

5th International Meeting of *Agora Paleobotanica*

Programme & Résumés

10-12/07/2017, Montpellier (France)



Comité d'organisation / Organizing Committee

Anne-Laure DECOMBEIX – *CNRS-UMR AMAP, Montpellier.*

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Giovanni SCANU — *Università degli Studi di Cagliari.*

PROGRAMME

10/07		Accueil 10:00-11:00	Intro & Keynote 11:00-12:00	repas	Communications orales 13:30-17:10			AG 17:30-18:30	
11/07	Communications orales 9:00-11:50			repas	Communications orales 13:30-15:10	Posters 15:10-17:00			Dîner 19:30-21:00
12/07	Excursion 8:30-18:00								

Lundi 10 juillet / Monday July 10

Université de Montpellier

Accueil / Welcome

Communications orales & affichées/ Talks and posters

Assemblée générale / General assembly

Mardi 11 juillet / Tuesday July 11

Université de Montpellier

Communications orales & affichées/ Talks and posters

Restaurant le Petit Jardin

Dîner de gala & remise du prix Boureau/ Banquet & Boureau award announcement

Mercredi 12 juillet / Wednesday July 12.

Excursion dans le bassin permien de Lodève / Fieldtrip in the Permian basin of Lodève

LUNDI 10 JUILLET/MONDAY JULY 11

Université de Montpellier, Bâtiment 1.

10h-11h	Accueil des participants /café etc Participant arrival/ Coffee etc.
11h-12h	Introduction Keynote <u>Ronny RÖBLER</u> A dream has become true - Background and outcomes of a palaeontological excavation.
12h-13h30	<i>Repas/lunch</i>

Université de Montpellier, Bâtiment 1.

Session PALEOZOÏQUE & PALEOBOTANIQUE GENERALE.

Chairs/Modérateurs :Véronique Daviero-Gomez & Carla Harper

13h30-13h50	<u>Philippe GERRIENNE</u> , <u>Oive TINN</u> , Gerard J.M. VERSTEEGH, Borja CASCALES-MINANA, Kalle KIRSIMAE, Leho AINSAAR, Viirika MASTIK, T. PANI, Thomas SERVAIS, Philippe STEEMANS, T. MEIDLA. An Early Silurian unambiguous megafossil evidence of polysporangiophytes?
13h50-14h10	Mathilde EVREINOFF, <u>Brigitte MEYER-BERTHAUD</u> , Anne-Laure DECOMBEIX, Renaud LEBRUN, Philippe STEEMANS, Paul TAFFOREAU. <i>Cymastrobis irvingii</i> gen. et sp. nov., a new isoetalean cone from the Late Devonian locality of Barraba, NSW, Australia.
14h10-14h30	* <u>Antoine CHAMPREUX</u> , Brigitte MEYER-BERTHAUD & Anne-Laure DECOMBEIX. The Late Devonian Cladoxylopsida from Australia: affinities and paleogeographic implications.
14h30-14h50	<u>Cyrille PRESTIANNI</u> & Anne-Laure DECOMBEIX. Bipolar or not that's the question: earliest spermatophyte growth habit into question.
14h50-15h10	<u>Carles MARTIN-CLOSAS</u> , Aixa TOSAL & Jean GALTIER. Palaeoenvironmental reconstruction of the Stephanian wetlands from Erillcastell from adpressions and permineralized plant fossils (Eastern Pyrenees, Catalonia).

- 15h10-15h40 *Break*
- 15h40-16h *Giovanni SCANU, Paola PITTAU & Josef PSENICKA
Late Paleozoic flora of Montarbu (central Sardinia)
- 16h-16h20 Anne-Laure DECOMBEIX, Nick P. ROWE, Rudolph SERBET &
Edith L. TAYLOR.
What is the functional significance of the unusual cambial
development in *Vertebraria* (Glossopteridales) roots? Some
geometrical and mechanical clues.
- 16h20-16h50 Borja CASCALES-MINANA, Philippe GERRIENNE, Thomas
SERVAIS, Daniele SILVESTRO, Wolfgang KIESSLING,
Claude MONNET, Taniel DANELIAN & Christopher J. CLEAL.
Independent diversity dynamics of land and sea across major
biodiversity crises
- 16h50-17h10 Nick P. ROWE.
Using biomechanics to interpret fossil plant growth forms and
their evolution.

Université de Montpellier, Bâtiment 1.

- 17h30-18h30 Agora Paleobotanica business meeting**

MARDI 11 JUILLET/TUESDAY JULY 11

Université de Montpellier, Bâtiment 1.

Session MESOZOIQUE.

Chairs/Modérateurs : Anaïs Boura & Borja Cascales-Minana

- 9h00-9h20 Jean GALTIER, Carla J. HARPER, Michael KRINGS & Ronny RÖBLER.
A fern or not a fern ?...
- 9h20-9h40 Carla J. HARPER, James F. WHITE, Edith L. TAYLOR & Michael KRINGS.
Endochaetophora, a paleomycological mystery revisited.
- 9h40-10h José B. DIEZ, Jean BROUTIN & George GAND.
"Retour" sur la palynostratigraphie du Trias du bassin de Lodève, Section Mas Tailleur (France).
- 10h00-10h20 Véronique DAVIERO-GOMEZ, Bernard GOMEZ & Abel BARRAL
Plant mesofossils from the Berriasian of Angeac-Charente (western France).
- 10h20-10h50 *Break*

Session CENOZOIQUE

Chairs/Modérateurs : Cyrille Prestianni & Giovanni Scanu

- 10h50-11h10 *Cédric DEL RIO & Dario DE FRANCESCHI.
Fruits and flower of Icacinaceae Miers from the Early Eocene of the Le Quesnoy locality (Oise, France).
- 11h10-11h30 *Sirella CHAMOREAU, Benoît MELLIER, Didier NEREAUDEAU & Christine STRULLU-DERRIEN.
Première contribution à la caractérisation du climat du Nord-Ouest de la France à l'Eocène : application des analyses CLAMP et LMA à la flore des grès à palmiers de l'Anjou et de la Sarthe.
- 11h30-11h50 *Aixa TOSAL & Carles MARTIN-CLOSAS.
Significance of small order climatic cycles in the understanding of leaf floras during the Eocene-Oligocene global climatic event.

