# Technical highlights

## Invasive plant and animal research

2020–21

Queensland Government

Cover photo: Ground-based radio telemetry is used to locate collared female chital deer and monitor the survival of their accompanying fawns (photo Hector Pople).

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## Contents

## Introduction

This document summarises the 2020–21 program of the Invasive Plants and Animals Research group in Biosecurity Queensland. Our applied research program aims to better manage Queensland's worst weeds and pest animals, reducing their impacts on agriculture, the environment and the community.

Our work is undertaken at five centres across the state:

- Ecosciences Precinct, Dutton Park
- Health and Food Sciences Precinct, Coopers Plains
- Pest Animal Research Centre, Toowoomba
- Tropical Weeds Research Centre, Charters Towers
- Tropical Weeds Research Centre, South Johnstone.

We also collaborate with numerous Queensland, interstate and overseas organisations. Higher degree students are supported to work on several research projects in weed and pest animal management.

The research projects summarised in this document cover the development of effective control strategies and methods (e.g. biocontrol and herbicides), as well as improved knowledge of pest species' biology and assessment of pest impact.

Notable activities of the research program for 2020–21 are outlined below.

## Invasive plant research

- A series of papers have now been published on determining weed priorities for management and research (see project #3). Priority species, usually those with high impact and costly to control, were identified from a series of workshops with local governments and other land managers. This was extended with a workshop to consider management feasibility. Very generally, control and research effort should focus on high impact species with a good likelihood of success. Another paper analysed the historical spread and increase in weed abundance using herbarium records and Biosecurity Queensland's annual pest distribution survey.

- Our weed biological control program has made progress on a number of fronts in the past year, despite COVID-19 pandemic-related travel restrictions. Applications to release new biological control agents (i.e. insects, mites and pathogens) for bellyache bush and prickly acacia have been submitted to the Australian Government for approval. A rust pathogen of mikania has been approved for release following testing in Australia and overseas. Agents for a suite of other weeds are having their host specificity tested in laboratories overseas and in quarantine in Brisbane. This is a lengthy process required to ensure closely-related native species, valued ornamentals and crop plants are not affected by the agent.

- Weed biological control involves lengthy laboratory trials, overseas exploration and overseas testing which are expensive. To identify and fully assess new agents for weeds requires successful grant applications to industry, the Australian Government and others outside Queensland state and local governments. These funding bodies are detailed at the end of this report. As an example, a partnership with Manaaki Whenua Landcare Research NZ Ltd is funding exploration, assessment and sharing of biological control agents for weeds in common between Queensland and Pacific Islands such as Vanuatu. This collaboration across borders reduces the risks of weed species spread between countries and enables sharing of expertise in weed management between countries. It is an efficient use of resources to find and test biocontrol agents for weeds common to multiple countries.

- We are mass-rearing and releasing approved biocontrol agents for Siam weed, parkinsonia and *Cylindropuntia* cacti. We are monitoring the establishment and impact of a gall fly on Siam weed. The weed is in its early stages of spread and the hope is that the fly can reduce its rate of spread and minimise its impact as it has done overseas. The rust pathogen of mikania is yet to be released. Deliberations are determining how best to integrate the agent into the eradication program for the weed. The rust is likely to reduce detection of plants by field staff. However, the rust will also restrict spread of undetected plants and reduce the chance of reproduction; essentially buying time.

- Projects are supporting state and national eradication programs for numerous weeds, including red witchweed, miconia, mikania, limnocharis and white ball acacia. We carry out ecological studies to determine seed bank persistence and age to maturity, developing control methods and techniques to monitor eradication progress. A combination of a false host crop of soybean and ethylene fumigation has the potential to eradicate red witchweed (an obligate parasite of sugarcane, corn and other grasses) in 4–5 years.

- Herbicide trials are being conducted for several weeds including sicklepod, gamba grass, Aleman grass and bogmoss. We are collaborating with the University of Queensland on the injection of encapsulated herbicide into the stems of woody weed shrubs and trees. Our research continues to address difficulties in the management of giant rat's tail grass. Projects cover herbicide management, the use of fertiliser to improve its digestibility and the use of endemic pathogens as bioherbicides. Researchers are examining optimal integrated strategies for controlling other weeds such as parthenium, Harrisia cactus and *Cylindropuntia* cacti where there are multiple control options including biocontrol and herbicides.

- Aquatic weeds are widespread in Queensland, but there are few control options and in particular few herbicides that can be used in the water column. However, flumioxazin has proved promising in research trials. It is now registered and will shortly be available for operational use. Control of cabomba has been highly effective using a variety of formulations of flumioxazin that are rapidly taken up by the weed while breaking down within 48 hours in water. Additional aquatic herbicides are also being developed. With limited research capacity in Australia for aquatic weeds, Biosecurity Queensland's scientists are playing an important role nationally.

- We are studying the ecology of a number of weeds to assist management. Information gained, such as seed longevity and age at maturity, help to determine the timing and duration of treatment at a site.

## Pest animal research

- Aerial and ground surveys of chital deer in north Queensland are showing rapid recovery of populations after substantial declines during drought over 2014-16. Encouragingly, low densities are being maintained on some properties through ground shooting. Appropriate strategies for management are becoming clear. Best practice guidelines for deer management will be developed over the coming year along with management workshops. Management guidelines are also being documented for peri-urban deer and wild dogs, and rabbits in south-eastern and northern Queensland.

- Broadscale control of feral pigs and feral cats is possible through baiting. Our researchers have collected data to support permit applications for the use of 1080 to control pigs and cats. Baiting can be effective, and the data so far indicates that it can be undertaken without population-level impacts to native fauna. We are now working with other jurisdictions to have a 1080 bait for feral cats approved in eastern Australia.

- The Centre for Invasive Species Solutions (CISS) supports a number of our pest animal projects through both funding and collaboration. These projects will be complete by mid-2022. We are hoping for an extension of the CISS and our involvement with a new portfolio of projects that includes weed management.

- Our wild dog research is two pronged. We are looking to finalise our study on the effectiveness of cluster fences for the control of wild dogs and other pest animals in western Queensland. In cattle grazing areas of northern and central Queensland, we are aiming to better understand their movements, feeding behaviour and the efficacy of baiting using satellite telemetry.

- With the help of CISS, we are using environmental DNA and other tools to better manage incursions of red-eared slider turtles and improve detection probability of Asian black-spined toads. Collaborators at James Cook University and in Indonesia are assisting with the latter.

## Research services

- At Coopers Plains, our chemistry group produces 1080 solution for use in pig, dog and fox baits. The group also tests various poisons as possible causes of death for animal mortalities reported by the public. In addition, testing for residues in baits is carried out to quantify how long chemicals last in the environment.

- We obtain minor-use permits from the Australian Pesticides and Veterinary Medicines Authority as required for certain weed species, herbicides, application methods and situations or environments. Eighteen minor-use or emergency-use permits were obtained in 2020-21.

## Funding, collaboration and research priorities

In the 2020–21 financial year, Biosecurity Queensland's Invasive Plants and Animals Research program received funding from a number of sources. Expenditure from Queensland Government base funds was $1.5 million; expenditure from the Land Protection Fund amounted to almost $2.3 million; and expenditure under contracts with external partners totalled $2.0 million (see 'External funding', page 66). Notable funding bodies for the latter were the Australian Government, AgriFutures Australia, CSIRO, Manaaki Whenua Landcare Research New Zealand, Seqwater and the Centre for Invasive Species Solutions.

Our research program for 2020–21 was endorsed by the Research Review Committee—a group of senior scientific, operations and policy staff from Biosecurity Queensland plus representatives from our external stakeholders, including local government, AgForce, the Queensland Farmers' Federation, the Queensland Conservation Council and NRM Regions Queensland. The committee critically reviews proposed project outcomes and allocated investments, and makes recommendations on strategic priorities, existing research gaps and projects due for scientific review.

## Further information

For more information, visit the 'Invasive plant and animal research' page at **daf.qld.gov.au**. Journal articles and scientific reports can be obtained by emailing project leaders (see 'Research staff', pages 68-69). In addition, you can browse our recent scientific publications in the eResearch archive at **daf.qld.gov.au** (search 'eResearch archive').

# Part 1: Invasive plant research

## 1. Water weed management research – integrated control of aquatic weeds

### Project dates

July 2012 – December 2022

### Project team

Tobias Bickel, Christine Perrett, Bahar Farahani and Joseph Vitelli

### Project summary

Management of aquatic weeds to protect valuable freshwater resources is notoriously difficult. Foremost, herbicides can be ineffective because of dilution and dispersion in the water, resulting in poor control and non-target damage.

A field trial was carried out in south-east Queensland to measure the efficacy of three different application techniques to control cabomba with flumioxazin. In a lake, we used designated plots with a gel, granular or liquid formulation. The gel and granular formulations released flumioxazin at a lower concentration and over a longer period, while the liquid application caused an instant herbicide peak. All treatments resulted in rapid uptake of flumioxazin by cabomba and the herbicide was largely broken down within 48 hours.

The control efficacy was measured through manual biomass sampling and sonar mapping of aquatic vegetation with a drone. Cabomba was forming a dense surface canopy and occupied the entire water column from around 2m depth before treatment. Three months after herbicide application there was very little viable cabomba material left. All three application techniques achieved excellent control (>85%).

The sonar mapping of aquatic vegetation provided detailed visual information of the temporal changes in cabomba cover after herbicide application. The granule and gel formulations show great promise for future use for spot treatments and application in slow moving water.

### Collaborators

- CSIRO
- Department of Environment and Science
- Seqwater
- Logan City Council
- University of Queensland
- NIWA New Zealand
- Brisbane City Council
- Noosa and District Landcare
- Department of Primary Industries Victoria
- Department of Primary Industries NSW

- University of Düsseldorf
- Macspred
- SePro USA
- Junfeng Xu (University of Queensland)
- Katarina Panjak (University of Queensland)
- Mathew McVay (University of Queensland)
- Nguyen Nguyen (University of Queensland)

### Key publications

Bickel, TO, 2019, Information on measures and related costs in relation to species included on the Union list: *Cabomba caroliniana*, Technical note prepared by IUCN for the European Commission, 43pp.

Nguyen, NHT, Bickel, TO, Perrett, C, & Adkins, S 2021, Alien invasive macrophyte put into the shade: The native floating-leaved macrophyte *Nymphoides indica* reduces *Cabomba caroliniana* growth performance through competition for light, Freshwater Biology, 66: 1123-1135.

## 2. Collaborative prioritisation for improved invasive species management at multiple scales

### Project dates

July 2019 – June 2022

### Project team

Olusegun Osunkoya and Christine Perrett

### Project summary

This is a collaborative project with the University of Queensland, Queensland University of Technology and Queensland Parks and Wildlife Service supported by funding from the Australian Research Council. Managing invasive species is complex. By necessity, it involves a range of stakeholders from the government and non-government sectors. Further complexity arises because invasive species affect a diversity of land tenures that span multiple jurisdictions. A single invasive species (e.g. foxes) can occur on both agricultural lands and protected areas, cross multiple local and regional governmental boundaries, and span freehold, leasehold and public land. Presently, invasive species management groups, like Biosecurity Queensland and Queensland Parks and Wildlife Service, almost always operate independently due to different jurisdictions and varying goals. However, there are potential benefits of a collaborative approach across agencies to planning and action in this space. A lack of coordination can lead to the inefficient use of limited resources and, importantly, reduced benefits for the environment and society. Since the inception of the project, we are developing and fine-tuning a new pest animal and plant prioritisation framework that recognises the fact that invasive species are better managed at multiple spatial scales, and by multiple agencies.

## Collaborators

- Moya Calvert and Brad Gray (Biosecurity Queensland)
- Associate-Professor Eve McDonald-Madden (University of Queensland)
- Dr Jonathan Rhodes (University of Queensland)
- Dr Mike Bode (Queensland University of Technology)
- Dr Geoff Lundie-Jenkins (Queensland Parks and Wildlife Services)
- Dr Chris O'Bryan (University of Queensland)
- Travis Sydes (Far North Queensland Regional Organisation of Councils)

## Key publications

Bode, M, Probert, W, Turner, WR, Wilson, K & Venter, O. 2010, 'Conservation planning with multiple organizations and objectives', *Conservation Biology*, vol. 25(2), pp. 295–304.

Epanchin-Niell, RS, Hufford, MB, Esian, CE, Sexton, JP, Port, JD & Waring, T 2010, 'Controlling invasive species in a complex landscapes', *Frontiers in Ecology and the Environment*, vol. 8(4), pp. 210–216.

Osunkoya, OO, Froese, J, Nicol, S, Perrett, C, Moore, K, Callander, J, Gooding, K & Campbell, S 2019, 'A risk-based inventory of invasive plant species of Queensland, Australia: regional, ecological and floristic insights', *Austral Ecology*, vol. 44(7), pp. 1123–1138.

Osunkoya, OO, Froese, J & Nicol, S 2019, 'Management feasibility of established invasive plants species in Queensland, Australia: a stakeholders' perspective', *Journal of Environmental Management*, vol. 246, pp. 484–495.

# 3. Using pest distribution and abundance to determine management and research priorities

## Project dates

July 2018 – June 2021

## Project team

Olusegun Osunkoya and Christine Perrett

## Project summary

This project built on previous work on pest species prioritisation and analyses compiled from the Annual Pest Distribution Survey (APDS) - a Queensland dataset spanning 2003-2014. Based on stakeholder consultation at a regional level, weeds and pest animals have been prioritised for research and management based on their distribution, current and future impact (Osunkoya et al. 2019). However, such prioritisation did not take into consideration the speed and patterns of invasions - a set of traits that are obtainable from standardized invasion curves. At the management level, invasion curves to guide control options are readily mentioned, but very few have been constructed for pest species in Queensland. In this project, we have combined the short-time APDS estimates with long term herbarium records (HERBRECS > 150 yrs.) to develop standardised invasion curves. Standardised invasion curves describe the temporal and spatial dynamics of both recent introductions (emerging species) and the widespread, established pests at regional and state-wide scales. The information can be used to allocate management effort to pest species management according to their current and future impact.

### Collaborators

- Joshua Buru (Queensland University of Technology)
- Claire Lock (New South Wales Department of Primary Industries)
- Jens Froese (CSIRO, Ecosciences Precinct, Brisbane)
- Sam Nicol (CSIRO, Ecosciences Precinct, Brisbane)
- Moya Calvert and Brad Gray (Biosecurity Queensland)

### Key publications

Department of Agriculture and Fisheries 2015, *Annual pest distribution survey 2013–14*, The State of Queensland, https://data.qld.gov.au/dataset/annual-pest-distribution-survey-series.

Morin, L, Heard, T, Scott, J, Sheppard, A, Dhileepan, K, Osunkoya, OO & van Klinken, R 2013, 'Prioritisation of weed species relevant to Australian livestock industries for biological control', 176 pages, Meat & Livestock Australia Limited, Sydney NSW 2059.

Osunkoya, OO, Froese, JG, Nicol, S, Perrett, C, Moore, K, Callander, J & Campbell, S 2019, 'A risk-based inventory of invasive plant species of Queensland, Australia: Regional, ecological and floristic insights', *Austral Ecology* 44, pp. 1123-1138.

Osunkoya, OO, Lock, C, Buru, JC, Gary, B & Calvert, M 2020, 'Spatial extent of invasiveness and invasion stage categorization of established weeds of Queensland, Australia', *Australian Journal of Botany* 68, pp. 557-573.

## 4. Integrated control of parthenium weed in southern Queensland

### Project dates

June 2016 – June 2021

### Project team

Olusegun Osunkoya, K Dhileepan, Christine Perrett and Boyang Shi

### Project summary

Landholders are managing *Parthenium hysterophorus* in central and northern Queensland through a combination of herbicide control and varying grazing pressure which is also supported by eleven biocontrol agents. In southern Queensland, at the invasion front for parthenium, landholders are having less success in managing the weed. Potential reasons for this include: biological control agents are few or not long established, the different climate and vegetation, and parthenium's life history appears different (e.g., timing and extent of flowering) in comparison to the north. Landholders are also not familiar with managing the weed, particularly the integration of biological and conventional control techniques. In July 2018, we commenced collaborative work with North Burnett Regional Council in the field to experimentally examine a range of control strategies for parthenium. This project aimed to determine the efficacy of biocontrol agents, optimal timing of herbicide control and the effect of grazing pressure on the weed growth. Experimental field plots are being used as demonstration plots and to provide extension to landholders. Aerial imageries using drones have been captured at two field sites (Gayndah and Monto) and from glasshouse grown plants to provide a pre-trial baseline as well as to compare remote-sensed demographic data of the weed with that obtained via small-scale ground-truthing.

### Collaborators

- Steve Adkins (The University of Queensland)
- Raghu Sathyamurthy (CSIRO, Ecosciences Precinct)
- Neale Jensen (North Burnett Regional Council)
- Peter Trotter (Aspect UAV Imaging, Sunshine Coast)
- Felipe Gonzalez (Australian Centre for Robotic Vision, School of Engineering, Queensland University of Technology)

### Key publications

Costello, B 2019, Automatic detection and mapping of invasive parthenium weed from airborne imagery using Yolov 3, Bachelor of Engineering Thesis, Queensland University of Technology, Brisbane, 18 pages.

Dhileepan, K, Callander, J, Shi, B & Osunkya, OO 2018, 'Biological control of parthenium (*Parthenium hysterophorous*): the Australian experience', *Biocontrol Science and Technology*, vol. 28 (10), pp. 970 -988.

Mao, R, Nguyen, TLT, Osunkoya, OO & Adkins, SW 2019, 'Spread pathways of the invasive weeds *Parthenium hysterophorous* L: the potential for water spread', *Austral Ecology*, vol. 44(7), pp. 1123- 1138.

## 5. Impact and management of Navua sedge

### Project dates

July 2020 – June 2021

### Project team

Olusegun Osunkoya, Christine Perrett, K Dhileepan and Boyang Shi

## Project summary

In a recent assessment of Queensland's worst weeds, Navua sedge ranked amongst the top 60 invasive alien species needing management in Queensland. It has indeed become a significant weed of grazing landscapes and roadsides in Far North Queensland (Osunkoya et al. 2019). Currently, there is little quantitative data on the yield loss to the grazing and cropping industries caused by Navua sedge; there is also dearth of information on herbicide efficacy (e.g., on the use of Sempra(R)) in controlling the weed. In this project, we have identified and surveyed major infestation sites in both coastal and upland localities (six in all) in Far North Queensland and have set up both glasshouse and field subplots of infestations of different densities for estimation of impact (on soil biota) and yield loss by the sedge weed under grazing/non-grazing and herbicide/non-herbicide treatments when grown with palatable pasture grass species (e.g., Humidicola and Signal grasses). We will quantify the yield loss, document changes in pasture diversity, soil seed and tuber banks caused by different levels of infestation of Navua sedge under different treatments. The identified infestation sites will also be used to examine efficacy of biocontrol (if, and, when ready for field assessments) in the future.

