

VIII Jornadas Internacionales sobre Paleontología de DINOSAURIOS y su entorno

8th Symposium about Dinosaurs Palaeontology and their Environment

Abstracts book Libro de resúmenes



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VIII International Symposium about Dinosaurs Palaeontology and
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Salas de los Infantes, Burgos, Spain

September 5-7th, 2019 / 5 al 7 de Septiembre de 2019

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INDEX

Schedule/programa,	9
---------------------------	----------

KEYNOTES / PONENCIAS

Brusatte, S.L. - The Rise and Fall of the Dinosaurs.	13
Castanera, D. - Dinosaur footprints across the Jurassic-Cretaceous interval in Europe: faunal changes and palaeoecology.	15
Herne, M.C., Bell, P., Nair, J.P., Salisbury, S.S., Hocknull, S., Weisbecker, V. - Eastern Gondwanan ornithopods: new findings and an update on their diversity, relationships and environments.	17
Malafaia, E., Mocho, P., Escaso, F., Ortega, F. - The fossil record of theropod dinosaurs from the Portuguese Upper Jurassic: ecological and biogeographical implications.	21
Ősi, A. - Santonian (85 Ma) continental vertebrate fauna in the Western Tethyan Archipelago.	25
Sander, P.M. - An Evolutionary Cascade Model for Sauropod Dinosaur Gigantism - Overview, Update and Tests.	29
Sender, L.M. - Palaeobotany associated with Early Cretaceous dinosaur fossil sites on the north of Spain and its palaeoenvironmental implications.	31
Torices, A. - Walking with dinosaurs: the use of new technologies in paleoichnology.	35

COMMUNICATIONS / COMUNICACIONES

Arias-Riesgo, C. - Uranium, thorium and lead study on dinosaurs by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) and its applications in the field of restoration and paleontological conservation.	41
Blanco, A., Moncunill-Solé, B., Puértolas-Pascual, E. - Niche partitioning in allodaposuchid crocodyliforms (Eusuchia, Crocodylia) during the Maastrichtian (Late Cretaceous) of the northeastern Iberian Peninsula.	47
Ciudad-Real, M., Pérez-García, A., Jurkovšek, B., Jurkovšek, T., Martínez, C. - Application of computerized tomography for the reconstruction of the partial skeleton of a turtle from the Upper Cretaceous of Slovenia.	51
Dieudonné, P., Torcida-Fernández Baldor, F. - Unrelated ornithopods with similar tooth morphology in the vicinity of Salas de los Infantes (Burgos Province, Spain): an intriguing case-study.	53

Ferrer-Ventura, M., Navarro-Lorbés, P., San Juan-Palacios, R., Torices Hernández, A. - Uso de modelo fotogramétrico para la realización de mapas de daños e intervención en la conservación y restauración paleoicnológica.	57
Gasca, J.M. Canudo, J.I., Aurell, M., Moreno-Azanza, M., Bádenas, B., Castanera, D., Cuenca-Bescós, G. - Updating the knowledge on the Mesozoic vertebrate faunas from the Galve syncline (Teruel province, Spain).	61
Guerrero, A., Pérez-García, A. - Analysis of the morphological variability of the Lower Cretaceous pleurosternid turtle <i>Pleurosternon bullockii</i> .	67
Isasmendi, E., Sáez-Benito, P., Torices, A., Pereda-Suberbiola, X. - Isolated theropod teeth from the Early Cretaceous of Igea (La Rioja, Spain).	69
Marcos-Fernández, F., Onrubia Chinarro, M., De Miguel Chávez, C., Ortega, F. - La Conservación restauración de <i>Paludidraco multidentatus</i> . Un tratamiento de conservación encaminado a la exposición.	71
Marcos-Fernández, F., Martínez Fernández, I., Fernández Fernández, E., Fernández Martínez, J., Plaza Beltrán, M., Ortega, F. - Revisión de distintas técnicas de engasado para la extracción de fósiles.	77
Martínez Fernández, I., Marcos-Fernández, F., Fernández Fernández, E., Fernández Martínez, J., Ortega, F. - La reintegración estructural en la restauración paleontológica: estudio de propiedades de diversos materiales.	81
Medrano-Aguado, E., Parilla-Bel, J., Canudo, J.I. - The vertebrate paleobiodiversity of the Blesa formation (Barremian, Lower Cretaceous) in northeast Spain.	85
De Miguel, C., Ortega, F., Pérez-García, A. - Updating the Iberian fossil record of Triassic Sauropterygia.	89
Mocho, P., Parámo, A., Ortega, F. - Titanosaurs from the Iberian Peninsula: an overview and future perspectives.	93
Páramo, A., Mocho, P., Ortega, F., Sanz, J.L. - Three-dimensional analysis of the titanosaurian limb skeleton: implications for systematic analysis.	95
Parrilla-Bel, J., Fortuny, J., Llacer, S., Canudo, J.I. - Rostrum of <i>Maledictosuchus riclaensis</i> (Rhacheosaurini, Thalattosuchia). 3D reconstruction: difficulties, new structures and interpretations.	99
Pérez-García, A. - New information on the anatomy and systematics of the basal turtles (Helochelydridae) from the Spanish Cenomanian site of Algora.	103
Pérez-García, A. - The first pleurodiran turtle identified in the Soria Province (Spain): a finding from the Upper Cretaceous levels of Cabrejas del Pinar.	105
Pérez-García, A., Ortega, F., Murelaga, X. - The bothremydid turtles from the Spanish Campanian site of Laño: an update.	107

Pérez-García, A., Canudo, J.I., Castanera, D. - New data on the Iberian record of pleurosternid turtles based on the finding of the first representative of this clade in the Cameros Basin (Spain).	109
Pérez-Pueyo, M., Gilabert, V., Moreno-Azanza, M., Puértolas-Pascual, E., Bádenas1 B., Canudo, J.I. - Late Maastrichtian fossil assemblage of Veracruz 1 site (Beranuy, NE Spain): wildfires and bones in a transitional environment.	111
Rivera-Sylva, H.E., Guzmán-Gutiérrez, J.R., Zapata Jaime, R., García de la Garza, J.P., Guajardo Guajardo, R.D., Enríquez Mendoza, S.P. - Un ceratópsido proveniente de la Formación Olmos (Campaniano-Maastrichtiano), de Sabinas, Coahuila, México.	115
Santos, V.F., Castanera, D., Cachão, M., Caetano, P.S., Callapez, P.M., Carvalho, C.N., Mocho, P., Oliveira, J., Santos, C., Silva, C.M - New Middle Jurassic dinosaur tracks from Outão (Setúbal, West Central Portugal).	119
Santos, V.F., Alho, J.M. - Monumento Natural das Pegadas de Dinossáurios de Ourém / Torres Novas, Portugal: 25 years of research and dissemination of scientific knowledge.	121
Simarro-Cano, A., Armañanzas Alpuente, C. - Reducción de los dígitos en terópodos.	125
Torcida-Fernández Baldor, F., Canudo, J.I., Huerta, P. - New data of sauropod paleobiodiversity at Jurassic-Cretaceous transition in Spain (Burgos).	129

Horario	Jueves día 5
8:30	Recepción de asistentes y entrega de documentación.
9:00	Presentación de las Jornadas.
9:15	Conferencia Plenaria. S. Brusatte The Rise and Fall of the Dinosaurs.
10:15	Sesión de comunicaciones. 10:15-10:30. Blanco et al. , Niche partitioning in allodaposuchid crocodyliforms Peninsula (Eusuchia, Crocodylia) during the Maastrichtian (Late Cretaceous) of the northeastern Iberian. 10:30-10:45. Gasca et al. , Updating the knowledge on the Mesozoic vertebrate faunas from the Galve syncline (Teruel province, Spain). 10:45-11:00. Dieudonné; Torcida-Fernández Baldor , Unrelated ornithopods with similar tooth morphology in the vicinity of Salas de los Infantes (Burgos Province, Spain): an intriguing case-study.
11:00	Pausa café.
11:30	Conferencia Plenaria. E. Malafaia The fossil record of theropod dinosaurs from the Portuguese Upper Jurassic: ecological and biogeographical implications.
12:30	Sesión de comunicaciones. 12:30-12:45. de Miguel Chaves et al. , Updating the Iberian fossil record of Triassic Sauroptrygia. 12:45-13:00. Mocho et al. , Titanosaurs from the Iberian Peninsula: an overview and future perspectives. 13:00-13:15. Pérez-Pueyo, et al. , Late Maastrichtian fossil assemblage of Veracruz 1 site (Beranuy, NE Spain): wildfires and bones in a transitional environment.
13:30	Actos Protocolarios.
14:00	Comida.
16:00	Conferencia Plenaria. D. Castanera Dinosaur footprints across the Jurassic-Cretaceous interval in Europe: faunal changes and palaeoecology.
17:00	Sesión de comunicaciones. 17:00-17:15. Guerrero y Pérez García , Analysis of the morphological variability of the Lower Cretaceous pleurosternid turtle <i>Pleurosternon bullockii</i> 17:15-17:30. Marcos-Fernández et al. , La conservación restauración de <i>Paludidraco multidentatus</i> . Un tratamiento de conservación encaminado a la exposición. 17:30-17:45. Martínez Fernández et al. , La reintegración estructural en la restauración paleontológica: estudio de propiedades de diversos materiales.
17:45	Pausa café.
18:15	Conferencia plenaria. M. Herne Eastern Gondwanan ornithopods: new findings and an update on their diversity, relationships and environments.
19:15	

Horario	Viernes día 6
9:00	Conferencia Plenaria. L.M. Sander Palaeobotany associated with Early Cretaceous dinosaur fossil sites on the north of Spain and its palaeoenvironmental implications.
10:00	Sesión de comunicaciones. 10:15-10:30. Marcos-Fernández et al. , Revisión de distintas técnicas de engasado para la extracción de fósiles. 10:30-10:45. Ciudad Real et al. , Application of computerized tomography for the reconstruction of the partial skeleton of a turtle of the Upper Cretaceous of Slovenia. 10:45-11:00. Ferrer-Ventura et al. , Uso de un modelo fotogramétrico para la realización de mapas de daños e intervención en la conservación y restauración paleoicnológica.
11:00	Pausa café.
11:30	Conferencia Plenaria. A. Ösi A Santonian (85 Ma) continental vertebrate fauna in the Western Tethyan Archipelago
12:30	Sesión de comunicaciones. 12:30-12:45. Medrano-Aguado et al. , The vertebrate paleobiodiversity of the Blesa formation (Barremian, Lower Cretaceous) in northeast Spain. 12:45-13:00. Torcida Fernández-Baldor et al. , New data of sauropod paleobiodiversity at Jurassic-Cretaceous transition in Spain (Burgos). 13:00-13:15. Páramo, et al. , Three-dimensional analysis of the titanosaurian limb skeleton: implications for systematic analysis. 13:15-13:30. Parrilla-Bel et al. , Rostrum of <i>Maledictosuchus riaensis</i> (<i>Rhacheosaurini</i> , <i>Thalattosuchia</i>). 3D reconstruction: difficulties, new structures and interpretations.
13:45	Comida
16:00	Conferencia plenaria. A. Torices Walking with dinosaurs: the use of new technologies in paleoichnology.
17:00	Pausa café.
17:30	Conferencia Plenaria. M. Sander Biology of the Sauropod Dinosaurs: The Evolution of Gigantism.
18:30	Pósters y Cerveza
21:15	Cena de clausura (gratuita para todos los participantes).
22:45	Concierto: <i>Swing Machine Orchestra</i> .

Horario	Sabado día 7
10:00	Excursión Sierra de la Demanda.

PONENCIAS

The Rise and Fall of the Dinosaurs

Brusatte, Stephen L.

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Keywords: dinosaurs, Triassic, Jurassic, Cretaceous, avian evolution, mass extinction.

Dinosaurs are icons of prehistory: they were preeminent animals on land globally during much of the Mesozoic, and persist today as over 10,000 species of birds. We are rapidly learning about the evolutionary history of dinosaurs, as the modern, diversifying generation of palaeontologists discovers new species across the globe and uses new techniques to study dinosaur anatomy, biology, phylogeny, evolution, and behaviour. In this keynote talk, I review the evolutionary story of dinosaurs, from the origins of their immediate small-bodied dinosauromorph ancestors in the aftermath of the end-Permian extinction, to the origin of true dinosaurs in the Triassic ca. 230 million years ago, through their Jurassic rise to dominance, and to the end-Cretaceous extinction of the non-avian species. I highlight recent research that shows how dinosaurs evolved from humble cat-sized ancestors soon after the end-Permian extinction; gradually rose to dominance over 30+ million years of the Triassic after being eclipsed by the more diverse, abundant, and disparate crocodile-line pseusoduchian archosaurs; and became pre-eminent in the Jurassic, after the end-Triassic extinction. I discuss how some species evolved colossal size, keen intelligence and neurosensory behaviours (as revealed by computed tomography scanning), and others developed feathers, wings, and flight, giving rise to today's birds. Then, the non-avian species suddenly went extinct after the Chicxulub bolide impact, setting the stage for the Age of Mammals. Recent work strongly demonstrates that dinosaurs remained diverse and abundant, and continued to occupy a wide range of niches and body sizes, up until the asteroid impact, including emerging evidence from the Pyrenees of Spain. I provide examples of recent fieldwork, statistical studies, and laboratory work that help piece together this story, including the work of my students at the University of Edinburgh and our colleagues, and discuss a new project I am leading (the ERC-funded PalM project) on the rise of mammals after the dinosaur extinction, in the Paleogene.

Dinosaur footprints across the Jurassic-Cretaceous interval in Europe: faunal changes and palaeoecology

Castanera, D.

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Keywords: Theropoda, Ornithopoda, Sauropoda, Tyreophora, Kimmeridgian, Tithonian, Berriasian.

The Jurassic-Cretaceous boundary (around 145 m.y.a.) is a significant period of time from both a geological and a paleontological point of view. Recent studies have argued that this boundary is characterized by a significant decrease in diversity in several groups of vertebrates suggesting a faunal turnover across the Tithonian-Berriasian boundary (Tennant *et al.*, 2017). Regarding the European dinosaur record, Late Jurassic faunas are fairly well known with significant sites in Portugal (Lusitanian basin), Spain (Maestrazgo, Southiberian and Asturian basins), France and Switzerland (Jura platform) or Germany (Lower Saxony basin). On the other hand, the earliest Cretaceous (Berriasian) is one of the most poorly known ages of the Mesozoic with just few dinosaurs described from the Purbeck in England and from the “Wealden” in Germany. When looking into the footprint record, several units have provided a substantially rich Berriasian record in Spain (Huérteles Formation, Castanera *et al.*, 2018), Germany (Obernkirchen Sandstone, Bückerberg Formation, Hornung *et al.*, 2012) and England (Purbeck Limestone Group, Wright, 1998). The aim of this work is to provide an overview of the European dinosaur footprint record across the Kimmeridgian-Berriasian interval putting especial emphasis in the possible faunal changes. Several main morphotypes have been identified in different areas and over the whole interval: *Megalosauripus transjuranicus*-like, *Jurabrontes*-like, and Grallatorid-like among theropods; *Anomoepus*-like, *Dineichnus*-like and Iguanodontipodidae-like among ornithopods; *Deltapodus*-like, among stegosaurs; *Brontopodus*-like and *Parabrontopodus*-like, among sauropods. Besides, the importance of the study of footprints with high score in the recently proposed morphological preservation scale (Marchetti *et al.*, 2019) in ichnotaxonomic studies will be discussed. Some clues about the distinction between tridactyl (theropods vs ornithopods) and quadrupedal (sauropods, stegosaurs and ankylosaurs) trackmakers will be also provided. Finally,

some comments about the faunal composition in the ecosystems will be also commented.

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Eastern Gondwanan ornithopods: new findings and an update on their diversity, relationships and environments

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Keywords: Cretaceous, eastern Gondwana, Australia, Antarctica, Ornithopoda, Phylogeny, Palaeoenvironment.

Ornithopods were a diverse and long-lived clade of derived neornithischian dinosaurs with a phylogenetic history traced over 100 Ma from at least the Callovian (~166 Mya) to the K–Pg boundary. They are known from nearly all major landmasses and ranged from small-bodied (turkey-sized) bipeds to large-bodied facultative bipeds/quadrupeds (up to ~16 tons). Compared to Laurasia, the body fossil record of ornithopods in Gondwana is relatively scarce, with the highest diversity from western Gondwana (Africa, South America) and Argentina in particular. The ornithopod record from eastern Gondwana (Australia, New Zealand, Antarctica, India/Madagascar) is limited to Late Cretaceous west Antarctica, Early-middle Cretaceous Australia and to a minor extent Late Cretaceous New Zealand.

Until relatively recently, only five ornithopods had been named from eastern Gondwana; all of which were from Australia. These included: the large-bodied *Muttaburrasaurus langdoni* from the Albian of Queensland (Molnar, 1996); three small-bodied taxa from Victoria, *Atlascopcosaurus loadsi* and *Leaellynasaura amicagraphica*, from the Albian and *Qantassaurus intrepidus* from the Barremian (see Herne *et al.*, 2019); and the femoral taxon *Fulgurotherium australe* from the Cenomanian of Lightning Ridge in New South Wales. *Muttaburrasaurus* is known from associated cranial and postcranial skeletons and the Victorian taxa are known from isolated craniodental remains. The ornithopod record for New Zealand consists of a partial ilium attributed to a dryosaurid, and a single hadrosaurid tooth was reported from the Maastrichtian of western Antarctica (Case *et al.*, 2000), importantly, confirming the

occurrence of faunal interchange across land bridges between North and South America and Antarctica in the upper Late Cretaceous.

Atlascopcosaurus and *Leaellynasaura* are known from craniodental remains, without associated dentaries, while *Qantassaurus* is only known from dentaries (see Herne *et al.*, 2019). A partial postcranial skeleton (NMV P185992/P185993) from the *Leaellynasaura* holotype locality of Dinosaur Cove, with an impressively long tail (Herne, 2009), was originally considered assignable to *Leaellynasaura* as a part of the holotype (Rich and Rich, 1989). However, based upon taphonomic reassessment of the holotype locality, this referral is equivocal, and a second partial ornithopod postcranium (NMV P186047) from the same deposit also remains unassigned (Herne *et al.*, 2016).

Recent research has resulted in an explosion of new small-bodied, non-hadrosauriform ornithopod discoveries across eastern Gondwana. *Trinisaura santamartaensis* and *Morrosaurus antarcticus*, known from associated postcranial remains, have been named from the Late Cretaceous of Antarctica (Coria *et al.*, 2013; Rozadilla *et al.*, 2016) and three Early–middle Cretaceous ornithopods have been described from Australia, including: *Diluvicursor pickeringi* and *Galleonosaurus dorisae* from the Albian and Berremian, respectively (Herne *et al.*, 2018; Herne *et al.*, 2019), of Victoria; and *Weewarrasaurus pobeni* from the Cenomanian of Lightning Ridge (Bell *et al.*, 2018).

Known from postcranial remains, *Diluvicursor* is differentiated from the other Victorian ornithopod postcranial skeletons by having more robust features. *Galleonosaurus* is known from an ontogenetic series of five maxillae. Its cranium was more gracile than its contemporary *Qantassaurus* and is differentiated from the ~12 Ma younger taxa *Leaellynasaura* and *Atlascopcosaurus* by maxillary morphology and crown ornamentation. From new CT imagery, additional diversity among the Victorian ornithopodan maxillae is also detected. Known only from the dentary *Weewarrasaurus* differs from *Qantassaurus* in being more gracile, having rounder crown profiles and curved roots rather than straight.

Until recently, the Australian ornithopod body fossil record mostly consisted of small-bodied taxa and the single megaherbivore *Muttaburrasaurus*. A new ‘mid-sized’ taxon, *Fostoria dhimbangunmal*, is now described from Lightning Ridge (Bell *et al.*, in press). Known from partial crania and postcrania, *Fostoria* has a broad robust cranium, sub-rectangular frontals, an unusual fossa on the quadrate and a short tibia. Our understanding of the morphological disparity among the eastern Gondwana ornithopods has increased with *Fostoria*. Using 3D CT imagery, new work on *Muttaburrasaurus*

now indicates that the expanded nasal region ('nasal bulla') has more complexity than previously understood.

Phylogenetic analysis recovers the Australian, Antarctic and Argentinian non-hadrosaurid ornithopods within the Gondwanan Elasmaria, which is the sister clade to Clypeodonta (= *Hypsilophodon* + Iguanodontia). Callovian aged divergence between the elasmarians and clypeodontans is hypothesised (Herne *et al.*, 2019). The interchange of ornithopods across intermittent terrestrial connections between eastern and western Gondwana, and between western Antarctica and Australia (via the Antarctic Victoria Basin, Lisker and Läufer, 2013) is expected through the Cretaceous. Although the record of ornithopod body fossils in eastern Gondwana is presently restricted to the upper Barremian–Maastrichtian, trackways in the Valanginian–Barremian of Western Australia (Salisbury *et al.*, 2017) suggest small- to large-bodied ornithopods were well established in eastern Gondwana throughout the Cretaceous.

