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Research Idea

BASS - Biodiversity Assessments at Small Scales

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Abstract

Much of the work developed on biodiversity dynamics due to climate change focuses on large scales. Yet, we know that small scale is critical to fully understand biodiversity change, particularly for plants and small or less mobile organisms which might seek refuge in sites that keep specific microclimatic and biotic conditions dampening the effects of large-scale changes. The project BASS - Biodiversity Assessment at Small Scales - aims to explore the intricate relationships between small-scale environmental variations in space and time and biodiversity patterns. Central to our study is researching how microclimatic conditions, such as potential solar radiation, influence species occurrence, abundance, community composition and biotic interactions within a Mediterranean context. Our objectives include gaining a deeper understanding of the effects of localised environmental conditions and their change in time on biodiversity, providing critical data for an under-researched Mediterranean Biodiversity Hotspot region, and examining the dynamics of small-sized species, particularly plants and invertebrates. We have established a network of 16 fixed sampling points across the Lisbon University field station - Herdade da Ribeira Abaixo (HRA), Grândola (South

Portugal): eight with high and eight with low potential solar radiation. Each of these plots will serve as a 'mesocosm' for detailed ecological studies in the next decades. This framework will support a variety of research projects each focusing on different taxa and questions, including Masters' theses, PhD dissertations and independent studies, thereby fostering a collaborative research environment. By integrating previously collected data during the last three decades with new findings, we aim to offer valuable insights into the processes underlying ecosystem functioning and change at small spatial scales. This project not only addresses fundamental ecological questions, but also contributes to sustainable landscape management and biodiversity conservation efforts.

Keywords

microclimate, biodiversity change, long-term research, species occurrence, abundance, community composition, functional traits

Overview and background

Much of the work developed on biodiversity dynamics due to climate change focuses on large scales under the scope of Macroecological studies (McGill 2019). Yet, we know that small scales are critical to fully understand biodiversity change, particularly for small or less mobile organisms which might seek refuge in small patches that maintain particular microclimatic and biotic conditions, dampening the effects of large-scale change. What happens at small spatial and temporal scales does not stay there; instead can significantly influence broad ecological patterns. Moreover, there is the need to connect micro- and macroecological processes since most of the interesting ecological and evolutionary research questions imply connecting these two scales (McGill et al. 2019). Microclimate and associated environmental conditions at small scales (hereafter referred to as microclimate) directly affect all organisms and often differ greatly from the broader regional environmental conditions (Pincebourde et al. 2016, Príncipe et al. 2022). Due to its fine-scale nature, microclimate can vary dramatically over short distances and time periods, playing a crucial role in the survival and reproduction of organisms. For instance, soils exhibit high spatial variation, which directly impacts the distribution of all forms of biodiversity, including microorganisms, plants, invertebrates and other animals (Garten et al. 2007, Eldridge et al. 2024). Topography also greatly influences local conditions, such as temperature, water availability, solar radiation and wind currents Nunes et al. 2019, De Frenne et al. 2021, Kemppinen et al. 2024. Particular microclimates enable organisms to thrive in niches such as below the soil surface, in tree canopies or in cavities, even when the broader macroclimate is unsuitable (Pincebourde et al. 2016, De Frenne et al. 2021). Conversely, extreme microclimatic conditions can lead to the absence of certain organisms in otherwise suitable habitats (Pincebourde et al. 2016, De Frenne et al. 2021). Research on the influence of microclimate on biodiversity can thus provide valuable insights into the processes that underpin ecosystem functioning (Kemppinen et al. 2024). However, ecological studies focusing on this scale are often lacking. Moreover, ecological studies tend to focus on large spatial scales, despite

organisms experiencing climate also at a microclimatic level, which can differ significantly from broader macroclimates (Potter et al. 2013). Therefore, integrating microclimate data into ecological and biogeographic research is essential for a more comprehensive understanding of ecosystem dynamics. Bridging this gap requires finer-scale field data which, together with the increasing availability of microclimatic data (Lembrechts and Lenoir 2020), will revolutionise our understanding of the relationship between microclimate, biodiversity and ecological functions. These data, capturing information at fine scales, are crucial for addressing the impacts of global change and preserving biodiversity and ecosystem services (De Frenne et al. 2021).

The project BASS - Biodiversity Assessment at Small Scales - focuses on the dynamics of local-scale variations and how they affect and shape ecological community patterns and interactions in time. Central to BASS research studies is a common overarching question: do areas with high or low potential solar radiation exhibit different patterns of biodiversity, such as species occurrence and abundance, community composition or biotic interactions? These areas, characterised by distinct vegetation profiles, provide a compelling setting to investigate variations in soil microorganisms, lichens, insects, spiders and other invertebrates. By examining these diverse environments, BASS aims to uncover the intricate relationships between solar radiation as an indicator of microclimatic conditions and biodiversity across various taxa. You can follow the project on our dedicated website.