## Collaborators

- Roger Shivas (University of Southern Queensland)
- Melissa Setter and Stephen Setter (Tropical Weeds Research Centre, South Johnstone)
- Joe Rolfe and Bernie English (Agri-Science Queensland, Mareeba)
- Rob Pagano (Tarazali)
- Travis Sydes (Far North Queensland Regional Organisation of Councils, Cairns)
- Malanda Beef Plan Group (Malanda)
- Tablelands Regional Council (Atherton)
- Cassowary Coast Regional Council (Innisfail)
- Hinchinbrook Shire Council (Ingham)

## Key publications

Chadha, A, Florentine, SK, Dhileepan, K, Dowling, K & Turville C 2021, 'Germination biology of three populations of Navua sedge (*Cyperus aromaticus*)', *Weed Science*, vol. 69, pp. 69–81, doi: 10.1017/wsc.2020.82

Osunkoya, OO, Froese, JG, Nicol, S, Perrett, C, Moore, K, Callander, J & Campbell, S 2019, 'A risk-based inventory of invasive plant species of Queensland, Australia: Regional, ecological and floristic insights', *Austral Ecology* vol. 44, pp. 1123-1138.

Son Abhishek 2019, Management of Navua sedge (*Cyperus aromaticus*) using competition and simulated herbivory interactions of Humidicola grass (*Brachiaria humidicola*) and Rhodes grass (*Chloris gayana*), *Master of Science Degree*, School of Agriculture and Food Science, The University of Queensland, Gatton, 98 pgs.

Vitelli, JS, Madigan, BA & van Haaren, PE 2010, 'Control techniques and management strategies for the problematic Navua sedge (*Cyperus aromaticus*), *Invasive Plant Science and Management*, vol. 3, pp. 315- 326.

Figure 1. Navua sedge growing between row spaces in newly planted sugar cane plantation in far north Queensland.

## 6. Biocontrol of bellyache bush (*Jatropha gossypiifolia*)

### Project dates

January 2007 – June 2021

### Project team

K Dhileepan, Di Taylor and Kai Hart

### Project summary

Bellyache bush (*Jatropha gossypiifolia*), a Weed of National Significance, is a serious weed of rangelands and riparian zones in northern Australia. Bellyache bush has been a target for biological control since 1997 with limited success to date. Surveys in Mexico, central and northern South America, and the Caribbean resulted in the release of the seed-feeding jewel bug (*Agonosoma trilineatum*) in 2003, which failed to establish. A leaf rust (*Phakopsora jatrophicola*), a leaf-miner (*Stomphastis* sp.) and a gall midge (*Prodiplosis* sp.) have been identified as prospective biological control agents. Host specificity testing of the leaf rust has been completed and a release application is being prepared. No choice and choice host specificity tests for the leaf-miner has been completed and an application seeking approval to release the agent in Australia has been submitted. Future research will focus on importing the gall midge from Paraguay into a quarantine facility in Australia for detailed host specificity testing.

### Jatropha rust

Host-specificity testing of the Jatropha leaf rust (*P. jatrophicola*) commenced in 2009 and continued until 2015. Full host-range testing of 42 non-target species was conducted using an accession of the rust from Trinidad under quarantine conditions at CABI-UK. Based on these results, dose-response experiments and a field host-range assessment in Trinidad were conducted to better understand the potential impact of the rust on three Australian native species. Research subsequently focused on elucidating the life cycle of the agent. Based on the results from both the quarantine and field host-range assessment, an application to release the Jatropha leaf rust in Australia will be prepared for submission.

### Jatropha leaf-miner

The Jatropha leaf-miner (*Stomphastis* sp.) from Peru was imported into quarantine in 2014 and a colony established. In no-choice oviposition and larval development trials in quarantine, oviposition was evident on 35 test plant species and on 28 species of test plants eggs hatched. However, larval development and completion of the lifecycle occurred only on bellyache bush (target weed) and its congener physic nut (*Jatropha curcas*) also a weed approved as a biological control target. On all non-target test plants, the first instar larvae died without any further development. In choice oviposition trials involving 26 non-target test plant species on which oviposition was observed in no-choice tests, very few eggs were laid on non-target test plant species, and none of the emerging larvae developed beyond the first instar stage, demonstrating that none of the non-target species are suitable hosts. In choice-minus-control oviposition trials involving six test plant species on which high numbers of eggs were laid in no-choice trials, no eggs were laid on any of the non-target test plants. Results from the no-choice and various choice tests confirmed that the Jatropha leaf miner is highly host specific. A full genome sequencing of the Jatropha leaf miner has been completed and will be uploaded to GenBank. An updated release application including additional results from choice oviposition trials has been submitted to the Australian Department of Agriculture, Water and the Environment.

### Jatropha midges

A gall midge (*Prodiplosis* sp.) recorded feeding on *Jatropha clavuligera* in Bolivia and on *J. gossypiifolia* in Paraguay has been prioritised as a prospective biocontrol agent. The midge induces rosette galls in shoot-tips, emerging leaves, petioles, and stems resulting in shoot-tip dieback on *J. clavuligera* in Bolivia. In Paraguay the midge feeds on the emerging leaves of *J. gossypiifolia*, causing leaf necrosis and shoot-tip die back without causing prominent gall symptoms. Morphological, behavioural (host specificity) and genetic studies suggest that the *Prodiplosis* populations on *J. clavuligera* from Bolivia and on *J. gossypiifolia* from Paraguay belong to a previously undescribed species, that is distinct from the polyphagous *P. longifolia* assemblage. There are no morphological and molecular mitochondrial (COI gene sequences) differences between the midge populations from Bolivia and Paraguay, and the midge is being described as a single new species. Permits to import the gall midge from Paraguay have been obtained allowing it to be imported into quarantine when the international borders restrictions are lifted in South America.

## Collaborators

- Marion Seier, Kate Pollard (CABI, UK)

- Guillermo Cabrera Walsh, Marina Oleiro, Carolina Mengoni (Fundación Para El Estudio De Especies Invasivas, Buenos Aires, Argentina)
- Peter Kolesik (South Australian Museum, Adelaide)
- Kumaran Nagalingam (CSIRO, Brisbane)
- Dr Jurate De Prins (Royal Museum of Central Africa, Belgium)

## Key publications

Dhileepan, K, Neser, S & De Prins, J 2014, 'Biological control of bellyache bush (*Jatropha gossypiifolia*) in Australia: South America as a possible source of natural enemies',in Impson, FAC, Kleinjan, CA & Hoffmann, JH (eds), *Proceedings of the XIV International Symposium on Biological Control of Weed*, Kruger National Park, South Africa, 2-7 March 2014, pp. 5 – 10..

Heard, TA, Dhileepan, K, Bebawi, F, Bell, K & Segura, R 2012, '*Jatropha gossypiifolia L.* – bellyache bush', in Julien, M, McFadyen, RE & Cullen, J (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne. pp. 324 – 333.

# 7. Biocontrol of Navua sedge (*Cyperus aromaticus*)

## Project dates

July 2017 – June 2022

## Project team

K Dhileepan, Olusegun Osunkoya, Di Taylor and Boyang Shi

## Project summary

Navua sedge (*Cyperus aromaticus*) is an aggressive, perennial grass-like weed that affects the beef, dairy, sugarcane, sweet potato and banana industries in the Queensland wet tropics. Navua sedge is unpalatable for livestock forming dense stands that replace palatable tropical pasture species. In grazing areas, the current management options are mechanical and chemical control, which are expensive and impractical for large areas. In addition, these control methods only provide short-term relief. Biological control of Navua sedge has the potential to reduce the amount of conventional control needed to minimise production losses.

Native range surveys for natural enemies of Navua sedge were conducted in parts of eastern Africa (Kenya and Tanzania) and western Africa (Nigeria). Surveys identified the pathogens, *Cintractia kyllingae*, *Uredo kyllingae-erectae*, and *Curvularia tanzanica*, as potential biological control agents. Two of these fungal pathogens (*C. kyllingae* and *C. tanzanica*) have been shown by morphological and molecular methods to represent species new to science. The three pathogens were exported to CABI, UK for detailed host specificity tests. Student research projects in collaboration with universities in Australia are currently filling knowledge gaps in the biology, ecology and management of Navua sedge. Future work will focus on surveys in other native range countries for biological agents and host specificity testing of potential agents already identified.

### Native range survey

Due to travel restrictions caused by the COVID-19 pandemic, surveys for biological control agents of Navua sedge in Africa have been suspended. However, surveys in Tanzania and Nigeria were undertaken by local collaborators (John Elia Ntandu in Arusha, Tanzania and Emmanuel Chukwuma in Ibadan, Nigeria). In Tanzania, surveys were conducted in three sites, and Navua sedge samples with leaf spot disease symptoms, and leaf and stem rust (*U. kyllingae-erectae*) infections were collected and exported to CABI-UK. In Nigeria, surveys were conducted in 174 sites, and Navua sedge samples with flower smut (*Ci. kyllingae*) and leaf and stem rust (*U. kyllingae-erectae*) were collected and exported to CABI-UK.

Taxonomic studies using morphological and molecular methods were used to describe two new species of fungal pathogens found on Navua sedge (*Ci. kyllingae* and *Cu. Tanzanica*). Currently, isolation, culturing and identification of the casual agents of leaf spot disease in Navua sedge are in progress at CABI-UK.

### Genetic studies

Navua sedge leaf samples from the native (220 samples from 20 countries) and introduced ranges (300 samples from the wet tropical regions of northern Queensland and 31 samples from Fiji) were collected for genotype matching studies. These studies will identify genetically matching Navua sedge populations in the native range countries to Navua sedge populations in Australia and Fiji. Genotyping-by-sequencing studies are in progress in collaboration with the University of Queensland. Results will be used to source biological control agents from countries with matching Navua sedge genotypes, and to undertake surveys for potential agents in those countries

Cytogenetic studies conducted in collaboration with James Cook University (Cairns) indicated no evidence of polyploidy among Navua sedge populations sampled in far north Queensland.

### Host specificity testing

Navua sedge has been declared as an approved target for biocontrol in Australia by the Environment and Invasives Committee. A draft test plant list comprising about 40 species has been developed and circulated to the Department of Agriculture, Water and the Environment (DAWE).

A contract was previously signed with CABI-UK, to conduct host specificity tests for the Navua sedge flower smut (*Ci. Kyllingae*). Navua sedge seeds and rhizomes field collected from northern Queensland, and test plants sourced from Queensland, were exported to CABI for pathogenicity studies and host specificity testing. Host specificity tests for the flower smut (*Ci. Kyllingae*) are in progress in a quarantine facility at CABI, UK.

Funding to conduct host specificity testing of the Navua sedge leaf and stem rust (*U. kyllingae-erectae*) was recently secured from the Australian Government (DAWE). Host specificity tests for the stem and leaf rust will be conducted at CABI, UK.

### Mycoherbicide research

Surveys for leaf and stem pathogens on Navua sedge in north Queensland were completed in September 2020 and April 2021. Samples of leaves and stems with symptoms of disease (leaf spots, blight, necrosis, discoloration) yielded 36 fungal cultures that were identified by morphological and molecular barcode methods. Most of the species isolated belonged to *Curvularia* (3), *Epicoccum* (3), *Fusarium* (6), *Neopestalotiopsis* (4), *Nigrospora* (16), and

*Phaeosphaeria* (1). Some of these species will be tested for pathogenicity on Navua sedge in glasshouse trials.

### Ecological research

Studies on the biology, ecology and management of Navua sedge by Aakansha Chadha as part of her PhD program are in progress at the Federation University, Ballarat, Victoria. In glasshouse-based studies, regrowth of rhizomes was positively correlated to rhizome fragment size and negatively correlated with burial depth. Studies on the soil seed bank dynamics of pastures infested with Navua sedge, in relation to invasion history, soil types, above ground vegetation composition and weed infestation levels are in progress. In glasshouse trials, Navua sedge seedlings were susceptible to herbicides halosulfuron-methyl and florpyrauxifen-benzyl. In contrast, in Navua sedge plants with established rhizomes, the rhizomes survived and regrew after the herbicide treatment. Hence, sequential spraying trials are being carried out to understand the number of times herbicide application is required to control Navua sedge. Artificial herbivory trials are currently underway in the glasshouse to mimic the effect of biological control on Navua sedge plants.

## Collaborators

- Prof Roger Shivas (University of Southern Queensland)
- Dr Marion Seier, Dr Daisuke Kurose (CABI-UK)
- Prof Florentine Singarayer, Aakansha Chadha (Federation University, Ballarat)
- Dr Yu Pei Tan (Queensland Plant Pathology Herbarium)
- Dr Alistair McTaggart (QAAFI, UQ)
- Melissa Setter, Stephen Setter (Centre for Wet Tropics Agriculture, South Johnstone)
- Dr Shane Campbell, Prof Steve Adkins, Abhishek Soni (UQ, Gatton, Qld)
- Dr Mutuku Musili, Frederick Munyao Mutie (East African Herbarium, Kenya)
- Dr John Elia Ntandu (National Herbarium of Tanzania)
- Emmanuel. C. Chukwuma (Forest Research Institute, Ibadan, Nigeria)
- Ocholi T Edogbanya (Kogi State University, Anyigba, Nigeria).
- Dr Isabel Larridon (Kew Gardens, UK)
- Dr Julia Kruse (Natural History Museum, Germany)
- Dr James Hereward, Prof Gimmie Walter (UQ, St Lucia)
- Dr Matthew Barrett (James Cook University, Cairns)
- Joe Rolfe, Bernie English (Agri-Science Queensland, Mareeba)
- Rob Pagano (Beef grazier, Tarazali)
- Travis Sydes (Far North Queensland Regional Organisation of Councils, Cairns)
- Malanda Beef Plan Group (Malanda)
- Tablelands Regional Council (Atherton)
- Cassowary Coast Regional Council (Innisfail)
- Hinchinbrook Shire Council (Ingham)

## Key publications

Chadha, A, Florentine, SK, Dhileepan, K, Dowling, K and Turville, C 2021, 'Germination biology of three populations of Cyperus aromaticus', *Weed Science* vol. 69, pp. 69-81.

Vitelli, JS, Madigan, BA & van Haaren, PE 2010, 'Control Techniques and Management Strategies or the problematic Navua sedge (*Cyperus aromaticus*)', *Invasive Plant Science and Management*, vol. 3, pp. 315-326.

Vogler, WD, Carlos, EH, Setter, SD, Roden, L & Setter, MJ 2015, 'Halosulfuron-methyl: A selective herbicide option for the control of the invasive *Cyperus aromaticus* (Ridley) Mattf. and Kunth (Navua sedge)', *Plant protection quarterly*, vol. *30,* pp. 61-66.

# 8. Biocontrol of parthenium (*Parthenium hysterophorus*)

## Project dates

July 2004 – June 2021

## Project team

K. Dhileepan, Olusegun Osunkoya and Boyang Shi

## Project summary

Parthenium weed (*Parthenium hysterophorus* L.), a noxious weed of grazing areas in Queensland, is a Weed of National Significance in Australia. Parthenium also causes severe human and animal health problems. Eleven biological control agents (nine insect species and two rust pathogens) have been released against parthenium in Australia. All agents established but not all are widespread. They have proven effective against the weed in central Queensland (CQ). Parthenium is spreading into south Queensland (SQ) and south-east Queensland (SEQ), where many of the widespread and effective biological control agents in the CQ are not present. Hence, the seed-feeding weevil (*Smicronyx lutulentus*), the stem-boring weevil (*Listronotus setosipennis*), the root-boring moth (*Carmenta ithacae*), the summer rust (*Puccinia xanthii* var. *parthenii-hysterophorae*) and the winter rust (*Puccinia abrupta* var*. partheniicola*) have been redistributed from CQ into SQ and SEQ. Redistribution of field collected biological control agents from CQ and monitoring their establishment status in SQ and SEQ will continue.

Due to COVID-19 pandemic-related travel restrictions only limited field visits were conducted. A survey was conducted in December 2020, covering parthenium infested areas in SQ (St George and Mitchell) and CQ (Emerald, Springsure, Rolleston and Injune). In St George and Mitchell, due to very dry conditions, no green parthenium was found, and hence occurrence of any parthenium biocontrol agents could not be ascertained there. In central Queensland, due to dry conditions, green parthenium was not found in most places, except along creeks (Mooliyember Creek and Sandhurst Creek), where the incidence of Epiblema moth (*Epiblema strenuana*), Smicronyx weevil, Carmenta moth was recorded.

Surveys were conducted at Woodford in January 2021 and in Helidon spa, Gatton and other Lockyer Valley areas in March 2021. Except for a very low-level incidence of the stem galling Epiblema moth, no other biological control agents were found as there was no parthenium in most sites due to the drought.

Whole genome sequencing of the Carmenta moth was undertaken to resolve its taxonomic status. Samples of the Carmenta moth were also sent to a lepidopteran taxonomist (Dr Jean-Francois Landry, Agriculture-and Agri-Food Canada) to further validate its species status.

## Collaborators

- Chris Hoffmann (Lockyer Valley Regional Council, Gatton)
- Lachlan Grundon (Balonne Shire Council, St George)
- Melinda Clarke (Burnett Catchment Care Association, Monto)
- Prof Steve Atkins (UQ, Gatton)
- Dr Asad Shabbir (University of Sydney)
- Ken Woodall (RAPAD Workforce, Mitchell)
- Tom Garrett and Holly Hosie (Queensland Murray-Darling Committee)
- Ross Bigwood and Bruce Lord (Healthy Land and Water)
- Pat Ryan (Junction View Pest Management Group)
- Glen Proctor, Jenny Voigt, Neale Jensen and John Pieters (North Burnett Regional Council)
- Eric Dyke (Bundaberg Regional Council)
- Dr Jean-François Landry (Agriculture and Agri-Food Canada)

## Key publications

Dhileepan, K, 2009, Managing *Parthenium hysterophorus* across landscapes: limitations and prospects, pp. 227-260. In: *Management of Invasive Weeds* (ed. Inderjit, S.), Invading Nature - Springer Series in Invasion Ecology Vol. 5, Springer Science.

Dhileepan, K and Strathie, L 2009, 20. *Parthenium hysterophorus*. pp. 272-316. In: *Weed Biological Control with Arthropods in the Tropics: Towards Sustainability* (eds. Muniappan, R., Reddy, D.V.P. & Raman, A), Cambridge University Press, Cambridge, UK.

Dhileepan, K. and McFadyen, RE 2012. *Parthenium hysterophorus* L. – parthenium, pp. 448-462. In: *Biological control of weeds in Australia: 1960 to 2010* (Eds. M. Julien, R.E. McFadyen & J. Cullen), CSIRO Publishing, Melbourne.

