

Environmental Biosecurity at JCU



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James Cook University

James Cook University (JCU) is a world class, research-intensive institution with a strategic intent focused on discoveries and graduates that make a difference in the tropics worldwide. JCU is defined by its tropical locations and is focused on meeting the knowledge needs for the grand challenges in the tropics. Our three tropical campuses (Townsville, Cairns, and Singapore) are complemented and extended by regional and remote study centres and research stations. Research at JCU aims to provide knowledge that will ensure sustainable communities, industries and livelihoods into the future.

Environmental Biosecurity at James Cook University

Effective biosecurity measures are essential to protect our \$32 billion agriculture and aquaculture industries as well as safeguard our unique flora and fauna and growing population. However, environmental biosecurity is under increasing pressure due to a number of ecological, climatic, demographic and behavioural changes occurring globally. Major outbreaks of novel diseases and introduced pests and weeds in Australia can cost billions, and unfortunately most expenditure on biosecurity is reactive rather than preventive.

JCU is focused on meeting the knowledge needs for the grand

challenges in the tropics. With tropical Australia defined as a biosecurity hotspot, JCU strives to meet the present and future environmental biosecurity challenges for this region, as well as nationally and globally. JCU provides expertise and capacity in the areas of invasive species prevention, monitoring, and outbreak response. Tropical Australia is a high risk region for Australia, due in part to its proximity to neighbouring countries, its high diversity of wildlife reservoirs, and its environmental characteristics. JCU is ideally situated to work with industry, communities and all levels of government to ensure cost effective environmental biosecurity to meet our needs for now and into the future.





Prevention/Risk Analysis

Social Marketing and Human Dimensions

Overview

Prevention of biological invasion requires effective development and implementation of biosecurity policy. However, an understanding of the social and human factors that may influence effective implementation and adherence to these policies is also necessary. Successful engagement in biosecurity practices requires a bottomup approach to policy development to ensure that stakeholders recognise the need for biosecurity management, and that the benefits of the recommended practices outweigh the costs of engagement. To address this issue, biosecurity research at JCU includes researchers from across social and behavioural sciences, business, governance and economics to explore the underlying mechanisms of successful adoption of biosecurity practices that have measurable outcomes for industry, community and government.

Research and Development

Current research activities focus on biosecurity policy, practices and issues in primary industries, such as livestock and aquaculture. A current challenge for biosecurity management across these industries is to communicate key policy messages appropriately to on-the-ground stakeholders. A lack of communication can result in inconsistencies in adherence to recommended biosecurity practices. Research within the livestock industry suggests that key social and contextual factors may explain this gap between policy and practice. These factors include low trust between stakeholders and policy communicators, accessibility issues due to isolation from services, and cost-benefit imbalance whereby the cost of time and potential financial ramifications outweigh the benefit of implementing a practice that may not be effective.

Industry Engagement

The research team has strong existing relationships with stakeholders within diverse industry groups, multiple levels of government, and a range of community organisations and individual enterprises. Existing industry group relationships include those with livestock, sugar, horticulture and aquaculture industries. The research team also has working relationships with local water management groups, workforce and regional development officers, and local farmers and producers. The research team is conscious of the importance of working collaboratively with these groups to engage in projects that are stakeholder driven.

Team

A range of academic profile staff from across multiple disciplines have active research interests and experience in: biosecurity policy evaluation; biosecurity governance at a national, state and regional levels; effective communication of biosecurity practices to stakeholders; mechanisms of behavioural engagement in biosecurity practices; and health economic evaluation of cost of implementing versus not implementing biosecurity maintenance and prevention measures. Disciplines include Environmental Sciences, Psychological Sciences, Health Economics, Business and Governance, and Social Marketing.

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Modelling Invasive and Native Species' Distributions and Dispersal

Overview

Researchers at JCU are at the forefront of innovative and novel approaches for species distribution models. Understanding invasive species' potential to spread across the landscape is crucial for prevention, impact mitigation, containment, and eradication. High quality species distribution models help us assess where pest species are, where they could potentially spread, and how they interact with native species. The modelling approaches developed at JCU (i) are broadly applicable to all taxa, (ii) draw on internal expertise on geographic information systems, information technology, high performance computing, and ecology, and (iii) already provide decision making tools to many external stakeholders.

Facilities

JCU has the computing and storage capacity to carry out extensive modelling using JCU High Performance Computing capabilities and the eResearch storage facilities.

Research and Development

There is ongoing research and development in a range of activities in this space. Areas of research include: 1) optimization of and development of new modelling algorithms; 2) novel ways to collect data on species and their habitats; and 3) transformative ways to visualize and expose data such that people can use the data to inform management and policy development.

Industry Engagement

Researchers at JCU collaborate with many local, state and federal government agencies, natural resources management groups (NRMs), other Australian universities and industry stakeholders. These include the Northern Territory Department of Land Resource Management, Western Australia Department of Parks and Wildlife, Queensland Department of Environment and Heritage Protection, multiple northern Australian NRMs, the Atlas of Living Australia, BirdLife Australia, Wet Tropics Management Authority, and many others.

