XIX International Colloquium on Plant Ecophysiology

Katalapi Park, Puerto Montt, Chile; January 27-30, 2026

The **International Colloquium on Plant Ecophysiology** has, since its beginnings, been an event that fosters open, engaging, and relaxed scientific conversations where discussions on ecophysiology flow naturally. In this way, we maintain our goal of cultivating a welcoming environment that promotes the exchange of ideas, sharing of experiences, and the building of valuable relationships between students and professors in the field of **Plant Ecophysiology.**

To honor your important contributions, we have compiled your participation in the XIX International Colloquium on Plant Ecophysiology 2026, which included 6 conferences from **keynote** speakers, 7 **mini-conferences**, and 10 short communications.

The organizing committee extends heartfelt gratitude to our participants, both national and international. We truly appreciate your enthusiasm, your valuable feedback, and the time you dedicated to fostering meaningful discussions. It is thanks to the collective commitment of individuals like you that our community continues to grow, advancing the field of plant ecophysiology and establishing this Colloquium as a unique event in its field. We especially appreciate the commitment of our regular participants, who are now recognized as "**Katalapiers**." We look forward to continuing this collaborative journey in the study of plant ecophysiology.

Thank you!

Special recognition goes to the event sponsors whose support has been invaluable: Universidad de Concepción, Universidad de La Frontera, Instituto de Ecología y Biodiversidad & Parque Katalapi.

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GENERAL PROGRAM

Time	Tuesday 27th	Wednesday 28th	Thursday 29th	Saturday 30th
8:00-9:00		**Breakfast**	**Breakfast**	**Breakfast**
9:00-9:40		**Conference 1** Marilyn Ball	**Conference 3** Jaume Flexas	**Conference 5** Danielle Way
9:40-10:25		**Short Communications 1**	**Short Communications 4**	**Mini-Conferences 6**
9:40-9:55		Enrique Ostria-Gallardo	Cade Kane	Michele Holbrook
9:55-10:10		Luisa Bascuñán	Victor Ardiles	
10:10-10:25		José M. Retamal	María Eriksson	**Conference 6** Antonio Díaz-Espejo
10:30-11:00		**Coffee Break**	**Coffee Break**	
11:00-11:40		**Conference 2** Ariel Orellana	**Conference 4** Francisco Matus	**Coffee Break**
11:40-12:10		**Mini-Conference 1**	**Mini-Conference 3**	**Mini-conference 7**
11:40-12:10		Tomás Fuenzalida	Beatriz Fernández-Marin	Eduardo Guzmão-Pereira
12:10-12:40		**Short Communications 2**	**Mini-Conference 4**	Trekking Katalapi Trails (optional)
12:10-12:25		Daniela Aros	Juan F. Alfaro	
12:25-12:40		Celia Rodríguez		
13:00-14:30		**Lunch**	**Lunch**	**Lunch**
15:00-15:30		**Mini-Conference 2**	**Mini-Conference 5**	**Departure**
15:00-15:30	**Arrivals and accommodation**	Ignacio García Plazaola	Nestor Fernández	
15:30-16:15		**Short Communications 3**	**Rayuela Finals**	
15:30-15:45		Benjamin Pineda		
15:45-16:00		León A. Bravo		
16:00-18:00		**Rayuela Preliminars**		
19:00	**Cata en Kata**	Dinner	Dinner	

ABSTRACTS BOOKLET

CONFERENCES

Foliar water uptake by the mangrove, *Avicennia marina*: up, down and all around.

Marilyn C. Ball.

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Since 2012, my lab has explored variation in sources of atmospheric water, pathways of uptake, and consequences of **F**oliar **W**ater **U**ptake (FWU) for physiological functioning in mangroves, particularly *Avicennia marina*. It absorbs atmospheric water that accumulates during shoot wetting events caused by deliquescence of salt, dew, and interception of rainfall and mist, with seasonal variation in the relative contributions of these water sources to rehydration. In *A. marina*, liquid water is primarily absorbed through epidermal features, notably trichomes and salt secretion glands in leaves and lenticels in bark. Water uptake rates are enhanced by light, implicating aquaporins, with subsequent water movement through symplastic pathways enabling water dispersal within leaves and to vascular tissues enabling transport to more distant water storage sites. Water absorbed via FWU enables elevation of leaf water potentials above those that could be obtained from absorption of soil water alone. Rehydration of leaves through FWU enables recovery of hydraulic conductance previously lost through dehydration, together with repair of embolized vessels in leaf midveins, petioles and attached stems. Notably, the enhanced rehydration of both leaves and stems recharges water storage capacitance. Release of nocturnally stored water during subsequent photoperiods enables shoot function at water potentials less negative than those induced by soil water, thereby reducing vulnerability to tension-induced loss in hydraulic function, while also contributing water that enhances stomatal conductance and hence also carbon gain. Indeed, enhanced leaf rehydration following wetting events increases the maximum rates and duration of photosynthetic carbon assimilation, particularly during wet season conditions.
Acknowledgement: This work was supported by the Australian Research Council.

