# FABI

# BIENNIAL REPORT

MAY 2019 – MAY 2021

**The Forestry and Agricultural Biotechnology Institute** (FABI) is based at the University of Pretoria. The primary objectives of the Institute are to:

- Promote the broad field of plant biotechnology through an interdisciplinary approach and with close linkage to a wide range of academic departments.
- Undertake research of the highest possible calibre, while at the same time providing short and longer term benefits to the forestry and agricultural sectors of South Africa.
- Establish partnerships with industries linked to agriculture and forestry, both nationally and internationally.
- To produce new and improved products and thus to promote competitiveness in business.
- Promote education, particularly of South Africans, in the fields of forestry and agriculture.

The association of FABI with the University of Pretoria, the largest residential University in South Africa, provides access to a wide range of human and technological resources. Currently, academic staff and postgraduate students from research programmes in the Departments of Biochemistry Genetics and Microbiology (BGM), Chemistry, Plant and Soil Science, Physics, and Zoology and Entomology are associated with FABI. This affords FABI the opportunity to build future resources in biotechnology which will be crucial to the future of forestry and agriculture in South Africa.

FABI, in every way, represents an amalgamation of a tremendous base of expertise in forestry and agriculture from different universities and research organisations in South Africa and other countries through our collaborations. The Institute has been operational since 1998. This document represents the eleventh FABI Biennial Report covering the period from May 2019 to May 2021.

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FABI
Forestry and Agricultural Biotechnology Institute

# BIENNIAL REPORT
MAY 2019 – MAY 2021

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

# CONTENTS



## *DIRECTOR'S FOREWORD*

This report looks back on the most difficult period in the history of the Forestry and Agricultural Biotechnology Institute (FABI), due to the COVID-19 pandemic and its consequences. We mourn colleagues and friends who have passed away due to SARS-CoV-2 infections, and the damage to our economy and society that has affected us and our partners deeply. Yet, we also look back on a period that has reinforced the sense of community - the anchor and the stability that FABI offers.

During the pandemic, FABI very quickly adapted to alternative ways of engagement (both within the group and internationally) and to implement protocols that allowed us to continue our laboratory and field-based work safely. We are proud that we could maintain near-normal laboratory and field activity without a single case of work-related SARS-CoV-2 transmission. We developed our own health and facilities management App to facilitate facilities use, and quickly and successfully moved all our meetings and workshops online or into a hybrid online/in-person format. We have had as many, or even more, international engagements during this time as we had before, and often lead the international community in this respect. During this period, we did not miss any of our in-house group activities and likely connect more people weekly than we did during in-person meetings before the pandemic.

FABI is a dynamic and growing platform. The FABI community has grown to include 25 research programmes, some of which are based outside of South Africa. The launch of the Grain Research Programme in 2020 is of note. There is also a growing number of satellite labs; the Satellite Lab in Applied Chemical Ecology is now well-established, while Satellite Labs in Remote Sensing of Plant Health and Artificial Intelligence (AI) in Agriculture were established in 2020. These linkages provide access to materials, high quality knowledge, experience and management tools for pests and diseases.

The FABI team has grown to over 350 people, including researchers and students, as well as technical and administrative staff. We are fortunate to have a world-class team in the institute, and we pride ourselves in the quality of our personnel, students and the training we provide to them. We also rely on a strong and high-quality international network. The hub that FABI provides for local talent and leading researchers and programmes around the world is one of the most significant contributions that the institute makes to the University and country.

Significant changes were made to the management of FABI at the University of Pretoria in 2020. FABI now resides in Innovation Africa @UP as an administrative structure. Innovation Africa @UP is a research park being developed by UP to support the development of long term industry-government-university research partnerships. FABI remains deeply connected to the Faculty of Natural and Agricultural Sciences, but is now better positioned to act as an interfaculty institute and platform. At the same time, FABI can act as a foundation for the development of Innovation Africa @ UP, building on the success of some of the well-established programmes in FABI.

Many of the programmes in FABI provide a high quality service to industry and government through the use of biotechnological tools and information systems. For example, the FABI pest and disease diagnostic clinic serves various agricultural and forestry industries. The work on the data infrastructure that supports this programme, including a data management system in the Innovation Africa @UP Information Hub and an associated App, has continued and is now available to the industry and government. This platform is, for example, being developed as a national biosecurity database to support national pest and disease monitoring and management programmes.

Regular engagement with our stakeholders is critical to FABI's success. We therefore emphasise various platforms of communication, including through in-person and in-field contact, stakeholder listservers, our website, structured working groups and meetings, and the newly-developed Innovation Africa @UP Information Hub App. Various FABI members also engage in national and government structures. This communication is not just for sharing information with our partners, but is also important to inform and shape our research agenda and projects.

We look back with deep appreciation for another two years of engagement, support and impact with and for our stakeholders, personnel, postdoctoral fellows and students. THANK YOU for being such an incredible team! We could not do it without the strong sense of community and partnership with you. We look forward to using this foundation to increase the reach and impact of our work. With the high quality of our community, systems and experience, FABI will continue to act as an anchor for national and international research networks, and serve as an incubator for new and high-quality research platforms with industry and government and research partners.

**Prof. Bernard Slippers**
*Ph.D. (Pretoria), ASSAf, GYA, SAYAS*
*Director of FABI, the Tree Protection Co-operative Programme (TPCP) and Innovation Africa @UP*

# FABI IN A NUTSHELL

The Forestry and Agricultural Biotechnology Institute (FABI) at the University of Pretoria is a postgraduate research institute that was established in 1997, based on a recognition that the future of forestry and agriculture in South Africa will strongly depend on the incorporation of new and emerging technologies into these industries. Major opportunities for these industries have emerged in recent times, from the applications of biotechnology and information sciences to many others.

| NUMBER OF PUBLICATIONS SINCE 1998 | NUMBER OF PUBLICATIONS (2019-2021) | SUM OF FABI PUBLICATION CITED SINCE 1998 | H-INDEX |
|---|---|---|---|
| 1 960 | 281 | 49 929 | 89 |

## WORLDWIDE COLLABORATION

Map depicting FABI research collaborations based on joint journal publications. Yellow lines indicate papers where a FABIan is the first author. White lines indicate papers where another institution has the lead author. Line thickness represents the number of papers.



**3** Clarivate analytic global highly cited researchers

Prof. Mike Wingfield
Prof. Bernard Slippers
Prof. Pedro Crous

**34** NRF ratings

3 A-ratings
7 B-ratings
13 C-ratings
3 P-ratings
8 Y-ratings

**20** Research groups

- African Plant Systems Biology for the Bioeconomy (APSB)
- Applied Mycology
- Bacterial Genomics and Host Pathogen Interactions
- Biophysics
- Crop Floral Biology and Environments (CFBE)
- DSI-NRF Centre of Excellence in Plant Health Biotechnology (CPHB)
- DSI-NRF SARChI Chair, Fungal Genomics
- Eucalyptus and Pine Pathogen Interactions (EPPI)
- Forest Molecular Genetics (FMG) Programme
- Grain Research Programme (GRP)
- Hans Merensky Chair in Avocado Research
- Macadamia Protection Programme (MPP)
- Molecular Plant Physiology
- Phytobacteriology
- Plant Virology
- Potato Pathology Programme @UP
- Social Insects Research Group
- Systematics and Evolution of Symbiotic Nitrogen-Fixing Bacteria
- Transcriptional Regulation and Bioengineering of Wood Formation
- Tree Protection Co-operative Programme (TPCP)

**Satellite labs and International Programmes**

- Satellite lab in Applied Chemical Ecology
- Satellite lab in Artificial Intelligence in Farming
- Satellite lab in Remote Sensing of Plant Health
- CERC-FABI Tree Protection Programme (CFTPP)
- RGE-FABI Tree Health Programme

**Staff and researchers 2019 - 2021**

| | |
|---|---|
| Full time academic staff: | *39* |
| External research associates: | *20* |
| Postdoctoral / research fellows: | *33* |
| PhD students: | *85* |
| MSc students: | *114* |
| Admin / technical and support staff: | *40* |
| Interns: | *22* |
| PhD students graduated: | *37* |
| MSc students graduated: | *54* |
| Hons students supervised: | *30* |

# ART AND BIODIVERSITY

FABI has an extensive collection of artwork on display in the institute that serve both as a source of enjoyment and as an inspiration in our exploration of new frontiers of knowledge. During the United Nations International Year of Plant Health in 2020, FABI started to explore the close and complex relationship between art and biodiversity represented in this collection.

An 'Art and Biodiversity' page was created on the FABI website to showcase the numerous artworks on display in FABI along with a short biography of the artists. The webpage also contains the works of FABI students and staff from a project called 'Picking the fruit of the heritage tree' that celebrate the diverse heritage of FABIans through art and reflection.

In the latter part of 2020, FABI partnered with the Javett Arts Centre at the University of Pretoria to extend this exploration to other collections of UP to create a series of videos termed "Aesthetics of Biodiversity". These can be viewed on our 'Art and Biodiversity' webpage and YouTube channel. The work draws on themes cutting across science, art and culture, including in the context of the African continent. We anticipate this to be the first seeds of a larger science outreach and communication initiative, as well as to spark new transdisciplinary research.

The theme of the current report takes its inspiration from the FABI Art and Biodiversity project. Throughout the report artwork are shown that are displayed in FABI and on the FABI website. This work include, among other artists, those of the staff and students of FABI.

Artist: Lucky Sibiya

## *FABI BECAME THE FIRST INSTITUTE OF INNOVATION AFRICA @UP*

In 2020, FABI became the first institute to join the Innovation Africa @UP Research Park. Innovation Africa @UP is a new business unit within the University of Pretoria (UP) that stems from the renaming and repositioning of UP's Hatfield Experimental Farm. It aims to provide a more effective platform for the development of long-term industry-university-government partnerships. FABI has more than 22 years of experience in developing cross-sectoral partnerships and therefore provides a strong foundation for the development of Innovation Africa @UP.

The University of Pretoria's 2025 strategic vision is to be "a leading research-intensive university in Africa". To achieve this requires a reimagined partnership with industry and government. Innovation Africa @UP is UP's response to such a partnership. It aligns with the well-established concept of a university-linked 'research park' that can serve as a national and pan-African research investment platform. Innovation Africa @UP is envisioned as a platform with a broad research focus that can unlock potential across faculties and other structures. A key initiative for Innovation Africa @UP is developing a national digital infrastructure that will anchor collaborations among the community of researchers and stakeholder partners in academia, industry and government. The Innovation Africa @UP Information Hub (Big Data Hub) is a cloud-based data platform. This hub will serve as a centralised point to integrate and coordinate the governance of various data resources and link/develop innovative tools to facilitate standardised data collection, data-driven research, automated processing, AI analysis, and visualisation to support industry and other stakeholders in decision-making.

In establishing the Innovation Africa @UP initiative, closely linked with Future Africa, Engineering 4.0 and the Javett Art Centre, the University demonstrates its commitment to 'rethink, reimagine and reposition' itself for greater impact in our society through transdisciplinary, impactful research and development. The Faculty of Natural and Agricultural Sciences (NAS) will continue to have the same strong links to teaching, learning and postgraduate research undertaken by FABI as it has in the past. By using FABI as an engine to drive the development of Innovation Africa @UP, NAS takes a bold step to connect its resources more strongly to the rest of the University structures to create new opportunities to strengthen research and development for South African and African development.

INNOVATION AFRICA
UNIVERSITY OF PRETORIA

# RESEARCH REPORTS

# *African Plant Systems Biology for the Bioeconomy (APSB)*

**Research Leader:** Prof. Eshchar Mizrachi

## *BACKGROUND*

Some 70% of the earth's carbon in living biomass exists in land plants, most of it in the woody stems and roots of vascular plants. This means coordination at multiple levels (the plant's environment, the plant itself, organs, tissues, cells, and even compartments within cells) to acquire and manage carbon, as well as other crucial nutrients including nitrogen and phosphorus. Land plants, including many plants endemic to southern Africa and the African continent, have evolved multiple mechanisms over the past 450 million years to acquire and utilise carbon and other nutrients from the environment. Understanding these mechanisms at a molecular level will allow us to engineer desired traits into food and biomass crops.

## *OBJECTIVES OF THE RESEARCH PROGRAMME*

We use systems biology, evolution of development (evo-devo) approaches, genome engineering and synthetic biology to study important traits in African plants of ecological and economic importance. This includes how plants acquire, manage and invest sequestered carbon, and how they adapt to low-nutrient environments. In addition to working on the commercially important tree genus *Eucalyptus*, we conduct research on Southern African species such as the cycad *Encephalartus natalensis*, the aquatic fern *Azolla filiculoides*, and our National flower - the King Protea (*Protea cynaroides*), whose genome we have sequenced.

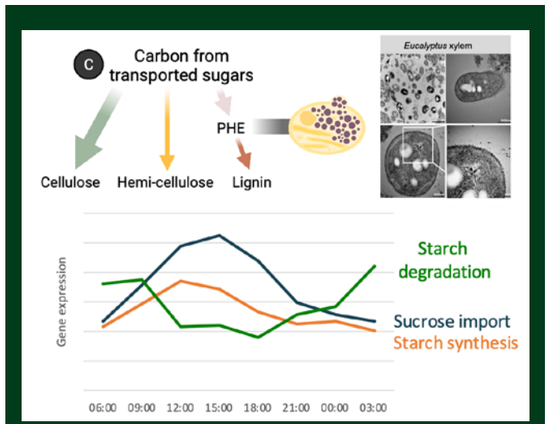
## *HIGHLIGHTS OF THE RESEARCH*

- In the past two years, we have gained a deeper insight into how plants control carbon during secondary growth. We have built on our discovery of a new plastid type called the "xyloplast", which is the main compartment inside cells where carbon is partitioned between what will end up as sugars in polysaccharide biopolymers such as cellulose and hemicelluloses, and the phenolic biopolymer lignin. The work, revealing the xyloplast morphology and regulation, has been submitted for publication.

- We completed the data gathering phase of a large experiment examining diurnal regulation of wood formation in trees, from the molecular level to whole tree tissues and organs. The work explains how trees "budget" carbon from sunrise to sunset, balancing between capturing it from the air, sequestering it into sugars and investing it in forming wood, all the while managing reserves by synthesis and degradation of starch. The work shows how multiple inputs, including the genetically encoded circadian clock and other external inputs, impact these processes.

- We have sequenced the genome of the King Protea (*Protea cynaroides*), as a flagship South African Plant genome. In addition to the Protea's cultural and ecological significance, and its relevance in the South African horticultural industry - its adaptation below ground is of special interest as we look towards adaptations to climate change in agriculture and forestry.

- *Protea* species produce specialized cluster roots (also called "proteoid roots") which, by releasing a combination of organic acids and enzymes, allow the plant to access phosphorus which is usually not bioavailable. By modelling these processes to acquire phosphorus and nitrogen as a system we hope to identify key genes involved, and ultimately use synthetic biology to engineer novel metabolites, as well as complex traits such as cluster roots and/or the ability to acquire nitrogen by partnering with cyanobacteria into crops of interest, to expand the range of planting and reduce fertilization requirement.



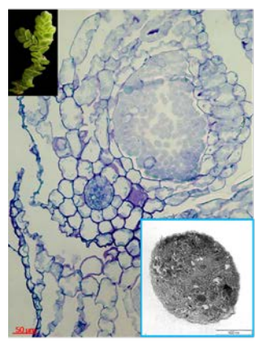

In wood-forming tissue or xylem, sequestered carbon in the form of sugars is either directly used for cellulose and hemicellulose or - through metabolism via specialized plastids we have named xyloplasts - converted to phenolics that end up as the biopolymer lignin. Carbon is provided consistently by storing excess sugar in starch when supply is high, and degrading starch when supply is low, as indicated by corresponding expressed genes over a diurnal cycle. Xyloplasts extracted from *Eucalyptus* xylem tissue demonstrate actively degraded starch granules and a unique morphology when compared to other known plastid types.

Cycads make specialized coralloid roots that house symbiotic cyanobacteria, which provide bioavailable nitrogen to the plant. (Credit: C. Schoeman)

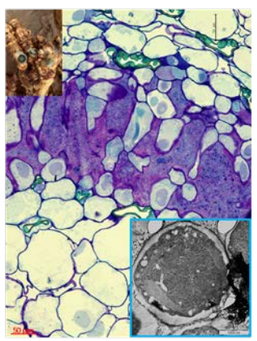
A young flower of South Africa's national flower - the King Protea (*Protea cynaroides* "Little Prince")

Three vascular plants that have independently evolved symbioses with cyanobacteria: The aquatic fern *Azolla* (inside leaf cavities), the cycad *Encephalartos* (in specialized roots called coralloid roots) and the River pumpkin (*Gunnera*, inside specialized stem cells). Insets show parts of the plants where the cyanobacteria can be found, and transmission electron micrographs of individual cyanobacteria residing inside these plants

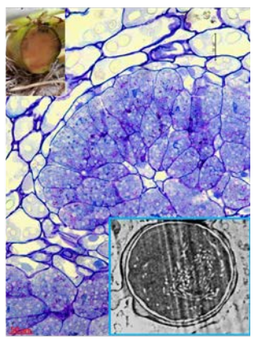
*Azolla filiculoides*

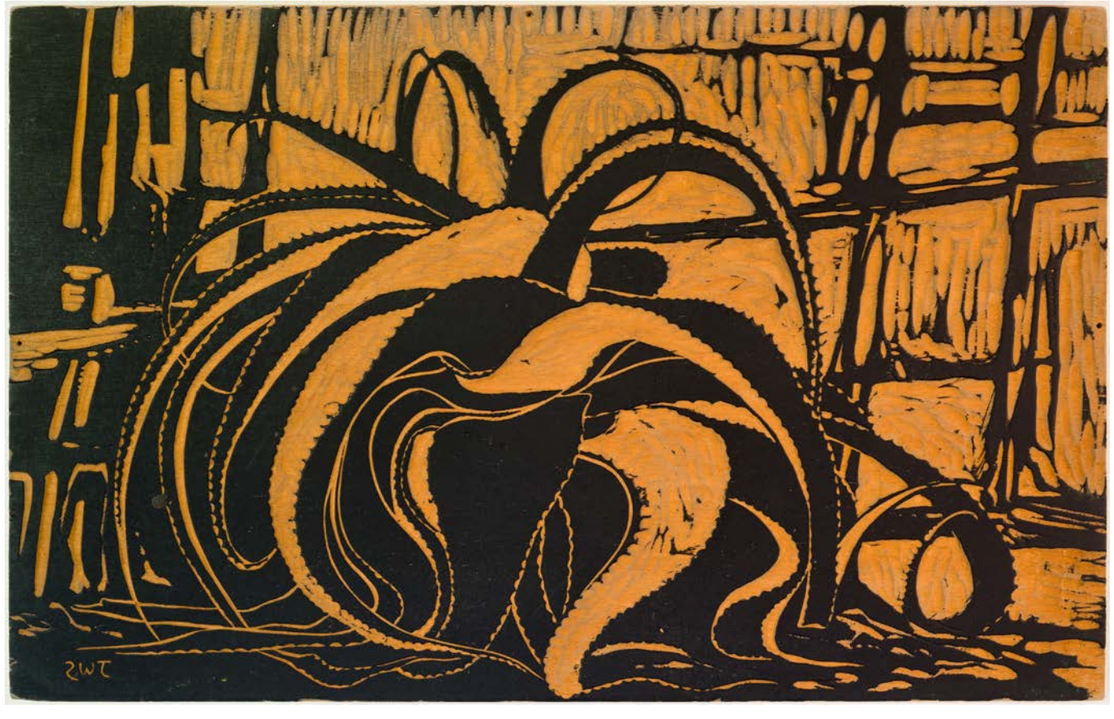


*Encephalartos natalensis*



*Gunnera perpensa*





Artist: Wynand Steyl



# *Applied Chemical Ecology*

**Research Leader:** Prof. Jeremy Allison

**Team Members:** Prof. Almuth Hammerbacher
Prof. Brett Hurley
Prof. Bernard Slippers
Dr Gerda Fourie

## *BACKGROUND*

The primary focus of research conducted by the Applied Chemical Ecology group is the development of an understanding of the chemical ecology of insect pests of plantation forests and agricultural tree crops. By using pest species as model systems the group is able to simultaneously make discoveries that advance the understanding of the natural world and provide pest management tools to stakeholders. The research is conducted in co-operation with the Great Lakes Forestry Centre of Natural Resources Canada.

Specific ongoing projects include the development and optimization of survey and detection tools, characterization of the active space of semiochemical-baited traps and the biotic and abiotic factors that influence it, the impact of chemical ecology on the efficacy of biological control, the chemical ecology of insect pests of plantation and fruit and nut trees, the causes and consequences of variation in insect sex pheromones, and the development of management tactics that exploit our understanding of the chemical ecology of pest species.

## *OBJECTIVES OF THE RESEARCH PROGRAMME*

- Development and optimization of survey and detection tools.
- Characterization of the active space of semiochemical-baited traps and the biotic and abiotic factors that influence it.
- Study the impact of chemical ecology on the efficacy of biological control.
- Expand knowledge about the chemical ecology of insect pests of plantation and fruit and nut trees.
- Elucidating the causes and consequences of variation in insect sex pheromones.
- Understand the influence of visual signals in the behaviour and response of insects to chemical signals.

## *HIGHLIGHTS OF THE RESEARCH*

- We established a fully functional chemical ecology lab, able to study all the aspects of the insect systems, from the chemistry itself, to the electrophysiological responses and behaviour.
- Discovered new pheromones or confirmed the pheromone composition of *Sirex noctilio*, *Coryphodema tristis*, *Nudaurelia clarki*, *Euproctis terminalis*, *Gonipterus* sp. 2 and *Bathycoelia distincta.*
- Developed and tested field-based tools for the monitor and management of the above mentioned pests. In the case of *Coryphodema tristis*, the pheromone is currently used for mass trapping of this pest for management in *Eucalyptus nitens* plantations.
- As a relatively newly formed group, we are proud of a number of high quality research papers, the graduation of a number of PhD and MSc students, hosting of Postdoctoral fellows, national and international research collaborations, and strong industry partnerships. Two of the recent PhD graduates from the program now serve in leadership roles in IUFRO working groups.
- Hosted two online seminar series for the IUFRO Working Party 7.03.16 on Behavioral and Chemical Ecology of Forest Insects, and jointly with Working Party 7.03.05 on Ecology and Management of bark and wood-boring insects.
- Hosted the first International Society for Chemical Ecology Annual Symposium in/from Africa. The meeting was scheduled to be held in September 2020, but was postponed to September 2021. A PhD student linked to the group won the best student presentation at the symposium.

# *Applied Mycology*

**Research Leader:** Prof. Cobus Visagie

**Team Members:** Prof. Pedro Crous
Prof. Bernard Slippers
Prof. Emma Steenkamp
Prof. Brenda Wingfield
Prof. Mike Wingfield
Dr Mahlane Godfrey Kgatle
Dr David Nsibo
Dr Neriman Yilmaz

## *BACKGROUND*

Fungi play important roles in many aspects of human life, such as acting as decomposers in the carbon cycle, being used to produce food and beverages, while many species produce useful pharmaceuticals or enzymes. For all these benefits, fungi can cause serious problems for humans, animals and plants. One of the most important is the production of various mycotoxins in food and feed commodities that cause serious health problems in both humans and animals when consumed above threshold levels. Mycotoxins affect producers, suppliers, retailers and consumers, and places food security and the United Nations Sustainable Development Goal 2 (SDG2) of no hunger by 2030 at significant risk.

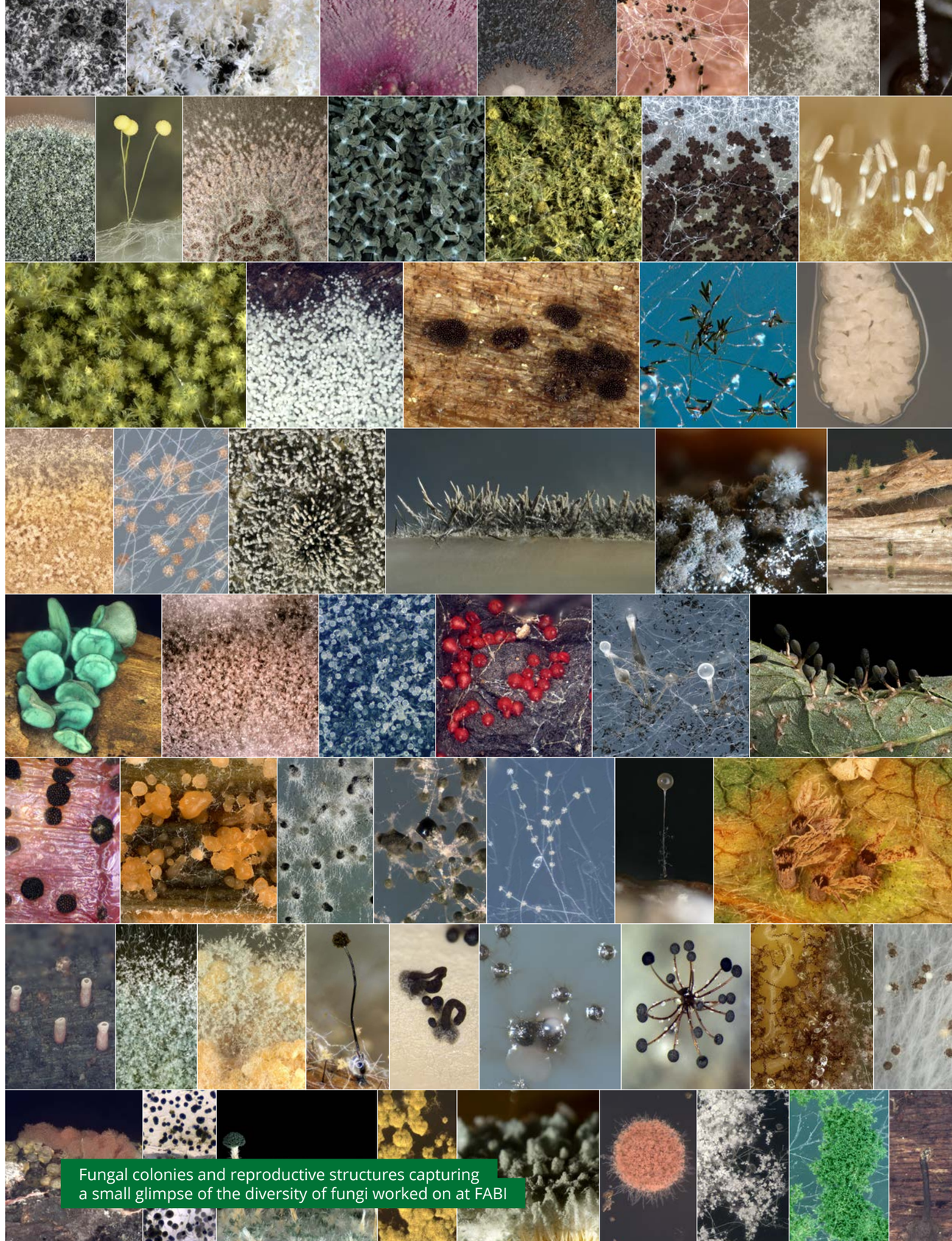
Our research focuses on better understanding the fungal communities that produce mycotoxins in agricultural crops, food, and animal feed. Emphasis is placed on the diversity and taxonomy of genera such as *Alternaria*, *Aspergillus*, *Fusarium, Penicillium* and *Talaromyces*, but many others are also studied. During this process we isolate and identify fungi using modern taxonomic approaches, publish and release newly generated DNA reference sequences, while building national biodiversity resources by depositing species to national and international fungal culture collections. Our research group is also developing unified rapid monitoring methods to identify important mycotoxin producing species along the value chain. Ultimately, our goal is to secure food and feed from farm to fork for future generations.

## *OBJECTIVES OF THE RESEARCH PROGRAMME*

- Expand biodiversity resources such as culture and DNA collections.
- Complete taxonomic revisions of important fungal genera, like *Aspergillus*, *Fusarium* and *Penicillium*.
- Develop novel culture-independent detection methods to detect species and microbiomes better.
- Study genomes and transcriptomics to better understand why, when and how specific species produce mycotoxins.
- Study specific grain diseases like Northern corn leaf blight caused by *Exserohilum turcicum*.

## *HIGHLIGHTS OF THE RESEARCH*

- Morphological identifications in the genus *Aspergillus* are notoriously difficult. The taxonomy of this important genus was updated in recent years, with great emphasis placed on DNA sequence-based approaches. As a result, we deemed it necessary to update identifications of catalogued South African strains. This study resulted in the re-identification of 300 strains into 63 species, including the description of seven new species.
- A significant update on the taxonomy of *Eurotiales*, containing important genera like *Aspergillus*, *Byssochlamys*, *Penicillium* and *Talaromyces* was published in 2020. An overview of the five families and 28 genera (four newly described) is provided and includes a comprehensive list of 1,186 accepted species. For each species accepted in the list, important data have been linked to each name, including MycoBank numbers, collection numbers of type and ex-type cultures, subgeneric classification, its mode of reproduction, and GenBank accession numbers of ITS, beta-tubulin, calmodulin and RNA polymerase II second largest subunit (RPB2) sequences. This is a taxonomic undertaking that should serve the stakeholder community deeply and allow most people the opportunity to work with and correctly identify these incredibly important fungi.
- Several projects were funded (FLAIR, Maize Trust and NRF-FBIP) from which the research will support Eastern Cape maize farmers. The projects aim to document fungal diseases in the region, isolate, preserve and characterise the causal agents and set priorities for future research projects.
- The *Fusarium fujikuroi* species complex (FFSC) includes more than 60 phylogenetic species that are of both phytopathological and clinical importance. A stable taxonomy and nomenclature are thus crucial. As a result, we reviewed the FFSC using morphology and phylogenetics, introducing three new species, epitypifying six species, neotypifying one species and validating two species.



Fungal colonies and reproductive structures capturing a small glimpse of the diversity of fungi worked on at FABI

# Bacterial Genomics and Host Pathogen Interactions

**Research Leader:** Prof. Lucy Moleleki

**Team Members:** Prof. Teresa Coutinho
Prof. Sanushka Naidoo
Dr Thabiso Motaung
Dr Daniel Bellieny-Rabelo
Dr Divine Shyntum

## BACKGROUND

Potato is the fourth most important crop world-wide. South African potato production contributes about 0.3% of to the global potato production and about 45% of gross vegetable production in South Africa. Some of the most important pests and pathogens affecting potato production include soft rot bacteria (*Pectobacterium and Dickeya* spp.), root knot nematodes (*Meloidogyne* spp.) and oomycetes (*Phytophthora* spp.). Our research seeks to understand the potato host pathogen interactions. To this end, our research group uses a variety of omics approaches to understand virulence mechanisms of potato pests and pathogens as well as defence mechanisms used by the host against this arsenal of virulence factors.

## OBJECTIVES OF THE RESEARCH PROGRAMME:

- Identify virulence factors in different potato pests and pathogens
- Identify potato host defences elicited by important pathogens

## HIGHLIGHTS OF THE RESEARCH:

- We combined comparative genomics of 100 Soft Rot Pectobacteriaceae (SRP) with whole-transcriptome data sets obtained from *Pectobacterium brasiliense* strain PBR 1692 after potato tubers were infected with this bacterium. This allowed us to identify novel genomic and key transcription and pathogenicity factors as well as antibacterial factors that play a role in virulence and fitness of this pathogen.
- We characterised the role of antibacterial factors in conferring *Pectobacterium brasiliense* competitive advantage over other bacteria including closely related SRP. Two specific factors, carbapenem and bacteriocins were found to play a major role in antibacterial activity of *Pectobacterim brasiliense*.
- Important transcription factors such as Fur and PhoPQ were found to play a regulatory role on host adaptation and many antibacterial factors involved bacterial competition systems
- Transcriptome profiling of susceptible potato plants challenged with *Meloidogyne javanica* enabled us to identify defence pathways targeted by the root knot nematodes including suppression of jasmonic acid and ethylene signalling pathways.