11h50-13h30 *Repas/lunch*

- 13h30-13h50 *Agathe TOUMOULIN, Lutz KUNZMANN & Karolin MORAWECK.
Fragmented fossil leaves, how to deal with? A methodological and palaeoecological study through the middle and late Eocene of central Germany.
- 13h50-14h10 *Fiona LAVIANO, Séverine FAUQUETTE, Serge MULLER & Najat FEDDI.
Palaeogeography of neogene plant communities in the Western Mediterranean: the contribution of a new macroflora from North Africa
- 14h10-14h30 Dario DE FRANCESCO & Christian France-LANORD
Bois fossiles pléistocènes de l'océan indien.
- 14h30-14h50 *Mélanie TANRATTANA, Dario DE FRANCESCO & Anaïs BOURA.
Disentangling phylogenetic from climatic signal in *Cinnamomum* leaf traits: implications in paleoclimatic studies
- 14h50-15h10 Anaïs BOURA, Ninon ROBIN, Adeline KERNER, Dario DE FRANCESCO, B. CARRE, Marc PHILIPPE, Nima SAEDLOU & Nicole SALEL.
ABLES: Anatomical Base for Identifying Softwood.
- 15h10-17h** **Posters**
Discussion générale
[Délibération prix Boureau/Bureau award committee]
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Restaurant Le Petit Jardin

- 19h30-21h** Dîner de gala et remise du prix Boureau.
Banquet and Bureau award announcement.

MERCREDI 12 JUILLET/WEDNESDAY JULY 12

Excursion 8h30-18h

Départ devant l'université / Departure in front of the University

RESUMES

ABSTRACTS

ABIEs: Anatomical Base for IdEntifying Softwood.

Anaïs Boura^{1*}, Ninon Robin¹, Adeline Kerner¹, Dario De Franceschi¹,
B. Carré², Marc Philippe³, Nima Saedlou⁴, Nicole Salel⁵

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Wood identification is a common task for many palaeobotanists. The production of this secondary tissue began during the Devonian and evolved independently in several major lineages of vascular plants since then. Wood composition and toughness usually ensure its fossilization, in many cases without major deformation. Numerous atlases or publications dedicated to specific areas (Détienne & Jacquet 2000, Schweingruber 1990) or systematic groups (Metcalf & Chalk 1950; Illic 1991; Klaassen 1999; Liang & Baas 1991) for extant and fossil taxa exist to facilitate identifications. The IAWA community also formatted two lists of the main wood anatomical characters suitable for wood identification (IAWA committee 1989, IAWA committee 2004). The latest advance, approximately ten years ago, was the building of the Insidewood database (Insidewood 2004, Wheeler 2011), which allows online identification for extant and fossil hardwood. Nevertheless, an important part of the fossil wood found in sediments is softwood. Our ABIEs project aims to build a knowledge database dedicated to these extant and fossil species which produce homogenous wood, in order to provide a support for identification of fossil softwoods. The beginning of this important project was dedicated to the development of the architecture of the database with the Xper3 online platform (Ung et al. 2010) and the inclusion of 101 characters. We followed Phillips (1949) and the IAWA nomenclature but also added numerous quantitative features. For the moment, 50 modern species (i.e. 27 genera among the 75 genera of conifer known) represented in the xylarium of the “Muséum national d’Histoire naturelle” in Paris and 70 fossil species from the Boureau collection of the “Université Pierre et Marie Curie” are described in the knowledge base.

References

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Independent diversity dynamics of land and sea across major biodiversity crises.

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Three significant mass extinctions and five mass depletions in biodiversity are currently accepted in the Phanerozoic marine fossil record. While some of these marine biodiversity crises seem to correspond to important extinctions on land it is unclear if the dynamics are always similar. Here we compare the trajectories of marine and terrestrial life to test if they have similar dynamics on Phanerozoic time scales. Results show that four out of five marine mass depletions in biodiversity were coeval with diversification episodes in terrestrial ecosystems. For instance, while the marine realms show highly significant extinction rates in the Late Ordovician, the terrestrial environments experienced the first radiation of land plants that triggered the greening of the Earth's surface. Likewise, while we see anomalously high extinction rates in the marine Late Cretaceous, there is no mass extinction of terrestrial life besides dinosaurs and some mammals. On the contrary, the terrestrial fossil record reveals diversification events of angiosperms, insects, reptiles, birds, and mammals at this time. In the Late Devonian, marine extinctions and a crisis in reef habitats correspond to the transition to a forested planet and the initial diversification of tetrapods and insects. Moreover, while the end-Triassic extinction event triggered devastating effects on marine faunas, the land ecosystems mainly experienced the heyday of gymnosperms and an important tetrapod turnover before the dinosaur dominance. We conclude that diversity dynamics between the two main biospheres may be decoupled.

Première contribution à la caractérisation du climat du Nord-Ouest de la France à l'Eocène : application des analyses CLAMP et LMA à la flore des grès à palmiers de l'Anjou et de la Sarthe.

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Au cours de ces dernières années, de nombreux proxies (micropaléontologiques, géochimiques, ...) ont fourni des données détaillées sur le climat éocène dans différentes régions du monde. La plupart d'entre eux concernent le milieu marin alors que les proxies associés à des environnements continentaux sont plus rares. Ces derniers exploitent généralement la relation directe qui existe entre flore et climat, ce que nous avons privilégié dans notre étude. Le matériel analysé a pour objectif (i) de décrire avec précision le climat du Nord-Ouest de la France à l'Eocène, d'en caractériser les températures, la pluviométrie et la saisonnalité et (ii) de mettre en évidence les éventuelles particularités climatiques par comparaison avec d'autres sites européens. Le Nord-Ouest de la France a livré, au sein de blocs de grès fluvio-lacustres, une paléoflore riche et diverse, constituée en majorité d'empreintes de feuilles, qui a été largement étudiée au XIX^{ème} siècle. Ce matériel est maintenant disponible dans les collections du Muséum et de l'Université Catholique de l'Ouest d'Angers, du Musée vert du Mans, du Muséum de Laval, de l'Université de Rennes et du MNHN. La détermination taxonomique de cette flore a permis à des auteurs tels que Crié et Bureau de la comparer avec les taxons les plus proches de la flore actuelle et, d'après leurs habitats, d'en déduire un paléoclimat. Cette méthode de reconstitution paléoclimatique appelée Nearest Relative Living, utilisée de longue date par les paléobotanistes, a montré ses limites. D'autres méthodes ont été mises au point afin d'obtenir des données paléoclimatiques plus fiables tout en faisant abstraction de la systématique. Nous avons choisi l'analyse CLAMP (Climate Leaf Analysis Multivariate Program) comme méthode principale d'analyse, couplée à l'analyse LMA (Leaf Margin Analysis). CLAMP est un programme de statistiques multivariées exploitant les caractères morphologiques foliaires de plantes dicotylédones actuelles ainsi que les relevés climatiques des zones géographiques associées. Cette approche nous a semblé d'autant plus pertinente qu'aucune révision taxonomique des spécimens foliaires n'a été effectuée depuis le XIX^{ème} siècle. La méthode LMA a été retenue pour une comparaison avec l'analyse CLAMP. Plusieurs centaines d'échantillons ont été pris en compte et quarante-quatre morphotypes ont été définis. Les analyses effectuées à partir de ces morphotypes ont permis de caractériser plus précisément le paléoclimat continental du Nord-Ouest de la France. Les premiers résultats obtenus semblent indiquer qu'un climat subtropical humide régnait sur cette région.