Phenotypic and molecular plasticity of *Cistanthe longiscapa* reveals environment-dependent modulation of CAM photosynthesis.

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Cistanthe longiscapa, a dominant annual of the Atacama Desert, displays notable resilience to extreme aridity. Along a natural precipitation gradient, plants showed pronounced variation in CAM intensity, reflected in differences in nocturnal acid accumulation, $\delta^{13}C$ values, succulence, and pigment ratios. Transcriptomic profiling further revealed site-specific regulation of circadian, stress-response, and CAM-related genes, including differential expression of *LHY*, *NADP-ME*, *TDT*, and *NCED3*, indicating distinct molecular strategies associated with contrasting environmental conditions.To explore whether these field differences arise from intrinsic phenotypic plasticity, we carried out preliminary laboratory assays under controlled irrigation. These experiments suggest that *C. longiscapa* modulates stomatal behavior and photosynthetic mode in response to water availability: plants under full irrigation displayed a C3-like pattern, intermediate watering produced partial daytime opening consistent with CAM cycling, and severe drought induced nocturnal opening or, under extreme deficit, a CAM-idling pattern with stomata closed both day and night. Although preliminary, these results support the potential for environmentally driven transitions among C3, weak/strong CAM, CAM cycling, and CAM idling. Together, the ecophysiological, transcriptomic, and controlled-environment data converge on a consistent picture of high metabolic flexibility in *C. longiscapa*. This integrative evidence positions the species as a valuable model for dissecting the regulatory mechanisms underlying CAM plasticity and for understanding plant resilience in water-limited environments.
Acknowledgments: *ANID–Millennium Science Initiative ICN2021_044; supporting laboratories of CBV-UNAB; and all contributors to fieldwork and controlled-environment experiments.*

Going up a little higher: ecophysiology of Himalayan plants.

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Vascular plants growing at the highest elevations (> 6000 m a.s.l.) have been reported for the Himalayas (Ladakh, India). Being this the apparent elevational limit for vascular plants, we aimed studying a potential extreme for the photosynthesis – stress tolerance trade-off. A field campaign was carried out in summer 2022. For a mix of logistic and geopolitical reasons we could not reach the highest elevations, which was later proven to be a surprising advantage. Plant assemblages were studied at two steppe sites (4150 - 4520 m a.s.l.), two alpine sites (4860 - 5160 m a.s.l.) and two subnival sites (5310 - 5490 m a.s.l.). No differences in leaf

desiccation tolerance were found across elevations, and only a minor yet significant decline in photosynthetic capacity from steppes to subnival. While photosynthesis rates were generally high (15 – 30 μmol CO_2 m^{-2} s^{-1}), no species behaved as a true outline of the photosynthesis – tolerance trade-off. Reduced photosynthesis with elevation was mostly related to decreased nutrient availability (N and P) as revealed by leaf contents, resulting in reduced photo-biochemical capacity. However, the latter was compensated by high diffusional conductances to CO_2, i.e. stomatal and mesophyll conductance. Mesophyll conductance was kept high despite significantly increased cell wall thickness with elevation, thanks to a compensatory mechanism based on increasing intercellular air spaces (IAS), decreasing chloroplast thickness and keeping a surface of chloroplasts exposed to IAS (Sc) larger than reported for any other plant group, including crops. The results are discussed in terms of their potential adaptive value.

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Vanishing organic carbon in Maritime Antarctic soils: Freeze–thaw effects on early soil development.

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Maritime Antarctica, particularly King George Island, is one of the fastest-warming regions in the Southern Hemisphere, providing a natural model for early soil formation. Soil organic matter (SOM), the main driver of incipient soil development, may decline under more frequent freeze–thaw (FT) cycles induced by ongoing warming. However, the priming effect (PE), in which labile carbon inputs accelerate (positive PE) or suppress (negative PE) native SOM decomposition, could amplify or counteract these losses. Microorganisms preferentially metabolizing freeze-preserved SOM may induce negative PE, promoting SOM accumulation. SOM inputs in Maritime Antarctica are scarce, mainly from lichens, mosses, avian faeces, and minor contributions from *D. antarctica* and *C. quitensis*. We investigated the effect of FT frequency on SOM accumulation via PE. Two soils with contrasting clay contents were incubated with or without ^{13}C-glucose for 21 days under three FT regimes: (i) none, (ii) one, and (iii) three cycles (−18/12 °C). CO_2 and $^{13}CO_2$ fluxes were measured, and SOC was characterized by ATR-FTIR spectroscopy. Glucose-derived CO_2 declined with increasing FT cycles (26 ± 2.2 to 8.6 ± 0.1 mg g^{-1} C), and positive PE was highest in controls (72–76%), moderate after one FT cycle (41–64%), and negligible or negative after three cycles (−9.5 to 0.4%). SOC increased with FT frequency (103 ± 14 to 212 ± 7 mg C kg^{-1} in low-clay soil; 129 ± 14 to 156 ± 2 mg C kg^{-1} in high-clay soil) and inversely correlated with PE ($R^2 = 0.87$, $p < 0.01$). Freeze–thaw cycles reduced CO_2 emissions by shortening decomposition time and inducing negative PE, promoting SOC accumulation that may offset native SOM losses, while future warming could enhance positive PE, ultimately influencing early SOC formation in maritime Antarctic soils.

