Technical highlights

Invasive plant and animal research
2019–20

Queensland Government

DAF1339 02/21

Cover photo: Cactoblastis larvae in a prickly pear cladode

If you need an interpreter to help you understand this document, call **13 25 23** or visit **daf.qld.gov.au** and search for 'interpreter'.

Contents

Introduction

This document summarises the 2019–20 research 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 2019–20 are outlined below.

Invasive plant research

- We continue to assess new biological agents for control of prickly acacia, Navua sedge, bellyache bush, giant rat's tail grass and cat's claw creeper. Overseas collaboration is essential for this work, with host-specificity of potential agents being assessed in South Africa, Argentina, India and the United Kingdom. Not surprisingly, there has been some delay due to the COVID-19 pandemic, but this is likely to be temporary. With closed international borders, strong overseas collaboration is now highly valued.
- Unfortunately, the agent for mother-of-millions was not sufficiently host-specific to seek approval for release. This highlights the lack of certainty in biocontrol. However, the successes for weed biocontrol should outweigh the disappointments in the long term, as results show an average cost–benefit ratio of 23:1.
- We are mass-rearing and releasing approved biocontrol agents for Siam weed, parkinsonia, lantana, parthenium and *Cylindropuntia* cacti. Release programs are accompanied by monitoring, which serves a number of purposes. Firstly, it determines when the agent is established, and therefore when releases can cease. Secondly, it can indicate where, when and what type of other agents or control methods are needed. Thirdly, it evaluates the program in terms of benefits and costs. For example, the agent released on coral cactus is highly damaging, but the one released on snake cactus is not. We are now seeking an alternative lineage for the latter.
- 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. The recently tested rust for mikania has been approved for release. Discussion is now needed on how this can be integrated into an eradication program.
- We have done a considerable amount of work on herbicide control of high-priority weeds, including the use of splatter guns (for high-concentration, low-volume herbicide applications). We have marshalled resources 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 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 is a promising option, and an application for its registration has been submitted. We are now turning our attention to delivery systems to improve contact time and allow strategic application. Additional aquatic herbicides could also be developed. There is limited research capacity in Australia for aquatic weeds, so 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

- Satellite telemetry, camera trapping and vehicle surveys have described a remarkably clumped distribution of chital deer in northern Queensland. This pattern seems to match the distribution of soil nutrients, particularly phosphorus. The clumped distribution has benefited control, as has drought, and numbers have been reduced substantially with slow recovery. In peri-urban areas of south-eastern and central Queensland, we are monitoring the effectiveness of ground-shooting and trapping programs. Through national collaboration, we plan to develop management guidelines.
- Four lethal strains of calicivirus, one non-lethal strain of calicivirus and the myxoma virus are now circulating in Australia's rabbit population. Because of the low proportion of susceptible rabbits, further releases of the calicivirus strains are not warranted. Recent work has shown that rabbit biocontrol can have minimal effect if there is no follow-up mechanical control, such as warren ripping.
- Broadscale control of feral pigs and feral cats is possible through baiting. Our researchers are collecting 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 it can be undertaken without population-level impacts to native fauna.
- There has been considerable public and private investment in building fences with dog netting around 'clusters' of properties in the rangelands of western Queensland. The idea is to deny reinvasion following control of wild dogs and other pest animals inside the fenced area. Our researchers are evaluating the production and environmental benefits of cluster fencing. This will need long-term assessment (for at least 10 years), as changes in the rangelands are typically episodic, driven largely by rainfall.
- In the peri-urban environment, wild dogs must be managed differently. Control is local rather than landscape-scale. Reinvasion is problematic and community views on pest management are diverse. Our researchers are assessing canid pest ejectors, which deliver a toxin specifically to dogs and foxes. We are also consulting with communities on acceptable management of wild dogs in their areas.

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. Twelve minor-use or emergency-use permits were obtained in 2019–20.

Funding, collaboration and research priorities

In the 2019–20 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 $1.7 million; expenditure from the Land Protection Fund amounted to almost $2.4 million; and expenditure under contracts with external partners totalled $1.6 million (see 'External funding', pages 30–31). Notable funding bodies for the latter were the Australian Government, AgriFutures Australia, CSIRO, Manaaki Whenua Landcare Research New Zealand and the Centre for Invasive Species Solutions.

Our research program for 2019–20 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 32–33). 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

Control of aquatic weeds in freshwater bodies faces many challenges. One of these is the dilution and dispersion of herbicides after application, which can result in low control efficacy and non-target impacts. We developed novel delivery systems for the herbicide flumioxazin in the form of a gel and a granular formulation.

The gel and the granular formulation (herbicide carriers) are based on guar gum (a food additive), which binds the herbicide and slows down its release in the water column. The carriers rapidly sink through the water column, resulting in a targeted delivery of flumioxazin to aquatic weeds while reducing the risk of non-target damage.

We also performed field trials with flumioxazin to investigate its environmental fate and to measure control efficacy. A single application of flumioxazin at 200 parts per billion active ingredient in the water column provided 100% control of the emerging aquatic weed Amazon frogbit (*Limnobium laevigatum*) within 3 months. Flumioxazin applied to a freshwater lake with dense cabomba was rapidly taken up by the weed. The herbicide broke down quickly (below detection limit after 24 hours) and moved only a few metres from the application sites.

The new carrier systems will greatly improve the efficacy of flumioxazin application, making this an environmentally safe and efficient tool for control of established and emergent aquatic weeds in Queensland. We submitted a registration application for flumioxazin to control of a range of aquatic weeds in freshwater situations to the Australian Pesticides and Veterinary Medicines Authority early this year.

Collaborators

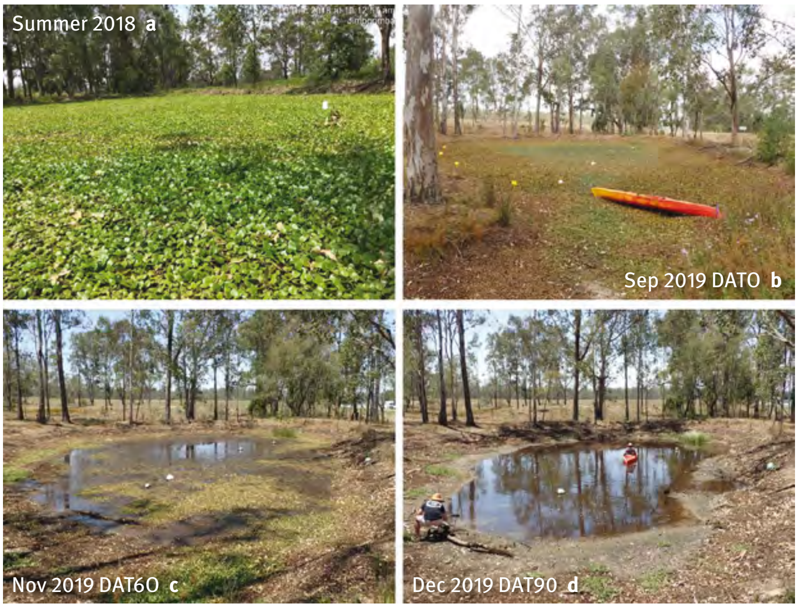
- Junfeng Xu and Katarina Panjak (The University of Queensland)
- CSIRO
- Queensland Department of Environment and Science
- Seqwater
- NIWA
- Brisbane City Council
- Noosa and District Landcare
- Victorian Department of Jobs, Precincts and Regions
- New South Wales Department of Primary Industries
- University of Düsseldorf (Germany)
- Macspred Australia

Key publications

Bickel, TO, Perrett, C, Vitelli, J, Xu, J & Adkins, S 2018, 'Control of *Cabomba caroliniana* with flumioxazin: control efficacy and the effect of environmental factors', *15th international symposium of aquatic plants*, Queenstown, New Zealand.

Hofstra, D, Schoelynck, J, Ferrell, J, Coetzee, J, de Winton, M, Bickel, TO, Champion, P, Madsen, J, Bakker, ES, Hilt, S, Matheson, F, Netherland, M & Gross, EM 2020, 'On the move: new insights on the ecology and management of native and alien macrophytes', *Aquatic Botany*, vol. 162, p. 103 190.

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



Frogbit infestation in a dam in Jimboomba over time:
a before treatment (2018); **b** at the time of treatment (September 2019), with the entire dam covered by a thick mat; **c** 2 months after treatment, with frogbit covering about half the water surface area; **d** 3 months after treatment, with only fragments of frogbit left

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

Project dates

July 2019 – June 2021

Project team

Olusegun Osunkoya and Christine Perrett

Project summary

This is an Australian Research Council Linkage Project with The University of Queensland, Queensland University of Technology and Queensland Parks and Wildlife Service.

Managing invasive species is complex. It involves a range of different social bodies, including government departments and agencies, and non-government sectors (such as local management groups and individual landowners). It is further complicated when 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, such as Biosecurity Queensland and Queensland Parks and Wildlife Service, almost always operate independently due to different jurisdictions and varying goals. However, there are potential benefits from greater collaboration in planning and action across agencies. A lack of coordination across agencies can lead to the inefficient use of limited resources and, importantly, reduced benefits for the environment and society. The aim of this project is to develop and apply a new pest animal and plant prioritisation framework recognising that invasive species are managed at multiple spatial scales, and by multiple agencies.

Collaborators

- Eve McDonald-Madden, Jonathan Rhodes and Chris O'Bryan (The University of Queensland)
- Mike Bode (Queensland University of Technology)
- Geoff Lundie-Jenkins (Queensland Department of Environment and Science)
- Bradley Gray and Moya Calvert (Biosecurity Queensland)

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.

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.

Epanchin-Niell, RS, Hufford, MB, Esian, CE, Sexton, JP, Port, JD & Waring, T 2009, 'Controlling invasive species in complex social landscapes', *Frontiers in Ecology and the Environment,* vol. 8(4), pp. 210–216.

3. Using pest distribution to assess pest risk and prioritise management

Project dates

July 2019 – June 2021

Project team

Olusegun Osunkoya and Christine Perrett

Project summary

We have prioritised weeds and pest animals for research and management using their distribution, current impact and expected future impact. To do this, we used data from the Annual Pest Distribution Survey (APDS), plus information gained from stakeholder consultation at the regional level. However, this prioritisation exercise did not consider the speed and patterns of invasions, which can be obtained from standardised invasion curves.

We have now combined the short-term APDS estimates (2003 to 2014) with long-term (>150 years) herbarium records from Herbrecs for many established and emerging weeds of Queensland, and used the datasets to develop standardised invasion curves. The standardised invasion curves can monitor, confirm or predict the temporal and spatial dynamics of both recent introductions (emerging species) and widespread, established pests at regional and statewide scales. The information is critical for cost-efficient management.

Collaborators

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

Key publications

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

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 plant species in Queensland, Australia: a stakeholders' perspective', *Journal of Environmental Management*, vol. 246, pp. 484–495.

Osunkoya, OO, Buri, JC, Lock, CB, Grey, B & Calvert, M in press, 'Spatial extent of invasiveness and invasion stage categorization of established weeds of Queensland, Australia', *Australian Journal of Botany*.

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 successfully managing parthenium (*Parthenium hysterophorus*) in central and northern Queensland through a combination of herbicide control, varying grazing pressure and 11 biocontrol agents. In southern Queensland, at the invasion front for parthenium, landholders are having less success in managing the weed. This could be because the biocontrol agents are few or not long established, the climate and vegetation are different, and parthenium's life history appears different (e.g. in timing, extent of flowering and seed production). Landholders are also not familiar with managing the weed, particularly the integration of biological and conventional control techniques.

In July 2018, with North Burnett Regional Council, we commenced an experiment examining a range of control strategies for parthenium. It aims to determine the efficacy of biocontrol agents, optimal timing of herbicide control and the effect of grazing pressure on the weed's growth. Experimental field plots are also being used as demonstration plots to provide extension to landholders. We have captured aerial imagery at two field sites (Gayndah and Monto) to provide a pre-trial baseline as well as to compare remotely sensed demographic data of the weed with that obtained via small-scale ground-truthing. Identification of a parthenium spectral signature will help with surveys elsewhere and for monitoring, to direct control and evaluate control programs.

Field experimental design

At two sites in Monto and Gayndah, where climate is moderately predicable, 7 of 11 biocontrol agents (the stem-galling *Epiblema* moth, the seed-feeding *Smicronyx* weevil, the stem-borning *Listronotus* weevil, the root-boring *Carmenta* moth, the sap-sucking plant hopper *Stobaera*, the summer rust *Puccinia xanthii* and the winter rust *Puccinia abrupta*) are now established.

Fenced-off plots (each ~ 40 × 40 metres) were established at each site, with smaller subplots (4 × 4 metres) set up for long-term monitoring of parthenium growth under different management regimes. An agricultural irrigation sprinkler, connected to a twin-piston firefighter pump, was deployed at each site to ensure adequate moisture availability during prolonged dry periods. The experimental sites each have three treatment plots and one control plot:

- **control**—biocontrol alone (no chemical control, no grazing management)
- **treatment 1**—ad hoc chemical control (one spray at the beginning of the growth season of parthenium weed) + biocontrol
- **treatment 2**—best-practice chemical management (involving multiple spray periods of the weed, usually 1–2 weeks post rainfall) + biocontrol
- **treatment 3**—best-practice grazing management + biocontrol.

Chemical control of parthenium within the experimental plots continues to be organised by the landholder and North Burnett Regional Council. The council has taken the lead in the management of the trial sites and the chemical control of the plots. The landholders have assisted in the construction and maintenance of the fencing throughout the duration of the trial.

Treatment and control plots are being surveyed. Aerial images have been captured by drone only once during the current growing season, due to a prolonged drought from August 2019 to January 2020 and travel restrictions due to the COVID-19 pandemic. Quantitative surveys within each plot recorded densities of biocontrol agents and different stages of parthenium growth. More images were taken at the Monto site, as there was more vigorous growth of parthenium plants than at the Gaydah site.

Determining parthenium density using both ground surveying and aerial imagery in experimental plots in Monto

Collaborators

- Steve Adkins (The University of Queensland)
- Raghu Sathyamurthy (CSIRO, Ecosciences Precinct)
- Neale Jensen (North Burnet 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

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.

Costello, B 2019, 'Automatic detection and mapping of invasive parthenium weed from airborne imagery using Yolov 3', BEng thesis, Queensland University of Technology, Brisbane, 18 pp.

5. 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. It has been a target for biocontrol since 1997, with limited success to date. Surveys in Mexico, central and northern South America, and the Caribbean resulted in the release in 2003 of the seed-feeding jewel bug (*Agonosoma trilineatum*), which failed to establish. A leaf rust (*Phakopsora arthuriana*), a leaf-miner (*Stomphastis* sp.), a gall midge (*Prodiplosis* sp.) and a leaf-feeding midge (*Prodiplosis* sp.) have been identified as prospective biocontrol agents.

We have completed host-specificity testing for the leaf rust. We have also completed no-choice host-specificity testing for the leaf-miner, and choice tests are in progress. We plan to submit release applications for the leaf rust and the leaf-miner. Future research will focus on identifying a gall midge from Bolivia and a leaf-feeding midge from Paraguay, and host-specificity testing for these prospective agents.

Jatropha rust

We carried out host-specificity testing for the Jatropha leaf rust from 2009 until 2015. Since then, we have focused on clarifying the life cycle of the agent. Using a Trinidadian accession of the Jatropha leaf rust, host-range testing was conducted for 42 non-target species under quarantine conditions at CABI in the United Kingdom. Based on these results, dose-response experiments and a field host-range assessment were conducted in Trinidad to better understand the potential impact of the rust on three selected non-target species. Using the positive results from this work, we will prepare and submit an application to release the Jatropha leaf rust in Australia.