The Late Devonian Cladoxylopsida from Australia: affinities and paleogeographic implications.

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The Barraba flora (late Famennian, New South Wales) comprises plant permineralizations and compressions, recorded in the marine deposits of the Mandowa Mudstone formation. Those sediments were deposited in the Drummond foreland basin, inboard of a volcanic arc in eastern Australia during the Late Devonian. Besides the numerous *Leptophloeum* compressions, previous studies have documented the presence of some other lycophytes, affiliated with the Isoetales *s.l.* The lignophytes *Callixylon* (Archeopteridales) and *Kalymma* (Calamopityaceae), along with *Polyxylon australe* (Cladoxylopsida *s.l.*), have also been identified and suggest affinities with the late Tournaisian flora from the New Albany Shales (U.S.A.).

The five anatomically preserved axes collected in Barraba that we describe here have a diameter smaller than 2 cm. The complex structure of their vascular system suggests affinities with the Cladoxylopsida *s.l.*

Three specimens show a stele characterized by the quadruple repetition of a common asymmetric pattern. They correspond to a new genus affiliated with the Iridopteridales, and are the first known Famennian occurrences of this group. However, some characters distinguish them from the Iridopteridales *s.s.*, especially the organotaxy. Two other specimens show affinities with the genus *Cladoxylon*, recorded in several Laurussian localities in the Tournaisian, such as Saalfeld (Germany) or the Montagne Noire (France).

A cladistic analysis of the Cladoxylopsida *s.l.* is performed to re-evaluate the affinities within the group. The Barraba plants show affinities with the Frasnian flora from South China and the Tournaisian flora from Laurussia. This suggests interchanges between the three major Upper Devonian continents, and is consistent with the freshwater fish fossil record.

Plant mesofossils from the Berriasian of Angeac-Charente (western France).

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Marlstones and claystones containing plant mesofossils were collected from the gravel quarry of Angeac-Charente, Charente, western France. These rocks are now considered to be a single bed Berriasian in age. Mesofossils were extracted after immersing previously-dried rocks into water and then sieve the resulting mud through a column of sieves with various meshes. The specimens were sorted under the stereomicroscope. The plant assemblage consists of fragments of ferns (pinnules, circinate pinnae), two types of leafy conifers (one with spirally arranged leaves temporarily assigned to the genus *Brachyphyllum*, one with opposite decussate leaves or three whorled leaves belonging to *Watsoniocladius*), several conifer cones and a number of seeds. Cuticles of conifers were also treated using the Schulze's reagent and observed under the microscopes. The palaeoenvironment probably corresponded to a freshwater coastal marsh.

Pleistocen fossil woods from Indian Ocean.

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During the Bay of Bengal drilling program (IODP 354) in 2015 (cf France-Lanord et al 2016), the core U1454 on a turbidite levee, along the West of Sri Lanka, were recovered ligneous fragments in a sandy layer from Middle Pleistocene (> 40Ky) situated immediately below the levee at 34m under the oceanic floor. These turbidites belong to the present turbidite channel linked to the Ganga and Brahmaputra situated 1500km northward. This level corresponds to a change of sedimentation. Some fragments could be anatomically studied. Another series coming from the Miocene level, but of less good conservation, did not allow for the moment a thorough anatomical study.

The Pleistocene samples present a variable conservation. A part is of the wood floated type with organic matter and very well preserved structures: iodine green stain is partially fixed on the cell walls, showing that lignin residues are still present. For one of the samples, the cell walls are relatively altered.

Among the 9 studied samples three different structures are observed, corresponding to secondary formations, among which two at least are wood. The third structure is difficult to identify, considering the poor preservation and the reduced size of the sample.

A first structure is found in 7 samples, potentially from the same tree. According to the observed anatomical characters, it shows affinities with a conifer of the genus *Picea* and more particularly the western Himalayan *Picea smithiana*, from relatively high elevation (2000 - 3500m). The second wood shows close similarities with Myrtaceae and particularly with *Syzigium cumini*, who is found in the Ganga and Brahmaputra plains, but also overall the Indian peninsula (at altitude < 1200m).

The presence of these fossils, far away from any coast, evokes an exceptional sedimentation event. This example demonstrates also that the conditions of sedimentation are key points of the interpretation of the fossil assemblages: the wood assemblage from different biogeographical zones, very distant from the point of sedimentation implies great cautions for the paleogeographical and paleo-environmental interpretations.

What is the functional significance of the unusual cambial development in *Vertebraria* (Glossopteridales) roots? Some geometrical and mechanical clues.

Anne-Laure Decombeix^{1,2,*}, Nick P. Rowe¹, Rudolph Serbet², Edith L. Taylor².

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Developmental changes in the onset of secondary growth are a powerful source of variation for the hydraulic and mechanical properties of woody plants. A fascinating example from the fossil record is the Permian morphogenus *Vertebraria*. *Vertebraria* axes represent the roots of the glossopteridalean seed plants, which dominated Southern Hemisphere floras during the Permian. In the first stages of their secondary growth, *Vertebraria* roots typically have a discontinuous production of secondary xylem around the axis. The lengthening of this phenomenon results in a wood cylinder that is discontinuous and appears star-shaped in cross-section, with lacunae between the wedges of wood. In older roots, xylem production becomes continuous around the axis, surrounding the central discontinuous wood development. This unique anatomy of the young developmental stages and the following "inside out" transformation likely has a strong impact on the functional properties of *Vertebraria* axes.

