Hawkesbury Institute for the Environment

Summer Scholarship Research Program 2019

Project Lists

Project 5: Touching plants to prime defence against insect herbivory 3

Project 6: Understanding drought tolerance in Australian tree species 5

Project 7: Understanding historical bushfire fuel moisture patterns in NSW 7

Project 8: Vigorous trees for urban greening: from the nursery to the field 9

Project 9: Evaluating cooling and biodiversity benefits of trees in urban environments 11

Project 10: Role of aquaporins in water use efficiency of sorghum 13

Project 11: Ectopic expression of Setaria Viridis HXK5 and HXK6 into Glucose insensitive null mutant (gin2 mutant) of Arabidopsis thaliana to determine differences between the C3 and C4 sugar sensors....14

Project 12: Assessing floral preferences for native pollinators in agricultural landscapes 16

Project 13: Mapping mistletoe distribution across the Cumberland Plain woodland communities....18

Project 14: Floral choice by stingless bees: colour, pattern or scent? 20

Project 15: Death by a thousand cuts: does plant silica enhance drug delivery in caterpillars?22

Project 16: Flight behaviour by stingless bees in polytunnels: effects of microclimate and plant spacing.... 24

Project 17: When bugs get bugs: how plant defences affect insect immune responses 26

Project 18: Plants bite back: investigating how plants use physical defences against insect pests 29

Project 19: Dealing with messy eaters: Do caterpillar oral secretions increase plant susceptibility to future feeders?....31

Project 20: From plant parts to pastures: plant ecology and ecophysiology under climate extremes 34

Project 21: What is the future cooking up for hungry cattle? Pasture nutrition under climate extremes 37

Project 22: Next Generation Sequencing of Bacterial Genomes from Insect Pests........ 40

Project 23: Measuring post-fire biomass changes in dry sclerophyll forests of the Sydney Basin 43

Project 24: Addressing the drivers of dieback in an endangered Australian shrub: A landscape plant-soil survey, and plant-soil feedback experiment. 45

Project 25: Climate change and community ecology: Understanding the effects of drought on plant-pollinator interactions in a local grassland........ 47

Project 26: Interactions of Queensland fruit fly with maternally inherited *Wolbachia* bacteria and viruses........ 50

Project 27: Insect pollen transport: an assessment of pollen vectors in orchard crops........ 53

Project 28: Co-evolution of eggshell traits in a polyandrous species, the emu 55

Project 29: Thermal tolerance and adaptive capacity of Acacia under climate change 57

Project 5: Touching plants to prime defence against insect herbivory

Supervisor: Christopher Cazzonelli (Principal Supervisor)

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Project description

Plants sense and respond to wind, rubbing, insect feeding, touch and mechanical stress by altering their phenotype; a phenomenon called thigmomorphogenesis. Thigmomorphogenesis results in developmental and morphological change to the plant that manifests as a shorter, stronger and hardier plant, better acclimated to the prevailing environmental conditions. Mechanical stress has been applied in agricultural systems for over a century in Asia; a practice where farmers stamp on wheat or barley to increase strength, promote dwarfism and prime stress tolerance. The molecular nature of how touching a plant regulates gene expression and promotes long-term stress acclimation remains enigmatic. Evidence in our laboratory shows that epigenetic and memory forming processes regulate touch-induced gene expression (Cazzonelli et al., 2014 Frontiers in Plant Science). We have demonstrated that a short period of mechanical stress can induce thigmomorphogenesis, a phenotype that can persist throughout plant development in the absence of continued stress. In this project, students could investigate the molecular mechanisms that prime epigenetic memory formation and promote stress acclimation in plants (e.g. Arabidopsis and/or tomato). Students can discover the physical and chemical barriers altered by mechanical stress and reveal how these promote resistance to insect herbivory and/or facilitate the hardening of seedling transplants. Knowledge generated from this project can be translated to improve mechanical strategies that harden seedling transplants for the protected greenhouse and horticultural tree crop industries.

Project Aims

1) Elucidate molecular mechanisms controlling gene expression in response to short, repetitive and prolonged mechanical stress.
2) Identify phytohormone signaling pathways that prime plant defense against insect herbivory.
3) Discover how mechanical stress can train memory forming process to generate a hardier plant.

Project Methods

Students will gain valuable experience in the latest physiological, molecular, biochemical and/or genetic sequencing technologies that are translational in agriculture, biotechnology and synthetic biology research. The person could learn how to; 1) characterize the impact of mechanical stress on plant development and explore changes in cellular structure, 2) research how different mutants affecting metabolic and epigenetic pathways perturb plant responses to mechanical stress, 3) quantify plant defense against herbivory, and 4) quantify phytohormone levels and gene expressions associated with mediating thigmomorphogenesis. The student will design and perform research-based experiments in HIE PC2 laboratories.

Opportunity for Skill Development

The student will gain a greater understanding of how plants/trees respond to mechanical stress and the degree of mechancial stress necessary to enhance horticultural crop traits without adversly affecting yield. The student will develop laboratory techniques in microbiology, physiology, biochemistry, molecular biology (e.g. RNA extraction, gene expression analysis, High Powered Liquid Chromatograph, Mass Spectrometry), genetics and phenomics. Successful outcomes upon research project delivery could constitute a contribution towards a peer-reviewed publication where she/he may be a co-author (or acknowledged appropriately) which will help in their future career aspirations.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

Student must be enrolled in a biological or environmental sciences degree with a great motivation for research. Knowledge of plants and microorganisms would be advantageous.

Project 6: Understanding drought tolerance in Australian tree species

Supervisor(s): Brendan Choat (Principal Supervisor)
Prof Belinda Medlyn (Second Supervisor)

Supervisor(s) contact information: b.choat@westernsydney.edu.au
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Project description

One of the principal risks faced by Australian tree species under climate change is drought death. Aridity was a major driver of adaptive radiation in many Australian plant taxa, and the hydraulic architecture of most species is closely adapted to their rainfall environment. Warming exacerbates drought stress by increasing plant demand for water, particularly during heatwaves when eucalypts use transpiration to prevent leaves reaching dangerous temperatures. Increasing severity of drought stress under warming thus has the potential to cause widespread mortality in trees, and may be one of the main ways in which climate change will alter the future distributions of species. We have recently set up the Dead Tree Detective, a citizen science initiative hosted by Atlas of Living Australia, to document tree dieback events. Observations so far are deeply concerning; they indicate unprecedented drought death in many areas across south-eastern Australia, confirming that physiological tolerance thresholds are starting to be exceeded.

There is thus an urgent need to identify the vulnerability and adaptive capacity of trees to severe drought stress. The Summer Scholar would work with recently developed techniques to assess drought tolerance traits across a range of Australian tree and shrub species. This would provide an exciting opportunity to work with world leaders in the field of plant ecophysiology while leaning a range of techniques that could applied to research in natural and agricultural systems. This Summer Scholar project would be nested within a larger body of work focused on tree adaptation to drought and the impacts of climate change. This would include interaction with HIE academics, post doctoral research fellows, and PhD students working on various aspects of the project.

Our research group has been at the forefront of drought mortality research in Australia. We have developed process-based models to predict species' vulnerability to drought, but now need to test these models against field observations. We propose to use these observations as the basis for a nationally-significant research project combining fieldwork to quantify the scale and magnitude of current drought mortality; experimental studies to determine species' drought tolerance traits; and validation of physiological models predicting drought vulnerability. Outcomes will be both fundamental and applied: providing new scientific insights into the way that aridity has shaped tree diversity and distributions, and providing critical information for managing forests in a future, more drought-stressed Australia.

Project Aims

1. Establish the physiological thresholds of Australian plant species to drought induced injury across a range of forest and woodland environments.
2. Understand the physiological mechanisms by which plants recover from drought.
3. Determine the response of Australian plant species to severe drought.

Project Methods

Our broader project has four components: fieldwork, physiological studies, predictive modelling, and community engagement. The Summer Scholar will have the opportunity to work in with any of these components, depending on the timing of activities and the preference of the student.

Fieldwork will be carried out at several sites chosen from Dead Tree Detective records. The goal of the fieldwork is to gather data for ground-truthing our models predicting drought mortality risk. At the field sites, we will carry out surveys of the proportions of different species that have died during drought. We will continue to monitor the field sites during the project; depending on rainfall, we will be able to determine ongoing rates of drought death, or rates of recovery. Physiological studies will be carried out in a common garden at WSU-Hawkesbury, using a newly developed optical method and standard protocols to measure species' vulnerability to drought. Traits to be measured will include xylem cavitation resistance, leaf turgor loss point, stomatal response to drought, and leaf cuticular conductance. The goal of these studies is to characterise thresholds to drought induced mortality across a range of species. We will synthesise existing datasets, and carry out new experimental measurements, targeting species identified in the fieldwork. Process-based models based on the physiological measurements will be applied to predict drought risk for different species at the field sites. Comparison against field-based data will enable us to test these predictions.

Opportunity for Skill Development

The student will have an opportunity to learn a broad range of techniques used to determine drought tolerance in plants. This includes a newly developed optical technique that is currently being used at HIE to estimate thresholds for drought tolerance in native tree species (e.g. Eucalyptus, Acacia) and crop species (e.g wheat, sorghum). This technique allows fully automated measurement of xylem cavitation resistance, a trait of critical importance to plant survival under water limited conditions. The student would also learn to use of standard instruments used to assess plant moisture stress (Scholander pressure chamber, stem psychrometer) and leaf gas exchange of CO2 and water vapour (Licor 6400 gas exchange system). Students interested in developing quantitative skills would have an opportunity to work with modellers developing predictive tools to forecast forest mortality during drought.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

No specific skill set is required for the project.

Project 7: Understanding historical bushfire fuel moisture patterns in NSW

Supervisor(s): Hamish Clarke (Principal Supervisor)
Associate Professor Matthias Boer (Second Supervisor)

Supervisor(s) contact information: h.clarke@westernsydney.edu.au
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Project description

Fuel moisture is a critical driver of bushfire risk, along with fuel amount, ignitions and fire weather conditions. Dead fine fuels are particularly important in determining key fire behaviour properties such as rate of spread and intensity.

Recent research has shown that dead fine fuel moisture can be reliably predicted from surface weather observations. Further, it has been shown that in south-eastern Australia, the relationship between wildfire activity and fuel moisture exhibits threshold behaviour, with critical fuel moisture values being associated with step changes in landscape wildfire activity.

Although we know major fire seasons are associated with very dry fuels, we still don't understand what 'normal' fuel moisture patterns are, how they vary from year to year and how frequently dry patches join up, sending the landscape into an 'armed' state. The development of a new gridded climate dataset presents an opportunity to address this question using data at high spatial and temporal resolution.

In this project you will explore historical patterns of fuel moisture and connectivity and their links to fire activity in NSW. You will calculate dead fine fuel moisture and then derive climatologies of fuel moisture and the size of patches below defined thresholds in fuel moisture. You will also identify any trends in these values. Finally, you will explore the relationship between these values and metrics of fire activity (wildfire, but potentially also prescribed fire) in NSW such as fire frequency and burned area, building on existing work in this field. This project is part of the NSW Bushfire Risk Management Research Hub, which brings researchers from across the country together with fire managers to support improved fire management in NSW. Understanding fuel moisture climatology and dynamics is of great interest to fire agencies and you will have an opportunity to present your results to fire managers at the conclusion of the project.

Project Aims

This project will build on existing work on fuel moisture and connectivity modelling to systematically explore historical spatiotemporal variation in fuel moisture patterns in NSW by:

- Calculating fuel moisture using a newly available high quality Australian climate dataset
- Deriving climatologies of fuel moisture across NSW, covering mean values, extremes and interannual variation
- Establishing measures of the connectivity of dry vegetation by calculating the size of patches below defined fuel moisture thresholds
- Identifying any trends in fuel moisture over the observational record
- Exploring the relationship between the above quantities and measures of wildfire activity in NSW

- Presenting your results to NSW fire managers

This project will contribute to the evidence base for bushfire management in Australia. Understanding past and current distributions of fuel moisture and their links with fire incidence has immediate implications for operational fire management and strategic planning.

Project Methods

- Dead fine fuel moisture (Resco de Dios et al 2015; Nolan et al. 2016) will be calculated at daily (and possibly subdaily) timestep across the landscape from 1990-2018 using the Bureau of Meteorology's new reanalysis dataset (BARRA).
- Key analyses will address:
    1. Mean and extreme (e.g. 95th percentile) values of dead fine fuel moisture at monthly, seasonal and annual timescales, as well as interannual variation
    2. How much of the landscape is below identified thresholds for flammability,
    3. How much of the flammable landscape is connected/contiguous.
    4. Whether there have been any significant changes in these properties in the past
    5. How these changes relate to metrics of wildfire activity such as area burned

Opportunity for Skill Development

Students will have the opportunity to develop:

- data analysis skills, including
    1. Writing code (probably in R) to read data, run analyses and create plots
    2. Working with climate data (NetCDF format) and fire history data (shapefile format)
    3. Managing data (storage, metadata, etc)
- an understanding of the role of fuel moisture in driving bushfire risk from a climatological perspective
- an understanding the implications of fuel moisture properties for fire managers
- writing and presentation skills, including the opportunity to contribute as co-author to a peer-reviewed scientific paper arising from the project

Students are required to have the following skills/meet the following pre-requisite(s) to apply

Essential: experience with data analysis software (e.g. R, ArcGIS) or a willingness to learn. Training will be provided.

Desirable: familiarity with or interest in Australian fire regimes and environmental management

Project 8: Vigorous trees for urban greening: from the nursery to the field

Supervisor(s): Professor David Ellsworth (Principal Supervisor)
Dr. Renée Prokopavicius (Second Supervisor)

Supervisor(s) contact information: D.Ellsworth@westernsydney.edu.au
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Project description

With a succession of recent hot summers in Sydney and the spectre of climate change, a key challenge for greening Australia's urban and peri-urban areas is to ensure that future plantings with trees are successful. This requires ensuring that our tree plantings can tolerate hot and dry climate conditions that will occur in the future. This summer project is part of the Which Plant Where project (https://www.whichplantwhere.com.au/) involving 8 scientists here at Western Sydney working with Macquarie University, City of Penrith, and NSW government. Which Plant Where project aims to inform the community and local councils about selecting the right plants for the right place, with an eye on the future. The Which Plant Where program is a five-year series of research that will find out where current favourites are unlikely to thrive under the more extreme climates that Australian cities face, and stress-test major landscape species to find opportunities for new species and varieties to be planted.