Engagement with these and other stakeholders is often a co-development such that results from any project are directly used by the stakeholders in their day-to-day activities for e.g. conservation decision making and pest species management. In addition to the numerous scientific publications on the topic, many outputs have been made publicly available to facilitate easy access to stakeholders and to promote public engagement, education, and participation through citizen science.

Team

Numerous staff, students and co-investigators are involved in such projects across many disciplines of e.g., data science, ecology and biology, veterinary sciences, engineering and IT.

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Veterinary Preventive Medicine

Overview

Our work focuses on the epidemiology of health events relevant to domestic and wild animals as well as the economic impacts of epidemic and endemic animal and zoonotic diseases using the latest methods and approaches in veterinary epidemiology and public health. Work is currently being carried out on disease and infection control or eradication measures and the development of new techniques in surveillance systems and diagnosis leading to the evaluation and control of diseases in animal populations. Encompassing this is the "One Health" concept and the relationships between veterinary medicine, human health, animal production systems, and the environment.

Facilities

We have a range of computer laboratories with state of the art computers that enable advanced training in epidemiology, disease modelling and applied statistics. This is backed by the university's IT management team and the expertise in the College of Public Health, Medical and Veterinary Sciences.

Research and Development

We have been instrumental in developing a food biosecurity network between Pacific Island Countries and Territories and developing food security and animal health surveillance programmes within Africa. This has resulted in several PhD studies using market chain and social network analysis methods to identify high risk biosecurity hubs where syndromic surveillance and rapid disease detection can be implemented. Underpinning this work has been the creation of several qualitative and quantitative risk assessment and economic models that have been used to pioneer ensemble modelling at JCU, putting us at the cutting edge of Veterinary Preventive Medicine internationally. We have several surveillance projects looking at diseases in horses in tropical regions of the world, poultry diseases in developing countries and trans-boundary diseases, in and around national parks.

Industry Engagement

Underpinning our work has been the training of animal health officials in disease surveillance and biosecurity in several neighbouring countries as part of DFAT programmes. This has resulted in close association with veterinary services in Papua New Guinea, Vanuatu, Solomon Islands and Fiji as well as the Secretariat of the Pacific Community. We also have close ties with the University of Pretoria in South Africa, the University of Zambia, several universities in Thailand, the Zambian Veterinary services and South African Veterinary Services in Ethiopia.

Team

Professor Bruce Gummow leads the JCU team of experts in Veterinary Public Health, State Veterinary Medicine and Aquaculture, Microbiology, Molecular Epidemiology, Equine Medicine, Reproduction & Environmental Infertility, and Biosecurity.

Teaching and training

Our training programmes extend from short continuing education courses to academic PhD level studies, with veterinary epidemiology and public health being core subjects within the coursework, Graduate Certificate, Diploma and Masters of Tropical Veterinary and Tropical Animal Science.

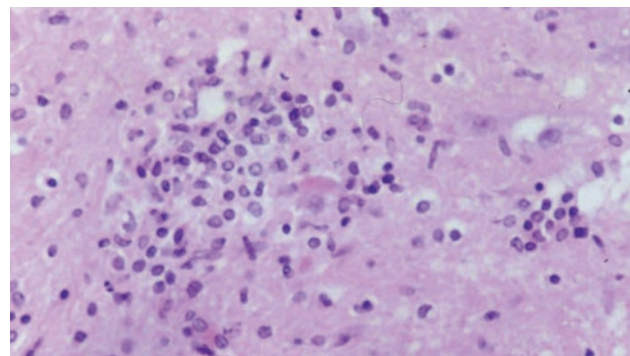
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Diagnosis and Control of Pathogens and Parasites



Overview

JCU Veterinary Sciences (VS) is the only Australasian veterinary school located in the tropics. In addition, it is situated closest to the most likely entry points for a number of exotic pathogens which could devastate Australian livestock, fisheries, companion animals and wildlife. Thus, since its inception as a graduate program in Tropical Veterinary Science in 1969, VS has taken its biosecurity obligations and role very seriously. Accordingly, VS possesses specialist expertise in veterinary preventive medicine and a spectrum of diagnostic capabilities for biosecurity related research, including anatomic and clinical pathology, histopathology, bacteriology, virology, parasitology and mycology.

Facilities

We utilise JCU's Anatomic Pathology, Clinical Pathology, Microbiology and Parasitology Laboratories.

Research and Development

Post-graduate Veterinary Sciences and Agricultural students are engaged in biosecurity research and protecting the biosecurity interests of Australia. These are co-funded by their respective governments and Australian Aid programmes and scholarships. Several short courses have been run to build capacity in the diagnostic skills required to support biosecurity and early detection of animal health diseases within the region.

