Phanerozoic. Most fossil and living species are egg-shaped with a low spire and rapidly expanding whorls. Many possess a thin outer calcitic shell layer and a thick inner aragonitic crossed-lamellar one. Their aperture is commonly D-Shaped, with callus and teeth on the inner lip. Most of them have a massive, mineralized operculum. Most living neritimorphs (Neritidae) have resorbed the inner shell walls and only few living members of the Neritopsidae do not resorb the inner shell walls. Neritidae with planktotrophic larval development have a characteristic convolute larval shell with hardly visible sutures. Neritopsidae lack known living species with planktotrophic larvae. Middle Palaeozoic members of Neritimorpha may have uncoiled larval shells (Cyrtoneritimorpha) but forms with similar teleoconch morphologies have tightly coiled larval shells similar to those of caenogastropods as new data from the Silurian of Gotland confirm. This suggests that the impact of larval coiling on the higher systematics of gastropods might be overestimated. Naticopsidae and Trachyspiridae form a large part of the Late Palaeozoic neritimorph diversity. New data suggest that species with planktotrophic larval development representing the wide-spread Late Palaeozoic genus *Trachydomia* have caenogastropod larval shells with axial ribs and thus belong to Trachyspiridae. Naticopsidae have smooth larval shells and probably gave rise to Neritidae with resorbed inner whorl, a feature that is reported from the Early Triassic for the first time. Further new data about the evolution of Neritimorpha come from newly discovered larval shells and opercula (some in situ) from the Late Palaeozoic to Late Triassic.

EVOLUTIONARY TRANSITIONS OF PARASITES BETWEEN FRESHWATER AND MARINE ENVIRONMENTS

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Evolutionary transitions of organisms between environments have long fascinated biologists, but attention has been focused almost exclusively on free-living organisms and challenges to achieve such transitions. This bias requires addressing because parasites are a major component of biodiversity. We address this imbalance by focusing on transitions of parasitic animals between marine and freshwater environments. We highlight parasite traits and processes that may influence transition likelihood (e.g., transmission mode, life cycle, host use), and consider mechanisms and directions of transitions. Evidence for transitions in deep time and at present are described, and transitions in our changing world are considered. We propose that environmental transitions may be facilitated for endoparasites because hosts reduce exposure to physiologically challenging environments and argue that adoption of an endoparasitic lifestyle entails an equivalent transitioning process as organisms switch from living in one environment (e.g., freshwater, seawater, or air) to living symbiotically within hosts. Environmental transitions of parasites have repeatedly resulted in novel forms and diversification, contributing to the tree of life. Recognizing the potential processes underlying present-day and future environmental transitions is crucial in view of our changing world and the current biodiversity crisis.

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GROWTH IN DWARFS: ARE ONTOGENETIC CHANGES REFLECTED BY ISOLATED BRAINCASE ELEMENTS IN *EUROPASAURUS*?

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Europasaurus holgeri is a dwarfed macronarian sauropod from the Upper Jurassic of Lower Saxony. It is one of few sauropod species with cranial elements from different ontogenetic stages. The availability of juvenile and adult material of sauropods is scarce, making the excellently preserved cranial elements of *Europasaurus* a rarity. Ontogenetic stages in *Europasaurus* have been described earlier based on bone histology, and morphological definitions of skull bones. However, the internal morphology of its cranial elements has not been reported yet. We analyse the internal and external morphology of four isolated exoccipital-opisthotic complexes, three prootics and one fragmentary braincase, allowing direct comparisons of the paleoneuroanatomy, size and external morphology. Internal and external features were documented with macrophotography and micro-computed tomography (µCT). 3D reconstructions were done of the endosseous labyrinth, cranial nerves and vascular structures. External and internal characteristics of all specimens were measured to record differences in size and proportion.We discuss implications and consequences, based on the new findings for the ontogenetic changes in *Europasaurus*.

FIRST SCALE-ATLAS FOR CICHLID FISHES

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The teleost family Cichlidae is a large group of tropical freshwater fishes with four subfamilies and over 1700 recognised extant species, whereas only about 30 nominal fossil species are currently known. One reason for the low number of fossil species is that the classification and systematic assignment of fossil cichlids is often very challenging due to the generally conservative "bauplan" of these fishes and the frequent occurrence of convergent characters. Moreover, most of the fossil cichlids are based on incomplete specimens. On the other hand, cichlid fossils commonly bear body scales of adequate quantity and quality. However, a systematic approach to explore the taxonomic information of these scales for the wide variety of African cichlids has not yet been conducted. Our aim is to provide such information on the basis of a photographic atlas of flank scales for extant cichlid fishes to help to resolve identification of fossils. The extant study material comprises 128 specimens of all 27 lineages of the "African cichlids" (Pseudocrenilabrinae; 59 genera, 79 species) and also 17 specimens of the other three subfamilies (Etroplinae, Ptychochrominae, Cichlinae; 8 genera, 9 species). Scales were extracted after a standardised pattern from subadult and adult (alcohol- and formalin-preserved) fish vouchers of the Bavarian State Collection of Zoology in Munich, photographed and detailed descriptions of scale characteristics - all recognisable in scales of fossil cichlids - were prepared. Eleven overall flank scale forms (much more than expected), four different scale focus positions, and a broad variety of scale ornamentation pattern such as grain- or tooth-like projections of different shape and size and circuli of roundish (roman-type) or pointy (gothic-type) appearance were reported. Preliminary results indicate that modern cichlid lineages can be diagnosed and distinguished on the basis of distinct scale character combinations. Our results and new scale atlas will greatly facilitate future works on the classification of fossil cichlid specimens and will also serve as a comprehensive reference when new extant cichlid species are described.