Jatropha leaf-miner

The Jatropha leaf-miner was imported from Peru and a colony was established in quarantine in November 2014. We have completed no-choice host-specificity testing. Adults laid eggs on non-target species (due to egg dumping), but larval development occurred on only bellyache bush and its congener physic nut (*J. curcas*). In choice oviposition trials, females laid eggs equally on both bellyache bush and physic nut. Test results provided strong evidence that the leaf-miner is highly host-specific and suitable for release in Australia, so we applied for its release. However, because of feedback from the Australian Government Department of Agriculture, Water and the Environment (DAWE), we carried out no-choice tests for additional test plant species and choice oviposition tests for most of the test plants on which eggs were laid in previous no-choice tests. Choice-minus-control trials are currently in progress.

As required by DAWE, morphological and molecular studies on the Jatropha leaf-miner have been initiated in collaboration with the Royal Museum of Central Africa in Belgium and CSIRO in Brisbane. We will submit a release application when the host-specificity tests are completed and the leaf-miner's taxonomic status is resolved.

Choice host-specificity tests for the Jatropha leaf-miner in the quarantine facility in Brisbane

Jatropha midges

A gall midge induces rosette galls in shoot-tips, emerging leaves, petioles and stems, resulting in shoot-tip dieback on *J. clavuligera* in Bolivia. A morphologically similar midge species (*Prodiplosis* sp.) occurs on *J. gossypiifolia* in Paraguay, feeding on leaves but not inducing galls. The two morphologically similar species, with distinct feeding habits, have been prioritised as prospective biocontrol agents. Preliminary no-choice host-specificity tests involving 14 test plant species have been completed for the leaf-feeding midge from Paraguay at the Fundación para el Estudio de Especies Invasivas in Argentina. The midge caused shoot-tip damage and completed its life cycle on bellyache bush only and not on any of 12 crop plants tested (alfalfa, avocado, bean, tomato, zucchini, cotton, capsicum, onion, citrus, grape, squash and potato) or the closely related Euphorbiaceae species (*J. curcas* and *Ricinus communis*). This confirms that it is likely to be host-specific, unlike the closely related polyphagous pest species *Prodiplosis longifila*. Due to civil unrest in Bolivia, collection of the gall-inducing midge species for host-specificity testing was not possible.

Morphological and molecular studies on the two midge species are in progress. Preliminary analyses suggest that the gall midge from Bolivia and leaf-feeding midge from Paraguay are two distinct species, and not the polyphagous pest species *Prodiplosis longifila*.

Collaborators

- Marion Seier and Kate Pollard (CABI, United Kingdom)
- Guillermo Cabrera Walsh, Marina Oleiro and Carolina Mengoni (Fundación para el Estudio de Especies Invasivas, Buenos Aires, Argentina)
- Peter Kolesik (Bionomics, Adelaide)
- Kumaran Nagalingam (CSIRO, Brisbane)
- 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', *Proceedings of the XIV international symposium on biological control of weeds*, Kruger National Park, South Africa, pp. 5–10.

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

6. Biocontrol of giant rat's tail grass

Project dates

July 2016 – June 2023

Project team

Michael Day and Natasha Riding

Project summary

Giant rat's tail grass is the common name for the species *Sporobolus pyramidalis* and *S. natalensis*. Current control efforts for weedy *Sporobolus* grasses rely on chemical, mechanical and pasture-management methods. However, control is difficult and the results have been variable. Weedy *Sporobolus* grasses continue to rapidly spread into new areas. A biocontrol project was implemented in the 1990s but did not result in the release of any agents. The indigenous fungus *Nigrospora oryzae* does not appear to be as damaging against giant rat's tail grasses as it is to giant Parramatta grass.

With funding from the Australian Government Department of Agriculture, Water and the Environment and AgriFutures Australia, this project is now exploring biocontrol options in South Africa. We are building on the earlier biocontrol program, which identified several phytophagous species worth investigating. Populations of wasps from the genera *Tetramesa* and *Bruchophagous* have been found on different species of *Sporobolus*. Field host-range testing indicated that three wasp species were suitable for introduction into Australia. Laboratory testing in South Africa on *Tetramesa* species A confirmed specificity and the insect will be imported into Australia when COVID-19 restrictions allow. Under a new round of funding, a second *Tetramesa* species will be tested in South Africa.

Collaborators

- Rhodes University (South Africa)
- Economic Development of Queensland
- Gladstone Regional Council
- Bundaberg Regional Council
- AgriFutures Australia
- Australian Government Department of Agriculture, Water and the Environment

Key publications

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

Palmer, WA, Yobo, KS & Witt, AB 2008, 'Prospects for the biological control of the weedy sporobolus grasses in Australia', *Proceedings of the 16th Australian weeds conference,* The Weed Society of Queensland, Brisbane, pp. 18–22.

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.

7. Biocontrol of mother-of-millions

Project dates

July 2016 – June 2020

Project team

Michael Day, Natasha Riding and David Comben

Project summary

Mother-of-millions (*Kalanchoe* spp. = *Bryophyllum* spp.) is native to Madagascar and has become a major weed in Queensland and northern New South Wales. In an earlier biocontrol project, field surveys were conducted in Madagascar and four potential agents were prioritised. Host-specificity testing was conducted on two species, but these attacked closely related ornamental plants in several genera.

A new biocontrol project on mother-of-millions, plus several other weed species, was funded by the Australian Government Department of Agriculture, Water and the Environment and AgriFutures Australia. The project aims to improve available control options for farmers by exploring options for biocontrol in Madagascar. It builds on the earlier work, which identified several species worth investigating. We imported a root-feeding flea beetle (*Bikasha* sp.) into quarantine at the Ecosciences Precinct to study its biology and host-specificity. Unfortunately, the adult beetles fed on all non-target species to which they were exposed. Also, larvae completed development to the adult stage on most non-target plant species tested. Therefore, the beetle is deemed not suitable for release in Australia and the culture will be destroyed. At this stage, there are no plans to continue this work, as no other potential agents worth pursuing have been identified in Madagascar.

Collaborators

- AgriFutures Australia
- Australian Government Department of Agriculture, Water and the Environment
- New South Wales Department of Primary Industries
- University of Antananarivo (Madagascar)
- Local government and NRM groups

Key publications

Palmer, B & Rafter, M 2012, '*Bryophyllum delagoense* (Ecklon & Zeher) Schinz—mother-of-millions', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia*, CSIRO Publishing, Melbourne, pp. 99–107.

Witt, A & Rajaonarison, J 2004, 'Insects associated with *Bryophyllum delagoense* (Crassulaceae) in Madagascar and prospects for biological control of this weed', *African Entomology (South Africa)*, vol. 12, pp. 1–7.

8. Biocontrol of pasture weeds in Vanuatu and Queensland

Project dates

October 2018 – June 2023

Project team

Michael Day and Tamara Taylor

Project summary

Biosecurity Queensland is collaborating with Manaaki Whenua Landcare Research New Zealand on a 5-year weed biocontrol project based in Vanuatu (funded by the New Zealand 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 risk of weed species spreading to other countries, including Australia, and enable sharing of weed management practices between countries. They are also an efficient use of resources, with the cost of finding and testing biocontrol agents shared.

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 weed in Queensland). These weeds are new biocontrol targets, and overseas exploration in the respective native ranges is needed to locate potential candidates. Potential candidates for *S. tora* will be brought into quarantine at the Ecosciences Precinct, while those for *S. torvum* and *U. lobata* will be studied in New Zealand. If appropriate, we will prepare and submit applications seeking approval to release the agents in Australia and Vanuatu. Potential agents for all three target species have been located, but have not yet been imported into a quarantine facility. Due to COVID-19 restrictions, the candidates for *S. tora* and *U. lobata* will be studied in Malaysia until the agents can be shipped to Australia and New Zealand.

Five other weeds will also be targeted under this project and will involve importing effective agents from Queensland or elsewhere into Vanuatu. The weeds are *Spathodea campanulata*, *Parthenium hysterophorus*, *Lantana camara*, *Mimosa diplotricha* and *Dolichandra unguis-cati*, all restricted weeds in Queensland. Agents for *S. campanulata* will be considered for introduction into Queensland to help manage the weed here if warranted. The tingid *Carvalhotingis visenda*, a biocontrol agent for cat's claw creeper (*D. unguis-cati*), was introduced into Vanuatu in 2019 and has established at several sites. All biocontrol 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 New Zealand Ltd
- New Zealand Ministry of Foreign Affairs and Trade
- Biosecurity Vanuatu
- Vanuatu Department of Environmental Protection and Conservation
- 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.

9. Biocontrol of *Cylindropuntia* species

Project dates

July 2009 – June 2020

Project team

Michael Day, Tamara Taylor and Jason Callander

Project summary

Cylindropuntia cactus species are native to tropical America. The group includes eight species that have naturalised in Australia. *C. 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.

A lineage (genetic variant) of the cochineal *Dactylopius tomentosus* was introduced into Australia for the biocontrol of *C. imbricata* in 1925, but it does not attack the other *Cylindropuntia* species. Over the last four years, we released an additional five lineages of *D. tomentosus* in Queensland for the control of the remaining *Cylindropuntia* species, and each of the lineages performed best on particular species. We are currently monitoring the efficacy of these agents in the field. The agent for coral cactus is providing excellent control. Other lineages have established in at least one release site, with some providing good control. However, the lineage released for the control of *C. spinosior* is not performing well in the field in Queensland, so we are undertaking trials to find an alternative lineage. One lineage is promisingly damaging on *C. spinosior*, but is still undergoing testing. We have planned release and field monitoring for late 2020.

The different lineages can now be identified with genetic tools. These will help determine which lineages are effectively controlling cactus in the field in locations where their identity is unknown.

With additional field releases and dispersal of *D. tomentosus* lineages, the likelihood of two lineages interacting increases. We have conducted three hybridisation experiments between the most likely interacting lineages. Two experiments suggested little or no loss of effectiveness from interbreeding. However, the third experiment indicated a significant reduction in efficacy of the hybrid lineages on the target *Cylindropuntia* species. We will repeat the experiment to confirm the results, as this will influence release strategies for these lineages.

We are running an integrated management field trial for *C. imbricata*. Initial results suggest that a combination of biocontrol, mechanical control and chemical control is most effective in controlling *C. imbricata*.

Tamara Taylor and Jason Callander collecting *C. imbricata* at Gladfield for cochineal culture

Collaborators

- Ted Vinson, Craig Hunter, Pedro Hodgson, John Conroy, Garry Pidgeon and Cameron Wilson (Biosecurity Queensland)
- Jeffery Newton (Longreach Regional Council)
- Andrew McConnachie (New South Wales Department of Primary Industries)
- Andrea Fletcher and Mat Savage (Castlereagh Macquarie County Council)
- Iain Paterson (Rhodes University, South Africa)
- Dr Helmuth Zimmermann (Consultant, South Africa)

Key publications

Holtkamp, RH 2012, '*Cylindropuntia imbricata* (Haw.) F. M. Knuth—rope pear *Cylindropuntia rosea* (DC.) Backeb.—Hudson pear', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia*, CSIRO Publishing, Melbourne, pp. 198–202.

Jones, PK, Holtkamp, RH, Palmer, WA & Day, MD 2015, 'The host range of three biotypes of *Dactylopius tomentosus* (Lamarck) (Hemiptera: Dactylopiidae) and their potential as biological control agents of *Cylindropuntia* spp. (Cactaceae) in Australia', *Biocontrol Science and Technology*, vol. 25, pp. 613–628.

Jones, PK, Holtkamp, RH & Day, MD 2016, 'The host range of four new biotypes of *Dactylopius tomentosus* (Hemiptera: Dactylopiidae) from southern USA and their potential as biological control agents of *Cylindropuntia* spp. (Cactaceae) in Australia: part II', *Biocontrol Science and Technology*, vol. 26, pp. 1033–1047.

10. 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. Biocontrol is the most desirable option for managing the weed and commenced in 2001. 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 released into the field. All three agents have established but their distribution and abundance vary widely. Our current research focus is on monitoring the establishment and spread of the leaf-tying moth and the leaf-mining beetle.

Because cat's claw creeper is a perennial vine with abundant subterranean tuber reserves, it can only be effectively controlled when multiple agents attack various parts of the plant. Therefore, future research will focus on testing plant pathogens such as a leaf-spot disease (*Cercosporella dolichandrae*), a leaf rust (*Prospodium macfadyena*) or a gall rust (*Uropyxis rickiana*) for release in Australia.

Leaf-tying moth

A leaf-tying moth 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 and tie them together with silk, creating silken tunnels. We conducted monthly systematic surveys in four regions (Boompa, Lake Moogerah, Coominya and Oxley) in Queensland from November 2019 to May 2020, monitoring the incidence and intensity of damage. Larval activities in the field were evident from December 2019 to June 2020. In contrast to CLIMEX model predictions, establishment to date has been mostly restricted to riparian zones. Field collection and redistribution of the leaf-tying moth larvae from the established sites to riparian sites in other river and creek systems is recommended.

Leaf-mining beetle

A leaf-mining beetle 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 adults feed on young leaves. The beetle continues to spread from release sites to new areas. An unidentified parasitoid of the leaf-mining jewel beetle was collected from the field. Our future research will focus on the seasonal incidence and abundance of the parasitoid in the field. We have commenced a glasshouse trial to study the potential impact of the leaf-mining jewel beetle (no jewel beetle v. one generation of jewel beetle v. two generations of jewel beetle v. three generations of jewel beetle) on cat's claw creeper (short-pod form v. long-pod form).

Plant pathogens

A leaf-spot pathogen that causes necrotic spots and premature leaf abscission and two rust fungi (a gall rust and a leaf rust) have been identified as prospective biocontrol agents for cat's claw creeper in Australia. Research with two of the pathogens (the leaf-spot pathogen and the gall rust) is underway at CABI in the United Kingdom. Subterranean tubers of the short-pod form of cat's claw creeper from Queensland and 10 test plant species were exported to CABI's quarantine facility for culturing the pathogens and for preliminary host-specificity testing.

For the leaf-spot disease, a reliable inoculation technique has been developed. In inoculation studies, the long-pod form of cat's claw creeper was found to be less susceptible than the short-pod form to the disease. To date, nine non-target species have been inoculated with the leaf-spot pathogen. While the total number of replicates for these species needs to be increased, initial indications are promising, with no symptoms recorded on any non-target species.

Photo courtesy of CABI, United Kingdom

Cat's claw creeper leaf infected with *Cercosporella dolichandrae*, CABI, United Kingdom

For the gall rust, due to infrequent germination of teliospores and inconsistent infection by basidiospores, host-range testing (either with the basidiospore or the urediniospore stage) is yet to commence. Experiments to determine the life cycle of the gall rust have continued and a more reliable inoculation technique using teliospores and resulting basidiospores has been developed by targeting the actively growing meristematic tissue.

Photo courtesy of CABI, United Kingdom

Cat's claw creeper infected with the gall-forming rust *Uropyxis rickiana*, CABI, United Kingdom

A survey for the leaf rust was conducted in Brazil in January 2020, but the rust pathogen could not be collected. Further surveys will be conducted once pandemic risks have eased and travel in Brazil can be undertaken safely.

Collaborators

- Seqwater
- Marion Seier and Kate Pollard (CABI, United Kingdom)
- Kevin Jackson (Gympie, Queensland)
- Anthony King (Plant Protection Research Institute, Pretoria, South Africa)
- Tanya Scharaschkin (Collinsvale, Tasmania)
- Robert Barreto and Adans Colman (Universidade Federal de Viscosa, Brazil)

Key publications

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.