In this study, we combine new anatomical observations of *Vertebraria* from the Late Permian of Skaar Ridge, Antarctica, with geometrical and mechanical approaches. We investigate (1) to what extent *Vertebraria* differs from "normal" roots with a conventional circular outline, and (2) what is the functional significance of its derived organization. Comparisons of tissue distribution in cross-section between a normal root with an entire cylinder of wood and a star-shaped organization show "cheaper" growth in the latter where a smaller number of wood cells are produced to develop a given overall diameter. The star-shaped organization of the wood in young *Vertebraria* roots also leads to a reduced surface for hydraulic conductivity compared to a normal root but a potentially higher bending rigidity owing to its "I"-beam-like organisation. Young *Vertebraria* specimens are observed to have grown inside the wood of a trunk, suggesting that the star-shaped organization provided a potentially effective method for growth through the surrounding matrix by young roots.

The unique organization of the wood in young *Vertebraria* roots possibly represents a "light structural organisation" and efficient strategy for fast root growth and rapid establishment in a wet environment such as a peat swamp. The "inside out" transformation to a more classical root anatomy might reflect the prioritization of new functions (such as carbon storage, water transport and strength) in later stages of root development. The ecological implications of these functional strategies in high-latitude peat swamps will be discussed.

Fruits and flower of Icacinaceae Miers from the Early Eocene of the Le Quesnoy locality (Oise, France).

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The study of the paleoflora of Le Quesnoy (early Eocene, Paris Bassin) has been mainly focused on ambers and pollen embedded in amber and lignitic fossil endocarps of the Menispermaceae family (De Franceschi and De Ploëg, 2003; Jacques and De Franceschi, 2005). However, the diversity of this flora remains understudied.

In particular, fossils of the Icacinaceae family are the most representative of this site with 185 nearly complete lignitic endocarps and numerous fragments. Here, we described three species within which two are new. These species show affinities with taxa described in other Eocene localities of Europe (London Clay, Reid and Chandler, 1933) and North America (Clarno Formation, Manchester, 1994) and in the close Paleocene locality of Rivecourt. In addition, we described a new flower preserved in amber.

The flower from Le Quesnoy has Asian affinities with the extant genera *Natsiatum* Buch.-Ham. ex Arn. and *Hosiea* Hemsl. & E.H. Wilson and represents an extinct new genus of Icacinaceae. The endocarps species presents the diagnostic characters of the modern African genus *Iodes* Blume. The extant Icacinaceae are usually lianas. These forms are frequent in megathermal forests, which could have occurred in Europe during the early Eocene global warming. They indicate mixed vegetation with Asiatic and African affinities corresponding to a successional flora during the PETM. In particular, the « I-beam » ridge shape observed in one of these fossil taxa could correspond to an innovation linked to a new ecological niche and associated with the emergence of new mammal frugivorous groups during the global warming. Further study of this remarkable site, with a focus on the other present families, is therefore necessary in order to describe more precisely the paleogeographical links of Le Quesnoy flora with past and extant ones and to highlight the association between flora and fauna through time.

References

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“Retour” sur la palynostratigraphie du Trias du bassin de Lodève, Section Mas Tailleur (France).

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Dans cette communication nous présentons les résultats des analyses palynologiques des échantillons de sédiment prélevés dans les dépôts triasiques affleurant dans le sud-ouest du bassin de Lodève, près du village de « Mas tailleur ».

Ce sont des dépôts de faciès typiquement germanique : Buntsandstein, Muschelkalk et Keuper (Lopez, 1987). La base de la série triasique repose de façon sub – parallèle au-dessus de la discordance angulaire qui la sépare du Permien supérieur sous-jacent.

Les échantillons fossilifères (numérotés LD1, LD2 et LD3) ont été prélevés dans des lentilles de lutites laminées, « incrustées » sous le conglomérat de base du Trias et reposant juste au-dessus de la discordance P / T.

Ils ont livré l'association palynologique fort bien conservée au sein de laquelle la présence du marqueur *Hexasaccites muelleri* indique un âge Anisien *s.l.*, associé à *Illinites chitonoides*, *Illinites kosankei*, *Concentricisporites nevesi*, *Microcachryidites sittleri*, *Protodiploxypinus gracilis* y *Punctatisporites triassicus* ce qui permet de lui attribuer un âge Pelsonien inférieur. Cette datation correspond bien à l'âge un peu moins précis attribué par Doubinger & Cheylan (1964) et Doubinger & Adloff (1981) à des niveaux similaires du bassin de Lodève, pouvant être corrélés à ceux de Mas Tailleur.

Un deuxième niveau fossilifère situé à quelque 45m au dessus du précédent, juste sous le conglomérat de base du Muchelkalk supérieur, a été prospecté. Il renferme une petite association composée de *Hexasaccites muelleri*, *Microcachryidites sittleri*, *Illinites chitonoides* et *Lunatisporites noviaulensis* à laquelle un âge Pelsonien *s.l.* peut seulement être attribué.

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***Cymastrobis irvingii* gen. et sp. nov., a new isoetalean cone from the Late Devonian locality of Barraba, NSW, Australia**

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The Lycopsidea represent important components of the Australian floras throughout the Devonian. Yet, they appear poorly diversified in the latest part of the Devonian where they consist mainly of stems and branches of *Leptophloeum*, a genus of worldwide occurrence. In this presentation, we describe a new bisporangiate cone, *Cymastrobis irvingii* gen. et sp. nov., that we analyzed by means of X-ray synchrotron microtomography. The cone was collected by Mr. John Irving at Barraba, a locality of northern New South Wales dated from the Famennian. This large strobilus shows numerous sporophyll-sporangium units helically arranged around a narrow axis characterized by a lobed siphonostele. Sporophyll traces depart from the bays of the primary xylem cylinder. The proximal part of the cone is megasporangiate and clearly separated from the microsporangiate part. The sporophylls are comprised of a long, narrow pedicel with an abaxial keel and a distal heel, and of a delicate distal lamina oriented perpendicularly to the pedicel. Megaspores and microspores are represented by the casts of their inner bodies. The megaspore casts are up to 500 µm wide, with numerous small circular pores arranged in several rows around the trilete mark. They are comparable to the central bodies of the spora dispersae *Duosporites*, *Pilatrilletes*, *Surangeasporites* and *Talchirella* which are common in the Permian and Triassic palynological assemblages of Gondwana. The microspore casts are less than 100 µm in diameter, with one small pore between the rays of the trilete mark. They are assignable to the genus of spora dispersae *Endosporites* that ranges from the Late Devonian to the Permian. *Cymastrobis* is close to the contemporaneous genera *Clevelandodendron* and *Bisporangiostrobis*, and to the Mississippian-Pennsylvanian genus *Flemingites*. It may have occupied a basal position in the phylogeny of the rhizomorphic lycopsids.

A fern or not a fern ?...