The main scope of work for this summer project involves work in local tree nurseries and on trees from them that are planted in local developments, Western Sydney's Hawkesbury campus, and alongside road verges. We will quantify health indicators for normal growing conditions and during hot summer periods for 15-25 species of major horticultural trees. The student will get training with scientific equipment and measure the temperature of leaves, and stress-test major landscaping tree species to find opportunities for new species and varieties to be planted as well as what plantings could be expected to fail. The work will involve measurements with high-tech equipment (IR leaf temperature, chlorophyll fluorescence and greenness, and water-use) of nursery stock and out-planted trees, along with measurements of local temperature and moisture conditions. The student will receive some backing from the Which Plant Where project (https://www.whichplantwhere.com.au/) and interact with some of the science team of WPW. The project also leverages a portion of work associated with a recent ARC DECRA application by Dr. Prokopavicius.

Project Aims

Tree stock can be influenced by watering, nutrition, climate, as well as other factors related to how they are cultivated. Our aims are:

- Gain experience with scientific equipment
- Measure some key indicators of health/vigour for nursery stock from across different pot sizes and from pot to the field/urban environments.
- Determine the norms of biological variability for well-watered, unstressed nursery trees
- Learn how to summarise and report your findings to others

Project Methods

This project uses plant ecophysiological techniques as the basis for the measurements. The measurements involve leaf-level measurements in a local nursery, and in the field (on campus and in nearby development areas). Leaf greenness (SPAD meter), leaf chlorophyll fluorescence with a pulse-amplitude modulated fluorometer (MINI-PAM-II/B, Heinz Walz GmbH, Effeltrich, Germany) will be used for the measurements, Leaf temperature will be made using a point-measurement infrared thermometer, including during high-heat conditions as they may occur during the summer period. The student will be contributing to the larger bulk of data collection to be undertaken by a team of researchers at HIE, including the project supervisors (Dr. Prokopavicius and Prof. Ellsworth).

Opportunity for Skill Development

This project will introduce the student to the fields of plant physiology and urban ecology. The student will develop skills using several pieces of scientific equipment, as well as skills for proper data collection, organisation, hypothesis-testing and analysis.

- The student gains the ability to make and interpret scientific measurements
- The student will see how inclement environmental conditions, and also
- The student learns about the precision and accuracy of measurements. He/She gets the opportunity to work with a few different electronic sensors
- The student learns how to analyse the data quantitatively, and present it appropriately

The student will learn to function independently after receiving proper guidance, learn how to work in a team, and learn how to contribute to a research team effort.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

- Student candidates should be willing to work in the field and glasshouse while following safe-work practices. Work will sometimes be involving brief inclement conditions (hot days during summer).
- Ability to drive (holder of a NSW or other Australian state's standard drivers licence).

Project 9: Evaluating cooling and biodiversity benefits of trees in urban environments

Supervisor(s): Dr Manuel Esperon-Rodriguez (Principal Supervisor)
Professor Sally Power (Second Supervisor)

Supervisor(s) contact information: m.esperon-rodriguez@westernsydney.edu.au
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Project description

More than 50% of the world's population now lives in urban areas and this number will continue to increase over time, particularly in developing countries. Large urban conurbations result in dramatic changes in land surface characteristics, as well as having a profound influence on biodiversity and ecosystem services. The Urban Heat Island (UHI) effect leads to warmer temperatures in built up areas, with associated effects on energy consumption, plant and animal performance, and human thermal comfort. Loss of biodiversity is another common feature of urbanisation, resulting principally from the replacement of natural habitat with tarmac, pavement and other impervious surfaces. The Which Plant Where (WPW) project, funded by Hort Innovation Australia, aims to increase the knowledge base that will help make our cities more liveable not only now but under future climatic conditions. An essential part of having a liveable city is the maintainance (and expansion) of green spaces that provide many core benefits to society, including cooling, carbon sequestration and biodiversity support.

This summer scholarship project focuses specifically on how different plant attributes are related to the provision of ecosystem services on a local scale. The student joining our project will examine thermal benefits (the degree of cooling, through plant transpiration and shading) and insect biodiversity associated with tree species commonly deployed in urban contexts. A variety of measurement techniques (e.g. surface and air temperature, tree biometrics and insect trapping) will be used to obtain data on which vegetation traits (e.g. leaf area index, height, canopy density) are associated with maximum provision of thermal/biodiversity benefits. The student will be introduced to the concepts of ecosystem services and local micro-climate and will have the opportunity to learn about survey design, sampling strategies, data management and develop their skills in the relevant statistical techniques and software. This project also offers enormous opportunity benefits to the student via interactions with a large team of post-docs and PhD students contributing to related questions as a part of the wider WPW project.

Project Aims

1. Evaluate how different plant attributes and traits are related to the provision of cooling benefits in urban locations.
2. Understand the role of structural complexity of vegetation for invertebrate abundance and diversity in an urban context.

Project Methods

This project involves field work in different locations within the Penrith/Richmond region and in the Living Lab research facilities at Western Sydney University's Hawkesbury Campus. All fieldwork will be supervised in conjunction with the primary supervisor and the associated PhD student (Mahmuda Sharmin). Research conducted for this project is mostly undertaken outdoors, so a willingness to spend time in the field is important for this project.

Data collection for this project will include spot measurements of different biological and physical parameters (such as tree height, diameter at breast height, leaf area index (LAI), wind speed, air and surface temperatures) and insect sample collection along streets and in parks, followed by species identification. This will contribute to a comprehensive evaluation of which tree species, and vegetation characteristics are better at reducing temperatures within the streetscape – and thus increasing human thermal comfort - and also increase local biodiversity in an urban context. All these findings will be shared with industry partners and plant nurseries and will help to advocate the importance of having appropriate tree species in our cities to maximise the benefits they bring to to urban populations.

Opportunity for Skill Development

This project will provide a sound understanding of the fundamentals of research – from hypothesis development to experimental design and data collection – providing a solid framework for future participation in HDR study in the area of urban ecology. The student joining this project will have the opportunity to tailor their research skills development from measurements to data analysis and inference focussing on applied topics, such as insect identification, biodiversity assessment and mitigation of urban heat. In addition, they will have the opportunity to learn about a wide range of ongoing projects run by affiliated PhD students and post-docs conducting research on related questions using the WPW framework, gaining experience of how to work as part of a wider research team. As part of the WPW team, they will be supported in connecting ecological theory to practice, developing research questions, hypotheses and predictions and, if interested, learning about writing for a general audience and the scientific community.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

A driving licence is desirable but not required.

Project 10: Role of aquaporins in water use efficiency of sorghum

Supervisor(s): A/Prof Oula Ghannoum (Principal Supervisor)
PhD student Yazen Al-Salman (Second Supervisor)

Supervisor(s) contact information: o.ghannoum@westernsydney.edu.au
Y.Al-Salman@westernsydney.edu.au

Project description

Sorghum provides the staple food for over 500 million poor rural people in the semiarid tropics of Asia and Africa and is used as fodder for poultry and cattle in developed countries, including Australia. Sorghum is well known as a drought tolerant and heat tolerant crop species with relatively high water use efficiency (WUE). Aquaporins (AQPs) are a class of channel-forming proteins that play an important role in water transport in plants. This study aims to investigate the link between AQP genetic variability and WUE across a NAM diversity panel of sorghum (Sorghum bicolour). AQP genes have already been identified by our ANU colleague Dr Michael Grozsmann and 110 lines representing the various alleles in sorghum from diverse habitats have been curated (by our UQ colleague Dr Emma Mace) and sent to WSU. A large-scale WUE screening experiment will be undertaken this summer and this will be ideal opportunity to train an undergraduate student.

Project Aims

1. Screen for WUE diversity and crop growth traits across 110 sorghum lines representing the genetic AQP diversity in a NAM population
2. Link AQP with WUE and its underlying traits (e.g., leaf hydraulics, gas exchange, stomatal and vein morphology, enzyme and hormone activity)

Project Methods

1. 110 Sorghum lines will be grown under well-watered conditions in the glasshouse at 20/30 °C night/day temperatures in the summer of 2019-2020.
2. Whole-plant water use (via pot weighing) and soil-to-leaf hydraulic conductivity will be measured by leaf water potential differentials between pre-dawn and midday.
3. Leaf gas exchange measured using infra-red gas analysis.
4. Leaf samples will be taken and stored via liquid nitrogen for leaf enzyme, hormone, sugar and RNA analysis.
5. Leaf sections will be taken for leaf anatomical measurements
6. At the end of the experiment, plant harvesting will assess total leaf area, total biomass, seed head weight, and will sample leaves for anatomical analysis.

Opportunity for Skill Development

The student will be involved in growing plants, measuring leaf gas exchange and hydraulic measurements, plant harvest and leaf sampling for biochemistry and anatomical analysis. At the end of the project, the student would have gained excellent and broad plant physiology skills.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

Basic undergraduate training is sufficient. It is desirable the student has some plant biology skills.

Project 11: Ectopic expression of Setaria Viridis HXK5 and HXK6 into Glucose insensitive null mutant (gin2 mutant) of Arabidopsis thaliana to determine differences between the C3 and C4 sugar sensors

Supervisor(s): A/Prof Oula Ghannoum (Principal Supervisor)
PhD student Y.Chaudhari@westernsydney.edu.au (Second Supervisor)

Supervisor(s) contact information: o.ghannoum@westernsydney.edu.au
Y.Chaudhari@westernsydney.edu.au

Project description

The main purpose of photosynthesis is production of sugars for use in plant growth, maintenance and propagation (Udo Gowik and Westhoff 2004). During light periods, photosynthetic carbon fixation occurs in the leaf, where these sugars ultimately are transported throughout the plant to be used for cell maintenance, growth and storage. While at night the plant consumes the stored sugars (Blasing 2005). This indicates that the high level of fluctuation in sugar levels of plant source tissue is partly due to changes in light resources. CO2 concentrations also affects the levels of photosynthetic sugars produced during the day, with higher levels of CO2 available for photosynthesis resulting in a higher accumulation of sugars (Thompson et al. 2017). In response to high levels of sugars, key photosynthetic genes have been shown to be down regulated. For example, RbcS is down regulated under high CO2 levels, where sugar have accumulated (Thompson et al. 2017). The steps between sugar levels and transcript regulation are not yet well understood, due to a complex regulatory network of sugar metabolism and sensing genes encompassing many mechanisms other than regulation on photosynthesis. Three known sugar sensors (TOR, HXK and SnRK1) have been proposed to play a role in photosynthetic regulation. Manipulation of these genes in planta, would allow for a mechanism to understand this process.

The objective of this project (which constitutes part of Yogesh PhD project) is to better study the regulation of sugar sensors such as HXK5 and HXK6 in C4 photosynthesis. This study will establish a relation between the sugar sensors and photosynthesis. Once this link is established it will open the door to understand the mechanism by which photosynthesis is regulated by these sensors. In this study, Glucose Insensitive null (gin2) mutant (null mutant of AtHXK1) will be used to express S. viridis HXK5 and HXK6 ectopically in order to characterise them. Over-expressed mutant lines and gin2 WT lines will be fed with the sugar in order to determine the photosynthesis activity. The main objective of this study is to determine whether the SvHXK5 and SvHXK6 will be able to compliment the role of AtHXK1 in glucose sensitivity in A. thaliana. To carry out phenotypic characterisation, plants will be grown under optimal conditions for 3-4 weeks. They will then be subjected under different conditions such as different light intensity and/or high exogenous sugar environment which will be used a way of manipulating sugar status. This will allow us to determine the responses which are due solely to the higher sugar levels and the potential differences that may exist between the sensing responses of C3 and C4 source leaves. The parameters such as leaf anatomy, leaf sugar contents (e.g. glucose, fructose, sucrose and starch), photosynthetic rates, protein contents, gene expression (photosynthetic/ sugar sensing) will be considered for phenotypic characterisation of sugar sensors.

Project Aims

The main objective of this study is to determine whether the SvHXK5 and SvHXK6 will be able to compliment the role of AtHXK1 in glucose sensitivity in A. thaliana. Glucose Insensitive null (gin2) mutant (null mutant of AtHXK1) will be used to express S. viridis HXK5 and HXK6 ectopically in order to characterise them.

Project Methods

Over-expressed mutant lines will be generated.
OE and gin2 WT lines will be fed with the sugar in order to determine the photosynthesis activity. To carry out phenotypic characterisation, plants will be grown under optimal conditions for 3-4 weeks. They will then be subjected under different conditions such different light intensity and/or high exogenous sugar environment which will be used a way of manipulating sugar status. This will allow us to determine the responses which are due solely to the higher sugar levels and the potential differences that may exist between the sensing responses of C3 and C4 source leaves. The parameters such as leaf anatomy, leaf sugar contents (e.g. glucose, fructose, sucrose and starch), photosynthetic rates, protein contents, gene expression (photosynthetic/ sugar sensing) will be considered for phenotypic characterisation of sugar sensors. The student will be involved in gene cloning, A.thaliana transformation, taking LI-COR measurements for photosynthesis rate, metabolite extraction from mutant lines, carrying out RT-PCR for gene expression studies and analysis, growing Arabidopsis plants through different generations, etc. At the end of the project the student will be expected to have hands on experience on different molecular biology as well as some of the plant physiological techniques.

Opportunity for Skill Development

The student will be involved in gene cloning, A.thaliana transformation, taking LI-COR measurements for photosynthesis rate, metabolite extraction from mutant lines, carrying out RT-PCR for gene expression studies and analysis, growing Arabidopsis plants through different generations, etc. At the end of the project the student will be expected to have hands on experience on different molecular biology as well as some of the plant physiological techniques.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

Basic undergraduate training is sufficient. It is desirable the student has some molecular biology skills.