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VERLOREN – VERGESSEN – NICHT ERKANNT
ALIENS
UNTER DEN FOSSILIEN DER SOLNHOFENER PLATTENKALKE

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In Karl Albert Frickhingers Buch „Die Fossilien von Solnhofen / The Fossils from Solnhofen“ sind in Band 2 (1999) zwei „Problematica“ als unbestimmbare Reste von Fischen oder Reptilien abgebildet (Abb. 286 und 287), die ich mir 2015, nach Fertigstellung unseres Buches „Solnhofen – Ein Fenster in die Jurazeit“, näher ansehen wollte. Beide Stücke galten aber zu diesem Zeitpunkt als verschollen. Zufällig wurde 2015 im Besuchersteinbruch von Mühlheim ein merkwürdiges unbestimmbares Fossil entdeckt, das durch die charakteristische Form seiner chordalen Verkalkungen (kleine runde dorsale Arcozentren und größere halbringförmige ventrale Arcozentren) sowie das Fehlen wichtiger Schädelknochen, z.B. bezahnter Ober- und Unterkiefer, auch von Flossen und Schuppen, eine Beziehung zu Frickhingers Problematica vermuten ließ. Nach intensiver Recherche wurden nicht nur weitere ähnliche Exemplare – die meisten in privaten Sammlungen – entdeckt, sondern auch beide von Frickhinger abgebildeten Stücke wiederentdeckt. Einige Exemplare weisen einen komplexen Kiemenapparat auf, mit eng aneinander gereihten, langen Branchiospinen an den Kiemenbögen und zahlreichen winzigen Odontoden an allen Oberflächen des Branchialapparats und am immer vorhandenen Parasphenoid. Nicht alle, aber einige Exemplare haben Neural- und Hämalbögen mit unterschiedlich langen Dornfortsätzen und mit teils komplexen Gelenkverbindungen mit den dorsalen und ventralen Chordazentren. Zunächst schien die Herkunft dieser Problematica auf Mühlheim (Unter-Tithonium, Mörnsheim-Formation, Mühlheim-Subformation, 150–150,8 Mio. J.), Eichstätt und Wintershof (Unter-Tithonium, Altmühltal-Formation, Obere Eichstätt-Subformation, 150,8–152 Mio. J.) beschränkt, aber kürzlich wurde ein bereits 2015 in Wattendorf (Kimmeridgium, Torleite-Formation, Wattendorf-Subformation, 153,6–154,5 Mio. J.) gefundenes Exemplar mit neuen Details fertig präpariert und die Überraschung war perfekt, als mir Anfang August Dr. Martin Röper ein dem Wattendorfer Exemplar in vielen Details erstaunlich ähnliches Exemplar aus Painten (Ober-Kimmeridgium bis Unter-Tithonium, Painten-Formation, 151–152,4 Mio. J.) zeigen konnte, das erstmals ein vollständig erhaltenes Schwanzflossenskelett aufweist ... das in praktisch allen diagnostischen Merkmalen identisch mit dem eines „*Pholidophorus*“ sp. ist, das Gloria Arratia in Mesozoic Fishes 4 (2008, Fig. 11) abgebildet hat. So gut erhalten dieses Schwanzflossenskelett auch sein mag, alles was sonst an diesem Exemplar erhalten ist, gibt Rätsel auf. Insbesondere fehlt der Kopf, die Dorsal- und Analflosse, es fehlen paarige Flossen und es gibt keinen Hinweis auf die für *Pholidophorus* typischen Schuppen. Könnte es das Resultat eines Verwesungsprozesses sein, durch den die Wirbelsäule eines „*Pholidophorus*“ samt Schwanz vom Rest des Körpers isoliert wurde? Für die beiden neu hinzugekommenen Problematica aus Wattendorf und Painten könnte das zutreffen. Aber damit ist das Rätsel um die anderen „Aliens“ mit ihren Filterapparaten noch nicht gelöst.