Acknowledgment: *NEXER NXR17-0001; INACH project RT_17_23 and MEC 80180029 (ANID-Chile). The authors are also grateful to the RUDN University Strategic Academic Leadership Program.*

Assessing the vulnerability of northern forests to climate change: from seedlings to the continent.

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Rising atmospheric CO_2 concentrations could increase from 425 ppm today to up to 1000 ppm by the year 2100, increasing global temperatures by 3-4 °C and causing widespread atmospheric drought through higher vapor pressure deficits (VPDs). Elevated CO_2 levels, warming and higher VPDs all affect plant physiology, growth, health and survival. Climate change-induced shifts in photosynthesis and biomass accumulation also affect the global carbon cycle, and these shifts can either mitigate or accelerate further climate change. Understanding how plants acclimate to future climate conditions is therefore critical for accurately predicting the trajectory of future climate change, as well as for estimating plant productivity in a warmer, drier, high CO_2 world. I'll discuss my team's work on how elevated temperatures, high CO_2 concentrations and increased VPDs impact the performance of boreal tree species, focusing on carbon fluxes and growth. By connecting our results from boreal seedlings grown under future climate conditions, mature trees in the field exposed to high CO_2 and warming conditions, and a Canada-wide network of tree ring data, I will highlight how climate change endangers our northern forests.

Plants on the wire: How fast signals shape stress responses.

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Plants have evolved a wide array of mechanisms to interact with—and respond to—environmental change. Many of these mechanisms, related to abiotic drivers such as radiation, temperature, vapor pressure deficit, and soil water deficit, have been studied in depth, providing a solid understanding of their operation across organizational levels. Likewise, biotic factors including pathogens, herbivores, plant–plant interactions, and plant–microbiome relationships have been extensively characterized. Yet, several processes central to integrated coordination at the whole-plant scale, and potentially to plant–plant communication, are receiving renewed attention. Among these, volatile compounds and, especially, electrical signals are increasingly recognized as rapid modulators of wound and herbivory responses, stress acclimation, systemic coordination, and hormonal regulation. Classical examples include rapid leaf movements in carnivorous plants and systemic defense activation during herbivory, while recent work points to complex gas-exchange responses to wounding in which electrical, hydraulic, and chemical cues coexist and propagate beyond the injured tissue. In this talk, I will briefly outline an experimental framework to examine how fast electrical events converge with hydraulic and chemical signals to modulate gas-exchange dynamics under environmental stress, and describe planned measurements to test predicted impacts on stomatal behavior and CO_2 exchange. As future work, I will succinctly introduce a project to explore whether these rapid signals contribute to the regulation of root growth during progressive soil drying.

Acknowledgment: *The author is grateful to the Fulbright Commission in Spain for a fellowship that made this research possible.*

MINI CONFERENCES

Using control theory to understand plant water status regulation during drought.

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For over 50 years, plant scientists have used control theory to explain stomatal behaviour, yet the specific physiological variable that plants monitor to regulate water status remains unidentified. Control theory distinguishes between process variables (sensed targets) and manipulated variables (factors modified to achieve control). In this work, I apply this framework to identify the water status metrics plants utilise as process variables for feedback control. I further propose the hypothetical structure of a plant-water status controller and study how the introduction of a binding constraint to preserve cellular water volume affects the marginal water cost of carbon gain (λ). This framework offers mechanistic and testable predictions for drought acclimation and the iso/anisohydry continuum, suggesting that plants dynamically switch between optimality goals either maximizing photosynthetic water use efficiency or conserving the water volume essential for survival.

Acknowledgements: *Work funded by ANID via grant 3230209. I thank Jacques Dumais for valuable input.*

Chill at the Bottom: Ecological and Ecophysiological Insights into Cold-Air Pools at Mt. Teide (Canary Islands).