Project 12: Assessing floral preferences for native pollinators in agricultural landscapes

Supervisor(s): Dr Amy-Marie Gilpin (Principal Supervisor)
Lena Alice Schmidt (Second Supervisor)

Supervisor(s) contact information: A.Gilpin@westernsydney.edu.au
L.Schmidt@westernsydney.edu.au

Project description

Pollination carried out by wild animals is a critical ecosystem service, underpinning plant reproductive success and, for crop species, associated yields. However, populations of wild insect pollinators are in decline worldwide while the dependence on a single agricultural pollinator – the European honeybee (Apis mellifera) – is increasing. While in the northern hemisphere a wide range of studies has explored the benefits of native floral enhancement plantings on farmland, in Australia there is a knowledge gap regarding the extent to which locally adapted plant species can provide essential floral resources year-round to a diverse array of native pollinator groups within agricultural landscapes. Research in this area is underway at HIE with a broader Hort Innovation Australia (HIA) - funded research program "Healthy Bee Populations for Sustainable Pollination in Horticulture". One of the key milestones is linked with the importance to develop new knowledge on the contribution of floral resource species to maintaining and improving pollinator health in cropping systems. Since April last year we have been working on quantifying floral resource provisioning of a borad range of plant species native to the Sydney region while assessing pollinator visitation patterns. In the next step we will identify whether pollinator visits to native, year-round floral enhancements differ from those of an exotic mix characterised by short flowering windows. Off hive pollen collection and pollinator observations on native and exotic flower strips at the Hawkesbury campus as well as on-farm level in Bilpin, NSW, will be used to broaden the understanding of foraging limitations and requirements for native pollinators. The results of this study will help inform and advise appropriate farm-level floral enhancement schemes in order to enhance floral resource availability within agricultural landscapes.

Project Aims

The aims of this student project are to:

- Advance understanding of foraging limitations and requirements for native pollinators.
- Assess differences in resource provisioning between native and exotic floral plantings for native pollinators.
- Identify key floral species (native vs. exotic) exploited by introduced honeybees and native sugarbag bees.

Project Methods

Field work:
Undertake pollinator observational surveys.
Collect insects visiting flowers on floral enhancement strips and horticultural crops (using

sweep nets).
Collect pollen off stingless bees and from honeybee hives.
Conduct floral counts assessing flowering phenology of both native and exotic floral strips.

Laboratory work:
Preserve specimens for storage in ethanol and propylene glycol.
Identify insect specimens under a stereomicroscope to genus or species level using morphological keys (training will be provided).
Conduct pollen identification through light microscopy.
Analyse nectar and pollen using High Performance Liquid Chromatography (HPLC).

Data management:
Learn how to collect, organise and analyse data.

Manuscript preparation:
Opportunity to be involved in preparing findings for publication in a peer-reviewed scientific journal.

Opportunity for Skill Development

The Summer Scholarship student will learn a variety of field and laboratory techniques while developing statistical, analytical and communication skills. Assisting with on-going fieldwork will provide the opportunity to develop skills regarding pollinator observational surveys, flowering phenology surveys and hive maintenance. In the laboratory entomological skills will be taught in relation to the processing and identification of insect specimens. Further the student will be able to explore pollen identification through light microscopy as well as the analysis of nectar and pollen using High Performance Liquid Chromatography (HPLC). Post data collection the student will develop skills in data management, statistical analytical methods and data presentation and have the opportunity to be actively involved in the process of manuscript preparation. The research skills acquired in this project are invaluable to early career scientists learning the scientific process and the opportunity to be included as an author on a published journal article is a critical part of a researcher's career development.

As part of the plant-pollinator interactions group the student will have the opportunity to interact with a large and diverse cohort of scientists at all career levels. The student will learn to function independently after receiving proper guidance, and will contribute to a research team effort.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

Students should be willing and able to work out of doors for several hours a day in summer temperatures during periods of field data collection. It is advantageous, but not essential, to have some background understanding of and/or interest in pollination biology. Most importantly the student should be enthusiastic about insects and fieldwork and willing to learn. Training will be provided in all techniques associated with this project.

Project 13: Mapping mistletoe distribution across the Cumberland Plain woodland communities

Supervisor(s): Anne Griebel (Principal Supervisor)
Associate Professor Matthias Boer (Second Supervisor)

Supervisor(s) contact information: A.Griebel@westernsydney.edu.au
M.Boer@westernsydney.edu.au

Project description

The critically endangered Cumberland Plain woodland within the greater Sydney metropolitan area hosts a dwindling population of remnant eucalypt woodlands, which are scattered across the landscape in small, highly fragmented patches. The woodlands can feature a high concentration of mistletoes, a parasitic plant that taps into the host's water system and exaggerates climate stress during summer.

Recent observations across Australia support an increasing distribution of mistletoes, which were linked to increasing rates of tree mortality in a range of ecosystems. However, to date the only reliable measure to assess mistletoe infection relies on manual detection and accounting of the parasite infection levels, as no suitable automated method has been established to remotely identify mistletoe distribution across the landscape.

This project will test the suitability of remotely sensed data (satellite images and observations from remotely piloted aircraft systems) to identify mistletoe distribution within the Cumberland Plain woodland. The student will identify suitable woodland patches from existing geospatial data sets and satellite images, and will then assist in surveying identified sections for mistletoe infection using traditional ground-based inventory methods. These methods include biomass inventories, canopy health assessments, as well as geo-referencing infected trees. The student will be part of a research team using remotely piloted aircraft systems (RPAS) to map forest structure and the spectral properties of the canopy, and this particular student project will provide vital ground validation data that contribute to establishing automated mistletoe detection algorithms in the canopy and subsequent modelling of infection level across the landscape. Thus, this student project will compliment a larger research project aimed at assessing the vulnerability of the Cumberland Plain woodland to natural disturbances.

Project Aims

This student project aims to

- use existing spatial mapping to identify all patches of Cumberland Plain woodland
- test the suitability of satellite images for identifying woodland patches that are infected with mistletoes
- validate mistletoe infection rates using traditional ground-based inventory methods

This data will then feed into a larger research effort aimed to:

- establish the effect of mistletoe infection on forest structure and on the spectral properties of the canopy using remotely piloted aircraft systems
- generate automated routines for mistletoe detection
- model the mistletoe infection level across the landscape.

Project Methods

The project will combine satellite images with local inventory data to complement observations from two remotely piloted aircraft systems. The student will use existing spatial datasets provided from the Office of Environment and Heritage to identify all remaining patches of Cumberland Plain woodland. The student will then combine this data set with satellite data for a preliminary assessment of mistletoe presence in identified woodland patches. The team will aid the student in identifying suitable patches for airborne assessments of vegetation properties, which will be led and implemented by the research team with the student's assistance. The student will primarily assist the team using traditional ground-based inventory methods to survey woodland properties and to quantify mistletoe infection. This hands-on fieldwork includes woodland surveys for mistletoe infection, georeferencing of infected trees and assessing their level of mistletoe infection. The data gathered in the field will subsequently be used by the research team as ground-validation data for the remotely sensed data from satellites and RPAS surveys.

Opportunity for Skill Development

The student would specifically learn skills in the areas of:

- standard forest inventory approaches, specifically
    - biomass inventory
    - canopy health assessments
    - geo-referencing
    - plant area assessments using canopy photography
- geospatial data analysis, specifically
    - vegetation mapping
    - using satellite images for parasite identification
    - geo-tagging and geo-referencing
- basic data analysis and visualization in R.

The student will primarily be trained in geospatial data analysis and in field-based inventory approaches, and the research team will handle the acquisition and the processing of the RPAS-based data. The forest inventory and parasite identification approaches, as well as the geospatial techniques are routinely used by this group in teaching settings and for research purposes, which ensures feasibility of the student's project. The student project will feed into a larger project aimed at assessing the vulnerability of the Cumberland Plain woodland to natural disturbances, and will be complemented by novel applications of RPAS-based vegetation surveys. We therefore anticipate that the project will result in a high quality peer-reviewed publication, on which the student would be a co-author.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

This student project will involve field work, so the student should be willing to spent time outdoors in native Australian bushland. The techniques and approaches outlined above are standard forest inventory approaches, and training for field measurements will be provided on this project. The student doesn't require specialised skills, but experience with, or an interest in learning, the use of spatial analysis software or Geographical Information Systems (GIS) along with an interest in plants and in environmental science would be desirable.

Project 14: Floral choice by stingless bees: colour, pattern or scent?

Supervisor(s): Mark Hall (Principal Supervisor)
Michael Duncan (Second Supervisor)

Supervisor(s) contact information: Mark.hall@westernsydney.edu.au
M.Duncan@westernsydney.edu.au

Project description

Bees are attracted to flowers in multiple ways, primarily through scent, colour or floral pattern, or a combination of these. Yet little is known of the preferences of native stingless bees (Tetragonula carbonaria and T. hockingsi) to these floral characteristics. Such preferences may influence the utility of these bee species in pollinating important commercial crops. Here, we will conduct a choice experiment where bees will be provided with false flowers (made form plastic and cut into flower shapes) varying in their colour, representing common flower colours such as yellow, blue and white. Replicates of these will receive a pattern treatment, whereby invisible UV ink will be drawn onto flowers to represent typical floral patterns which bees use to navigate to the reproductive parts of flowers. Additional replicates will receive a scent treatment, where a floral attractant will be added to different flowers, while others will receive no scent. Comparisons will be made to determine which factor(s) most influence floral choice by Australian stingless bees.

This work will be run concurrently with a flight arena experiment, where individual bees will be given these choices in a controlled environment. It contributes to the wider work on stingless bee foraging efficiency and behaviour, funded by Hort Innovation. It will aid understanding of floral choice and help determine potentially suitable crop species on which to use stingless bees. Results will be presented in a peer-reviewed manuscript, milestone reports for the project and presentations to the scientific community and general public.

Project Aims

- To investigate if floral colour, scent or pattern are more attractive to Australian native stingless bees
- To determine if plant position influences bee floral choice

Project Methods

Surveys will be conducted on WSU Hawkesbury campus, adjacent to S10, where native bees are kept and will have direct access to the false flowers. Flowers will be cut into similar shapes from plastic, representing a typical flower shape, and coloured either blue, yellow, mauve or remain white (n=60). These will then be divided into three groups: Colour only (n=20: 5 x blue, 5 x yellow, 5 x mauve and 5 x white), colour plus pattern (n=20), colour plus scent (n=20). In all instances, the plain white flowers will be considered control to determine whether an individual factor (colour, scent or pattern) or a combination of these is more attractive to stingless bees. Flowers will be attached to wooden stakes concreted into flower pots so that they can be randomly distributed within the study site and avoid spatial clustering or biases. Each flower will be assigned a unique number/code based on its category. Once distributed in the study site, bees will freely forage on them for nectar rewards (microtube inserted into middle of flower). The student will assist with the production of flowers and establishment of study site. Regular surveys will be conducted throughout the day at each flower on warm sunny days during peak activity periods (e.g. 9am to 4 pm). The number of bees visiting flowers per 2-minute period will be recorded by the student. This will be replicated across multiple days and randomly rotated across flower types to avoid bias caused by fatigue. Flower pots will be moved randomly throughout the study area each day to test if plant position further influences floral choice. The location of each plant on each day will thus be recorded and a network made of nearest neighbours to see if visitation is influenced by either proximity to other flower types, or distance from bee nest entrances.

Opportunity for Skill Development

This project will enable the student to manage a scientific research question, from preparing the study, searching for literature, conducting experiments, performing analyses and writing both a final report and contributing to a scientific paper. They will gain knowledge of the behaviour of stingless bees on flowers, some of their ecology and their potential as crop pollinators. They will develop key skills required of further study (e.g. honours or master's degrees). A key component will be learning some basic statistical skills and the ability to interpret and discuss results.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

No additional skills required.

Project 15: Death by a thousand cuts: does plant silica enhance drug delivery in caterpillars?

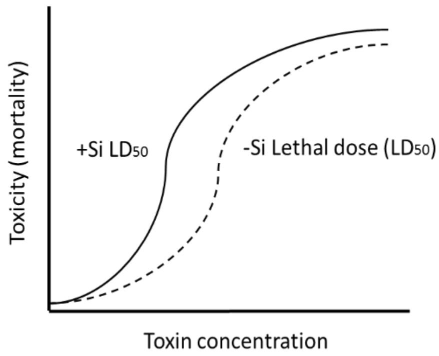
Supervisor(s): Casey Hall (Principal Supervisor)
Assoc. Professor Scott Johnson (Second Supervisor)

Supervisor(s) contact information: Casey.Hall@westernsydney.edu.au
Scott.Johnson@westernsydney.edu.au

Project description

Plants have been locked in an evolutionary arms race with insects that want to eat them for 300 million years. Plants deploy an arsenal of physical (e.g. spikes) and chemical (e.g. toxins) defences that either deter insect herbivores or cause them harm. Insects, in turn, adapt or begin to tolerate such defences and may overcome them. Researchers have increasingly realised that many plants, especially grasses, obtain silicon from the soil and use this as a form of defence. Physical defences include tougher plant tissues, which are harder to chew or penetrate, and also discrete structures on the leaf surface (e.g. phytoliths or trichomes) which obstruct feeding and/or interfere with digestion if eaten.

It has recently been hypothesised that the sharp needle-like silica phytoliths may also wound herbivores internally, increasing herbivore susceptibility to pathogens. Microscopic wounds inside the herbivore's digestive tract may also enhance the effectiveness of defensive chemicals. Some pest caterpillars are able to detoxify these compounds due to the presence of specialised enzymes in their saliva. However, if the digestive tract is microscopically damaged by silica and thus more permeable, these toxic drug-like compounds may enter the caterpillar tissues before they can be detoxified.



This project will test this novel hypothesis using different concentrations of a toxic drug-like alkaloid found in several grass species applied to silicon-rich and silicon-free plants and fed to a pest caterpillar of crops world-wide (Helicoverpa armigera). The student will grow the plants and apply the toxin, then measure caterpillar growth, mortality and enzyme concentration in caterpillar saliva. The student will join an international group of researchers who are investigating the functional role of silicon in various plant systems (see http://bit.ly/2tRATHY). This distinct project will both benefit from and compliment the group's research funded by the Australian Research Council.