Industry Engagement

JCU Veterinary Sciences has long been instrumental in providing diagnostic services in pathology, clinical pathology and microbiology for suspected animal diseases and remains one of the only comprehensive veterinary diagnostic facilities in the region. We receive a wide range of samples for diagnostic purposes from industry and veterinary private practitioners.

Team

We have over a dozen academic staff and associated research assistants and post-graduate students.

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Advancing Biosecurity Systems through Seasonal Climate Forecasting and Data Mining Methods

Overview

Climate is a major driver of pest and disease outbreaks in primary industries. Understanding our climate and predicting future climates is important for advancing Australia's biosecurity systems for primary industries. We also develop and apply sophisticated pattern recognition methods that can detect early outbreaks of pests and disease from satellite imagery.

Research and Development

Our research focuses on working in partnership with industry to identify the key climate trigger points that induce pest and disease outbreaks. Once we have identified these key trigger points, we target weather and climate forecasts at a range of spatial and temporal scales to help farmers minimise the damage caused by pest and disease. Forecasts for pest and disease outbreaks are helpful for a range of primary industries that include, but are not limited to, sugarcane, bananas, mangoes, tomatoes, pineapples, and aquaculture.

Our research also develops and applies pattern recognition methods that can be used to monitor the health status of cropping systems from remotely sensed imagery.

Industry Engagement

Our research engages heavily with industry partners from Australia and overseas so that outputs are adopted and applied in practice. Our research allows for applied solutions for industry by integrating the use of different technologies such as cropping systems simulators, climate science and data-mining. This group has worked extensively with the Australian sugar industry and Department of Environment and Science.

Team

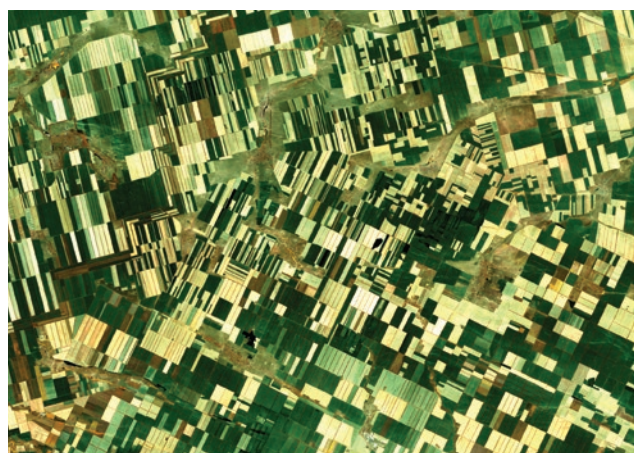
Our highly multidisciplinary team consists of two senior academic staff and associated PhD students. Our team has a range of skills and experience in climate impacts, climate prediction, data science, agricultural science, crop modelling and outreach.

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Weed Ecology, Evolution, and Management



Overview

Invasive weeds cost Australians \$13m every day, predominantly in management costs and losses to agriculture businesses. The plant biosecurity team at the Australian Tropical Herbarium develops basic and applied research programs to understand the evolutionary processes responsible for invasion success, and on how that knowledge can be better used to reduce their impact to the environment, and cost to farmers and livestock producers.

Facilities

JCU has a large range of analytical equipment as well as shade houses and plots to conduct experiments. We can also sample in remote locations across northern Queensland.

Research and Development

Our research is divided in several main lines of action: 1) studying biogeographic variability across world populations of target weeds, and researching why species become invasive in only parts of their introduced ranges; 2) empirical assessments of the presence and impact of invasive species, their response to different land management strategies, and development of effective weed management practices; 3) identification, characterisation, and genomic ecology of fungal pathogens.

Industry Engagement

The weed ecology group has a broad range of national and international collaborators, allowing for cross-continental studies of species of interest. We offer our capabilities to the public and private sectors, and help to design and to develop case-specific targeted studies. We also develop outreach activities to promote public awareness about good land management practices.

Team

One Senior Research Fellow and one Postdoctoral Fellow are at the core of the group, with variable numbers of students and external collaborators.

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Monitoring and Surveillance

Identification, Surveillance, and Monitoring of Invasive Species

Overview

The fast and accurate identification of potential introduced and invasive species is key to the control and ultimate eradications of these threats to the Australian economy and environment. JCU has extensive expertise in the identification, surveillance, and monitoring of terrestrial, marine, and freshwater flora and fauna.

TERRESTRIAL FLORA

The Australian Tropical Herbarium (ATH) has extensive expertise in all areas of plant identification and plant biology and works extensively with government and industry to provide terrestrial plant identification and vegetation mapping. The ATH has a reference and research collection comprising nearly 200,000 items including herbarium specimens, DNA samples, living collections, and spirit-preserved material. Researchers at the ATH also have extensive expertise in survey and monitoring techniques for introduced and invasive plants.

Team

The ATH has a dedicated team of 12 scientists with expertise in plant surveys, monitoring, and identification. The ATH also has research students and volunteers who increase the skill sets and the capacity of the ATH to undertake large projects.