The Victorian ornithopods inhabited riverine floodplains laid down in the extensional rift valley between Australia and Antarctica, while the ornithopods of Lightning Ridge, such as *Fostoria* and Queensland's *Muttaburrasaurus* inhabited floodplains and deltas that bordered the epeiric Eromanga Sea. Sediment supply to these environments, however, was from a single, large-scale, contemporaneous volcanic province that was positioned along the eastern margin of the Australian continent (Bryan *et al.*, 1997).

From the Valanginian to Maastrichtian, the interconnected Australian-Antarctic landmasses straddled the South Pole and were positioned within 40–90° S. The distance from the northern tip of western Antarctica to the northern tip of Australia extended ~8,900 km. The record of Cretaceous eastern Gondwana ornithopods, therefore, extends over a large geographic and temporal range (~70 Ma), with warm tropical–subtropical to arguably cool temperate climatic conditions interpreted for the region (e.g., Francis *et al.*, 2008). Gymnosperm forests dominated with the angiosperm record increasing from the Albian. Sediments deposited in forested lowland fluvial settings shed from contemporaneous volcanic provinces similarly host the ornithopod body fossils from eastern Australia and western Antarctica (Francis *et al.*, 2008; see Herne *et al.*, 2019 and authors within). High rainfall, warm climatic conditions, volcanogenic sediment input and periodically disturbed riverine floodplains and deltas would have facilitated diverse habitat and niche opportunities for dinosaur herbivores. These factors are reflected in the increasing record of ornithopod diversity across the region. Investigations on eastern Gondwanan ornithopod functional disparity and

palaeoecology are in their infancy, with the anticipated discovery of new specimens set to shed new light on these questions.

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The fossil record of theropod dinosaurs from the Portuguese Upper Jurassic: ecological and biogeographical implications

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Introduction

The Upper Jurassic levels from Portugal have yielded the most significant record of dinosaurs for this age in Europe and one of the most abundant worldwide. These levels correspond to filling deposits of the Lusitanian Basin, a tectonosedimentary structure which origin is related to the opening of the north sector of the Atlantic Ocean. The central sector of the Lusitanian Basin corresponds mainly to distal fluvio-deltaic or coastal environments and produced the richest fossil record of Mesozoic terrestrial vertebrates in Portugal (e.g. Lapparent & Zbyszewski, 1957; Dantas, 1990). This sector has been divided into four Upper Jurassic sub-basins (Consolação, Turcifal, Arruda, and Alcobaça-Bombarral), based on isopachs and facies distribution (Pena dos Reis *et al.*, 2000). These areas might represent diverse contemporaneous communities, occupying different palaeoenvironments, more or less open to coastal influences (Mocho *et al.*, 2017). Theropod remains are relatively abundant in Upper Jurassic levels of the Lusitanian Basin and include mainly medium to large-sized forms with a transatlantic distribution.

Here we present an overview of the current knowledge on the fossil record of theropod dinosaurs from the Late Jurassic of the Lusitanian Basin and we discuss the palaeoecological and palaeobiogeographic implications of this record for the interpretation of the evolutionary history of this group of dinosaurs.

Diversity and distribution of theropod dinosaurs from the Upper Jurassic fossil record of the Lusitanian Basin

The distribution of theropod remains between the different sub-basins of the Lusitanian Basin is very unequal, probably biased by the fact that the best prospecting conditions occur in coastal areas. Most of the theropod specimens known in the Portuguese Upper Jurassic record come from the coastal region of the Central Sector of the Lusitanian Basin, corresponding to the Consolação Sub-basin. Less frequent, there are also significant fossil sites with theropod remains at the northern area of the Bombarral-Alcobaça Sub-basin, such as Guimarota (Leiria) and Andrés (Pombal). On the other hand, theropod material is currently unknown in the Arruda Sub-basin and only few occurrences are known in the Turcifal Sub-basin.

The fossil record of theropod dinosaurs from the Late Jurassic of the Lusitanian Basin represents a very diverse fauna, which includes primitive clades such as ceratosaurs and both basal and more derived tetanurans. Ceratosaurs are represented by few specimens, including some appendicular elements and isolated teeth assigned to *Ceratosaurus* (e.g. Mateus & Antunes, 2000; Malafaia *et al.*, 2015). Some isolated theropod teeth collected in Kimmeridgian–Tithonian sediments were tentatively identified as belonging to Abelisauridae (Hendrickx & Mateus, 2014a). Tetanurans are the most abundant theropods so far represented in the Portuguese record. Several specimens collected in Kimmeridgian levels and identified as belonging to the megalosaurid *Torvosaurus* (e.g. Hendrickx & Mateus, 2014b; Malafaia *et al.*, 2017). The more abundant and well-known tetanuran in this record is the allosauroid *Allosaurus* (e.g. Pérez-Moreno *et al.*, 1999; Mateus *et al.*, 2006). This taxon is represented by abundant cranial and postcranial elements found in different sites extending from the Kimmeridgian to the late Tithonian. Other possible allosauroid, *Lourinhanosaurus* is represented by few postcranial remains and possibly a nest with embryos, all found in sediments upper Kimmeridgian–lower Tithonian in age (Mateus, 1998; Mateus *et al.*, 2001). This taxon has been considered a basal allosauroid closely related with metriacanthosaurids. One large-sized partial postcranial skeleton found in upper Tithonian levels and a small-sized, juvenile individual collected in upper Kimmeridgian sediments have been recently interpreted as members of Carcharodontosauria (Malafaia *et al.*, 2019). Finally, the Portuguese Upper Jurassic record also comprises some isolated remains interpreted as belonging to coelurosaurians, including the primitive tyrannosauroid *Aviatyrannis*, and several isolated teeth identified as compsognathids, dromaeosaurids, troodontids, *Paronychodon* and *Richardoestesia* (e.g. Zinke, 1998).

The taxonomic diversity of theropods currently known in the Upper Jurassic fossil record of the Lusitanian Basin may indicate some level of niche partitioning in order to minimize competition, through behavioural or spatial dietary segregation. Wide niche partitioning has been proposed for other theropod communities (Frederickson *et al.*, 2018) and for Late Jurassic sauropod dinosaurs from the Iberian Peninsula (Mocho *et al.*, 2017).

Palaeobiogeographic context of the Late Jurassic Portuguese theropods

The faunal composition of theropods from the Morrison Formation and the Lusitanian Basin is much similar with most of the genera currently known in the Portuguese record having a closely related taxon at the North American record. However, the Portuguese record also includes some exclusive taxa (*Lourinhanosaurus*) and clades up to now unknown in North American Jurassic (Carcharodontosauria). This combination of shared and endemic taxa is compatible with an incipient vicariant evolution related with the first stages of the north Atlantic opening. The development of dispersal routes between Europe and North America after the late Tithonian could explain the presence of carcharodontosaurians during the Early and Late Cretaceous of North America (e.g. Harris, 1998). A land reconnection between Europe and North America due to a dramatic drop in sea level during the mid-Valanginian was previously proposed to explain the palaeobiogeographic context of other dinosaur groups such as the turiasaurian sauropods (Royo-Torres *et al.*, 2017).

Conclusions

Theropod dinosaurs are well-represented in the Upper Jurassic of the Lusitanian Basin. The major theropod clades are present from the Kimmeridgian to the end of the Tithonian, mostly in the Consolação and Bombarral-Alcobaça sub-basins. This higher incidence of findings along the coastline may be in part a sampling bias due to more prospection in these areas. The high taxonomic diversity of theropods currently known may indicate some level of niche partitioning. The combination of shared and endemic taxa in the Upper Jurassic of the Lusitanian Basin is compatible with an incipient vicariant evolution related with the north Atlantic opening. The Iberian Peninsula may have had an important role in the dispersion of dinosaur faunas to North American landmasses during the early Lower Cretaceous.

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A Santonian (85 Ma) continental vertebrate fauna in the Western Tethyan Archipelago

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Introduction

The European Late Cretaceous continental vertebrate record is relatively poorly known compared to other regions of the world that is mainly due to the low number and in many cases small extension of localities. This phenomenon is usually explained by the relatively high sea level characteristic for the Mesozoic (see e.g. Haq *et al.*, 1987, Smith *et al.*, 1994), that resulted in an archipelago with coastal to shallow marine deposits instead of expanded landmasses with potential terrestrial, fluvial or lacustrine sedimentary basins (Pereda-Suberbiola 2009, Mannion & Upchurch 2011, Csiki-Sava *et al.*, 2015). From the Late Cretaceous, Campanian-Maastrichtian sites (e.g. in Spain, France, Austria, Hungary, Romania, Sweden) have produced most of the continental record (Csiki-Sava *et al.*, 2015). However, from the preceding, ca. 15 Myr long, late Cenomanian to Early Campanian interval, only some tracksites and a few assemblages give us some information on the development of the end-Mesozoic European vertebrate communities (e.g. Nicosia *et al.*, 1999, Ruiz-Omeñaca *et al.*, 2009, Buffetaut & Pouit, 1994, Ősi *et al.*, 2016, 2019).

The Santonian vertebrate fauna from Iharkút and Ajka, Hungary is one of the few exceptions from this critical period that helps for a better understanding of the end-Mesozoic faunal compositions in the European or Western Tethyan Archipelago.

Vertebrate faunal compositions

Excavations at the almost contemporaneous Iharkút and Ajka vertebrate sites resulted in close to 100.000 bones and teeth of various groups including at least seven different families of fish, albanerpetontid and anuran amphibians, turtles, mosasaurs, at least six different groups of lizards, four crocodyliforms, pterosaurs, and ornithischian and non-

avian saurischian dinosaurs and birds (Fig. 1). Interestingly, not a single tooth of mammals has been unearthed yet.



Figure 1.- Representative elements of the Late Cretaceous (Santonian) continental vertebrate fauna from Iharkút, Hungary. A, *Pannoniasaurus inexpectatus* (Squamata, Mosasauroidea), dorsal vertebra in dorsal view (photo by Réka Kalmár). B, Basal tetanuran (Theropoda, Tetanurae), tooth (MTM V.01.54). C, *Mochlodon vorosi* (Ornithopoda, Rhabdodontidae), left dentary (holotype, MTM V 2010.105.1) in lateral view. D, *Bakonydraco galaczi* (Pterosauria, Azhdarchidae), mandible (holotype, MTM 2007.110.1) in dorsal view. E, *Hungarosaurus tormai* (Ankylosauria, Nodosauridae), right dentary (MTM 2007.25.2) in lateral view. F, *Iharkutosuchus makadii* (Eusuchia, Hylaeochampsidae), skull (holotype, MTM 2006.52.1) in dorsal view. G, *Bauxitornis mindszentyae* (Aves, Enantiornithes), left tarsometatarsus (holotype, MTM V 2009.38.1) in anterior view. H, *Ajkaceratops kozmai* (Ceratopsia, Coronosauria) fused rostral and premaxillae (holotype, MTM V 2009.192.1) in lateral view. Scale bars equal 2 cm in A, C, D, E, F; 1 cm in B, G, H.

A rough comparison of the Hungarian Santonian fauna shows high family-level similarities with the European Campano-Maastrichtian sites (27 of the 33 suprageneric

taxa (82%) are present continuously). Compared to the Turonian-Coniacian record the similarity is still significant (8 of the 10 suprageneric taxa: 80%), but note that the record from this age is extremely poor (Ősi *et al.*, 2019). The Cenomanian faunas, however, are more different from the Santonian to Maastrichtian vertebrate communities with 11 of the 22 suprageneric taxa (50%) lacking from later faunas. These elements (e.g. bernissartiid, goniopholidid, and pholidosaurid crocodiles, ornithocheirid, lonchodraconid, pteranodontoid pterosaurs, iguanodontoid and carcharodontosaurid dinosaurs) might have been disappeared from the European Archipelago (Csiki-Sava *et al.*, 2015). This suggests that the late Cenomanian-early Santonian period, - a time when relative sea-level was one of the highest during the Mesozoic -, witnessed a significant faunal change and the appearance of some endemic clades/forms in this Archipelago.

An island of unique forms

The Santonian vertebrate fauna from Hungary includes some peculiar forms that show unique anatomical or ecological features suggesting the highly adaptive nature of the Iharkút-Ajka faunal elements. One of them is *Pannoniasaurus*, a tethysaurine mosasaur that was well adapted to freshwater environments (Makádi *et al.*, 2012) as it was also supported by stable isotope analysis of the tooth enamel (Kocsis *et al.*, 2009). Among the four different crocodyliforms there was the small bodied, hylaeochampsid *Iharkutosuchus* with multicusped teeth. Being an herbivore it was able to grind its food using a complex jaw mechanism (Ősi & Weishampel 2009, Melstrom & Irmis 2019). Thirdly, *Hungarosaurus*, a medium-sized nodosaurid ankylosaur had a fore- and hindlimb proportion of 1:1, paravertebral elements along the epaxial musculature, and a dorsally hypertrophied cerebellum. All these features suggest that the posture and movement of this quadruped low-browser could have been more advanced, and it was more cursorial than other ankylosaurs (Ősi *et al.*, 2014).

These specialized forms along with some dwarf representatives of some other, well known groups (*Magyarosaurus dacus* from the Maastrichtian of Romania Stein *et al.*, 2010, *Mochlodon* spp. from the Campanian of Austria and the Santonian of Hungary Ősi *et al.*, 2012) clearly suggest that insular effect, endemism and the adaptation to ecological niches, otherwise filled by other groups, should have been decisive factors during the evolution of Late Cretaceous European insular faunas.

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An evolutionary cascade model for sauropod dinosaur gigantism overview, update and tests

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Keywords: dinosaurs, sauropod gigantism, evolutionary cascade model.

Sauropod dinosaurs are a group of herbivorous dinosaurs which exceeded all other terrestrial vertebrates in mean and maximal body size. Sauropod dinosaurs were also the most successful and long-lived herbivorous tetrapod clade, but no abiological factors such as global environmental parameters conducive to their gigantism can be identified. These facts justify major efforts by evolutionary biologists and paleontologists to understand sauropods as living animals and to explain their evolutionary success and uniquely gigantic body size. Contributions to this research program have come from many fields and can be synthesized into a biological evolutionary cascade model of sauropod dinosaur gigantism (sauropod gigantism ECM). This presentation focuses on the sauropod gigantism ECM. The model consists of five separate evolutionary cascades (“Reproduction”, “Feeding”, “Head and neck”, “Avian-style lung”, and “Metabolism”). Each cascade starts with observed or inferred basal traits that either may be plesiomorphic or derived at the level of Sauropoda. Each trait confers hypothetical selective advantages which permit the evolution of the next trait. Feedback loops in the ECM consist of selective advantages originating from traits higher in the cascades but affecting lower traits. All cascades end in the trait “Very high body mass”. Each cascade is linked to at least one other cascade. Important plesiomorphic traits of sauropod dinosaurs that entered the model were ovipary as well as no mastication of food. Important evolutionary innovations (derived traits) were an avian-style respiratory system and an elevated basal metabolic rate. Comparison with other tetrapod lineages identifies factors limiting body size.

Palaeobotany associated with Early Cretaceous dinosaur fossil sites on the north of Spain and its palaeoenvironmental implications

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Keywords: Palaeobotany, palaeoenvironments, Early Cretaceous, dinosaurs, north of Spain.

Fossil plants are an essential resource of information in order to establish the palaeoclimatic and palaeoenvironmental conditions of the landscapes that were inhabited by dinosaurs and other terrestrial vertebrates during the Mesozoic era. These palaeobotanical data come from the study of both macroscopic and mesoscopic plant remains (i.e. trunks, leaves, fruits, seeds, flowers) and also microscopic ones (i.e. palynomorphs). In addition, a lot of information can be deduced from plant-animal interactions preserved in these palaeobotanical records and also from the indirect related evidences as they are the vegetation affected by ancient wildfires (Sender, 2018) and plant remains contained inside coprolites (Vajda *et al.*, 2016). The researches carried out since the last 20 years by the members of the *Grupo de Paleobotánica Ibérica* - using the combination of palaeobotanical data with the related taphonomical information- have let us to establish both the plant assemblages and the related palaeoenvironmental conditions presented in Early Cretaceous fossil sites containing dinosaur remains in the north of Spain.

The western sector of the Cameros Basin in Burgos province present several plant fossil sites placed in the vicinities of Salas de los Infantes village that ranges from Hauterivian to Aptian in age. These sites also had yielded a number of remains of different kinds of dinosaurs corresponding to ornithopods, sauropods, thyreophorans and theropods together with a variety of plant fossils consisting on at least four types of permineralized logs of bennettitales within Family Cycadeoideaceae (Huerta *et al.*, 2001; Diez *et al.*, 2018), false trunks of the tree fern *Tempskya* (Puente-Arauzo *et al.*, 2014) and a diversity of macro and micro-floral remains corresponding to both terrestrial and aquatic ferns (Families Dicksoniaceae, Schizaeaceae and Marsileaceae), conifers and a minor presence of angiosperms (Sender *et al.*, 2010, 2011, 2013, 2014; Villanueva-

Amadoz *et al.*, 2010). These plants grew up in the fluvial plains and shores of wide anastomosed fluvial channels -and their associated depositional sub-environments- indicating subtropical to warm-temperate climatic conditions.

The northwest zone of the Maestrazgo Basin in Teruel province shows fossil sites containing both dinosaurs and plant remains comprising nearly all the Early Cretaceous temporal interval. The classical locality in the well-known Galve area, where the first new Spanish dinosaur –*Aragosaurus ischiaticus*- was found, shows a variegate fern assemblage Berriasian in age composed of both palynomorphs and leaves of several types of ferns (Santos *et al.*, 2018) indicating warm-temperate and humid conditions present in the coastal environment where these organisms lived. Other fossil sites - Barremian in age- containing both adults and perinates ornithopod dinosaurs from the same area in Galve, show palynological assemblages composed of several types of conifers, ferns and some cycadophytes, and also a scarce number of angiosperms, in addition to macrofossil remains corresponding to the conifer genus *Pseudofrenelopsis* within Family Cheirolepidiaceae (Villanueva-Amadoz *et al.*, 2015a). The xeromorphic features from the cuticle of the leaves of this kind of extant conifers indicate adaptations to a semi-arid or seasonally climate conditions during that temporal interval in a nearly coastal environment with a main continental influence.

An extraordinary variety and abundance of plant fossil assemblages have been found in several, Albian in age, localities from Teruel province -some famous ones as the sites in Utrillas and Ariño villages- containing abundant dinosaur remains that include ornithopods, thyreophorans, theropods and scarce remains of sauropods as well as a variety of other vertebrates. The plant assemblages show a marked change in the palaeofloras in relation to older Early Cretaceous ones, which also display a clear compositional differentiation depending on their associated depositional environments within the deltaic-estuarine system that developed in this area of Spain during Albian times. In this sense, deposits of marshes and coastal swamps contain similar plant assemblages corresponding mainly to different kinds of conifers with a predominance of those within Family Cheirolepidiaceae, as well as some ginkgoales, both of them showing xeromorphic characters, which indicate adaptations to environmental stress conditions (Sender, 2012, Villanueva-Amadoz, 2009). In the other hand, the fluvial and fresh-water swamp deposits show a variety of plant assemblages with a predominance

of pteridophytes (Families Matoniaceae, Schizaeaceae, Gleicheniaceae) as well as conifers (Families Cupressaceae, Araucariaceae, Cheirolepidiaceae, Podocarpaceae), ginkgoales, bennettitales, cycads and other gymnosperms and also a diversity of terrestrial angiosperms (Sender, 2012, Villanueva-Amadoz, 2009; Sender *et al.*, 2008, 2016, 2019). The morphological characters disposed on the leaves of these kinds of plants indicate humid conditions with some dry epochs within a subtropical palaeoclimate. In addition, the abundance of charcoalified wood remains present in almost all the fossil sites studied would indicate the presence of recurring wildfires affecting to these environments during the last part of the Early Cretaceous in this area (Sender *et al.*, 2015; Villanueva-Amadoz *et al.*, 2015b).

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Walking with dinosaurs: the use of new technologies in paleoichnology

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Keywords: Rioja, dinosaur footprint; photogrammetry; preservation of Information.