# Biophysics

**Research Leader**: Prof. Tjaart Krüger

## BACKGROUND

When oxygenic organisms, including plants and cyanobacteria, are subjected to stressful environments such as excessive light illumination, drought, non-optimal temperatures, and various diseases, a substantial amount of the light energy absorbed by the organisms is dissipated as heat. The energy is thus "wasted" during the first steps of the photosynthetic process. This rapid photoprotective response serves as a safety valve to lower the risk of the production of deleterious reactive oxygen species that can destroy the photosynthetic apparatus and eventually kill the organism.

## OBJECTIVES OF THE RESEARCH PROGRAMME

The main objective of this research programme is to investigate the molecular details of the photoprotective response of oxygenic organisms, particularly plants and cyanobacteria. Our main experimental tools are spectroscopy and fluorometry. Considering that the fastest and sometimes most significant photoprotective changes occur in the light-harvesting pigment-protein complexes, our research is focused mainly on these complexes.

## HIGHLIGHTS OF THE RESEARCH

- We have built a state-of-the-art and globally unique experimental facility that allows us to do spectroscopy at the level of single proteins. We use this highly sensitive technique to obtain detailed information about how the light-harvesting complexes of photosynthetic organisms switch between light-harvesting and photoprotective states.
- The light signals emitted by the light-harvesting complexes are an extremely valuable source of information about the performance, functioning and, to some degree, the composition of various components of the photosynthetic machinery in response to light. We have been able to perform non-invasive, *in situ* fluorometric measurements of microbiological communities in the Namib Desert that thrive underneath translucent stones. We discovered that those organisms have no active light-induced molecular stress mechanisms, but that water availability is the primary limiting factor for their photosynthetic activity. The study highlights the astonishing ability of photosynthetic organisms to adapt to harsh environments.

Working on our home-built single-molecule spectroscopy experimental facility

# *CERC-FABI Tree Protection Programme (CFTPP)*

**Research Leader:** Dr ShuaiFei Chen (CERC, China & FABI)

**Team Members:** Prof. Irene Barnes
Prof. Bernard Slippers
Prof. Mike Wingfield
Prof. YaoJian Xie (CERC, China)
Dr Tuan Duong
Dr FeiFei Liu (CERC, China)
Mr GuoQing Li (CERC, China)
Ms QianLi Liu (CERC, China)

## *BACKGROUND*

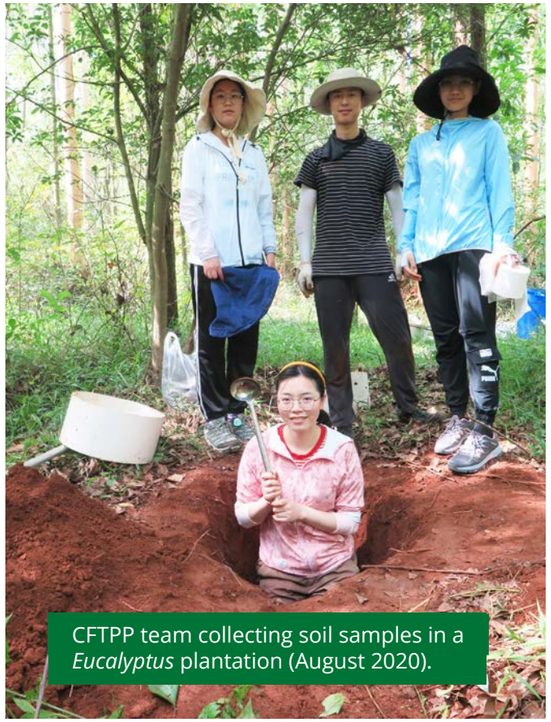
Science and technology innovation co-operation between China and South Africa is an integral part of the comprehensive strategic partnership between the countries. Both South Africa and China have large and important natural forest ecosystems and dynamic forest industries that are threatened by insect pests and pathogens. There is, for this reason, a substantial need to build a strong and mutually beneficial base of research and training to protect these important resources. The co-operation between China and South Africa in forest protection research has a solid foundation through their long-standing relationship between the China Eucalypt Research Centre (CERC) and the Forestry and Agricultural Biotechnology Institute (FABI). The CERC-FABI Tree Protection Programme (CFTPP), a formal structure first established in 2006 and revised in 2015 is responsible for promoting research collaboration and education in all aspects of tree health in China, and between China and South Africa.

## *OBJECTIVES OF THE RESEARCH PROGRAMME*

- Study the distribution, genetic diversity and biology of pathogens and pests threatening plantation forestry in southern China.
- Understand the interactions between pathogens insects and their hosts, and provide support towards breeding and selection of pest-tolerant planting stock.
- Provide education for tree-health specialists and facilitate research collaboration between researchers at CERC and FABI.

## *HIGHLIGHTS OF THE RESEARCH*

- The primary focus of the CFTPP is to understand the distribution, genetic diversity, biology, and pathogenicity of the important pathogens of eucalypt trees. This includes studies on several important eucalypt plantation diseases, including leaf blight and seedling rot caused by species of *Calonectria*, stem canker disease caused by *Botryosphaeriaceae*, *Cryphonectriaceae*, and wilt caused by species of *Ceratocystis*. The CFTPP team made good progress on the taxonomy of *Calonectria* and *Botryosphaeriaceae*, and established a set of effective species identification technology systems based on phylogeny, morphology and mating type for *Calonectria*. The population studies over the past two years help us to understand the distribution and movements of important species of *Calonectria* and *Ceratocystis* at a global scale.
- The CFTPP continues to screen *Eucalyptus* hybrids for tolerance to important diseases. The genotypes of *Eucalyptus urophylla*, *E. urophylla* x *E. grandis* were used to test their tolerances to pathogens in *Botryosphaeriaceae* and *Calonectria* at CERC. The tolerant genotypes will be further tested in different regions for use in commercial forestry.



CFTPP team collecting soil samples in a *Eucalyptus* plantation (August 2020).

Members of CFTPP team at CERC (May 2021)

CFTPP team planting *Eucalyptus* trees in the field (May 2020)

# *Crop Floral Biology and Environments (CFBE)*

**Research Leader:** Dr Nicky Creux

**Team Members:** Prof. Emma Archer (Department of Geography, UP)
Dr Gert Ceronio (Department of Soil, Crop and Climate Sciences, UFS)
Dr Safiah Maali (Grain Crops, ARC)
Dr Dirk Swanevelder (Biotechnology platform, ARC)
Dr Markus Wilken
Deon du Toit (Grain Crops, ARC)

## *BACKGROUND*

The Crop Floral Biology and Environments (CFBE) programme was established in 2019 with a major focus on understanding how changing environments will affect crop floral biology, pollination and ultimately yield. The programme has grown rapidly over this period and has expanded the focus to understanding the broader effects of climate on crop plant development, pathogen load and yield. This multi-disciplinary programme has brought together meteorologists, agronomists, biotechnologists, engineers and plant biologists to provide a holistic view of plant-environment interactions. The growing connections with local and international university and industry partners have provided a strong basis from which to explore the important questions facing agriculture in light of climate change.

## *OBJECTIVES OF THE RESEARCH PROGRAMME*

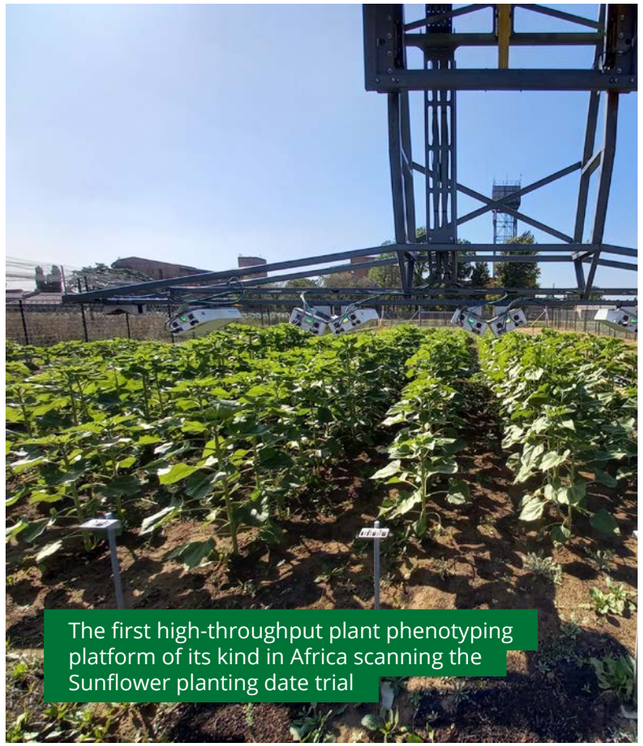
Pollination is a fundamental process in plant biology describing the transfer of pollen from the male to female parts of the plant. In out-crossing plant species, this pollen transfer is difficult, often requiring the movement of pollen between plants and sometimes across great distances. Plants have evolved a large array of different strategies to overcome these physical barriers using either abiotic (wind or rain) or biotic (insects) methods to mobilize pollen. Many of these pollination strategies are affected by external environmental conditions such as seasonal changes and fluctuations in ambient temperature. There is currently little information on how plants regulate the timing of floral organ maturation or what implications climate change may have on these precisely timed mechanisms or pollination strategies. These events are particularly understudied in crop species. Little is known about the combined effects of agricultural practices and a changing environment on plant development or pollination, which directly impact yield and food security.

The objectives of the research programme are:

- To investigate the regulatory mechanisms underlying a flower's response to temperature and how these can be harnessed to protect flowering and pollination from extreme weather events such as heatwaves.
- To identify the factors associated with agricultural practices, such as planting date, which alter the climate under which a crop is grown and assess how these changes might affect crop development, pollination and yield.
- To predict the local effects of climate change on crop development and yield in South Africa.

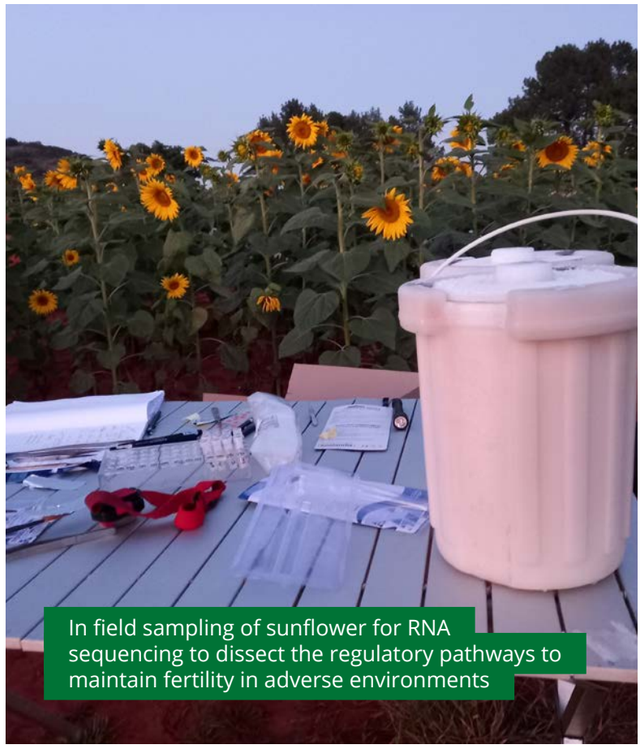
## *HIGHLIGHTS OF THE RESEARCH*

- Detailed physiological measurements of sunflower floral organs were taken. The data indicated that temperature regulates the timing of pollen emergence and pollinator visits, suggesting that heat waves during flowering could have dire consequences for yield.
- There have been several conflicting reports of how climate change might affect crop production in South Africa. Our recent findings suggest that the planting date could be altered to adjust to the longer summers predicted under climate change but that this will require sufficient moisture or supplemental irrigation.
- We are using the ARC high-throughput phenotyping platform to assess phenotypic changes in plant development at different planting dates. This state-of-the-art platform is the first of its kind in Africa, and our planting date maize and sunflower projects would be the first to run on the system. Data obtained from the platform will provide detailed measurements of plant growth and development under different planting dates for these critical South African crops.



The first high-throughput plant phenotyping platform of its kind in Africa scanning the Sunflower planting date trial

Manual phenotyping of our maize planting date trial to assess the factors affecting yield for late planting dates



In field sampling of sunflower for RNA sequencing to dissect the regulatory pathways to maintain fertility in adverse environments

Detailed imaging and flower phenotyping to assess the effect of adverse environments on sunflower pollination and pollinators

# *DSI-NRF Centre of Excellence in Plant Health Biotechnology (CPHB)*

**Director:** Prof. Emma Steenkamp
**Programme Manager:** Prof. Martin Coetzee

**Project Leaders:**
Prof. Irene Barnes
Prof. Pedro Crous
Prof. Wilhelm de Beer
Prof. Leanne Dreyer (University of Stellenbosch)
Prof. Eastonce Gwata (University of Venda)
Prof. Almuth Hammerbacher
Prof. Brett Hurley
Prof. Ednah Kunjeku (University of Venda, Retired)
Prof. Sanushka Naidoo
Prof. Francois Roets (University of Stellenbosch)
Prof. Jolanda Roux (Sappi)
Prof. Bernard Slippers
Prof. Alex Valentine (University of Stellenbosch)
Prof. Noëlani van den Berg
Prof. Albé van der Merwe
Prof. Fanus Venter
Prof. Cobus Visagie
Prof. Brenda Wingfield
Prof. Mike Wingfield
Dr Tuan Duong
Dr Gerda Fourie
Dr Thabiso Motaung
Dr Marinda Visser (Grain SA)

## *BACKGROUND*

The primary goal of the CPHB (previously the Centre of Excellence in Tree Health Biotechnology (CTHB)) is to promote the health of South Africa's woody and agricultural resources through the application of biotechnology tools. To achieve this goal, the CPHB team studies the pathogens and pests associated with trees and agricultural crops. Members of the Centre also explore the possible effects that factors such as climate change, fire, genetic diversity and human activity may have on the health of plant resources and ecosystems. Although most of the CPHB's activities happen at FABI, it also conducts research via a collaborative network of scientists, both locally and abroad.

## *OBJECTIVES OF THE RESEARCH PROGRAMME*

- Understand the biology, ecology, genetics, population biology and systematics of insects and microbes associated with woody plants and agricultural crops.
- Broaden our knowledge regarding the biology and ecology of specific tree species, as well as the effect that human practices might have on these species, the ecosystems in which they occur and the conservation of natural habitats.
- Study the possible impacts of soil properties and nutrients, microbial symbioses and climatic factors on the health of woody plants and in diverse landscapes and on various agricultural crop species.
- Assessing the effects of drought, frost, fire and human activity on the sustainable use of indigenous woody and agricultural resources.
- Develop human capacity in phytosanitation and biosecurity through an internship programme.

Field work in Kruger National Park

## *HIGHLIGHTS OF THE RESEARCH*

- One of the main highlights of the CPHB was the formal launch of the multi-disciplinary Grain Research Programme (GRP), which functions under the umbrella of the Centre of Excellence and the joint FABI-Grain SA initiative, on 21 August 2020. The GRP conducts research that will support the grain sector. It provides extension, and together with its stakeholders, identifies future challenges and opportunities for the industry. The overarching role of the GRP is to contribute to South Africa's food security and bioeconomy by conducting basic and solution-oriented research, which in turn forms a basis for further innovation in the South African agricultural sector.
- As a successful Centre of Excellence, the CPHB is involved in various activities that either inform its research or that emanate from the previous research of the Centre. For example, the CPHB routinely conducts surveys and field experiments in various parts of South Africa and elsewhere on the continent. Together with its partner programmes (i.e., GRP and the Tree Protection Co-operative Programme (TPCP)), the CPHB also maintains a world-class disease and insect pest diagnostic clinic. To facilitate and enhance the research and extension activities of the CPHB, the Centre has developed and implemented several ancillary processes. These include various databases and collections to manage and store information, data and biological material used in projects.
- The CPHB was actively involved in outreach initiatives to promote a robust and skilled South African human resource base. To this end, a formal mentorship programme was used to target undergraduate students specifically. The CPHB was also involved in several initiatives aimed at improving the public's understanding of science and providing high school learners with information about post-secondary education opportunities in the natural sciences.
- The CPHB Internship Programme was initiated in 2019. The programme was successful in training a total of 14 interns between 2019 and 2020. Five of the interns from the 2019-2020 cohort continued with their MSc studies in FABI. The success of the initial CPHB Internship Program led to the establishment of the FABI Internship Programme in Biosecurity and Phytosanitation in 2021. In the reporting period for 2021, 10 interns were accepted into the program.
- The CPHB members were highly productive in their research outputs and training of students. During the reporting period, the CPHB, together with its sister program, the TPCP, published more than 186 scientific papers that dealt with the health issues of trees and agricultural crops. In total, 24 MSc and 15 PhD students graduated with research projects linked to the programme.

*Amanita* spp. found in a miombo woodland of Angola

# *DSI-NRF SARChI Chair, Fungal Genomics*

**Research Leader:** Prof. Brenda Wingfield

**Team Members**:
Prof. Irene Barnes
Prof. Martin Coetzee
Prof. Wilhelm de Beer
Prof. Almuth Hammerbacher
Prof. Bernard Slippers
Prof. Emma Steenkamp
Prof. Albé van der Merwe
Prof. Cobus Visagie
Prof. Mike Wingfield
Dr Tuan Duong
Dr Magriet van der Nest
Dr Markus Wilken

## *BACKGROUND*

The field of molecular genetics of fungi has expanded rapidly now that we have access to hundreds of fungal genomes on which to base our research questions. This field is now firmly established in the genomics domain and many questions which would have been impossible to address are now largely within our grasp. Biological systems are highly dynamic and new pathogens of plants are being discovered every year. Using tools developed in our past research, we can now identify new pathogens and then apply an ever-increasing number of technologies to manage them. We have developed and implemented new techniques to ascertain the threat of pathogens to forests and forestry. We can also establish whether a newly discovered pathogen is closely related to other known species, what the population diversity of the pathogen is and potentially determine whether it has been introduced or has jumped from a native host. Answering questions such as these allow us to determine global pathways of the spread of pathogens and how some pathogens seem to be able to infect new hosts.

## *OBJECTIVES OF THE RESEARCH PROGRAMME*

Research conducted in this programme focuses on the global movement and evolution of fungal tree pathogens. These fungi provide superb models that allow us to interrogate the research questions relating to the structure of mating-type genes in fungi, chromosome number and structure, pathogenicity, fungicide resistance and population genetics of fungal plant pathogens. We use phylogenetic, population genetic and genomics tools, as well as molecular tools such as gene knockouts (including CRISPR-Cas) to answer these research questions.

## *HIGHLIGHTS OF THE RESEARCH*

- A Genome-Wide Association Study (GWAS) study on various isolates of *Fusarium circinatum* was conducted to determine loci associated with pathogenicity. For this purpose, genome sequences for all the isolates were obtained and compared to find loci linked to pathogenicity. Pathogenicity tests on pine trees using the same isolates were done to confirm the GWAS results.

- Several genomes of important and emerging fungal tree pathogens were published.

- Mating-type genes and the mating system of fungi governs their population biology and evolution. It is thus important to understand which genes are involved in mating and how these genes differ between species and between isolates within a species. In this regard, we made significant progress in unpacking unisexuality in *Huntiella*, understanding the mating systems in *Ceratocystis, Thielaviopsis* and *Chrysoporthe* and characterizing the MAT locus in *Teratosphaeria* and *Calonectria* species.

- The Repeat-Induced Point (RIP) mutation pathway is a fungus-specific genome defence mechanism that mitigates the deleterious consequences of repeated genomic regions and transposable elements (TEs). We developed a RIP pipeline to study RIP *in silico* and used the pipeline to study this mechanism in Ascomycota fungi.

- We produced the first JOVE video publication for Africa. In this publication, we explain how we use CRISPR-Cas9-Mediated genome editing in the filamentous Ascomycete *Huntiella omanensis* (https://www.jove.com/video/61367).

- A diagnostic marker for *Teratosphaeria* species was developed; this marker will enable rapid identification of species of this genus.

Blister beetle on rust gall (2006)
Artist: Julia Kreiss


Artist: Appie van Wyk



# *Eucalyptus and Pine Pathogen Interactions (EPPI)*

**Research Leader:** Prof. Sanushka Naidoo

**Team Members:** Prof. Martin Coetzee
Prof. Zander Myburg
Prof. Bernard Slippers
Prof. Emma Steenkamp

## *BACKGROUND*

One of the greatest threats to the sustainability of global forestry is the ever-increasing number and spread of pests and diseases that can severely reduce the productivity of the plantations. Changing climate is also expected to negatively impact forestry, introducing a stressful environment for forest trees and increasing susceptibility to pests and pathogens. Coupled with biological control, improved silvicultural processes and knowledge of the pests and pathogens, is the need to identify and develop resilient tree genotypes with increased resistance against these abiotic and biotic stresses.

## *OBJECTIVES OF THE RESEARCH PROGRAMME*

It is critical that we have an in-depth understanding of the *Eucalyptus* immune system, Pine defence mechanisms and various plant-pest and plant-pathogen interactions that can be exploited to confer resistance against the swath of pests and pathogens that currently threaten productivity in these species. Our research, therefore, focuses on:

- Defining the early responses of *Eucalyptus* to the insect pest, *Leptocybe invasa*, to reveal pest manipulation targets.
- Examining the interaction between *Eucalyptus* and the stem canker pathogen, *Chrysoporthe austroafricana*.
- Uncovering the host defence mechanism in pine and against the pitch canker pathogen *Fusarium circinatum*.
- Developing an integrated model of defence to uncover the basis of resistance and susceptibility in pines and *Eucalyptus*.
- Identifying key regulatory sequences and pathways that are important for improving defence against the insect pest.

## *HIGHLIGHTS OF THE RESEARCH*

- Invasive pests have become major problems in plantation forestry, and as global trade increases, it is apparent that curbing the tide of new introductions is becoming more challenging. One invasive pest, *Leptocybe invasa*, induces gall formation on *Eucalyptus* trees. We are curious about the early mechanisms leading to gall formation in susceptible trees. We examined the early responses to gall formation using microscopy and gene expression (transcriptomics). We identified the triggers to the gall induction in the leaves at the molecular level.

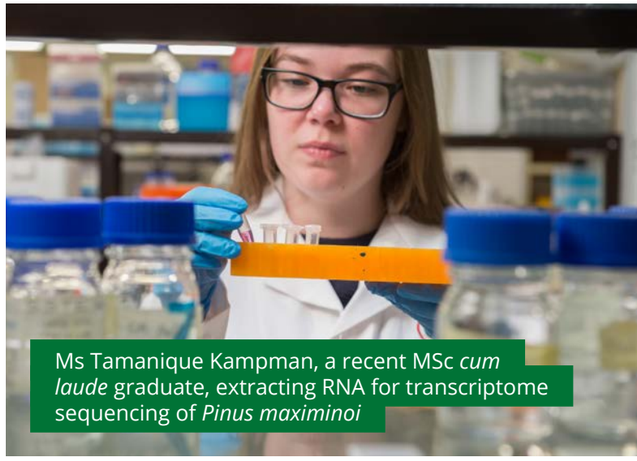
- Our partnership with Mondi resulted in the identification of the DNA markers associated with resistance against *Leptocybe invasa*. These markers, subjected to a South African patent, forms the basis to identify resistant trees in future, greatly empowering breeders.

- We worked closely with Sappi to begin a large-scale systems genetics study in *Eucalyptus.* A major milestone was an inoculation trial on over 3,000 ramets of one-year-old *Eucalyptus grandis* x *Eucalyptus urophylla* backcross to *E. grandis* clones in December 2020. This is a significant step towards identifying markers linked to stem canker resistance in *Eucalyptus*.

- Our work in Pines has focused on the generation of transcriptomic resources for some of the important pine species in South Africa. This sequence information was used as a resource for the development of the tropical pine SNP chip by the Pine Consortium (refer to FMG report). Transcriptomes were generated for *Pinus patula, Pinus tecunumanii, Pinus maximinoi, Pinus greggii* and *Pinus oocarpa* seedlings under challenge with *Fusarium circinatum*, a fungal pathogen that causes wilting in the nursery, affecting Pine production. We employed these high-quality data sets to develop models of defence against this devastating pathogen and identified resistance genes and the terpene synthase genes responsible for the production of some secondary metabolites (chemicals) in pine.

- We have also embarked on investigating the intersection between abiotic stress such as drought and pathogen infection at the molecular level. This type of research becomes increasingly important in light of climate change.

- Overall, the research within the programme continues to produce novel insights into tree defences and translational outputs to improve forest resilience.



Ms Tamanique Kampman, a recent MSc *cum laude* graduate, extracting RNA for transcriptome sequencing of *Pinus maximinoi*

# *Forest Molecular Genetics (FMG) Programme*

**Research Leader:** Prof. Zander Myburg

**Team Members:** Prof. Eshchar Mizrachi (Team Leader: Systems Biology and Evolution of Wood Formation)
Prof. Sanushka Naidoo (Team Leader: Tree Pest and Disease Resistance)
Dr Steven Hussey (Team Leader: Transcriptional Regulation and Bioengineering of Wood Development)
Dr Nanette Christie
Dr Raphael Ployet

## *BACKGROUND AND OBJECTIVES*

The Forest Molecular Genetics (FMG) Programme is an industry- and government-supported initiative focused on the genetic control of growth and development in fast-growing plantation trees with a view to enhance biomass production and improve wood properties for timber, pulp, paper, and biomaterials production. Concomitant with this, we aim to understand molecular pest and disease resistance mechanisms in trees for yield protection and resilience. We work in close collaboration with South African forestry companies through the FMG Consortium to develop capacity and resources for the application of tree biotechnology in operational tree improvement programmes.

## *HIGHLIGHTS OF THE RESEARCH*

We summarize research highlights for each of the major FMG focus areas below. Progress and research highlights towards pest and disease resistance mechanisms are reported in the section for the *Eucalyptus* and Pine Pest and Disease Interactions (EPPI) Programme of Prof. Sanushka Naidoo.

### Genomic Technologies for Precision Tree Breeding

In the past two years, we have developed a new genome-wide DNA marker chip (with 50,000 markers) for tropical pine trees grown in South Africa and implemented a similar resource with 72K markers for *Eucalyptus* and *Corymbia* species. We have completed proof-of-concept genomic selection experiments for *E. grandis* and *E. dunnii* with forestry partners. We are also developing DNA marker resources for *Acacia* (wattle) species grown in South Africa. Towards this, we have started a project to sequence the genome of Black wattle (*A. mearnsii*). A major new development is the completion of the first phase of a new landscape genomics effort aimed at understanding the population genomic diversity of the entire natural range of *E. grandis* and the association of that variation with environmental factors. Finally, we have used new long-read DNA sequencing technology to sequence and assemble the genomes of the *E. grandis* and *E. urophylla* contained in an F1 hybrid of these species as a first step to understanding the genomic basis of hybrid compatibility and superiority in these species.

### Systems Biology and Evolution of Wood Formation

In the past two years, we have deepened our insight into how trees partition carbon in developing wood, focusing especially on the spatial (i.e., within fibre, vessel and parenchyma-forming cells) as well as temporal (i.e., over the full light/dark course of 24 hour days in the field) regulation. We have also sequenced, assembled and quantified the expression of thousands of genes in key species representing missing links in the evolution of plant vasculature, to better understand genes and gene networks regulating secondary growth and nutrient acquisition (primarily nitrogen and phosphorus). Key genes emerging from this research are being functionally tested using reverse genetics to better understand their physiological roles on plant biomass formation, and these represent biotechnological targets for synthetic biology improvement of plant biomass. Full details on progress and research highlights towards systems biology and evolution are reported in the section for the African Plant Systems biology for the Bioeconomy (APSB) Programme.

### Transcriptional Regulation and Bioengineering of Wood Development

We have produced pioneering work on the accessible chromatin landscape in developing xylem, including the first use of DNA Affinity Purification sequencing to identify transcription factor gene targets in *Eucalyptus*. Recently, we have received NRF funding to screen for some 6,400 possible interactions between 200 regulatory genes and their potential gene targets in *Eucalyptus*. This work is aimed at future bioengineering of novel wood chemical and structural properties for advanced bio-based products. Finally, we have set up local capacity for novice-friendly electronic engineering for biosensors and devices through the Biomaker Challenge, in partnership with the University of Cambridge and UP Makerspace. More details are provided in the section on Transcriptional Regulation and Bioengineering of Wood Formation.

# *Grain Research Programme (GRP)*

**Research Leader:** Prof. Bernard Slippers and Prof. Emma Steenkamp (interim leadership)

**Research Team:**

Prof. Dave Berger
Prof. Martin Coetzee
Prof. Brett Hurley
Prof. Albe van der Merwe
Prof. Cobus Visagie
Prof. Brenda Wingfield
Dr Chrizelle Beukes
Dr Nicky Creux
Dr Lieschen de Vos
Dr Gudrun Dittrich-Schröder
Dr Miekie Human (Grain SA)
Dr Mahlane Godfrey Kgatle
Dr Robert Mangani
Dr Thabiso Motaung
Dr Esther Muema
Dr David Nsibo
Dr David Read
Dr Quentin Santana
Dr Michelle Schröder
Dr Marinda Visser (Grain SA)
Dr Markus Wilken
Dr Neriman Yilmaz
Mr Stefan Links (Grain SA)

## *BACKGROUND*

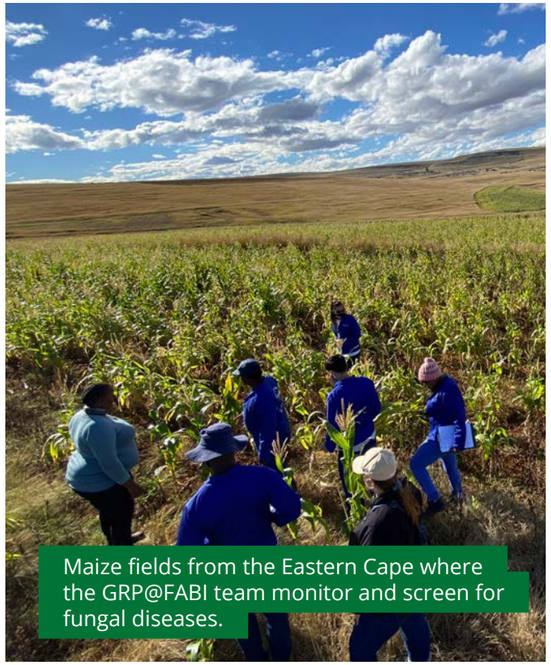
The Grain Research Programme (GRP) is a new FABI initiative that was formally launched in 2020. It was developed by a team of researchers from diverse organizations and disciplinary backgrounds in South Africa, including the University of the Free State. The GRP was formed to engage directly with grain stakeholders to initiate research that will support the sector and to identify future challenges and opportunities for the industry. To its stakeholders in agriculture, the GRP also provides extension and disease/pest diagnostic services. The vision of the GRP is to contribute to South Africa's food security and bioeconomy by conducting basic and solution-oriented research, which in turn forms a basis for further innovation in the South African agricultural sector.

## *HIGHLIGHTS OF THE RESEARCH*

- A significant milestone for the GRP, this early in its existence, is launching various research projects within the grain health domain. By May 2021, the FABI part of the GRP team consisted of 23 PhD-level researchers, 11 postgraduate students and six interns.