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TERRESTRIAL FAUNA

JCU researchers have expertise in the identification of both vertebrate and invertebrate terrestrial fauna and have developed and implemented novel techniques for surveying and monitoring introduced and invasive species. These researchers have worked extensively with government, industry, and non-government organizations. JCU has active research spanning a broad tax a of invasive species, such as ants, terrestrial flatworms, mosquitos, bees, reptiles, cane toads, and mammal species.

Team

These researchers are also involved in the training of post-graduate students who have projects in biosecurity related areas.

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MARINE FLORA

The Seagrass Ecology group specialises in tropical research with a specific interest in the Indo-Pacific region but also manages projects that extend globally. The group has a strong focus on research, advising management agencies responsible for coastal development and coastal planning decisions. Researchers in this group were responsible for the eradication and management of green lipped mussel (*Perna viridis*) from Cairns harbour and continue to provide advice to ports and industry on species that pose a threat to Australia's marine environments.

Team

This group has 13 dedicated staff that work full time on marine flora. This group is world renowned for their expertise in this area and have years of experience in working with stakeholders.

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MARINE FAUNA

The Estuary and Coastal Wetlands Ecosystem Research Group is an active collaboration of established scientists and new enthusiastic researchers specialising in cross disciplinary research into the ecological functioning of tropical estuaries and coastal wetlands. As well as conducting a diversity of research, the group provides expert consultancy services in fisheries ecology, and estuaries and coastal wetlands. JCU researchers have expertise in the identification of marine fauna including invertebrate and vertebrate species.

Team

This group has 7 core staff and 9 postgraduate students.

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FRESHWATER FLORA AND FAUNA

JCU's TropWATER is one of Australia's largest research groups of freshwater expertise in areas of water science, resource management, and the ecology of water ecosystems, with a special focus on achieving sustainable use of water resource systems and water ecosystems. This group also offers the ability to identify freshwater flora and fauna and has novel methods for detection of invasive species in freshwater waterways using eDNA. These services are available via consultancy or research project.

Team

TropWATER has over 100 researchers with expertise in water science, biosecurity research, and provision of management outcomes.

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CASE STUDY



Detecting and understanding the ecology of new invasive plants

While studying the regeneration of rainforest in Australia's Wet Tropics, scientists from JCU found an unexpected and potentially deadly weed infestation. Cherry guava (also known as strawberry guava, *Psidium cattleianum*) is a shade-tolerant shrub, an invader of tropical and subtropical regions and considered among the world's top 100 worst invasive species. Originally from Brazil, it is named for its delicious fruits and was probably introduced to domestic gardens in the region as far back as the mid 1900's. Cherry guava has now exploded in abundance in secondary forests on the Atherton Tableland and poses a serious threat to the rainforests of the Wet Tropics World Heritage Area.

Researchers from JCU have identified the key characteristics of the species which has already caused ecological havoc in tropical regions such as Hawaii, Seychelles and Mauritius. Cherry guava is a dangerous invader for a number of reasons. First, it can out-compete native species and form the dense impenetrable monocultures the scientists observed, thereby replacing native habitat. Second, it produces abundant edible fruit that is attractive to animals and readily dispersed by them. Finally, unlike most weedy plants that thrive in sunlight, this species is highly tolerant of shade, so the shady understorey of our World Heritage rainforests is habitat ripe for invasion. Understanding the ecology of cherry guava was the first research step, next we need to explore the management options if we are to stop this species before it spreads.

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Environmental DNA – Detecting Invasive Species

Overview

All species shed their unique DNA codes into the environment via skin, faeces, blood, mucus, sperm and other biological material. This is called Environmental DNA (eDNA). Researchers have developed eDNA techniques that uses water, soil, or sediment samples to detect target species, without even sighting them. JCU has strong capabilities in the application of eDNA technologies that can be used to address a broad range of biosecurity and ecological applications.

Environmental DNA analysis is an efficient, non-invasive and easy-to-standardise sampling approach that allows rapid field surveys to be conducted. Coupled with sensitive, cost-efficient, and ever-advancing DNA sequencing technology, eDNA has transformed our way of conducting biosecurity and conservation related environmental science. Environmental DNA techniques have a wide range of applications from biodiversity monitoring and early detection of invasive species to animal diet assessment. These techniques can be used to detect a wide variety of taxonomic groups such as bacteria, viruses, fungi, plants, crustaceans, molluscs, invertebrates, fish, amphibians, birds, and mammals. Researchers at JCU are at the forefront of developing and applying eDNA solutions in Australia, with proven application of the technology in northern Australia.

Facilities

The eDNA program is situated within TropWATER and the Centre for Sustainable Tropical Fisheries and Aquaculture at JCU and utilizes the TropWATER and Molecular Evolution and Ecology laboratories.