NEOFLABELLINA RETICULATA (REUSS, 1851) – THE FOSSIL OF THE YEAR 2022

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The Paläontologische Gesellschaft (Palaeontological Association) has been awarding the title Fossil of the Year since 2008. Every year an important fossil is chosen to promote palaeontology in the public. This year, after presenting several vertebrate, invertebrate and plant fossils, a microfossil was selected for the first time. Arguments for the selection of the foraminifer *Neoflabellina reticulata* are:

- *Neoflabellina reticulata* is a beautiful fossil.
- *Neoflabellina reticulata* is an index fossil of the Maastrichtian, thus underlines the utility of microfossils in biostratigraphy. The Maastrichtian is the last stage of the Cretaceous and ends with the best-known mass extinction event.
- *Neoflabellina reticulata* lived in marine shelf environments below the storm-wave base, i.e., it can be used as palaeoecological indicator.
- *Neoflabellina reticulata* can be found in practically all chalk environments of the Maastrichtian and is documented from such well-known sites as the chalk cliffs of Rügen Island.
- The first description of *Neoflabellina reticulata* was published by August Emil Reuss in 1851, in the period of the establishment of micropalaeontology as a science.
- The type locality of *Neoflabellina reticulata* is the chalk marls of Lemberg, todays Lviv in Ukraine. This underlines the connectivity of science.

The Fossil of the Year was presented in a public lecture in the Pommersches Landesmuseum in Greifswald on 22 May 2022. We provide more information on our poster.

FOSSIL JELLYFISHES: NEW MATERIAL FROM THE LOWER PERMIAN BROMACKER SITE AND SELECTED ASPECTS ON THE KNOWLEDGE OF FOSSIL MEDUSAE PRESERVATION

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The present study describes new findings of medusae from the Tambach Sandstone Member (Tambach Formation, Rotliegend Group; early Permian) at the Bromacker early tetrapod site near the town Tambach-Dietharz (Thuringian Forest Basin, Free State of Thuringia, central Germany). The umbrellas of medusa-stages described herein were discovered in deposits from a fluvial lithofacies and are preserved as concave hyporeliefs in fine- to slightly medium-grained sandstone. Its limited preservation allows only a preliminary determination as "*Medusina*" sp. As in Recent freshwater jellyfish, their gelatinous, water-rich body substance implies a poor fossil preservation potential of medusae. Thus, this occurrence in sandstone at the Bromacker site is remarkable. The association of jellyfish and tetrapod ichnia demonstrates a spatial overlap in the habitats of both groups, presumably along the shorelines of temporary ponds. Some information on the taxonomy, taphonomy and palaeoecology of medusae can be derived from the current literature-based state of knowledge, which may serve as indicator of palaeoenvironmental and taphonomical conditions as well as a motivation for future studies.

JAW MECHANICS IN SHREWS AND THE ROLE OF THE DOUBLE ARTICULATION

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The efficient fragmentation of food, essential for sustaining a high metabolic rate, is determined by the molar morphology and the movement of the jaw which is in turn related to the jaw morphology and the arrangement of the masticatory muscles. Already in early Mammaliaformes such as *Morganucodon oehleri* the typical mammalian arrangement of the three masticatory muscles (temporalis, masseter, pterygoid) and their subdivision into two parts were present. The evolution of the angular process on the mandible which provides the insertion area for the pterygoid and the masseter is, depending on the author, either linked to an increasingly yaw (rotation around vertical axis) dominated chewing stroke or to an enhanced roll movement (rotation around longitudinal axis).
Besides the development of a strongly posteriorly elongated angular process, the mandible of shrews shows a unique condylar process which is characterized by a separation of the articulation facet into a dorsal and a ventral part. This double articulation is thought to allow a more differentiated movement of the jaw. With the observation of tooth wear, 3D-reconstructions of the chewing paths, and the usage of the diceCT method, a non-destructive technique for visualizing soft tissue, we are able to show that the double articulation enables a combination of yaw and roll rotation which is governed by the two muscles inserting on the angular process. In conjunction with the contraction of the temporalis, mainly responsible for the pitch motion (rotation around transverse axis), the lower jaw gets rolled into occlusion (Phase I). During Phase II, when the protocone is grinding through the talonid, the internal pterygoid and the masseter produce an alternation of inversion and eversion of the mandible. These movements lead to an increased fragmentation of food due to the induction of a twist motion to the bolus in Phase I and a more varied grinding, caused by additional movement directions of the protocone, in Phase II. This allows for a more efficient energy gain and the maintenance of a high metabolic rate.

FOSSIL RHODOLITHS AND CORALLINE ALGAL BUILDUPS OF THE AZORES ARCHIPELAGO

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Coralline algae forming rhodoliths (unattached nodules composed of corallines, Rhodophyta) and entire buildups, are a common producer of carbonates on modern and ancient shelves worldwide, and there is growing evidence that they thrive on volcanic insular shelves. Nevertheless, little is still known on how corallines cope with the demands of this particularly dynamic environment.