Project Aims

The project aims to:

- Determine the effective and lethal dose of hordenine (grass toxin effective against caterpillars) against Helicoverpa armigera caterpillars when given silica-rich and silica-free leaves.
- Quantify detoxifying enzyme levels in caterpillar saliva when exposed to toxic compounds in the presence and absence of dietary silica.

Measure toxin levels in caterpillar tissues to establish if more of the compound is absorbed when fed silica-rich leaves (supporting the hypothesis that silica needles enhance plant "drug-delivery" in caterpillars).

Project Methods

The project will use the model grass species Brachypodium distachyon. The student will be involved in the exact design of the project, but our group would germinate and grow the plants one month prior to project commencement to maximise research activities during the project. Plants would be grown hydroponically; half in a silicon supplemented solution (+Si plants) and half in a silicon-free solution (-Si plants).

The student will coat leaves of the plant in solution containing various concentrations of the toxic compound which will be fed to Helicoverpa armigera caterpillars. The student will measure caterpillar growth and mortality over a one-week period to determine the lethal and effective dose of the compound with and without silicon. Plant silicon levels will be quantified using X-ray fluorescence spectrometry. Caterpillar detoxifying enzymes will be quantified using enzyme activity assays on extracted caterpillar tissues. Extracts will also be analysed using advanced chromatography techniques (UPLC-MS) to quantify the presence of the toxin in caterpillar tissues.

Opportunity for Skill Development

This project would specifically provide training in the areas of:

- Insect rearing and plant cultivation
- Experimental design involving herbivore measurements and toxicology bioassays
- Chemical analysis including X-ray fluorescence spectrometry (silicon), enzyme assays and UPLC-MS

All of the methods and techniques are routinely used by this group which ensures feasibility of this research. The project is based on our previous work in the field but tests an entirely novel hypothesis. We therefore anticipate that the project will result in a high quality peer-reviewed publication, on which the student would be a co-author.

In addition to benefits to the student (i.e. research experience and training, CV opportunities), this project would provide mentorship opportunities for an early career researcher (Dr Casey Hall) under the guidance of Assoc. Professor Scott Johnson. The findings from the project would be used as proof-of-concept for subsequent grant applications including the ARC DECRA scheme.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

The techniques and approaches outlined above are routinely taught to undergraduate and postgraduate students, and training will be provided on this project. The student doesn't require specialised skills but an interest in plants, insects and/or environmental science would be desirable.

Project 16: Flight behaviour by stingless bees in polytunnels: effects of microclimate and plant spacing

Supervisor(s): Mark Hall (Principal Supervisor)
James Makinson (Second Supervisor)

Supervisor(s) contact information: Mark.hall@westernsydney.edu.au
J.Makinson@westernsydney.edu.au

Project description

With increasing worldwide demand for fresh fruit and vegetables, producers are increasingly turning to protected cropping in order to expand suitable growing regions, stabilize yields and improve product quality. Such structures allow for manipulation of the crop micro-environment to facilitate optimal plant growth, induce early flowering and extend fruit production duration, allowing growers to produce valuable out-of-season produce. Yet, little is known about the behaviour, performance and response to climatic conditions of beneficial insect pollinators in these systems. Unventilated protected cropping environments commonly have higher temperature and humidity and lower radiation levels than the external environment Wind speed is reduced and plants are provided with consistent water, nutrients and in some systems, CO2. The capacity to control these factors may act to enhance growing conditions for some crop species but likely influence bee foraging behaviour and longevity in protected cropping systems.

Here, we will build on previous work in commercial polytunnels investigating the effects of microclimatic conditions on bee flower visitation. Those results showed altered conditions in the centre of tunnels which reduced forager activity and decreased fruit yield and quality. We aim to manipulate the microclimatic conditions in polytunnels on WSU Hawkesbury campus through different plant spacing and removal to create air pockets that may improve foraging conditions and increase crop yields along the entire length of tunnels. This work will contribute to the wider work on stingless bee foraging efficiency and behaviour, funded by Hort Innovation. It will aid understanding of foraging behaviour and help determine suitable environmental conditions in which to use stingless bees. Results will be presented in a peer-reviewed manuscript, milestone reports for the project and presentations to the scientific community and general public.

Project Aims

- To determine how pollinator visitation rates vary with distance from the edge of polytunnels
- To investigate whether microclimatic environmental conditions (e.g. temperature and relative humidity) vary along the length of polytunnels
- To investigate if microclimatic conditions within polytunnels affect Australian native stingless bee foraging rate on melon crops
- To determine if manipulation of plant spacing and removal at the centre of tunnels improves bee foraging and/or crop yield and quality

Project Methods

Surveys will be conducted on WSU Hawkesbury campus, in two existing polytunnels. Native stingless bees are to be kept in hives and will have direct access to the flowers within the tunnels. This experiment will be run concurrently with a current PhD project exploring the foraging efficiency of stingless bees on cucurbit crops (e.g. melon). Starting with the plant closest to the end of the polytunnel, surveys will be conducted for one minute at selected plants, recording the number of individuals visiting the reproductive parts of flowers This will be repeated at intervals along the row to the opposite end of the tunnel. Microclimatic conditions within tunnels will be recorded during the entirely of the study period, using temperature and relative humidity loggers spaced evenly along the length of the tunnel. The average wind speed at each survey point along the tunnel will also be recorded during insect surveys using a wind meter. Light intensity, both UV and white light, may also be recorded at each survey point, using a dual UV and white light meter. One polytunnel will be used as a control, representing typical production conditions, whilst the second will be subject to manipulation of plant spacing and/or removal of plants toward the centre of tunnels to test if this alters the climatic conditions.

The student will assist with the establishment of this component of the wider study. They will be responsible for taking all climatic data and conducting pollinator surveys at regular intervals throughout the flowering period. Surveys will be conducted throughout the day at allocated plants during peak activity periods (e.g. 9am to 4 pm). The number of bees visiting the reproductive parts of flowers per 1-minute period will be recorded by the student. This will be replicated across multiple days and randomly rotated across polytunnels and start point (e.g. rotating which end of the polytunnel to begin at) to avoid bias caused by fatigue. Plants will be moved/removed by the student throughout the study to test if plant spacing influences foraging behaviour and microclimatic conditions.

Opportunity for Skill Development

This project will enable the student to manage a scientific research question, from preparing the study, searching for literature, conducting experiments, performing analyses and writing both a final report and contributing to a scientific paper. They will gain knowledge of the behaviour of stingless bees on flowers, some of their ecology and their potential as crop pollinators. They will develop key skills required of further study (e.g. honours or master’s degrees). A key component will be learning some basic statistical skills and the ability to interpret and discuss results.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

No additional skills required.

Project 17: When bugs get bugs: how plant defences affect insect immune responses

Supervisor(s): Assoc. Professor Scott Johnson (Principal Supervisor)
Ximena Cibils-Stewart (Second Supervisor)

Supervisor(s) contact information: Scott.Johnson@westernsydney.edu.au
x.cibilsstewart@westernsydney.edu.au

Project description

Insect herbivores destroy enough crops to feed a billion people a year. Synthetic insecticides are widely used for their management, being often environmentally damaging because of their impacts on wildlife and water contamination. Natural anti-herbivore defences available to plants, such as silicon (Si), and mutualistic fungi (beneficial agents) are currently unexploited because of knowledge gaps, yet have clear potential for plant protection with fewer environmental impacts than the insecticides they replace.

Si is taken up by plants via the roots as silicic acid, and stored in and around plant tissues. The amount of Si in plant tissue varies widely among species, with grasses accumulating more Si than other plants. Si can negatively affect herbivores by making tissues tougher or less nutritious. Furthermore, some grasses (e.g. fescue) associate with non-pathogenic fungi (e.g. endophytes; ENDO) which can also adversely affect herbivores. Working together, Si and ENDO may make insect herbivores more susceptible to disease and pathogenic organisms (e.g. parasitic nematodes).

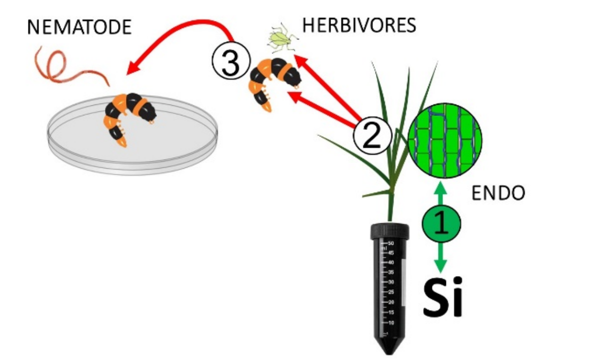


Fig. 1. **Main project questions**: 1) Do endophytes (ENDO) increase silicon (Si) uptake in grasses? (2) If so, how do they do it and does this affect herbivores? (3) Finally, do these effects make insects more susceptible to pathogenic organisms.

Recent evidence from hydroponic studies (Si-free environments) from our lab revealed that ENDO altered Si concentrations in grass tissue, but plants were not challenged with herbivores. Thus, this project aims to evaluate how interactive effects of Si and ENDO affect herbivores growth, feeding, and immunity (herbivores challenged with nematodes after the feeding trial is performed). We will use this study to address the following questions (Fig. 1). The student will join an international group of nine researchers who are investigating the functional role of silicon in various plant systems (see HIE; SI LAB) .This distinct project will both benefit from and compliment the group's research funded by the Australian Research Council.

Project Aims

The study system will be used to address the following questions (Fig. 1):

(1) Do endophytes (ENDO) increase silicon (Si) uptake in grasses?

(2) If so, how do they do it and does this affect herbivores?

(3) Finally, do these effects make insects more susceptible to pathogenic organisms (nematodes).

Project Methods

Interactions between Si and ENDO will be investigated using a study system comprised of:

- forage grass (Festuca arundinacea),
- commercially available ENDO (Epichloë spp.) and
- two aboveground herbivores with different feeding habits (Chewing: Helicoverpa armigera, and piercing-sucking: Rhopalosiphum padi)
- in silicon-supplemented (Si+) and non-supplemented (Si-) hydrophobic conditions. The student will be involved in the exact design of the project.

After a 6-week growth period in hydroponic solution (Si- or Si+) plants will be checked for endophyte infection using both Enzyme linked immunoassay (ELISA) and histological techniques to determine endophyte infection. After week 10, plants will be assigned to herbivore treatment as follows:

- ¼ destructively sampled (for baseline Si measurements).
- ¼ of the plants will be caged and inoculated with 1 early third instar Helicoverpa armigera (pre-weighed),
- ¼ of the plants will be caged and inoculated with 10 adult Rhopalosiphum padi of the same age pre-weighed), and
- ¼ of the plants will be caged and left un-inoculated.

Before herbivore inoculation plant height, leaf number and herbivore initial mass (H. armigera individuals and R. padi groups) will be recorded.

One week after herbivore inoculation insects will be removed and re-weighed to determine relative growth rates. R. padi individuals will be categorized (nymph/adult/alate) and placed in alcohol vials. H. armigera will be placed in individual Petri dishes and assigned a nematode treatment (inoculated-10 entomopathogenic nematodes, or uninoculated –no nematodes). Immunity response will be assessed after 72 hours by collecting H. armigera haemolymph (insect blood).

All plants will be harvested, freeze-dried, weighed and then analyses by the student for: specific leaf area (mass of this as a proxy for leaf thickness), Si tissue concentration, Carbon: Nitrogen (proxy for plant nutrition).

Opportunity for Skill Development

This project would specifically provide training in the areas of:

- Insect rearing (aphids - Rhopalosiphum padi and caterpillar- Helicoverpa armigera)
- Hydroponic plant cultivation
- Endophyte fungi seed and foliar tissue detection (Enzyme-linked immunosorbent assay-ELISA, and histological detection)
- Chemical analysis of plant tissue including: X-ray fluorescence spectrometry (silicon), CHN analyser (carbon nitrogen), and HPLC (alkaloid analysis).
- Insect immunity responses: Phenoloxidase activity (spectrophotometer) and melanisation response.

All methods and techniques are routinely used by this group which ensures feasibility of this research. This project is based on our previous work in the field but tests an entirely novel hypothesis- since interaction between Si and ENDO have not yet been tested. We therefore anticipate that the project will result on a high quality peer-reviewed publication, which the student would be co-author.

In addition to benefits of the student (i.e. research experience and training, CV opportunities), this project would provide mentoring opportunities for Assoc. Professor Scott Johnson, Ximena Cibils Stewart (2nd year PhD student), and Tarikul Islam, (1st year PhD student).

Students are required to have the following skills/meet the following pre-requisite(s) to apply

The techniques and approaches outlined above are routinely thought to undergraduate student and postgraduate students, and training will be provided on this project. The student doesn't require specialized skills but interest in plant, insect and/or environmental sciences would be desirable.

Project 18: Plants bite back: investigating how plants use physical defences against insect pests

Supervisor(s): Associate Professor Scott N. Johnson (Principal Supervisor)
Rocky Putra MSc (Second Supervisor)

Supervisor(s) contact information: Scott.Johnson@westernsydney.edu.au
R.Putra@westernsydney.edu.au

Project description

In nature, plants are attacked by a myriad of insect herbivores which are determined to eat them. Plants fight back, however, and employ a banquet of defensive tactics, such as the production of toxic compounds and the formation of tough structures (e.g. spines) on their leaves to deter feeding.

Physical defences on leaves, such as silica bodies and calcium crystals are widespread among plant kingdom. Plants obtain silicon and calcium from the soil which they use to make these structures. Given silica bodies and calcium crystals serve the same purpose, why do plants need both? Which is better for herbivore defence or do plants just use whatever is available to them in the soil?

This project will examine the 'trade-off hypothesis of physical defence allocation' between silica bodies and calcium crystals when the soil nutrient is enriched with silicon by using a range of bio-assays with an insect and platforms in analytical chemistry.