Research and Development

JCU is at the vanguard of developing eDNA technology with proven experience in using eDNA to detect populations of the invasive tilapia *Oreochromis mossambicus*, rare freshwater sawfish *Pristis pristis*, numerous native fish species, as well as presently developing metabarcoding technologies to catalogue aquatic biological communities. With a modern and comprehensive equipped molecular genetics laboratory, including an Illumina MiSeq next-generation sequencer at its disposal, eDNA approaches can be quickly developed and applied to any species where the technology has an application.

Industry Engagement

Researchers at JCU are engaged with a broad spectrum of government partners, stakeholders and community groups who are interested in developing eDNA detection capabilities for invasive and rare species. These include Regional Resource Management Agencies, State Fisheries Agencies and Indigenous Ranger Groups. The eDNA team also provide training in eDNA techniques to our industry partners and community groups.

Team

The team led by Dr Jan Strugnell and Dr Cecilia Villacorta-Rath is supported by several academic staff and post-graduate students undertaking research to further develop innovative eDNA methods.

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Remote Sensing and Spatial Science

Overview

The Remote Sensing group provides remotely sensed data collection and processing capabilities for collaborators across a range of disciplines and organisations. Our fleet of Remotely Piloted Aircraft systems (RPAS, or drones) and specialised sensors are equipped to collect a wide range of quantitative, high resolution environmental data such as water quality, crop health (including plant stress and disease), and weed spread.



Facilities

JCU has a unique range of remote sensing field survey equipment and image processing capabilities including:

- Hyperspectral imaging and field sensors
- Thermal cameras
- Lighting and calibration equipment
- Photogrammetric camera
- A fleet of small and medium sized multi-rotor drones with associated gimbals for stabilising sensor and cameras in-flight
- Specialist image pre-processing and processing software and hardware
- Specialist staff to carry out aerial surveys, sensor programming and use, data analysis and reporting

Research and Development

We are currently focusing our research and development on integrating specialised sensors and drones to perform surveys for mapping and monitoring purposes. We are always working to improve our data collection and analysis process by improving our understanding of light interactions with the unique biophysical characteristics of different environments. Our current projects include disease spread, nutrient limitation), mapping weeds, and monitoring water quality. Ultimately we are working towards providing non-invasive, tailored decision support systems for a variety of mapping and monitoring applications.

Industry Engagement

We work closely with government representatives, several agricultural growers, agricultural industry research offices, aquaculture (barramundi and prawns), and the cattle industry, all of whom provide support for collaborative research (knowledge, research income, data, resources and access to study sites and equipment).

Team

Our team comprises 13 remote pilots, 5 academic profile staff, and associated post-doctoral researchers and post-graduate students.

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CASE STUDY

Applying ant ecology to the battle against yellow crazy ants

Yellow crazy ants (*Anoplolepis gracilipes*) have invaded about 1000 hectares of rainforest, residential, sugar cane, and riparian areas around Cairns and pose a threat to the environment, human health, and agricultural yields. The ants are also causing concern elsewhere in Queensland and northern New South Wales. They are one of the world's top 100 worst invaders and have a well-deserved reputation for destruction after causing ecosystem-level changes on Christmas Island.

Researchers at JCU have been working closely with the Wet Tropics Management Authority for several years on their Yellow Crazy Ant Eradication Program, which aims to eradicate yellow crazy ants from in and around the Wet Tropics World Heritage Area. JCU has developed and implemented protocols to measure ant activity, evaluate macronutrient and bait preferences, and monitor for effects on non-target species. JCU staff have worked closely with Program staff to test detection probabilities associated with different survey methods and develop objective measures of confidence in yellow crazy ant absence. JCU staff manage, analyse, and interpret the monitoring and other data collected across the Program and present the results to Program staff and the broader community on a regular basis. These steps have led to changes in treatment strategy with promising results. JCU researchers are also gaining insights into yellow crazy ant biology and have to-date maintained over 450 yellow crazy ant colonies in controlled facilities for experiments to gain insights into colony reproduction, behaviour, and response to insecticidal baits.

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Aquatic Animal Health



Overview

JCU research expertise ranges from viral and bacterial pathogens of fish and crustaceans, through to metazoan parasites of fish. Research conducted by JCU researchers enables fisheries, aquaculture and government stakeholders, to make informed decisions in regards to stock structure, disease management and import regulations. This marriage of pure and applied research has led to the development of unique and strong partnerships among industry, academia and government agencies. With access to many expert researchers in genetics, nutrition, biotechnology and bioinformatics, the Aquatic Animal health team is well resourced to adopt a multidisciplinary approach to disease management in Tropical Aquaculture species.

Facilities

The Aquatic Animal Health research group has access to Australia's largest tertiary aquarium research infrastructure at JCU if required to undertake larger-scale industry-relevant R&D. JCU has developed a NATA accredited pathogen detection laboratory, JCU AquaPATH, with high throughput capability for shrimp and finfish viral and bacterial pathogens, and offers R&D and commercial testing services to industry.