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New permineralized specimens from the Triassic of Germany are assigned to the poorly known genus *Knorripteris* (Knorripteridaceae), an enigmatic group with fern-like affinities, but originally described as probable lycopsid.

These plants are characterized by: a discontinuous phloem cylinder, xylem strands of leaf traces which are continuing down and converging at the very centre of the stem, cells with spiral thickenings (i.e. transfusion tissue) accumulating within the central zone, and xylem strands possessing an abaxial protoxylem. All of these characters are considered of generic value and as a consequence the diagnosis of *Knorripteris* is emended.

Specific characters that allow to distinguish the new species from the former *K. jutieri*, include anatomical features of the cortex, as well as detail of the xylem strands and their arrangement in the most central region.

The new species presents several major features that are not considered as characteristic of ferns, e.g. the stelar organisation does not conform to the protostele/ siphonostele/ dictyostele types traditionally recognized in fossil and living ferns, the abaxial vs adaxial orientation of the protoxylem in leaf traces and the acropetal decrease vs increase of the xylem in the leaf trace are the reverse of the organisation generally observed in ferns.

Amongst the Mesozoic ferns preserved as compressions, *Knorripteris* may be comparable, in general morphology and habit, to the genus *Todites* with rhizomes bearing short leafy stems. *Todites* was attributed to the Osmundaceae based on the characteristics of the sporangia which are not known in *Knorripteris*. Whilst the latter presents a stelar anatomy that does not conform to the siphono – dictyostelic types known in the Osmundaceae.

The vascular system of the *Knorripteris* plant is of particular interest. The discontinuous phloem cylinder shows a cauline dictyostelic aspect, in contrast to the xylem that appears foliar in origin. In the new species presented herein there is not a central protostelic column of vascular tissue; the small foliar xylem strands come in close contact but there is no evidence of fusion of the tracheids bundles. The stelar organisation of *Knorripteris* is therefore unique.

Finally, in the absence of new argument supporting systematic affinities with the ferns, the place of the Knorripteridaceae within the pteridophytes remains quite enigmatic.

An Early Silurian unambiguous megafossil evidence of polysporangiophytes?

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The present contribution is dedicated to the description and the interpretation of well-preserved fossils from the Early Silurian Kalana Lagerstätte in Estonia (Baltica palaeocontinent). The fossils are found in a sedimentary succession comprising exclusively shallow marine to lagoonal carbonates. They have first been interpreted as a land plant, more precisely an early polysporangiophyte – to make it simple, a precursor of vascular plants. According to us, the plant demonstrated clear adaptation to terrestrial life: anchoring structures, epidermal outgrowths, presumable cuticle, and pitted, elongated, possibly conducting cells. All of those characters were well described and illustrated. The complex morphology of this Early Silurian plant and its large size were said to contrast markedly with the habit of all other Silurian basal polysporangiophytes.

Even though some uncertainties remain, it now turns out that this “early polysporangiophyte” could be a graptolite. Most characters that fitted so well with a land plant interpretation fit equally well – to be completely honest, even better – with a graptolite interpretation. In this talk, we analyze the two interpretations in detail, and evaluate the pros and cons of the plant vs. graptolite identification.

A scientific heritage: the palaeobotanical collections at the Montpellier University?

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A presentation of the wealth and diversity of a collection housed at the Montpellier University since the 19th century. More than 5 000 fossil specimens from Devonian to Pliocene deposits document the early development of vascular plants as well as the evolution of local flora.

***Endochaetophora*, a paleomycological mystery revisited.**

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Leaf associated fungi represent a major segment of extant fungal diversity. However, there is little documented evidence of pre-Cretaceous leaf associated fungi in the fossil record. The difficulty in studying fungi as fossils is that the fine microdetail of the fungus, i.e., sexual, asexual, and vegetative remains needed for taxonomic assignment, are often not preserved or lost through investigative techniques. In the Triassic (240 Ma) leaf mats from Fremouw Peak, central Transantarctic Mountains, Antarctica, there are multiple specimens of *Endochaetophora* sp., a fungus that is considered a type of zygomycete (Mucoromycotina). Previously, *Endochaetophora* has been described only as isolated structures, so called “sporocarps”, in blocks of peat dominated by roots. Specimens range from 100–500 µm in diameter, possess a three-layered mycelial investment encasing a central cavity, and some specimens display a distinct opening. New specimens of *Endochaetophora* occur as isolate forms without investment formation within leaf mats and in large clusters (<1.2 cm in diameter) surrounding and encasing entire leaves that are in varying stages of decay. The consistent association of *Endochaetophora* with leaves may suggest its role in decomposing Triassic leaf mats or perhaps as a latent leaf endophyte. Although the precise systematic affinities of *Endochaetophora* currently remain unknown, these new specimens provide an additional piece of information that allows us to speculate on the parental status, nutritional mode(s), and life history biology of the fungus.

Palaeogeography of Neogene plant communities in the Western Mediterranean: the contribution of a new macroflora from North Africa.

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The Mediterranean floras developed following changes in the Neogene palaeogeography and palaeoclimates, especially the increase of the seasonality within climates. While the northern Mediterranean Basin floras are numerous and well known, the southern ones remain poorly investigated. The new Boudinar flora (Morocco) enables to capture the North African vegetation at the beginning of the lower Pliocene just after the messinian salinity crisis (upper Miocene). Thus, to know vegetation origin and history of the southern margin of the Alboran sea presents a palaeobiogeographic interest in a historical context still debated. This macroflora, mainly leaves, was discovered in marine sediments of the basal Zanclean. The leaf layer, deposited in the context of a storm episode, is present throughout the basin and can be precisely dated by chronostratigraphy between 4.37 and 5.32 Ma (Achalhi *et al.* 2016).

Preserved in sandstones, Boudinar's macroflora reveals a diverse forest cover, including tropical and subtropical taxa (e.g. Lauraceae, Melastomataceae, Menispermaceae), oak (*Quercus faginea* and *Q. pseudosuber*) and ripisylve (including *Alnus hoernesii* which has now disappeared and several Salicaceae). Its exotic taxa proportion seems globally more important than in the northern shore. They could have persisted in this area according to a warmer climate. The Boudinar vegetation seems to present a Mediterranean configuration, with adaptations to drought adaptations, what is also confirmed by the palynological record. This new macroflora suggests an altitudinal zonation with a progressive shift from tropical to subtropical and finally to temperate taxa. Temperate taxa could also interpenetrated the two lower vegetation belts especially nearby water courses. Conversely, the weak presence of boreal taxa supports the hypothesis of the absence of high altitude mountains in the countryside.