Introduction

In La Rioja (North of Spain) you can find one of the most important records of dinosaur footprints in the world with more than 150 sites described and 10,000 footprints studied. The studies carried out over 45 years have greatly contributed to our knowledge of the behaviour of dinosaurs and their paleogeographic conditions (Pérez-Lorente, 2015). The richness of this Natural Heritage has a double value: scientific and educational. These sites are the perfect framework for the scientific study of the evolution of dinosaur faunas and the understanding of the changes in diversity and the environment that occurred. On the other hand, they constitute a perfect tool for the development of the curricula of Natural Sciences in Primary Education and Biology and Geology in High School Education and an outreach tool that allow us to reach the general public and introduce concepts such as biodiversity, evolution and climate change.

Paleontology, as has happened with other nearby sciences such as archeology, is experiencing great advances thanks to the updating of its techniques. The use of these new technologies for the collection and processing of data has opened new research horizons full of possibilities; many of them still to be explored (García Ortiz *et al.*, 2018, Valle-Melon *et al.*, 2019).

Objectives

One of the objectives that arise in the research project of the Chair of Paleontology of the University of La Rioja is the development of a digital catalog of the dinosaur footprint sites of La Rioja for the preservation of this heritage and its subsequent use in research, education and outreach.

The on-site evaluation of its current state of conservation has allowed the establishment of prioritization criteria for the selection of those paleoichnological sites that will be first incorporated into the digital archive.

These prioritization criteria have been:

- Significance and singularity
- Accessibility
- Risk of erosion
- Size
- Footprint density
- Infrastructures
- Economic impact

Methodology

The Heritage Geometric Documentation Laboratory (LDGP) of the University of the Basque Country (UPV / EHU) collaborates with the Chair of Paleontology of the University of La Rioja in the development, optimization and dissemination of methodologies for geometric documentation of paleontological sites.

In the selected sites that have already been scanned, such as La Virgen del Campo (Enciso), Las Navillas (Rincon de Olivedo), Peñaportillo (Munilla) or La Era del Peladillo (Igea), a series of steps have been followed that will allow us to establish a protocol for the digital preservation and dissemination of information about paleontological sites using photogrammetry (Valle-Melon *et al.*, 2019).

These steps include:

- Precise geolocation using GNSS (Global Positioning Satellite System) techniques, of the whole site and its surroundings
- Mark points in the site
- Topographic survey and establishment of coordinates of the marked points in the site
- Photographic record for the photogrammetric generation of three-dimensional models

Results and Conclusions

The information obtained from the geometric documentation process has allowed us to generate a series of products, such as 3D models, orthophotos, perfectly geolocated maps, which will be key to the research projects that the Chair of Paleontology is leading in footprint biomechanics, accurate taking of measures for ichnotaxonomy and development of damage maps for the conservation and preservation of the deposits.

Also, it will allow us to develop educational and outreach products that are able to become important tools for the economic development of the region in the rural areas where these sites are located.

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COMUNICACIONES

Uranium, thorium and lead study on dinosaurs by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) and its applications in the field of restoration and paleontological conservation

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Key words: ICP-MS, paleontological restoration, Upper Jurassic, Cretaceous, preventive conservation, dinosaurs.

Introduction and methodology

Technological advances, just as cost reduction in different analytical methods, have allowed the use in recent years of new methodologies of analysis and study. This is the case of the inductively coupled mass spectrometry (ICP-MS) technique, whose use is particularly extended in disciplines such as biology, material science, environment, geochemistry, geology, archaeology and palaeontology among others, but not in the fields of restoration and conservation of paleontological material.

In this study, the ICP-MS technique has been used with its main aim being the identification of minority elements in fossil dinosaurs bones and applies such results in the field of conservation and paleontological restoration. For this purpose, these specific aims have been defined:

- Select, locate and study paleontological sites with dinosaurs' bones and classify them according to their scientific importance, age, geological formation and sedimentary basin.
- Identify the concentrations of uranium, thorium and lead in the fossils.
- Evaluate whether the concentrations are related to the lithology of the sites, their age, formation or basin.
- Lastly, determine the utility of this type of analysis and its possible uses in preventive conservation.

We have specially focused in the presence of uranium and thorium in fossil bones, because they are radioactive elements that can emit radiation and contaminant by-products that can negatively affect the people who manipulate them, and in the presence of lead, due to the fact that it is the final result of the disintegration of the two previously mentioned elements. Thus, we try to raise awareness among the staff that is

frequently in touch with fossil material, as it sometimes can present high levels of radioactive elements and/or lead, which can be harmful to health.

Due to this reason, 50 samples of fossil vertebrates, found in 31 different sites, belonging to different ages between Upper Jurassic and Upper Cretaceous have been analysed. These sites are geographically located in Valencia, Castellón, Lleida and Barcelona, in four different basins (Figure 1): the Íbero-levantina, the Maestrazgo, the Sinclinal del Tremp and the Sinclinal de Vallcebre.



Figure 1. - Geographical location of the Basins where the samples have been found.

Once the samples have been analysed at the Serveis Científicotècnics of the University of Barcelona, these are the results obtained (Fig. 2):

It can be observed that in the analysed samples the lead concentration varies between the sample with the least concentration that contains 1.47 ppm of this element, and the sample with the greatest concentration that has 542.39 ppm. The average concentration of this element in the 50 samples is 62.94 ppm. Similarly, uranium presents a sample with a minimum quantity of 0.10 ppm, and another one with a high amount, 1468.74 ppm, with an average of 285.71 ppm. Finally, thorium, which can be found in low concentrations, presents 0.02 ppm as minimum and just 8.01 ppm as maximum, with an insignificant average of 1.69 ppm.

Número	Muestra	Pb	U	Th
1	229P0	14,04	214,27	-
2	Baldovar C58	68,10	653,58	-
3	Cerro Tadón	114,01	327,50	0,69
4	Corral de Marin	67,04	105,61	2,86
5	El Collado 1	59,65	185,08	5,09
6	HTC-1-2004 Corral de los Álamos	14,72	690,73	0,53
7	HTC-2-2004	26,62	30,49	-
8	HTC-3-2004	336,36	751,18	1,62
9	La Cañada Aras	59,66	1469,74	-
10	Molino Quemado	21,60	536,79	3,34
11	PSM-Andrés	6,18	180,78	-
12	PSM-Carles	357,48	1342,54	-
13	PSM-Maite	19,07	309,47	0,48
14	PSM-Mila	30,50	561,53	-
15	Rascaña	38,09	227,83	1,32
16	David P07	30,91	340,15	-
17	CH1C	1,72	31,84	0,36
18	CH2M	4,17	16,42	0,28
19	CL1C	1,48	0,10	1,27
20	3ANA58-MED	3,78	6,44	0,13
21	4ANA12-MED	77,48	37,55	0,34
22	4ANA43-COR	23,69	70,01	0,28
23	4ANA43-MED	22,58	95,00	2,28
24	4ANA65-MED	23,71	58,63	1,16
25	4ANA75-COR	28,50	80,52	0,15

Número	Muestra	Pb	U	Th
26	ANAHUCOR05	27,88	4,66	0,09
27	Comptidores 1	30,87	31,71	0,73
28	Costella 1 SAV08	40,15	53,42	7,06
29	Costella 2 SAV08	44,07	53,98	3,51
30	EAP-40-39 (2)	147	24,53	0,02
31	HYP5IMD	94,62	116,86	8,01
32	Mas Roig	25,16	272,57	7,06
33	Povet	19,08	317,04	4,97
34	SAV05BE1-HU	3,71	3,12	0,13
35	SAV05C3-HU	7,08	2,83	0,21
36	SAV67-HU	7,42	3,78	0,80
37	Barranc de la Boiga	542,89	679,24	5,06
38	BP-07-HU	30,49	222,31	0,45
39	BP-PK-1595-2008	70,15	610,21	0,67
40	BPOS-1	27,50	303,35	0,21
41	BPOS-2	65,47	321,50	-
42	BPOS-3	26,40	388,42	0,29
43	Els Nerets	151,74	392,34	0,15
44	La Llau de Bas	53,54	797,37	0,35
45	Lo Bas	308,62	994,22	1,08
46	PB-ISONA	50,61	318,13	-
47	PG-73	11,86	3,68	2,68
48	PG-M-OS	18,33	15,80	0,18
49	PG-M-OS-COR	20,32	16,31	1,03
50	PG-M-OS-MED	17,11	15,47	0,04

Figure 2. Results of the analyzed samples. Red signals maximum values and green minimum ones.

Moreover, with the purpose of finding a correlation among the analysed elements, a normal distribution statistic model was used. With this model, pairs of elements were analysed, and the linear correlation index was calculated. Once the linear regression analysis was completed, it showed that there is only one possible, positive correlation between uranium and lead levels. In other words, the more lead levels increase the more the uranium levels do, and vice versa.

Discussion and conclusions

The three elements analysed are part of the natural uranium decay chain that starts with uranium-238 and ends with lead-206, which is already stable. Three radioisotopes make up natural uranium: ^{238}U , ^{235}U and ^{234}U . As it can be seen in the table (Fig. 2), some of the uranium concentrations obtained are significantly high. In fact, if we consider that the average value in the floor is about 3 ppm and about 0,1 ppm in living beings' bones, very few of them present near values and most of them present values over 100 ppm or even 500 ppm. In terms of lead concentration in the samples, few are higher than 100 ppm and only a sample exceeds 500 ppm. On the other hand, the thorium concentrations obtained are significatively low, not exceeding in any sample 10 ppm, with an average value in the floor of 6 ppm.

It is important to highlight that 11 out of 31 sites analysed present high uranium concentrations and, as we can see image number three, there is a direct link between the rock formation to which (Formation-Tremp or Formation-Villar del Arzobispo) belong,

the basins (Sinclinal del Tremp or Íbero-levantina), and, lastly, their age (Maastrichtian or middle Tithonian-basal Berriasian).

Muestra	Litología	Localidad	Formación	Cuenca	Edad
Barranc de la Boiga	Margas	Conques (LI)	Tremp	Sinclinal de Tremp	Maastrichtiense (Cretácico Superior)
PSM-Carles	Brechas poligénicas	Puebla de San Miguel (V)	Villar del Arzobispo	Íbero-levantina	Titónico medio - Berriasiense basal (Jurásico Superior - Cretácico Inferior)
HTC-3-2004	-	Alpuente (V)	Villar del Arzobispo	Íbero-levantina	Titónico medio - Berriasiense basal (Jurásico Superior - Cretácico Inferior)
Lo Bas	Areniscas	Abella de la Conca (LI)	Tremp	Sinclinal de Tremp	Maastrichtiense (Cretácico Superior)
Els Nerets	Lutitas y areniscas	Vilamitjana (LI)	Tremp	Sinclinal de Tremp	Maastrichtiense (Cretácico Superior)
Cerro Tadón	Areniscas	Alpuente (V)	Villar del Arzobispo	Íbero-levantina	Titónico medio - Berriasiense basal (Jurásico Superior - Cretácico Inferior)
BP-PK-1595-2008	Margas	Basturs (LI)	Tremp	Sinclinal de Tremp	Maastrichtiense (Cretácico Superior)
Baldovar C58	Areniscas	Alpuente (V)	Villar del Arzobispo	Íbero-levantina	Titónico medio - Berriasiense basal (Jurásico Superior - Cretácico Inferior)
BPOS-2	Margas	Basturs (LI)	Tremp	Sinclinal de Tremp	Maastrichtiense (Cretácico Superior)
La Cañada-Aras	Areniscas micáceas	Aras de los Olmos (V)	Villar del Arzobispo	Íbero-levantina	Titónico medio - Berriasiense basal (Jurásico Superior - Cretácico Inferior)
La Llau de Bas	Arcillas	Abella de la Conca (LI)	Tremp	Sinclinal de Tremp	Maastrichtiense (Cretácico Superior)

Figure 3. Characteristics of the samples with high uranium values.

Furthermore, sometimes it is necessary to restore and store fossils that have significant uranium, thorium and lead levels, so it is essential to analyse the samples that can contain these elements, as they can be a health hazard. The dangers of the exposure to the analysed elements are radiation emitted by uranium and/or thorium or radon gas inhalation as a result of their decay. It is advisable to avoid the inhalation of particles with high concentrations of uranium, thorium and lead, as they can accumulate in our organism, they are harmful and difficult to remove by our bodies.

Definitely, ICP-MS technique has been an effective method to identify minority elements and making the analysis of 50 samples quick and reliable. These results let us confirm that thorium concentrations are not significant, while those of uranium and thorium are, proving the existence of a positive relationship among the concentrations and, as well, among these concentrations and their basins, Sinclinal del Tremp or Íbero-levantina.

Finally, it is important to establish corrective and/or special preventive measures when working and storing fossil materials with concentrations of uranium and/or thorium higher than 100 ppm and high concentrations of lead. Installing a periodic monitoring programme that will allow us to control and locate possible changes in the work environment or storage area is essential, in order to reduce the periods of exposure to

those materials and activate a security protocol which informs workers about the risks and the protection measures they should take.

For restoration works, specific equipment should be employed, giving preference to collective protection rather than individual protection. Moreover, in relation to storage areas and exposure, storage areas should be correctly chosen, install ventilation systems and appropriate equipment, have specific signposting and have standardised labelling.

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Niche partitioning in allodaposuchid crocodyliforms (Eusuchia, Crocodylia) during the Maastrichtian (Late Cretaceous) of the northeastern Iberian Peninsula

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Keywords: Palaeoecology, Allodaposuchidae, trophic specialization, Tremp Formation.

Allodaposuchids are probably the most emblematic eusuchians from the late Campanian and Maastrichtian of Europe due to its broad distribution along the archipelago during the end of the Cretaceous (Csiki-Sava *et al.*, 2015; Puértolas-Pascual *et al.*, 2016). Up to now, at least 8 species compose the clade: *Allodaposuchus precedens* from Vălioara and Oarda de Jos (Romania); *Arenysuchus gascabadiolorum* and *Allodaposuchus subjuniperus*, from Arén and Serraduy (Huesca, northeastern Spain); *Allodaposuchus palustris*, from the Fumanya Sud site (Barcelona, northeastern Spain); *Allodaposuchus hulki*, from Casa Fabà site (Lleida, northeastern Spain); *Lohuecosuchus megadontos* and *Agaresuchus fontisensis* from Lo Hueco (Cuenca, central Spain), and *Lohuecosuchus mechinorum* from Fox-Amphoux (southern France). Most of these species coexisted in the southern Pyrenean basin during the early and late Maastrichtian (*Arenysuchus*, *A. subjuniperus*, *A. palustris* and *A. hulki*), and it is intriguing how such diversity of supposed generalist predators could cohabit in the same geographical area during a small time-span.

On the other hand, the vertebrate microfossil composition was recently studied in 14 different localities of the southern Pyrenean area, encompassing the complete stratigraphic Maastrichtian series. They cover from coastal and marginal marine to fully

continental palaeoenvironments (Blanco *et al.*, 2016, 2017, 2018). Isolated crocodylomorph teeth are, by far, one of the most frequently recovered elements from the microfossil samples. The study of these samples (Blanco *et al.*, 2018) identified 16 different tooth morphotypes that might represent, at least, 10 different taxa, including several allodaposuchids: *Allodaposuchus palustris*, one generalist morphotype that might correspond to *Allodaposuchus subjuniperus*, *A. hulki*, *Arenysuchus*, or a mixture of them, and another different cf. *Allodaposuchus* sp. In addition, 6 new mandibular remains recovered from the sampled sites support the taxonomical interpretations.

Based on untransported teeth, the abundances of each taxa differ significantly among sites with different depositional settings. In this regard, the indeterminate allodaposuchid that might correspond to *A. hulki*, *A. subjuniperus* and/or *Arenysuchus* is more abundantly found in freshwater and terrestrial settings (84,62% of the well-preserved teeth were recovered in fully continental deposits); whereas the cf. *Allodaposuchus* sp. has a high presence in coastal environments (80.0% of its well-preserved teeth were recovered in marine-influenced localities), as well as all the well-preserved remains referred to *A. palustris*. The occurrence of the macrofossil record supports these observations: the mandibular remains referred to the cf. *Allodaposuchus* sp. and to *A. palustris*, as well as the holotype of this taxon, come from brackish aquatic palaeoenvironments together with abundant batoid remains (Blanco *et al.*, 2017; Blanco, 2019); whereas the mandibular remains with generalist tooth morphotypes were found in continental palaeoenvironments, as well as the holotypes of *A. hulki*, *A. subjuniperus* and *Arenysuchus*.

In addition, allodaposuchids show different conditions for some specific morphological characters, which can drive further ecomorphological distinctions: the development of the supratemporal fenestrae, the degree of heterodonty, the festooning of the jaw and the length of the mandibular symphysis are morphofunctional features correlated with trophic specialization (Iijima, 2017). An increased size-related heterodonty and presence of festooned jaws are advantageous for holding large prey firmly, whereas linear jaws with near-homodont dentition are retained in piscivorous forms. At the same time, a shorter symphyseal length incur lower strains than large ones under equivalent loads during biting; but larger symphyses might allow a greater acceleration for rapid jaw closure against agile prey (Walmsley *et al.*, 2013). Accordingly, an increased area

of the supratemporal fenestrae is associated with the increased mass of adductor muscles, allowing a faster but weak jaw closure in piscivorous forms (Iijima, 2017).

Based on these evidences, we propose the hypothesis that allodaposuchids reduced their interspecific competence by means of niche partitioning. Hence, forms with linear outline of the jaw, low disparity in tooth size and absence of the shelf in the supratemporal fenestrae, such as *Allodaposuchus palustris*, match the ecomorphological traits observed in fish-eating crocodylomorphs. On the other hand, allodaposuchids with festooned jaws, higher tooth size disparity and shorter mandibular symphysis, like the cf. *Allodaposuchus* sp. and the indeterminate allodaposuchid that might represent *A. hulki*, *A. subjuniperus* and/or *Arenysuchus* display ecomorphological characters advantageous for catching prey that put up higher resistance. Therefore, the southern Pyrenean allodaposuchid assemblage might have included generalist predators in freshwater (*Arenysuchus*, *Allodaposuchus subjuniperus*), terrestrial (*A. hulki*) and coastal environments (cf. *Allodaposuchus* sp.), as well as piscivorous taxa (*Allodaposuchus palustris*) in coastal and marginal marine habitats.

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Application of computerized tomography for the reconstruction of the partial skeleton of a turtle from the Upper Cretaceous of Slovenia

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Key words: Testudines, Microcomputed tomography, volumetric reconstruction

X-Rays Computerized Tomography (CT), and the techniques later developed to acquire a greater resolution as X-Rays Computerized Microtomography (MicroCT), represents a tool of great utility as complement to the traditional anatomical studies, as it allows the visualization and quantification of internal structures. Thus, although these techniques have been mainly used in fields related to medicine and industry, in recent years they have been applied in other disciplines, including paleontology, offering novel results as they allow the analysis of structures and surfaces hidden by sediment or corresponding to the internal structure of fossil remains.

Here is an example of the application of these techniques as a complement to the traditional systematic studies, generally applied to the field of vertebrate paleontology. The processed specimen corresponds to a partial skeleton of a sea turtle, coming from the Upper Cretaceous (Santonian-Campanian) of Dobravlje, in Slovenia. The bone remains of the specimen are partially included in a limestone matrix. In order to carry out its three-dimensional reconstruction and facilitate its subsequent study, it was scanned with the Nikon XTH225 ST Micro CT scanner located at the University of Bristol, obtaining 3,141 projections and a final pixel size of 0.066 mm. The tomograms obtained were processed using the AVIZO LITE 9 software for the individual segmentation of each of the bones and their three-dimensional extraction from the matrix without damaging the specimen. To soften the imperfections generated during

the segmentation process with Avizo Lite 9 (such as cracks, roughness or irregularities), Geomagic Studio 2012 was used. Subsequently, the models obtained were reloaded into the Avizo Lite 9 program to compose them again with the set of segmented bones. Finally, the final images were obtained through captures from all angles and combinations of interest for the present study. Finally, these images were sorted and prepared with the Photoshop C6 raster graphics editor.

The application of these techniques in the study of fossil turtles is very novel nowadays. The model obtained will facilitate the subsequent precise systematic study of this specimen.

Unrelated ornithopods with similar tooth morphology in the vicinity of Salas de los Infantes (Burgos Province, Spain): an intriguing case-study

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Keywords: Ornithopod, “Hypsilophodontidae”, Rhabdodontidae, tooth morphometry, Multivariate Analysis of Variance.

