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# book of abstracts

XXII Symposium of Cryptogamic Botany





#### Dear coleagues and friends,

#### **Paula Matos**

president of the organizing committee

#### **Cristina Branquinho**

president of the scientific committee

Juliana Monteiro | Pedro Pinho | Helena Serrano | Bernardo Rocha It is with great pleasure that we welcome you to Lisbon for the XXII edition of the Symposium of Cryptogamic Botany, 2019.

First, we would like to thank you all for joining this symposium. We are very happy with this year edition, which is an excellent show-case of the main scientific advances on the last two years of research in cryptogamic botany. The program has four invited talks, a selection of 9 hot-topics sessions and a poster session, all intended to be a of learning and discussion. We are also going to award a prize to the best oral and poster student presentations, sponsored by the Marine and Environmental Sciences Centre - MARE. The symposium counts also with a busy social program. We will have a welcome reception at Lisbon's Greenhouse, and the opening of an art exhibition inspired in cryptogamic diversity, "Hidden Diversity", with Lisbon Municipality support and integrating the program of Lisbon European Green Capital 2020.

All this has been possible thanks to your work, to our sponsors' support and to our team engagement. We do hope you enjoy your attendance at XXII SCB 2019!



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general schedule

	24 <sup>th</sup> July		25 <sup>th</sup> July		26 <sup>th</sup> July	
8:30 - 09:00	registration (next to room C8.2.30)		plenary session III (room C8.2.30)		plenary session IV (room C8.2.30)	
09:00 - 09:30	opening (room C8.2.30)					
09:30 - 10:00			=	=	۵ŏ	_
10:00 - 11:00	plenary session I (room C8.2.30)		biodiversity & biogeography (room C.8.2.30)	physiology & ecophysiolog) (room C8.2.47)	management conservation (room C.8.2.47)	systematics & evolution II (room C.8.2.30)
11:00 - 11:30	<b>coffee break</b> (C6 atrium)		<b>coffee break</b> (C6 atrium)		coffee break (C6 atrium)	
11:30 - 13:00	global change l (room C8.2.30)	biodiversity & biogeography I (room C8.2.47)	systematics & evolution I (room C.8.2.30)	biomonitoring (room C.8.2.47)	extreme environments (room C.8.2.47)	global change II (room C8.2.30)
13:00 - 14:30	lunch (C6 cantine)		lunch (C6 cantine)		lunch (C6 cantine)	
14:30 - 15:00	plenary session II (room C8.2.30)		visit to Monsanto Biodiversity space		technological applications (room C.8.2.30)	
15:00 - 15:30						
15:30 - 16:00	× 1				coffee break (C6 atrium)	
16:00 - 16:30	urban environments (room C.8.2.30)	physiology & ecophysiolog (room C8.2.47)			society me	etings
16:30 - 17:00	coffee break (C6 atrium)					
17:00 - 18:00	poster session (C6 atrium)				closing ceremony (room C8.2.30)	
19:00 - 20:30	welcome reception & art exhibition					
20:30			symposium dinner			

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### Diversity, phylogeny and evolution of lichen-inhabiting basidiomycetes

#### Ana María Millanes Romero

Departamento de Biología y Geología, Física y Química Inorgánica y Analítica (ESCET), Universidad Rey Juan Carlos, Madrid, Spain

Lichens are complex systems that, in addition to the mycobiont and the photobiont, harbor a diversity of organisms, including both bacteria and fungi other than the mycobiont. Among the lichen-inhabiting fungi the term "endolichenic" was coined to refer to endophytic-like fungi living asymptomatically inside lichens, whereas the term "lichenicolous" was generally used for mostly macroscopically visible fungi living on them. There are currently up to 2319 species of lichenicolous fungi described, which belong both in Ascomycota and Basidiomycota. Lichenicolous basidiomycetes include only a handful of generalists, and most taxa are very host-specific. The latter include, among others, genera in the Pucciniomycotina (Chionosphaera and Cyphobasidium) and in the Tremellomycetes (Heteroacanthella, Heterocephalacria, Syzygospora and *Tremella* s. l.). The Tremellomycetes as a group are also interesting in that they include, apart from lichenicolous fungi, representatives with a variety of nutritional habits, their actual diversity and evolution are still poorly known, and they exhibit remarkable coevolutionary patterns with their hosts. Hostspecialization has in fact revealed as an important driver of speciation in lichenicolous basidiomycetes. Both Cyphobasidium and Tremella are dimorphic fungi, which means that they include a haploid veast phase and a dikaryotic filamentous phase in their lifecycle, and it has recently been shown that species growing on Parmeliaceae are able to complete their life cycle within the lichen thallus. In the last years molecular phylogenetics, studies on character evolution, species delimitation methods and cophylogeny analyses have increased our understanding of these fascinating fungi. Relevant results on the diversity, systematics and evolution of lichenicolous basidiomycetes are presented, together with an outline for future prospects.

## New and old paradigms in photoprotection and photoinhibition of photosynthesis: lessons from algae

#### João Serôdio

Departamento de Biologia, Universidade de Aveiro CESAM - Centro de Estudos do Ambiente e do Mar | Centre for Environmental and Marine Studies, Aveiro, Portugal

Photoinhibition is an unavoidable consequence photosynthesis. Light-induced of oxygenic inactivation of PSII represents a major limiting factor of photosynthesis and primary productivity in both terrestrial and aquatic environments. New paradigms have been proposed to explain the fundamental processes of photoinhibition, namely the relative importance of direct photoinactivation and repair of PSII, and the role of excess light energy vs inactivation of the MnCaO5 cluster as primary mechanisms of PSII photoinactivation. These shifts in paradigms were originally based on research done on specific groups of algae or cyanobacteria, but more recent evidence suggest that these views may not hold when tested against the large functional diversity of the various algal groups. Also older paradigms, long established from plant-based research are currently challenged by experimental evidence from various algae groups. Among these is the photoprotective role of energy dissipation processes (e.g. xanthophyll cycle, XC), guestioned by their small contribution in effectively preventing PSII photoinactivation, and the discovery of fully functional XC-deficient monophyletic group of algae. Current uncertainties reside in part in difficulties in characterizing the large functional, phenotypical diversity present in cyanobacteria photosynthetic algal protists. Ongoing and developments in novel high throughput phenotyping platforms, based on bioimaging of photosynthetic traits, and the growing field of algal phenomics, are promising solutions.

#### Joaquín Hortal

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Departamento de Ecologia, Instituto de Ciências Biológicas, Universidade Federal de Goiás, Goiânia, Brazil

#### Niche, environmental responses, species interactions, biogeographical processes and the dynamics ecological local communities and regional assemblages

Understanding the nature and dynamics of ecological communities is a key guestion in ecology. Evidence points to communities functioning both as relatively deterministic structures shaped by predictable local interactions, or highly dynamic entities determined by the environmentally-driven spatial dynamics of species. I aim at understanding the role of ecological interactions, environmental requirements, metacommunity dynamics and largescale biogeographical processes as determinants of species coexistence across scales. To do this, I study the effects of two aspects of the niche concept (i.e. abiotic conditions and biotic interactions) and spatial processes in different systems through several collaborative research programs. We assess the responses of moss species using field and controlled to study how neutral competitive interactions and responses to environmental conditions determine species occurrence and local success. We also conduct detailed field work on dune xerophytic plant communities, assessing the effects of positive and negative interactions (i.e. facilitation and competition) on the distribution and local co-occurrence of species. Further, we use macroecological analyses and ecological niche models to study how climatic suitability and coexistence with other species determine the local success of each species. Finally, we develop theoretical models based on existing theory on the dynamics of local communities, metacommunities and species' geographic ranges. These models are parameterized based on the aforementioned study systems, with the aim to obtain realistic outcomes from the stochastic simulations. I use the results of empirical analyses and theoretical models to describe the scaling of the different ecological processes that lead to the spatial and temporal dynamics of biodiversity gradients.

## Lichens matter. Exploring the scale of lichens functions and responses in ecosystems

Paolo Giordani

University of Genova, DIFAR, Genova, Italy Do small organisms produce small responses? Is their function in the ecosystem negligible? Being small, but extremely complex organisms, lichens can help answer these questions. During this plenary talk, the known responses of lichens to environmental drivers will be reviewed and their main ecosystem functions will be examined from the micro- to macro-environmental scale. Several research ideas will be proposed for future studies that connect the biological and ecophysiological knowledge on lichens with the investigation of broader ecosystem processes.

systematics & evolution



oral communications

### Species delimitation in the *Tremella ramalinae* complex

#### Alejandro R. Gijón<sup>1</sup>,

Sergio Pérez Ortega<sup>2</sup>, Raquel Pino Bodas<sup>3</sup>, Otto Gockman<sup>4</sup>, Jacob Walden<sup>4</sup>, Ana M. Millanes<sup>1</sup>

 <sup>1</sup> Universidad Rey Juan Carlos, Spain
<sup>2</sup> Real Jardín Botánico, Spain
<sup>3</sup> Royal Botanical Gardens Kew, England
<sup>4</sup> Independent Researcher Species of Tremella s. I. (Basidiomycota, Fungi) grow associated with other fungi, including both lichenized and non-lichenized fungi and are often highly host specific. Taxa growing on lichens often induce characteristic galls or deformations on the host thalli. The lichen genus Ramalina hosts several previously described Tremella species: T. celata Pérez-Ort., Millanes, V.J. Rico & J.C. Zamora, T. ramalinae Diederich and T. tuckerae Diederich. Tremella ramalinae was originally described growing on Ramalina fraxinea and R. lacera, but it has recently been reported on several additional hosts. This, together with some morphological variation, suggests that T. ramalinae could represent a species complex. In this study, we analyze, both molecularly and morphologically, the diversity of Tremella species on Ramalina which appear close to T. ramalinae. Our sampling includes specimens from Europe, Macaronesia and North America growing on different Ramalina species. Species delimitation methods based on two ribosomal DNA markers (ITS rDNA and LSU rDNA) are used to identify independent evolutionary lineages. A phylogeny is estimated to determine the phylogenetic relationships among them. In parallel, we reconstruct molecular phylogenetic hypotheses of the Ramalina hosts, and use cophylogenetic methods to investigate possible events of cospeciation in this association. Our results show that host selection, rather than geography is shaping species delineation in this complex.

## AustralasianHypnodendrales(Bryophyta):addressingunresolvedtaxonomic and phylogenetic questions

#### Diego Sánchez-Ganfornina<sup>1</sup>, Isuru U. Kariyawasam<sup>1</sup>, Mark Hughes<sup>1</sup>, Neil E. Bell<sup>1</sup>

<sup>1</sup> The Royal Botanic Garden Edinburgh, No 20 A, Inverleith Row, Edinburgh, EH3 5LR, Scotland

Bryophytes are highly resilient descendants of the nexus between green algae and tracheophytes. Around 50% of bryophyta (mosses) derive from a rapid radiation in the pleurocarpous orders, which form a monophyletic group defined by a key innovation in reproductive branching. Previous studies identified an the Hypnodendrales, early-diverging order, which presents plesiomorphic characters informative for the evolution of pleurocarpy. A dated phylogeny for the Hypnodendrales based on nuclear and plastid regions confirms its earlydiverging position and generates hypotheses about extinction-driven current diversity. An in-depth study targeting the Australasian Sciadocladus kerrii, S. menziesii, Hypnodendron vitiense and H. marginatum, was undertaken using ITS2 and rbcL. Sciadocladus kerrii and S. menziesii are resolved as monophyletic, concluding past taxonomic uncertainties. Hypnodendron vitiense was found to be taxonomically tortuous and paraphyletic with respect to H. marginatum and taxonomic solutions are investigated. Studied taxa are hypothesised to present an intriguing evolutionary history with unique dispersal pathways.

#### Species boundaries in European species of Inocybe sect. Cervicolores (Agaricales, Basidiomycota) through a multigene phylogeny

#### Fernando Esteve

**Raventós<sup>1</sup>**, Alberto Altés<sup>1</sup>, Lidia Plaza<sup>1</sup>, Ibai Olariaga<sup>2</sup>, Gabriel Moreno Hortal<sup>1</sup>

<sup>1</sup> Dpto. Ciencias de la Vida (Botánica), Universidad de Alcalá, E-28805 Alcalá de Henares (Madrid), Spain <sup>2</sup> Área de Biodiversidad y Conservación, Universidad Rey Juan Carlos, E-28933 Móstoles (Madrid), Spain Inocybe sect. Cervicolores comprises species with a squamulose-tomentose pileus, often reddening flesh, smooth basidiospores and non-metuloid cheilocystidia. Species identification relies strongly on the basidioma odour: a sweet plumlike (I. bongardii), earthy (I. cervicolor), fish-like (I. pisciodora) or pelargonium-like (I. geraniodora) odour are used to identify species within the group. Nevertheless, the odour is subject to variation during development, and may lead to wrong species recognition. Also, the interpretation of some species by early mycologists remains doubtful in the absence of type specimens or detailed odour descriptions. Other morphological characters, such as basidioma size and colour, or spore and cystidial size and shape, have not been drawn much attention as diagnostic, but detailed morphological studies in the light of molecular data have not been carried out yet. In order to assess species limits, we constructed an ITS-LSU-RPB1-RPB2 phylogeny using maximum likelihood and Bayesian approaches in connection with detailed morphological studies. Type specimens available were sequenced for the ITS region to propose correct name interpretations. Based on our analyses, we recognize at least 11 species in Europe and prove that species like I. bongardii, I. cervicolor and I. pisciodora, are often erroneously identified. The I. cervicolor group comprises at least 6 species, while I. calamistrata is actually a species complex that needs to be disentangled.

#### About the presence of the lichen genus *Anzia* in the Canary Islands

#### Israel Pérez-Vargas,

Esther Gaya

The Canary Islands belong to the Macaronesian region, and with large areas protected by the Natura 2000 regulations since 2001 it is listed as one of the top 25 World Biodiversity Hotspots (Myers et al. 2000). A phytogeographical region that is characterized by high levels of biodiversity and endemism across a vast array of organisms (Juan et al., 2000). The lichen-forming genus Anzia Stirt. comprises about 40 foliose species that occur mainly in (sub)tropical areas (Yoshimura 1987, Thell et al., 2012). The genus is poorly represented in Macaronesia, with an isolated species described from the very small island of PortoSanto, A. centrifuga (Haugan 1992), with a very restricted habitat (Sparrius et al. 2017); and a second species recorded from the Canary Islands as A. colpodes (Sánchez-Pinto et al. 1989) that has passed unnoticed for a long time. In this study, we want to elucidate the proper circumscription of this poorly known taxon from the Canaries and the phylogenetic affinities and relationships between macaronesian and nonmacaronesian species of this genus.

## Taxonomy and Phylogeny of Polytrichum sect. Polytrichum (Polytrichaceae; Bryophyta)

#### Isuru Kariyawasam<sup>1,2</sup>,

Neil E. Bell<sup>1</sup>, Catherine A. Kidner<sup>1,2</sup>, Laura L. Forrest<sup>1</sup>, David G. Long<sup>1</sup>

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Polytrichum sect. Polytrichum comprises a well-circumscribed clade.. Within Polytrichum sect. Polytrichum, P. commune s.l. seems to be polyphyletic, representing one or more species complexes with a number of cryptic forms. Two molecular approaches were taken to study the phylogeny of the group. Sanger sequencing approach is conducted with nuclear ITS-2 and two chloroplast markers rbcL and trnL-F. The Sanger phylogeny has resolved the confusion between P. commune var. perigoniale and P. commune s.s. and also the two South American taxa P. brachymitrium and P. ericoides. Moreover, scanning electron microscopy (SEM) of spore characters and other defining morphological characters such as leaf lamellar end cell morphology and capsular characters were helped to delimit the taxa within the section. The type species, Polytrichum commune Hedw., is ubiguitous and ecologically important, having been recognised since pre-Linnaean era even after 200 years after its valid publication, P. commune remains to be typified. The name P. commune has been erroneously used for many morphologically cryptic and pseudocyptic taxa. The "genuine" P. commune concept has been established and a lectotype has been designated from the original material for this name. Other nomenclatural issues linked to allied subspecific taxa were also addressed in this study.

#### Evaluation of three methods for aminoacid substitution model estimation

#### **João Brazão<sup>1</sup>,** Cymon Cox<sup>1</sup>

<sup>1</sup> Centro de Ciências do Mar (CCMAR), Universidade do Algarve, Portugal

Typically, prior-computed empirical amino-acid substitution models are applied in phylogenetics by choosing the best-fitting model. However, applying data-specific substitution models is now a greater opportunity, but is often timeconsuming and therefore requires efficient computational methods. In this study we test the computational efficiently and accuracy of three methods for computing substitution matrices. Data-specific substitution matrices were estimated using P4, PAML, and FastMG using simulated and empirical amino-acids data sets. The simulated data sets were produced with different lengths using a given model and tree. ML trees were inferred under the generated data-specific models and the resulted ML score and topology were used for assessment of these models. Bayesian analyses from P4 took considerably longer, but P4 models showed to be the most accurate, since the resulted ML scores and tree topologies from analyses using the simulated data sets presented mainly the lowest differences to the simulation model and tree. Differently, FastMG models pointed to be the least accurate. Nevertheless, empirical data sets analyses under the FastMG-estimated models were always able to outperform the best-fitting models from previous studies, showing ML score improvements. The three methods although with different features support the estimation of our own data-specific substitution matrices as an efficient and non time-expensive solution.

#### Gametophyte phylogeny and gametophytic character evolution in Pteridaceae subfam. Cheilanthoideae (Pteridaceae, Polypodiopsida): testing cladistic tools for gametophytic data

Fern systematics always looked with interest at gametophytes, but a seemingly low variation in finer traits has led to the view that gametophytic characters are non-useful at low taxonomic levels. In the context of the study the gametophyte of Doryopteris triphylla, a member of the hemionitids within the subfamily Cheilanthoideae (Pteridaceae), we decided to use the gametophytic information to test its phylogenetic utility. The aim of this work is: a) build a phylogeny of the cheilanthoid ferns based on gametophytic characters and compare it with previous molecular phylogenies; b) propose evolutionary hypotheses of gametophytic trait evolution in the group. We selected species representing the following clades: Doryopteris, other heminonitids, and other cheilanthoids. We selected Jamesonia rotundifolia, a non cheilanthoid Pteridaceae. as outgroup. We codified information of 15 gametophytic relevant traits. The matrix analysed by maximum was parsimony. The phylogeny obtained is congruent with previous molecular trees of the cheilanthoids, at least the basic topology at the genus level. We also were able to pinpoint the main events in gametophyte evolution in this lineage. While we are conscious that a better sampling of species and characters is much needed, we show in this work that it is possible to apply cladistic techniques to gametophytic characters, to help understanding and resolving questions about fern phylogeny and evolution.

#### Jose María Gabriel

**y Galán¹**, Andrea Seral¹, Sonia Molino¹, Sofia Ruano¹, Rubén Vázquez¹

<sup>1</sup> Fern Systematics Lab, UCM, Madrid, Spain

### Family and genus delimitation within the Lichinomycetes

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Wedin2, Matthias Schultz<sup>3</sup>

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Pflanzenwissenschaften und Mikrobiologie IPM, Universität Hamburg
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Hamburg, Germany Lichinomycetes, with ca. 350 species distributed worldwide, is a poorly understood but ecologically important lichen-forming fungal group. Together with the Coniocybomycetes they constitute a clade distantly related to the main lineage of most lichenized groups, the Lecanoromycetes. The natural relationships and character evolution in the Lichinomycetes are still very poorly understood and, both generic and family delimitation are major challenges within the group. The delimitation of the Class has also been demonstrated to remain unsettled as shown with the recent exclusion of the genus Lichinodium and its inclusion in the Leotiomycetes, a group thought to be exclusively composed by fungal species until now. Main diagnostic characters as the type of photobiont, thallus morphology and anatomy, ascoma ontogeny and ascus structure can occasionally overlap, be ambiguous or symplesiomorphic and cannot be used to delineate natural groups. Thus, the main aim of this study is to propose a natural classification of the group combining molecular, morphological and ecogeographical data. For this purpose we developed a 3-gene phylogeny (mtSSU, mcm7 and RPB2) including a dataset covering a broad selection of taxa within the Lichinomycetes and studied character evolution of selected traits and photobionts. As a result we propose a well-supported systematic treatment of the Lichinomycetes.

### Revisiting the concept of indusia in the Blechnaceae (Polypodiopsida)

#### María Vicent<sup>1</sup>,

Jose María Gabriel y Galán<sup>2</sup>, Carmen Prada<sup>2</sup>, Andrea Seral<sup>2</sup>, Sonia Molino<sup>2</sup>, Rubén Vázquez<sup>2</sup>

 Faculty of Pharmacy, Universidad Alfonso X El Sabio, Madrid, Spain
Ferns Systematics Lab, Unit of Botany, Department of Biodiversity, Ecoology and Evolution, Faculty of Biology, Universidad Complutense de Madrid, Spain

Blechnaceae is a leptosporangiate fern family (250 species in 25 genera) with subcosmopolitan distribution. In the classic description of the family, blechnoid ferns are treated as plants with monomorphic to dimorphic fronds, presence of linear sori, usually continuous or nearly so, and protected by elongate introrse indusia (rarely exindusiate), among other characteristics. We are conducting an anatomical survey of the fertile fronds in the family, and the results are surprising. In this work we will focus in a character that, under our perspective, should be renovated or at least questioned for the family: the concept of indusia. We have detected that the presence of typical indusia actually is an exception in this family: most of the dimorphic genera (for example Parablechnum, Lomariocycas or Lomaridium) present complex structures with indusial function, i.e. "lamina"-like structures with complex anatomy, protruding from flat contracted pinnae and with cell differentiation between adaxial and abaxial surfaces. There are other cases in which the indusia are heavily enrolled, such as Spicantopsis, Salpichlaena or Lorinseria. And even so, in Austroblechnum, the fertile fronds have strongly revolved pinnae, whose margins are very much displaced with respect to the costa. These pinnae can bear laminar, typical indusia but small, vestigial and non-functional, being possible the fact that we should be talking about the presence of a pseudoindusia.