In addition, pollen collected from the same stratigraphic sequence suggests a predominantly herbaceous formation with a relatively high proportion of deciduous and evergreen oaks, as well as some thermophilic elements (Jiménez-Moreno and Fauquette, personal communication).

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Palaeoenvironmental reconstruction of the Stephanian wetlands from Erillcastell from adpressions and permineralized plant fossils (Eastern Pyrenees, Catalonia).

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The Carboniferous record from the Pyrenees was deposited in intramontane late Variscan basins, usually filled in with alluvial and fluvio-lacustrine deposits. The flora of such basins is generally preserved as adpressions. However, in Erillcastell (Pont de Suert Basin) well-preserved silicified wood were found as well. A sedimentological and taphonomic analysis was carried out in order to elucidate the paleoenvironmental distribution of plants.

Autochthonous assemblages are composed by sphenophytes in life position, found in floodplain facies, and *Stigmaria* associated to *Sigillaria* in floodplain peat-swamps and in oxbow lakes from abandoned channels. Parautochthonous assemblages are formed by *Sigillaria* in lag-deposits of meandering rivers, *Alloiopteris* found in the early infilling facies of peat-swamps, while a monospecific *Calamites* assemblage was found in the accretional facies of a meandering river channel and also in floodplain deposits, associated with *Pecopteris* foliage. Allochthonous assemblages are composed by portions of fern, pteridosperm and cordaitalean foliage found in the floodplain deposits with evidence of being transported there by tractive river flows. In braided rivers, *Cardiocarpus*, *Sigillaria* and woody axes of Cordaitales and sphenopsids were transported by traction forming lag-deposits of the river channel. There, some cordaitalean and sphenopsid woods, were silicified during fossil-diagenesis.

The anatomical features of these cordaitalean stems belong to *Dadoxylon rollei* Unger. They show well-preserved examples of tyloses observed within the tracheids. The sphenopsid wood is most affine to *Arthropitys medullata* Renault. Its secondary wood is made of fascicular tracheids showing scalariform punctuations separated by interfascicular medullar rays, uniseriate and multiseriate, showing well-developed marginal punctuations.

In sum, *Sigillaria* grew in the peat-swamp and was the source of organic matter precursory of the coal that was exploited in the Malpàs coal mines. *Alloiopteris* grew the initial stages of peat-swamp. *Sigillaria* and *Calamites* grew in the meandering river banks forming a riparian community. *Calamites* could form monospecific stands in the floodplain. Marattialean tree ferns grew near the floodplain margins while the pteridosperms grew in indeterminate areas beyond the floodplain. Finally, *Cordaites* lived upstream from the studied area. These results differ from other south-European intramontane basins i.e. Graissessac-Lodève (France) and Surroca-Ogassa (Catalonia) by the occurrence of *Sigillaria* forming part of the riverine vegetation in meandering rivers of late-Variscan intramontane basins, probably located at a certain altitude within the chain. These habitats may have offered a refugium for some of the last European sigillariaceans.

Bipolar or not that's the question: earliest spermatophyte growth habit into question.

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The earliest true spermatophytes are found in the Upper Devonian where up to 20 species have been described. They show a wide morpho-anatomical disparity of their reproductive structures. By contrast, the vegetative systems of almost all of them are characterized by a very narrow diversity. In all documented cases, it consists in a zigzag-shaped pseudomonopodial main axis bearing helically arranged dichotomous branching systems. This general organisation appeared early in the lignophyte phylogenetical tree. The earliest diverging trimerophytes include several well described fossil genera such as *Psilophyton* and *Pertica* that are similarly characterized by a pseudomonopodial stem and helically arranged dichotomous branching systems. This bauplan, though experiencing considerable variations, was as well conserved within Middle Devonian lignophytes such as the aneurophytales and stenokoleales.

By contrast, the data available for the Lower Carboniferous spermatophytes indicate that though the morpho-anatomical disparity of ovules was comparable to that of the Devonian, a much higher disparity is observed for the vegetative parts, with the apparition of various growth habits and new characters of the primary and secondary vascular system. Exogenous ecological reasons are most often advocated to explain this major change as the disappearance of *Archaeopteris* and new climatic conditions allowed the exploration and occupation of new niches. We however suspect a major breakthrough to have occurred among spermatophyte growth habit with the apparition of bipolar growth around the Devonian/Carboniferous boundary. We will here discuss this hypothesis based on new available developmental evidences.

A dream has become true - Background and outcomes of a palaeontological excavation

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During the last decade a classical site of the lower Permian Chemnitz Fossil Forest, NE-Germany, provided multiple evidence for an outstanding fossil assemblage buried instantaneously by pyroclastics. After both geological and geophysical exploration and associated fundraising the fossil-bearing rocks were systematically uncovered within four 7-month field seasons. To shed light into the structure of the entombing volcanic deposits and their underlying sediments for the first time detailed sampling and documentation was performed in an area close to the volcano. The comprehensive dataset of 3D coordinates gathered for every fossil find resulted in a special database and a 3D model applied as research tool to attain fundamental information not only on the specific volcanic taphonomy with complex diagenetic and fossilisation processes, but also permits the reconstruction of this ancient ecosystem.

A unique window to the past gives insights into a restricted lowland environment sheltering a dense hygrophilous vegetation as well as a diverse fauna of vertebrates, gastropods and arthropods. Among the latter the youngest records of the extinct arachnid order Trigonotarbida and of the so far largest terrestrial arthropod, *Arthropleura*, were discovered. Additionally the first complete body fossils of scorpions from the Permian were obtained from the palaeosol with a compacted network of different-sized woody roots and thus have been preserved in situ in their likely life position, even within their original burrows. Based on five articulated skeletons with integumentary preservation a new fossil amniote was discovered and found to plot as a basal varanopid synapsid. Anatomical and taphonomical characteristics of this tiniest varanopid at all increase the knowledge on the rare basal varanopids. Moreover, it implies an arboreal lifestyle and therefore reveals a so far unexpected ecotype among early synapsids. Highlighted by many arborescent trees, still standing upright in their places of growth and rooting in the underlying palaeosol, this fossil lagerstätte preserves the most complete Permian forest ecosystem known to date.