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

11. Biocontrol of Siam weed (*Chromolaena odorata*)

Project dates

July 2011 – June 2020

Project team

Michael Day, Natasha Riding, Liz Snow, Tamara Taylor, Jason Callander, David Comben, Kelli Pukallus and Ainsley Kronk

Project summary

Siam weed (*Chromolaena odorata*) was first reported in Queensland in 1994 and is also present in the Australian territories of Christmas Island and Cocos Islands. It was the target of a nationally cost-shared eradication program until 2012, and was approved as a target for biocontrol in 2011, following several reviews of the eradication program.

The *Chromolaena* gall fly, *Cecidochares connexa*, is deemed host-specific. It was tested in 7 countries against a total of 122 species before it was released in 12 countries, including Papua New Guinea, Indonesia, Guam and Timor Leste, where it is controlling or aiding the control of *Chromolaena*. It was imported into quarantine at the Ecosciences Precinct in 2012 and tested against species in the Eupatorieae tribe before being approved for release in December 2018.

C. connexa was collected in Papua New Guinea and re-imported into Australia. We reared one generation in quarantine before establishing a culture at the Tropical Weeds Research Centre in Charters Towers. We released *C. connexa* widely in northern Queensland, and it has established at numerous sites and is beginning to spread. It has also been released in the Northern Territory, where it has established. We are monitoring its impact on *C. odorata*.

Collaborators

- Sim Sar (National Agricultural Research Institute, Papua New Guinea)
- Anna Kawi (National Agriculture Quarantine and Inspection Authority, Papua New Guinea)
- Local governments in northern Queensland

Key publications

Day, M & McFadyen, RC 2012, '*Chromolaena odorata* (L.) King and Robinson—chromolaena', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia*, CSIRO Publishing, Melbourne, pp. 162–169.

Day, MD, Riding, N & Senaratne, KADW 2016, 'The host specificity and climatic suitability of the gall fly *Cecidochares connexa* (Diptera: Tephritidae), a potential biological control agent for *Chromolaena odorata* (Asteraceae) in Australia', *Biocontrol Science and Technology*, vol. 26, pp. 691–706.

12. 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 and spread throughout pastures along the coast of New South Wales and south-eastern Queensland. However, its distribution in Australia is now unclear due, at least in part, to its confusion with the native *S. lautus* complex.

Fireweed is difficult to eradicate and has the potential to compete strongly with useful pasture species under a range of fertility conditions. 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 than cattle and horses to poisoning from pyrrolizidine alkaloids.

Through this three-year collaborative doctorate project with The University of Queensland, we are investigating:

- the reproductive output of fireweed in the Queensland environment
- its impact on native and introduced pasture plants
- determinants of invasiveness (in addition to reproductive capacity)
- management effectiveness.

The PhD candidate Kusinara Wijayabandara has completed a comprehensive study on the seed biology of fireweed, aimed at reducing its impact on pasture productivity. The biological data produced could be used to develop a sustainable integrated weed management program for fireweed. The foliar herbicide trial at Beechmont identified additional lines of research that need to be investigated. 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 per square metre in the plots. A masters student will be undertaking additional integrated weed management studies during 2020–21, pending easing of COVID-19 restrictions.

Collaborators

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

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

Project dates

February 2017 – June 2020

Project team

Joseph Vitelli, David Holdom, Annerose Chamberlain, Tracey Steinrucken, Drew Rapley, Nontaporn Kukuntod and Jimmy Hosking

Project summary

Sporobolus R.Br. is a genus of 186 accepted grass species and 12 unresolved species in tropical and subtropical areas of the world, including Africa, temperate Asia, tropical Asia, Australasia, North America and South America. In Australia, 18 species are endemic and a further 6 species are naturalised. In rangeland situations, *Sporobolus* species are not desirable pasture grasses and usually indicate a degraded grazing system. The few native species regarded as favourable fodder species (*S. actinocladus, S. caroli, S. mitchellii* and *S. virginicus*), due to their high protein content when fresh, do not provide much bulk. The 5 introduced weedy *Sporobolus* grasses are a serious concern to the grazing industry of eastern Australia. They cost the industry an estimated $60 million per annum and have the potential to completely dominate pastures at the exclusion of most other species. These weeds are part of the *S. indicus* complex, which includes *S. pyramidalis* and *S. natalensis* (giant rat's tail grass), *S. fertilis* (giant Parramatta grass), *S. africanus* (Parramatta grass) and *S. jacquemontii* (American rat's tail grass).

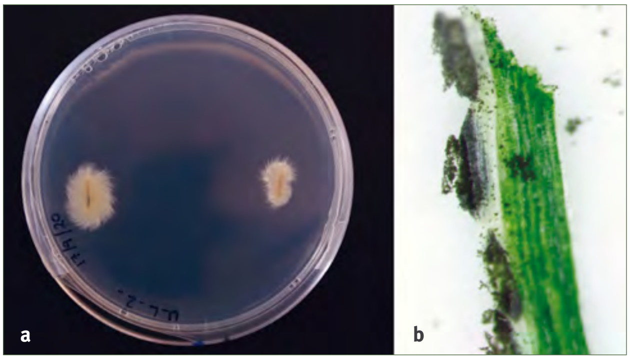
This project has two components:

- use of molecular tools to construct a phylogenetic tree of introduced and native *Sporobolus* grasses in Australia, to help identify classical biocontrol agents that are host-specific for weedy *Sporobolus*
- investigation of endemic Australian pathogens of *Sporobolus* that are effective against weedy *Sporobolus*.

Because the 5 weedy *Sporobolus* grasses are so morphologically similar, they are often difficult to distinguish from each other and from some of the native species. We are continuing to refine an identification tool (based on molecular technology utilising nuclear and plastid markers) to help distinguish these weedy *Sporobolus* grasses from all other *Sporobolus* species. Plant material from over 100 voucher *Sporobolus* samples used in the Simon and Jacob *Sporobolus* revision[1] were sourced from the Queensland Herbarium for destructive sampling to further strengthen the phylogeny of the *Sporobolus* genus. The study to date has found that only 44% of samples align molecular phylogeny to morphological identification, 47% of the taxon contain data where morphology and molecular data disagree and 9% of the taxon data had no molecular referencing. One of the rare *Sporobolus* species, *S. pamelae* (a native listed as endangered in Schedule 2 of the Queensland *Nature Conservation Act 1992*), has been grouped within the weedy *S. indicus* complex. Further testing is underway, as this may influence the pathogenicity screening of endemic pathogens and other biocontrol agents.

We carried out pathogen surveys (during 2017–2020) of pasture, roadsides and forest verges across 64 *Sporobolus*-infested sites. We removed from the field 159 tussocks and pieces of symptomatic plant material belonging to 13 species of *Sporobolus* and transported them to the Ecosciences Precinct for further examination. Of these, 134 plants displayed foliar disease symptoms, yielding over 500 isolates belonging to 44 fungal genera, 9 of which (*Colletotrichum, Curvularia, Microdochium, Neopestalotiopsis, Paraphaeosphaeria, Pestalotiopsis, Phoma, Septoria* and *Stagonospora*) are known to contain fungal species pathogenic on grasses worldwide. We will focus on 24 genera and 7 novel genera. The genera of interest contain 70 species (80% of which are new species) and will require additional sequencing before we can complete prioritisation.

Two honours students are contributing essential baseline knowledge on pathogens that could lead to the development of a bioherbicide aimed at reducing the impact of giant rat's tail grass. Drew Rapley is focusing on *Ustilago sporoboli-indici* and Nontaporn (Jess) Kukuntod is focusing on *Microdochium dawsoniorium*, *Neopestalotiopsis nebuloides*, *Pestalotiopsis etonensis*, *Alternaria* sp. BRIP68540, *Colletotrichum* sp. BRIP69684, *Colletotrichum* sp. BRIP70194, *Curvularia* sp. BRIP69020, *Dictyochaeta assamica* BRIP69688, *Epicoccum draconis* BRIP70661, *Magnaporthiopsis* sp. BRIP69698, *Neopestalotiopsis* sp. BRIP68236, *Neopestalotiopsis* sp. BRIP70881 and *Phaeosphaeria* sp. BRIP70656.



Koch's postulate testing for *Ustilago sporoboli-indici* following its inoculation onto *Sporobolus laxus*: **a** showing the recovered pathogen and **b** showing sori development typically found on plants infected with *U. sporoboli-indici*

Pathogenicity testing of the endemic pathogen *Neopestalotiopsis nebuloides* on five introduced *Sporobolus* species

1 Simon, BK & Jacobs, SW 1999, 'Revision of the genus *Sporobolus* (Poaceae, Chloridoideae) in Australia', *Australian Systematic Botany*, vol. 12, pp. 375–448.

Collaborators

- Roger Shivas, Kaylene Bransgrove, Sharon Bishop-Hurley and Yu Pei Tan (Biosecurity Queensland)
- Australian Government Department of Agriculture, Water and the Environment
- AgriFutures Australia
- New South Wales Department of Primary Industries
- Victorian Department of Economic Development, Jobs, Transport and Resources
- New South Wales Weed Biocontrol Taskforce
- New South Wales Environmental Trust
- Bundaberg Regional Council (including Eric Dyke and James Anderson)
- Gladstone Regional Council (including Brett Cawthray, Glenn Cox, Melissa Hele and Rob Teakle)
- Gympie Regional Council
- HQPlantations Pty Ltd
- Trevor and Margaret Dawson (Taunton)

Key publications

Lock, C, Vitelli, JS, Holdom, DG, Tan, YP & Shivas, RG 2020, '*Microdochium dawsoniorium*. Fungal planet description sheet: 1092', *Persoonia*, vol. 44, pp. 416–417, ‹https://doi.org/10.3767/persoonia.2020.44.11›.

Lock, C, Vitelli, JS, Holdom, DG, Tan, YP & Shivas, RG 2020, '*Neopestalotiopsis nebuloides*. Fungal planet description sheet: 1097', *Persoonia*, vol. 44, pp. 426–427, ‹https://doi.org/10.3767/persoonia.2020.44.11›.

Lock, C, Vitelli, JS, Holdom, DG, Tan, YP & Shivas, RG 2020, '*Pestalotiopsis etonensis*. Fungal planet description sheet: 1102', *Persoonia*, vol. 44, pp. 436–437, ‹https://doi.org/10.3767/persoonia.2020.44.11›.

Vitelli, JS 2020, *Giant rat's tail grass endemic pathogen project (QDAF—RnD4Profit—15-02-005): rural R&D for profit program final report*, submitted to AgriFutures Australia.

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

Project dates

February 2017 – June 2021

Project team

Joseph Vitelli, Annerose Chamberlain, Jimmy Hosking, Tim Boniface, Drew Rapley and Nontaporn Kukuntod

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 horizon. 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 managing tussock weeds such as giant rat's tail grass. 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 giant rat's tail tussocks, 29% of the applied granular flupropanate but only 13% of the applied liquid flupropanate was found in the soil 24 months after application. Of the applied flupropanate, irrespective of application method, ~10% 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), 55% (granular application) and 59% (liquid application) of the applied flupropanate was found 24 months later.

We also established an in-vitro experiment, to determine the survival of either seed or seedlings of nine competitive pasture species [Bambatsi (*Panicum coloratum*), Bisset creeping bluegrass (*Bothriochloa insculpta*), buffel grass (*Cenchrus ciliaris*), Callide rhodes grass (*Chloris gayana*), forest bluegrass (*Bothriochloa bladhii*), kikuyu (*Cenchrus clandestinus)*, Premier digit (*Digitaria eriantha*), setaria (*Setaria sphacelata*), signal grass (*Urochloa decumbens*) and silk sorghum (*Sorghum* spp.)] and five *Sporobolus* grasses [Parramatta grass (*S. africanus*), slender rat's tail grass (*S. creber*), giant rat's tail grass (*S. natalensis*) and marine couch (*S. virginicus*)] when exposed to five different flupropanate concentrations (0, 375, 750, 1500 and 6000 grams of active ingredient per hectare). The recommended flupropanate rate of application to control giant rat's tail grass (1500 grams of active ingredient per hectare) killed over 70% of the Bisset creeping bluegrass, buffel grass, Callide rhodes grass and Premier digit seedlings. Only 13% and 1% of setaria and kikuyu seedlings, respectively, were killed when using flupropanate at 6000 grams of active ingredient per hectare. Bisset creeping bluegrass and Premier digit were also the most susceptible pasture seed species killed, with a seed mortality of 59%, irrespective of flupropanate concentration. The average seed mortality for kikuyu, *S. africanus* and *S. creber* was below 10%. Among all competitive pastures tested, kikuyu was the most tolerant to flupropanate (followed by setaria and Bambatsi) and could be involved in integrated management of weedy *Sporobolus* grasses when conditions for pasture growth are optimum.

Giant rat's tail grass after late dry-season boom-spray application of flupropanate (untreated grass in background)

Dense signal grass established following boom-spray, seed and fertiliser application (untreated giant rat's tail grass in background)

Collaborators

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

15. 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 and sugarcane industries in the Queensland Wet Tropics. It is unpalatable for livestock, and can form 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. Further, these control methods only provide short-term relief. Biocontrol of Navua sedge has the potential to offer an additional weapon in the arsenal of tools available to manage the weed.

Native range survey

We carried out surveys in Tanzania, Zanzibar and Kenya in partnership with research collaborators (mycologist and plant taxonomists) from the University of Southern Queensland, National Herbarium of Tanzania and East African Herbarium. Several prospective fungal biocontrol agents were discovered on these surveys. These included a smut fungus (*Cintractia* sp.) that infected the inflorescences and destroyed florets and seeds, a leaf- and stem-infecting rust (*Uredo kyllingae-erectae*), an inflorescence-infecting ascomycete (*Curvularia* sp.), a systemic stem-colonising ascomycete (*Balansia* sp.) and several unidentified leaf- and stem-spotting fungi. Taxonomic studies using morphological and molecular methods have shown that the smut fungus and *Curvularia* represent new species.

The smut fungus (*Cintractia* sp.) was collected from multiple field sites in Nigeria and Tanzania. Specimens of the rust, smut and *Curvularia* fungus, together with rhizomes of Navua sedge, were collected and exported from Africa to CABI in the United Kingdom, for establishment of the fungi in quarantine. These fungi will be evaluated as potential biocontrol agents in pathogenicity trials and host-specificity tests. Dried material was also deposited as reference specimens at herbariums in Africa, Germany and Australia.

Due to travel restrictions caused by the COVID-19 pandemic, future planned surveys for biocontrol agents of Navua sedge elsewhere in Africa have been temporarily suspended.

Testing agents for host-specificity

We have submitted an application to have Navua sedge endorsed as a suitable candidate for biocontrol to the national Environment and Invasives Committee. This is a prerequisite for the release of biocontrol agents for its control in Australia.

We have developed a draft test plant list comprising about 40 plant species for host-specificity testing of Navua sedge biocontrol agents in quarantine. Test plants were selected based on their phylogenetic relationship with the target weed, with an emphasis on Cyperaceae species formerly placed in *Kyllinga*, which are characterised by distinct terminal capitate inflorescences. Australian native C4 species of Cyperaceae and other economically important grasses have also been included in the test list. We will circulate the list to relevant sedge taxonomists and biocontrol researchers in Australia for refinement. The seeds or plants of test species will be procured and exported to CABI in the United Kingdom for host-specificity tests.