The student who is interested in the project will join an enthusiastic and a diverse group of researchers who are investigating the role of silicon in plant biology with different approaches and techniques (see: https://www.scott-johnson.org/people) in collaboration with a chemical ecologist Dr Ben Moore (see: https://www.westernsydney.edu.au/hie/people/researchers/doctor_benjamin_moore). This unique project is part of a bigger project funded by the Australian Research Council.

Project Aims

The project aims to:

- Quantify the concentration of foliar silica bodies and calcium crystals in silicon-supplemented and silicon-unsupplemented plants.
- Determine insect feeding choices, insect biomass, mortality and feeding behaviour on such plants.

Project Methods

The project will use the model legume species Medicago truncatula which will be grown in the soils amended with and without silicon. Plants and silicon treatments will be prepared in advance by both supervisors to ensure the student can accomplish the project punctually.

There will be two sets of experiments to answer both aforementioned aims. Firstly, to determine the concentration of silica bodies and calcium crystals in the leaves, the student will be guided to follow protocols established by our group (Associate Professor Scott N. Johnson) and Dr Ben Moore by using UV-VIS spectrophotometer and X-ray fluorescence spectrometry, respectively. Finally, to assess insect feeding preference and its performance, bio-assays with intact and detached leaves by using the model insect herbivore Helicoverpa armigera will be performed independently from the first set of experiment.

Opportunity for Skill Development

This project would provide research experience in:

- Experimental design consisting of plants and insects.
- Plant analytical chemistry (e.g. X-ray fluorescence spectrometry and UV-VIS spectrophotometer).
- Conducting bio-assays with a leaf-chewing insect.

The methods have been routinely used by our group to ensure that this project is feasible for the student. This project is part of Rocky's ongoing PhD project who has been working on these systems for more than a year but examines a completely new hypothesis-driven research direction. Hence, we will make sure that the project will not end up in a drawer but will be published in a high quality peer-reviewed journal on which the student would be listed as one of the co-authors.

Besides the advantages of the project for the student (e.g. research experience, training and potential publication), this project would provide supervisory experience for a PhD student (Rocky Putra MSc) under the guidance of Associate Professor Scott N. Johnson and Dr Ben Moore.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

The student does not require a specific skill for the project because the training will be provided. However, we do expect an enthusiastic and curious student especially who is interested in plant-insect interactions and chemical ecology and a high willingness to learn new things under our supervisions.

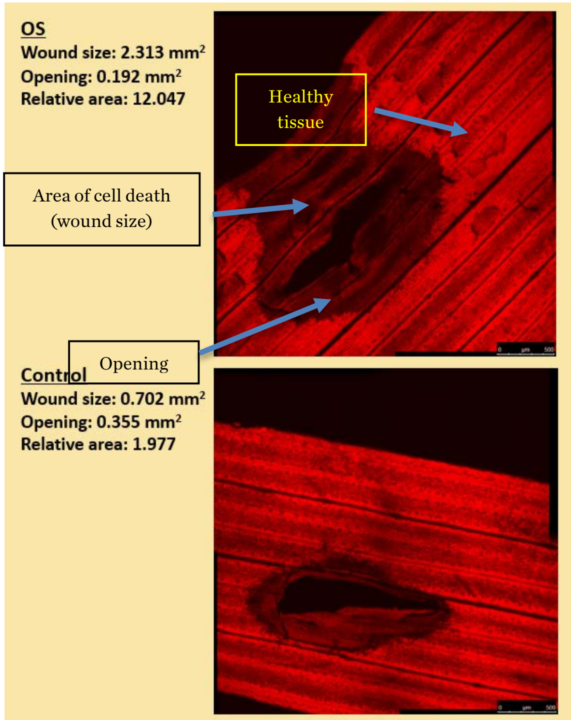
Project 19: Dealing with messy eaters: Do caterpillar oral secretions increase plant susceptibility to future feeders?

Supervisor(s): Assoc. Professor Scott Johnson (Principal Supervisor)
Jamie Waterman (Second Supervisor)

Supervisor(s) contact information: scott.johnson@westernsydney.edu.au
j.waterman@westernsydney.edu.au

Project description

Plants and herbivorous insects are locked in an evolutionary arms race in which plants deploy an arsenal of defences to which herbivores evolve counter-adaptations. How do plants perceive herbivore attack and respond accordingly? During herbivory, plants experience numerous stimuli including chemical signals either produced by the insect or microbes found in the insect's gut and saliva. Considering insect-specific signals (e.g. mechanical damage) and microbial signals (e.g. microbe-derived chemicals) activate divergent signalling pathways, gut microbes may serve as insect symbionts by suppressing defences against herbivores, as it has been hypothesised that insect and microbe defences may operate antagonistically. Many of these microbes are harboured in the insect gut and saliva. It has been well documented that during feeding, caterpillars secrete oral secretions (OS) from their mouths onto the open wounds they create in leaf tissue.

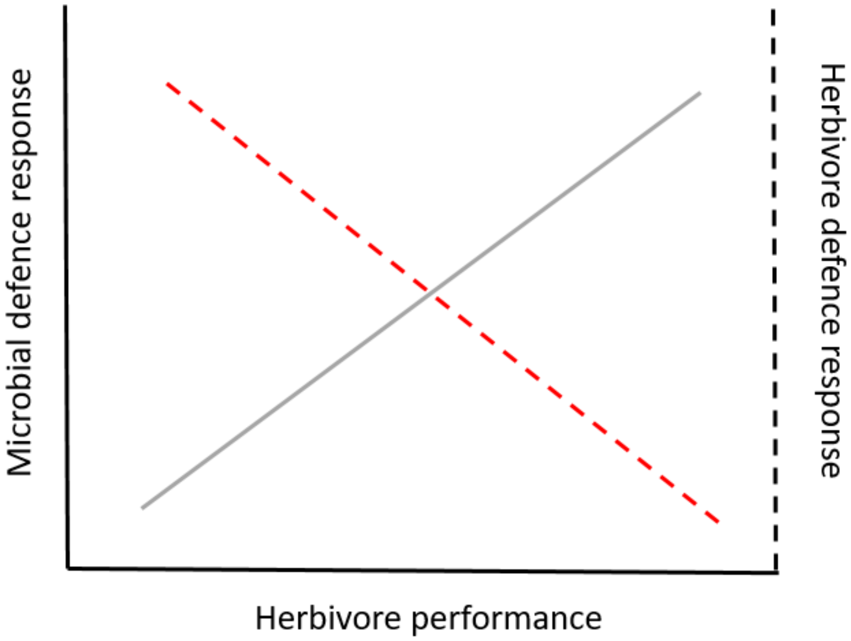


Confocal images of both OS-treated and control wounds

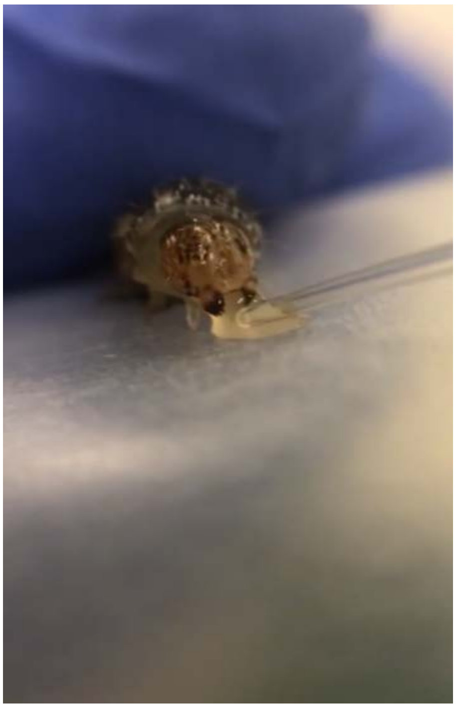
We predict that microbes found in the OS of caterpillars will induce a metabolic response to microbial pathogens, likely suppressing insect-specific defences, thus making the plant more susceptible to herbivore attack. This may be an important evolutionary feat in the arms race between insects and plants, perhaps giving insects an upper hand.

In response to microbial pathogens plants often induce what is called the 'hypersensitive response' (HR). This is a mechanism whereby plants induce the rapid death of cells surrounding the local region of an infection in order to prevent the growth and spread of the infecting pathogen. We have shown that plant wounds treated with caterpillar OS induce an identical response.

This project will test whether the plant responses to OS-derived microbes from the generalist herbivore Helicoverpa armigera is decreasing resistance in the model grass species Brachypodium distachyon. The student will grow the plants and collect insect OS, then measure caterpillar performance as well as metabolic responses in the plant. The student will join an international group of researchers who are investigating plant-insect interactions (https://www.scott-johnson.org/research). This project fits well with and will complement Jamie's thesis work.



Effects of varying defence responses on herbivore performance. The grey line represents the predicted relationship between microbial defences and herbivore performance. The dashed line represents the predicted relationship between herbivore defences and herbivore performance



Collection of OS from *H. armigera*

Project Aims

The goals of this project are to:

- Determine the effects of insect oral secretions on plant resistance to herbivory
- Measure known metabolic responses to both microbes and herbivory
- Determine whether plants previously exposed to oral secretions are more susceptible to subsequent herbivory

Project Methods

The project will use the model grass species Brachypodium distachyon. The student will be involved in the exact design of the project, but our group would germinate and grow the plants prior to project commencement to maximise research activities during the project. Plants would be grown hydroponically to reduce belowground stress.

During the project we will collect OS from Helicoverpa armigera caterpillars and apply them to leaf wounds. Treated tissues will be fed to caterpillars, and caterpillar growth and mortality will be measure to determine the impacts of OS on caterpillar feeding. Metabolites will be measured by Jamie and the student using chromatography techniques (HPLC) coupled with mass spectrometry. Abundance of microbes in OS will be determined by plating oral secretions on LB media at various concentrations.

Opportunity for Skill Development

This project would provide the student with training and experience with:

- Insect rearing and plant cultivation
- Experimental design involving herbivore measurements, analytical chemistry and microbiology

- A better understanding of the complexities of nature and ecological interactions

All of the methods and techniques are routinely used by this group which ensures feasibility of this research. The project is based on work previously conducted by Jamie, but tests a novel hypothesis. It is likely that this project will result in a high quality peer-reviewed publication, on which the student would be a co-author.

In addition to benefits to the student (e.g. hands-on research experience and training and CV opportunities), this project would provide a mentorship opportunity for a PhD candidate (Jamie Waterman) with the assistance and guidance of Assoc. Professor Scott Johnson.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

All training will be provided to the student. The student doesn't require specialised skills but an interest in plants, insects, microbes, and/or analytical chemistry would be desirable.

Project 20: From plant parts to pastures: plant ecology and ecophysiology under climate extremes

Supervisor(s): Professor Belinda Medlyn (Principal Supervisor)
Dr Amy Churchill (Second Supervisor)
Vinod Jacob PhD Candidate (Third Supervisor)

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Project description

Global change factors such as drought, warming and heatwaves have important impacts on ecosystem processes both individually and via their interactions. The extent to which different species are affected by changing climate – particularly climate extremes – is driven by host of plant traits including metrics such as leaf area and how effectively the plant can use water in producing sugars. These fine-scale responses at the leaf level or for individual plants underlie our understanding of whole ecosystem change. Our study, the Pastures in Climate Extremes (PACE) project, uses a factorial experimental manipulation of elevated air temperature and winter + spring extreme drought to examine plant responses to predicted regional changes in climate, and to quantify their ability to recover from the effects of prolonged water stress. The experiment includes ten pasture grass and legume species, all of which are regularly measured for growth and performance over time, in a core experiment maintained by a team of post-docs, PhD students and field technicians.

A winter-spring extreme drought (60% precipitation reduction) was initiated at PACE in June 2018 and 2019, and Dec. 2019 marks the start of the second recovery phase for all plant species. This summer scholarship project, "From plant parts to pastures: plant ecology and ecophysiology under climate extremes," focuses specifically on the high temperature summer months, when residual drought effects may have a particularly negative consequence on plant performance. The student joining our project will examine pasture plant responses following the winter-spring drought, using a variety of measurements such as plant stem density, leaf area, biomass and leaf level physiology. The student will be introduced to the ecological concepts of plant ecology and ecophysiology, and they will have the opportunity to learn data processing and management skills. Furthermore, this project offers enormous opportunity benefits to the student via interactions with a large team of post-docs and PhD students contributing to related questions as a part of the wider PACE project.

Project Aims

The aims of this student project are to:

- Investigate the impact of warming and drought – singularly and in combination – on the productivity of widely cultivated pasture species.
- Investigate the physiological mechanisms underpinning plant responses to temperature and water availability including gas exchange rates, plant water status and leaf morphology

Project Methods

This project involves a substantial portion of field time, where the student will be working at the Pasture and Climate Extremes (PACE) research facility in Richmond. All field work will be supervised in conjunction with the second supervisors. Research conducted at this facility is mostly undertaken outdoors, with exposure to sun and heat for part of the working day. The PACE facility includes six polytunnel rain-out shelters (48 m long and 8 m wide), each with 8 experimental plots. Four of these plots are part of a full factorial warming and drought experiment and the other four plots per shelter comprise a drought experiment focused on a 60% reduction in winter+spring precipitation. Each plot contains four subplots of different pasture plant species or species combinations, for a total of 192 subplots used in experimental manipulations. Warming for the inner plots has remained continuous since April 2018 and our second winter-spring extreme drought was applied to plots beginning in June 2019.

The student will focus their project on summer plant growth and recovery from drought conditions and the traits influencing differences in response among the diverse species grown at PACE. Existing methods for multiple plant responses are based on pasture industry recommendations or are standard within plant ecology, for example measurements of stem density, plant biomass and leaf area. Physiological plant traits will include measuring leaf level gas exchange (carbon, water) and detecting plant water stress. Laboratory work will include measurements of plant water status and examining stomatal morphology following standard methods in ecophysiology.