- Research projects in the GRP span a wide range of themes and disciplines. Various projects survey and explore the diversity of microbes associated with grain crops such as maize, soybean and sunflower. Special attention is given to potential plant pathogens, while the group is also studying the impact and possible control of mycotoxigenic fungi in these crops. Other projects explore genetic avenues for potentially enhancing maize and sunflower production under South African conditions. Several studies involving insect pests have also been launched. These are aimed at developing control strategies based on biocontrol or modern gene-editing strategies. Several studies are also integrating production, plant physiology, climate, planting practices and disease development.

- The activities are made possible through significant funding from various national and international sources. These include the entities associated with the agriculture industry and relevant government departments in South Africa, as well as the FLAIR (Future Leaders - African Independent Research) Fellowship programme in partnership with the African Academy of Sciences and the Royal Society funded by the UK Government's Global Challenges Research Fund.



Maize fields from the Eastern Cape where the GRP@FABI team monitor and screen for fungal diseases.

Close-up image of maize, soybean and sunflower seeds.

# *Hans Merensky Chair in Avocado Research*

**Research Leader:** Prof. Noëlani van den Berg

**Team Members:** Dr Robert Backer
Dr Ashok Prabhu
Dr Velushka Swart
Dr Nicolette Taylor
Juanita Engelbrecht

## *BACKGROUND*

The Hans Merensky Chair in Avocado Research was officially launched at UP in 2020 as a result of the previous successful 12-year research partnership between the Hans Merensky Foundation (HMF) and the Avocado Research Programme. The HMF board made a strategic decision to continue the financial support for a further 10 years - to ensure that the Merensky vision of building science capacity for the betterment of the South African people continues. Research is focussed on several aspects of avocado tree health - host defence mechanisms, pathogen biology and genomics, transcriptomics and proteomics of both the host and important pathogens. This academic-industrial research partnership is a flagship initiative for both the HMF and the University of Pretoria. It is also an example of how such a partnership can benefit both the industry and academia.

## *OBJECTIVES OF THE RESEARCH PROGRAMME*

- Investigate mechanisms of avocado defence against *Phytophthora cinnamomi*, the causal agent of Phytophthora root rot.
- Sequencing and utilizing genome, transcriptome and proteome data of avocado and *P. cinnamomi*, to support the understanding of host defence and pathogen invasion strategies, respectively.
- Identify pathogenicity/virulence genes in the pathogen, *P. cinnamomi*.
- Identify and monitor *Rosellinia necatrix* and ambrosia beetles and their symbionts on avocado in South Africa
- Assessing the use of biocontrol agents as alternative control methods against *R. necatrix*, *P. cinnamomi* and *Fusarium euwallaceae* on avocado

## *HIGHLIGHTS OF THE RESEARCH:*

***Avocado Defence***

- Avocado demonstrates a biphasic phytohormone defence response in response to *P. cinnamomi* infection. This response allows for the timely expression of pathogenesis-related genes *via* the NPR1 defence response pathway.
- Cell wall modification *via* callose deposition has been demonstrated in resistant avocado rootstocks in response to *P. cinnamomi* infection.

***Avocado Genome Resources***

- The ARP is a founding member of the Avocado Genome Consortium, an international collaborative effort dedicated to assembling a high-quality, chromosome level assembly of the avocado genome.
- To unearth some of the differences between susceptibility and resistance to *P. cinnamomi*, we performed dual RNA-sequencing analyses of two well-known avocado rootstocks with varying susceptibilities. Data from this research is significantly contributing to several ongoing projects.

**Phytophthora cinnamomi *Genomic Resources and Pathogenicity***

- The genome of an isolate of *P. cinnamomi* collected from an avocado orchard in South Africa has recently been sequenced using a combination of short and long-read technologies. RNA-Seq data from *in planta* infection of avocado rootstocks have also been generated and used for annotating the genome.
- By analysing this newly sequenced genome, it was revealed that *P. cinnamomi* has a complex genome with a larger genome size than previously estimated.
- The better genome assembly and annotation allowed the identification and characterization of pathogenicity genes that were not previously detected.

ARP team celebrating the establishment of the Hans Merensky Chair in Avocado Research with Dr Khotso Mokhele, Prof. Tawana Kupe, Prof. Barend Erasmus and Prof. Bernard Slippers

**Rosellinia necatrix *on Avocado***

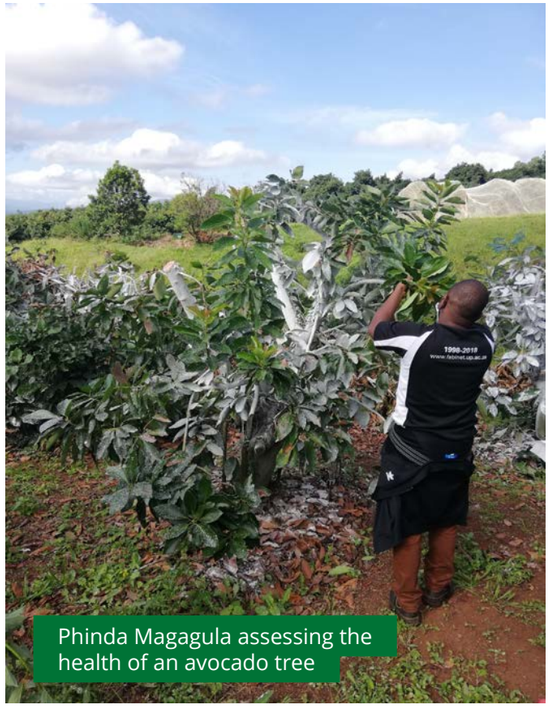
- Since the first report of *Rosellinia necatrix* in South African avocado orchards, the research programme has surveyed the spread and found the pathogen occurring in orchards in Limpopo, Mpumalanga and KwaZulu-Natal.
- Our research on *R. necatrix* control in avocado has contributed to the emergency registration of Fluazinam for use in avocado orchards in South Africa.

**Ambrosia beetles and their symbionts on avocado**

- We are continuously monitoring the presence of ambrosia beetles in avocado orchards throughout South Africa in a collaborative effort with the South African Avocado Growers' Association (SAAGA).
- To date, the Polyphagous Shot Hole Borer has only been detected in backyard avocado trees, but the avocado industry remains on high alert.

**Biological control of avocado diseases**

- The use of biocontrol agents as part of an integrated disease management strategy for root pathogens in avocado is becoming increasingly important. *In vitro* and greenhouse trials conducted by the ARP has identified commercially available biocontrol products which may constitute viable candidates for the management of *R. necatrix* on avocado.



Phinda Magagula assessing the health of an avocado tree

Members of the ARP team collecting samples in avocado orchards

Casey Gill inspecting avocado trees for ambrosia beetles

Ncobile Kunene during a research visit to the University of California, Riverside, inspecting *Phytophthora cinnamomi* cultures

# *Macadamia Protection Programme (MPP)*

**Research Leader:** Dr Gerda Fourie

**Team Members:** Prof. Jeremy Allison (Natural Resources Canada)
Prof. Brett Hurley
Prof. Bernard Slippers
Prof. Noëlani van den Berg
Prof. Mike Wingfield

## *BACKGROUND*

The Macadamia industry is regarded as one of the fastest growing agricultural industries in South Africa. The crop is, however, affected by several pests and diseases that cause a decrease in nut yield and quality. Control strategies are mostly based on the use of commercially available pesticides and fungicides. However, this is not sustainable, and the implementation of alternative control strategies and management options are therefore needed. Effective implementation of these measures is built on knowledge regarding pest identity, origin and genetic diversity, disease cycle and epidemiology as well as cultivar susceptibility. Such information is often lacking or not well understood.

## *OBJECTIVES OF THE RESEARCH*

- Provide biologically relevant information for the effective implementation of alternative control strategies and management options.
- Assist in the generation of knowledge that will support the improvement or development of biological control as well as pheromone-based products.

## *HIGHLIGHTS OF THE RESEARCH*

- The disease diagnostic clinic provides a platform where growers can report pest and disease problems observed in the field. A marked increase of Dry flower, caused by *Pestalotiopsis macadamiae* and *Neopestalotipsis macadamia*, branch dieback and tree decline, caused by species in the Botryosphaeriaceae, as well as Scolytidae beetle damage, have been observed. Dedicated research projects working towards improved management solutions are currently underway.

- The polyphagous shot hole borer and its pathogenic fungal symbiont *Fusarium euwallaceae* were reported from single trees in KwaZulu-Natal. *Fusarium euwallaceae* pathogenicity trials on nine commercial cultivars revealed restricted growth within macadamia tissue as low levels of lesion incidence and severity were observed. This restricted growth likely contributes to the status of macadamia as a non-reproductive host.

- *Rosellinia necatrix*, the causal agent of White Root Rot, was isolated from roots and confirmed as a causal agent of macadamia by means of Koch's postulates. The impact of this disease on macadamia is unknown and continued monitoring is underway.

- In terms of nut diseases, species in the genera *Colletotrichum* and *Diaporthe* were confirmed as macadamia husk rot causal agents. A new *Calonectria* species was also isolated from infected nuts collected at farms in Limpopo.

- *Thaumatotibia batrachopa* was the dominant Lepidoptera species present in damaged nuts. Molecular markers for species previously associated with nut borer damage were developed and will serve as a quick and reliable identification tool for future monitoring. Population analysis of *T. batrachopa* obtained from different growing regions indicated that the populations are not separated from each other, and this might suggest recent gene flow.

- Twenty stink bug species were identified from macadamia orchards. A DNA database for these species was developed and will serve as an important tool to monitor abundance and species fluctuations over time. A *Boerias* species was detected in high numbers in KwaZulu-Natal, and this is the first report of this stink bug species being associated with macadamia in South Africa.

- In terms of characterization of the alarm pheromone of dominant stink bug *Bathycoelia distincta*, 16 compounds were present in the scent glands of males and females. Dynamic headspace sampling of stressed *B. distincta* suggests that six major compounds and three minor compounds are secreted.

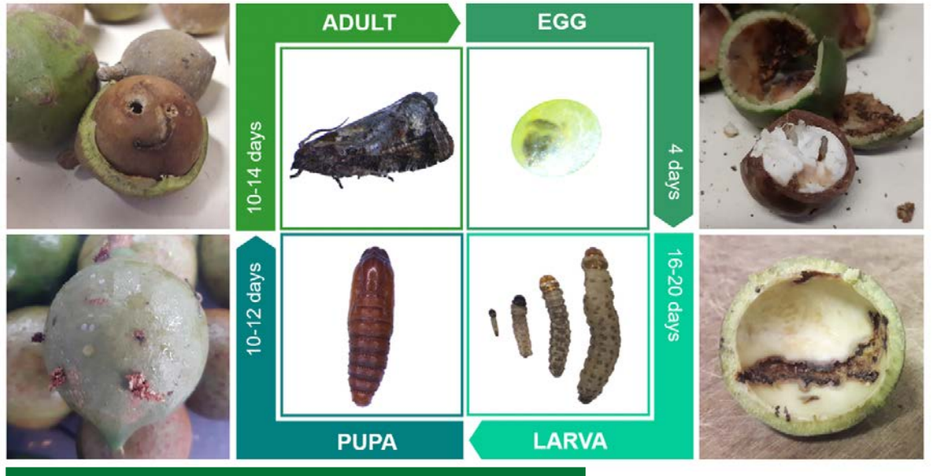
- A molecular detection assay to identify alternative host plant tissue in stink bug guts was developed. Two barcoding genes were optimized and a feeding trial, to determine how long after feeding plant material can still be detected in the gut, was conducted.


Research visit to Australia

International research symposium in China


Two-spotted stink bug (*Bathycoelia distincta*) eggs on macadamia nut


The macadamia team isolating husk rot fungi



Life stages and life cycle of *Thaumatotibia batrachopa*

# *Molecular Plant Physiology*

**Research Leader:** Prof. Juan Vorster

**Team Member:** Prof. Karl Kunert

## *BACKGROUND*

Research within the Molecular Plant Physiology group focuses on plant stress, particularly the effect of drought stress on the growth and development of legume crops such as soybean and dry beans. The research aims to develop climate-resilient varieties adapted to local growing conditions. Climate change is causing many parts of the world, especially Africa, to become warmer and dryer. This can severely affect food production in the future. Legumes have the unique ability to form a symbiotic association with nitrogen-fixing rhizobacteria in root structures called nodules. The ability to bind atmospheric nitrogen provides an advantage in that legume crops require lower input relating to synthetic fertilizers. Therefore, it provides for more sustainable production; it also results in protein-rich food that contributes to food and nutritional security. Production and nutrition are negatively affected by drought, and a better understanding of the mechanisms related to drought tolerance is needed. We, therefore study the molecular pathways involved in drought stress responses to provide targets for crop selection and improvements.

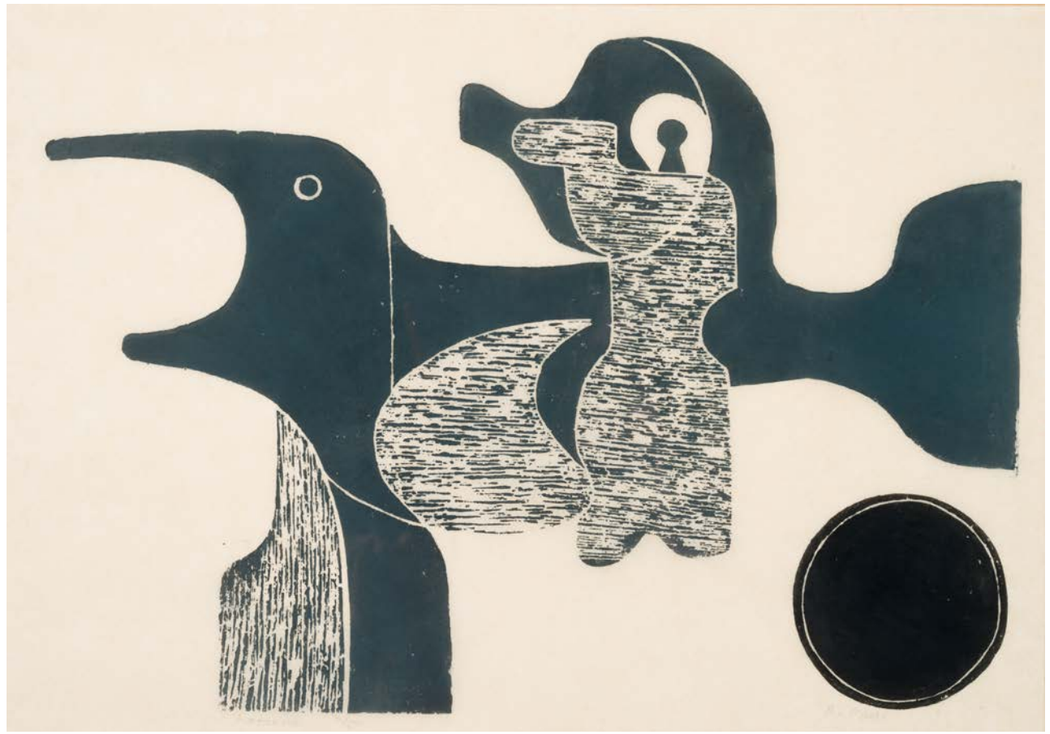
## *OBJECTIVES OF THE RESEARCH PROGRAMME*

- Evaluate legume development under controlled and drought conditions.
- Develop markers for drought tolerance.
- Evaluate the effects of stress on the nutritional value of legume seeds.

## *HIGHLIGHTS OF THE RESEARCH*

- We have developed a catalogue of genes influenced by drought stress during soybean development in different plant tissues using transcriptome sequencing. Using this catalogue, we have identified specific pathways that are critical in the plant's response, which might provide targets for selecting improved tolerance against drought stress.
- We have also evaluated how root characteristics and specific rhizobacteria influence nodulation and nitrogen fixation under drought conditions.

Soyabean cultivated in a phytotron at FABI



Artist: Ranko Pudi

# *Molecular Plant-Pathogen Interactions (MPPI)*

**Research Leader:** Prof. Dave Berger

**Team Members:**
Prof. Mathews Dida (Maseno University, Kenya)
Prof. Ingo Hein (James Hutton Institute, Scotland)
Prof. Fourie Joubert (Department of Biochemistry, Genetics and Microbiology, UP)
Prof. Nelishia Pillay (Department of Computer Science, UP)
Prof. Jacques Theron (Department of Biochemistry, Genetics and Microbiology, UP)
Prof. Yves van de Peer (VIB and Ghent University, Belgium)
Prof. Terry Aveling
Prof. Irene Barnes
Prof. Kerstin Krüger
Prof. Gerhard Pietersen
Dr Nicky Creux
Dr Bridget Crampton
Dr Tuan Duong

## *BACKGROUND*

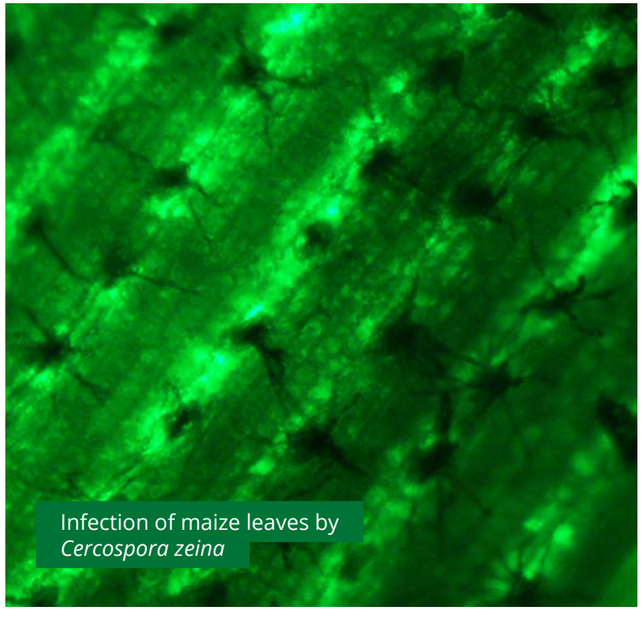
The MPPI research group conducts collaborative research on crop diseases of economic importance in Africa and globally. The main research focus is Grey leaf spot (GLS) disease in maize. This pathosystem is used as a research model to understand molecular mechanisms of plant host resistance and fungal pathogenicity. In addition, the MPPI group completed fungal disease surveys, maize virus discovery and explored maize defences against the Fall armyworm pest. The goal is to develop sustainable management strategies for long-term food security.

## *OBJECTIVES OF THE RESEARCH PROGRAMME*

- Understand maize resistance to GLS at the molecular level.
- Catalogue the population dynamics of *Cercospora zeina* in Africa.
- Surveying maize foliar diseases on smallholder farms in KwaZulu-Natal and Eastern Cape.
- Quantify the impact of foliar diseases on maize yield.
- Evaluate maize secondary metabolites against Fall armyworm.

## *HIGHLIGHTS OF THE RESEARCH*

- A maize basal resistance gene against GLS was identified. Gene discovery research was carried out in a maize line with resistance to GLS disease. This led to the identification of a receptor protein thought to recognise the mannose sugars in the cell wall of the invading fungal pathogen *Cercospora zeina*.
- Northern leaf blight was the most severe foliar disease in a three-year survey of maize smallholder farms in KwaZulu-Natal and Eastern Cape. GLS, Phaeosphaeria leaf spot and common rust were also present in all fields at high incidence.
- Susceptible maize hybrids had yield losses from northern leaf blight of 36%-72% in a controlled field trial. However, several local maize hybrids exhibited resistance to NLB on account of resistance breeding efforts locally.
- Maize yellow mosaic virus (MaYMV) was reported for the first time in South Africa through analysis of RNA genomics data, and found in the oldest material (2009) sampled to date worldwide. A countrywide maize virus survey showed that it was present in maize grown in six provinces of South Africa. The virus is present at extremely low levels in maize plants and leaf reddening symptoms were not observed. This aphid-borne virus appears to be widespread globally and is not associated with observable yield losses.



Infection of maize leaves by *Cercospora zeina*



- One of the most comprehensive population genetics studies of a cereal fungal pathogen in Africa was completed and resulted in the following outcomes:
  - *Cercospora zeina* is the causal agent of GLS in five countries of East and Southern Africa surveyed (South Africa, Kenya, Uganda, Zambia, and Zimbabwe). *Cercospora zeae-maydis*, which can also cause GLS, was not present.
  - Single introduction of *C. zeina* into Africa is unlikely due to high genetic diversity observed from microsatellite marker analysis of 964 isolates.
  - The *C. zeina* population sampled in Zambia appears to be distinct. Populations in Kenya and Uganda clustered together, as well as populations in South Africa and Zimbabwe, indicating gene flow between countries that ar e in close proximity.
  - Rare cases of identical microsatellite haplotypes of the fungus near Cedara, South Africa and in Kenya and Uganda point to human-mediated dispersal.
  - Differences in cropping systems between southern Africa and East Africa did not result in differences in genetic diversity of the pathogen. This indicated that a single summer season and a fallow/ alternative crop winter season in the south did not impact pathogen populations differently from the continuous, two-season per year maize cropping in East Africa.
- Maize treated with an endogenous peptide that activates defences against other insect pests resulted in a reduction in Fall armyworm larvae growth rate in field assays, but the difference was not significant in growth room assays. Maize plants with reduced kauralexin levels showed higher larval growth rate than wild-type plants in growth room assays. However, this result was not seen with a different Fall armyworm culture. The cultures differed in the content of corn strain, rice strain and hybrid insects. This highlights the need for DNA monitoring of Fall armyworm laboratory cultures for strain type when conducting feeding assays.

# Phytobacteriology

**Research Leader:** Prof. Teresa Coutinho

**Team Members:** Prof. Jacquie van der Waals
Dr Pedro Lebre (CMEG, UP)

## BACKGROUND

The Phytobacteriology Programme was initiated in 2003 and has, for 15 years, focused on the opportunistic pathogen, *Pantoea ananatis*. Unlike many other bacterial pathogens, this bacterium lacks a Type 3 secretion system, a key component of pathogenicity. Discovering how this pathogen initiates infection and eventually causes symptoms in their hosts has been at the core of this programme. Over the last couple of years, however, our research has expanded to include other bacterial pathogens of vegetables (tomatoes and onions) and fruit trees (stone fruit and bananas). Our focus has been on attempting to understand their biology (how they interact with their host), ecology (how they interact with the environment and other organisms) and epidemiology (how the disease develops in populations of the pathogen and host).

## OBJECTIVES OF THE RESEARCH PROGRAMME

- Characterizing and typing isolates of pathogenic bacteria responsible for economically important diseases of agricultural crops.
- Study the epidemiology, ecology and biology of selected emerging plant pathogenic bacteria.
- Identify bacterial members of the microbiome of selected plant tissues using 16S rRNA profiling and attempting to determine their functional role using a metagenomic approach.

## HIGHLIGHTS OF THE RESEARCH

- The taxonomic status of *Xanthomonas vasicola* and its pathovars has now been verified. The economically important pathogen of banana responsible for wilt is now *X. vasicola* pv. *musacearum*.
- The pathogen causing bacterial streak of maize and many other diseases has been placed in *X. vasicola* pv. *vasculorum*. This includes the pathogen responsible for blight and dieback of *Eucalyptus* that jumped from sugarcane to this host. The molecular mechanisms allowing this host jump to occur are still being investigated.
- A study on the genetic diversity of *X. vasicola* pv. *musacearum* has confirmed that the centre of origin of this pathogen is Ethiopia.
- It was established that nematode infestation, drought and *Pseudomonas syringae*, cause of bacterial canker of plum trees, are not solely responsible for plum decline in the Western Cape.
- Onion bulbs harbour several bacteria including known bacterial pathogens viz. *P. ananatis, P. agglomerans, P. allii* and *Burkholderia cepacia.* Characterizing and typing isolates of pathogenic bacteria responsible for economically important diseases of agricultural crops.
- Study the epidemiology, ecology and biology of selected emerging plant pathogenic bacteria.
- Identify bacterial members of the microbiome of selected plant tissues using 16S rRNA profiling and attempting to determine their functional role using a metagenomic approach.

Bacterial streak disease of maize



# Plant Virology

**Research Leader:** Dr David Read

**Team Members:** Prof. Gerhard Pietersen (University of Stellenbosch)
Dr Ronel Roberts (ARC-TSC)

## BACKGROUND

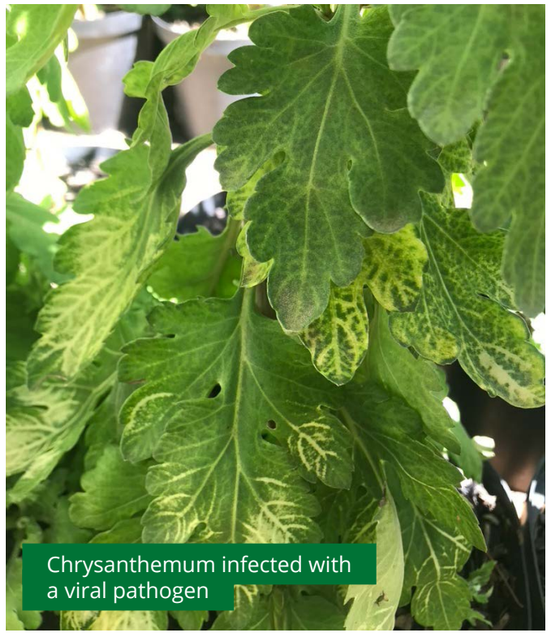
The Plant Virology Group was incorporated into FABI in 2010 and focussed primarily on the viruses of citrus and grapevine. At that stage, the group was led by Prof. Gerhard Pietersen, who, in 2017, relocated his primary research functions to the University of Stellenbosch. Following his departure, the University of Pretoria was left with very limited capacity in terms of plant virology. Dr David Read obtained his PhD within the plant virology group in 2015 and re-joined FABI in November 2020 in order to re-establish capacity within plant virology. Currently, the plant virology group is working on gaining a better understanding of the viral status of crop, ornamental and native plants, using an RNAseq metaviromics approach. To date, approximately 500 samples have been collected from diverse plant species, including deciduous fruits, oilseeds and winter and summer grains. These samples are in the process of being prepared for a large-scale sequencing project, which will provide an improved overview of the viral status of economically important plants and their companions. This in turn will allow for much more comprehensive diagnostics platforms. This ties in with the longer-term vision of bringing plant virology capacity into the developing Plant Health Centre at FABI and Innovation Africa @UP, which is an essential addition to the research and services we offer to government and industry partners.

## OBJECTIVES OF THE RESEARCH PROGRAMME

- Genomic characterization of known and novel viruses from a highly diverse set of crop, ornamental, and native plant species
- Establishment of a set of diagnostic assays based on PCR and/or isothermal amplification methods.

## HIGHLIGHTS OF THE RESEARCH

- The group is currently undertaking the largest viral survey of South African pome and stone fruit.
- Seven novel viruses from various species of the Amaryllidaceae family have been characterised at the genomic level.
- The presence of grapevine virus L has been reported on South African wine grape cultivars for the first time, which included diverse divergent variants.



Chrysanthemum infected with a viral pathogen

Foliar symptoms of sunflower infected with a novel viral pathogen

# *Potato Pathology Programme @UP*

**Research Leader:** Prof. Jacquie van der Waals

**Team Members:** Prof. Teresa Coutinho
Prof. Quenton Kritzinger (Plant and Soil Sciences, UP)
Prof. Martin Steyn (Plant and Soil Sciences, UP)
Prof. Wayne Truter (Plant and Soil Sciences, UP)

## *BACKGROUND*

The primary research focus of this programme is the epidemiology, diagnosis and control of soil- and seedborne diseases of potatoes. Diseases currently being investigated include powdery scab (*Spongospora subterranea* f. sp. *subterranea*), black scurf and stem canker (*Rhizoctonia solani*), and blackleg and soft rot (*Pectobacterium* and *Dickeya* spp.).

## *OBJECTIVES OF THE RESEARCH PROGRAMME*

Soil- and seedborne diseases are among the most limiting factors in the production of potatoes and thus the main focus of the Potato Pathology Programme @UP is understanding the pathogens and epidemiology of the diseases to improve management in the field. To do this, various techniques are combined to better understand disease spread and development in the field, and ultimately use this information to provide growers with a risk management strategy for the disease under consideration.

## *HIGHLIGHTS OF THE RESEARCH*

- *Spongospora subterranea* f. sp. *subterranea* (Sss) causes three diseases on potatoes, namely root infection, root galling and powdery scab on tubers. It is notoriously difficult to control due to the longevity of its resilient resting spores in soil, scarcity of effective chemical controls, and lack of fully resistant cultivars. No single management measure will control powdery scab, and accordingly growers must use as many of the available options as possible to control the disease. Research results from the Potato Pathology Programme have provided growers with answers to many questions in the fight against this devastating disease, such as optimal field choice, soil treatment at pre-planting or planting stages, selection of resistant cultivars, seed tuber treatment, post-planting crop management, harvesting strategies, and post-harvest hygiene.

- We investigated the role of microbial factors and water stress in causing corky crack blemishes of potatoes in South Africa. Greenhouse trials indicated that planting of tubers in soil contaminated with a combination of *Rhizoctonia* species resulted in the development of corky crack blemishes on progeny tubers. The findings of this study are crucial in the development of effective integrated strategies for the management of corky crack disease and to improve the tuber quality in the South African market and globally.

- The blackleg-soft rot-aerial stem rot disease complex causes serious losses to the South African potato industry. It is caused by species in the genera *Pectobacterium* and *Dickeya*, that are collectively known as the Soft Rot Pectobacteriaceae (SRP). A study was conducted to determine the predominant and most pathogenic SRP species infecting potatoes in South Africa. It was found that *Pectobacterium brasiliense* represented the overwhelming majority of the isolates, while a few *P. carotovorum* subsp. *carotovorum* isolates were also found. Two isolates each, of the novel species, *Pectobacterium versatile* and *Pectobacterium polaris*, were also identified. Results from the pot trial and tuber slice assay revealed that *Pectobacterium brasiliense* was the most pathogenic species as it had a significantly higher incidence and severity of symptoms compared to the other species.

- A long-term crop rotation trial in the eastern Free State was established in 2013 to determine the long-term impact of agriculture on soil microbial diversity, the structure and composition of root-associated microbial communities of different crop species used in different crop rotation sequences, and the variations in DNA levels of soil-borne fungi in the *Fusarium solani* species complex (FSSC). Plant developmental stage significantly influenced bacterial community composition as bacterial communities were observed to diverge at germination and converge at maturity. Although plant-soil feedbacks revealed that all the cropping sequences promoted the proliferation of pathogenic bacterial species, the sunflower crop and the fallow period had a suppressive effect on the pathogenic bacteria assessed in this study. Crop type, crop growth stage, rotation sequence, season and soil chemistry all had significant effects on both bacterial diversity and abundance of FSSC in the rhizosphere of rotation crops.

*Spongospora* - potato field trials in KwaZulu-Natal

Powdery scab lesions on a potato tuber

# *RGE-FABI Tree Health Programme*

**Research Leader:** Prof. Mike Wingfield

**Research Team:** Prof. Irene Barnes
Prof. Bernard Slippers
Dr Jupiter Mauro Abad (RGE)
Dr Alvaro Duran (RGE)
Dr Fahimeh Jami
Dr Leonardo Oliveira (RGE/Bracell)

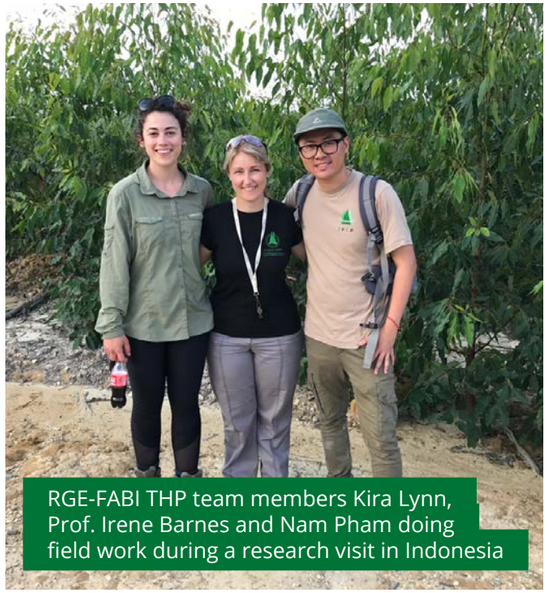
## *BACKGROUND*

The RGE-FABI Tree Health Programme (RGE-FABI THP) was established in 2018 as a collaborative venture between the Indonesian-based Royal Golden Eagle (RGE) Group and the Forestry and Agricultural Biotechnology Institute (FABI) at the University of Pretoria. This partnership addresses challenges posed by pests and diseases to RGE's forestry operations in Indonesia and Brazil. The initiative involves FABI researchers working in partnership with RGE's divisions: Asia Pacific Resources International Holdings Limited (APRIL) and Brazil-based Bracell Limited.