# 9. Biocontrol of prickly acacia (*Vachellia nilotica* ssp. *indica*)

## Project dates

January 2007 – June 2022

## Project team

K Dhileepan, Di Taylor, Boyang Shi, Md Mahbubur Rahman and Kai Hart

## Project summary

Prickly acacia (*Vachellia nilotica* subsp. *indica*) is a Weed of National Significance and a target for biological control, albeit with limited success to date. Plant phenotype and climate matching were used to prioritise countries and areas for the native range surveys. Native range surveys for prospective biological control agents were conducted in Ethiopia and Senegal. During native range surveys, priority was given to gall-inducing agents, in view of their host specificity. Based on field host range, geographic range and damage potential, a thrips (*Acaciothrips ebneri*) inducing shoot-tip rosette galls, a gall-inducing mite (*Aceria* sp.) deforming leaflets, rachides and shoot-tips in Ethiopia and a gall-inducing fly (*Notomma mutilum*) inducing stem-galls in Senegal, have been prioritised for further studies. Host specificity testing for the gall-inducing thrips has been completed. Host specificity testing for gall-inducing mite in South Africa has been delayed due to COVID-19 pandemic related restrictions. Host specificity tests for the gall-inducing fly are in progress.

### Gall thrips

The prickly acacia gall-inducing thrips (*A. ebneri*), field collected in Ethiopia induces rosette galls in the axillary and terminal buds of prickly acacia, resulting in shoot-tip dieback. The gall thrips has a short lifecycle, completing its entire lifecycle in 25 days under quarantine conditions. No-choice host specificity tests involving 59 test plant species have been completed with a minimum five replicates of each test species. Under no-choice conditions, the gall thrips induced galls and produced progeny only on Australian prickly acacia (subsp. *indica*). No other test species were suitable hosts for the gall thrips. A bioclimatic model based on its native range distribution predicts that the entire inland region of northern Australia, including the Mitchell grass downs area where prickly acacia is a serious problem, is climatically suitable for the gall thrips. Complete genome sequencing of the gall thrips was carried out and uploaded to GenBank. An application seeking approval to release the gall thrips in Australia has been submitted to the Department of Agriculture, Water and the Environment in Australia.

### Gall mites

The eriophyid gall mite (*Aceria* sp. type-3) induced hairy mushroom-like galls on leaflets, rachides and shoot-tips in prickly acacia in Ethiopia and Senegal. A colony of type-3 gall mite from Ethiopia was established on *V. nilotica* subsp. *indica* sourced from Australia in a quarantine facility in Pretoria, South Africa in December 2017. To date no-choice host specificity tests have been completed only for seven test plant species. The gall mite induced galls only on prickly acacia sourced from Australia and not on any other non-target test plant species, highlighting that the gall mite is highly host specific, at the subspecies level of the target weed.

The colony of the gall mite in the quarantine facility in South Africa (Agricultural Research Council, Pretoria) crashed in November 2019 with no new gall development since then. As a result, further host-range testing was not possible. Additional importations of the gall mite from Ethiopia have been delayed due to the current COVID-19 pandemic-related international travel restrictions. Our Ethiopian collaborator (Mindaye Teshome) has agreed to collect and export the gall mites to South Africa late 2021. Host specificity testing will recommence following establishment of a colony in the quarantine in South Africa.

Gall mites from Ethiopia and Senegal were exported to Turkey (Ondokuz Mayis University) for identification. Due to the COVID-19 panemic-related lockdown in Turkey, no further progress has been made with the identification of the gall mite.

### Gall fly

A stem gall-inducing fly *Notomma mutilum* (Bezzi) (Diptera: Tephritidae) has been identified in Senegal as a prospective biological control agent. A colony of the gall-inducing fly has been established and is being maintained in a quarantine facility from stem galls imported from Senegal in April 2018 and June 2019. To enhance the quarantine colony, an additional importation of 1839 cut stem-galls from Senegal was made in June 2021. Imported galls are being maintained in quarantine for adult emergence.

Lifecycle studies for the gall fly were completed and rearing methods have been standardised. Adults live for about 30 days and females laid eggs in growing green shoots. The eggs hatched in 12 days, though signs of gall formation were detected within four days of oviposition. Each female fly induced an average of 44 galls in its lifetime. Developing larvae remained within the gall until pupation, when mature larvae exit the galls to pupate in the soil. The durations of larval and pupal development were about 124 and 12 days, respectively. The complete life cycle (egg to adult) takes about 162 days.

Adults emerging from the stem-galls imported from Senegal and those emerging from the existing quarantine colony are being used in no-choice host specificity tests. No-choice host specificity tests are in progress.

## Collaborators

- Anthony King, (Agricultural Research Council - Plant Protection Research Institute, Pretoria, South Africa)
- Dr Nathalie Diagne (Senegalese Institute of Agricultural Research, Centre National de Researches Agronomique, Bambey, Senegal).
- Mindaye Teshome (Forestry Research Centre, Addis Ababa, Ethiopia)
- James Hereward (School of Biological Sciences, University of Queensland, St Lucia).
- Ocholi Edogbanya (Department of Biological Sciences, Kogi State University, Anyigba, Nigeria)
- Sebahat Ozman Sullivan (Ondokuz Mayis University, Turkey).

## Key publications

Dhileepan, K 2009, 2. *Acacia nilotica* ssp. *indica*. pp. 17-37. In: *Weed Biological Control with Arthropods in the Tropics: Towards Sustainability* (eds. Muniappan, R, Reddy, DVP & Raman, A), Cambridge University Press, UK.

Dhileepan K, Shi B, Callander J, Taylor, D, Teshome M, Neser, S, Diagne N & King A 2019, Biological control of prickly acacia (*Vachellia nilotica* subsp. *indica*): New gall-inducing agents from Africa. In: H.I. Hinz et al. (eds.), *XV International Symposium on Biological Control of Weeds*, Engelberg, Switzerland, pp. 13-19, 26-31 August 2018. https://www.ibiocontrol.org/proceedings/

# 10. Risk assessment for weed biocontrol

## Project dates

March 2020 – March 2022

## Project team

Di Taylor

## Project summary

Host testing of weed biocontrol agents is an effective way of predicting the likelihood of damage by a proposed biocontrol agent on non-target species. However, sometimes “false positives” occur when an agent attacks non-target plants which it would not under natural conditions and this can lead to a host specific agent being rejected for release by regulatory bodies. New Zealand regulatory authorities have adopted a quantitative risk analysis approach for interpreting such results. Victorian researchers (with our assistance), propose to validate this method for Australian weed biocontrol targets. The implementation of this approach will assist with the testing and release of suitable biocontrol agents in Queensland to control target weeds.

An extensive literature search was undertaken compiling published and unpublished reports detailing host specificity testing and post release non-target attacks. Following analysis of this literature, case studies were prioritised for field surveys, including several in Queensland. Field surveys are being conducted in southeast Queensland to determine if the potential non-target attacks are realised.

## Collaborators

- Agriculture Victoria Research Division, Department of Jobs, Precincts and Regions

## Key publications

Paynter, Q, Fowler, SV, Gourlay, AH, Peterson, PG, Smith, LA & Winks, CJ 2015, ‘Relative performance on test and target plants in laboratory tests predicts the risk of non-target attack in the field for arthropod weed biocontrol agents’, *Biological Control, vol.* 80, pp. 133–142.

# 11. Biocontrol of giant rat’s tail grass

## Project dates

July 2016 – June 2023

## Project team

Tamara Taylor, Michael Day, Natasha Riding, Lauren Kelk and David Comben

## Project summary

Giant rat’s tail grass (GRT) is the common name of two species, *Sporobolus pyramidalis* and *S. natalensis*. Current control efforts for weedy *Sporobolus* grasses rely on the use of chemical, mechanical, plant competition and pasture management. However, weedy *Sporobolus* grasses continue to rapidly lower pasture production and spread into new areas. A biological control project was implemented in the 1990s but did not result in the release of any biological control agents. A new biological control project on GRT, along with several other weed species, was funded by the Australian Government (DAWE) through AgriFutures. Under this project, two wasps from the genera *Tetramesa* and one from *Bruchophagous* were found on the weedy *Sporobolus* species in South Africa. Field host-range testing has suggested that all three wasp species appear to be suitable for introduction into Australia. Laboratory testing in South Africa is completed for *Tetramesa* sp. A, and it appears to be host specific to GRT. However, importation of this species for further host testing in Australia is on hold due to COVID-19 restrictions preventing the transport of live insects from South Africa. Host testing research of *Tetramesa* sp. B is being conducted in South Africa. So far, *Tetramesa* sp. B also appears to be host specific to GRT, but further host testing is needed. The three wasp species will be sent to a taxonomic specialist in Iran for formal identification. A sample collection of these species has been received in Australia. The transport of preserved samples to the taxonomist has been attempted from both Australia and South Africa, however freight companies did not travel from either country to Iran during 2020-2021 due to travel bans.

### Collaborators

- Rhodes University (South Africa)
- AgriFutures Australia
- Australian Department of Agriculture, Water and the Environment

### Key publications

Palmer, B 2012, '*Sporobolus* spp.-weedy *Sporobolus* grasses', in Julien, M, McFadyen, R & Cullen, J (eds), *Biological control of weeds in Australia*, CSIRO Publishing, Melbourne, pp. 569-575.

Sutton, GF, Canavan, K, Day, MD & Paterson, ID, 2021, 'Field-based ecological studies to assess prospective biological control agents for invasive alien plants: an example from giant rat's tail grass', *Journal of Applied Ecology,* vol. 58(5), pp. 1043-1054. https://doi.org/10.1111/1365-2664.13834.

Sutton, GF, Canavan, K, Day, MD, den Breeyen, A, Goolsby, JA, Cristofaro, M, McConnachie, A & Paterson, ID 2019, 'Grasses as suitable targets for classical weed biological control', *BioControl*, vol. 64, pp. 605–622.

## 12. Biocontrol of pasture weeds in Vanuatu and Queensland

### Project dates

October 2018 – June 2023

### Project team

Tamara Taylor, Michael Day, Natasha Riding, Lauren Kelk and David Comben

### Project summary

Biosecurity Queensland is collaborating with Landcare Research NZ on a 5-year weed biocontrol project based in Vanuatu, funded by the NZ Ministry of Foreign Affairs and Trade. The work will build upon previous work in Vanuatu funded by the Australian Government and managed by Biosecurity Queensland. International collaborative projects such as this minimise the risks of weed species spreading to other countries, including Australia, and enable sharing of weed management practices between countries. It is an efficient use of resources, sharing the costs of finding and testing biocontrol agents for weeds common to multiple countries.

The three main pasture weeds targeted under this project are *Senna tora* (a restricted weed in Queensland), *Solanum torvum* (a weed declared by some local governments in Queensland) and *Urena lobata* (a widespread environmental weed in Queensland). These weeds are new biological control targets, requiring overseas exploration in their respective native ranges to locate potential candidates. Potential candidates for *S. tora* will be brought into the quarantine facility at the Ecosciences Precinct in Brisbane, while those for *S. torvum* and *U. lobata* will be studied in New Zealand. If appropriate, applications seeking approval to release the agents in Australia will be prepared and submitted to the Australian Government regulatory authorities. Potential agents for all three target species have been identified and host specificity testing is underway in New Zealand with agents selected for *S. torvum* and *U. lobata.*

Additional weeds have been targeted as part of this project. Effective agents have been collected from Queensland and will be imported into Vanuatu to assist with the control of their invasive weeds. The biological control agent, *Zygogramma bicolorata,* released in Australia for control of the weed *Parthenium hysterophorus*, has been collected and mass reared at Ecosciences Precinct. Likewise, a collection and culture of the psyllid biocontrol agent, *Heteropsylla spinulosa*, for the control of *Mimosa diplotricha* is ready for export to Vanuatu. Under this project, a biocontrol agent (*Carvalhotingis visenda*) was successfully released in Vanuatu during 2019 for the control of cats-claw creeper (*Dolichandra unguis-cati)*. An additional biological control agent released in Queensland for *Lantana camara* will also be introduced in Vanuatu. All biological control agents tested and released in Vanuatu will be made available to other countries in the Pacific, as part of a regional invasive species management program.

## Collaborators

- Manaaki Whenua Landcare Research NZ Ltd
- Ministry of Foreign Affairs and Trade, NZ
- Biosecurity Vanuatu
- Department of Environment, Vanuatu
- Malaysian Agricultural Research and Development Institute
- CABI-Asia
- University of the West Indies (Jamaica)

## Key publications

Day, MD & Bule, S 2016, ‘The status of weed biological control in Vanuatu’. *Neobiota*, vol. 30, pp. 151-166.

Day, MD & Winston, RL 2016, ‘Biological control of weeds in the 22 Pacific island countries and territories: current status and future prospects’, *Neobiota*, vol. 30, pp. 167-192.

# 13. Biocontrol research of cactus species

## Project dates

July 2020 – June 2021 (Originally 2009 – 2020)

## Project team

Jason Callander, Lauren Kelk and Tamara Taylor

## Project summary

*Cylindropuntia* cactus species are native to tropical America. The group includes eight species that have naturalised in Australia. *Cylindropuntia kleiniae* (candle cholla) and *C. leptocaulis* (pencil cactus) are prohibited weeds in Queensland, while *C. fulgida* (coral cactus), *C. imbricata* (devil's rope pear), *C. pallida* (Hudson pear), *C. prolifera* (jumping cholla), *C. spinosior* (snake cactus) and *C. tunicata* (brown-spine Hudson pear) are restricted weeds in Queensland. All species are approved targets for biocontrol.

*Dactylopius tomentosus*, a species of cochineal insect that attacks *Cylindropuntia* species in their native range, was first introduced to Australia as a biological control agent against *Cylindropuntia imbricata* in 1925. It is recognised that there are different 'lineages' of this species, each of which have most impact on the different *Cylindropuntia* species. More recently, an additional five lineages of *D. tomentosus* have been released in Queensland for the control of the remaining *Cylindropuntia* species.

The impact of these agents in the field is currently being monitored. The agent for coral cactus is providing excellent control. Other lineages have established in at least one release site, with some providing partial to good control. However, the lineage released for the control of *C. spinosior* is not performing as well in Queensland as it is in New South Wales, and trials were undertaken to find an alternative lineage.

Host screening of ten lineages held in Ecosciences Precinct (ESP) quarantine facility has been completed and an alternative *Dactylopius* lineage for the control of *Cylindropuntia spinosior* was identified. Efficacy trials were conducted and have confirmed that this lineage, named 'Spinosior-safford', is more effective than the previous released lineage released on *C. spinosior*. The agent has been released from quarantine and is in culture at ESP awaiting favourable weather conditions to be released at Longreach, Queensland.

With the impending field release of the 'Spinosior-safford' lineage at Longreach, where the 'Bigelovii' lineage has already established, the likelihood of these two lineages interacting is unavoidable. Three hybridisation experiments have been conducted and, while the first two experiments indicated that there was little or no impact from hybridisation, the third experiment showed a significant reduction in efficacy of the hybrid lineages on the target *Cylindropuntia* species. We will conduct a hybridisation experiment between the 'Spinosior-safford' and 'Bigelovii' lineages to determine what effect, if any, this may have on field establishment and impact of the new lineage in Longreach.

An integrated management field trial for *C. imbricata* suggests that a combination of biological control, mechanical control and chemical control is more effective in controlling *C. imbricata* than any method alone. Routine monitoring has also revealed the devastating impact a native Australian ladybird beetle, *Cryptolaemus montrouzieri*, has on cochineal populations attacking cacti species at the field site.

## Collaborators

- Garry Pidgeon, Senior Biosecurity Officer, Longreach
- Jeffery Newton, Longreach Regional Council
- Cameron Wilson, Biosecurity Officer, Charleville
- Craig Hunter, Senior Biosecurity Officer, Dalby
- Dr Andrew McConnachie, NSW Department of Primary Industries
- Australian Department of Agriculture, Water and the Environment
- Iain Paterson, Rhodes University, South Africa
- Dr Helmuth Zimmermann, Consultant, South Africa

## Key publications

van Steenderen, CJM, Paterson, ID, Edwards, S & Day, MD 2021, 'Addressing the red flags in cochineal identification: the use of molecular techniques to identify cochineal insects that are used as biological control agents for invasive alien cacti', *Biological Control*, vol. 152. https://doi.org/10.1016/j.biocontrol.2020.104426

# 14. Biocontrol of *Mikania micrantha*

## Project dates

July 2020 – June 2021

## Project team

Tamara Taylor, Natasha Riding, David Comben, Lauren Kelk and Mike Day

## Project summary

*Mikania micrantha* was first reported in Queensland in 1998 and is also present on the Australian territories, Christmas and Cocos Islands. *Mikania* is the target of a national cost-share eradication program. Cyclones hampered early eradication progress and a review of the program suggested that biocontrol options should be investigated. *Mikania micrantha* was nominated as a target for biological control in 2014, and host testing of rust pathogen *Puccinia spegazzinii* was conducted in 2015. Fifteen species in the Eupatorieae and six species in the tribe Heliantheae were host tested in quarantine at the Ecosciences Precinct (ESP). Pustules did not form on any other species other than *M. micrantha*. The rust *Puccinia spegazzinii* is deemed host specific, having been tested in four countries against a total of 274 species, representing 73 families, including 87 species in the Asteraceae and 21 species in the tribe Eupatorieae. Approval of the release of *P. spegazzinii* on *M. micrantha* has been endorsed through the Department of Agriculture, Water and Environment and the Plant Health Committee. A culture of *P. spegazzinii* has been removed from quarantine and is being maintained in a glasshouse at ESP, awaiting field release.

## Collaborators

- Biosecurity Vanuatu

- National Agricultural Research Institute, PNG
- National Agriculture Quarantine and Inspection Authority, PNG
- CABI-UK

## Key publications

Clements, DR, Day, MD, Oeggerli, V, Shen, SC, Weston, LA, Xu, GF, Zhu, X 2019, Site-specific management is crucial to managing *Mikania micrantha,* Weed Research, 59(3), 155-169.

Day, MD & Riding, N 2019, Host specificity of *Puccinia spegazzinii* (Pucciniales: pucciniaceae), a biological control agent for *Mikania micrantha* (Asteraceae) in Australia, *Biocontrol Science and Technology*, 29(1), 19-27.

Day, MD, Clements, DR, Gile, C, Senaratne, KADW, Shen, S, Weston, LA, Zhang, F 2016, Biology and impacts of Pacific islands invasive species: *Mikania micrantha* Kunth (Asteraceae), *Pacific Science* 70, 257-285.

# 15. Efficacy of biocontrol on *Harrisia martinii* in southern Queensland

## Project dates

July 2020 - June 2022

## Project team

Tamara Taylor, Michael Day, Jason Callander and Lauren Kelk

## Project summary

Native to Argentina, *Harrisia martinii* is a spiny cactus species that can form dense infestations, choking out pasture species and native vegetation. Infestations can inhibit movement and cause injuries to stock. *Harrisia martinii* was introduced to Queensland in the 1890s and is now found at numerous sites across the state. As the species produces many seeds in fruit that is attractive to animals, it spreads quickly and has the ability to take over large grazing areas. It is also impacting upon the nationally endangered Brigalow ecological community. A biological control agent, *Hypogeococcus* spp. (mealybug), was released in the 1970s and provided initial control of *H. martinii* in central Queensland. However, the cactus is not considered to be under adequate control in south Queensland, with the core Goondiwindi infestation spreading out to Moonie, Millmerran, Toobeah and Yelarbon, as well as into NSW. Infestations also appear to be increasing again in central Queensland.