Opportunity for Skill Development

Skills development from this project will provide the student with a sound understanding of the fundamentals of research – from hypothesis development to exprimental design and data collection – providing a solid framework for future participation in HDR study in the area of plant eco-physiological ecology. The student joining this project will have opportunity to collect data supplemental to the larger project needs and aligned with their own interests (e.g focussing on the consequences of heatwaves). The Scholar will gain an understanding of some of the key physiological factors which modulate the response of plants to climatic conditions. In addition, they will contribute to ongoing projects run by affiliated PhD students and post-docs conducting research on related questions using the PACE framework, learning how to work as part of a wider resarch team. As part of the PACE team, they will be supported in connecting ecological theory to practice, developing research questions, hypotheses and predictions and, if interested, learning about writing both for general audiences and for the wider scientific community.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

A basic understanding of plant physiology would be ideal, but the essential criteria for student participation in the Summer Scholarship Program are sufficient for skill pre-requisites. Bachelor of Science, or Bachelor of Natural Science students are most likely to benefit fully from this project, but students with a particular interest in plants, ecology, and/or climate change research who are enrolled in other programs are welcome to apply. Students should be willing and able to work out of doors for several hours a day in summer temperatures during periods of field data collection.

Project 21: What is the future cooking up for hungry cattle? Pasture nutrition under climate extremes

Supervisor(s): Dr Ben Moore (Principal Supervisor)
Dr Amy Churchill (Second Supervisor)
Karen Catunda PhD Candidate (Third Supervisor)

Supervisor(s) contact information: B.Moore@westernsydney.edu.au
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Project description

Under a future that is both warmer and drier there is continued concern for the sustainability of livestock and dairy production around the globe. Current predictions suggest reductions in both the quantity and nutritional quality of the pasture feedbase that supports the diets of domestic livestock (e.g. cattle and sheep). Importantly, should the nutritional quality of natural pasture forage decline, farmers are forced to augment livestock diet using supplemental feed, a factor that increases input costs in the livestock production systems under climate change scenarios. Our study, the Pastures in Climate Extremes (PACE) project, uses a factorial experimental manipulation of elevated air temperature and winter + spring extreme drought to examine plant responses to predicted regional changes in climate, and specifically to examine shifts in the nutritional quality and digestibility of forage produced under climate extreme conditions. The experiment includes ten pasture grass and legume species, all of which are regularly measured for production and performance over time, in a core experiment maintained by a team of post-docs, PhD students and field technicians.

At the start of the summer 2019-2020 season we will have completed a series of coordinated harvests during a winter-spring extremes drought (60% reduction in precipitation) designed to support cross species comparisons among the diverse pastures included in the field facility. Once these harvests are completed in the field, however, substantial processing occurs in the laboratory to quantify plant nutritional components that are important for predicting livestock production. This summer scholarship project therefore focuses specifically on the consequences of extreme drought and sustained warming during spring for nutritional quality and digestibility of pasture species. The student will be introduced to the ecological concepts of plant ecology and rangeland science, as well as applied metrics associated with livestock production. They will have the opportunity to learn X-ray fluorescence analysis, sequential detergent and acid digestions and laboratory safety and procedures, as well as data processing and management skills. Furthermore, this project offers enormous opportunity benefits to the student via interactions with a large team of post-docs and PhD students contributing to related questions as a part of the wider PACE project.

Project Methods

This project involves minimal field time however, during such collections the student will be working at the Pasture and Climate Extremes (PACE) research facility in Richmond. Research conducted at this facility is mostly undertaken outdoors, with exposure to sun and heat for a portion of the working day. Laboratory processing of samples will occur predominantly in building L9 on the Hawksbury Campus of WSU, and the Scholar will receive appropriate laboratory inductions and training as needed.

The student will focus their project on a subset of samples collected at peak drought conditions from the end of spring 2019 to examine the consequences of drought and any interaction with warming on nutritional quality of pasture forage. Forage nutritional quality can be defined as the extent to which a forage has the potential to produce the desired response in animal performance (e.g. high rates of daily gain, ample milk production, efficient reproduction). Forage quality depends on nutrient composition, which in turn determines digestibility and forage intake (is a measure of the amount of food consumed in a given time, for example per day), which in turn are indicators of potential animal production. In view of this, evaluation of forage nutrient composition is essential to determine whether the quality is adequate and to guide livestock managers/farmers in determining how much forage and ration supplementation is needed to optimize food use efficiency for a particular animal and production goal. Historically, forage nutritional quality was evaluated primarily by assessment with animal trials (e.g., *in vivo* and *in situ* digestibility with fistulated animals), however, this method has logistical constraints associated with expense, labour, time investment and amount of the feed required in the trials. Consequently, this method is not suitable to examine large ranges of forages samples as needed to examine the implications of climate extremes on pastures. More commonly used analyses of forage chemical composition (nutrient and anti-nutrient composition), simulated digestions e.g., in vitro digestibility) and use of near-infrared reflectance spectroscopy have been used successfully to evaluate forage nutritional quality. The Scholar will gain exposure to these methods and contribute to the sequential handling of samples collected during extreme drought conditions.

Opportunity for Skill Development

Skills development from this project will provide the student with a sound understanding of the fundamentals of research – from hypothesis development to experimental design and data collection – providing a solid framework for future participation in HDR study in the area of animal nutrition. The student joining this project will have opportunity to tailor their research skills development to their own interests (e.g. focussing on applied topics such as pasture and grassland management or alternatively more computational work such as data management and statistical analysis, depending on interest). In addition, they will contribute to ongoing projects run by affiliated PhD students and post-docs conducting research on related questions using the PACE framework, learning how to work as part of a wider research team. As part of the PACE team, they will be supported in connecting ecological theory to practice, developing research questions, hypotheses and predictions and, if interested, learning about writing both for general audiences and for the wider scientific community.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

The essential criteria for student participation in the Summer Scholarship Program are sufficient for skill pre-requisites. Bachelor of Science, or Bachelor of Natural Science students are most likely to benefit fully from this project, however students with an expressed interest in animals, plants, ecology, and/or climate change research who are enrolled in other programs are welcome to apply. Students should be willing and able to work out of doors for several hours a day in summer temperatures during periods of field data collection, and to work confidently around chemicals in a laboratory setting following appropriate training implementation.

Project 22: Next Generation Sequencing of Bacterial Genomes from Insect Pests

Supervisor(s): Dr Jennifer Morrow (Principal Supervisor)
Prof Paul Holford (Second Supervisor)

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Project description

Bacteria have a single chromosome comprised of DNA that is organised into units called genes. Most of these genes encode proteins and determine the types of functions that bacteria can perform. Some bacteria live inside the cells of insects (intracellular) and are highly beneficial to the insect due to the types of proteins they can produce, while others can be deleterious. It is important to understand the proteins these intracellular bacteria produce, as they affect the biology of their host and may be used as novel, environmentally-friendly biological control agents for insect pests.

The DNA of whole chromosomes can be sequenced using modern technologies. Therefore, it is possible to determine all the genes they contain and, consequently, all the proteins bacteria are able to make. Previous research has enabled us to produce large datasets of short DNA sequences using a "shotgun" sequencing method (part of what is widely called Next Generation Sequencing [NGS]). In this method, whole chromosomes are broken into small pieces, the small fragments are sequenced and then overlapping fragments are assembled using specialised bioinformatics programs to generate long contiguous sequences. By having complete chromosome assemblies (their genomes), we can then compare the genes found among closely related bacteria. No prior experience of NGS is required.

Psyllids are a diverse group of insects that can damage crop plants and spread plant pathogens. They feed on plant sap and, because of this restrictive diet, they have a strong association with intracellular bacteria that can synthesise food components missing in their diets. The bacterium, Carsonella, which helps the psyllid meet its nutritional requirements, is found in all psyllids, but all psyllids also appear to have other intracellular bacteria that are specific to particular psyllid species or genera that may also provide their hosts with various benefits. For instance, the Asian citrus psyllid, Diaphorina citri, contains two species of intracellular symbiotic bacteria, Carsonella and Profftella; the genomes of both Carsonella and Profftella have been sequenced in D. citri. D. citri is an important pest because it is the principal vector of 'Ca. Liberibacter asiaticus', a plant pathogen that causes citrus greening in parts of Asia, the Americas and Africa. This disease is the most serious threat to citrus production world-wide.

Staff from Western Sydney University have recently participated in a project funded by the Australian Centre for International Agricultural Research (one of Australia's aid agencies) studying this citrus greening and its potential insect vectors in Bhutan. This study has identified five psyllid species feeding on citrus, three of which have been shown to harbour the pathogen. Subsequent work on these psyllids is using NGS to characterise their genomes, determine the spectrum of bacteria found within them and the genomes of the most important intracellular bacteria. This work is focussing on the black psyllid, D. communis, due to its similarity to D. citri. Preliminary work indicates that D. communis also harbours Profftella (so far, only Diaphorina species have been shown to contain this bacterium), but the genome of this bacterium has yet to be completely sequenced. Comparing the complete chromosome sequences of both Carsonella and Profftella from D. citri and D. communis is a useful step in understanding the impact of Profftella on the biology of these psyllids, and may lead to strategies for managing this pest. A recent study has suggested that this bacterium can produce a compound with anticancer properties.

Project Aims

The overall aim is to assemble and compare the genomes (here the single chromosomes of the bacteria) of the intracellular bacteria associated with D. citri and D. communis from Bhutan.

The specific aims are to:

(1) utilise genomic datasets derived from NGS to assemble the complete genomes of the endosymbiont, Profftella, from these two insect hosts; and,

(2) use a variety of open source bioinformatics tools to compare these genomes by identifying the genes they contain and comparing gene content.

Project Methods

Next Generation Sequencing of genomic DNA from an insect provides DNA sequences of the insect host and its microbiota (microbes associated with the host). Two genomic datasets have already been generated from DNA extracted from D. citri and D. communis individuals collected in Bhutan. The genomes of the symbiont, Carsonella, from both host species have already been assembled. The next phase is to assemble the genomes of Profftella from these datasets and compare their complements of genes using standard NGS technologies.

1. Assembly of Profftella genomes. Assembling any organism's genome, including small bacterial genomes, can be difficult and labour intensive; however, it is a task made more manageable when reference genomes are available that are expected to be similar. Profftella genomes, derived from D. citri populations from Japan and China, have been completely sequenced and are publicly available, making the assembly of Profftella from Bhutanese populations of D. citri and the closely related D. communis an achievable task.

The work will use 'CLC genomics workbench'. This is a computer system with a graphical interface that performs bioinformatics processes including assembly of short sequences into longer contiguous sequences (contigs). The BLAST algorithm is used to identify contigs of interest, following which they are mapped to target contigs in CLC then a manual examination of the mapping quality is performed to verify the complete genome sequence.

2. Comparative genomics. Annotating genomes (that is, finding the genes and naming them based on similarity to other known genes) and comparing genomes to determine gene content is then performed using bioinformatics tools, many of which use the linux command line to implement programs. The genomes of other intracellular bacteria have been assembled and compared in this way by the research group at HIE, and a robust pipeline for all methodologies has been produced that will be the guide for this project.

Opportunity for Skill Development

This project will use NGS, a technology revolutionising medicine and biology. Although NGS data can now be acquired with ease, its downstream analysis is problematic, as data sets are growing in size, producing a 'data deluge' that requires analysis by specialised personnel. The student will receive hands-on training and the project provides an opportunity to gain experience and knowledge of NGS technologies. These are highly sought after and transferrable skills and can be applied to applications of NGS in other areas of biology or medicine. In addition, the project will enhance the student's competencies in molecular biology and bioinformatics through gaining further knowledge of genes and their functions.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

The project will consist entirely of computer-based analysis of biological data; therefore, attention to detail, a knack for problem-solving, and the ability and desire to spend time on detailed analysis is a must. No direct familiarity with linux command line or any computer language is a prerequisite, but basic computer skills with Microsoft Word and Excel, and the aptitude to understand and the desire to learn the basics of command line is necessary. A student's experience may come from genetics and molecular biology, or from computer / data science.

Project 23: Measuring post-fire biomass changes in dry sclerophyll forests of the Sydney Basin

Supervisor(s): Dr Rachael Nolan (Principal Supervisor)
A/Prof Matthias Boer (Second Supervisor)

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Project description

Bushfires consume biomass, resulting in smoke pollution and carbon emissions. While fire is a natural process in the dry sclerophyll forests of the Sydney Basin, fire frequency is expected to increase under climate change due to hotter and drier conditions. It is thus important to quantify how much biomass is consumed by fire, in order to predict changes in the amount of carbon stored by these forests, and also to assess the risk of smoke plumes over the Sydney Basin.

During fire, not all biomass is consumed. For example, the amount of biomass consumed during fire may be as little as 5% for trees. However, most models often assume biomass consumption rates are much higher, leading to over-estimation of carbon emissions. For temperate Australian forests there is currently little information quantifying the amount of biomass consumed following bushfires. This Summer Scholarship project aims to quantify biomass consumption of shrubs following bushfires in the dry sclerohpyll forests of the Sydney Basin. This will be done by firstly quantifying the amount of biomass that constitutes "fuel" for common shrub species, with fuel simply being the portion of shrub biomass that burns (e.g. leaves and twigs will burn, but the larger stems will not). Additionally, fieldwork will be undertaken to quantify differences in shrub biomass between unburnt and recently burnt forest.

This Summer Scholarship project is expected to result in a peer-reviewed publication. Additionally, this project will contribute to a larger research project which is quantifying changes in total biomass (including leaf litter, coarse woody debris, tree biomass) following both bushfires and prescribed fires (i.e. management burns). This research will lead to improved models of carbon emissions, smoke plumes and changes in fuel loads (and thus fire risk) across NSW forests.

Project Aims

This Summer Scholarship project aims to:

1. Develop allometric relationships between stem diameter and the dry weight of fuel (i.e. leaves and twigs <6 mm diameter) for common shrub species in the dry sclerphyll forests of the Sydney Basin.
2. Apply these allometric relationships to quantify shrubby fuel loads in unburnt forests.
3. Measure remaining biomass of shrubby fuels following bushfire.

This research will then contribute to two larger research projects which aim to:

1. Quantify the effect of fire severity on total forest fuel loads.
2. Model smoke emissions from bushfires and prescribed fires in the Sydney Basin.