As a case study for rhodoliths, we describe fossil rhodoliths from a Pliocene sequence at the southeastern coast of Santa Maria Island, (Azores Archipelago, central North Atlantic). They occur as a massive accumulation within a larger submarine volcano-sedimentary sequence that was studied from the macro- to the microscale in order to reconstruct the paleoenvironmental conditions under which the rhodolith accumulation was deposited and buried. All fossil rhodoliths from this setting are multispecific and demonstrate robust growth forms with a lumpy morphology. Moreover, taphonomical analyses show the succession of several destructive events during rhodolith growth, suggesting life under a highly dynamic system prior to stabilization and burial. The rhodoliths therefore tell a story of an eventful life, with multiple transport and growth stages, owing to the environment in which they lived. Transport and deposition to their final resting place was storm-associated, as supported by the general sedimentary sequence. In particular, the sequence features an amalgamation of tempestites deposited under increasing water depths, sediment aggradation, and before burial by volcanic activity. This transgressive trend is also attested by the overall characteristics of the volcano-sedimentary succession, which exhibits the transition to subaerial environment in excess of 100 m above the rhodolith bed.

Located on the northern coast o, the Lagoinhas section preserves a carbonate buildup correlated with Marine Isotope Substage (MIS) 5e, the warmest interval of the Last Interglacial. The buildup is formed mainly by crustose coralline algae (CCA) identified as *Spongites* sp., and some subordinate crusts of *Lithophyllum* sp. and *Neogoniolithon* sp., as well as cf. *Titanoderma* sp. Extant CCA buildups are not recorded in the archipelago. We describe the morphological and taphonomical features of the Lagoinhas CCA buildup and interpret the environment in which it grew. Additionally, this buildup is compared with another of similar age, exposed in the Prainha-Praia do Calhau section on the island's opposite southern coast. The hydrodynamic regime appears to play a crucial role in the development of Azorean CCA buildups during the MIS 5e.

FOSSIL CORALS OF THE CAPE VERDE ARCHIPELAGO

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Although coral reefs are unknown from the fossil record of the Cape Verde archipelago, many fossil corals can be found on land, trapped in marine terraces, in tsunami deposits or as deposits on land as a result of the quaternary swell uplift. This study provides a survey of fossil corals from outcrops of seven different islands, from either different level of marine terraces or tsunami deposit. A total of 170 scleractinian corals extracted from different sample blocks has been analysed and identified to genus and/or species level. 13 taxa of the families Acroporidae, Dendrophylliidae, Faviidae, Pocilloporidae, Poritidae and Rhizangiidae, respectively, could be identified. All coral samples are from the Quaternary, ranging from the Middle Pleistocene to the Holocene. The hermatypic fossil corals found at the Cape Verde Archipelago most likely migrated only recently (Quaternary) from the Caribbean to the West African coast, while ahermatypic species probably originate from the Indo-Pacific. Differences in coral assemblages now and thousands of years ago might be the result of changing environmental factors.

REDESCRIPTION OF THE NEOTYPE OF *PLATEOSAURUS*

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The taxonomy of *Plateosaurus*, the fifth dinosaur genus named, has been majorly problematic. In the early 1900's more than 30 species were erected within multiple different genera that are currently all synonymised with *Plateosaurus trossingensis*. There is, however, an enormous amount of morphological variability within the *P. trossingensis* specimens in the collection of the Staatliches Museum für Naturkunde Stuttgart (SMNS) in Germany, as well as with specimens from the same locality in other collections and from other localities. In recent literature, it has been proposed that the variability is consequential of developmental plasticity; however, the explanation is evidently multifaceted, with further investigation of material from all horizons and localities essential to resolve this question. In 2019, SMNS 13200 was designated as the neotype of *Plateosaurus* after the holotype was deemed undiagnostic – however, no modern description of a relatively complete, mature specimen of *P. trossingensis* is currently available. The most recent description was made by von Huene in 1926, written in German. Here we redescribe the neotype of *Plateosaurus trossingensis*, and focus on several ambiguous and previously undescribed features. The results will form the basis of several other associated projects currently underway, such as a large-scale 3D geometric morphometric study of *Plateosaurus* material from across all known localities and collections, description of pathologies, both in the neotype and other undescribed specimens, as well as fieldwork at the historical Trossingen site to collect more stratigraphic and sedimentological data, excavate additional *Plateosaurus* specimens from the underrepresented beds and retrace the stratigraphical origin of several historical specimens.