A University of Queensland PhD student, co-supervised and assisted by IP&A researchers, is conducting a study to quantify the impact of the mealybug biocontrol on the growth and flowering of *H. martinii* in Goondiwindi. Additionally, the UQ student aims to confirm the identity of the *Hypogeococcus* species introduced into Australia using molecular techniques and study the effect of temperature on the life history of the insect.

## Collaborators

- University of Queensland
- Goondiwindi Regional Council
- Harrisia Cactus Working Group
- Northern Slopes Landcare Association
- Macintyre Ag Alliance
- NSW Department of Primary Industries
- Horizon Ecological Consulting

## Key publications

McFadyen, R 2012, '*Harrisia (Eriocereus) martinii* (Labour.) Britton – Harrisia cactus' in (eds) Julien, MH, McFadyen, RE, Cullen, J, *Biological control of weeds in Australia*. pp.(274-281) CSIRO Publishing, Collingwood, Vic.

Novoa, A, Brundu, G, Day, MD, Deltoro, V, Essl, F, Foxcroft, LC, Fried, G, Kaplan, H, Kumschick, S, Lloyd, S, Marchante, E, Marchante, H, Paterson, I, D, Pyšek, P, Richardson, DM, Witt, A, Zimmermann, HG, Wilson, JRU 2019, Global Actions for Managing Cactus Invasions, *Plants*, 8(10), 421.

# 16. Biocontrol of cat's claw creeper (*Dolichandra unguis-cati*)

## Project dates

July 2001 – June 2022

## Project team

K. Dhileepan, Di Taylor, Boyang Shi and Md Mahbubur Rahman

## Project summary

Cat's claw creeper is a Weed of National Significance in Australia. Biological control is the most desirable option to manage the weed. Biological control of cat's claw creeper commenced in 2001, and since then three agents, a leaf-sucking tingid (*Carvalhotingis visenda*), a leaf-tying moth (*Hypocosmia pyrochroma*) and a leaf-mining beetle (*Hedgwigiella jureceki*) have been field released. All the three agents have established but their geographic range and abundance varies widely. The current research focus is on monitoring the establishment and spread of the leaf-tying moth and the leaf-mining beetle; and evaluating the potential of fungal pathogens as complementary biocontrol agents to the insects already released. The pathogens prioritised for investigation include the cat's claw creeper leaf-spot disease (*Cercosporella unguis-cati*), the cat's claw creeper leaf-rust (*Prospodium macfadyenae*) and the cat's claw creeper gall-rust (*Uropyxis rickiana*).

### The leaf-tying moth

The leaf-tying moth (*H. pyrochroma*) was field released from 2007 to 2011 targeting both "short-pod" and "long-pod" forms of cat's claw creeper. The larvae feed destructively on leaves, by tying leaves together with silk, leading to the creation of silken tunnels.

Systematic surveys were conducted in four regions (Boompa, Lake Moogerah, Coominya and Oxley) in Queensland, at monthly intervals. Larval activities in the field were evident from December 2020 to May 2021. The moth continued to spread from 1.5 to 23 km from release sites along riparian areas. In contrast, there is only limited establishment and dispersal in non-riparian corridors, highlighting the importance of microclimate for establishment and spread. Field collection and redistribution of leaf-tying moth larvae from the established sites to riparian sites in other river and creek systems is recommended.

#### The leaf-mining beetle

The leaf-mining beetle (*H. jureceki*) was field released from 2012 to 2017 targeting both "short-pod" and "long-pod" forms of cat's claw creeper. Both the larvae and adults are very damaging - larvae mine within the leaves and the adults feed on young leaves. The agent currently occurs in all release sites and is continuing to spread to new areas.

Adults (about 1500) field collected from established sites in Brisbane were field released in cat's claw creeper infestations in Atherton in November 2020. Establishment was confirmed during a follow-up survey in April 2021.

A glasshouse trial to study the potential impact of the leaf-mining jewel beetle on cat's claw creeper (short-pod form and long-pod form) has been completed and data are being analysed.

#### Plant pathogens

While native to South America, *C. unguis-cati* is also present on cat's claw creeper introduced in South Africa. A culture of the agent was obtained from this country and has been established at CABI-UK. The leaf-spot pathogen was found to be virulent towards both the long- and short-pod forms of the weed in Australia. However, infection was generally less prolific on the long-pod form, with smaller lesions developing on inoculated leaves. Host-specificity testing of 17 non-target test plant species has shown that *C. unguis-cati* exhibits high levels of host specificity, with no evidence of the characteristic disease symptoms or sporulation of the agent observed on any of the non-target species tested to date. Thus, the leaf-spot pathogen has been prioritised for further evaluation. Host specificity testing for the remaining 18 non-target species is in progress.

A culture of the gall-forming rust (*U. rickiana*) has been established under quarantine conditions at CABI-UK. Life cycle studies have confirmed that the rust is macrocyclic and autoecious. All spore stages of the rust form on either stem or leaf tissue of cat's claw creeper plants. Following infection of meristematic tissue, large conspicuous galls developed on inoculated cat's claw creeper plants under quarantine conditions. However, infrequent teliospore germination and difficulties in producing and maintaining an uredinial culture of the pathogen *in vivo* is currently hampering further work with this agent.

It was not possible to locate the leaf- rust (*P. macfadyenae*) in either Paraguay or Brazil. Hence, no further work on this agent was undertaken.

### Collaborators

- Seqwater
- Marion Seier, Kate Pollard (CABI, UK)
- Kevin Jackson (Gympie, Qld)
- Evizel Seymour (Terrain NRM, Atherton)

- Melinda Clarke (Burnett Catchment Care Association, Monto)
- Anthony King (Plant Protection Research Institute, Pretoria, South Africa)
- Robert Barreto, Adans Colman (Universidade Federal de Viscosa, Brazil)

### Key publications

Dhileepan, K 2012, *Macfadyena unguis-cati* (L.) A.H. Gentry - cat's claw creeper, in, Julien, M, McFadyen, RE & Cullen, J (eds) *Biological control of weeds in Australia: 1960 to 2010* , CSIRO Publishing, Melbourne. pp. 351-359.

Dhileepan, K, Taylor, D, Treviño, M & Lockett, C 2013, 'Cat's claw creeper leaf-mining beetle *Hylaeogena jureceki* Obenberger (Coleoptera: Buprestidae), a host specific biological control agent for *Dolichandra unguis-cati* (Bignoniaceae)', *Australian Journal of Entomology* vol. 52, pp. 175-181.

## 17. Invasive species management in the Pacific

### Project dates

November 2020 – June 2023

### Project team

Jason Callander and Michael Day

### Project summary

This project is entirely funded by Manaaki Whenua Landcare Research NZ Ltd and builds on previous work in the Pacific and the recent NZ-funded project on the biological control of weeds in Vanuatu. This funding has expanded the number of priority Queensland weeds in Biosecurity Queensland's biocontrol program. Two of the weeds that have been targeted under this project, African tulip tree (*Spathodea campanulate*) and Singapore daisy (*Sphagneticola trilobata*), are restricted weeds in Queensland. Both weeds were brought into Australia as ornamentals but have since escaped cultivation. *Sphagneticola trilobata* is widespread in Queensland and NSW, invading pastures and riparian zones. *Spathodea campanulata* infests gullies and disturbed rainforest, where it out-competes native vegetation.

Controlling weeds in neighbouring countries reduces the risk of those weeds spreading into Queensland or neighbouring countries. In addition, overseas information is gained on the biology and management of potential new weeds in Queensland. Work has already been conducted on a biological control agent for *S. campanulate* overseas, where it was found host specific and damaging. This agent could be imported into quarantine at the Ecosciences Precinct where supplementary host testing and assessment would determine whether it would also be suitable for release in Queensland. As *S. trilobata* has never been targeted for biological control previously, overseas exploration in the native range will be required to find potential candidates.

## Collaborators

- Manaaki Whenua Landcare Research NZ Ltd
- Secretariat of Pacific Regional Environment Programme (SPREP)
- Department of Environment and Biosecurity, Niue
- Ministry for Natural Resources, Republic of Marshall Islands
- Department of Environment, Tonga
- Ministry of Agriculture, Tonga
- Department of Agriculture, Tuvalu
- Biól. Ricardo Segura Ponce de León, Mexico

# 18. Biological control of *Clidemia hirta*

## Project dates

July 2020 – June 2022

## Project team

Jason Callander, David Comben, Natasha Riding, Michael Day and Liz Snow

## Project summary

*Clidemia hirta* (Koster's curse) is a fast growing weed of grazing, plantations, cropping and natural ecosystems in many countries. Soon after being discovered that it had established in north Queensland, Koster's curse was made a target of a national cost-share eradication program. However, as more infestations were detected, eradication of the species was determined no longer viable and the weed is now in 'transition to management'. If left uncontrolled, it is possible that Koster's curse could spread south along the Queensland coast as far as Hervey Bay. Prospects for biological control of *Clidemia hirta* in Australia are very good, with seven agents already being identified, tested, and released in Hawaii. This project has initially focused on *Liothrips urichi* Karny (Thysanoptera: Phlaeothripidae), which has been released in numerous countries where it appears to be very effective. Host specificity testing is underway in the quarantine facility at the Ecosciences Precinct. Should this tiny insect prove to be host specific, an application seeking its release will be submitted to the Australian regulators.

## Collaborators

- Tracy Johnson, US Department of Agriculture, Hawaii
- Aradhana Deesh, Ministry of Agriculture, Fiji
- Barbara Waterhouse, Northern Australia Quarantine Strategy, Cairns
- Kim Erbacher and Kim Badcock, National Four Tropical Weeds Eradication Program, South Johnstone
- Peter Green, Senior Biosecurity Officer, Cairns
- Sid Clayton, Kuranda City council, Kuranda
- Garry Sankowsky, Cairns

## Key publications

Comben, DF, Callander, JT, Taylor, T & Day, MD 2020, *Proposed plant host test list for assessing the risk of biological control agents for Clidemia hirta (L.) D.Don*. (submitted to Department of Agriculture, Water and the Environment), Department of Agriculture and Fisheries Queensland, Australia.

Figure 2 Host specificity testing of *Liothrips urichi* on *Clidemia hirta* in the quarantine facility at the Ecosciences Precinct, Dutton Park

# 19. Rearing and releasing biocontrol agents in northern Queensland

## Project dates

July 2019 – June 2023

## Project team

Kelli Pukallus and Ainsley Kronk

## Project summary

This project aims to mass-rear and release biocontrol agents in northern Queensland and monitor their establishment and impact.

Australia's first biological control agent for Siam weed (*Chromolaena odorata*), the stem galling fly (*Cecidochares connexa)* was approved for release in late 2018. Mass-rearing and releasing commenced in late 2019 at Tropical Weeds Research Centre. The stem galling fly was previously released in other countries where it has produced significant damage. *C. connexa* has been released within six Local Government Areas within Queensland and galls have been detected at and spreading from release sites in all six. In addition to releases, pre and post-establishment damage assessments have been conducted every two months at northern Queensland sites.

Monitoring previously released biological control agents is important to determine when and where agents are established and therefore when releases can cease. It also identifies what other agents or types of control are needed to supplement the released agent. Yearly and monthly surveys are conducted on a variety of agents and collections of associated insects are catalogued. Other biological control programs are also assisted through field assessments e.g., parthenium and lantana agents.

## Collaborators

- Charters Towers Regional Council
- Townsville City Council
- Biosecurity Officers, Biosecurity Queensland
- Hinchinbrook Shire Council
- Douglas Shire Council
- Cassowary Coast Regional Council
- Queensland Department of Environment and Science
- Australian Department of Defence
- NQ Dry Tropics
- Bush Heritage Australia
- Tablelands Regional Council
- Queensland Department of Natural Resources, Mines and Energy
- Queensland Department of Transport and Main Roads
- Northern Territory Government - Department of Environment and Natural Resources
- Department of Defence
- Ergon Energy
- State Land Management, Dept of Natural Resources, Mines & Energy
- Queensland Corrective Services, Townsville
- Burdekin Shire Council
- Central Highlands Regional Council

## Key Publications


Pukallus, K 2019, *Siam weed biocontrol newsletter*, Biosecurity Qld, October 2019 (edition 1).

Pukallus, K 2020, *Siam weed biocontrol newsletter*. Biosecurity Qld, February 2020 (edition 2).

## 20. Biocontrol of parkinsonia (*Parkinsonia aculeata*) (UU2)

### Project dates

February 2020 – December 2021

### Project team

Kelli Pukallus and Ainsley Kronk

### Project summary

*Parkinsonia aculeata* is a woody invasive weed species found throughout northern Australia. Previous biological control projects have seen UU (*Eueupithecia cisplatensis*) mass-reared in large numbers at Tropical Weeds Research Centre and released within Queensland, Northern Territory and Western Australia.

This project will see the expansion of mass-rearing and releasing of the biological control agent UU2 (*Eueupithecia vollonoides*) throughout northern Australia. This project's aim is to establish UU2 in areas climatically suitable, where UU2 has not previously been released or established. Releases are conducted in Queensland, Northern Territory and Western Australia. This project is conducted with funding from Meat and Livestock Australia and CSIRO.

### Collaborators

- CSIRO, Brisbane
- Fitzroy Basin Association Inc
- Meat and Livestock Australia
- Mount Isa City Council
- Central Highlands Regional Council
- Flinders Shire Council
- Cloncurry Shire Council
- McKinlay Shire Council
- Isaac Regional Council
- Winton Shire Council
- Barcaldine Regional Council
- Charters Towers Regional Council
- Biosecurity Queensland DAF Biosecurity Officers
- Livingstone Regional Council
- Longreach Regional Council
- Northern Territory Government –Department of Environment and Natural Resources
- Western Australia Government - Department of Primary Industries and Regional Development
- Samantha Williams and Mary Butler (Queensland Department of Agriculture and Fisheries)

# 21. Management and ecology of fireweed (*Senecio madagascariensis*)

## Project dates

July 2017 – June 2021

## Project team

Joseph Vitelli

## Project summary

Fireweed (*Senecio madagascariensis* Poir.) is a short-lived perennial (sometimes, annual) plant native to South Africa and Madagascar. It was introduced to Australia over 90 years ago, spreading throughout pastures along the coast of New South Wales and south-east Queensland. However, its distribution in Australia is now unclear due, at least in part, to its confusion with the native *S. lautus* complex.

*Senecio madagascariensis* is difficult to control and has the potential to compete strongly with useful pasture species across a broad range of soil fertility. Further, like many *Senecio* species, it produces pyrrolizidine alkaloids, which when ingested by livestock reduce growth and in severe cases cause mortality. Sheep and goats are reported as being less susceptible to poisoning from pyrrolizidine alkaloids than cattle and horses.

Through this 3-year collaborative doctorate project with the University of Queensland, we investigated: the reproductive output of *S. madagascariensis* in the Queensland environment, its impact on native and introduced pasture plants, determinants of invasiveness (in addition to reproductive capacity) and management effectiveness.

The PhD candidate Kusinara Wijayabandara has now completed a comprehensive study on the seed biology of fireweed and reducing the weeds impact on pasture productivity. Biological data were collected to develop a sustainable integrated weed management (IWM) program for fireweed. The study confirmed that whilst fireweed has invaded Australia and several other countries, climatically there are still large areas within these and other countries that it could infest. Fireweed was found to germinate under a wide range of temperatures (9 to 28°C), with an optimum at 12-15°C, but with no germination at or above 35°C under either light or dark conditions. Similar results were also obtained for seeds placed at constant temperatures with the highest germination occurring under 12/12-hour photoperiod at a temperature regime of 15/5ºC.

The project also investigated the efficacy of chemical management on plant mortality, and the viability and germination of seeds produced. All tested herbicides [bromoxynil (Bromicide® 200), fluroxypyr/aminopyralid (HotShot™), metsulfuron-methyl (Brush-Off®), triclopyr/picloram/ aminopyralid (Grazon™ extra) and triclopyr/picloram /aminopyralid (TordonTM Regrowth Master)] were effective at controlling fireweed plants. Among those tested herbicides, Grazon™ extra and TordonTM Regrowth Master were the most effective in controlling fireweed plants at all growth stages. The tested herbicides also reduced the viability and germination of seeds present on plants when treated with herbicides. Overall there was a reduction of 11-43% on the fireweed soil seedbank following herbicide application.

The foliar herbicide trial at Beechmont had identified additional lines of research. The impact of two sequential herbicide applications (winter plus spring) with no grazing controlled up to

100% of the fireweed plants with no recruitment in the non-grazed plots, despite an initial soil seed bank of over 15,000 seeds $m^2$ in the plots. A Masters student will be undertaking additional IWM studies during 2021-22, pending COVID-19 pandemic-related restrictions changes.

## Collaborators

- Kusinara Wijayabandara (PhD), Steve Adkins and Shane Campbell (School of Agriculture and Food Sciences, The University of Queensland)
- Irene and Bruce Mills, property owners, Beechmont

## Key publications

Wijayabandara, K 2021, Biology, ecology, and sustainable management of fireweed (Senecio madagascariensis Poir.). PhD Thesis, School of Agriculture and Food Science, The University of Queensland.https://doi.org/10.14264/03387cd

# 22. GRT wick wiper

## Project dates

February 2017 – June 2022

## Project team

Joseph Vitelli, Drew Rapley, Anna Williams, Natasha Riding and David Holdom

## Project summary

*Sporobolus* is a genus of ~200 grass species in tropical and subtropical parts of the world, including Africa, temperate and tropical Asia, Australasia, North and South America. In Australia, 19 species are endemic, and a further eight species are naturalised weeds. Giant rat’s tail grass (GRT) and the other introduced weedy *Sporobolus* grasses are unpalatable, perennial, tussock-forming grasses of serious concern to the grazing industry across eastern Australia. GRT reduces carrying capacity and productivity of more than 450,000 ha of pastoral land in eastern Queensland, New South Wales and areas of Victoria and is a high-risk fodder contaminant.

Producer and local government uptake of integrated management methods for GRT in open pasture paddocks is building, particularly in the use of wick wipers in combination with grazing. However, there is limited understanding on how to incorporate the herbicides glyphosate and flupropanate more effectively in the presence of endemic and naturalised pathogens, along with heavy grazing that will led to the effective management of GRT.

This project aims to optimise two herbicides (glyphosate and flupropanate) through the use of weed wipers and the spray volume required to control and suppress seed production of GRT plants growing in pastures and along roadsides.