A smut fungus (*Cintractia* sp.) from Tanzania and Nigeria that attacks flower heads and destroys florets and seeds has been prioritised as the first agent for detailed host-specificity testing by CABI in the United Kingdom. Teliospores of the smut collected from both countries successfully infect Navua sedge plants from Australia. Sporidia from teliospores of both strains have been successfully cultured on artificial medium. Inoculation testing showed that sporidia of both strains are able to consistently infect the flowers of Australian Navua sedge plants. All the seeds are infected when young flowers are inoculated. However, for older flowers, some of the seeds are not infected. Funding to conduct host-specificity testing of this smut fungus was secured from AgriFutures Australia and the Australian Government Department of Agriculture, Water and the Environment. For the rust fungus (*Uredo kyllingae-erectae*), inoculation testing using urediniospores is ongoing. All the pathogens have been deposited in liquid nitrogen in CABI in the United Kingdom.

Ecological research

A CLIMEX model for Navua sedge has been developed, based on its native range distribution. The University of Queensland will conduct genetic matching studies using Navua sedge leaf samples sourced from the native range (equatorial Africa) and Australia to determine the source of Australian Navua sedge populations. This information will be used to target future native range surveys in countries with genetically similar Navua sedge populations.

A field experiment by PhD candidate Aakansha Chadha to study the impact of burial depth on seed longevity on a northern Queensland grazing property (Tarazali) infested with Navua sedge

A masters study on the management of Navua sedge using competition and simulated herbivory of desirable pasture species (humidicola grass and rhodes grass) was completed in November 2019. The study identified that rhodes grass was more competitive than humidicola grass in glasshouse studies that simulated the effect of grazing.

A PhD study on the biology, ecology and management of Navua sedge is in progress at the Federation University (Ballarat, Victoria). The study encompasses laboratory, glasshouse and field research, focusing on seed ecology (longevity, germination and seed bank), rhizome biology and efficacy of chemical control. Due to COVID-19, some aspects of the field studies have been suspended till the travel restrictions are lifted in Victoria.

Collaborators

- Roger Shivas (University of Southern Queensland)
- Carol Ellison, Marion Seier and Daisuke Kurose (CABI, United Kingdom)
- Florentine Singarayer and Aakansha Chadha (Federation University, Ballarat)
- Alistair McTaggart (QAAFI, The University of Queensland)
- Yu Pei Tan (Queensland Plant Pathology Herbarium)
- Melissa Setter and Stephen Setter (Tropical Weeds Research Centre, South Johnstone)
- Shane Campbell, Steve Adkins and Abhishek Soni (The University of Queensland, Gatton)
- Mutuku Musili and Frederick Munyao Mutie (East African Herbarium, Kenya)
- John Elia Ntandu (National Herbarium of Tanzania)
- Ocholi T Edogbanya (Kogi State University, Anyigba, Nigeria)
- Emmanuel C Chukwuma (Forest Research Institute of Nigeria)
- Isabel Larridon (Kew Gardens, United Kingdom)
- Julia Kruse (Natural History Museum, Germany)
- James Hereward and Gimmie Walter (The University of Queensland, St Lucia)
- Joe Rolfe and Bernie English (Agri-Science Queensland, Mareeba)
- Rob Pagano (Tarazali)
- Sydes Travis (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

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.

16. Biocontrol of parthenium (*Parthenium hysterophorus*)

Project dates

July 2004 – June 2021

Project team

K Dhileepan, Olusegun Osunkoya, Boyang Shi and Christine Perrett

Project summary

Parthenium weed (*Parthenium hysterophorus* L.) is a noxious weed of grazing areas in Queensland and a Weed of National Significance in Australia. Parthenium also causes severe human and animal health problems. Eleven biocontrol agents (nine insect species and two rust pathogens) have been released against parthenium in Australia. The majority of these agents have become widely established and have proven effective against the weed in central Queensland.

Parthenium is spreading into southern Queensland, where many of these biocontrol agents are not present. Therefore, we have redistributed 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*) into southern Queensland. We will continue redistributing these agents and will monitor their establishment in the field.

Due to the extended dry spring and summer, continued field collection and redistribution of agents from central Queensland was not possible. We conducted surveys at Helidon Spa, Gatton and Wivenhoe dam in November 2019, but no agents were found as there was no parthenium due to the drought. Field establishment of the seed-feeding *Smicronyx* weevils was confirmed along the Burnett River near Gayndah in December 2019. In February 2020, establishment and persistence of all four released agents (summer rust, *Epiblema* moth, *Carmenta* moth and *Smicronyx* weevil) were confirmed in the Kilcoy release sites. Since then, due to travel restrictions because of COVID-19, we have not conducted any follow-up surveys.

Field survey of parthenium biocontrol agents along the Burnett River, Gayndah

Collaborators

- Steve Atkins (The University of Queensland, Gatton)
- Asad Shabbir (University of Sydney)
- Ken Woodall (RAPID 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)

Key publications

Dhileepan, K & McFadyen, RE 2012, '*Parthenium hysterophorus* L.—parthenium', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia*, CSIRO Publishing, Melbourne, pp. 448–462.

Dhileepan, K 2009, 'Managing *Parthenium hysterophorus* across landscapes: limitations and prospects, in S Inderjit (ed.), *Management of invasive weeds*, Invading Nature—Springer Series in Invasion Ecology, vol. 5, Springer Science, pp. 227–260.

Dhileepan, K & Strathie, L 2009, '20. *Parthenium hysterophorus*', in R Muniappan, DVP Reddy & A Raman (eds), *Weed biological control with arthropods in the tropics: towards sustainability*, Cambridge University Press, Cambridge, United Kingdom, pp. 272–316.

17. 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 is a Weed of National Significance and a target for biocontrol, but there has been limited success with this to date. We used plant phenotype and climate matching to prioritise countries and areas for native range surveys for prospective agents, and surveys were conducted in Ethiopia and Senegal. During the native range surveys, priority was given to galling agents because of their host-specificity. Based on field host range, geographic range and damage potential, a gall thrips (*Acaciothrips ebneri*) that induces shoot-tip rosette galls, a gall mite (*Aceria* sp.) that deforms leaflets, rachides and shoot-tips in Ethiopia, and a gall fly (*Notomma mutilum*) that induces stem-galls in Senegal have been prioritised for further studies. Host-specificity testing of these agents is in progress.

Gall thrips

The gall thrips induces rosette galls in the axillary and terminal buds of prickly acacia, resulting in shoot-tip dieback. The gall thrips from Ethiopia was imported into a high-security quarantine facility at the Ecosciences Precinct in Brisbane, and host-specificity tests are nearing completion. To date, over 55 test plant species have been tested, with a minimum of 5 replicates of each species. The gall thrips induced galls and reproduced on prickly acacia only, and not on any of the non-target test plant species. Life-cycle and adult longevity studies on the gall thrips are in progress. Adults live for up to 12 weeks, and females live longer than males. A female can produce approximately 200 progeny in a lifetime. Preliminary life-cycle studies suggest that the gall thrips completes a generation in 30 days at 20 ± 2 degrees Celsius. We are preparing an application for submission to the regulatory authorities in Australia seeking approval to release the gall thrips in Australia.

No-choice host-specificity testing of gall thrips in the high-security quarantine facility in Brisbane

Gall mite

In Ethiopia, three morphologically distinct *Aceria* mite galls were found on prickly acacia: red spherical leaflet galls (type-1), creamy-white fluted leaflet galls (type-2) and hairy mushroom-like galls on leaflets, rachises and shoot-tips (type-3). In Senegal, the type-2 and type-3 galls found in Ethiopia were also recorded. The gall mites have been sent to a mite taxonomist in Turkey, to resolve their taxonomy.

A colony of the type-3 gall mites from Ethiopia was established on prickly acacia (sourced from Australia) in a quarantine facility in Pretoria, South Africa, in December 2017. To date, no-choice host-specificity tests have been completed for 7 test plant species. Results suggest that the gall mite induced galls on prickly acacia sourced from Australia only 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. Unfortunately, the colony of the gall mite in quarantine in South Africa collapsed in November 2019, with no new gall development. Further host-range testing was not possible, due to the low number of mites available for inoculation of test plants. Importation of additional gall mites from Ethiopia has been delayed due to international travel restrictions because of COVID-19. Host-specificity testing will recommence when it is safe to travel to Ethiopia to collect and export gall mites to South Africa.

No-choice host-specificity testing of a gall mite (*Aceria* sp. type-3) in a quarantine facility in Pretoria, South Africa

Gall fly

In Senegal, the fly *Notomma mutilum* (Bezzi) (Diptera: Tephritidae), which induces stem galls, has been identified as a prospective agent. This is the first time that a gall-inducing tephritid fly associated with prickly acacia has been collected. Stem galls were imported from Senegal in October 2017, April 2018 and June 2019 into quarantine in Brisbane, for colony establishment and host-specificity testing. A total of 686 adults emerged from stem galls imported from Senegal in June 2019. Emerged adults were used for colony establishment and preliminary host testing. Oviposition and gall formation were observed in a majority of the prickly acacia plants exposed to the gall fly in quarantine. However, the number of galls induced was highly variable and only 119 adults emerged from the colony cages. All emerging adults were utilised for colony establishment. Next-generation adults are also being utilised for colony establishment. The reasons for the varied oviposition and therefore very low adult emergence are not known. Additional importations of the gall fly from Senegal are needed to enhance the quarantine colony in Brisbane. Due to the current travel restrictions because of COVID-19, importation of the gall fly has been delayed. Host-specificity testing will recommence following further importation.

Stem galls induced by *Notomma mutilum* on prickly acacia in the quarantine facility in Brisbane

Collaborators

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

Key publications

Dhileepan, K, Taylor, DBJ, Lockett, CJ, Balu, A, Seier, M, Murugesan, S, Tanner, RA, Pollard, KM, Kumaran, N & Neser, S 2014, 'Biological control of prickly acacia (*Vachellia nilotica* subsp. *indica*): current research and future prospects', *Proceedings of the XIV international symposium on biological control of weeds*, Kruger National Park, South Africa, pp. 21–30.

Dhileepan, K, 2009, '2. *Acacia nilotica* ssp. *indica*', in R Muniappan, DVP Reddy & A Raman (eds), *Weed biological control with arthropods in the tropics: towards sustainability*, Cambridge University Press, Cambridge, United Kingdom, pp. 17–37.

18. Weed seed dynamics

Project dates

August 2007 – June 2022

Project team

Simon Brooks, Danielle Brazier and Clare Warren

Project summary

There are many weeds for which we know little about seed ecology and longevity. Such information is invaluable for the timing and duration of weed control programs. In this project, we investigate the seed longevity of priority weeds by burying seeds enclosed in bags in two different soil types (black clay and river loam), with and without grass cover, and up to four burial depths (0, 2.5, 10 and 20 centimetres). We retrieve seeds at predetermined times, then test them for germinability and viability.

We have completed testing on seeds of yellow oleander, mesquite, chinee apple, gamba grass, calotrope, leucaena, yellow bells, neem tree and stevia. Completed trials have shown that neem and yellow bells have a relatively transient seed bank that is exhausted after 1 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 5 years. Trials of lantana and parthenium concluded in 2019 and small numbers of viable seeds were retrieved between 5 and 10 years burial. Retrievals of prickly acacia and sicklepod seed are continuing.

We are also undertaking a seedling emergence trial to quantify the environmental conditions influencing the field emergence of neem tree, leucaena, prickly acacia, chinee apple and mesquite seeds. Seedling emergence has been recorded after several rainfall events. Neem tree seedling emergence was consistent with short-term persistence, while prickly acacia and leucaena emergence reflects weeds with long-lived seed banks.

We have commenced experiments that compare the data from buried seed packet trials with a laboratory test of relative longevity (the controlled ageing test). Correlating these results will reduce the time needed to classify weed seeds into broad longevity categories.

Collaborators

- Shane Campbell (The University of Queensland)
- Faiz Bebawi

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.

Experimental area for determining seed longevity at the Tropical Weeds Research Centre, Charters Towers

19. Research supporting the management of nationally significant tropical weeds

Project dates

July 2008 – June 2021

Project team

Simon Brooks, Kirsty Gough, Stephen Setter and Melissa Setter

Project summary

In this project, we develop and refine methods for monitoring progress towards eradication of species under the National Tropical Weeds Eradication Program. We also investigate key aspects of the biology of these species (such as seed-bank persistence, age to maturity and dispersal potential) and effective control measures.

Field trials investigating seed persistence of *Miconia calvescens*, *M. racemosa, M. nervosa* and *Mikania micrantha* have been running for 4 to 10 years, and all species have shown persistent seed banks. Also, our glasshouse trial of *Limnocharis flava* seed persistence under varying periods of immersion in water has been underway for 8 years.

Annually, we collect and process field soil seed-bank samples from *L. flava* and *M. micrantha* infestations. We are collating observations on the growth to maturity and reproductive seasonality of invasive melastomes to refine guidelines for identifying plants and preventing plants producing seed. The field data is being supplemented by results from glasshouse pot trials, where seedlings are established at regular intervals and grown to flowering. In 2018, we established a field plot to measure the growth of *M. nervosa*. More recently, we have commenced studies on field seed-bank densities and age to maturity for the prohibited weed white ball acacia (*Acaciella angustissima*) to support its eradication.

We continue to investigate aspects of the biology and control of the former eradication target species *Chromolaena odorata* and *Clidemia hirta*. Local trials are investigating seed-bank longevity, seed-bank depletion, age to maturity, germination requirements and herbicide efficacy.

Collaborators

- National Tropical Weeds Eradication Program
- Biosecurity officers (Biosecurity Queensland, North Region)
- Queensland Parks and Wildlife Service (Queensland Department of Environment and Science)
- Mareeba Shire Council
- Cassowary Coast Regional 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.

Flowering white ball acacia surrounded by leucaena clearly seen in a drone-recorded image

20. Mass-rearing and release of biocontrol agents in northern Queensland

Project dates

July 2019 – June 2023

Project team

Kelli Pukallus and Ainsley Kronk

Project summary

In this project, we mass-rear, release and monitor biocontrol agents in northern Queensland.

Australia's first biocontrol agent for Siam weed (*Chromolaena odorata*), a stem-galling fly (*Cecidochares connexa*), was approved for release in late 2018. Mass-rearing at the Tropical Weeds Research Centre, followed by releases, commenced in late 2019. The stem-galling fly was previously released in other countries, where it has been highly damaging to the weed. We have now released the fly within six local government areas in Queensland and have detected galls at and spreading from release sites in all six areas. We have also conducted pre- and post-establishment damage assessments every two months at six northern Queensland sites.

Monitoring of previously released biocontrol agents is important to determine their establishment rates and spread as well as factors influencing these. This information guides future releases, helps to determine the need for additional biocontrol and influences how biocontrol should be integrated with conventional control. We conduct yearly and monthly surveys on a variety of agents and catalogue collections of associated insects.

Adult female *Cecidochares connexa*

Chromolaena odorata stem with *Cecoidochares connexa* galls

Ainsley Kronk releasing adult *Cecidochares connexa* flies on *Chromolaena odorata*

Kelli Pukallus assessing *Chromolaena odorata* at an El Arish trial site

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 Government 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 Department of Environment and Natural Resources

21. Ecology and management of aquatic weeds of northern Australia

Project dates

January 2015 – June 2021

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 Amazonian 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 reproduction abilities in regional populations of hygrophila
- herbicide control of bogmoss
- seed viability and longevity in regional populations of Amazonian frogbit.

Initial results indicate that stem fragments of hygrophila are able to float and survive for 3 weeks in fresh or brackish water and 2 weeks in salt water, demonstrating the potential for dispersal via water movement. Also, regional populations of Amazonian frogbit were found to have viable seed.

Collaborators

- Biosecurity officers (Biosecurity Queensland)
- 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 & Setter, MJ 2019, 'Adapting autonomous underwater vehicles (AUV) for aquatic weed control', *Proceedings of the Queensland pest animal and weeds symposium*, The Weed Society of Queensland, Gold Coast.