Objectives

The primary objective of this research initiative is to enhance our understanding of biodiversity patterns in response to small-scale environmental variations. Through this approach, we aim to understand the effects of small-scale environmental variation on biodiversity patterns. By examining localised environmental factors, we seek to uncover how minor variations in microclimate may impact species occurrence, abundance, community composition and biotic interactions across time. In particular, we will focus on the role of Potential Solar Radiation—serving as a proxy for various factors, particularly water availability—on ecosystem dynamics, especially within the Mediterranean drylands' context.

Our project framework is intentionally broad and adaptable, allowing it to support a wide range of research endeavours. This includes providing a platform for Masters' and PhD students, as well as other researchers, to explore specific ecological questions within a cohesive, larger context. Standardised sampling protocols will be applied to ensure long-term monitoring of target taxonomic groups. Past biodiversity surveys will be also replicable within the new experimental context. Furthermore, we will collect and provide valuable data for a relatively under-researched region of the Mediterranean Biodiversity Hotspot. This includes gathering information on small-sized species, particularly invertebrates, to better understand their ecology, dynamics and responses to both temporal and spatial environmental variations. Our research aims to contribute significantly to the field of ecology, offering insights into the intricate relationships

between environmental factors and biodiversity. This will ultimately enhance our ability to manage and conserve ecosystems more effectively.

Location

The project is based at the Herdade da Ribeira Abaixo (HRA) (Fig. 1). The HRA is a field station of CE3C - Centre for Ecology, Evolution and Environmental Changes and the Faculty of Sciences of the University of Lisbon, dedicated to research and education focused on ecology, sustainable landscape management and biodiversity conservation. Its goal is to be a sustainable estate, serving as an example of montado management. The montado is a silvo-pastoral system predominant in southern Portugal, covering ca. 1 million hectare and combines forestry with livestock production. This system features cork and holm oaks at varying densities, with an understorey of either cultivated land or semi-natural pasture that may include shrubs based on management practices. It supports extensive livestock grazing, with pastures sometimes cultivated for supplementary forage crops. The low intensity of human use, along with diverse vegetation layers and a mosaic of tree and shrub densities, creates a rich landscape that fosters high biodiversity. Montados are often considered High Nature Value (HNV) farming systems (Ferraz-de-Oliveira et al. 2016). The HNV concept, introduced in the early 1990s, recognises the importance of certain farming systems in preserving biodiversity and landscape quality in Europe. It is based on the idea that low-intensity agricultural management, while yielding smaller production outputs, enhances biological and landscape diversity on farmland.

Implementation

The interdisciplinary nature of BASS fosters collaboration between researchers and Masters'/PhD students. We have established a network of 16 fixed sampling points across the HRA, each covering approximately 400 m². The sites were selected, based on contrasting Potential Solar Radiation levels, used as a surrogate of microclimatic conditions. Potential Solar Radiation estimates the potential amount of solar radiation that reaches a surface on the ground with a clear sky (Fu and Rich 2002), calculated from a digital elevation model with 25 m resolution. Eight points were selected within areas of higher Potential Solar Radiation (top 10%, range 990-1,197 kW/m^2) and the other eight sites
within areas of lower Potential Solar Radiation (bottom 10%, range 1,332-1,401 kW/m^2). These points serve as 'mesocosms' where different students and researchers can develop and investigate their specific questions. Additionally, students have the opportunity to use information previously collected in other studies performed at these sites, enhancing their research with a wealth of existing data. This setup facilitates a diverse range of studies within a controlled framework, allowing for detailed examination of ecological patterns and processes. With a pilot field study already conducted for spiders and expected expansion to other taxa in the upcoming spring, BASS promises to catalyse scientific enquiry and drive knowledge generation in the realm of ecological research.

Ongoing and planned studies encompass the functional and taxonomic distribution patterns of plants, invertebrates and soil biodiversity. However, the scope of potential research questions is vast and we encourage researchers to collaborate with our team and students by applying to conduct their studies at our facilities. Please see our website and send us your ideas of research.