The wick wiper trials consist of two parts, a pot experiment and a field component with plants at both sites infected with the GRT leaf smut. The pot experiment will examine the spray volume (2.5, 5, 10, 20 and 40L $ha^{-1}$) required to control individual tillers when concentrations of glyphosate (1188 g a.i.), flupropanate (1500 g a.i.) or both actives are least constant. A second component of the pot trial will examine 3 glyphosate concentrations (540, 1080 and

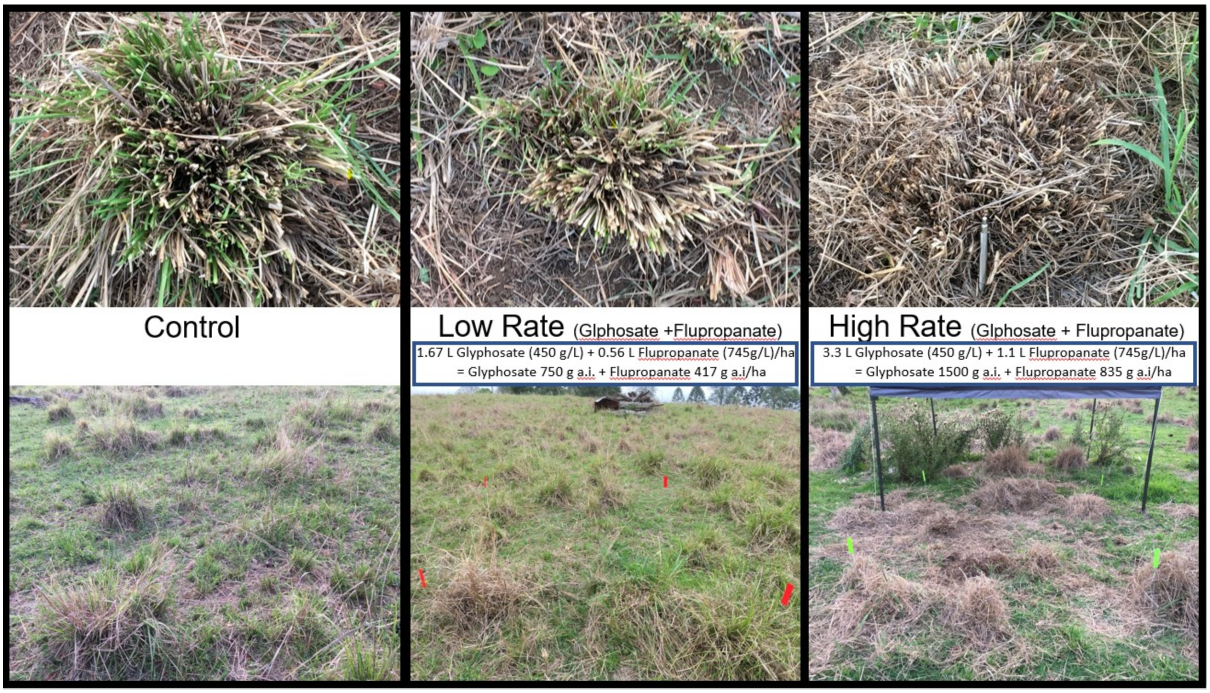


*Figure 3 Mortality of GRT tillers following the application of two rates of glyphosate and flupropanate applied through a wick wiper.*

2160 g a.i.), 3 flupropanate concentrations (375, 750 and 1500 g a.i.) and a mixture (glyphosate (540 g a.i.) + flupropanate (375 g a.i.)) when spray volume is maintained at 10L ha$^{-1}$.

GRT tussocks were grown in 150mm pots at the Ecosciences Precinct. Four to six weeks prior to the application of herbicides, the tillers were cut at 100 or 150cm above ground level to simulate a slashing event in the paddock. Measured quantities of herbicide were then applied to the tillers of the fresh GRT regrowth and an uncut control. Glyphosate treatments either alone or in combination with flupropanate killed almost 73% of the treated tillers compared to only12% of tillers treated with flupropanate only, at three months post application.

A pilot study was also implemented in the field at Conondale following the slashing of dense stands of GRT four weeks prior to herbicide application. A C-Dax Eliminator equipped with a 6 m swath was used to apply either glyphosate (750 g a.i.) + flupropanate (417 g a.i.) ha$^{-1}$ or glyphosate (1500 g a.i.) + flupropanate (835 g a.i.) ha$^{-1}$. Both rates were applied at ~10L of spray mix ha$^{-1}$. The low rate resulted in 35% of the treated tillers dying compared to 68% using the higher glyphosate plus flupropanate rate (Figure 1).

Findings from the pot trial will be incorporated into future trials at Conondale

## Collaborators

Peter Thompson, property manager, “Elgin”, Conondale

## 23. Native and introduced pathogens of giant rat's tail grass

### Project dates

February 2019– June 2023

### Project team

Joseph Vitelli, David Holdom, Annerose Chamberlain, Drew Rapley and Sharon Bishop-Hurley

### Project summary

*Sporobolus* is a genus of almost 200 grass species from tropical and subtropical parts of the world. Until recently Australia had 18 endemic and 6 introduced species, with the number now changing to 19 natives and 8 naturalised species (*Thellungia*, *Spartina* and *Crypsis* species have been revised). The genus *Sporobolus* is divided into 15 major clades of closely allied species, including the *S. indicus* complex, comprising of at least 23 species. In Australia, the *S. indicus* complex includes five introduced weedy species, Parramatta Grass, Giant Parramatta grass, American rat's tail grass, Giant rat's tail grass (GRT), as well as six native species, *S. blakei*, *S. creber*, *S. elongatus*, *S. laxus, S. sessilis* and the rare and endangered species *S. pamelae*. Weedy *Sporobolus* grasses (WSG) threaten to cost the grazing industry of eastern Australia $60 million per annum, having the potential to infest 60% of Queensland and 30% of Australia over a range of soil types, where the annual rainfall is greater than 500 mm.

Endemic plant pathogens are components of all-natural ecosystems. Funding from a previous round of the Australian Government's Rural R&D for Profit program provided an opportunity to survey endemic pathogens of *Sporobolus* in Australia over 2017 to 2019. The survey yielded several endemic fungi, potentially specific, safe and effective against WSG species. This project will have five distinct outputs: a) prioritise and report on endemic pathogens found on *Sporobolus* species; b) conduct and report on field experiments to determine the impact of the recently discovered GRT leaf smut (*Ustilago sporoboli-indici*); c) develop and report on rearing methods for prioritised endemic pathogens on *Sporobolus* species; d) conduct Koch's postulate and pathogenicity testing on a minimum of five pathogen species; and e) report on progress to release at least one suitable native pathogen for biocontrol of GRT.

Koch's postulate testing has been completed for all pathogens prioritised from the previous project. Of the 60 pathogens tested, 28 caused disease in at least one of the WSG species [*S. africanus, S. fertilis, S. jacquemontii, S. natalensis* and *S. pyramidalis*] tested, 12 species infected and caused disease symptoms in all of the WSG seedlings, and five pathogens caused all tested WSG seedlings to die.

Species of genera sporulating well on artificial media to date include isolates of *Colletotrichum, Microdochium, Neopestalotiopsis, Pestalotiopsis, Fusarium, Leptosphaerilina, Parasarocladium, Dictyochaeta*, and *Pyrenochaetopsis*. Isolates belonging to *Stagonospora*, are sporulating very poorly or not at all.

Pathogenicity of the GRT leaf smut (*Ustilago sporoboli-indici*) is currently being evaluated on 34 non-*Sporobolus* species and 20 *Sporobolus* species belonging to five distinct clades.

## Collaborators

- Australian Department of Agriculture, Water and the Environment
- AgriFutures Australia
- New South Wales Environmental Trust
- NSW Biocontrol Fund
- Bundaberg Regional Council (including Eric Dyke and James Anderson)
- Gympie Regional Council
- HQ Plantations Pty Ltd
- AgForce Queensland
- CSIRO Health & Biosecurity
- The University of Queensland, School of Agriculture & Food Sciences
- Tracey Steinrucken (CSIRO)
- Roger Shivas (University of Southern Queensland)
- Kaylene Bransgrove (DAF Plant Biosecurity and Product Integrity)
- Yu Pei Tan (DAF Plant Biosecurity and Product Integrity)

# 24. Influence of soil type on flupropanate availability for managing giant rat's tail grass

## Project dates

February 2017 – June 2022

## Project team

Joseph Vitelli, Annerose Chamberlain and Drew Rapley

## Project summary

The herbicide flupropanate (developed in the 1960s) is reported to have a long-lasting residual activity but is prone to movement within the soil horizons. Its selective residual activity (limiting the growth of emerging tussock grass seedlings), knockdown ability and availability (in both liquid and granular form) has made it the preferred herbicide for management of weedy tussock grasses. Unfortunately, land managers are experiencing inconsistent levels of control following high-cost treatment with flupropanate.

To investigate this, we have commenced two trials. The first focuses on the use of flupropanate and its effectiveness on a range of soils. The second will determine the flupropanate concentration required to effectively control or suppress tussock seedling emergence and the concentrations at which flupropanate begins to have adverse effects on competitive pasture emergents.

We established a pot trial involving five soil types (chromosol, dermosol, ferrosol, kurosol and vertisol) and two application methods (liquid and granular) to determine the residual behaviour of flupropanate. In pots containing GRT tussocks, 22% of the applied granular flupropanate but only 8% of the applied liquid flupropanate was found in soil 24 months after application. Of the applied flupropanate, irrespective of application method, ~5% was found in giant rat's tail grass tussocks 24 months after application. In treatments in which flupropanate had been applied to bare soil void of plant material (potentially as a tool to control seedling recruitment once adult plants had been removed), 73% (granular application) and 72% (liquid application) of the applied flupropanate, was found 24 months later.

### Collaborators

- Powerlink Queensland
- School of Earth and Environmental Sciences, The University of Queensland
- Peter Thompson, property manager, Elgin, Conondale
- Judith Ruhle, property owner, Jalbirri, Bongeen
- Errol Stenzel, property owner, Bunburra, Boonah.

## 25. Weed seed dynamics

### Project dates

August 2007 – June 2030

### Project team

Simon Brooks, Danielle Brazier and Clare Warren

### Project summary

For many weeds little is known about their seed ecology and longevity, which determines the timing and duration of weed control activities. This project investigates the seed longevity of priority weeds by burying seeds enclosed in packets in two different soil types (black clay and river loam), under grassed and non-grassed cover conditions and up to four burial depths (0, 2.5, 10 and 20 cm).

Completed trials have shown that neem and yellow bells have a relatively transient soil seed bank that is exhausted after one year. In the absence of fresh seed input, the seed banks of yellow oleander, stevia, gamba grass, chinee apple, calotrope and mesquite are likely to be exhausted in under five years. Trials of lantana and parthenium showed small numbers of seeds could retain viability for 5 and 10 years respectively. Retrievals of prickly acacia and sicklepod seed are continuing and new seed packets will be added to this trial area.

We are recording seedling emergence in field enclosures to monitor the emergence of seedlings of neem, leucaena, prickly acacia, chinee apple and mesquite. Neem tree seedling emergence concluded in less than a year, which was consistent with the buried packet trial, while prickly acacia and leucaena emergence reflects weeds with long-lived seed banks.

Packet trials can be used to rapidly evaluate a controlled ageing test (CAT) in the laboratory. The CAT will allow seeds of numerous weeds to be classified into broad categories of seed longevity.

We have also established a trial investigating the seed longevity of the aquatic weed *Sagittaria* under constant immersion.

This project also continues to support operational staff to assess the effect of time, depth and site management on field seed banks of white ball acacia.

Figure 4 *Sagittaria* seed longevity trial

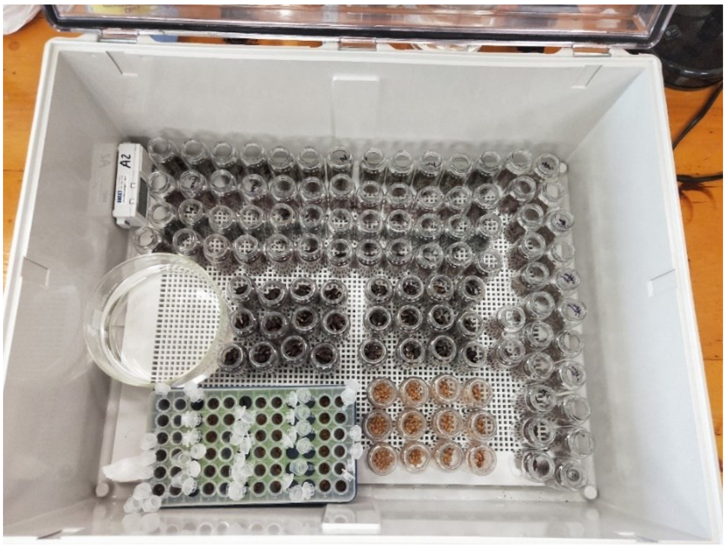

Figure 5 Controlled aging of weed seeds in the laboratory to more rapidly assess their longevity soil burial trials.

## Collaborators

- Shane Campbell (University of Queensland)
- Faiz Bebawi
- Tony Salisbury, Philip Hayward, Christine Perret and Tobias Bickel (Biosecurity Queensland)
- Norman Lees and Melissa Green (Townsville City Council)

## Key publications

Bebawi, FF, Campbell, SD & Mayer RJ 2013, 'Persistence of bellyache bush (*Jatropha gossypiifolia* L.) soil seed banks', *The Rangeland Journal*, vol. 34, pp. 429-438.

Bebawi, FF, Campbell, SD, Mayer, RJ, Setter, MJ & Setter, SD 2018, 'Effects of temperature and burial on seed germination and persistence of the restricted invasive *Stevia ovata* in northern Queensland', *Australian Journal of Botany*, vol. 66, pp. 388-397.

Long, RL, Panetta, FD, Steadman, KJ, Probert, R, Bekker, RM, Brooks, SJ & Adkins, SW 2008, 'Seed persistence in the field may be predicted by laboratory-controlled ageing', *Weed Science,* vol. 56, pp. 523-528.

# 26. Research supporting the management of nationally-significant tropical weeds

## Project dates

July 2008 – June 2024

## Project team

Simon Brooks, Kirsty Gough, Stephen Setter and Melissa Setter

## Project summary

The project helps determine eradication progress for species targeted under the National Tropical Weeds Eradication Program. We also contribute to the annual reporting of eradication progress against program milestones, supporting external reviews and implementation of the eradication program three-year response plan.

The project also determines aspects of weed life history that are critical to attempting eradication, such as seed-bank persistence, age to maturity and dispersal potential. Effective control measures are also investigated. Field trials investigating *Miconia calvescens*, *M. racemosa, M. nervosa* and *Mikania micrantha* seed persistence have been running for five to 11 years, with all species showing persistent seed banks. A glasshouse trial of *Limnocharis flava* seed persistence under varying periods of immersion in water has been underway for nine years. Field soil seed bank samples are collected and processed annually from *L. flava* and *M. micrantha* infestations. Field crew data and observations on the growth to maturity and reproductive seasonality of invasive melastomes are being collated to refine guidelines for identifying and preventing seed producing plants and investigations of survey accuracy. A field plot to measure the growth of *M. nervosa* was established in 2018. We continue to present results from local germination trials of seed from invasive tropical Melastomataceae and Asteraceae weeds.

The project supports stakeholders implementing transitional management plans by providing biological and management information on the former eradication target species *Chromolaena odorata* and *Clidemia hirta*. We are also determining age-to-maturity of *Acaciella angustissima*, a prohibited weed in Queensland that is currently the focus of an eradication attempt.

## Collaborators

- Kim Erbacher, Peter Green, Alex Dicbalis , Moya Calvert, Tony Salisbury, Rob Cobon and David Green (Biosecurity Queensland)
- Queensland Parks and Wildlife
- Mareeba Shire Council
- Johnstone Shire Council

## Key publications


Breaden, RC, Brooks, SJ & Murphy, HT 2012, 'The biology of Australian weeds 59. *Clidemia hirta* (L.) D. Don.', *Plant Protection Quarterly*, vol. 27(1), pp. 3–18.

Brooks, S & Jeffery, M 2018, 'The effects of cyclones on a tropical weed eradication program', *Proceedings of the 21st Australasian weeds conference*, The Weed Society of New South Wales, pp. 119–123.

Brooks, S & Jeffery, M 2018, 'Progress in the eradication of *Mikania micrantha* from Australia', *Proceedings of the 21st Australasian weeds conference*, The Weed Society of New South Wales, pp. 350–353.


# 27. Aquatic weeds of northern Australia - ecology and control

## Project dates

January 2015 – June 2023

## Project team

Melissa Setter and Stephen Setter

## Project summary

Aquatic weeds are a burgeoning problem with the increase in commercial trade of aquatic plants, particularly via the internet. Several escaped aquarium plants are particularly problematic in the Wet Tropics and have potential distributions across large parts of northern Australia. These include hygrophila (*Hygrophila costata*), bogmoss (*Myacca fluviatilis*) and Amazon frogbit (*Limnobium laevigatum*).

In this project, we address a number of ecological questions to improve management of current infestations and to predict and restrict further infestations. We are also investigating control options. Specifically, we are researching:

- seed and vegetative reproductive output in regional populations of hygrophila
- herbicide control of bogmoss
- seed viability and longevity in regional populations of Amazonian frogbit.

## Collaborators

- Biosecurity Queensland officers
- Far North Queensland Regional Organisation of Councils
- Terrain NRM
- Cairns Regional Council
- Cassowary Coast Regional Council
- Hinchinbrook Shire Council
- Russell Landcare and Catchment Group
- Jaragun Pty Ltd

## Key publications

Setter, SD, Patane, KA, Madigan, BA & Setter, MJ 2011, 'Bogmoss (*Mayaca fluviatilis* Aubl.)—investigating control options for this new threat to our waterways', Proceedings of the 11th Queensland Weed Symposium, The Weed Society of Queensland, Mackay.

Setter, MJ, Setter, SD & Styman, DT 2017, 'Survival and buoyancy of *Hygrophila costata* stem fragments in salt, brackish and fresh water', Proceedings of the 14th Queensland Weed Symposium, The Weed Society of Queensland, Port Douglas.

Setter, SD, Graham, MF, Setter, MJ & Waterhouse, BM 2017, '*Limnobium laevigatum* (Amazon frogbit) ecology and control in the Wet Tropics', Proceedings of the 14th Queensland Weed Symposium, The Weed Society of Queensland, Port Douglas.

Setter, SD & Setter, MJ 2019, 'Adapting autonomous underwater vehicles (AUV) for aquatic weed control'. Proceedings of the Queensland Pest Animal and Weeds (PAWS) Symposium, Gold Coast, Queensland.