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, Michael F, Setter, MJ & Waterhouse, BM 2017, '*Limnobium laevigatum* (Amazonian frogbit) ecology and control in the Wet Tropics', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Port Douglas.

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.

22. Best-practice research on Wet Tropics weeds

Project dates

January 2009 – June 2021

Project team

Melissa Setter and Stephen Setter

Project summary

Weeds are a major threat to the economic productivity and environmental integrity of the Wet Tropics. Many economically significant industries (including grazing, horticulture and fisheries) are affected if Wet Tropics weeds are not managed effectively. Weed encroachment can decrease biodiversity, placing rare and threatened communities and species at greater risk of extinction.

Socially, weed invasion can decrease people's enjoyment of the Wet Tropics (e.g. affecting recreational fishing through the debilitation of fish nurseries, reducing the scenic quality of natural areas, and decreasing the diversity of birds). Both the social and environmental considerations also affect the high tourism value of the region.

There is very little information on several key weed species threatening the Wet Tropics bioregion. Our study species include three Weeds of National Significance (pond apple, hymenachne and bellyache bush) and several others declared under state or local government legislation (e.g. Navua sedge, neem tree and leucaena). Our research includes aspects of ecology and control tools that will support on-ground management, such as seed longevity in soil and water, age to reproductive maturity, rate of spread, dispersal mechanisms and control options developed in herbicide trials.

Collaborators

- Biosecurity officers (Biosecurity Queensland)
- Far North Queensland Regional Organisation of Councils
- Terrain NRM
- Cairns Regional Council
- Cassowary Coast Regional Council
- Tablelands Regional Council
- Etheridge Shire Council
- Mareeba Shire Council
- Douglas Shire Council
- Hinchinbrook Shire Council
- Cook Shire Council

Key publications

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. & Kukenth (Navua sedge)', *Plant Protection Quarterly*, vol. 30(2).

Brooks, SJ & Setter, SD 2012, 'Soil seed bank longevity information for weed eradication target species', *Pakistan Journal of Weed Science Research*, vol. 18.

Setter, SD, Setter, MJ, Patane, K, Logan, P & Sydes, D 2012, 'Pond apple (*Annona glabra* L.)—investigating novel mechanical control options', *Pakistan Journal of Weed Science Research*, vol. 18.

23. Tolerance of gamba grass and native plant species to pre-emergent herbicides

Project dates

December 2019 – June 2021

Project team

Melissa Setter, Stephen Setter, Clare Warren and Wayne Vogler

Project summary

Gamba grass (*Andropogon gayanus*), a high-biomass perennial grass, is a Weed of National Significance and a declared weed in Western Australia, the Northern Territory and Queensland. It is well documented as a species that can alter ecosystems by fuelling intense, catastrophic fires in northern Australia. Gamba grass can be managed with grazing, mechanical control and herbicide control, but the only herbicide registered for use on this weed to date is glyphosate, as a spot spray in the Environmental Weeds Permit (PER11463), or via aerial application in specific situations in the Northern Territory.

This collaborative project with CSIRO is externally funded by the National Environmental Science Program. A trial will provide herbicide information to improve management of gamba grass and restoration of native plant communities following gamba grass control. We will test pre-emergent herbicides on co-occurring native plant species and gamba grass to determine herbicide efficacy and species tolerance of each herbicide. We determined the test species and herbicides by consulting colleagues and experts and considering the outcomes of a gamba grass workshop held in Cairns in 2019.

Specifically, we aim to:

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

Melissa Setter and Clare Warren preparing pots for a trial of pre-emergent herbicides for gamba grass

Collaborators

- Helen Murphy, Andrew Ford and Matt Bradford (CSIRO, Queensland)
- John Clarkson (Queensland Department of Environment and Science)
- Natalie Rossiter-Rachor (Charles Darwin University, Northern Territory)
- Steve Dwyer and Tom Price (Northern Territory Department of Environment, Parks and Water Security)

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 Management and Restoration*, vol. 20, pp. 214–221, <https://doi:10.1111/emr.12376>.

24. Biocontrol of parkinsonia (*Parkinsonia aculeata*)

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. In previous biocontrol projects, UU (*Eueupithecia cisplatensis*) was mass-reared in large numbers at the Tropical Weeds Research Centre and released in Queensland, the Northern Territory and Western Australia.

In this project, we will expand the mass-rearing and release of the biocontrol agent UU2 (*Eueupithecia vollonoides*) throughout northern Australia. Our aim is to gain optimal establishment of UU2 in climatically suitable areas where UU2 has not previously been released or established. Releases will be in Queensland, the Northern Territory and Western Australia. This project is supported with funding from Meat & Livestock Australia and CSIRO.

Collaborators

- CSIRO (Brisbane)
- Fitzroy Basin Association Inc.
- Meat & Livestock Australia
- Mount Isa City Council
- Central Highlands Regional Council
- Flinders Shire Council
- Cloncurry Shire Council
- McKinley Shire Council
- Isaac Regional Council
- Winton Shire Council
- Barcaldine Regional Council
- Charters Towers Regional Council
- Biosecurity officers (Biosecurity Queensland)
- Northern Territory Department of Environment, Parks and Water Security
- Western Australia Department of Primary Industries and Regional Development

25. Sicklepod ecology and control

Project dates

January 2016 – June 2021

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 determine the longevity and production of sicklepod seed, including the seasonality of seed production and environmental triggers for germination (rainfall and temperature) relative to local conditions. We are also investigating 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.

Trials to test pre-emergent herbicide options in field situations were established in late 2019. We have had promising preliminary assessments in early 2020.

Stephen Setter applying pre-emergent herbicide to sicklepod in a field trial at Morehead River

Collaborators

- Biosecurity officers (Biosecurity Queensland)
- Cape York NRM
- Local governments in northern Queensland (e.g. Cook Shire Council)
- Queensland Parks and Wildlife Service (Queensland Department of Environment and Science)
- 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.

26. Control and ecology of *Stevia ovata*

Project dates

July 2012 – June 2021

Project team

Melissa Setter, Stephen Setter and Simon Brooks

Project summary

While *Stevia ovata* (candy leaf) is recorded only in the southern Atherton Tableland region of northern Queensland, it is deemed such a threat to the area that it has been declared under local law by the Tablelands Regional Council. It is also included in the weed lists from the Far North Queensland Pest Advisory Forum and the Wet Tropics Management Authority and is category 3 restricted biosecurity matter under the *Queensland Biosecurity Act 2014*.

A working group of stakeholders—including representatives from local governments, Queensland Government, energy companies and landholders—requested research into herbicide control of candy leaf, along with studies on its ecology. We have completed research on the weed's germination requirements, age and size at reproductive maturity, seed longevity in soil (in the Wet Tropics and Dry Tropics of northern Queensland) and seed longevity in water.

We have also identified effective herbicides for both high-volume foliar and low-volume, high-concentration (splatter-gun) application techniques. Using pots containing seeds of candy leaf, we tested 14 herbicides for pre-emergent control, identifying several that were effective. These results have been incorporated into local *Stevia ovata* management plans.

Collaborators

- *Stevia ovata* Stakeholder Group (including community members and representatives from industry and government)
- Biosecurity officers (Biosecurity Queensland)
- Far North Queensland Regional Organisation of Councils
- Tablelands Regional Council
- Terrain NRM

Key publications

Bebawi, FF, Campbell, SD, Mayer, RJ, Setter, S & Setter, M 2018, 'Effects of temperature and burial on seed germination and persistence of Stevia ovata (*Stevia ovata* Willd.)', *Australian Journal of Botany*, vol. 66(5), pp. 388–397.

Setter, MJ, Setter, SD, Brooks, SJ & Campbell, SD, 2016, '*Stevia ovata*—not so sweet', *Proceedings of the 20th Australasian weeds conference*, Weeds Society of Western Australia, Perth, pp. 13–16.

27. 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 is an invasive grass that is widespread predominantly in eastern Queensland but is continuing to spread. It causes significant problems in animal production systems, forestry and the wider environment. In this project, we concentrate on improving the use of the herbicide flupropanate, fertiliser and fire in management of the grass. We also investigate 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 the grass in a range of situations including grazing, peri-urban development and forestry.

In small-scale plot trials, we are investigating low-disturbance methods for returning dense infestations of the grass to productive pastures and have significantly reduced its presence over two wet seasons. We have shown that ash from grass fires does not reduce the efficacy of flupropanate, and that 20 millimetres of rain is all that is needed to push flupropanate into the soil. Trials have also confirmed that high levels of dry grass and spray volume at the time of application of flupropanate do not reduce its efficacy.

We are continuing work on how to manage the grass in seasonally waterlogged areas. Application of flupropanate late in the dry season and low-volume, high-concentration spot application show high levels of efficacy in experimental situations. Fertiliser application can significantly improve the nutritional value and digestibility of immature giant rat's tail grass as fodder for cattle. However, more work is needed to determine whether this could be applied on a larger scale.

Collaborators

- Economic Development Queensland
- Biosecurity 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.

28. Herbicide application research

Project dates

July 2009 – June 2020

Project team

Wayne Vogler, Dannielle Brazier and Clare Warren

Project summary

The Australian Government Department of Agriculture, Water and the Environment is providing funding to test applications of low-volume, high-concentration herbicide (e.g. using splatter guns) on prickly acacia (*Vachellia nilotica*), rubber vine (*Cryptostegia grandiflora*), chinee apple (*Ziziphus mauritiana*) and gamba grass (*Andropogon gayanus*).

We have completed a trial on gamba grass to determine the efficacy of glyphosate applied at seven different rates. Splatter-gun application of glyphosate at 36, 45 and 54 grams active ingredient per litre resulted in 100% mortality 3 months after treatment, while the lower glyphosate rates produced mortality rates ranging from 29% to 80% 3 months after treatment. A further trial on more mature gamba grass stands using both glyphosate and flupropanate has shown that both are effective herbicides for the control for gamba grass.

Another trial aims to improve herbicide efficacy on prickly acacia by identifying the optimum way to spray plants. We investigated the amount of herbicide (based on the surface area of one or both sides of plants) and the area of spraying (one or both sides of plants). The results recorded variable effectiveness.

A trial on rubber vine compared the efficacy of monthly applications (from December to May) of two herbicides [metsulfuron-methyl (Brush-off®) and triclopyr/picloram/aminopyralid (Grazon™ Extra)] to determine if there are seasonal and environmental influences that may affect mortality. This trial demonstrated that rubber vine plant mortality with both herbicides was highly variable and is likely to be influenced by plant health, the presence of biocontrol agents (such as rust fungus) and prevailing weather conditions during herbicide application. Further research is needed to understand the causes of this variability and to develop reliable protocols for the successful use of splatter guns.

In a screening trial on chinee apple, we applied five herbicides at two rates. This trial showed that metsulfuron-methyl/aminopyralid (12 grams per litre Stinger®) produced >90% mortality on plants ≤2 metres tall. Mortality on larger plants was much lower, at <23%. This indicates that using a splatter gun to apply this herbicide may be an effective control option for small or regrowth chinee apple plants. Further work is needed to refine application rates using a splatter gun, which should improve efficacy.

We have completed a series of herbicide trials on the control of night-blooming cereus (*Cereus uruguayanus*) and are analysing the data.

Collaborators

- Northern Gulf Resource Management Group
- Desert Channels Queensland
- Central Highlands Regional Council
- Central Highlands Regional Resources Use Planning Cooperative
- Biosecurity officers (Biosecurity Queensland)
- Shane Campbell (The University of Queensland)
- Cook Shire Council
- Mareeba Shire Council

Key publications

Campbell, SD & Brazier, DA 2016, 'Developing additional herbicide control options for rubber vine (*Cryptostegia grandiflora* R.BR.), *Proceedings of the 20th Australasian weeds conference*, The Weeds Society of Western Australia, Perth, pp. 284–287.

Campbell, S, McMillan, H, Brazier, D, Setter, M & Setter, S 2019, 'Advancing splatter gun technology for rangeland weeds', *Proceedings of the 1st Queensland pest animal and weed symposium*, Weed Society of Queensland, pp. 101–104.

29. Control packages for statewide 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

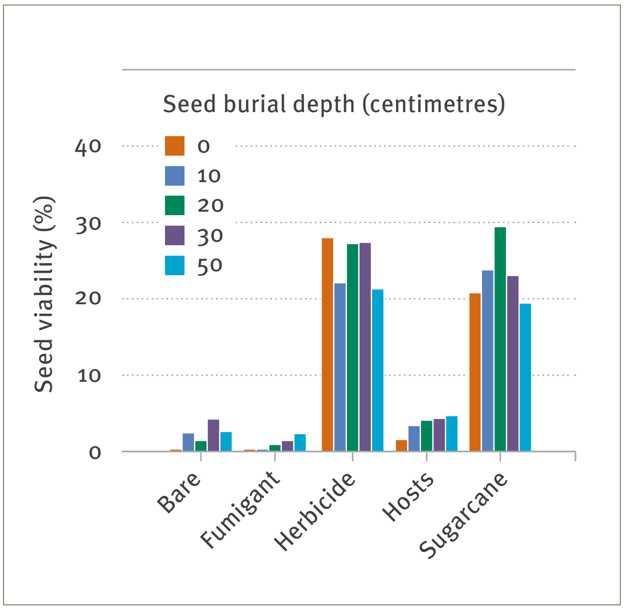
In this project, we aim to develop reliable and effective control options that can be integrated into eradication programs for priority weeds in Queensland.

We are investigating the efficacy of agronomic practices for depleting the red witchweed seed bank and preventing further seed production over a 10-year period. We are evaluating 15 treatments—comprising pre- and post-emergent herbicides, catch crops (true host), trap crops (false host) and fumigants—by monitoring the viability of seeds in sachets buried at five depths (0, 10, 20, 30 and 50 centimetres).

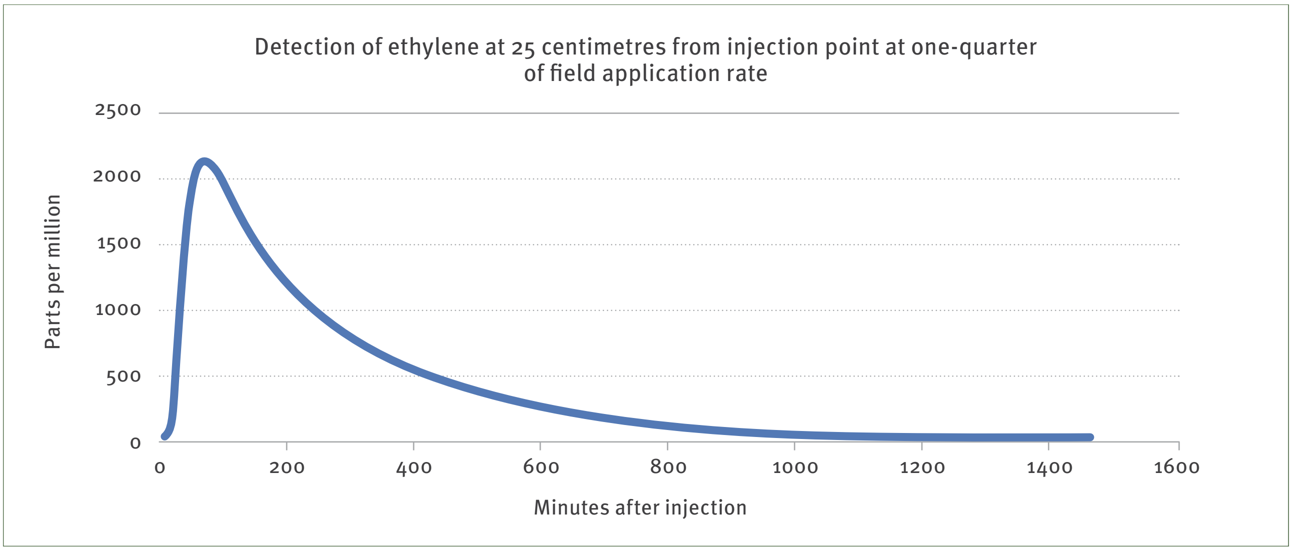
Current treatments involve soybean (false host), ethylene and dazomet (fumigants) being applied repeatedly or in combination on 8 infested properties across different topographies. We are evaluating these treatments using 300 perforated PVC canisters, each containing 3 sachets of about 100 seeds, buried at depths of 10, 30 and 50 centimetres across 25 sites.