#### Further information about origins and evolution of the fern *Asplenium x arantohanum*, a rare hybrid endemic to the Iberian Peninsula

#### Pablo de la Fuente<sup>1</sup>,

Sonia Molino<sup>1</sup>, Andrea Seral<sup>1</sup>, Jose María Gabriel y Galán<sup>1</sup>, Luis García Quintanilla<sup>2</sup>, Emily Sessa<sup>3</sup>

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Asplenium is one of the most diverse genera of ferns in the Iberian Peninsula, and its proneness to hybridization and polyploidization maybe one of the most important factors to explain this fact. Two common species in this region are A. trichomanes and A. billotii, which show similar ecological requirements and can often be seen growing in the same rocks. Given the ease of hybridization in Asplenium, it might be thought that an hybrid between these two plants would be common, but it is in fact extremely rare, and only three individuals have been detected so far. This hybrid has been called A. x aran-tohanum. One of the three known individuals was found in Madrid, from which we carried out a genetic study, certifying that the maternal origin of the hybrid was A. billotii. After this first approach, we had the opportunity to study material from the other two individuals; therefore a more exhaustive survey was made about the origins and evolution of the hybrid, including: 1) the certification of maternal origin in all cases, which was unilateral; 2) the observation of viability of the spores and later in vitro sowing that lead to growth of gametophytes, and that could suggest that the hybrid may have offspring, and from this fact: 3) a study was made to prove the single or multiple origin of the taxon; also with these data in mind: 4) a molecular dating of the parental taxa was created, to calculate from which moment this hybrid could have been formed back in time.

#### Análisis filogenómico del orden Ceramiales (Rhodophyta): implicaciones para la clasificación

#### Pilar Díaz Tapia<sup>1</sup>,

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<sup>3</sup> Portaferry Marine Laboratory, Queen's University Belfast, Belfast, Northern Ireland El orden Ceramiales incluye un tercio de la diversidad de algas rojas (ca. 2700 especies). Tradicionalmente se ha clasificado en cinco familias en base a estudios morfológicos. Sin embargo, los primeros estudios filogenéticos basados en uno o dos genes evidenciaron importantes problemas para resolver la mayoría de esas familias como monofiléticas, así como resolver las relaciones filogenéticas para entre los principales linajes. En base a esas filogenias, la familia Ceramiaceae se dividió en cinco familias, mientras que las familias Delesseriaceae y Dasyaceae se dividieron en tres y dos subfamilias, respectivamente. El objetivo de este trabajo es resolver las relaciones filogenéticas entre los principales linajes del orden Ceramiales y reevaluar su clasificación a nivel de familia. Para ello secuenciamos y anotamos 28 genomas nuevos plastídicos que se combinaron con los 53 genomas previamente publicados, incluyendo especies representativas de los principales linajes del orden Ceramiales. Los 208 genes del genoma plastídico se alinearon y se emplearon para construir un árbol filogenético de máxima verosimilitud que resolvió la mayor parte de los nodos con valores de bootstrap de 100%. Las familias Rhodomelaceae, Ceramiaceae y Wrangeliaceae se resolvieron como monofiléticas y proponemos mantener su circunscripción actual. Por el contrario, familias Callithamniaceae. Dasvaceae. las Delesseriaceae, Sarcomeniaceae, Spyridiaceae e Inkyuleeaceae necesitan ser revisadas.

#### Systematics of the genus *Lomaridium* C. Presl (Blechnaceae, Polypodiopsida): preliminary results

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Lomaridium C. Presl. is a Blechnaceae fern genus, created in 1851 and resurrected by Gasper in 2016. It comprises above 15 species of hemiepiphytic plants that occur on tropical and intertropical rainforests. Its main geographical distribution regions are in America and in Africa-Indic, with a single species occurring on New Caledonia and Lord Howe Island (Oceania). Traditionally, this genus has been systematically interpreted by traits like the type of rhizome scales (denticulate or entire, bicolorous or concolorous), presence and number of vestigial auricles proximally on the sterile blade, and adnate pinnae with basal portion truncate, falcate or narrowed. There is some partial taxonomic information available, although some classification problems persist, like the morphological separation of some species along with a good definition and delimitation of the type species of the genus. A first approach to its phylogeny and biogeographical history has been performed, with not all species included; also, there are some taxa of another Blechnoideae genera proposed to be in Lomaridium instead by new molecular studies, whose anatomical traits have not been checked. We are studying most of these species, giving them a first morpho-anatomical treatment and adding their sequences to phylogenetic trees for the first time.

#### Approximation to solve the systematics of the complex *Parablechnum cordatum* (Blechnaceae, Polypodiopsida)

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The genus *Parablechnum* is the largest in the family Blechnaceae with 66 species. It occurs in tropicalsubtropical America, Austropacific and South Africa. The classification of the genus may not be reliable enough due to the lack of a complete phylogeny and the lack of consensus among authors, as not all consider the same number of species. This is the case of the complex Parablechnum cordatum. Parablechnum cordatum, P. chilense and P. schiedeanum are 3 similar species which are difficult to discriminate by classical taxonomical characters, so they have been treated as different species by some authors and as synonyms of P. cordatum by others. First molecular approaches show that they could be different species. In addition, some other taxa are similar to these species and, in our opinion, deserve further research. This is the case of *P. falciforme*, which is accepted as a different species but has morphological features that resembles plants of this complex. Also, Blechnum varians, which has been treated as a synonym of *P. schiedeanum* and thus has not been included in the new classification but presents some characters that make it somehow easy to separate it morphologically from the rest. Our aim is to complete the molecular study with more samples including P. falciforme and B. varians and make a morphological and anatomical study which provides taxonomic characters to discriminate the different species within the complex.

poster communications

#### Widespread stomatal degeneration in the pleurocarpous moss family Brachytheciaceae

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The presence and morphology of stomata in the moss capsule is often recorded as a taxonomical character, although its usefulness depends on the group considered. In the course of a revision of the genus Brachythecium s.l., we have been observing a striking high frequency of degenerating stomata, with guard cells showing shape alterations and disrupted, reddish cell content. This is a rarely recorded phenomenon in mosses, and as its significance is unclear, we decided to extend the study to the whole family Brachytheciaceae. Here we present our observations on 16 species belonging to 8 genera of Brachytheciaceae, with the addition of two external species: Nogopterium gracile (fam. Leucodontaceae) and Hypnum cupressiforme (fam. Hypnaceae). Using both herbarium and freshly collected samples, we dissected 5 capsules per species, and recorded the status of all stomata present. Our results indicate that stomatal degeneration, even in immature and submature capsules, is a widespread, common feature in the family Brachytheciaceae. Stomata showing at least degree of degeneration is usually some and complete degeneration, above 30%, mostly well over 10% (in B. salebrosum, as high as 70%), whereas in Nogopterium and Hypnum it affects only 1-3% of the stomata. This previously overlooked character raises questions on the stomata functionality in these mosses, and on the use of precocious degeneration as a distinctive feature in the group.

#### Ontogeny of internal cephalodia in the lichen *Ricasolia virens* (With.) H.H. Blom & Tønsberg, a novel research

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"Cavanilles" de Biodiversidad y Biología Evolutiva, Botánica, Fac. CC. Biológicas, Valencia, 46100 Burjassot, Spain The ontogeny of internal cephalodia were investigated on fresh thalli of Ricasolia virens using O.M., epifluorescence, SEM and TEM techniques. *R. virens* shows different anatomical features in both cortex, the lower one is covered by a feltlike covering of downy hyphae ("tomentum"). Cephalodiaoriginatefromcontactbetweenhyphae and cyanobacteria on the paraplectenchymatous lower cortex, being initiated in small concave portions and enabling the development of them owing its plasticity. Consortia of cyanobacteria can be observed between the tomentum hyphae. The cyanobacterial inclusion process begins with cortical hyphae growing out towards adjacent cyanobacterial colonies, wrapping them up and incorporating them into the thallus. This intrusive process is accompanied by a fast division of cyanobacteria cells. Finally, developing cephalodia reach the center of the thallus bulk continuing its growth there. Simultaneously, various mycobiont hyphae, contiguous to the cephalodium, spread through the sealing area and reconstruct the lower cortex. Cephalodium growth crops a disappearance of the phycobionts layer (Dictyochloropsis reticulata) in the upper region thereof. At the end of the development process some of them make appear a slightly concave degeneration structure in the upper cortex called "ostiole". Cellular organization of these ostioles is analogous to that of the pycnidia found in other Lobaria species.

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### Hongos liquenícolas de Isla Livingston (Antártida)

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Se han estudiado 23 localidades antárticas situadas en Isla Livingston (Antártida) con el objetivo de revisar la importancia de la flora liquenícola en estos ecosistemas, hasta el momento apenas estudiada en el continente. encontrado unos 100 taxones Hemos liguenícolas, de los cuales alrededor de 20% eran desconocidos y se nombrarán en el futuro; algunos de ellos necesita incluso la creación de géneros nuevos. Otras 47 especies se han recopilado de la bibliografía, por lo que alrededor de 150 taxones componen el catálogo actual antártico. La capacidad fúngica (Etayo & Sancho 2008) de los líquenes hospedantes ha sido establecida por primera vez en el continente. El género más importante en este apartado, con gran diferencia respecto a los siguientes, fue Usnea (con 23 hongos liguenícolas), curiosamente varios hongos pueden encontrarse en Usnea y también en su más abundante hongo parasimbionte: Phacopsis usneae. En segundo lugar se encuentran Psoroma y Ochrolechia (con 8) y Caloplaca s.lat. y Cladonia (con 7). Lecania, Lecanora, Mastodia, Pertusaria, Physcia v Rhizoplaca presentan 4 taxones cada uno. Siete hongos y líquenes de amplio espectro pueden colonizar varios líquenes o vivir autónomamente sobre ellos. Otros 34 géneros de líguenes presentan al menos una especie liguenícola.

#### Study of the gametophytic phase of *Diplazium caudatum* (Athyriaceae, Polypodiopsida)

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<sup>1</sup> Unit of Botany, Department of Biodiversity, Ecology and Evolution, Faculty of Biology, Universidad Complutense de Madrid. Avenida Jose Antonio Nováis, 12. 28040-Madrid, Spain The gametophytes of the Athyriaceae are not very well known, with many species yet to be described, such as Diplazium caudatum. The aim of this work is to analyze the gametophytic phase of this species, which includes, germination study, morphological development and reproductive phase. Spores belonging to two different sporophytes from Spain, Canary Islands, have been mixed and sown in multisporic cultures. Plates have been cultured in chambers with nutritive agar at 25°C and 12 hours photoperiod. The germination was registered every three days, and the main vegetative and reproductive development was checked throughout the observational period. The germination rate reached a maximum of 58%. The spore germination followed a Vittaria pattern meanwhile prothallial development followed an Adiantum pattern (with a tendency to delay the growth of the meristematic cell) or almost Drynaria type. The adult gametophytes were totally unisexual, all of them developed as females, and no antheridia were detected in any individual. In addition, vegetative proliferations appeared on most of the prothalli.

#### Molecular study on the genus Schistidium (Grimmiaceae, Bryophyta) in the South of the Iberian Peninsula

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The study of relevant morphological characters in a large number of samples of all the species of the genus Schistidium Bruch & Schimp., present in the south of the Iberian Peninsula, allowed perceiving incongruities that suggested the existence of unknown or undescribed taxa. The lack of molecular data of the species reported in the south of the Iberian Peninsula led us to undertake a phylogenetic study in order to show the interspecific relationships and confirm the results of the morphological study. For this study was used the rDNA ITS1-2 region. This region had already been used in several works on phylogeny of Schistidium, in such a way that sufficient data were available for a complete study. The results obtained show the necessity of the present study, since a new specie was described, Schistidium convergens J. Guerra & M.J. Cano. In addition, has been confirmed the presence in the Baetic System of S. brunnescens Limpr., S. flaccidum (De Not.) Ochyra, S. confertum (Funk) Bruch & Schimp., S. helveticum (Schkuhr) Deguchi, S. atrofuscum (Schimp.) Limpr. and S. crassipilum H. H. Blom. By other way the presence of S. pulchrum H. H. Blom (cited in Sierra Nevada Mountains) and S. apocarpum (Hedw.) Bruch & Schimp. has been discarded because they had been confused with the new species. The isolated populations of conflicting taxa are still being studied from the point of view of their taxonomic identity.

#### *Physcia* (Physciaceae, Caliciales) from Mato Grosso do Sul state, Brazil: ten new records and two new species

#### Natália Mossmann

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Physciaceae is the ninth largest family of lichenized fungi. For the state of Mato Grosso do Sul (MS), ten genera and 45 species are known. Physcia, with about 80 known species, is the second largest foliose genus of Physciaceae and in Brazil it is represented by only 30 taxa (28 species and two varieties), being only seven species recorded for MS. The objective of this work was to provide a floristic inventory about Physcia from MS (in natural and urban areas). Fresh specimens were collected in 72 localities and were deposited in CGMS herbarium. Furthermore, all Physcia specimens previously housed at CGMS and COR herbaria were also studied raising the total sampled localities to 81. The specimens were analyzed morphologically, anatomically and chemically. From the 16 species found, six are new records for MS, three are new records for Brazil, one species is a new finding to the Neotropics and two species are proposed as new to science. These data indicate that the diversity of *Physcia* has been underestimated, since our results showed an addition of 128% of this genus diversity for MS and 20% for Brazil. Physcia aipolia and P. rolfii showed an extensive distribution, being found in Cerrado, Chaco and Pantanal and in natural and urban areas, while P. kalbii was growing only in two Cerrado areas. Finally, P. crispa occurred only in Pantanal. Studies dealing with other genera of Physciaceae can potentially bring similar results.

#### DNA Barcoding of *Parmotrema* s.*l.* (Parmeliaceae) in the Atlantic Rain Forest of the extreme south of Brazil

#### Natália Mossmann

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<sup>1</sup> Universidade Federal de Mato Grosso do Sul – UFMS, Brazil The internal transcribed spacer region of the ribosomal DNA (ITS) has been largely used as a tool for the identification of lichenized fungi. However, its use becomes challenging where there are few sequences available for comparison. The present work was based in an integrative approach combining morphological, chemical and phylogenetic analyses to discriminate species of Pamotrema s.l., a high diverse genus in the southern region of Brazil. Sampling was made in areas of restingas (coastal vegetation from the Atlantic Rain Forest), extreme south of Brazil. DNA extraction, amplification and sequencing of the ITS region were performed. Phylogenetic analyses were based on sequences generated by us and from GenBank. Bayesian inferences were used to test monophyly, and genetic distances calculated and compared with the values proposed for Parmeliaceae. In total, 128 specimens were examined, 40 ITS sequences were generated, representing 23 species. Sequences from ten of these species were found in GenBank, though only P. tinctorum was considered conspecific. P. austrosinense, P. haitiense, P. clavuliferum, P. praesorediosum and P. pilosum grouped to conspecific sequences, but with higher divergence intraspecific. Three species with different reproductive forms and chemical compounds were genetically indistinguishable. Additionally, seven new species to science were discovered. From our results, we reinforce the need of local databases for the successful use of DNA barcoding.

#### Illumina assay reveals habitat/location as the main factor driving microalgal diversity in *Ramalina farinacea*

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 <sup>2</sup> University of Trieste, Department of Life Sciences, via L. Giorgieri 10, 34127 Trieste, Italy Lichens provide interesting and poorly known habitats (microecosystems) for many other organisms besides the traditionally considered as unique lichen symbionts: a mycobiont and one photobiont. The current literature reveals that the coexistence of multiple microalgal taxa in lichens is more common than previously thought. Ramalina farinacea (L.) Ach. has proven to be suitable model to study this multiplicity due to the constant coexistence of at least two microalgae species (Trebouxia sp. TR9 and T. jamesii) in long-distant populations. In 2017, we analyzed the microalgal diversity and its community structure in the lichen R. farinacea applying a 454 pyrosequencing approach. In addition to corroborating the coexistence of *Trebouxia* sp. TR9 and T. jamesii taxa in the same thallus, this study showed a much higher microalgal diversity associated with this lichen. Along the thallus laciniae, we also detected variations in phycobiont distribution that might correlate with the apical growth and founder effects. These results were the background to perform an Illumina pairedend assay to go into detail about the microalgal diversity performing an accurate sampling. In this study we show interesting results used to analyse the different factors influencing the microalgal diversity inside Ramalina farinacea thalli. PCoA analyses have stated the habitat/ location as the main factor driving the microalgae arrangement.

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### Contenido de ADN y modelo nuclear en el género *Plocamium* J.V. Lamouroux

#### **Rafael Pablo Martín**

**Martín,** Rubén Solsona Mayor, Amelia Gómez Garreta, Jordi Rull Lluch

El contenido de ADN nuclear es un carácter fundamental en biología, utilizado en filogenia v biogeografía. No obstante, para macroalgas solo hay valores para menos del 3 % de los taxones conocidos, según la base de datos de este parámetro del Real Jardín Botánico de Kew (http://www.rbgKew.org.uk/cval), entre los que no existe ninguna especie del género Plocamium J.V. Lamouroux. En este trabajo se presentan los valores de este parametro en P. cartilagineum (Linnaeus) P.S. Dixon y P. maggsiae G.W. Saunders & Lehmkuhl procedentes de distintas localidades (Antártida, Atlántico y Mediterráneo). Además, se describe el modelo nuclear que presentan estas especies. La cuantificación se ha realizado mediante fluorometría, utilizando DAPI (4', 6-diamidino-2-phenylindole) como marcador del ADN y eritrocitos de Gallus gallus (Linnaeus) como patrón de contenido nuclear estable, y análisis informático de las imágenes obtenidas. En cuanto al modelo nuclear, se ha confirmado la presencia observada por Goff & Coleman (1990) de células axiales con un núcleo poliploide acompañado de pequeños núcleos y células pericentrales con numerosos núcleos pequeños. Por el contrario, se ha observado que la célula apical posee un núcleo poliploide, y gran cantidad de núcleos pequeños que habían sido observados hasta el momento. Para el contenido de ADN nuclear, se han observado núcleos de ploidía 2C, 8C, 16C y 32C. El valor mínimo, corresponde a 2C, siendo 0,05 pg y el más elevado, de 32C, siendo 0,8 pg.

#### Morpho-anatomical observations towards a global understanding of the genus *Cranfillia* Gasper & V.A.O. Dittrich (Blechnaceae, Polypodiopsida)

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Cranfillia Gasper & V.A.O. Dittrich is a Blechnaceae fern genus, which comprises currently 12 species, three of them occurring in the neotropics and the rest in Oceania. This genus is very poorly known, since it has been created recently and only relating its species with molecular traits. The scarce morphological works with some Cranfillia species have noticed a great variation in macromorphological features, which could be pointing to an entity of dubious circumscription. However, phylogenies performed to date seem to support these relationships, showing in Cranfillia two main clades; one with 4 members in New Zealand, New Caledonia and South America, and probably having one single species in Africa revealed by new phylogenies. The other main clade comprises around 5 species with an indo-pacific distribution; there are at least three species which are not included in phylogenies yet. We are trying to provide new anatomical data to relate the taxa of the genus. In this work, we will show our first results and observations to a global morphoanatomical treatment for the genus.

#### Breaking a lichen relationship: looking at the mycobiont when the photobiont has gone

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Many authors tend to consider lichens as a form of controlled parasitism, mainly due to observation of parasitic behaviors of the mycobiont in re-synthesis experiments with incompatible algae. Moreover, saprophytism is a form for the mycobiont to supply carbon in case of insufficient production by the algal partner in nature. Accordingly, we hypothesized that facultative saprophytism in the mycobiont can be stimulated by the death of the photobiont: deprived of its carbon source, the fungus could survive for some time degrading the algal cells and feeding on them. In a laboratory experiment, the photobionts of Xanthoria parietina and Parmotrema hypoleucinum were either killed or inhibited through application of herbicide or incubation in the dark, respectively, to induce starvation in the fungus. Measures of vitality indexes in both the lichen partners and of extracellular enzymatic activity in the mycobiont did not indicate a shift to saprotrophic lifestyle in the lichen fungus after a month in the experimental conditions. However, our results showed a functional supply of degrading extracellular enzymes in the mycobionts of the two lichen species, each one with a unique profile. This suggests that, in certain conditions, parasitic/saprophytic modes of nutrition can be relevant for the sustenance of the mycobiont or even of the lichen association.

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#### Study of the gametophytic phase of *Amphineuron immersum* (Thelypteridaceae, Polypodiopsida)

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The gametophytic phase is a stage in the life cycle of a fern that is generally guite unknown especially in some species with tropical distribution such as those of the family Thelypteridaceae. The aim of the work is to describe this phase of the tropical species Amphineuron immersum, with a distribution in the islands of Southeast Asia and North Oceania, which includes the germination rate and morphological study of each of the most important phases of development. For this purpose, spores were extracted from a single specimen and spores were sown in Petri dishes with nutritive agar at 22°C, with a photoperiod of 12+12 hours. The germination rate was recorded every three days counting one hundred spores randomly. In less than three weeks a germination rate of 47% is reached, being the germination pattern of the Vittaria type. The ontogenetic development model conforms to the Drynaria type. The adult gametophyte reaches the cordated-thalloid form by the fourth week presenting abundant simple, unicellular secretory hairs on both surfaces and all over the margin. The majority of the prothalli are unisexual, with the females developing first. Female gametophytes have been shown to produce anteroidiogen. In addition, older gametophytes present vegetative reproduction.