THE FRASNIAN AMMONOIDS (TORNOCERATIDAE) OF OUIDANE CHEBBI (EASTERN TAFILALT, MOROCCO)

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The Frasnian (Upper Devonian) ammonoids of Morocco have been incompletely studied so far, with important faunas and time intervals that have not been treated by any systematic investigation. At the Ouidane Chebbi section in the easternmost Tafilalt, an upper Frasnian haematitic (primarily pyritic) ammonoid fauna occurs in a marl unit that is part of the locally thick, organic-rich, dark-grey Kellwasser succession. The section lies 45 km southeast of Erfoud in the easternmost Anti-Atlas region, in a military zone near the Algerian border with strongly restricted access. In terms of age, the studied fauna can be assigned to the intra-Kellwasser level ("*Archoceras*" Genozone, UD I-K), based on the occurrence of "*Archocheras*" *varicosum* and the alternative index fossil *Retrotornoceras*. The upper Kellwasser level (*Crickites* genozone, UD I-L) is indicated slightly upwards in the section based on the entry of the index fossil *Crickites holzapfeli*.

The upper Frasnian Ouidane Chebbi fauna contains 10 tornoceratid species, including one new genus, and two new species. The fauna is comprised of species of the Tornoceratinae, Crassotornoceratinae, and Aulatornoceratinae. The new genus of the Aulatornoceratinae is defined by its small adult size (< 20 mm dm) and a characteristic late ontogenetical opening of the umbilicus. The typical Kellwasser goniatite *Phoenixites frechi* is missing in the UD I-K fauna but occurs abundantly in the overlying black limestones.

Interestingly, all tornoceratid specimens at Ouidane Chebbi display dense sutural spacing. This reflects slow growth, probably as a consequence of harsh environmental conditions linked with the hypoxic Kellwasser Facies. There is hardly any associated benthos, which suggests an anoxic sea floor. This probably explains why the alpha biodiversity is lower than at the contemporaneous Rhenish localities (Bergisch-Gladbach Sand, Büdesheim) or in Southwest England (Waterside Cove). Furthermore, some of the Ouidane Chebbi species show a tendency towards a simplified suture compared with other Frasnian species.

The investigation of the new Frasnian ammonoid fauna contributes to the knowledge of their evolutionary pathways and ecological adaptions during the global Kellwasser Crisis. Together with other upper Frasnian assemblages from Morocco, it also provides important data for a quantitative analysis of biodiversity and biogeography patterns along a palaeolatitudinal gradient within the crisis.

PERMIAN (SUB)ARBORESCENT LYCOPSID MACROFOSSILS FROM THE *GLOSSOPTERIS* FLORA: WHAT DO WE KNOW SO FAR?

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The so-called *Glossopteris* flora covered a large part of Gondwana throughout the Permian. Glossopterids are the best-known floral elements in the southern strata of that period, but other groups, such as (sub-)arborescent lycopsids, also flourished successfully within this flora. Macrofossils of these lycopsids correspond to fragmented axes, often lacking characters with larger scale systematic value, and reproductive structures are known only for a few of them. They are notoriously difficult to identify taxonomically and have been out of the focus of research for many years. Recently, we started to re-examine such macrofossils to clarify their morphology and constrain their taxonomic circumscriptions and spatio-temporal distribution. (Sub-)arborescent lycopsid genera from the *Glossopteris* flora include *Brasilodendron*, *Lycopodiopsis*, *Cyclodendron*, and *Azaniadendron*. The oldest remains of *Brasilodendron* occur in Pennsylvanian interglacial strata from South America, but it reached its acme during the deposition of the Cisuralian coal beds in Brazil. Some remains of this genus also occur in the Guadalupian of South Africa. *Brasilodendron* comprises casts, impressions, and compressions of axes, which bear attached leaves or are covered in leaf cushions lacking leaf scars. *Lycopodiopsis* consists of casts, impressions, and anatomically preserved axes. This genus, common in Guadalupian beds from Brazil, has a discontinuous vascular cylinder and is covered in leaf cushions bearing a leaf scar. Reproductive structures of *Brasilodendron* and *Lycopodiopsis* remain unknown. *Azaniadendron* and *Cyclodendron* comprise vegetative and fertile impressions or compressions of axes. Both were heterosporous with sporangia arranged in fertile zones. *Azaniadendron* axes are covered in leaf cushions of variable shape, bearing a not always obvious leaf scar, whereas *Cyclodendron* axes are covered in leaf scars, without developing well-defined cushions. Convincing evidence of *Azaniadendron* is only known from the Guadalupian of South Africa. *Cyclodendron* co-occurs with *Azaniadendron* in South Africa but may have had a wider geographical and stratigraphical distribution in Gondwana, extending down to the Cisuralian. Besides these taxa, *Bumbudendron* has been reported from Cisuralian beds of Argentina, and recently we discovered remains of a new lycopsid form from coeval strata in Brazil. These Gondwanan lycopsids have been traditionally interpreted as lacking evidence of ligule. The presumed absence of ligule has been used to distinguish them from the Euramerican Carboniferous arborescent lycopsids. Although convincing evidence of a ligule is still missing for most of these taxa, a re-investigation of *Azaniadendron* revealed that it was ligulate and part of the Isoëtalean clade. So far, there is no evidence of "northern" genera (e.g., *Sigillaria*) in the *Glossopteris* flora. Re-investigation of a specimen from Brazil first assigned to *Sigillaria* revealed that it was not a lycopsid but the oldest anatomically preserved cycad.