Research and Development

Aquatic health specialists undertake sponsored and contract R&D and partner closely with industry to develop solutions that assess and lower disease risk. Research is also focused on viral and bacterial pathogens in tropical species. Research in finfish focusses on Ranavirus and Betanodavirus. JCU AquaPATH has regulatory permission to test for Whitespot Syndrome Virus (WSSV) and Yellowhead Virus-1 (YHV-1) and applies this testing capability to support translocation of prawn stocks. Translocation testing is supplemented with analysis to detect endemic viruses including IHNV, HDV, GAV, YHV-7, Whenzhou Shrimp Virus-2 (When-2) and the Pir-A toxin gene which provides industry partners with strong support to manage biosecurity risk. Another major R&D capability is in the *Vibrio harveyi* clade of bacteria and their virulence determinants including the role of bacteriophages. Projects currently include assessment of tissue samples to determine the presence of a range of bacterial and viral pathogens in wild and aquaculture raised stock.

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Outbreak Response

Invasion Biology and Pest Management

Overview

Preventing, managing, and mitigating the effects of invasive species requires knowledge of their biology. The study of invasion biology includes species dispersal, establishment, persistence, and spread. A key aim is to identify characteristics that distinguish invasive from other introduced and native species. This knowledge can then be used to advise an outbreak response. Experience has shown us that efforts to eradicate unwanted species usually fail once a species has become widespread, so a rapid and effective response is our aim. At JCU, researchers have experience with a range of invasive taxa that threaten northern Australia and the management responses that are necessary to minimise the threats.

Facilities

We have access to a range of facilities at JCU including shade houses, insect flight cages, mosquito rearing facilities, advanced genetics laboratories, PC2 laboratories, and a microbiology laboratory.

Research and Development

JCU researchers have a diverse range of biological expertise encompassing all major taxa: plants, fungi, vertebrates (birds, mammals, herpetofauna, fish), and invertebrates. Being based in the tropics, we are well-situated to research the biology of the many species that are introduced through our ports and threaten the agriculture and unique diversity of northern Australia. For example, Queensland has the distinction of having more invasive social insect species than any other state. These ants and bees have significant effects on local, state, and national economies through their impacts on agriculture, tourism, human health, and the environment. Similarly, invasive plants, vertebrates and fungal outbreaks are one of the highest priorities for land management in the region. JCU researchers are internationally recognised for their expertise in the ecology and biology of a diverse range of taxa, and readily apply their knowledge to local and regional problems.

Industry Engagement

JCU researchers work closely with industry partners to identify and address invasive species key limitations to industries such as agriculture, forestry, public health, natural resources management, and mining. We have multiple Honours, Masters, and PhD students who receive funding from our industry partners and whose projects align with the needs of industry.

Team

JCU has more than 12 profile academic staff members who conduct research on different aspects of invasion biology. These academic staff members are supported by diverse teams of research and technical staff and currently advise post-graduate students on a diverse range of projects on invasive species.

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Spot Spraying of Weeds Using Machine Learning



Figure 1: AutoWeed system in operating in a sugarcane field near Ayr, Queensland.

Overview

Spot spraying is the targeted application of herbicides. Instead of indiscriminately spraying an entire field, spot spraying technology allows for targeting of only the areas that contain the weeds. The key advantage of this approach is to greatly reduce the amount of pesticide chemicals that are required. In turn, this improves farming practice, reduces the cost of weed control, and reduces the environmental impact of the weed control efforts.

Facilities

We have engineering workshops to construct equipment, as well as high performance computing infrastructure for training machine learning models.

Research and Development

JCU researchers are collaborating with industry partners to develop the algorithms to visually detect the weeds using video cameras mounted to a farm vehicle. In industry, there is well established technology for 'green-on-brown' spot spraying, which targets any living plant without regard for what it is. However, a much greater challenge is 'green-on-green' spot spraying, which targets only the weeds and does not spray the desired plant. Our research has developed machine learning technology for spot spraying of multiple weeds of economic significance to Northern Australia. Specifically, the method uses a convolutional neural network to detect the weeds, and then triggers the release of the pesticide if a weed is observed.

Industry Engagement

This technology has been spun out into a start-up company called AutoWeed, which is currently developing it for commercial use.

Team

The engineering academic group has at least 4 academics with strong interests in machine learning technology. They are supported by a team of workshop technicians and research students.

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Controlling Infectious Diseases using a One Health Approach

Overview

We improve the control of infectious diseases of humans, domestic animals and wildlife by using a One Health approach to better understand their causes and how these can be managed using a One Health approach. We investigate the pathogenesis and epidemiology of infectious diseases as well as the impact of global changes that drive disease emergence including climate change. Our expertise covers all of the major disciplines needed to effectively control infectious diseases including epidemiology, pathology, microbiology, virology, entomology, parasitology, molecular biology as well as systems development, health promotion, environmental change and behavioural sciences. We apply our expertise within the biosecurity frameworks of risk analysis, surveillance and outbreak investigation.