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Cold Air Pools (CAPs) are topographic depressions where dense cold air accumulates under stable atmospheric conditions. CAPs are a worldwide phenomenon, that typically develop at night, producing dramatic temperature drops that decouple local microclimate from regional climate patterns. In the present study we have characterized CAP formation across a latitudinal gradient in Spain (43 °N- 28 °N). In contrast to our expectations the strongest and more recurrent CAPs occurred at the lowest latitude in “Las Cañadas”, Teide National Park (Canary Islands), a closed volcanic caldera at 2000 m a.s.l. that acts as a cold trap forming a massive cold air lake. At the bottom of the CAP mean nocturnal temperatures are regularly 4 °C lower than outside, and occasionally under stable atmospheric conditions up to 10 °C lower. Frost events occur year-round with minimum temperatures dropping to values lower than -10 °C even during periods of active plant growth (late spring-early summer). This singular thermal regime shapes the soil microbiota, favoring more diverse bacterial communities but poorer fungal communities. It also imposes critical constraints to the local flora and individuals from the bottom of the CAP are regularly more tolerant to freezing than their upper counterparts. These differences reflect the existence of biochemical differences among populations, highlighting the role of CAPs as natural laboratories for the study of plant cold-stress responses. The biological singularity of CAPs as climate refugia in a context of global warming is also explored.

Acknowledgment: *Organismo Autónomo de Parques Nacionales (OAPN), proyecto REBECA (3011/2023).*

Sunbathe or hydrate? Light-water interaction in Antarctic photosynthetic organisms.

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Photosynthetic organisms inhabiting the inhospitable terrestrial ecosystems of Antarctica must cope with extremely limited water availability, either through direct desiccation or indirectly via tissue freezing, compounded by naturally prolonged photoperiods at certain times of the year. Under these conditions, highly efficient and flexible photoprotective mechanisms are required to regulate the partitioning of absorbed light energy between photochemical and dissipative pathways. However, due to logistical constraints, few studies have examined the natural dynamics of photosynthetic pigments and tocochromanols in situ in Antarctica. This study addresses this gap by assessing how hydration state, and its interaction with light and temperature (i.e., light–water availability), modulate photoprotective responses in two widespread cohabiting species of Maritime Antarctica: the moss *Sanionia georgicouncinata* and the angiosperm *Colobanthus quitensis*. Our results show that hydration state and cumulative irradiance over preceding days—rather than instantaneous irradiance—govern xanthophyll-cycle de-epoxidation and the induction of non-photochemical quenching. This modulation is markedly stronger in poikilohydric species such as mosses, yet a significant dynamic response is also evident in the homoiohydric vascular species. Together, these findings highlight the pivotal role of recent environmental history and water status in shaping photoprotective performance across contrasting Antarctic photosynthetic lineages.

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Evaluation of high-productivity traits and adaptation to drought-prone environments of different quinoa genotypes in Chile.

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Quinoa (*Chenopodium quinoa* Willd.) is a nutritious grain crop cultivated in the Andes, recognized for its tolerance to abiotic stresses such as drought, cold, and high salinity. It grows across various latitudes with different day lengths, reflecting regional adaptations in its flowering regulation. Traits related to adaptation to drought-prone environments, including flowering time, harvest index (HI), and yield, are essential for breeding resilient cultivars. This work aimed to evaluate the productive potential and identify traits in 196 genotypes associated with high yield potential and resistance in drought-prone areas. Genotypes were assessed under rainfed (Hidango and Cauquenes) and irrigated (Santa Rosa, Chillán) conditions over two growing seasons (2023/24 and 2024/25). In the irrigated environment of Santa Rosa, the GY averaged 641 g m-2. However, in environments most prone to drought (Hidango and Cauquenes), it decreased by 80% compared to irrigated areas. Comparing harvest indices, the rainfed environments Hidango and Cauquenes showed decreases of 20% and 50%, respectively, relative to Santa Rosa. Days from sowing to flowering (DSF) and from flowering to maturity (DFM) varied clearly among genotypes and were negatively correlated with GY and HI. Additionally, shoot dry weight (SDW) in both environments was 65% lower than in irrigated conditions. Across all three environments, there was a significantly positive correlation between GY and both HI and SDW, with some genotypes showing high values in each one of the rainfed conditions (Cauquenes and Hidango). The preliminary results and ongoing analyses are expected to identify candidate genotypes capable of adapting to drought-prone environments in Chile.

Acknowledgment: *Tecnofen team, Anillo Project ANID High-Throughput Field Phenotyping to Accelerate Crop Breeding and Adaptation to Drought-Prone Environments" Agricultural Research Institute (INIA).*

Alternative and Cytochrome Oxidase Pathways Dynamics in Response to Carnivory in Nepenthes × gaya.