Insect pests and diseases are emerging as one of the most important threats to plantation forestry globally. This situation presents significant challenges for all forestry companies. The RGE-FABI THP recognises FABI's capacity as the largest single group of scientists working on tree health globally. The research conducted by the FABI tree health team is broad, including trees in natural ecosystems and planted forests. But its core focus is on reducing the impact of insect pests and pathogens in plantations of mainly non-native trees such as species of *Eucalyptus*, *Acacia* and *Pinus*. It is in this domain that RGE and FABI collaborate.

Professor Mike Wingfield, who has the responsibility of coordinating the RGE-FABI THP, is passionate regarding global collaboration. In this regard, his philosophy is that collaboration between forestry companies globally is essential in order to resolve insect pest and pathogen problems affecting plantation forestry. Agents of plantation destruction are moving increasingly rapidly across continents. Consequently, knowledge of problems before they arise in new areas provides forestry companies with opportunities to plan ahead and to reduce losses. Likewise, collaboration in dealing with insect pests via for example biological control requires global partnerships and strategies that stretch beyond country borders. As with other FABI-Industry partnerships, the focus of the RGE-FABI THP is on fundamental research and education, which seeks to empower in-house research and development that can be applied at the operations level. In this way the RGE-FABI THP is valuable not only to the specific partners involved in the project but also to a broader international forestry community who must benefit from increased knowledge regarding pest problems in plantations globally.

The RGE-FABI THP is one of the most important and exciting recent global partnerships to focus on tree health. It closely links the significant research programmes of RGE and FABI. It also funds postgraduate students and postdoctoral Fellows from different parts of the world to study priority disease and pest problems across international boundaries. It has placed RGE's forestry divisions at the forefront of pest and disease problems affecting particularly *Eucalyptus* and *Acacia*. In doing so, it has also expanded the research opportunities, education and experiences of young researchers with an interest in tree health and global collaborative ventures.



RGE-FABI THP team members Kira Lynn, Prof. Irene Barnes and Nam Pham doing field work during a research visit in Indonesia



## *OBJECTIVES OF THE RESEARCH PROGRAMME*

- Conduct research on key pest and disease problems affecting plantations belonging to the RGE Group in Indonesia and Brazil.
- Together with RGE R&D teams, transfer research results to pest and disease management options for RGE operations.
- Education and capacity building for the RGE Group.
- Provision of support for the RGE research team, particularly pertaining to diagnoses of pest and disease problems.

## *HIGHLIGHTS OF THE RESEARCH*

- Various new pests and pathogens affecting *Acacia* and *Eucalyptus* have been discovered and are currently being studied.
- One of the most important disease problems being tackled by the RGE-FABI THP team is *Eucalyptus* scab and shoot malformation (formerly known as *Eucalyptus* Little Leaf Syndrome (ELLS)). Very substantial effort has been expended on this project, and a fungal pathogen *Elsinoe necatrix* sp. nov. has now been identified as the cause and formally described.
- Discovery of new *Fusarium* species and their bark beetle vectors damaging *Acacia crassicarpa* in Indonesia.

Members of the RGE-FABI Tree Health Programme leading one of many field days aimed at extending knowledge on tree health problems and bridging the research/technology transfer/operations chasm

# Social Insects Research Group

**Research Leader:** Prof. Christian Pirk

**Team Members:** Prof. Robin Crewe
Prof. Robin Moritz (extra ordinary)
Prof. Sue Nicolson
Dr Hannelie Human (extra ordinary)
Dr Abdullahi Yusuf

## BACKGROUND

The Social Insects Research Group (SIRG) also known as the 'Bee group' focuses its studies, but does not limit itself, to fundamental and applied aspects of sociality in ants, bees, termites and wasps with a particular focus on honey bees. Hence, we are teaching and building capacity for bee research, including pollination services and disease control, on the African continent and beyond.

## OBJECTIVES OF THE RESEARCH PROGRAMME

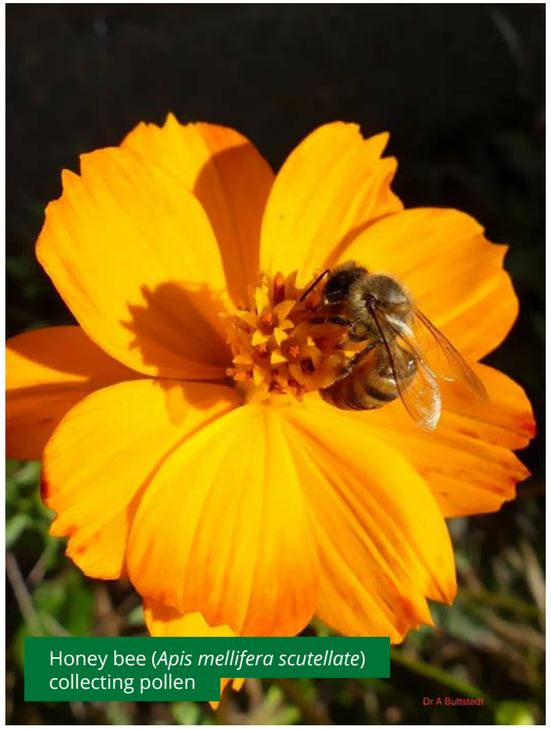
One of our main topics of research is the analysis of pheromonal communication between colony members, using behavioural observations, analysis of the relatedness of the individuals involved, bioassays of their responses to pheromonal compounds and gas chromatographic analysis of chemical signals produced. This work allows us to explore the regulation of reproductive conflicts in honey bee colonies. We also study other aspects of social organisation, such as the diet of workers that reproduce, division of labour, regulation of nest homeostasis, etc.

The group's research on pesticides investigate the impacts they have on the survival and decline of bees as well as the environment. Here our focus is on effects such as mortality, learning and behavioural impairment (foraging, taste, memory, responses to pheromones), physiological (detoxification) and impacts of climate change (temperature). We also investigate the interactions with other organisms including factors shaping the pollination behaviour and ecology of honey bees. With the threats to the survival of managed honey bee colonies, we are doing research into bee diseases and the potential threats they pose to honey bee health and sustainable apiculture. Our group is also part of global initiatives such as COLOSS (Prevention of honeybee Colony LOSSes) and SUPER-B networks that focus on research and improving the wellbeing of pollinators at the global level. In 2015, we were selected onto the Executive Council of the Africa Apiculture Platform (AAP) for honey production, bee health and pollination services of the African Union.

From a more local perspective, we are investigating the population genetics of wild honey bees in South Africa with a view to making recommendations about the conservation of local populations. Honey bees are major pollinators of both native flora and agriculturally important crops. The bees have recently been threatened by several parasites that affect the colonies of commercial beekeepers, and whose effect on the wild population is poorly understood. We are monitoring the population densities of honey bee colonies in different habitats to establish a benchmark against which we will be able to assess the effect of parasites on wild populations in the future.

## HIGHLIGHTS OF THE RESEARCH

The last two years were very productive and resulted in numerous highlights. The group published more than 30 peer-reviewed articles including an invited review on the Cape honey bee.



Honey bee (*Apis mellifera scutellate*) collecting pollen



# Systematics and Evolution of Symbiotic Nitrogen-Fixing Bacteria

**Research Leaders:** Prof. Fanus Venter and Prof. Emma Steenkamp

**Research Team:** Prof. Martin Coetzee
Dr Chrizelle Beukes
Dr Esther Muema
Dr Marike Palmer (University of Nevada, Las Vegas)

## BACKGROUND

South Africa is remarkably rich in legumes and their bacterial symbionts, with which they contribute significantly to biological nitrogen-fixation. In the case of non-native agricultural legumes, these symbiotic bacteria (also referred to as rhizobia) are relatively well-studied, but very little is known about those associating with native legumes in the region. In all cases, however, rhizobial associations are crucial for legume establishment and general ecosystem health. From a biodiversity point of view, rhizobia may also facilitate invasion by non-native legumes such as Australian *Acacia* species, and/or encroachment by generalist native species such as *Vachielia karroo*.

## OBJECTIVES OF THE RESEARCH

Our overall goals are to characterise and describe the rhizobia associated with both native and non-native legume species and to reconstruct their evolutionary histories. For this purpose, we employ standard microbiological procedures combined with genetics and genomics approaches to study the processes driving rhizobial evolution. In this way, we endeavour to determine how rhizobial identity and genetics relate to legume host, geography and environmental factors, to ultimately shed light on the possible forces shaping the biogeography and ecology of these bacteria.

## HIGHLIGHTS OF THE RESEARCH

- We formally described various new rhizobial species. Two of these were *Paraburkholderia strydomiana* and *P. steynii*, which were isolated from the fynbos legume *Hypocalyptus sophorides* and named in honour of the pioneering rhizobial research performed by Prof. Ben Strydom (1932-2018) and Prof. Piet Steyn (1936-). Most recently we also identified and described *P. youngii*, which is a symbiont of mimosoid legumes in South America and whose taxonomy was confused with that of the native South African species *P. tuberum.* We named it in honour of Emeritus Professor Peter Young at the University of York (United Kingdom) who has revolutionized the field of rhizobial ecology.

- Phylogenomics and comparative genomics continues to improve the systematic frameworks underlying rhizobial taxonomy at various levels. For example, we previously used genome data to stabilize the taxonomy of the agriculturally and medically important genera *Burkholderia*, *Paraburkholderia* and *Caballeronia*, amongst others. Now we have extended this work to the agriculturally important genus *Bradyrhizobium* where we demonstrated that phenotypically important traits such as the symbiotic capacity and photosynthesis have distinct evolutionary origins.

- Genome data are also contributing to bacterial systematics in the form of the widely used metric Average Nucleotide Identity (ANI), which provides an average measure of similarity across homologous regions shared by a pair of genomes. An ANI cut-off value is typically employed for delineating bacterial species. Recently this metric has undergone numerous refinements to improve and enhance the calculation process. By using a representative set of bacterial taxa, we clearly demonstrated that "all ANIs are not created equal" and that ANI values obtained are dependent on the specific calculation method used.

- Overall, our research contributed to establishing a solid knowledge base of the diversity of rhizobia associated with native and other locally relevant legumes, and development of the necessary tools for studying the evolution of this assemblage of agriculturally- important bacteria.


Successful hunt for nodules on *Acacia mearnsii*

# *Transcriptional Regulation and Bioengineering of Wood Formation*

**Research Leader:** Dr Steven Hussey

**Team Members/Collaborators:** Prof. Eshchar Mizrachi
Prof. Zander Myburg
Prof. Sanushka Naidoo
Dr Nanette Christie
Dr Raphael Ployet

## *BACKGROUND*

Wood formation involves a strictly controlled developmental programme in which stem cells proliferate, elongate and differentiate into cell types that specialize in structural support, water transport and the transfer of metabolites. A dynamic network of regulatory genes ensures that wood cells deposit thickened cell walls and undergo programmed cell death in a precisely controlled fashion. Using biotechnology and particularly synthetic biology, we now have the tools to decipher the structure of this network and strategically re-engineer its topology to potentially alter wood development in forest trees such as *Eucalyptus*.

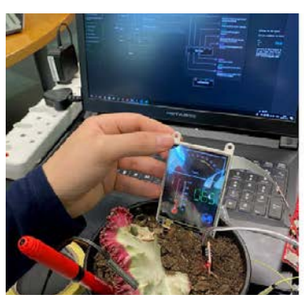
## *OBJECTIVES OF THE RESEARCH PROGRAMME*

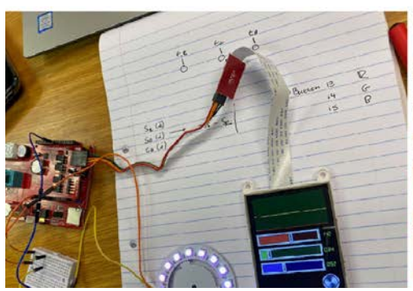
- Develop gene regulatory network models of wood formation.
- Uncover how DNA-binding proteins and the dynamic packaging of DNA influences gene expression during wood formation.
- Design and produce synthetic gene constructs that can be easily assembled to facilitate woody biomass re-engineering approaches.
- Identify and test regulatory genes as potential candidates for altering wood development.

## *HIGHLIGHTS OF THE RESEARCH*

- Our group has produced pioneering research into identifying the unique patterns of accessible DNA in development wood which facilitate regulatory protein binding and gene activation in *Eucalyptus* spp.
- We have also analysed the evolutionary conservation of a gene switch promoting fibre cell development across distantly related plants, showing conserved function across woody and non-woody plants.
- Dr Raphael Ployet, a postdoctoral Fellow in this group, has made excellent progress in developing improved machine learning models for the prediction of gene targets activated by regulatory proteins, and we have greenhouse trials involving bioengineered trees with modified hormone signalling genes.
- Through national and international collaborative work, the group has supported the elucidation of gene networks underlying drought tolerance in resurrection plants, as well as the publication of three review papers over the last two years.
- The group has received NRF funding to screen for some 6,400 possible interactions between 200 regulatory genes and their potential gene targets in *Eucalyptus*. This work is aimed at future bioengineering of novel wood chemical and structural properties for advanced bio-based products.
- Finally, we have set up local capacity for novice-friendly electronic engineering for biosensors and devices through the Biomaker Challenge, in partnership with the University of Cambridge and UP Makerspace.

*Eucalyptus* plantlet with transgenic roots (red)





Participants of a Biomaker Challenge workshop (2019)

# *Tree Protection Co-operative Programme (TPCP)*

**Research Leader:** Prof. Bernard Slippers

**Research Team:**

Prof. Irene Barnes
Prof. Martin Coetzee
Prof. Wilhelm de Beer
Prof. Almuth Hammerbacher
Prof. Brett Hurley
Prof. Sanushka Naidoo
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Dr Tuan Duong
Dr Gerda Fourie
Dr Fahimeh Jami
Dr Thabiso Motaung
Dr Trudy Paap
Dr Quentin Santana
Dr Michelle Schröder
Dr Neriman Yilmaz

## *BACKGROUND*

The Tree Protection Co-operative Programme (TPCP) celebrated its 32nd year of operation in 2021. Over this period the TPCP has become an institution in the South African forestry industry and has been critical to its ability to deal with one of the greatest threats to its sustainability, namely pests and diseases. Today the programme serves all role players in the South African forestry community: from large industries to small growers, to government and civil society. The programme has demonstrated that it can deliver outstanding services to support the pest management needs of the forestry sector, while at the same time ensuring that the highest quality of research and training of graduate students is maintained.

The TPCP provides a hub for international expertise and research on plantation pests and diseases. This linkage is increasingly relevant given the accelerating rate at which pests and pathogens are moving around the world. This rate has increased at least four-fold over the past two decades, and simply cannot be dealt with efficiently solely at a local scale. The connections with researchers and industries globally provide key early warnings about new emerging pests and pathogens, but crucially also provides access to the best knowledge and experience for their management and control.

The successes of the TPCP is the result of the dedicated and high-quality collaborative work of many contributors including students, technical and academic staff members of the University of Pretoria, industry members of the TPCP and their staff, government partners, as well as forestry researchers and managers in other parts of the world. The TPCP research team is grateful to this remarkable group of people who make important contributions to the common goal of the TPCP, namely, “keeping trees healthy”.

The impact of the TPCP has, over the past 32 years, stretched well beyond dealing with forest pests and diseases. The programme provided the anchor for the establishment of the Forestry and Agricultural Biotechnology Institute (FABI) in 1998, which today houses a number of internationally-recognised forest and agricultural biotechnology research programmes. Through this influence, the TPCP has made a major contribution to the development of research in this field in South Africa and globally.

## *OBJECTIVES OF THE RESEARCH PROGRAMME*

- Maintain a comprehensive programme that address the forestry pest and disease needs of the country and beyond, including knowledge generation, training of specialists, and the development and support for integrated management solutions.
- Conduct high quality research that covers all key pathogen and pest groups in the country, including well-known and emerging global pests and pathogens, developing frontier technologies to understand the biology, epidemiology and community ecology of these organisms, and developing and supporting biological control, surveillance and other management tools.
- Provides a platform to engage with various other research programmes in forestry and agricultural biotechnology globally to share knowledge, facilities and capacities.
- Ensuring that the industry can efficiently access the knowledge and pest management services required to ensure long-term sustainability of plantation forestry in South Africa.

## *HIGHLIGHTS OF THE RESEARCH*

- The TPCP is a leader in Precision Pest Management of plantation pests, a concept that considers the variation and diversity in pest systems. This includes both inherent (genetic and phenotypic) variation and differences in the expression of these systems in a landscape, due to variance in both abiotic and biotic interactions.

- The TPCP supported the implementation of a very efficient management program that has brought the *Sirex noctilio* outbreaks in the country under control. This included world-class basic research on the biology of the system, and translation of this information for implementation of the management practices (in particular biological control). The program has made leading contributions to understanding global invasion patterns, key traits that influence the woodwasp’s ecology and biological control, including its mating system, visual and chemical ecology. Ongoing work is translating our strong fundamental understanding of the system to a genetics and genomics level.

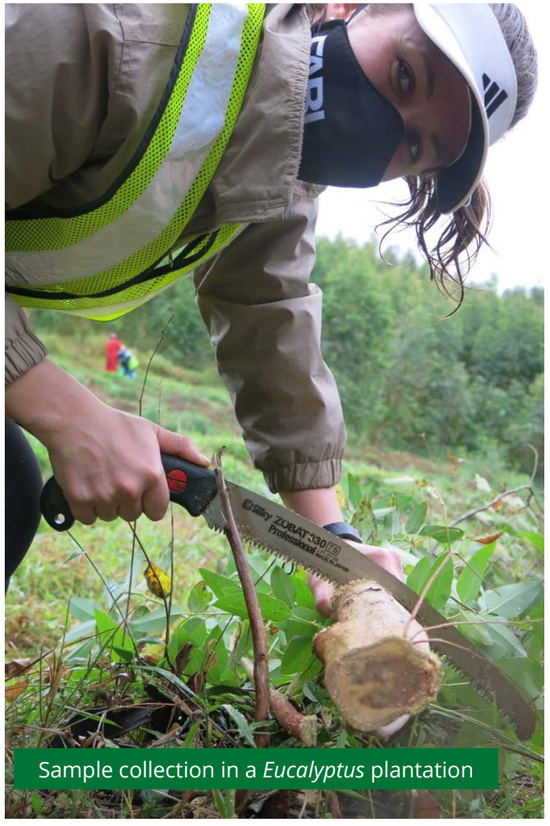
- Several invasive insect pests affect the health of *Eucalyptus* trees around the world. The TPCP has made significant contributions to revealing the importance of cryptic lineages, which matter for its management. For example, the team has tracked the invasion of two cryptic lineages of the *Eucalyptus* gall wasp, *Leptocybe invasa*, around the world, as well as its interaction with its host and various parasitoids (including *Selitrichodes neseri*, *Quadrastichus mendeli* and *Megastigmus zebrinus*). Similarly, the team has characterised cryptic and population-level diversity in populations of *Gonipterus* and its natural enemies in native and invasive regions.

- The TPCP has become one of the leading programs globally studying chemical communication systems in plantation pests, including work on both pheromones and kairomones. Identification and use of pheromones for mass trapping of pests has been one of the long-term goals of the TPCP. Systems for which this has been characterised include *Coryphodema tristis*, *Gonipterus* sp. 2, *Nudaurellea* sp., *S. noctilio* and *Euproctis terminalis*. Outcomes of this work are already being applied in surveillance and mass trapping programs, and is now leading to research on mating disruption and the potential for reverse chemical ecology from genomics.

- The TPCP has made a significant contribution to the identification and characterization of biological control agents, as well as the development methods to use them against plantation pests. Apart from the nematode biological control program on the devastating Sirex wood wasp, the team also discovered and described known and previously unknown species of entomopathogenic nematode species of *Heterorhabditis* and *Steinernema*, and their bacterial symbionts, that show potential as biological control agents against white grubs (larvae of chafer beetles) that are important forestry and agricultural pests in the country. Furthermore, additional parasitoids of *Gonipterus*, *Anaphes inexpectatus* and *Centrodora damoni*, were collected and their basic biology studied.

- The TPCP contributed extensive knowledge on the diversity, genetics, genomics and evolution of fungal symbionts of bark and ambrosia beetles, especially those associated with invasive species. The group is also playing a leading role in research, legislation and management of the Polyphagous Shot Hole Borer, *Euwallacea whitfordiodendrus*, in South Africa, including leading the development of biological control for it. This beetle poses a major threat to a large number of tree species in urban, agricultural and native environments.

Mapping out treatment plots for mating disruption trials of *Coryphodema tristis* (Cossid moth) in an affected *Eucalyptus nitens* plantation



Sample collection in a *Eucalyptus* plantation

- The TPCP represents a global centre of excellence for the study of the pitch canker fungus, *Fusarium circinatum*, which is one of the most serious diseases of Pine globally. The work included gaining deep insights into the genome of *F. circinatum* and genes harboured by its genome linked to virulence/pathogenicity, mating and other factors associated with evolutionary fitness, and with relevance to management. Work also focusses on field biology aimed at understanding the dynamics of the pathogen in the nursery environment, climatic modelling, infection biology on seedlings, as well as the possible role of seedlings in attracting the pathogen to its roots.

- The TPCP commonly works on emerging global pests and pathogens years before they are introduced into South Africa, and in the process provide both national and international biosecurity resources and support. One such example is the rust pathogen *Austropuccinia psidii*, which poses a significant threat to Myrtaceae in South Africa and other regions of the world. The TPCP is deeply involved in both basic and applied work to understand the diversity, genetics, epidemiology and host association of the pathogen, across its global distribution.

- Soilborne diseases, and in particular those caused by *Phytophthora* diseases, remain some of the most serious locally and globally. The TPCP has, over the past 32 years, advanced the understanding of the introduced and native diversity of these organisms in natural and plantation forests of South Africa. We have also studied their pathogenicity on various hosts. We are now characterizing the total microbiome in forestry soils, with an understanding of other factors influencing these pathogens, as well as the health of soils and the plants that it sustains in general.

- Endophytic fungi in plants are important elements to study in the biology of plants as they can contribute significantly to the health and response of a plant to its environment, both biotic and abiotic. These endophytes can also harbour pathogens that are then easily spread around the world. In this regard the Botryosphaeriales have been a model system for us. We have characterised diversity, from orders to populations, for these fungi at a global level, and characterized its interaction with its host. The group is building on this work through whole microbiome studies to understand its interaction with the endophytic community.

- Canker diseases of trees can cause major damage, especially in clonal forestry. Such pathogens in the Cryphonectriaceae and Teratosphaeriaceae can be credited with the establishment of the TPCP in the first place. Research in the group has contributed to the understanding of global distribution, mating systems, origins and spill-over from native environments to commercial species and threats for future emergence of new disease outbreaks. The TPCP also contributed significantly to the understanding of genomes of all the key species infecting *Eucalyptus* and is leading work that explores the intersection between this information and our basic understanding of biology in the group.

- Wilt and canker diseases caused by *Ceratocystis* species are amongst the most serious global threats to trees in forestry and agricultural industries, and have already resulted in severe losses of *Eucalyptus* spp. in South America and *Acacia mangium* in Asia. The TPCP is one of the leading groups internationally contributing to monitoring and research of *Ceratocystis* on a global scale, including the description of new species linked to emerging disease outbreaks, understanding origins and global patterns of spread, as well as host range, ecology and management. We have the largest collections of these fungi from around the world and have used this to contribute substantially to the global genomics resources for this group of pathogens. The TPCP is also the leading producer of genome sequences and an understanding of evolution and speciation in this group.

- Leaf diseases of *Eucalyptus* caused by the Teratosphaeriaceae and Mycosphaerellaceae are amongst the most serious, and have caused devastation and forced changes of species in many parts of the world. Work from the TPCP has, however, also shown that this group of fungi is amongst the most common amongst endophytic fungal communities in *Eucalyptus*. The TPCP has long-standing work on various species in these groups, but in particular focus on understanding the global diversity, spread, genomics, mating strategy and infection biology of *T. destructans*. Ongoing work seeks linkages between the infection process, resistance and plant genetic markers.

- Pine needle pathogens are receiving increased attention globally as a number of new disease outbreaks are being reported, both in native and non-native pine growing regions. The group has done ground-breaking work on pathogens such as *Phytophthora pinifolia*, *Dothistroma* species and *Lecanosticta* species. The work includes global distribution of diversity, new species discoveries, genomics, mating biology and hybridization patterns, and infection biology. Sentinel trials with South African Pine material, have been planted in other parts of the world in order to determine the effects of this pathogen on our hybrid species.

- The research group has contributed to global studies on bacterial diseases that affect plantation forestry. These bacterial pathogens include *Pantoea ananatis*, *Ralstonia pseudosolanacearum* and *Xanthomonas* species. Work in the group includes genomics, epidemiology and community ecology. While these pathogens typically do not cause major damage in South Africa, they are known to do so in other parts of the world. The TPCP therefore maintains capacity and monitors these pathogens.

- *Acacia* species only make up a small percentage of the total forestry estate in South Africa, but are nevertheless a valuable and important species. The TPCP has contributed to understanding pest and disease diversity on this host in South Africa, and how this spills over from and to native species. The group has also contributed to understanding basic biology of important emerging diseases such as the rust caused by *Uromycladium acaciae*, and is now exploring the chemical ecology of important pests such as the wattle bagworm.



- The research group maintains a very active diagnostic clinic that screens hundreds of samples annually for members of the programme. These diagnostic services not only provide members with valuable information for management, but helps the program to stay in touch with new diseases, or disease outbreaks around the country. The group also supports the industry via extension services, both through expert technicians and via student and staff visits; typically including more than 70 trips a year to all parts of the country.

- There is significant other work on systems such as *Armillaria*, *Ophiostoma* and insect pests that cannot all be covered here, and for which we suggest the reader visits our website: ***www.fabinet.up.ac.za/tpcp***

*Gonipterus* sp. 2 (Eucalyptus snout beetle), an important pest of various *Eucalyptus* species in South Africa

Screening of disease-resistant clones in TPCP projects at the Disease Screening facility of FABI

*Sirex noctilio* (Sirex woodwasp), a serious pest on pine trees in South Africa and other countries

# NEW SATELLITE LABS IN FABI

Two new Satellite Labs were established in FABI during this reporting period. The satellite laboratories at FABI, in partnership with prestigious international institutions, cements the Institute's commitment to excellence in transdisciplinary research that advances plant health and food security. They are critical to building capacity and world-class collaborations for long-term research programmes as they create a link between a host institute and a partner in industry or academia to transfer knowledge and are led by next-generation experts in fields in which the host institute wants to build capacity. In return, the partner can benefit from another field of expertise that might be well developed at the host institute.

**Artificial Intelligence in Farming**
The satellite lab in Artificial Intelligence in Farming was officially launched on 7 September 2020. It is led by Prof. Abdoulaye Banire Diallo of the Bioinformatics Laboratory at Université de Québec à Montréal in Canada.

The current explosion in next generation biological- and information technologies is disrupting agriculture business globally, opening transformative new opportunities for intensification and diversification in a sustainable manner. Africa is rich in agricultural growth opportunities and the intersection of these opportunities makes this a key moment for the continent to stimulate economic and social development through accelerated agricultural development.

Africa lacks the capacity and data needed to unlock the opportunity that the era of digital and precision agriculture offers. These opportunities will also need to be connected with a fragmented agricultural community in a way that allows ownership, social development and resilience. At the same time, the intended intensification needs to be mindful of the value of the continent's biodiversity and landscapes that provide vital ecosystem services, as well as the threats that it will face from climate change, pests and disease.

The satellite lab in Artificial Intelligence in Farming at FABI together with Future Africa (a global research hub at the University of Pretoria dedicated to transdisciplinary research for innovation on the continent) will, in partnership with Engineering 4 @UP, will contribute in transforming the Innovation Africa @UP Experimental Farm into a digital research hub. This will be done by combining development in sensor technology, autonomous vehicle and drone technology, virtual reality, data science and artificial intelligence with the biological sciences. Innovation Africa @UP will provide an anchor for the development of a network of like-minded Agricultural Research Hubs that are transformed into 'digital and precision agriculture research and training hubs' across the continent, sharing resources, capacity and data. This network can provide a focused investment platform for the future of agriculture on the continent by developing an interface between business, governments, development and research organizations.

**Remote Sensing of Plant Health**
The satellite lab in Remote Sensing of Plant Health, established on 7 September 2020, will harness remote and close-range sensor data (acquired through the use of satellites and unmanned aerial vehicles) to monitor crop and forest health. Dr René Heim and Prof. Wouter Maes of the UAV Research Centre at Ghent University lead this programme.

The acquisition of remote and close-range sensor data via satellites, aeroplanes or unmanned aerial vehicles (UAVs) has already been proven valuable.  For example, this data is used for pest and disease detection in managed and natural landscapes. The application of UAVs in combination with optical sensors for crop and forestry status monitoring is a rapidly developing field that offers immense opportunities for plant health management at a scale and level of detail never before possible.

FABI is hosting world-leading programs focusing on vexing problems regarding the global burden of plant diseases and pests in commercial systems, as well as their spill-over into native vegetation. The university also has extensive capacity in Engineering and Information Sciences relevant to remote sensing of plant health, in particular in departments such as Civil, Electrical, Electronic and Computer Engineering and Computer Science. The University of Pretoria wishes to capitalise on these capacities by developing capacity in the field of remote sensing of plant health. Such an endeavour will also link to developments in the chemical ecology, plant phenotyping and data science capacity in FABI.

The UAV Research Centre (URC) is a recently established centre of excellence that merges knowledge on UAV remote sensing applications at Ghent University. This multidisciplinary research centre is led by Prof. Wouter Maes and Prof. Hiep Luong (Faculty of Engineering). Sustainable precision agriculture is one of the two key focus domains, with particular expertise in early detection of plagues and diseases. In addition, the application of UAV technology in improving agricultural practices in developing countries is one of its main targets.

The collaboration with FABI is a perfect fit for the URC. It will help to expand research through shared projects, and to expand knowledge and experience on plant health monitoring in other regions and for other crops and plants. The expertise of FABI in plant health biotechnology is highly complementary with the expertise of the URC, and provides the basis for potential fruitful and long-lasting collaboration.