#### Sporangia and spores as characters to support the separation of *Spicantopsis* and *Struthiopteris* (Blechnaceae, Polypodiopsida)

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Following a multi-character study of the fern genus Struthiopteris, a small genus of the family Blechnaceae, it has been demonstrated that it constituted a paraphyletic group, and to solve this problem the genus Spicantopsis was resurrected. Thus, right now there are three species within Struthiopteris: S. castanea, S. fallax and S. spicant, the latter with 2 varieties recognised in the Iberian Peninsula, S. spicant var. homophyllum and S. spicant var. pradae. The rest of the species are now in Spicantopsis: S. amabilis, S. niponica and S. hancockii. Spicantopsis niponica has an accepted variety, S. niponica var. minima. In that study, apart from the molecular evidence, some morphological and anatomical features that support the separation of the 2 genera were presented, as the anatomical section, the stomatal pattern, the color of the petioles and the spore morphology. Since spore and sporangia characters have been widely used by the pteridologists in taxonomy, we decided to carry on a broader study of these traits in this group, using both electronic and optical microscopy. We have noticed that the best characters to separate both genera regarding spores are perispore structure and ornamentation. Sporangia also provides valuable information, mainly the number and the thickness of lip cells, which notably differ between both genera. In addition, we got full descriptions of the spores and sporangia of Struthiopteris and Spicantopsis, which were lacking in most of the taxa.

physiology & ecophysiology



#### Adaptations to environmental stresses: the case of *Seirophora villosa* (Ach.) Frödén

#### Elisabetta Bianchi<sup>1</sup>,

Ilaria Colzi<sup>1</sup>, Andrea Coppi<sup>1</sup>, Paolo Giordani<sup>2</sup>, Cristina Gonnelli<sup>1</sup>, Lorenzo Lazzaro<sup>1</sup>, Stefano Loppi<sup>3</sup>, Luca Paoli<sup>4</sup>, Alessio Papini<sup>1</sup>, Andrea Vannini<sup>3</sup>, Renato Benesperi<sup>1</sup>

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<sup>4</sup> Department of Biology, University of Pisa - via L. Ghini 13, 56126 Pisa, Italy Seirophora villosa is strictly associated with coastal juniper habitats and could be used as an indicator of their status of conservation. This study aimed to evaluate how light regime and water availability affect individual specimens of S. villosa, by studying the relationship between photosynthetic activity and water content in thallus areas of different thalli sizes. Furthermore, we investigated the role of the thin tomentum on thallus surface characterizing S. villosa to withstand the effects of seawater by continuous exposure to marine aerosols. Our results showed that the size of the thalli influence the water retention capacity of S. villosa species, and consequently influence responses to strong exposure to light. S. villosa are susceptible to sudden increases in light exposure, especially in the case of small specimens, which after photoinhibition exhibited a reduced ability to recover. Our work evidenced the relevance of hairs as a strategic morphological trait. Hairs could offer a passive, but selective, water control. Hairs could repel the salt dissolved in water, by activating a passive resistance mechanism, which by not allowing salt to enter, allows the thallus to tolerate the presence of salt. In brief, considering that light regime, water availability and high salt concentrations are generally the main ecological factors modified by habitat fragmentation, an incorrect management of dune systems could be detrimental to the survival and establishment of this species.

#### Which is the role of state-transitions in the photoprotection of lichen phycobionts during desiccation/rehydration cycles?

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Lichens employ photoprotective several mechanisms to avoid the formation of reactive oxygen species during desiccation/ rehydration cycles. It has been demonstrated that chlorolichens can activate the xanthophyll cycle and alternative guenching mechanisms -specific of poikilohydric organisms- in response to desiccation. However, little is known about the role of the state-transitions (ST) of photosystem II (PSII) light-harvesting complexes (LHCII). LHCII detachment from PSII reaction centres is induced by the over-reduction of the PQ pool via reversible phosphorylation of LHCII. We have studied the activation of ST in isolated phycobionts employing chlorophyll fluorescence, immunoblot analysis and phosphatases inhibitors. The results indicate that LHCII are not phosphorylated during desiccation, only after rehydration. The inhibition of LHCII dephosphorylation increases the non-photochemical guenching and decreases the photochemical yield of PSII. Probably, detached-LHCII could form aggregates able to dissipate the excess of excitation energy. This mechanism might prevent the damage of the photosynthetic machinery of lichen phycobionts during the first stages of rehydration when the electron transport chain is still impaired and the Calvin cycle is not fully active.

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#### Quantification of nitrate reductase enzyme activity in *Ramalina farinacea* and its isolated phycobionts

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NO is a key molecule in cellular functions, such as plant growth, defence against pathogens and tolerance to abiotic stress, among others. It is also involved in the establishment of important symbioses like Rhizobium-legume, plant-mycorrhizae and corals. In lichens, NO release and reactive oxygen species (ROS) increase during rehydration and in presence of heavy metals. We observed that NO inhibition increases ROS release during rehydration in Ramalina farinacea and its isolated phycobionts. Part of NO production can be catalysed by nitrate reductase (NR). Experimental inhibition with tungstate increases catalase activity and leads to oxidative stress. This enzyme has been studied in plants and macroalgae but not in lichens. We hypothesize that lichen NO synthesis may be partly mediated by NR. Our objectives were to quantify both the plant-like NR (EC 1.6.6.1) activity and protein levels in *R. farinacea*. A specific protocol for activity was designed using the Griess method for the indirect measurement of nitrite. The value found for plant-like NADHdependent NR specific activity in R. farinacea is in the µU/mg protein range, lower than specific activity reported for the chlorophyceae Ulva intestinalis but similar to the bryophyte Physcomitrella patens values and in the same order of magnitude as some rhodophytes and Arabidopsis thaliana. Immunodetection of EC 1.6.6.1 NR isoform by Western blot showed the presence of multiple precursors and degradation products.

### What might be the early function of the phytochelatin synthase enzyme?

#### Luigi Sanita' di

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 <sup>2</sup> Dipartimento di Biologia, Università di Pisa, via Luca Ghini 13, 56121 Pisa, Italy The phytochelatin synthase enzyme (PCS) is constitutively expressed in the majority of plants, other eukaryotes and certain cyanobacteria. In the presence of metal(loid)s (i.e., Cd, Pb, Hg, As, etc.) eukaryotic PCSs are activated and produce the so-called "phytochelatins" (PCn), thiolpeptides able to segregate the above metals in the vacuolysosomal compartment. However, the constitutive expression of the PCS enzyme throughout the plant clade, even in the absence of toxic metal(loid)s, would lead us to postulate other possible functions of this enzyme. Iron (Fe) has always been widely c in all environments, but, at the same time, its scarce solubility and bioavailability pose serious problems for the vast majority of organisms. Thus, we hypothesise that PCSs and PCn might not only plays the "classic" role directed to Cd detoxification, but also possesses a function geared towards the homeostatic control of physiological requirements of Fe. To this end, our work deals with molecular and functional characterisation of PCSs in early organisms, such as the charophyte Nitella mucronata, the liverworts Lunularia cruciata and Marchantia polymorpha, the moss Leptodyctium riparium, the lycophyte Selaginella denticulata, as well as some cyanobacterial strains (Geitlerinema sp., Gloeobacter violaceus, Nostoc sp.). The results would allow us to achieve comparative characterisations of ancestral PCSs and further clarify their functions in a number of photoautotrophic organisms.

## Characterization of extracellular components in dessication-tolerant lichen microalgae

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One of the most distinctive features of desiccation-tolerant plants is the high flexibility of their cell walls. Most lichen microalgae are tolerant to drastic conditions of dehydrationrehydration (D/R), however, their mechanisms of D/R tolerance are scarcely known. Apart from its cell walls, the extracellular polysaccharides substances (EPS) have an important role to protect from abiotic or biotic stresses as desiccation. We tested the hypothesis that differences in D/R tolerance among lichen algae could be due to differences in EPS composition, which in turn could be remodeled by exposition to D/R. We extracted the EPS from isolated Trebouxia sp. TR9 (TR9, adapted to rapid D/R cycles) and Coccomyxa solorinae-saccatae (Csol, adapted to seasonal dry periods), exposed to 0 or 4 cycles of D/R. Thereafter, we analyzed the molecular profile of neutral and anionic (e.g. uronic acids and S-sugars) polysaccharides by liquid chormatography (Sepharose 4B, Q-sepharose). Each alga showed a characteristic molecular profile of neutral and anionic polysaccharides, which changed after cyclic D/R. Interestingly, only TR9 EPS contained significant amounts of sulfated polysaccharides, which were strongly induced by D/R, as confirmed by specific stain in agarose and polyacrylamide gels. Our results suggest that the extracellular matrix is a dynamic component that play an important role in D/R tolerance of lichen algae.

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## Facilitation effects of moss vegetative shoots and spores on *Dicranum* germination and early development

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The colonization and establishment of a moss community is known to be constricted by both biotic factors, of which the interactions with other bryophytes may play a major role. Nevertheless, the occurrence and extent of these effects is not very well known in bryophytes. We have adjusted the sandwich in vitro culture technique, that was designed to assess allelopathic effects in vascular plants, and checked the inhibitory effects of spores and vegetative shoots on the spore germination and early development of Dicranum scoparium Hedw. Surprisingly, the protonematal development of Dicranum is apparently promoted by the presence of other mosses. In at least two species (Hypnum cupressiforme Hedw. and Tortula muralis Hedw.), the positive effect was triggered by spores and shoots as well as by only an aqueous extract of the shoot exudates. In contrast, positive intraspecific effects (in cultures of shoots and spores of Dicranum with its own spores) are not so apparent. The water-soluble substance mediating the positive effects of different species on Dicranum spores is unknown as yet, but the addition of vitamins, auxins (NAA), or sacarose, did not result in a similar enhancement. Our results suggest a rare case of development facilitation, here in juvenile stages of mosses. This phenomenon could be a successful competition strategy of Dicranum spores that may enable them to benefit from their potential competitors.

### Is ABA involved in the responses of the symbiotic green microalga *Trebouxia* sp. TR9 to dehydration?

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Although tolerance to abiotic stresses have been thoroughly studied in plants and, to an extent, freeliving microalgae, experimental data regarding stress on symbiotic lichen microalgae is scarce to non-existent. Since lichen phycobionts are capable of enduring harsh, restrictive and rapidly changing environments, they are interesting candidates to study the metabolic machinery operating under these extreme conditions. Previous results obtained exposing to high salt concentrations the symbiotic phycobiont Trebouxia sp. TR9, isolated from the lichen Ramalina farinacea, revealed that this organism displays a rather different molecular response compared to land plants and free-living halophile microalgae, with no noticeable increase in ABA levels and ABA-related gene expression until the external NaCl concentration raised 3 M NaCl (Hinojosa-Vidal et al., Planta, 248: 1473-1486 2018). However, the ABA transduction pathway seems functional, given that the ABA-related genes tested are responsive to exogenous ABA. Since in its natural environments lichens are often subjected to dehydration we are now analysing the behaviour of Trebouxia SD. TR9 under mannitol induced osmotic stress conditions. We are trying to find out whether this symbiotic green microalga uses the ABAdependent pathway or develops alternative strategies to cope with highly dehydration.

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### Ecophysiology studies on different strains of *Coolia monotis* from the Portuguese coast

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The genus Coolia Meunier is considered potentially toxic genus of epibenthic а dinoflagellates that co-occurs with species of other harmful genera such as Amphidinium Claparède & Lachmann, Prorocentrum Ehrenberg, Ostreopsis Schmidt and Gambierdiscus Adachi & Fukuyo. Coolia monotis Meunier, the type species of the genus, is frequently found on different substrates such as macroalgae and sediments. Its geographic distribution is restricted to the Mediterranean Sea and the North Atlantic, unlike other species of *Coolia* that have a transoceanic distribution. So far, not much is known on the physiology of species in the genus Coolia. The presentworkinvestigatestheeffectoftemperature (15°C and 19°C) and light intensity (20-30 and 120-145  $\mu$ mol photons m<sup>-2</sup> s<sup>-1</sup>) on the growth and photophysiology of distinct strains of C. monotis isolated from different sites along the Portuguese coast. Several parameters were analysed namely growth characteristics, photophysiology and photosynthetic pigment composition. For growth characterization, two methodologies were compared (in vivo fluorescence and cell counts). Results indicate significant differences between strains and treatments. Strains acclimated to low light showed a better photophysiology than the ones of high light, indicating to be a dark-adapted species. Furthermore, for each treatment, a consistent relationship between cell number and in vivo fluorescence was observed. The in vivo fluorescence in C. monotis showed to be a fast and reliable methodology to follow growth rate.

### A multidisciplinary approach to the lichen-nitrogen relation

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Sensitivity to nitrogen is one of the most used lichen functional traits in bioindication. However, although the numerous observations in the field and experiments in the laboratory, the lichen-nitrogen relation is still not completely understood. Here, I use a multidisciplinary approach to the question presenting a synthesis of ecological, physiological and molecular results. Results of a proteomic analysis conducted on the species Cladonia portentosa showed how at the molecular level different nitrogen forms affect different metabolic pathways in the photobiont (mainly energy production) and the mycobiont (mainly protein synthesis machinery), thus contributing to explain previous eco-physiological observations. The analysis of the proteome of Xanthoria parietina collected in areas with different nitrogen availabilities revealed that changes in protein expression mostly occurred in proteins involved in the protein synthesis machinery (production, regulation, transport), carbohydrate metabolism and production of stress proteins. responsible Among them, proteins for polyamines biosynthesis, tolerance to oxidative stress and energetic metabolism. These findings are discussed in relation to ecological and physiological observations from previous studies.

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### How tissue expansion occurs in the thick-walled prosoplectenchyma of the lichen *Ramalina usnea*

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Relatively little is known about where growth occurs in thalli of fruticose lichens, or how such growth is achieved anatomically where thick-walled fungal tissue is present. We used TEM to study tissue sections of Ramalina usnea, a beard lichen recently shown to have a diffuse ("intercalary") growth pattern, to better understand how the highly thickened cell walls of the prosoplectenchymous cortex behave under conditions of continued expansion. Cell protoplasts were surrounded by massive accumulations of electron-dense wall layers and amorphous, electron-transparent substances, visible as concentric rings in transverse section. With increasing distance from the protoplast, the electron-dense wall layers were increasingly disrupted and intermixed among the electrontransparent materials. New cell branches grew through the accumulated wall materials. interrupting the layers they penetrated while producing their own concentric wall layers. These observations suggest that cell walls are disrupted by diffuse tissue expansion and continually replaced by new walls and wall materials deposited to their interior at the interface with the protoplast. This pattern of development, documented previously in R. menziesii and U. longissima, suggests that component cells of lichen prosoplectenchyma behave guite differently from those of diffusely expanding filaments studied in non-lichen-forming fungi. where a single, discrete cell wall is maintained throughout growth.

poster communications

## How do liverworts from different geographic regions deal with water availability?

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Bryophytes have unique physiologies that allow them to survive and prosper in extreme conditions of cold and dryness, more than any other group of plants. It has traditionally been assumed that bryophytes can persist in microhabitats where a suitable microenvironment persists, long after the general climate of the area has changed. Among bryophytes, the thallus liverworts Exormotheca pustulosa has a widespread distribution, that covers the Macaronesia, Mediterranean region, tropical and southern Africa, the south Atlantic and western Indian Ocean Islands of Saint Helena and Reunion. The aim of this work was to: i) evaluate carbon fixation patterns of *E. pustulosa* populations from different geographic regions; ii) to relate thallus evaporation and water status with the characteristics of their habitats; iii) perform predictive distribution models to infer the impact of climatic changes in the distribution of the species. For that we have used a combination of C, O and N stables isotopes ( $\delta$ 13C,  $\delta$ 18O and  $\delta$ 15N) and morphological traits of this species along a large geographical gradient, covering tropical, Atlantic and Mediterranean climatic conditions. The adaptive potential of the bryophytes makes them, good models to address hypotheses about adaptation to changing environments and survival to past and present climatic changes.

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#### Analysis of phycobionts by fourier transform-near infrared spectroscopy (FT-NIRS)

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Near infrared spectroscopy appears as an alternative to conventional methods. The absorption of an incident light beam on the surface of a material causes the vibration of molecular bonds known as absorption bands which are a unique spectral signature of each compound. This is a quick, cheap, precise, nondestructive and safe technique, able to analyse various compounds simultaneously. Few studies have used this fingerprinting tool to study cryptograms metabolism. The optimization of non-destructive techniques for the study of the metabolomics of lichen symbionts would greatly help in the elucidation of their complex biology. Our aim is to develop a microbioassay in which metabolomic changes in Asterochloris erici can be analyzed using NIRS. The spectra of desiccated and post-rehydrated algae were obtained using NIRS working in reflectance mode. The samples were scanned over the range from 1000 to 2500 cm<sup>-1</sup> with a resolution of 16 cm<sup>-1</sup> and 32 scans. In the dehydrated algae spectra, we observed correspondence between adsorption bands at 1206 nm, 1494 nm and 2166 nm with lipids, proteins and unsaturated fatty acids respectively. Rehydration of algae in physiological or stress conditions cause changes on the metabolic spectra. The normalized FT-NIR spectra of phycobiont exposed to several types of stress suffered alterations in different spectral areas.

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## Variability of hydration traits in the lichen genus *Ramalina* and its relation with habitat and thallus anatomy

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 University of Alcala
 (UAH). 28807, Alcalá de Henares, Spain Water is an evasive resource in many terrestrial habitats, and organisms in general have to deal with its changing availability, both daily and seasonally. This is especially true for poikilohydric organisms, such as lichens, because they lack active control of their water relations. The three main water sources for lichens are dew, rain and humid air. In order to optimize algal photosynthesis under specific hydration regimes lichens have evolved specialized thallus morphologies and anatomies. Ramalina, a genus of lichen-forming fungi with c. 200 species known worldwide and present in all continents, shows a remarkable diversity in morphological architecture and medullar anatomy, which is hypothesized to be related to habitat type. Morphology ranges from tiny, cushion-like thalli not larger than 1 cm to large pendulous thalli up to 1 m long. Medullar anatomy has been divided into several anatomical types described on the basis of presence and position within the thallus of chondroid and cortical tissues as well as the medullar hyphal density. In this study we explore the variability of hydration traits (specific thallus mass, water-holding capacity and water content) and hydration and dehydration kinetics in Ramalina species collected in all continents and their relation with thallus anatomy and habitat.

# The importance of hydration traits in the radiation of the Macaronesian *Ramalina decipiens* group (Ramalinaceae, lichenized Ascomycota)

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Oceanic islands natural laboratories. are providing innumerable replicated experiments in the processes controlling speciation. One such process is adaptive radiation, the differentiation of a single ancestor into an array of species that inhabit a variety of environments and that differ in traits used to exploit those environments. Adaptive radiations of plants and animals are well studied in islands, but other putative cases may occur in other organisms. Ramalina is a genus of lichen-forming fungi with c. 200 species known worldwide. In Macaronesia it shows high diversity (c. 40 species), coupled with high levels of endemicity (c. 50%). These figures are remarkable considering most lichen-forming fungi show very wide distribution ranges. In this study we focus on the Ramalina decipiens group radiation, which shows its highest diversity in the Canarian archipelago and has several single-island endemisms. The genus Ramalina is characterized by the ability to obtain water from humid air and fog. We hypothesize that one of the main drivers of the radiation is that the species evolved differentiated ecophysiological strategies to exploit the different water sources. In order to characterize these strategies, we studied surface hydrophobicity, hydration traits, hydration and dehydration kinetics, thallus anatomy by means of light and SEM microscopy and cell wall composition by Fourier-transform infrared spectroscopy. Results are analyzed and discussed in a phylogenetic framework.

## Monitoring moss growth and physiological state using a low-cost image analysis system

#### Nagore G.

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Mosses are an important element of soil plant communities, being a main component of soil biocrusts together with other photosynthetic organisms like lichens and microalgae. The last years have seen an increasing interest in using mosses as model organisms for ecological studies. To address this issue, ways for precisely monitoring physiological activity are needed. We have developed a protocol that takes advantage of remote sensing and image analysis techniques as non-destructive ways to monitor moss growth and physiological status in small scale experiments. We culture six common soil moss species (Dicranum scoparium, Hypnum cupressiforme, Homalothecium aureum, Ptychostomum capillare, Tortella squarrosa and Syntrichia ruralis) in three localities along an altitudinal gradient in central Spain. We use a low-cost system of modified drone visible (VIS) and near infrared (NIR) cameras to take moss pictures. We tried a set of more than fifteen indexes and twelve autothreshold methods to estimate moss area and physiological status using ImageJ and a modified version of the R package crustCover that we developed for these image analyses. We provide an optimized protocol that allows monitoring moss growth and physiological status with an easy to implement, non-destructive and low-cost method.

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#### Preliminary study of chlorophyll: a fluorescence measurement in bryophyte *Syntrichia ruralis* [Hedw] from different microhabitats in semiarid grasslands, Hungary

The objective of this study was to determine the effect of microhabitats and seasons on chlorophyll fluorescence parameters; Fv/Fm, gP, PS II, gNP and NPQ after rehydration. S. ruralis (Hedw.) were collected from semi-arid grasslands near Kiskúnság region in Hungary from the two microhabitats based on orientation of the sandy dunes; north-east (NE) and southwest (SW) direction in the four seasons. Our results showed statistical differences in terms of PS II, gP, gNP and NPQ values ( $p \le 0.05$ ) between microhabitats except Fv/Fm. In contrast, Fv/Fm , gP, gNP and NPQ were found to be statistically significant within each pair of seasons except PS II. In both microhabitats, more favorable humidity conditions observed from spring to autumn on NE slope in comparison SW slope. In conclusion, NE slope showed better photosynthetic activity than SW slope. Spring and autumn season were found to be the optimal periods for the growth of S.ruralis in semi-arid dry grasslands.