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Carnivorous plants of the genus Nepenthes have evolved specialized morphological and physiological traits to acquire nutrients from prey, enabling survival in nutrient-poor environments. This study investigated mitochondrial respiratory responses to carnivory in *N. × gaya* by examining the in vivo activities of cytochrome c oxidase (COX) and alternative oxidase (AOX) pathways, together with nutrient levels, nitrogen isotope composition, protein content, and free-radical-scavenging capacity. Following mealworm feeding, tissues from leaves, lids, and the basal digestive zone of pitchers were sampled at 2 and 4 days post-feeding. Our results revealed a pronounced increase in total respiration and a shift toward the COX pathway in pitchers, presumably consistent with a high ATP demand associated with digestion or secretory activity. AOX activity remained stable or decreased, suggesting a role in maintaining redox homeostasis before prey addition. In leaves, a different pattern was observed, reflecting differences in metabolic priorities linked to photosynthetic function and nutrient assimilation. Despite the absence of detectable nitrogen and low protein content in *N. × gaya*, the observed respiratory rates and AOX capacity were comparable to those of non-carnivorous plants, highlighting nitrogen use efficiency. These findings support the existence of a spatially regulated respiratory response to carnivory and shed light on the physiological adaptations of these intriguing plants.
Acknowledgment: *Maria Zambrano programme of the Spanish Ministerio de Ciencia, Innovación y Universidades through the European Union 'NextGenerationEU', RYC2023-044592-I funded by /AEI/10.13039/501100011033.*

Secreting salt glands constrain cuticle fracture to enhance desalination efficiency.

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Plants responding to excessive soil salinity by discharging brine onto their leaf surface risk dehydration through the osmotic continuity between the living tissue and the surface brine,

which further enriches with evaporation. Cuticle cracks have long been identified as essential for salt to reach the leaf surface but enable a potentially desiccating continuity between the brine and the gland interior. Using the secreting salt gland of *Nolana mollis* as a model system, we integrate mathematical modeling, imaging, and physiological measurements to examine the mechanical and biochemical processes required for efficient salt removal. We find that the subcuticular space between the concentrated surface brine and the more dilute secreting cell eases the energetic limits of active salt secretion by reducing the concentration gradient of salt across the cell membrane. We show that crack size plays a critical role in balancing the osmotic and pressure gradients required for salt removal without runaway foliar desiccation.

Acknowledgements: *DMR2011754, DGE1745303; Hertz Foundation; PID2021129074OB100, FULBR23036.*

Ecophysiological mechanisms underpinning tropical grass resilience in mine rehabilitation.

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The rehabilitation of areas disturbed by iron ore mining is challenging, as few plant species can establish in such harsh environments. Plant growth is limited by the physicochemical constraints of tailings storage facilities, including high metal concentrations, low organic matter, nutrient scarcity, and poor water retention. Selecting native, stress-resistant grass species based on their ecophysiological traits offers a promising approach for restoring iron ore mine sites and promoting their reintegration into the reference ecosystem. Recent studies have highlighted a range of adaptive mechanisms in tropical native grasses that ensure restoration success. Resistance to excessive iron occurs through avoidance or tolerance mechanisms involving restricted metal uptake via root apoplastic barriers and detoxification pathways that mitigate oxidative damage. Adjustments in root morphology and anatomy, coupled with metal sequestration away from sensitive cellular sites, play crucial roles in iron toxicity responses. Moreover, resistant grasses often display the capacity to cope with nutrient deficiencies typical of impoverished mining substrates. Photosynthetic acclimation is another key trait, with rapid stomatal regulation, photoprotection and C4 metabolism supporting resilience to multiple abiotic stressors. Collectively, these ecophysiological strategies enable native grasses to thrive under the extreme conditions of mining-impacted landscapes and can serve as effective criteria for species selection and management in tropical mine rehabilitation programs.

Acknowledgement: *CNPq, CAPES, FAPEMIG.*

SHORT COMUNICATIONS

Integrated physiological, metabolic, and transcriptomic analysis reveals divergent heat stress responses in *Chenopodium quinoa* and *Amaranthus cruentus*.

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Heatwaves are increasing in frequency and intensity under current climate change scenarios, posing a major threat to crop productivity and resilience. Understanding the mechanistic basis of heat stress responses in crops is therefore critical. We compared the physiological, metabolic, and transcriptomic responses of quinoa (*Chenopodium quinoa*; C_3) and amaranth (*Amaranthus cruentus*; C_4) to a simulated heatwave, focusing on post-stress performance. Heatwave exposure reduced net CO_2 assimilation, stomatal conductance, and electron transport rate in *A. cruentus*, accompanied by a substantial decrease in midday leaf water potential, while intrinsic water-use efficiency remained unchanged. In contrast, *C. quinoa* maintained stable photosynthetic rates, stomatal conductance, electron transport, and leaf water status. Antioxidant capacity revealed higher SOD and CAT activities in *C. quinoa*, whereas *A. cruentus* exhibited higher APX activity, suggesting species-specific antioxidant strategies. Metabolomic analyses demonstrated divergent metabolic adjustments. *A. cruentus* showed enhanced accumulation of amino acids and soluble carbohydrates and enrichment of pathways related to carbon metabolism, redox homeostasis, and osmoprotection. *C. quinoa* preferentially enriches amino acid catabolism, organic acid metabolism, and the tricarboxylic acid cycle. Transcriptomic analyses in *A. cruentus* revealed upregulation of genes associated with heat shock protection, proteolysis, antioxidant defense, and cellular transport, whereas *C. quinoa* predominantly accumulated transcripts linked to ABA signaling regulation, ubiquitination, and antioxidant processes. These results show different yet effective strategies of *C. quinoa* and *A. cruentus* to cope with extreme heat events.
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Nitrogen use efficiency in two contrasting Lowland ecotypes of *Chenopodium quinoa* Willd (*Amaranthaceae* family).