# PEST AND DISEASE MONITORING AND DIAGNOSTIC SUPPORT

# Monitoring Tree Health at Sentinel Sites: Botanical Gardens and Arboreta

**Responsible persons:** Prof. Brett Hurley
Prof. Bernard Slippers
Prof. John R Wilson (Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Stellenbosch & South African National Biodiversity Institute, Kirstenbosch Research Centre, Cape Town)
Prof. Mike Wingfield
Dr Mesfin Gossa
Dr Trudy Paap

## PROJECT RATIONALE

The number of non-native forest pests and pathogens is increasing globally. This is mainly attributed to the increasing international trade and movement of plant material. Unfortunately, many non-native organisms are unknown to science prior to their arrival in a new environment or at least not known to cause severe damage in their native range. Consequently, they can not be regulated against or detected and stopped at checkpoints. In response to this, there has been a move towards the use of 'sentinel plantings' to provide an early warning system to identify new plant pest and pathogen risks before they are moved from their place of origin. Botanical gardens and arboreta host diverse collections of exotic and native plant species in diverse regions around the world, thus presenting a unique opportunity for sentinel research. Plants in botanical gardens can be used to identify novel host-pest associations and for early detection of damaging plant pests and pathogens. Furthermore, they can be used to identify native pest and pathogen risks that could emerge as a result of change in the environment or management regimes. Understanding the value of botanical gardens for plant health research, a postdoctoral research project focusing on monitoring plant health in botanical gardens in South Africa was initiated in 2016.

## COLLABORATION WITH THE SOUTH AFRICAN NATIONAL BIODIVERSITY INSTITUTE'S DIRECTORATE: BIOLOGICAL INVASIONS (SANBI DBI)

The key objectives of the project reside firmly within the South African National Biodiversity Institute's Directorate: Biological Invasions (SANBI DBI). The stated mission of the Institute is to protect biodiversity and ecosystems from the negative impact of invasive species. The central focus of this project is the detection of current and potential pests and pathogens using sentinel plants within botanical gardens. Information gathered about a particular pest or pathogen, including potential host range, can then be used to determine the risk that they pose and potentially aid in the development of appropriate eradication and/or containment programmes. The project also presents the opportunity to work with and train garden staff to increase capacity with regards to detection and management of tree pests.

## PROJECT HIGHLIGHTS

- Assessment of plant health was undertaken in 10 botanical gardens across South Africa, namely Free State, Harold Porter, Kirstenbosch, KwaZulu-Natal, Lowveld, Pretoria and Walter Sisulu National Botanical Gardens, Pretoria National Zoological Garden, Arderne Gardens and Durban Botanical Gardens. Samples were collected from damaged/attached plants and identified using morphological and molecular techniques.

- Some non-native insect pests such as Cypress aphids, Cypress pine aphid, Woolly aphid and Aulacaspis scale, and many emerging native pests including aloe snout beetles, Cycad stem borers, gall forming psyllid insects, Leopard magpie moth, and *Opogona scaphobis* were identified from the various botanical gardens.

- Phosphite treatment trial against dieback on silver trees caused by *Phytophthora cinnamomi* was set up at Kirstenbosch National Botanical Garden on Silver trees.

Setting up phosphite treatment trail on the iconic Silver trees against dieback caused by *Phytophthora cinnamomi* at Kirstenbosch National Botanical Garden



# The Polyphagous Shot Hole Borer (PSHB) Research Network

**Responsible persons:** Prof. Wilhelm de Beer
Dr Trudy Paap

The ongoing invasion of the Polyphagous Shot Hole Borer (PSHB) in South Africa is of major concern to farmers, foresters, landscapers, home owners and ecologists, as this beetle and its symbiotic fungus can be aggressive tree killers. The beetle is native to Southeast Asia, and was detected in Israel and California in the early 2000s where it has since caused serious damage to several ornamental tree species, as well as commercial avocado trees.

Its presence in South Africa was first confirmed in 2017 by the FABI team, but ongoing surveys confirmed that South Africa currently hosts the largest geographical outbreak of this beetle in the world. It is affecting trees in all sectors: the agricultural and commercial forestry sector, urban trees (public spaces, streets, gardens), as well as native trees in natural forests. Prior to the 2000s, almost no research had been conducted on the biology and possible control measures of the beetle and fungus. Although several research papers have been produced during the past 15 years from Israel and the USA, the body of research on the topic remains small and much more work is needed to support proper mitigation measures that can be implemented by all levels of government and other stakeholders in South Africa.

The research team at FABI realized that dealing with the PSHB at a national level needed a multi-disciplinary approach involving experts from across the country. They started collaborating with senior academics from several universities and from these engagements a multi-institutional research network evolved. The PSHB Research Network was established at a meeting of these researchers in May 2019 at FABI. The aims and strategies of the PSHB Research Network are:

1. To align and co-ordinate all research efforts by *bona fide* researchers from academic institutions in South Africa. This is to make sure that expertise and resources are utilized to the maximum in order to answer the most important research questions related to PSHB and its fungal symbionts.
2. To provide science- and data-based advice to all stakeholders in government and private sectors.
3. To effectively communicate new research findings related to PHSB among network members and to stakeholders and the public.
4. To leverage funding. By showing that research projects form part of a well-structured, coherent research programme, more funding opportunities should become available.

At present 22 academics, 17 postgraduate students, and several interns and technical staff are involved in a range of research projects ranging from monitoring the impact of PHSB on trees in orchards and urban and natural forests, to exploring biological control options for the PSHB and its fungal symbiont. Research partners are based at FABI, Rhodes University, Stellenbosch University, University of the Witwatersrand, Durban University of Technology, University of the Free State, UNISA, University of Limpopo and Sol Plaatje University.

PSHB galleries in *Acer negundo* (box elder)

PSHB infested *Platanus x acerifolia*

# *Tree Health Extension and Diagnostic Clinic*

**Responsible Persons:** Prof. Brett Hurley (Supervising tree health extension and TPCP/CPHB diagnostics)
Prof. Bernard Slippers (FABI Director)
Dr Lieschen de Vos (FABI Diagnostic Clinic)
Dr Trudy Paap (TPCP/CPHB diagnostics, until January 2021)
Dr Gabrielle Carstensen (TPCP/CPHB diagnostics, from February 2021)
Mr Darryl Herron (TPCP/CPHB extension)

The extension services of the Tree Protection Co-operative Programme (TPCP) and the DSI-NRF Centre of Excellence in Plant Health Biotechnology (CPHB) at FABI form an integral part of the research and services provided by these research programmes. These services include the monitoring and diagnoses of pests and pathogens of native and plantation trees.

Extension services of the TPCP/CPHB involve routine field visits across the country, as well as field visits in response to emerging pest and disease issues, including new detections and outbreaks. Extension activities are also important to create awareness of plant health amongst the general public, foresters, farmers and conservation staff. Thus, extension activities include presentations at field days, reports in magazines and newspapers, radio and TV interviews, and articles posted on the TreeHealthNet list server. The extension services work closely with the FABI diagnostic clinic, submitting samples to the clinic, and visiting sites from where samples were submitted when further investigation is required to confirm the identity or evaluate the impact of a pest or pathogen.

Correct diagnoses are crucial to the monitoring function of the TPCP/CPHB. Samples that are submitted through the extension services and via our stakeholders are processed by the FABI diagnostic clinic, with the manager overseeing the sample processing and reporting, supported by a capable team of postgraduate students and interns. The clinic is well positioned within the TPCP and CPHB, allowing it access to some of the best laboratories on the continent and to draw on the skills, expertise and research of a world-class tree health programme.

Besides the crucial services the field extension and diagnostic clinic provide to the relevant stakeholders, these services also include training for postgraduate students and interns, and thus contribute to the development of future capacity in tree health for South Africa.

Collecting insect sticky traps in a *Eucalyptus* stand


Insect collection in a *Eucalyptus* stand

Artist:
Retha Buitendach

# FABI WORKSHOPS AND CONFERENCE ORGANISATION

## *BIOLOGICAL CONTROL OF FOREST INSECT PESTS*

The International Union of Forest Research Organizations (IUFRO) Working Party 7.03.13 meeting on the 'Biological Control of Forest Insect Pests and Pathogens' was hosted by FABI from 5-8 November 2019. The meeting was held at the Future Africa campus at the University of Pretoria and it was the first time this Working Party has met in Africa. The meeting was organized by Prof. Brett Hurley and Dr Marc Kenis (CABI, Switzerland) and sponsored by FABI, FAO, CABI, Sappi and York Timbers. Prof. Jolanda Roux, Ms. Kayla Noeth and the rest of the Sappi team, as well as Mr Philip Croft (ICFR) organised the field trips.

This relatively small meeting (about 65 people) attracted participants from 27 countries from around the world. The sessions included 'Classical Biological Control', 'Forest Insect Pests in Africa', 'Entomopathogens, Nematodes and Insects in Augmentative Biocontrol', 'Biological Control of Pathogens and Nematodes', and the 'Future of Biological Control'. Prof. Bernard Slippers (FABI, Future Africa) and Mr Michael Peter (Forestry South Africa) were guest speakers, with Keynote addresses from Prof. Timothy Paine (University of California) and Dr Maartje Klapwijk (Swedish University of Agriculture).

Some of the participants also attended the post-meeting field trip from 8-11 November, where they were exposed to some of South Africa's amazing fauna and flora as well as plantation forestry in the Lowveld. This included visits to sites of infestations of some of the main forestry insect pests, a demonstration of the Sirex biological control programme, and a visit to a forestry nursery.

## *BIOMAKER WORKSHOP*

The Biomaker Workshop, funded by the UK's Global Challenges Research Fund (GCRF), was initiated with the aim of building capacity in practical applications of open-source environmental sensors, 3D printing technology, Arduino micro-controllers and graphical programming that enthusiasts can implement in DIY projects without prior experience in how to code.

Prof. Jim Haseloff, a world-leading plant synthetic biologist at the University of Cambridge, developed the so-called Biomaker Challenge with his colleagues in which transdisciplinary teams of students and staff learn to use OpenSmart Arduino Rich Uno R3 kits and low-cost sensors and devices to build DIY bio-instruments, sensors or hardware for various practical applications in the biological and related fields. Biomakers have, for a fraction of the cost of commercial equipment, designed field-deployable 3D-printed microscopes, microbial bioreactors, blood oxygenation systems and even yeast-counting imaging systems for home brewing, as documented on the Hackster developer community site.

The GCRF pump-priming funding has allowed Prof. Haseloff's Biomaker activities to extend to African countries including Egypt, Ethiopia and Ghana at strategic institutions aside from the University of Pretoria. They disseminate Biomaker training and starter kits including a suite of Shenzhen-manufactured environmental sensors and low-cost devices, accompanied by useful online tutorials on how to programme DIY prototypes using simplified XOD graphical programming. Professor Haseloff presented a two-day workshop in November 2019 that was coordinated by Dr Steven Hussey, a Senior Lecturer affiliated with FABI and hosted by the UP Makerspace. Over 20 undergraduate and postgraduate students and UP researchers from diverse departments across the university - a quarter of them associated with FABI - rapidly mastered basic Arduino circuitry and simple-to-use 4D programmable touchscreens to create simple device prototypes.

## *BIOSAFETY SA SYMPOSIUM*

In March 2019, the second annual BioSafety SA symposium was held in Pretoria. The theme of the symposium was sustainable biotech innovation with a special focus on gene editing. Amongst the symposium attendees were government representatives of the Technology Innovation Agency (TIA) as well as the Department of Science and Technology (DST). FMG research Fellow, Dr Victoria Maloney, was invited to speak to the recent advances in CRISPR-Cas technology as well as how scientists in South Africa can take advantage of this technology to address challenges currently faced in the South African forest and agricultural industries.

## *FOREST INVASIVE SPECIES NETWORK FOR AFRICA WORKSHOP*

From 3-5 November 2019, FABI hosted the Forest Invasive Species Network for Africa (FISNA) Workshop at the University of Pretoria's Future Africa campus. FISNA is one of the regional networks facilitated by the Food and Agricultural Organization (FAO) of the United Nations. The network aims to "co-ordinate the collation and dissemination of information relating to forest invasive species in sub-Saharan Africa for sustainable forest management and conservation of biodiversity". The workshop dealt with the implementation of classical biological control to manage insect pests in plantation forests and followed the recent FAO "Guide to the classical biological control of insect pests in planted and natural forests".

The workshop was organized by the current coordinator of FISNA, Prof. Brett Hurley, together with Ms. Samantha Bush and a great FABI Team. The participants for the workshop were funded by FAO and included 23 delegates from 14 different African countries. This is in addition to the FABI staff and students involved in the workshop, as well as Dr Marc Kenis (CABI, Switzerland), Prof. Jeremy Allison (Natural Resources Canada) and Dr Shiroma Sathyapala (FAO, Rome), who contributed to the discussion sessions.

The workshop was successful in providing training, sharing information and building capacity towards implementing biological control - a key strategy in responding to invasive forest insect pests on the continent.



## *IUFRO TREE BIOTECHNOLOGY MEETING*

In June 2019, the IUFRO Tree Biotechnology 2019 Meeting was held in Raleigh, NC, USA. This is the premier international meeting in the field of tree biotechnology, and this year featured new topics such as phenomics, big data, biomaterials and biorefinery from woody biomass. Professor Myburg from FABI was the international scientific co-ordinator and co-organiser of this meeting.

## *NEXT EINSTEIN FORUM GLOBAL GATHERING PANEL DISCUSSION*

Professor Sanushka Naidoo led a panel discussion at the Next Einstein Forum Global Gathering that took place online on 8-10 December 2020. The theme was "Building Africa's resilience through education, research and innovation". She led a discussion on Leadership during COVID-19: best practices and recommendations for futuristic policies to combat pandemics. Panelists included Mr. Oliver Chinganya, the Director of African Centre for Statistics Economic Commission, Prof. Mama Foupouagnigni, Chief Academic Officer, AIMS Global Network, Aurelia Calabro, Director, Africa Center for Statistics, United Nations Economic Commission for Africa, Ms Olivia Bryanne Zank Founder and CEO, BeneFactors Ltd. The discussion centered on the education and industrial sectors and the lessons learned from the pandemic in 2020. The aim was to assess the impact of COVID-19 on critical socio-economic sectors with emphasis on youth and women, identify best practices in pandemic response across Africa and the world, highlight best practices for building resilience to future pandemics, including the crucial role of digital economy, stimulate new partnerships on innovation with the aim to drive Africa's resilience and transformation. In addition, the panel aimed to recommend policies and strategies for African governments to adopt in order to better respond to COVID-19 and prepare for future pandemics.

## *NRF-NSF FUNDED BARK BEETLE MYCOBIOME NETWORK*

In October 2019, the Bark Beetle Mycobiome Network had a week-long workshop in South Africa. The network has been established to accommodate an international collaborative project between researchers at FABI that work with bark and ambrosia beetles and American peers. The project is jointly-funded by the National Research Foundation (NRF) and National Science Foundation (NSF). The South African consortium is led by Prof. Wilhelm de Beer, and the American team by Prof. Jiri Hulcr of the University of Florida, Gainesville. The funding specifically aims to promote collaboration and the establishment of long-term research partnerships in the field of Bark and Ambrosia beetles and their microbial associates. This initiative is very pertinent in view of the current outbreak of the Polyphagous Shot Hole Borer (PSHB) in South Africa.

## *WOMEN IN BIOTECH PANEL DISCUSSION*

Biosafety SA and FABI hosted the Women in Biotech panel discussion on 29 October 2019. The aim of the discussion was to engage and empower a new generation of women biotechnologists, and focused on the challenges faced by women in the biotechnology sector. The panel spoke of how their passion for science and perseverance have carried them through a number of obstacles and made them determined to let the quality of their science and their records of accomplishment "speak for themselves". Project Manager at Biosafety SA, Dr Liezel Gouws, chaired the discussion steered by a panel of five female scientists from different institutions, including three from FABI. On the panel were Dr Farhahna Allie of the University of Johannesburg, Dr Sindi Buthelezi of the Council for Scientific and Industrial Research, Dr Nicky Creux, Prof. Lucy Moleleki and Prof. Sanushka Naidoo.

## *3RD AFRICAN POSTGRADUATE SCHOOL ON SOLAR ENERGY AND PHOTOSYNTHESIS*

The Biophysics research group, under the leadership of Prof. Tjaart Krüger organized the 3rd African Postgraduate School on Solar Energy and Photosynthesis in 2019. Dr Steven Hussey was also involved in organizing this event.

Artist: Erich Mayer

# RESEARCH SUPPORT FACILITIES AT FABI

## ACGT MICROARRAY FACILITY

**Facility director:** Prof. Dave Berger
**Microarray scientific officer:** Dr Nicky Olivier

The ACGT (African Centre for Gene Technologies) Microarray Facility has a proven track record in providing microarray services for researchers throughout Africa, including FABI. Current users of the ACGT Microarray Facility make use of the Agilent microarray platform, enabling the creation of custom array designs for organisms of choice. Proprietary or publicly available sequencing information is used to design slides containing 4 x 44,000 or 8 x 15,000 separate probes. The facility boasts extensive expertise in experimental design, hybridization procedures and custom data analysis using open-source software (R and Bioconductor). In addition, the facility is housed in a building with well-appointed laboratories for RNA isolation and all relevant molecular biology techniques. Researchers with limited access to such facilities at their home institutions are accommodated in these laboratories to perform the critical RNA isolations and hybridization procedures to ensure that the final data is representative of the biological effect under study. The facility has not only been of great support to researchers in the Faculty of Natural and Agricultural Sciences, but also of the Faculties of Medicine and Veterinary Sciences, as well as numerous national and international research institutions.

## BIOCONTROL AND INSECT REARING FACILITY AT FABI

**Responsible persons**: Prof. Brett Hurley and Prof. Bernard Slippers

The FABI Biocontrol and Insect Rearing Facility, based on the Innovation Africa @UP campus of the University of Pretoria provides state-of-the-art facilities for CPHB/TPCP research projects. There are several laboratories equipped with walk-in fridges, autoclaves, incubators and microscopes. These are used for the rearing of, and experimentation on insect pests relevant to forestry and agriculture, and the biological control agents of these pests, including parasitic wasps, and entomopathogenic and parasitic nematodes. The facility contains specialized equipment such as a liquid nitrogen system for cryopreservation of nematodes, and a newly-built insect diet room to produce artificial diet for insect rearing. External facilities include greenhouse tunnels where large-scale inoculation trials are conducted and seedlings are grown over winter, specialized climate-controlled tunnels for pathogen screening under different climate scenarios and walk-in-cages that allow for trials under semi-natural conditions that can exclude or include insect pests, depending on what is needed. There is also a nursery where plants are grown for various research projects. In addition, access-controlled Government-certified insect quarantine laboratories and quarantine glasshouse allow for screening and research on potential biological control agents, to use against insect pests of forestry and agricultural crops, before applying to Government for permission for release. Research at the FABI Biocontrol and Insect Rearing Facility is undertaken by postgraduate students and highly qualified and experienced staff. There are annual undergraduate practicals and frequent tours showcasing the facilities to both international and national guests.

Dissection of *Sirex noctilio*, a pest of *Pinus* species in South Africa



## CHEMICAL ECOLOGY AT FABI

**Responsible persons:** Prof. Almuth Hammerbacher
Mr Quentin Guignard

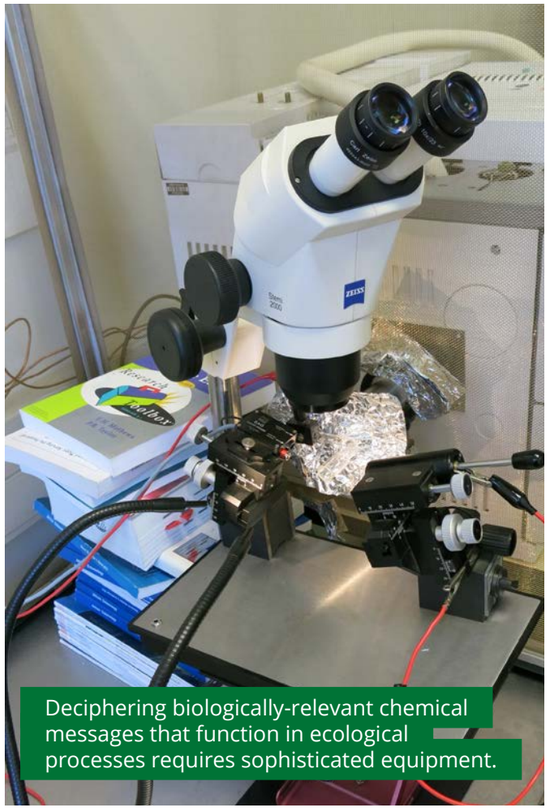
Chemical ecology is the study of how organisms interact with each other and their environment through chemical messages. These messages occur between different species and within a species. A good example of a chemical signal within an insect species is a sex pheromone which is produced to attract a mating partner.

Chemical signals between species are often complex. Plants, for example, can produce volatile compounds in response to feeding by an insect herbivore. These volatiles can be a direct deterrent to the herbivore or can indirectly affect the herbivore by attracting natural enemies to the emitting plant.

Understanding the chemical ecology between pests and pathogens will aid in developing pest management strategies. A variety of instruments are therefore available at FABI to strengthen chemical ecology at the Institute and to expand research relating to tree health. These instruments include a gas chromatography system coupled to an electro-antennogram detector to detect the response of insects to certain compounds. A state-of-the-art Agilent gas chromatograph coupled to a mass spectrometer as well as an Agilent liquid chromatograph coupled to a UV diode-array detector and a small Bruker ion trap mass spectrometer are available for non-targeted metabolomics.

Recently a new facility was added to FABI where insect behaviour can be studied. This includes a wind-tunnel as well as assay arenas equipped with light sources and cameras to study insect orientation towards volatile organic compounds.

Chemical ecology Agilent GC



Deciphering biologically-relevant chemical messages that function in ecological processes requires sophisticated equipment.

## DNA SANGER SEQUENCING FACILITY

**Custodians:**
Prof. Paulette Bloomer
Prof. Sanushka Naidoo
Prof. Wolf-Dieter Schubert

**Staff:**
Ms. Renate Zipfel
Ms. Gladys Shabangu
Mr Thuso Mapotsane (until December 2019)
Ms. Onkgopotse Seabi (from March 2020 - current)

The DNA Sanger Sequencing Facility - in the Faculty of Natural and Agricultural Sciences - has provided a DNA Sanger sequencing and fragment analysis service for researchers at the University of Pretoria for more than 22 years. The laboratory is situated on the third floor of the FABI Square and Bioinformatics building. The genetic analysers are funded by the University of Pretoria and partly by a grant awarded by NRF National Equipment Platform (NEP 2011/2012; UID: 78566). More than 50 research groups at the University of Pretoria use the services of the facility to support their research, including 34 FABI researchers and the students under their supervision. In the period May 2019 to May 2021 the facility processed more than 87,000 samples.

The resulting data are used for a wide range of applications including diagnostics related to diseases and pests; taxonomy of animals, plants, insects, fungi and bacteria; phylogenetics and population genetics analysis; DNA fingerprinting for parentage analysis and many other applications.

The DNA Sanger Sequencing Facility also provides technical support and training to clients making use of its services. The facility co-ordinates and hosts an annual Introductory Microsatellite Workshop in collaboration with Thermo Fisher Scientific in South Africa. The workshop is facilitated by members of staff and postdoctoral Fellows of the Department of Biochemistry, Genetics and Microbiology and Thermo Fisher Scientific. Four FABIans shared their expertise: Prof. Irene Barnes, Dr Arista Fourie, Dr Felix Fru and Ms. Melissa Reynolds. Strict lockdown restrictions resulted in the workshop being updated and hosted online in early May 2020. Thirty-five participants attended, 28 from FABI including two Fabians who joined the online workshop from China. In April 2021, the online version workshop was presented again with FABIans representing half of the 16 participants.

## FABI FUNGAL CULTURE COLLECTION

**Academic member overseeing the collection:** Prof. Wilhelm de Beer
**Curator:** Dr Seonju Marincowitz
**Technical staff:** Ms. Lydia Twala and Ms. Valentina Nkosi

The FABI Culture Collection (also known as CMW in the scientific community) was established within the Tree Protection Co-operative Programme (TPCP) in 1989 as a small private collection of fungal pathogens of *Eucalyptus* diseases in South Africa. The collection has grown to accommodate more than 56,000 living cultures isolated from over 150 tree species worldwide. These cultures are generated from tree health related projects by FABI researchers and their collaborators worldwide. The fungal cultures represent more than 150 fungal genera and over 1,000 fungal species. More than 2,600 new cultures were deposited in the collection between May 2019 and May 2021, while 1,800 cultures were requested for research and extracted from long-term storage. During the same period, more than 200 academic articles were published based on studies using the cultures provided by the CMW. It is the largest living fungal collection in Africa and the largest in the world containing tree health related fungi.

The fungal cultures are stored in various ways. The main collection is housed in three walk-in cold-rooms in the FABI building, while certain groups of fungi are freeze-dried or stored in dedicated -80°C freezers.

In addition to maintaining cultures, the collection staff also oversee the microscope room with various state-of-the-art microscopes, a cryo-microtome which sections a sample at -20°C and a freeze dryer that is available for use to all FABI researchers.

Three postgraduate students assist the collection staff for limited hours per week with some of the duties in the collection. All fungal culture collection staff salaries are funded by the TPCP.

Fungal cultures preserved in glass vials at the Fungal Culture Collection of FABI

## FMG PRECISION TREE BREEDING PLATFORM

**Custodians:** Ms Melissa Reynolds
Mrs Zelda du Toit-Boshoff
Prof. Zander Myburg

The Forest Molecular Genetics (FMG) Programme's Precision Tree Breeding Platform supports postgraduate student training in population genomics and provides a research service for tree improvement in the SA forestry industry. The main aim of the Platform is to make high-throughput DNA marker technologies accessible to students and breeders in South Africa. DNA markers can be used for diagnostic services in breeding programmes such as DNA fingerprinting, verification of clonal identity, confirming and reconstructing pedigrees, and estimating the species composition of pure species and hybrid individuals. Researchers and industry collaborators are also able to make use of genome-wide genotyping capacity in the Platform for molecular breeding applications, such as genomic selection. Two new single nucleotide polymorphism (SNP) genotyping arrays consisting of 72,000 SNP markers for eucalypt trees (including *Corymbia*) and 50,000 SNPs for tropical pines have been developed in collaboration with international consortia and represent valuable resources for molecular breeding and applications such as genome-wide ancestry mapping in breeding lines.

Historically, the FMG Programme has focussed on pine and eucalypt species of interest to the forestry industry. DNA fingerprints and/or genome-wide genotypes have been produced for more than 80,000 trees representing much of the core breeding material in the country. More recently, capacity has been expanded to develop DNA marker resources for *Acacia* (wattle) and *Macadamia*. These are being used by the Platform to establish microsatellite DNA marker panels for routine research applications such as cultivar identification and parentage analysis in *Macadamia*, and identification of disease and frost resistant *Acacia* varieties.

The GenoGrinder can homogenize up to 568 samples in just two minutes

### *HIGH-THROUGHPUT DNA ISOLATION FACILITY*

The new DNA marker resources, expansion into additional species and an increased demand for DNA marker technologies in tree breeding prompted the Technology Innovation Agency (TIA) to fund a new high-throughput DNA isolation facility at FMG. A newly refurbished laboratory in the Agricultural Sciences building houses a state-of-the art equipment platform including a GenoGrinder for sample homogenization, an oKtopure DNA Isolation Robot (LGC Genomics) and a DNA Biobank. The GenoGrinder can homogenize up to 576 samples in under two minutes, and the oKtopure robot can process up to 768 DNA isolations in a morning. This significant increase in capacity (more than 200,000 samples per year) will enable the Platform to meet the requirements of large-scale molecular breeding efforts. The high-throughput DNA isolation capacity will also be available as a research service to other tree, fruit, vegetable and grain crops starting in 2022 (contact ***zander.myburg@up.ac.za***).



## ION TORRENT SEQUENCING FACILITY

**Facility Director:** Prof. Paulette Bloomer
**Facility Staff:** Ms. Renate Zipfel
Dr Nicky Olivier

The Ion Torrent Sequencing Facility at the University of Pretoria provides high-quality high-throughput sequencing solutions to researchers in Southern Africa. The managers of the facility believe strongly in student training and capacity building in high-throughput sequencing, and students are encouraged to attend project planning sessions together with their supervisors to understand the complex planning process for optimal experimental outcomes in their respective research projects. Samples are sequenced in collaboration with the University of Stellenbosch utilizing the Ion Proton and Ion S5 instruments, yielding up to 10GB of data with 200bp read lengths or 15GB data with 400bp read lengths.

The facility provides project planning, sample quality technical support, library building and raw data management services to researchers, including those from FABI. To date, whole genome, targeted amplicon and metagenomic sequencing has been processed for virus, bacterial, fungal, human and veterinary samples. The facility presents annual seminars on high-throughput sequencing technology and advances to interested researchers and students in the region.

## NEW INDUSTRY DISEASE RESISTANCE SCREENING FACILITY AT FABI

Due to the impact of climate change and human activities, South African foresters are faced with unprecedented yield losses due to high levels of pests and diseases in planted forests. Screening tree varieties that are being developed in South African forestry tree breeding programs for resistance or tolerance against pests and diseases is thus imperative to sustain healthy future forests. FABI (in collaboration with Forestry South Africa and the Department of Science and Technology) has therefore started to develop a state-of-the-art pest and disease screening facility. The project, initiated in 2019, aims to build the physical facilities to accommodate industry screening trials and to develop new methods for rapid and accurate measurement of pest and disease levels on tree saplings. Construction of three fully-automated greenhouse units for industry screening trials on the Innovation Africa campus was completed in 2020. Screening methods for *Fusarium circinatum* on pine and *Teratosphaeria destructans* on *Eucalyptus* have also been developed in parallel.

FABI is now acquiring a high-resolution radiospectrometer which will be used for accurate assessment of pest damage and disease in trials using hyperspectral data. The screening program now also employs a postdoctoral Fellow and an intern on a full-time basis to assist with the screening trials and development of screening procedures for other pests and diseases. The first industry screening trials for Pine and *Eucalyptus* resistance to *F. circinatum* and *T. destructans* respectively, will be conducted in 2021. With this project, FABI and the TPCP aims to fulfil an important need of the South African forestry industry, as well as pushing the technical boundaries of conducting large-scale, accurate assessments of pest and disease damage using novel technologies for even greater precision in our pest management programs.