Figure 6. Stephen Setter collecting Amazonian frogbit near Mareeba

## 28. Tolerance of gamba grass and native plant species to pre-emergence herbicides

### Project dates

December 2019 – June 2021

### Project team

Melissa Setter, Stephen Setter, Clare Warren and Wayne Vogler

### Project summary

Gamba grass (*Andropogon gayanus*) is a high-biomass perennial grass that is a Weed of National Significance and a declared weed across northern Australia. It is well documented as a species that changes ecosystems and fire regimes in northern Australia and is a serious threat to the wider environment. The only registered herbicide to date is glyphosate as a spot spray under an Environmental Weeds Permit (PER11463), or aerial application of glyphosate in specific situations in the Northern Territory.

This collaborative project with CSIRO is externally funded by the National Environmental Science Program. This trial will provide herbicide information to improve management of gamba grass and restoration of native plant communities following gamba grass control. Pre-emergence herbicides will be tested on co-occurring native plant species and gamba grass to determine herbicide efficacy and species tolerance to each herbicide. The test species and herbicides have been determined in consultation with relevant colleagues and experts and considering the outcomes of a gamba grass workshop held in Cairns in 2019.

The aims of this project are to:

- Determine the tolerance of gamba grass and nine co-occurring native plant species to a range of pre-emergence herbicides.
- Produce pre-emergence herbicide recommendations to assist gamba grass control and restoration of native plant communities.

Figure 7 Clare Warren and Melissa Setter plant seeds for gamba grass research

Figure 8 Clare Warren, Wayne Vogler and Melissa Setter setting up a gamba grass trial

## Collaborators

- Helen Murphy, Andrew Ford, Mark Bradford (CSIRO, QLD)

- John Clarkson (Department of Environment and Science, QLD)
- Natalie Rossiter-Rachor (Charles Darwin University, N.T)
- Steve Dwyer (Parks, Wildlife and Heritage Division, N.T)
- Tom Price (Department of Environment and Natural Resources, N.T)

### Key publications

Luck, L, Bellairs, SM & Rossiter-Rachor, NA 2019, ‘Residual herbicide treatments reduce Andropogon gayanus (Gamba Grass) recruitment for mine site restoration in northern Australia’, *Ecological Managagement and Restoration*, vol. 20, pp. 214-221. doi:10.1111/emr.12376

## 29. Sicklepod ecology and control

### Project dates

January 2016 – June 2023

### Project team

Melissa Setter and Stephen Setter

### Project summary

Sicklepod (*Senna obtusifolia*) is a serious weed of many parts of northern Queensland (from Cape York to Mackay) and occurs in pastures, crops and corridors such as road and powerline clearings and creek banks. In this project, we aim to improve knowledge about the longevity and production of sicklepod seed, including the seasonality of seed production, and environmental triggers for germination (rainfall and temperature). We also investigate pre-emergent and low-volume, high-concentration herbicide control options for sicklepod.

Some early experimental results are:

- Seeds are persisting for at least 36 months after burial.
- In pot trials, seedling emergence and establishment have been effectively suppressed by herbicides containing picloram.

Figure 9 Mario DiCarlo and Stephen Setter collecting soil seed bank samples at a site assessing pre-emergence herbicides for sicklepod management

## Collaborators

- Biosecurity Queensland officers
- Biosecurity Queensland research officers and centres
- Cape York NRM
- Local governments in northern Queensland (e.g., Cook Shire Council)
- Queensland Parks and Wildlife Service
- Landowners and pastoralists
- Herbicide manufacturers

## Key publications

Setter, MJ, Setter, SD, Higgins, D & Vogler, W 2019, 'Controlling weed recruitment in isolated areas of Cape York Peninsula', *Proceedings of the 1st Queensland pest animal and weed symposium*, The Weed Society of Queensland, Gold Coast.

# 30. Efficacy of foliar herbicides on Aleman grass (*Echinochloa polystachya*) and Nemo wetting agent for broad application in aquatic environments

## Project dates

July 2020 – June 2023

## Project team

Melissa Setter and Stephen Setter

## Project summary

The project is a field-based herbicide trial which will be conducted in the lower Herbert and Murray River basins with in-kind support from Hinchinbrook Shire Council, Cassowary Coast Regional Council, Mungalla Aboriginal Corporation, Canegrowers Tully and FNQROC. The first component of the trial will investigate effective herbicide and wetter rates for the control of Aleman grass in the field. If effective and safe rates can be demonstrated, a minor use permit application for Aleman grass control will be submitted to the Australian Pesticides and Veterinary Medicines Authority. If the herbicide trial is inconclusive an additional screening process may be instigated. In addition, the trial will test the field efficacy of 'Nemo' wetting agent as a replacement for 'Bonus' which is currently the only aquatic wetter registered for use and has been withdrawn from the Australian market.

## Collaborators

- Biosecurity Queensland officers
- Far North Queensland Regional Organisation of Councils
- Canegrowers Tully
- Cassowary Coast Regional Council
- Hinchinbrook Shire Council
- Mungalla Aboriginal Corporation
- Marcus Bulstrode, Senior Development Officer DAF Sustainable Farming Systems RD&E

## Key publications


Abbott, BN, Wallace, J, Nicholas, DM, Karim, F & Waltham, NJ 2020, 'Bund removal to reestablish tidal flow, remove aquatic weeds and restore coastal wetland services — North Queensland, Australia', *PLoS ONE,* vol. 15(1), pp. e0217531.

Hannan-Jones, M & Weber, J 2008, updated 2016, 'Pest plant risk assessment: Aleman grass (Echinochloa polystachya)', Biosecurity Queensland, Department of Primary Industries and Fisheries, Queensland

Lemcke, B & Cameron, A 2019, Department of Primary Industry and Resources Agnote No: E63 Aleman Grass - A high value grazing species grown in flooded or ponded areas


Figure 10 Aleman grass near sugar cane

## 31. Giant rat’s tail grass management

### Project dates

July 2017 – June 2022

### Project team

Wayne Vogler and Clare Warren

### Project summary

Giant rat’s tail grass (GRT) is a widespread invasive grass predominantly in eastern Queensland. It continues to spread causing significant problems in animal production systems, forestry and the wider environment. This project is concentrating on improving knowledge about the use of the herbicide flupropanate, effective use of fertiliser, the effect of fire on flupropanate and GRT management in seasonally wet areas. The project is being conducted in conjunction with Gladstone Regional Council and Economic Development Queensland to improve the management of GRT in a range of situations including grazing land, peri-urban areas and forestry.

In small-scale plot trials, we are investigating low disturbance methods for returning dense GRT infestations to productive pastures and have significantly reduced the presence of GRT over two wet seasons. We have demonstrated that ash from grass fires does not reduce the efficacy of flupropanate, and that 20 mm of rain is all that is needed to push flupropanate into the soil and make it safe from fire. Trials have also confirmed that high levels of dry grass and spray volume (100 – 500 L/ha) at the time of application of flupropanate does not influence herbicide efficacy. Work is continuing on how to manage GRT in seasonally waterlogged areas with late dry season flupropanate application and low volume high concentration flupropanate spot application showing high levels of efficacy in experimental situations. Fertiliser application has been shown to significantly improve the nutritional value and digestibility of immature GRT as fodder/forage for cattle. However, whether this is applicable on a larger scale is yet to be determined.

## Collaborators

- Economic Development Queensland
- Biosecurity Queensland officers (particularly John Reeve and Nathan March)
- Gladstone Regional Council (including Rob Teakle, Lewis Heuvel and Kelvin Dawson)
- Landholders
- Brett Cawthray (landholder and contractor)

## Key publications

Vogler, W, Carlos, E & Hosking, K 2017, 'Extending flupropanate use—spot application on perennial mission and gamba grass', *Proceedings of the 14th Queensland weed symposium*, Weed Society of Queensland, Brisbane.

Figure 11. Wayne Vogler discussing GRT management at a GRT field day at Miriam Vale

# 32. Encapsulated herbicide control of woody weeds

## Project dates

January 2021- June 2025

## Project team

Simon Brooks, Dannielle Brazier, Clare Warren

## Project summary

Stem injection has been identified as a possible but under-utilised tool for the control of woody shrubs and small trees. There is now a new tool to deliver a granular encapsulated herbicide directly into woody stems. This method is particularly safe to applicators as there is no need to mix with water or diesel as a carrier, or to have any contact with the herbicide. This method is also safer for the environment as the herbicide is contained in the target plant. As such, it may be suitable for use near creeks and rivers.

Collaborators and field sites have been identified, and planning undertaken for initial trials involving rubber vine, leucaena and African tulip tree. In subsequent years the project will use field trials to refine the rates of the most effective herbicides relative to stem size and target weeds such as pond apple and neem. Where gaps in past control research are identified, weeds such as prickly acacia, blue thunbergia (tubers) and yellow bells may also be tested. This project has assisted a PhD candidate from the University of Queensland establish encapsulated herbicide trials on chinee apple.

*Figure 12 Tree Injecta treating chinee apple tree*

## Collaborators

- Vic Galea (University of Queensland and Bioherbicides Australia)
- Shane Campbell (University of Queensland)
- Matt Buckman (Hinchinbrook Shire Council)

## Key publications

Goulter, KC, Galea, VJ & Riikonen, P 2018, ‘Encapsulated dry herbicides: A novel approach for control of trees’, in, Johnson, S, Weston, L, Wu, H & Auld, B (eds) Proceedings 21st

Australasian Weeds Conference 2018,The Weed Society of New South Wales Inc. Sydney, pp. 247-250.

McKenzie, J, Brazier, D, Owen, A, Vitelli, J. & Mayer, B 2010, ‘Stem injection: a control technique often overlooked for exotic woody weeds’, in, Zydenbos, SM (ed). Proceedings of the 17th Australasian Weeds Conference, New Zealand Plant Protection Society, Christchurch, Pp. 459 – 461.

## 33. Control packages for state-wide weed eradication targets - red witchweed eradication

### Project dates

July 2014 – June 2025

### Project team

Joseph Vitelli, Annerose Chamberlain, Natasha Riding and Anna Williams

### Project summary

This project aims to develop reliable and effective control options that can be integrated into eradication programs for priority weeds in Queensland.

Through an integrated control study in a sugarcane-growing area near Mackay, we are investigating the efficacy of agronomic practices for depleting the red witchweed (RWW) seed bank and preventing further seed production over a ten-year period. Fifteen treatments, comprising of pre- and post-emergent herbicides, catch crops, trap crops and fumigants are being evaluated over time through the monitoring of seed viability in 5800 RWW seed sachets that were buried at five depths (0, 100, 200, 300 and 500 mm).

To further evaluate eradication efforts on infested properties, an additional 300 perforated PVC canisters were buried, each containing three sachets of ~100 RWW seeds at depths of 100, 300 and 500 mm across 25 sites covering the spectrum of “best practice” treatments (soybean, ethylene and dazomet). These are currently being applied repeatedly or in combination on eight infested properties across different topographies.

Five annual applications of either ethylene gas, dazomet, ethephon, sorghum, corn or soybean reduced the RWW soil seedbank viability to 0%, irrespective of seed burial depth. Almost 14% of RWW seed buried within sugarcane remained viable after five years, with no significant difference to seed viability (12%) in sugarcane treated with herbicides.

Over the next few years, PhD candidate Anna Williams will investigate the optimisation of ethylene when applied to different soil types, moisture levels and aggregate composition to determine the frequency and concentration of ethylene required to trigger the highest suicide germination of RWW seed. To complement this study, a series of experiments will be established at the Ecosciences Precinct to determine whether depletion of RWW seeds can be accelerated with a continuous false host soybean crop, punctuated with multiple applications of the fumigant ethylene.

## Collaborators

- Local Governments
- Biosecurity Queensland Officers (Michelle Smith and Tom Bowditch)
- The University of Queensland

# Part 2: Pest animal management

## 34. Ecology and management of chital deer in northern Queensland

### Project dates

July 2014 – June 2022

### Project team

Tony Pople, Michael Brennan and Matt Amos

### Project summary

This project studies aspects of the ecology and management of chital deer (*Axis axis*), which were established in northern Queensland in the late 1800s. In the last 20 years, landholders have reported an increase in chital deer abundance and an expansion of their range to a point where they were considered major pests. Information on their impacts, control methods and capacity for increase and spread is needed to develop long-term management strategies.

Aerial and ground surveys have recorded populations that are highly clumped within four kilometres from homesteads and not far from water sources, as well as dramatic declines during drought over 2014-16. This decline plus the spatial concentration provided a strategic opportunity for their control. Aerial culling further reduced populations to low densities. However, populations increased on culled and unculled properties at close to the species' maximum rate of increase. On other sites, low density was maintained probably largely through ground shooting.

Satellite telemetry and grids of remote cameras are describing the habitat use of deer to better understand their current and future distribution. Telemetry in combination with remote cameras is indicating high survival in both adults and fawns under average pasture conditions. These relationships will be modelled to understand and predict population dynamics. Through the Centre for Invasive Species Solutions and with interstate collaborators, we will be providing best practice management guidelines for wild deer in 2022.

### Collaborators

- Keith Staines, Glen Harry (Sporting Shooters Association of Australia)
- Kurt Watter (PhD University of Queensland)
- Dave Forsyth, Andrew Bengsen, Sebastien Comte (NSW Department of Primary Industries)
- Carlo Pacioni, Luke Woodford (Arthur Rylah Institute, Victoria)
- Jordan Hampton (Ecotone Wildlife Veterinary Services)
- Landholders in the Charters Towers region
- Ashley Blokland (Charters Towers Regional Council)
- Heather Jonsson (Dalrymple Landcare)

- Thijs Krugers, Rachel Payne (NQ Dry Tropics)
- Catherine Kelly, Jodie Nordine, Ben Hirsch, Lin Schwarzkopf, Jan Strugnell, Iain Gordon (James Cook University)
- Centre for Invasive Species Solutions

### Key publications

Forsyth, DM, Pople, A, Woodford, L, Brennan, M, Amos, M, Moloney, PD, Fanson, B & Story, G 2019, 'Landscape-scale effects of homesteads, water, and dingoes on invading chital deer in Australia's dry tropics', *Journal of Mammalogy,* vol. 100(6), pp. 1954 – 1965, doi: 10.1093/jmammal/gyz139.

Watter, K, Baxter, G, Brennan, M, Pople, A & Murray, P 2019, 'Decline in body condition and high drought mortality limit the spread of wild chital deer in north-east Queensland, Australia', *The Rangeland Journal* vol. 41, pp. 293-299.

Watter, K, Baxter, GS, Pople, T, & Murray, PJ 2019, 'Effects of wet season mineral nutrition on chital deer distribution in northern Queensland' *Wildlife Research* vol. 46, pp. 499-508.

## 35. Feral cat ecology and management – refinements and alternatives

### Project dates

July 2020- June 2021

### Project team

Matthew Gentle, James Speed and Lana Harriott

### Project summary

Feral cat field baiting trials assessing the efficacy and non-target impacts of 1080 baits throughout Queensland, including the Eradicat® sausage bait, have been completed. These data are broadly supportive of their use, but currently Eradicat® baits are only approved for use in Queensland at Taunton National Park (Scientific) under an Australian Pesticides and Veterinary Medicines minor use permit. This project now supports a Biosecurity South Australia-led project to collate and provide information on the efficacy and non-target impacts of Eradicat® in Queensland. This information was submitted as part of a broader package of data from other jurisdictions to support registration of Eradicat® across eastern Australia. Pending approval, this registration will provide a method for the broadscale control of feral cats in Queensland.

This project has supported analysis and reporting of foundational data on feral cat ecology (e.g. cat movements) and baiting use (e.g. efficacy, uptake by non-target species) collected as part of previously-conducted field research. This information has been used to further examine and formulate appropriate control strategies for effective and safe broadscale management of feral cats in Queensland with poison baits. This project has also provided data, supervisory and technical support to two post-graduate studies assessing the ecology and impacts of feral cats (i. the spatial ecology of feral cats and the implications for effective management, and ii. prevalence of pathogens important to human and companion animal health in unowned feral cats in south-east Queensland).

Collectively, this project has provided data required for the registration of Eradicat® across Queensland, information on guidelines for the safe and effective use by practitioners, and supported further research on feral cat management and impacts in Queensland by collaborating agencies.

## Collaborators

- Brad Page and Myall Tarran (Biosecurity South Australia)
- Bronwyn Fancourt (NSW Department of Primary Industries/ University of New England)
- Cameron Wilson (University of New England)
- Diana Fisher and Jess Guidotti (University of Queensland)
- Barry Nolan and John Augusteyn (Queensland Parks and Wildlife Service)
- Rowland Cobbold and Tamar Michaelian (University of Queensland)
- Dan Franks, Bill Manners and Robyn Jones (Brisbane City Council)
- Mat Warren (Southern Downs Shire Council)

## Key publications

Fancourt, BA, Augusteyn, J, Cremasco, P, Nolan, B, Richards, S, Speed, J, Wilson, C & Gentle, MN 2020, ‘Measuring, evaluating and improving the effectiveness of invasive predator control programs: feral cat baiting as a case study’, *Journal of Environmental Management*, vol. 280, pp. e111691 DOI: 10.1016/j.jenvman.2020.111691

Fancourt, BA, Zirbel, C, Cremasco, P, Elsworth, P, Harry, G & Gentle, MN 2021, ‘Field assessment of the risk of feral cat baits to nontarget species in eastern Australia’. *Integrated Environmental Assessment and Management,* doi: https://doi.org/10.1002/ieam.4445.

Gentle, M 2020, Improving broadscale feral cat management,in, 'Final report to Queensland Feral Pest Initiative', Pest Animal Research Centre, Invasive Plants and Animals, Biosecuity Queensland: Toowoomba, Queensland, pp. 13.

# 36. Feral pig baits – registration, refinements and alternatives

## Project dates

July 2020- June 2022

## Project team

Matthew Gentle and Peter Elsworth

## Project summary

This project provides support to progressing and assessing alternatives to the registration of two feral pig 1080 baiting practices - application of meat baits in the absence of pre-feeding or bait-stations, and the use of baits prepared from fruit materials. These practices have a long history of use in Queensland to protect agriculture and the environment. Neither of these methods are included on the commercial 1080 concentrate labels, effectively precluding their use once supply of the remaining stock of Queensland 1080 concentrate is exhausted. Efficacy and non-target species impact data from previous research has been submitted to the Australian Pesticides and Veterinary Medicines Authority (APVMA) as part of minor use permit applications (early 2020) for limited use on fruit (Wet Tropics, northeast Queensland) and meat baits (rangeland areas). Since submission, additional information has been provided to the APVMA as part of the assessment of both permits, including additional supporting information on use, efficacy and viability of alternative baiting techniques.

The registration (early 2020) of Hoggone® meSN® (microencapsulated sodium nitrite) provides a potential alternative to conventional (ground) 1080 baiting techniques, but has not been tested in Wet Tropics production environments where fruit baiting is common. We are collaborating with local government and industry end-users in the Wet Tropics to determine the effectiveness and safety of Hoggone® meSN®, and alternative safety mechanisms for fruit baiting (e.g. excluder devices including Bait Box) for feral pigs. Trials utilise remote cameras to monitor feeding stations to quantify pig and non-target animal visitation for each bait type and presentation method. Bait consumption is also being measured. Control sites ensure treatment (baiting) effects can be identified. The use of excluder devices in these trials will also allow local government and industry end-users to undertake strategic, coordinated feral pig control under the new 1080 protocols. Excluders have so far been successful, with no evidence of non-target species accessing bait boxes in field trials in north Queensland.