The Salas de los Infantes locality (Burgos Province, Spain) has yielded a rich assemblage of ornithopods, although many fossils are still under study. Notable amongst these are the ornithopod-bearing sites of El Peñascal and Vegagete, which lie in close vicinity (about 650 m from each other) within the Castrillo de la Reina Formation. Torcida Fernández-Baldor *et al.* (2005) described the ornithopod teeth from the El Peñascal site, and observed that they are similar to those of “hypsilophodontids” (a waste-basket family that now solely contains *Hypsilophodon foxii*; see Boyd, 2015) and “rhabdomorphs” (a polyphyletic clade that was informally used to group together *Tenontosaurus*, *Muttaburrasaurus* and rhabdodontids; see Ruiz-Omeñaca, 2001). The Vegagete ornithopod has been described as belonging to *Hypsilophodon* cf. *foxii* (Fuentes Vidarte & Meijide Calvo, 2001), then referred to Ornithopoda indet. (Izquierdo *et al.*, 2005), and finally diagnosed as an early rhabdodontid (Dieudonné *et al.*, 2016). The latter authors also noticed a strong morphological similarity between the teeth of the Vegagete and El Peñascal sites, possibly indicating some phylogenetic affinity between both taxa. In both sites, the maxillary teeth are actually spade-like and show a varying number of apicobasally extending secondary ridges onto the labial surface (Fig. 1A, C), and the dentary teeth feature a prominent lingual primary ridge (Fig. 1B, D). In spite of such morphological similarity, a rapid examination of cranial and postcranial remains of the El Peñascal ornithopod shows that it clearly differs from that of Vegagete. In fact, the former would more closely resemble to some kind of undetermined “hypsilophodontid” (unpublished data). The aim of the present work is to assess whether the teeth from both sites could be distinguished or not based on a quantitative morphometric analysis.

Our morphometric analysis was performed with R (R Core Team, 2016) on the basis of three morphological variables measured on 25 completely preserved tooth crowns from Vegagete (6 maxillary and 8 dentary teeth) and El Peñascal (4 maxillary and 7 dentary). Three raw variables correspond to the height, mesiodistal length and labiolingual width. In order to remove the size-effect, we transformed these variables as ratios of: (1) crown height to mesiodistal length (mesiodistal slenderness index: “MDSI”); (2) crown height to labiolingual width (labiolingual slenderness index: “LLSI”); and (3) mesiodistal length to labiolingual width (mesiodistal sharpness index: “MDSHI”). All of these variables were found as normally distributed and with a homogeneous variance ($p > 0.05$, see Table 1). An Analysis of Variance (AnOVA) showed a significant statistical difference between both ornithopod taxa for the parameter MDSHI ($F = 5.103$, $p = 0.0337$), but not for MDSI ($F = 1.845$, $p = 0.188$) and LLSI ($F = 0.001$, $p = 0.974$). In addition, we wanted to test the morphological similarity by considering all three dependent variables at the same time. However, performing a Multivariate Analysis of Variance (MAnOVA) requires multivariate normal distribution of the whole data (R package “mvn”, Korkmaz *et al.*, 2014). Multivariate normal distribution was only achieved for one multivariate normality test out of four (Royston’s test is positive with $p = 0.18$; and Mardia’s, Henze-Zirkler’s, Doornik-Hansen’s are negative with $p < 0.05$). We therefore performed a nonparametric MAnOVA (R package “npmv”, Ellis *et al.*s 2017). The AnOVA-type test showed non-significant p-values ($T_A = 0.415$, $p = 0.109$ and $p = 0.098$ with 1000 permutations). As a consequence, the null hypothesis that the teeth from the El Peñascal and Vegagete sites are morphologically similar and proceed from a single homogeneous distribution cannot be rejected. However, the relative effects of each variable show that MDSHI is significantly higher in the Vegagete ornithopod (Table 2).

We conclude that both visual and morphometric differentiation between the Vegagete and El Peñascal teeth is difficult. In the Santonian of Hungary, the teeth of the neoceratopsian *Ajkaceratops kozmai* and the rhabdodontid *Mochlodon vorosi* are much similar morphologically (Virág & Ösi, 2017). Tooth morphology intimately relates to long-term feeding habits, so two species living within the same ecosystem and featuring similar tooth morphology might indicate stronger ecological interactions between them (see Ricklef & Miles, 1994). Yet, an increase in sample size would be welcome in order to increase the power of the analysis, and the implementation of more parameters such

as mesowear or microwear might possibly allow to more fully distinguish between the teeth from El Peñascal and Vegagete. It is worth noting that the teeth of Late Cretaceous rhabdodontids usually appear more blade-like in morphology (e.g. the teeth of *Matheronodon provincialis*; Godefroit *et al.*, 2017). Therefore, the finding of a significantly higher sharpness index for the teeth of the Vegagete ornithopod (see the relative effects of MDSHI in Table 2) might be seen as coherent with its attribution to an early shoot of the European-endemic Rhabdodontidae.

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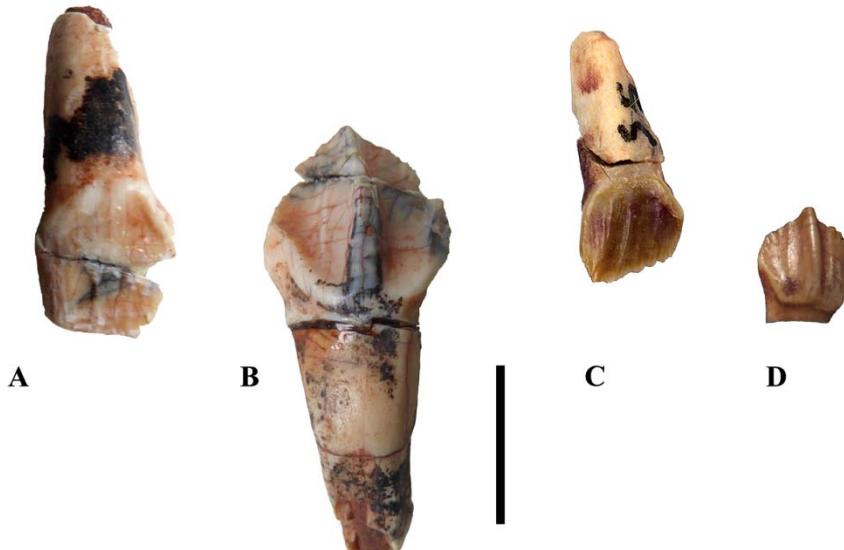


Figure 1. Maxillary and dentary ornithopod teeth recovered from the El Peñascal (A, B) and Vegagete (C, D) sites (Burgos). (A) and (C) correspond to right maxillary teeth in labial view, and (B) and (D) correspond to left dentary teeth in lingual view. Scale is 5 mm.

Table 1. Tooth shape variables and their respective mean, standard deviation (SD) and p-values of the Shapiro-Wilks's normality test (H_0 = normal distribution), given separately for the Vegagete (V), El Peñascal (EP), and for both (V+EP) localities. The p-value of the Levene's test is given for both the Vegagete and El Peñascal samples as it compares their respective variances (H_0 = homoscedastic distribution).

Variable \ Statistics	Mean (mm.)	SD (mm.)	Shapiro Wilks (p)	Levene (p)
MDSI (V)	1.006	0.214	0.237	NA
LLSI (V)	1.816	0.246	0.824	NA
MDSHI (V)	1.844	0.249	0.484	NA
MDSI (EP)	1.111	0.155	0.315	NA
LLSI (EP)	1.813	0.197	0.798	NA
MDSHI (EP)	1.646	0.166	0.275	NA
MDSI (V+EP)	1.052	0.194	0.236	0.203
LLSI (V+EP)	1.814	0.221	0.660	0.450
MDSHI (V+EP)	1.757	0.234	0.075	0.245

Table 2. Empirical nonparametric relative effects of treatment group (i.e. the tooth-bearing ornithopod sites of El Peñascal and Vegagete) for each tooth morphometric variable. The effects give the probability that one randomly selected measure for a given site is higher than all other measures of the same variable, whichever the site.

Site \ Variable	MDSI	LLSI	MDSHI
El Peñascal	0.66559	0.47078	0.24675
Vegagete	0.33441	0.52922	0.75325

Uso de un modelo fotogramétrico para la realización de mapas de daños e intervención en la conservación y restauración paleoicnológica

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Keywords: Huellas de Dinosaurio, Fotogrametría, Conservación, Restauración.

El patrimonio paleoicnológico de La Rioja (España) contiene una gran diversidad y riqueza. Los yacimientos datan del Cretácico Inferior, con edades comprendidas entre los 145 y los 113 millones de años (Pérez-Lorente, 2015). Destacan las icnitas de dinosaurio, siendo una de las regiones con un mayor número de huellas de Europa, conteniendo unas diez mil huellas descubiertas, aunque la estimación llega a las veinticinco mil (Pérez-Lorente, 2015).

Actualmente, la documentación fotográfica es una herramienta de gran utilidad para el estudio paleontológico, concretamente de los rastros, aportando diferentes niveles de documentación gráfica del yacimiento, desde la fotografía convencional hasta la realización de fotogrametrías y modelos 3D.

El proceso de documentación mediante fotogrametría se engloba dentro de la conservación preventiva, salvaguardando el patrimonio y la información que contiene. La realización de dichos modelos es polivalente, por un lado, es útil para la investigación paleontológica, y por otro lado, tiene un gran valor para la conservación y restauración (Díaz-Martínez *et al.*, 2018). A continuación, se explica cómo se realizó la propuesta de intervención de un rastro de huellas perteneciente al conjunto del yacimiento de La Virgen del Campo, Enciso (La Rioja) descrito en Pérez-Lorente, 2015, empleando el modelo 3D obtenido mediante fotogrametría.

La realización del estudio de conservación *in situ*, determina cuáles son los daños de la huella, desarrollándose de forma paralela al conjunto fotográfico que dará lugar al modelo fotogramétrico (Valle-Melón, 1993).

La toma de imágenes se realizó con la luz incidiendo de forma difusa y perpendicular al rastro, empleando la cámara réflex Canon EOS 1200D y el objetivo EFS 18-55mm de Canon. Se tomaron más de 150 fotografías que posteriormente fueron tratadas mediante el software Agisoft PhotoScan. La malla 3D resultante se trabaja con el software Sculptris® (Niquet y Barberà, 2018) y con la tableta gráfica Kamvas Pro20 de Huion®. Después de ajustar el modelo 3D, se realiza en primer lugar, un mapa de daños cambiado el color y/o textura de aquellas zonas con patologías con el software antes indicado. Tras realizar el mapeo, se añade una leyenda para poder facilitar la lectura del croquis.

Una vez realizado el mapa de daños y la propuesta de intervención, se puede emplear este mismo modelo para la realización del croquis del proceso (Lamolda y Cano, 2010), añadiendo la correspondiente leyenda. De este modo, se pueden observar paralelamente las zonas afectadas y el método de restauración a emplear en cada parte. Si es necesario se pueden realizar los mapas de las intervenciones por fases, separándose la limpieza, consolidación y reintegración. Documentar fotográficamente tras la intervención, del mismo modo que al inicio, ayuda al desarrollo de un tercer y último mapa. En este mapa se indica, qué zonas han sido intervenidas y de qué modo.

Cabe destacar que el material con el que se trabaja es material tridimensional, por lo tanto, es útil poder realizar el mapa de daños e intervención sobre una superficie 3D. De este modo, la pérdida de información se minimiza en relación con los mapas 2D realizados en distintas vistas. Además, ofrece las mismas posibilidades que los mapas 2D de comparación entre los diferentes mapas.

Por otro lado, la realización de los mapas de intervención mediante fotogrametría no sólo permite ver dónde y cómo intervenir, también proporciona información sobre la pérdida o reintegración volumétrica del material durante el proceso. La realización de estos mapas requiere algo más de tiempo que los croquis de daños convencionales, pero aporta significativamente más información, tanto de forma previa como posterior.

Por lo tanto, la realización de modelos 3D para la investigación paleontológica, puede ser empleada para la conservación y restauración del mismo material, optimizado de este modo los recursos empleados. La documentación, de forma previa, proporciona

información sobre el estado de conservación, apoyando al estudio sobre los agentes de degradación y las patologías identificadas *in situ*. Posteriormente al proceso de intervención, es de gran utilidad para observar el trabajo realizado, y el volumen de material perdido o reintegrado.

La modelización 3D tiene diversos usos dentro de la investigación y la conservación del patrimonio paleontológico. El mismo recurso puede emplearse para el estudio de la paleoiconología, para la conservación, tanto preventiva como documental, y para la restauración del patrimonio. Por lo tanto, se optimiza un mismo recurso empleándose en distintas disciplinas.

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Updating the knowledge on the Mesozoic vertebrate faunas from the Galve syncline (Teruel province, Spain)

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Keywords: Vertebrata, Dinosauria, Biodiversity, Upper Jurassic, Lower Cretaceous, Spain.

Introduction

Among the hotspots in the field of Spanish Palaeontology, Galve stands out as the place of provenance of *Aragosaurus ischiaticus*, the first dinosaur species erected in Spain. The Galve area has become a reference site for the study of Mesozoic vertebrates. Now it is 15 years since the last thorough review of the vertebrate fossil record from the Galve outcrops (Ruiz-Omeñaca *et al.*, 2004), and during this time spam many significant advances concerning the chronostratigraphic framework or the number of described dinosaur and other vertebrates have been produced. We present here an update on the geological-palaeontological knowledge of the vertebrate fossil faunas of Galve synthesizing the most relevant contributions in the last 15 years.

Stratigraphic framework

Around the village of Galve (Central Iberian Range, Teruel province, Spain), a set of Mesozoic (Upper Jurassic-Lower Cretaceous) fossiliferous deposits crop out in the so-called Galve syncline. Palaeogeographically, the Upper Jurassic-Lower Cretaceous succession in Galve belongs to the Galve subbasin, in the western part of the Maestrazgo Basin. Boundaries and chronology of the lithostratigraphic units in Galve have been the subject of an intense scientific discussion (e.g., Royo-Torres *et al.*, 2009; Canudo *et al.*, 2012; Royo-Torres *et al.*, 2014; Aurell *et al.*, 2016, 2019), and as a result our knowledge of the stratigraphic framework has been significantly improved.

The Upper Jurassic-Lower Cretaceous succession consists of a set of unconformity-bounded units. Overlaying the marine carbonate deposits of the Loriguilla and Higueruelas formations, there is a set of vertebrate-bearing lithostratigraphic units including from bottom to the top: 1) the latest Kimmeridgian–mid-early Tithonian Cedrillas Fm, a mixed carbonate-siliciclastic unit representing sedimentation in carbonate lagoons and wave-dominated deltaic systems; 2) the Tithonian-early Berriasian Aguilar del Alfambra Fm, a mixed carbonate-siliciclastic unit formed in a wave-dominated open-coast tidal flat; 3) the alluvial siliciclastic, Berriasian-Valanginian? Galve Fm; 4) the early Barremian El Castellar Fm, characterized by palustrine-shallow lacustrine marls and limestones; 5) the Barremian Camarillas Fm, a siliciclastic fluvial to coastal unit; and 6) the late Barremian Artoles Fm, formed by transitional-shallow marine marls and limestones.

Vertebrate record

Both new discoveries and the revision of classic specimens have resulted in increasing the list of fossil vertebrate taxa described in Galve. The known list is made up of the chondrichthyan *Lonchidion microselachos*, the lissamphian *Galverpeton ibericum*, the sauropod dinosaur *Aragosaurus ischiaticus* and the mammals *Galveodon nanothus*, *Lavocatia alfambrensis*, *Eobaatar hispanicus*, *Parendotherium herreroi*, *Aliaga* (=*Spalacotherium*) *henkeli* and *Pocamus pepelui*, and the latest described: the ornithopod dinosaurs *Gideonmantellia amosanjuanae*, “*Delapparentia turolensis*” and *Iguanodon galvensis*, the sauropod *Galvesaurus herreroi*, the testudine *Galvechelone lopezmartinezae* and the mammal *Crusafontia amoae* (Barco *et al.*, 2005; Cuenca-Bescós *et al.*, 2011; Ruiz-Omeñaca, 2011; Pérez-García and Murelaga, 2012; Ruiz-Omeñaca *et al.*, 2012; Verdú *et al.*, 2015).

Dinosaurs are still the better studied clade. Apart from the new species erected, there are many recent contributions reporting new taxon occurrences or re-describing already known taxa (e.g., Sánchez-Hernández *et al.*, 2007; Royo-Torres *et al.*, 2014; Gasca *et al.*, 2015). Other vertebrate groups have been subject of recent developments as chelonians and mammals, reporting a noticeable diversity (Badiola *et al.*, 2011; Pérez-García *et al.*, 2013). The eggshell record has been also deeply analysed. The ootaxa *Macroolithus turolensis* has been re-described as *Guegoolithus turolensis* and its ornithopod affinities (i.e. Spheroolithidae oofamily) has been proposed for the first time (Moreno-Azanza *et al.*, 2014). Also, other ootaxa were described in fossil localities

from the El Castellar and Camarillas formations (e.g., Moreno-Azanza *et al.*, 2015). In the field of the dinosaur track record, new ichnites have been discovered (e.g., Herrero Gascón & Pérez-Lorente, 2017) and also the most remarkable ichnosite, Las Cerradicas (upper Cedrillas Fm), has been restudied (e.g., Castanera *et al.*, 2013).

Discussion and conclusion

During the last years, the Mesozoic outcrops of the Galve syncline have yielded new data for the contribution of knowledge of the paleontology and geology of the Late Jurassic-Early Cretaceous in Europe as indicate the new discoveries published in dozens of scientific papers and several doctoral theses conducted. As mentioned above, new abundant discoveries concerning the vertebrate record (including osteology, oology and ichnology) have been reported. However, one of the most decisive improvements on the knowledge of Galve fossil record has been the updating of their chronostratigraphic framework, including the redefinition of lithostratigraphic units and the refinement of its ages (see Aurell *et al.*, 2019). Also new sedimentological studies (Bádenas *et al.*, 2018) as well as the analysis of other evidences (Villanueva-Amadoz *et al.*, 2015; Delvene *et al.*, 2018) and neighbouring outcrops (e.g., Navarrete *et al.*, 2014) resulted in an improvement of knowledge on the palaeoenvironments inhabited by the faunas from Galve. In conclusion, new discoveries and research carried during the last 15 years by different research teams have resulted in a much better understanding of the vertebrate fossil faunas from Galve, and the world they inhabited.

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Analysis of the morphological variability of the Lower Cretaceous pleurosternid turtle *Pleurosternon bullockii*

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Keywords: Testudines, Paracryptodira, Mesozoic, United Kingdom, morphometry.

Turtles are a very diverse group of reptiles, which shows a high degree of intraspecific morphological variability. Studies on this variability, and, therefore, those based on the comparisons between different species considering the variability of each of them, are still very scarce for the extinct species, since they are generally represented by a very limited number of specimens. Such studies are even more complex when morphometric characterizations try to be performed, due to this require a considerable amount of well-preserved individuals. In most cases, a relatively high number of well-preserved specimens is not available, especially for the Mesozoic taxa.

Pleurosternidae is a relatively diverse clade of North American and European Mesozoic turtles, known from the Late Jurassic to the end of the Early Cretaceous (Pérez-García *et al.*, 2015). Phylogenetic relationships among some members of this clade still arises controversy, due to the lack of information on several representatives. Furthermore, a relatively great range of intraspecific variability has been identified in this family. This caused problems in the interpretation of several characters, and the characterization of some taxa, as is the case of the type species of this clade. It is the European turtle *Pleurosternon bullockii*, especially represented in the British record, by abundant specimens from the Berriasian (Lower Cretaceous) levels of the Purbeck Limestone Group, found in several localities. In fact, a valid diagnosis for this species considering the current knowledge about this clade is not available, and numerous erroneous interpretations of the anatomy of its shell continue to be present in the literature. Thus, some of the encodings of this form in the matrices of morphological data are affected by these issues.

Knowledge about the European pleurosternids has been remarkably improved during the last years, especially by the description of new forms (e.g. *Selenemys lusitanica*, *Riodevemys inumbragigas*, *Toremys cassiopeia*), but also by the detailed study of

poorly-known taxa (e.g. *Dorsetochelys typocardium*) (Pérez-García & Ortega, 2011; Pérez-García *et al.*, 2014, Pérez-García *et al.*, 2015; Pérez-García, 2014). Considering this remarkable increase in the knowledge of this clade, the so far unpublished detailed revision of the type species (i.e. *Pleurosternon bullockii*), started several years ago (Pérez-García & Ortega, 2011), could be of great interest. Thus, the main results of this study are presented here.

To achieve with the proposed objective, more than fifty well-preserved shells and partial shells of *Pleurosternon bullockii*, from United Kingdom, have been analysed. This collection includes the specimens previously cited in the literature, many of them of high historical value (Owen, 1842; Lydekker & Boulenger, 1887; Milner, 2004), as well as other unpublished or poorly known. The qualitative and quantitative analysis of its morphological variability allow us to establish which characters are more variable, each of them being justified as caused by one or more specific factors (ontogeny, sexual dimorphism, individual variability and anomalies). Therefore, a better understanding of the intraspecific variability of the shell of this species and, for the first time, its detailed characterization, are provided.