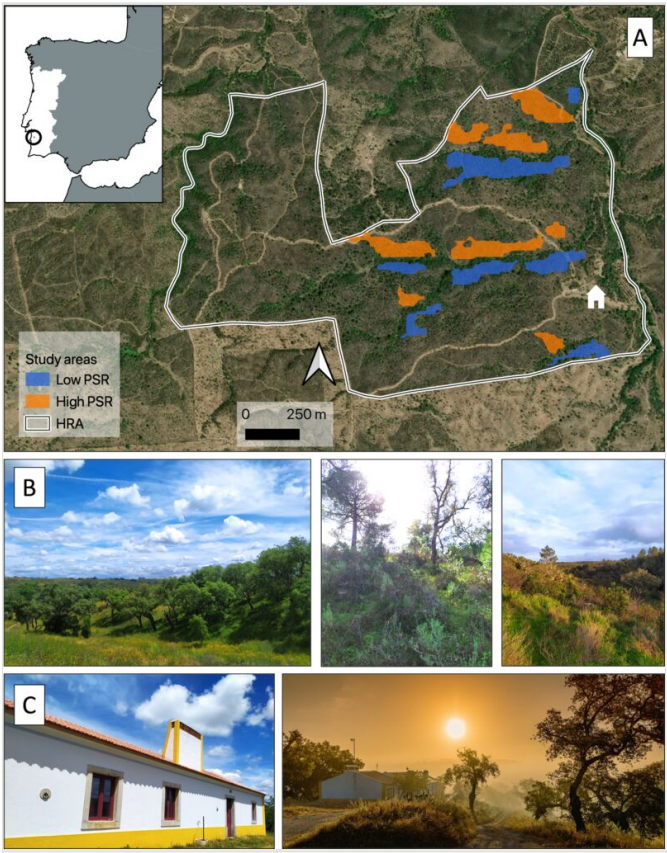

Figure 1. doi

The Herdade da Ribeira Abaixo is a property managed by the Faculty of Sciences of the University of Lisbon, embedded in High Nature Farmland areas, dominated by the montado system (A). Sampling sites, indicated in orange and blue, represent areas with high and low solar radiation potential, respectively, each with distinct vegetation types and structures (B). The field station (C), located within the property (symbol in A), provides convenient walking-distance access to all sampling sites.

Biodiversity Databases

Following the FAIR principle, all data that will be collected will be properly organised, curated and stored for future use. Concerning data on occurrence and abundance of species, the DARWIN CORE standards (Wieczorek et al. 2012) will be used for

publishing and integrating biodiversity information. The GBIF IPT (Integrated Publishing Toolkit, Version 2.5.6) will archive the data and, thus, serve as the data repository. The datasets to be submitted to GBIF will be structured as a sample event and occurrence datasets following the Darwin Core Archive (DwCA), which is a standardised format for sharing biodiversity data as a set of one or more data tables. If needed, Darwin Core data can also be linked with other aggregators and tools (e.g. Encyclopedia of Life, eMonocot Portal, CartoDB, Common Data Model) for secondary use (Baker et al. 2014). Codification of the eventID will be carefully curated to guarantee its proper interpretation and should include always the code of one of the 16 focal areas. In the OCCURRENCE table, the taxonomic data will follow the standards of the most updated nomenclature for each taxonomic group and, when applicable, validated by the GBIF taxonomic backbone.

Impact

Beyond its scientific contributions, the BASS project offers benefits that extend beyond academia. Through its education and training programmes, BASS serves as a platform for undergraduate and Masters' students to develop research skills and contribute to broader ecological understanding. It also aligns with HRA's objectives, enhancing its role as a centre for ecological research and conservation. Moreover, BASS's integration into the European Long-Term Ecosystem Research Network (eLTER, https://elter-ri.eu/) underscores its role in supporting long-term ecological research. By contributing data to the eLTER database, BASS strengthens the collective knowledge base and provides information for decision-making for sustainable management practices.

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Funding program

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Hosting institution

CE3C is an Excellent Research Centre with 39 Groups that develop fundamental and applied research in ecology, evolution, environmental science and related societal issues. Its main goal is to develop cutting-edge research to understand biological systems across levels of organisation and use such knowledge to support and inform

governmental agencies, non-profit organisations, private companies and citizens. CE3C is highly involved in graduate training, integrating science and education to contribute to a generation of competent scientists. CE3C facilities allow high quality research, including a unique Field Station (HRA) in the core of our Study Area. HRA is located in the Serra de Grândola, within a large region dominated by cork oak stands, being one of the Research and Monitoring stations of the LTsER Montado Platform. Besides this semi-natural landscape, HRA also provides on-site research facilities (laboratory, class and meeting rooms), lodging and everything needed for short to long-term stays for researchers and students. BASS will further enhance the current regular activities while serving as the backbone project in biodiversity research in the region.

Conflicts of interest

The authors have declared that no competing interests exist.

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