Fully automated greenhouse units for industry screening trials on the Innovation Africa @UP campus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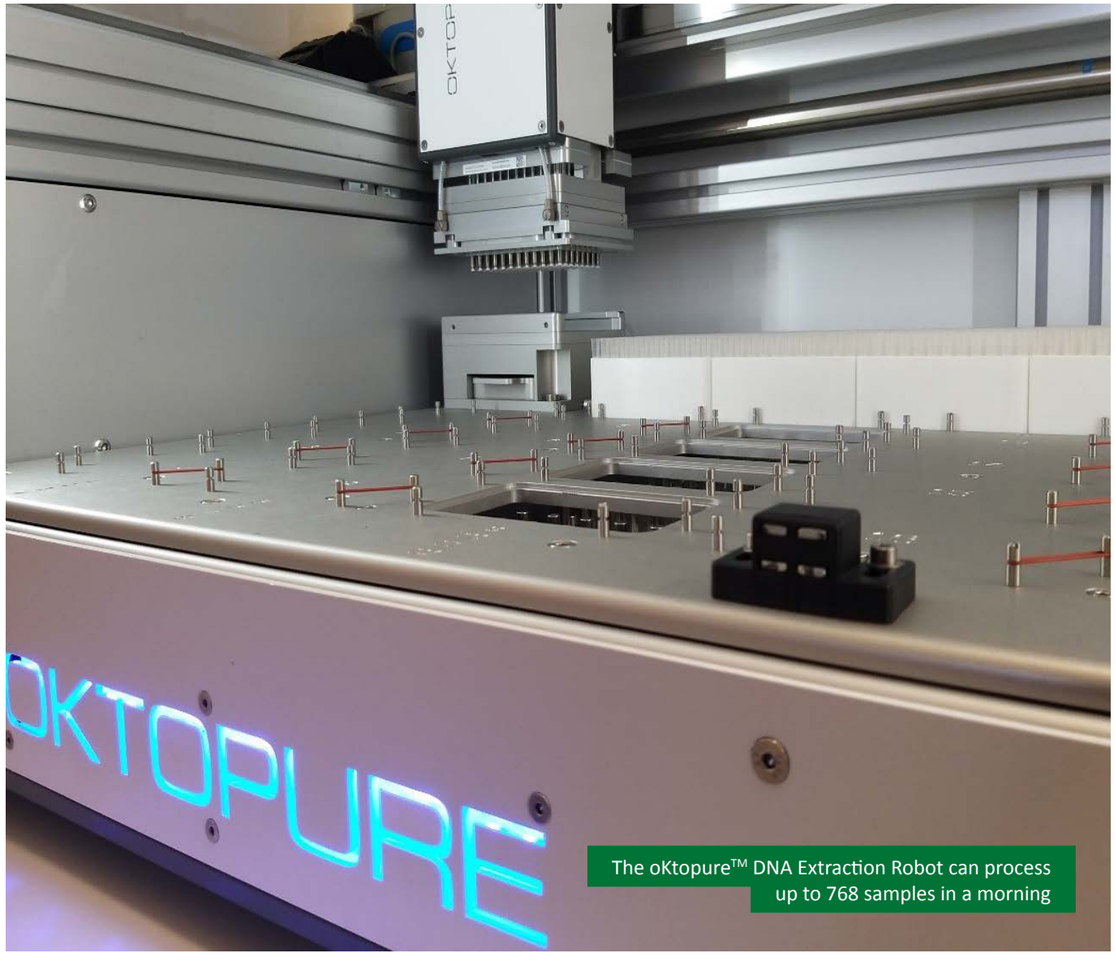
## THE QUANTSTUDIO™ 5 PLATFORM

**Platform director:** Prof. Zander Myburg
**Platform staff:** Ms Melissa Reynolds
**Platform technician**: Ms Julia Candotti

The QuantStudio™ 5 Platform provides a quantitative real-time PCR service to staff and students at FABI and in the rest of the University of Pretoria. Gene expression (RT-qPCR) analyses and (SNP) marker genotyping can be performed on the QuantStudio™ 5 for small to medium-scale experiments, making it an indispensable tool for research linked to FABI. This platform is ideal for studies in which the expression of multiple target genes under varying conditions or treatments are determined. The QuantStudio™ 5 is a 384-well platform and multiplexing up to six targets can be done, resulting in high throughput analysis. Researchers from FABI use the platform for analysing gene expression during wood development, disease resistance interactions and pathogenicity genes.




The oKtopure™ DNA Extraction Robot can process up to 768 samples in a morning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## PLANT TISSUE CULTURE PLATFORM AT FABI

**Custodians:** Prof. Zander Myburg
Prof. Sanushka Naidoo
Ms Adri Veale
Dr Steven Hussey
Dr Raphael Ployet

*Eucalyptus* species are cultivated as sources of woody biomass for various forest products. However, the long generation time of trees and the prolonged period required for evaluation of mature traits are strong limitations for classical breeding and selection. Functional genetics is an avenue that allows one to assess the function of candidate genes involved in wood formation as well as disease and pest resistance using genetic engineering tools such as transformation. Despite having established transformation protocols in several model species, these procedures have been particularly challenging in woody plant species such as *Eucalyptus*.

Poplar has become a model tree species for genetic transformation, due to its high susceptibility to *Agrobacterium* and high regeneration rates. Production of transgenic Poplar trees has been perceived as a possible approach for the control of diseases, and improvement of the plant quality. The development of genome engineering technologies based on the CRISPR-associated RNA-guided endonuclease Cas9 (CRISPR-Cas9) systems have broadened the agricultural research area. This technology brought new opportunities to develop novel plant varieties through genetic engineering of plants, including poplar trees. It has become a powerful approach to develop plants with traits that are of high commercial value, such as trees with increased cellulose and hemi-cellulose biosynthesis.

The Plant Tissue Culture Platform in FABI has established the capacity to develop transgenic *Arabidopsis* and poplar plants, and gene testing in the laboratory. We can transfer the plants from the laboratory to plant growth facilities for comparative growth studies. We further have the capacity for routine tissue culturing and *in vitro* propagation of a variety of different *Eucalyptus* genotypes.

Tissue cultures of Poplar

Young *Eucalyptus* grown from tissue cultures

Poplar tissue cultures at various stages of growth


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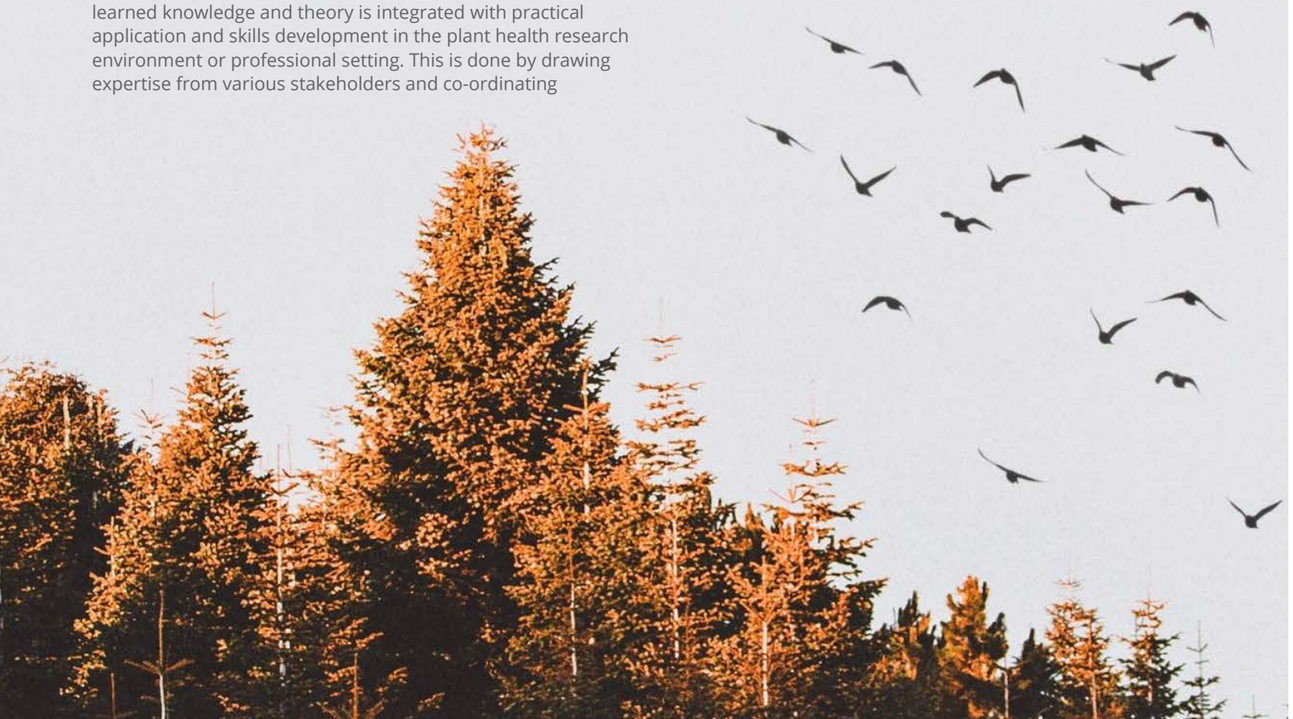
# FABI INTERNSHIP IN PHYTOSANITATION AND BIOSECURITY

Human capacity development is a priority for South Africa - both for improving employability and entrepreneurialism. There is also a constant need to monitor and upgrade skills to ensure that the graduates of such training and education programmes are addressing the requirements and evolving needs of industry and the country. In the agricultural sector, for example, population growth drives an increased need for food security and quality, which is in turn dependent on advancements in science and technology. One of the key areas where skilled human resources are lacking in the country is phytosanitation and biosecurity. Much like in other parts of Africa, our capacity to deal with pests and pathogens affecting our biodiversity resources is severely limited. This is not only because of limited funding and a paucity of relevant infrastructure, but also due to the limited capacity of other bodies tasked to deal with these threats.

To contribute to addressing human capacity development in agriculture and forestry, the DSI-NRF Centre of Excellence in Plant Health Biotechnology (CPHB), together with the Tree Protection Co-operative Programme (TPCP) launched a formal one-year internship programme in 2019. This programme targeted graduates with BSc Honours or equivalent degrees and who have the potential to ultimately pursue higher degrees. In this period, 10 interns were trained through the programme. In 2021, the Grain Research Programme (GRP) and the TPCP, under the umbrella of the CPHB, replaced the initial internship programme with the 'Phytosanitary Internship Programme', and nine interns were accepted for training. The Phytosanitary Internship Programme provides interns with a period of experiential learning during which previously-learned knowledge and theory is integrated with practical application and skills development in the plant health research environment or professional setting. This is done by drawing expertise from various stakeholders and co-ordinating the training with the needs of forestry, the grain and seed industries, producer organisations and government.

Our vision is that this programme will provide additional technical support to improve the updating of outdated import requirements; assist with a higher turnover of completed pest information packages (PIPs) and pest risk assessments (PRAs), surveillance of emerging pathogen risks, pest/pathogen diagnostics and implementation/monitoring of phytosanitary protocols. Overall, this will contribute positively to increased market access for SA commodities and help with maintaining a positive trade balance.



# AWARDS AND HONOURS

Ever since its establishment in 1998, FABI has pursued excellence across its many key performance indicators. This approach has resulted in many accolades for FABI students, academic staff members and for the Institute itself. Large numbers of students have thus received prestigious bursaries from various organisations, awards for research excellence and for travel to mention but a few. Likewise, academic staff members have received special awards from organisations such as the Department of Water Affairs and Forestry, the Department of Science and Technology, the National Research Foundation, the South African Association for Art and Science, the Royal Society of South Africa, the Academy of Sciences of South Africa and various others.

## FABI AWARDS

A suite of awards made annually to exceptional FABIans and FABI stakeholders. FABI awards were presented for the first time in 2007 and these have come to be recognised as important and highly prized. The FABI awards for the reporting period were as follows:

**Best FABI Student Publication**
Given the importance of research quality in FABI, one award recognises the best publication produced by a FABI student in the award year. The recipient in the case of this award is chosen based on the ISI impact factor of the paper produced.

2019 Desre Pinard, Martin Wierzibicki, and Katrien Brown
2020 QianLi Lui

**Best Postdoctoral Fellow Publication**
This award recognises the best publication produced by a postdoctoral Fellow in the award year. The recipient in the case of this award is chosen based on the ISI impact factor of the paper produced.

2019 Dr Runlei Chang
2020 Dr Erik Visser

**Best FABI MSc Thesis**
This award is given to an MSc student who achieved the highest mark through external examination of a thesis.

2019 Annah Zanele Mahlangu
2020 Lizette Loubser

**FABI Award for Mentorship**
MSc or PhD students who have demonstrated outstanding mentorship, in the broad sense, to other students.

2019 Angel Maduke
2020 Ingrid Marias and Johannes Christoff Joubert

**FABI Award for "Getting the Message to the Public"**
This award goes to a student who has excelled in transferring the FABI science message to the public. Tangible evidence of transferring the accomplishments of FABI, or the science conducted by FABI or its members to the public must be demonstrated.

2019 Darryl Herron, Joey Hulbert, Juanita Avontuur, Benedicta Swalarsk-Parry, Modjadji Makwela, Fezile Mthunhzi, and Sthembiso Mngadi
2020 Quentin Guignard

**FABI Award for Recognising Contributions by a Member of Staff of the University**
This award is made to a member of staff of the University of Pretoria that has provided exceptional support to FABI.

2019 Prof. Fourie Joubert
2020 Prof. Paulette Bloomer and Ms. Rianie van der Linde

**FABI Award for Recognising Contributions by a Person External to the University**
This award acknowledges the exceptional contributions to FABI by a stakeholder external to the University of Pretoria. Selection of the recipient is made by the FABI community.

2019 Dr Khotso Mokhele
2020 Mr Jannie de Villiers and Ms. Lukeshni Chetty

**FABIan of the Year**
This is FABI's premium award for students and it recognises excellence across a broad range of contributions including research, mentorship, support to the maintenance of the structures of the Institute and others. The recipient is chosen by FABI students.

2019 Stephanie van Wyk
2020 Joséphine Queffelec

**Best FABI Student Personal Website**
Awarded to the student with the most creative, informative and up to date personal website.

2019 Elisa Pal and Joséphine Queffelec
2020 Joséphine Queffelec

**Photographic Awards**
Two awards are made annually for photographs judged to be the best in their category. These categories are:

***Best Photograph Illustrating a FABIan or FABIans at Work***
2019 Prof. Wilhelm de Beer
2020 Dr David Nsibo

***Best Photograph Illustrating FABI Research***
2019 Prof. Brett Hurley
2020 Prof. Irene Barnes

## UNIVERSITY OF PRETORIA AWARDS

**Chancellor's Award For Research**
Prof. Zander Myburg (May 2019)

**Exceptional Achiever Awards**
Prof. Dave Berger (2020)
Prof. Fanus Venter (2020)
Prof. Teresa Coutinho (2019)
Prof. Eschar Mizrachi (2019)

**Other University of Pretoria Awards**
Prof. Robin Crewe received the University of Pretoria Vice-Chancellor's Book Award for "The dark side of the hive" in 2020.

## OTHER AWARDS TO FABI MEMBERS

**Prof. Wilhelm de Beer** was awarded the 2020 'Distinguished Forestry Award' by the Southern African Institute of Forestry (SAIF). The award recognised his substantial contribution and efforts in response to the invasion of the Polyphagous Shot Hole Borer (PSHB). Professor de Beer is a research leader and Professor at the Forestry and Agricultural Biotechnology Institute (FABI) and the Department of Biochemistry, Genetics and Microbiology at the University of Pretoria. His research focus is mycology, including fungi of bark and ambrosia beetles. He is one of the world leaders in this area of research, having published a book "Ophiostomatoid Fungi: Expanding Frontiers", numerous book chapters and about 150 papers in scientific journals.

**Prof. Zander Myburg,** research leader of the Forest Molecular Genetics (FMG) Research group in FABI, was awarded the prestigious Biotechnologist of the Year Award by the Institute of Forest Biosciences (IFB). The award was handed over to Prof. Myburg on 27 June 2019 at the gala dinner of the International Union of Forest Research Organizations (IUFRO) Tree Biotech meeting held from 23-28 June in Raleigh, North Carolina in the USA. The award winner is an individual who best exemplifies environmentally and socially responsible forest biotechnology. Candidates should also work diligently to promote science, dialogue, and stewardship in this field.

FABI Director **Prof. Bernard Slippers** was selected as the 2020 recipient of the prestigious Havenga Prize for Natural Sciences by the Suid-Afrikaanse Akademie vir Wetenskap en Kuns (South African Academy for Arts and Science). He was the fourth FABIan to receive this award following FABI founding Director Prof. Mike Wingfield (1998), Prof. Pedro Crous (2001) and Prof. Jolanda Roux (2017). The Havenga Prize, established in 1945, is an annual award to recognise significant and original research work in the natural sciences or technical fields. It has, since 1979, been awarded as a gold medal. The award recognised Prof. Slippers' very substantial achievements as a world-recognised tree health specialist and academic.

**Prof. Mike Wingfield** was selected as the recipient of the National Science and Technology Forum (NSTF) Annual Theme Award: Plant Health. This Special Annual Theme Award, recognising the 2020 United Nations International Year of Plant Health (IYPH-2020), was one of 13 awards conferred at the NSTF-South32 Awards ceremony on 30 July. It acknowledged Prof. Wingfield as being a globally-recognised South African plant pathologist and recognised his lifetime of contributions to the identification and management of plant diseases, as well as the education and mentorship of large numbers of plant pathologists and entomologists globally." He is also the Immediate Past President of the International Union of Forest Research Organizations (IUFRO), having served a five-year term as the Organization's President from 2014-2019.

**Prof. Mike Wingfield** was again included in the 2020 Clarivate Web of Science Highly Cited Researchers list - the fourth consecutive year he has achieved this status. This list, revised and published annually, recognises "scientists and social scientists who have demonstrated significant influence through publication of multiple papers, highly cited by their peers, during the last decade". Their highly cited publications rank in the top 1% by citations for field and year in the Web of Science.

**Dr Osmond Mlonyeni** was appointed as a Trustee of the Mandela Rhodes Foundation (MRF) in 2020. He is also a member of FABI and Manager for Partnerships and Programs for Innovation at Future Africa at the University of Pretoria. Dr Mlonyeni is the first-ever alumnus of The Mandela Rhodes Scholarship to join its Board of Trustees, making his appointment a historic first for Nelson Mandela's legacy organisation for leadership development.

**Dr Gudrun Dittrich-Schröder, Dr Esther Muema and Prof. Cobus Visagie** were awarded Future Leaders - African Independent Research (FLAIR) fellowships. These were the only of these fellowships awarded to the University of Pretoria and only 15 in South Africa. The African Academy of Science and the Royal Society, supported by the Global Challenges Research Fund, award FLAIR fellowships to early career researchers in the natural sciences with the "potential to become leaders in their fields". Dr Dittrich-Schröder's research focuses on the development and application of CRISPR-Cas9 gene-editing tools to control major insect pests in the agricultural and forestry sectors. Dr Muema's study aimed at unveiling the native soil rhizobia that nodulate *Cicer arietinum* (chickpea) in South Africa, select the effective strains and compare them with commercial inoculants for chickpea production. Professor Visagie's research focuses on surveying the fungi on maize, sunflower and soy seeds (raw products in animal feed), as well as poultry, cattle and pig feed from commercial, small and subsistence farmers.

**Dr Elrea Strydom** was awarded the Protein Research Foundation's "Best PhD Award of the Year 2018" at a ceremony at their head office in Woodmead, Johannesburg on 30 January 2020. Dr. Strydom successfully defended her PhD thesis on 28 January 2019. Her project, titled "Soybean blotchy mosaic virus: Molecular characterization and seasonal persistence" was done under the supervision of Prof. Gerhard Pietersen, who also nominated Dr. Strydom for the award. Soybean blotchy mosaic virus (SbBMV) infects *Glycine max* and contributes significantly to annual yield losses. Managing the virus therefore is crucial for food security as soybean is one of the most widely grown crops in South Africa.



**Quentin Guignard** (a PhD candidate at FABI) received a R30,000 cash prize paid towards attending an international conference of his choice after winning a writing competition held in conjunction with the DSI-NRF Centre of Excellence in Plant Health Biotechnology (CPHB) and The Conversation Africa in January 2020. The Conversation staff selected the winner from eight submissions received. The competition was open to PhD students and postdoctoral fellows in FABI and they had to write an article on their research. The winner was selected based on the length of their articles, their relevance to the public and their accessibility to readers who are not scientists. They therefore had to explain the science behind them simply without the use of jargon. Quentin's prize-winning article was published on The Conversation, an online platform that gives a journalistic spin to articles written by academics from institutions worldwide. Interested mainstream media then publish the articles as they are on their respective platforms.

One of FMG's former MSc students, **Martin Wierzbicki**, was one of three recipients of the Global 2018-2019 Blue Sky Young Researchers and Innovation Award. The International Council of Forest and Paper Associations (ICFPA) gave the prestigious accolade in recognition of Martin's MSc research on systems genetics modelling of genes involved in xylan biosynthesis in *Eucalyptus* towards improvement of wood process ability for bio refinery applications. Martin was supported to present his innovative work to a roundtable of international CEOs in Vancouver, BC, Canada.

Two FABIans have each earned a spot in the FameLab SA contest. MSc student **Christoff Joubert** and PhD candidate **Josephine Queffelec** were crowned winner and first runner-up respectively at the FameLab heats at FABI on 5 February. FABI hosted the contest, with a special focus on plant health, in celebration of 2020 as the International Year of Plant Health. FameLab is an international competition open to anyone between the ages of 21 and 35 studying or working in the science, technology, engineering and mathematics fields. The aim is for the contestants to interpret their work to a lay audience in just three minutes. Thirty postgraduate students at the Institute participated in a science communication workshop facilitated by training facilitator Sthabile Mazubane from Jive Media Africa and Darryl Herron (a FameLab South Africa 2018 finalist) on 4 February in preparation for the heats.

**Prof. Robin Crewe** received the National Science and Technology Forum (NSTF) Lifetime Award for achievement by an individual in 2019. Prof. Crewe received this award for his contributions to science in South Africa and for his contribution to management and related SET activities.

**Prof. Tjaart Krüger** was awarded the Meiring Naudé Medal from the Royal Society of South Africa in 2019 and the CSIR National Laser Centre Innovation Excellence Award in 2020. He was also selected as a member of the South African Young Academy of Science (SAYAS) in 2019.

**Prof. Eschar Mizrachi** was officially inducted into the Global Young Academy (GYA) in April 2020. The GYA is a large international network that works to give a voice to and empower initiatives by young scientists around the world, including scholars facing persecution as well as systemic discrimination.

**Prof. Sanushka Naidoo** was elected as Chair of the Next Einstein Forum's Community of Scientists at the annual meeting held in Nairobi, Kenya on 24 March 2019.

**Dr ShuaiFei Chen** was, in 2019, selected for the "Leading Scientific and Technological Innovation Talent" of the National Forestry and Grassland Science and Technology Innovation Talent Plan of China.

**Dr Hannelie Human** received the I.H. Wiese Award from the South African Beekeeping Organisation (SABIO) for her outstanding technical contribution to beekeeping in South Africa in 2020.

**Dr Abdullahi Yusuf** received a Tandem Research Fellowship as well as an alumni prize for networking initiatives from the Alexander von Humboldt Foundation in Germany.

## FELLOWSHIPS AWARDED:

**Prof. Teresa Coutinho** was awarded a fellow of the South African Society of Plant Pathology (SASPP) in 2019.

**Dr Danielle Roodt** received a Claude Leon Postdoctoral Fellowship.

Artist: Retha Buitendach

## IYPH 2020 CELEBRATED AT FABI

The United Nations declared 2020 the International Year of Plant Health (IYPH), in recognition of the urgent need for greater global collaboration to protect plant health. Plants are more central to our daily existence than most people realise; they are the foundation of our ecosystems and its biological diversity and functioning. Plants affect everything from our water and air quality, to the food we eat and clothes we wear, and our physical and mental health. Unfortunately, the health of plants is increasingly threatened, globally, by pests, pathogens and climate change, to a point where whole ecosystems and plant production systems could collapse.

During the IYPH, FABI had many plant health related activities and outputs, including research, training, plant health services, seminar series, conferences, workshops and outreach events. One notable initiative was the launch of the FABI International Seminar Series using a virtual platform to reach a global audience. The Institute also co-hosted a webinar series on the "Behavioural and chemical ecology of bark and wood boring insects" under the auspices of the International Union of Forests Research Organizations (IUFRO) Working Parties 7.03.16 and 7.03.05.

FABI co-hosted the virtual congress of the South African Society of Plant Pathology (SASPP) on 20 January 2021. The 52nd Congress of the Society was scheduled to take place at UP's Future Africa Institute, which was not possible due to COVID-19. Instead of postponing the meeting, a virtual conference was held as it marked the ending of the United Nations International Year of Plant Health (IYPH), an important global milestone focussing attention on the urgent need for greater global collaboration to protect plant health.

The IYPH-focused research outputs included a number of contributions from FABIans to two special issues in locally managed, international, rated peer-reviewed journals, namely the South Africa Journal of Science (SAJS) and Southern Forests. In total FABIans contributed 15 articles, reviews and commentaries to these special issues. In launching the special issue of the SAJS (Volume 116, issue 11-12), at the 52nd Congress of the SASPP Prof. Jane Carruthers, Chief Editor of SAJS described the special issue "as one of the most important" since the journal's inception 116 years ago. Furthermore, the issue of the SAJS would serve as an excellent source of the latest research, reviews and commentaries from leading plant pathologists and entomologists in South Africa. It will inform not only plant pathologists and food growers, but also policymakers and the public of the importance of plant health".

## FABI COMMUNITY OUTREACH

### *BLANKET DRIVE MAY 2020*

FABIans have continued to share warmth to the less fortunate, albeit from their homes while under lockdown. FABIans opened their hearts and wallets in April and collected more than R11,000 to buy blankets for community organisations in Tembisa, east of Johannesburg. Professor Noëlani van den Berg co-ordinated this effort and delivered 196 blankets to Reverend Leon Geel of the Midstream Family Church for distribution on 4 May.

### *BRING A GIRL CHILD TO WORK*

In May 2019, the Forest Molecular Genetics (FMG) team collaborated with Lehlabile Secondary School as part of the "Bring a Girl Child to Work" day. The DNA Fingerprinting Platform and the Plant Tissue Culture Platform hosted 20 Grade 10 biological science learners. The learners were exposed to sterile techniques for tissue culture procedures and participated in DNA extraction from plant material. Over the course of the day, FMG staff and students engaged with the learners to encourage and inspire a career in science. The science teacher of Lehlabile Secondary School requested that FMG also host Grade 11 and Grade 12 learners in future.

### *CPHB OUTREACH TEAM*

Apart from promoting postgraduate learning, the DSI-NRF Centre of Excellence in Plant Health Biotechnology (CPHB), as part of FABI, has placed a strong emphasis on community engagement. Each year an outreach team consisting of postgraduate students from the Centre are engaging school learners, teachers, and the general public. The team for 2019 included Juanita Avontuur (team leader, PhD), Benedicta Swalarsk-Parry (PhD), Modjadji Makwela (MSc), Fezile Mthunzi (MSc), Lizzy Ramela (MSc) and Sthembiso Mngadi (MSc). The team is responsible for the outreach activities associated with science engagement initiatives such as the National Science Week, AgriCAREER Connect, 'Fungi for Future', visits to local schools, and visits by school learners to FABI and other SAASTA (South African Agency for Science and Technology Advancement) initiatives. Several activities were planned by the Outreach Team for 2020 and 2021; however, these activities were not possible because of the restrictions on travelling and restricted access to schools due to the COVID-19 pandemic.

### *FABI DONATES BICYCLES TO THE N'WA-VANGANI PRIMARY SCHOOL*

On Friday 18 October 2019, the DSI-NRF Centre of Excellence in Plant Health Biotechnology (CPHB) Outreach Team handed over five bicycles to learners from the N'wa-Vangani Primary School for their outstanding academic achievements. These bicycles were a donation from FABI as an award for the top five learners in Grades 4 to 6. The recipients, Ramanyimi Tshifhiw and Chabalala Nyeleti (both Gr. 4), Makhubele Tshiamo, Ndlovu Trevor (both Gr. 5) and Chauke Gontse (Gr. 6) achieved an average of between 77-87%. This donation encouraged the rest of the learners to continue to work hard and stay focused.

Artist: Bettie Cilliers-Barnard

### *FMG A FOUNDER-MEMBER OF WOMEN IN FORESTRY AFRICA ASSOCIATION*

The FMG Programme hosted the launch of the Association for Women in Forestry Africa (WiFA) in October 2020. Delegates from the South African Department of Trade, Industry and Competition (DTIC) were hosted at FABI and FMG provided support in terms of hosting the event virtually as well as logistical support. The organisation strives to bring together women forestry practitioners in Africa to engage in their professional growth and expand their skills and capabilities.

### *FUNGI FOR FUTURE SCHOOL OUTREACH LAUNCHED*

The DSI-NRF Centre of Excellence in Plant Health Biotechnology (CPHB) outreach team from FABI was involved in a 'Fungi for Future' initiative which forms part of their citizen science project. This initiative was launched by the Westerdijk Fungal Biodiversity Institute (WI) and the University Museum Utrecht in the Netherlands. The aim of this project is to generate awareness and excite young children about science and mycology specifically. A sampling kit is distributed to the learners between the ages of 10-13 who use it to collect soil samples from their surrounding environments. The soil samples are then examined at WI, and fungal species isolated and identified. If a new fungal species is discovered from the learners' soil samples, it will be named after them. WI, in collaboration with FABI, sought to interest primary school learners in South Africa to take part in this project.

FABI Research Fellow Dr Neriman Yilmaz and the outreach team (Juanita Avontuur, Modjadji Makwela, Fezile Mthunzi, Benedicta Swalarsk-Parry) visited two schools in Mamelodi, Nwa'vhangani and Tlakukani Primary School and Laerskool Menlopark with the aim of choosing three learners from each school to actively participate in this project. With the help of the outreach team, Dr Yilmaz gave a short presentation at each school, educating the learners about the importance of fungi and getting them excited about science. She told them about the good and the bad fungi, making an example of *Penicillin* which is used in pharmaceuticals to make antibiotics. She also told them about other industrial uses of fungi including making blue cheese which she also gave to learners to see and taste. The learners were keen to know more, and they asked a lot of questions about fungi.

At the end of the presentation, the team asked a few questions to test the learners' interest. Learners who showed the most interest and participated more by answering the questions were then chosen to participate in the WI initiative. Instructions were then given to the teachers and the chosen learners on how to do the sampling. Overall, the CPHB Outreach Team, together with Dr Yilmaz were pleased to have taken part in this initiative and shared their passion for science and mycology with these very eager learners.

University of Pretoria Vice-Chancellor and Principal, Prof. Tawana Kupe also participated in the project and collected soil samples at the Future Africa campus on 30 October. FABI Director and Director of Future Africa, Prof. Bernard Slippers noted that this project puts children in contact with world class research being done at the University but also educates them on fungi.