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Isolated theropod teeth from the Early Cretaceous of Igea (La Rioja, Spain)

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Keywords: Lower Cretaceous, Cameros Basin, Enciso Group, Theropoda, Spinosauridae, Baryonychynae.

The sector of the Cameros Basin in La Rioja is the region of the Iberian Peninsula with the highest density of ichnrite sites, especially from the Lower Cretaceous (Pérez-Lorente, 2015). Instead, skeletal remains are much scarcer, being represented by fragmentary bones and isolated teeth (e.g. Viera & Torres, 2013, Navarro-Lorbés & Torices, 2018, Isasmendi *et al.*, in press). In this context, the purpose of this communication is to provide information on the study of isolated spinosaurid teeth found in four different sites from Igea.

Igea is situated on the southeast of La Rioja (Spain). The studied sites are La Era del Peladillo 6, Peña Cárcena, Barranco de la Cañada and Umbría de Costarrey. All the teeth have been found throughout the Enciso Group, which is dated as Barremian-Aptian (Doublet, 2004). This group was formed in a deltaic plain where two different environments are distinguished: a lacustrine environment at the base and a transition to a tidal plane towards the top (Aguirrezzabala *et al.*, 1985; Clemente, 2010).

The material studied consists of nine theropod teeth. Among them, two different morphotypes have been identified. Overall, the teeth are similar to those of the holotype of *Baryonyx walkeri* (Charig and Milner, 1997) since they show an elliptical or subcircular cross-section, fine and chisel-like denticles and a crown ornamentation based on flutes. Nonetheless, some differences can be found (Isasmendi *et al.*, in press). Indeed, the Igea teeth seem to bear a resemblance to those found in Burgos (Torcida

Fernández-Baldor *et al.*, 2003) and Teruel (Alonso & Canudo, 2016). This is supported by anatomical features and preliminary statistical analyses. Therefore, the teeth have been tentatively assigned to Baryonychinae indet.

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La Conservación Restauración de *Paludidraco multidentatus*. Un tratamiento de conservación encaminado a la exposición

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Introducción

Habitualmente los fósiles son objetos de estudio y, generalmente, las fases de extracción y preparación se enfocan en la correcta conservación y la accesibilidad del ejemplar para su estudio. No es frecuente que estos tratamientos incluyan desde el principio una estrategia para que los ejemplares sean expuestos ya sea en una exposición temporal o permanente de un museo.

En este trabajo se muestran los resultados obtenidos al realizar la preparación de un ejemplar relativamente completo de un sauropterigio Simosauridae con un valor científico, unas características estéticas y didácticas, y un estado de conservación que permiten considerarlo un ejemplo adecuado para la difusión de información sobre los organismos que habitaron las áreas costeras del Triásico de la península ibérica.

El ejemplar, MUPA ATZ0103, ha sido preliminarmente asignado a la especie *Paludidraco multidentatus*, un sauropterigio basal descrito en el yacimiento del Triásico Superior de El Atance, en las cercanías de la población de Sigüenza (Guadalajara, Castilla – La Mancha, España) (de Miguel Chaves *et al.*, 2018). Este yacimiento, descubierto en 2008, se encuentra situado en Facies Keuper, en un intervalo temporal Carniense-Noriense, y está compuesto por una sucesión de margas y arenas, depositadas en un ambiente marino de aguas poco profundas (de Miguel Chaves *et al.*, 2018).

La información proporcionada por el material encontrado en El Atance, que incluye abundantes restos craneales y poscraneales, permite identificar a *Paludidraco multidentatus* como un eosauropoterigio notosauroideo del clado Simosauridae (de Miguel Chaves *et al.*, 2018). Simosauridae se consideraba hasta hace poco tiempo un grupo monoespecífico compuesto únicamente por *Simosaurus gaillardotii*, un depredador de 3-4 metros de longitud cuyos restos provienen del Triásico Medio de Francia y

Alemania (Rieppel, 1994). *Paludidraco multidentatus* presenta varios caracteres que hasta ahora se consideraban autapomórficos de *Simosaurus gaillardotii*, siendo estos considerados hoy en día sinapomorfías del clado Simosauridae (de Miguel Chaves *et al.*, 2018). No obstante, a pesar de que ambos taxones comparten varios caracteres y son de tamaños similares, *Paludidraco multidentatus* presenta varias autapomorfías que sugieren un modo de vida y alimentación muy diferente al de *Simosaurus gaillardotii*, incluyendo un esqueleto axial muy paquiotóxico y un cráneo y mandíbulas muy frágiles, con un elevado número de dientes (de Miguel Chaves *et al.*, 2018). Así, se ha propuesto que *Paludidraco multidentatus* sería un organismo filtrador y un nadador lento con una maniobrabilidad reducida, que se desplazaría lentamente por el lecho marino en aguas poco profundas mientras filtraba el sustrato en busca de alimento.

El objetivo de este trabajo incluye describir y analizar el proceso y los tratamientos aplicados a un esqueleto articulado y complejo de un individuo de tamaño medio desde su extracción hasta su instalación en la exhibición permanente del Museo de Paleontología de Castilla-La Mancha en Cuenca. De forma particular, se pretenden mostrar los resultados obtenidos en la creación de un soporte fijo que, al mismo tiempo, es fácilmente eliminable.

Métodos

Para adecuar los tratamientos se ha realizado una revisión bibliográfica de Conservación y Restauración de materiales de gran formato y soportes de exposición para la difusión de bienes culturales (Fayos Bou, 2012)

Se han realizado pruebas de dureza y adhesión de distintos morteros para seleccionar el más adecuado para la fabricación del soporte, así como pruebas de color sobre estos mismos materiales para conseguir un resultado más estético de cara a su exposición.

Para elegir los morteros más adecuados para la fabricación del soporte se realizaron unas probetas de 10x10x2 cm y se comprueba su dureza con un durómetro. Debido a que los morteros fueron elaborados a mano son muy heterogéneos, por esto, las medidas se tomaron en distintos puntos de la superficie eligiendo las más lisas y tomó la dureza media de los morteros (ver tabla 1).

Proporción	1:0	1:1	1:2	1:3
PLM + Blanco Verona	97 - 100 Hc	97 - 99 Hc	94,5 – 99,5 Hc	93,5 – 98,5 Hc
Cal + Blanco de Verona	82,5 – 92 Hc	94,5 – 99 Hc	95 – 99,5 Hc	97,5 – 101 Hc

Tabla 1. Dureza de los morteros

Tratamiento

El ejemplar se encuentra articulado formando una estructura densa y difícil de desarticular, por lo que durante la fase de excavación se decidió su extracción en bloque sólido capaz de soportar el traslado para su intervención en laboratorio. Para ello, se estabilizó y reforzó mediante el pegado, la reintegración de las facturas y el engasado con un textil embebido en Paraloid B72. Posteriormente se procedió a generar una carcasa externa mediante un textil embebido en escayola, con la que se pudo realizar el arranque del ejemplar en una única estructura.

Una vez en el laboratorio de restauración, se abrió la mitad del bloque de escayola para proceder al ajuste del fósil por la parte inferior. Por las características de la matriz se decidió eliminarla para mejorar la conservación del ejemplar (Marcos *et al* 2018). Esta fue desbastada con el empleo de vibroincisores. Durante este proceso se reconoció la complejidad del ejemplar en su parte ventral y la necesidad de la eliminación de la matriz para realizar una adhesión de los huesos fragmentados. Para no poner en riesgo la integridad del ejemplar, la eliminación de la matriz más adherida al individuo se realizó una limpieza controlada para la que se usó la gelificación de una disolución de agua con un agente quelante (EDTA)

Durante este proceso también se realizaron trabajos de consolidación, adhesión de fragmentos empleando la resina acrílica Paraloid B-72 a una concentración entre 5-10%. Las grietas y fisuras fueron reintegradas con resina epoxídica Araldite© SV-427, que asegura una unión fuerte de los fragmentos, pero permite cierta movilidad.

Para su exposición en el Museo Paleontológico de Castilla-La Mancha, y dada la complejidad de sus elementos en conexión, fue necesario generar un soporte que asegurase la estabilidad del bloque a largo plazo, pero que además fuese reversible considerando las dos caras del individuo como objeto de estudio. Atendiendo a esto, se optó por fabricar un soporte similar al que se usa para estructuras arqueológicas de gran formato, como los mosaicos, aplicando un mortero inerte en el reverso que evitase la

desarticulación del ejemplar y creando un código de colores en las capas de mortero que permitiese identificar la distancia al fósil y facilitar su eliminación en el caso de que fuera necesario.

La ejecución del soporte se realizó en dos fases. Primero se eligió el tipo de mortero que respondía a las necesidades de cada una de las capas que se iban a colocar en el estratificado. El PLM© es un mortero de cal hidráulica mezclado comercialmente con sílice impalpable. Se colocó sobre el original porque es el que más adhesión presenta a las superficies con una dureza alta y sin necesidad de llevar árido, esta característica del PLM© es muy interesante ya que, en su aplicación, al llevar sílice impalpable no presenta riesgo de erosionar la superficie del fósil que presentan una delicada ornamentación. Sobre esta capa se colocó una capa fina de PLM + polvo de mármol (1:2) que alisa los relieves de la superficie y cubre los restos de arcillas que, por razones estructurales, no fueron completamente eliminados en la limpieza.

Para llenar todo el relieve de la parte ventral del individuo sin incrementar de forma excesiva el peso del soporte se seleccionó un mortero liviano generado mediante la adición de Arlita, una arcilla expandida de baja densidad. Todas las zonas vistas de mortero se llenaron con un mortero formado por Cal Aérea + polvo de mármol (1:3). Este mortero queda expuesto, por lo que fue pigmentado en ocre oscuro que resulta neutro en relación con el color natural del fósil. Para añadir rigidez al soporte, se adhirieron a la parte inferior planchas de Aerolam© y se utilizó poliestireno extruido como capa de intervención. Las planchas de Aerolam© se adhirieron con resina epoxídica cargada con polvo de mármol.

Finalmente, tras el volteo del bloque se aplicó sobre el soporte una capa de resina epoxídica + carga de polvo de mármol en el perímetro del soporte, cubriendo las planchas de poliestireno y de Aerolam©. Sobre la resina curada se aplicó un mortero de PLM + Blanco de Verona (1:2) pigmentado en un tono oscuro, con la intención de dar al soporte un resultado más estético de cara a su exposición.

Para una mejor exposición del ejemplar en la vitrina del museo, se procedió a colocarlo con un ángulo de 70º sobre la horizontal mediante su instalación en un atril. Por último, para mejorar su interpretación, se ha incorporado a la instalación en la vitrina del museo, una impresión en tres dimensiones de un modelo 3D de un cráneo realizado con la información obtenida de otros ejemplares procedentes del mismo yacimiento.

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Revisión de distintas técnicas de engasado para la extracción de fósiles

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Introducción

El engasado es un tratamiento habitual en los procesos de extracción de fósiles ya que se considera que es una forma de minimizar los riesgos de fractura asegurando la resistencia estructural de los materiales (Pastor Pérez *et al.*, 2018).

El engasado consiste en la colocación de una tela de gasa de algodón embebida en una resina sintética disuelta a distintos porcentajes en un disolvente que proporciona consistencia superficial a los materiales sobre los que se coloca. Como principio, este tratamiento debe ser totalmente reversible ya que se trata de un tratamiento temporal para asegurar el momento de la extracción y traslado al laboratorio de los ejemplares.

Atendiendo a algunos problemas que generan los engasados tradicionales, dado que el tratamiento es opaco y los procesos de desengasado pueden ser arriesgados en aquellos materiales muy frágiles, se ha comenzado a realizar estructuras de extracción con papel japonés de distinto gramaje. Este refuerzo ha resultado útil para realizar estructuras de extracción en materiales con superficies muy endebles. La técnica genera estructuras más frágiles, pero que presentan como ventaja que son relativamente transparentes.

En este trabajo se analiza la utilidad de las estructuras de engasado realizadas en procesos de extracción de fósiles. Para ello, se ha realizado un ensayo de flexión en 3 puntos (según la Norma UNE-EN 13279-2) para probar engasados con tela de gasa veladina y empapelados con papel japonés de 6 gr para cuya adhesión se han utilizado las resinas acrílicas de uso común en la conservación paleontológica (Paraloid B-72[©] y Acetato de Polivinilo -Vinac[©]) (Aberasturi, 2011) y otras menos comunes pero que podrían solventar problemas concretos. Entre estas se encuentran las dispersiones

acuosas sintéticas, como Acril ME[©] que es una microemulsión acrílica caracterizada por las reducidas dimensiones de las partículas. El uso de estas dispersiones acuosas posibilitaría la protección estructural de las piezas en situaciones en que la humedad o de lluvia complican la adhesión de las resinas disueltas en acetona.

Objetivos

El objetivo principal es evaluar la resistencia que aportan distintos tipos de engasado para la extracción de los materiales paleontológicos. Se evalúa también la validez del método del empapelado como sustitución de las gasas para reforzar superficies frágiles.

Material y métodos

Se han utilizado 10 probetas de escayola tipo E-35 A1 de acuerdo a la norma UNE-EN 13279-2:2014 (Yesos de construcción y conglomerantes a base de yeso para la construcción. Parte 2: Métodos de ensayo.), con un tamaño de 40 x 40 x 160 mm y una grieta central de 30 mm La dureza de las probetas es de 97 HC (medida con un durómetro portátil digital TYP-100C), que es similar a la dureza superficial de los ejemplares fósiles del yacimiento de Lo Hueco, Fuentes (Cuenca). Una vez secas, las probetas se han consolidado con Paraloid B-72[©] disuelto al 5% en acetona llevado hasta la saturación.

Para valorar la resistencia mecánica de las estructuras de engasado se ha realizado un ensayo de flexión en tres puntos, según las normas UNE-EN 196-1:2018 (Métodos de ensayo de cementos. Parte 1: Determinación de resistencias). La máquina de ensayo ha sido SERVOSIS modelo ME401/1 y la velocidad de ensayo ha sido 0.002 mm/s. El ensayo se ha realizado hasta la rotura de la probeta. Se han realizado también pruebas de resistencia en probetas engasadas con una humedad del 89%.

<i>Nº</i>	<i>TIPO DE MUESTRA</i>	<i>FUERZA MÁXIMA SOPORTADA (kN)</i>
<i>P.1</i>	PROBETA MACIZA DE ESCAYOLA, SIN GRIETA	1,516
<i>P.2</i>	PROBETA CON GRIETA SIN REINTEGRAR	0,082
<i>G02</i>	2 CAPAS DE GASA CON PARALOID AL 10%	0,622
<i>G03</i>	1 CAPA GASA + PARALOID B72 10% EN ACETONA	0,313
<i>G04</i>	PAPEL JAPONÉS DE 6 GR + PARALOID AL 10% EN ACETONA	0,376
<i>G05</i>	1 CAPA GASA+ ACETATO DE POLIVINILO 10% ACETONA	0,147
<i>G06</i>	PAPEL JAPONÉS DE 6 GR +1 GASA+ PARALOID AL 10% EN ACETONA	0,489
<i>G08</i>	1 CAPA GASA+ PARALOID AL 10% EN ACETONA HUMEDAD DEL 89%	0,101
<i>G09</i>	1 CAPA GASA+ ACRIL ME	0,232

Tabla 1: Fuerza máxima (kilónewton) soportada por los distintos tipos de tratamiento aplicados sobre las probetas analizadas.

Discusión y Conclusiones

Las pruebas realizadas corroboran que el uso de los engasados aporta resistencia a los materiales a los que se aplica, incrementando su resistencia. Por ejemplo, en el caso de la colocación de una doble capa de engasado una probeta de análisis puede llegar a soportar 62 kg (0,62 kN).

La humedad de las muestras afecta mucho a su resistencia. De hecho, la resistencia del engasado con Paraloid B-72© disuelto al 10% en acetona, cae de 0,313 kN a 0,101 kN si se aplica en condiciones de humedad. Esto hace aconsejable realizar un secado de la superficie de adhesión antes de proceder a cualquier engasado o a la utilización de una resina en emulsión acuosa como Acril ME®. Esta última presenta una resistencia de 0,232 kN, que, si bien está por debajo de la de la probeta con el Paraloid B-72© en seco, es más resistente que la prueba con Paraloid B-72© en húmedo. Por otra parte, Acril ME® es sensible a los rayos UV, por lo que, si se utiliza como alternativa, hay que evitar la incidencia de la luz sobre los engasados realizados o su eliminación en un corto periodo de tiempo. El acetato de polivinilo (Vinac®) no genera engasados resistentes.

El empapelado con papel japonés de 6 gr embebido en Paraloid B-72© disuelto al 10% en acetona iguala la resistencia del engasado en las mismas condiciones. Sin embargo, cuando se incrementan las capas de textil en el engasado la resistencia crece

considerablemente, mientras que el empapelado no mejora significativamente su resistencia al incrementar las capas de papel.

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La reintegración estructural en la restauración paleontológica: estudio de propiedades de diversos materiales

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Introducción

La reintegración estructural es un proceso necesario en la restauración paleontológica, que tiene la función de mantener la estabilidad de los fósiles asegurando su conservación (Onrubia *et al.*, 2017).

Esta intervención debe realizarse con un material capaz de aportar resistencia mecánica y adhesión a la grieta, fractura, o pérdida de material óseo que rellene, siendo discernible del original y respetando la fisionomía de la pieza.

Algunos estudios previos de otros autores (Martínez y Carrascosa, 2016; Marcos-Fernández, 2018) se centran en el envejecimiento de las resinas o en sus propiedades como material, pero sin ensayar cómo funcionan en relación al fósil. Además, las diferentes propiedades de las resinas que se han utilizado a lo largo de la historia –en muchas ocasiones, epoxídicas con elevada resistencia mecánica pero poco o nada reversibles– muestran la necesidad de investigar sobre métodos y materiales (Martínez, 2015), tratando de buscar rellenos alternativos que ofrezcan una mayor reversibilidad.

Objetivos

Este estudio pretende aportar información objetiva al proceso de selección de los materiales de reintegración estructural utilizados en la preparación paleontológica, determinando cuáles son los más adecuados en cada caso (dependiendo de las propiedades intrínsecas de cada pieza). Para ello, de forma transversal, se pretende evaluar la penetración, la reversibilidad y la facilidad de aplicación de varias resinas, en base a un mismo método de aplicación; y comprobar la resistencia mecánica de estas resinas en relación con el fósil.

Materiales y métodos

Con intención de reproducir unas propiedades generales similares a los fósiles, los ensayos se han elaborado con probetas de escayola E-35, que una vez secas tienen una dureza aproximada de 97 HC, similar a las mediciones tomadas en diversos fósiles.

Se han sometido al ensayo cinco resinas de diferentes características utilizadas con frecuencia en la reintegración paleontológica y en otros ámbitos de la conservación patrimonial: Paraloid B72® y acetato de polivinilo (Vinac®) disueltos en acetona en diversas concentraciones, Acril ME®, Araldite SV427® y Epoxy Devcon® 5 minutos. Salvo en el caso de las epoxídicas, el resto de resinas se han aplicado con una carga de microesferas de vidrio, material inerte que aporta viscosidad y consistencia a la resina.

Las probetas se han preparado de acuerdo a la norma UNE-EN 13279-2:2014 (Yesos de construcción y conglomerantes a base de yeso para la construcción. Parte 2: Métodos de ensayo), con 40 x 40 x 160 mm y una grieta central de 30 mm que se ha consolidado con Paraloid B72® disuelto al 5% en acetona hasta su saturación para después rellenarla con cada una de resinas ensayadas.

Para valorar la resistencia mecánica que ofrecen estas resinas se han sometido las probetas a un ensayo de flexión en tres puntos, según la norma UNE-EN 196-1:2018 (Métodos de ensayo de cementos. Parte 1: Determinación de resistencias) pudiendo medir la fuerza necesaria para romper la probeta reintegrada, y comparando los valores resultantes con una probeta sin grieta, y de una probeta con grieta sin reintegrar:

La fractura una vez reintegrada, ha permitido evaluar además los siguientes parámetros, que caracterizan la eficacia de la reintegración estructural (Lastras, 2006; Fox, 2001): Facilidad de preparación y aplicación de forma limpia y concisa, la penetración del material dentro de la grieta y la reversibilidad del material añadido sin causar daños a la probeta; unificando su evaluación mediante una valoración numérica del 0 al 5.