## Hydration traits in epiphytic lichens of fragmented subcantabric *Quercus* forests

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<sup>1</sup> Universidad de León, Universidad Rey Juan Carlos Epiphytic lichens present different functional strategies according to their growth form or type of photobiont. Hydration traits may be also influenced by these factors and many others related with forest structure. Our main goal was to assess changes in lichens water holding capacity (WHC) in relation with specific thallus mass (STM), growth form and type of photobiont in 10 subcantabric Quercus forests with different fragmentation level. For this purpose, we chose seven species of epiphytic macrolichens and we collected five samples per species and forest. We measured WHC and STM in each of the thalli collected by calculating weight at full hydration (wet mass, WM), weight after 72h at 60°C (dry mass, DM), and scanning area (A). Based on WM, DM and A values, water holding capacity was calculated as WHC= (WM-DM)/A and specific thallus mass as STM =DM/A. Our results showed dissimilar performances among the species studied due to their different functional traits. Besides, STM resulted to be a main driver of WHC. High specific thallus mass was related to higher water holding capacity. In addition, fragmentation level could affect the hydration strategy of some species, although further research is required.

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global change & long-term



oral communications

### Effects of fragmentation on fungal-algal interaction networks

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Habitat fragmentation is one of the main causes of current biodiversity loss. Identifying the effect of this disturbance on interaction networks between organisms can help to understand in advance the degree of threat that the species have in ecosystems. In this work we study the interaction networks between lichen-forming fungi and their photobionts in epiphytic lichen communities in a fragmented Mediterranean forest (Quercus rotundifolia) embedded in an agricultural cereal matrix. Using new generation sequencing (Illumina MiSeg) we barcoded the photobiont ITS2 region occurring in epiphytic lichens in a gradient of 10 fragments of increasing size (from 0.002 ha to 250 ha). All interaction networks showed low connectivity, anti-nestedness, high modularity and high specificity. In addition, these properties showed significant trends along the gradient. As the fragment area becomes smaller, modularity, the number of interacting bionts, and specificity decrease. In contrast, nestedness, connectivity and niche overlap increase. These results confirm previous results and open a new line in the field of the study the effects of global change on lichens.

#### Facing the challenges of climate and hydrological change: a case study on the distribution of western oceanic riverine bryophytes

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Several moisture-dependent, niche-specialist bryophytes are closely associated with high humidity watercourses. Such species may face major threats from climate-mediated hydrological change. The alteration of rainfall patterns and flow regimes is hypothesised to impact the distribution and abundance of these bryophytes, and western oceanic macrophytes and rheophytes are expected to be particularly vulnerable. In this work, we assessed the impact of climate and hydrological change in the distribution of four western oceanic rheophillous bryophytes - Dendrocryphaea Fissidens lamvana, grandifrons, Fissidens polyphyllus and Racomitrium hespericum. Distribution data of the target species was obtained from natural history collections and on-line biodiversity databases. We modelled the distribution of the four species for the present and 2050 climate change scenarios, using habitat suitability modelling to quantify potential areas of occurrence, identifying gains and losses and range shifts for each species. Our results indicate a northwards range shift for the species distributions in Europe. Overall, the area of suitable habitat is projected to contract, with increased habitat loss in the Mediterranean linked to a greater seasonality in precipitation and flow regimes. The results provide insights into the European distribution of these conservation-interest bryophytes. informing monitoring and presenting the first spatial assessment of climate change impacts on their distributions
# **One-year passive warming effect on antarctic lichens** *Placopsis antarctica*

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Although in Antarctica. long-term ecophysiological studies have been carried out on the only two existing vascular plants, only few experiments have been focused on the far more species-rich and dominant cryptogamic biota. Here we report a field study of lichens growing under passive warming inside open top chambers (OTC) installed on Fildes Peninsula (King George Island, South Shetland Island Archipelago). We compared primary photochemical processes of photosynthesis between thalli of the lichen Placopsis antarctica growing for one year inside the OTC with controls outside OTC under ambient conditions. We measured effective quantum yield of photosystem II (**P**SII) and photosynthetic electron transport rate (ETR) in daily courses. We examined the responses of diurnal  $\Phi$ PSII to PAR and in relation to environmental factors through continuous 12-d-long monitoring of chlorophyll fluorescence parameters. Our results indicate that the OTC warming microenvironment leads to partial limitation of photosynthetic processes in P. antarctica during the austral summer season. We suggest, that the limitation is caused by accelerated dehydration of thalli inside OTC compared to the outside conditions which are generally colder and wetter, and thus shorter physiologically active periods of lichens in OTC. We deduct that global warming and correlated desiccation potentially decrease photosynthetical performance of lichens.

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# Impacts of ocean acidification on macroalgae communities: evidence from a natural laboratory

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The impact of how acidification will affect the biodiversity and functionality of marine ecosystems is still uncertain. Laboratory approaches predict major changes in marine communities. However, these studies can only predict a small fraction of changes expected, since the number of species tested and the experimental time are limiting. These limitations raise questions about the reproducibility of the environment and the importance of indirect effects and synergies in the final results of these experiments. One way to address these experimental problems is by conducting studies in situ, in natural areas where expected future pH conditions already occur, such as CO<sub>2</sub> vent systems. These places are located in volcanic territories, where CO<sub>2</sub> from volcanic activity combines with sea water; changing the abundance and the relative proportion of inorganic carbon compounds; and decreasing pH. Recently, we discovered one of these CO<sub>a</sub> vents in the south of La Palma (Canary Islands, Spain), in rocky shallow bottoms (0-5 m) of Punta de Fuencaliente. In this place macroalgae are the dominant organisms in the shallow subtidal communities. Our first studies show a strong change in the structure and composition of the communities following the gradient of CO<sub>2</sub> and pH. These changes are mainly based on the reduction in the abundance of calcifying macroalgae, and the increase of filamentous red macroalgae. The findings suggest that shallow macroalgae are very sensitive to changes in CO<sub>2</sub> concentration and ph decrease. In the future, if CO<sub>2</sub> emissions continue mayor changes in subtidal vegetation are expected.

# Lichen trait variation along a latitudinal gradient in Chile

#### Clara Rodríguez-

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Understanding the inter- and intraspecific functional trait variability will help us to predict the capacity of communities to cope with climate change and acclimate to future environmental conditions. Detailed protocols have been developed for the analyses of functional traits in vascular plants, but little is known in other groups of organisms such as lichens. Thus, we have evaluated the inter- and intraspecific variability of different functional traits in more than 100 macrolichen species growing on Nothofagus pumilio forests along its distribution range in the Southern Hemisphere. To know which drivers are behind this functional variation, we sampled 24 forests across a latitudinal gradient in Chile, which covers a broad variety of climatic conditions. Within each forest, we collected five thalli of each macrolichen species found and we measured the specific thallus mass (STM) and the water holding capacity (WHC). Preliminary results indicate that these 'hard' functional traits related to water use strategy were influenced by easily measurable 'soft' functional traits such as growth form and type of photobiont. Besides, after analysing trait-environment relationships, we found significant effects of climatic drivers shaping the response of these functional traits. We also noticed contrasting functional responses of the studied lichen communities and those from Fagus sylvatica forests located in a similar environmental gradient in the Northern Hemisphere.

# Historic herbaria offer first-hand data for global change, long-term ecology and documenting cryptogams

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 <sup>2</sup> Museu Nacional de História Natural e da Ciência, MHUNAC, Universidade de Lisboa, Portugal
 <sup>3</sup> Instituto Nun'Alvres (INA), Caldas da Saúde, Santo Tirso, Portugal The story of cryptogamic studies in the Iberian Peninsula is inseparable of the origins of Porto University and Instituto Nun'Alvres herbaria. Both share intertwined botanists of late 19 and early 20th centuries that often corresponded and united efforts to gather the greatest information on plants and fungi other botanists did not venture to study. These collections present thousands of specimens with types and collections that were the early basis of the cryptogamic research in Portugal. To this day they support Floras and academic publications. Sincetheseherbaria are going through renovations and efforts to digitizing their collections to inventory, their data and meta-data are becoming increasingly accessible. In this paper, we will present their meta-inventory, collectors, and databases and report the data typologies and accessibility for future ecological studies. Βv presenting their taxonomic and spatiotemporal spectra and by revealing recently detected specimens from imminent botanists or naturalists, we aim to appeal to the uniqueness of these cryptogamic collections and alert researchers to contribute to its potential future uses. Finally, we will present the sphere of global change and long-term studies that could be instructed by these collections, including non-target specimen research.

We would like to acknowledge the support of the Portuguese Infrastructure of Scientific Collections - POCI-01-0145FEDER-022168 (PRISC.pt).

# Modelling the invasibility of *Campylopus introflexus*: a spatiotemporal framework

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Cecília Sérgio<sup>2</sup>, César Garcia<sup>2,3</sup>, Manuela Sim-Sim<sup>2,3</sup>, Cristiana Vieira<sup>3</sup>, Ana Paula Portela<sup>4,5</sup>, João Gonçalves<sup>1</sup>

<sup>1</sup>CIBIO/InBio - Centro de Investigação em Biodiversidade e Recursos Genéticos. Universidade do Porto, Campus Agrário Vairão, 4485-661, Vila do Conde, Portugal <sup>2</sup> Museu Nacional de História Natural e da Ciência. MHUNAC, Rua da Escola Politécnica, 56/58, 1250-102, Lisboa, Portugal <sup>3</sup>cE3c - Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências da Universidade de

Lisboa, Portugal <sup>4</sup>Museu de História Natural e da Ciência da Universidade do Porto, Praça Gomes Teixeira, 4099-002, Porto, Portugal <sup>5</sup>Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre, FC4-Biologia, 4169-007 Porto, Portugal Campylopus introflexus (Hedw.) Brid. is a widespread moss in the Southern hemisphere, recently introduced in Europe, threatening habitats that are often of high conservation interest. Understanding which sites are most susceptible to invasion is paramount for invasion management. Satellite-based remote sensing is now providing the means for tracking landscape change over time. This study presents a spatiotemporal framework aiming to predict the areas of high susceptibility to invasion by this moss. We compiled more than 200 mainland localities of C. introflexus in Portugal. The current invasion pattern for C. introflexus was predicted by species distribution models using three sets of variables: (i) regional variables ('coarse scale'); (ii) local variables ('fine scale'); and (iii) integrative indicators of ecosystem condition and change. Regional variables were related to climate and local variables to land cover and human pressure. The integrative indicators of ecosystem condition and change were based on Ecosystem Functional Attributes (EFAs), derived from Terra/MODIS satellite time-series (2001-2017) of the Enhanced Vegetation Index. Our results suggest that this multi-scalar spatiotemporal framework is important to characterize a more detailed and realistic invasion. pattern, improving the prediction of C. introflexus invasibility. Therefore, this approach can offer valuable contributions for effective management of this invasive moss.

## The phylogenetic diversity of biocrust lichens is maintained along multiple gradients of fragmentation

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Habitat fragmentation is one of the most threatening drivers of global change for biodiversity. The reduction and isolation of natural habitats can exert severe effects on community structure and diversity. This has been demonstrated for taxonomic diversity, while fragmentation consequences for the phylogenetic component remain largely unexplored. This is particularly true for cryptogams, especially for those living in the uppermost soil layers or biocrusts. Here we show that the phylogenetic diversity of lichen-biocrusts is rather resistant to fragmentation. All phylogenetic indices (e.g., mean phylogenetic distance of taxa, mean distance to the nearest taxon) were similar in 50 remnants of a Mediterranean shrubland that varied widely in size, the degree of connectivity and distance to a road. Our results indicate that the biocrust-lichen species are not structured phylogenetically in fragmented habitats. These findings support the recent evidence that biocrusts can cope relatively well with changes in habitat structure and have important implications for conservation and restoration ecology. The knowledge generated in this work should be combined with the evaluation of biocrust functional structure in future research to better understand the assembly rules operating on these communities in changing landscapes.

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# Assessing habitat determinants in the southern border of *Blechum spicant* (Pteridophyta): a perspective of range margin dynamics

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<sup>1</sup> Depts. of Plant Biology and Geology, FCUL, Lisbon, Portugal <sup>2</sup> Dept. of Geology, FCUL & Instituto Dom Luiz (IDL), Lisbon, Portugal Understanding species range dynamics and shifts is a prominent issue towards wise sustainable decisions concerning biodiversity and prevention of extinction. A key part is understanding how organisms have reacted to climatic changes and its ability to colonize and promote stable populations in extreme marginal areas. Here we analyze southern Portuguese palaeorange models for the last 15000 years BP of the terrestrial fern Blechnum spicant (L.) Roth, discussing in light of habitat preferences, range expansion and contraction after the Last Glacial Maximum and its effects on present habitat in its southern border. Migration northwards of a dry warmer climate made plausible a substantial loss of habitat diversity, conducing to population fragmentation and probably to the increase of local adaptation. Comparatively with northern distribution under a more temperate climate, the southern range mismatches the set of suitable environments by which population growth compensates for recolonization of disturbed locations. A significant ecological specialization is thought as a relevant long-term mechanism for persistence on most favorable long-lived micro-habitats, strictly located in the margins of medium altitude water streams

# Rapid shifts in lichen trait diversity due to recent climate change

**Paula Matos<sup>1</sup>,** Pedro Pinho<sup>1</sup>, Alice Nunes<sup>1</sup>, Amadeu VM Soares<sup>2</sup>, Cristina Branquinho<sup>1</sup>

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Climate is changing rapidly, with impacts expected in ecosystems' structure and composition worldwide. Lichens are within the organisms more rapidly responding to recent warming. Our objective is to understand what is changing in lichen diversity due to recent climate shifts. For that, we used lichen diversity collected over 20 years at a five-years interval (1994 to 2015) in 22 sampling sites in Southern Portugal. Several taxonomic and trait-based metrics based on two traits that respond to climate were tested. 22 climate variables representing range, seasonal and annual variation of temperature and precipitation, annual mean relative humidity and the number of days with relative humidity higher than 95% were calculated. Changes over time and with climatic shifts were assessed using generalized linear models.

Lichen taxonomic metrics didn't change significantly over time. However, a functional turnover was observed for some functional groups, functional diversity indices based on abundance increased over this period and the functional structure of some functional groups changed also significantly over time. These temporal shifts were strongly related to subtle changes in climate, namely to an increase in average relative air humidity and the number of days with relative air humidity higher than 95%. Overall, lichen trait diversity is changing with recent climatic shifts, showing the importance of looking beyond taxonomic metrics to track the effects of climate change.

# Are functional, phylogenetic and taxonomic optimal climatic niches congruent along a wide latitudinal gradient?

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<sup>2</sup> Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisbon, Portugal Spatial variation in biodiversity provides critical information about the response of natural communities in a changing world. Identifying the optimal climatic conditions where communities maximize their functional, phylogenetic and taxonomic diversity is useful to assess the impact of environmental changes. We surveyed epiphytic lichen communities in 23 beech forests along Europe covering a wide climatic gradient from Sweden to Italy. We quantified functional, phylogenetic and taxonomic diversity metrics of lichen communities for each forest. To detect where the diversity metrics peaked, we illustrated non-parametric regressions of these metrics against the climatic space using the 'hilltop plot' method. Functional optimal climatic niches overlapped with taxonomic and phylogenetic ones, implying that functional traits shaped the response of lichen communities to climate. However, phylogenetic and taxonomic hotspots did not overlap. These results highlight the need of an integrative approach to assess the effect of environmental changes on communities. Type of photobiont and growth form showed clearly defined climatic niches pinpointing their role as ecological indicators, which can be used as a rapid assessment method to evaluate the effects of macroclimatic changes. In turn, hard traits did not show clearly defined climatic niches in response to macroclimatic variables and further research is needed to unveil their response to other environmental and small-scale variables.

## Comparative effect of climate change on the germination dynamics of tropical and temperate fern species

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Sonia Molino<sup>1</sup>, Andrea Seral<sup>1</sup>, Rubén Vázquez<sup>1</sup>

<sup>1</sup> Unit of Botany, Department of Biodiversity, Ecology and Evolution, Faculty of Biology, Universidad Complutense de Madrid. Avenida Jose Antonio Nováis, 12. 28040-Madrid (Spain) Ferns are an important component of ecosystems around the world and climate change is one of the major environmental problems we are facing in the 21<sup>st</sup> century. Studies on global change impacts are scarce and indicate that some species of ferns may be particularly sensitive to climate change. Of special interest are tropical species from rainforests, which are among most affected by global change. The aim of this work was to compare the impact of increased temperatures, as expected in a climate change scenario, on germination capacity of tropical species (Amphineuron immersum and Christella subpubescens), and temperate species (Dryopteris affinis and Athyrium filix-femina). To do this, spores were extracted from a single specimen of each species and were sown in Petri dishes with nutritive agar. The spores were cultured at two temperatures: T1 representing the mean annual temperature of the location of the plants; and T2 8°C higher than T1, with a photoperiod of 12+12 hours. The germination rate was recorded every three days counting one hundred spores randomly. Germination rates were use to feed predictive models to evaluate how temperature increase affects the studied species. For the four species studied, the increase in temperature produces a statistically significant drastic reduction in germination dynamics. On the one hand, the final germination is reduced by 30-40%. On the other hand, this maximum percentage is reached in the middle of time when the temperature increases, despite the fact that the beginning of the germinations does not present significant differences, occurring around the ninth day after sowing in all cases.

poster communications

# Can beard-forming lichens of high elevation forests help to detect the impact of global change in the Alps?

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Global processes, including climate change and anthropic emissions, are threatening the European Alps that host habitats and species of huge conservation value. In this scenario detecting early warning signals of changes that can affect ecosystem stability is crucial. In the alpine landscape, high elevation forests, provide a unique environmental setup that allow to take full advantage of the potential of epiphytic lichens as sensitive indicators for climate change and air pollution. The dynamics of these forests, are mainly driven by natural factors. Further, in absence of local human disturbance, lichen patterns are mainly boosted by factors acting at large spatial scale, emphasizing their suitability, to detect the effects of global change. Our literature review aimed to provide a starting point for developing practical biomonitoring tools elucidating the potential of fruticose-filamentose (beard-forming) lichens associated to high elevation forests as ecological indicators of global change in the Alps. By revising the available literature retrieved from the main scientific databases, we found support for a practical use of beard-forming lichens to detect the impact of climate change and nitrogen pollution in high elevation areas of the Alps. The use of these organisms as ecological indicator could provide a predictive tool in high elevation areas sustaining decisions on how to mitigate the effects of global change in the Alps.

urban environments



oral communications

## Testing the poleotolerance lichen response trait as an indicator of anthropic disturbance in an urban environment

#### Bernardo Rocha<sup>1</sup>,

Pedro Pinho<sup>1</sup>, Joana Vieira<sup>1</sup>, Cristina Branquinho<sup>1</sup>, Paula Matos<sup>1</sup>

<sup>1</sup> Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisbon, Portugal Urban environments are densely populated areas buzzing with wide range of anthropic activities that cause disturbances like air pollution or the heat island effect, threatening both human and environmental health. Mitigating its impacts implies understanding the integrated effects that those disturbances exert on urban environments. Lichen diversity is frequently used as an ecological indicator, being able to integrate environmental effects in a guantifiable way. The poleotolerance response trait classifies lichens according to their tolerance to human disturbance, but it was developed for Italy's flora, and has seldom been applied outside Italy or in urban context studies. The aim of this work is to assess this trait suitability as an indicator of urban anthropic disturbance and test it outside Italy. For that, we sampled lichen diversity in 41 green spaces in Lisbon. Lichens were classified into the respective poleotolerance trait functional groups and their community weighted mean related with environmental variables used as surrogates of urban disturbance. We showed that disturbance-tolerant functional aroups could be used as an ecological indicator of the integrated effects of environmental disturbances. Some species were clearly misclassified so we propose reclassification for those. Natural and semi-natural functional groups didn't behave like expected, nevertheless, disturbance-tolerant functional groups have potential to be used in in others southern European cities.

# Differential physiological responses to nitrogen pollution by lichen *Trebouxia* phycobionts

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Leonardo Casano<sup>1</sup>, Sergio Pérez-Ortega<sup>2</sup>

<sup>1</sup> University of Alcala, Spain <sup>2</sup> Real Jardín Botánico-CSIC, Spain Lichens are widely recognized as bioindicators of air quality because they show a wide range of sensitivity to atmospheric pollution. Main pollutants in the atmosphere have changed in the last decades from sulphur dioxide to nitrogen oxides (NOx), fine particles and ozone as consequence of changes in legislation and energy sources. At the same time, it has been observed a general change of urban lichen flora from acidophilous to more nitrophilous and xerophytic species and the re-colonization of the downtown "lichen desert". In the present study we tested whether the phycobionts may act as drivers of this change in the most polluted areas of the city. We isolated and cultured the algae from lichen species occurring in areas with contrasting levels of pollution in Madrid city (downtown and a Quercus ilex forest on the outskirts) and exposed them to different concentrations of NO3 and NH4 during three months. After nitrogen exposition the cultures were maintained dried for 9 months. Photobionts isolated from city centre lichens showed a higher growth rate and a better photosynthetic performance during nitrogen treatments than those from uncontaminated areas, although all of them showed similar tolerance to desiccation. These results indicate that the absence of certain species of mycobionts in cities may be mediated by the sensibility of their photobionts to common atmospheric pollutants.