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THE CROCODYLOMORPH *TERRESTRISUCHUS* AND OTHER ARCHOSAURS FROM THE LATE TRIASSIC FISSURE FILLS LOCALITY OF PANT-Y-FFYNNON, WALES

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The Late Triassic to Early Jurassic fissure fill localities of the Bristol Channel area preserve a diverse fauna of mostly small-bodied vertebrates, which has provided important insights into the early evolution of major tetrapod groups such as mammaliaforms, rhynchocephalians, crocodylomorphs, and dinosaurs. The Late Triassic site at Pant-y-ffynnon yields a particularly rich, but poorly understood assemblage of archosaurs, including the recently named theropod dinosaur *Pendraig milnerae*, the cursorial crocodylomorph *Terrestrisuchus gracilis*, the small sauropodomorph *Pantydraco caducus*, and the enigmatic pseudosuchian *Aenigmaspina pantyffonnensis*. Ongoing research has revealed several new insights into this fauna. *Pendraig* is identified as a small-sized non-coelophysid coelophysoid dinosaur. A revision of *Aenigmaspina*, characterised by unique, bifurcating osteoderms and conspicuously T-shaped neural spines on the cervical and anterior dorsal vertebrae, recovers this genus as the sister taxon of Erpetosuchidae + Aetosauriformes in a new phylogenetic analysis. Finally, CT-scanning has elucidated new anatomical details for *Terrestrisuchus gracilis*. Its braincase is extensively pneumatized, which has previously been considered to be a derived crocodylomorph feature. Together, these studies reveal the significance of the fissure fills fauna for our understanding of early archosaur evolution and diversity.

TAXONOMY AND SYSTEMATIC POSITION OF THE MESOZOIC HYBODONTIFORM SHARK-LIKE CHONDRICHTHYAN *STROPHODUS*

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With an estimated maximum body length of up to three meters and its massive, powerful jaws equipped with highly specialized crushing teeth suitable for breaking up various kinds of marine hard-shelled invertebrate prey, the extinct hybodontiform shark-like chondrichthyan *Strophodus* is one of the most iconic durophagous predators that ever roamed the Mesozoic seas. Extending for more than 130 million years, from the Middle Triassic to the late Early Cretaceous, *Strophodus* boasts an extensive fossil record that is mainly dominated by its characteristic teeth, which occur frequently in a wide variety of depositional environments, providing discrete combinations of dental characters for use in species identification and establishing reliable diagnoses. *Strophodus* recently has received much research effort, which shed new light on better understanding its palaeogeographic distribution and diversity dynamics. However, despite almost two centuries of research, much uncertainty still surrounds the systematic position of *Strophodus*. This is mainly due to the scarcity of well-preserved skeletal material, which commonly provides important morphological features for inferring phylogenetic interrelationships. *Strophodus* is currently considered to be closest to *Tribodus*, which is unique among hybodontiforms in lacking direct cranio-palatoquadrate articulations and having a skeletal jaw support that is formed by the hyoid arch only. However, no phylogentic analysis has ever been performed to test this hypothesis up to now. Here, we provide a synopsis of the global fossil record of *Strophodus* including well-preserved but largely unstudied skeletal material from the Middle and Late Jurassic of Europe, and discuss its significance for re-evaluating the phylogenetic position of *Strophodus* within the chondrichthyan tree of life using strict cladistic principles.

DIVERSITY AND HABITAT PREFERENCES OF SHALLOW-WATER FORAMINIFERA FROM UPWELLING AREAS OF OMAN

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The shallow water ecosystems of Oman are a critical stepping stone for the dispersal of benthic foraminifera in the Indian Ocean and the Red Sea. The coast of Oman is subject to intense seasonal upwelling and unlike many other oligotrophic tropical areas, is impacted by strong, seasonal nutrient-rich eutrophic conditions. Situated at a key position between the high-diversity Coral Triangle and the tropical Red Sea/eastern African coast, the coastal waters of Oman act both as a biogeographic stepping stone but also as a nutrient-rich and cold-water barrier for benthic foraminifera migrating from the east to west. Upwelling zones have a deep impact on coastal areas, displace oligotrophic water masses and influence the settlement of highly diverse tropical coral reef and foraminiferal faunal communities. The environmental conditions provide a setting for presumably unique foraminiferal faunal assemblages. However, despite intensive research on tropical foraminifera, detailed studies on coastal foraminifera from Oman have not yet been conducted. We have analyzed the shallow water benthic foraminifer to shed new light on the composition, species richness and habitat preferences and to document the role of the southern Oman coast as biogeographic stepping stone. To place the Oman assemblages in a biogeographic context, we compare the foraminiferal fauna to assemblages from the Maldives, the Chagos Islands, the Coral Triangle and the Red Sea/eastern African faunal province.