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Chenopodium quinoa Willd. is a native species that originated from the Altiplano, and many landraces are cultivated today in the south of Chile. Nitrogen use efficiency (NUE) is a key trait for crop productivity under low nitrogen (LN) soils conditions. In this study, two contrasting *Chenopodium quinoa* genotypes in the NUE (Faro and UdeC) were compared to characterize the physiological, metabolic, and molecular mechanisms underlying NUE during critical reproductive stages. Under LN conditions, the UdeC genotype exhibited lower protein concentrations in leaves and panicles, consistent with reduced NUE. Carbon partitioning analysis indicated that a substantial proportion of starch stored in roots was translocated to the panicle during grain filling, with clear genotypic differences in total soluble sugars, which were higher in Faro leaves. Hormonal profiling in leaves and panicles revealed genotype-dependent responses, with a marked increase in indole-3-acetic acid (IAA) in Faro under LN. At the level of nitrogen transport, Faro showed a strong induction of the nitrate transporter *CqNRT1.1* under LN in both leaves and panicles, while other homologs were downregulated. In roots, UdeC displayed a stronger up-regulation of the high-affinity transporter *CqNRT2.1* under LN, suggesting a higher perception of nitrogen limitation. Ammonium transporters (*CqAMT1.1*) exhibited genotype-specific expression patterns, with a more pronounced LN-induced response in Faro. The results highlight distinct physiological and molecular pathways employed by contrasting NUE genotypes to cope with low nitrogen conditions. In particular, the pathways preferentially induced in Faro represent promising targets for enhancing productivity under low nitrogen inputs.
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Effects of endophytic insect-pathogenic fungi on growth and nitrogen metabolism in *Araucaria araucana* (Mol.) K. Koch.

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The symbiotic association between plants and endophytic fungi (EF) represents one of the most important interactions in plant evolution and played a key role in the colonization of terrestrial ecosystems. Although EFs have been extensively studied in angiosperms, they are also present in ancient plant lineages, such as primitive conifers. *Araucaria araucana*, considered a living fossil from the Jurassic period, is distributed throughout southern Chile and Argentina, where it grows in oligotrophic volcanic soils characterized by low nitrogen

(N) availability. N is an essential macronutrient for plant growth and development, as it is a structural component of amino acids, proteins, chlorophyll, and other biomolecules. The assimilation of N after its capture by plants depends on enzymatic pathways that convert inorganic forms into organic compounds. In this study, *A. araucana* seedlings were inoculated for 5 months with two strains of EFs known to be insect pathogens, *Beauveria* (Bb) and *Metarhizium* (Ms), as well as with a co-inoculation of both (Bb and Ms) under HN and LN controlled conditions. Our results indicate that the effects of inoculation depended largely on both nitrogen availability and fungal inoculation. Fungal inoculation improved nitrogen assimilation by activating nitrate reductase (NR), glutamine synthetase (GS), and glutamate dehydrogenase (GDH) at both HN and LN. These responses were closely related to changes in non-structural carbohydrates (NSC) where it is suggested that C is actively used to maintain amino acid and protein synthesis, resulting in an increased leaf and root biomass. Overall, co-inoculation with Bb and Ms was the most effective treatment to prompt nitrogen metabolism under both HN and LN conditions, highlighting its potential relevance for conservation strategies.

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Unique stomatal responses of a CAM fern to changes in CO_2 concentration in the dark.

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Ferns and angiosperms differ fundamentally in their stomatal responses to changes in ambient CO_2. In angiosperms, stomata close as CO_2 concentration increases and open as CO_2 declines, with responses occurring in both the light and the dark. Ferns, by contrast, exhibit pronounced stomatal opening only in response to decreasing CO_2, show little to no response to elevated CO_2, and respond exclusively in the light. This muted sensitivity has been attributed to the evolution of ferns under substantially higher atmospheric CO_2, leading to the suggestion that modern experimental ranges (e.g. 400–600 ppm) may fall below their effective response threshold. In this talk, I show that transitions among 100, 400, and 1000 ppm CO_2 elicit strong stomatal responses in ferns and that these responses are tightly coupled to photosynthetic metabolism. This link is supported by observations in a CAM fern, in which stomatal responses occur in the dark, but only when CAM photosynthesis is active.