# Tools to measure the provision of ecosystem services by cities green infrastructure to create more livable and resilient cities

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Ongoing urbanization creates environments challenging to ecosystems and to human life. Cities' green infrastructure is suggested by UN New Urban Agenda to tackle the effects of cities atmospheric pollution and urban heat island effect. Parks and urban forests are critically important for this, as they provide important support & regulation ecosystem services, such as microclimate and air quality regulation. Greenery importance to human wellbeing was made evident by Lisbon citizens movements across the city to visit green spaces. Biodiversity and Ecosystem services are also affected by the same problems that challenge human life, added to other factors that influence ecosystem functioning, such as habitat fragmentation. Because monitoring stations cannot measure impacts in ecosystems, we used ecological indicators in urban areas of Portugal and Brazil, to show how accumulation of metals, satellite and microclimate measures, and trait-based metrics of lichen diversity, can be used as to quantify the impacts of urbanization. This effect was modelled at city, park and square spatial scales, allowing us to map, with high resolution the provision of multiple ecosystem services. This provided evidences of the tradeoffs that occur between ecosystem services, and also how can management and city planning can influence the provision of ecosystem services.

# LiquenCity: A citizen science project to explore lichen diversity and air quality in Madrid and Barcelona

#### Sergio Pérez-Ortega<sup>1</sup>,

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Air pollution is the main cause of respiratory diseases in cities, causing thousands of deaths per year around the world. Lichens has been used as indicators of air pollution for decades with a significant correlation between lichen diversity and air quality. Liquencity is citizen science project funded by FECYT and focused on using lichens as sentinels of air pollution in Madrid and Barcelona cities. Didactic materials on lichen biology, their use as air quality bioindicators as well as species profiles of indicator species (epiphytic) are available at the project website. Contributors to the project uploaded lichen occurrences (pictures) as well as phorophyte identifications by means of the Natusfera app for mobile devices. Records were subsequently checked by expert lichenologists and those passing the quality filter incorporated to the Global Biodiversity Information Facility (GBIF) database. More than 4000 observations were uploaded to Natusfera, and c. 2000 students from more than 60 secondary education centers participated in Madrid and Barcelona. Maps for both cities depicting zones of isopollution based on lichen diversity were generated from data. Results showed that involving citizens in research projects of this kind two main goals may be achieved: 1) to get quality data for a scientific aim, and 2) to sensitize citizenship about the problem of air pollution in urban environments through the contact with highly sensitive organisms to perturbations.

poster communications

# Revisiting the bryophytes of "Mata-Jardim de José Canto (São Miguel Island)" after 81 years

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Parks and gardens are increasingly being considered as useful refuges for a great number of non-vascular species, otherwise absent from urban areas. However, the knowledge of cryptogamic species in gardens is often incomplete. One of the aims of the project "Green Garden Azores" (PO2020-ACORES-01-0145-FEDER-000070) is to inventory the biodiversity associated with Azorean parks and gardens, including understudied biota. The historic park "Mata Jardim José do Canto", in São Miguel Island, is one of the largest and most interesting of the Azores. In 1937, the Allorge couple, H. Persson, and T. M. Silveira, collected 43 bryophyte species there, 27 liverworts and 16 mosses. Almost 100 years later, the purpose of this work was to collect and identify the species present in the park, in order to compare the evolution in terms of diversity (richness). In 2018, it was possible to collect 65 bryophyte species (one hornwort, 30 liverworts and 34 mosses). About half of the species (n=23; 54%) were present in both inventories. However, some differences emerge, with a few of the most rare species (e.g. Anastrophyllum minutum, Dumortiera hirsuta, Cyclodictyon laetevirens, Tetrastichium fontanum) not being found in the most recent collections. It appears that, despite the protection and the influence of this park as a reservoir of biodiversity, some alterations of anthropic or climatic origin have been affecting the ecosystem.

extreme environments



oral communications

## The cryptogamic cover in the Antarctica: the response to the temperature discriminates Antarctic and cosmopolitan species

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In maritime Antarctica, the cryptogamic cover that forms the tundra is dominated by lichens and mosses, both with species with a broad ecological distribution and endemic. The knowledge of the photosynthetic and respiratory responses of the species with respect to the main environmental parameters will allow us to anticipate changes in the composition and distribution of vegetation in this Antarctic region where temperature oscillation is being more pronounced. We examine the photosynthetic and respiratory responses against light and temperature of key species of the Antarctic tundra. Species of lichens and mosses, with different distribution were selected: endemic species to Antarctica such as the lichen Himantormia lugubris and the moss Andreaea gainii and cosmopolitan species as the lichen Sphaerophorus globosus and the moss Sanionia uncinata. Measurements were carried out in the laboratory of Juan Carlos I Base (Livingston Island) using infrared gas exchange measurement systems. Results showed optimal temperatures for net photosynthesis at 7 and 11 °C in the endemic species (H. lugubris and A. gainii, respectively) while cosmopolitan species (lichen and moss) showed optimal temperatures around 20 °C. Photosynthetic rates for the latter were as twice as high than for the ones with Antarctic distribution. Considering that cosmopolitan species are under suboptimal conditions in Antarctica, it is suggested that these species could be favored under a climate warming scenario.

## Epiphytic diatoms on Deception Island (Antarctica): effects of host macroalgae phylum on diatom size

#### Andrea M. Burfeid Castellanos<sup>1</sup>, Rafael P. Martín Martín<sup>2</sup>

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Marine ecosystems are characterized by a reduced availability of substrate and light. This increases the colonization of all present surfaces, including multicellular organisms. As macrophytes (algae and plants) need light to thrive, the adherence of smaller uni- and multicellular organisms create a competition between these basibionts and their epibionts. A biological arms race ensues. In this study we have investigated epiphytic diatoms. For these organisms, their size correlates to their ability to utilise light. Here we show that diatom size depends on the basibiont they inhabit. The same taxon varies in size depending on whether the macroalgal host is a phaeophyte (brown algae), a rhodophytes (red algae) or a chlorophyte (green algae). Our results demonstrate that the morphological study of the understudied epiphyte-host relationship could give information about the biocidal and chemical warfare of these organisms. Because of the inhospitable conditions in a volcanic, Antarctic island, this warfare is exacerbated and. thus. easier to observe. This study can be a starting point to further understand the effects of macroalgae metabolites on diatoms.

# Estructura de la comunidad bacteriana asociada al desarollo de cubiertas de musgos y líquenes en suelos deglaciados

#### Asunción de los

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El desarrollo y la diversidad de cubiertas dominadas por musgos y líquenes ha sido muy estudiado en suelos de zonas áridas, posiblemente debido a su potencial contribución a los ciclos biogeoguímicos globales. Sin embargo, el conocimiento que se tiene sobre su dinámica, estructura y función en zonas polares es reducido, especialmente respecto a la diversidad de microorganismos presentes en ellas. En este trabajo hemos planteado caracterizar por Illumina la estructura de la comunidad bacteriana en suelos dominados por criptógamas de áreas deglaciadas por retroceso del glaciar Breiðamerkurjökull (Islandia). Los resultados muestran que la estructura de la comunidad de bacterias asociada a las criptógamas difiere de la de suelos bajo ellas. Mientras que el filo Proteobacteria fue el más abundante tanto en la cubierta, como en los suelos subvacentes, las cianobacterias alcanzaron solo una proporción significativa en la cubierta. Nuestros análisis también han revelado que existe cierta especificidad entre la composición bacteriana y la criptógama dominante en cada cubierta. Por otro lado, la estructura de la comunidad de los suelos con cubierta criptogámica difiere de la de los suelos sin colonización por musgos y líquenes. Estas diferencias apuntan a que las comunidades bacterianas asociadas al desarrollo de cubiertas criptogámicas podrían iugar un papel fundamental en la sucesión ecológica, desarrollo del suelo y, por tanto, en la colonización de áreas deglaciadas.

# Growing in the dark: bryophytes from Terceira Island (Azores) at cave entrances

#### **Clara Polaino-**

**Martín<sup>1,2</sup>,** Laura Jennings<sup>3</sup>, Cristina Peroni<sup>2,4</sup>, Fernando Pereira<sup>1,2</sup>, Isabel R. Amorim<sup>1,2</sup>, Rosalina Gabriel<sup>1,2</sup>

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Due to their specific conditions of light, humidity and availability of substrates, volcanic caves are extreme environments for many plants. Notwithstanding, a set of bryophyte species may be observed in these habitats, growing as pioneers on the bedrocks. The main purpose of this study is to compare the diversity of bryophytes inside and at the entrance of 11 of the 69 lava caves from Terceira Island (Azores); the two show-caves ("Algar do Carvão"; "Gruta do Natal") were included in this study, along with other, less visited caves. Data from bibliographic references, Herbarium collections and fieldwork are compared in order to assess if the bryophyte communities remain as rich as they were and continue to include endemic and/or rare species. More than 150 species (about 30% of the Azorean bryoflora) were referred to Terceira caves, and although the number of species varies over the time, the total number per cave is guite impressive, particularly at the largest, "Algar do Carvão". Many IUCN conservation concern species continue to be found in these habitats (e.g. Tetrastichium fontanum, T. virens, Cyclodictyon laetevirens). Thus, cave entrances clearly serve as a refuge for native species, who are not able to survive in the surrounding matrix of unsuitable habitats (e.g. grasslands, exotic forests) and should be protected and recognized as biodiversity special areas for bryophytes.

# Is morphology inducing desiccation tolerance in bryophytes?

#### Ricardo Cruz de

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Bryophytes descend from early plants that developed desiccation tolerance (DT) mechanisms, enabling to completely dry out and recover function upon rehydration. They occupy practically every habitat, and recent research showed that even bryophytes from aquatic environments can have DT mechanisms similar to their desert counterparts, if slowly dehydrated. This led to the hypothesis that, if bryophytes from contrasting habitats can have similar responses, colony morphology may be responsible for inducing individual shoot DT. Denser colonies will have higher water surface tension and water will be lost at lower rates than less dense colonies. Therefore, morphology, life form and colony structure, may be a determinant factor in the adaptation of bryophytes to each habitat and corresponding predicted levels of desiccation. In the current approach, X-ray computed microtomography (microCT) was used to assess the three-dimensional structure of contrasting and similar bryophyte colony morphologies, particularly of its inner structure. The aim of this study was to determine if morphology of the bryophyte colony, with different life forms, is a trait that controls water dehydration rate and correlates it with individual shoot desiccation tolerance, measured as recovery of chlorophyll a fluorescence

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# Towards a worldwide checklist of lichens living in gypsum soils

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Lichens are one of the dominant life-forms in arid ecosystems, including gypsum soils. Although there has been a high number of studies focused on these organisms, their taxonomy, ecology and functionality, until the moment it does not exist a review of lichens. growing on gypsum soils. Additionally, as the affinity for the substrate is variable, it should be necessary to study this affinity for the gypsum substrate. In order to solve these questions, we have compiled a worldwide checklist of lichens growing on gypsum areas and soils. We have searched in different bibliographic data bases using different key words related with substrate and bibliographic information from countries where gypsum soils occur. As a result, we have checked a total of 283 articles in which we have found information about 26 countries. The checklist includes 5392 specimens, with 381 terricolous and saxicolous species from gypsum soils. Spain and Germany, with 179 and 106 species, respectively, were the countries for which more data and more species were found. It is important to note the low or absent number of species found in countries of the southern hemisphere (i.e. Australia or Chile).We compared and discussed similarities between countries. We have further analysed the species occurrences in gypsum substrates and found a gradient in their gypsum affinity: from strict gypsophiles to gypsovags, but also species accidentally growing on gypsum substrates or with different degrees of appearance.

poster communications

# Epiphytic diatoms on Deception Island (Antarctica): observation of specific pairings of epiphytes and macroalgal hosts

#### Andrea M. Burfeid Castellanos<sup>1</sup>, Rafael P. Martín Martín<sup>1</sup>

<sup>1</sup> AWI, Germany <sup>2</sup> Faculty of Pharmacy, University of Barcelona, Spain

Marine ecosystems are characterized by a reduced availability of substrate and light. This increases the colonization of all present surfaces, including multicellular organisms. As macrophytes (algae and plants) need light to thrive, the adherence of smaller uni- and multicellular organisms create a competition between these basibionts and their epibionts. A biological arms race ensues. To counteract to the extrusion of metabolites of the host, specific diatoms can acclimate and/or adapt to them. Thus, the creation of metabolites can create specificity of host and epiphyte. Our results show that, even though most epiphyte taxa are shared throughout phyla, some diatoms are only found on one of the studied taxa: Desmarestia J. V. Lamouroux, Palmaria Stackhouse and Himantothallus Skottsberg. This first light microscope approach demonstrates that the ecology of this interspecific relationship is a necessary first step to understand this extreme ecosystem. This study is the starting point for a further morphological study of diatoms which will be presented in this symposium.

# Bryophytes in mining areas: the case of study of "Su Suergiu", South-Eastern Sardinia (Italy)

#### Antonio De Agostini<sup>1</sup>,

Pierluigi Cortis<sup>1</sup>, Andrea Vacca<sup>2</sup>, Annalena Cogoni<sup>1</sup>

<sup>1</sup>Department of Life and Environmental Sciences, University of Cagliari, Botany Section, Viale S. Ignazio 1, 09123, Cagliari (CA), Italy <sup>2</sup>Department of Chemical and Geological Sciences, University of Cagliari, Cittadella Universitaria (Blocco D) – S.S. 554 bivio per Sestu, 09042, Monserrato (Ca), Italy The characterization of bryophytic biodiversity in ecological contexts strongly compromised by the contamination of heavy metals in the soil (such as abandoned mining areas) could help the integration of taxa belonging to this group in projects of phytoremediation and phytostabilization of environmental pollutant. Sardinia (Italy), hosted an intense mining activity and today many abandoned mining areas are present in the island. The present case of study focuses on a small mining dump of about 100 m3 in volume, located in the abandoned mining site of "Su Suergiu" (South-Eastern Sardinia). This dump consists of the residues of the mechanical treatment of the extracted material and is mainly composed of gravel and sand. The dump is characterized by elevated concentrations of numerous heavy metals and metalloids (Sb 24.5 mg/g; As 0.7 mg/g; Cd 0.007 mg/g; Hg 0.002 mg/g, etc.). Data are obtained from the "Plan of initial investigation of the mining area of "Su Suergiu", carried out by IGEA SPA. A sampling of bryophytes was carried out on the mining dump and this led to the identification of exclusively acrocarpic species belonging to the Bryophyta class, having a predominantly cushion and small mats growth form and forming small isolated populations. In numerous individuals, white-colored crystalline concretions have been registered at the apices of the philloids. A SEM analysis will permit to characterize these formations and clarify their possible nature of biominerals.
# Taxonomic and functional diversity of lichens along an environmental gradient in gypsum soils

## María Prieto<sup>3</sup>, Luca

Di Nuzzo<sup>1</sup>, Renato García<sup>2</sup>, Sergio Muriel<sup>3</sup>, Isabel Martínez<sup>3</sup>, Gregorio Aragón<sup>3</sup>

<sup>1</sup> Department of Biology, University of Florence, Via La Pira 4, 50121 Firenze, Italy <sup>2</sup> Laboratorio de Biodiversidad y Genética Ambiental (BioGeA), Universidad Nacional de Avellaneda, Mario Bravo 1460, 1870 Pyñeiro,Argentina <sup>3</sup> Department of Biology and Geology, Physics and Inorganic Chemistry, Rey Juan Carlos University, Madrid, Spain Lichens are among the most important organisms in gypsum soils, where they contribute to the total diversity and biomass of these environments. In the Iberian Peninsula, drivers shaping lichen communities are quite well-known. Still, some main drivers that could influence lichen diversity in these communities are poorly investigated. The aim of this work is to analyze the changes on the taxonomic and functional diversity and composition of gypsum lichen communities along an environmental gradient in Spain. For this purpose, we sampled these communities by establishing 3 plots in different sites along a broad environmental gradient in Spain. Within each plot we established ten 50x50 cm quadrats and we recorded the coverage of all lichen species. We calculated species richness and diversity indices and characterized every lichen species by a set of functional traits to calculate the community weighted mean (CWM). We also measured several quantitative functional traits, including the specific thallus mass (STM) and water holding capacity (WHC). Climatic variables were retrieved at plot level from WorldClim database. We analyzed the influence of the climatic variables on the taxonomic and functional composition and diversity using Linear Mixed Models and PERMANOVA analyses. As a result we observed differences in both taxonomic and functional diversity in relation with changes in temperature and precipitation.

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# Changes in stomatal traits and its relations with bioclimatic variables in three species of saxicolous ferns in the Iberian Peninsula

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Stomata are specialized and conserved structures in plants that are involved in gas exchange between the atmosphere and plant; due to this, plants can vary their stomatal traits to adapt themselves to different environmental conditions in order to maximize the photosynthetic rate and water use efficiency. Density, length and PCI (Potencial Conductance Index) are three main stomatal traits that has been widely used to know how plants, mainly angiosperms, are adapted to different temperatures and rainfall regimens. The studies focused to the variation in stomatal traits and its relation with climate variables in ferns are scarce. The aim of this study is to analyse the variations of the three functional traits mentioned in three species of Asplenium that are broadly distributed across Iberian Peninsula and correlate these variations with macroclimatic variables. Iberian Peninsula is a great scenario to carry out this type of studies due to the existence of two distinctly bioclimatic regions: Atlantic and Mediterranean. We sampled several individuals of three species from different populations living under the two macroclimates and examined the variation of the three functional traits between both bioclimatic regions and the relations of this variation with the following bioclimatic variables: average of the maximum temperature in the warmest month and in the coldest month. annual rainfall and altitude. Analysis have shown that stomatal traits are correlated with the climatic variables selected

# Spatial dynamics within epiphyll communities in a tropical lowland forest

Anna Mežaka<sup>1</sup>, Noris Salazar Allen<sup>2</sup>, Glenda Mendieta Leiva<sup>3</sup>, Maaike Y Bader<sup>3</sup>

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Algae, fungi, lichens and liverworts can form complex epiphyll communities on rainforest leaves. Due to their short life-span, these assemblages are a promising model system for studying community dynamics. The aim of the present study was to characterize the dynamics of spatial interactions in epiphyll communities by following individual leaves during one year. We hypothesized that young epiphyll communities will have a random spatial structure, determined by chance arrival of the particular epiphyll. We expected stronger positive interactions in the drier and lighter conditions of forest gaps, and more negative (competitive) interactions in the dark forest understorey. We photographed epiphylls on the same twenty leaves four times between November 2016 and December 2017 in rain forest of Barro Colorado Island. We analyzed spatial and temporal patterns of the occurrence of algae, fungi, lichens and liverworts using spatial point pattern analyses, to detect aggregation and segregation within and among functional groups. Spatial patterns indicate epiphylls increasingly interact that durina community development. Understanding these interactions and their effects on community structuring in epiphylls may also contribute to theory development for biotic communities more generally.

The study was financially supported by the European Union Framework Programme for Research and Innovation Horizon 2020 Marie Skłodowska-Curie action Global Fellowship.

# Fungal specificity and selectivity of microalgae in predominantly vegetative reproducing (*Parmelia saxatilis* and *P. sulcata*) species complexes

### Arantzazu Molins<sup>1</sup>,

Cristina Dumitru<sup>1</sup>, Salvador Chiva<sup>1</sup>, Patricia Moya<sup>1</sup>, M<sup>a</sup> Carmen Molina<sup>3</sup>, Ana Crespo<sup>2</sup>, Pradeep K. Divakar<sup>2</sup>, Eva Barreno<sup>1</sup>

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Parmelia s. str. is a widespread genus of lichenforming fungi with centres of distribution in borealtemperate Europe, North America and eastern Asia. This genus belongs to the parmelioid crown of the Parmeliaceae family and includes 41 currently accepted species. Usually, it has been strictly associated with Trebouxia phycobionts and several studies focused on microalgae diversity have revealed a high specificity in the fungus-algae association patterns within the members of the Parmeliaceae. Recently, the presence of cryptic species-level lineages has already been detected in early molecular studies involving Parmelia taxa. P. saxatilis s. lat. mainly reproduces asexually via isidia and P. sulcata s. lat. through soredia diaspores. Co-dispersal of fungal and algal partners (high specificity) has been postulated in vegetative asexually reproducing taxa. In this study, we aimed to unravel potential fungus-algae associations in P. saxatilis s. lat. and P. sulcata s. lat., recently identified as major groups within the genus. The microalgae were identified using a nuclear and a chloroplast genetic marker to unveil the diverse assemblages of Trebouxia species forming holobionts with the lichenized fungi in P. saxatilis (Trebouxia Clade I) and P. sulcata (Trebouxia Clade S). Fungal specificity and selectivity for microalgae seems to play a major role in determining lichen partnerships across diverse ecogeographic regions in the genus Parmelia.

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# Limited effects of marine protected areas on the distribution of invasive species, despite positive effects on diversity in shallow-water marine communities

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Marine protected areas (MPAs) can be an effective tool for the conservation and management of marine coastal habitats. MPAs have been shown to halt habitat degradation, and enhance the biomass of exploited species and diversity in general. Yet, we still know little about its role in halting the spread of non-native species. In this study, we assessed the role of marine protected areas in the structure of shallow subtidal communities around São Miguel Island, in general, and particularly on distribution of the two species of genus Asparagopsis: A. armata and A. taxiformis. The former is in the Azores a wellestablished invasive species, whereas the status of A. taxiformis is still questionable. Overall, there was a significant greater diversity in terms of both species richness and number of macroaldal functional groups within MPAs. However, when considering the relative abundance of the various macroalgal functional groups, or the assemblage as a whole, there was no significant difference between areas within and outside MPAs. The cover of A. taxiformis was significantly greater within MPAs but not its biomass, whereas no significant variation was observed for A. armata. Overall, results suggest that surveyed MPAs had a positive effect on the diversity of shallowwater macroalgal communities. However. they have a limited role on the distribution of both Asparagopsis spp. and negligible effects when considering the relative abundances of macroalgal functional groups.