Project Methods

For the first aim, the student and the principal supervisor will collect ~10-15 shrubs from ~5 common species from dry sclerophyll forests around Sydney. These shrubs will be transported back to Hawkesbury where the student will cut the shrubs up, separating out leaves and twigs <6 mm in diameter. The student will then dry the plant material in an oven, and weigh the dry biomass. The student will then analyse the data, developing regressions between stem diameter and the dry biomass of leaves and twigs for each species.

For aims 2-3, the student will join a larger research team (comprising the principal supervisor and two additional researchers from a partner institution), to measure shrub biomass in unburnt and recently burnt forest sites. It is anticipated that the burnt measurements will be undertaken in forest burnt by bushfire in the preceding 2-3 months, however, if no suitable sites are available we will measure biomass in sites burnt by prescribed burns (with numerous prescribed burns scheduled over spring across the greater Sydney area). The specific field based measurements the student will undertake will be measurements of the diameter of shrubs. During fieldwork the student will also have the opportunity to participate in other types of fuel load measurements (e.g. assessments of fuel hazard, measurements of litter loads, leaf area index). The student will then calculate shrubby fuel loads in burnt and unburnt forest using the regression relationships they developed in aim 1. The student will then calculate the amount of biomass consumed by fire.

Opportunity for Skill Development

The student will specifically develop skills in the following areas:

- Fieldwork planning and logistics;
- Standard forest inventory approaches, in particular biomass inventory;
- Fuel hazard assessments;
- Data analysis and visualization – the student will have the opportunity to learn how to undertake analyses in R.

We anticipate that the project will result in a high quality peer-reviewed publication, on which the student would be a co-author.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

This project will involve field work, so the student should be willing to undertake research in burnt and unburnt forests. Note, the student will be accompanied at all times in the field by the principal supervisor, who will ensure all safety requirements are met. Specific methods and analyses will be taught to the student during the project. While no specific skills are required, an interest in ecology / environmental science is desirable.

Project 24: Addressing the drivers of dieback in an endangered Australian shrub: A landscape plant-soil survey, and plant-soil feedback experiment.

Supervisor(s): Jeff Powell (Principal Supervisor)
Samantha Andres (Second Supervisor)

Supervisor(s) contact information: Jeff.Powell@westernsydney.edu.au
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Project description

Persoonia hirsuta is a critically endangered shrub species endemic to the Sydney Basin region. Dieback has been observed in this species by an unknown cause. *P.hirsuta* is experiencing population decline across its range due to threats of urban development, and low seedling recruitment. To date, there is limited information on the seed biology, soil biology, and habitat requirements for this species. This research will fill in the biological knowledge gaps, described above, for *P.hirsuta* using a combination of field and laboratory techniques in order to characterize and quantify the variation in the communities of microbes as well as the physical and chemical soil environment for *Persoonia hirsuta* across its distribution in the landscape. The resulting deeper understanding will inform practical conservation approaches, by identifying factors to consider when implementing conservation, and management actions for this species.

The summer scholarship holder will contribute to this project by assisting in a landscape-level survey of soil biotic and abiotic factors related to *P. hirsuta* population health. This will form the basis for a publication describing environmental factors associated with *P. hirsuta* density and health status, as well as provide valuable information for a developing a technical document for land managers and government organizations called a species status assessment. The selected student will have the opportunity to play an active role in a research-oriented applied conservation project, develop new skills, and contribute to the conservation and management of an endangered species. This project is co-funded by the Australian Botanic Gardens in Mt. Annan through the *Persoonia* conservation program. Researchers Nathan Emery and Cathy Offord have been investigating the seed biology and practical management of *Persoonia* species for some time now, and are also actively involved in this project.

Project Aims

- Develop a deeper understanding of the ecology of *Persoonia hirsuta in situ*.
- Address potential agents of dieback in the landscape.

Project Methods

The scholarship recipient will have the opportunity to gain a number of skills associated with research in the ecological, botanical and soil sciences, in the field and the lab, as well as in data analysis. Sampling is designed to collect soil samples associated with *P. hirsuta* and other co-occurring *Persoonia* species from sites distributed across the Sydney region. These soil samples will be analysed using nutrient analyses and molecular techniques to produce an understanding of the difference in the abiotic and biotic variation associated with *P.*

hirsuta's specific localized soil community and that of the local community without direct influence of *P. hirsuta*, as well as co-occurring *Persoonia* in the landscape. The student will work along the supervisors to gain experience with a variety of techniques.

Additional measures to be collected at each sample population will involve vegetation sampling, level of disturbance in the associated community, number of plants in the sample population, and focal plant health to address differences across healthy *P. hirsuta* plants in the landscape, and plants experiencing dieback. The student will have the opportunity to learn about these approaches but this will not be an explicit component of the research during the scholarship.

Opportunity for Skill Development

Participation in this project should help a student familiarise themselves with new techniques and gain experience in conservation biology, plant ecology, soil biology, and molecular biology. Participation in this research might be helpful for a student considering avenues of research or conservation later on following their degree. They will have the opportunity to work with University researchers at different career stages as well as network with colleagues from the Royal Botanic Gardens & Domain Trust, very valuable experience for individuals considering their next steps following their undergraduate degree.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

Preference will be given to students with some background in soil biology, plant ecology or molecular biology. The candidate should also be physically capable of performing the associated work components of the project if need be (i.e. capable of walking on uneven terrain, standing or squatting for long periods of time, lifting small objects, etc.).

Project 25: Climate change and community ecology: Understanding the effects of drought on plant-pollinator interactions in a local grassland

Supervisor(s): Dr Sally Power (Principal Supervisor)
Dr Amy Churchill (Second Supervisor)
Dr Amy-Marie Gilpin (Third Supervisor)

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Project description

Native pollinators provide huge economic benefits to Australian agriculture, and ongoing work conducted at HIE is examining the importance of non-crop floral resources in sustaining pollinator populations outside of the relatively short flowering periods of the major crop plants. Unfortunately, native pollinators face a variety of threats that are contributing to declines in their abundance across the globe, ultimately reducing their ability to provide these important pollination services within agricultural and horticultural systems. Climate change is a major factor affecting pollinators at local, regional and global scales, via a number of direct and indirect routes. Direct effects of drought or increased temperatures (especially heatwaves) can influence the activity and resource requirements of pollinators, via impacts on their metabolism. Indirect effects such as shifts in the timing of flower production relative to the life cycle of pollinators, and changes in both the availability and quality of floral resources can also drive shifts in plant-pollinator interactions. In addition, the availability and quality of pollen and nectar resources can be affected by shifts in the plant community that arise as a result of changes in plant-plant interactions under climate stress.

Our experiment is a new project lead by the Community Interactions subgroup of the DRI-Grass facility, a long-term grassland drought manipulation experiment at Hawkesbury Campus. This effort covers three scales of community interactions to determine the consequences of drought treatments on pollinator abundance and activity. These include 1) plant-plant interactions (competition and facilitation) that underlie changes in composition and availability of different floral resources, 2) plant-pollinator interactions associated with floral visitation and collection of nectar and pollen, and 3) pollinator interactions to assess impacts on the community of pollinators using plant resources.

Experimental treatments include a 50% reduction in precipitation, a reduction in the frequency of rainfall events (rainfall applied only once every 3 weeks) and a control (ambient rainfall). Flowering plant communities were seeded into plots, following an experimental burn, during July 2019. This summer scholarship project will take advantage of rapid plant growth and high pollinator activity during the spring/summer period, as plant communities respond to the imposed drought treatments. The student joining our project will have the opportunity to learn multiple types of surveys and sample collection, with opportunities for developing specialised skills in plant or insect sides of the project, depending on the student's specific interests. The successful student will gain experience of population, community, and ecosystem ecology and have the opportunity to develop skills in data processing, management and analysis.

Project Aims

The aims of this student project are to:

- Quantify the effect of different precipitation regimes on floral abundance and pollinator resources
- Assess the importance of weedy species in supporting pollinators under altered precipitation regimes including drought
- Examine plant trade-offs in abundance and floral production associated with altered precipitation regimes

Project Methods

This project involves a substantial proportion of field time, where the student will be working at the DRI-Grass research facility at the Hawkesbury campus of WSU. After on-site training the student may conduct surveys alone, but typically field work will be supervised by either Dr Gilpin or Dr Churchill. Research conducted at this facility is mostly undertaken outdoors, with exposure to sun and heat for part of the working day. The DRI-Grass facility includes 48 rainout shelters that allow manipulation of rainfall patterns using automated sprinkler/precipitation systems based upon ambient rain inputs on site. Each rainout shelter comprises a single 2m by 2m plot, and 24 of these plots were modified as part of the Community Interactions Subgroup manipulation during winter 2019 to simulate a severe drought and plant community dieback, followed by high intensity fire. Weedy flowering species common in early succession and abundant on local farms and orchards were then seeded onto burned plots in July 2019. The Community Interactions subgroup will be monitoring germination and establishment among the introduced individuals during spring, and we expect peak treatment effects during the summer months. Scholar activities would include contributing to pollinator community surveys and collections as well as pollinator behaviour surveys. From the plant side of the community the Scholar would learn floral surveys for determining pollinator resource availability and abundance, make collections of floral resources such as pollen and nectar, and contribute to analyses of plant community composition data.

Opportunity for Skill Development

Skill development from this project will provide the student with a sound understanding of the fundamentals of research – from hypothesis development to experimental design and data collection – providing a solid framework for future participation in HDR study in the area of climate change ecology, plant ecology and pollination ecology. The student joining this project will have opportunity to tailor their research skills development to their own interests (e.g. focusing on pollinator behaviour, shifts in floral resources, or plant community and ecosystem responses to drought conditions, depending on interest). In addition, the student will have the opportunity to contribute to ongoing affiliated work through the Pastures and Climate Extremes facility, addressing floral resources associated with heating and warming treatments for pasture species. Finally, as a member of the newly formed Community Interactions subgroup of DRI-Grass the student will be supported in connecting ecological theory to practice, developing research questions, hypotheses and predictions and, if interested, learning about writing both for general audiences and for the wider scientific community.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

The essential criteria for student participation in the Summer Scholarship Program are sufficient for skill pre-requisites. Bachelor of Science, or Bachelor of Natural Science students are most likely to benefit fully from this project, however students with an expressed interest in insects, plants, ecology, and/or climate change research who are enrolled in other programs are welcome to apply. Students should be willing and able to work out of doors for several hours a day in summer temperatures during periods of field data collection.

Project 26: Interactions of Queensland fruit fly with maternally inherited *Wolbachia* bacteria and viruses

Supervisor(s): Assoc. Prof Markus Riegler (Principal Supervisor)
Sharon Towett (Second Supervisor)
Dr Jennifer Morrow (Third Supervisor)

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Project description

True fruit flies (Tephritidae) are destructive pests of horticulture throughout the world. Queensland fruit fly (*Bactrocera tryoni*) is Australia's most significant horticultural pest, due to its wide geographic distribution and wide host fruit range. Fruit spoilage occurs because these flies lay their eggs into ripe or ripening fruit. Following egg hatch the larvae feed on the fruit throughout larval development before pupating in the soil. Beyond this, fruit fly infestations also lead to severe interstate and international market access restrictions for any produce from infested regions.

Fruit fly has primarily been controlled with insecticides however many of these have been banned because of health and environmental concerns. Sterile insect technique (SIT) has been developed as a safer alternative. SIT involves mass-release of flies that have been sterilised by irradiation. Matings between mass-released sterilised flies and wild flies in the field do not produce offspring, resulting in suppression of fly numbers. However, irradiation of flies decreases their performance (in particular mating performance) when compared with the targeted field flies. There is a potential solution to this: many insects have a maternally inherited bacterium, *Wolbachia,* which can cause cytoplasmic incompatibility (CI). *Wolbachia* occurrs naturally in 50% of all insects species. CI is a crossing sterility that occurs when *Wolbachia*-infected males mate with uninfected females. Incompatible insect technique (IIT) involving Wolbachia has been successfully co-developed and tested for tephritid control by Markus Riegler, and is currently successfully used for mosquito control in Australia and overseas. Based on our previous research, we know that B. tryoni do not naturally contain Wolbachia that can induce CI. Therefore, this important pest is amenable to an IIT control approach.

In order to test the potential of IIT for *B. tryoni*, we have invested substantial efforts in optimising experimental procedures, and we were successful in infecting Queensland fruit fly with *Wolbachia*. However, against expectations, it appears that these new interactions are not stably inherited to the next generations despite success with this in other insect species. Our research has recently revealed a potential key limitation. It is known from other insects that *Wolbachia* can suppress RNA viruses. We have found several RNA viruses in all our laboratory Queensland fruit fly populations and many field populations. We have also found tools to reduce viral titres in these lines. We now hypothesise that these viruses reduce our chances of success in establishing a *Wolbachia*-infected fruit fly line, and would like to test this. We expect that removal of viruses will lead to success. Providing support for our hypothesis that viruses are a barrier for the transmission of new *Wolbachia* infections would be a major research break-through (as it is currently not understood what limits Wolbachia infections), on top of the anticipated positive outcome of establishing *Wolbachia* IIT in Queensland fruit fly as a new population control for this problematic pest species.

Project Aims

The overarching aim of this project is to establish a B. tryoni laboratory line that harbours *Wolbachia*, and to determine its utility for pest control by testing the stability of *Wolbachia* transmission from mother to offspring (transmission efficiency), the strength of cytoplasmic incompatibility (CI), and any other fitness impacts of *Wolbachia* in the fruit fly. However, this requires several experiments to optimise protocols and experimental target insect populations

The specific aims are to:

- Rearing of virus-free *B. tryoni* to develop new recipient line for *Wolbachia*.
- Use microinjection as technique to transfer *Wolbachia* cells from infected *Drosophila* fruit fly eggs (donor) into fertilised *B. tryoni* eggs (recipient).
- Optimise microinjection techniques and experimental recipient populations.
- Rear the microinjected eggs to adulthood, obtain offspring from females and keep as isofemale line.
- Screen the microinjected mother flies and their offspring to confirm *Wolbachia* is present and inherited to the offspring by using established protocols based on molecular biological techniques such as PCR.
- Select positive flies to establish infected isofemale lines.
- Test the positive isofemale lines for various parameters including induction of CI by *Wolbachia*, transmission efficiency, titre (number of bacteria) in individuals at various life stages.