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The impact of belowground events during soil drought on maize stomatal conductance.

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Root functioning is crucial for water and nutrient uptake, sustaining plant gas exchange and productivity. On the other hand, stomata, located at the leaf surface, regulate water loss and carbon assimilation, yet the link between stomatal conductance and belowground processes under drought remains unclear. Recent evidence indicates that soil–root interface changes during drought—such as root shrinkage, cortical lacunae formation, and partial soil–root disconnection—increase hydraulic resistance outside the root xylem, limiting water flow to shoots and potentially constraining stomatal conductance. However, direct quantification of these effects is scarce due to technical challenges in studying intact soil-root complexes. Advances in imaging techniques, such as synchrotron-based X-ray microcomputed tomography (micro-CT), now allow detailed visualization of root responses to soil drying. This study investigates how belowground events under progressive soil drying affect stomatal conductance in maize (*Zea mays* L.) seedlings. Combining high-resolution micro-CT imaging with stomatal conductance measurements across soil water potentials (0 to -3 MPa), we observed sequential changes: initial root hair shrinkage/collapse at -0.01 to -0.30 MPa, followed by cortical cell collapse, lacunae formation, root shrinkage, and air-filled gaps at the soil–root interface, leading to root-soil disconnection. Maximum stomatal conductance ($g_{s,max}$) was highest at near-saturated soil (-0.1 MPa), likely due to intact root hairs maintaining water continuity. Early root hair shrinkage caused a steep $g_{s,max}$ decline, followed by a slower decrease likely linked to rising hydraulic resistance in the root cortex and soil–root interface. These findings underscore the critical role of belowground dynamics in regulating plant water use under drought.

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Environmental temperature effects on thermal tolerance and metabolic profile of *Polytrichum strictum* in the Sub-Antarctic Andes: preliminary findings

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The Climate Variability Hypothesis (CVH) postulates that organisms inhabiting environments with more severe thermal extremes should exhibit a broader thermal tolerance breadth (TTB). This TTB could be explained by adjustments in secondary metabolism and soluble sugar and amino acid content. The Sub-Antarctic Andes constitute a high-elevation, high-latitude system where freezing temperatures predominate, and plant diversity includes many bryophyte species. We aimed to evaluate environmental temperature effects on TTB and metabolic profile of the moss *Polytrichum strictum* in the Sub-Antarctic alpine zone. We determined freezing ($LT50_{freezing}$) and heat ($LT50_{heat}$) tolerance, to calculate TTB in populations from two slopes with contrasting thermal exposures (East and West), and characterized their metabolic profiles using UHPLC-Orbitrap-ESI–MS–MS. We found that $LT50_{heat}$ was similar for both slopes (42.05 ± 0.23 ºC). In contrast $LT50_{freezing}$ was -23.1 ± 1.9 ºC for the eastern slope and -27.2 ± 1.2 ºC for the western slope, resulting in a TTB 4.6 ºC higher in plants from the western slope. Unexpectedly, eastern individuals, which experienced more severe freezing temperatures, exhibited a narrower TTB, driven mainly by lower freezing tolerance. This physiological difference was aligned with different metabolic profiles, particularly higher contents of soluble sugars and amino acids in western plants. These findings do not support the CVH, suggesting instead that other environmental factors, such as the higher wind speed observed on the Western slope, could indirectly modulate *P. strictum* TTB. Ultimately, these results provide insight into the metabolic strategies enabling moss adaptation and dominance in the Sub-Antarctic zone.

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Freezing Resistance and Cryoprotective Sugar Accumulation in Legumes.

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Climate change is accelerating a shift toward autumn sowing of cool-season grain legume crops, where freezing significantly limits its performance. In this study, *Vicia faba*, *Pisum sativum, Lupinus albus, Lupinus angustifolius, Lupinus mutabilis*, and four highly diverse accessions of *L. luteus* were evaluated, in order to understand mechanisms involved in freezing resistance within grain legume species and to detect intraspecific genetic variability for improving it in *L. luteus*. Freezing resistance was evaluated on excised leaves by determining LT_{50} (Lethal temperature at 50% photoinactivation) with the aid of chlorophyll imaging fluorescence. The results were validated at plant level after controlled frost. Thermal analysis provided ice nucleation temperatures and freezing points. Freezing resistance correlated with foliar soluble sugars. *V. faba* demonstrated true freezing tolerance (LT_{50}=-10.7°C), while *L. albus*, *L. angustifolius*, and *P. sativum* grouped around -6°C. *Lupinus mutabilis* was the most sensitive (LT_{50} approx. -0.4°C), and *L. luteus* accessions ranged from -3 to -7°C, exhibiting freezing avoidance through supercooling around -8°C. Soluble sugar profiling showed a negative exponential relationship with LT_{50}, suggesting a role in cold resistance. *V. faba* accumulated the highest sugar levels, while *L. mutabilis* had the lowest. Intraspecific variation in *L. luteus* LT_{50} and sugar content suggests soluble sugars, especially sucrose, aid freezing avoidance. The insight in *L. luteus* is highly promising to improve freezing resistance in this species.
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Coordinated seasonal shifts between turgor loss point and abscisic acid production in *Quercus rubra* leaves.