Discusión y resultados

Se ha corroborado que cualquiera de las resinas utilizadas como material de reintegración aumenta de forma considerable la resistencia que ofrece la probeta en el ensayo de flexión, llegando en algunas ocasiones incluso a ser mayor que en el caso de la probeta maciza (Ver tabla I):

		<i>Fuerza máxima soportada (kN)</i>
<i>P.1</i>	Probeta maciza de escayola, sin grieta	1,5166
<i>P.2</i>	Probeta con grieta sin reintegrar	0,0822

R.01	Paraloid B72® al 10% en acetona + microesferas de vidrio	0,1286
R.17	Acril ME® + microesferas de vidrio	0.4728
R.18	Epoxy Devcon® 5 minutos	2,3786
R.19	Acetato polivinilo (Vinac®) al 10% en acetona + microesferas de vidrio	0,623
R.20	Paraloid B72® al 30% en acetona + microesferas	0,7869
R.21	Araldite SV427®	1,3435

Tabla I: Resumen de los resultados obtenidos en el ensayo de flexión en tres puntos

La mayor resistencia mecánica ensayada la ofrece la resina Epoxy Devcon®, llegando a soportar una carga máxima de 2,4 kN (242,5 kg), pero una fuerza tan elevada provoca la rotura de la probeta antes que la de la resina, algo desaconsejado en la reintegración de fósiles reales, pero que puede ser útil en la realización de soportes.

El Acril ME® ofrece una resistencia baja en relación con la penetración. Por el contrario, el Araldite SV427®, a pesar de su baja penetración en el interior de la grieta, soporta 1,3 kN (132,5 Kg), un valor que se encuentra muy cerca del de la probeta maciza.

El Paraloid B72® disuelto al 10% en acetona y aplicado ya mezclado con las microesferas de vidrio presenta un problema de penetración en el interior de la grieta debido a la rápida evaporación del disolvente durante su aplicación. La baja penetración influye notablemente en su comportamiento mecánico, que soporta una fuerza máxima de 0,13kN (13,2 kg). Puesto que este resultado se obtuvo en un pre-ensayo, se ha realizado una prueba complementaria en la probeta R.20 incorporando primero las microesferas y añadiendo después la resina disuelta al 30%. Este caso muestra un incremento notable de la penetración, y consecuentemente, de la resistencia mecánica, ofreciendo unos resultados muy similares a los conseguidos con el Vinac®.

Además, se han evaluado otros valores que pueden ser relevantes a la hora de elegir objetivamente la resina más adecuada para la reintegración, como son la facilidad de preparación, la capacidad de penetración en la grieta y su reversibilidad (ver tabla II).

		Resistencia mecánica	Preparación- aplicación	Penetración en la grieta	Reversibilidad
R.01	Paraloid B72® 10%	1	3	1	5
R.17	Acril ME®	2	4	4	2
R.18	Epoxy Devcon® 5 minutos	5	3	4	0
R.19	Acetato polivinilo	3	3	3	4
R.20	Paraloid B72® 30%	3	2	3	5
R.21	Araldite SV 427®	4	2	1	3

Tabla II: Resumen de la evaluación de los parámetros constatados en las probetas reintegradas con distintas resinas. El valor 5 es el mejor/mayor resultado posible

Conclusiones

Aunque la resina Epoxy Devcon® ofrece la mayor resistencia mecánica, su nula reversibilidad la convierte en la resina menos adecuada para la reintegración paleontológica. El Paraloid B72®, una de las resinas más utilizadas en la preparación paleontológica debido a su buen envejecimiento y a su gran reversibilidad, no ha obtenido buenos resultados en los parámetros relacionados con la penetración en la grieta, ni ha probado la resistencia mecánica necesaria para la mayoría de los casos, siendo necesario ensayar en un futuro proyecto diversos métodos de aplicación, o la utilización de otro disolvente.

El Araldite SV427® ofrece una buena resistencia en relación con su baja penetración, por lo que puede ser una resina adecuada para grietas de pequeño tamaño en la que no sea necesario aplicar gran cantidad de producto. Se valorará en un futuro el resultado que ofrece la aplicación de esta resina en pequeños puntos de unión, que facilitarían su reversibilidad.

El Acril ME® es la resina más sencilla de aplicar y ofrece una penetración ideal, pero su resistencia mecánica es inferior a las demás. Además, su pérdida de reversibilidad al ser expuesta a la luz ultravioleta, le convierte en una resina poco adecuada.

El acetato de polivinilo (Vinac®) ha ofrecido resultados muy adecuados con el método de aplicación utilizado, aunque no tiene un buen envejecimiento debido a su cristalización a largo plazo, por lo que no se considera una resina idónea.

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The vertebrate paleobiodiversity of the Blesa formation (Barremian, Lower Cretaceous) in northeast Spain

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Keywords: Barremian, Paleobiodiversity, Maestrazgo basin, continental and coastal environment.

Introduction

Oliete subbasin is located in the northwestern marginal area of the Maestrazgo basin (eastern Spain). Aurell *et al.*, (2018) published a stratigraphic, sedimentological and tectonic research about the Blesa formation (Barremian), the oldest formation of the Oliete subbasin. These authors divided the Blesa Formation in three unconformity bounded sequences: lower, middle and upper Blesa. The vertebrate fossils are abundant in the three sequences, generally preserved as isolated and fragmentary remain. The study of this isolated fossils as a whole is a powerful tool to know the biodiversity of continental and marine vertebrates in the Barremian of the Northwest of the Iberian Peninsula. In this context, the aim of this work is to carry out a complete review of vertebrate fossil material of the Blesa formation and their distribution along the stratigraphic sequence.

Methodology

In addition to the bibliographic review, some prospecting campaigns and fossil preparation (mechanical and chemistry methods) have been realized. The collection of vertebrate fossils of the Blesa formation is deposited in the Museo de Ciencias Naturales de la Universidad de Zaragoza (Canudo, 2018).

Results

The paleontological research of the Blesa Formation dates back to the 1990s when La Cantalera-1 site was discovered in Josa (Teruel, Spain). This site is located in lower part of lower Blesa sequence. The fossils of this site are complete or fragmented isolated bones, tooth, eggshell fragments and coprolites that have allowed to recognize 31 vertebrate taxa and 9 ootaxa. Amphibians, chelonian, lizard, crocodylomorphs,

pterosaurs, ornithopods, sauropods, theropods and multituberculate mammals are represented, of which the discovery of a new taxa *Cantalera abadi* stands out (Badiola *et al.*, 2008). Very few vertebrae remains of Osteichthyes have also been found. La Cantalera-1 site was formed in a lacustrine environment with an intermittent body of water besides that most of the fossils show no evidence of transport so the preserved association is a good representation of the ecosystem in or around the marshy area of La Cantalera-1 (Canudo *et al.*, 2010). Laterally there are other fossil levels as Cantalera-2 with ornithopod remains (Gasca *et al.*, 2014).

The upper part of the lower Blesa sequence includes distal alluvial to palustrine-lacustrine deposits where fossil remains are scarcer. The undescribed Río Cabra tracksite (Obón) was located in these calcareous levels. More than 50 footprints have been identified. Most of them belong to sauropod dinosaurs, but ornithopods and possibly theropod footprints are represented too. Middle Blesa sequence consist of oyster-rich limestone and marls with continental influence deposited in a shallow restricted bay. Bones and tooth are abundant in oyster-rich limestone. Some levels are plenty of small fragmented bones and osteichthyes isolated tooth related with storm events. Some orders and families are represented (Kriwet *et al.*, 2009) and at least Alepisauroidei have been recognized (Kriwet, 2003). One picnodontiforme vomer is morphologically similar to *Arcodonichthys pasiegae* from the Early Cretaceous of Santander (Medrano-Aguado *et al.*, 2019). In addition, Hybodontiformes and Lamniformes morphologically close to *Eoptolamna* are represented in these stratigraphic levels (Kriwet *et al.*, 2008).

In the marls levels and the oyster-rich limestone several isolated and fragmented bones of tetrapod have been recovered, and most of them shows a very good conservation and show no evidence of transport. The most abundant are vertebrae of Plesiosauria indet. (Parrilla-Bel & Canudo, 2015). Isolated testudines plates are abundant in these levels along the Blesa formation and some fragmented bones related to sauropods and ornithopods have been recovered too. Parrilla-Bel & Canudo (2018) described two longirostrine crocodylomorph rostrum fragments and an isolated ilium have been recovered recently. The new Anhangueria pterosaur taxa *Iberodactylus andrei* have been described thanks to a rostrum recovered in this limestone levels (Holgado *et al.*, 2019). Dinosauria remains are represented by isolated bones of Ornithopoda,

Thyreophora, Sauropoda and Theropoda. It has been recovered one dorsal vertebral centrum of Ornithopoda indet. One dermal spine and one dorsal vertebral centrum are assigned to Thyreophora indet. One ischium from a sauropod, probably a Titanosauriformes has been recovered and some fragmented remains of another Sauropoda are located. Finally, one dorsal vertebra assigned to Theropoda has been initially described (Medrano-Aguado *et al.*, 2019).

In the upper Blesa sequence the coastal environment gave way to a lacustrine-palustrine and distal alluvial planes areas. The upper Blesa sequence is represented by continental clay/marls and local intercalations of conglomerates and sandstones. In this sequence the vertebrate remains are scarcer than in the other sequence. One fossil site, Barranco del Hocino-1 in Estercuel (Alonso *et al.*, 2016, 2018) had been discovered few years ago in one of the grey marls levels and the work continues today. Several isolated Ornithopoda bones and two different Theropoda tooth had been described as well as some microvertebrate remains (crocodylomorph and osteichthyan teeth), turtle shell fragments, coprolites and eggshells. The preservation of these isolated bones is so good and they show no evidence of transport. Some isolated bones have been recovered recently in the upper Blesa sequence, like one Goniopholididae indet. osteoderm and some fragmented bones in the marl levels near Alacón village and one Mesoeucrocodylia teeth was recovered in conglomerate levels north of Obón village. Finally, some footprints have been discovered recently in limestone levels apparently related with the basal part of the upper Blesa formation near Barranco del Hocino-1 site.

Conclusions

There is a significance abundance of marine and continental vertebrate fossils in the Blesa formation. The large number of taxa recognize in lower Blesa sequence and the different clades of marine vertebrate recorded along the middle Blesa sequence provide a good example of the Barremian paleobiodiversity in the Iberian Peninsula, in continental and coastal environments respectively. Although the number of fossils recovered in the upper Blesa sequence is scarce this may be due to the fact that not enough prospection campaigns have been carried out. Seen the paleontological potential that Blesa formation shows, the work continues trying to amplify the vertebrate Barremian record and his change along the time.

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Updating the Iberian fossil record of Triassic Sauropterygia.

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Keywords: Placodontia, Pachypleurosauria, Pistosauroidea, Nothosauria, Simosauridae

Introduction

The origin and quick diversification of Sauropterygia, a successful clade of extinct Mesozoic aquatic reptiles, took place during the Triassic (Stubbs and Benton, 2016). Throughout this period, sauropterygians adapted to a wide disparity of lifestyles and trophic specializations, including herbivory, filter-feeding, durophagy and piscivory, some of them becoming apex predators, and inhabiting brackish waters, lagoons and open seas.

The fossil record of the Triassic sauropterygians is relatively abundant, spreading throughout Europe, Middle East, Asia, North of Africa and North America (see Rieppel, 2000). However, the record of this clade in the Iberian Peninsula has traditionally been poorly known when compared with those of other European areas (e.g., Germany, Italy), being composed by scarce, fragmentary and isolated remains, preventing detailed systematic attributions. Here, we carry out a review of recent studies on Triassic sauropterygians from the Iberian Peninsula, allowing an update in our knowledge on the diversity of these animals.

Discussion and conclusions

Placodontia is composed by durophagous members of Sauropterygia. The Iberian record has recently been increased with the description of a new taxon, *Parahenodus atancensis* (de Miguel Chaves *et al.*, 2018a) and the identification of the genus *Psephosauriscus*, so far exclusive of the Middle East (de Miguel Chaves *et al.*, 2018b). The genus *Paraplagodus* has also been identified based on an isolated rib (Pinna, 1990), but the putative identification of other placodont taxa cannot be currently confirmed due to the poorly informative nature of the remains attributed to them (de Miguel Chaves *et al.*, 2018b).

The Iberian diversity of Nothosauroidea, a sauropterygian clade which includes large top predators, small piscivorous forms and filter feeders, has also increased in recent years with the description of the new taxa *Hispaniasaurus cranioelongatus* (Márquez-Aliaga *et al.*, 2019) and *Paludidraco multidentatus* (de Miguel Chaves *et al.*, 2018c). The nothosauroid record from the Iberian Peninsula also includes at least two different forms of the genus *Nothosaurus*, based on the morphology of isolated vertebrae (de Miguel Chaves *et al.*, 2016), and two species of the genus *Lariosaurus*: *Lariosaurus balsami* (Rieppel and Hagdorn, 1998) and *Lariosaurus calcagnii* (Quesada and Aguera González, 2005).

Pistosauroids were a clade of Triassic sauropterygians that inhabited open waters and to which the plesiosaurs belong. This clade could be represented by a partial specimen of an indeterminate pistosauroid (Alafont & Sanz, 1996).

Finally, Pachypleurosauria is represented by several specimens of small forms among which there are some that could belong to a new taxon (under study) (Rieppel & Hagdorn, 1998; Fortuny *et al.*, 2011). Thus, at least 11 different sauropterygian species can currently be identified in the Triassic record of the Iberian Peninsula. The update on these forms allows as to propose a synthesis relative to the knowledge about this group, new data being provided.

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Titanosaurs from the Iberian Peninsula: an overview and future perspectives

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Keywords: Titanosauria, Cretaceous, Ibero-armorian domain, Systematics, Phylogeny.

The first titanosaurian occurrences of the Iberian Peninsula are reported in the Maastrichtian of the Tremp Basin in the middle of the 20th century. Posteriorly, titanosaurs have been referred in several other localities from the Lower, and especially, Upper Cretaceous of the Iberian Peninsula, including several localities in Spain (in Castilla-La Mancha, Valencia, Cataluña, Castilla y León and Aragón) and also Portugal. The oldest unambiguous occurrence referred to Titanosauria is the recently published lithostrotian material from the Cenomanian of Algora (Castilla-La Mancha), which was tentatively related with titanosaurian representatives from the Cretaceous of Africa. However, the titanosaurian fossil record has an important gap up to the sedimentary rocks of the Iberian Campanian-Maastrichtian, where there is a diverse and rich fossil record. The same small-to-medium sized titanosaur *Lirainosaurus astibiae* was the first established titanosaurian species from the Iberian Peninsula and was found in the locality of Laño (Basque-Cantabrian Region). In Laño quarry, several titanosaurian individuals were identified, and they have been referred to this taxon. However, the possibility of two sauropod taxa in this locality is not excluded. After Laño, several other localities have been found, especially in the Castilla-La Mancha region (e.g. Lo Hueco in Cuenca or Poyos in Guadalajara). The most impressive locality is Lo Hueco (Cuenca, Spain), which represents a Campanian-Maastrichtian multitaxic bonebed, with several partial titanosaurian skeletons, articulated or with low dispersion. This accumulation is key for the comprehension of the titanosaur evolutionary history in the European territory. Preliminary studies suggested for the presence of two different taxa

(including *Lohuecotitan pandafilandi*, the second titanosaurian species established from the Iberian record), but recent works on axial remains are suggesting a higher diversity. The evolutionary history of the middle to Late Cretaceous Iberian titanosaurs is still uncertain. The first phylogenetic analyses suggested the presence of saltasaurid affinities, but they have been recently recovered as close related forms with other Ibero-armorian (*Ampelosaurus atacis* and *Atsinganosaurus velauciensis*) and Eastern Europe (*Paludititan nalatzensis*) titanosaurs, which in other hand have been related with North-African forms. A higher diversity has been suggested for Ibero-armorian domain, including Iberian Peninsula, during the Campanian-early Maastrichtian, followed by its decline and replacement during a faunal turnover event in the early-late Maastrichtian.

Three-dimensional analysis of the titanosaurian limb skeleton: implications for systematic analysis.

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Keywords: Titanosauria, Cretaceous, Geometric Morphometrics, Appendicular skeleton.

Introduction

Current knowledge of the appendicular skeleton of titanosaur sauropods highlights more diversity than previously reported (González Riga *et al.*, 2019). However, no consensus on the appendicular synapomorphies of several more inclusive groups of Titanosauria could be established. Analysis of the morphology of the appendicular skeleton of the titanosaurian sauropods have been scarce based on the lack of sample (Bates *et al.*, 2016; Bonnan, 2007; Ullmann *et al.*, 2017). There are also major differences between non-Titanosauriformes neosauropods and more inclusive clades of Titanosauriformes related to the acquisition of wide-gauge posture (Bonnan, 2007). In this study, the morphology of titanosaur appendicular skeleton is explored through 3D Geometric Morphometric Toolkit.

Methodology

We sampled several taxa representative of several more inclusive groups within Titanosauria. Each element was digitized via photogrammetry following the method proposed by Mallison (2011). Landmarks were collected for the humerus, ulna, radius, femur, tibia and fibula, including curve and surface semilandmarks following method described by Souter *et al.*, (2010). Morphology was analysed via Geometric Morphometric (GM) Toolkit implemented in R. Clade differences were assessed via

Discriminant Function Analysis (DFA) and the current phylogenetic hypothesis for titanosaur sauropods (see Carballido *et al.*, 2017; González Riga *et al.*, 2019).

Results

Our results show morphological differences between most inclusive lineages among Titanosauria. Besides DFA is sensitive to uneven group distribution and few Colossosauria titanosaurs were sampled, we recovered major differences between non-lithostrotian titanosaurs, Colossosauria, non-saltasauridae Lithostrotia and Saltasauridae.

Discussion

These results are congruent with current phylogenetic hypothesis (González Riga *et al.*, 2019). It can be observed differences among major titanosaurian lineages. These morphological differences are congruent with current hypothesis of Centre of Mass (CoM) distribution and body plan evolution (see Bates *et al.*, 2016; Ullmann *et al.*, 2017).

There is no current trend of morphological change directly relatable toward increasing on the CoM. Instead, groups with different CoM are recovered overlapping similar values in each discriminant function. The implications for several different within-group morphofunctional specialization are discussed, as previous reports did not find systematic correlation between whole-body CoM position and skull or neck functional morphology (Bates *et al.*, 2016). Moreover, minor morphological trends recovered in these analyses within each more inclusive clade suggest differences in the mediolateral musculature of the girdles and differences in proportions of the anterior part of the body (Ullmann *et al.*, 2017).

It is also discussed the advantages of GM Toolkit for quantification of morphological differences via inter-landmark Procrustes distances between the different inclusive clades. The quantification of shape differences allows to assess which areas of each appendicular elements present most of the variation between groups. This morphological variation can be related with morphological features useful in character data matrices already used in sauropod systematics.

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Rostrum of *Maledictosuchus riclaensis* (Rhacheosaurini, Thalattosuchia). 3D reconstruction: difficulties, new structures and interpretations

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Keywords: Middle Jurassic, Metriorhynchidae, marine crocodylomorphs, Computerised Tomography.

Introduction

Metriorhynchids are a group of Mesozoic marine crocodylomorphs that evolved from land-living or semi-aquatic ancestors to a pelagic lifestyle, developing numerous adaptations convergent with other marine amniotes such as hydrofoil-like forelimbs, hypocercal tail and large salt glands (Young *et al.*, 2010). Parrilla-Bel *et al.*, (2013) described *Maledictosuchus riclaensis* as the basal-most member of Rhacheosaurini (Thalattosuchia). The holotype and unique specimen known of *M. riclaensis* (MPZ 2001/130) consists on an almost complete and well preserved skull, part of the lower jaw and three vertebrae (Parrilla-Bel & Canudo, 2015). It comes from the Callovian (Middle Jurassic) of Ricla (Zaragoza, Spain), in the Northeast of the Iberian Peninsula.

The skull of *M. riclaensis* bears external morphological features linked to increasing marine specialization of the Rhacheosaurini clade (Young *et al.*, 2010). The rhacheosaurins are a tribe that includes the more derived members of Metriorhynchinae. However, in order to occupy marine environments, internal osteological features and physiological specialisations (usually reflected in soft tissues that rarely fossilize, e.g. salt glands) are also necessary, and these inner skull structures and their “function” are very poorly known. Exceptionally, such soft tissues can be found in well-preserved endocasts, such as in *Cricosaurus* (Fernández & Gasparini 2000, 2008; Herrera *et al.*, 2013), in internal cavity molds or thanks to computerized tomography (CT) scanning

techniques (e.g. Brusatte *et al.*, 2016; Fernández *et al.*, 2011; Pierce *et al.*, 2017; Serrano-Martínez *et al.*, 2019).