RECONSTRUCTING KUNGURIAN (CISURALIAN, PERMIAN) TERRESTRIAL ENVIRONMENTS WITHIN A MEGACALDERA IN THE SOUTHERN ALPS (N-ITALY) USING LITHOFACIES ANALYSIS, PALYNOLOGY AND STABLE CARBON ISOTOPES

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During the Permian, climate experienced a change from icehouse to greenhouse conditions. Few multidisciplinary studies have investigated Kungurian tropical terrestrial ecosystem and climate changes. Here, we apply an interdisciplinary approach on two alluvial-lacustrine successions of the Athesian Volcanic Group (Southern Alps, northern Italy) deposited in a Kungurian megacaldera during periods of volcanic quiescence. Sedimentological analysis combined with palynofacies studies allowed to reconstruct the depositional environments. The study of sporomorph assemblages and stable organic carbon isotopes provided information on plant communities and the climate context. Two different depositional environments were present in the megacaldera and occupied distinct depositional settings: one proximal and one more distal with respect to the source, distinguished by a slightly different composition of the sediments, palynomorphs and organic carbon isotopes. The plant community in the area was dominated by xeromorphic-hygromorphic taxa. The δ13Corg values are comparable with those of other Cisuralian continental organic matter and plants. The stable carbon isotope values evidence a small variability, which correlates weakly but significantly with the abundance of xeromorphic elements. All observations support deposition during semiarid to arid climate conditions, typical of the mid-late Cisuralian in the area.

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EINE HISTORISCHE FOSSILIENSAMMLUNG IN DEN BESTÄNDEN DES NATURMUSEUMS SÜDTIROL: DIE SAMMLUNG GEORG GASSER (1857–1931)

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Der Bozner Privatgelehrte und naturwissenschaftliche Autodidakt Georg Gasser (1857–1931) erlangte vor allem wegen seiner vorbildlich geführten Mineraliensammlung einen Ruf, der ihn weit über die Grenzen seiner Tiroler Heimat bekannt machte. Seine Sammlerinteressen waren jedoch nicht auf Mineralien beschränkt; vielmehr erstreckten sie sich auf nahezu jede Art von Naturobjekten, ob Tierpräparate und Skelette, Conchylien, Insekten, Gesteine oder Fossilien. Während seine zoologischen Sammlungen weitestgehend verloren gegangen sind und die mineralogische Sammlung heute teils in die Bestände der Universität Padua eingegangen ist, teils am Naturmuseum Südtirol aufbewahrt wird, befindet sich seine Fossiliensammlung weitestgehend vollständig im Naturmuseum Südtirol in Gassers Heimatstadt Bozen. Sie wurde in den vergangenen Jahren wissenschaftlich und historisch überarbeitet.

Die mehr als 3000 Exemplare zählende Sammlung scheint in Gassers Absicht als didaktische Schausammlung angelegt worden zu sein, deren Ziel es war, als damals einzige öffentlich zugängliche paläontologische Sammlung in Südtirol dem Museumsbesucher einen Eindruck von der Entwicklung des Lebens im Verlauf der Erdgeschichte zu vermitteln. Besondere Interessenschwerpunkte auf bestimmte taxonomische Gruppen oder geologische Zeitalter lassen sich nicht erkennen. Stücke von besonderem ästhetischem Wert sind die Ausnahme; bei den meisten Fossilien handelt es sich um eher unscheinbare Belegstücke. Für den Aufbau seiner Sammlung scheint Gasser sehr stark auf Kontakte zu Händlern und anderen Sammlern im deutschsprachigen Raum vertraut zu haben. So stammen etwa 67% seiner Fossilien mit Sicherheit, weitere 10 bis 20% mit hoher Wahrscheinlichkeit aus Gebieten, die um 1900 entweder zum Deutschen Reich oder zu Österreich-Ungarn gehörten. Zahlreich vertreten sind z.B. tertiäre Mollusken aus dem Wiener und Mainzer Becken, Ammoniten aus dem süddeutschen Jura, Pflanzen aus den Kohleabbaugebieten in Deutschland und Böhmen. Ein besonderes Augenmerk galt auch den Wirbeltierfossilien. Nebst Fischen aus dem Mansfelder Kupferschiefer und den Solnhofener Plattenkalken umfasst die Sammlung Gasser auch Haizähne aus der Kreide bei Quedlinburg oder dem Miozän bei Ulm, Zähne des Meereskrokodils *Dakosaurus* aus dem Weißjura bei Sigmaringen, einen fragmentarischen Cetaceenwirbel aus dem Miozän von Dingden (Westfalen), sowie eine Sammlung pleistozäner Säugetierknochen aus der Warsteiner Höhle (ebenfalls Westfalen).