# Tras los pasos de J.D. Hooker: filogeografía conjunta de Mastodia-Prasiola en las islas del Océano Antártico y Oceanía

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Mastodia es un género de hongos liguenizados perteneciente a la familia Verrucariaceae (Ascomycota) que establece simbiosis con algas macroscópicas del género Prasiola (Trebouxiophyceae). En estudios anteriores, se evaluó la filogeografía de ambos biontes a partir de poblaciones representativas del Hemisferio Norte (Alaska y Canadá) y Hemisferio Sur (Tierra del Fuego y península antártica), con importantes repercusiones para el conocimiento del origen de la funga liguénica antártica y de la distribución bipolar en líguenes. En el presente estudio se ahonda en la filogeografía de estos organismos aportando muestras del Océano Antártico y Oceanía. Algunas provienen de islas remotas que fueron inspeccionadas con interés criptogámico por J.D. Hooker a mediados del siglo XIX, como por ejemplo las Kerguelen, Auckland, Campbell y Tasmania. Además, se investiga material de otras islas al norte y sur de Nueva Zelanda, las islas Marion y Macquarie, así como poblaciones todavía no estudiadas genéticamente de la Tierra de Victoria (Antártida Continental). Algunas de las muestras de herbario analizadas exitosamente son históricas, datando de mediados de siglo pasado. Los primeros resultados plantean cuestiones interesantes sobre la diversidad y distribución geográfica de los linajes del hongo y alga liquenizados. En definitiva, este estudio representa una de las primeras investigaciones minuciosas de biogeografía de líguenes en el Hemisferio Sur y, en particular, en el ámbito insular.

# Estudio del género Diderma (Myxomycetes) en la Cordillera de los Andes peruanos

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<sup>1</sup> Real Jardín Botánico de Madrid, Spain Diderma Pers. es un género de Myxomycetes con más de 80 especies reconocidas. Los datos sobre su ecología y distribución en Sudamérica son escasos, más aún en los Andes. En este trabajo se dan a conocer los resultados de 6 años de recolección (2012-2018) en las vertientes occidentales de la cordillera andina peruana. Se abarcó un rango altitudinal de 500 a 5000 m desde los 4-17°S, en 107 localidades. Se enumeran los sustratos en los que habita, y se analizan sus patrones de distribución. Para ello se generaron modelos de nicho ecológico con el Programa Maxent, a partir de 19 variables bioclimáticas (WorldClim.org), data de colecciones propias, y la disponible en GBIF.org. Se han analizado 17 especies, destacando Diderma hemisphaericum en nro. de colecciones. El género presenta un patrón de mayor diversidad y abundancia hacia zonas más elevadas (>3000 m) en sustratos como hojarasca y corteza de árboles o arbustos. A nivel latitudinal hay una mayor rigueza de especies entre los 8-10°, zona que coincide con las mayores elevaciones de los Andes tropicales. Por último, se analiza el papel de la cordillera andina como barrera biogeográfica para este género de Myxomycetes.

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# Populations of marine alga *Polysiphonia subtilissima* (Ceramiales, Rhodophyta) in freshwater habitats of Croatia

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<sup>1</sup> Division of Botany, Department of Biology, Faculty of Science, University of Zagreb, Marulićev trg 20/II, 10000 Zagreb, Croatia The ceramialian genus Polysiphonia includes over 207 currently recognized marine species distributed along nearly all the coastlines of the Earth. It is primarily a marine macroalgal genus, with physiological mechanisms underpinning its tolerance to varying salinity. Polysiphonia subtilissima is the only species from the genus recorded in truly freshwater habitats, with three known records: (1) Juniper Creek, Florida, USA, North America; (2) Jamaica, Caribbean Sea, Central America and (3) Pego-Oliva Natural Park, Spain, Europe. Molecular studies have confirmed that the freshwater populations are conspecific with the marine collections of *P. subtilissima*. The fourth freshwater record of this species is from the Neretva River Valley, a complex of wetland habitats in the Mediterranean part of Croatia, SE Europe. The alga covered solid submerged surfaces, mainly reed and other aquatic plants, from the surface to approximately 50 cm of depth at salinity levels ranging from 0.4 to 4.59 PSU. Vegetation surveys revealed coverage of P. subtilissima between 5 and 75 %, forming blooms in two sites: a river segment of 7 km and a wetland area of 70 ha. All populations were dense and associated with allochtonous tropical red alga Compsopogon caeruleus and invasive aquatic plant Myriophyllum heterophyllum. The most recent record from Croatia provides new insight into the species' general distribution, spread into freshwater habitats and its ecological preferences.

# Polysiphonia scopulorum (Rhodophyta): una especie cosmopolita o un complejo de especies.

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 <sup>1</sup> Coastal Biology Research Group, University of A Coruña, A Coruña, Spain
<sup>2</sup> School of BioSciences, University of Melbourne, Melbourne, Australia Polysiphonia scopulorum es una pequeña (<2 cm) alga roja cespitosa de la familia Rhodomelaceae. Su localidad tipo se encuentra en Rottnest Island (Australia) y ha sido citada en base a identificaciones morfológicas en diversas localidades del Atlántico, Índico y Pacífico. Hasta la fecha, sólo se han publicado unas pocas secuencias de esta especie provenientes de su localidad tipo y de la Península Ibérica. Éstas indican que P. scopulorum podría ser un complejo de especies. El objetivo de este trabajo es reevaluar la diversidad de especies que morfológicamente se corresponden con P. scopulorum. Para ello recolectamos 122 muestras en Australia, Sudáfrica, Canarias, Azores, Francia (Mediterráneo) y el Atlántico de la Península Ibérica. A partir de ellas se amplificaron los genes rbcL y cox1, que se analizaron empleando PTP, GMYC y ABGD. Nuestros análisis indican que P. scopulorum es un complejo que incluye al menos 11 especies en el área estudiada. La mayor parte de esas especies presentan una distribución restringida. Por el contrario, una de esas especies se ha encontrado en Australia, Sudáfrica y el Atlántico norte oriental. Todas las especies comparten las características morfológicas más relevantes que se emplean para la delimitación de especies en el género Polysiphonia. A pesar de ello, algunas especies pueden distinguirse en base a caracteres morfológicos concretos, mientras que la diferenciación de otras especies requiere el uso de secuencias de ADN.

# Microalgal selectivity patterns in biocrusts lichen communities

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<sup>1</sup> Universitat de València, Inst. "Cavanilles" de Biodiversidad y Biología Evolutiva, Botánica, Fac. CC. Biológicas, Valencia, 46100 Burjassot, Spain Biocrusts are considered to be ecosystem pioneers in colonizing soil surfaces creating a consistent layer and binding soil particles due to their presence and activities. These biocrusts are particularly important in gypsum ecosystems which are normally dominated by lichens.

Different areas throughout the Iberian Peninsula show gypsum biocrusts, that are colonised by a well-developed terricolous lichen communities cohabiting in these areas: crustose species such as *Diploschistes diacapsis, Acarospora placodiiformis, A. nodulosa* and *Buellia zoharyi,* occasionally accompanied by *Diplotomma rivasmartinezii* and *Rhizocarpon malenconianum.* A squamulose community composed of *Psora decipiens, P. saviczii, Clavascidium* spp. and *Placidium* spp.. Moreover, foliose (Cladonia spp.) covers microareas with an extra water.

We present a detailed study based on the myco/phycobiont relationships and its microalgal selectivity patterns. Barcode nrITS mycobiont analyses were performed to construct phylogenies, haplotype networks and biogeographical hypothesis. For the microalgae and chloroplastic several nuclear aenetic markers were studied, moreover isolation and ultrastructural characterisation were included. Three different microalgal genera where detected in the community: Trebouxia, Asterochloris and Myrmecia. We suggest the morphology and/or growth type could be influencing the selection of each mycobiont for a particular microalgal genus.

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# The Macaronesian endemic *Ramalina decipiens* group (lichenized Ascomycota), phylogenetic insights of an island radiation

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Most lichen-forming fungi show wide distribution ranges, usually larger than vascular plants, and similar to other cryptogams such as bryophytes. There are not many examples of endemism in reduced areas and most of them correspond to island endemics. The genus Ramalina with c. 200 species worldwide is a rather characteristic group of lichenized fungi, easily recognizable by their fruticose, usually straw-yellow thalli. Although Ramalina occurs from the tropics to high latitudes, included Antarctica, the highest diversity is found in subtropical xeric areas with constant fog, especially in the Northern Hemisphere. In the Canary and Madeira archipelagos, Ramalina shows an amazing diversity (20% of total global diversity) including two putative radiations: the Ramalina decipiens and Ramalina bourgaeana groups. The Ramalina decipiens group is defined by the presence of chondroid strands adjoining the cortex. Last taxonomic work on the groups dates from 1980, including 4 species. Subsequent work on Madeira archipelago added two extra species, endemic from Porto Santo island. Based on a broad sampling in the Canary Islands, Madeira and also Cape Verde, we studied the phylogenetic relationships in the Ramalina decipiens group by means of novel molecular markers. Diversity of the group was clearly underestimated in previous works. Assumed morphological and chemical plasticity in some species actually correspond to independent and well delimited lineages.

poster communications

# The genus Cladonia in Sicily (Italy)

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Sicily is the largest island in the Mediterranean and belongs to the Italian territory. It is located in the southern part of the country separated by the Messina Strait of the continent. The island is montainous along the northern coast with the mountain ranges of Madonie (2000 m), Nebrodi (1800 m) and Peloritani (1300 m). In the east the Etna mount (3220 m) an active volcano, is the highest pick. There are many different geological domains represented by metamorphic, igneous and sedimentary rocks. The climate is mediterranean temperate but very variable related to its altitude. The vegetation is constituted by woodlands of Quercus ilex, Q. suber, deciduous woods of Quercus ssp., Fagus sylvatica, Betula aetnensis, Castanea sativa in the mountainous areas mixed with maguis shrubs and garrigues in lower altitudes. There are no previous studies of the group although there are scattered data in the bibliography and by this the study of the Cladoniaceae family has been carried out being only represented the genus Cladonia. The total number of localities visited was 70 and the number of specimens collected was 225. The catalog amounts to 24 taxa of which 6 are new for the island: Cladonia cariosa, C. coccifera, C. conista, C. humilis, C. rei and C. subulata. The chemical variability and the distribution area of the species is discussed.

A. R. Burgaz received financial support from the project CGL2013-41839-P, Ministry of Economy and Competitiveness, Spain.

# The genus Cladonia in Sardinia (Italy)

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Sardinia is the second largest island in the Mediterranean and belongs to the Italian territory. It is located in the western part of the country. It is a montainous island with complex geological history. The oriental part is montainous and largely granitic while the occidental is volcanic and separated by a broad depression filled with Tertiary deposits. The highest pick of Sardinia is Punta La Marmora (1834 m) of the Gennangertu Ranges located in the central part. The climate is mediterranean temperate but very variable related to its altitude. It is a very windy island suffering differents winds as the Mistral in winter and spring. The vegetation is constituted by woodlands of Quercus suber, Q. ilex and deciduous Quercus ssp. in the mountainous areas, mixed with maguis shrubs in lower altitudes. There are no previous studies of the group although there are scattered data in the bibliography and by this the study of the Cladoniaceae family has been carried out only represented the genus Cladonia. The total number of localities visited was 58 and the number of specimens collected was 234. The catalog amounts to 28 taxa of which 6 are new for the island: Cladonia conista, C. diversa, C. firma, C. novochlorophaea, C. subturgida and C. subulata. The chemical variability and the distribution area of the species is discussed.

A. R. Burgaz received financial support from the project CGL2013-41839-P, Ministry of Economy and Competitiveness, Spain.

# Study of gametophytic competence between several saxicolous species of spleenworts (*Asplenium*)

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Interspecific competition in ferns could occur in either of the two biological stages, gametophyte and sporophyte, because these two generations are manifested as independent living individuals. The gametophytic phase is particularly interesting from an ecological perspective, because spore germination controls ultimately the recruitment gametophytic both and sporophytic of populations, so competitive species could gain advantage if competence is directed to the spore germination and/or gametophyte reproduction of the other species. In the Peninsula Iberica, ferns are common as saxicolous plants, forming very characteristic rock communities, dominated by the spleenworts (Asplenium sps).

The objective of this work is increase knowledge about the functioning of these communities, beginning with the study of inter-specific competition in the spore germination. To this aim, we selected three common species: Asplenium trichomanes. A. ceterach and A. billotii. We sampled fertile fronds of two individuals per species from two different populations. Spores were sown in Petri dishes with agar mineral at 25 °C. To observe the existence of competition in spores germination we performed the following experiments: controls (cultures with only spores of one species) and competition experiments (cultures with spores of two species). In order to verify the existence of inter-specific competition, we count the number of spores germinated of each species over time in each experiment.

# *Placynthium coerulescens* (Harm.) Gyeln. in the Iberian Peninsula

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<sup>1</sup> Departament de Biologia Evolutiva, Ecologia i Ciències Ambientals, Universitat de Barcelona - Institut de Recerca de Biodiversitat (IRBio), Spain Placynthium coerulescens (Harm.) Gyeln. (Syn. Placynthium baumgartneri (Zhalbr.) Gyeln.) is reported for the first time in the Iberian Peninsula. Therefore, with the new record, the genus has a diversity of 10 species in the Iberian Peninsula if we consider Placynthium dolichoterum in to the genus Sphaerulina Mycosphaerellaceae. belonging the to P. coerulescens was found in the Cadí-Moixeró Natural Park (Catalonia) grown on limestone, at 2.200 m. Their thallus crustoseplacodioid, without hypothallus, is very similar to P. subradiatum, but when they are fertile, P. coerulescens has 3-septate ascospores and P. subradiatum has 1-septate ascospores. Previously, it was known from Austria, Croatia, Slovakia, Switzerland, and France, with the optimum between the supramediterranean and subalpine belts.

# Preliminary data from the lichenological field trip of the Spanish Lichen Society (SEL) in the Sierra Nevada National Park

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Manuel Casares<sup>1</sup>, Violeta Atienza<sup>3</sup>, Ana Rosa Burgaz<sup>4</sup>, María José Chesa<sup>5</sup>, Salvador Chiva<sup>3</sup>, Cristina Dumitru<sup>3</sup>, Laura Force<sup>2</sup>, Sergio Muriel<sup>6</sup>, Maria Prieto<sup>6</sup>, Víctor J. Rico<sup>7</sup>, Clara Rodríguez<sup>6</sup>

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In the second week of September 2018, the Spanish Society of Lichenology (SEL) conducted a lichenological field trip to the Sierra Nevada National Park. Sierra Nevada, recognized as a biosphere reserve, is a mountain range located in the provinces of Granada and Almería (Andalucía, Spain). The main areas of the mountain range are included in the Sierra Nevada National Park. The Park is integrated into the Penibaetic system and has the highest altitude in Mulhacén (3479 m) that is highest peak of the Iberian Peninsula. Here more than 60 endemic plants and very original communities find refuge. In a total of 7 localities, between 3,167 and 1,600 m a.s.l., saxicolous, terricolous and epiphytic lichens, as well as their lichenicolous fungi were prospected. These localities included from siliceous to carbonated rocks and diverse types of forests and meadows. The first data on lichens from Sierra Nevada were given by Colmeiro (1867) and the most recent compilation can be extracted from Burgaz (2014). Considering the limits of the Sierra Nevada in a broad sense, a total of 457 lichen and lichenicolous taxa had been published until now, some of them of doubtful identification. In this study we present a list of the inventoried species during this field trip widening the knowledge of the already known lichen and lichenicolous biota. So far and provisionally, 24 lichen species and 6 of lichenicolous fungi have been added to the Sierra Nevada check-list.

# Unravelling the microalgae associated with sphaerothallioid *Circinaria*: *Trebouxia izcoana* sp. nov. as representative of a new clade

### Arantzazu Molins<sup>1</sup>,

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<sup>1</sup> Universitat de València, Inst. "Cavanilles" de Biodiversidad y Biología Evolutiva, Botánica, Fac. CC. Biológicas, Valencia, 46100 Burjassot, Spain The spaherothallioid lichen species are interesting candidates to analyze the phycobionts diversity due to the different morphology and growth forms wich occur under diverse ecological settings. The majority of molecular studies in sphaerothallioid lichens are focused on mycobiont analyses, but phycobionts have been generally ignored and are poorly known.

A previous study based on the genus *Circinaria* has highlighted an interesting algal diversity. In this investigation different *Circinaria* spp. were explored, the adequate identification of the fungal partners was corroborated by the ITS rDNA barcode and phycobiont phylogenetic analyses were also made with the ITS rDNA using Sanger sequencing. Remarkably, a new *Trebouxia* clade strongly supported was obtained in *Circinaria gyrosa*, a vagrant lichen growing in very continental areas in the Iberian Peninsula.

Here, in order to analyse more extensively the microalgal taxa associated with the thalli of these *Circinaria*, and to corroborate the presence of this new *Trebouxia* species, we have increased the number of specimens examined which incorporate different locations of *Circinaria gyrosa* along the Iberian Peninsula. We provide a detailed ultrastructural characterization and phylogenetic analyses of this novel phycobiont species, here described as *Trebouxia izcoana* sp. nov.

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# Assessing species-specific traits for vegetative dispersal in six Iberian soil mosses

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Bryophytes strongly rely on vegetative reproduction for colonization and population maintenance. Many moss species are able to regenerate from fragments of vegetative tissue. However, little is known about how establishment potential differs between species, as well as how it relates with the type and size of the fragments. We evaluate the differences in size and viability of shoot fragments that were artificially obtained through mechanical milling of dry samples, for six soil moss species (Hypnum cupressiforme, Dicranum scoparium, Ptychostomum capillare, Homalothecium aureum, Tortella squarrosa and Syntrichia ruralis). For each species, we measured the specific breakage rate sieving them into three size classes. We cultured the fragments of each size class in controlled conditions and measured the percentage of colonized surface after two months. The six species differed in the proportions of fragment types and sizes after sieving, as well as in the establishment success and growth rates. For all fragment sizes, D. scoparium showed the lowest colonization percentage (below 1% of the cultured surface), whereas P. capillare showed the highest success (above 30% of the surface). The differences in viability and growth in the propagules of the six species point at a specific process of fragmentation, in which the singularity of each species fragment size could promote differences in vegetative dispersal.

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# Orthotrichum comosum F. Lara, Medina & Garilletii (Orthotrichaceae, Bryophyta) in the Iberian Peninsula and the most important environmental factors determining its occurrence

Orthotrichum tenellum Bruch ex Brid. s.l., one of most common species in Iberian Peninsula, was revised by Medina et al. (2013), who recognized five species based on morphological and molecular approaches, each of them distributed in different parts of Europe or Western North America. One of these species, Orthotrichum comosum F. Lara, Medina & Garilletii, resulted to be a moss frequently found in Iberian area. This taxon is nowadays known from several Macaronesian and Mediterranean disjunct areas, namely Madeira, Canary Islands, Morocco and Sicily, being more recently reported from the Nederlands. Orthotrichum comosum is an epiphytic species, growing on distinct trees, in areas of Mediterranean submontane climate, with mild, wet winters and hot dry summers. It was initially reported from ca 10 sites in Spain and two from Portugal. However, after a recent revision of herbarium collections, it has been identified for ca 50 new localities in Portugal, the majority in the Eastern areas and ca 40 in Spain peninsular. The objectives of this study are: 1) to determine the most important environmental factors influencing the distribution of this species in the Iberian territory (based on herbarium and/or bibliography); 2) based on the present distribution in the Iberian Peninsula develop predicting models indicating the areas with higher probabilities of occurrence; 3) to recognise the of phorophyte types that preferentially support this species considering its future conservation.

Wild African Cryptogams: more than one thousand specimens understudied at the Natural History and Science Museum at Porto University (PO) Herbarium

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The herbarium of the Natural History and Science Museum at Porto University (PO) is a reference collection of Portuguese flora, comprising collections since the 19th century including former Portuguese colonies. All specimens deposited in this herbarium are readily accessible with meta-data (location and date of collection and name of collector). But some of the cryptogamic collections generated as secondary or opportunistic specimens in field surveys end up as unnamed or unpublished. This worsens when no documentation refers to these collections or when collections resulted from personal or casual collections made by botanists focused on vascular plants. PO African cryptogams comprise a total number of 3308 specimens (algae, fungi, lichens, bryophytes, pteridophytes). Some of these were the basis of new species to science or the first records for some countries. but 1484 are clearly understudied, being potentially interesting discoveries awaiting at the shelves. The main objective of this work was to recognize, repackage, numerate, and database these irreplaceable specimens. In this way, we hope to ensure their accessibility to staff and researchers. By presenting these collections, from a curatorship perspective, the associated missions, protagonists, and meta-data we hope to promote their study and application.

We would like to acknowledge the support of the Portuguese Infrastructure of Scientific Collections - POCI-01-0145FEDER-022168 (PRISC.pt).

# Survey of the bryophytes in the floodplain habitats of Kopački rit Nature Park (Croatia)

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The Kopački Rit Nature Park is one of the largest alluvial wetlands of Europe, with significant wildlife diversity and ecological importance. It is located in northeastern Croatia, between courses of the Danube and Drava Rivers. Terrestrial, wetland and aquatic habitats are in permanent dynamic exchange, depending on the frequency and duration of the Danube flooding, as well as drought periods. The field surveys were conducted in September 2017 and August 2018, at five localities in various floodplain habitats. Samples were taken from bark and lignum of deciduous trees, concrete substrates, water and soil surface. As a result, a total of 36 bryophyte taxa have been recorded, classified into 9 liverworts (7 thallose and 2 foliose) and 27 mosses (17 acrocarps and 10 pleurocarps). According to the type of substrate, the majority of taxa were found on soil (21) and tree bark (8). Among the most frequently recorded were Anomodon viticulosus and Hypnum cupressiforme, as common epiphytic mosses. Particularly noteworty was Riccia cavernosa, growing in exceptional numbers on exposed muddy or sandy bottoms during periods of extreme droughts. Furthermore, two aquatic liverworts, Riccia fluitans and Ricciocarpos natans, have been observed as well. This survey presents an important contribution to the knowledge of bryophyte flora of the Kopački rit Nature Park and floodplain of the Danube River in its middle course.