X-ray computerized tomography is a technique that has been widely used for paleontological research in last years. It is a non-destructive technique that allows an outside digital record of fossil specimens and the reconstruction, visualization and measurement of internal features (Cunningham *et al.*, 2014).

Methodology

The skull of *M. riclaensis* was scanned at the Institut Català de Paleontologia (ICP) (Sabadell, Spain), with an industrial CT scanner, at 430 kV and 3.45 mA. The interslice space was 0.5 mm, obtaining 1,206 slices in total. The segmentation was done using the software Avizo-7.1.

Results

Due to the density and similar composition between bone and internal matrix of the fossil, the grey-scale images obtained from the CT scan present poor contrast between bone and matrix. In addition, ring artifacts mask some of the endocranial structures.

Despite the difficulties, the CT scan images show density differences among some skull bones, being some of the orbital bones more porous. 3D reconstruction of the rostral region reveals the large nasal cavity with a wider posterior region, where the nasal salt glands were located, the maxillary canal, a developed antorbital sinus and the nasopharyngeal ducts. A cavity not described in other thalattosuchians can be recognised in the lachrymal region, inside or medial to that bone.

Some hypotheses for this structure are: 1) Consequence of the osteoporotic lightening described in Metriorhynchinae (Hua & Buffrénil, 1996); 2) Holding the salt gland or being part of it; 3) Pneumatic cavity; 4) Holding another gland. The structure seems to be well defined, quite symmetrical in both sides of the skull and clearly separated from the nasal cavity, so it would reject hypothesis 1. The presence of pneumatic cavities or sinuses in the lachrymal region has been described in some non-avian theropods and birds; crocodiles bear in that region a nasolachrymal duct and gland, but the absence of this canal has been proposed as a distinctive feature for thalattosuchians (Witmer,

1997). It could also be the salt gland, but its size and position is very different to the ones observed in *Cricosaurus* (e.g. Fernández & Gasparini, 2008; Herrera *et al.*, 2013).

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New information on the anatomy and systematics of the basal turtles (Helochelydridae) from the Spanish Cenomanian site of Algora

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Keywords: Upper Cretaceous, Spain, Guadalajara Province, Stem Testudines.

Introduction

Thanks to the recent findings made during the last decade, the Spanish paleontological area of Algora (Guadalajara Province, Castilla-La Mancha) has provided the largest collection of Cenomanian vertebrate macroremains currently known in south-western Europe. However, the available faunistic list of the site has not yet been updated, being mainly based on the analysis of scarce and partial remains collected in geological surveys carried out more than thirty years ago. Two excavation campaigns have been recently performed. As a result, numerous vertebrate remains were found, and a new project is currently in process, allowing a much greater potential knowledge about several of the clades represented there. However, most of these remains have not been, so far, published. They are currently under study.

Discussion and conclusions

Turtles are the most abundant group of vertebrates in Algora. A new pleurodiran turtle, corresponding to the oldest bothremydid in Europe, was defined there: *Algorachelus peregrina*. In addition to this very abundant littoral turtle, a much scarcer taxon, corresponding to a terrestrial form, was recognized. It is attributable to a basal form (Stem Testudines), corresponding to the clade Helochelydidae. Only a partial plate of uncertain anatomical position, recognized as belonging to an indeterminate helochelydrid, was analyzed so far. However, the new findings have allowed recognizing numerous plates and other bones corresponding to this clade. The anatomical study of these remains is presented here, so that the precise systematic attribution of the form represented in Algora is discussed, taking into account the European record of Helochelydidae.

The first pleurodiran turtle identified in the Soria Province (Spain): a finding from the Upper Cretaceous levels of Cabrejas del Pinar

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Keywords: Pleurodira, Bothremydidae, Iberian record, Castilla y León

The finding of pleurodiran turtles, attributable to the clade Bothremydidae, is relatively common in the Campanian and Maastrichtian levels of Southwestern Europe (Pérez-García, 2017a). In fact, the bothremydids are the best represented aquatic turtles in those sites. Recent findings in the fossiliferous locality of Algora (Guadalajara Province, Spain), as well as in Nazaré (West Central Portugal), have allowed to identify that this lineage, of Gondwanan origin, reached Europe at the middle Cenomanian or before (Pérez-García, 2017b; Pérez-García *et al.*, 2017). With the exception of these findings, no other remains attributable to this group of pleurodiran turtles had been documented, so far, at pre-Campanian levels of southwestern Europe. In this context, a new specimen is presented here. It corresponds to the internal mold of a shell. This specimen comes from Cabrejas del Pinar, in the Soria Province, belonging to the Spanish autonomous community of Castile and Leon. Characters such as those relative to the disposition of its pelvis, contacting both the carapace and the plastron, allow its attribution to Pleurodira. No remains of Pleurodira had been found until now in the Soria Province. The potential attribution of the new specimen to Bothremydidae and, in particular, to *Algorachelus peregrina* (i.e., the only member of the crown group of Pleurodira so far defined in the Iberian pre-Campanian record) is discussed.

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The bothremydid turtles from the Spanish Campanian site of Laño: an update

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Keywords: Pleurodira, Bothremydidae, *Polysternon atlanticum*, Iberian record, Spain, Upper Cretaceous

The finding of the Spanish Campanian site of Laño (Treviño County, Burgos Province, Castile and Leon) brought a significant increase in the knowledge about the European Upper Cretaceous vertebrate faunas (Lapparent de Broin and Murelaga, 1996, 1999). Several lineages were identified there for the first time in the Iberian record, and new taxa were defined. In the case of the turtles, the findings performed in Laño were very relevant. Thus, several new forms were described, including basal taxa (the representative of Helochelydridae *Solemys vermiculata*); a basal lineage of Pan-Pleurodira (the clade Dortokidae, represented by the new taxon *Dortoka vasconica*); and a representative of the pleurodiran group Bothremydidae (*Polysternon atlanticum*) (Lapparent de Broin and Murelaga, 1996, 1999). More recent findings have allowed to identify abundant material attributable to this last clade of Pleurodira in other Spanish and French Campanian and Maastrichtian sites (see Pérez-García, 2017 and references therein), highlighting, due to its abundance and good preservation, the remains coming from Lo Hueco fossil site (Cuenca Province, Castilla-La Mancha). Thus, two synchroinic and sympatric forms, both shared with the Upper Cretaceous record of southern France, have been identified in Lo Hueco: *Iberoccitanemys convenarum* and *Foxemys mechinorum* (Pérez-García and Ortega, 2018).

Information on the relatively small bothremydid species defined in Laño (i.e. *Polysternon atlanticum*) is, so far, very limited. In fact, scarce material was attributed to that form. Despite the abundant Iberian record of this group identified after the findings from Laño, its presence has not been, until now, confirmed outside this site.

Abundant specimens of Bothremydidae from Laño, which remained until now unpublished, have been prepared for the study. The detailed analysis of these

specimens, together with the revision of the previously known material of Bothremydidae from the site, allows us to improve the knowledge about the anatomy and systematics of the form or forms present in this site, as well as to carry out the comparative study with the material identified in other sites. Therefore, new implications on the diversity and distribution of Bothremydidae in the uppermost Cretaceous record of southwestern Europe are proposed.

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New data on the Iberian record of pleurosternid turtles based on the finding of the first representative of this clade in the Cameros Basin (Spain)

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Keywords: Paracryptodira, Pleurosternidae, European record, Soria Province, Jurassic-Cretaceous transition.

Introduction

One of the most abundant and diverse freshwater groups of turtles in the Upper Jurassic and Lower Cretaceous levels of Europe is Pleurosternidae. It corresponds to a lineage of Paracryptodira with a wide palaeobiogeographic distribution, being known in both North America and Europe, its larger stratigraphic range having been identified in this last continent (Pérez-García *et al.*, 2015a). The Iberian record of this lineage was very poorly known until a few years ago, and only scarce remains attributable to indeterminate forms of Pleurosternidae have been traditionally recognized. The recent discovery of several new specimens has allowed to identify a wide diversity, three new taxa having been described: the Upper Jurassic *Selenemys lusitanica* and *Riodemys inumbragigas*, and the Lower Cretaceous *Toremys cassiopeia* (Pérez-García and Ortega, 2011, Pérez-García *et al.*, 2015a, 2015b). All these Iberian forms are exclusively known by elements of the postcranial skeleton, especially by the shell (Pérez-García, 2017).

A new finding is presented here, corresponding to several elements attributable to a single turtle specimen. This finding comes from the locality of Ágreda, in the Soria Province (Autonomous Community of Castile and Leon), this town being located in the eastern Cameros Basin. The specimen has been collected in the upper part of the Tera Group, in a level probably belonging to the Matute Formation, being Tithonian-early Berriasian in age. This formation was deposited in a fluvio-lacustrine environment, during the Jurassic-Cretaceous transition.

Discussion and conclusions

The characters available in the new specimen presented here allow its attribution to a paracryptodiran representative and, more specifically, to Pleurosternidae. This is the first evidence on this clade documented not only in the Autonomous Community of Castile and Leon but also in the Cameros Basin, being the oldest record of a turtle documented in this basin. In addition to shell elements, the new specimen preserves the posterior half of the skull. The information about the cranial skeleton of Pleurosternidae is very limited (Pérez-García *et al.*, 2015a, 2015b). Thus, only a single skull was so far known for the European record, being attributable to the Lower Cretaceous species *Pleurosternon bullockii*, from Great Britain. The comparison of the new skull with that of the British taxon is carried out here. In addition, the detailed study of the preserved elements of both the carapace and the plastron is carried out, based on the first-hand study of all taxa so far defined in Europe. The relatively good preservation of the outer surface of several of the bony elements of the specimen from Ágreda (considering both some regions of the skull as well as the plates), allows us to carry out the comparative study with the ornamentation patterns known for the other members of Pleurosternidae, this character having been recognized as of high interest from a systematic perspective. Thus, the precise systematic attribution of the new specimen within Pleurosternidae is discussed.

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Late Maastrichtian fossil assemblage of Veracruz 1 site (Beranuy, NE Spain): wildfires and bones in a transitional environment

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Keywords: Late Maastrichtian, Southern Pyrenees, lagoonal environment, wildfire, dinosaur eggshells.

Introduction

Late Cretaceous outcrops of the southern Pyrenees (NE Spain) have yielded relevant findings about the last tetrapods that inhabited North Iberia before the K/Pg extinction event (Canudo *et al.*, 2016; Fondevilla *et al.*, 2019). The Tremp basin represents the wider area with outcropping Maastrichtian deposits of this part of Iberia, and the one where more paleontological sites have been found. Some of these sites include diverse and rich assemblages of vertebrates, invertebrates and fossil plants (*e.g.*, Molí del Baró-1' site, Marmi *et al.*, 2016), thus allowing an accurate characterization of the ecosystems of the Maastrichtian. The present work focuses on the analysis of a new fossil site of the Tremp Fm, ‘Veracruz 1’ (VE1), which holds a diverse and complex fossil assemblage and also shows evidences of the occurrence of wildfires during the Late Maastrichtian.

Geographic and geological context

VE1 is located near the locality of Bascas de Obarra, in the south of the municipality of Beranuy (Aragón, NE Spain), in the southern Pyrenees. The Late Maastrichtian deposits in this area are included in the Tremp Fm (Maastrichtian-Paleocene), and specifically they correspond to the two lower informal units defined in this formation (Rosell *et al.*, 2001), dated both as Late Maastrichtian in this area (Puértolas-Pascual *et al.*, 2018): *Grey Garum*, formed by marls and limestones deposited in transitional and lagoonal

environments, and the overlaying *Lower Red Garum* unit, dominated by continental mudstones and sandstones, with local tidal influence. VE1 site is situated in the upper part of the *Grey Garum*.

Results

VE1 site is a 5,7 m-thick level of bioturbated grey marls with abundant invertebrate and vertebrate fossil and plant remains. This level passes gradually upwards to ocher-brown mudstones without bioturbation. Plant remains show a wide range of sizes (from mm to dm) and have been classified as charcoal, product from combustion by wildfires, since they show homogenized cell walls in SEM microscopy (Scott, 2010).

The fossil assemblage is composed by both micro and macrofossil remains, including: vertebrates, invertebrates, charophyte gyrogonites and planktic foraminifera. Sample sieving allowed to recover charophyte gyrogonites and planktic foraminifera. The latter are very scarce but they are compatible with a Maastrichtian age for this site and the nearby sections dating. Invertebrate fossils include bivalves, gastropods, crabs serpulids and bryozoans. Vertebrates are represented by osteichthyans, testudines, crocodylomorphs and hadrosaurid dinosaurs. Osteichthyans remains correspond to isolated scales. Testudines remains are mainly disarticulated plates from the carapace and the plastron, showing most of them fine dichotomic grooves, pointing a high vascularization of the carapace (Murelaga & Canudo, 2005). Crocodylomorphs are represented mainly by teeth and by isolated osteoderm. Hadrosaurid dinosaurs remains consist of eggshells fragments (mm to cm), identified tentatively as *Spheroolithus aff. Europaeus* (Sellés *et al.*, 2014), and isolated bones, among these, a caudal vertebra, a tooth and a fragment of a dentary. Hadrosaurid bones show clear evidences of resedimentation, as they appear as isolated and disarticulated elements scattered in the marly matrix, and have signs of abrasion, carbonated crusting and bioerosion, and occasionally appear colonized by bryozoans.

Discussion and conclusions

VE1 site represents fine-grain mixed sedimentation in a low-energy, transitional environment (*e.g.* lagoon or small ponds in the coastal area), with fine-grain, mixed sedimentation. This environment was inhabited by a rich community of invertebrates, receiving occasionally remains of marine invertebrates and of terrestrial vertebrates

from the continent, which were resedimented there. Occasionally, some vegetated inland areas would experiment wildfires. The charcoal produced by them would be transported into the lagoon. As the size of the charcoal fragment does not point the degree of transport (charcoal floats; Scott, 2010), it is difficult to determine if the fires occurred near the lagoon or in more distant areas. However, the absence of sorting in the fragments, which size vary from mm to dm, could imply that the lagoon could have acted as a small local catchment area for a close fire (Ali *et al*, 2009). Nevertheless, a deeper sedimentological and taphonomical analysis should be done, as some of the fossils preserved show features (borings, colonization by bryozoans...) that point to a complex taphonomic story.

Due to its location in the area where the land met the sea, VE1 recorded the biodiversity of both marine and terrestrial Late Maastrichtian in this part of Iberia.

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Restos de un ceratópsido proveniente de la Formación Olmos (Campaniano-Maastrichtiano) en Sabinas, Coahuila, México

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Palabras clave: Cretácico, México, Ceratopsidae.

Introducción

Los ceratópsidos son el grupo más diverso además de ser componentes característicos y abundantes de las asociaciones de dinosaurios del oeste de Norte América (Laramidia) durante el Cretácico Tardío. Estratos del Campaniano han producido numerosos especímenes tanto de centrosaurinos como de chasmosaurinos, principalmente de Canadá y Estados Unidos. En contraste, el registro de la parte sur de Laramidia es sorprendentemente escaso. Restos de ceratópsidos son extremadamente raros en el Cretácico Tardío de México, contrastando con las asociaciones más ricas de hadrosaurios. Sin embargo, restos de dinosaurios han sido reportados de estratos mexicanos, aunque la mayoría de este material no es diagnóstico, y solamente dos taxones, *Yehuecauhceratops mudei* y *Coahuilacertops magnacuerna*, provenientes de las formaciones Aguja y Cerro del Pueblo (Campaniano) respectivamente, han sido nombrados.

De la Formación Olmos solo se tienen dos registros, el más antiguo data de 1968 con el descubrimiento de un esqueleto parcial de un ceratópsido indeterminado, y en 2011, la descripción de un cuerno de chasmosaurino, ambos provenientes del municipio de Múzquiz, Coahuila. De este último sugieren los autores pudiera ser nuevo género por la morfología que presenta.

Nuevos especímenes de ceratópsidos provenientes de la Región Carbonífera de Coahuila, proveen nueva información sobre la distribución y diversidad de los dinosaurios ceratópsidos al sur de Laramidia. Estos materiales son de la Formación Olmos cercana a Sabinas, Coahuila.

Resultados

Ceratopsidae Marsh, 1888

Ceratopsidae indet.

El espécimen PASAC 2002 fue descubierto el 7 de marzo del año 2002 por miembros de PASAC (Paleontólogos Aficionados de Sabinas A.C.), a 50 m al sur de la cantera donde se descubrió el hadrosaurio kritosaurino conocido como “Sabinosaurio”, en el ejido El Mesquite, 6 km al sur de Sabinas (Loc. #1-2). Se ha recuperado un centro anfiplatiano de una vértebra dorsal, el cual es corto craniocaudalmente además de que se encuentra ligeramente constreñido por el medio; el fragmento distal de un húmero derecho donde se aprecian los cóndilos distales bien preservados; un fragmento proximal del fémur izquierdo; y la parte proximal de la tibia izquierda, mostrando en su cara proximal una superficie rugosa y con la cresta cnemial bien preservada (Fig. 1).

Conclusiones

El material descubierto de ceratópsidos proveniente de la Formación Olmos, demuestra conclusivamente que los ceratópsidos ocuparon la región de Laramidia a través del Campaniano-Maastrichtiano. El material incompleto de la Formación Olmos de Coahuila está lamentablemente muy fragmentado para identificar más allá del nivel de familia como resultado de la pobre e incompleta naturaleza de su preservación.

A pesar de los escasos materiales fósiles, los ceratópsidos parecen ser un componente abundante de las comunidades dinosaurianas del Campaniano-Maastrichtiano al norte de Coahuila tanto en términos de abundancia relativa como en riqueza de especies. Factores tafonómicos y de facies pudieron influir en el registro fósil actual de los ceratópsidos. Sin embargo, este nuevo registro de ceratópsidos para Coahuila es de interés ya que ayuda a dilucidar las diferencias entre las faunas del norte y sur de la región oeste de Norte América durante el Cretácico Tardío.

A pesar de que el material disponible es limitado, los esfuerzos continuos en campo en la Región Carbonífera resultarán en material más completo y diagnóstico de ceratópsido que será invaluable en hacer asignaciones taxonómicas definitivas, como también comparaciones biogeográficas entre los taxa que habitan las regiones del norte y la sur de Laramidia durante el Campaniano-Maastrichtiano. Este trabajo es parte del proyecto

de catálogo de localidades con presencia de restos de dinosaurios en la Región Carbonífera de Coahuila.

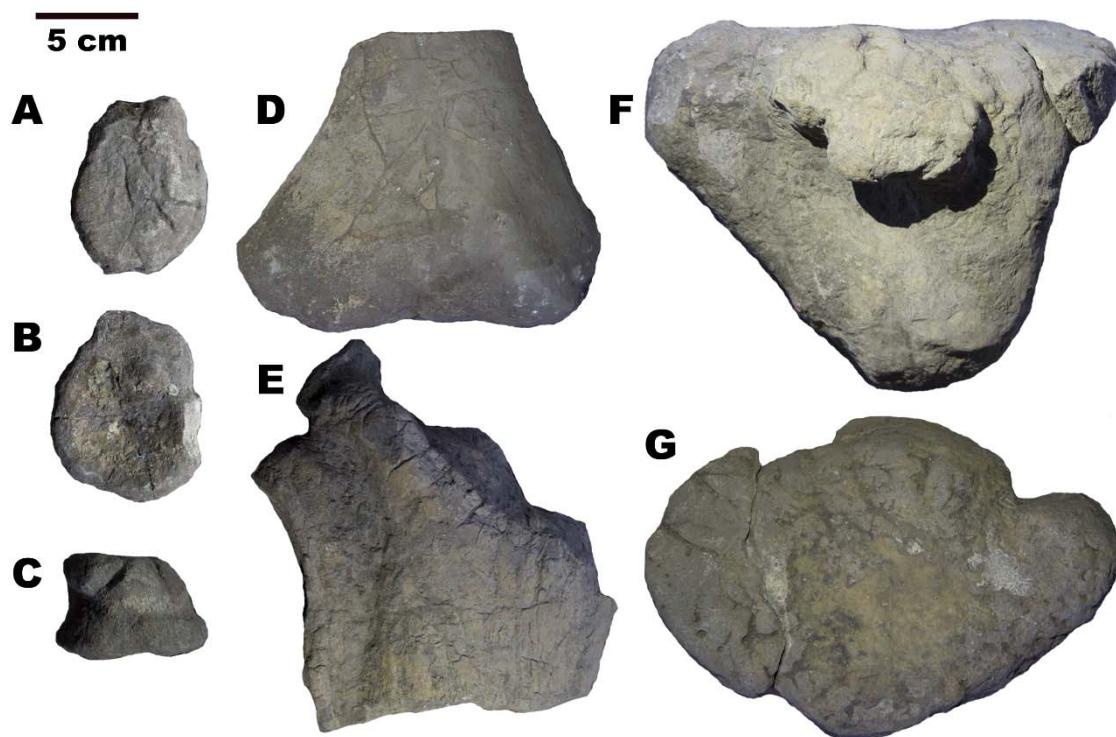


Figura 1.- Ceratópsido PASAC 2002. Vértebra dorsal en A) vista craneal; B) vista caudal; C) vista ventral; D) Húmero derecho; E) Fémur izquierdo; Tibia izquierda en F) vista media; G) vista craneal. Escala = 5 cm.