## Collaborators

- Michael Graham (Biosecurity Queensland)
- Col Dollery (Queensland Parks and Wildlife Service)
- Matthew Buckman (Hinchinbrook Shire Council)
- John Bideganeta (Burdekin Shire Council)
- Jade Monda (Cairns Shire Council)
- Joshua Palmer (Cassowary Coast Regional Council)
- Norman Lees (Townsville City Council)

## Key publications

Cremasco, P, Gentle, M, Wilson, CJ, Di Bella, L & Buckman, M 2016, ‘Feral pig baiting with fruit in the Wet Tropics’, in, *Proceedings of the 5th Queensland Pest Animal Symposium,* Townsville, 7-10 November, pp. 103 - 106.

Gentle, M, Speed J & Pople A 2014, ‘Impacts on nontarget avian species from aerial meat baiting for feral pigs’, *Ecological Management and Restoration,* vol. 15(3), pp. 222-230.

Millar, A, Gentle, M & Leung L 2015, ‘Non-target species interaction with sodium fluoroacetate (1080) bait for controlling feral pigs (*Sus scrofa*) in southern Queensland’, *Pacific Conservation Biology,* vol. 21, pp.158-162.

## 37. Improved rabbit management in horticultural regions of south-east Queensland and northern Queensland

### Project dates

July 2020 – June 2021

### Project team

Peter Elsworth

### Project summary

Field data are being analysed and results documented to support rabbit management in south-east and northern Queensland. Damage to horticultural cropping can be significant but is limited primarily to very early stages of crop development. Damage to later stages is reduced and while it may impact the plant, it does not affect the saleable product in the crops investigated (broccoli, head lettuce, and corn). Targeted control prior to planting, or excluding rabbits during the early development stage, will greatly reduce the damage to crops providing the best cost:benefit outcome.

Management improvements in north Queensland to limit impacts of rabbits rely on strategic use of traditional control tools. Localised rabbit populations can increase following periods of good rainfall and destroying breeding harbour will limit their increase. Where rabbits are more dispersed at low numbers across the landscape, targeted poisoning or virus releases can help reduce numbers. The cyclical nature of good and poor rainfall periods causes rabbit populations to fluctuate and it appears to be a key driver in rabbit numbers in that region.

Additionally, samples obtained through these research activities, as well as targeted sampling has provided information to interstate collaborators on phenotypic changes in rabbits across Australia, and Q-fever carriage in rabbits across Queensland.

### Collaborators

- Nathan Ring, Greg Wilson (Darling Downs and Moreton Rabbit Board)
- Luke Leung, Ruishu Wang, Mark Rusli, Lisa Steinke, Shannon Mills (University of Queensland)
- Emma Sherratt, Anne-Lise Chaber (University of Adelaide)
- Syd Clayton (Mareeba Shire Council)
- Brian Wienert (Tablelands Shire Council)
- Raymond Stacey (Dalrymple Landcare)
- Glen Alchin (Pest Animal Management Queensland)

### Key publications

Caraguel, C, Bassett, S, González-Barrio, D, Elsworth, P & Chaber, A 2020, ‘Comparison of three serological tests for the detection of *Coxiella burnetiid* specific antibodies in European wild rabbits’, *BMC Veterinary Research*, vol. 16, pp. 315. https://doi.org/10.1186/s12917-020-02526-w

Cooke, BD, Brennan, M & Elsworth, P 2018, ‘Ability of wild rabbit, *Oryctolagus cuniculus*, to lactate successfully in hot environments explains continued spread in Australia’s monsoonal north’, *Wildlife Research*, vol. 45, pp. 267-273. https://doi.org/10.1071/WR17177

## 38. Assessment of the biodiversity, economic and productivity gains from exclusion fencing

### Project dates

April 2018 – June 2022

### Project team

Malcolm Kennedy, Peter Elsworth and Tony Pople

### Project summary

Cluster fences were initiated in southwestern Queensland in 2013 to facilitate control of wild dogs, kangaroos and other pest species. Subsequent construction of cluster fences has exceeded all expectations. This project was developed to evaluate the impacts and longer-term benefits of cluster fences on livestock production, land condition, regional economies and biodiversity. Initially intended as a 5-year study, dry conditions and ongoing Commonwealth and State investment have extended this project for a further 5 years to capture expected longer-term impacts. This project includes wildlife monitoring, remote sensing of pasture, assessment of livestock production data and an economic evaluation of cluster fencing.

Wildlife monitoring has been undertaken in two clusters since 2013. Since fencing of the Morven cluster was closed in 2015, wild dog activity inside the fenced area has declined rapidly and is now very low. This decline is significantly lower than the wild dog activity outside the cluster. Kangaroo density has declined in both monitored clusters since monitoring began, likely influenced by climatic conditions and management of kangaroo numbers.

Remote sensing of pasture has been undertaken inside and outside of three of the longest-running clusters. There is a lack of detectable change in vegetation cover inside relative to outside clusters which may be because total grazing pressure (TGP) remains similar, or because cover is insensitive to changes in TGP. Both these hypotheses are currently being tested.

Economic data have been collected from case study properties and developed into a bioeconomic model to understand the implications of exclusion fencing on production outcomes. This work includes an assessment of the marginal changes to total property gross margin. Results from the bioeconomic model demonstrate fencing made a significant difference to lambing for the study properties, although the increase was more modest than expected.

### Collaborators

- Lester Pahl (Department of Agriculture and Fisheries, Animal Science)
- John Carter (Department of Environment and Science)
- Megan Star (Central Queensland University)

- Ben Allen (University of Southern Queensland)
- Geoff Castle (University of Southern Queensland)

## Key publications

Allen, LR 2017, ‘Managing pests with exclusion fences: progress and potential biodiversity benefits’, 17th Australasian vertebrate pest conference, Invasive Animals Cooperative Research Centre, Canberra.

Pacioni, C, Kennedy, MS & Ramsey, DSL 2020, ‘When do predator exclusion fences work best? A spatially explicit modelling approach’, *Wildlife Research*, vol. 48, pp.209-217.

Pickard, J 2007, ‘Predator-proof fences for biodiversity conservation: some lessons from dingo fences’, in Dickman, C, Lunney, D & Burgin, S (eds) *Animals of Arid Australia: out on their own?,* Royal Zoological Society of New South Wales, Mosman, NSW, Australia.

# 39. Peri-urban wild dog management

## Project dates

April 2018 – June 2022

## Project team

Matthew Gentle, Lana Harriott, James Speed and Tamar Michaelian

## Project summary

Wild dogs are common in peri-urban regions of Australia and cause impacts such as predation on livestock, wildlife, and domestic pets. Various forms of control are implemented but their use in peri-urban environments can be limited due to small landholdings, varied land use, proximity to human habitation, and poor adoption by the community. Targeted control of individual animals or small groups may be more successful in these regions in managing impacts than landscape-scale population reduction. In this project we aim to refine and assess tools and strategies for best practice management of peri-urban wild dogs.

Canid pest ejectors (CPEs) containing either 1080 or PAPP toxin have been assessed at four sites to determine encounter and activation rates and compare the attractiveness of different lures to wild dogs. Video footage of wild dog behaviour and outcomes of control efforts have been collected using motion sensing cameras. The efficiency and cost-benefits of CPEs and traditional trapping methods (commonly used in peri-urban areas) is also being compared through assessments of capture rates, with additional data supplemented from routine control programs conducted by Sunshine Coast Regional Council.

Data from eleven GPS collared wild dogs were used to quantify and compare encounters with three different densities (spacings of every 200 m, 500 m or intersections only) of modelled ejector (CPE) locations. Ejectors spaced at closer intervals (200 m) had a greater proportion of days with wild dog encounters. However, CPEs at intersections were 1.5 times more likely to be encountered than those at the alternative spacings (200 m and 500 m). These findings are important to guide the short- or long-term deployment of CPEs.

Local government collaborators have collated camera monitoring data from long-term wild dog baited (1080) and unbaited (nil treatment) sites. These data are being formally examined for changes in wild dog and prey activity resulting from wild dog baiting. Outcomes will help to provide recommendations on the application and implementation (e.g. scale) of baiting activities in peri-urban areas.

To determine the longevity of PAPP and 1080 CPE capsules in the environment, a twelve-month degradation trial has been initiated in peri-urban south-east Queensland and will be compared to a concurrent study in the rangelands of Western Australia. To complement the ecological research, a community-led planning approach to peri-urban pest animal management is being investigated by collaborators. This aims to identify wild dog management options that are acceptable to the community in these environments.

## Collaborators

- Sunshine Coast Regional Council
- Gympie Regional Council
- Brisbane City Council
- HQ Plantations
- Griffith University
- Landholders
- Centre for Invasive Species Solutions
- New South Wales Department of Primary Industries

## Key publications

Gentle, M, Allen, BL, Oakey, J, Speed, J, Harriott, L, Loader, J, Robbins, A, de Villiers, D & Hanger, J 2019, 'Genetic sampling identifies canid predators of koalas (*Phascolarctos cinereus*) in peri-urban areas', *Landscape and Urban Planning,* vol. 190, doi: 10.1016/j.landurbplan.2019.103591

Harriott, L, Gentle, M, Traub, R, Soares Magalhaes, RJ & Cobbold, R 2019, 'Zoonotic and economically significant pathogens of peri-urban wild dogs across north-eastern New South Wales and south-eastern Queensland, Australia', *Wildlife Research*, vol. 46(3) pp. 212-221.

McNeil, AT, Leung, LKP, Goullet, MS, Gentle, M & Allen, BL 2016, 'Dingoes at the doorstep: Home range sizes and activity patterns of dingos and other wild dogs around urban areas of north-eastern Australia', *Animals,* vol. 6(8), pp. e48

Figure 13. Field trial established for testing canid pest ejector (CPE) capsules on the Sunshine Coast
Photo: Lana Harriott

## 40. Management of peri-urban deer in south-eastern Queensland

### Project dates

July 2018 – June 2022

### Project team

Matt Amos, Michael Brennan and Tony Pople

### Project summary

Wild deer appear to be increasing in abundance and distribution across most jurisdictions in eastern Australia, including in peri-urban environments. Wild deer have the potential to cause significant impacts in peri-urban areas including traffic accidents, destruction of high value plantings, habitat modification, and competition with native fauna. They are also potential vectors for disease. Pest managers have very limited options for monitoring and control of wild deer in the peri-urban environment due to small landholdings, varied land use, high human density and media exposure. Peri-urban local governments have identified the need for further development and evaluation of tools and strategies for control and monitoring of wild deer in peri-urban areas.

This project forms part of a larger four-year project with interstate collaborators on deer management with funding through the Centre for Invasive Species Solutions. The research team have been working to provide and refine monitoring methods for peri-urban deer populations. This allows some evaluation of control effectiveness. At Brisbane and Wollongong we have been undertaking faecal pellet counts to monitor trends in abundance and distribution of rusa and fallow deer and relate these to numbers removed. The Wollongong rusa population appears to be expanding, despite a long-running ground control program. In contrast, at the Sunshine Coast analysis of thermal counts from vehicles and photographs from 'plotwatcher' remote cameras have both indicated a marked decline in the rusa and red deer from a ground shooting program that commenced in 2015. At North Pine Dam, Yeppoon and Wild Duck Island we have deployed grids of >35 cameras to provide densities of rusa deer for various land managers to assess their control programs. In addition, a collaborative project with the Queensland University of Technology has been undertaken to compare camera grid estimates of rusa deer with those of drones equipped with a thermal imager. This project also compared the efficiency of deer imagery assessment by machine learning to conventional assessment by human observers showing that machine learning is much more efficient.

## Collaborators

- Mark Kimber, Tony Cathcart and Jesse Wojtala (Sunshine Coast Regional Council)
- Jess Doman, Perry Ward, (Seqwater)
- Darren Sheil (Moreton Bay Regional Council)
- Bree Galbraith (Gympie Regional Council)
- Bill Manners, Dan Franks and Robyn Jones (Brisbane City Council)
- Grant Hamilton and Ashlee Sudholz (Queensland University of Technology)
- Dave Forsyth and Andrew Bengsen (New South Wales Department of Primary Industries)
- Steve Burke, Cam Mulville, Marine Parks (Department of Environment and Science, Yeppoon)
- Leise Childs, Dave Mitchell and John Wyland (Livingstone Shire Council)

## Key publications

Amos, M, Cathcart, A & Kimber, M 2019, 'Counting deer, not tourists, on the Sunshine Coast', in Sydes, T (ed), *Proceedings of the 1st Queensland Pest Animals and Weed Symposium,* The Weed Society of Queensland, Gold Coast, 20-23 May.

Amos, M, Brennan, M, Pople, T, Cathcart, T, Kimber, M, Wojtala, J, Doman, J, Manners, B, Franks, D, Jones, R, Childs, L, Mitchell, D & Wyland, J 2021, 'Broadscale monitoring of feral deer population trends and control effort in Queensland peri-urban environs', *18th Australasian Vertebrate Pest Conference*, Virtual, 25-27 May.

Forsyth, D, Pople, T, Page, B, Moriarty, A, Ramsey, D, Parkes, J, Wiebkin, A & Lane, C (eds) 2017, '2016 national wild deer management workshop proceedings', Invasive Animals Cooperative Research Centre, Canberra. *Wildlife Biology*, vol. 20(6), pp. 362–370.

Sudholz, A, Denman, S, Pople, T, Brennan, M, Amos, M & Hamilton, G 2021, 'A comparison of manual and automated detection of Rusa deer (*Rusa timorensis*) from RPAS-derived thermal imagery', *Wildlife Research*, https://doi.org/10.1071/WR20169

## 41. Wild dog predation on cattle and wild herbivores in the Queensland dry tropics

### Project dates

June 2020 – June 2024

### Project team

Malcolm Kennedy, James Speed and Catherine Kelly

### Project summary

Wild dogs (free-living domestic dogs, dingoes and their hybrids: *Canis familiaris*) can have substantial impacts on livestock enterprises. The effects of wild dogs on sheep and goats are unequivocal, with several studies identifying that dingoes and small stock are incompatible. The impacts of dingoes on cattle production enterprises can include up to 30% calf loss. Some producers therefore actively control wild dogs. Conversely, there is evidence that impacts of wild dogs on cattle can be modest and wild dogs may benefit cattle producers through suppression of native and introduced herbivores, under some conditions.

This project seeks to better understand the movement and feeding behaviour of wild dogs on cattle enterprises in northern Queensland. This work will entail satellite telemetry of wild dogs, including a pilot trial of video-GPS collars with accelerometers and of next generation, light weight, solar powered satellite tags (Ceres tags) to determine if these tools can help assess wild dog predation and other activity. Using satellite telemetry will allow us to also determine the effectiveness of biannual baiting on wild dog numbers.

Field site evaluation has been undertaken at Spyglass Research Station and on cattle properties in the Monto area. Ethics approval has been gained for the project and video GPS collars and Ceres tags have been purchased (delivery of these first commercially available Ceres tags is anticipated September 2021) for deployment in spring 2021.

### Collaborators

- Dr Dave Forsyth (Department of Primary Industries and Regional Development)
- Dr Ben Hirsch (James Cook University)
- Tony Salisbury, Phillip Hayward (Department of Agriculture and Fisheries)

### Key publications

Allen, LR, 2014, 'Wild dog control impacts on calf wastage in extensive beef cattle enterprises', *Animal Production Science*, vol. 54(2), pp.214-220.

Campbell, G, Coffey, A, Miller, H, Read, JL, Brook, A, Fleming, PJ, Bird, P, Eldridge, S & Allen, BL 2019, 'Dingo baiting did not reduce fetal/calf loss in beef cattle in northern South Australia', *Animal Production Science*, vol. 59(2), pp.319-330.

Prowse, TA, Johnson, CN, Cassey, P, Bradshaw, CJ & Brook, BW 2015, 'Ecological and economic benefits to cattle rangelands of restoring an apex predator', *Journal of Applied Ecology*, vol. 52(2), pp.455-466

## 42. Improving the detection of and response to red-eared slider turtles

### Project dates

July 2020 – June 2023

### Project team

Malcolm Kennedy, James Speed, Catherine Kelly and Peter Elsworth

### Project summary

Red-eared slider turtles (REST) are the most commonly traded reptile in the world and have significant environmental impacts where they establish outside of their native range. In Australia REST have been assessed as having an 'Extreme' risk of establishment. Established populations in south-east Queensland, originating from the illegal pet trade, were the focus of control from 2005. Individuals have recently been detected within the area of previously established populations and control efforts have been undertaken from September 2018. This work is challenging due to the cryptic and evasive nature of REST.

This project aims to increase effectiveness of REST management and improve confidence of detection and eradication of REST. It aims to do this through improving understanding of REST detection, behaviour, ecology and management approaches using operational data (detection locations and camera trap images), genetic analysis and ecological experimentation. To date we have analysed all camera trap imagery since September 2018. As a result, we have been able to identify all REST records to the individual level allowing analysis of basking behaviour and accurate knowledge of control effectiveness. This population is now at functional eradication with only two males known to remain. Working with a Centre for Invasive Species Solutions study to expand and improve the use of environmental DNA (eDNA) detection ("Real time eDNA tools to improve early detection and response approaches) we have piloted use of swabbing 'eDNA traps' on basking pontoons. We can now reliably detect REST use of pontoons using eDNA.

Continuation of this project will increase DAF's understanding of REST ecology and effectiveness of eradication efforts and assist in responding to 'at large' detections of REST and determining the feasibility of eradication of specific populations.

### Collaborators

- Prof. Dianne Gleeson (University of Canberra)
- Jack Rojahn (University of Canberra)

- Dr David Ramsey (Arthur Rylah Institute)

### Key publications

Furlan, EM, Gleeson, D, Wisniewski, C, Yick, J & Duncan, RP 2019, 'eDNA surveys to detect species at very low densities: A case study of European carp eradication in Tasmania, Australia', *Journal of Applied Ecology*, vol. 56(11), pp. 2505-2517.

García-Díaz, P, Ramsey, DS, Woolnough, AP, Franch, M, Llorente, GA, Montori, A, Buenetxea, X, Larrinaga, AR, Lasceve, M, Álvarez, A & Traverso, JM 2017, 'Challenges in confirming eradication success of invasive red-eared sliders', *Biological Invasions*, vol. 19(9), pp. 2739-2750.

O'Keefe, S 2009, 'The practicalities of eradicating Red-eared slider turtles (*Trachemys scripta elegans*)', *Aliens: The Invasive Species Bulletin. Newsletter of the IUCN/SSC Invasive Species Specialist Group* 28: 17-25.