Four annual applications of either ethylene gas, sorghum (true host), dazomat or soybean reduced the viability of the red witchweed seed bank to 0%, 0.3%, 2% and 3%, respectively, irrespective of seed burial depth. Almost 23% of the seed buried within sugarcane remained viable after 4 years. This does not differ significantly from seed viability in sugarcane treated with herbicides (25%).

Over the next few years, PhD candidate Anna Williams will investigate the optimal application of ethylene to different soil types, moisture levels and aggregate compositions. The aim is to determine the frequency and concentration of ethylene required to trigger the highest suicide germination of red witchweed seed. To complement this study, a series of experiments will be established at the Ecosciences Precinct to determine whether seed depletion of red witchweed can be accelerated with a continuous soybean crop, punctuated with multiple applications of the fumigant ethylene. Through the use of sensors, ethylene concentrations can now be monitored in the soil over time in an effort to optimise field ethylene injection.



Viability of red witchweed seed exhumed after 4 years of burial, following the annual application of 15 treatments



Ethylene detection in soil following its injection

Part 2: Pest animal management

30. 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

In this project, we study aspects of the ecology and management of chital deer (*Axis axis*), which were established in northern Queensland in the late 1800s. Unlike many other invasive vertebrate species, their spread has been relatively slow. However, 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 are considered major pests. To develop long-term management strategies, we need information on their impacts, their capacity for increase and spread, and control methods. Limiting factors are likely to be a combination of dingo predation and food supply, particularly availability of water and high-quality food.

Aerial and ground surveys have described a highly clumped distribution of the population with animals rarely seen more than 4 kilometres from homesteads. Deer density also declines with increasing distance from permanent water. Areas of high chital density are characterised by relatively high concentrations of soil phosphorus and sodium and zinc in food plants. Analysis of wild dog scats indicates deer are a common prey but, when deer are at high density, wild dog predation appears insufficient to strongly limit or regulate the population.

Satellite telemetry and grids of remote cameras are describing the habitat use of deer. This helps us 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. However, there was heavy mortality during drought over 2014–15. We will model these relationships to understand and predict population dynamics.

Continued monitoring of properties where chital have been culled and not culled indicates a slow population recovery and, so far, effective control. This has been made cost-effective by the heavy drought mortality and by populations being concentrated near homesteads.

Collaborators

- Keith Staines and Glen Harry (Sporting Shooters Association of Australia)
- Kurt Watter (PhD candidate, The University of Queensland)
- Dave Forsyth, Andrew Bengsen and Sebastien Comte (New South Wales Department of Primary Industries)
- Carlo Pacioni and Luke Woodford (Arthur Rylah Institute for Environmental Research, Victoria)
- Jordan Hampton (Ecotone Wildlife Veterinary Services)
- Tony Salisbury, Rodney Stevenson, Carl Anderson, Chrissy Zirbel, Sean Reed and Steve Anderson (Queensland Department of Agriculture and Fisheries)
- Ashley Blokland (Charters Towers Regional Council)
- Heather Jonsson (Dalrymple Landcare)
- Thijs Krugers and Rachel Payne (NQ Dry Tropics)
- Catherine Kelly, Jodie Nordine, Ben Hirsch, Lin Schwarzkopf and 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*, ‹https://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.

31. Feral cat ecology and management—improving feral cat management techniques

Project dates

June 2014 – June 2020

Project team

Matthew Gentle and James Speed

Project summary

Feral cats threaten wildlife, agriculture and human health through predation, competition and the spread of infectious diseases. Control of feral cat populations can be effective, but most techniques (such as trapping) are resource-intensive and generally unsuitable for broadscale use. In this project, we investigate and test options for the broadscale control of feral cats in Queensland environs. Also, through collaboration with external researchers, we are investigating the response to, and benefits of, cat removal on prey species.

During the winter of 2019, we completed a broadscale baiting trial at Moorrinya National Park in northern Queensland. Trapping yielded 14 cats, which were subsequently fitted with GPS collars. We assessed the mortality of these animals following aerial baiting (10 baits per linear kilometre) with fresh meat baits (6 milligrams 1080 per 125 grams). The mortality rate (~43%) compares favourably with that of baiting studies using fresh meat baits elsewhere (~15–50%).

We monitored the 58 baits using remote cameras for 14 days to determine bait uptake rates and interaction of both target and non-target species with baits. This data complements that from similar trials in southern, central and northern Queensland and helps to assess the potential risk to non-target species from fresh-meat or chipolata-style baits. Non-target bird species, particularly corvids, removed some of the monitored baits. However, there was no significant difference in bird species densities before and after baiting, indicating no population-level effect on monitored avian taxa.

The project will provide guidelines for using baiting to control feral cat populations, and will support future permit applications to use the technique under specific circumstances. The GPS location data collected will also help us understand the fine-scale movements of feral cats and identify areas of high cat activity for targeting control.

Collaborators

- Shellie Cash, Barry Nolan and John Augusteyn (Queensland Parks and Wildlife Service, Queensland Department of Environment and Science)
- Jane Oakey and Craig Smith (Biosecurity Queensland, Coopers Plains)
- Jessica Guidotti, Diana Fisher and John Dwyer (The University of Queensland, St Lucia)
- Neal Finch (Queensland Department of Environment and Science)
- Greg Falzon (Deves Falzon Pty Ltd)
- Various private landholders

Key publications

Fancourt, BA, Cremasco, P, Wilson, C & Gentle, MN 2019, 'Do introduced apex predators suppress introduced mesopredators? A multiscale spatiotemporal study of dingoes and feral cats in Australia suggests not', *Journal of Applied Ecology*, vol. 56(12), pp. 2584–2595, ‹https://doi:10.1111/1365-2664.13514›.

Fancourt, B, Speed, J & Gentle, M 2016, 'Uptake of feral cat baits in eastern Australia', *Proceedings of the 5th Queensland pest animal symposium*, Townsville, pp. 99–102.

Wilson, C, Fancourt, B, Speed, J & Gentle, M 2017, 'Home range and habitat utilisation of feral cats (*Felis catus*) in central Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 99.

32. Non-target impacts of 1080 pig baits

Project dates

June 2014 – June 2021

Project team

Peter Elsworth, David Holdom and Matthew Gentle

Project summary

Effective feral pig control in Queensland—to protect agriculture and the environment—relies heavily on the use of 1080 bait. However, there is not sufficient formal data to support the future registration by the Australian Pesticides and Veterinary Medicine Authority of 1080 baits prepared from fruit, vegetables and fresh meat. In this project, we collect efficacy data on feral pig baiting programs, identify non-target species visiting and consuming bait material, conduct population counts of theoretically susceptible birds, and monitor activity of varanids before and after baiting. We use control sites to ensure treatment (baiting) effects, if any, can be identified.

We completed feral pig control programs with fruit baits (bananas or mangoes) on nine baited sites and four non-baited sites in the Hinchinbrook Shire near Ingham, in northern Queensland. Camera monitoring indicated feral pig activity was reduced following baiting by an average of 92% (baited site) and 94% (baited property) respectively. Cameras and surveys indicated very limited interaction with baits by non-target species and no evidence of population-level impacts.

We monitored actual and simulated aerial meat-baiting programs on some sites where aerial baiting for feral pigs commonly occurs—in Gore (south-eastern Queensland), Culgoa Floodplain National Park (south-western Queensland) and Greenvale (northern rangeland districts). Collectively, non-target bird species (and assemblages) and varanids remained common and widespread or increased on the baited sites following baiting; their abundance was similar to or greater than on the non-baited sites. These results show no population-level impacts on native varanid or bird species from the use of meat baits for feral pig control in these environs.

Collaborators

- Charters Towers Regional Council
- Goondiwindi Regional Council
- Hinchinbrook Shire Council
- Herbert Cane Productivity Services
- Queensland Parks and Wildlife Service
- Landholders

Key publications

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.

Cremasco, P, Gentle, M, Wilson, CJ, Di Bella, L & Buckman, M 2016, 'Feral pig baiting with fruit in the Wet Tropics', *Proceedings of the 5th Queensland pest animal symposium*, Townsville, pp. 103–106.

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

33. Monitoring the efficacy of new rabbit biocontrol

Project dates

April 2014 – June 2020

Project team

Peter Elsworth and Michael Brennan

Project summary

The release in 2017 of an additional biocontrol virus (RHDV-K5) for the management of rabbits again highlighted the over-reliance of landholders and operators on viruses to control rabbits. For 70 years, since the release of myxoma virus, biocontrol viruses have been at the forefront of rabbit management. Following each release of a virus, however, the pressure to continue control has eased in the face of lower rabbit abundance. Small-scale control programs have traditionally used the success of biocontrol releases to justify using a virus release as the first option. This often leads to a 'job done' attitude and no follow-up management, allowing rabbits to return in short time frames.

With the release of RHDV-K5 and the recent incursions of RHDVa and RHDV2, Australia now has four lethal strains of calicivirus and one non-lethal strain of calicivirus as well as myxoma virus circulating freely in the environment. As a result, there are few rabbit populations that have not been exposed to one of these viruses. Deliberately releasing commercially available RHDV-K5 into a population is likely to have little effect, as there will not be a high proportion of susceptible rabbits. Long-term research has shown that the best control method for reducing rabbit numbers over long periods is to remove breeding harbour through warren destruction and clearing rabbit habitat. Our research has shown that effective results can be achieved by doing this mechanical control without an initial virus release. This, in turn, can lead to long-term reductions in rabbit populations.

Collaborators

- Tanja Strive (CSIRO)
- Tarnya Cox and Dave Forsyth (New South Wales Department of Primary Industries)
- Dave Ramsey (Arthur Rylah Institute for Environmental Research, Victoria)
- Vanessa MacDonald, Holly Hosie and Lachlan Marshall (Southern Queensland Landscapes)
- Nathan Ring and Greg Wilson (Darling Downs – Moreton Rabbit Board)
- Craig Magnussen and Matt Warren (Southern Downs Regional Council)
- Jim O'Sullivan (Toowoomba Regional Council)

Key publications

Elsworth, P 2019, 'Reorganising the rabbit control toolbox: do we need to reach for virus first?', *Proceedings of the 1st Queensland pest animal and weed symposium*, Gold Coast.

Cox, TE, Ramsey, DSL, Sawyers, E, Campbell, S, Matthews, J & Elsworth, P 2019, 'The impact of RHDV-K5 on rabbit populations in Australia: an evaluation of citizen science surveys to monitor rabbit abundance', *Scientific Reports*, vol. 9(1), pp. 1–11.

Ramsay, DSL, Cox, T, Strive, T, Forsyth, DM, Stuart, I, Hall, R, Elsworth, P & Campbell, S 2020, 'Emerging RHDV2 suppresses the impact of endemic and novel strains of RHDV on wild rabbit populations', *Journal of Applied Ecology*, vol. 57(3), pp. 630–641.

34. 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 introduced in south-western Queensland in 2013 to facilitate control of wild dogs, kangaroos and other pest species. Subsequent construction of cluster fences has exceeded all expectations. Initially, a 5-year study was developed to evaluate the impacts and longer term benefits of cluster fences on livestock production, land condition, regional economies and biodiversity. However, dry conditions affected outcomes in this period, and ongoing national and state investment have allowed this project to continue for a further 5 years to better capture the impacts of exclusion fencing.

In this project, we monitor the abundance of wild dogs, kangaroos and other wildlife, the biomass and condition of pasture, and livestock production. The monitoring is before and after the erection of cluster fences, and compares sites within cluster fences with sites that are immediately outside the fences.

There are several direct and indirect economic benefits of cluster fencing. However, its success will ultimately be determined by the extent to which livestock production inside the clusters improves relative to livestock production in comparable areas outside clusters, less the cost of constructing and maintaining the fences, plus the benefit of reduced pest populations.

We incorporate biogeographical and livestock production data in an economic evaluation of cluster fencing. To date, the results have been driven primarily by prevailing weather conditions. These patterns are likely to change with recent rainfall, highlighting the need for long-term (≥10 years) assessment of rangeland management in semi-arid and arid Australia.

Collaborators

- Lester Pahl (Queensland Department of Agriculture and Fisheries, Animal Science)
- John Carter (Queensland Department of Environment and Science)
- Megan Star (Central Queensland University)
- Ben Allen and Geoff Castle (University of Southern Queensland)
- Centre for Invasive Species Solutions

Key publications

Allen, L & Engeman, R 2014, 'Evaluating and validating abundance monitoring methods in the absence of populations of known size: review and application to a passive tracking index', *Environmental Science and Pollution Research*, vol. 22, pp. 2907–2915.

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

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

35. Peri-urban wild dog management

Project dates

April 2018 – June 2022

Project team

Matthew Gentle, Lana Harriott, James Speed and Tamar Michaelian

Project summary

Lethal control of wild dogs is implemented to mitigate impacts (such as predation on livestock, wildlife and domestic species), to reduce the potential for disease transmission, and to conserve biodiversity. However, in peri-urban environments, the landscape-scale application of control methods is restricted by small landholdings, varied land use, high human density and diverse opinions. Because of this, control may need to focus on specific individuals, small groups or reported impacts, rather than on broadscale population reduction.

In this project we aim to refine and assess strategies and to produce best-practice guidelines for the management of wild dogs in peri-urban areas. We are assessing canid pest ejectors (CPEs) containing 1080 or PAPP toxin (both lethal to wild dogs) at sites in the Gympie and Sunshine Coast local government areas. The data being collected includes the attractiveness of CPEs (e.g. encounter rates, number and percentage of dogs locating CPEs) and the acceptance or rejection of CPEs by each individual.

Two sites have also been selected for a trial comparing the effectiveness of CPEs with results from traditional trapping methods. All control efforts are monitored with motion-sensing cameras. Sightings or impacts reported to local authorities are captured as an outcome of control.

Also, we are comparing the costs and benefits of CPE deployment with those of alternative control methods (trapping and other tools). Project collaborators are assessing the value of the community-led planning approach for improving peri-urban pest animal management. Community engagement approaches will complement ecological research and help to identify acceptable management options for wild dogs in these environments.

Wild dog pups at a CPE

Collaborators

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

Key publications

Gentle, M, Allen, BL & Speed, J 2017, *Peri-urban wild dogs in north-eastern Australia: ecology, impacts and management*, PestSmart Toolkit publication, Centre for Invasive Species Solutions, Canberra.

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), p. e48.

36. Adaptive 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 abundance and distribution are increasing across Australia. A greater interaction between growing deer and human populations in peri-urban regions is of particular concern. Deer present a significant road hazard, and fatalities from deer collisions have occurred. They also have other negative impacts, including loss of pasture and crops, spreading of disease, habitat modification and competition with native fauna. However, current monitoring and control options are limited in built-up areas. Best-practice guidelines for monitoring and controlling wild deer, together with on-ground training and supporting technical expertise, were identified as key needs at the 2016 National Wild Deer Management Workshop.