# Preliminary checklist of lichens and lichenicolous fungi of Portugal

### Graciela Paz-

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The Checklist of Iberian Lichens and Lichenicolous Fungi, published in 2001, provided an important account of the lichen flora in the Iberian Península, helping to shape the series Flora Liquenológica Ibérica, currently under-way. However, a checklist of lichens of Portugal is needed, for research, conservation and management purposes. The idea of a Portuguese checklist was originally placed by Pier Luigi Nimis, immediately after the publication of the Iberian work, but, although it had several start/stop periods, only recently the joint effort of the authors allowed the project to reach a guasi-final, and consolidation phase. This work is a preliminary overview of the lichen diversity from continental part of Portugal, between 1789 and 2017. The compilation is based on circa 400 publications, which screening provided an aggregation of more than 28000 citations of lichen occurrences in Portugal. The catalogue will include all lichenised species, plus a set of nonor doubtfully lichenised taxa frequently treated by lichenologists. This work compiled, up to now, a preliminary list of circa 1200 taxa (with synonyms) hitherto reported from the country, including the species distribution by the provinces applied in botanical floras for Portugal. Data on the main substrates and on the altitudinal distribution whenever is possible are also provided.

# Are the climatic responses of moss sister taxa similar at both sides of the Atlantic?

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Bryophyte disjunctions between the New World and the Old World are common and often entail morphological variations that are structured space. These geographically structured in differences lead to controversies regarding the taxonomic status of the populations at both sides of the Atlantic. Those disjunctions have often been evaluated through genetic and morphological analyses, however, the ecological differences among disjunct mosses have rarely been assessed quantitatively, despite their potential importance for speciation processes. We evaluate the similarities on the climatic responses between two pairs of soil mosses under controversial taxonomic status: Homalothecium aureum and the synonymized H. pinnatifidum; and Tortella squarrosa (= Pleurochaete squarrosa) and the American P. luteola. We first model their responses to large-scale environmental gradients using publicly available data of their global distributions. Then, we evaluate the reliability of the modelling approach based on climatic information and Ecological Niche Factor Analysis (ENFA). Finally, we assess the similarities in their responses using niche overlap analysis. The results indicate that both moss taxa pairs show climatic differentiation, corresponding with a comparatively larger latitudinal range in The Americas in Homalothecium but not so clearly in the Pleurochaete-Tortella pair which could suggest that they are the result of different diversification or dispersal histories.

# Biodiversidad liquénica en iglesias graníticas del noroeste de la península Ibérica. ¿Relación con el cambio climático?

### M<sup>a</sup> Eugenia López

**de Silanes,** Graciela Paz-Bermúdez, María Calviño-Cancela, Beatriz Prieto

Se estudian los líguenes de 4 iglesias de granito, situadas en la provincia de Lugo, Galicia, NW de España. Se eligieron teniendo en cuenta unas características determinadas, una de ellas es que estuvieran situadas en una zona que es análoga espacial de otra zona portuguesa. Para conocer la biodiversidad, se realizan muestreos en todas las orientaciones y cotas posibles. Para conocer la rigueza y abundancia liguénica, se eligieron las orientaciones N y S, los muestreos se realizaron utilizando una red de 20 x 20 cm dividida en cuadrados de 2 x 2 cm. Hasta la fecha se han identificado 79 taxones, siendo 53 los encontrados en las orientaciones N-S, domina el biotipo crustáceo con algas verdes y reproducción sexual. Tanto la abundancia como la rigueza están influenciadas significativamente por la orientación, hay mayor cobertura en el N y más rigueza en el S. Lecanora muralis, L sulfurea, Physcia caesia, Xanthoparmelia tinctina, X. verruculifera caracterizan la orientación S y Cresponea premnea, Dirina massiliensis, Haematomma ochroleucum caracterizan la orientación.

Análogos espaciais para o cambio climático. Xunta de Galicia, Consellería de Medioambiente e Desenvolvemento Sostible. Cap 30: 609-6015 https://www.researchgate.net/ publication/259189239\_Analogos\_espaciais\_ para\_o\_cambio\_climatico. Trabajo financiado por el proyecto: Project CGL2016-79778-R (AEI/ FEDER, UE)

# Community assembly patterns of byrophytes and tracheophytes and future ecosystem vulnerability in boreal peatlands of North-Western Québec

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In a context of changing climate and humain activities, boreal peatlands in North-Western Québec are facing a changing environment. Due to access difficulties, few inventories exist for the region meaning that there is a need to improve scientific knowledge on plant communities and ecosystem functionings. Forty-five peatlands for this doctoral project are selected in 3 sectors along a 1000 km transect representing several environmental gradients: geology, topography and climatic conditions. Peatlands are also selected along a gradient of hydrological conditions, minerotrophy and vegetation structure (Black Spruce bogs vs. open bogs). Bryophytes and tracheophytes are inventoried, but information on lichens is included from a parallel Master's project. Assembly patterns are studied in observed vegetation communities at 4 spatial scales and according to 4 environmental filtres. For example, we expect to observe strong effets from abiotical conditions on local species pools and the ecosystem community being affected by niche differentiation and biological interactions. Abiotical conditions are examined in detail so as to better understand functions tied to hydrology, peat accumulation and decomposition. Results will then be used in combination with future climate scenarios to assess risk. Final results will serve to develop understanding of peatland ecosystems in the region and as a baseline for future studies. Preliminary results are presented here concerning Black Spruce bogs.

# Why are you here? Drivers of bryophyte epiphytic community structure across scales

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The factors that influence species composition across different spatial and temporal scales have been extensively investigated. However, most studies focus on specific sets of factors (e.g. environment, geographic distance, or species pool for example), while large sets of factors and their interactions are seldom considered. We focus on the combined impact species pool, environmental gradients, of geographic distance and scale on the diversity of epiphytic bryophytes. We identify biogeographic modules of co-occurring species using network modularity analyses, evaluate their consistency at two scales of analysis (forest and tree), and study the relationships between environment and geographic distance at these two scales and within each biogeographic unit. Our results show that the structuring of the communities is a byproduct of the balance between niche-related and stochastic processes. This balance changes with biogeographic region and scale in a structured way so that environmental filters have a larger impact in the most favorable regions and at the smaller scales.

# The Phaeophyceae (marine macroalgae) on the coast of Algeria: biodiversity and biogeography

## Nora Ould Ahmed<sup>1</sup>,

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<sup>2</sup> Laboratori de Botànica, Facultat de Farmàcia, Universitat de Barcelona, Av. Joan XXIII s/n, E-08028 Barcelona, Spain The seaweed diversity of the Mediterranean is still not completely known, especially in some areas of its African coasts. As an effort to complete a more detailed catalogue to fill such gap, an updated checklist of the brown seaweeds (Phaeophyceae) from Algeria, based on updated literature records, is provided using as starting point the checklist of Perret-Boudouresque & Seridi published in 1989. As a result, the total number of taxa at specific and infraspecific levels accepted for Algeria, under current taxonomy and nomenclature, is 95. Biogeographically, the Algerian flora of Phaeophyceae is characterized by a high number of Cosmopolitan or Subcosmopolitantaxa followed by the Mediterranean taxa.

# Rare Vascular Cryptogams on the territory of Ukraine

## Olesya Bezsmertna<sup>1</sup>

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There are about 100 species of Vascular Cryptogams in Ukraine, namely 12 - Lycophytes, 66 - True ferns, 11 - Horsetails and 6 -Ophioglossoid ferns. Among them 31species are protected on the state level. 7 True ferns, 6 Horsetails and 2 Lycophytes species from Ukraine are under only LC category in the IUCN Red List of Threatened Species. The European Red List includes 69 Vascular Cryptogams that are occurred in Ukraine, but only 3 species are considered as threatened: Botrychium simplex, B. virginianum and Marsilea guadrifolia. B. simplex in Ukraine is known only from the outskirts of Kharkiv City. But indicated localities undergone considerable urbanization and population of this species is most likely lost. Among 29 known findings of *B. virginianum* in Ukraine only three are confirmed during the last 20 years. Populations are small (up to 6 individuals). After our revision of 35 localities of M. guadrifolia we have confirmed only 6 of them and 2 have been found new in Transcarpathia and Kyiv regions. Now 4 populations are threatened because the reservoirs get dry and only in 2 localities thickets are formed, thus these populations are in good condition

# Competition and abiotic stress factors in three species of Mediterranean mosses

## Paula Martínez Domínguez<sup>1</sup>, Belén Estébanez<sup>1</sup>, María Leo<sup>2</sup>

<sup>1</sup>TFac. Ciencias, UAM, Spain <sup>2</sup>Real Jardín Botánico, CSIC, Spain Interspecific competition is a conditioning factor of plant community structure, distribution and dynamics. Using three moss species, we aim at assessing different factors affecting the coexistence of some species along an altitudinal gradient in both natural conditions and outdoors experimental settings. We have selected three terricolous species: *Homalothecium aureum*, *Hypnum cupressiforme* and *Tortella squarrosa*, all three very common in Central Spain, and studied their interactions via two different approaches:

-Coexistence experiment: we established outdoor cultures of artificial moss communities, both monospecific and mixed (homogeneous tufts with shoots of two or all three species), in three localities at 490 m, 720 m and 1500 m.

-Systematic sampling of the species in natural conditions: we established 10 altitudinal bands covering the same gradient, in order to observe and register the abundance and coexistence of these species in their natural habitats.

Our results, in spite of a remarkable culture stress, suggest species-dependent incongruences between natural and experimental settings. For instance, Tortella squarrosa shows better survival and physiological status in all three outdoor culture localities, whereas it is almost absent in the higher altitudinal bands. We also recorded some clear competition effects quite consistent along the gradient, as mixed communities with all three species tend to show a worse performance.

# Diversity and ecology of the lichen family Lobariaceae (lichenized Ascomycota: Peltigerales) in Croatia

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The Lobariaceae is the second largest lichen family in the Ascomycota. In Croatia, findings of five species were recorded, namely: Lobaria pulmonaria, Lobarina scrobiculata, Ricasolia amplissima, Ricasolia virens and Sticta fuliginosa. Data about locations and habitats were collected from literature, by checking at herbaria collections in Croatia and abroad, and from the records of recent field surveys. Distribution maps has been produced for each species. All studied species belong to the epiphytic alliance Lobarion pulmonariae. Distribution maps show frequent distribution in the montane belt of the Dinaric Mountains, and in the Middle and southern Dalmatia, with a disjunctive distribution in the montane and lowland belt in the Pannonian region. Distribution of the species is matching the areas in Croatia with mean annual precipitation above 1.000 mm. The main substrates are Fagus sylvatica, Acer pseudoplatanus, Quercus pubescens, Quercus ilex, Picea abies and Abies alba. Mean host tree circumference ranged 106-179 cm, with maximum 390 cm. Bark pH was in optimal range (5.8-6.9). Nowadays, in some parts of Croatia, big and fertile thalli of Lobaria pulmonaria, Lobarina scrobiculata and Ricasolia amplissima can still be found. The number of findings of *Ricasolia virens* is small, since it was discovered in 2002. For Sticta fuliginosa, there was only one historical record from 1869, up to recent discovery in 2008. Conservation measures are related to forest management practice.

# Lichen communities in northwest Quebec, Canada: Biodiversity and influencial environmental factors

## **Tana Route**<sup>1</sup>, Nicole Fenton<sup>1</sup>, Marc-Frederic Indorf<sup>1</sup>, Mireille Martel<sup>1</sup>

<sup>1</sup> Université du Québec en Abitibi-Témiscamingue, Canada Our primary goal is to document lichen biodiversity in dominant peatland types in the Eeyou Istchee James Bay region of northwestern Quebec, Canada. This region has been little studied for lichen diversity, so with increasing development and climate change it is vital information to obtain. With this we hope to provide recommendations on management and protection of lichens to managers and industries in the region. Such biodiversity studies can also be baselines for future research and monitoring.

Our secondary interest is to understand how environmental factors affect lichen communities in different peatlands. These environmental factors are: relative air humidity, light availability, microhabitats, tree/stand age, climate and disturbance. This information will help us understand regional lichen communities better and assess future impacts.

We selected three roughly equidistant study sites to reflect north-south and east-west gradients that show wetter to dryer territory. At each site three dominant peatland types were studied: Uniform Bogs, Spruce Bogs and Uniform Ferns. Data on lichens and environmental factors were collected on two 20 meter transects in three replicates of each peatland type per site. Lichen samples are currently being identified in the laboratory. We are still analyzing the preliminary results, which we hope to present at this conference, but initial findings include possible range expansions of several hundred kilometers and new provincial reports.
managment & conservation



oral communications

El estado actual de los líquenes, briofitos y helechos, especies vedadas en Colombia, una evaluación desde la política ambiental colombiana

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En Colombia, para obtener el licenciamiento ambiental de proyectos minero-energéticos y de infraestructura por parte de entidades privadas, se requiere realizar un aprovechamiento de flora nacional, que implica una afectación a la vegetación criptogámica. Por lo tanto, se debe realizar el trámite de levantamiento de la veda para los líquenes, briofitos y helechos establecido por la Autoridad Ambiental según las Resoluciones 0213 y 0801 de 1977, configurando un procedimiento legal de obligatorio cumplimiento. Esta revisión se fundamentó en una evaluación formativa desde su formulación, la naturaleza del instrumento público y su contribución al conocimiento de la diversidad direccionado hacia su conservación, que podría aportar a la actualización del estado de amenaza de las especies vedadas. Además, permitió diagnosticar la capacidad institucional de la Autoridad Ambiental y sus limitaciones; indagar si las medidas de manejo ambiental que se proponen actualmente son eficaces, cuentan con un seguimiento que garantice la restauración ecológica de los hábitats, y si aportan herramientas útiles para la conservación de las comunidades criptogámicas. Finalmente, se concluve que el alcance de las resoluciones administrativas de dichas políticas públicas ambientales, deben tener mayor claridad operativa, para que los proyectos de desarrollo económico ejecuten medidas de mitigación de impactos y de compensación adecuadas, que favorezcan el estatus de las especies criptogámicas vedadas.

# Bringing the concept of nitrogen critical levels into managing for conservation

## Bernardo Rocha<sup>1</sup>,

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Multiple agricultural activities often origin excessive nitrogen concentrations, which impact ecosystems structure and functioning. To protect them, critical levels where established but they are often overlooked in management strategies. They are legal-binding concentration values above which, according to present knowledge, direct adverse effects on ecosystems may arise. Our objective was to provide a tool to bring the concept of critical levels into management of atmospheric nitrogen impacts. Lichen diversity was sampled in 19 sites in a cork oak woodland (Montado) classified as a High Nature Value Farmland with multiple agricultural activities surrounded by high-intensity agricultural activities. We selected the best performing trait-based metrics and determined the main environmental drivers of change. The most responsive metric was the abundance of oligotrophic lichen species, which was responding to nitrogen deposition from nearby high-intensity agricultural areas. Local low intensity agricultural activities had no effect. Using the known ammonia critical levels for that ecosystem, we modelled and mapped the longterm exceedance of critical levels for the entire study area. Model interpretation allowed us to identify and signal nearby crops as the source of impact and thus where further attention should be focused: either decreasing fertilization in nearby fields or by considering these as buffer areas, outside the scope of conservation (and of the HNVF concept).

# Evaluation of environmental factors promoting the presence of forest lichen species deserving an especial protection

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Protected areas are committed to preserve and increase biodiversity hosted within their borders, as well as surrounding areas. In order to fulfil this assignment, a careful survey on global diversity is required. However, achieving such goals is limited by several aspects like budget availability, expertise knowledge, etc. The Natural Park "Capçaleres del Ter i del Freser" (PNCTF) is located in the Eastern Pyrenees (NE Iberian Peninsula); despite of its natural values, PNCTF lacks a good survey on lichen diversity. The first priority of PNCTF focused on locating and evaluating the presence of lichen species included in the Catalan catalogue of species deserving special protection. A survey has been carried on three species meant to be present in PNCTF and bound to forest habitats: Lobaria pulmonaria, Nephroma parile, and Sticta limbata. A hierarchical sampling based on habitat and GIS was established to prioritize potentially interesting localities. Because the park is in a high mountain area; only seven sites satisfied the criteria, and just one brought in a positive match. Environmental factors from surveyed sites were analysed and compared with sites where these species have been certainly reported from NE Iberian Peninsula. Two factors arose as main drivers: forest cover continuity for at least 60 years, and low summer precipitation. Selected sites from PNCTF have high summer precipitation and lack forest continuity, factors prompting the absence of the selected species.

# Azolla as a case study for biological and environmental research in the context of climate change

# Francisco Carrapiço<sup>1</sup>

<sup>1</sup> Centro de Ecologia, Evolução e Alterações Ambientais e Centro de Filosofia das Ciências, Departamento de Biologia Vegetal, Faculdade de Ciências, Universidade de Lisboa, Portugal Azolla is a worldwide heterosporous floating or semi-aquatic pteridophyte presenting an overlapping scale-like bilobed leaves covering a slander and branched rhizome that floats horizontally on the freshwater surface. Each leaf contains a permanent endosymbiotic prokaryote community (N<sub>2</sub>-fixing filamentous cyanobacterium and bacteria) living immobilized inside the dorsal lobe cavity of the leaves and in the megasporocarps. The N<sub>a</sub>-fixing capacity presented by the cyanobacterium, allows the fern to grow in freshwater environments devoid of combined nitrogen, but enriched in phosphorus. Azolla filiculoides is the species present in Portugal and was introduced in Europe in the mid-XIX century as an ornamental plant. Due to climate change, in particular the subtropicalization of the South of Europe, and high nutrient concentration present in water bodies. Azolla has spread, being present in almost all of the Iberian Peninsula. Over the last three decades, several major blooms occurred in diverse regions of Portugal and Spain, promoted by low river flows and the presence of higher phosphorus concentration with serious consequences for the ecology and economy of the regions. In this communication, we highlight major Azolla blooms that occurred 1993, 1995. 2009 and 2019 in the international rivers Guadiana and Tagus. A transnational program for Azolla control, integrated in a European Observatory for Weeds Management, is proposed to avoid these environmental hazards.

# From ecophysiology to conservation: Lobaria pulmonaria (L.) Hoffm. as a model species for sensitive macrolichens

### Luca Paoli<sup>1</sup>, Anna

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Forest management practices may heavily impact epiphytic (tree inhabiting) organisms. An ecologically sustainable management should take into account also the survival of sensitive organisms with long-lasting generation times and, hence, ensure the overall protection of the ecosystems. Retaining tree patches and buffer strips in logged stands may contribute to preserve ecosystem functioning and the vitality of epiphytic organisms in managed forests. To test these statements, the threatened forest macrolichen Lobaria pulmonaria (L.) Hoffm. was used as a model species, since it is a "flag" indicator species of forest ecosystems with long ecological continuity. To this purpose, photosynthetic performances, thallus anatomy and water holding capacity (WHC) of samples of L. pulmonaria were investigated in a logged mixed oak forest (Tuscany, Italy), confronting lichen thalli from retained-forest patches and retained-isolated trees, 18 months after logging. analysis of chlorophyll The fluorescence emission, revealed a significant reduction of the vitality of the thalli on retained-isolated trees: furthermore such thalli were thinner and showed a lower WHC. In contrast, thalli from forest patches had performances comparable to those of healthy samples from unlogged forests. Our results provide important information for the implementation of sustainable forest management practices and the conservation of sensitive macrolichens in Mediterranean oak forests.

# Effect of different levels of forest management on epiphytic communities

### Noelia Fernández

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Deforestation is the major cause of biodiversity loss in tropical ecosystems. Epiphytic species, lichens and bryophytes, are very sensitive to environmental changes, including those produced by conversion of primary forests into secondary vegetation. We test the effect of different levels of forest management on the epiphytic communities. The study was done in southern Ecuador where four types of forests representing a management gradient were surveyed: Pinus patula plantations, monospecific secondary forests of Tibuchina lepidota, monospecific secondary forests of Alnus acuminata and mixed secondary forests. In each type of forest, we surveyed 2 zones, established 10 plots per zone, with 4 trees per plot where we estimated lichen and bryophyte cover in 4 inventories per tree and calculated epiphytic richness, diversity and composition. We identified 422 taxa (312 lichens and 110 bryophytes). Richness was higher in the least disturbed forests (mixed secondary forests with 319 species), and lower in the most disturbed forest (monospecific plantation, with 152 species). Canopy cover was the predictor for total diversity. Multivariate ordination analysis showed differences in epiphytic composition and a segregation between forests. Functional diversity was also different in relation with the type of forest. In conclusion, we observed changes in diversity (both taxonomic and functional) and composition of the epiphytic communities along the studied management gradient.

poster communications

# Bryophytes as potential indicators of forest degradation

## Sarah Stow<sup>1</sup>

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Bryophytes' reliance on microclimate makes them susceptible to forest degradation due to the decrease in humidity and increase in insolation. Species that are less desiccation tolerant (needing humid and sheltered conditions) will be more susceptible to degradation than tolerant ones. Bryophytes therefore have the potential to be indicators of fine-level changes not detectable by other taxonomic groups. Additionally, bryophytes are understudied, especially in the tropics, and so exploring their potential as indicators will add to the knowledge of tropical bryoflora. To determine bryophytes' potential as indicators a trait database was created for 1430 taxa, morphological and reproduction traits, 51 five environmental traits, 13 ecological and distribution traits and three conservation traits. Species, genera and families were assigned an indicator value based on their environmental preferences and traits. Many traits were found to affect species' environmental preferences, from life-form and plant size to cell shape and spore size. Taxa indicator values were validated by sampling bryophytes in a humid forest along a gradient of degradation. Certaintraits respond predictably to environmental conditions and forest degradation. Species that indicated humid and sheltered conditions tend to be large with open life-forms. Bryophytes with these traits could be used as a quick, simple and cost-efficient measure of forest degradation and therefore have potential as indicators.