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New Middle Jurassic dinosaur tracks from Outão (Setúbal, West Central Portugal)

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Keywords: Dinosaurs, Tracks, Middle Jurassic, Arrábida Chain, Portugal.

A new Middle Jurassic dinosaur tracksite discovered in an inactive sector of a limestone quarry exploited for cement by SECIL (Companhia Geral de Cal e Cimento, S.A.) is here reported and briefly discussed. It is located in the Arrábida Chain (a Betic Miocene tectonic structure inside the Mesozoic Lusitanian Basin) at Outão (Setúbal). Until now, only Late Jurassic and Early Cretaceous dinosaur tracks were known from the western sector of Arrábida in the Cabo Espichel-Sesimbra area (e.g. Santos *et al.*, 2016). This new tracksite is particularly important due to the scarcity of the Middle Jurassic dinosaur fossil record worldwide. The ongoing fieldwork and analyses identified at least three track levels in a succession of limestones belonging to the Upper Bathonian-?Lower Callovian Pedreiras Formation (Costa *et al.*, 2005). The palaeoenvironmental interpretation for this unit suggests deposition in a very shallow, restricted marginal-marine environment during the onset of a regressive cycle with intervals of sub-aerial exposure (Azerêdo *et al.*, 2003). The newly discovered dinosaur tracks reinforce this. Large narrow-gauge sauropod trackways have been identified in the three ichnological levels of the tracksite. Additionally, two smaller quadrupedal trackways of yet unknown

affinity have been identified on level 1 (Fig. 1). Of these, one is narrow-gauge while the other is intermediate to wide-gauge, suggesting three different trackmakers on this level. This tracksite opens a brand-new window of opportunity for the study of Middle Jurassic vertebrate ichnofaunas, being an exceptional source of data on early dinosaur evolution.

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Figure 1. At Outão tracksite (Setúbal, Portugal) there are three Middle Jurassic track levels. The track morphologies observed on level 1 suggest three different quadrupedal trackmakers on this level.

Monumento Natural das Pegadas de Dinossáurios de Ourém / Torres Novas, Portugal: 25 years of research and dissemination of scientific knowledge

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Keywords: Dinosaurs, Tracks, Middle Jurassic, Ourém / Torres Novas, Portugal

The Galinha quarry located on the eastern side of Serra de Aire in the municipal area of Bairro (Ourém), in the limit of this municipality with the one of Torres Novas, disclosed Middle Jurassic (Bathonian) long sauropod trackways. According to the official version, in 1994, João Carvalho who was in this active quarry (Alfredo Francisco Galinha, Lda.) with his colleagues from the Sociedade Torrejana de Espeleologia e Arquelogia, discovered these dinosaur tracks on the surface of the limestone layer that was used as circulation pavement for heavy machinery in service. This discovery it was an important event for Palaeontology and under the aegis of Rui Galinha, the person in charge of this quarry that was active at the time, observations of the slab started immediately in order to provide a first scientific evaluation of the new occurrence. Santos *et al.* (1994) was the first report on this tracksite and science outreach and public dissemination actions took place to get public attention on this component of the Portuguese natural heritage. These Middle Jurassic sauropod tracks were a novelty for Science as they witnessed the existence of an unknown group of primitive European sauropod dinosaurs that evolved in the Jurassic period.

The various scientific dissemination actions aimed at demonstrating the importance of the dinosaur tracksite and sensitizing the community to the need to protect the Portuguese geological / paleontological heritage, culminated in the designation of the Galinha quarry, in 1996, as a Natural Monument, being under the protection of the current Instituto da Conservação da Natureza e das Florestas (Institute of Nature Conservation and Forestry). The Decree 12/96 of 22nd October (Decreto Regulamentar n.º 12/96, de 22 de outubro) declared the importance of the Galinha quarry that was designated as *Monumento Natural das Pegadas de Dinossáurios de Ourém - Torres Novas*.

Novas (Ourém / Torres Novas dinosaur tracks Natural Monument). This dinosaur tracksite that has uncommon scientific, pedagogical and cultural value, has provided several scientific outcomes (e.g. Azerêdo, 2007; Azerêdo *et al.*, 1995, 2013, 2015; Castanera *et al.*, 2016; Razzolini, 2016; Razzolini *et al.*, 2013; Santos, 2003, 2016; Santos & Royo-Torres, 2010; Santos *et al.*, 2009) and constitutes a successful case of national geoconservation (e.g. Brilha, 2006; Santos *et al.*, 2008).

This remarkable site with Middle Jurassic sauropod trackways was one of the selected tracksites to be part of the “Dinosaur Ichnites of the Iberian Peninsula” *World Heritage Candidacy* (FCPTD, 2009). Nowadays at this tracksite there are ongoing studies performed by palaeontologists from national and international institutions, namely Faculdade de Ciências (Universidade de Lisboa), Institut Català de Paleontologia Miquel Crusafont - Universitat Autònoma de Barcelona (Spain) and, recently, the Korea *National Research Institute of Cultural Heritage* (NRICH).

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Figure 1. A long and wide-gauge sauropod trackway at the Middle Jurassic Galinha quarry - Monumento Natural das Pegadas de Dinossáurios de Ourém – Torres Novas (Portugal).

Reducción de los dígitos en terópodos

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Palabras clave: Terópodos, reducción digital, desarrollo.

Introducción

La reducción digital es una tendencia dominante en la evolución de las extremidades de los tetrápodos (Shubin *et al.*, 1997). El caso que provoca más controversia es la reducción que se da en la transición de los dinosaurios terópodos no avianos a las aves, donde se pasa de una mano pentadáctila a una mano tridáctila, tanto en terópodos tetanuros no avianos como en aves modernas. Clásicamente se ha considerado que los 3 dígitos de los tetanuros basales son homólogos a los de las aves, presentando ambos los dígitos I, II y III. Sin embargo, a finales del siglo pasado, aparecen estudios que contradicen esta idea a partir de datos embriológicos, argumentando que la mano aviar presenta los dígitos II, III y IV (Wagner & Gauthier, 1999). Esta controversia entre estos dos puntos de vista ha dado lugar a un amplio debate, y ha sido utilizada como argumento en contra de la hipótesis de la descendencia de las aves a partir de los dinosaurios (p. ej., Feduccia, 2002). Así pues, el objetivo del presente trabajo es hacer una revisión histórica sobre los conocimientos que se han ido obteniendo sobre este fenómeno macroevolutivo, poniendo énfasis en los estudios más novedosos y las últimas hipótesis que buscan explicar esta controversia, además de aportar una visión desde el punto de vista de la biología evolutiva del desarrollo, la cual parece haber pasado desapercibida en este asunto.

Enfoques paleontológico y ontogénico

La transición de una mano pentadáctila a una tridáctila en terópodos se puede entender desde los puntos de vista paleontológico y ontogénico. El primero se basa en estudios morfológicos y anatómicos de los dígitos de los restos de terópodos encontrados en el registro fósil, a partir de la comparación del número y configuración de falanges y metacarpianos con tetrápodos actuales. Estos estudios concluyen que la fórmula digital de este clado es I-II-III, que se explicaría con una reducción digital lateral (LDR) donde desaparecen los dígitos V y IV. Sin embargo, esta fórmula digital no es totalmente

apoyada por el criterio paleontológico, puesto que otros estudios parecen indicar un patrón de reducción bilateral (Xu *et al.*, 2009). El enfoque ontogénico defiende la fórmula digital II-III-IV, basándose en la topología de las condensaciones del mesénquima embrionario donde se desarrollan los dígitos aviares (p. ej., Wagner y Gauthier, 1999; De Bakker *et al.*, 2013). Según este enfoque, la configuración actual de la mano de las aves es consecuencia de una reducción bilateral de los dígitos (BDR), lo que concuerda con el patrón de reducción observado en otros tetrápodos (Wagner y Gauthier, 1999), a diferencia del primer enfoque expuesto. No obstante, como en el caso anterior, hay estudios que plantean la posibilidad de una fórmula digital I-II-III en embriones de aves (Towers *et al.*, 2011).

Hipótesis sobre la evolución digital en terópodos

A lo largo de los años se han propuesto varias hipótesis que intentan solucionar el debate en torno a este fenómeno macroevolutivo, intentando reconciliar las conclusiones obtenidas de ambos enfoques paleontológico y ontogénico. Aquí nos centraremos en las 4 hipótesis con mayor repercusión. La primera de ellas, “frame-shift”, propone la aparición de una morfología I-II-III a partir de las posiciones 2, 3 y 4, debido a transformaciones homeóticas simultáneas en los dígitos II, III y IV (Wagner y Gauthier, 1999; Beber *et al.*, 2011). Se explicaría con un modelo de reducción BDR. En la misma línea, “lateral-shift” propone la misma idea, aunque en este caso las transformaciones son incompletas, dando lugar a una morfología I-II-III con vestigios de las morfologías II-III-IV (Xu *et al.*, 2009). En contraposición, “axis-shift” asume un modelo I-II-III a partir de un modelo LDR. Según esta propuesta, el dígito III se habría desarrollado de manera precoz, de manera que el eje principal de la extremidad atravesaría el dígito III en vez del IV como ocurre en la mayoría de tetrápodos (Chatterjee, 1998). Por último, “central-loss” propone la desaparición del dígito III, dando lugar a un modelo I-II-IV (Xu *et al.*, 2014).

Novedades en el registro fósil: *Saltriovenator*

Muy recientemente, Dal Sasso *et al.*, (2018) realizaron un análisis filogenético del clado Theropoda incluyendo un nuevo género descubierto por ellos mismos, *Saltriovenator*, con resultados que parecen solucionar el debate tratado en este trabajo. Este concluye que la fórmula falángica a lo largo de la filogenia de Theropoda apoya una tendencia de reducción lateral paso a paso, que lleva a una condición tetrametacarpiana y tridáctila en

la base del clado Tetanurae. Además, revela que la mano de *Saltriovenator*, identificado como un ceratosaurio basal según el análisis filogenético, es homóloga a la del resto de clados. Por lo que trata a la mano ceratosauroidea, que parece sufrir una reducción bilateral (Xu *et al.*, 2009), como una condición única sinapomórfica del clado. Esta consistencia morfológica entre todos los clados de terópodos apoya la hipótesis “axis-shift”, por lo que Tetanurae presentaría un modelo digital I-II-III. Por otra parte, los autores también hacen alusión a la aparente retención de los dígitos I, II y III a lo largo de la filogenia. Este hecho se relaciona con un alto valor adaptativo debido a la utilidad depredadora de dos de los dígitos dominantes, I y III, ya que se resistiría la dislocación digital durante movimientos violentos en el momento de agarrar manualmente a la presa.

Argumentación desde la perspectiva de la evo-devo

Si bien podemos tratar a esta reducción digital como una adaptación que surge debido a presiones medioambientales, tampoco podemos descartar las posibilidades que plantea la biología evolutiva del desarrollo o *evo-devo*. Según esta visión, la reducción o desaparición de los diferentes dígitos resulta ser una tendencia producto de una serie de restricciones internas del propio programa de desarrollo de los terópodos, que puede dar lugar a cambios fenotípicos sin la acción de la selección natural. Por tanto, siguiendo el modelo del paisaje epigenético de Waddington (1957), la mano tridáctila sería una morfología que emergió en el clado de los tetanuros como consecuencia de cambios genéticos que provocaron perturbaciones en el desarrollo y que permitieron que este fenotipo se canalizara a lo largo del clado. Los estudios embriológicos deberían de ayudarnos a reconocer si en este caso el desarrollo tiene más peso que la selección natural, ya que el programa de desarrollo está regulado por determinados genes que pueden ser estudiados. Sin embargo, a pesar de que hay trabajos que ponen de manifiesto la influencia genética en el desarrollo digital (Towers *et al.*, 2011; De Bakker *et al.*, 2013), se necesita un mayor énfasis en este tipo de estudios para así comprobar si hay patrones en los genes reguladores que dan lugar a la mano tridáctila.

Conclusiones

La evolución de la mano tridáctila en los terópodos ha causado controversia debido a las diferencias entre los enfoques paleontológico y ontogénico, surgiendo varias hipótesis que intentan reconciliar ambos enfoques. Recientemente, las incorporaciones en el

registro fósil sugieren un modelo digital I-II-III de la mano de los terópodos, probando la hipótesis “axis shift” como la más plausible, mediante una reducción lateral de los dígitos. Por otra parte, las causas de la reducción o desaparición de los dígitos no son del todo comprendidas, aunque se abre la posibilidad de que dicha reducción sea debida a restricciones en el propio programa de desarrollo de los terópodos. Sin embargo, también se ha de tener presente el papel de la selección natural, puesto que independientemente de porqué se redujeron los dígitos, dos de los dígitos dominantes (I y III), con presunta utilidad depredadora, se mantienen a lo largo de la filogenia, por lo que no se puede descartar el posible valor adaptativo que esta configuración digital pudo suponer para los dinosaurios terópodos.

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New data of sauropod paleobiodiversity at Jurassic-Cretaceous transition in Spain (Burgos)

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Introduction

Sauropods at the end of the Jurassic and the beginning of the Cretaceous in the Iberian Peninsula have a different record, with taxa described as *Lusotitan*, *Turiasaurus*, *Galvesaurus*, *Losillasaurus* and *Aragosaurus*, as well as diplodocimorphs taxa described in several sites, but at the moment they have not been assigned to any specific taxon. Before the last decade, the Jurassic-Cretaceous transition in the Cameros Basin was one of the areas of the Iberian Peninsula with scarcity of sauropod bones record (Canudo et al., 2010). The systematic excavation of the Valdepalazuelos - Tenadas del Carrascal site (Torrelara, Burgos), which initiated four years ago, has contributed to increase the number of sauropod fossils in the Cameros basin. The site is geologically located at the lower part of the Rupelo Formation (Platt, 1986), in the transition between the Las Viñas and the Ladera Members. Las Viñas Member is interpreted as distal alluvial deposits and the Ladera Member records pedogenically modified limestones that upwards evolve into lacustrine/palustrine deposits formed during Tithonian-Berriasican age (Platt, 1986; Martín-Closas & Alonso Millán, 1998). The top of the Rupelo formation preserves the mega-site of Las Sereas known by abundant ichnites of sauropods (Torcida Fernández-Baldor et al., 2012).

The fossils recovered during the excavations of the site correspond to at least two large sauropod individuals. The objective of this work is the description of a complete humerus (VPCR, 214) recovered at the site. The humerus of the Iberian sauropods

described in literature for the Jurassic - Cretaceous transition will allow us to make a proposal on the systematic position of VPCR, 214.

Description

VPCR, 214 is a right humerus conserved almost complete and conserved in 2 separate fragments (Fig. 1). VPCR, 214 is a straight and graceful bone, presenting a mediolateral expansion at their proximal end with respect to their distal one. The proximal area of VPCR, 214 has a slight projection towards the medial side, which differs from *Turiasauria* (Royo-Torres *et al.*, 2006). The proximal margin of VPCR, 214 lacks a coracoid process; the proximomedial and proximal lateral corners are slightly convex. The humeral head forms a prominent process of the posterior margin of the humerus in lateral view.

The middle part of the shaft has an elliptical cross section, a synapomorphy of *Eusauropoda* (Wilson, 2002). The deltopectoral crest is well expanded anteroposteriorly and extends toward the midline of the shaft, plesiomorphic character of the *Titanosauriformes* (Upchurch *et al.*, 2015).

The distal end of VPCR, 214 is widened mediolateral. Its anteromedial corner is convex, without the presence of an entepicondilar process present in some titanosaurs (Upchurch *et al.*, 2015). The radial and ulnar condyles are prominent and rough and have a similar development. Between the condyles there is a narrow groove that extends at the articular end. The condyles are slightly displaced to the lateral half. The posterior surface of the distal part of the diaphysis has a shallow supracondylar or anconeal cubital fossa bounded by two crests, medial and lateral.

The distal articular surface of VPCR, 214 is flat-convex in anterior view, without division between the ulnar and radial condyles, a character that shares with the derived somphospondylans and differs with the plesiomorphic condition of the well separated condyles (Mannion *et al.*, 2017). The distal joint surface extends to the anterior and posterior surfaces of the humerus, as occurs in several neosauropods (Harris, 2006).

Comparison with Iberian taxa

VPCR, 214 presents morphological characters that differentiate it from the rest of the sauropod taxa described in the Iberian Jurassic - Cretaceous transition, such as its deltopectoral crest that is exclusively lateral in all its proximodistal development. The humerus of *Losillasaurus* differs from VPCR, 214 because it lacks well differentiated distal condyles and its different robustness index. The humerus of *Turiasaurus* (Royo-Torres *et al.*, 2006) differs from VPCR, 214 in its proximal area, which has a marked medial projection. The ulnar and radial condyles are far apart and the contour of the distal edge is straight. The humerus of *Galvesaurus* (Barco, 2009) differs from VPCR, 214 because it lacks prominent processes on the anterior aspect of the distal area of the bone and the lateral edge of the shaft is concave.

Discussion

VPCR, 214 shows a series of primitive characters such as the proximal convex corner, the presence of 2 condylar projections on the anterior surface of the distal area and the straight distal articular surface, without condylar division. VPCR, 214 also presents derivative characters, such as its poor robustness and its gracility, its prominent humeral head, the well developed deltopectoral crest, the medial position of the distal portion of the deltopectoral crest, the elliptical sectional diaphysis and almost lateral margin right and distal articular surface extended anteriorly and posteriorly.

VPCR, 214 shares with somphospondylans some characters such as high gracility values and the rounded shape of the lateral corner of the proximal end (Mannion *et al.*, 2011). Other characters of VPCR, 214 show similarities with Titanosauriformes, such as the humeral head that has a prominent posterior process, the medial position of the distal portion of the deltopectoral crest and the lateral margin of the straight diaphysis. VPCR, 214 could be tentatively identified as a brachiosaurid titanosauriform.

This preliminary result of the description of VPCR, 214 provides new evidence of the presence of primitive brachiosaurids as in the Iberian Peninsula at the end of the Jurassic and at the beginning of the Cretaceous.

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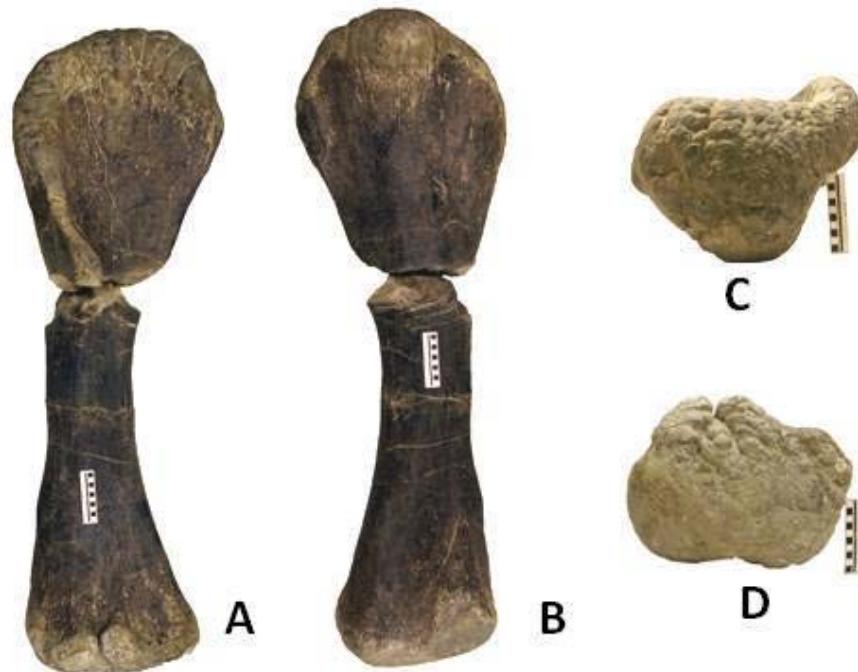


Figure 1. VPCR, 214 anterior view (A), posterior (B), proximal (C) and distal (D). The line is 10 cm.