This project forms part of a larger 4-year project with interstate collaborators on deer management funded through the Centre for Invasive Species Solutions. In the project, we:

1. evaluate the reduction in deer numbers and impacts achieved by available control options, including various traps and ground shooting
2. refine monitoring methods for peri-urban deer populations (faecal pellet counts, camera trapping, aerial surveys, vehicle and aerial surveys using thermal imagery, and removal data)
3. investigate strategies and tools to assist deer management (attractants, repellents, wildlife corridors and fencing).

Collaborators

- Mark Kimber and Tony Cathcart (Sunshine Coast Regional Council)
- Jess Doman and Perry Ward (Seqwater)
- Darren Sheil (Moreton Bay Regional Council)
- Bree Galbraith (Gympie Regional Council)
- Bill Manners, Dan Franks and Robyn Jones (Brisbane City Council)
- Centre for Invasive Species Solutions

Key publications

Amos, M, Brennan, M, Pople, T & Bengsen, A 2020, *Yeppoon 2019 camera trap survey report*, submitted to Livingstone Shire Council, Pest Animal Research Centre, Department of Agriculture and Fisheries, Toowoomba.

Amos, M, Brennan, M, Pople, T & Bengsen, A 2020, *Wild Duck Island 2019 camera trap survey report*, submitted to Queensland Parks and Wildlife Service, Pest Animal Research Centre, Department of Agriculture and Fisheries, Toowoomba.

Amos, M, Cathcart, A & Kimber, M 2019, 'Counting deer, not tourists, on the Sunshine Coast', *Proceedings of the 1st Queensland pest animals and weed symposium*, The Weed Society of Queensland, Gold Coast.

Part 3: Research services

37. Chemical registration—providing tools for invasive pest control

Project dates

July 2012 – June 2022

Project team

Joseph Vitelli and David Holdom

Project summary

Biosecurity Queensland holds permits for the 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.

Twelve new permits (including two emergency-use permits) were issued to Biosecurity Queensland during 2019–20 by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Nine permits related to weeds—Bahia grass and fireweed, florestina, hymenachne, kidneyleaf mudplantain, kudzu, pond apple, running and clumping bamboo, salvinia and water primrose (*Ludwigia peruviana*). One permit was for the aquatic surfactant Bonus®, one was for the control of feral cats and one was for the prohibited browsing ant species *Lepisiota frauenfeldi*. A further seven permits have also been lodged with the APVMA, for the control of weeds on dam walls and dam infrastructure, for the aquatic surfactant Nemo to aid aquatic weed management, and for the control of calotrope, lippia, sagittaria, giant American rat's tail grass, Parramatta grass, Kahilli ginger, white ginger and yellow ginger.

Collaborators

- Local governments
- Seqwater
- Agribusiness (including Sumitomo Chemical, Nufarm Australia, Macspred and Corteva Agriscience)
- Queensland Department of Environment and Science
- Queensland Department of Transport and Main Roads
- Biosecurity Queensland officers, including Sonia Jordan, Steve Csurhes, Craig Hunter, Michael Graham, Lyn Willsher, John Reeves, Stacey Harris and Michelle Smith

Key publications

Twelve new permits (including two emergency-use permits) were issued by the APVMA to Biosecurity Queensland during the 2019–20 financial year:

1. Permit (PER88624) 2,4-D amine, metsulfuron methyl, 2,4-D amine + picloram/Pasture stock routes, roadsides and non-crop situations/Florestina, expires 30 June 2021, ‹http://permits.apvma.gov.au/PER88624.PDF›.
2. Permit (PER11540) Haloxyfop/Ponds, drainage areas, waterways, pastures, roads and utility reserves/Hymenachne, expires 30 June 2025, ‹http://permits.apvma.gov.au/PER11540.PDF›.
3. Permit (PER14849) Various herbicides/Non-agricultural, native vegetation and pasture/Kudzu, expires 31 August 2024, ‹http://permits.apvma.gov.au/PER14849.PDF›.
4. Permit (PER13684) Triclopyr, picloram (Access Herbicide and Tordon DSH); fluroxypyr (Starane Advanced Herbicide); glyphosate (Roundup Biactive) and imazapyr (Unimaz 250 SL Herbicide)/Various situations/Pond apple, expires 30 June 2025, ‹http://permits.apvma.gov.au/PER13684.PDF›.
5. Permit (PER10892) Glyphosate/Aquatic areas in Queensland/*Salvinia molesta*, expires 31 August 2022, ‹http://permits.apvma.gov.au/PER10892.PDF›.
6. Permit (PER80929) Metsulfuron-methyl/Pastures, roadsides, non-crop areas, rights of way, forests, reserves and bushland/Bahia grass and fireweed, expires 31 May 2025, ‹http://permits.apvma.gov.au/PER80929.PDF›.
7. Permit (PER14122) Metsulfuron-methyl/Non-potable waterways/Kidneyleaf mudplantain, expires 30 June 2025, ‹http://permits.apvma.gov.au/PER14122.PDF›.
8. Permit (PER81236) Nufarm Bonus adjuvant/Surfactant/Herbicides, expires 30 June 2023, ‹http://permits.apvma.gov.au/PER81236.PDF›.
9. Permit (PER14015) Curiosity 1080 (sodium fluoroacetate) cat bait/Forests, pastures, non-crop, pre-plant and fallow land/Feral cats, expires 30 September 2022, ‹http://permits.apvma.gov.au/PER14015.PDF›.
10. Permit (PER83165) Flupropanate/Small infestations/Running and clumping bamboo species, expires 30 June 2025, ‹http://permits.apvma.gov.au/PER83165.PDF›.
11. Permit (PER88541) Various products/Aquatic and terrestrial areas/Water primrose, expires 30 November 2022, ‹http://permits.apvma.gov.au/PER88541.PDF›.
12. Permit (PER88595) Pyriproxyfen/Various situations/Browsing ant, expires 31 October 2021, ‹http://permits.apvma.gov.au/PER88595.PDF›.

38. Pest management chemistry

Project dates

Ongoing

Project team

Alyson Herbert

Project summary

This project provides chemistry services to science, 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 is 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 50 investigations into possible animal poisonings—29 for sodium fluoroacetate, 12 for strychnine, 6 for anticoagulants and 3 for metaldehyde. While most investigations related to domestic dogs and cats, some involved livestock and macropods.

Formulation chemistry

During the year, our formulation facility produced 570 litres of 1080 (36 grams per litre) pig bait solution for use in baiting programs coordinated by Biosecurity Queensland and local governments.

Testing of post-preparation sodium fluoroacetate solutions continued throughout the year.

Collaborators

- Stephen Were, Patrick Seydel and Chien Cao (Biosecurity Queensland)

External funding

Research and development contracts

Project/research area	Funding body	Funds spent ($)
Integrated management of cabomba	CSIRO	150 000
Biocontrol of cat's claw creeper	Seqwater	70 000
Biocontrol of *Clidemia hirta*	AgriFutures Australia	1 000
Biocontrol of pasture weeds, Vanuatu	Manaaki Whenua Landcare Research New Zealand	115 000
Biocontrol of parkinsonia	CSIRO	500
Biocontrol of mother-of-millions	New South Wales Department of Primary Industries	129 000
Biocontrol of prickly acacia	AgriFutures Australia	210 000
Biocontrol of parthenium	Australian Government	2 500
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 Weed Biocontrol Task Force	230 000
Biocontrol of giant rat's tail grass	AgriFutures Australia	76 000
Giant rat's tail grass flupropanate control	Powerlink	17 000
Giant rat's tail grass management in central Queensland	Gladstone Regional Council	34 000
Giant rat's tail grass management in Aldoga, Gladstone State Development Area	Economic Development Queensland	6 000
Giant rat's tail grass management	Australian Government	1 000
Navua sedge	AgriFutures Australia	
Herbicide control of rangeland weeds	Australian Government	124 000
Gamba grass pre-emergent herbicide	CSIRO	21 000
Four tropical weeds eradication	National cost share	64 000
Red witchweed eradication	National cost share	56 000
Peri-urban wild dog and deer management	Centre for Invasive Species Solutions	145 000
Cluster fencing evaluation	Centre for Invasive Species Solutions	85 000
Wild dog exclusion fencing	Centre for Invasive Species Solutions	28 000
Total		**1 565 000**

Land Protection Fund

Project/research area	Funds spent ($)
Weed seed dynamics	28 000
Herbicide application research	64 000
Biocontrol of bellyache bush	101 000
Biocontrol of prickly acacia	295 000
Biocontrol of cat's claw creeper	57 000
Biocontrol of cactus	182 000
Biocontrol of *Clidemia hirta*	34 000
Biocontrol of mother-of-millions	14 000
Biocontrol of Navua sedge	56 000
Biocontrol of parthenium	24 000
Biocontrol of giant rat's tail grass	49 000
Biocontrol of parkinsonia	7 000
Rearing and release of weed biocontrol agents	164 000
Giant rat's tail grass flupropanate control	35 000
Integrated management of parthenium	137 000
Prioritising pest management	29 000
Water weed ecology and management	65 000
Integrated management of cabomba	122 000
Modelling decision support	107 000
Feral deer best-practice research	102 000
Deer management	72 000
Rabbit best-practice research	26 000
Management of peri-urban wild dogs and deer	134 000
Non-target impacts of 1080 feral pig baits	73 000
Feral cat ecology and management	71 000
Wild dog exclusion fencing	47 000
Pest spatial dynamics	51 000
Pesticide permits	74 000
Pest management chemistry and chemical registration	78 000
Quarantine management	62 000
Total	**2 360 000**

Research staff

Ecosciences Precinct

GPO Box 267
BRISBANE QLD 4001

Tel: (07) 3255 4518 **Fax:** (07) 3846 6371

Email: donna.buckley@daf.qld.gov.au
Email for other staff: firstname.lastname@daf.qld.gov.au

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

Health and Food Sciences Precinct

PO Box 156
ARCHERFIELD QLD 4108

Tel: (07) 3708 8811 **Fax:** (07) 3708 8764

Email: alyson.herbert@daf.qld.gov.au

Alyson Herbert	Science technician

Pest Animal Research Centre

PO Box 102
TOOWOOMBA QLD 4350

Tel: 13 25 23 **Fax:** (07) 4688 1199

Email for staff: firstname.lastname@daf.qld.gov.au

Matthew Gentle	Principal scientist
Malcolm Kennedy	Senior scientist
Matt Amos	Scientist
Peter Elsworth	Senior science technician
James Speed	Senior science technician
Tamar Michaelian	Science technician (casual)

Tropical Weeds Research Centre, Charters Towers

PO Box 976
CHARTERS TOWERS QLD 4820

Tel: (07) 4787 5300

Email: Wayne.Vogler@daf.qld.gov.au
Email for other staff: firstname.lastname@daf.qld.gov.au

Wayne Vogler	Principal scientist
Simon Brooks	Senior scientist
Dannielle Brazier	Science technician
Kelli Pukallus	Science technician
Clare Warren	Science technician
Kirsty Gough	Science support officer
Ainsley Kronk	Science support officer

Tropical Weeds Research Centre, South Johnstone

PO Box 20
SOUTH JOHNSTONE QLD 4859

Tel: (07) 4220 4177 **Fax:** (07) 4064 2249

Email: leanne.wright@daf.qld.gov.au
Email for other staff: firstname.lastname@daf.qld.gov

Melissa Setter	Scientist
Stephen Setter	Senior science technician

Publications and presentations

Journal articles

Aigbedion-Atalor, P, Adom, M, Day, MD, Uyi, O, Egbon, IN, Idemudia, I, Igbinosa, IB, Paterson, ID, Braimah, H, Wilson, DD & Zachariades, C 2019, 'Eight decades of invasion by *Chromolaena odorata* (Asteraceae) and its biological control in West Africa: the story so far', *Biocontrol Science and Technology*, vol. 29, pp. 1215–1233.

Ali, S, Shabbir, A & Dhileepan, K 2020, 'Bionomics and damage potential of fruit fly *Dacus persicus* (Diptera: Tephritidae); a prospective agent for *Calotropis procera* (Apocynaceae) biological control', *Biocontrol Science and Technology*, vol. 30, pp. 716–727, ‹https://doi10.1080/09583157.2020.1765982›.

Augusteyn, J, Pople, A & Rich, M 2020, 'Evaluating the use of thermal imaging cameras to monitor the endangered greater bilby at Astrebla Downs National Park', *Australian Mammalogy*, ‹https://doi.org/10.1071/AM19040›.

Bengsen, AJ, Forsyth, DM, Harris, S, Latham, ADM, McLeod, SR & Pople, A 2020, 'A systematic review of ground-based shooting to control overabundant mammal populations', *Wildlife Research*, vol. 47, pp. 197–207, ‹https://doi.org/10.1071/WR19129›.

Campbell, S, Vogler, W, Brazier, D, Vitelli, J & Brooks, S 2019, 'Weed leucaena and its significance, implications and control', *Tropical Grasslands—Forages Tropicales*, vol. 7(4), pp. 280–289.

Cox, TE, Ramsey, DSL, Sawyers, E, Campbell, S, Matthews, J & Elsworth, P 2019, 'The impact of RHDV-K5 on rabbit populations in Australia: an evaluation of citizen science surveys to monitor rabbit abundance', *Scientific Reports*, vol. 9(1), pp. 1–11.

Day, MD & Witt, ABR 2019, 'Weed biological control: challenges and opportunities, *Weeds— Journal of Asian–Pacific Weed Science Society*, vol. 1, pp. 34–44.

Day, MD, Witt, ABR & Winston, RL 2020, 'Weed biological control in low- and middle-income countries', *Current Opinion in Insect Science*, vol. 38, pp. 92–98.

Fancourt, BA, Cremasco, P, Wilson, C & Gentle, MN 2019, 'Do introduced apex predators suppress introduced mesopredators? A multiscale spatiotemporal study of dingoes and feral cats in Australia suggests not', *Journal of Applied Ecology*, vol. 56(12), pp. 2584–2595, ‹https://doi:10.1111/1365-2664.13514›.

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*, ‹https://doi:10.1093/jmammal/gyz139›.

Harriott, L, Gentle, M, Traub, R, Cobbold, R & Soares Magalhaes, RJ 2019, 'Geographical distribution and risk factors for *Echinococcus granulosus* infection in peri-urban wild dog populations', *International Journal for Parasitology: Parasites and Wildlife*, vol. 10, pp. 149–155, ‹https://doi.org/10.1016/j.ijppaw.2019.08.005›.

Hofstra, D, Schoelynck, J, Ferrell, J, Coetzee, J, de Winton, M, Bickel, TO, Champion, P, Madsen, J, Bakker, ES, Hilt, S, Matheson, F, Netherland, M & Gross, EM 2020, 'On the move: new insights on the ecology and management of native and alien macrophytes', *Aquatic Botany*, vol. 162, p. 103 190.

Kelman, M, Harriott, L, Carrai, M, Kwan, E, Ward, MP & Barrs, VR 2020, 'Phylogenetic and geospatial evidence of canine parvovirus transmission between wild dogs and domestic dogs at the urban fringe in Australia', *Viruses*, vol. 12(6), p. 663, ‹https://doi.org/10.3390/v12060663›.

Kreplins, TL, Gaynor, A, Kennedy, MS, Baudains, CM, Adams, P, Bateman, PW & Fleming, PA 2018, 'What to call a dog? a review of the common names for Australian free-ranging dogs', *Pacific Conservation Biology*, vol. 25, pp. 124–134.

Lock, C, Vitelli, JS, Holdom, DG, Tan, YP & Shivas, RG 2020, '*Microdochium dawsoniorium.* Fungal planet description sheet: 1092', *Persoonia*, vol. 44, pp. 416–417, ‹https://doi.org/10.3767/persoonia.2020.44.11›.