# Contribution to assessment of threatened species in red list of lichenforming and lichenicolous fungi in Spain and Portugal

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The Spanish Lichen Society (SEL) has recently launched an initiative to create a Red Lists of lichen-forming and lichenicolous fungi for Spain and Portugal (including the Canary Islands, Madeira and Azores) in order to increase the knowledge on the extinction risk of putative threaten species by assessing threats according IUCN criteria and to provide accurate information for conservation measures. The profiles of 19 lichen-forming fungi including their threat assessment are presented. Profiles follow recommendations proposed by Atienza & al. (2017, British Bulletin 120). Datasheets contribute the following aspects: 1) Main characters for identification; 2) Ecology and habitat description; 3) Map of areas of occurrence and IUCN classification: extent of occurrence (EOO), area of occupancy (AOO), number of localities; 4) Main threats to species survival; 5) IUCN Red list category and criteria used for assessment; 6) Proposed conservation actions that are needed to mitigate these threats; and 7) Research needed. The following species are documented : Buellia zoharyi, Calicium corynellum, Cetraria islandica, Cladonia bellidiflora, C. borealis, Cyphellium marcianum, Heteroplacidium contumescens, Leptogium cochleatum, Lobarina scrobiculata, Polyblastiopsis subericola, Pseudocyphellaria aurata, R. clementeana, Ramalina confertula, R. deminuta, Ramalina erosa, R. parva, Ramalina pluviariae, Seirophora lacunosa and S. villosa.

technological applications



oral communications

Valoración de la capacidad antioxidante de dos Fucales: Cystoseira amentacea var. stricta (Mediterráneo) y Cystosphaera jacquinotii (Antártida).

#### **Carolina Pena-**

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En los últimos años, se han estudiado la composición química y la capacidad antioxidante de numerosas especies de algas, a menudo sobre especies del orden Fucales, va que poseen gran capacidad antioxidante por su alta composición en carotenoides y polifenoles. Así, dentro del marco de un estudio de valoración de la capacidad antioxidante de distintas especies de Fucales a diferentes latitudes, presentamos estudios preliminares con las especies Cystoseira amentacea (C. Agardh) Bory var. stricta Mont. y Cystosphaera jacquinotii (Mont.) Skott., evidenciando diferencias en la capacidad antioxidante y su cinética. Para ello se han escogido dos métodos: CUPRAC y DPPH. El primero mide la capacidad antioxidante reductora a través de una reacción redox, mientras que el segundo, además, también mide la capacidad antirradical. Los datos obtenidos muestran que con CUPRAC la capacidad antioxidante en Cystosphaera jacquinotii es un 40% mayor que en Cystoseira amentacea var. stricta. Sin embargo, con DPPH Cystoseira amentacea var. stricta presenta una capacidad antioxidante un 30% mayor que Cystosphaera jacquinotii. Además, en este último método se evidencia una cinética diferente para cada especie, presumiblemente por su diferente composición guímica, lo cual se comprobará en breve mediante técnicas cromatográficas, evaluándose la correlación entre composición y capacidad antioxidante.

# Bioactivity of *Fucus vesiculosus* (bodelha) from the Tagus estuary (Lisbon, Portugal): correlation with thallus age and genre

## Diogo Nunes-da-

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*Fucus vesiculosus* L. (bladderwrack or bodelha) is a brown macroalga (Phaeophyceae, Fucaceae) distributed along the Portuguese coast. This common alga is reported to have several traditional uses with defined dosages. The beneficial effects for health are attributed to different types of biological macromolecules. The less studied compounds are the phlorotannins, produced generally by the brown algae. Phlorotannins are synthesized by polymerization of phloroglucinol produced via the shikimate pathway and seem to have defense functions against ROS species formed during photosynthesis. In this study of *F.vesiculosus* from the Tagus river estuary (Lisbon, Portugal), aqueous extracts were prepared and analysed for phlorotannin concentration and antioxidant activity and those values correlated with thallus size classes (as a proxy for age) and genre. SEM of each development stage was also carried out, as well as ecotoxicological assays. Phlorotannins were quantified by the Folin-Ciocalteu method and determined as equivalent of gallic acid. In young thalli, males have a higher phenolic content while in adult stages the amount of phlorotannins is approximately the same. Antioxidant activity determined as the capacity to scavenge free radicals like DPPH was higher in the young male thalli.

# A tale of two walls: bryophyte establishment on green walls with different irrigation levels

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Green Walls (GWs) have been increasingly recognized as an important restoration technique for steep slopes resulting from guarrying activities or major infrastructure construction. GW irrigation is usually considered mandatory to ensure an adequate vegetation growth and establishment. However, studies concerning the effects of sustainable irrigation practices on GW vegetation are widely lacking. In this context, our main goal was to assess differences in taxonomic and functional diversity and composition of two hydro-seeded GWs with different irrigation regimes, located in Peneda-Gerês National Park (NW Portugal). Both GWs were installed to minimize the visual impact of shotcrete walls and promote their ecological restoration. Bryophyte and vascular species cover was recorded 3 years after GW installation, and species were classified according to their growth-form, life-form, and lifestrategy. Despite hydroseeding application, we observed that both GWs were already dominated by spontaneous species, namely acrocarpous mosses. Species and functional richness was significantly higher in the irrigated GW, although no significant differences were found for trait composition. Overall, irrigation did not affect the structure and functioning of GW communities, given their similarity in functional composition. These findings suggest that bryophytes should be considered when hydroseeding GWs, as they are highly adapted to their specific environmental conditions

# Spore cultures of the red seaweed gracilariopsislongissima(gracilariales), a species of high economic value

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<sup>1</sup> Department of Biology, University of Cadiz, Spain G. longissima is of economic importance because it is consumed worldwide and is also an agar source. The method of its mass cultivation is mainly based on vegetative fragments. The use of carpospores as propagation unit can be an alternative for the mass production of this species. Samples used for sporulation were obtained in 2019 from Cadiz Bay. Fertile gametophytes were cleaned in the laboratory with sterile seawater and treated with 10µM of GeO<sub>2</sub>. The fragments were cut to 1 cm length. Two culture media, Provasoli (P1 and P2) and Miguel (M1 and M2) were used at a temperature of 18 °C and at irradiance of 30 µmol m<sup>-2</sup> s<sup>-1</sup>. The extraction was carried out after two days. Carpospores were planted in multiple well plates. The spores from the first day died after a week. However, the spores obtained on the second day showed a basal disc after 12 days and new microscopic seedlings were observed after 20 days. After one month the spores of M1 and M2 evidenced an undeveloped frond whereas the spores of P1 and P2 showed prominent fronds and even bifurcated thalli. Diatoms grew in all wells but apparently did not affect the development of the spores. Seedlings are currently being grown in a culture chamber and will be cultured in the field. Vegetative cultures of G. longissima have been previously monitored during 2017. The present study is an important step for the development of seaweed cultures in Cadiz bay, especially as part of integrated cultures in earthen ponds.

poster communications

# Novel lichen tissue culture methodology suitable for the isolation and propagation of microalgae in foliose lichens

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Lichen studies have traditionally focused on the mycobiont, thus phycobionts diversity is not so well surveyed. In current investigations, phycobiont isolation is an essential procedure to perform ultraestructural characterization. Here, we illustrate a novel lichen tissue culture method to isolate and propagate lichen microalgae. This methodology have been arranged for the isolation of phycobionts foliose lichens, e.g. Parmelia s. lat. genus, and is based on Muggia et al., (Ann. Bot. 114: 464, 2014) protocol. As a result of this procedure, a collection of axenic cultures of symbiont microalgae was obtained and allowed to provide the experimental basis for physiological, ecophysiological and genomic studies. In addition, ultrastructural features of the isolated algae can be observed by transmission electron microscopy to compare the anatomy between lichenized and isolated microalgae which normally varies under different culture conditions. The approach here proposed identification provides an improvement to and characterization of the taxonomical intrathalline traits in microalgal diversity

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# Protocol for the isolation of yeasts associated with lichens, modified from the previous developed for lichen bacteria (patent ES2575752B2)

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Traditional description of lichens has changed during the last decade. Currently, lichens are not only considered as symbiotic organisms composed of a fungal partner (mycobiont) and a photoautotrophic partner (photobiont). In these symbioses more than a unique lineage of photoautotrophic partners have been found in each individual, even more, diverse bacteria and yeasts are also imbibed in thallus structure (Muggia & Grube, Life 8: 15, 2017, and references therein). Biosca et al. (PLoS One 11: 8, 2016) developed a patented method to improve lichen associated bacteria isolation using media enriched with novel lichen extracts (ES2575752B2; P201431971). This method has now adapted to isolate yeasts associated with Ramalina farinacea. Changes in medium composition, washing and disinfection procedures and culture temperatures have been needed. First results revealed the presence of different genera and species within the families Saccharomycetaceae, Tremellaceae and Dothioraceae. Therefore, the method may not only be adapted for bacteria associated to other lichen species, but also to other associated microorganisms.

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biomonitoring



oral communications

# Biomonitoring epiphytic macrolichens plots after 21 years revealed severe symptoms of injury and changes in diversity in Maestrazgo territories (NE Spain)

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Lichens are powerful and fast bioindicators for environmental changes and air pollution impacts. Epiphytic lichen diversity has been widely used as a standard procedure for biomonitoring the effects of air pollution. In 1984, due to the start-up of a thermal power-plant in Andorra (Teruel), epiphytic lichen diversity and damage surveys were done for the Maestrazgo territories, which include parts of Castellón and Teruel provinces (NE Spain). A sampling network was established in this area registering different air pollution impacts, specially photo-oxidants and nitrogen deposition. These studies were regularly conducted until 1997. Methodology used to assess the lichen communities diversity was the one proposed by the European Union and extensively used at the moment. Along time, different damages were observed in several macrolichens, accordingly the previous research team developed a new method to quantify these symptoms for target species. These species were beforehand selected by the velocity of the symptoms evolution in only five years. After 21 years, in 2018 a great part of the localities from this sampling network have been re-evaluated to scrutinize the evolution of these lichen communities after a so long time. The results obtained show a decrease in the diversity of several sampling plots and a strong and generalized increase in the symptoms of injury on the target lichen species proposed in 1997.

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# Mapping impacts of EU - Air Quality Directive (NECD) at the ecosystem level

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To protect human health and the environment, the 2001 EU Air Quality Directive imposed national emission ceilings for atmospheric pollutants (Directive 2001/81/EC), including the reduction of sulfur (S) and nitrogen (N) emissions, by 2010. The evaluation of the results of this emission reduction at the ecosystem level has not been thoroughly done. Our aim was to use biomonitors to map the emission's reduction at the ecosystem level. This was done in a region with multiple industrial activities using in situ ecological indicators (lichen: Parmotrema hypoleucinum), comparing data at the onset of the Directive implementation (2002)and nine vears after (2011).The reduction of sulfur emissions was a success at the ecosystem level, emphasizing that most S deposited to the ecosystem had an industrial origin. However, for nitrogen that was not the case. Although a reduction of emissions was achieved related to industries (NO2 and NO3measured in the air), on the other hand, there was an increase in NH3. Thus, the impact at the ecosystem level was insignificant except near industries. These areas with more NH3 are agriculture dominated, stressing the difficulty of reducing N emissions originating in that sector. Acknowledgements: Research supported by project GISA; project NitroPortugal EU H2020 research and innovation programme, n.692331. NitroPortugal is a co-financer for the project "Towards INMS", implemented by UN Environment."

# Evolución del estado ecológico en ríos de la cuenca del duero usando organismos fitobentónicos como bioindicadores (diatomeas y macrófitos)

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La Directiva Marco de Agua requiere la identificación de los elementos de calidad biológica, parámetros y métricas más adecuados que permitan establecer el estado ecológico de las masas de agua epicontinentales. Algunos de los indicadores biológicos más utilizados en ríos son las diatomeas epilíticas y los macrófitos, de los que existen numerosos estudios que confirman su sensibilidad ante las variaciones ambientales y los cambios guímicos del agua. El uso de estos bioindicadores en España se ha extendido a todas las cuencas hidrográficas, aunque aún dista de algunas regiones europeas con largas series de datos espacio-temporales. En el marco del "Servicio para la explotación parcial de los programas de seguimiento de las masas de agua superficiales de las categorías "ríos", "lagos" y "embalses", en aplicación del artículo 8 de la Directiva Marco del Agua en la cuenca hidrográfica del Duero", durante la primavera-verano de los años 2014 a 2017, IPROMA como parte de la UTE adjudicataria llevó a cabo el muestreo de las diatomeas epilíticas y los macrófitos. Tanto la recogida de muestras, como el tratamiento, identificación y cuantificación de las especies se hicieron siguiendo lo dictado por los protocolos vigentes. Se presentan los resultados de la evolución temporal del estado ecológico y la comparativa de los índices diatomológicos y de macrófitos, teniendo en cuenta la tipología fluvial de la masa de agua y los más recientes valores de corte de las categorías de calidad.

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<sup>4</sup>Universitat Rovira i Virgili, Spain Using the bioaccumulative potential of lichens to assess toxicity of environmental pollutant mixtures to human lung cells in a petrochemical and chemical industrial area in Southern Europe

The aim of this study was to use lichens to assess toxicity of environmental pollutant mixtures to human lung cells. For that, we conducted a study in the largest chemical and petrochemical industrial complex in Southern Europe, located in Tarragona County, Spain. Lichens were collected from a background area and transplanted to 15 sites in the study area. After two months of exposure, lichen transplants were collected, and the toxicity of the pollutant mixture accumulated in each sample was evaluated. Toxicity tests consisted on a cytotoxic analysis using human lung epithelial cancer cells A549 as target cells. Incremental Lung Cell Mortality (ILCM) was calculated based on the increment of cytotoxic effect of each lichen sample mixture after exposure in relation to pre-exposed lichens. In order to disclose relevant contaminants contributing for the toxicity, the concentrations of the 16 USEPA-PAHs and 17 metals were quantified in the same lichen samples. Results allowed identifying areas with highest potential toxicity, located in the petrochemical complex (P), followed by areas in the chemical complex (C); urban areas (U) had the lowest potential toxicity. The same decreasing trend P-C-U was found for concentrations of 516 PAHs. These results open new perspectives on the use of lichens in environmental health studies.

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# Effect of lead on shoots and spores of four moss species with contrasted ecological affinities

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Nagore G. Medina², Belén Estébanez²

<sup>1</sup>Universidad Rey Juan Carlos,Madrid, Spain <sup>2</sup>Universidad Autónoma de Madrid, Spain Mosses are regarded as good bioindicators of the impact of pollutants in ecosystems, but it is necessary to understand to what extent the resistance mechanisms they present interfere with their utility as biomonitors. In this study, we assess the effect of experimentally supplied lead in in vitro cultures of four common species of mosses with contrasted sensitivity to atmospheric pollution: Hypnum cupressiforme, Homalothecium aureum, Ptychostomum capillare and Syntrichia ruralis. We tested four lead nitrate doses (0-10-3 M) in both spores and shoot tips of all those four species. Both of them were cultivated directly in liquid medium with the corresponding lead dose. For shoot tips, we recorded survival and damage rates, and for germination experiments, we registered spore/ sporeling vitality and developmental stage. Our results show a high degree of resistance in all four species, as they show only minor effects except for the highest dose (10-3 M). Even in this dose, we have observed some survival on in vitro cultures of the shoot tips in *H. cupressiforme*. Spore germination and protonemal development are observed in doses up to 10-4 M. The highest dose (10-3 M) is lethal except for H. aureum, where we observed protonemal growth. The widespread resistance of mosses seems to be related to their ability to exclude heavy metals a mechanism that must be taken into account in biomonitoring programs.

## Estudio de bioacumulación con trasplantes de *Evernia prunastri* (L.) Ach.: Establecimiento del nivel de referencia en un entorno urbano

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La zona del Bierzo (León) cuenta con varias industrias emisoras de contaminantes atmosféricos en un entorno bastante urbanizado. En los últimos meses, se está considerando la posibilidad del cambio de combustible en alguna de esas industrias. Ante esta situación, se hace necesario conocer el estado de la calidad del aire en dicha zona, por lo que hemos realizado un estudio de biomonitorización con líguenes. Por ello, se han recolectado talos de Evernia prunastri (L.) Ach. de la localidad Tejedo de Ancares, utilizada como control, y se han trasplantado a 19 puntos en la zona de estudio. Tras 11 semanas de trasplante, se han analizado los datos de acumulación de 14 elementos en dichos talos (As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sb, Sn, Tl, V y Zn), y se han examinado los patrones de deposición de estos en la zona de estudio. Los datos se comparan con los obtenidos antes del trasplante (tiempo 0) y con los de la localidad control. Se observan diferencias espaciales entre los distintos puntos estudiados y, por tanto, se observa la existencia de zonas con diferente calidad del aire. Por otro lado, se aprecian diferentes patrones de deposición de los elementos analizados. El resultado final es un mapa sintético de elementos totales, donde se ponen de manifiesto las zonas con mayor deposición, en consecuencia, las que presentan peor calidad del aire.

## Fluorescencia de la clorofila como indicador de estrés en cultivo ex situ de briófitos

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El cultivo ex situ de briófitos es de gran interés en estudios experimentales y de conservación. Sin embargo, se necesitan medidas sencillas y no invasivas de las alteraciones por estrés de cultivo. En concreto, el análisis de la fluorescencia de la clorofila permite caracterizar los efectos diferentes tipos de estrés ambiental. de Cultivamos tres meses en invernadero dos especies de musgos con formas de crecimiento V afinidades ecológicas contrastadas: Homalothecium aureum y Tortula muralis. El análisis de la fluorescencia de la clorofila se realizó en 24 réplicas mediante 1) toma de imágenes de fluorescencia mediante una cámara CCD y 2) análisis espectroscópico de su espectro de emisión. Como fuente de excitación se utilizó un haz laser de baia potencia (405 nm) y la detección se centró en la región roja del espectro (600-700 nm). Las imágenes y los espectros de fluorescencia permiten observar las diferencias entre ambas especies durante todo el experimento. Inicialmente, se observa que el contenido en clorofila es algo superior en H. aureum. Transcurrido un tiempo, se observan daños físicos en H. aureum, mientras que T. muralis incluso fructifica. Las medidas de fluorescencia corroboran esta observación, e indican mayor contenido en clorofila en T. muralis. Fn conclusión. ambas técnicas revelan tanto diferencias interespecíficas como de aclimatación, con lo que podrían ser adecuadas para la monitorización de manera no invasiva de cultivos en diversas especies de musgos.

# Using mosses as indictors of conservation in NW Iberian ombrotrophic mires

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Active ombrotrophic mires are rare in the Iberian Peninsula, being restricted to northern mountain areas with high precipitation. Human activities such as pasture creation and wind farming, along with climate change, pose a threat to these relict habitats.New,locallyadeguatebiomonitoringtools are needed to ensure an efficient management of ombrotrophic mires. This work explores the use of mosses as indicators of conservation in these habitats protected by the Habitats Directive of the European Union (92/43/CEE, Habitat 7130). Four areas covered by ombrotrophic mires were selected based on two criteria: (i), they were adjacent, sharing parameters such as climatology and altitude and (ii), they were subject to different management practices, ranging from no human intervention to active draining and manuring. Vegetation sampling considering vascular plants and bryophytes was conducted twice (late winter and spring). In each of the areas, micro-habitats were identified and three 1 m<sup>2</sup> plots were analysed per microhabitat. Soil samples were also collected in each plot and different soil parameters including pH were considered in the analyses. Different multivariate analyses were used to assess the correlation between environmental parameters (mainly soil characteristics), vascular vegetation and bryophyte diversity. A decrease in bryophyte diversity was detected with the intensification of human activities. More work is needed to assess the efficacy of mosses as indicators

## Efecto de la contaminación del aire sobre la vitalidad de líquenes trasplantados en las inmediaciones de una industria papelera, Morelia, México

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<sup>1</sup> Herbario de la Facultad de Biología, Universidad Michoacana de San Nicolás de Hidalgo, Morelia, Mexico <sup>2</sup> Área de Botánica, Dpto. de Biodiversidad y Gestión Ambiental, Universidad de León, Spain <sup>3</sup> Instituto de Investigaciones en Ciencias de la Tierra, Universidad Michoacana de San Nicolás de Hidalgo Morelia, Mexico Los líquenes Flavopunctelia praesignis (Nyl.) Hale v Usnea ceratina Ach. fueron utilizados como biomonitores de la contaminación del aire en las inmediaciones de una industria papelera Kraft en Morelia, México. El objetivo de este estudio fue evaluar el efecto de la contaminación en el área sobre la vitalidad de los líguenes, medida a través del contenido de clorofila y la presencia de daños visibles en el talo. Para ello, muestras de ambas especies fueron trasplantadas a diferentes puntos alrededor de la industria y monitoreadas durante cuatro meses. De igual manera, se colocaron trasplantes en dos sitios control. Tras la exposición, se registró un incremento significativo en el contenido de clorofila en los trasplantes de F. praesignis ubicados alrededor de la papelera. Esta misma respuesta fue observada en los sitios control, lo cual sugiere posibles variaciones estacionales en el contenido de pigmentos fotosintéticos. Los talos de U. ceratina trasplantados cerca del área industrial y en dirección de los vientos dominantes exhibieron claros síntomas de estrés, al presentar mayores daños visibles sobre el talo y una reducción en su contenido de clorofila. La sensibilidad mostrada por ambas especies de líguenes pudiera variar debido a sus características morfológicas. Los cambios observados sobre la vitalidad parecen estar relacionados con la presencia de contaminantes tóxicos como SO<sub>2</sub> en los alrededores de la papelera. Se agradece a CONACvT por el financiamiento.