As significant indicators of deep-time palaeoclimate, a number of new palaeontological, pedological and geochemical characteristics are provided for the Chemnitz site to depict more precisely its environmental conditions. For the first time, several lines of evidence indicate that this relatively young forest once received an annual precipitation of around 800–1100 mm, and grew on a nearly unweathered soil. Although the composition of this rich and diverse T⁰ assemblage suggests a dense and multi-aged vegetation dominated by conservative lineages, the habitat was affected by environmental disturbances and pronounced seasonality. For the first time we applied standard dendrochronological methods to Paleozoic trees. Ring sequences were analysed to determine both annual growth rates and mean sensitivity, as well as to correlate growth increments of the trees among themselves. The woody trees (pycnoxylic gymnosperms, medullosan seed ferns and calamitaleans) not only revealed a regular 10.62yr cyclicity in tree-ring formation. They enabled to appraise the fourth dimension of this in situ forest ecosystem and elucidated the last 80 years of the environment.

Using biomechanics to interpret fossil plant growth forms and their evolution.

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The mechanical organisation of plants contributes directly to form, size and complexity of plant growth forms and the communities they make up. While it is relatively easy to measure and compare the mechanics of living plants, it is much more difficult to test ideas on the likely mechanical organisation and potential growth forms of fossils.

In the first part of this talk I shall present a brief overview of over twenty years of research where we have studied the biomechanics of living plants which have helped us interpret the biomechanics and growth form diversity of fossil plants.

We will then discuss three main “findings” relevant to applying biomechanics to fossil plants: (i) that biomechanics of living plant growth forms are far more diverse, variable and adaptable in terms of their mechanical organisation than we initially thought. (ii) This finding is actually more of a help than a hindrance if we are to confidently identify mechanical architectures for fossil plants even though they might represent growth forms that no longer exist and for which there are no living analogues. (iii) We suspect that radiations in terms of form, size and life form, which can involve big organisational “jumps” for example from herbaceous to large-bodied trees, might be mediated via relatively simple changes in the developmental timing of key traits that underlie the mechanical organisation. The facility for growth form switches via developmental timing much depended on accumulated rather than *de novo* developmental motifs within different clades.

Providing a minimum of prerequisites is in place: (a) cellular preservation, (b) complete or near complete cross-sections, (c) presence of “young” to “old” developmental stages of growth and (d) reliable taxonomic identification, biomechanical approaches have a lot to offer for the reconstruction of plant growth forms and the functional biology of fossil plants.

Late Paleozoic flora of Montarbu (central Sardinia).

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Late Palaeozoic successions bearing plant macrofossils are located in different areas of Sardinia, and each plant assemblage is characterized by a different composition and state of preservation. According to published data the Carboniferous age is assigned only to one plant assemblage that comes from San Giorgio locality (southwestern Sardinia). New collected material from Montarbu locality (Seui territory, central Sardinia) shows another putative Late Carboniferous plant assemblage with typical taxa recorded only for this interval of time.

This collection, composed of about 300 specimens includes seed ferns such as *Mixoneura*, *Neurocallipteris*, *Callipteridium*, *Autunia*, conifers (e.g. *Ernestiodendron*, *Culmitzchia*), several fragments of large taeniopterid leaves and ferns (*Acithea*, *Pecopteris*, *Remia*). Other rare *Sobernheimia* sp. fragment is recorded. Especially two species, *Callipteridium pteridium* and *Remia pinnatifida* indicate a Late Carboniferous age to the deposit. A statistical analysis based on a presence-absence index (Sørensen-Dice: IS) was performed between paleogeographically Carboniferous and Permian closest floras. Then, the combination of stratigraphical, sedimentological and paleobotanical data will help to reconstruct this ancient paleoenvironment.

Acknowledgments

GGS gratefully acknowledges the Sardinia Regional Government for its PhD scholarship (P.O.R. Sardegna F.S.E. Operational Programme of the Autonomous Region of Sardinia, European Social Fund 2007–2013 - Axis IV Human Resources, Objective I.3, Line of Activity I.3.1). The authors also acknowledge financial support from the Institutional Grant Projects of the West Bohemian Museum in Pilsen (Czech Republic) via the project UU2016/05.

Disentangling phylogenetic from climatic signal in *Cinnamomum* leaf traits: implications in paleoclimatic studies

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The relationship between leaf physiognomy and climate has been studied for more than a century. Various methods have been developed by paleobotanists to use leaf physiognomy as a terrestrial paleoclimatic proxy. In the physiognomic taxon-free approach, climate reconstruction methods are based on the underlying assumption of an adaptive convergence of leaf traits in all plant families, under the same climatic constraints. In the past decades, several studies have enlightened the relative importance of phylogenetic signal in the distribution of leaf traits. Therefore, further work is needed to assess the impact of evolutionary history on leaf traits distributions.

We started our investigations using a taxon-based approach on the genus *Cinnamomum* Schaeff. (Lauraceae). Fossil leaves of *Cinnamomum* are quite abundant in the Cenozoic fossil record of Europe. However, studies on its fossil and extant variability towards phylogeny and climate through geologic times are scarce. Thus the aims of this study are (1) to evaluate the potential phylogenetic signal (PS) in leaf traits in extant *Cinnamomum*, (2) to measure PS impact on physiognomy-climate relationship and (3) to assess if there are any trait convergences due to climate. Quantitative and qualitative leaf traits of 30 species were extracted using worldwide-distributed herbarium specimens and traditional morphometrics. The sampling included 260 specimens distributed in 30 species, with one leaf considered per specimen. In order to test the phylogenetic signal, we calculated Blomberg's K for each trait.

Preliminary analyses show that most of the variability observed in *Cinnamomum* leaf physiognomy does not seem to be highly influenced by the phylogeny of the genus. Indeed, we observed low K values, indicating that the leaf physiognomy of *Cinnamomum* might comprise convergent traits linked to environmental variables. However, further work is needed on additional characters, especially on the apex and the venation pattern. Statistical analyses of the variability of *Cinnamomum* towards climate should allow us to verify this hypothesis (work in progress). Finally, the analysis of fossil specimens in order to derive paleoclimatic variables should testify the usefulness of isolated fossil leaves of *Cinnamomum* in paleoclimatic reconstruction.

Nouveaux spécimens de *Sphenophyllum* du Carbonifère inférieur d'Europe : anatomie, distribution et écologie.

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Les fossiles du Tournaisien (Carbonifère inférieur) de la Montagne Noire (France) et de Kahlleite (Allemagne) sont préservés en impressions/compressions et en perminéralisations. Parmi l'ensemble des restes retrouvés dans ces localités, cette étude se focalise sur les spécimens appartenant au genre *Sphenophyllum*. Ils sont décrits à partir de l'observation de huit portions d'axes anatomiquement conservés provenant de Kahlleite et quatre provenant de la Montagne Noire.