Lock, C, Vitelli, JS, Holdom, DG, Tan, YP & Shivas, RG 2020, '*Neopestalotiopsis nebuloides.* Fungal planet description sheet: 1097', *Persoonia*, vol. 44, pp. 426–427, ‹https://doi.org/10.3767/persoonia.2020.44.11›.

Lock, C, Vitelli, JS, Holdom, DG, Tan, YP & Shivas, RG 2020, '*Pestalotiopsis etonensis.* Fungal planet description sheet: 1102', *Persoonia*, vol. 44, pp. 436–437, ‹https://doi.org/10.3767/persoonia.2020.44.11›.

Massetti, L, Colella, V, Zendejas, PA, Ng-Nguyen, D, Harriott, L, Marwedel, L, Wiethoelter, A & Traub, RJ 2020, 'High-throughput multiplex qPCRs for the surveillance of zoonotic species of canine hookworms', *PLOS Neglected Tropical Diseases*, vol. 14(6), p. e0008392, ‹http://doi.org/10.1371/journal.pntd.0008392›.

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, ID, Pyšek, P, Richardson, DM, Witt, A, Zimmermann, HG & Wilson, JRU 2019, 'Global actions for managing cactus invasions', *Plants*, vol. 8(10), p. 421.

Ramsay, DSL, Cox, T, Strive, T, Forsyth, DM, Stuart, I, Hall, R, Elsworth, P & Campbell, S 2020, 'Emerging RHDV2 suppresses the impact of endemic and novel strains of RHDV on wild rabbit populations', *Journal of Applied Ecology*, vol. 57(3), pp. 630–641.

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.

Wijayabandara, K, Campbell, S, Vitelli, J & Adkins, S 2019, 'Plant and seed mortality of fireweed *Senecio madagascariensis* following herbicide application', *Proceedings*, vol. 36(1), p. 160, ‹https://doi.org/10.3390/proceedings2019036160›.

Books and book chapters

Shi, B, Taylor, DBJ & Dhileepan, K 2019, *Proposed plant host test list for assessing risk of biological control agents for* Vachellia nilotica *subsp.* indica, Department of Agriculture and Fisheries, Queensland.

The Weed Society of Queensland Inc. 2019, *Weeds of central and northern Queensland,* (working group Craig Magnussen, Belinda Callanan, Craig Hunter, Melinda Laidlaw, Sheldon Navie, Michelle Smith, Joseph Vitelli, Bruce Wilson, Janet Barker & Jo Glasheen), 81 pp.

Conference proceedings and presentations

Day, MD 2019, 'Biological control: the forgotten tool in weed management', *Proceedings of the research and development conference on invasive alien species management and biosecurity measures in the Asia–Pacific region*, Manila, Philippines, 9–12 July.

Day, MD 2019, 'Weed biological control: challenges and opportunities', *27th Asian–Pacific weed science society conference*, Kuching, Malaysia, 3–6 September.

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', *XV international symposium on biological control of weeds*, Engelberg, Switzerland, pp. 13–19, 26–31 August 2018.

Sankaran, K & Day, MD 2019, 'Invasive plant alerts for countries in the Asia–Pacific region', *Proceedings of the research and development conference on invasive alien species management and biosecurity measures in the Asia–Pacific region*, Manila, Philippines, 9–12 July.

Shabbir, A, Ali, S & Dhileepan, K 2019, 'Exploration of natural enemies of Calotrope in its native range: predispersal seed-predation in Pakistan', *XV international symposium on biological control of weeds*, Engelberg, Switzerland, pp. 42–43, 26–31 August 2018, ‹https://www.ibiocontrol.org/proceedings/›.

Taylor, DJB & Dhileepan, K 2019, 'Impact of cage size on the oviposition of *Stomphastis* sp. (Lepidoptera: Gracillariidae)', *Australasian entomological society conference*, Brisbane, Australia, 1–4 December.

Taylor, DJB, Dhileepan, K, Day, M & Pople, T 2019, 'Biological control of Queensland weeds: achievements and progress', *Australasian entomological society conference*, Brisbane, Australia, 1–4 December.

Wijeweera, WPSN, De Silva, MPKSK, Dhileepan, K & Senaratne, KAW 2020, 'Use of MaxEnt modelling in determination of distribution of *Calotropis gigantea* (Apocynaceae) in Sri Lanka', *Proceedings of 7th Ruhuna international science and technology conference*, University of Ruhuna, Matara, Sri Lanka, 22 January.

Reports, newsletters, fact sheets and theses

Amos, M, Brennan, M, Pople, T & Bengsen, A 2020, *Wild Duck Island 2019 camera trap survey report* (submitted to Queensland Parks and Wildlife Service), Pest Animal Research Centre, Department of Agriculture and Fisheries, Toowoomba, May.

Amos, M, Brennan, M, Pople, T & Bengsen, A 2020, *Yeppoon 2019 camera trap survey report* (submitted to Livingstone Shire Council), Pest Animal Research Centre, Department of Agriculture and Fisheries, Toowoomba, June.

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, 43 pp.

Bickel, TO, Perrett, C, Xu, J & Vitelli, J 2020, *Control of Amazon frogbit (*Limnobium laevigatum*) with flumioxazin: efficacy of submersed and foliar application* (submitted to Sumitomo Inc.), Department of Agriculture and Fisheries, Brisbane, 6 pp.

Bickel, TO, Vitelli, J & Sathyamurthy, R 2020, *Integrated management of cabomba*, milestone report (submitted to Department of Agriculture, Water and the Environment), Department of Agriculture and Fisheries and CSIRO, Brisbane, 5 pp.

Carter, J 2020, *Satellite data calibration data sets (woody cover, ground cover, biomass, pasture height, drone imagery)*, National Spatial Database, Department of Environment and Science, Brisbane.

Ebner, BC, Millington, M, Holmes, BJ, Wilson, D, Sydes, T, Bickel, TO, Power, T, Hammer, M, Lach, L, Schaffer, J, Lymbery, A & Morgan, DL 2020, *Scoping the biosecurity risks and appropriate management relating to the freshwater ornamental aquarium trade across northern Australia*, Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER) publication 20/17, James Cook University, Cairns, 96 pp.

Elsworth, P, Cremasco, P, Scanlan, J & Gentle, M 2020, *Evaluating potential non-target impacts of feral pig (*Sus scrofa*) aerial meat-baiting using sodium fluoroacetate*, Pest Animal Research Centre, Department of Agriculture and Fisheries, Toowoomba.

Elsworth, P, Cremasco, P, Wilson, C, Scanlan, J & Gentle, M 2020, *Efficacy and non-target impacts of fruit baiting for feral pigs at Ingham, northern Queensland*, Pest Animal Research Centre, Department of Agriculture and Fisheries, Toowoomba.

Gentle, M & Speed, J 2020, *Broadscale feral cat baiting trial Moorrinya National Park, 2019*, Pest Animal Research Centre, Department of Agriculture and Fisheries, Toowoomba.

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

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

Shi, B, Taylor, DBJ & Dhileepan, K 2020, *Nomination of Navua sedge (*Cyperus aromaticus*) as a target weed for biological control*, out-of session paper submitted to the Australian Weeds Committee, July.

Soni, A 2019, *Management of Navua sedge (*Cyperus aromaticus*) using competition and simulated herbivory interactions of humidicola grass (*Brachiaria humidicola*) and rhodes grass (*Chloris gayana*)*, MSc thesis, The University of Queensland, Gatton, November.

Vitelli, JS 2020, *Giant rat's tail grass endemic pathogen project (QDAF—RnD4Profit—15-02-005): rural R&D for profit program final report*, submitted to AgriFutures Australia.

Watter, K 2019, *How nutrition influences the distribution and abundance of chital deer (*Axis axis*) in northern Queensland*, PhD thesis, The University of Queensland, Gatton.

Print media

'Step forward in Navua sedge battle' 2019, *North Queensland Register*, 3 December, ‹https://www.northqueenslandregister.com.au/story/6523228/step-forward-in-navua-sedge-battle›.

Thomas, R 2019, 'Positive step in fight against noxious weed Navua sedge', *The Express,* 10 December, ‹https://www.theexpressnewspaper.com.au/local-news/positive-step-in-fight-against-noxious-weed-navua-sedge›.

Radio, television and web

Department of Agriculture and Fisheries 2019, *Potential biocontrol agents for Navua sedge found in Nigeria*, intranet story, 22 July, ‹http://dafintranet.lands.resnet.qg/our-department/news-events/news/biosecurity/potential-biocontrol-agents-for-navua-sedge-found-in-nigeria›.

Elsworth, P 2019, *Ongoing drought, calicivirus decimate feral rabbit populations in Queensland's Southern Downs*, 'ABC news', ABC television, 13 October and 'Rural report', ABC radio, 14 October.

Pukallus, K, 2020, *New aerial weapon in fight against noxious Siam weed*, interview on 'Queensland country hour', ABC radio, 4 June, ‹https://www.abc.net.au/radio/programs/qld-country-hour/queensland-country-hour/12298738›.

Pukallus, K, 2020,*'Warplane' insect a new weapon in fight against noxious Siam weed*, ABC North Queensland Facebook page, 4 June, ‹https://www.facebook.com/ABCnorthqld/posts/10157367935948309› and ‹https://www.abc.net.au/news/rural/2020-06-04/new-aerial-weapon-in-fight-against-noxious-siam-weed/12317142›.

Posters

Wijayabandara, K, Campbell, S, Vitelli, J & Adkins, S 2019, 'Plant and seed mortality of fireweed *Senecio madagascariensis* following herbicide application', *TropAg international tropical agriculture conference*, Brisbane Convention & Exhibition Centre, 11–13 November.

Forums and workshops

Brooks, S 2020, 'How long do weed seeds last in the soil?', *Dalrymple Landcare meeting*, Charters Towers, 13 March.

Day, MD 2019, 'Biological control of invasive weeds', Malaysian Agricultural Research and Development Institute, Kuala Lumpur, 10–13 September.

Day, MD 2019, 'Biological control workshop', Department of Agriculture and Water Resources, Canberra, 24–25 September.

Day, MD 2019, 'Natural enemies—natural solutions', Secretariat of the Pacific Regional Environment Programme, Apia, 28 October – 3 November.

Day, MD 2020, 'Natural enemies—natural solutions', Department of Environment, Niue, 27 February.

Day, MD 2020, 'Natural enemies—natural solutions', Ministry of Environment, Nuku'alofa, 20 February.

Dhileepan, K 2019, 'Biological control of Navua sedge: research updates', *Malanda Beef Plan Group meeting*, Malanda, 11 December.

Dhileepan, K 2020, 'Biological control of cat's claw creeper and parthenium', *Natural resource management forum: changing landscapes—managing water, land and biodiversity for the future*, Local Government Association of Queensland, Brisbane, 10 March.

Dhileepan, K 2020, 'Biological control of prickly acacia: research updates', *Prickly acacia Alliance (stakeholders) meeting*, Ecosciences Precinct, Brisbane, 18 March.

Elsworth, P 2019, 'Feral pig biology, control and new technologies', *Mary River Environs wild dog group*, Nambour, 23 October.

Elsworth, P 2019, 'Rabbit control and virus release', *Mary River Environs Wild Dog Group*, Nambour, 23 October.

Elsworth, P 2020, 'Rabbit biology and biocontrol', *Rabbit management workshop*, Stanthorpe, 27 February.

Pukallus, K 2019, 'Siam weed (*Chromolaena odorata*) biological control update on new agent *Cecidochares connexa*', *Natural Assets Management Advisory Committee meeting*, Tully Civic Centre, Tully, 19 November.

Pukallus, K 2020, 'Overview of biocontrol projects at TWRC', *Dalrymple Landcare meeting*, Tropical Weeds Research Centre, Charters Towers, 13 March.

Pukallus, K 2020, 'Review of *Cecidochares connexa* release site at Longpocket Road', informal meeting with Hinchinbrook Shire Council, Queensland Parks and Wildlife Service and landholders, Abergowrie, 18 June.

Pukallus, K & Kronk, A 2019, 'Siam weed (*Chromolaena odorata*) biological control information session on new agent *Cecidochares connexa*', Townsville City Council, Reid Park Complex, Townsville, 26 November.

Setter, M & Setter, S 2020, 'Research update', *Biosecurity team meeting*, South Johnstone, February.

Vogler, W 2019, 'Prickly acacia ecology for management', *Desert Channels Queensland/DAF Grazing Futures BMP workshop*, Winton, 28 November.

Vogler, W 2020, 'Overview of invasive plant research at TWRC', *Local Government Association of Queensland local government forum*, Townsville, 31 March.

Lectures and seminars

Bickel, TO 2020, *Weed science PLNT3012/6894: aquatic plant ecology and management*, The University of Queensland, Gatton, April.

Brooks, S 2019, *Weed eradication research*, The University of Queensland students, Charters Towers, 10 July.

Brooks, S 2019, *Weed seed longevity studies*, Shire Rural Lands Officer Group, Charters Towers, 14 November.

Brooks, S 2020, *Research update*, Central Region biosecurity officers, Mackay, 12 February.

Day, MD 2019, *Biological control of* Mikania micrantha, Agricultural Genomics Institute, Shenzhen, 26 November.

Elsworth, P 2020, *Biological control: vertebrate pest applications*, Animal and Plant Biosecurity, School of Veterinary Science, The University of Queensland, Gatton, 9 March.

Gentle, M 2019, *Vertebrate pests—overview and control strategies*, School of Veterinary Science, The University of Queensland, Gatton, 16 March.

Harriott, L 2019, *Personal stories on One Health: an ecological approach*, School of Veterinary Science, The University of Queensland, St Lucia, 23 July.

Kronk, A 2019, *Biological control at TWRC overview*, The University of Queensland students, Charters Towers, 10 July.

Pukallus, K 2019, *Overview of biocontrol projects at TWRC*, Shire Rural Lands Officers Group meeting, Tropical Weeds Research Centre, Charters Towers, 14 November.

Williams, AM 2020, *Optimising application of ethylene for RWW seed bank decline*, confirmation milestone presentation, The University of Queensland, Gatton, 12 February.

Williams, AM 2020, *The goal is which weed? Not witchweed!*, SAFS virtual 3MT 2020.

Vogler, W 2019, *What do you mean I am responsible for biosecurity: biosecurity principles and risk*, The University of Queensland students, Tropical Weeds Research Centre, Charters Towers, 10 July.

Field days

Brooks, S 2020, 'All about Siam weed' & 'Siam weed—all you need to know!', *NQ Dry Tropics & Charters Towers Regional Council Siam weed (*Chromolaena odorata*) information small landholder sessions*, Reid River, 29 February.

Brooks, S 2020, 'All about Siam weed' & 'Siam weed—all you need to know!', *NQ Dry Tropics & Charters Towers Regional Council Siam weed (*Chromolaena odorata*) information small landholder sessions*, Herveys Range, 14 March.

Pukallus, K 2020, *NQ Dry Tropics & Charters Towers Regional Council Siam weed (*Chromolaena odorata*) information small landholder sessions*, Reid River, 29 February.

Pukallus, K 2020, *NQ Dry Tropics & Charters Towers Regional Council Siam weed (*Chromolaena odorata*) information small landholder sessions*, Hervey Range, 14 March.

STEM Professionals in Schools

Pukallus, K & Kronk, A 2019, Under 8s day, Distance Education Campus, Charters Towers, 1 November.

Technical highlights
Invasive plant and animal research 2019–20

biosecurity.qld.gov.au
@BiosecurityQld
@DAFQld

DAF1339 02/2021

Queensland Government