Facilities

We have a range of PC2 and PC3 laboratories and animal experimental facilities to study infectious diseases of wildlife and companion animals. In addition, we have a range of insect-proof and climate controlled facilities for livestock (cattle, sheep and pigs); and purpose built pathology and clinical pathology diagnostic laboratories and four semi-field cages for the study of mosquitoes (Cairns). We utilise the supercomputer at JCU for risk analysis and modelling transmission of infectious diseases.

Research and Development

Our research has improved risk assessments for the introduction of important exotic diseases, such as avian influenza and surra, which threaten humans and livestock and developed technologies such as diagnostic tests and remote sensing methods of mosquitoes and systems to improve surveillance of emerging infectious diseases including avian influenza, dengue, Zika, Australian bat lyssavirus, ranaviruses, Hendra virus and surra. We have led outbreak investigations to identify and control chytridiomycosis which threatens biodiversity and the entomology team has led the releases of Wolbachia-infected *Aedes aegypti* in Queensland. We are currently working on other synthetic methods to engineer disease resilience including genome editing and RNA interference and developing transmission and risk models for pathogens, such as Hendra virus and fasciolosis, to better manage their risks and climatic models to predict how risk will change with climate change. A conjoint position with CSIRO supports this work.

Industry Engagement

We work closely with biosecurity agencies and stakeholders including Biosecurity Queensland, Biosecurity Australia, Queensland Health, Queensland Department of Environment and Heritage Protection, Queensland Department of Agriculture and Fisheries, Northern Australia Quarantine Strategy, Wildlife Health Australia, conservation agencies, Meat and Livestock Australia and shire councils. International linkages include International Union for the Conservation of Nature, World Organization for Animal Health, World Health Organization, National Wildlife Health Centre (USA), International Atomic Energy Agency (UN) and the Centres for Disease Control and Prevention (USA) and is the WHO Collaborating centre for Vector Borne and neglected tropical diseases.

Team

The One Health Research Group comprises forty scientists largely based within the College of Public Health, Medical and Veterinary Sciences but includes other areas of expertise within JCU.

Contacts

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Tropical Mosquito Research

Overview

Tropical mosquito research on the JCU Cairns campus is focused on the vectors of arboviruses (e.g. dengue and Zika), malaria, and helminths (e.g., lymphatic filariasis). These efforts are complementary and take place in purpose built facilities with the exclusive goal of studying the biology, behaviour, and physiology of mosquito vectors of human diseases. JCU has five controlled temperature rooms in three buildings dedicated to the study of arthropods, featuring two secure semi-field flight cages and a secure facility designed to hold malaria infected mosquitoes. The large semi-field flight cages are unique in Australia and are the gold-standard for such systems globally, enabling experiments in rear-and-release methods using *Wolbachia*-infected mosquitoes, RNAi sterilized mosquitoes, and other emerging control technologies under a controlled natural environment prior to actual field releases. These cages were an integral part to the research, development, and field release of *Wolbachia*-infected *Aedes aegypti* mosquitoes for use in the recent Eliminate Dengue (eliminatedengue.com/au) initiative. In addition, an *Anopheles farauti* colony enables laboratory studies to complement field work in the Solomon Islands and Papua New Guinea. Mosquito research at JCU includes the molecular analyses of vectors by standard and real-time quantitative PCR for a variety of applications.

JCU also has an active research program on the surveillance and control of *Ae. albopictus*, the Asian tiger mosquito, in the Torres Strait where studies on a novel sound lure trap were tested. Studies on sugar feeding are exploring the potential of attractive targeted sugar baits to complement traditional insecticide-based intervention to halt the spread of this highly invasive species. JCU leads a consortium of a dozen institutions in building the capacity of 15 Pacific island countries to undertake mosquito surveillance and control to enable more rapid detection of invasive vector species.

Facilities

The Cairns campus houses four semi-field cages for the study of mosquitoes, especially *Aedes* vectors of dengue and Zika viruses, six non-QIC2 constant temperature rooms, one QIC2 ready constant temperature room, one temperature and humidity controlled room, two large secure semi-field flight cages, two non-secure semi-field flight cages, a secure room for holding malaria infected mosquitoes, and molecular biology facilities.

Team

The team is led by Tom Burkot and comprises several post-doctoral researchers, post-graduate students, and research support staff.

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CASE STUDY



Invasive amphibian detection and control

Invasive amphibians are a serious and growing problem worldwide. Three are listed as among the world's top 100 worst invasive species because they can spread rapidly, and obtain high densities, and they can threaten biodiversity over large scales. At JCU we have significant capacity and experience in researching amphibians to reveal the aspects of their biology that make them vulnerable to various detection and control measures. We have a particular interest in the control of amphibians in vulnerable locations, such as islands, wetlands, and other areas of conservation significance.