# FABI STAFF AND STUDENTS

**Director:** Prof. Bernard Slippers
**Deputy Director:** Prof. Fanus Venter
**Founder Director:** Prof. Mike Wingfield

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Mr Lindokuhle Masimula
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Ms. Vera Röder
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Mr Sean Schultze
Ms. Lebone Sebapu
Ms. Precious Sedibane
Mr Preston Shaw
Mr Bernard Smit
Mr Byron Sonnekus
Ms. Medha Sood
Mr Hannes Strydom
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Ms. Shae Swanepoel
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Ms. Taponeswa Tasiya
Ms. Louisa Terblanche
Ms. Cheyenne Theron
Mr Garyn Townsend
Ms. Dee Twiddy
Ms. Elmarie van der Merwe
Mr Willem van der Westhuizen
Ms. Nicole van Vuuren
Ms. Lente van Zyl

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Mr Edwin Wanjofu
Ms. Raven Wienk
Ms. Shannon Wilson
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Ms. Jessica Freedman
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Ms. Renel Groenewald
Ms. Bianca Hattingh
Mr Anthony Hobden
Ms. Marisca Hough
Ms. Bianca Hough
Ms. Busisiwe Maphangela
Ms. Otlotleng Moloto
Ms. Monique Muller
Ms. Ruth Nante
Ms. Tiphany Nkomo
Ms. Denine Rudolph
Ms. Amy Schreiber
Mr Alinaswe Selebi
Mr Michal Slupski
Ms. Chrizanne Smit
Ms. Hannah Tate
Ms. Chanel Thomas
Ms. Jade Tulloch
Ms. Kerri-Anne van Gaalen
Mr Jaco Willemse

**INTERNS**
Ms Ayabulela Mirriam Binase (2020 - 2021)
Ms Amy Collop (2021 - July 2021)
Ms Vinolia Danke (2019 - 2020)
Mr. Harris Xolane Keetse (2021 - current)
Mr. Nakana Kegotswe (2021 - current)
Ms Cebeni Langa (2018 – 2020)
Ms Thembela Lulane (2020)
Mr. Jabulile Mahlangu (2021 - current)
Ms Patricia Malapile (2020 - 2021)
Mr. Kgetise Petros Malele (2021 - current)
Mr. Welapie Malukele (2021 - current)
Ms Khomotso Maredi (2019 - 2020)
Ms Langanani Tshiwela Matodzi (2020 - 2021)
Ms Thembeka Mkhize (2021 - current)
Ms Relebohile Mofokeng (2020 - 2021)
Ms Tebego Molemela (2018 – Present)
Ms Reabetsoe Molia (2020 - 2021)
Ms Mokgantsho Moroke (2020 - 2021)
Ms Alice Mthembu (2020 - 2021)
Ms Anza Muthabi (2021 - current)
Mr. Lungani Nkosi (2021 - current)
Ms Jostina Rakoma (2020 - 2021)
Mr. Innocent Lephaswa Rakubu (2020 - 2021)
Ms Esther Seanego (2018 – Present)
Ms Doleen Sehlabane (2018 – Present)

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Ms. Susanna Anbu (2020)
Ms. Jana Botes (2020)
Ms. Thandeka Dantjie (2020)
Ms. Deanne du Plessis (2019)
Mr. Jireh Janse van Rensburg (2019)
Ms. Ropafadzai Jawa (2019)
Ms. Marizanne Jones (2019)
Mr Lesego Malekana (2019)
Ms. Monique Potgieter (2020)
Ms. Micaela Schagen (2019)
Ms. Nhlanhla Simelane (2019)
Ms. Sizwe Tshabalala (2019)
Ms. Samu Thwala (2020)
Ms. Jade Tulloch (2019)
Ms. Melandré van Lill (2019)
Mr. Luka van Wyk (2019)
Mr. Damian vaz de Sousa (2019)
Mr. Sheldon Viviers (2019)

**STUDENT ASSISTANTS**
Ms Susanna Anbu (2021)
Mr. Christiaan Grobler (2021)

Artist: Gregoire Boonzaier



# FABI GRADUATES

## *PhD*

**Dr Teddy Amuge**
Title of thesis: Genome-wide transcriptome analysis of cassava challenged with Uganda cassava brown streak virus (UCBSV).
Supervisor: DK Berger
Co-supervisors: AA Myburg, M Ferguson (International Institute of Tropical Agriculture, Kenya)

**Dr Akua Antwi-Agyakwah**
Title of thesis: Development of semiochemical-based tools for the management of the African citrus triozid (ACT) *Trioza erytreae* Del Guercio (Hemiptera: Triozidae).
Supervisor: CWW Pirk
Co-supervisors: B Torto, AA Yusuf

**Dr Robert Backer**
Title of thesis: Molecular and bioinformatic analysis of the *Persea americana* (Mill.) NPR1-dependent defence signalling pathway in response to *Phytophthora cinnamomi* infection.
Supervisor: N van den Berg
Co-supervisors: S Naidoo

**Dr Chrizelle Beukes**
Title of thesis: Genomic diversity and phylogeography of South African rhizobia.
Supervisor: ET Steenkamp
Co-supervisors: SN Venter, TM Stepkowski (Warsaw University of Life Sciences), MM le Roux (South African National Biodiversity Institute)

**Dr Khumbuzile Bophela**
Title of thesis: The effect of drought and ring nematode stress combinations in predisposing *Prunus domestica* (plum) to infection by *Pseudomonas syringae*.
Supervisor: TA Coutinho
Co-supervisors: CT Bull (Penn State University, USA), Y Petersen (Agricultural Research Council)

**Dr Gabrielle Carstensen**
Title of thesis: Bacterial wilt of *Eucalyptus*: understanding pathogenicity and the virulence of the causal agents.
Supervisor: TA Coutinho
Co-supervisors: SN Venter, MJ Wingfield

**Dr Runlei Chang**
Title of thesis: Ophiostomatoid fungi associated with conifer-infesting bark beetles in China.
Supervisor: ZW de Beer
Co-supervisors: MJ Wingfield, X Zhou, TA Duong

**Dr Katrin Fitza**
Title of thesis: Diversity, specificity and admixture in the *Sirex - Amylostereum - Deladenus* symbiosis.
Primary supervisor: B Slippers
Co-supervisor: J Garnas

**Dr Arista Fourie**
Title of thesis: A genomic approach towards understanding host specificity and pathogenicity in two *Ceratocystis* species.
Supervisor: I Barnes
Co-supervisors: BD Wingfield, MJ Wingfield, MA van der Nest

**Dr Joey Hulbert**
Title of thesis: The hunt for plant destroyers in the Cape Floristic Region.
Supervisor: MJ Wingfield
Co-supervisors: TI Burgess (Murdoch University, Australia), F Roets (Stellenbosch University, South Africa)

**Dr Miekie Human**
Title of thesis: Effector identification from the susceptible *Exserohilum turcicum - Zea mays* interaction.
Supervisor: B Crampton
Co-supervisors: D Berger

**Dr Zander Human**
Title of thesis: The microbial ecology of *Protea repens* (Proteaceae) infructescences and the surrounding environment.
Supervisor: ZW de Beer
Co-supervisors: SN Venter, MJ Wingfield

**Dr Estiene Jordaan**
Title of thesis: Triangulating charcoal rot in South Africa.
Supervisor: JE van der Waals
External co-supervisor: NW McLaren (University of the Free State)

**Dr Jieqiong Li**
Title of thesis: Taxonomy, mating type distribution and population biology of *Calonectria* species.
Supervisor: SF Chen
Co-supervisor: I Barnes, MJ Wingfield

**Dr Feifei Liu**
Title of thesis: Species diversity and host associations of plant pathogenic *Ceratocystis* species in China.
Supervisor: SF Chen
Co-supervisors: MJ Wingfield, I Barnes

**Dr Edgar Mangwende**
Title of thesis: Identification and control of *Colletotrichum* species associated with *Eucalyptus* seeds.
Supervisor: TE Aveling
Co-supervisors: P Chirwa

**Dr Jan Nagel**
Title of thesis: Genomic insights into the biology and evolution of Botryosphaeriaceae.
Supervisor: B Slippers
Co-supervisors: MJ Wingfield

**Dr Gloria Valentine Nakato**
Title of thesis: *Xanthomonas campestris* pv. *musacearum*: population diversity and the identification of potential sources of resistance from banana accessions representing the *Musa* diversity worldwide.
Supervisor: TA Coutinho
Co-supervisors: G Mahuku (International Institute of Tropical Agriculture (IITA), Tanzania), EPP Wicker (CIRAD Agricultural Research for Development, France)

**Dr Ntombikayise Nkomo**
Title of thesis: The use of transcriptome and functional analysis to unravel the role played by Phop and SlyA in the biology of *Pectobacterium brasiliense* 1692 (Pb1692).
Supervisor: LN Moleleki
Co-supervisors: DY Shyntum, D Bellieny-Rabelo (Umea University, Sweden)

**Dr David Nsibo**
Title of thesis: Population genetics of the maize foliar pathogen *Cecospora zeina* in five countries of sub-Saharan Africa.
Supervisor: D Berger
Co-supervisors: I Barnes

**Dr Inosters Nzuki**
Title of thesis: QTL mapping for pest and disease resistance in cassava varieties Kiroba and AR37-80 and coincidence of QTLs with introgression regions from *Manihot glaziovii*.
Supervisor: AA Myburg
Co-supervisors: NA van der Merwe, ME Ferguson (International Institute for Tropical Agriculture, Kenya)

**Dr Caryn Oates**
Title of thesis: *Eucalyptus* morphological and molecular responses to *Leptocybe invasa* oviposition.
Supervisor: S Naidoo
Co-supervisors: KJ Denby (University of Warwick, United Kingdom), AA Myburg, B Slippers

**Dr Nicky Olivier**
Title of thesis: Genome assembly, annotation and comparative analysis of the maize fungal pathogen *Cercospora zeina*.
Supervisor: O Reva
Co-supervisor: DK Berger

**Dr Yewande Orubuloye**
Title of thesis: Chemical ecology of Equid-Tsetse interactions for improved control of African Trypanosomosis.
Supervisor: AA Yusuf
Co-supervisors: CWW Pirk, B Torto

**Dr Desré Pinard**
Title of thesis: Systems biology of organellar carbon metabolism in *Eucalyptus* xylogenesis.
Supervisor: E Mizrachi
Co-supervisor: AA Myburg

**Dr Ronel Roberts**
Title of thesis: Genetic and biological diversity of *'Candidatus Liberibacters*' from South Africa.
External supervisor: G Pietersen (Stellenbosch University)

**Dr Danielle Roodt**
Title of thesis: The evolution of xylogenesis in vascular plants.
Supervisor: E Mizrachi
Co-supervisor: YEP van de Peer

**Dr Quentin Santana**
Title of thesis: Population and genomic analyses of the pitch canker pathogen *Fusarium circinatum* Nirenberg & O'Donnell.
Supervisor: MPA Coetzee
Co-Supervisors: ET Steenkamp, BD Wingfield, MJ Wingfield

**Dr Mohammad Sayari**
Title of thesis: Secondary metabolite pathways in Ceratocystidaceae.
Supervisor: BD Wingfield
Co-supervisors: ET Steenkamp, MA van der Nest

**Dr Gi Yoon (Gina) Shin**
Title of thesis: Functional characterization of Hfq and identification of Hfq-dependent sRNAs in *Pantoea ananatis*.
Supervisor: TA Coutinho
Co-supervisor: LN Moleleki, DY Shyntum

**Dr Vou Moses Shutt**
Title of thesis: Bacterial pathogens of tomato in South Africa: identification, population diversity and cultivar susceptibility.
Supervisor: TA Coutinho
Co-supervisors: JE van der Waals, T Goszczynska (Agricultural Research Council)

**Dr Elrea Strydom**
Title of thesis: Soybean blotchy mosaic virus: Molecular characterization and seasonal persistence.
Supervisor: G Pietersen

**Dr Michel Tchoumi Tchotet**
Title of thesis: Wood-rot fungi in the Garden Route National Park (GRNP) and surrounds of South Africa: Identification and taxonomy.
Supervisor: J Roux
Co-supervisors: MPA Coetzee, M Rajchenberg (CIEFAP - Centro de Investigacion y Extension Forestal Andino Patagonico, Argentina)

**Dr Stephanie van Wyk**
Title of thesis: Repeat-induced point mutations in the *Fusarium fujikuroi* species complex.
Supervisor: ET Steenkamp
Co-supervisors: BD Wingfield, NA van der Merwe, L de Vos

**Dr Erika Viljoen**
Title of thesis: Genetic diversity analysis of the *Amaranthus* genus using genomic tools.
Supervisor: DK Berger

**Dr Erik Visser**
Title of thesis: Transcriptomic model of resistance mechanisms in the *Pinus-Fusarium circinatum* interaction.
Supervisor: S Naidoo
Co-supervisors: AA Myburg, ET Steenkamp, JL Wegrzyn (University of Connecticut, USA)



**Dr Andi Wilson**
Title of thesis: Unisexual reproduction in filamentous Ascomycete fungi.
Supervisor: BD Wingfield
Co-supervisors: MJ Wingfield, PM Wilken, MA van der Nest

## *MSc*

**Katrien Brown** (with distinction)
Title of Dissertation: Identification and functional associations of DNase I hypersensitive sites in developing secondary xylem of *Eucalyptus grandis* W.Hill.
Supervisor: SG Hussey
Co-supervisor: E Mizrachi, AA Myburg

**Julia Candotti** (with distinction)
Title of Dissertation: Genetic dissection of growth and wood properties in a nested, half-sib *Eucalyptus* hybrid pedigree.
Supervisor: AA Myburg
Co-supervisor: E Mizrachi

**Cameron Cullinan** (with distinction)
Title of Dissertation: The response of Soybean Cysteine. Protease CP3 to drought
Supervisor: BJ Vorster

**Claudio de Nuzzo**
Title of Dissertation: Endogenous peptide defence in maize against the fall armyworm *Spodoptera frugiperda* (J.E. Smith).
Supervisor: DK Berger
Co-supervisor: K Krüger

**Claudette Dewing** (with distinction)
Title of Dissertation: Comparative genomics reveal processes implicated in host-specificity in species within the American clade of the *Fusarium fujikuroi* species complex.
Supervisor: L de Vos
Co-supervisors: ET Steenkamp, BD Wingfield, MA van der Nest

**Esna du Plessis**
Title of Dissertation: Population biology and impact of *Austropuccinia psidii* in South Africa.
Supervisor: J Roux
Co-supervisors: I Barnes, AR McTaggart

**Michael du Toit**
Title of Dissertation: Assessing the threat of the Polyphagous Shot Hole Borer ambrosia beetle and its fungal symbiont, *Fusarium euwallaceae*, to *Persea americana* in South Africa.
Supervisor: N van den Berg
Co-supervisors: ZW de Beer, G Fourie

**Ludwig Eksteen**
Title of Dissertation: Patterns and drivers of host use by the European woodwasp, *Sirex noctilio*, in South African pine plantations.
Supervisor: JR Garnas
Co-supervisor: BP Hurley

**Stephanus Engelbrecht** (with distinction)
Title of Dissertation: Allele-specific expression in xylogenic tissues of *Eucalyptus grandis* x *E. urophylla* hybrids.
Supervisor: AA Myburg
Co-supervisor: E Mizrachi

**Shaina Facey** (with distinction)
Title of Dissertation: Detection of grapevine leafroll associated virus 3 in South African rootstock clones.
External supervisor: G Pietersen (Stellenbosch University)
Co-supervisor: J Theron

**Caitlin Gevers**
Title of Dissertation: The diversity, distribution and role of Hymenoptera associated with *Leptocybe* galls in South Africa.
Supervisor: BP Hurley
Co-supervisors: G Dittrich-Schröder, B Slippers

**Alessandro Gricia** (with distinction)
Title of Dissertation: The type VI secretion system in *Pectobacterium* spp: Role in virulence and regulation by Zur.
Supervisor: LN Moleleki

**Lichelle Grobler**
Title of Dissertation: Agrobacterium-mediated CRISPR-Cas9 genome editing in *Nicotiana benthamiana*.
Supervisor: BG Crampton
Co-supervisors: MM O'Kennedy (Council for Scientific and Industrial Research), P Pillay (Council for Scientific and Industrial Research).

**Mathew Harris** (with distinction)
Title of dissertation: Characterising patterns in fungal community ecology at local and global scales.
Supervisor: M Greve
Co-supervisor: B Slippers
External co-supervisor: M Kemler (Ruhr-University Bochum, Germany)

**Jesse Hartley** (with distinction)
Title of dissertation: Surveillance and isolation of *Rosellinia necatrix* in South African avocado orchards.
Supervisor: N van den Berg

**Rochelle Janse van Rensburg**
Title of dissertation: *'Candidatus Liberibacter africanus'* in non-rutaceous alternate host species from South Africa.
External supervisor: G Pietersen (Stellenbosch University)

**Christoff Joubert**
Title of dissertation: Constitutive chemical defense of *Eucalyptus* against herbivory by *Gonipterus* sp. n. 2.
Supervisor: A Hammerbacher
Co-supervisors: Brett Hurley, Michelle Schröder

**Melissa Joubert** (with distinction)
Title of dissertation: Discovery of *Phytophthora cinnamomi* RxLR effector genes expressed in avocado during infection.
Supervisor: N van den Berg
Co-supervisor: SA Prabhu

**Eugene Kabwe**
Title of dissertation: Discovery and genomic architecture of *Cercospora zeina* (Crous & U. Braun) effector genes.
Supervisor: DK Berger
Co-supervisor: TA Duong

**Tamanique Kampman** (with distinction)
Title of dissertation: The transcriptome of *Pinus maximinoi* under *Fusarium circinatum* challenge.
Supervisor: S Naidoo
Co-supervisor: D Visser

**Frances Lane** (with distinction)
Title of dissertation: Development of a genetic transformation system in the family Ceratocystidaceae with specific reference to *Ceratocystis albifundus*.
Supervisor: BD Wingfield
Co-supervisor: PM Wilken

**Nico le Roux**
Title of dissertation: Soil surface temperature effects on the establishment of three grass-legume seed mixtures used in surface mine rehabilitation.
Supervisor: WF Truter
Co-supervisor: TAS Aveling

**Lizette Loubser** (with distinction)
Title of dissertation: Genetic architecture of gene expression during xylogenesis in *Eucalyptus* interspecific hybrids.
Supervisor: AA Myburg
Co-supervisors: E Mizrachi
Co-supervisor: N Christie

**Kira Lynn** (with distinction)
Title of dissertation: *Fusarium* spp. associated with ambrosia beetles on *Acacia crassicarpa* in Indonesia.
Supervisor: I Barnes
Co-supervisors: MJ Wingfield, ZW de Beer
External co-supervisor: AJ Durán Sandoval (Royal Golden Eagle International, Indonesia)

**Thapelo Maboko**
Title of dissertation: A genetic transformation system for *Chrysoporthe austroafricana.*
Supervisor: NA van der Merwe
Co-supervisor: BG Crampton
External co-supervisor: E Kunjeku (University of Venda)

**Lungile Mabuza**
Title of dissertation: Characterization of the basic leucine zipper (bZIP) gene family of *Eucalyptus grandis* and a bzip7 mutant homolog in *Arabidopsis thaliana*.
Supervisor : SG Hussey
Co-supervisor : AA Myburg

**Teresia Macharia**
Title of dissertation: Response of potato (*Solanum tuberosum* L.) to challenge by root-knot nematode *Meloidogyne javanica*.
Supervisor: LN Moleleki
Co-supervisor: D Bellieny-Rabelo

**Zanele Mahlangu** (with distinction)
Title of dissertation: Seed quality of farm-saved dry bean produced by smallholder farmers in the uThukela district of Kwazulu-Natal, South Africa.
Supervisor: TAS Aveling
Co-supervisor: Q Kritzinger

**Dineo Mailula** (with distinction)
Title of dissertation: Production of fusel alcohols in the species of the family Ceratocystidaecea.
Supervisor: A Hammerbacher
Co-supervisors: BD Wingfield, MA van der Nest

**Lazarus Mavima** (with distinction)
Title of dissertation: Taxonomic characterization of *Paraburkholderia tuberum*-like rhizobia from diverse legumes.
Supervisor: ET Steenkamp
Co-supervisors: SN Venter, CW Beukes

**Pfano Mbedzi**
Title of dissertation: Evaluation of simple sequence repeats (SSR) markers associated with resistance to *Sclerotinia sclerotiorum* (Lib.) de Barry in commercial South African soybean cultivars.
Supervisor: BJ Vorster
Co-supervisor: JE van der Waals

**Nikki Miguel**
Title of dissertation: Identification of antibacterial type VI secretion system effectors in *Pectobacterium carotovorum* subsp. Brasiliense 1692.
Supervisor: Prof LN Moleleki

**Tsakani Miyambo** (with distinction)
Title of dissertation: Identification and characterization of polygalacturonases in *Phytophthora cinnamomi.*
Supervisor: N van den Berg
Co-supervisor: SA Prabhu

**Zimbili Mlunjwa**
Title of dissertation: Expression analysis of selected maize primary metabolism genes in response to *Cercospora zeina* inoculation in the glasshouse.
Supervisor: DK Berger

**Mateka Modiba**
Title of dissertation: The identification of Oomycetes associated with plum orchards in the
Westen Cape Province, South Africa.
Supervisor: TA Coutinho
Co-supervisor: T Bose

**Gontse Modisane**
Title of dissertation: Metabolic profiling for identification of potential biomarkers in potato tuber extracts associated with tolerance to *Spongospora subterranea* f. sp. subterranean infection.
Supervisor: Z Apostolides
Co-supervisor: JE van der Waals



**Seamus Morgan**
Title of dissertation: Taxonomy and biology of *Quambalaria* spp. infecting eucalypts in South Africa.
Supervisor: ZW de Beer
Co-supervisor: MJ Wingfield

**Sanele Moyana**
Title of dissertation: Diversity of rhizobial Methylobacterium species associated with indigenous legumes in South Africa.
Supervisor: SN Venter
Co-supervisors: ET Steenkamp, EK Muema

**Fezile Mthunzi**
Title of dissertation: Identification and characterisation of terpene synthase genes in the fungal genus *Armillaria*, with special reference to *A.mellea*.
Supervisor: MPA Coetzee
Co-supervisors: BD Wingfield, A Hammerbacher

**Lufuno Mudau**
Title of dissertation: Development of an effective phytosanitary regulatory system for onion (*Allium cepa*) export in South Africa.
Supervisor: TAS Aveling
Co-supervisor : MT Mutengwe

**Zanelle Mufamadi**
Title of dissertation: Identification of the causal agents and management of husk rot on macadamia in South Africa.
Supervisor: N van den Berg
Co-supervisor: G Fourie

**Khumbudzo Ndhlovu**
Title of dissertation: Symbiotic nitrogen fixation efficiency of native rhizobia in selected South African legume crops.
Supervisor: ET Steenkamp
External co-supervisor: AI Hassen (Agricultural Research Council)

**Alex Nepomuceno**
Title of dissertation: Inferred evolutionary relationships of the dung beetle tribe Scarabaeini (Coleoptera: Scarabaeidae) using gland morphology and cuticular hydrocarbons (CHCs).
Supervisor: CL Sole
Co-supervisor: CWW Pirk

**Willem Pretorius**
Title of dissertation: *In silica* identification of a putative two component system in *Pectobacterium brasiliense*.
Supervisor: LN Moleleki
Co-supervisor: D Bellieny-Rabelo (Umea University, Sweden)

**Miranda Procter** (with distinction)
Title of dissertation: Redefining generic boundaries in the Ophiostomatales (Ascomycota).
Supervisor: ZW de Beer
Co-supervisors: MJ Wingfield, TA Duong

**Redzuan Rauf**
Title of dissertation: Ceratocystis wilt on *Acacia mangium* and Chrysoporthe canker on *Eucalyptus* in Sabah, Malaysia.
Supervisor: MJ Wingfield
Co-supervisor: I Barnes

**Bianca Rodrigues-Jardim**
Title of dissertation: Characterisation of *Sirex noctilio* and *Culicoides imicola* sex determination pathways.
Supervisor: WC Fick
Co-supervisors: B Slippers, A Postma-Smidt

**Sydney Sithole**
Title of dissertation: Non-ribosomal peptide synthetases from the genomes of selected *Chrysoporthe* species.
Supervisor: NA van der Merwe
Co-supervisors: S Naidoo
Co-supervisor : ET Steenkamp

**Ashleigh Smith**
Title of dissertation: Characterisation of Lepidoptera species associated with Macadamia in South Africa.
Supervisor: G Fourie
Co-supervisors: BP Hurley, B Slippers

**Robyn Smith**
Title of dissertation: The partial characterisation of the terpene synthase genes implicated in the defence response by *Pinus patula* and *Pinus tecunumanii* to *Fusarium circinatum.*
Supervisor: S Naidoo
Co-supervisor: MPA Coetzee

**Nicole Soal**
Title of thesis: Characterisation of the catechol dioxygenase genes in the Ceratocystidaceae.
Supervisor: BD Wingfield
Co-supervisors: MPA Coetzee, A Hammerbacher, MA van der Nest

**Catherine Tatham**
Title of dissertation: Characterization of the *Teratosphaeria destructans* genome.
Supervisor: BD Wingfield
Co-supervisors: MJ Wingfield, PM Wilken, MA van der Nest

**Tanya Welgemoed**
Title of dissertation: *De novo* assembly of transcriptomes from near-isogenic maize lines for novel defence gene discovery.
Supervisor: DK Berger
External co-supervisor: RE Pierneef (Agricultural Research Council)

**Nomakula Zim**
Title of dissertation: Comparative genomics and pathogenicity of *Xanthomonas vasicola*.
Supervisor: TA Coutinho
External co-supervisors: EPP Wicker (CIRAD Agricultural Research for Development, France), SA McFarlane (South African Sugarcane Research Institute)

## BSc Honours

Vasili Balios (with distinction)
Surprise Baloyi
Shivan Bezuidenhout
Gergard Botha
Carla Buitendag (with distinction)
Jenna Craddock
Ruby Ebbeling
Hendrik Esterhuizen
Shawn Fell
Stefan Ferreira
Alicia Fick
Eleanor Froneman
Casey Gill
Phillip Greef
Verushka Ibanez
Robert Jansen van Vuuren
Marizanne Jones
Daniella Kramer
So Ri La
Kristiann Labuschagne
Christopher Liakos
Anneri Lotter
Ophelia Maila
Ingrid Marais (with distinction)
Aaron Maringa
Nomaswazi Maseko
Kayla Midgley
Sthembiso Mngadi
Jamie Mollentze
Trystan Nadasen (with distinction)
Chizné Peremore
Jenna-Lee Price
Boitshoko Rammuki
Claire Randolph
Vera Röder
Kevin Scheepers (with distinction)
Cassandra Schoeman
Lebone Sebapu
Precious Kothibe Sedibane
Preston Shaw
Bernard Smit (with distinction)
Byron Sonnekus
Medha Sood
Tessa Stallard (with distinction)
Shae Swanepoel
Taponeswa Tasiya
Hannah Tate
Louisa Terblanche
Palesa Thys
Amber Tulloch
Dee Twiddy
Nicole van Vuuren
Lente van Zyl
Sumari Venter (with distinction)
Anien Viljoen
Raven Wienk
Jasper Willemse (with distinction)
Keenan Williams

## BSc

Bernard Smit

## BSc (Agric)

Erika Botha
Cheyenne Theron

## Postgraduate Diploma (Entrepreneurship)

Prof. Albé van der Merwe


Artists: Julia Kreiss



# OBITUARIES

The FABI community mourned the passing of three FABI stalwarts: **Dr Eugene Makgopa** (9 September 2020), **Prof. Terry Aveling** (18 December 2020) and **Prof. Stefan Neser** (17 February 2021). They will be dearly missed.

### IN MEMORIAM: DR EUGENE MAKGOPA

Dr Matome Eugene Makgopa, Senior Lecturer in the Department of Plant and Soil Sciences, passed away on 9 September 2020 after a prolonged illness. As a lecturer and teacher, Dr Makgopa was widely respected, and he taught biotechnology-related content at second and third-year levels, as well as honours courses. His students often gave rave reviews of his teaching, and he was an open, friendly and approachable person. He always had a ready smile and quick joke, and was quietly professional.

Eugene was a rising star at the University of Pretoria and in South African academia and nominated for election as a council member of the South African Association of Botanists. His research interests lay in plant biotechnology, especially in cysteine protease inhibitors and the role they play in helping the plant (notably soybean) respond to biotic and abiotic stress. He was a research leader within the Molecular Plant Physiology research group and the Grain Research Programme. At the time of his passing, he was growing his research group and expanding his collaborations. He also graduated five postgraduate students.

### IN MEMORIAM: PROF. TERRY AVELING*

Prof. Terry Aveling, an associate Professor in the Department of Plant and Soil Sciences at the University of Pretoria's Faculty of Natural and Agricultural Sciences and a research leader in FABI passed away on 18 December 2020. She was considered one of the leading seed scientists in the country and established the internationally recognised Seed Research Unit at the University of Pretoria (UP). Prof. Aveling also developed the Seed Science course that is now mandatory for all seed analysts working in South Africa, according to the requirements of the South African National Seed Organisation (SANSOR). She was internationally recognised for her leadership role in seed science through her active engagement with the International Seed Testing Association (ISTA). She also served as chairperson on many ISTA committees. As invited/guest Professor and researcher, she established long-term research international collaborations with institutions in Spain, Norway, Poland, France and Benin.

Twenty-seven MSc and 13 PhD students have graduated under Terry's leadership during her 33 years at UP. Paying tribute to her, they described her as an inspiration and fearless soul who taught them to be brave and 'live life to the fullest even if you have a disability'. She made everybody feel like somebody, saw the potential in every student and never judged people.

*Acknowledgement for the eulogy to Prof. Lise Korsten, Prof. Nigel Barker and UP Plant Pathology staff.

### IN MEMORIAM: PROF. STEFAN NESER

Professor Stefan Neser passed away on 17 February 2021. Stefan was archetypical the iconic naturalist. His broad and deep knowledge of natural history as well as the passionate and contagious way he shared this knowledge, was an inspiration to those privileged enough to have met him. At the same time, he was kind and humble, and he possessed an incredible ability to observe the small biological details so often missed by most other scientists.

He had connections and friendships with many FABI team members, long before he became formally associated with the Institute at the time of his retirement from the Agricultural Research Council (ARC). He was thus responsible for numerous first reports and important observations relating to insect pests of plantation trees. Amazingly, even though he was not a pathologist, he would, on occasion, discover new disease problems before these were seen by pathologists and mycologists, having had years of experience in the field.

During his long career in the ARC, Stefan contributed enormously to the development of biological control of invasive weeds, both in South Africa, as well as in other parts of the world where South African plants are invasive. At the time of his retirement from the ARC, Stefan established a close working relationship with FABI, especially focussed on developing biological control programmes and other projects important to the Institute. Here he provided guidance regarding the practical details of projects, the design of experiments, and he enthusiastically shared his vast knowledge and experience in interpreting observations with FABI students and staff members.

Stefan was the 'go-to person' in many of the biological control projects in FABI and it is hard to imagine a future in this field that does not include him. He played a fundamentally important role assisting FABI in developing biological control programmes for many forest pests including for example, the *Eucalyptus* snout beetle *Gonipterus* sp.2, the *Eucalyptus* bronze bug *Thaumastocoris peregrinus* and the *Eucalyptus* gall wasp *Leptocybe invasa*. In the case of the latter pest, the biological control agent (now utilised widely in South Africa and in many countries of the world) was named in his honour as *Selitrichodes neseri*. Stefan was the kind of person to simply smile and downplay this honour, his contribution to these programmes and his accomplishments that were so admired by others.

Above all else, Stefan was a great mentor, colleague and friend. He was a truly wonderful person in every sense; admired, respected and loved by everyone who had the privilege of knowing him.

# FABI RESEARCH OUTPUT

## *THE FIRST JOVE VIDEO SHOOT IN AFRICA*

Prof. Brenda Wingfield, Dr Andi Wilson, Dr Tuan Duong and Vinolia Danki produced a JoVE video in 2020. Prof. Wingfield and Dr Wilson wrote the publication detailing the CRISPR-Cas9-based fungal transformation system developed by Dr Wilson during her PhD studies. They were joined in the making of the video by Dr Duong and MSc student Vinolia Danki. What they only learned just before the cameras started rolling was this was a first for Africa! JoVE is an online open-access journal and producer and provider of science videos. The article written by Prof. Wingfield and Dr Wilson supports the video (https://www.jove.com/v/61367/crispr-cas9-mediated-genome-editing-filamentous-ascomycete-huntiella).

## *FABI BOOKS*

Professor Mike Wingfield and FABI alumnus Dr Carlos Rodas co-authored a new book entitled "**Important insect pests and diseases of *Pinus* and *Eucalyptus* in Colombia**". This lavishly illustrated book results from a 26-year-long professional research collaboration and friendship between the authors and an equally long research partnership between Colombian forestry company Smurfit Kappa and FABI. The official launch of the book took place virtually on 4 March 2020. This event was hosted by the Colombian forestry company Smurfit Kappa that also generously sponsored the production of the book. It provides a historical record of the health problems that Colombian *Eucalyptus* and *Pinus* tree plantations have experienced. But many of these forestry pests and pathogens are also present in South Africa and elsewhere globally, pointing to their global spread and the importance of international collaboration to find solutions to these problems.

Professors Teresa Coutinho and Mike Wingfield launched a new book they co-authored chronicling the **60 year history of the SASPP and 130 years of plant pathology in South Africa**. This book, that has been in planning and production for a number of years, was launched during the 52nd Congress of the South African Society of Plant Pathologists (SASPP) in January 2021. The 300-plus page book that will be published shortly is the first comprehensive account of the history of the Society and discipline to have been produced. Prof. Wingfield noted that it should not be seen as a final product, but rather a "work in progress" that can be easily expanded in the future.