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Stomata serve the dual purpose of allowing CO_2 to enter leaves for photosynthesis while regulating water loss under unfavorable conditions, like drought. In seed plants, such drought-induced stomatal closure is driven by the hormone abscisic acid (ABA). It has been established that leaf turgor loss points (TLP) and osmotic potentials ($\Psi\pi$) can shift over the course of a growing season, typically becoming more negative later in the year. Despite current interest in seasonal adjustments in turgor, little is known about how these seasonal shifts impact leaf ABA production during drought. We tracked the monthly TLP, $\Psi\pi$, and ABA production in a Northern red oak individual (Quercus rubra) from the summer solstice

until leaf fall. We found that during the summer, TLP dropped by almost 1MPa from June to early October. This trend matched both Ψπ and ABA production, which showed similar drops throughout the season. Once leaf senescence had progressed substantially by late October, both TLP and Ψπ rose to around -1 MPa. At this point, no clear ABA production to a declining water potential was observed; leaves contained very high levels of ABA across all measured water potentials.) Our results indicate that seasonal osmotic adjustment drives changes in TLP, which in turn changes when leaves produce ABA to close stomata. Consequently, plants can keep their stomata open at lower water potentials later in the season.
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Tolerance to multiple stresses and morphoanatomical-photosynthetic characterization of mosses inhabiting deglaciated microhabitats of South Patagonian Icefield, Chile.

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Non-vascular plants offer an interesting case study to disentangle the photosynthesis-stress (i.e. heating, freezing, UV-light and high light) tolerance trade-off, since – as a phylogenetic group – they are positioned at the lower end of photosynthetic capacity and the higher end of tolerance. In this sense, mosses (Bryophyta) dominate harsh deglaciated microhabitats of the South Patagonian Icefield (SPI), representing cold ecosystems that serve as a natural laboratory for studying mosses under extreme conditions of wind, cold and desiccation. The aim of this survey is to assess tolerance to multiple stresses in 10 mosses species growing at SPI. The 2025 field campaign surveyed two Andean-Patagonian terricolous moss communities: a *Nothofagus* forest-associated community, with clear-cut canopy near O'Higgins glacier (OG) and a high-elevation grassland near Mosco Glacier (MG). Five species of mosses were characterized and assessed in each area. Floristic and vegetation sampling along transects in 1-3 m^2 sampling plots was used to characterize the life forms, growth type (prostrate-erect), microhabitat, and microclimate (HOBO). Chlorophyll fluorescence-based electron transport rate (ETR) was recorded in situ in the field and used as a proxy for photosynthetic capacity. Samples were taken for later laboratory analyses of leaf mass area, leaf anatomy and multi-stress tolerance. The latter included tolerance tests for heat, desiccation, UV radiation, freezing, and high light exposure, which were conducted using the "UIB Test". The results are discussed in perspective of developing new

ecophysiological tools to the conservation of Andean-Patagonian bryophytes in the face of increased human access to glaciers at SPI.
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Linking circadian clock function to stress adaptation and growth in *Populus* sp. Trees.

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Published findings and recent, unpublished results from my laboratory underscore the potential of circadian system manipulation as a strategy for developing novel tree lines adapted to climate change and abiotic stress. Our investigations in hybrid aspen (*Populus tremula* ×*P. tremuloides* (*Ptt*)) trees, conducted under both controlled environments and field conditions, demonstrate that circadian clock-associated components function as critical regulators of plant growth. In *Populus* sp., dormancy is initiated when the photoperiod falls below a species-specific critical daylength. Hybrid aspen trees with perturbed expression of circadian regulators - PttLATE ELONGATED HYPOCOTYL 1 (PttLHY1), PttLHY2, and PttTIMING OF CAB2 EXPRESSION 1 (PttTOC1) - exhibit shortened critical daylength thresholds and delayed entry into dormancy. Under field conditions, this disruption prolongs the growing season and enhances biomass accumulation relative to control trees cultivated at the same site. Furthermore, we have examined the impact of salt stress on circadian regulation in Populus, revealing links between clock function and growth through modulation of Cyclin D3, a key regulator of cell cycle progression. Collectively, these findings highlight the strategic importance of circadian clock research, offering a conceptual framework for future approaches aimed at engineering stress-resilient trees and other species capable of withstanding increasingly unpredictable environmental conditions.
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