GIVING THE RIGHT WEIGHT: COMPARATIVE STUDY OF SPECIMEN-LEVEL PHYLOGENETIC ANALYSES

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Over the past few decades, weighting methods in phylogenetic analysis have been a controversial topic. As far as maximum parsimony is concerned, they include three main strategies: equal weights, implied weights (different weights based on the homoplastic rate of the characters and depending on the *K*-value), and extended implied weights (includes an estimate for the unknown distribution of homoplasy in missing data). Here, we compare these weighting strategies using a real-life osteological dataset composed of 252 morphological characters and 120 specimen-level operational taxonomic units represented by skeletons of lacertilians. The ingroup comprises the genera *Lacerta* and *Timon* with 54 and 15 specimens, respectively. Derived from this dataset, we created two fossil-simulation matrices with different degrees of incompleteness (45% and 65%), with the same character and specimen sampling. We analysed the three character matrices under 36 different weighting strategies: equal weighting, implied weighting with seven different *K*-values, and extended implied weighting with the same *K*-values as in the traditional implied weighting and four different settings for the assumed homoplasy for missing entries. Subsequently, we measured the tree accuracy for the resulting phylogenetic topologies, based on six criteria (e.g., clade delimitation and support metrics), and created final rankings of the 36 weighting strategies for each matrix. The highest-ranked weighting strategy was in all cases an analysis under extended implied weights with *K*-values of 150 or 200 and an assumed homoplasy between 50% and 100%. Changing the setting for the assumed homoplasy had a greater effect on the fossil-simulation datasets than on the real-life dataset. Our data emphasize the advantages of (extended) implied weighting over equal weights when applying a high *K*-value (>10) for specimen-level phylogenies (and probably also for species-level ones).

DETECTING MELANIN PIGMENTS IN FOSSIL VERTEBRATES AND INVERTEBRATES

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Melanins represent a widespread and important group of natural pigments found in bacteria, fungi, plants and animals and are responsible for the colouration of skin, hair, feathers and eyes in animals. In recent years, studies on fossil melanin pigments or melanosomes (melanin-containing organelles) have attracted great interest, which aimed to reconstruct the actual colours of fossil organisms such as dinosaurs, marine reptiles and birds. However, the detection of melanins, especially in fossil samples, is still challenging due to the macromolecular nature of this group of pigments. Non-destructive methods like Raman spectroscopy can be easily applied to fossil samples, but provide only limited structural information. Currently, the most reliable methods for the identification of melanins are based on chemical degradation of the pigments followed by analysis of the products by chromatography with UV detection or mass spectrometry. These methods, however, have rarely been applied to fossil material, because they require large sample amounts of several milligrams. Here, a selective and sensitive method based on alkaline oxidation followed by liquid chromatography–multiple reaction monitoring mass spectrometry is shown that provides chemical evidence for different melanin pigments in small fossil samples of well below one milligram. Measurements indicate a very similar composition of fossil melanins of an ink sac from a Lower Jurassic squid from Holzmaden compared to the melanins from the present-day *Sepia officinalis*. Further examinations of mammals and birds from the Eocene of Messel are currently underway.

WHAT DOES IT TAKE TO LIVE IN WOOD? THE FOSSIL RECORD OF WOOD-ASSOCIATED BEETLE LARVAE AND THEIR IMPACT ON PAST ECOSYSTEMS

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Despite the fact that beetles represent a dominating share of the terrestrial biodiversity, beetle larvae, even economically important ones, are rarely depicted in the literature. This seems especially true for beetle larvae that live hidden within various plant material, especially when it comes to wood. Despite the newest technologies and scientific advances the numbers of still unknown larvae of already known species are further on very high. The fossil record of wood-associated beetle larvae has even fewer reported specimens then the extant record; the overall record of such larvae appears in fact almost absent. However, fossil larvae interacting with plants and also wood, as it turns out, are often found especially within different types of ambers of different origins and from different times. By knowing that the origin of amber is plant-related this information should not come as a surprise. And yet, the numbers of reported larval forms, that are often so drastically different from the adult morphologies of the same species, is very low. Here, we summarise the known record and expand it by numerous new finds of fossil wood-associated beetle larvae preserved in different ambers (from the Cretaceous, Eocene or Miocene) and reconstruct their possible lifestyles associated with plants. We discuss the variation of the morphological characters between the fossil larvae that presumably lived in hardwood, softwood, fungi-infested wood and submerged wood. We also emphasize that these larvae must have had a great impact on the past wood ecosystems while acting as primary decomposers of trees contributing significantly to carbon-cycling. In addition, we discuss the lifestyle and morphological characters of the predatory fossil beetle larvae that used wood as a living space, but did not feed on it; instead they fed on the wood-consuming larvae found within the wood. All these finds significantly refine our view on the past tree-associated ecosystems, by allowing us to include various so far unconsidered ecological roles.

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