# RESEARCH PUBLICATIONS

## *2019*


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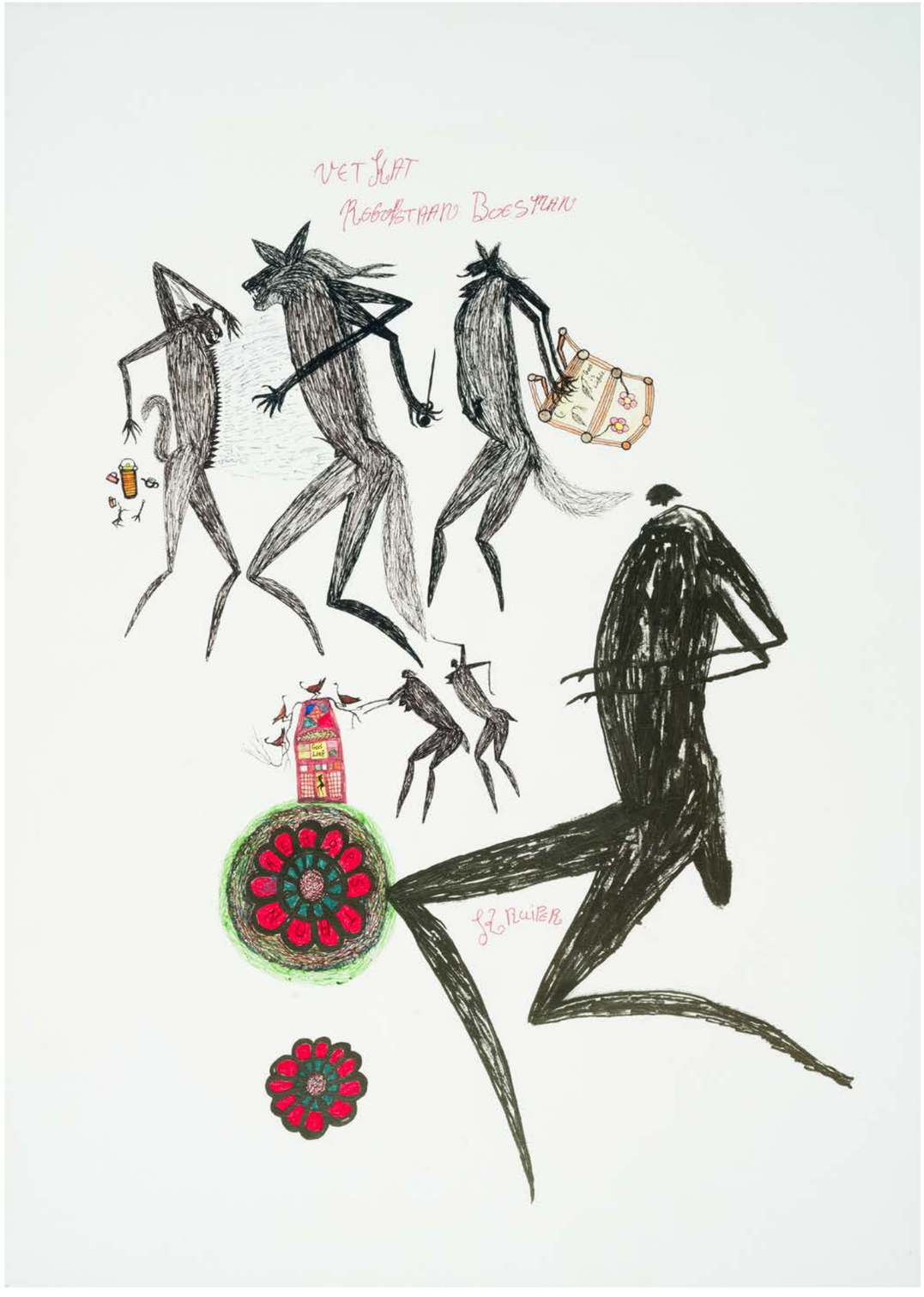


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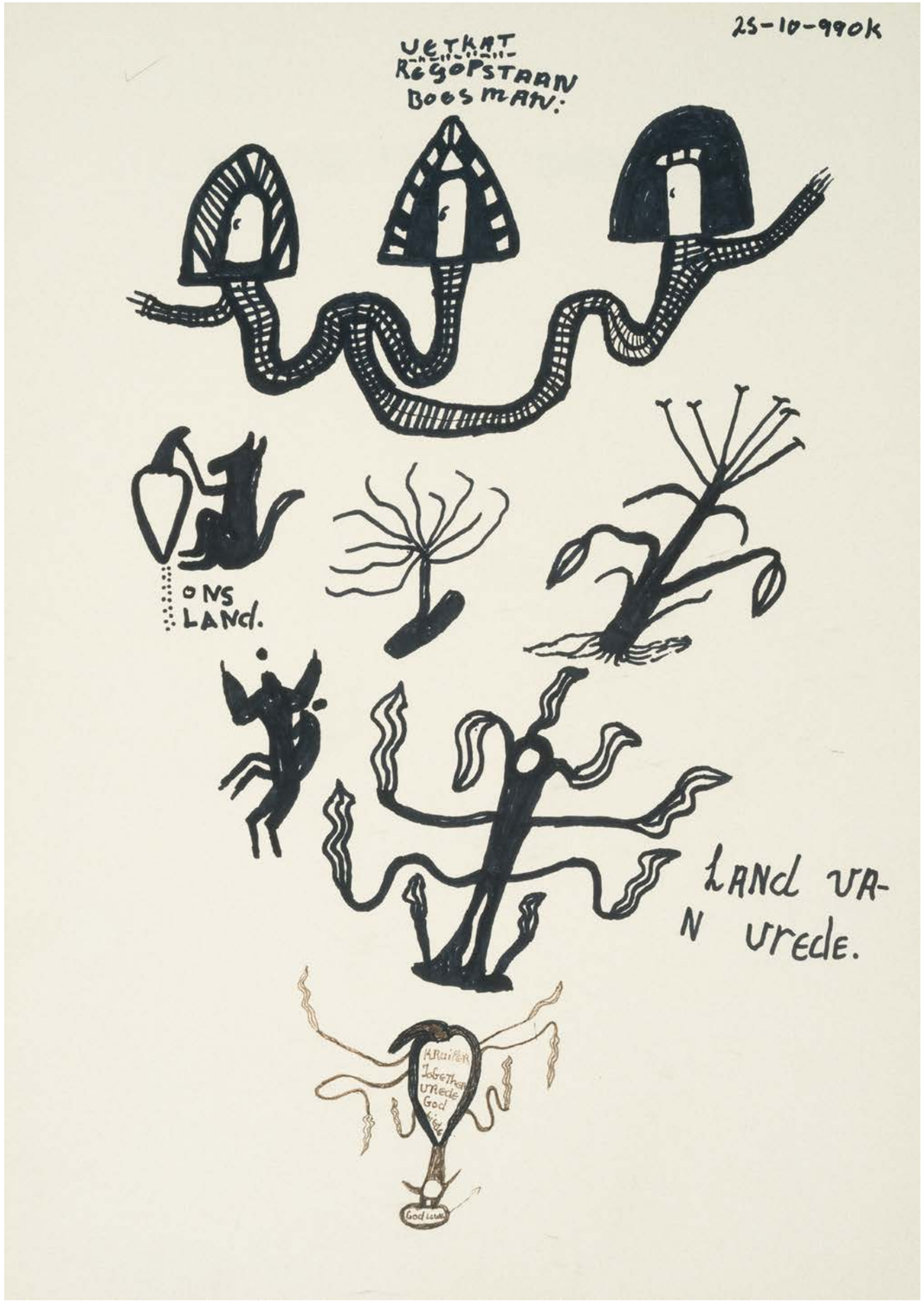


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## *2021 (up to end of May)*

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Artist: Alistair McTaggart



# FABI VISITORS & SEMINARS

## *FABI International Seminar Series*

**Dr Matthew Kasson**
West Virginia University, USA
Deciphering fungus-arthropod interactions: from ambrosia fungi to cicada-killing "Zygomycetes".
June 2020

**Dr Celine Caseys**
University of California, Davis, USA
Plant versus Botrytis: a story of quantitative plant-pathogen interactions.
July 2020

**Dr Marie-Agnès Jacques**
National Institute for Agricultural Research, France
Addressing the threat posed by *Xylella fastidiosa* to the agriculture and the environment.
August 2020

**Prof. Katherine Denby**
University of York, UK
A systems approach to disease resistance against necrotrophic fungal pathogens.
September2020

**Dr Robert Waterhouse**
University of Lausanne, Switzerland
Evolutionary genomics of arthropods impacting plant health.
October 2020

**Prof. Eva Stukenbrock**
Max Planck Institute / Kiel University, Germany
Interspecific hybridization in fungal grass pathogens shape genome-wide variation.
November 2020

**Prof. Sarah de Saeger**
Ghent University, Belgium
Mycotoxins, an important threat to human health?
January 2021

**Prof. Prof Daniel Croll**
University of Neuchâtel, Switzerland
Drivers and brakes of pathogen emergence.
February 2021

**Prof. Marc Stadler**
Helmholtz Centre for Infection Research, Braunschweig, Germany
Discovery of biologically active fungal metabolites from new and hitherto unexplored species.
March 2021

**Dr Andrew Liebhold**
US Forest Service, USA
Macroecology of insect invasions.
April 2021

**Prof. Jonathan Gershenzon**
Max Planck Institute for Chemical Ecology, Germany
Tree texts: How poplars communicate with friends and foes using volatile organic compounds.
May 2021

## *Special Seminars*

**Prof. Robin Crewe**
University of Pretoria, South Africa
The dark side of the feminine monarchy: Individual behaviour in honeybees.
August 2019

**Prof. John Taylor**
University of California, Berkeley, USA
Characterising fungal species and their ecology with cultivated sorghum.
September 2019

**Prof. Jiri Hulcr**
University of Florida, USA
Which of the 1000 bark beetles indigenous to Asia is the greatest threat to American forests?
November 2019

**Dr Maartje Klapwijk**
Swedish University of Agricultural Sciences in Uppsala, Sweden
Trophic interactions in the Anthropocene.
November 2019

**Prof. Tim Paine**
University of California, Riverdale, USA
Invasive ambrosia beetles: Biology and control.

### Visitors

**Ms Sebueng Chipeta**
Department of Agriculture, Forestry and Fisheries, South Africa
May 2019

**Prof. Lori Eckhardt**
Auburn University, USA
August 2019

**Prof. Claudio Maggi**
Universidad de Concepción, Chile
September 2019

**Dr Rodrigo Ahumada**
Bioforest, Chile
September 2019

**Prof. Sylwia Wdowiak-Wróbel**
University of Maria Curie - Skłodowska (UMCS), Poland
October 2019

**Dr Michal Kalita**
University of Maria Curie - Skłodowska (UMCS), Poland
October 2019

**Prof. Tomasz Stępkowski**
Institute of Bio-organic Chemistry Polish Academy of Science, Poznań, Poland October 2019

**Joanna Banasiewicz**
Institute of Bioorganic Chemistry Polish Academy of Science,
Poznań, Poland October 2019

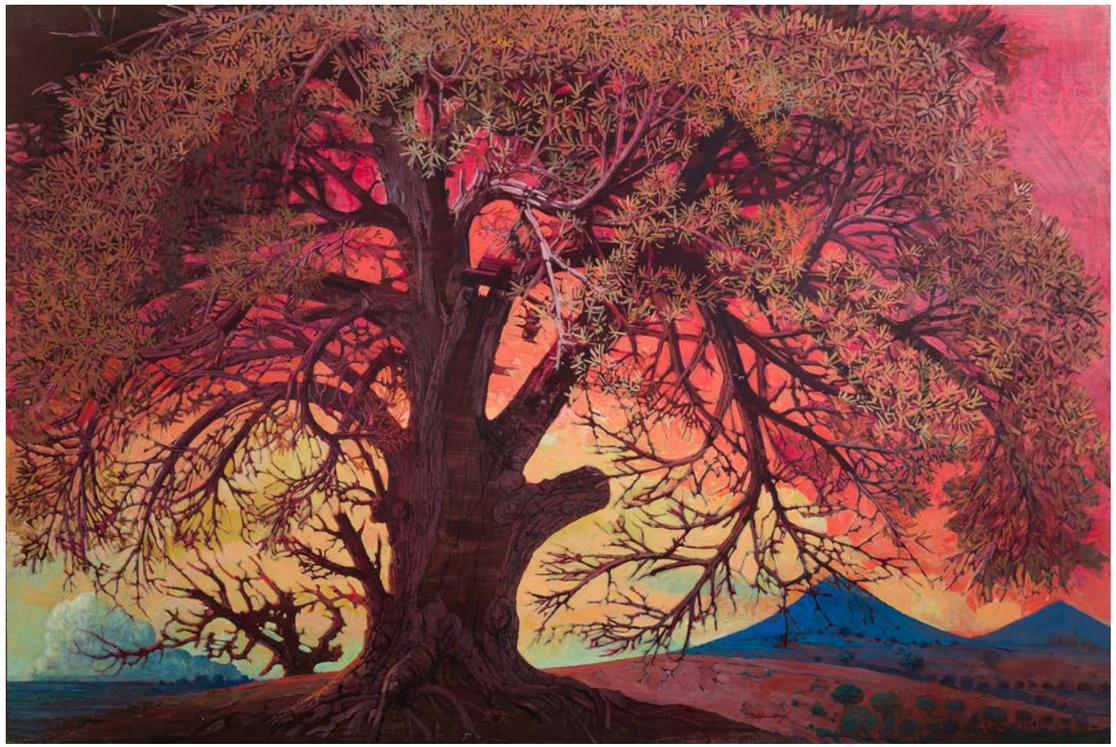
**Rafał Banasiewicz**
Institute of Bioorganic Chemistry Polish Academy of Science,
Poznań, Poland October 2019

**Dr Thiago Romanos Banetti**
Suzano Pulp and Paper
March 2020

**Dr Aurelio Mendes Aguiar**
Suzano Pulp and Paper
March 2020

**Dr Deepak Balaji Thimiri Govinda Raj**
Centre for Synthetic Biology and Precision Medicine, CSIR,
South Africa
March 2020

**Duane Roothman**
Vice President: Sappi Forests, South Africa
December 2020



Artist: Appie van Wyk



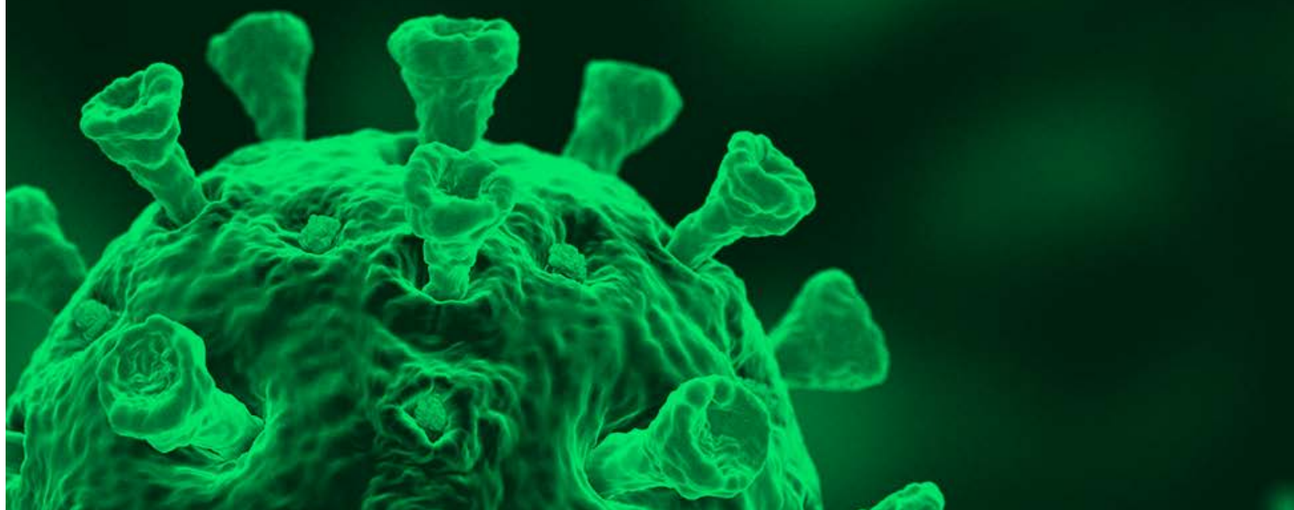
# *COVID DOES NOT STOP FABI*

The COVID-19 pandemic saw South Africa enter an extremely strict lockdown from 26 March to arrest the spread of the virus. These restrictions initially prevented any staff or student access to the campus and resulted in a cessation of all laboratory and field-based activities in the Institute. Anticipating an imminent lockdown weeks before the event, plans were put in place by the FABI Management Committee to pivot research activities and ensure as little disruption as was possible to the Institute's activities during this period. Meetings and student presentations were quickly moved online using the Zoom virtual platform and this in fact allowed more people to connect than if we had met in person, including participation from research collaborators from as far afield as China, Colombia, Indonesia and New Zealand. The first Thursday Morning Seminar was hosted virtually on 19 March, a week before the lockdown. The first virtual Prestige Seminar was presented by Stephanie van Wyk on 2 June. The Annual TPCP/CPHB Symposium was held as a one-day event in May.

Field extension services were halted but again resumed in June with the support of our industry partners and the University of Pretoria. A health check App was commissioned to monitor access to FABI facilities and track possible contacts with infected persons. This App has proven to be very successful and has subsequently been adopted for use by several other faculties and departments at the University of Pretoria. To the credit of all FABIans, there has not been, to date, one tracked reinfection within the institute where social distancing protocols are strictly enforced (and respected) at all times. All FABIans were also given free branded face masks to wear.

All conferences were cancelled, so in response to this FABI launched a very popular FABI International Seminar Series where invited speakers presented their work to a global audience once a month. FABI also co-hosted a webinar series in partnership with the International Union of Forest Research Organizations (IUFRO) on the "Behavioural and chemical ecology of bark and wood-boring insects". The webinar series was co-hosted with Forest Entomology, Forest Pathology and Forest Protection, BOKU, the Universidad de la República, Uruguay and the Canadian Forest Service. FABI also co-hosted the 52nd (virtual) Congress of the South African Society of Plant Pathologists (SASPP) on 20 January 2021.

But the lockdown resulted in many people feeling isolated, depressed and starved of social contact. To address this the FABI social club rose to the challenge and moved popular social events such as SPOOF (Society for the Presentation Of Outrageous Findings) and the year-end function onto a virtual platform. They also hosted a very popular online Quiz Evening as well as a Meet-and-Greet where new FABIans could meet other members of the institute virtually and get to know them.



## INDUSTRY PARTNERS

- Allesbeste Farming
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- Camcore Breeding and Conservation Cooperative
- Cape Pine (Pty) Ltd
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- Department of Higher Education
- Department of Science and Innovation (DSI)
- DSI-NRF Centre of Excellence Programme
- Future Leaders-African Independent Research (FLAIR) Fellowship
- Forestry South Africa (FSA)
- Global Challenges Research Fund (GCRF)
- Grain SA
- Hans Merensky Foundation
- Hortgro
- Institute for Commercial Forestry Research (ICFR)
- Macadamias South Africa NPC (SAMAC)
- Maize Trust
- Merensky Timber LTD
- Mondi Ltd
- MTO Forestry
- NCT Forestry Cooperative
- NRF Competitive Programme For Rated Scientists
- NRF Poland/SA Bilateral Grant
- NRF SARChI Research Chair
- NRF-Thuthuka
- Oil and Protein Seed Development Trust
- PG Bison (Pty) Ltd
- Potatoes South Africa
- Royal Golden Eagle (RGE)
- Safcol/Komatiland Forests (Pty) Ltd
- Sanparks
- Sappi Southern Africa (Pty) Ltd
- SCRI (Speciality Crop Research Initiative)/USDA (United States Department of Agriculture): "Stop the rot: Combating onion bacterial diseases with pathogenomics tools and enhanced management strategies"
- South African Grain Lab
- South African Pecan Nut Producers Association (SAPPA)
- Southern African Avocado Growers Association (SAAGA)
- Technology Innovation Agency (TIA)
- The Forestry Sector Innovation Fund (FSIF)
- The National Research Foundation (NRF)
- The University of Pretoria
- TWK Agriculture Ltd
- Ukhanyo Farmer Development Programme
- US Department of Energy Joint Genome Institute
- Westfalia Technological Services
- York Timbers (Pty) Ltd



## *BACKGROUND INFORMATION ABOUT THE ARTISTS WHOSE ARTWORK WAS INCLUDED IN THE REPORT*

**Bettie Cilliers-Barnard**
Born 1914, near Rustenburg - died in 2010.

Barnard studied at the University of Pretoria and painted for nearly 80 years of her life. During her career as one of South Africa's most important woman artists, she represented the country at a number of international exhibitions, including the Xie Grand Prix International d'Art Contemporian de Monte Carlo in Monaco (1977), the 5th International Biennale for Graphic Art in Italy, the Gulbennkaian Exhibition in Portugal (1968), the Venice Biennale (1956 and 1964), and the São Paulo Biennale (1957, 1959, 1961 and 1963). She also exhibited in countries such as Austria, Germany, Spain, Greece and Israel to name a few. Her tapestries, paintings, and murals in oils have been commissioned both for public, museum and private collections in South Africa and abroad. She has won several major art awards, and received two honorary doctorates from South African universities.

The Art Historian, Muller Ballot, says the following about her work: "The central message in her works... is certainly related to the artist's serious search for a reconciliation of earthly and transcendental perspectives on human existence. Her reaching out to esoteric horizons, to the boundaries of time and space... seeks fulfilment in the symbolic values of the human figure. Sometimes these occur with, for example, strange alien beings, primeval animal forms, arrows and sharp triangular shapes."

**Gregoire Boonzaier**
Born in 1909, Cape Town - died in 2005 (Onrus) after a hunger strike of almost two months following the death of Mary, his partner of 60 years.

Born from a father that was an artist in his own right, Boonzaier rubbed shoulders with some of the most important South African artists from an early age and learned from them. Gregoire's father was dead set against a formal training in art and felt that he had more to learn from the artists around him. The boy received his first box of paints at age 13 and his own easel at age 17, putting him onto an artistic path of 80 years. By 1925 he held his first one-man exhibition. His landscapes, portraits, still lifes and historical paintings now hang in galleries worldwide.

Boonzaier was a famous exponent of Cape Impressionism, a founder of the New Group, and a contributor, through his art works, to the struggle against apartheid. For many years he regularly visited District Six and the Malay Quarter in Cape Town, sitting in the streets, painting its colourful life, and unknowingly at the time, recording it historically, before the forced removal of the inhabitants from these areas.

Boonzaier was a friend and well-known contributor to the University of Pretoria, with a bursary fund named after him, and more than 30 works donated to the institution during his lifetime.

**Retha Buitendach**
Born in 1968, Vereeniging.

Retha Buitendach's artworks deals with nature in both its macrocosmic and microcosmic detail. The hidden interconnectedness of all living things is an important underlying theme, as is the chance connections between seemingly unrelated things or even words. Unusual and microscopic life-forms as well as those seen every day are sometimes portrayed in unusual contexts, thereby inducing the onlooker to discover them anew. The human figure is seldom directly visible in her artworks, although human presence is often implied. Man is shown to be unique in his ability to experience nature as a supremely beautiful artwork and to be unique in his ability to destroy it all. Her work is both naturalistic and surrealistic, combining the recognisable with what the imagination can add to it.

Her oil paintings hang in many galleries, homes and corporate office throughout South Africa. She is also known for her unique use of unconnected wooden objects to recreate natural life forms. By doing this she forces the viewer to rediscover the form they are looking at by using their imagination.

**Julia Kreiss**
Born in Germany.

Julia Kreiss lived in South Africa from 2005 to 2008 together with her mycologist husband, Wolfgang Mayer, while he was doing research on rust fungi in FABI as a postdoctoral fellow.

Prior to their time in South Africa, Julia received her formal training in Classical Art Restoration in Germany. However, after spending one year on restoring a one square meter roof painting in a gothic cathedral, her creative spirit became frustrated and she started teaching art to children. During her stay in South Africa, FABI commissioned her to create the artwork for three of FABI's annual Seasonal Greeting cards on themes related to research projects in FABI. The works on display in FABI are the original works created for these cards.

**Vetkat Kruiper**
Born in 1969, Twee Rivieren, Kgalagadi Transfrontier Park National Park - died in 2007, on the farm Blinkwater where he lived, just outside the Park.

Vetkat Kruiper Regopstaan Boesman was a member of the Khomani San tribe who lived in the now Kgalagadi Transfrontier Park. His father was a healer and crafter in his community, and clearly had a huge impact on Vetkat's knowledge and understanding of San culture and customs. He is one of very few San artists who sustained the 'lost' (according to some) tradition of San rock art, but with ink on paper as medium. The animality, spirituality and symbolism in Vetkat's works has been the topic of several academic studies.

Vetkat's works are in private collections at the Natal Museum Services, the McGregor Museum at Kimberley and the University of Pretoria. From 2002 to 2005 his art was displayed at the United Nations (UN) as part of an exhibition of indigenous art, while his 2004 tour of the United States of America culminated in his addressing the UN.

Shortly before his death in 2007, Vetkat was invited by the Department of Built Environment at the University of Pretoria to do a solo exhibition on the UP campus. All the works on exhibit were purchased by the University, and constitutes the largest assemblage of the artist's works in a single collection.

**Erich Mayer**
Born in 1876, Karlsruhe, Germany - died 1960, Pretoria.

Erich Mayer was educated in Berlin, could not afford to study art, but won a bursary for architectural training. His studies were discontinued as a result of ill health. Seeking a healthier climate, Mayer came to South Africa in 1896 and worked as a land surveyor in the Free State. He was captured during the South African War (1899-1902) and sent back to Germany by the British. He returned to South Africa in 1911, and eventually worked as a newspaper artist in Pretoria. Here he became acquainted with Wenning and Pierneef, to whom he taught the art of woodcut.

He held his first exhibitions in 1916, and in later years travelled the country with his wife by caravan, painting rural scenes. By the late 1920s his work became popular resulting in many commissions and exhibitions. Although he gained recognition during his career, he never reached the heights of his contemporaries during his lifetime.

**Alistair McTaggart**
Born in Australia.

Allistair was a postdoctoral fellow in FABI from 2014 to 2017. He is a mycologist interested in the systematics and identification of fungi. He has also worked as a science and maths teacher in the Australian state and private education systems. Allistair says "I take any opportunity to be creative, and science has largely inspired my portfolio"

**André Naudé**
Born 1950, in Pretoria.

Naude has completed both his BA and MA degrees in Fine Arts at the University of Pretoria. During the 1970s and 1980s, he was teaching art at several high schools in Johannesburg and Cape Town. He then was a part-time lecturer at the University of Pretoria from 1988 to 1998, and after that at UNISA. Since 2001 he has worked full time as an artist.

Naude has participated in approximately 30 solo and 50 group shows in South Africa and has taken part in exhibitions in the Algarve, Lisbon, New York, Washington DC, Toronto, Paris, Riberac, Hamburg and Barcelona.

The subject matter in his paintings are raked with environmental issues, hope and absurd social conditions. He plays in his work with a dark humour surrounding his subject matter and so calls attention to the more serious underlying matters.

**Trudy Paap**
Born in Australia.

Trudy is a postdoctoral Fellow in FABI. She grew up in Western Australia where her fascination with the natural world led her to study science. She worked in the field of forest health research in the south west of the state prior to joining FABI. Despite working as a research scientist and having had no formal art training, she has always enjoyed drawing natural forms. In 2016 she attended a botanical art workshop with Gill Condy (SANBI's resident botanical artist) during which she developed greater confidence, and a deeper appreciation of botanical art as a means of merging her passions for nature, science and art. One of her artworks was displayed in the Everard Read Gallery in Johannesburg in 2018 as part of the global exhibition 'Botanical Art Worldwide'.

**Ranko Pudi**
Born in 1950, Makapanstad, Pretoria.

As a child, Pudi lived a life of poverty, but often watched when his maternal grandfather, David Motladi, a carpenter, was at work. In order to survive, Pudi herded goats for relatives and thus only started school at age 11. Frustrated by his academic deficit, he soon dropped out, joined a local gang and became a street fighter.

A forced removal relocated Pudi's family to Ga-Rankua Township outside Pretoria, and the separation from his gangster friends had a positive consequence, as at age 15 he met a teacher who encouraged him to take up wood carving. He went back to school at age 21, but again became despondent and dropped out. At that point Pudi sought out the company of other artists for advice. He met Motshile Nthodi, an artist who had contact with the Schweickerdt Arts Gallery in Pretoria. Nthodi was impressed by Pudi's work and helped him to stage his first one-man exhibition, which launched his career as an artist.

Pudi's works are classified as African expressionistic, his forms are distorted and exaggerated. His wood carvings depict humans in their most abstract forms. He rejects the forms and conformity of naturalism, yet aim to evoke personal emotions. His works are reflections of his upbringing. His naivety to financial security motivates the style and appearance of his works. One of the most prominent figures in his works is the black male figure in his environment.



**Lucky Sibiya**
Born in 1942, Vryheid, KwaZulu Natal - died in 1999.

Sibiya was, from an early age, inspired by ideas of the mystical and abstract as a result of frequent visits with his father to the Sangoma. The boy would 'borrow' some of the healers' artefacts, attempt to recreate them at home, and return them promptly before anyone would notice their disappearance.

Sibiya grew up in the colourful neighbourhood of Sophiatown, but due to the politically-motivated destruction of the area the 1950s, his family had to relocate to Soweto. He went to school in Hammanskraal where the young boy experimented with woodcarvings. Before completing his school education, Lucky introduced himself and some of his painted 'found' objects to Cecil Skotnes, who was at the time one of South Africa's foremost contemporary artists. Skotnes was head of the Polly Street Art Centre in Johannesburg and was eager to accept Sibiya as a private pupil.

Sibiya took folklore and traditional mediums and images to a new level of sophistication. However, they maintained their raw and ritualistic feel. Over time, his wood carvings evolved towards his distinctive engravings, coloured by rubbing powdered pigments into them.

Lucky Sibiya's works are still some of the most distinct and desirable throughout the art community, and exhibited in many galleries.

**Wynand Steyl**
Born in 1923, Modderfontein, Johannesburg - died 2014.

Born and raised humbly, Steyl grew up herding sheep on his parents' farm, where his love for nature and ability to observe, was shaped. In later years he worked for the Department of Agriculture. He always carried a sketch pad with him as his job demanded of him to travel frequently. His sketches in his personal work pads were only done in Indian ink, pen or pencil, due to the fact that he was colour-blind. However, he did paint in colour, but became better known for his sculptures and woodcuts.

Steyl viewed his own work as semi-abstract, but admitted that he never diverged from nature. All that is known about Wynand's works is that he, much like Pierneef, liked to create art in nature. Steyl had a great love of nature and natural landscapes. His passion for drawing began in the Karoo and he never stopped after that. He often went on trips to the Kruger National Park which is where he would carve and sketch. Each carving captures the moment and presents itself as almost three dimensional.

**Abraham Jacobus (Appie) Van Wyk**
Born on the farm Klipwerf, Agter-Hantam, Calvinia, in 1926 and died in Stellenbosch, 2016.

Appie was a self-taught artist and was married to botanical artist Elise Bodley. He had 15 one-man exhibitions between 1952 and 1968 and five exhibitions on general appeal between 1991 and 1996. A few collectors regularly bought his work, hence the low number of exhibitions in later years. His paintings, outside of private collections in South Africa and abroad, are not well known.

Human figures feature strongly in almost all of his work. Early paintings are reminiscent of aspects of Hieronymus Bosch and also later, the surrealist Salvador Dali. Trees form the basis of many of his later works (in the period 1990 to 2010), often with autumnal colours, human and animal figures and a dream-like, mystical atmosphere.

The two paintings of Appie on display are on loan to FABI from the collection of his son, the well-known botanist, Ben-Erik van Wyk.

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