Project Methods

1. Virus free *B. tryoni*: protocols established for removal of RNA viruses from *Drosophila* populations will be applied to obtain a virus-free *B. tryoni* line.
2. *Wolbachia* microinjection: this involves the transfer of *Wolbachia* bacteria contained within the egg from a donor species to eggs of a recipient species. Eggs from *Wolbachia*-carrying *Drosophila* flies will be collected, processed, and placed on a microscope slide on double-sided sticky tape; at the same time recipient *B. tryoni* eggs will be collected from gravid females and 30-40 eggs aligned in the same orientation on double-sided sticky tape on a slide. Under a microscope, using the microinjection apparatus, a very fine needle is used to extract egg contents from at least three donor eggs, and a small amount is injected into the posterior end of each recipient eggs. A large number of eggs need to be injected because only a small proportion (less than 10%) will develop to adults.
3. Selection of *Wolbachia* infected *B. tryoni* lines: larvae that hatch from microinjected eggs will be transferred to small cups with larval diet, and after development to adulthood set up in cages for mating. Eggs will then be collected from individual females.
4. Molecular diagnostics of *Wolbachia*: After sufficient numbers of offspring have been produced by individual females, DNA extracts from these females are tested for *Wolbachia* by using PCR. The PCR outcome is visualised using gel electrophoresis. If successful, a small number of their offspring are also tested for *Wolbachia* transmission to the next generation.

The next steps will only be pursued if a Wolbachia positive line has been established.

5. Transmission efficiency tests will be performed on positive lines by obtaining offspring from individual females in replicated cages. Offspring will be screened to

determine the percentage of offspring that carry *Wolbachia*.

6. *Wolbachia* titre (abundance of *Wolbachia* in host cells) will be measured across different life stages (egg, larva, pupa, adult male and female) and in different tissue types (such as reproductive organs) by utilising quantitative PCR. This compares relative abundance of *Wolbachia* DNA to host insect DNA using an established protocol.
7. Initial cytoplasmic incompatibility (CI) test: CI is embryonic mortality that occurs in crosses between infected males and uninfected females. In order to assess the level of CI, replicated crosses will be set up, using (a) males that harbour *Wolbachia* (from the established *Wolbachia* line) with females from the original recipient line (do not harbour *Wolbachia*), (b) the reciprocal cross (uninfected male x infected female) and (c) the two control crosses (infected male x infected female and uninfected male x uninfected female). Eggs will be collected from these females, and egg ratch rate calculated in order to assess the strength of CI.

Opportunity for Skill Development

The student will be part of a team that aims to establish a *Wolbachia* infected laboratory line of Queensland fruit fly. As part of this project the student will develop skills in fruit fly husbandry, standard molecular biology techniques such as DNA extraction, PCR, and gel electrophoresis, as well as quantitative PCR. The student will also be exposed to the extensive knowledge and expertise in our insect microbial symbioses research team (e.g. we have weekly lab meetings and journal clubs). The student will gain hands-on experience in working with living organisms, in terms of both maintenance and experimental manipulation of fruit fly. Microinjection is a specialised technique and the student will have the opportunity to contribute to every aspect of the process, including fly rearing/selection, egg collection from flies, preparing and manipulating the eggs for injection, microinjection, counting and collecting the surviving larvae and maintaining the flies through to production of the next generation, molecular diagnostics, data collection and simple statistical analysis. Previous volunteering and summer scholarship students have become co-authors on journal manuscripts, research assistants in our or other teams, and entered Honours or Master of Research programs.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

The project is laboratory-based. For the project, the student will be required to handle fruit flies which requires no fear with dealing with insects that are not harmful (other than the economic damage they cause to farmers). It will also require attention to detail with fruit fly maintenance and experimentation (e.g. loss of individual flies and/or fly lines would mean loss of experimental results). Molecular techniques also require focus and attention to detail. Prior knowledge of DNA and the principals of PCR is highly beneficial. A basic understanding of statistics is also helpful.

Project 27: Insect pollen transport: an assessment of pollen vectors in orchard crops

Supervisor(s): Dr Simon Tierney (Principal Supervisor)
Olivia Bernauer (Second Supervisor)

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Project description

A central component of the broader WSU & HIA funded project (*Healthy Bee Populations for Sustainable Pollination in Horticulture*) is the *Crop Pollination* work package. Understanding which insects are visiting crop flowers is the keystone objective, because all other work packages depend upon this information. In addition to understanding which insects are pollinating crop flowers, we strive to understand the quality of different pollinator species. Understanding pollinator quality will help us to better understand the pollinator community as a whole present in crop orchards and can lead to improved on-farm management and bushland conservation strategies to maximize crop pollination. High quality pollinators are those that carry a large quantity of crop pollen on their bodies. When pollinators carrying large amounts of crop pollen visit crop flowers they are likely to transfer crop pollen to the stigmas leading to successful pollination and fruit set. When pollinators are collected from crop flowers, the pollen grains found on their bodies can be quantified, removed, and identified, helping us to better understand their quality as a crop pollinator.

Project Aims

- To quantify and identify the loose pollen grains present on the bodies of insect visitors to crop flowers.
- To statistically analyse and graphically summarize results from the 2019 field season using R statistical software. These results will be compared to the results from the 2018 field season to identify possible year to year variation.
- To identify the pollinator specimens collected during 2019 field season. Specimens will be identified to Order, Family, or if time, to Genus or species-level identification.
- To create and curate a reference specimen collection from the insects collected during the 2019 field season.

Project Methods

In the laboratory:

- Remove loose pollen grains from individual insects using a microscope, forceps, and sticky tape.
- Use light microscopy to identify pollen grains as crop or non-crop.
- Create and curate an insect collection. Student will pin insects, generate and affix labels, organize an insect collection, and use dichotomous keys and a microscope to identify pinned insect specimens.

Database management:

- Maintain a spreadsheet of all data collected.
- Work with existing databases for data analysis.

Manuscript preparation:

- Learn how to use R statistical software to run basic statistical tests and create graphs and figures appropriate for presentations and manuscripts.

- Learn how data analyses translate into written results for publication in a peer-reviewed scientific journal.

Opportunity for Skill Development

The Summer Scholarship student will have the opportunity to hone their microscopy skills, learn entomological techniques, and gain experience in data analysis and scientific writing. The student will use both compound and dissecting scopes and will learn basic laboratory techniques that are transferrable to different subjects. During this experience the student will learn important entomological skills including the creation and curation process involved in building an insect collection. Furthermore, students will learn to identify the insects in this collection with the aid of dichotomous keys and a reference insect collection. Identification skills are incredibly valuable in many ecological fields and are especially valuable in entomology as many insects cannot be identified without the aid of a microscope. The student will learn the basics of the statistical software, R, a common and useful statistical program utilized by scientists of all fields. R will be used to run statistical tests and to generate figures that can be used in presentation and manuscripts. Once the student has analysed their data, they will gain experience with scientific writing by preparing a report in the standard format of a scientific manuscript. This experience will allow the student to gain new laboratory and entomology skills as well as refining their statistical and writing abilities.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

Student needs to be enthusiastic about insects and labwork, have good attention to detail and a pleasant demeanour.

Project 28: Co-evolution of eggshell traits in a polyandrous species, the emu

Supervisor(s): Ricky Spencer (Principal Supervisor)
Julia Ryeland (Second Supervisor)

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Project description

Selection for optimal propagule size and early-life phenotype are likely under strong selection pressure to maximize the probability of offspring survivorship during early life-history stages. The characteristics of the avian egg mediate hatching success and parent reproductive success. As such, egg traits should be under strong selection pressure for an optimal range for traits, such as eggshell colour, thickness and permeability, as well as internal composition characteristics. This is particularly the case for species with male parental care, where females do not have to balance investment in propagules with investment in parental care. Few studies have looked at the selection on egg characteristics in a system with male only parental care and few have measured a wide multitude of egg characteristics to understand how these characteristics may co-evolve. The Australian emu is a relatively understudied species with an uncommon mating system. Male incubate the eggs and care for the young, and as such the female is able to maximize the resources she invests in laying. As they are often farmed, they provide an ideal species to study the co-evolution of eggshell characteristics under male parental care. Here we aim to measure a number of traits of emu eggs that have been incubated in natural setting, within a male parental care system. This project will quantify eggshell structural and chemical composition to better understand how specific traits are correlated and as such may co-evolve to produce an optimal avian egg phenotype. This data will be included in a larger project testing the strength of selection on specific eggshell characteristics in a male parental care system.

Project Aims

We aim to quantify emu eggshell structural and chemical characteristics to better understand how specific traits are correlated and as such may co-evolve to produce an optimal avian egg phenotype. The project will measure a number of specific traits of eggs that have been naturally incubated and are under natural selection, and test whether these traits are correlated. The emu is an ideal system as females do not have to trade-off investment in certain egg characteristics with the investment of parental care. This will give preliminary evidence that specific characteristics of the avian egg co-evolve and may be selected for. The project will quantify eggshell thickness, strength and conductivity which singularly have been found in many papers to be correlated to hatching success. Recordings have already been taken of the colour of all eggs, but additionally we aim to understand how light permeability correlates with colour. Finally, we aim to understand how chemical composition correlates with these other traits and whether there is a trade-off in resources between how resources are allocated within the eggshell.

Project Methods

To quantify eggshell characteristics, we will use shells collected from ca. 600 naturally incubated eggs, for which each have a known fate (hatched or failed to hatch). These eggs have been collected from within a farmed context, but unlike many former studies, have not been artificially selected for. Each egg will be measured for the following characteristic;

1. Shell thickness and strength
2. Shell water conductance
3. Light permeability
4. Chemical composition (Calcium, nitrogen, crude protein, and bileverdin concentration)

These characteristics will be measured across 6 regions of the egg, to provide a mean per individual.

From these traits, recorded in a central database, we will run correlative analysis on these traits, to determine which traits likely co-evolve. This will then be included in further analysis within a larger project using a more complex selection analysis for publication.

Opportunity for Skill Development

The diversity of lab work and the range of equipment that will be used in this project will provide a student with important technical skills, that will be applicable not only to future ecological research but will also be applicable to many industry position. The data that will be collected will require some research and creation of detailed protocol (with help from the supervisory team), which will help students to gain skills in project creation and management. They will be providing support for a current HDR study, for which they will gain exposure to the PhD program. The data will be analysed using basic statistical tests, which will build skills in correlative matrix plotting.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

The student must have basic laboratory skills and safety awareness in the lab.

Project 29: Thermal tolerance and adaptive capacity of Acacia under climate change

Supervisor(s): Paul Rymer (Principal Supervisor)
Katie Rolls (Second Supervisor)

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Project description

Climate change poses a significant threat to biodiversity with the continued pressure of global warming combined with extremes (such as heat waves) pushing species beyond their physiological tolerance to extinction. Species may have the adaptive capacity to be able to persist to climatic changes through genetic adaptation and phenotypic plasticity. While species restricted narrow ranges are assumed to have limited adaptive capacity and be at greater risk of extinction, the current distribution of some species may not reflect their physiological tolerance to temperature. Determining species ability to adapt to changing conditions is crucial to identifying vulnerable species that may require additional active management strategies.

The Acacia genus consists of many diverse and ecologically important species that inhabit a range of different biomes throughout Australia, including species widespread from Tasmania to far-north Queensland and other restricted species, some of which are listed as national threatened. This study focuses on Acacia species with contrasting distributions along a temperature gradient spanning the east coast of Australia for glasshouse experiments to investigate the thermal tolerance and adaptive capacity of species from contrasting biomes and range sizes.

The summer project will cover the period of physiological assessment and plant harvest of a large glasshouse experiment led by Katie Rolls as part of her PhD. Growth measurements will be taken including measures of height, volume, leaf area and fresh/dry weight to explore biomass allocation for populations from different climates of origin grown under different temperature regimes.

This project makes up a component of a larger PhD project that will use the results to determine species phenotypic plasticity and ability to respond to climate change. In addition, other chapters of the PhD will explore species fundamental thermal niche in another glasshouse temperature experiment, along with a reciprocal transplant field experiment to explore range limitations and species distribution modelling to explore species distributions under current and future conditions to identify species vulnerable to range shifts, losses and local extinctions. These projects contribute to informing best practices for natural resource management.

Project Aims

Gain an understanding of the thermal tolerance and adaptive capacity to climate change of widespread and rare Acacia species to inform conservation management.

Compare growth within and between populations of restricted and widespread Acacia species from cool and warm origins grown under different growth temperatures determine if species exhibit phenotypic plasticity.

Determine how species range size and climate of origin relates to growth response under the different temperatures.

Project Methods

The student will assist with the harvest of 16 populations of Acacia species grown under two temperature regimes in a glasshouse alongside PhD students involved in the project. Plants include two populations of 8 species from contrasting climates of origin and restricted and widespread thermal ranges.

Contributing to the harvest will allow the student to gain an understanding of a variety of important measuring techniques that will be transferrable to many kinds of research projects involving plant growth that they may peruse through further studies. In addition to basic growth measurements (height, perpendicular widths, base diameter), they will be able to obtain measures of canopy and stem volume and leaf area through the use of a leaf area meter for species with various leaf forms. They will also obtain fresh and dry mass for stems, leaves and roots and compare measures within and among populations to explore how these traits may vary and how such variation relates to environmental conditions.

The results will be analysed in relation to species climate of origin and range size to determine if species exhibit phenotypic plasticity and are potentially able to adjust to changing climatic conditions. They will also be able to identify species that may be more vulnerable to warming and how that may relate to their climate of origin.

Opportunity for Skill Development

The student will gain a number of transferrable skills in relation to measuring plant growth traits and carbon allocation. This includes height, width, base measures, leaf area, and stem/leaf/root fresh and dry biomass. They will see how glasshouse facilities are used to perform temperature manipulation experiments and what is involved in keeping measurements and treatments standardised to avoid bias such as randomised design and control of nutrients.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

Understanding of basic plant biology, good organisation and analytical skills, accuracy in taking and recording measurements. The student needs to be enthusiastic with the ability to work in a team and communicate clearly.