Les spécimens sont caractérisés par des axes fins (2-10 mm), marqués par des sillons externes se poursuivant au travers des nœuds. Ces derniers portent des feuilles de forme plutôt linéaires organisées en verticilles. L'anatomie des axes présente systématiquement une stèle organisée sous forme d'un triangle à côtés concaves. L'écorce est caractérisée par une zone de cellules allongées verticalement et à paroi épaisse située en périphérie. Certains spécimens présentent un peu de xylème secondaire.

Les nouveaux spécimens de la Montagne Noire et de Kahlleite sont assignés au genre *Sphenophyllum* et possèdent tous le même type d'axe et la même structure anatomique. Ils présentent plusieurs similarités avec *Sphenophyllum tenerrimum* qui est l'espèce emblématique du Carbonifère inférieur. La comparaison avec les spécimens en compressions de la Montagne Noire et de Kahlleite montre aussi des similarités en ce qui concerne le diamètre des axes et le type de feuillage. La combinaison de l'anatomie et de la morphologie externe ne permet cependant pas d'identifier avec certitude la ou les espèce-s présente-s.

La présence du genre *Sphenophyllum* à la Montagne Noire et à Kahlleite est un nouvel exemple de genre en commun entre ces deux localités, suggérant un environnement d'origine comparable. Les environnements de dépôt et l'anatomie des axes confirment l'écologie hypothétique du genre *Sphenophyllum*, surtout basée sur des spécimens plus récents (Carbonifère Supérieur). Il semble être particulièrement présent dans des milieux humides où l'eau n'est pas limitante tel que les ripisylves, les marais et tourbières.

Significance of small order climatic cycles in the understanding of leaf floras during the Eocene-Oligocene global climatic event.

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The uppermost Eocene (Priabonian) leaf beds from Sarral and the Oligocene (Rupelian) leaf beds from Cervera, located in the Eastern Ebro Basin, are two well-known paleobotanical localities related to the Eocene-Oligocene boundary in southern Europe. These plant localities have been long studied mainly from the biostratigraphic, taxonomic, palaeoecological and palaeoclimatological viewpoints, leaving aside taphonomic studies. The present paradigm is that these fossil assemblages, separated by more than 4 Ma time, represent nevertheless very similar arid vegetations within the context of the global climate change occurred during the Eocene-Oligocene boundary. In both localities recent collections based on taphonomic criteria allowed us to obtain new palaeoenvironmental and palaeoclimatic data based on leaf floras.

Both localities display similar taphofacies: (1) Assemblage composed by size-sorted (small) leaves. In Sarral, it is composed by *Zizyphus*, leaflets of Fabales and *Pinus* needles, while in Cervera is composed by leaves of *Rhamnus* and leaflets of *Rhus* and Fabales. Their size-selection reflects wind transport from open woodlands located distally from the lake forming a xerophytic community. (2) Assemblage composed of whole leaves without any selection. At Sarral it is represented by Salicaceae, *Myrica arenesi*, *Comptonia schrankii*, Lauraceae and helophytic stems. A similar assemblage but with lower diversity was recognized in Cervera. These features are consistent with a direct supply of plant remains to the lake from the lake shores and would represent a riparian community. (3) Assemblage formed by fragmented plant organs. This assemblage is represented in Sarral by disarticulated shoots and isolate bract-scales complexes of *Tetraclinis*, fragments of palm costae and a few torn leaves of *Myrica arenesi*. In contrast, in Cervera this taphofacies is composed by torn leaves of Salicaceae, Lauraceae, *Myrica* aff. *faya* and *Myrica oligocena*. Broken plant remains would indicate that they were transported by tractive flows. In both cases, they represent parts of the riparian forest upstream. Additionally in the case of Sarral *Tetraclinis* and palms were located beyond the riparian forest with direct supply to temporal streams, while in the case of Cervera a small laurisilva would grow beyond the riparian forest.

The deposition of the Sarral and Cervera plant-bearing beds were deposited during the development of small sedimentary cycles, climatically driven. However, while the Sarral flora corresponds to the drier periods of such cycle, the flora from Cervera would represent the wetter stages of a small sedimentary cycle. In conclusion deposition of both plant localities occurred in opposite terms of probably third order sedimentary cycles representing different climatic pulses. In sum, minor order climatic cycles would mask the main polarity of the large order Eocene-Oligocene climatic event. Hence, during the presumably wetter upper Eocene the Sarral leaf beds would correspond to a relatively drier part of a minor order cycle, while during the presumably drier Oligocene, the Cervera leaves would represent the wetter part of a minor order cycle.

Fragmented fossil leaves, how to deal with? A methodological and palaeoecological study through the middle and late Eocene of central Germany.

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Fossil leaves are interesting tools to reconstruct ancient environments and climates. However, they are sometimes poorly preserved and fragmented, what limits the applicability of their leaf-traits and physiognomic characters (*i.e.* size and shape) within palaeoecological approaches. The present study aims to deal with this problem and build a methodology to estimate leaf size from fragments. Three methods were applied and their results confronted: (1) an empirical reconstruction of the leaf perimeter and shape using the appearance of the leaf fragment based on experiences in taxon-specific gross-morphology; (2) an estimation of the length of the missing leaf part through an approach based on the midvein tapering; and (3) a last one, initiated by Sack *et al.* (2012), returning leaf-size from its scaling with second order venation density.

These methods were applied to extinct *Eotrigonobalanus furcinervis* (Fagaceae) from two lignite horizons of the middle and late Eocene of central Germany (~45/46 and 35/36 Ma in age respectively). The three approaches give similar leaf-size estimations and conclusively indicate significantly bigger leaves in the late Eocene assemblage. This is consistent with the global cooling trend described from the marine record during this period and highlights its impact on Northern hemisphere's vegetation.

To complete these data, a palaeoclimatic analysis (CLAMP) and estimations of atmospheric $p\text{CO}_2$ (Stomatal Density approach) were made. Their results indicate a warm-temperate and seasonal climate since at least the middle Eocene, and rather low $p\text{CO}_2$ values for the late Eocene comparably to other non-plant derived proxy data (316.89 ppm, s.d.: 57.49).

Thus, these results underline the significance of ecophysiological studies for tracing palaeoclimatic changes. More researches must be made to enhance the description and accuracy of the midvein tapering method initiated here. However, there is big hope that the new size estimations methods tested here will help to conduct physiognomically-based palaeoenvironmental reconstructions and thus to add pages to our Earth history.

References

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