In conjunction with our industry partners Animal Control Technologies Australia, we have developed an acoustic and visual lure to accompany a trap designed specifically for invasive amphibians (cane toads). With collaborators in Australia and overseas, we have been testing our trap on various amphibian species, in addition to developing cane toad control and early detection measures in Australia. We have the expertise to conduct research on other invasive species, to discover their vulnerabilities or to adapt our trapping system. We have been developing control and prevention programs with island communities to avoid introductions, or to help control them when they arrive.

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Research Centres at JCU

Centre for Tropical Environmental and Sustainability Science



The mission of TESS is to promote cutting-edge ecological and environmental research in the tropics, and the wise management, conservation, and sustainable use of tropical terrestrial and coastal ecosystems, in Australia and internationally.

Tropical Australia is resource-rich, ecologically fragile and infrastructure poor, and is undergoing unprecedented growth and development. It is a national priority to develop growth strategies that are ecologically, socially, and economically sustainable. TESS is taking a leading role in developing, implementing and exporting solutions for the environmental and sustainability issues faced by Australia and the rapidly developing tropical world.

Invasive Species and Biosecurity in Tropical Australia is a flagship within this centre. A focus of current and past projects is the advancement and application of invasive species biology to the prevention, mitigation, and control of species invasions.

To find out more visit: research.jcu.edu.au/tess

Centre for Sustainable Tropical Fisheries and Aquaculture

The Centre for Sustainable Tropical Fisheries and Aquaculture aims to provide knowledge to underpin aquatic food security for Australia, the tropics, and globally.

With aquatic food resources already under pressure and declining, it is essential to gather data related to wild fisheries to ensure their long-term sustainability, as well as to develop sustainable aquaculture products to supplement that coming from wild fisheries. Both sources of seafood have to be produced in a sustainable, socially and economically viable fashion to improve aquatic food security. This will come about not only by improved biological understanding, but also through examination of the human systems that produce and consume aquatic food resources, and by restoring already degraded systems to re-establish their production potential.

The Centre brings together a multidisciplinary team organised into three main Research Themes: aquatic food security and safety, novel aquatic products and applications, and human dimensions of aquatic resources and production.

To find out more visit: research.jcu.edu.au/cstfa



TropWATER



The Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER) is an amalgamation of aquatic expertise from across JCU. It brings together over 150 research and supporting staff and over 100 post-graduate students into one cohesive research group. TropWATER provides a unique opportunity for multidisciplinary research activities by integrating JCU's aquatic expertise into one unit, which covers the full spectrum of freshwater, estuarine and marine waters, with expertise from ecology, water quality, hydrology, engineering, physics, oceanography, modelling and resource economics.

TropWATER aims to conduct highly-recognised and influential research in fields related to water science, resource management and the ecology of water ecosystems, with a special focus on achieving sustainable use of water resource systems and water ecosystems. Our overall goal is to secure the future of water ecosystems and maintain their critical functional processes. The Centre has a strong but not exclusive focus on tropical water systems, both in Australia and internationally. It is concerned with major issues in water science, including water resources, water quality and aquatic biodiversity in relation to economic, social and environmental needs, constraints and change.

To find out more visit: tropwater.com

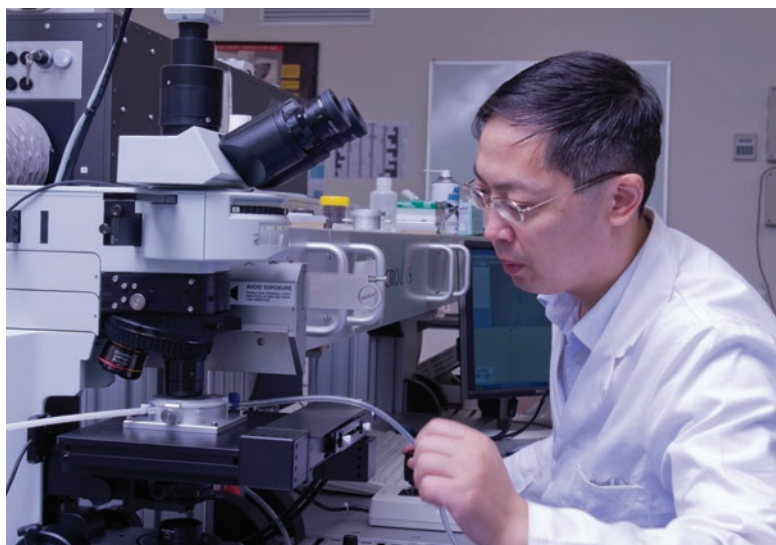
Advanced Analytical Centre

The Advanced Analytical Centre (AAC) is a central analytical facility that supports research and industry, providing a wide range of analytical instrumentation backed by experienced and professional staff.

The AAC provides access to a range of techniques covering the fields of microscopy and microanalysis, inorganic and organic chemical analysis, mineralogy/crystallography and genetic analysis. The centre provides a full range of services from sample preparation through to final analysis and reporting as well as specific hands-on training in instrument use. It is also a Linked Laboratory to Microscopy Australia.

To find out more visit:

jcu.edu.au/advanced-analytical-centre



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