## 43. Towards an optimised multi-platform surveillance network for Asian black-spined toads

### Project dates

July 2020 – June 2023

### Project team

Malcolm Kennedy, Catherine Kelly and Peter Elsworth

### Project summary

As the most common stowaway species arriving in Australia in cargo and baggage, the Asian black-spined toad (ABST, *Duttaphyrnus melanostictus*) is a species of biosecurity concern. ABST has established populations in a number of locations outside its native range in Asia, where it causes significant economic and environmental impacts. Much of northern and eastern Australia is suitable for establishment of ABST.

To better manage the risk of an ABST population establishing in Queensland there is a need for a targeted, robust surveillance network with a high level of confidence of incursion detection. A suite of tools including those developed for cane toad control and monitoring (audio lure traps) and new tools in development (audio detection and environmental DNA (eDNA)) could be applied to ABST surveillance. In this project we are seeking to test, optimise and determine the effectiveness of some of these tools, starting with the optimisation of cane toad audio lure traps (e.g. lure call provenance, frequency, pulse rate and volume) and investigating the use of eDNA.

The project has engaged cane toad expert Lin Schwarzkopf at James Cook University and Dr Mirza Kusrini of IPB University in Indonesia to undertake field work on ABST in their native range. This work will optimise and test ABST auditory lures in traps. We have sourced ABST calls from Singapore, India and Indonesia. The call library in Indonesia consists of 30 calls with matching toad morphology data. These calls have been analysed for their audio characteristics and will be used to develop a range of lure calls for testing. The Indonesian team have also tested the suitability of cane toad traps for holding ABST and taken 90 environmental DNA (eDNA) samples from a variety of water bodies to validate a University of Canberra eDNA assay for ABST.

## Collaborators

- Prof. Lin Schwarzkopf (James Cook University)
- Dr Mirzura Kusrini (IPB University, Indonesia)
- Prof. Dianne Gleeson (University of Canberra)
- Dr Doug Beattie (University of Canberra)
- Dr Peter Caley (CSIRO)
- Dr Susan Campbell (DPIRD)
- Dr David Ramsey (Arthur Rylah Institute)
- Assoc. Prof. Phil Cassey (University of Adelaide)

## Key publications

Muller, BJ & Schwarzkopf, L 2017, 'Success of capture of toads improved by manipulating acoustic characteristics of lures', *Pest Management Science,* vol. 73(11), pp. 2372-2378.

Tingley, R, García-Díaz, P, Arantes, CRR & Cassey, P 2018, 'Integrating transport pressure data and species distribution models to estimate invasion risk for alien stowaways', *Ecography*, vol. 41(4), pp. 635-646

# Part 3: Research services

# 44. Chemical registration - providing tools for invasive species control

## Project dates

July 2012 – June 2022

## Project team

Joseph Vitelli and David Holdom

## Project summary

Biosecurity Queensland holds permits for use of pesticides to control invasive plants and animals. The need for permits has increased as pesticide registrants focus primarily on more profitable crop protection rather than environmental protection, resulting in reduced availability for controlling invasive species outside of crops.

Eighteen new permits were issued to Biosecurity Queensland during 2020–21 by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Sixteen permits related to weeds— Senegal tea plant sagittaria, salvinia, water hyacinth, water lettuce, hymenachne, pond apple, kidneyleaf mudplantain, lippia bitter weed, giant American rat's tail grass, Parramatta grass, rubber vine, Kahilli ginger, white ginger, yellow ginger, sicklepod, and florestina. One permit was for the aquatic surfactant Nemo® and one was for the control of weeds in water storage assets and facilities. A further four permits have also been lodged with the APVMA for the control of cacti, lippia, prickly acacia and exotic birds.

## Collaborators

- Local Governments
- Seqwater
- Sumitomo Chemical
- Nufarm Australia
- Macspred
- Cortevia
- Department of Environment and Science, Ecosciences Precinct
- Sonia Jordan, Steve Csurhes, Craig Hunter, Michael Graham, Lyn Willsher, John Reeves, Stacy Harris and Michelle Smith (Biosecurity Queensland)

## Key publications

Eighteen new permits were issued by APVMA to Biosecurity Queensland during the 2020-21 financial year:

1. Permit (PER87689) Glyphosate / Various Weeds / Water Storage Assets and Facilities. Expires 31 Aug 2023. (http://permits.apvma.gov.au/PER87689.PDF )

2. Permit (PER89268) Nemo Aquatic Surfactant / Various Situations - Wetting Agent / Various Pests. Expires 31 Jul 2023. (http://permits.apvma.gov.au/PER89268.PDF )

3. Permit (PER10540) 2,4-D Amine, Glyphosate and Metsulfuron / Pasture and Fallow (Floodplains) / Lippia. Expires 31 Jul 2026. (http://permits.apvma.gov.au/PER10540.PDF ) (28/07/20)

4. Permit (PER80934) Glyphosate / Artificial Ponds, Irrigation and Natural Waterways/ Sagittaria. Expires 30 Sep 2025. (http://permits.apvma.gov.au/PER80934.PDF )

5. Permit (PER83249) Flupropanate/ pastures & non-crop areas/ giant, american rat's tail grass & parramatta grass. Expires 30 Sep 2025. (http://permits.apvma.gov.au/PER83249.PDF )

6. Permit (PER12436) Metsulfuron-methyl, Triclopyr, Imazapyr and Picloram / Various situations / Kahili ginger, White ginger and Yellow ginger. Expires 31 Oct 2025. (http://permits.apvma.gov.au/PER12436.PDF)

7. Permit (PER12520) Various Product / Non-cultivated areas of native and other vegetation / Bitter weed. Expires 31 Jan 2026. (http://permits.apvma.gov.au/PER12520.PDF )

8. Permit (PER86933) Glyphosate / Water impoundments and associated channels / Salvinia, water hyacinth, water lettuce. Expires 30 Sep 2023. (http://permits.apvma.gov.au/PER86933.PDF )

9. Permit (PER82156) Conqueror, Grazon Extra / non-crop areas / Rubber vine. Expires 31 May 2026. (http://permits.apvma.gov.au/PER82156.PDF

10. Permit (PER13406) Glyphosate / Terrestrial & Aquatic Areas (Qld) / Hymenachne spp.. Expires 30 Jun 2022. (http://permits.apvma.gov.au/PER13406.PDF )

11. Permit (PER13684) Triclopyr, picloram (Access Herbicide and Tordon DSH); Fluroxypyr (Starane Advanced Herbicide); Glyphosate (Roundup Biactive) & Imazapyr (Unimaz 250 SL Herbicide) / Various situations / Pond Apple. Expires 30 Jun 2025. (http://permits.apvma.gov.au/PER13684.PDF )

12. Permit (PER12726) Roundup Biactive (glyphosate) / aquatic situations / Senegal tea plant. Expires 30 Jun 2022. (http://permits.apvma.gov.au/PER12726.PDF )

13. Permit (PER11540) Haloxyfop / Ponds, Drainage areas, Waterways, Pastures, roads & Utility reserves / Hymenachne. Expires 30 Jun 2025. (http://permits.apvma.gov.au/PER11540.PDF )

14. Permit (PER82158) Triclopyr/picloram/aminopyralid / Sicklepod. Expires 31 Mar 2026. (http://permits.apvma.gov.au/PER82158.PDF

15. Permit (PER14122) Metsulfuron-methyl / Non-potable waterways / Kidneyleaf mudplantain. Expires 30 Jun 2025. (http://permits.apvma.gov.au/PER14122.PDF

16. Permit (PER88624) 2,4-D Amine, Metsulfuron methyl, 2,4-D Amine + Picloram / Pasture Stock Routes, Roadsides & Non Crop Situations/ Florestina. Expires 30 Jun 2026. (http://permits.apvma.gov.au/PER88624.PDF )

17. Permit (PER81265) Haloxyfop / Hymenachne. Expires 30 Jun 2023. (http://permits.apvma.gov.au/PER81265.PDF )

18. Permit (PER89485) Various Products / Various Situations / Calotrope. Expires 30 Sep 2023. (http://permits.apvma.gov.au/PER89485.PDF )

## 45. Pest management chemistry

### Project dates

End date 30 June 2021

### Project team

Stephen Were, Patrick Seydel, Alyson Herbert and Chien Cao

### Project summary

This project provided chemistry services to research, policy and operational activities within Biosecurity Queensland's Invasive Plants and Animals Program.

These services comprise pesticide advice and 1080 production for pest management in Queensland and toxicological and eco-toxicological investigations into the use of vertebrate pesticides. The project was undertaken in Biosecurity Queensland's Chemical Residue Laboratory at the Queensland Government's Health and Food Sciences Precinct at Coopers Plains, Brisbane.

**Forensic toxicology**

Over the year, our laboratory performed 18 investigations into possible animal poisonings for QLD: 15 for sodium fluoroacetate; 3 for anticoagulants. While most investigations related to domestic dogs and cats, some involved livestock or macropods. Most investigations were from private submissions by Queensland veterinarians, with a few council submissions and Qhealth investigations.

**Formulation chemistry**

During the year, our formulation facility produced the last batch of 445L of 1080 (36 g/L) pig bait solution for use in Biosecurity Queensland and local government co-ordinated baiting programs, with the last batch made from the final remnants of 1080 powder in December 2020. All the remaining manufactured pig bait solution was delivered to regions with the last shipment in April 2021. There is no remaining sodium fluoroacetate in solid form or prepared solution.

## External funding

## Research and development contracts

| Project/research area | Funding body | Funds spent ($) |
|---|---|---|
| Integrated management of cabomba | CSIRO | 142,000 |
| Weed management in the Pacific | Landcare Research New Zealand | 21,000 |
| Biocontrol of pasture weeds, Vanuatu | Landcare Research New Zealand | 107,000 |
| Biocontrol of cat's claw creeper | Seqwater | 70,000 |
| Biocontrol of *Clidemia hirta* | AgriFutures Australia | 132,000 |
| Biocontrol of parkinsonia | CSIRO | 70,000 |
| Biocontrol of prickly acacia | AgriFutures Australia | 230,000 |
| Biocontrol of giant rat's tail grass | AgriFutures Australia | 140,000 |
| Biocontrol of Navua sedge | AgriFutures Australia | 213,000 |
| Managing established pests—parthenium biocontrol | Australian Government | 12,000 |
| Endemic pathogens of giant rat's tail grass | AgriFutures Australia, HQPlantations, Bundaberg Regional Council, Gladstone Regional Council, New South Wales Department of Primary Industries and New South Wales Biocontrol Task Force | 351,000 |
| Giant rat's tail grass management in central Queensland | Gladstone Regional Council | 27,000 |
| Giant rat's tail grass management in Aldoga, Gladstone State Development Area | Economic Development Queensland | 29,000 |
| Managing established pests—giant rat's tail grass | Australian Government | 23,000 |
| Tolerance to pre-emergent herbicide | CSIRO | 78,000 |
| Four tropical weeds eradication | National cost share | 63,000 |
| Red witchweed response program treatment | National cost share | 58,000 |
| Wild dog and deer management | Centre for Invasive Species Solutions | 130,000 |
| Cluster fencing evaluation | Centre for Invasive Species Solutions | 113,000 |
| Surveillance tools for pest animal incursions | Centre for Invasive Species Solutions | 18,000 |
| **Total** | | **2,027,000** |

## Land Protection Fund

| Project/research area | Funds spent ($) |
|---|---:|
| Pest management chemistry | 70,000 |
| Pesticide permits | 51,000 |
| Biocontrol of prickly acacia | 159,000 |
| Biocontrol of bellyache bush | 101,000 |
| Biocontrol of cat's claw creeper | 84,000 |
| Biocontrol of parthenium | 52,000 |
| Biocontrol of opuntioid cactus | 106,000 |
| Biocontrol of Harrisia cactus | 32,000 |
| Biocontrol of Navua sedge | 72,000 |
| Biocontrol of parkinsonia | 20,000 |
| Biocontrol of clidemia | 33,000 |
| Biocontrol of giant rat's tail grass | 166,000 |
| Weed biocontrol non-target risk | 5,000 |
| Quarantine management | 57,000 |
| Water weed ecology and management | 105,000 |
| Integrated management of cabomba | 85,000 |
| Rearing and release of biocontrol agents | 172,000 |
| Weed seed dynamics | 76,000 |
| Integrated management of parthenium | 109,000 |
| Giant rat's tail grass flupropanate control | 8,000 |
| Pest spatial dynamics | 38,000 |
| Prioritising pest management | 32,000 |
| Navua sedge ecology and management | 67,000 |
| Feral cat ecology and management | 26,000 |
| Red-eared slider eradication | 73,000 |
| Asian black-spined toad surveillance | 48,000 |
| Rabbit best practice research | 8,000 |
| Feral deer best practice research | 127,000 |
| Management of peri-urban wild dogs and deer | 158,000 |
| Wild dog exclusion fencing | 33,000 |
| Wild dog best practice research | 31,000 |
| Non-target impacts of 1080 feral pig baits | 86,000 |
| **Total** | **2,290,000** |

# Research staff

## Ecosciences Precinct

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| | |
|---|---|
| Tony Pople | Principal scientist |
| Michael Day | Principal scientist (entomologist) |
| Kunjithapatham Dhileepan | Principal scientist (entomologist) |
| Olusegun Osunkoya | Principal scientist (ecology) |
| Joseph Vitelli | Principal scientist (weeds) |
| Tobias Bickel | Senior scientist (aquatic weeds) |
| Sharon Bishop-Hurley | Senior scientist |
| Jason Callander | Scientist |
| Lana Harriott | Scientist |
| David Holdom | Scientist |
| Md Mahbubur Rahman | Scientist |
| Boyang Shi | Scientist |
| Di Taylor | Scientist |
| Tamara Taylor | Scientist |
| Michael Brennan | Principal science technician |
| Annerose Chamberlain | Science technician |
| David Comben | Science technician |
| Bahar Farahani | Science technician |
| Kai Hart | Science technician |
| Ellie Nicholson | Research Assistant |
| David Officer | PhD candidate (giant rat's tail grass) |
| Christine Perrett | Science technician |
| Drew Rapley | Science technician |
| Natasha Riding | Science technician |
| Liz Snow | Principal science technician (and quarantine manager) |
| Tracey Steinrucken | CSIRO post doctoral fellow (biological control of invasive plants) |
| Anna Williams | Science technician |
| Donna Buckley | Administration officer |

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| | |
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| | |
|---|---|
| Matthew Gentle | Principal scientist |
| Matt Amos | Scientist |
| Peter Elsworth | Senior science technician |
| Catherine Kelly | Senior science technician (casual) |
| Malcolm Kennedy | Senior scientist |
| James Speed | Senior science technician |

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| | |
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| Wayne Vogler | Principal scientist |
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| | |
|---|---|
| Melissa Setter | Scientist |
| Stephen Setter | Senior science technician |

# Publications and presentations

## Journal articles


Aigbedion-Atalor, PO, Idemudia, I, Adom, M, Forchibe, EE, Tossou, H, Wilson, DD & **Day, MD** 2021, 'Marching across and beyond West Africa: first record of the stem-galling fly *Cecidochares connexa* (Diptera: Tephritidae) in Central Africa and the implications for biological control of *Chromolaena odorata* (Asteraceae)', *Plos ONE*, vol. 16, pp. e0252770. https://doi.org/10.1371/journal.pone.0252770

Ali, S, **Dhileepan, K**, Hussain, A & Shabbir, A 2021, 'Reproductive biology, abundance, and control potential of *Paramecops farinosus* (Wiedemann) (Coleoptera: Curculionidae): a prospective biological control agent for *Calotropis procera* (Apocynaceae)', *Biocontrol Science and Technology,* vol. 31, https://doi.org/10.1080/09583157.2021.1953441.

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Caraguel, C, Bassett, S, González-Barrio, D, **Elsworth, P** & Chaber A 2020, 'Comparison of three serological tests for the detection of *Coxiella burnetiid* specific antibodies in European wild rabbits', *BMC Veterinary Research*, vol. 16, pp. 315. Doi: https://doi.org/10.1186/s12917-020-02526-w

Chadha, A, Florentine, SK, **Dhileepan, K**, Dowling, K & Turville, C 2021, 'Germination biology of three populations of Cyperus aromaticus', *Weed Science*, vol. 69, pp. 69-81.

**Comben, DF**, McCulloch, GA, **Dhileepan, K** & Walter, GH 2021, 'Genetic identify of Australian prickly acacia (*Vachellia nilotica*, Fabales: Mimosoideae) – assessing the target for biological control', *Biological Control,* vol. 155, pp. 104540.

**Dhileepan, K, Snow, E, Shi, B, Gray, B**, Jackson, K & Senaratne, KADW 2021, 'Establishment of the biological control agent *Hypocosmia pyrochroma* for *Dolichandra unguis-cati* (Bignoniaceae) is limited by microclimate', *Journal of Applied Entomology,* vol. 145 http://doi.org/10.1111/jen.12901.

**Fancourt, BA**, Zirbel, C, **Cremasco, P, Elsworth, P**, Harry, G, & **Gentle, MN** 2021, 'Field assessment of the risk of feral cat baits to nontarget species in eastern Australia', *Integrated Environmental Assessment and Management*. doi: https://doi.org/10.1002/ieam.4445.

Fleming PA, Crawford, HM, Stobo-Wilson, AM, Dawson, SJ, Dickman, CR, Dundas, SJ, **Gentle, MN**, Newsome, TM, O'Connor, J, Palmer, R, Riley, J, Ritchie, EG, **Speed, J**, Saunders, G, Stuart, J-MD, Thompson, E, Turpin, JM, & Woinarski, JCZ 2021, 'Diet of the introduced red fox Vulpes vulpes in Australia: analysis of temporal and spatial patterns'. *Mammal Review,* vol. 51, pp. 508-527 doi: https://doi.org/10.1111/mam.12251.

Hampton, JO, **Amos, M, Pople, A, Brennan M** & Forsyth, DM 2020, 'Minimising mortalities in capturing wildlife: refinement of helicopter darting of chital deer (*Axis axis*) in Australia', *Wildlife Research,* vol. 48, pp. 304-313. doi: https://doi.org/10.1071/WR20106.

Huaman, JL, Pacioni, C, Forsyth, DM, **Pople, A**, Hampton, JO, Carvalho, TG & Helbig, K J 2020, 'Serosurveillance and Molecular Investigation of Wild Deer in Australia Reveals Seroprevalence of Pestivirus Infection', *Viruses*, vol.12, pp. 752.

Huaman, JL, Pacioni, C, Forsyth, DM, **Pople, A**, Hampton, JO, Helbig, KJ & Carvalho, TG 2021, 'Evaluation of haemoparasite and Sarcocystis infections in Australian wild deer', *International Journal for Parasitology: Parasites and Wildlife,* vol. 15, pp. 262-269. doi: https://doi.org/10.1016/j.ijppaw.2021.06.006.

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Technical highlights
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